Chapter 3 - Part I

Lake Preservation & Restoration Concepts

Phoenix Lake Preservation & Restoration Plan

1.0 INTRODUCTION

This chapter describes lake-based management actions designed to restore and preserve the critical functions and values of Phoenix Lake. The restoration and preservation plan described in this chapter was developed in a two stage process. Stage 1, described in Part I of this chapter, characterized the physical and biological conditions of Phoenix Lake and identified **concepts** to improve lake water quality, restore storage capacity, and preserve or enhance ecological functions. Part I is organized as follows:

- Section 1 - Introduction
- Section 2 - Setting
- Section 3 - Restoration and Preservation Concepts
- Section 4- Conclusions and Next Steps
- Section 5- References and Glossary

The information presented in Part I was reviewed by the Tuolumne Utilities District (TUD) and Phoenix Lake Task Force (PLTF). Based on their feedback, a *Sediment Removal and Wetland Enhancement Plan* (Lake Plan) for Phoenix Lake was developed. The Lake Plan is presented in Part II of this chapter.

2.0 SETTING

Phoenix Lake is situated at 2,380 feet (ft) above mean sea level (MSL). The lake has a watershed area of 15,339 acres or 24.0 square miles. The characteristics of the Phoenix Lake watershed are described in Chapter 2 of the PLPLP.

For the purposes of communicating information about the lake and planning preservation and restoration activities, Phoenix Lake has been divided into "Management Units", which are depicted in Figure 3.1-1. This section continues with a description of the history of Phoenix Lake and existing conditions.

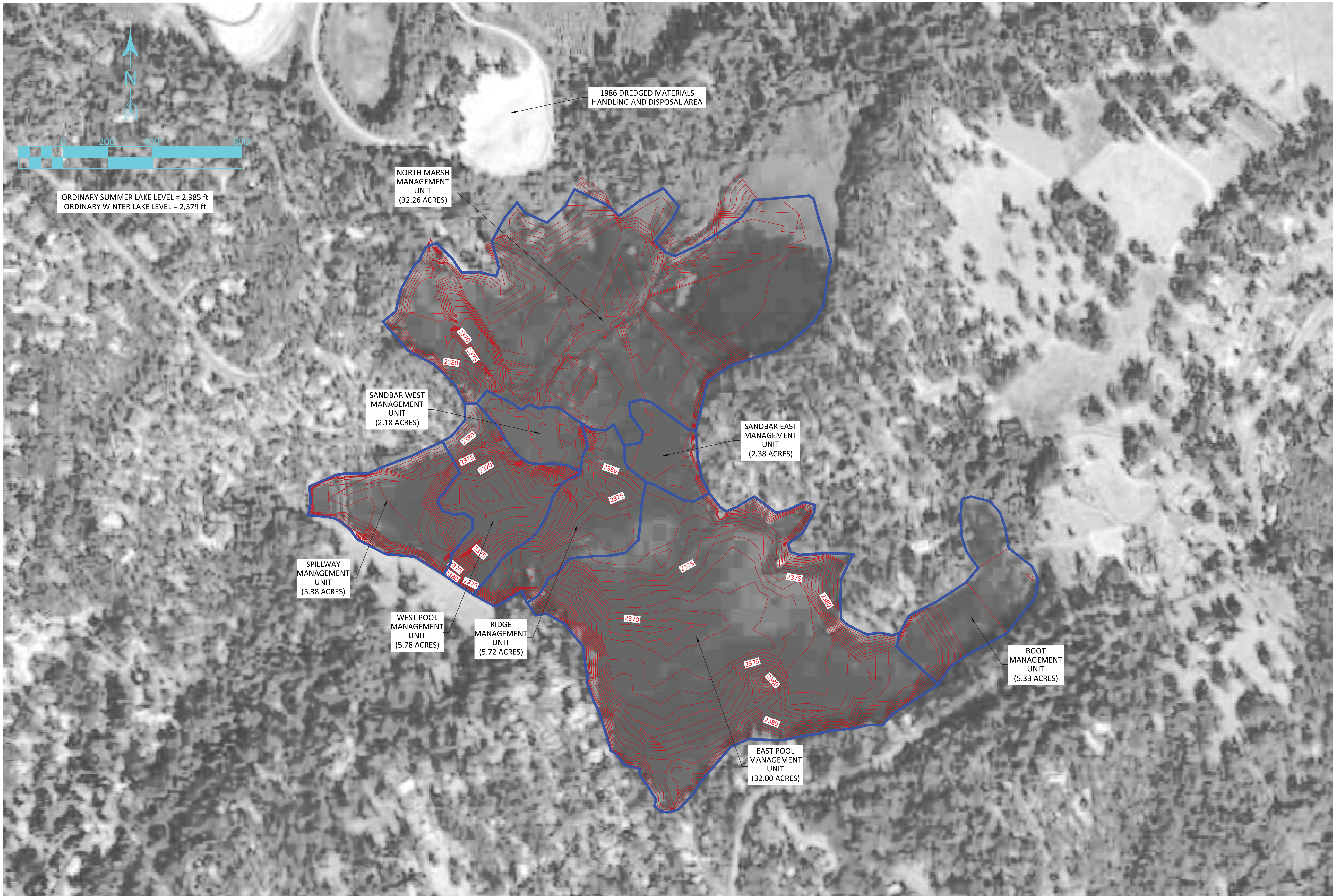
2.1 History of Phoenix Lake

The original dam impounding Phoenix Lake was constructed by Sullivan's Creek and Tuolumne Water Company in 1854, but was destroyed by a storm event in 1862 (PLTF, 2010a). The original reservoir may have been impounded by one or two dams (PLTF, 2010a; PLTF, 2010b). The dam which created the contemporary Phoenix Lake was completed in 1880 (California Division of Safety of Dams, 2012).

Historically, Phoenix Lake was a recreational destination for the people of the region. The Phoenix Lake Resort, established around the around turn of the 19th century, offered a variety of recreational facilities for visitors including fishing, swimming, boating, picnicking, and camping (Photo 3.1-1).

Photo 3.1-1: Phoenix Lake, 1894. Photo appears to be taken near the southwest corner of the existing dam.

In the 1920s and 30s, the lake was also used by filmmakers as an outdoor set for on-location filming. In the 1930s, there was an unsuccessful effort to establish a trout hatchery at the lake. Private development around the lake, beginning in the 1960s, has effectively closed the lake to public access. Opportunities to reestablish public access to the lake are presented in Chapter 5 of the PLPRP.



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3.1-1

In the 1980s, two dredging projects took place on the lake. A photograph from 1981 shows Phoenix Lake drained and construction equipment removing sediment from the lake. The report associated with this photograph notes that sediment removed from the lake was used to reinforce the dam (Mother Lode District Gas & Water Department, 1982). In 1986, Tuolumne County conducted a suction dredging project on the lake. Material from this dredging event was placed on the north side of the lake (Figure 3.1-1). The total volume of sediment removed from the lake during these projects is not known, but is estimated to be as much as 300,000 cubic yards (cy) (Pers. Comm., Allen 2011).

In 1983, Tuolumne County purchased a water system from the Pacific Gas and Electric Company (PG&E) which included Phoenix Lake water rights and facilities, as well as portions of the lake. The TUD was formed in 1992 to combine the Tuolumne Water System and Tuolumne Regional Water District into one agency; the water system including Phoenix Lake was transferred from the County to TUD. No additional dredging has occurred since 1992 under TUD's managment. The TUD's general operations of the lake are described in the following section.

2.2 Lake Hydrology & Operations

The major drainages that feed Phoenix Lake are Sullivan, Power and Chicken creeks. There are two, smaller unnamed watersheds that drain to the southern side of Phoenix Lake. In this report, these unnamed drainages are referred to as Ridgewood and Phoenix Lake Park.

Inflow to Phoenix Lake is dominated by natural runoff from the major drainages, with the greatest volume of runoff occurring in the wet season (November through April). However, there are also substantial out-of-basin diversions from the South Fork Stanislaus River which feed the lake year-round. Water is transferred from Lyons Reservoir on the South Fork Stanislaus via the Main Tuolumne Canal to a penstock that connects to PG&E's Phoenix Powerhouse in the Power Creek watershed. Between 4 to 30 cfs are regularly passed through the powerhouse and discharged to Power Creek. The TUD is able to divert a portion of the water released to Power Creek to its water supply treatment and distribution system through a system of canals and pipes that bypass Phoenix Lake. The water remaining in Power Creek is discharged to Phoenix Lake. The TUD also has an intake tower in Phoenix Lake that transfers water to the four treatment plants that supply the communities of Sonora, Jamestown, Scenic View and Mono Village.

Water surface elevation in Phoenix Lake is largely dictated by manual operation of a flashboard weir and outlet gates located at the reservoir spillway (Figure 3.1-1). The management of the flashboards controls the large-scale, seasonal fluctuations of lake levels; operations of a spillway gate and a smaller fish-flow bypass gate produce more modest adjustments in water surface elevation.

The flashboard weir operations follow a seasonal protocol set by the California Division of Safety of Dams (DSOD). The TUD cannot install the flashboards prior to May 15, and they must be removed by November 1. Installing the flashboards raises the elevation of the spillway weir by approximately 6 ft (Photo 3.1-2). This raises the lake water surface elevation to approximately 2,385 ft above MSL, which is the **ordinary summer lake level (OSLL)**. Lake water surface elevation data collected for this study indicate that there are relatively minor (0.5 to 1 ft) fluctuations of lake level during the summer months (See Technical Appendix II).

Photo 3.1-2. Flashboards being installed at the Spillway weir in 2008. The lake level will rise to the top of the flashboards, which is equivalent to the Ordinary Summer Lake Level (Photo from PLTF, 2010a).

In October of each year the flashboards are removed (Photo 3.1-3), which lowers water surface elevation to the **ordinary winter lake level (OWLL)** of approximately 2,379 ft above MSL. Lake water surface elevation data collected for this study indicate that winter storm events typically produce relatively small increases in lake level (approximately 1-2 ft), and that water surface elevation drops rapidly following the storm event (See Technical Appendix II).

Photo 3.1-3. Spillway weir without flashboards in place, which is equivalent to the Ordinary Winter Lake Level.

Several other factors also influence lake water surface elevation, including: Phoenix Powerhouse operations, TUD bypass and intake tower operations, direct precipitation, evaporation and infiltration. Lake level and streamflow data were collected as part of the PLPRP to help quantify the flow rates into and out of the lake. These data and supporting analyses are presented in Technical Appendix II of the PLPRP.

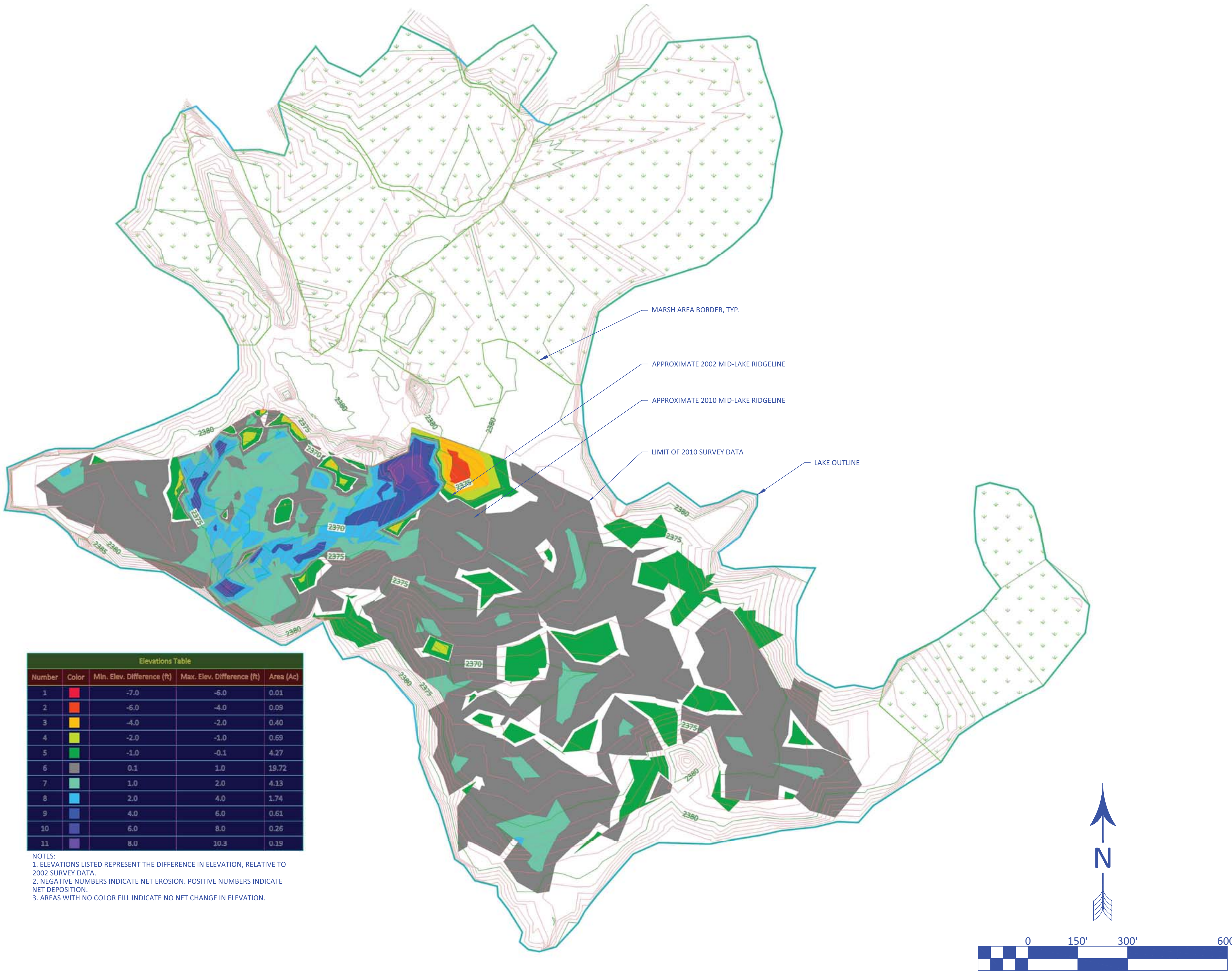
2.3 Bathymetry, Sedimentation and Capacity

Bathymetry

A bathymetric survey of Phoenix Lake was completed by TUD in 2002. Portions of the lake were resurveyed in 2010 as part of the PLPRP. Figure 3.1-2 shows lake bathymetry based on a compilation of the 2002 and 2010 survey data. The survey data show that most of the eastern portion of the lake is 5 ft deep or less at OWLL. The western portion of the lake is shallow in the Spillway Unit (1-2 ft deep at OWLL), with deeper sections in the West Pool and 1986 dredge hole (8-12 ft deep at OWLL). Maximum lake depth, measured at the TUD intake tower, is approximately 25 ft at OWLL.

Sedimentation Patterns and Rates

Figure 3.1-2 shows the change in elevation between 2002 and 2010 for unvegetated portions of the lake. Figure 3.1-2 indicates that the eastern portion of the lake largely experienced aggradation on the order of 0.1 to 1.0 ft during this time period. In comparison, the western portion of the lake saw more variable erosion and deposition patterns. This is because the eastern portion (i.e., the East Pool and Boot Units) of the lake largely receives deposition of fines that are suspended in the water column (See Section 2.4 for discussion). Whereas, the West Pool receives coarse sediment delivered directly from Sullivan, Chicken and Power creeks. Significant erosion and deposition near the sandbar area can be explained by migration of the Sullivan Creek channel within the lake.



Elevations Table				
Number	Color	Min. Elev. Difference (ft)	Max. Elev. Difference (ft)	Area (Ac)
1		-7.0	-6.0	0.01
2		-6.0	-4.0	0.09
3		-4.0	-2.0	0.40
4		-2.0	-1.0	0.69
5		-1.0	-0.1	4.27
6		0.1	1.0	19.72
7		1.0	2.0	4.13
8		2.0	4.0	1.74
9		4.0	6.0	0.61
10		6.0	8.0	0.26
11		8.0	10.3	0.19

NOTES:
1. ELEVATIONS LISTED REPRESENT THE DIFFERENCE IN ELEVATION, RELATIVE TO 2002 SURVEY DATA.
2. NEGATIVE NUMBERS INDICATE NET EROSION. POSITIVE NUMBERS INDICATE NET DEPOSITION.
3. AREAS WITH NO COLOR FILL INDICATE NO NET CHANGE IN ELEVATION.

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3.1-2

Comparison of the 2002 and 2010 bathymetric surveys suggest that the net average annual sedimentation rate exceeds 4,600 cy per year (See Technical Appendix I). While this estimate only includes volume comparisons for areas that were resurveyed in 2010 (Figure 3.1-2), field observations suggest that the vast majority of sedimentation has occurring in these areas. This is because significant deposition occurs in the winter season when the lake level is lowest. At those times, even high flows do not flood the wetlands in the North Marsh. Hence, significant sedimentation in the North Marsh is not likely to occur, and no evidence of widespread erosion was observed. Similarly, much of the Boot Unit also is above the OWLL and is not typically flooded by sediment-laden winter runoff, but the Boot Unit does appear to be aggrading and expanding, particularly in areas closest to the East Pool.

Storage Capacity

The 2002 and 2010 survey data were also used to calculate lake volume and usable storage capacity, which are summarized in Table 3.1-1.

Table 3.1-1. Summary of Phoenix Lake Volume and Usable Storage Capacity

Condition	Storage (ac-ft)
2010 Lake Capacity	600.2
2002 Lake Capacity	623.3
Difference in Capacity	-23.1
2010 Usable Storage – Summer	517.6
2002 Usable Storage – Summer	527.2
Difference in Usable Storage	-9.7
2010 Usable Storage – Winter	108.3
2002 Usable Storage – Winter	118.0
Difference in Usable Storage	-9.7

The current lake capacity is estimated to be 600 ac-ft, a reduction of approximately 23 ac-ft since 2002. However, not all of the lake volume is usable storage. The mid-lake ridge that separates the East and West Pools creates "dead storage" in the East Pool below elevation 2,377 ft (i.e., water in the East Pool cannot reach the intake structure in the West Pool due to lakebed topography). Smaller amounts of dead storage occur in the West Pool, 1986 dredge hole in the western portion of the lake, and portions of the North Marsh. Consequently, usable storage is substantially less than the total impounded lake volume.

2.4 Geomorphology

This section describes landforms and fluvial geomorphic processes that influence sedimentation patterns within the lake. The geomorphology of the Phoenix Lake watershed is described in detail in Chapter 2 of the PLPRP.

Pre-dam Landforms

There are no survey records or photographs that document the landforms that existed in the footprint of Phoenix Lake prior to construction of the dam. It is hypothesized that the confluence of Sullivan, Chicken and Power creeks was an unconfined, relatively low gradient alluvial valley. Downstream of this confluence it is believed that Sullivan Creek became confined by the ridge in the lake and hillslopes to the west (current location of Apple Valley Estates). This assertion is supported by the considerable depth of the West Pool, bedrock exposures near the spillway, the height of the dam, and the morphology of the Sullivan Creek valley downstream of the lake.

The eastern portion of the lake (i.e., East Pool and Boot Units, Figure 3.1-1) was likely a wet meadow that collected runoff and sediment from the Ridgewood and Phoenix Lake Park watersheds. To a certain degree, the ridge in the lake likely impounded water and sediment delivered from the drainages to the east. This assumption is supported by the relatively shallow, uniform configuration of the East Pool. Furthermore, this description may explain reports of the "two dams" that are alluded to in historical accounts of Phoenix Lake (PLTF, 2010b); constructing a dam on the ridge and another on Sullivan Creek would have been a logical approach to impound water.

Existing Landforms and Geomorphic Processes

The following sections describe landforms and geomorphic processes according to each lake Management Unit (Figure 3.1-1). These units were largely defined by differences in landforms and depositional patterns within the lake, as described in below.

<u>North Marsh and Sandbar West Units</u>

Construction of the Phoenix Lake Dam created calm backwater conditions and a <u>deltaic</u> environment where the principal tributaries (i.e., Sullivan, Chicken and Power creeks) enter the lake. The <u>deltas</u> of these tributaries originally formed near the margins of the lake. Over time, the deltas prograded into the lake and coalesced to form the North Marsh. Figure 3.1-3 provides a conceptual cross-section that depicts the history of sediment deposition in the lake and formation of the North Marsh and the current sandbar. The Sandbar West Unit is the distal end of the delta, and the active zone of deposition and delta extension (Figures 3.1-2 and 3.1-2, Photo 3.1-4).

Photo 3.1-4. The sandbar in Phoenix Lake is a depositional feature formed by sediment delivered from Sullivan, Chicken and Power creeks.

Photo 3.1-5 shows a photograph of a streambank taken near the mouth of Chicken Creek illustrating the process of sedimentation and subsequent formation of the North Marsh.

Photo 3.1-5. The streambank profile depicts a time sequence of sediment deposition and vegetation growth in the lake.

As shown in Photo 3.1-5, the bottom layer of the streambank is comprised of coarser sediment (i.e., sand and gravel) that was deposited soon after the dam was constructed. As the streambank grew in height, finer sediment carried in Chicken Creek as <u>suspended load</u> during higher streamflows was deposited overbank on the floodplain. Coarse sediment

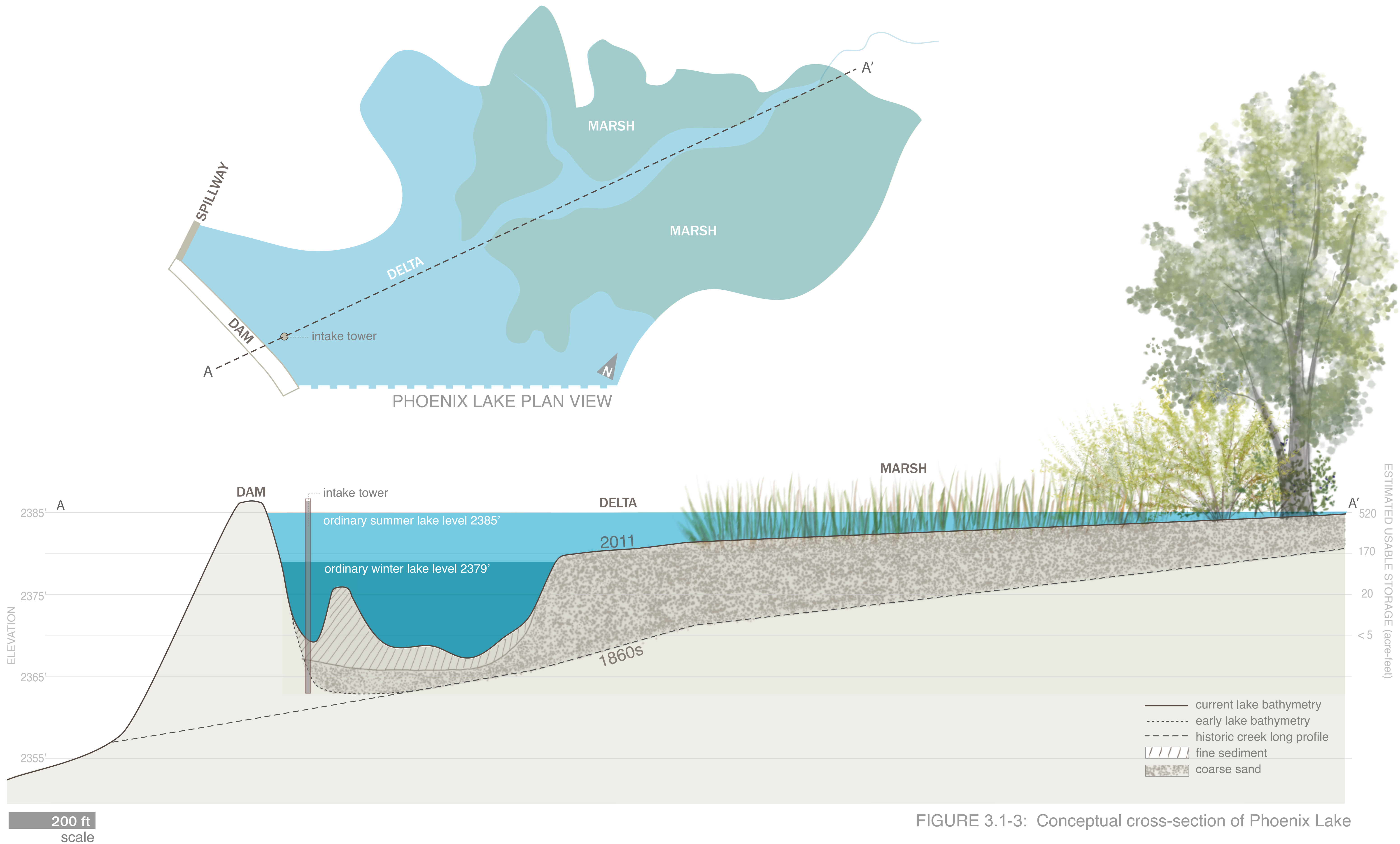

FIGURE 3.1-3: Conceptual cross-section of Phoenix Lake

transported as bedload was deposited further downstream. Eventually the floodplain reached an elevation appropriate for colonization by vegetation. Many years of vegetation growth have created a dense root mass and thick layer decomposed organic matter in the upper portion of the streambank profile (Photo 3.1-5).

It appears that the channel morphology within the North Marsh has been influenced by the lake water management regime and growth of emergent vegetation. While natural, low gradient channels typically exhibit a moderate to highly sinuous planform, the channels in the lake are relatively straight (Figure 3.1-2, Photo 3.1-6).

Photo 3.1-6. Stream channels in Phoenix Lake have low sinuosity and tall banks.

It is hypothesized that this is, in part, due to the lake level management regime. Vegetation that established on floodplain surfaces grew rapidly during successive summer growing seasons with a relatively constant lake level. This water regime, along with nutrient inputs, created ideal growing conditions for emergent vegetation (e.g., bulrush). Vegetation encroached on the channels and made them highly resistant to erosion.

These straight channels with tall banks have influenced sedimentation patterns in the lake. Sediment-laden runoff cannot reach the floodplain in marsh areas because of the tall bank heights. Consequently, sediment is readily transported into the unvegetated portion of the lake, as evidenced by the accumulation of coarse material in the Sandbar West Unit (Photo 3.1-4). Channel modifications and floodplain restoration that would allow for natural overbank sedimentation in marsh areas and reduction in flood flow hydraulics are discussed in Section 3.

West Pool Unit

This management unit includes the deepest portions of the lake (Figure 3.1-1). As mentioned previously, the pre-dam Sullivan Creek was likely confined by a ridge to the east and hillslopes to the west, which created a small valley in what is now the West Pool. It appears that depth in the West Pool is maintained to some degree by scour hydraulics associated with Sullivan Creek flood flows. However, it is clear that the West Pool is a depositional area over time (Figure 3.1-2).

Spillway Unit

This unit is a very shallow (1-2 ft deep at OWLL) portion the lake (Photo 3.1-7). Sediment has accumulated in this area because the spillway weir backwaters sediment-laded water before it exits the lake. This backwater effect slows water velocity and induces sediment deposition. Surface sediments in the Spillway Unit are primarily fine textured (silts and clays).

Photo 3.1-7. The shallow depth of the Spillway Unit is evident in this photo taken during sediment sampling activities conducted in April 2011.

Ridge Unit

This unit encompasses an area of high ground within the lake that was flooded by the construction of the dam. The Ridge Unit is important in that its elevation influences water mixing, sedimentation patterns, and the usable storage in the eastern portions of the lake. The topographic low point of the Ridge Unit is located close to the dam-side (southwest) of the unit. This location was likely the historical confluence between the eastern drainages and Sullivan Creek.

Sandbar East Unit

The Sandbar East Unit is part of the Sullivan Creek delta, but is somewhat segregated from the main delta lobe (i.e., the Sandbar West Unit) by the Ridge Unit. The Sandbar East Unit remains a depositional area, but in contrast to the Sandbar West Unit, sediment delivery appears to primarily be through suspended load as opposed to bedload. This observation is based on the finer grain sizes observed in this unit.

East Pool Unit

The East Pool is a broad, shallow portion of the lake. In the post-dam condition the East Pool continues to receive sediment from the Ridgewood and Phoenix Lake Park watersheds, but now also receives a portion of the suspended sediment delivered from the principal tributaries (i.e., Sullivan, Chicken and Power creeks). While the mixing hydraulics of the lake has not been studied, analysis of the landforms suggests that the eastern portion of the lake functions as a backwater area during storm events. In addition, the winter time prevailing winds are from the northwest. The wind “pushes” sediment-laden water into the northeastern portion of the lake; this effect is thought to be particularly significant to sedimentation dynamics in the Boot Unit.

Boot Unit

The Boot Unit is a vegetated wetland that is topographically higher than the East Pool. Sedimentation in the Boot Unit is the result of the backwater and lake circulation-induced deposition processes described above, as well as high sediment loads delivered from the Ridgewood watershed. There are several anecdotal accounts of high sediment delivery and rapid marsh expansion associated with construction of the Ridgewood development in the 1980s. Vegetated areas within the Boot Unit are very effective in trapping sediment delivered from the lake or watershed sources (Photo 3.1-8).

Photo 3.1-8. Dense growth of bulrush in the Boot Unit.

2.5 Biological Resources

Phoenix Lake supports a mosaic of aquatic and wetland habitats that are surrounded by forested uplands and developed areas. Habitats in and around the lake are described in this section. No focused surveys for fish or wildlife were conducted as part of this study, thus information presented in this section is based on casual observations, existing information, and knowledge of similar sites in the region.

Aquatic Habitat

Figure 3.1-4 depicts the biological zones that occur in a typical lacustrine system. The littoral zone in lakes is the area where there is sufficient light penetration to support the growth of aquatic macrophytes. Nearly all of Phoenix Lake functions as a littoral zone. A small portion of the total lake area functions as a limnetic zone (i.e., there is sufficient depth to limit light penetration and growth of macrophytes).

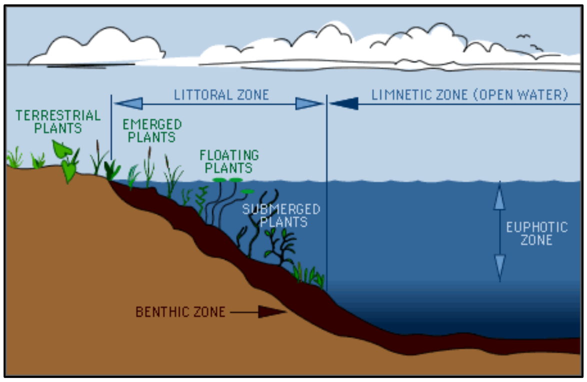

Figure 3.1-4. Physical and biological lake zones (Lakeaccess.org, 2011).

Most of the littoral zone in the lake has been invaded by Eurasian watermilfoil (watermilfoil, *Myriophyllum spicatum*) (Photo 3.1-9). The growth rates and spatial distribution of this nonnative, invasive plant are mainly influenced by light availability, nutrient concentrations and temperature. Watermilfoil tends to grow in waters up to 20 ft deep, depending on light penetration, though most plants are found in waters to 10 ft in depth (Donaldson and Johnson, 2002).

Photo 3.1-9. Eurasian watermilfoil and hydrilla in Phoenix Lake.

Eurasian watermilfoil can degrade aquatic habitat by displacing native submerged aquatic vegetation. Watermilfoil also interferes with municipal and recreational uses of the lake. Control methods and management strategies for this species area discussed in Section 3.

Other aquatic habitats in Phoenix Lake include relatively narrow channels that intersect vegetated wetlands. These channels do not support growth of aquatic vegetation because the streambed is disturbed during storm events, which limits the ability of plants to establish in these areas.

Aquatic habitats in Phoenix Lake support populations of warm water fishes such as bass (*Micropterus* sp.) and bluegill (*Lepomis macrochirus*). Native amphibians such as Pacific chorus frog (*Pseudacris regilla*) may breed in and along the margins of the lake. The lake provides suitable habitat for western pond turtle (*Actinemys marmorata*), which is a state species of concern. The lake's aquatic habitat is also used by numerous species of waterfowl such as American Coot (*Fulica americana*), Mallard (*Anas platyrhynchos*), Canada Goose (*Branta canadensis*) and Graylag Goose (*Anser anser*) (Photo 3.1-10). In addition, river otter (*Lontra canadensis*) may utilize the aquatic habitats in the lake (PLTF, 2010a)

Photo 3.1-10. Canada and Graylag Geese in Phoenix Lake.

Wetland Habitat

Vegetated wetland habitats in Phoenix Lake include the broad expanses of the North Marsh, the Boot, and "fringe" wetlands occurring along the margins of the lake. The vast majority of wetlands in the lake are emergent wetlands dominated by hardstem bulrush (*Schoenoplectus [=Scirpus] acutus*). Vegetation species diversity in the emergent wetlands is low.

Near the historical mouth of Sullivan Creek cottonwoods (*Populus fremontii*) and willow (*Salix* spp.) grow on top of the creek bank with blackberry (*Rubus* spp.) in the understory. Similar riparian vegetation communities and wet meadow habitats occur at the mouths of Power and Ridgewood drainages (Photo 3.1-11). Wetlands fed by subsurface seepage downstream of the Phoenix Lake Dam support white alder (*Alnus rhombifolia*) in the overstory and Himalayan blackberry (*Rubus discolor*) in the understory.

Photo 3.1-11. Wet meadow (foreground) and riparian (background) habitats near the mouth of the Ridgewood drainage.

Vegetated wetland habitats are utilized by a variety of wildlife species. The vast expanses of bulrush marsh provide nesting habitat for Red-Winged Blackbird (*Agelaius phoeniceus*), Marsh Wren (*Cistothorus palustris*), and Sora (*Porzana carolina*). There is a documented occurrence of Tricolored Blackbird (*Agelaius tricolor*), a state species of concern, in the North Marsh. Reptiles and amphibians described in the previous section may also use wetlands as nesting, foraging, and dispersal habitat.

When the lake level is low in the winter, unconsolidated shore wetlands are exposed in the Sandbar Units, portions of the Ridge Unit, and a small island in the East Pool. These areas provide foraging and loafing habitat for waterfowl.

Terrestrial Habitat

The lake is largely surrounded by landscaped residences interspersed with native oaks (*Quercus* spp.) and pines (*Pinus* spp.). The Phoenix Lake Dam face supports nonnative annual grassland. The North Marsh is bounded by ponderosa pine (*Pinus ponderosa*) forest and riparian habitat associated with the principal tributaries.

Terrestrial habitats surrounding the lake provide habitat for a variety of birds and mammals. Notable bird species that have been observed foraging around Phoenix Lake include Bald Eagle (*Haliaeetus leucocephalus*) and Osprey (*Pandion haliaetus*). Mammal species that are likely to occur in the vicinity of the lake include raccoon (*Procyon lotor*), black-tailed deer (*Odocoileus hemionus columbianus*), and bat species.

2.6 Water Quality

Addressing water quality in Phoenix Lake is a key component of the PLPRP as it affects potable water supply, habitat functions, lake aesthetics, and recreational opportunities. The Central Valley Regional Water Quality Control Board's (RWQCB) Basin Plan (RWQCB, 2009) establishes beneficial uses for the Upper Tuolumne watershed, which includes Phoenix Lake. While developing the PLPRP is a planning process and not a regulatory-driven process, the beneficial uses defined in the Basin Plan are useful to establish context and identify objectives for water quality management in Phoenix Lake. Specific beneficial uses applicable to Phoenix Lake include:

- Municipal and Domestic Supply (MUN)
- Non-water Contact Recreation (REC-2)
- Freshwater Habitat (WARM and COLD)
- Wildlife Habitat (WILD)

Protection of these Basin Plan beneficial uses is consistent with the overall objectives of the PLPRP.

The PLPRP included a water quality monitoring plan designed to describe current conditions in Phoenix Lake with respect to the objectives and the beneficial uses listed above. The water quality monitoring plan included continuous monitoring of lake water temperature and discrete measurements of various lake water quality parameters. Data collected were used to assess how well the lake can support these beneficial uses, and what measures can be implemented to improve water quality conditions. The findings of the water quality assessment are presented in Chapter 4 of the PLPRP.

3.0 PRESERVATION & RESTORATION CONCEPTS

This section presents describes activities that aim to restore storage capacity, improve water quality and aesthetics, and preserve or enhance aquatic and wetland habitats in Phoenix Lake. The main preservation and restoration activities include sediment removal, sediment forebays, and wetland area enhancements. Collectively, these activities represent a conceptual approach for improving and sustaining the lake's water supply functions while enhancing ecological conditions. This section continues with detailed descriptions of these actions, as well as proposed interim management measures that can be implemented in the nearer term, prior to longer term and larger actions.

3.1 Sediment Removal

Physical sediment removal is the most direct method to restore lake capacity in the near term. Sediment removal includes dredging and excavation to restore storage capacity, improve water quality and aquatic habitat, and enhance aesthetics. Restoring depth in shallow portions of the lake would improve water quality and aquatic habitat by expanding the limnetic zone, thereby reducing the area available to support the growth of invasive watermilfoil. Increasing lake depth would also decrease mean summer water temperature, which would reduce eutrophication rates and potentially expand cold water habitat.

Figure 3.1-5 shows lake areas where sediment removal activities are proposed. Sediment removal in these areas would have limited impact to existing vegetated wetlands. The sediment removal areas are offset from the lake shoreline to allow for gradual transitions along the lake margins and to account for potentially shallow bedrock.

Table 3.1-2 provides estimates of sediment removal quantities and the resultant storage capacity that would be restored by dredging or excavating the lake to a range of depths. For example, dredging Sandbar West Unit to 10 ft below the existing surface would generate approximately 35,000 cy of sediment and restore 21.8 ac-ft of storage.

For conceptual design purposes, a target water depth of 8 ft at OWLL and 14 ft at OSLL was selected for sediment removal activities (Table 3.1-2). This depth is equivalent to a lakebed elevation of approximately 2,370 ft above MSL. This target water depth is based on aquatic habitat objectives, lake bed morphology, estimated depth of sedimentation, and professional experience managing similar aquatic resources. Site observation suggests that restoring this lake depth would substantially limit the growth of watermilfoil, and improve water quality and aesthetics. This target depth also appears to be within the zone of sedimentation for all management units (i.e., there would not be dredging or excavation into native lakebed material).

A discussion of proposed sediment removal activities for each management unit follows. Sediment removal methods for each management unit also are described below. Table 3.1-3 summarizes the sediment removal volumes and the resultant increase in storage capacity for the conceptual plan presented below.

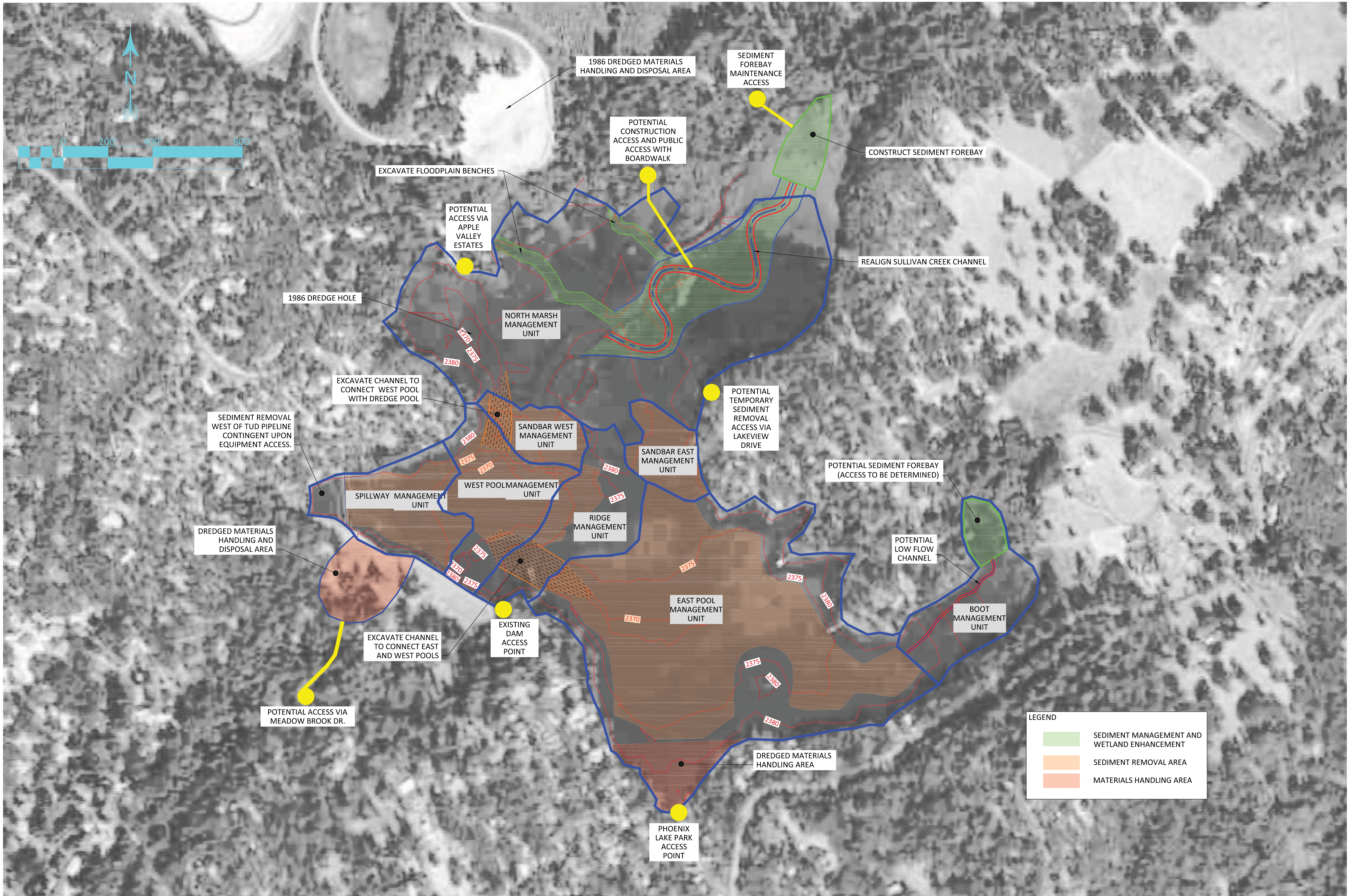

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Table 3.1-2: Conceptual-level Estimates of Sediment Removal Quantities and Resultant Storage Capacity Restoration

	Management Unit and Sediment Removal Areas						Total
	Spillway	West Pool	Sandbar West	Ridge	Sandbar East	East Pool	
Total Area (acres)	5.38	5.78	2.18	5.72	2.38	32.00	53.43
Total Area (ft^2)	234,296	251,663	95,047	249,334	103,494	1,393,793	2,327,627
Sediment Removal Area* (ft^2)	159,214	179,057	95,047	54,237	103,494	857,726	1,448,775

Depth of Sediment Removal below Existing Surface Elevation (ft)	**Volume of Sediment Removed by Depth (CY)** - (Volumes are cumulative, to depth shown)						Total
	Spillway**	West Pool	Sandbar West	Ridge	Sandbar East	East Pool	
1	5,897	6,632	3,520	402	3,833	31,768	52,051
2	11,794	13,263	7,041	4,018	7,666	63,535	107,317
3	17,690	19,895	10,561	6,026	11,499	95,303	160,975
4	23,587	26,527	14,081	8,035	15,332	127,071	214,633
5	29,484	33,159	17,601	10,044	19,166	158,838	268,292
6	35,381	39,790	21,122	12,053	22,999	190,606	321,950
7	41,278	46,422	24,642	14,061	26,832	222,373	375,608
8	47,175	53,054	28,162	16,070	30,665	254,141	429,267
9	53,071	59,686	31,682	18,079	34,498	285,909	482,925
10	58,968	66,317	35,203	20,088	38,331	317,676	536,583
Total of proposed sediment removal depths (blue cells)							**232,461**

Depth of Sediment Removal below Existing Surface Elevation (ft)	**Capacity Restored by Depth (ac-ft)** (Volumes are cumulative, to depth shown)						Total
	Spillway	West Pool	Sandbar West	Ridge	Sandbar East	East Pool	
1	3.7	4.1	2.2	0.2	2.4	19.7	32
2	7.3	8.2	4.4	0.5	4.8	39.4	65
3	11.0	12.3	6.5	0.7	7.1	59.1	97
4	14.6	16.4	8.7	1.0	9.5	78.8	129
5	18.3	20.6	10.9	1.2	11.9	98.5	161
6	21.9	24.7	13.1	1.5	14.3	118.2	194
7	25.6	28.8	15.3	1.7	16.6	137.9	226
8	29.2	32.9	17.5	2.0	19.0	157.6	258
9	32.9	37.0	19.6	2.2	21.4	177.3	290
10	36.6	41.1	21.8	2.5	23.8	196.9	323
Total capacity restored for concept plan (blue cells)							**139**

Table 3.1-2: Conceptual-level Estimates of Sediment Removal Quantities and Resultant Storage Capacity Restoration

NOTES:

*** Explanation of Sediment Removal Areas:**

Management Unit	Calculation Area
Spillway	Sediment removal area does not include the portion of the unit west of the TUD pipeline crossing due to potential access constraints. The majority of the calculation area is flat. Calculation of estimated sediment removal volume was taken over the calculation area (Figure 3-1) to the depths indicated.
West Pool	The sediment removal area avoids dredging: (1) existing deep area in the vicinity of the intake tower; (2) competent material the mid-lake Ridge; and (3) along the shoreline. Estimated dredging volume was taken over the calculation area to the depths indicated.
Sandbar West	This management unit is generally flat with average elevation of 2380 ft. Estimated excavation volume calculations were made over the entire area.
Ridge	The calculation area includes a mounded, sloping area of sediment aggradation. Volume estimates were roughly estimated over the calculation area to the depths shown, in order to meet the Winter storage depth goal. Additional excavation may be included to increase connectivity between East and West pools, but it is not included in this estimate.
Sandbar East	Volume estimate was taken over the area of the management unit to a depth of 4'.
East Pool	The sediment removal area avoids dredging along the shoreline and an existing island that provides winter time bird resting/loafing habitat. Estimated dredging volume was taken over the calculation area to the depths indicated.

**** Highlighted cells indicate proposed sediment removal depths for conceptual plan**

Table 3.1-3: Sediment Quantities and Storage Capacity Restoration associated with Proposed Sediment Removal Activities

	Management Unit						
	Spillway	West Pool[1]	Sandbar West	Ridge[1]	Sandbar East	East Pool	Total[1]
Total Area (acres)	5.38	5.78	2.18	5.72	2.38	32.00	53.43
Total Area (ft^2)	234,296	251,663	95,047	249,334	103,494	1,393,793	2,327,627
Sediment Removal Area (ft^2)	159,214	209,267	95,047	122,610	103,494	857,726	1,547,358
Proposed Depth of Sediment Removal below Existing Surface Elevation (ft)	6	2	10	5	3	4	NA
Resultant Mean Water Depth at OWLL (ft)	8	10	8	varies	4	8	NA
Volume of Sediment Removed (CY)	35,381	19,977	35,203	35,367	11,499	127,071	264,497
Storage Capacity Restored (ac-ft)	21.9	12.4	21.8	21.9	7.1	78.8	164.0
Notes:	1. Total sediment removal and storage capacity restored is greater than values presented in Table 3-2 because calculation for the West Pool include dredging a channel connecting to the 1986 dredge hole (6,713 cy), and calculations for the Ridge Unit include dredging/excavation of the East-West Pool connector channel (25, 323 cy)						

Spillway Unit

The existing water depth in this unit is approximately 2 ft at OWLL. Removing approximately 6 ft of sediment would achieve the target lake depth. Sediment removal in this unit may be accomplished through a combination of lake-based dredging and land-based excavation equipment operating primarily from the dam. The TUD pipeline which crosses this unit may restrict access for sediment removal in the portion of the unit that is closest to the spillway. For this reason, sediment removal estimates exclude this area (Figure 3.1-5, Tables 3.1-2 and 3.1-3).

West Pool Unit

Most of this unit already meets or exceeds the target water depths. Additional sediment removal of approximately 2 ft is proposed as maintenance dredging to restore lake storage capacity. Sediment removal in this unit would require dredging; land based excavation is not likely feasible.

Sandbar West Unit

This unit is currently 1-2 ft above OWLL (Figure 3.1-1). Removal of approximately 10 ft of sediment would achieve the target depth for water quality improvement. Sediment removal in this unit may be accomplished with conventional land-based excavation equipment operating during low water periods. Access for sediment removal could be accomplished by constructing temporary roads connecting to Lakeview Drive or by operating small barges on the lake to move material to another access point. Sediment removed from the Sandbar West Unit is anticipated to be predominately sand and gravel; this material may be suitable for construction aggregate and landscaping purposes. Further development of sediment removal plans will need to consider appropriate transition slopes between the excavation areas in this unit and existing wetlands in the North Marsh so as not to cause erosion.

Ridge Unit

Sediment removal is proposed in the northwestern portion of the unit that is contiguous with the West Pool. This portion of the Ridge Unit contains depositional material from Sullivan Creek. Additionally, dredging of a channel to connect the East and West Pools is proposed in the southern portion of the unit (Figure 3.1-5). This channel would improve connectivity between the East and West Pools and reduce the unusable storage volume in the East Pool. Sediment removal methods for this unit would likely be similar to methods described for the West Pool.

Sandbar East Unit

A shallow excavation depth (approximately 3 ft) is proposed in this unit because it believed that there is competent, native material near the surface. Removal of native, non-alluvial material is not recommended because it is likely more resistant to excavation than recently deposited alluvial sediments. Furthermore, removal of native, non-alluvial material may be considered by regulatory agencies as a reservoir “improvement” rather than maintenance of storage capacity. Sediment removal in this unit would likely be accomplished with conventional land-based excavation equipment similar to that described for the Sandbar West Unit.

East Pool Unit

The existing water depth in this unit averages approximately 4 ft at OWLL. Removing approximately 4 ft of sediment would achieve the target depth for water quality improvement. Sediment removal in this unit could be accomplished with low-draft dredging equipment. Alternatively, if the lake level is drawn down for a sufficient period of time, then sediment removal may be feasible with low ground pressure excavation equipment operating on construction mats. The PLTF Dredging report (PLTF, 2010a) presented the “two lake” concept, which would utilize the mid-lake ridge to divide the lake for dewatering. This concept has merit and should continue to be evaluated as a potential method for sediment removal in the East Pool.

Construction Access

Figure 3.1-5 shows locations that are potentially suitable access points for sediment removal operations. Potential access points include existing roads at Phoenix Lake Park, Phoenix Lake Dam and Apple Valley Estates, and new roads connecting the lake to Lakeview Drive and Meadowbrook Drive. It is important to note that the suitability of these access points is based mainly on physical conditions; private landowners and homeowner associations have not agreed to accommodate construction access.

Access through Phoenix Lake Park via Lori Lane is an existing lake access point that could be used to launch dredging equipment and remove sediment. In the current condition this location may be too shallow to launch conventional suction dredge equipment; low draft dredging equipment (Photo 3.1-12) may be needed along with site improvements to launch equipment.

Photo 3.1-12. Example of a small, low draft suction dredge.

This location also provides the most convenient connection to Phoenix Lake Road, which will likely be an important route if sediment needs to be moved by truck to disposal areas.

Access through the TUD easement to the dam would allow for land-based sediment removal from the dam. Improvements could be made at the dam which may allow for the launching of suction dredge equipment. However, the access may be constrained by clearance on the road leading to the dam. Specialized equipment, such as modular barges (Photo 3.1-13), may be useful for launching equipment at this location.

Photo 3.1-13. A modular barge provides a platform for excavation equipment (courtesy of flexifloat.com).

The existing boat ramp in Apple Valley Estates is another potential location for construction access (Figure 3.1-5). There have been some discussions with the homeowner association and they have indicated they may be amenable to use of the boat ramp, but some homeowners have expressed reservations about a high volume of construction traffic (PLTF, 2010a).

Establishing access via Meadowbrook Drive would require construction of a new road connecting to the dam. The TUD owns property in this location, but may need to acquire additional property or easements to construct a new road. Establishing access at this location is desirable because the new road could be designed to accommodate a range of dredging and hauling equipment. Additionally, the new road could be used for long-term access and maintenance.

It may be desirable to establish temporary access via property located on Lakeview Drive (Figure 3.1-5). Access at this location would allow for a land-based route for sediment removal in the Sandbar East and West Units. This access would likely include temporary gravel roads that could be removed and revegetated once sediment removal is completed.

Materials Handling

Materials handling includes the necessary procedures to prepare sediment for beneficial reuse or disposal. The materials handling procedures will vary based on sediment moisture content, texture, removal location and excavation methods. The moisture content of coarse material (sand and gravel) moved with conventional excavation equipment may be low enough to load directly into trucks for hauling to a reuse or disposal area. Sediment removed with suction dredge equipment will have high water content (typically 80% water) and will need to be dewatered in a materials handling facility.

Figure 3.1-5 shows proposed materials handing areas located within and around the lake. A temporary dredged materials handling area is proposed in the southeast portion of the lake to serve as a sediment drying and transfer point. A temporary levee or berm would be constructed in the lake to create the sediment drying area. Sediment pumped to this area with a suction dredge would settle and excess water would be decanted back into the lake. Sediment would be dried until it reaches a moisture content that is suitable for transport to a permanent disposal area.

The land-side of the dam is another potential location for dredged materials handling. Sediment may be placed at this location with a long-reach excavator or clamshell dredge operating from the dam or pumped directly to this area with suction dredge equipment. If this area is used to handle sediment delivered directly from a suction dredge operating in the lake, then substantial site modifications would be required including construction containment berms or levees and a dewatering system.

Finally, the area that was used in 1986 for dredged materials handling (Figure 3.1-5) is another potential option, though the landowner has not been contacted to gage interest or willingness to use the land for this purpose.

Beneficial Reuse and Disposal

Sediment texture and quality are important factors for evaluating potential reuse and disposal options. Coarse material removed from the Sandbar West Unit is potentially suitable for construction aggregate and landscaping purposes. Fine sediment (clay and silt) is well-suited for agricultural, wetlands restoration and some landscaping uses. The owner of the apple orchards adjacent to the lake has expressed interest in reusing sediment. Hauling sediment for reuse in Central Valley agricultural operations may also be feasible, but is likely to prove more costly than local reuse or disposal options. Other potential beneficial reuse options include a quarry restoration at the Jamestown Mine and a California Department of Fish and Game wetlands restoration site on the Merced River near Snelling, CA. Again, cost is likely to be the deciding factor, with on-site or local disposal likely to be the most cost-effective option. Grant funding is more likely to be available for beneficial reuse of sediment that involves habitat restoration such as TUD's Sierra Pines property near Twain Harte.

Sediment that cannot be reused will need to be disposed of. Figure 3.1-5 and Photo 3.1-14 show an on-site stockpile and disposal area on the land-side of the dam.

Photo 3.1-14. Potential sediment stockpile and disposal area on the land-side of Phoenix Lake Dam.

It is anticipated that placing material at this location would be the most cost effective disposal option because TUD owns the property and placing material at this location would require minimal transportation time. The site shown in Photo 3.1-14 has been altered previously for past lake dredging and management actions. The site's proposed use now for sediment storage and disposal purposes is consistent with past land uses of the site. Sediment removed from the lake with excavation equipment operating on the dam may be able to place material directly in this area. It is unlikely that material removed from the lake with suction dredge equipment would be able to placed directly at this location because the water content and volume of decant water would be too high. The dredged material would first need to be dried in a materials handling area, such as the location in the southeastern portion of the lake (Figure 3.1-5), and then moved to this location. This would require the material to be moved via the road on the dam or a new road to Meadowbrook Drive. Sediment removed from the lake could also be used to build the new road connecting to Meadowbrook Lane. The extents of this disposal area and the volume of material that can be placed at this location are under investigation.

Sediment samples were collected from several locations in the lake to test the material for contamination and suitability for reuse and land applications. Preliminary screening suggests that sediment in the lake does not contain hazardous levels of contaminants of concern and that the material may suitable for a broad range of reuse applications. (See Chapter 4 of the PLPRP for a more detailed assessment of the suitability of sediment for reuse and disposal).

3.2 Sediment Forebays

In contrast to removing sediment directly from the lake, the sediment forebay approach uses basins located just upstream of the lake to efficiently trap sediment prior to it entering the lake. From these forebay locations, the trapped sediment can then be removed and disposed. In the right locations, sediment forebay type basins provide an effective sediment reducing method. Used in combination with direct lake sediment removal, sediment forebays also provide sediment reducing benefits for the medium and longer-term timeframe. This section describes the use of sediment forebays to help achieve longer-term sustainability of lake functions.

Sullivan Creek Sediment Forebay

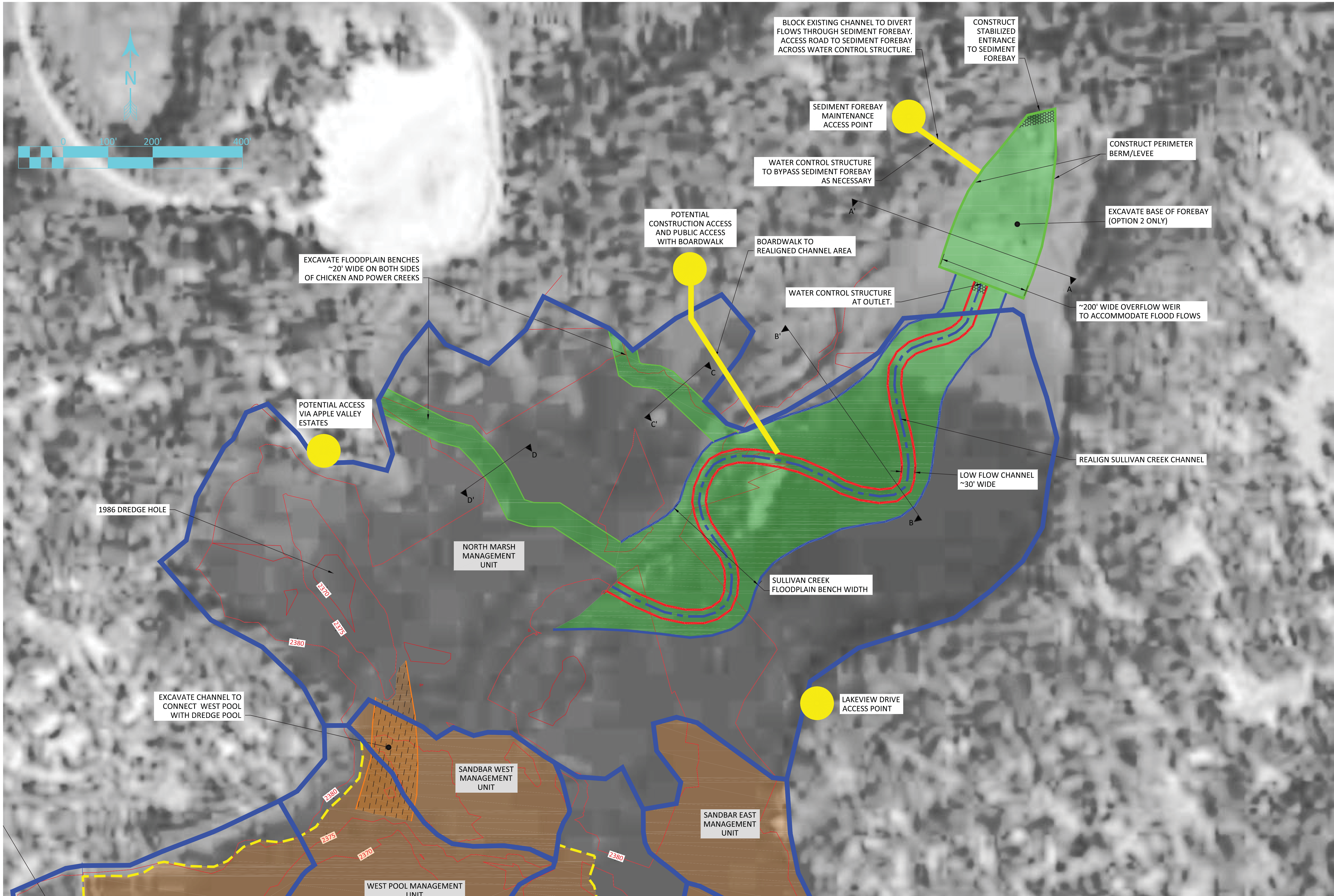
As mentioned in Section 2.4, the delta of Sullivan, Power and Chicken creeks has progressed into the center of the lake. This results in coarse sediment loads depositing in open water portions of the lake and gradual encroachment of wetlands. Use of a sediment trapping forebay upstream of this location can reduce the sediment loading and the rate of deltaic progression.

The sediment forebay functions by creating quiescent conditions where sediment can deposit before moving into the lake. Creating an impoundment and backwater conditions reduces flow velocity, slope and turbulence which will allow for the deposition of sediment. Deposited sediments can then be removed through a regular maintenance program using land-based excavation equipment rather than more costly subaqueous dredging. One of the key advantages of a sediment forebay is its known/defined location in terms of access and repeat maintenance operations.

A general sediment forebay design for Sullivan Creek includes three components: 1) a water control structure across the existing Sullivan Creek channel, 2) the sediment forebay, and 3) an outlet structure and overflow weir (Figure 3.1-6). The purpose of the water control structure across the existing Sullivan Creek channel is to divert water and sediment into the forebay. The water control structure is not intended to provide a permanent blockage to flows down the existing Sullivan Creek channel. Rather, it would be used to divert water through the sediment forebay during periods of elevated discharge and sediment transport. During periods when discharge and sediment transport levels are low, the water control structure could be opened allowing a bypass and drawdown of the sediment forebay to allow trapped sediments to drain and dry prior to handling and removal. The control structure could include a mechanically operated sluice gate, or alternatively could consist of multiple bays with manually removable boards.

As presented at this conceptual level, the Sullivan Creek sediment forebay is 1.5 acres in size, and 3 ft deep prior to the deposition of any sediment, resulting in an impounded volume of approximately 4.5 ac-ft. The existing ground surface elevation in the footprint of the sedimentation forebay is approximately 2,385 ft at the downstream extent, rising to approximately 2,387 ft at the upstream extent. Two conceptual design options have been considered. Typical cross-sections for these options are shown on Figure 3.1-7.

Option 1 sets the base elevation of the sediment forebay at 2,385 ft, which is equal to the OSLL. With this bottom elevation trapped sediments would sit above the summer water level and dry more readily, allowing for less costly removal during the summer months when the lake water surface elevation is at 2,385 ft. As conceptually designed, the water surface elevation in the forebay would be 2,388 ft, and the sediment forebay would be contained by a berm with a top elevation of 2,389 ft (allowing for 0.5-1 ft of freeboard). By setting the bottom of the sediment forebay at or above OSLL, a backwater would extend upstream along Sullivan Creek from the forebay. This backwater could increase flooding in the lower reach of Sullivan Creek, and could also promote deposition of coarse sediment in the creek channel, rather than in the sediment forebay, leading to more challenging maintenance and removal. In order to address these concerns, a second option is considered.



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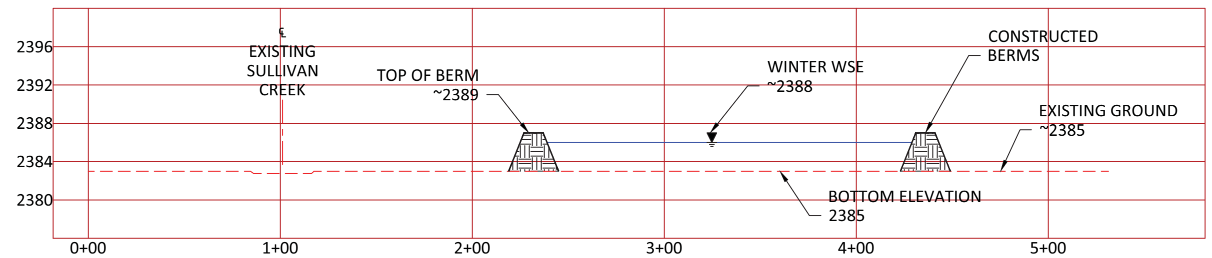
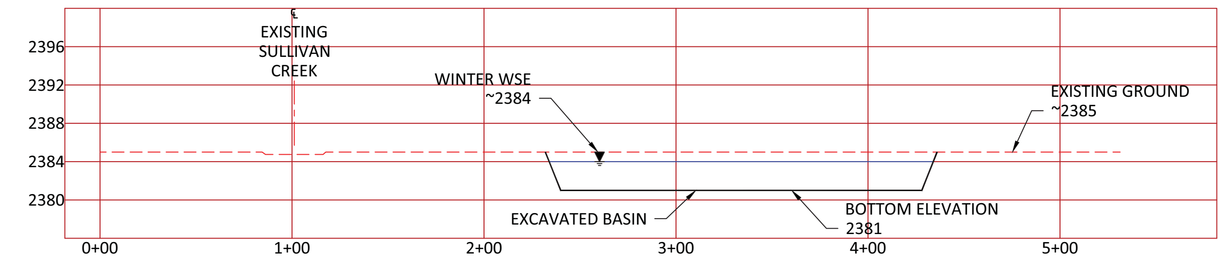
SONORA CALIFORNIA

PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
PROPOSED MARSH UNIT ELEMENTS

FILE NAME Mgt_Units.dwg
JOB NUMBER 10-1019
DATE June, 2011
FIGURE 3.1-6

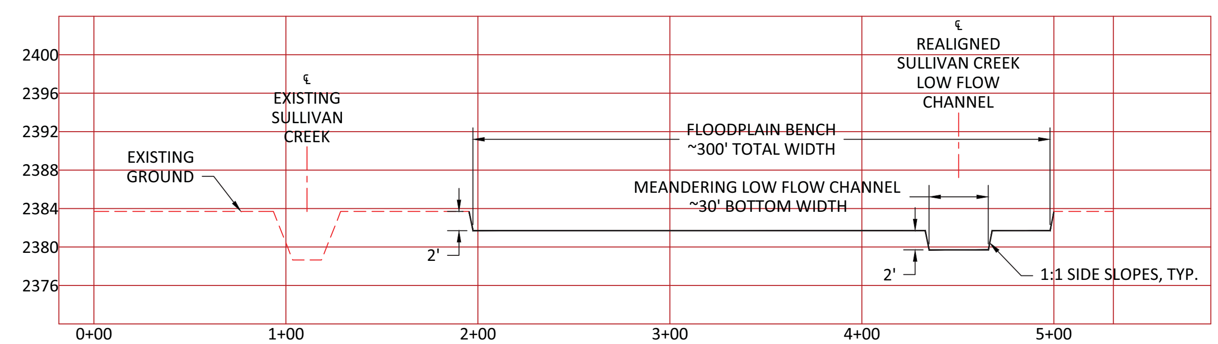


OPTION 1

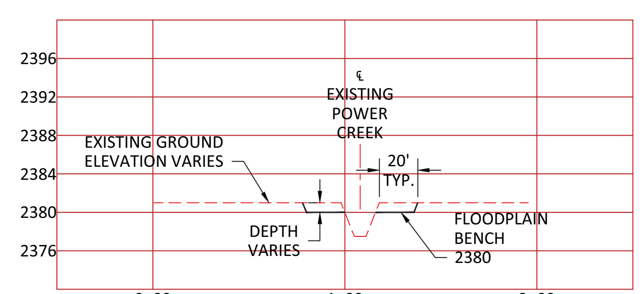


OPTION 2

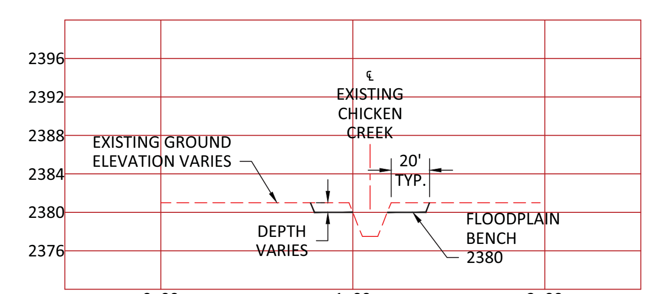
SECTION A-A'



SECTION B-B'



SECTION C-C'



SECTION D-D'

SCALE	
HORIZONTAL	1" = 50'
VERTICAL	1" = 10'

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PREPARED BY
Horizon WATER and ENVIRONMENT
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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
PROPOSED CROSS SECTIONS

FILE NAME: Mgt_Units.dwg
JOB NUMBER: 10-1019
DATE: June, 2011
FIGURE 3.1-7

Option 2, has the same footprint (1.5 acres) and operational depth (3 ft) as option 1, however it has a lower base elevation of 2,381 ft to address the backwatering issue anticipated for Option 1. With a lower base elevation, Option 2 would reduce the upstream extent of the backwater created by the sediment forebay. This would reduce the potential for flooding upstream, as well as reduce the amount of sediment deposited in the Sullivan Creek channel before entering the forebay. This option would present increased excavation costs at the time of construction, but reduced costs regarding the construction of the containment berm. One disadvantage of this option is in regard to the removal and handling of the trapped sediments. Since the base elevation of the sediment forebay is below OSLL, sediments will likely be saturated during the summer months, leading to more complex maintenance. However, if sediment could be removed on the shoulders of the wet season, either before (e.g., April) or after (October/November) the period when the lake surface is at 2,385 ft, then this option is perhaps preferable. This option may also require the construction of an inlet control structure to prevent creek water from entering the sediment forebay during times when forebay bypass is desired.

Either sediment forebay option will require the construction of an outlet control structure and overflow spillway. The outlet control structure would control the water surface elevation in the forebay, but also allow for complete drainage of the forebay for sediment drying and maintenance. As conceptualized, this would include a top down, bottom up sluice gate; however other options are available and should be explored if this sediment management concept is prioritized. In addition to outlet control, an overflow spillway is required to allow for the controlled passage of high flood flows. As conceptualized, an overflow weir is included in the containment berm flowing to the constructed channel through the marsh downstream.

Alternatives to the two options presented include a change in size of the forebay by either increasing its footprint or depth. As presented, the forebay is 1.5 acres; however more room is available at the proposed location to increase the spatial extent. As presented, the maximum operational depth of the forebay is 3 ft, prior to the deposition of sediment. This is the minimum depth that should be considered, however, the depth could be increased to 5 ft to increase the volume of the forebay. Depths exceeding 5 ft provide the need for more elaborate design of the containment berms to ensure public safety, however this is less of a concern in Option 2, as berm heights are lower.

Figure 3.1-6 shows a potential construction and maintenance access point for the sediment forebay. Construction and maintenance equipment could enter from the orchards on the north side of the lake, then cross Sullivan Creek to access the forebay area. The crest of the water control structure on Sullivan Creek would provide the access route for maintenance of the sediment forebay. The berm on the forebay would be designed to accommodate light excavation and hauling equipment for sediment removal.

Constructing the forebay at this location would require TUD to obtain property and/or easements for construction and maintenance. The owner of the orchard property has indicated that they may be amendable to establishing a maintenance easement.

Advancing the design of the sediment forebay would require the development of a hydraulic model to determine backwater effects of the proposed designs. Sediment transport sampling would provide valuable information towards the design and maintenance requirements. Additional engineering design would be required for all components of the water control structure and sediment forebay. Topographic surveys would be required for each of these components, and geotechnical investigations would be required for all components.

Boot Unit Sediment Forebay

Observations of stormwater flows have noted high sediment loads entering the lake from the Ridgewood drainage (PLTF, 2010d). A sediment forebay similar to the one detailed for Sullivan Creek may be considered in the Boot Unit to trap sediment entering the lake from the Ridgewood drainage. A conceptual footprint for a sediment forebay in the Boot Unit is shown in Figure 3.1-5. Conceptual designs for this sediment forebay have not been developed at this stage, but may be advanced and evaluated in subsequent phases of the PLPRP.

3.3 Floodplain & Wetland Area Enhancements

The wetland enhancements proposed in this conceptual plan aim to promote sediment deposition in marsh areas by restoring geomorphic function to the creek channels and adjacent floodplains. The proposed enhancements include a new alignment of Sullivan Creek downstream of the sediment forebay outlet, and floodplain benches along the principal creek channels (Figure 3.1-6).

A new alignment of Sullivan Creek would be required to connect the sediment forebay outlet with the existing Sullivan Creek channel. This affords an opportunity to construct a channel with appropriate geomorphic form and function. As mentioned previously, in the existing condition the creek channels are relatively straight, and isolated from the adjacent marsh surface due to the high banks of the channel. This limits the ability of the adjacent marsh plain to trap sediment. The proposed meandering channel for Sullivan Creek and floodplain benches would provide a higher level of connectivity between the channels and the floodplain such that as discharge levels exceed the channel's capacity, sediment-laden water would flow onto the floodplains. As flows spread out, and interact with vegetation growing on the floodplain, velocities would be reduced and finer sediments would be deposited prior to reaching the usable storage zones of the lake.

Floodplain benches are also proposed for the Power and Chicken creek channels to trap some portion of the fine sediment delivered from these drainages (Figure 3.1-6 and 3.1-7). In addition to improving sediment trapping, the new floodplains would provide temporary firebreaks in the marsh. Over time, the floodplain benches would increase in elevation and vegetation would become established. The floodplain surfaces and vegetation could be maintained at a prescribed elevation to maximize sediment trapping and firebreak functions.

Figure 3.1-7 shows a potential construction access point for the new channel construction and excavation of floodplain benches. Construction equipment could enter from the orchards on the north side of the lake. Most of the sediment excavated to create the new channel and floodplain benches would need to be removed from the lake. Some material may be placed into existing marsh areas to provide topographic relief, which would increase habitat diversity.

Establishing access at this location would require TUD to obtain an easement on private property for construction access. The property owner has indicated that they may be amendable to establishing a construction and maintenance easement and potentially long-term public access at this location. Public access improvements at this location could include picnicking facilities, as well as a boardwalk and fishing pier extending into the lake. Establishing public access at this location would provide an excellent educational opportunity with respect to the wetland ecology, sediment management, and water resources. (See Chapter 5 of the PLPRP for a more detailed discussion of public access at this location).

Other Wetland Enhancement Options

Other wetland enhancement options considered for the North Marsh include complete "open water restoration" and the "Channels and Islands" approach recommended by the PLTF (PLTF, 2010c). Complete open water restoration would involve dredging the entire North Marsh to restore open water (i.e., a lake environment). The Channels and Islands approach to wetland management involves excavating a network of channels within marsh areas to improve water circulation, expand "edge" habitat and provide fire breaks (PLTF, 2010c).

Table 3.1-4 provides a comparison of the various enhancement options considered for the North Marsh. The comparison table evaluates construction costs, storage capacity restored, and probable environmental impacts. The open water restoration option would have the highest cost and environmental impacts because it would remove the largest volume of sediment and wetland area. However, this option would also restore the greatest volume of storage capacity in the lake. The consultant team chose not to advance this option as the preferred approach because of the high cost and environment impacts relative to other options.

The Channels and Islands option has moderate cost and environmental impact relative to the other options considered (Table 3.1-4). This approach has merit with respect to habitat values and fire management (i.e., the channels would create fuel breaks), but may be problematic in terms of water quality. This would be particularly true for the proposed perimeter channel around the lake. The perimeter channel would likely have poor circulation, particularly in the summer months when the lake level is high. This would lead to stagnant water along the lake margins which may produce odors, suffer from low dissolved oxygen concentrations, and provide mosquito breeding habitat.

The concept presented in this chapter (i.e., the PLPRP Concept Plan) was advanced in favor of open water restoration and the Channels and Islands approach for several reasons. First, the wetland enhancement concepts presented in this chapter is the most effective means to promote or restore physical processes that will maintain water quality, storage capacity and wetland functions in the lake. This option was also viewed as being the most practical approach from a cost and environmental impact standpoint. Furthermore, the consultant team had concerns about the predictability of sedimentation patterns with the Channels and Islands approach.

In subsequent phases of design aspects of the channels and islands approach could be integrated into the wetland enhancement concepts presented in this chapter. Of particular value would be creating islands that are topographically lower and higher than the existing marsh plain. Topographically low areas

Table 3.1-4: Evaluation of North Marsh Restoration and Enhancement Options.

Option	Description	Approx. Volume of Sediment Removed	Approx. Capacity Restored	Approx.Total Capacity Restored Over Entire Lake	Loss of Emergent Wetland	Probable Construction Cost		Probable Mitigation Cost		Total Cost for North Marsh Unit Restoration/ Enhancement		Probable Environmental Impacts & Permitting Considerations
		(CY)	(ac-ft)	(ac-ft)	(ac)	Low	High	Low	High	Low	High	
Open Water Restoration	Restore open water in the North Marsh by dredging the entire area to 8 feet deep at Ordinary Winter Lake Level (OWLL, 2,379')	531,028	329	493	28.0	$6,372,337	$10,620,561	$280,156	$840,468	$6,652,493	$11,461,030	**High**. Much of the wetland habitat would be removed. Focused wildlife surveys have not been conducted, so impacts to special status species cannot be fully assessed.
Channels & Islands	Create wetland islands in an open water matrix. Assumes a 1:1 ratio of Channels (open water) to Islands (emergent wetlands).	277,759	172	336	11.9	$3,333,103	$5,555,172	$0	$357,000	$3,333,103	$5,912,172	**Low to Moderate**. This option restores a balance between open water and emergent marsh habitats. With respect to the existing condition, this would favor waterfowl over marsh dependent passerines. Further consultation with resource agencies is needed to identify wildlife management priorities. Focused wildlife surveys have not been conducted, so impacts to special status species cannot be fully assessed.
PLPRP Concept Plan	Excavate new Sullivan Creek alignment with expanded floodplain. Expand floodplain of Chicken and Power creeks.	53,600	33	197	11.1	$804,000	$1,340,000	$0	$333,000	$804,000	$1,673,000	**Low.** This option includes similar habitat tradeoffs to the Channels & Islands option. Waterfowl resting/loafing habitat would be expanded on the floodplains. This option also includes water quality benefits of trapping sediment on new floodplains. This option was favored in the development of the 2011 Draft Plan because it works with the dominant fluvial process operating in the lake. Therefore, the design rationale for this option is well supported, which increases the likelihood that the project will be viewed favorably by resource management agencies and grant funding entities.

Assumptions and Explanation of Calculations:

Open Water Restoration		The North Marsh Unit is approximately 32.2 acres with approximately 28 acres of wetlands and 4.2 acres of channels. Assume an average marsh elevation of 2,383' is dredged to 2371' (Difference of 12') to create 8' depth at OWLL. Channels at average elevation of 2,378' are dredged to 2371' (Difference of 7'). A 10% reduction in the total dredging volume is factored in to account for the transition slopes on the lake margins. Assume 1,613 cubic yards of material in 1 acre-foot.	Assume dredging of 1,613 cubic yards of material yields 1 acre-foot of storage.	North Marsh storage restoration plus 164 ac-ft in other management units	North Marsh area that is currently emergent marsh	Low construction estimate of $15 per cy for dredging and disposal. Assumes mobilization/demob are included in larger lake project.	High construction estimate of $25 per cy for dredging and disposal. Assumes mobilization/demob are included in larger lake project.	Assumes a 1:1.1 mitigation ratio for temporary loss of wetland functions.	Assumes a 1:1.2 mitigation ratio for temporary loss of wetland functions. Assume mitigation cost per acre is $150,000/ac.	Sum of low range estimates	Sum of high range estimates	
Channels & Islands	1:1 ratio of emergent marsh (islands) to open water (channels) is favorable for many species of wetland wildlife (Weller 1975, Kaminski and Price 1981, Murkin et al. 1982, Ball 1989) as cited in Ball 1990.	The North Marsh Unit is approximately 32.2 acres with approximately 28 acres of wetlands and 4.2 acres of channels. Assume 11.9 acres of marsh at average elevation of 2,383' is dredged to 2371' (Difference of 12') to create channels with 8' depth at OWLL. Assume 4.2 acres of channels at average elevation of 2,378' is dredged to 2371' (Difference of 7') to create channels with 8' depth at OWLL. This would yield 16.1 acres of channels and 16.1 acres of wetland remain.	Assume dredging of 1,613 cubic yards of material yields 1 acre-foot of storage.		Loss of Emergent Wetland			Assumes that enhanced wetland functions and values obviates mitigation				
PLPRP Concept Plan	Create depositional floodplains to trap and store fine sediment in marsh areas to improve water quality in downstream open water areas.	Includes dredging of new Sullivan Creek channel and floodplain benches on Sullivan, Chicken, and Power creeks.	Assume dredging of 1,613 cubic yards of material yields 1 acre-foot of storage.		Loss of Emergent Wetland			Assumes that enhanced wetland functions and values obviates mitigation				

would provide winter time resting/loafing habitat for waterfowl. Creating topographically higher areas would increase vegetation structure and diversity by providing suitable areas for willow and cottonwood growth. Over time, this woody vegetation would provide roosting and nesting habitat for a diverse range bird species.

3.4 Cost Estimates & Phasing

Conceptual Cost Estimates

Tables 3.1-5a and 3.1-5b provide conceptual level cost estimates for implementing the activities described in the previous sections. The cost estimates do not include inflation or long-term maintenance of the sediment forebay(s) or floodplains in the marsh areas.

Phasing

Several factors may influence the schedule for planning and implementing sediment management activities. The factors most likely to influence project schedule are funding, environmental permitting, and land acquisition or access agreements. Construction methods may also influence the phasing of the project, particularly if there is a limited area for dewatering and sediment drying to occur. Moreover, construction windows are likely to be constrained by biological concerns (e.g., bird nesting seasons) and lake levels (i.e., too shallow or too deep to operate equipment).

Most of the activities described above could be implemented as standalone projects within the larger PLPRP. However, it is important to recognize that costs for mobilization and demobilization for several small projects will be substantially higher than for a single, large project. This is particularly true for projects that involve water-based dredging equipment.

Finally, the PLTF recommends having sediment basins (or forebays) in place prior to conducting large-scale lake dredging so that the lake would not refill with sediment soon after dredging. This is prudent advice and should be considered when planning the phasing of lake preservation and restoration activities. However, water quality and aesthetics concerns in Phoenix Lake warrant timely intervention. The following section discusses interim management measures that can help address these issues while large-scale sediment removal and sediment management activities can be planned and implemented.

3.5 Other Lake Management Measures

Aquatic Vegetation Harvesting and Algae Removal

As mentioned in Section 2.5, much of the lake supports a dense growth of submerged aquatic vegetation including Eurasian watermilfoil and hydrilla. The removal of the accumulated vegetation biomass would minimize seasonal algal blooms and improve water quality and aesthetics. Aquatic vegetation sequesters nutrients accumulated from sediment and water column. When the plants die off seasonally they release nutrients back into the water, which are absorbed by algae. Harvesting vegetation will eliminate the bulk of the biomass, leaving the lake in an aesthetically pleasing condition, as well as slowing down the eutrophication process.

The PLTF has clearly stated opposition to using chemical treatments (i.e., herbicides) to treat infestation of aquatic vegetation, However, the TUD has not addressed this issue and at this time is neutral on using chemical treatments.
To perform mechanical maintenance, a large harvester could be employed with local disposal options (e.g., on the land-side of the dam). Given the size and density of infestation (estimated at 25-30 acres), harvesting would

Table 3.1-5a: Conceptual Level Opinion of Probable Cost for Select Components of the Phoenix Lake Preservation and Restoration Plan.

Item No.	Description	Qty	Units	$/Unit	Total	Notes and Assumptions
A. ACQUISITIONS, ENGINEERING, ENVIRONMENTAL COMPLIANCE, ADMINISTRATION						
A-1	Land Acquisition for Sediment Forebay	3	Ac	$31,500.00	$94,500	LandandFarm.com average cost/acre in Sonora
A-2	Access and Easement Purchases	TBD	TBD	TBD	0	To be Determined
A-3	Engineering - Sediment Removal, Forebays, Outlet Structures, and Channels	1	LS		$250,000	Horizon/cbec estimate. Assumes 60%, 90%, 100% plans and SWPPP. Other engineering analyses such as geotechnical investigation and sediment transport modeling not included.
A-4	Environmental Compliance and Permitting	1	LS		$300,000	Horizon/cbec estimate. Assumes CEQA compliance, USACE 404 permit, RWQCB 401 Certification and WDR, CDFG 1602 Stream and Lake Bed Alteration Agreement, ESA/CESA compliance.
A-5	TUD Project Administration	1	LS		$352,156	5% of construction costs
	Subtotal - Acquisitions, E&E, Admin				$996,656	
B. GENERAL CONSTRUCTION REQUIREMENTS						
B-1	Mobilization/Demobilization	1	LS		$140,862	2% of job cost. Assumes single mobilization/event
B-2	Construction Surveying	24	hr	$230.00	$5,520	2-man crew, Construction Staking
	Subtotal - GENERAL CONDITIONS				$146,382	
C. SEDIMENT REMOVAL						
C-1	Spillway Management Unit	35,381	CY	$18.00	$636,858	6' dredging depth; Assume fines and sand mix, on-site disposal, combination of land excavation and suction dredge.
C-2	West Pool Management Unit	19,977	CY	$20.00	$399,540	2' dredging depth; Assume fines and sand mix, on-site disposal, suction dredge.
C-3	Sandbar West Management Unit	35,203	CY	$15.00	$528,045	8' dredging depth; Assume sand/gravel mix, on-site disposal or reuse, land-based excavation.
C-4	Ridge Management Unit	35,367	CY	$22.00	$778,074	Includes dredging and connection channel. Assume fines and sand mix, on-site disposal, combination of land excavation and suction dredge.
C-5	Sandbar East Management Unit	11,499	CY	$15.00	$172,485	4' dredging depth. Assume sand/gravel mix, on-site disposal or reuse, land-based excavation.
C-6	East Pool Management Unit	127,071	CY	$20.00	$2,541,420	4' dredging depth; Assume fines and sand mix, on-site disposal, combination of land excavation and suction dredge.
	Subtotal - SEDIMENT REMOVAL				$5,056,422	
D. SEDIMENT FOREBAY OPTIONS						
D-1	Option 1 - Sediment Forebay bottom at elevation 2385	1	LS	$207,670.00	$207,670	See Table 3-3b for detailed costs
D-2	Option 2 - Sediment Forebay bottom at elevation 2381	1	LS	$631,412.00	$631,412	See Table 3-3b for detailed costs
E. WETLAND AREA ENHANCEMENTS						
E-1	Realign Sullivan Creek and Floodplain Benches	23,768	CY	$15.00	$356,520	Assume fines and sand mix, on-site or local disposal, land-based excavation.
E-2	Power Ck. Floodplain Benches	2,352	CY	$16.00	$37,632	Assume fines and sand mix, on-site or local disposal, land-based excavation.
E-3	Chicken Ck. Floodplain Benches	1,873	CY	$16.00	$29,968	Assume fines and sand mix, on-site or local disposal, land-based excavation.
	Subtotal - WETLAND AREA ENHANCEMENTS				$424,120	

Table 3.1-5a: Conceptual Level Opinion of Probable Cost for Select Components of the Phoenix Lake Preservation and Restoration Plan.

Item No.	Description	Qty	Units	$/Unit	Total	Notes and Assumptions
TOTALS						
	Sub-Total with Forebay Option 1				**$6,831,251**	
	Sub-Total with Forebay Option 2				**$7,254,993**	
	Sub-total average of Options 1 & 2				**$7,043,122**	
	Contingency	**25%**			**$1,760,780**	
				TOTAL	**$8,803,902**	

Table 3.1-5b: Conceptual Level Opinion of Probable Cost for Sediment Forebay Options.

Option 1 - Bottom of Sediment Forebay at existing ground elevation (~2385)						
Item No.	Description	Qty	Units	$/Unit	Total	**Notes and Assumptions**
SF-1-1	Clearing & Grubbing	1.5	Ac	$5,000.00	$7,500	brush, including stumps.
SF-1-2	Temporary BMPs	1	LS	$25,000.00	$25,000	Includes maint. & mon. for following wet season
SF-1-3	Excavation - Berm Foundation	3,050	CY	$3.00	$9,150	1030 LF, 40' wide, 2' deep
SF-1-4	Hauling & Disposal	8,900	CY	$12.00	$106,800	10% expansion factor included
SF-1-5	Compaction - Sullivan Ck. Sed. Forebay	7,200	SY	$3.00	$21,600	
SF-1-6	Construct Forebay Embankment	5,040	CY	$3.00	$15,120	place/compact 1030 LF, 34' base, 10' top , 6' tall, 2:1 sides
SF-1-7	Outlet Works	1	Ea.	$20,000.00	$20,000	~20 yds. Concrete + gate
SF-1-8	Overflow Weir Rip-Rap Slope Armor	500	SY	$5.00	$2,500	top and downstream face of overflow weir
	Subtotal - OPTION 1				**$207,670**	(Does not include access and property agreements)
Option 2 - Bottom of Sediment Forebay at elevation 2381						
Item No.	Description	Qty	Units	$/Unit	Total	Notes and Assumptions
SF-2-1	Clearing & Grubbing	1.5	Ac	$5,000.00	$7,500	brush, including stumps.
SF-2-2	Sediment Control	1	LS	$25,000.00	$25,000	Includes maint. & mon. for following wet season
SF-2-3	Excavation - Basin	39,808	CY	$3.00	$119,424	4' deep over area of Sed. Forebay
SF-2-4	Hauling & Disposal	43,789	CY	$10.00	$437,888	10% expansion factor included
SF-2-5	Compaction - Sullivan Ck. Sed. Forebay	7,200	SY	$3.00	$21,600	
SF-2-6	Outlet Works	1	Ea.	$20,000.00	$20,000	~20 yds. Concrete + gate
	Subtotal - OPTION 2				**$631,412**	(Does not include access and property agreements)

likely require 7 to 10 days to effectively remove the bulk of the growth. Depending upon the timing of the harvest, it is possible that one maintenance event would be sufficient for one year; however, shallower locations would likely re-grow, requiring a second cut to maintain aesthetics and access. The estimated cost is $25,000 per harvest event.

Mowing for Firebreaks

Mowing of the dense, dry stands of marsh vegetation would create firebreaks to contain the spread of wildfires (Photo 3.1-15).

Photo 3.1-15. Marsh vegetation can be mowed to provide temporary fire breaks. Note that vegetation shown in the photo is live, current-year growth. Mowing in Phoenix Lake would likely take place when vegetation is dry.

Mowing the lake perimeter, as well as dividing larger areas by creating additional breaks would contain wildfire within small areas as opposed the potential spread to the entire lake and potentially the surrounding watershed. Firebreaks would be delineated and pre-surveyed to exclude preferred or occupied bird nesting habitat. Mowing the lake perimeter would take approximately two to four days for a cut to the root crown or water level (based on anticipated plant densities). This would most likely be an annual or semi-annual event as the cutting would open up areas for new growth the following season. Mowing would take place when the lake level is low and prior to the start of bird nesting season (likely January or February). Costs for mowing the lake perimeter are estimated to be approximately $10,000. This estimate does not include permits and environmental compliance that would be needed to conduct this activity.

4.0 CONCLUSIONS AND NEXT STEPS

4.1 CONCLUSIONS

Phoenix Lake has served eastern Tuolumne County as a water storage and supply facility for over 150 years. The lake is also an important recreational amenity and currently provides wetland functions and values that are unique to this portion of the County. In the past 150 years the lake has received minimal maintenance to preserve these functions. In the absence of intervention many of the functions and values that the lake provides will continue to be degraded or lost.

Morris et al., (2008) identify five strategies to control sedimentation in reservoirs. These strategies are:

1. **Sediment yield reductions**. This involves control of sediment sources;
2. **Sediment storage**. This strategy assumes there is sufficient storage in the reservoir to allow for sedimentation;
3. **Sediment routing.** This strategy passes sediment around or through the storage pool to minimize trapping;
4. **Sediment removal.** This is removal of stored sediment by dredging and/or flushing; and
5. **Sediment focusing.** These are techniques used to tactically arrange or segregate sediments to solve localized problems so sediment does not interfere with operations.

Each of these strategies has been incorporated into the PLPRP as appropriate and feasible. **Sediment yield reductions** are described in Chapter 2 of the PLPRP. Since its inception, the lake has been operated as a **sediment storage** facility. Due to reduced lake capacity and water quality concerns, additional strategies are now needed. **Sediment routing** does not appear to be feasible at Phoenix Lake. **Sediment removal** and **sediment focusing** are the subject of this report.

If implemented, the concepts presented in this report would extend the life of the reservoir while preserving the recreational, aesthetics and wetland values of the lake. Assuming an average annually deposition rate of 4,600 cy, removing approximately 265,000 cy of sediment (Table 3.1-3) would extend the life of the reservoir by more than 55 years[1]. Sediment management activities in wetland areas would further increase the life of the reservoir by trapping sediment in locations that can be regularly managed with conventional equipment. These activities would also improve water quality in the lake.

In the absence of intervention, the lake will eventually achieve complete sedimentation infill (or full sediment balance). At that point the lake would be predominantly vegetated wetlands with open water habitat primarily associated with the Sullivan Creek. The lake could still be flooded with the flashboards in the summer time, but lake depth and water quality would be marginal.

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[1] Lake trap efficiency is a non-linear function whereby trap efficiency is highest when lakes are deepest. As lakes fill with sediment their trap efficiency reduces. This estimate does not account fo non-linear changes in reservoir trap efficiency that may result from sediment removal activities.

4.2 Next steps

The preservation and restoration concepts presented in this report represent an initial approach to improving conditions at Phoenix Lake. These concepts were reviewed and refined by TUD and the PLTF. The results of this review process are presented in Part II of this chapter.

Outstanding technical issues to be resolved in subsequent stages of design include sediment removal depths, equipment access routes, materials handling, phasing, and reuse and disposal areas. It is anticipated that additional subsurface investigation will be necessary to confirm sedimentation depths and to refine the depths and extents of sediment removal within each of the management units. As additional data become available future PLPRP sediment removal plans may propose deeper or shallower target depths than those proposed in this report.

Multiple administrative and environmental tasks will need to be completed for further development of the PLPRP. These tasks include obtaining access and easements agreements, conducting environment review and compliance, obtaining necessary permits, and identifying funding sources. Any proposed project developed by TUD will require compliance with the California Environmental Quality Act (CEQA). The public disclosure and outreach activities that occur through the CEQA process may also provide a valuable opportunity for public comment on any proposed actions. An environmental compliance strategy for implementing the PLPRP is detailed in Chapter 7.

5.0 REFERENCES & GLOSSARY

5.1 References

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5.2 Glossary

Bathymetric: Measurement of elevation or depth in water. Bathymetry is typically shown in contours of equal elevation. Alternatively, bathymetry can be shown as water depths.

Bedload: The sand, gravel, boulders, or other debris transported by rolling or sliding along the bottom of a stream.

Channel morphology: The physical form or shape of a stream channel.

Delta: A fan-shaped deposit of sediment formed where moving water (e.g., stream) enters a body of standing water and deposits a portion of its sediment load.

Deltaic: Of or relating to a delta

Emergent wetland: A wetland characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens.

Eutrophic: A biologically productive type of lake due to relatively high rates of nutrient input.

Eutrophication: The process by which lakes and streams are enriched by nutrients (usually phosphorus and nitrogen) which leads to excessive plant growth - algae in the open water, periphyton along the shoreline, and macrophytes in the nearshore zone.

Fluvial: Relating to processes associated with rivers and streams.

Full sediment balance: The final stage in the life of a reservoir where a balance between sediment inflow and outflow is achieved.

Geomorphology*:* The study of landforms, their history, and the processes which shape the earth's surface.

Lacustrine: Of or pertaining to a lake.

Macrophytes: Aquatic plants, growing in or near water that are emergent, submergent, or floating. Macrophytes are visible with the naked eye.

Passerine: Of or relating to birds of the order Passeriformes, which includes perching birds and songbirds such as the jays, blackbirds, finches, warblers, and sparrows

Planform: The shape or alignment of a channel as viewed from above.

Sediment Forebay: an impoundment, basin, floodplain, wetland or other flow or sediment storage feature designed to dissipate the energy of incoming runoff, and detain the runoff for initial settling of coarse sediments.

Sediment: Solid fragmental material transported and deposited by the actions of water, wind or ice.

Suspended load: Sediment that moves in a channel without coming in contact with the streambed.

Trap efficiency*:* The ratio of sediment trapped in a reservoir versus the amount that is passed through the reservoir, typically expressed as a percentage.

Unconsolidated shore: Wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock; (2) less than 30% areal cover of vegetation other than pioneering plants; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded.

Chapter 3 - Part II

Sediment Removal & Wetland Enhancement Plan

Phoenix Lake Preservation & Restoration Plan

1.0 INTRODUCTION

Part II of Chapter 3 describes the *Sediment Removal and Wetland Enhancement Plan* (Lake Plan) for Phoenix Lake. This **Lake Plan** builds on information presented in Part I of Chapter 3, *Lake Preservation and Restoration Concepts* (Concept Plan). Part I summarized lake management issues including loss of storage capacity and poor water quality and described a general approach to restore and improve these functions. The objective of this Lake Plan is to present a more detailed description of the activities and methods needed to implement the lake improvements. The Lake Plan includes the attached 30% engineering drawings (Attachment A) and construction cost estimate. Part II is organized as follows:

- Section 1 - Introduction
- Section 2 - Design Elements
- Section 3 - Construction Access & Materials Management
- Section 4- Construction Costs & Phasing
- Section 5- Conclusions & Next Steps
- Section 6- References

2.0 DESIGN ELEMENTS

2.1 Overview

Phoenix Lake has been divided into management units based upon the primary physical processes and dominant lake conditions in these areas (Figure 3.2-1). This Lake Plan targets specific management actions based on conditions and opportunities within these lake management units. Overall, the approach of the Lake Plan is consistent with the concepts presented in Part I of Chapter 3. Sediment removal is focused in the open water portions of the lake. Wetland enhancements, integrated with sediment management, are targeted for the North Marsh Unit, including a sediment forebay, realignment of Sullivan Creek, and channel modifications on Sullivan, Chicken and Power creeks.

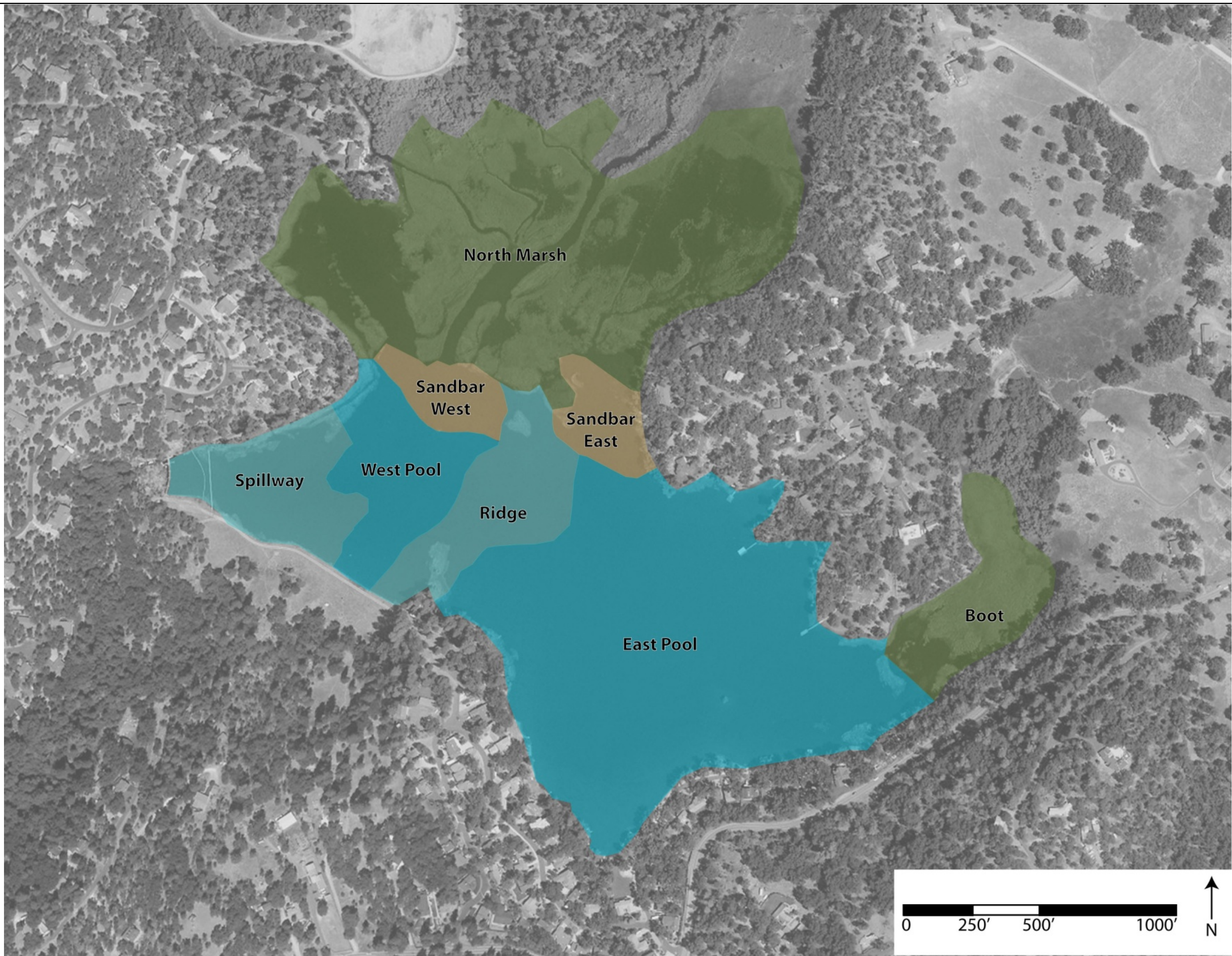
Through discussions with the Tuolumne Utilities District (TUD) and Phoenix Lake Task Force (PLTF), additional design elements have been incorporated into the Lake Plan to further improve water quality, expand usable storage, and reduce costs associated with materials disposal. These additional elements include sediment removal in the Boot Unit, deep dredging near TUD's intake tower, and "in-lake" sediment reuse to create beaches and habitat islands.

The major design elements that comprise the Lake Plan are described in the remainder of Section 2.

2.2 Sediment Removal in Open Water Management Units

As stated above, sediment removal is focused in open water portions of lake, including the Spillway, West Pool, East Pool, Sandbar East and West, and Ridge management units. Sediment removal areas are shown in Attachment A, Sheet 4.

The Lake Plan also includes sediment removal in the Boot Unit, which is dominated by emergent vegetation. Preliminary sediment removal approaches for each management unit were described in Part I of Chapter 3. In the sections below, revised and refined sediment removal approaches for each management unit are described. Where this Lake Plan differs from the concepts presented in Part I of Chapter 3, it is noted. Sediment removal methods for each management unit are also described below.



Notes: Base map courtesy of Bing maps

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Phoenix Lake Preservation & Restoration Plan

Lake Management Units

July 2012 | Created By: KF | **Figure 3.2-1**

Table 3.2-1 summarizes the sediment removal volumes and the resultant increase in storage capacity for each management unit.

Table 3.2-1. Sediment Removal and Increase in Lake Storage Capacity

Lake Management Unit	Sediment Removal Volume (cubic yards)	Increased Storage Capacity (acre-feet)
Spillway	72,900	45.1
West Pool	60,900	37.6
Sandbar West	45,400	28.1
Ridge	49,800	30.8
Sandbar East	28,300	17.5
East Pool	146,500	90.5
Boot	31,900	19.7
Total	**435,700**	**269**

Spillway Unit

Sediment removal at the Spillway Unit has been modified from the Concept Plan to include dredging up to the spillway structure. Previously, it was assumed that access to the spillway structure would be impeded by the TUD pipeline. Upon further consideration, it was determined that the benefits of dredging the area between the pipeline and spillway outlet likely outweigh the costs associated with temporarily relocating or replacing this section of the pipeline. The existing pipeline is also undersized, which further warrants its replacement.

The majority of the Spillway Unit would be dredged to a target elevation of 2,365 feet[1] (ft). The presence of shallow bedrock or native substrate near the lake shoreline may result in actual dredging depths that are shallower than the target elevation. Deeper dredging is proposed in the portion of this unit that is closest to the intake tower (See West Pool description for details).

Sediment removal in this unit may be accomplished through a combination of water-based dredging and land-based excavation with equipment operating from the dam. Approximately 72,900 cubic yards (cy) of sediment would be removed from this unit (Table 3.2-1). If moved by excavation equipment, this material could be placed directly in the proposed sediment disposal area on the land-side of the dam (Attachment A, Sheet 12). Material moved by water-based suction dredging equipment would be dewatered first and then moved to a reuse or disposal location (See Section 3).

West Pool Unit

Sediment removal in the West Pool Unit has been expanded to include deep dredging in the vicinity of the intake tower (Attachment A, Sheet 4). The intake tower has 3 gates that can be used to draw water from the lake; the deepest gate is at elevation 2,349 ft. TUD would like to have the ability to draw water from this gate during low water conditions. Furthermore, the quality of water drawn from this gate may be superior to the shallower gates, particularly in the summer months when water temperature and biological productivity decrease with depth. As such, the Lake Plan includes dredging to elevation 2,347 ft in the vicinity of the tower. The 2 ft over-excavation around the gate would allow for a modest amount of sediment settling and accumulation to occur without impacting gate operability. The Lake Plan also includes retaining a small earthen berm approximately 30 ft from the tower to

[1] All elevations are referenced to North American Vertical Datum (NAVD) 88.

minimize sediment infilling at the base of the tower (Attachment A, Sheets 4 and 13).

Most of the sediment removal in the West Pool Unit will require likely water-based dredging, though temporary dewatering of the lake may also be feasible. Some land-based excavation is also likely feasible in the areas closest to the dam. Approximately 60,900 cy of sediment would be removed from this unit (Table 3.2-1).

Sandbar West Unit

Sediment removal in this unit is similar to that proposed in the Concept Plan. Key features include excavating a channel in the unit's northwest portion to connect to the 1986 dredge hole, thereby eliminating the "dead storage" (i.e., unusable storage) in the dredge hole. The Lake Plan also includes grading transition slopes at 3h:1v (3 horizontal to 1 vertical) from the sediment removal area to the existing marsh to reduce erosion potential.

Access for sediment removal could be accomplished by constructing a temporary in-lake haul route that connects to Phoenix Lake Road (Attachment A, Sheet 4), or by operating small barges on the lake to move material to another access point. Approximately 45,400 cy of sediment would be removed from this unit (Table 3.2-1).

Ridge Unit

Sediment removal is proposed in the northwest portion of the unit that is contiguous with the West Pool and Sandbar West units. Dredging a channel to connect the East and West Pools is proposed in the southern portion of the unit to reduce the dead storage volume in the East Pool. The plan for this unit includes reusing excavated sediment to create a habitat island (See Section 2.4), thereby reducing disposal costs while providing an environmental benefit. Sediment removal methods for this unit are likely to include both land and water-based equipment. Approximately 49,800 cy of sediment would be removed from this unit (Table 3.2-1).

Sandbar East Unit

A modest excavation depth (2,370 ft) is proposed for the Sandbar East Unit because of the high likelihood of competent, native material near the lake bed. The target excavation depth(s) for this unit may be refined with subsurface investigations conducted in subsequent phases of design. Sediment removal in this unit would likely be accomplished with conventional land-based excavation equipment loading trucks that use a temporary in-lake haul route connected to Phoenix Lake Road. Approximately 28,300 cy of sediment would be removed from this unit (Table 3.2-1).

East Pool Unit

Sediment removal in this unit is similar to that proposed in the Concept Plan, however, the Lake Plan includes substantial placement of sediment on the east side of the lake to create a beach and expand an existing island. Details of these features are described in Section 2.4.

Based on guidance from TUD and the PLTF, temporarily dewatering the lake to enable sediment removal with land-based equipment is likely feasible from a water supply operations standpoint, as well as agreeable to homeowners. It is anticipated that a temporary cofferdam, such as a Portadam®, placed along the mid-lake ridge would allow for dewatering of the East Pool. Low ground pressure equipment would be used to excavate approximately 146,500 cy of sediment from this unit (Table 3.2-1).

Boot Unit

While the Concept Plan did not include significant sediment removal in the Boot Unit, opportunities to provide additional storage capacity in this unit were reconsidered. Through consultation with TUD and the PLTF, and further consideration of lake sedimentation processes, it was concluded that sediment removal in the Boot Unit is warranted. As described in the Part I of this chapter, sedimentation in the Boot Unit is largely the result of backwater settling and wind-circulation induced deposition of fine sediment. Sediment removal in the Boot Unit would create new depositional capacity and allow the Boot to continue to function as a "kidney" for the lake by trapping fine sediment. In the long-term, if watershed-based sediment source control measures are implemented, the depositional rates in the Boot should decline.

The proposed sediment removal plan for the Boot Unit includes dredging wide, deep channels and maintaining wetland islands (Attachment A, Sheet 7). Retaining wetland islands in the unit will preserve and enhance bird nesting habitat. The island habitat would be separated from uplands by channels, which would reduce predation on bird nests. The channels would also provide a fuel break between wetland and upland areas.

Sediment removal in this unit would likely be accomplished with conventional land-based excavation equipment loading trucks that use the temporary in-lake haul route. Approximately 31,900 cy of sediment would be removed from this unit (Table 3.2-1).

2.3 North Marsh Sediment Management & Wetland Enhancement

The wetland enhancement and sediment management activities in the North Marsh Unit are similar to those proposed in the Concept Plan. The design elements include a sediment forebay on Sullivan Creek at the lake transition zone, a realigned Sullivan Creek channel into the lake, and floodplain benches to store sediment on Chicken and Power creeks (Attachment A, Sheet 5). The objectives of these design elements are to: (1) reduce direct sediment loading into the lake from Sullivan, Chicken, and Power creeks, (2) manage and reduce the encroachment and expansion of wetlands into the open water lake, (3) improve habitat diversity, and (4) provide fuel breaks. The rationale for these objectives is described in Part I of this chapter. Key aspects of each design element follow.

Sullivan Creek Sediment Forebay

The Sullivan Creek sediment forebay (forebay) is intended to trap bedload and coarse suspended load (e.g., sand and coarser) sediments before they are delivered to Phoenix Lake. A key function and benefit of such a forebay is that it facilitates routine maintenance and sediment removal more easily than open lake sediment dredging.

In Part I of chapter, two options were presented which primarily differed in the elevation of the forebay. Option 1, placed the bottom of the forebay at the existing wetland surface, and created a basin through construction of a perimeter berm. Option 2 proposed excavating the forebay into (and below) the wetland surface, thereby creating a basin in the surrounding area. Upon further consideration and inspection of topographic data, Option 2 was selected and subsequently refined as the preferred alternative. This option was preferred for the following reasons:

- The weir controlling water surface elevation (WSE) for Option 2 would be several feet lower than Option 1. This would result in lower WSEs in the forebay, and upstream on Sullivan Creek. Maintaining higher WSEs on Sullivan Creek could have increased the potential flood risk and raised the local water table;

- The at-grade forebay (Option 1) would have created a backwater condition that would have extended upstream into Sullivan Creek, creating the potential for increased sediment deposition within the channel, resulting in the need for maintenance/removal of sediment outside of the forebay area, as well as increasing potential flood risk; and

- The Option 2 design does not require geotechnical engineering of the forebay containment berms, and carries considerably less risk of berm failure if overtopped during an extreme flood event.

The conceptual design for the forebay is shown in Attachment A, Sheet 9. The forebay was designed to be large enough to effectively trap sediment and minimize the frequency of maintenance. The proposed usable volume is 3,310 cy. This equates to 70% of the estimated average annual deposition in the lake. The Sullivan Creek watershed accounts for 67% of the lake's contributing drainage area. While all sub-watersheds draining to the lake are not likely to contribute sediment proportionally, it is anticipated that the Sullivan Creek forebay will have sufficient capacity to capture the expected annual delivery of coarse suspended load and bedload.

The bottom of the forebay would slope from elevation 2379.5 ft at the upstream northern inlet, to 2379 ft at the southern outlet. The adjacent ground is at elevation 2,385 ft, thus the forebay would be roughly 5 to 6 ft deep. These elevations optimize sediment storage volume, while keeping the forebay at the ordinary winter water level (OWLL) of 2379 ft, thus allowing for maintenance/sediment removal on the shoulders of a typical wet season (i.e., March-April or October-November).

The forebay inlet weir is sized to accommodate a 10-year return storm flow (Q10) of approximately 1,400 cubic feet per second (cfs) (See Technical Appendix II for estimates of stream flow). The inlet weir is a two-tier design, with a low-flow weir sized to accommodate a 2-year return storm flow (Q2 = 436 cfs), and an adjacent, elevated high flow weir that is designed to pass the Q10 (Attachment A, Sheet 13). The inlet weir is set slightly above the existing grade of Sullivan Creek channel and can be blocked with flashboards or sandbags to shunt flows into the existing Sullivan Creek channel during forebay maintenance, or periods of forebay bypass.

A diversion weir for the existing Sullivan Creek channel was designed in conjunction with the forebay inlet weir (Attachment A, Sheet 9). The diversion weir is intended to divert flows up to Q10 into the forebay. Flows in excess of Q10 would overtop the diversion weir and flow down the existing Sullivan Creek channel. The diversion weir also incorporates a sluice gate to allow low flows to pass into existing Sullivan Creek during maintenance/bypass of the forebay.

The forebay outlet weir is also a two-tier design. The two tiers are designed so that Q2 passes the lower tier and the upper tier passes Q10, while maintaining 1 ft of freeboard to the top of the forebay embankments. The forebay outlet weir would be armored with riprap to prevent erosion.

All, or a majority of the basin will be inundated during the summer when the lake level is high. Flashboards could potentially be installed to help keep the forebay dry. However, this solution may not be practical, as the length of the high flow outlet weir is approximately 230 ft at an elevation of 2384 ft. Because the forebay would be inundated at the OSLL (without flashboards), maintenance (i.e., sediment removal) would likely be performed before or after summer, when water levels do not inundate the forebay.

Preferably, maintenance would be scheduled prior to raising lake levels, in late March or April, after the majority of the wet season storms have passed. At that time, operators could open the sluice gate in the Sullivan Creek diversion weir and install flashboards or sand bags across the low-flow inlet weir to the forebay, allowing creek flows to bypass the forebay. Once the forebay is dry enough to allow passage of earth moving equipment, the forebay can be cleared of sediment down to design elevations. The excavation equipment would access the forebay from an earthen berm constructed around the perimeter of the forebay. Sediment could be hauled off-site immediately, or stockpiled nearby, allowed to dry out further, and then transported off-site.

The forebay design also includes a drain pipe to gravity drain ponded water from the forebay which is unable to exit through the outlet weir. This drain pipe would connect back to the existing Sullivan Creek channel.

Sullivan Creek Realignment

As described in Part I of this chapter, the main purpose of the Sullivan Creek channel realignment is to promote sediment deposition in existing wetland areas. Attachment A, Sheets 9 and 10 show the preliminary design for realignment of the Sullivan Creek channel. The proposed design is similar to that presented in the Concept Plan, with the main difference being that the channel has been moved further to the south and east. This was done to minimize the potential for the new alignment to recapture the existing channel.

The low flow inset channel for the new alignment of Sullivan Creek was designed to convey flows roughly equivalent to half of Q2. The channel was intentionally undersized to promote frequent overtopping of its banks and inundation of the adjacent excavated floodplain. Typically as flows leave the main channel, the cross-sectional flow area and roughness drastically increase, thereby reducing velocity and increasing sediment deposition.

Hydraulic analysis of the design channel will be necessary to refine its sizing and assess channel stability. This will likely be performed in subsequent design phases of the PLPRP. Erosion protection measures, such as leaving existing wetland vegetation in place along the margins of the channel at high energy locations, could provide additional stability to the channel.

Floodplain Benches

Floodplain benches are proposed for the Sullivan, Power and Chicken creek channels. The purpose of the floodplain benches is to trap some portion of the sediment delivered from these drainages. In addition to improving sediment trapping, the new floodplains would provide temporary fuel breaks. Over time, the floodplain benches would increase in elevation and vegetation would become established. Alternatively, the floodplain surfaces could be maintained at a prescribed elevation to maximize sediment trapping and fuel break functions. It is estimated that sediment removal on the floodplains would need to occur every 3-5 years, or following large flood events (e.g., 10-year flood). Sediment removal may require the use of low ground pressure excavators and haul trucks. The equipment would access the floodplain via pre-established routes. The floodplain maintenance program could be incorporated into the regulatory permits for the PLPRP (See Chapter 7) to alleviate the need to permit each sediment removal event on an individual basis.

The floodplain benches on Sullivan Creek would vary in width from approximately 40 to 120 ft on either side of the low flow channel (Attachment A, Sheet 13). The benches on Power and Chicken creeks would be 20 feet on either side of the channel. It is anticipated that channel construction and floodplain benching would be accomplished with conventional land-based excavation equipment operating on temporary haul roads or mats. Construction of the new Sullivan Creek channel and associated floodplain benching would result in removal of approximately 29,900 cy of sediment (Table 3.2-1). Approximately 1,100 cy of sediment would be removed to create floodplain benches on Power and Chicken creeks. Most of this sediment would be removed from the lake. Some material may be placed into existing marsh areas to provide topographic relief, which would increase habitat diversity.

2.4 Beach & Habitat Islands

Reusing dredged material to create beaches and islands within the lake has several potential benefits including: (1) providing habitat diversity; (2) reducing costs, traffic and greenhouse gas emissions associated with sediment disposal; and (3) creating recreational amenities.

Beaches

Beach creation is proposed on the south side of the East Pool Unit near Phoenix Lake Park (Attachment A, Sheet 6). Sandy material excavated from other portions of the lake (e.g., Sandbar West Unit) would be placed along the shoreline. Most of the beach would be at elevation 2,387 ft, which is approximately 2 feet above ordinary summer lake level (OSLL). A 12-ft wide channel would bisect the beach to allow for boat launching and storm water discharge from an existing drainage.

The beach would be designed so that it gradually slopes into the lake. Creation of the beach would reuse approximately 31,000 cy of dredged material that would otherwise be hauled to a sediment disposal area.

The beach may require some maintenance such as raking to minimize the accumulation of organic matter and reduce the potential for growth of vegetation. The PLTF has also discussed the potential for beach creation on the north side of the lake near the Apple Valley Estates.

Habitat Islands

Island creation or expansion is proposed in the East Pool and Ridge units. The primary reasons for creating island habitat are to reuse sediment and to minimize the loss of important waterfowl resting/loafing habitat, which is characterized by nonvegetated, unconsolidated shoreline areas such as the Sandbar Unit. The existing island in the East Pool (Photo 3.2-1) would be expanded by placing dredged material around the margins of the island (Attachment A, Sheet 6).

Photo 3.2-1. The proposed plan would expand the existing island (shown on the left side of the photo) to provide loafing (resting) habitat for waterfowl.

A new island is also proposed near the center of the lake in the Ridge Unit (Attachment A, Sheet 8). The target elevation for both of these islands would be approximately 2,381 ft. This elevation would provide loafing habitat for waterfowl in the winter months. The islands would be submerged in the summer time. Creation of the islands would reuse approximately 5,800 cy of dredged material that would otherwise be hauled to a sediment disposal area. It is anticipated that the extent and design of the islands will be refined in subsequent phases of the PLPRP through consultation with resource agencies such as the California Department of Fish and Game.

2.5 Other Options Considered

Other sediment removal and wetland management options considered in the development of this Plan included: (1) deeper dredging in open water portions of the lake, (2) the "Channels and Islands" approach recommended by the PLTF (PLTF, 2010), and (3) complete open water lake restoration (i.e., converting all wetlands to open water). The potential benefits and drawbacks of these options are discussed in Part I of this chapter. It is anticipated that public and resource agency input received during the regulatory compliance and design phase of the PLPRP will influence subsequent designs for sediment removal and wetland management.

3.0 CONSTRUCTION ACCESS & MATERIALS MANAGMENT

3.1 Construction Access

Construction access points are similar to those identified in the concept Plan. The potential access points include Lori Lane at Phoenix Lake Park, Phoenix Lake Dam, the existing boat ramp at Apple Valley Estates, and the Cedar Ridge Apple Ranch in the vicinity of the proposed sediment forebay.

In addition to these sites, a temporary, in-lake haul road is proposed along the lake shoreline in the Sandbar East, East Pool and Boot management units (Attachment A, Sheet 4). This temporary road would connect directly to Phoenix Lake Road, which would allow land-based excavation equipment to remove sediment from the Sandbar and Boot units. Establishing this road would require an easement over private property between the lake and Phoenix Lake Road.

Several of the construction access points listed above are also identified as potential locations for establishing public access to the lake (Chapter 5, *Public Access Plan*). The planning for construction activities and public access will be coordinated so that sites can serve the multiple objectives of the PLPRP.

3.2 Materials Handling

Materials handling includes the necessary procedures to prepare sediment for beneficial reuse or disposal. Several factors may influence the materials handling procedures including removal location and methods, sediment texture, project phasing, and adjacent landowner cooperation/participation.

As discussed in Section 2.2, it will likely be beneficial to draw down the lake and remove sediment from the East Pool with land-based excavation equipment. It is anticipated that much of the sediment removed from the East Pool would be loaded on to trucks and hauled off-site for reuse or disposal. During the excavation of the East Pool, it may be feasible to construct a settling basin near Lori Lane to handle hydraulically dredged sediment from the West Pool and Spillway units. This would allow these materials to dewater for later removal with land based equipment. Alternatively, sediment that is hydraulically dredged from the western portion of the lake could be dewatered in the settling basin that was used in the 1986 dredging event.

The land-side, southeast, of the dam is another potential location for dredged materials handling. Sediment may be placed at this location with a long-reach excavator or clamshell dredge operating from the dam or pumped directly to this area with suction dredge equipment. If this area is used to handle sediment delivered directly from a suction dredge operating in the lake, then substantial site modifications would be required including construction of a settling basin.

3.3 Beneficial Reuse & Disposal

Results of Preliminary Sediment Testing

A preliminary screening of sediment chemistry and texture (i.e., particle size distribution) was conducted to inform potential reuse and disposal options for sediments excavated from the lake. On April 26, 2011 sediment samples were collected at 5 locations within the lake (See Attachment B). At each sampling station, 3 core samples were collected from 0 to 3 ft below the sediment surface. In some instances, sediment could not be retrieved with the core sampler (due to consistency of the sediment), so the samples were collected with a shovel. A composite sample from each station was sent to BSK Analytical Laboratories in Fresno, CA for testing. Analyses included: general chemistry, nutrient concentrations, total metals concentrations, Waste Extraction Test (WET) metal concentrations, and particle size distribution.

The laboratory results of the sediment testing are provided in Attachment B. The pH of lake sediments ranged from 5.2 to 5.8, which is characterized as moderate to strongly acidic. The acidity of the lake sediments may be related to several factors including vegetation cover in the watershed (i.e., coniferous forest), chemistry of the parent material, and/or oxidation of organic matter in the lake. The pH levels measured in the lake sediments do not necessarily limit the potential for beneficial reuse, but certain reuse options (e.g., agricultural or restoration) may require a soil amendment such as lime ($CaCO_3$) to establish a neutral pH.

The initial screening of nutrient concentration in the sediment samples included analysis of total nitrogen (N), and nitrate and nitrite. Total N in California soils may vary greatly, but commonly ranges from 0.1 to 0.3% of the total soil volume (Singer, 2003). Total N in the sediment samples ranged from approximately 0.06 to 0.1%. Nitrate and nitrite, which are soluble forms of nitrogen, were very low or non-detectable in all samples. The laboratory also reported results for total phosphorus (P); the levels present in the sediment samples are not a concern for sediment reuse or disposal.

The Central Valley Regional Water Quality Control Board (Central Valley RQWCB) provided the consultant team with a list of Constituents of Concern (COCs) to analyze during pre-dredge sampling (See Attachment B). The list of COCs includes a suite of metals that are common pollutants. The concentrations of the COCs in all samples were within the range of naturally occurring background concentrations (Wedepohl, 1995), and below levels that are considered toxic by the State (See Tables 1 and 2 of Title 22, Chapter 11, Article 3, Section 66261.24 in Attachment B). Mercury, a metal commonly associated with legacy gold mining activity, was not detected in any of the samples.

Sediment texture ranged from silt loam in the Boot Unit to loamy sand in the Ridge Unit. All samples had a relatively high percentage of sand and much lower clay content. In most locations, the surface material was finer than the substrate at depth greater than 1 to 2 feet below the surface. Since the samples at each station were homogenized, this stratification is not evident in the data.

Results of the preliminary screening suggest that sediment in the shallow surface of the lake (i.e., 0 to 3 ft) is not likely to be classified as hazardous waste, and it is potentially suitable for a wide range of reuse applications. It is important to note that sediment samples were collected only from 0 to 3 ft below the surface, and therefore may not be representative of all the sediment that is proposed to be removed from the lake. A more robust sediment testing program will be developed in coordination with the Central Valley RQWCB during the design and regulatory compliance phase of the PLPRP.

Potential Reuse and Disposal Options

Table 3.2-2 lists potential reuse and disposal options for sediment removed from the lake. These options represent a broad range of opportunities for sediment reuse or disposal. The table provides a general description of each option, approximate area and volume available for reuse/disposal, and estimated relative costs.

At this stage of the planning process it is premature to determine which of the reuse or disposal options will be utilized. For each option listed in Table 3.2-2 action items have been identified to advance the planning for reuse or disposal. As is the case with most projects, cost will be the primary factor in determining the preferred option(s). The options that are likely to cost the least are those closest to the lake. However, there may not be sufficient or suitable disposal sites in the immediate vicinity of the lake. Costs will increase with distance from the lake, as will environmental impacts associated with greenhouse gas emissions and traffic.

Depending on construction methods, a large portion of the sediment proposed to be removed from the lake will need to be loaded into trucks and hauled to a disposal site (or sites). Assuming that each truck can accommodate 10 to 12 cy per trip, the entire project could generate more than 30,000 truck trips. This high volume of truck travel is likely to impact local roads. These aspects of the project will be considered during subsequent planning and environmental review phases of the PLPRP.

Table 3.2-2. Sediment Reuse and Disposal Options for Phoenix Lake					
Disposal/Reuse Area	**General Description**	**Approximate Area (acres)**	**Approximate Volume Available for Reuse/Disposal (cubic yards - dry)**	**Estimated Relative Cost**	**Planning Action Item**
Phoenix Lake Dam	Material disposal on land-side of dam. Area was previously used for materials disposal. TUD owns property. Dredged material could be used to build a new access road to connect the dam with Meadow Brook Drive.	TBD	25,000 - 50,000 cy; potentially greater if constructing a new access road.	Low for disposal only; High for new access.	> Collect topographic data > Delineate disposal area > Coordinate deposal plan with DSOD > Investigate easement options for long-term access.
North (1986) Disposal Area	Area was previously used for materials disposal. Existing (dry) material could be excavated and placed in adjacent orchards to make room disposal.	16 acres (8 upland and 8 wetland/riparian)	100,000 - 250,000 cy	Low-Moderate	> Coordinate with property owner > Conduct survey of pond area > Evaluate existing zoning/land use restrictions
Apple orchard fields	Place sediment in orchards to improve drainage/level fields.	15 - 20 acres	100,000 cy	Low	> Coordinate with property owner
Phoenix Lake Country Club	Provide fill material for golf course improvements/maintenance	TBD	TBD	Low-Moderate	> Coordinate with owner to determine if any large project are planned and potential stockpile capacity
Sierra Pines Property	TUD property in Twain Harte.	TBD	TBD	Low-Moderate	TBD
Jamestown Mine	Abandoned mine approximately 9 miles from Phoenix Lake. Several reclamation/development project are planned in the area.	300+ acres	Likely unlimited	Low-Moderate	> Communicate with owner to determine material needs and stockpiling capacity
Construction fill material/commercial landscaping/ aggregate	Reuse material for commercial landscaping or aggregate. Sand is the primary reusable material.	NA	TBD	Low-Moderate	> Contact local landscaping and aggregate companies to determine their needs and stockpiling capacity.
Local landfill	Material may be suitable for landfill daily cover or capping	NA	TBD	Moderate	> Contact local landfills to determine their needs and stockpiling capacity.
Other agricultural use	Land application in field or pastures of the foothills or Central Valley	NA	TBD	Moderate	> Contact local agricultural commissioners or farm bureaus
CDFG Merced River Ranch	Riparian restoration site near Snelling. Approximately 40 miles from Phoenix Lake. Fines may be more desirable than sand.	300+ acres	TBD	High	> Limited primarily by cost, but could be grant funded. > Further coordination with CDFG is needed.

Sediment disposal costs may be reduced by identifying grant funding for beneficial reuse of sediment such as habitat restoration, land conservation or reclamation. Timing of the sediment removal will also be an important factor as the need for material at reuse/disposal sites may change. The list of options should be periodically updated as information becomes available.

4.0 CONSTRUCTION COSTS & PHASING

4.1 Conceptual Cost Estimate

Table 3.2-3 provides conceptual level cost estimates for implementing the Lake Plan. The cost estimate does not account for inflation or long-term maintenance of the sediment forebay and floodplains in the wetland areas. At this stage of the design development it is difficult to identify which specific parcels and easements will be necessary to implement the project. Thus, Table 3.2-3 includes an estimated cost for acquisition of land for the sediment forebay and realignment of Sullivan Creek, but not for other acquisitions or easements that may be required for construction and maintenance access.

4.2 Phasing

As mentioned in the Concept Plan, several factors may influence the schedule for implementing the Lake Plan including funding, environmental permitting, and land acquisition or access agreements. At this juncture, funding is considered the most significant obstacle to completing the Lake Plan. The Lake Plan has been developed so that it can be implemented in segments or phases. However, it is important to recognize that costs for completing several small projects will be substantially higher than for a single, large project. This is particularly true for projects that involve water-based dredging equipment, which require significant mobilization costs.

In the absence of funding and administrative constraints, the following phasing plan is recommended:

Phase 1:

- Construct Sullivan Creek sediment forebay and wetland enhancements

Phase 2:

- Complete land-based sediment removal operations in open water (See Table 3.2-3)
- Construct beaches and islands
- Construct East-West Pool connection channel

Phase 3:

- Complete water-based sediment removal operations in open lake (See Table 3.2-3)
- Construct West Pool-Dredge Pool connection channel

As discussed in the Concept Plan, it would be prudent to have watershed BMPs in place that would reduce sediment loading to Phoenix Lake prior to implementing the Lake Plan. Similarly, it is advantageous to develop the Sullivan Creek sediment forebay and associated wetland enhancements in Phase 1 prior to other open water sediment removal actions.

Phase 2 would consist of large-scale, land-based sediment removal in the open lake, which is likely to be more cost-effective than water-based dredging. It is anticipated that it will be feasible to remove sediment from the East Pool with land-based excavation after the unit has been temporarily dewatered. Much of this

Table 3.2-3. Conceptual Level Opinion of Probable Construction Costs.

Item No.	Description	Qty	Units	$/Unit	Total	Notes and Assumptions
A. AQUISTIONS, ENGINEERING, ENVIRONMENTAL PERMITS & COMPLIANCE, ADMINISTRATION						
A-1	Land Acquisition for Sediment Forebay	9	Ac	$31,500.00	$283,500	LandandFarm.com average cost/acre in Sonora. Includes sediment Forebay and a portion of realigned Sullivan Creek
A-2	Access and Easement Purchases	TBD	TBD	TBD	0	
A-3	Engineering - Sediment Removal, Forebay, Outlet Structures, Beaches and Channels, Sediment Disposal	1	LS		$350,000	Horizon/cbec estimate
A-4	Environmental Compliance and Permitting	1	LS		$300,000	Horizon/cbec estimate
	Subtotal				$933,500	
B. GENERAL REQUIREMENTS						
B-1	Mobilization/Demobilization	1	LS		$412,883	10% of est. cost of water-based work, 2% of est. cost of land-based work
B-2	Construction Surveying	120	hr	$230.00	$27,600	2-man crew, Construction Staking
B-3	Environmental BMPs				$75,000	Horizon/cbec estimate
	Subtotal - GENERAL CONDITIONS				$515,483	
C. SEDIMENT REMOVAL & DISPOSAL - Hydraulic or clamshell dredging						
C-1	Spillway Unit	72,900	CY	$18.00	$1,312,200	Assume fines and sand mix, on-site disposal, combination of land excavation and suction dredge.
C-2	West Pool Unit	60,900	CY	$22.00	$1,339,800	Assume fines and sand mix, on-site disposal, suction dredge.
C-3	Dredge Pool/West Pool Connection	5,600	CY	$22.00	$123,200	Assume fines and sand mix, on-site disposal, combination of land excavation and suction dredge.
	Subtotal				$2,775,200	
D. SEDIMENT REMOVAL & DISPOSAL - Land-based excavation equipment						
D-1	East Pool Unit					Assumes dewatering of East Pool
	Excavation	146,500	CY	$5.00	$732,500	
	Hauling & Disposal	108,233	CY	$16.50	$1,785,845	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
D-2	Sandbar West Unit					Assume sand/gravel mix, on-site disposal or reuse, land-based excavation.
	Excavation	45,400	CY	$5.00	$227,000	
	Hauling & Disposal	43,130	CY	$16.50	$711,645	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
D-3	Sandbar East Management Unit					
	Excavation	28,300	CY	$5.00	$141,500	
	Hauling & Disposal	27,155	CY	$16.50	$448,058	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
D-4	Ridge Unit					
	Excavation	44,900	CY	$5.00	$224,500	Does not include East Pool/West Pool Connector Channel volume
	Hauling & Disposal	38,775	CY	$16.50	$639,788	Includes 5% volume reduction. Does not include Mid-Lake Island volume. Haul to local (within 20 minutes) site.
D-5	Boot Unit					
	Clearing & Grubbing	3	Ac	$5,000.00	$15,000	brush, including stumps
	Excavation	31,900	CY	$5.00	$159,500	
	Hauling & Disposal	27,550	CY	$16.50	$454,575	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
D-6	East Pool/West Pool Connector Channel Excavation					
	Excavation	4,900	CY	$5.00	$24,500	
	Hauling & Disposal	4,230	CY	$16.50	$69,795	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
	Subtotal				$5,634,205	
E. BEACH & ISLAND CREATION						

Table 3.2-3. Conceptual Level Opinion of Probable Construction Costs.

Item No.	Description	Qty	Units	$/Unit	Total	Notes and Assumptions
E-1	Beach Construction					
	Hauling	26,745	CY	$2.50	$66,863	Includes 5% volume reduction. Hauling within site.
	Finish Grading - Slopes	11,200	SY	$0.14	$1,568	
E-2	East Pool Island Construction					
	Hauling	1,605	CY	$2.50	$4,013	Hauling within site.
	Finish Grading - Slopes	4,000	SY	$0.14	$560	
E-3	Ridge Unit Island Construction					
	Hauling	4,200	CY	$2.50	$10,500	Hauling within site.
	Finish Grading - Slopes	10,900	SY	$0.14	$1,526	
	Subtotal				$85,029	
F. SEDIMENT FOREBAY & WETLAND ENHANCEMENTS						
F-1	Sullivan Creek Diversion Structure					
	Embankment/Compaction	300	CY	$5.00	$1,500	weir embankment
	Hauling	260	CY	$2.50	$650	Includes 5% volume reduction. Haul within site.
	Rip-Rap Slope Armor	200	SY	$5.00	$1,000	inlet and outlet protection
	Gravel Road, 6" depth	90	SY	$5.00	$450	inlet and outlet protection
	Outlet Works	1	Ea.	$20,000.00	$20,000	
F-2	Sediment Forebay					
	Temporary BMPs	1	LS	$25,000.00	$25,000	Includes maint. & mon. for following wet season
	Clearing & Grubbing	3	Ac	$5,000.00	$15,000	brush, including stumps
	Excavation	18,180	CY	$5.00	$90,900	
	Embankment/Compaction	1,120	CY	$5.00	$5,600	weir embankment
	Finish Grading - Slopes	2,820	SY	$0.14	$395	not including weir
	Compaction - Forebay Bottom Surface	7,740	SY	$3.00	$23,220	
	Rip-Rap Slope Armor	4,775	SY	$5.00	$23,875	inlet and outlet protection
	Hauling & Disposal	15,700	CY	$16.50	$259,050	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
	Outlet Works	1	Ea.	$20,000.00	$20,000	
F-3	Realigned Sullivan Creek					
	Clearing & Grubbing	9	Ac	$5,000.00	$45,000	brush, including stumps
	Excavation	29,900	CY	$5.00	$149,500	Low flow channel and floodplain benches
	Hauling & Disposal	25,825	CY	$16.50	$426,113	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
F-4	Power Creek Floodplain Benches					Assume fines and sand mix, on-site or local disposal, land-based excavation.
	Clearing & Grubbing	0.4	Ac	$5,000.00	$2,000	brush, including stumps
	Excavation	700	CY	$5.00	$3,500	Low flow channel and floodplain benches
	Hauling & Disposal	605	CY	$16.50	$9,983	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
F-5	Chicken Creek Floodplain Benches					Assume fines and sand mix, on-site or local disposal, land-based excavation.
	Clearing & Grubbing	0.7	Ac	$5,000.00	$3,500	brush, including stumps
	Excavation	400	CY	$5.00	$2,000	Low flow channel and floodplain benches
	Hauling & Disposal	345	CY	$16.50	$5,693	Includes 5% volume reduction. Haul to local (within 20 minutes) site. $100/hr for trucking, 20 cy per load (truck and transfer).
	Subtotal				$1,133,927	
G. EAST POOL DEWATERING						
G-1	Water Dam Installation	1	LS	$32,750.00	$32,750	Assume 3' of water impounded. Includes rental and installation.
	Subtotal				$32,750	
TOTALS						
	Subtotal				**$11,025,064**	
	Contingency	**10%**			**$1,102,506**	
				TOTAL	**$12,127,571**	

sediment could be removed via existing access at Lori Lane, which would not require major infrastructure improvements or permanent easements. Sediment removal in the East Pool would greatly improve water quality and storage capacity. Other land-based sediment removal actions (e.g., Sandbar East and West, Boot Unit) are likely to require establishing an in-lake haul road and a new easement to Phoenix Lake Road (Attachment A, Sheet 4). While these design elements are feasible to implement, they would add significant cost to the Phase 2 project. Construction of the beach and island in the East Pool may also be a component of the Phase 2 project. However, this would depend on whether the East Pool would later be used as a sediment handling area for water-based dredging. If this is the case, then a sediment handling area could be constructed in the East Pool during the Phase 2 project and the beach and island creation would be completed in Phase 3.

The Phase 3 project would likely encompass water-based sediment removal in the open lake and construction of the West Pool-Dredge Pool connector channel. Dredged material would likely be dewatered in the settling basin that was used for the 1986 dredging operations, or in the East Pool. Phase 3 operation may also include other components of the Lake Plan that were not completed in the Phase 1 and 2 projects.

This proposed phasing of project activities is preliminary and based on current understanding of project elements and lake conditions. TUD may alter the phasing plan to address more pressing operational needs, such as clearing the area around the intake tower. Finally, it is important to note that TUD intends to pursue multiple grant funding sources to implement various components of the PLPRP. Some funding sources may only be relevant to certain aspects of the Lake Plan, therefore, the phasing and approach should be flexible to accommodate the range of potential funding opportunities.

5.0 CONCLUSIONS & NEXT STEPS

5.1 CONCLUSIONS

The proposed Lake Plan described in this chapter presents a comprehensive approach to restore and preserve key functions and values provided by Phoenix Lake. If implemented, the Lake Plan would extend the life of the reservoir while preserving the recreational, aesthetics and wetland values of the lake. Assuming an average annual deposition rate of 4,600 cy, removing more than 400,000 cy of sediment (Table 3.2-1) would extend the life of the reservoir by more than 85 years[2]. Sediment management activities in wetland areas would further increase the life of the reservoir by trapping sediment in locations that can be regularly managed with conventional equipment. These activities would also improve water quality in the lake.

5.2 Next steps

It is anticipated that the next phase of the PLPRP will include detailed engineering design and regulatory compliance. For engineering design, key technical issues will include design of the sediment forebay and the new Sullivan Creek channel, construction access, materials handling procedures, and selection of reuse and

[2] Lake *trap efficiency* is a non-linear function whereby trap efficiency is highest when lakes are deepest. As lakes fill with sediment their trap efficiency reduces. This estimate does not account for non-linear changes in reservoir trap efficiency that may result from sediment removal activities.

disposal areas. It is anticipated that additional subsurface investigation will be performed to refine the depths and extents of sediment removal within each of the management units, and assess the suitability for equipment access (e.g., excavators, haul trucks).

Multiple administrative and environmental tasks will need to be completed for further development of the PLPRP. These tasks include obtaining access and easements agreements, conducting environmental review and compliance, obtaining necessary permits, and identifying funding sources. Any proposed project developed by TUD will require compliance with the California Environmental Quality Act (CEQA). The public disclosure and outreach activities that occur through the CEQA process may also provide a valuable opportunity for public comment on any proposed actions.

6.0 REFERENCES

Singer, M.J. 2003. Looking back 60 years, California soils maintain overall chemical quality. California Agriculture, Volume 57, Number 2.

Wedepohl, K.H. 1995. The composition of the continental crust. Geochimica Cosmochimica Acta, Vol. 59, No. 7, pp. 1217-1232

Chapter 3 – Part II

Attachment A

PHOENIX LAKE
PRESERVATION AND RESTORATION PLAN

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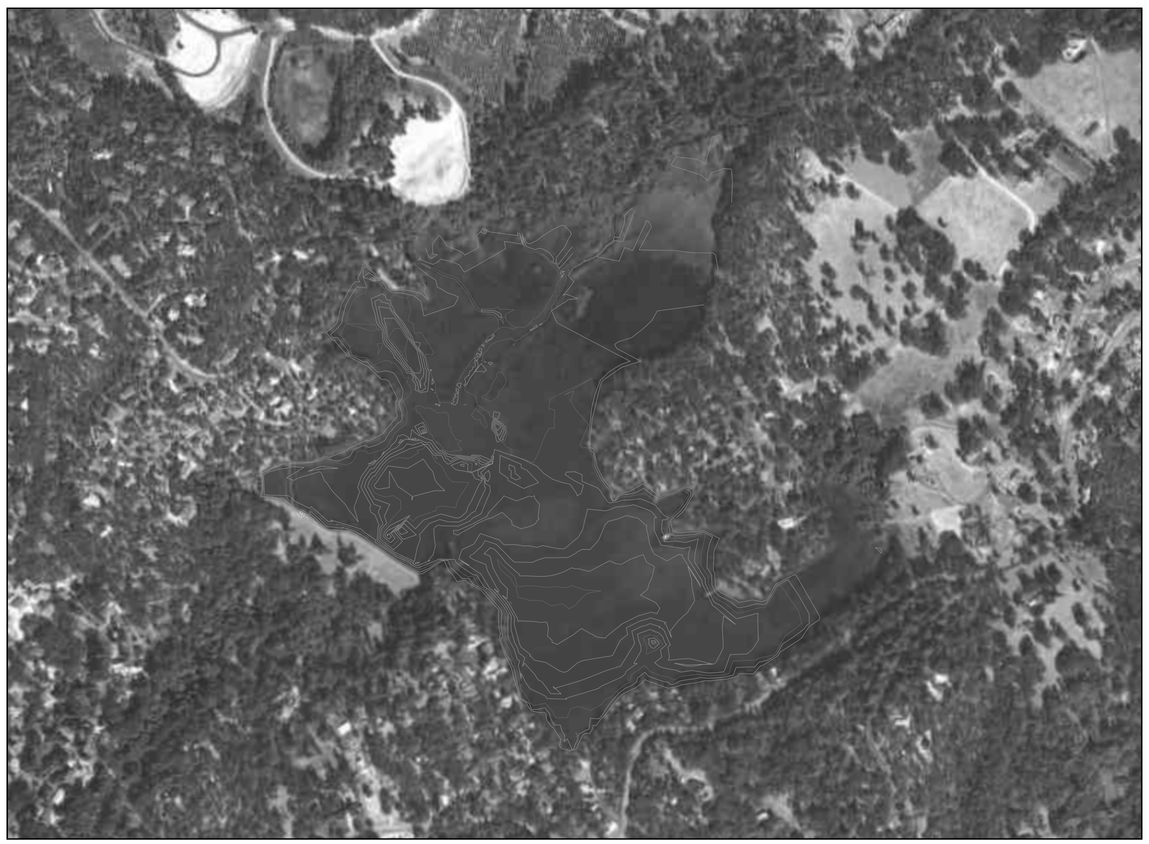

PROJECT MAP

VICINITY MAP

SHEET INDEX

LEGEND

- EXISTING CONTOURS
- PROPOSED CONTOURS
- GRADING BREAKLINE
- PROPERTY LINE

CONTACTS

TUOLUMNE UTILITIES DISTRICT	TED ALLEN, ASSOCIATE CIVIL ENGINEER	(209) 532-5536

TOPOGRAPHIC DATA REFERENCE CALIFORNIA STATE PLANE, ZONE 3, FEET.
VERTICAL DATUM IS NAVD88, FEET.

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REVISION NOTES

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APPROVED CBB

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cbec eco engineering

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18885 NUGGET BLVD.
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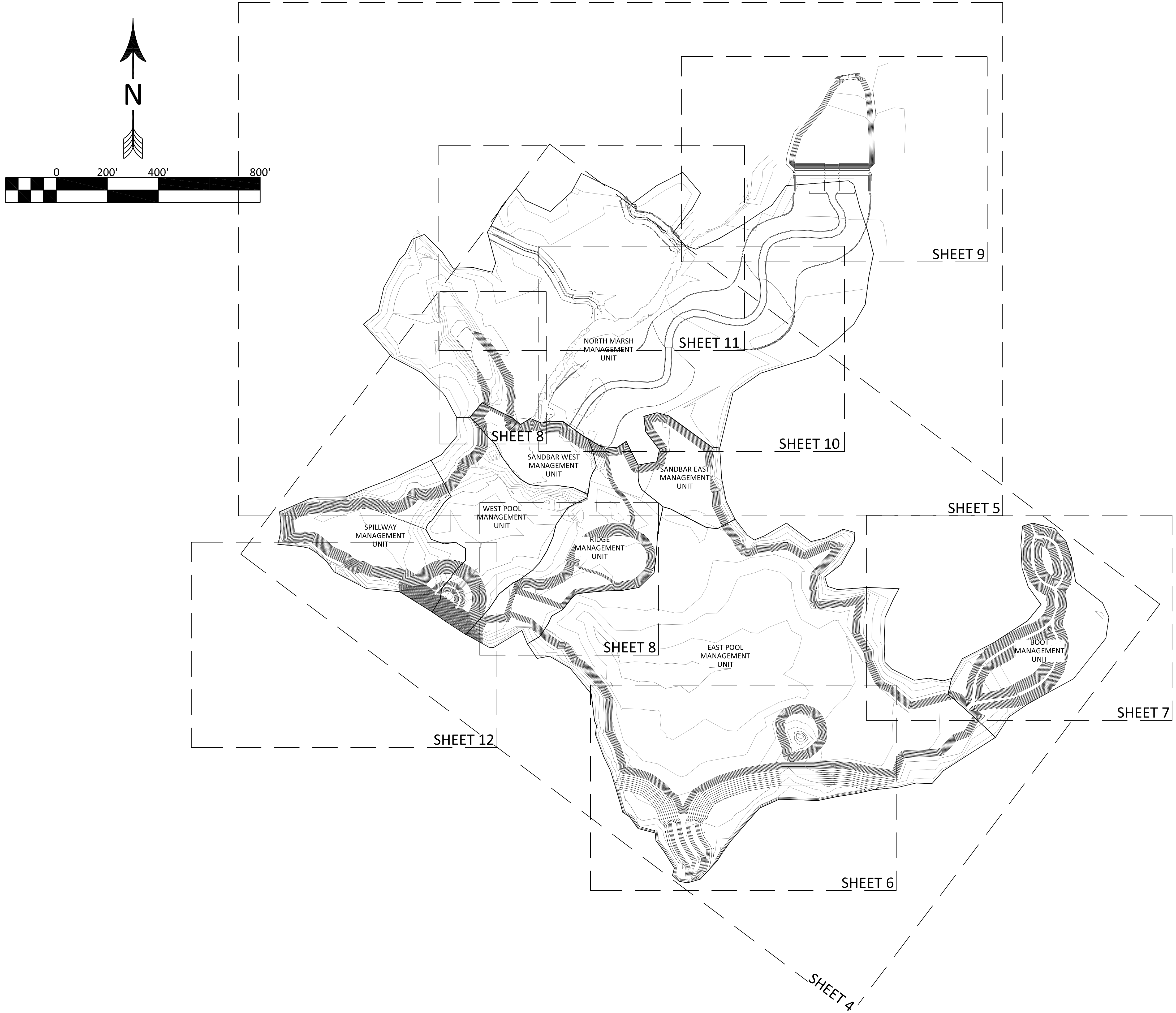
SONORA CALIFORNIA

PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
COVER SHEET

FILE NAME Cover.dwg
JOB NUMBER 10-1019
DATE February, 2012
SHEET NO. 1 OF 13



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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
SHEET INDEX

FILE NAME
Sheet_Index.dwg
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A B C D E

1 2 3 4

NOTES:
1. BATHYMETRIC AND TOPOGRAPHIC DATA OUTSIDE THE EXTENTS OF THE 2010 SURVEY WAS RECORDED IN A 2002 SURVEY EFFORT.
2. ALL SURVEY DATA REFERENCES THE CALIFORNIA STATE PLANE, ZONE 3 GEOGRAPHIC DATUM AND THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88)

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EXISTING CONDITIONS

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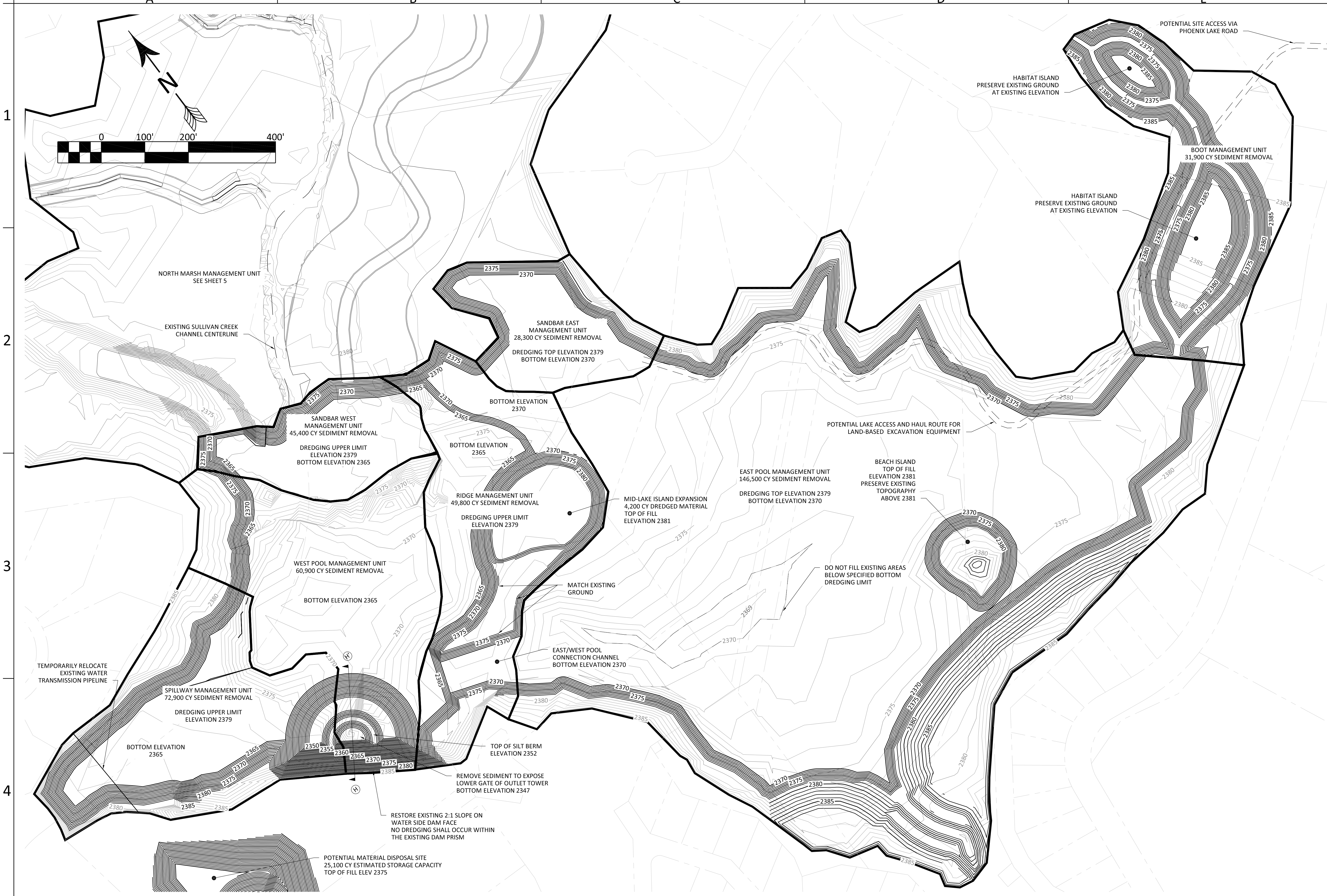

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
OVERALL LAKE DREDGING PLAN

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JOB NUMBER
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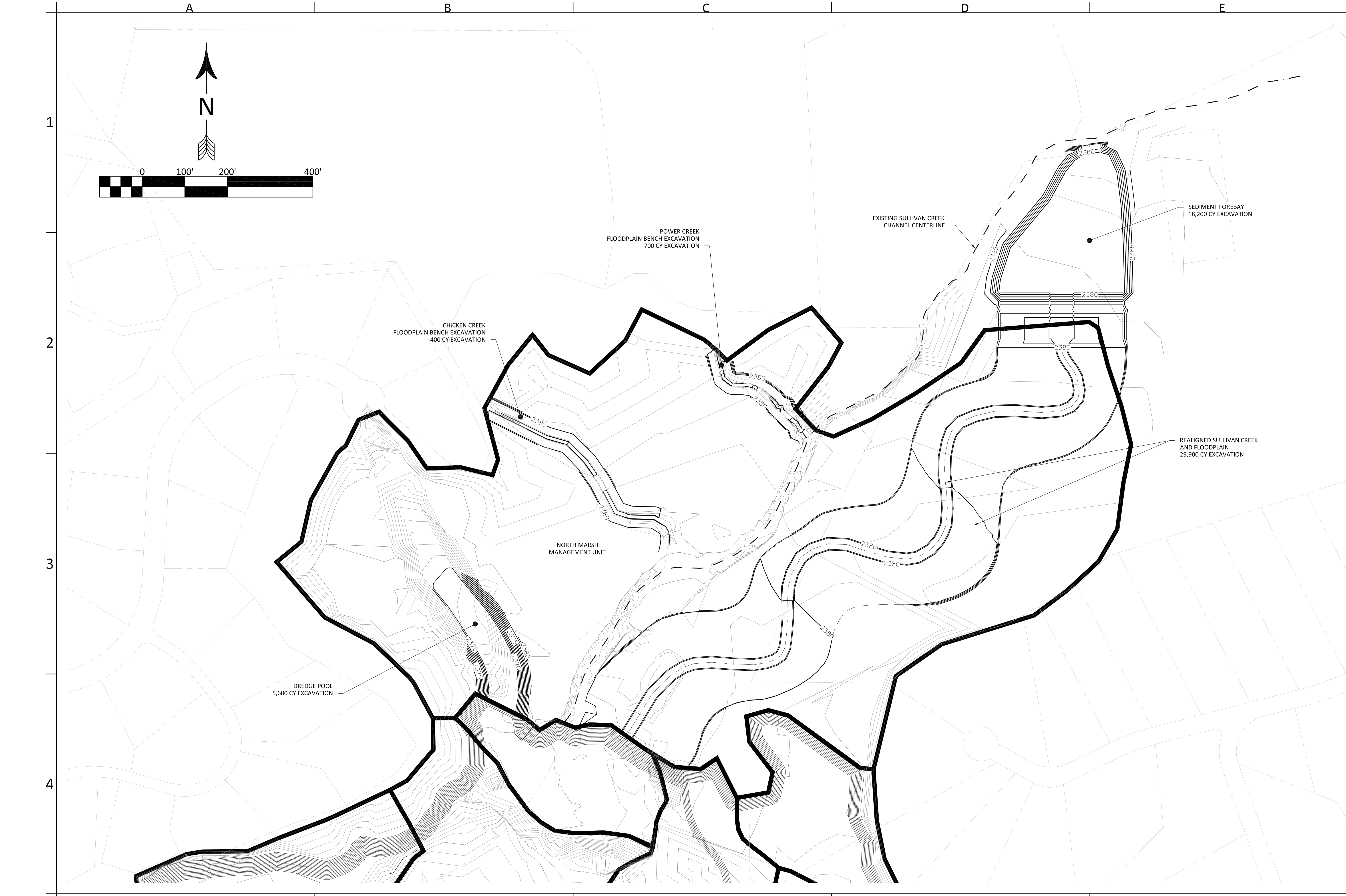

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN

OVERALL NORTH MARSH GRADING PLAN

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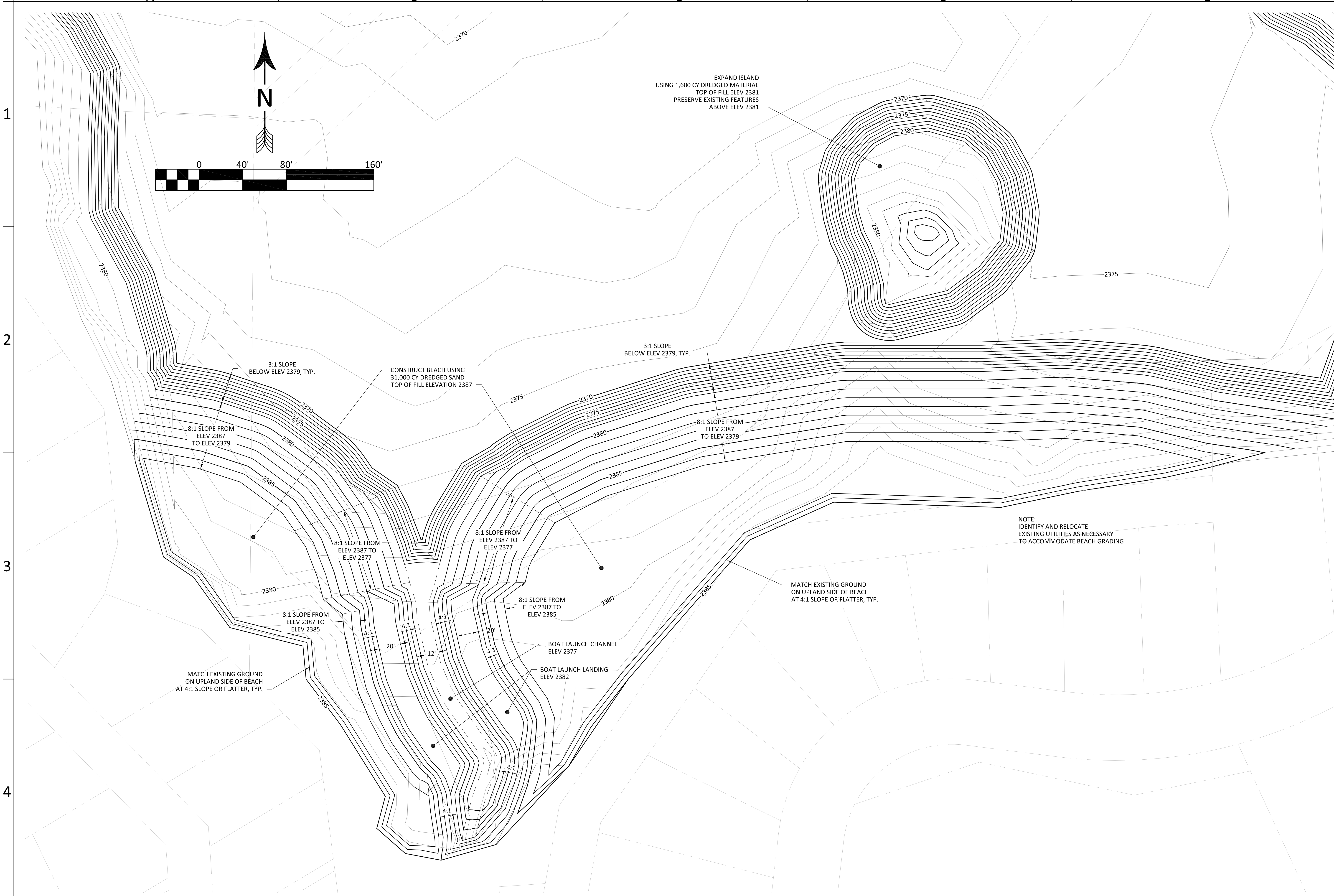

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
BEACH GRADING PLAN

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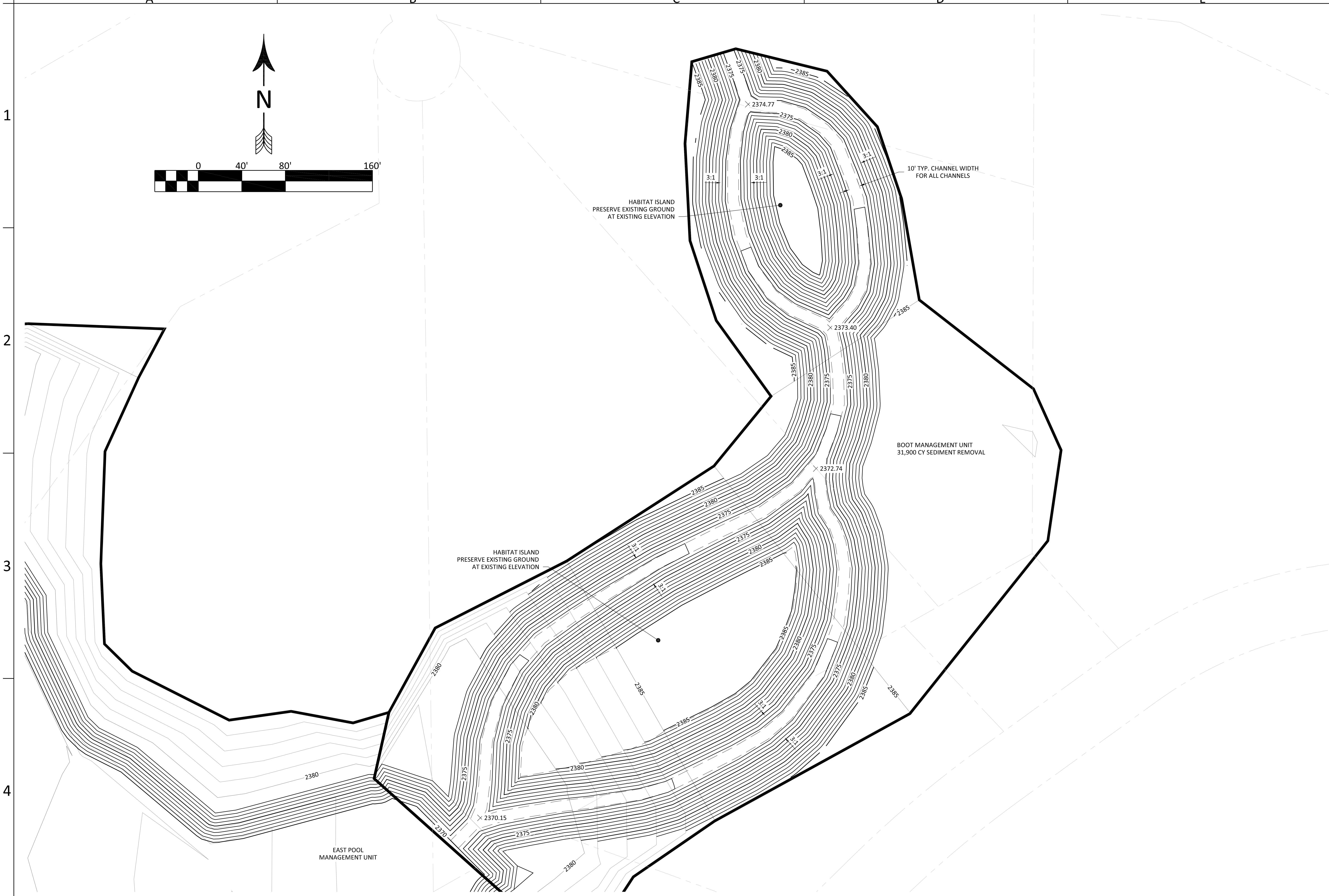

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN

BOOT MANAGEMENT UNIT GRADING PLAN

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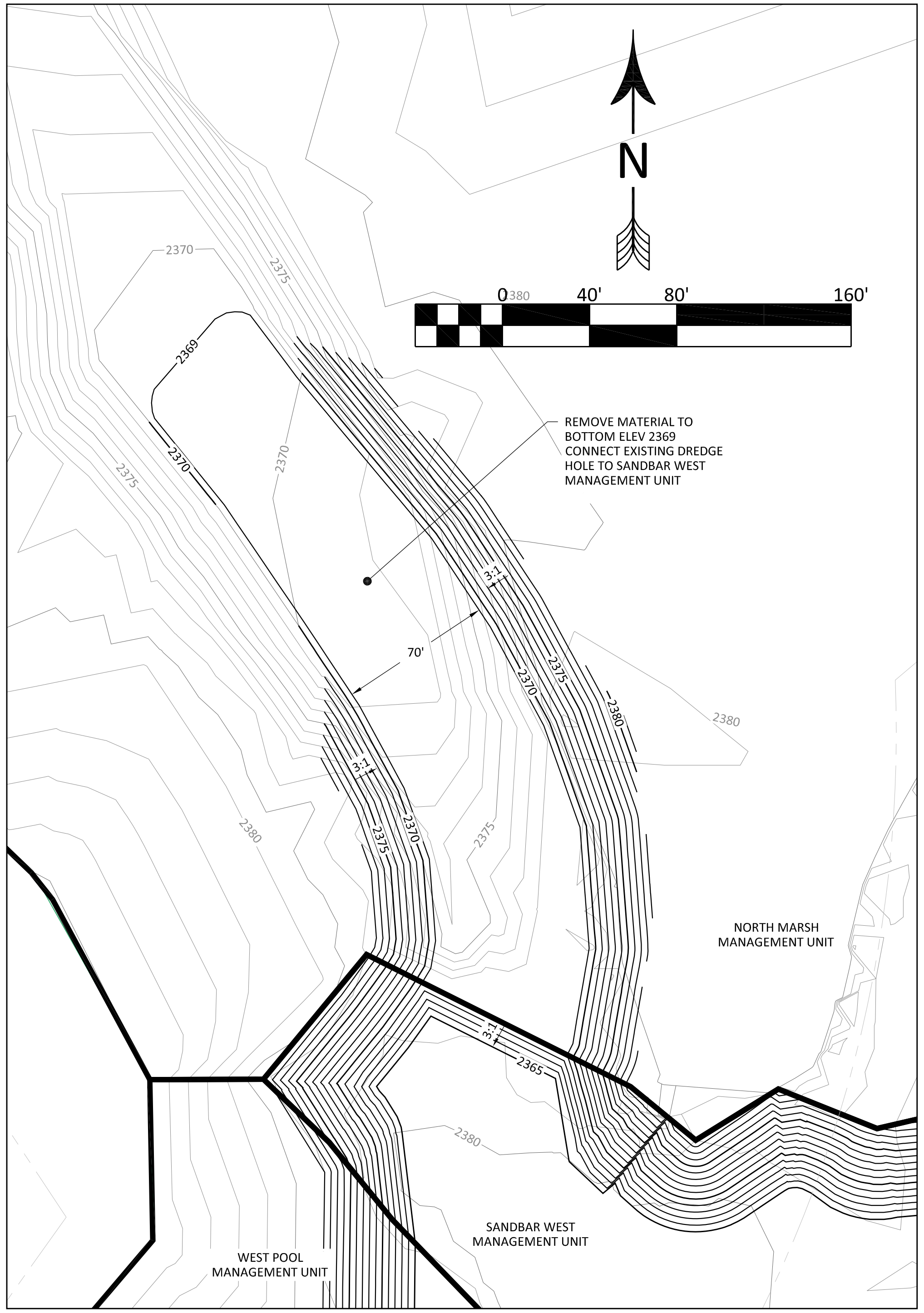
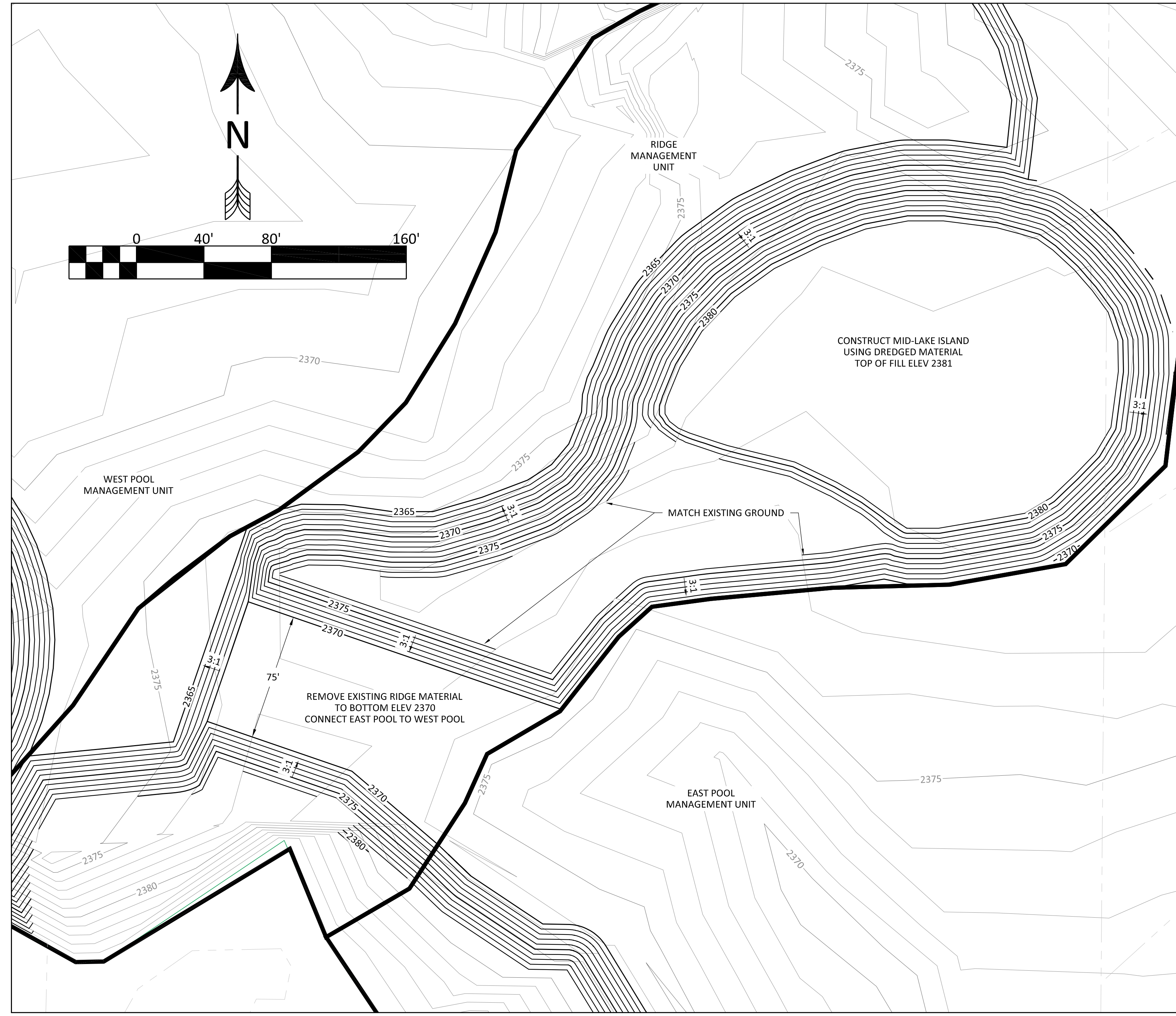


DREDGE POOL CONNECTOR CHANNEL GRADING



EAST/WEST POOL CONNECTOR CHANNEL AND MID-LAKE ISLAND GRADING

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POOL CONNECTORS AND ISLAND GRADING PLAN

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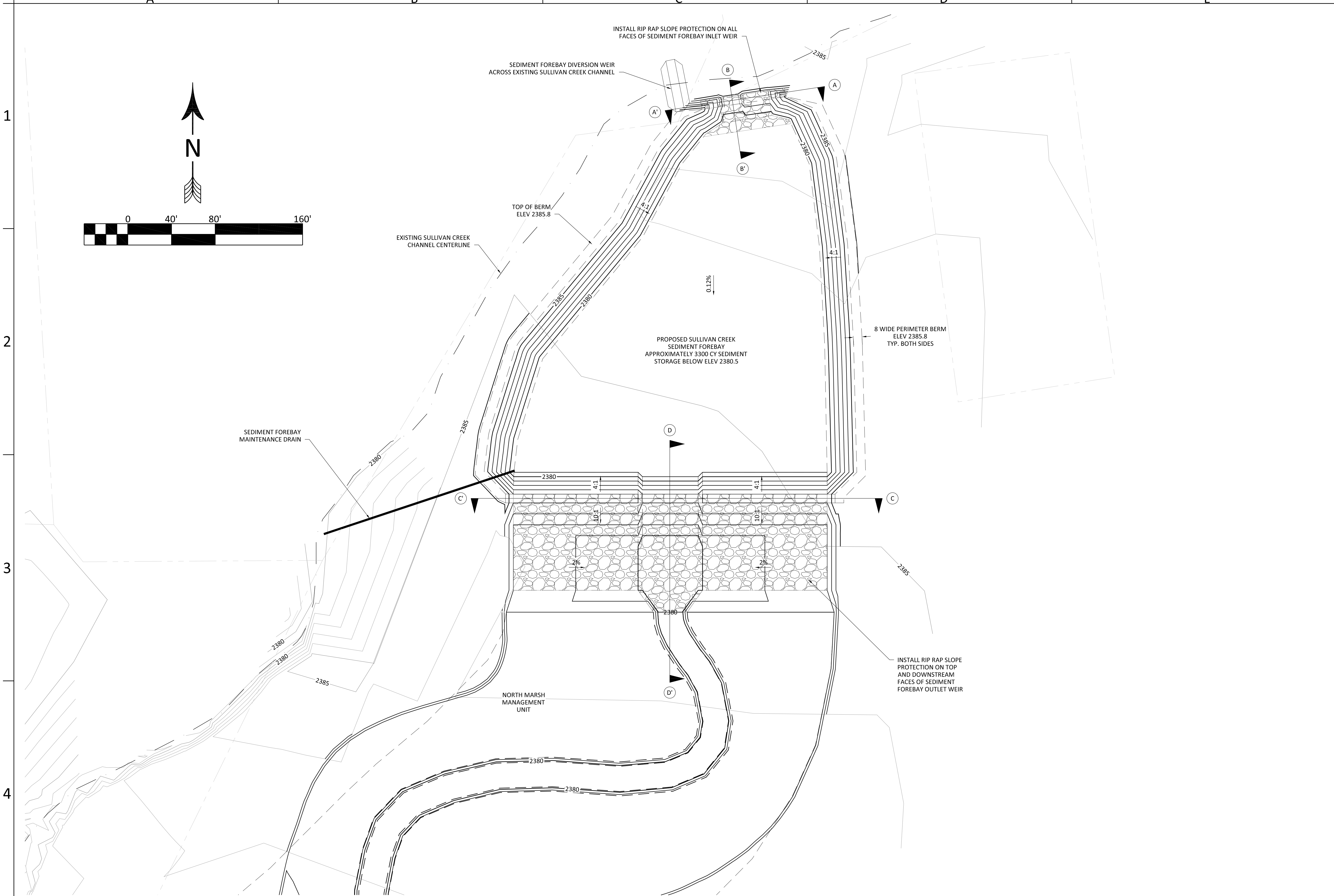

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
SULLIVAN CREEK SEDIMENT FOREBAY GRADING PLAN

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REALIGNED SULLIVAN CREEK GRADING PLAN

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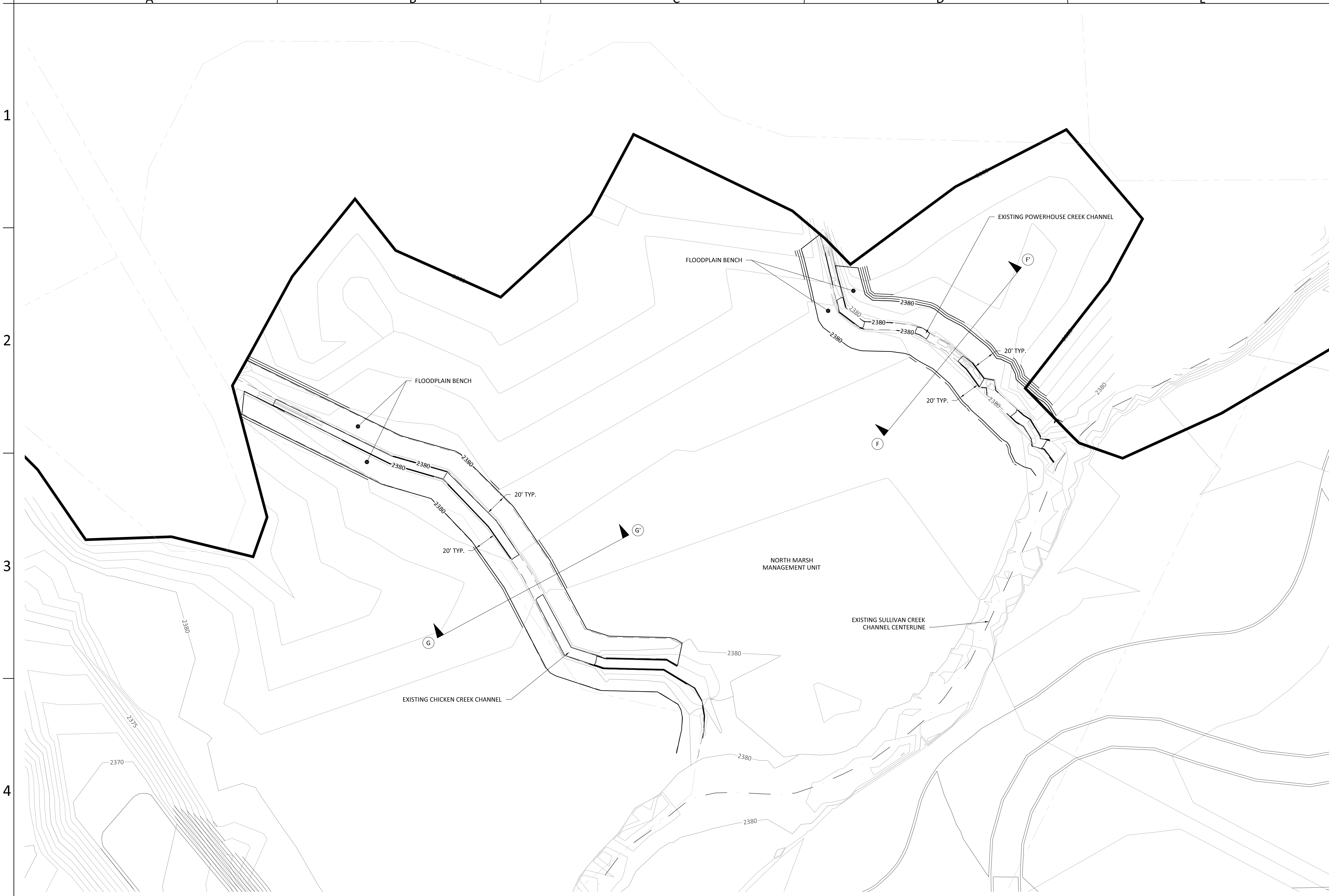

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN

POWERHOUSE AND CHICKEN CREEKS GRADING PLAN

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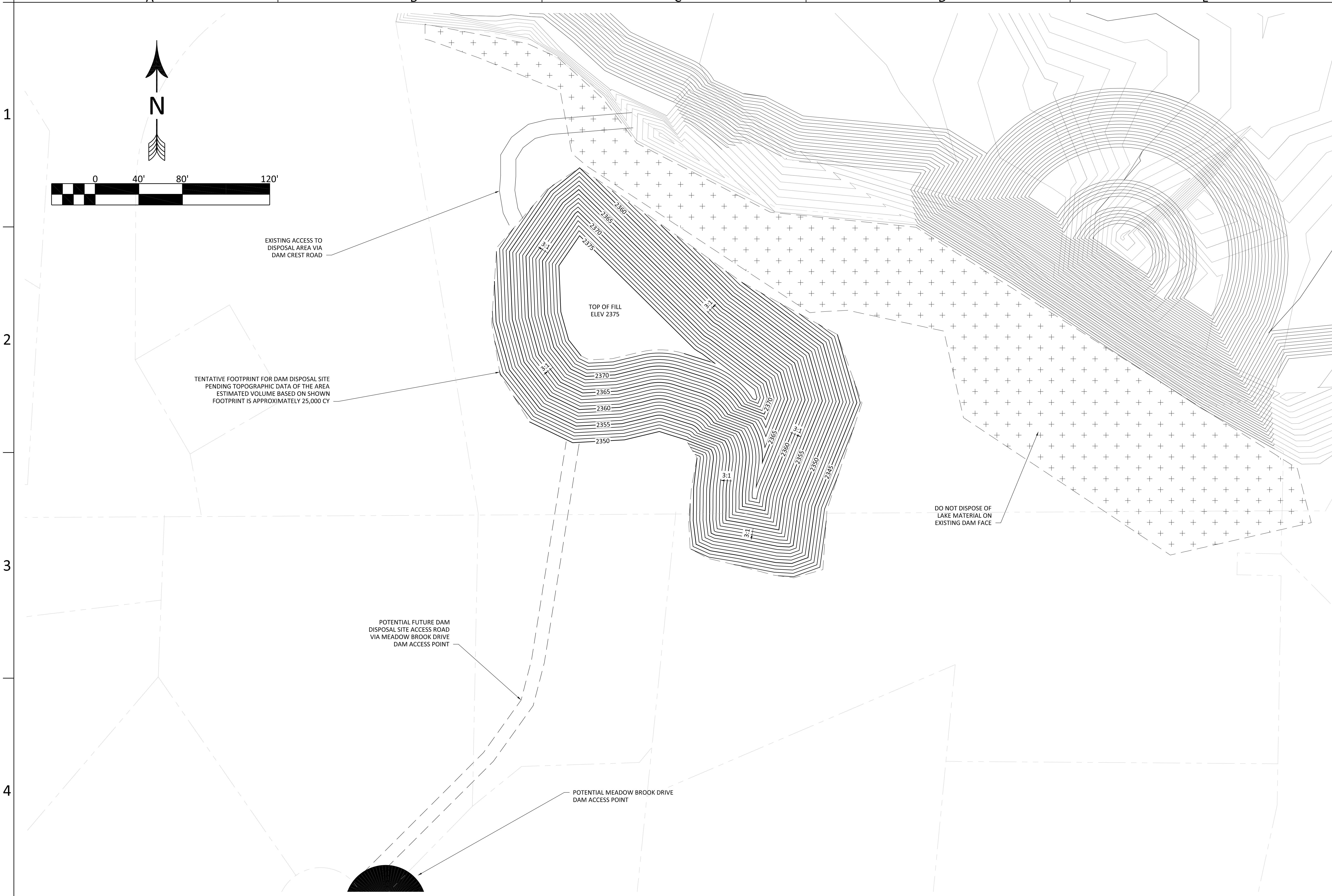

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
DAM DISPOSAL SITE GRADING PLAN

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February, 2012
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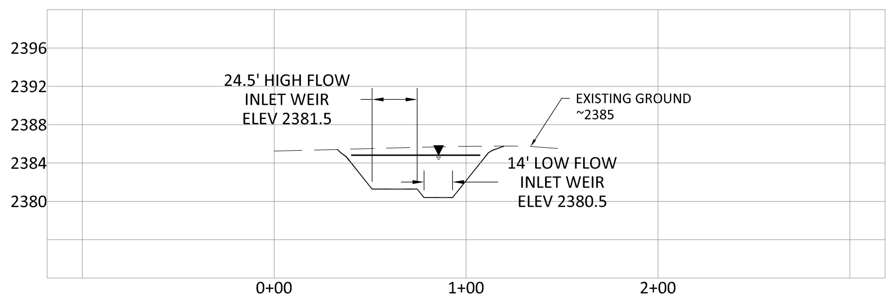
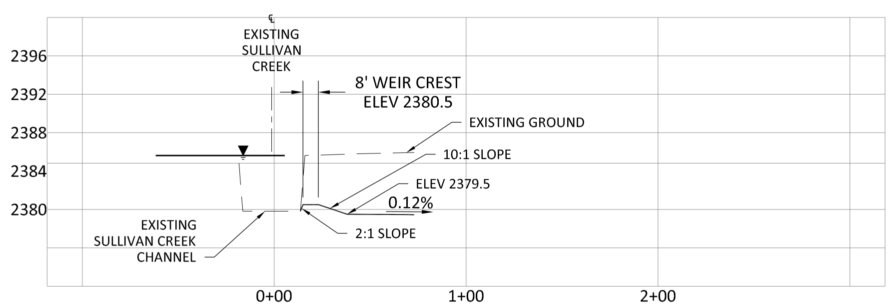
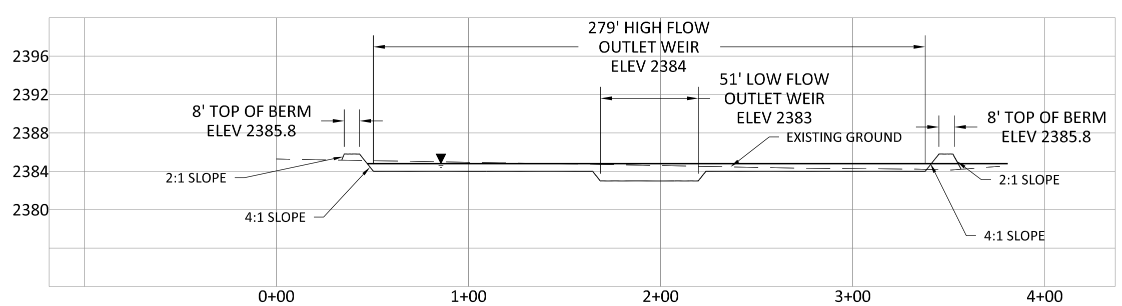


SECTION A-A' - PROPOSED SEDIMENT FOREBAY INLET WEIR CROSS SECTION



SECTION B-B' - PROPOSED SEDIMENT FOREBAY INLET LOW FLOW WEIR PROFILE



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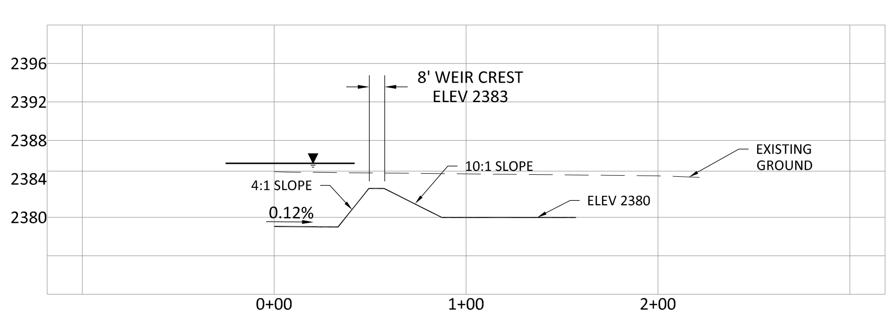
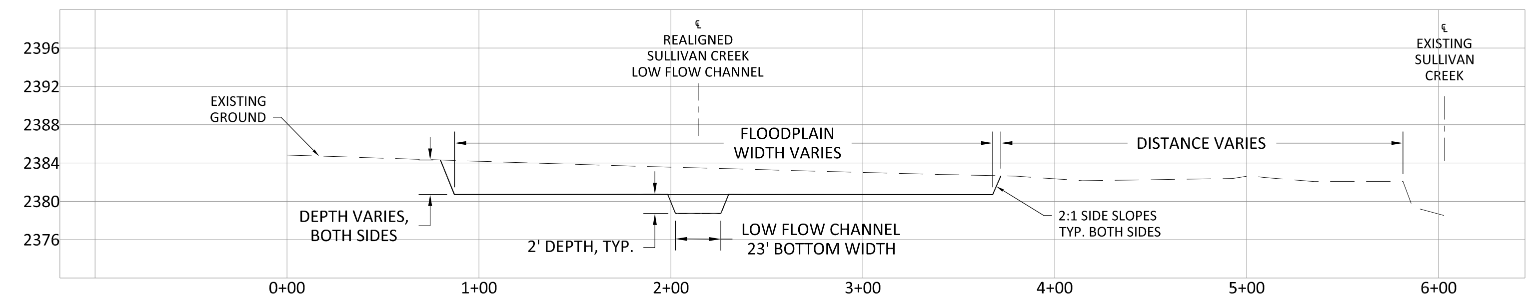
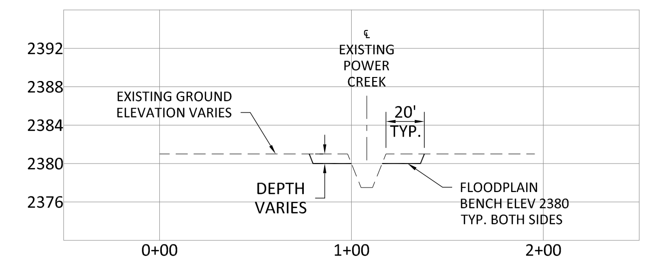


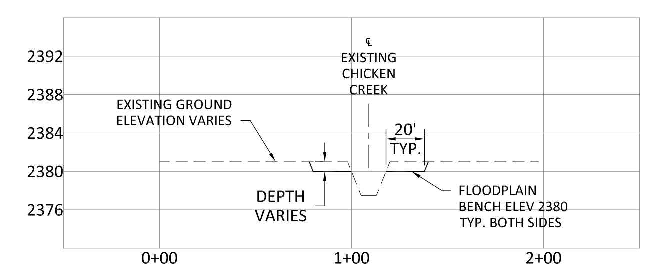
SECTION D-D' - PROPOSED SEDIMENT FOREBAY OUTLET LOW FLOW WEIR PROFILE



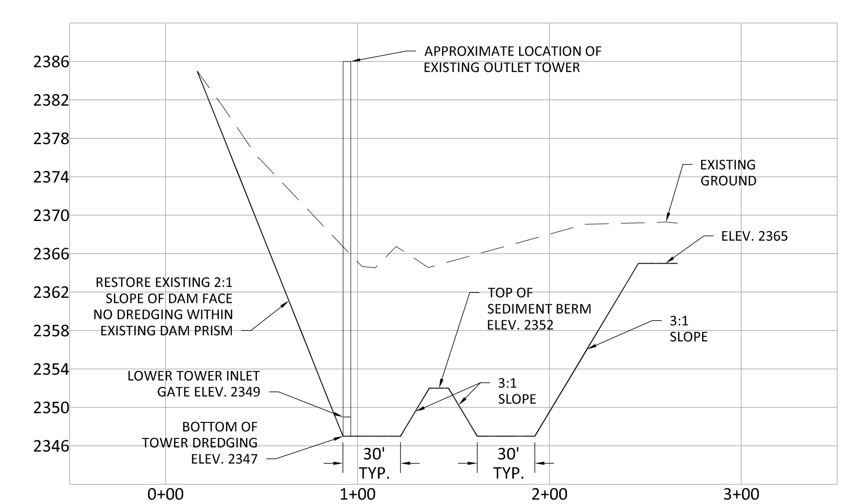
SECTION E-E' - PROPOSED SULLIVAN CREEK REALIGNMENT



SECTION F-F' - POWER CREEK FLOODPLAIN BENCHES



SECTION G-G' - CHICKEN CREEK FLOODPLAIN BENCHES



SECTION H-H' - TOWER INLET GRADING

SCALE

HORIZONTAL 1" = 50'
VERTICAL 1" = 5'

THIS LINE IS ONE INCH LONG WHEN THIS DOCUMENT IS PRINTED FULL SIZE

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PHOENIX LAKE PRESERVATION AND RESTORATION PLAN
PROPOSED GRADING CROSS SECTIONS

FILE NAME
Grading_XS.dwg
JOB NUMBER
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Chapter 3 – Part II

Attachment B

BSK Analytical Laboratories
Engineers & Laboratories

Certificate of Analysis

Kevin Fisher
Horizon Water and Environment
1330 Broadway, Suite 424
Oakland, CA 94612

Report Issue Date: 05/10/2011 16:18
Received Date: 04/28/2011
Received Time: 07 30

Lab Sample ID: A1D2092-01
Sample Date: 04/26/2011 10:00
Sample Type: Composite
Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Lake Out Let

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
***Conductivity @ 25C, DI Extract**	SM 2510 B	**15**	5.0	umhos/cm	1	A104866	04/29/11	04/29/11	
*Hexavalent Chromium	EPA 7199	ND	1.0	mg/kg	50	A105227	05/05/11	05/05/11	
*Nitrate as N, DI Extract	EPA 300.0	ND	1.2	mg/kg	1	A105212	05/05/11	05/05/11	
*Nitrite as N, DI Extract	EPA 300.0	ND	0.25	mg/kg	1	A105212	05/05/11	05/05/11	
***pH, DI Extract**	EPA 9045C	**5.5**		pH Units	1	A105143	05/04/11	05/04/11	
***pH Temperature in °C**		**24.7**							
***Phosphorus**	EPA 365.4	**120**	2.5	mg/kg	1	A105137	05/04/11	05/05/11	
***Total Kjeldahl Nitrogen**	EPA 351.2	**660**	120	mg/kg	5	A105137	05/04/11	05/04/11	
***Total Organic Carbon**	Walkley-Black	**20000**	50	mg/kg	1	A105399	05/09/11	05/09/11	
***Total Nitrogen, IC Solid**		**660**		mg/kg					

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Antimony	EPA 6020	ND	10	mg/kg	1	A104973	05/01/11	05/06/11	
*Antimony, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Arsenic	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
***Arsenic, WET**	EPA 6020	**0.10**	0.10	mg/L	1	A104982	05/02/11	05/05/11	
***Barium**	EPA 6020	**110**	6 2	mg/kg	1	A104973	05/01/11	05/06/11	
***Barium, WET**	EPA 6020	**5.3**	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Beryllium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Beryllium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
*Cadmium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Cadmium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
***Chromium**	EPA 6020	**17**	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Chromium, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Cobalt	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Cobalt, WET	EPA 6020	ND	2 5	mg/L	1	A104982	05/02/11	05/05/11	
***Copper**	EPA 6020	**19**	5 0	mg/kg	1	A104973	05/01/11	05/06/11	
*Copper, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Lead	EPA 6020	ND	6 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Lead, WET	EPA 6020	ND	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Mercury	EPA 6020A	ND	0 50	mg/kg	1	A104973	05/01/11	05/06/11	
*Mercury, WET	EPA 6020A	ND	0 020	mg/L	1	A104982	05/02/11	05/05/11	
*Molybdenum	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Molybdenum, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
***Nickel**	EPA 6020	**13**	12	mg/kg	1	A104973	05/01/11	05/06/11	

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Lab Sample ID: A1D2092-01
Sample Date: 04/26/2011 10:00
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Lake Out Let

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Nickel, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Potassium**	EPA 6010B	**1400**	200	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
*Silver	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Silver, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Thallium	EPA 6020	ND	2.0	mg/kg	1	A104973	05/01/11	05/06/11	
*Thallium, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Vanadium**	EPA 6020	**42**	12	mg/kg	1	A104973	05/01/11	05/06/11	
***Vanadium, WET**	EPA 6020	**2.0**	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Zinc	EPA 6020	ND	62	mg/kg	1	A104973	05/01/11	05/06/11	
*Zinc, WET	EPA 6020	ND	2.5	mg/L	1	A104982	05/02/11	05/05/11	

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Report Issue Date: 05/10/2011 16:18
Received Date: 04/28/2011
Received Time: 07 30

Lab Sample ID: A1D2092-02
Sample Date: 04/26/2011 13:00
Sample Type: Composite
Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Lake Park

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
***Conductivity @ 25C, DI Extract**	SM 2510 B	**17**	5.0	umhos/cm	1	A104866	04/29/11	04/29/11	
*Hexavalent Chromium	EPA 7199	ND	1.0	mg/kg	50	A105227	05/05/11	05/05/11	
*Nitrate as N, DI Extract	EPA 300.0	ND	1.2	mg/kg	1	A105212	05/05/11	05/05/11	
*Nitrite as N, DI Extract	EPA 300.0	ND	0.25	mg/kg	1	A105212	05/05/11	05/05/11	
***pH, DI Extract**	EPA 9045C	**5.2**		pH Units	1	A105143	05/04/11	05/04/11	
***pH Temperature in °C**		**24.9**							
***Phosphorus**	EPA 365.4	**200**	2.5	mg/kg	1	A105137	05/04/11	05/05/11	
***Total Kjeldahl Nitrogen**	EPA 351.2	**1100**	120	mg/kg	5	A105137	05/04/11	05/04/11	
***Total Organic Carbon**	Walkley-Black	**27000**	50	mg/kg	1	A105399	05/09/11	05/09/11	
***Total Nitrogen, IC Solid**		**1100**		mg/kg					

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Antimony	EPA 6020	ND	10	mg/kg	1	A104973	05/01/11	05/06/11	
*Antimony, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Arsenic	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
***Arsenic, WET**	EPA 6020	**0.15**	0.10	mg/L	1	A104982	05/02/11	05/05/11	
***Barium**	EPA 6020	**99**	6 2	mg/kg	1	A104973	05/01/11	05/06/11	
***Barium, WET**	EPA 6020	**3.9**	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Beryllium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Beryllium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
*Cadmium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Cadmium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
***Chromium**	EPA 6020	**25**	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Chromium, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
***Cobalt**	EPA 6020	**13**	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Cobalt, WET	EPA 6020	ND	2 5	mg/L	1	A104982	05/02/11	05/05/11	
***Copper**	EPA 6020	**32**	5 0	mg/kg	1	A104973	05/01/11	05/06/11	
*Copper, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
***Lead**	EPA 6020	**9.4**	6 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Lead, WET	EPA 6020	ND	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Mercury	EPA 6020A	ND	0 50	mg/kg	1	A104973	05/01/11	05/06/11	
*Mercury, WET	EPA 6020A	ND	0 020	mg/L	1	A104982	05/02/11	05/05/11	
*Molybdenum	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Molybdenum, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
***Nickel**	EPA 6020	**30**	12	mg/kg	1	A104973	05/01/11	05/06/11	

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Lab Sample ID: A1D2092-02
Sample Date: 04/26/2011 13:00
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Lake Park

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
***Nickel, WET**	EPA 6020	**0.68**	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Potassium**	EPA 6010B	**2400**	200	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
*Silver	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Silver, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Thallium	EPA 6020	ND	2.0	mg/kg	1	A104973	05/01/11	05/06/11	
*Thallium, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Vanadium**	EPA 6020	**55**	12	mg/kg	1	A104973	05/01/11	05/06/11	
***Vanadium, WET**	EPA 6020	**2.0**	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Zinc	EPA 6020	ND	62	mg/kg	1	A104973	05/01/11	05/06/11	
*Zinc, WET	EPA 6020	ND	2.5	mg/L	1	A104982	05/02/11	05/05/11	

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Report Issue Date: 05/10/2011 16:18
Received Date: 04/28/2011
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Lab Sample ID: A1D2092-03
Sample Date: 04/26/2011 10:30
Sample Type: Composite
Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Ridge

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
***Conductivity @ 25C, DI Extract**	SM 2510 B	**6.5**	5.0	umhos/cm	1	A104866	04/29/11	04/29/11	
*Hexavalent Chromium	EPA 7199	ND	1.0	mg/kg	50	A105227	05/05/11	05/05/11	
*Nitrate as N, DI Extract	EPA 300.0	ND	1.2	mg/kg	1	A105212	05/05/11	05/05/11	
*Nitrite as N, DI Extract	EPA 300.0	ND	0.25	mg/kg	1	A105212	05/05/11	05/05/11	
***pH, DI Extract**	EPA 9045C	**5.4**		pH Units	1	A105143	05/04/11	05/04/11	
***pH Temperature in °C**		**24.7**							
***Phosphorus**	EPA 365.4	**100**	2.5	mg/kg	1	A105137	05/04/11	05/05/11	
***Total Kjeldahl Nitrogen**	EPA 351.2	**370**	25	mg/kg	1	A105137	05/04/11	05/04/11	
***Total Organic Carbon**	Walkley-Black	**4800**	50	mg/kg	1	A105399	05/09/11	05/09/11	
***Total Nitrogen, IC Solid**		**370**		mg/kg					

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Antimony	EPA 6020	ND	10	mg/kg	1	A104973	05/01/11	05/06/11	
*Antimony, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Arsenic	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
*Arsenic, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
***Barium**	EPA 6020	**72**	6.2	mg/kg	1	A104973	05/01/11	05/06/11	
***Barium, WET**	EPA 6020	**3.6**	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Beryllium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Beryllium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
*Cadmium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Cadmium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
*Chromium	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Chromium, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Cobalt	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Cobalt, WET	EPA 6020	ND	2 5	mg/L	1	A104982	05/02/11	05/05/11	
***Copper**	EPA 6020	**10**	5 0	mg/kg	1	A104973	05/01/11	05/06/11	
*Copper, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Lead	EPA 6020	ND	6 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Lead, WET	EPA 6020	ND	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Mercury	EPA 6020A	ND	0 50	mg/kg	1	A104973	05/01/11	05/06/11	
*Mercury, WET	EPA 6020A	ND	0 020	mg/L	1	A104982	05/02/11	05/05/11	
*Molybdenum	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Molybdenum, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Nickel	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	

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Lab Sample ID: A1D2092-03
Sample Date: 04/26/2011 10:30
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Ridge

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Nickel, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Potassium**	EPA 6010B	**1200**	200	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
*Silver	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Silver, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Thallium	EPA 6020	ND	2.0	mg/kg	1	A104973	05/01/11	05/06/11	
*Thallium, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Vanadium**	EPA 6020	**28**	12	mg/kg	1	A104973	05/01/11	05/06/11	
***Vanadium, WET**	EPA 6020	**0.95**	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Zinc	EPA 6020	ND	62	mg/kg	1	A104973	05/01/11	05/06/11	
*Zinc, WET	EPA 6020	ND	2.5	mg/L	1	A104982	05/02/11	05/05/11	

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Lab Sample ID: A1D2092-04
Sample Date: 04/26/2011 11:00
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Wet Bar Tran ition

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
***Conductivity @ 25C, DI Extract**	SM 2510 B	**8.5**	5.0	umhos/cm	1	A104866	04/29/11	04/29/11	
*Hexavalent Chromium	EPA 7199	ND	1.0	mg/kg	50	A105227	05/05/11	05/05/11	
***Nitrate as N, DI Extract**	EPA 300.0	**1.5**	1.2	mg/kg	1	A105212	05/05/11	05/05/11	
*Nitrite as N, DI Extract	EPA 300.0	ND	0.25	mg/kg	1	A105212	05/05/11	05/05/11	
***pH, DI Extract**	EPA 9045C	**5.2**		pH Units	1	A105143	05/04/11	05/04/11	
***pH Temperature in °C**		**24.5**							
***Phosphorus**	EPA 365.4	**140**	2.5	mg/kg	1	A105137	05/04/11	05/05/11	
***Total Kjeldahl Nitrogen**	EPA 351.2	**320**	25	mg/kg	1	A105137	05/04/11	05/04/11	
***Total Organic Carbon**	Walkley-Black	**6000**	50	mg/kg	1	A105399	05/09/11	05/09/11	
***Total Nitrogen, IC Solid**		**320**		mg/kg					

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Antimony	EPA 6020	ND	10	mg/kg	1	A104973	05/01/11	05/06/11	
*Antimony, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Arsenic	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
*Arsenic, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
***Barium**	EPA 6020	**100**	6.2	mg/kg	1	A104973	05/01/11	05/06/11	
***Barium, WET**	EPA 6020	**5.1**	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Beryllium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Beryllium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
*Cadmium	EPA 6020	ND	1 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Cadmium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
***Chromium**	EPA 6020	**15**	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Chromium, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Cobalt	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Cobalt, WET	EPA 6020	ND	2 5	mg/L	1	A104982	05/02/11	05/05/11	
***Copper**	EPA 6020	**13**	5 0	mg/kg	1	A104973	05/01/11	05/06/11	
*Copper, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Lead	EPA 6020	ND	6 2	mg/kg	1	A104973	05/01/11	05/06/11	
*Lead, WET	EPA 6020	ND	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Mercury	EPA 6020A	ND	0 50	mg/kg	1	A104973	05/01/11	05/06/11	
*Mercury, WET	EPA 6020A	ND	0 020	mg/L	1	A104982	05/02/11	05/05/11	
*Molybdenum	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Molybdenum, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Nickel	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	

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1330 Broadway, Suite 424
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Report Issue Date: 05/10/2011 16:18
Received Date: 04/28/2011
Received Time: 07 30

Lab Sample ID: A1D2092-04
Sample Date: 04/26/2011 11:00
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Wet Bar Tran ition

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Nickel, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Potassium**	EPA 6010B	**1900**	200	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium	EPA 6020	ND	2.5	mg/kg	1	A104973	05/01/11	05/06/11	
*Selenium, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
*Silver	EPA 6020	ND	12	mg/kg	1	A104973	05/01/11	05/06/11	
*Silver, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Thallium	EPA 6020	ND	2.0	mg/kg	1	A104973	05/01/11	05/06/11	
*Thallium, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Vanadium**	EPA 6020	**42**	12	mg/kg	1	A104973	05/01/11	05/06/11	
***Vanadium, WET**	EPA 6020	**0.58**	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Zinc	EPA 6020	ND	62	mg/kg	1	A104973	05/01/11	05/06/11	
*Zinc, WET	EPA 6020	ND	2.5	mg/L	1	A104982	05/02/11	05/05/11	

BSK Analytical Laboratories
Engineers & Laboratories

Certificate of Analysis

Kevin Fisher
Horizon Water and Environment
1330 Broadway, Suite 424
Oakland, CA 94612

Report Issue Date: 05/10/2011 16:18
Received Date: 04/28/2011
Received Time: 07 30

Lab Sample ID: A1D2092-05
Sample Date: 04/26/2011 14:00
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Boot

General Chemistry

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
***Conductivity @ 25C, DI Extract**	SM 2510 B	**14**	5.0	umhos/cm	1	A104866	04/29/11	04/29/11	
*Hexavalent Chromium	EPA 7199	ND	1.0	mg/kg	50	A105227	05/05/11	05/05/11	
*Nitrate as N, DI Extract	EPA 300.0	ND	1.2	mg/kg	1	A105212	05/05/11	05/05/11	
*Nitrite as N, DI Extract	EPA 300.0	ND	0.25	mg/kg	1	A105212	05/05/11	05/05/11	
***pH, DI Extract**	EPA 9045C	**5.8**		pH Units	1	A105143	05/04/11	05/04/11	
***pH Temperature in °C**		**24.6**							
***Phosphorus**	EPA 365.4	**150**	2.5	mg/kg	1	A105137	05/04/11	05/05/11	
***Total Kjeldahl Nitrogen**	EPA 351.2	**1000**	120	mg/kg	5	A105137	05/04/11	05/04/11	
***Total Organic Carbon**	Walkley-Black	**13000**	50	mg/kg	1	A105399	05/09/11	05/09/11	
***Total Nitrogen, IC Solid**		**1000**		mg/kg					

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Antimony	EPA 6020	ND	10	mg/kg	1	A105038	05/02/11	05/10/11	
*Antimony, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Arsenic	EPA 6020	ND	2.5	mg/kg	1	A105038	05/02/11	05/10/11	
***Arsenic, WET**	EPA 6020	**0.10**	0.10	mg/L	1	A104982	05/02/11	05/05/11	
***Barium**	EPA 6020	**150**	6 2	mg/kg	1	A105038	05/02/11	05/10/11	
***Barium, WET**	EPA 6020	**6.5**	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Beryllium	EPA 6020	ND	1 2	mg/kg	1	A105038	05/02/11	05/10/11	
*Beryllium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
*Cadmium	EPA 6020	ND	1 2	mg/kg	1	A105038	05/02/11	05/10/11	
*Cadmium, WET	EPA 6020	ND	0 050	mg/L	1	A104982	05/02/11	05/05/11	
***Chromium**	EPA 6020	**25**	12	mg/kg	1	A105038	05/02/11	05/10/11	
***Chromium, WET**	EPA 6020	**0.60**	0 50	mg/L	1	A104982	05/02/11	05/05/11	
***Cobalt**	EPA 6020	**15**	12	mg/kg	1	A105038	05/02/11	05/10/11	
*Cobalt, WET	EPA 6020	ND	2 5	mg/L	1	A104982	05/02/11	05/05/11	
***Copper**	EPA 6020	**29**	5 0	mg/kg	1	A105038	05/02/11	05/10/11	
*Copper, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Lead	EPA 6020	ND	6 2	mg/kg	1	A105038	05/02/11	05/10/11	
*Lead, WET	EPA 6020	ND	0 25	mg/L	1	A104982	05/02/11	05/05/11	
*Mercury	EPA 6020A	ND	0 50	mg/kg	1	A105038	05/02/11	05/10/11	
*Mercury, WET	EPA 6020A	ND	0 020	mg/L	1	A104982	05/02/11	05/05/11	
*Molybdenum	EPA 6020	ND	12	mg/kg	1	A105038	05/02/11	05/10/11	
*Molybdenum, WET	EPA 6020	ND	0 50	mg/L	1	A104982	05/02/11	05/05/11	
*Nickel	EPA 6020	ND	12	mg/kg	1	A105038	05/02/11	05/10/11	

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Report Issue Date: 05/10/2011 16:18
Received Date: 04/28/2011
Received Time: 07 30

Lab Sample ID: A1D2092-05
Sample Date: 04/26/2011 14:00
Sample Type: Composite

Client Project: Sediment Project, 2011
Sampled by: Kevin Fisher
Matrix: Solid

Sample Description: Boot

Metals

Analyte	Method	Result	RL	Units	RL Mult	Batch	Prepared	Analyzed	Qual
*Nickel, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Potassium**	EPA 6010B	**3300**	200	mg/kg	1	A105038	05/02/11	05/09/11	
*Selenium	EPA 6020	ND	2.5	mg/kg	1	A105038	05/02/11	05/10/11	
*Selenium, WET	EPA 6020	ND	0.10	mg/L	1	A104982	05/02/11	05/05/11	
*Silver	EPA 6020	ND	12	mg/kg	1	A105038	05/02/11	05/10/11	
*Silver, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Thallium	EPA 6020	ND	2.0	mg/kg	1	A105038	05/02/11	05/10/11	
*Thallium, WET	EPA 6020	ND	0.50	mg/L	1	A104982	05/02/11	05/05/11	
***Vanadium**	EPA 6020	**82**	12	mg/kg	1	A105038	05/02/11	05/10/11	
***Vanadium, WET**	EPA 6020	**3.4**	0.50	mg/L	1	A104982	05/02/11	05/05/11	
*Zinc	EPA 6020	ND	62	mg/kg	1	A105038	05/02/11	05/10/11	
*Zinc, WET	EPA 6020	ND	2.5	mg/L	1	A104982	05/02/11	05/05/11	

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Report of Mechanical Analysis

BSK Analytical Laboratories
1414 Stanislaus
Fresno CA 93706-1623
573
50

Lab No. 155554
Sampled 4/26/11
Submitted 5/2/11
Submitted by
Reported 5/6/11
Job/Ranch/Site A1D2092
Copy To
FAX 559 485-6935
e-mail mzamora@bskinc.com

Identification

No.	Description	% Sand	% Silt	% Clay	Textural Class
	Methods	S14.10	S14.10	S14.10	S14.10
1	A1D2092-01 Lake Out Let 10:00	44	45	11	Loam
2	A1D2092-02 Lake Park 13:00	48	45	7	Sandy Loam/ Loam
3	A1D2092-03 Ridge 10:30	82	17	1	Loamy Sand
4	A1D2092-04 Wet - Bar Transition 11:00	77	20	3	Loamy Sand
5	A1D2092-05 Boot 14:00	28	55	17	Silt Loam

Central Valley Regional Water Quality Control Board
Constituents of Concern

List of constituents of concern for leachate analysis in pre-dredge sampling[1]. The constituents listed below are the minimum suite of constituents of concern commonly recommended for analysis. It is the responsibility of the discharger to accurately and completely characterize the material to be dredged to the best of their professional knowledge, including consideration site characteristics and any potential pollutants that may be present. Additional constituents may be specified for analysis, by Central Valley Water Board staff.

Constituent	Analytic Method
Aluminum	6010B/7400
Arsenic	7062/6010B/7400
Barium	6010B/7400
Cadmium	6010B/7400
Chromium – total	6010B/7400
Chromium VI	7195/7196/7191
Copper	6010B/7400
Lead	7421/6010B/7400
Manganese	6010B/7400
Mercury	7470A/7471A (RL<25 ng)
Molybdenum	6010B/7400
Nickel	7521/6010B/7400
Selenium	7740/7741
Zinc	6010B/7400

[1] Sampling requirements – Generally, a minimum of two core samples should be taken, and one core sample for each additional 5,000 cubic yards of material to be dredged. Composite samples may be prepared for analysis from at least two core samples for each 10,000 cubic yards of material to be dredged. Actual sample numbers, frequency and compositing may change depending upon particular site and dredged material characteristics. Samples must be representative of the entire depth and volume to be dredged.

Article 3. Characteristics of Hazardous Waste

§66261.20. General.

(a) A waste, as defined in section 66261.2, which is not excluded from regulation as a hazardous waste pursuant to section 66261.4(b), is a hazardous waste if it exhibits any of the characteristics identified in this article.

(b) A waste which is identified as a hazardous waste pursuant to one or more of the characteristics set forth in section 66261.21, 66261.22(a)(1), 66261.22(a)(2), 66261.23 or 66261.24(a)(1) is assigned the EPA Hazardous Waste Number set forth in this article for each characteristic that is applicable to that waste. These numbers shall be used in complying with the notification requirements of Health and Safety Code section 25153.6 and, where applicable, in the recordkeeping and reporting requirements under chapters 12 through 15, 18 and 20 of this division.

(c) Sampling and sample management of wastes and other materials for analysis and testing pursuant to this article shall be in accord with the sampling planning, methodology and equipment, and the sample processing, documentation and custody procedures specified in chapter nine of "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd edition, U.S. Environmental Protection Agency, 1986 (incorporated by reference, see section 66260.11 of this chapter). In addition to the sampling methods in chapter nine of SW-846, the Department will consider samples obtained using any of the other applicable sampling methods specified in Appendix I of this chapter to be representative samples.

NOTE: Authority cited: Sections 208, 25141 and 25159, Health and Safety Code. Reference: Sections 25141, 25159 and 25159.5, Health and Safety Code and 40 CFR Section 261.20.

HISTORY

1. New section filed 5-24-91; effective 7-1-91 (Register 91, No. 22).

§66261.21. Characteristic of Ignitability.

(a) A waste exhibits the characteristic of ignitability if representative samples of the waste have any of the following properties:

(1) it is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume, and has a flash point less than 60ºC (140ºF), as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D-93-79 or D-93-80 (incorporated by reference, see section 66260.11), or a Setaflash Closed Cup Tester, using the test method specified in ASTM Standard D-3278-78 (incorporated by reference, see section 66260.11), or as determined by an equivalent test method approved by the Department pursuant to section 66260.21;

(2) it is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard;

(3) it is an ignitable compressed gas as defined in 49 CFR section 173.300 (as amended September 30, 1982) and as determined by the test methods described in that regulation or equivalent test methods approved by the Department pursuant to section 66260.21;

(4) it is an oxidizer as defined in 49 CFR section 173.151 (as amended May 31, 1979).

(b) A waste that exhibits the characteristic of ignitability has the EPA Hazardous Waste Number of D001.

NOTE: Authority cited: Sections 208, 25141 and 25159, Health and Safety Code. Reference: Sections 25117, 25120.2, 25141, 25159 and 25159.5, Health and Safety Code and 40 CFR Section 261.21.

HISTORY

1. New section filed 5-24-91; effective 7-1-91 (Register 91, No. 22).

§66261.22. Characteristic of Corrosivity.

(a) A waste exhibits the characteristic of corrosivity if representative samples of the waste have any of the following properties:

(1) it is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using either the EPA test method for pH or an equivalent test method approved by the Department pursuant to section 66260.21. The EPA test method for pH is specified as Method 9040 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd edition and updates, (incorporated by reference, see section 66260.11);

(2) it is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55ºC (130ºF) as determined by the test method specified in NACE Standard TM-01-69 as standardized in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd edition and updates (incorporated by reference, see section 66260.11) or an equivalent test method approved by the Department pursuant to section 66260.21;

(3) it is not aqueous and, when mixed with an equivalent weight of water, produces a solution having a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using either Method 9040 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd edition and updates (incorporated by reference, see section 66260.11) or an equivalent test method approved by the Department pursuant to 66260.21;

(4) it is not a liquid and, when mixed with an equivalent weight of water, produces a liquid that corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55ºC (130ºF) as determined

by the test method specified in NACE Standard TM-01-69 as standardized in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd edition and updates (incorporated by reference, see section 66260.11) or an equivalent test method approved by the Department pursuant to 66260.21.

(b) A waste that exhibits the characteristic of corrosivity specified in subsection (a)(1) or (a)(2) of this section has the EPA Hazardous Waste Number of D002.

NOTE: Authority cited: Sections 25141, 25159, 58004 and 58012, Health and Safety Code. Reference: Sections 25117, 25120.2, 25141, 25159 and 25159.5, Health and Safety Code and 40 CFR Section 261.22.

HISTORY

1. New section filed 5-24-91; effective 7-1-91 (Register 91, No. 22).
2. Amendment of subsections (a)(1)-(4) and NOTE filed 10-13-98; operative 11-12-98 (Register 98, No. 42).

§66261.23. Characteristic of Reactivity.

(a) A waste exhibits the characteristic of reactivity if representative samples of the waste have any of the following properties:

(1) it is normally unstable and readily undergoes violent change without detonating;

(2) it reacts violently with water;

(3) it forms potentially explosive mixtures with water;

(4) when mixed with water, it generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment;

(5) it is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment;

(6) it is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement;

(7) it is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure;

(8) it is a forbidden explosive as defined in 49 CFR section 173.51 (as amended April 20, 1987), or a Class A explosive as defined in 49 CFR section 173.53 (as amended April 5, 1967) or a Class B explosive as defined in 49 CFR section 173.88 (as amended May 19, 1980).

(b) A waste that exhibits the characteristic of reactivity has the EPA Hazardous Waste Number of D003.

NOTE: Authority cited: Sections 208, 25141 and 25159, Health and Safety Code. Reference: Sections 25117, 25120.2, 25141, 25159 and 25159.5, Health and Safety Code and 40 CFR Section 261.23.

HISTORY

1. New section filed 5-24-91; effective 7-1-91 (Register 91, No. 22).

§66261.24. Characteristic of Toxicity.

(a) A waste exhibits the characteristic of toxicity if representative samples of the waste have any of the following properties:

(1) when using the Toxicity Characteristic Leaching Procedure (TCLP), test Method 1311 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846, third edition and Updates (incorporated by reference in section 66260.11 of this division), the extracts from representative samples of the waste contain any of the contaminants listed in Table I of this section at a concentration equal to or greater than the respective value given in that table unless the waste is excluded from classification as a solid waste or hazardous waste or is exempted from regulation pursuant to 40 CFR section 261.4. Where the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering using the methodology outlined in Method 1311, is considered to be the extract for the purposes of this section;

(A) a waste that exhibits the characteristic of toxicity pursuant to subsection (a)(1) of this section has the EPA Hazardous Waste Number specified in Table I of this section which corresponds to the toxic contaminant causing it to be hazardous;

(B) Table I - Maximum Concentration of Contaminants for the Toxicity Characteristic:

EPA Hazardous Waste Number	Contaminant	Chemical Abstracts Service Number	Regulatory Level Mg/l
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100.0

EPA Hazardous Waste Number	Contaminant	Chemical Abstracts Service Number	Regulatory Level Mg/l
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D019	Carbon tetrachloride	56-23-5	0.5
D020	Chlordane	57-74-9	0.03
D021	Chlorobenzene	108-90-7	100.0
D022	Chloroform	67-66-3	6.0
D007	Chromium	7440-47-3	5.0
D023	o-Cresol	95-48-7	200.0[1]
D024	m-Cresol	108-39-4	200.0[1]
D025	p-Cresol	106-44-5	200.0[1]
D026	Cresol		200.0[1]
D016	2,4-D	94-75-7	10.0
D027	1,4-Dichlorobenzene	106-46-7	7.5
D028	1,2-Dichloroethane	107-06-2	0.5
D029	1,1-Dichloroethylene	75-35-4	0.7
D030	2,4-Dinitrotoluene	121-14-2	0.13
D012	Endrin	72-20-8	0.02
D031	Heptachlor (and its epoxide)	76-44-8	0.008
D032	Hexachlorobenzene	118-74-1	0.13
D033	Hexachlorobutadiene	87-68-3	0.5
D034	Hexachloroethane	67-72-1	3.0
D008	Lead	7439-92-1	5.0
D013	Lindane	58-89-9	0.4
D009	Mercury	7439-97-6	0.2
D014	Methoxychlor	72-43-5	10.0
D035	Methyl ethyl ketone	78-93-3	200.0
D036	Nitrobenzene	98-95-3	2.0
D037	Pentachlorophenol	87-86-5	100.0
D038	Pyridine	110-86-1	5.0[2]

EPA Hazardous Waste Number	Contaminant	Chemical Abstracts Service Number	Regulatory Level Mg/l
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D039	Tetrachloroethylene	127-18-4	0.7
D015	Toxaphene	8001-35-2	0.5
D040	Trichloroethylene	79-01-6	0.5
D041	2,4,5-Trichlorophenol	95-95-4	400.0
D042	2,4,6-Trichlorophenol	88-06-2	2.0
D017	2,4,5-TP (Silvex)	93-72-1	1.0
D043	Vinyl chloride	75-01-4	0.2

[1] If o-, m- and p-Cresol concentrations cannot be differentiated, the total cresol (D026) concentration is used. The regulatory level of total cresol is 200 mg/l.

[2] Quantitation limit is greater than the calculated regulatory level. The quantitation limit therefore becomes the regulatory level.

(2) it contains a substance listed in subsections (a)(2)(A) or (a)(2)(B) of this section at a concentration in milligrams per liter of waste extract, as determined using the Waste Extraction Test (WET) described in Appendix II of this chapter, which equals or exceeds its listed soluble threshold limit concentration or at a concentration in milligrams per kilogram in the waste which equals or exceeds its listed total threshold limit concentration;

(A) Table II - List of Inorganic Persistent and Bioaccumulative Toxic Substances and Their Soluble Threshold Limit Concentration:

(STLC) and Total Threshold Limit Concentration (TTLC) Values.

Substance [a,b]	STLC mg/l	TTLC Wet-Weight mg/kg
Antimony and/or antimony compounds	15	500
Arsenic and/or arsenic compounds	5.0	500
Asbestos		1.0 (as percent)
Barium and/or barium compounds (excluding barite)	100	10,000[c]
Beryllium and/or beryllium compounds	0.75	75
Cadmium and/or cadmium compounds	1.0	100
Chromium (VI) compounds	5	500
Chromium and/or chromium (III) compounds	5[d]	2,500
Cobalt and/or cobalt compounds	80	8,000
Copper and/or copper compounds	25	2,500
Fluoride salts	180	18,000
Lead and/or lead compounds	5.0	1,000
Mercury and/or mercury compounds	0.2	20

Substance [a,b]	STLC mg/l	TTLC Wet-Weight mg/kg
Molybdenum and/or molybdenum compounds	350	3,500[e]
Nickel and/or nickel compounds	20	2,000
Selenium and/or selenium compounds	1.0	100
Silver and/or silver compounds	5	500
Thallium and/or thallium compounds	7.0	700
Vanadium and/or vanadium compounds	24	2,400
Zinc and/or zinc compounds	250	5,000

[a]STLC and TTLC values are calculated on the concentrations of the elements, not the compounds.

[b]In the case of asbestos and elemental metals, the specified concentration limits apply only if the substances are in a friable, powdered or finely divided state. Asbestos includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

[c]Excluding barium sulfate.

[d]If the soluble chromium, as determined by the TCLP set forth in Appendix I of chapter 18 of this division, is less than 5 mg/l, and the soluble chromium, as determined by the procedures set forth in Appendix II of chapter 11, equals or exceeds 560 mg/l and the waste is not otherwise identified as a RCRA hazardous waste pursuant to section 66261.100, then the waste is a non-RCRA hazardous waste.

[e]Excluding molybdenum disulfide.

(B) Table III - List of Organic Persistent and Bioaccumulative Toxic Substances and Their Soluble Threshold Limit Concentration (STLC) and Total Threshold Limit Concentration (TTLC) Values:

Substance	STLC mg/l	TTLC Wet Weight mg/kg
Aldrin	0.14	1.4
Chlordane	0.25	2.5
DDT, DDE, DDD	0.1	1.0
2,4-Dichlorophenoxyacetic acid	10	100
Dieldrin	0.8	8.0
Dioxin (2,3,7,8-TCDD)	0.001	0.01
Endrin	0.02	0.2
Heptachlor	0.47	4.7
Kepone	2.1	21
Lead compounds, organic	--	13
Lindane	0.4	4.0
Methoxychlor	10	100
Mirex	2.1	21
Pentachlorophenol	1.7	17
Polychlorinated biphenyls (PCBs)	5.0	50
Toxaphene	0.5	5
Trichloroethylene	204	2,040
2,4,5-Trichlorophenoxypropionic acid	1.0	10

(3) it has an acute oral LD_{50} less than 2,500 milligrams per kilogram;

(4) it has an acute dermal LD_{50} less than 4,300 milligrams per kilogram;

(5) it has an acute inhalation LC_{50} less than 10,000 parts per million as a gas or vapor;

(6) it has an acute aquatic 96-hour LC_{50} less than 500 milligrams per liter when measured in soft water (total hardness 40 to 48 milligrams per liter of calcium carbonate) with fathead minnows (*Pimephales promelas*), rainbow trout (*Salmo gairdneri*) or golden shiners (*Notemigonus crysoleucas*) according to procedures described in Part 800 of the "Standard Methods for the Examination of Water and Wastewater (16th Edition)," American Public Health Association, 1985 and "Static Acute Bioassay Procedures for Hazardous Waste Samples," California Department of Fish and Game, Water Pollution Control Laboratory, revised November 1988 (incorporated by reference, see section 66260.11), or by other test methods or test fish approved by the Department, using test samples prepared or meeting the conditions for testing as prescribed in subdivisions (c) and (d) of Appendix II of this chapter, and solubilized, suspended, dispersed or emulsified by the cited procedures or by other methods approved by the Department;

(7) it contains any of the following substances at a single or combined concentration equal to or exceeding 0.001 percent by weight:

(A) 2-Acetylaminofluorene (2-AAF);
(B) Acrylonitrile;
(C) 4-Aminodiphenyl;
(D) Benzidine and its salts;
(E) bis (Chloromethyl) ether (BCME);
(F) Methyl chloromethyl ether;
(G) 1,2-Dibromo-3-chloropropane (DBCP);
(H) 3,3'-Dichlorobenzidine and its salts (DCB);
(I) 4-Dimethylaminoazobenzene (DAB);
(J) Ethyleneimine (EL);
(K) alpha-Naphthylamine (1-NA);
(L) beta-Naphthylamine (2-NA);
(M) 4-Nitrobiphenyl (4-NBP);
(N) N-Nitrosodimethylamine (DMN);
(0) beta-Propiolactone (BPL);
(P) Vinyl chloride (VCM);

(8) it has been shown through experience or testing to pose a hazard to human health or environment because of its carcinogenicity, acute toxicity, chronic toxicity, bioaccumulative properties or persistence in the environment.

(b) A waste containing one or more materials which exhibit the characteristic of toxicity because the materials have the property specified in subsection (a)(5) of this section may be classified as nonhazardous pursuant to section 66260.200 if the waste does not exhibit any other characteristic of this article and is not listed in article 4 of this chapter and its head space vapor contains no such toxic materials in concentrations exceeding their respective acute inhalation LC_{50} or their LC_{LO}. The head space vapor of a waste shall be prepared, and two milliliters of it shall be sampled using a five milliliter gas-tight syringe, according to Method 5020 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 2nd edition, U.S. Environmental Protection Agency, 1982 (incorporated by reference, see section 66260.11). The quantity in milligrams of each material, which exhibits the characteristic of toxicity because it has the property specified in subsection (a)(5) of this section, in the sampling syringe shall be determined by comparison to liquid standard solutions according to the appropriate gas chromatographic procedures in Method 8010, 8015, 8020, 8030 or 8240 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, 3rd edition, U.S. Environmental Protection Agency, 1986 (incorporated by reference, see section 66260.11). The concentration of each material in the head space vapor shall be calculated using the following equation:

$$C_A = \frac{Q_A}{MW} \times \frac{29.8ml}{mmole} \times \frac{1}{2 \times 10^{-6} M^3}$$

where C (in parts per million) is the concentration of material A in head space vapor, Q (in milligrams) is the quantity of material A in sampling syringe and MW (in milligrams per millimole) is the molecular weight of material A. Where an acute inhalation LC_{50} is not available, an LC_{50} measured for another time (t) may be converted to an eight-hour value with the following equation:

Eight-hour LC_{50} = (t/8) x (t-hour LC_{50}).

(c) A waste containing one or more materials which exhibit the characteristic of toxicity because the materials have either of the properties specified in subsection (a)(3) or (a)(4) of this section may be classified as nonhazardous pursuant to section 66260.200 if the waste does not exhibit any other characteristic of this article and is not listed in article 4 of this chapter and the calculated oral LD_{50} of the waste mixture is greater than 2,500 milligrams per kilogram and the calculated dermal LD_{50} is greater than 4,300 milligrams per kilogram by the following equation:

Calculated oral or dermal $$LD_{50} = \frac{100\%}{\sum_{x=1}^{n} \frac{\%A_x}{T_{A_x}}}$$

where $\%A_x$ is the weight percent of each component in the waste mixture and $^{T}A_X$ is the acute oral or dermal LD_{50} or the acute oral LD_{LO} of each component.

NOTE: Authority cited: Sections 25141, 25159, 58004 and 58012, Health and Safety Code. Reference: Sections 25117, 25120.2, 25141, 25159 and 25159.5, Health and Safety Code and 40 CFR Section 261.24.

HISTORY

1. New section filed 5-24-91; effective 7-1-91 (Register 91, No. 22).
2. Amendment of table II filed 1-31-94; operative 1-31-94 (Register 94, No. 5).
3. Editorial correction of equation (Register 95, No. 36).
4. Amendment of subsection (a)(1) and NOTE filed 10-13-98; operative 11-12-98 (Register 98, No. 42).
5. Change without regulatory effect amending subsections (a)(3) and (c) filed 6—3—2004 pursuant to section 100, title 1, California Code of Regulations (Register 2004, No. 23).