APPENDIX D

SOUTHERN EDEN LANDING PRELIMINARY DESIGN MEMORANDUM

ATTACHMENT 1. SOUTHERN EDEN LANDING RESTORATION PRELIMINARY DESIGN: 1D AND 2D HYDRODYNAMIC MODELING

ATTACHMENT 2. EDEN LANDING GEOTECHNICAL INVESTIGATION AND ANALYSES

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MEMORANDUM

TO: Members of the South Bay Salt Pond Restoration Project Management Team

FROM: AECOM

DATE: October 2016

RE: **Southern Eden Landing Restoration Preliminary Design**

1. INTRODUCTION

This memorandum documents the preliminary design of the South Bay Salt Pond (SBSP) Restoration Project's Phase 2 actions at the southern half of the Eden Landing Ecological Reserve (ELER). For the purposes of this document, these ponds are referred to as the southern Eden Landing Ponds. This memorandum provides information for the CEQA and NEPA clearance, regulatory agency permitting processes, and a basis for the next, more detailed design phase.

1.1 Project Background

The ELER, and the southern Eden Landing Ponds within it, are owned and operated by the California Department of Fish and Wildlife (CDFW). This complex is near the eastern end of the San Mateo Bridge, south of State Route (SR) 92 as it passes through the City of Hayward in Alameda County (see Appendix A, Figure A-1). The Phase 2 actions at southern Eden Landing are focused on the ponds south of the Old Alameda Creek (OAC) and north of the federally constructed Alameda Creek Flood Control Channel (ACFCC). Existing public access components include alignment of the San Francisco Bay Trail "spine" such that the trail connects from the existing SF Bay Trail within the northern half of ELER to the existing Alameda Creek Regional Trail operated by East Bay Regional Park District (EBRPD) along ACFCC.

The Phase 2 Eden Landing preliminary design, along with the rest of the SBSP Restoration Project, is managed by the SBSP Project Management Team (PMT), which includes the State Coastal Conservancy (SCC), U.S. Fish and Wildlife Service (USFWS), CDFW, Santa Clara Valley Water District (SCVWD), and others.

The Programmatic EIS/R for the SBSP Restoration Project (EDAW 2007) prescribed the initial framework under which restoration would proceed. In that document, program-level alternatives range from a restoration design of 50/50 tidal action/managed pond scenario for the entire restoration project area (Programmatic Alternative B) to a 90/10 tidal action/managed pond scenario for the entire restoration project area (Programmatic Alternative C) (see Appendix A, Figures A-11 and A-12). Programmatic Alternative C was selected and used as a foundation for project-level planning. Phase 1 of the project has since been completed, and involved restoring clusters of ponds at all three pond complexes. The Phase 1 actions at northern Eden Landing were completed in 2016 and included year-round and seasonal trails, a kayak launch, and a combination of tidal marsh restoration and enhancements to managed ponds to improve habitat for various species.

A design charrette was held May 13, 2010 to discuss conceptual restoration design ideas for Phase 2 of the project. Ideas proposed in the charrette document were further refined in coordination with the PMT to develop memoranda that described the opportunities and constraints associated with the construction or implementation of design ideas (URS 2012).

From this, through a year-long process of developing and screening alternatives, modeling the tidal and fluvial peak water elevations that would result, and assessing rational combinations of recreation and public access alternatives, three conceptual designs for action alternatives were developed and finalized with the PMT and other stakeholders including the Alameda County Flood Control and Water Conservation District (ACFCWCD), the EBRPD, and the Association of Bay Area Governments (ABAG). These three preliminary design concepts are described in detail in the Eden Landing Preliminary Alternatives Analysis Report (URS 2014a) and served as the basis for the alternatives proposed in this preliminary design memorandum.

This set of three alternatives was developed for conceptual design and analysis in the site-specific Public Draft EIS/EIR for Phase 2 at Eden Landing. Following the public comment period, a preferred alternative that best meets the project objectives while providing a cost-efficient design will be identified in the Final EIS/EIR. This memorandum describes the work conducted as part of the conceptual level design.

1.2 Organization and Scope

This memorandum presents the conceptual (approximately 10% to 30%) design for the Phase 2 action alternatives at the southern Eden Landing Ponds. It also briefly documents the design constraints and considerations that formed the basis for the conceptual design.

The preliminary design memorandum is organized as follows:

- Section 1: introduction, organization, and limitations
- Section 2: objectives, design constraints, and considerations
- Section 3: preliminary design analyses, including hydraulic modeling, salinity/water quality management approaches, and topography and geotechnical data
- Section 4: preliminary design including restoration components, construction implementation

1.3 Limitations

This memorandum provides a preliminary design based on information available at the time and professional judgment pending future engineering analyses. Future design decisions or additional information may change the findings, and corresponding professional judgments presented in this memo. Additional engineering will be necessary prior to construction. In the event that conclusions or recommendations based on the information in this memorandum are made by others, such conclusions are not the responsibility of AECOM, or its subconsultants, unless we have been given an opportunity to review and concur with such conclusions in writing.

2. OBJECTIVES, DESIGN CONSTRAINTS, AND CONSIDERATIONS

The southern Eden Landing Ponds includes 11 ponds that are described in three groups in this memorandum, based on their location within the complex and their proximity and similarity to each other. The groups are as follows and as shown in Figure 2.1:

- The Bay Ponds: Ponds E1, E2, E4, and E7 are the four large ponds closest to San Francisco Bay, bordered to the north by the OAC and to the south by Alameda County-owned property including the Alameda County Wetlands and the ACFCC.
- The Inland Ponds: Ponds E5, E6, and E6C are somewhat smaller ponds in the northeast portion of the complex. They are bordered to the north by OAC, to the east by the Union Sanitary District Waste Water Treatment Plant and Alameda County owned property (used by the Southern Alameda County Radio Controllers Aircraft Club), and to the south by an Alameda County-owned freshwater outflow channel and diked marsh areas known collectively as the "J-Ponds".
- The Southern Ponds or C-Ponds: Also sometimes called the C-Ponds, the Ponds E1C, E2C, E4C, and E5C are in the southeastern portion of the complex. They are separated from the Inland Ponds and the Bay Ponds by the J-Ponds. The Southern Ponds are bordered to the east by property owned by Cargill (Cargill Pond 3C).

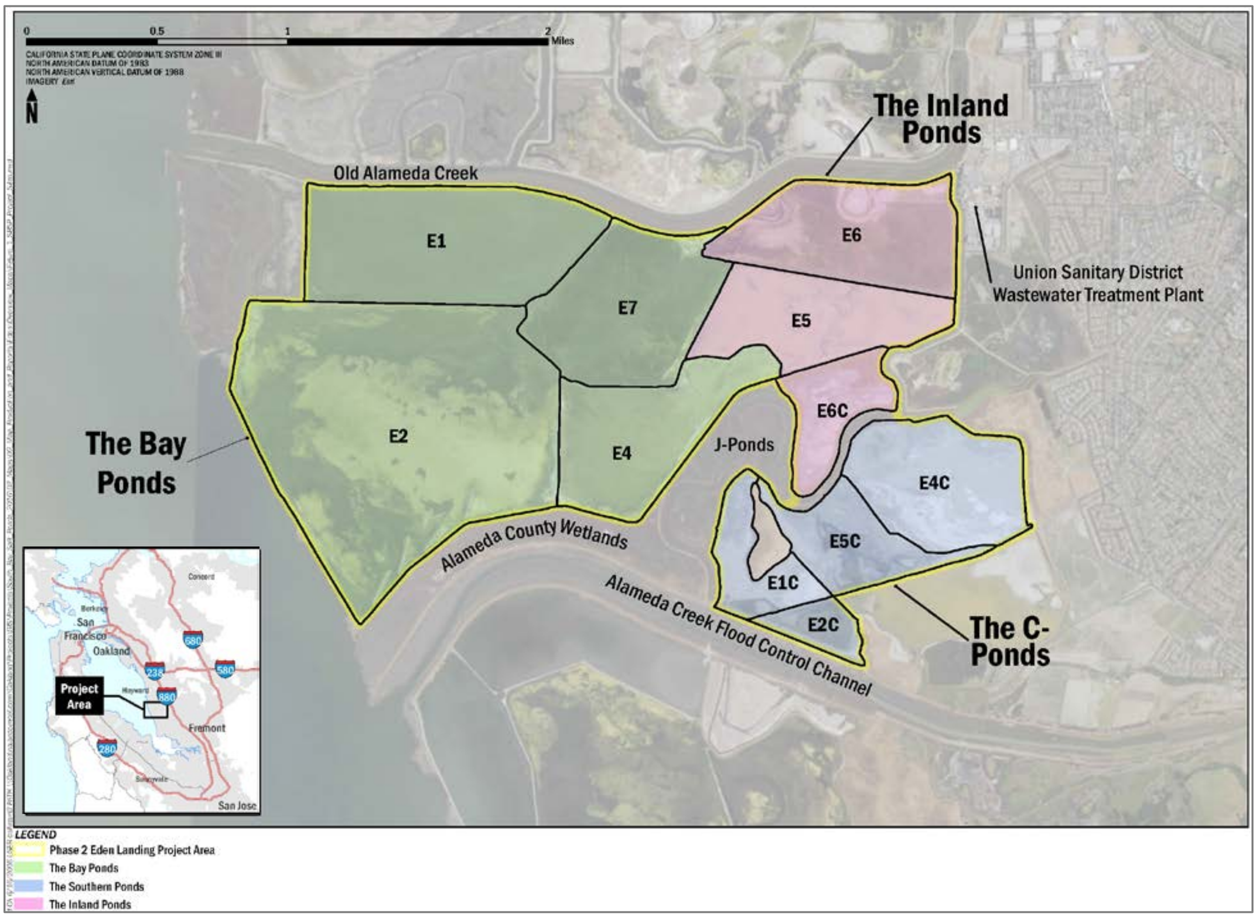

Figure 2.1. Project Vicinity Map

2.1 Objectives

The Phase 2 objectives for southern Eden Landing include a restoration action objective, a flood protection objective, and a recreation and public access objective. The objectives are summarized below.

- *To restore and enhance a mix of wetland habitats*. Restored habitat should be of sufficient size, function, and appropriate structure to promote restoration of special status species, support current migratory bird species that utilize existing salt ponds and associated structures, and increase abundance and diversity of native species in various South San Francisco Bay aquatic and terrestrial ecosystem components (EDAW et al. 2007). In particular, under both Programmatic Alternative B and Programmatic Alternative C, the entire southern Eden Landing ponds would all be restored to tidal marsh. Under Alternative D a portion of the Eden Landing ponds would be restored to tidal marsh.
- *To provide flood protection in the South Bay*. All project designs and features (e.g. levee improvements) would provide the same level of protection as existing features (i.e. match existing outboard levee elevations), and restored tidal marsh is expected to provide additional flood protection in the long-term. Additionally, at Eden Landing, the flood protection options must direct attention to the topic of fluvial flooding and drainage in the federal ACFCC and not increase current flood risk or reduce the level of protection currently provided against both tidal and fluvial flooding.
- *To provide wildlife-oriented public access and recreational opportunities*. Public access activities may include hiking, wildlife viewing, occasional hunting and fishing, and other wildlife-compatible recreational activities.

The restoration preliminary design summarized in this memorandum was developed taking into account several design constraints and considerations. Design constraints are limiting factors that must be considered while developing the design. Design considerations are issues that contribute to design formulation, but are not limiting factors.

2.2 Design constraints

- *Flooding.* The primary constraint on the introduction of tidal action is that – following breaching of the Eden Landing ponds – fluvial and/or tidal flooding could increase in the areas to the east of the ponds unless additional flood protection is provided. Thus, in order to introduce tidal action to southern Eden Landing, additional flood protection may be required. There are two primary options for coastal flood protection: a landside and a mid-complex levee. Multiple-staged (or phased) restoration could be supported by a mid-complex levee, which could be kept either permanently or temporarily for adaptive management purposes and/or monitoring wildlife response to restoration activities.
- *Breaches.* The number, size, and location of internal and external levee breaches were sized to allow tidal flows into the ponds at southern Eden Landing. AECOM performed hydrodynamic modeling to simulate regular daily tides as well as 100-year tides separately and in combination with peak storm water outflows (e.g., 100-year fluvial flows) under a range of breach scenarios. The alternatives developed and presented here satisfy the SBSP Restoration Project's goal of filling and draining the ponds with each day's tides while still providing the same or better flood protection against extreme tidal and fluvial elevations.

- *Federal Levees.* The ACFCC is bordered by the northern and southern Federal levees. Breaching the northern levee to connect the C-Ponds or the Alameda County Wetlands to the ACFCC would require a permit from the ACFCWCD, a Section 408 permit from the U.S. Army Corps of Engineers (USACE), potential de-authorization of a portion of the Federal project, and act of Congress to do so, and potential construction of additional Federal levees to protect against the 100-year fluvial flows. For these reasons, full breaches in the ACFCC were eliminated in the design and replaced with water control structure (i.e., culvert) options for the purpose of fish passage from ACFCC into southern Eden Landing.
- *Erosion and scour.* Reintroducing tidal flows into southern Eden Landing may result in erosion and scour of the OAC, which will be the main conveyance channel for the increased tidal prism entering southern Eden Landing. An undersized or non-hardened levee breach may result in erosion and scour of the remaining levee; in some places, this effect is a goal of the project. Tidal flows through new breaches are also expected to scour channels in the tidal marsh.
- *Volume of fill material*. The ability to construct habitat transition zones between pond bottoms and the adjacent uplands or levees, the bay-side levee, the mid-complex or landside levee, and extent of levee enhancements will depend on the volume and type of fill available for reuse. Fill material may come from onsite pilot channel excavation or from offsite (upland) construction sources. From a construction perspective, the excavation and placement of material is ideally balanced on a site understanding that different material types may not be used for all purposes.
- *Public access near sensitive species habitat.* Providing recreation and public access is a key goal of the project, but in some areas, public access may negatively affect wildlife using the area.
- *Permitting.* Impacts to wetlands, fill volumes, and impacts to special-status species could all affect the ability to obtain permits on the desired schedule.
- *Long-term maintenance.* Constructed features such as levees, trails, and water control structures will need to be maintained into the future.
- *Soils and hydrology*. Habitat restoration is in part dependent on the soils and hydrology of the site. Habitat opportunities are limited by the existing or constructed environmental conditions. Because the C-Ponds will continue to experience a muted tide due to the limited conveyance through culverts (as opposed to a breach), habitat establishment may be slower and of a different value compared to the other restored areas in the complex.
- *Existing rights-of-way, easements, and utilities.* These features may serve as constraints to installation of control structures, culverts, or other features. The preliminary design needs to consider rights-of-way owned by Alameda County, the Cargill Company, and others. These groups would need to be notified and included during the design process if construction would impact their properties, facilities, or rights-of-way.

2.3 Design considerations

- *Reconnection of historic sloughs.* The design breach locations consider the position and size of historic slough systems, taking advantage of areas where natural conditions may already exist for channel formation and water exchange capacity.
- *Sedimentation.* The existing levees, if left in place, will help slow the discharge of flood and tidal waters, increasing the potential for natural sedimentation within the ponds. This sedimentation is desired to raise pond surface elevations to levels that promote the growth of tidal marsh vegetation species and to provide resiliency for sea level rise.

- *Predation.* Levee breaches may serve to isolate habitat from upland predators. Connecting levees through bridges and trails for public access may limit this value.
- *Fish nursery habitat.* The tidal marsh habitat and channel network provided through the restoration of tidal action into the ponds could provide protected fish nursery habitat, ultimately increasing fish and populations and recreational opportunities for fishing and birding.
- *Habitat transition zone habitat.* The primary purpose of the habitat transition zones is to provide habitat complexity and refugia for tidal marsh wildlife species during high tides. In addition, the transitional area will provide resiliency to sea level rise and may provide opportunity for improved public education and outreach.
- *Western snowy plover.* Ponds in northern Eden Landing were enhanced for and are currently being managed to provide habitat for nesting western snowy plover. This provides some latitude for emphasizing tidal marsh restoration in southern Eden Landing. However, additional habitat to support this species may be able to be provided in the short-term (e.g., by leaving large sections of breached levees as habitat islands or by retaining some of the Inland Ponds or C-Ponds as managed ponds with habitat suitable for western snowy plover nesting). Long-term maintenance of these features would continue under a managed pond scenario, however would cease with the tidal marsh restoration scenario as the islands will either become vegetated or eroded over time. Substrate (e.g., shells, salt, sand), visual screens, and size and location (e.g., distance from trails) are all factors in the design of western snowy plover habitat.
- *Hydrology.* The number and location of the breaches and the decision to utilize and expand existing borrow ditches influences filling and draining of the restored ponds. Hydrology was assessed and modeled to inform the preliminary design.
- *Recreation.* Retained levees provide opportunity for recreation and educational signage describing the restoration. Breaches and sensitive wildlife habitat may limit locations for recreational opportunities.
- *Site access.* In addition to serving as recreational facilities, trails increase accessibility for scientists to study wildlife and conduct required monitoring, while also increasing access for maintenance and operational activities.
- *Water quality.* Adequate circulation, more of an issue in managed ponds than in the breached and tidal ponds planned for southern Eden Landing, remains necessary to prevent dissolved oxygen (DO) levels from dropping too low. Pond design elements, such as complete tidal drainage, can reduce the risk of low DO.
- *Material quality.* Imported fill material from upland sources will require environmental screening to assess suitability based on material type and constituent concentrations (USFWS 2012). A Quality Assurance Project Plan (QAPP) and permit will be required to accept upland fill placement at southern Eden Landing.

3. AVAILABLE DATA AND PRELIMINARY DESIGN ANALYSES

AECOM developed a two-dimensional hydrodynamic model using MIKE21 to refine the design of restoration features including levee breach and pilot channel dimensions, levee raising and lowering heights and locations, and culvert locations and numbers. A one-dimensional hydraulic model using HEC-RAS was also developed to efficiently analyze culvert sizes for the C-Ponds and Inland Ponds, as HEC-RAS has a more robust culvert routine and the model runtime is minutes instead of hours with MIKE21. Analyses were performed on the three project action alternatives (Alternatives Eden B, C and D). These alternatives are graphically depicted in Appendix A on Figures A-3, A-4, and A-5.

3.1 Site Topography and Project Datum

Table 3.1 lists the three sources of topographic and bathymetric data used in this preliminary design and associated modeling analysis.

Table 3.1. Topographic and Bathymetric Data

Data Source	Year Collected	Horizontal Datum	Vertical Datum	Projection
USGS 2010 SBSP Project LiDAR	2010	NAD83	NAVD88	UTM-10 10N
USGS 2005 SBSP Project Bathymetry	2003-2004	NAD83	NAVD88	CA State Plane III
USGS (Foxgrover et al.) 2007 South San Francisco Bay Bathymetry	2005	NAD83	NAVD88	UTM-10 10N

The available site topography is high-accuracy LiDAR from the 2010 USGS San Francisco Coastal LiDAR project (San Francisco, Marin, Solano, Contra Costa, Alameda, San Mateo, Santa Clara counties, California). The LiDAR data was collected between June 11, 2010 and July 11, 2010.

USGS (2005) also conducted a bathymetric survey of the SBSP Project pond complexes between August 2003 and March 2004 using a shallow-water sounding system to measure water depths with a precision of 1 cm. The system was comprised of a single beam echosounder, a differential global positioning system (DGPS) unit, and a laptop computer on a shallow-draft kayak with a trolling motor. Sample depths were converted to elevation based on water surface elevations recorded every 15-20 minutes at the ponds. Transects were made at 100 meter intervals.

The below water elevations in the Bay adjacent to the project site were obtained from 2005 Hydrographic Survey of South San Francisco Bay, California by Foxgrover et al. (USGS), published in 2007. These data consisted of xyz data collected using a single beam acoustic sampler.

The digital elevation point files used in the hydrodynamic model were generated by merging the three sets of data using the horizontal spatial reference system of NAD83, CA State Plane III meters and vertical datum NAVD88, meters.

The data from the bathymetric survey of the SBSP pond complexes and the bathymetric survey of the South Bay were inserted into areas with no LiDAR coverage (to prevent overlapping points between the datasets). To reduce the number of LiDAR points for use in CADD and the hydrodynamic model, the LiDAR datasets were down sampled using a “model key point” algorithm. “Model key points” are points selected to represent local topography and are not removed during a point thinning process. This algorithm thins the ground class within a user-specified vertical tolerance. Areas which exhibit a greater variation in the terrain have more model key points than in areas with a smaller variation in terrain (for example a parking lot). The vertical tolerance parameter required for the algorithm mandates that a triangulated irregular network (TIN) surface generated from the model key points would be within the user-specified distance of a TIN surface generated from the original ground points. The algorithm vertical tolerance parameter was set to 6 inches (0.15 meters) for this study.

In general, the project site is comprised of fairly flat pond bottoms separated by levees. Many of the levees have borrow ditches directly adjacent to them. Figure 3.1 depicts the distribution of pond bottom elevations of the three groups of ponds, most of which are between MSL and MHW. About half of the pond bottoms are 1 ½ to 2 feet or more below MHW and less than 10% are higher than MHW. The C-Ponds are the highest group of ponds, followed by the Inland and Bay Ponds.

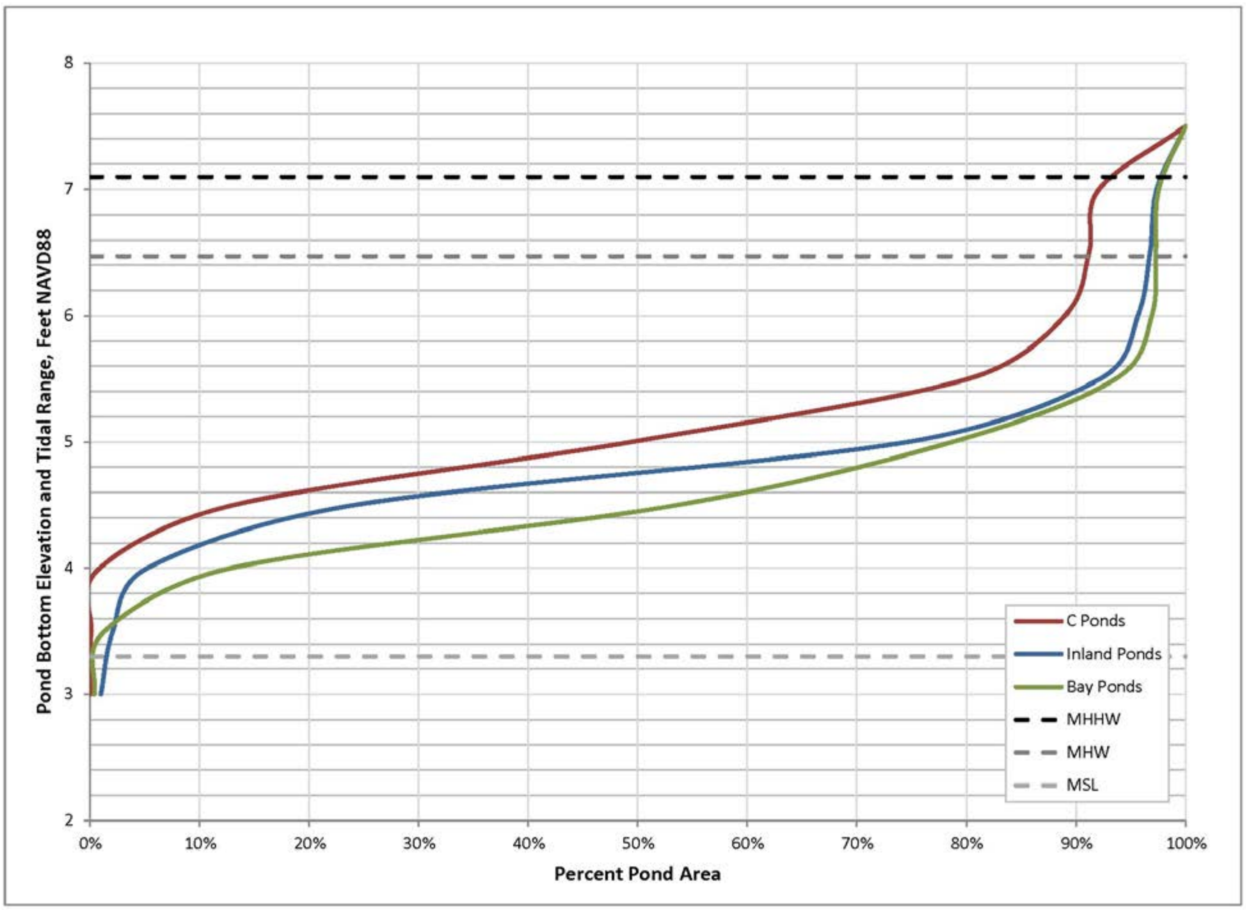

Figure 3.1. Average Pond Group Bottom Elevations

3.2 Historical Slough Network

The historical slough network (mid-1800s) in the project vicinity is shown in Figure 3.2 (SFEI 2013). As indicated by the red arrows and the dashed line, approximately half of the Bay and Inland Ponds historically drained to the south across the present-day Alameda County property and towards the present location of the ACFCC. A large part of Pond E2 drained directly to San Francisco Bay. Because breaching the federal ACFCC levees and the County's J Pond Stormwater Detention Basin levees is a design constraint, recreating the historical slough network was not possible. The proposed levee breach and pilot channel designs described in this memo attempt to align with historical slough features where possible.

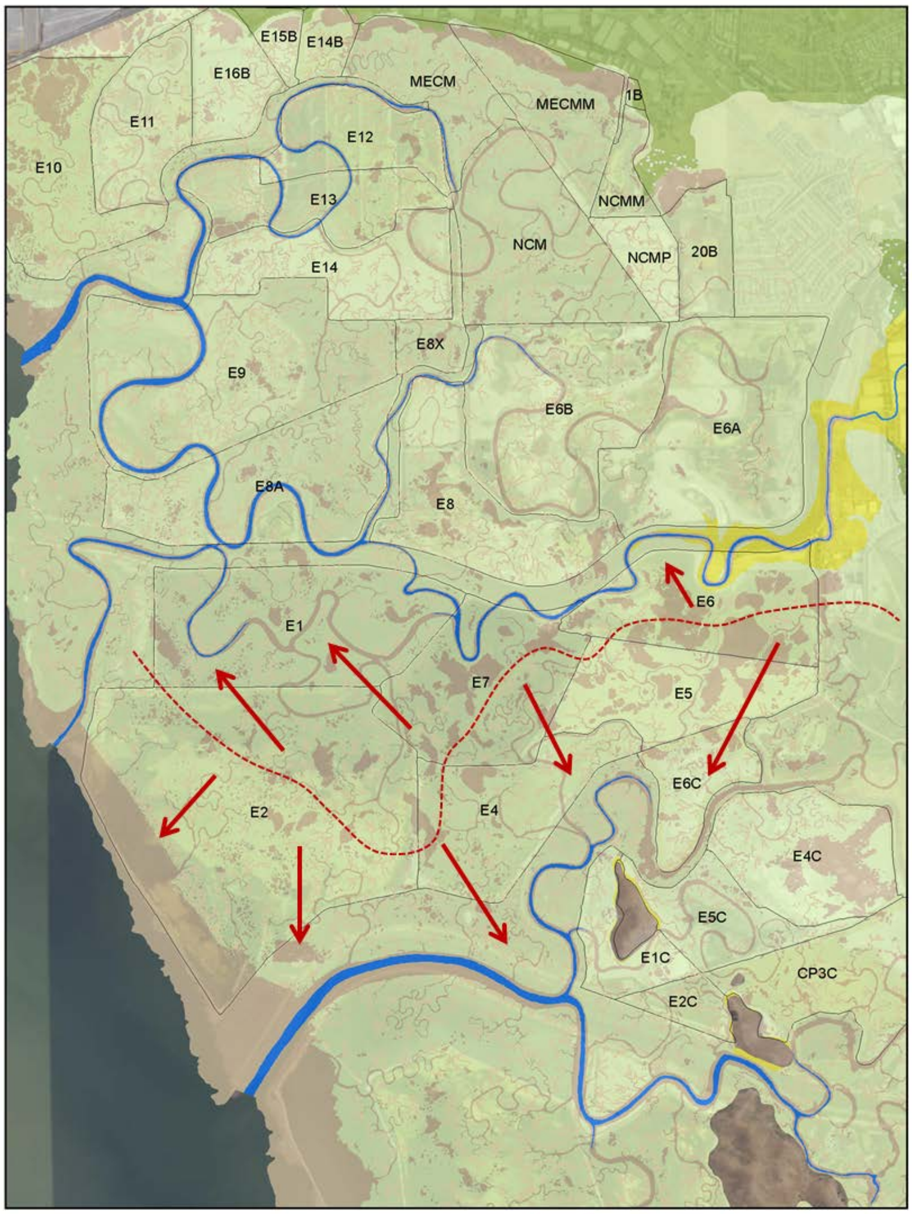

Figure 3.2. Historical Tidal Sloughs and Local Watershed Division

3.3 Hydrologic Data

Water Levels

Water surface elevations representative of tides at Eden Landing were obtained from the Redwood City tide gauge (NOAA gauge 9414523), located roughly 7 miles (11 kilometers) west of Eden Landing. The 6 minute daily tide data were obtained from National Oceanic Atmospheric Administration's Tides and Currents website (NOAA 2016) and converted to NAVD88 using NOAA conversions listed in AECOM 2016. Table 3.2 summarizes the tidal datums for the three NOAA tide gauges near the project site, showing that the mixed-semidiurnal tides are amplified in the South Bay from a MHHW elevation of 6.9 feet at San Mateo Bridge up to 7.2 feet at Dumbarton Bridge and MLLW from -0.8 to -1.4 feet. Sources of conversions from tidal to geodetic (NAVD88) datum are listed in Table 3.2.

Table 3.2. Tidal Datums and Extreme Still Water Tide Levels in South Bay

	San Mateo Bridge West, CA Station ID 9414458	**Redwood City, CA Station ID 9414523**	**Dumbarton Bridge, CA Station ID 9414509**
	Feet, NAVD88	Feet, NAVD88	Feet, NAVD88
100-year[1]	10.4	10.7	10.9
10-year[1]	9.3	9.4	9.6
MHHW	6.92	7.10	7.20
MHW	6.29	6.47	6.59
MSL	3.31	3.30	3.27
MTL	3.34	3.28	3.22
NAVD88	0	0.00	0
MLW	0.39	0.10	-0.15
MLLW	-0.80	-1.10	-1.41
NAVD88 Datum Source	Foxgrover et al. 2007	AECOM 2016	NOAA 2016

[1]Extreme still water tide levels from the *San Francisco Bay Tidal Datums and Extreme Tides Study Final Report* (AECOM 2016).

Riverine Discharge

The hydrographs for the 10- and 100-year discharge events from the OAC and ACFCC are shown in Figure 3.3. The hydrographs were obtained from DHI (2015). To confirm that the hydrographs represent a reasonable approximations to the 10- and 100-year events HEC-SSP V2.0 was used to analyze 56 years of peak flow data collected in the Federal Flood Control Channel at Union City (USGS # 11180700, located 0.2 mi upstream of Interstate 880 crossing). The analysis resulted in a 100-year peak flow of 30,410 cfs and a 10-year flow of 14, 116 cfs consistent with the hydrographs in DHI (2015). Sufficient data were not available for the OAC so the DHI (2015) values were assumed to also be sufficiently accurate for conceptual design.

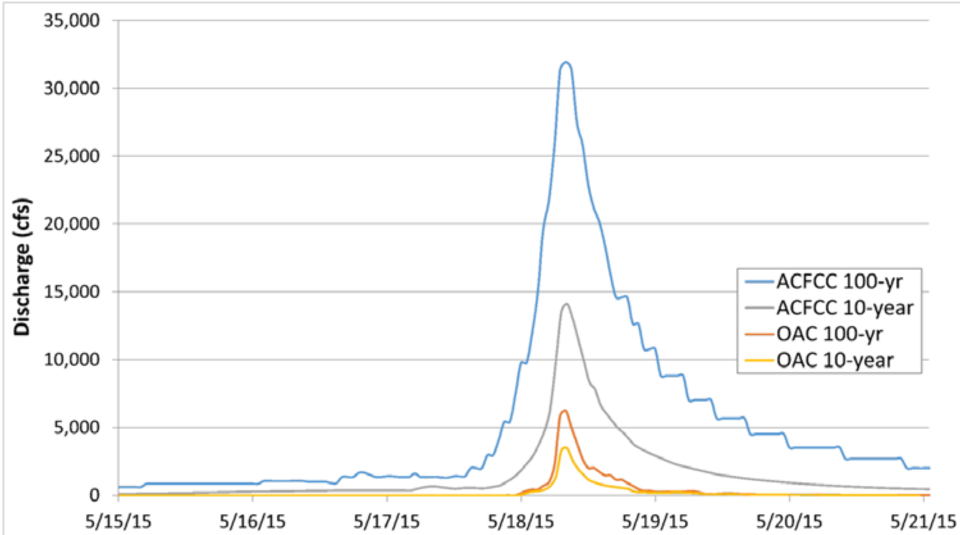

Figure 3.3. 10- and 100-year Discharge Event Hydrographs of ACFCC and OAC

3.4 Hydraulic Modeling

AECOM developed a two-dimensional hydrodynamic model using MIKE21 to refine the design of restoration features including levee breach and pilot channel dimensions, levee raising and lowering heights and locations, and culvert sizes and numbers. A one-dimensional hydraulic model using HEC-RAS was also developed to analyze culvert sizes for the C-Ponds and Inland Ponds. The methodology and results of both of these analyses are located in Attachment 1.

The result of the modeling analyses are the restoration features shown in Alternatives B, C, and D Figures (Appendix A Figures A-3, A-4, and A-5) and the content of this preliminary design beginning in Section 4 of this memo.

3.5 Water Quality Management Approaches in Managed Ponds

Currently the southern Eden Landing pond complex is managed to meet water quality objectives in accordance with the Initial Stewardship Plan, Phase 1 actions and the requirements of the Regional Water Quality Control Board's (RWQCB) Final Order, and other regulatory requirements (CDFW 2016). Alternatives C and D include continued pond management of the Inland and C-Ponds, where current management practices would continue and be supported with the installation of additional water control structures, many of which are replacements of existing deteriorating structures.

Described below are the hydraulic design criteria and managed pond operations for key water quality objectives including salinity, dissolved oxygen, and pH. The following information coincides with CDFW's (2016) System E2 and E2C Operation Plan and PWA's (2009) northern Eden Landing Pond E12/E13 Restoration Preliminary Design.

3.5.1 Hydraulic Design Criteria

The design of the managed pond hydraulics and water control structures for the Inland and C-Ponds in Alternatives C and D is based on the following design criteria.

1. Provide water level flexibility through the use of water control structures to adaptively adjust the depth and area of shallow water habitat.
2. Rely on gravity-driven flow where possible to manage water depths and meet discharge criteria. Minimize pumping.
3. During normal operations, reduce the amount and frequency of manual management of the ponds.
4. Provide management flexibility and redundant flow paths where possible.
5. Provide for supplemental approaches to salinity management when managed pond discharge criteria are not met through normal operations.

3.5.2 Managed Pond Operations

In the Inland Ponds, managed pond hydraulics are designed to flow from the OAC into Pond E6, through Pond E5 and E6C, using gravity-flow water control structures (with gravity flows driven by the tides). Water will exit in a similar path. Combination gates at both the inlets and outlets throughout the ponds will allow for flexibility in water level control.

In the C-Ponds, managed pond hydraulics are designed to flow from the ACFCC into Pond E2C, then through breaches and culverts into Ponds E2C, E5C, and CP3C. Pond E4C is fed with water from Pond E5C. Weekly readings of pond salinity and water levels, as well as visual structure inspections, will continue in ponds proposed for pond management.

3.5.2.1 Salinity

Salinity in the C-Ponds is currently maintained between 35-44 parts per thousand (ppt) over the summer, with a maximum discharge salinity of 44 ppt. Pond salinity is decreased by increasing pond inflows, in addition to circulation with adjacent seasonal ponds (such as E5C, E4C, and E1C). Whereas intake gates are usually kept fully open, discharge gate settings are routinely modified. By adjusting flow rates in this way, salinity throughout the ponds can be manipulated over a period of days to weeks.

The Inland Ponds are typically operated in the summer as seasonal (dry) or as “batch” ponds, which retain high salinity waters. Salinity in batch ponds typically increases from approximately 30 ppt in May to 120 ppt by November. Water levels and salinities in the Inland Ponds are controlled by inflows from the Bay Ponds. At the end of the evaporation season (typically October), higher salinity water from the Inland Ponds is rerouted through the Bay Ponds where it is diluted to below 44 ppt prior to discharge into the Bay. Circulation flows can also be reduced to increase pond salinity if intake salinity or pond salinity is low (~20 ppt at the intake or 30 ppt in the ponds).

These salinity management practices will continue in the C-Ponds and Inland Ponds for the managed pond Alternatives C and D.

3.5.2.2 Dissolved Oxygen

Currently the ponds are managed to retain water if dissolved oxygen falls below, or is anticipated to fall below, the trigger value of 3.3 mg/L. Discharge gates are adjusted on an approximately weekly basis. Pond E2C waters may be periodically drained into the adjacent seasonal ponds to improve circulation and water quality. Continued monitoring of receiving waters is being conducted to identify potential effects of low dissolved oxygen discharges and to evaluate whether the slough conditions meet water quality objectives. These operations will continue for the managed pond Alternatives C and D.

3.5.2.3 pH

Currently if the pH of the discharge is expected to fall outside the range of 6.5 to 8.5, an analysis of the impact of discharge pH on the receiving water waters may be performed; if the pH in the receiving waters approaches 9.0, samples may be collected from the receiving waters for analysis. Corrective measures (outlined above for dissolved oxygen and salinity) may be implemented to reduce pond discharges if it is determined that receiving water quality is being impacted. These operations will continue for the managed pond Alternatives C and D.

3.6 Geotechnical Analysis

There is limited existing geotechnical data available near the Eden Landing Pond Complex and no available subsurface data within the project area. Two previous geotechnical investigations conducted by ACFCWCD in 2011 and AMEC (2009) in 2010 provide some general geotechnical information near the project area.

The ACFCWCD's investigation of the ACFCC levees in 2011 included a series of soil borings, cone penetration tests (CPTs), and laboratory testing along the north levee of the ACFCC from the intersection of the creek and Union City Boulevard and extending downstream towards the Bay approximately 8,650 feet. The western extent of the investigation was near Pond CP3C, just south of Cal Hill. AMEC conducted an investigation in 2010 of the northern Eden Landing Ponds E8/E9 and E12/E13. The investigation included three soil borings, collection of bulk samples, and laboratory testing. Data from both of these investigations may aid in the design of project elements and provide general information about the subsurface conditions in the Eden complex, but due to the investigations occurring outside the project area, an additional investigation is recommended to support detailed design.

AECOM executed a subsurface investigation in the summer of 2016 to obtain data within the project area. Six soil borings were collected across the project area located in the vicinity of specific project elements such as levee raisings and bridge installations (see Figure 3.4). Soil samples were collected during drilling and analyzed based on the material encountered and the design inputs needed in the boring locations. Laboratory tests and geotechnical analysis are summarized in Attachment 2, Eden Landing Geotechnical Analysis.

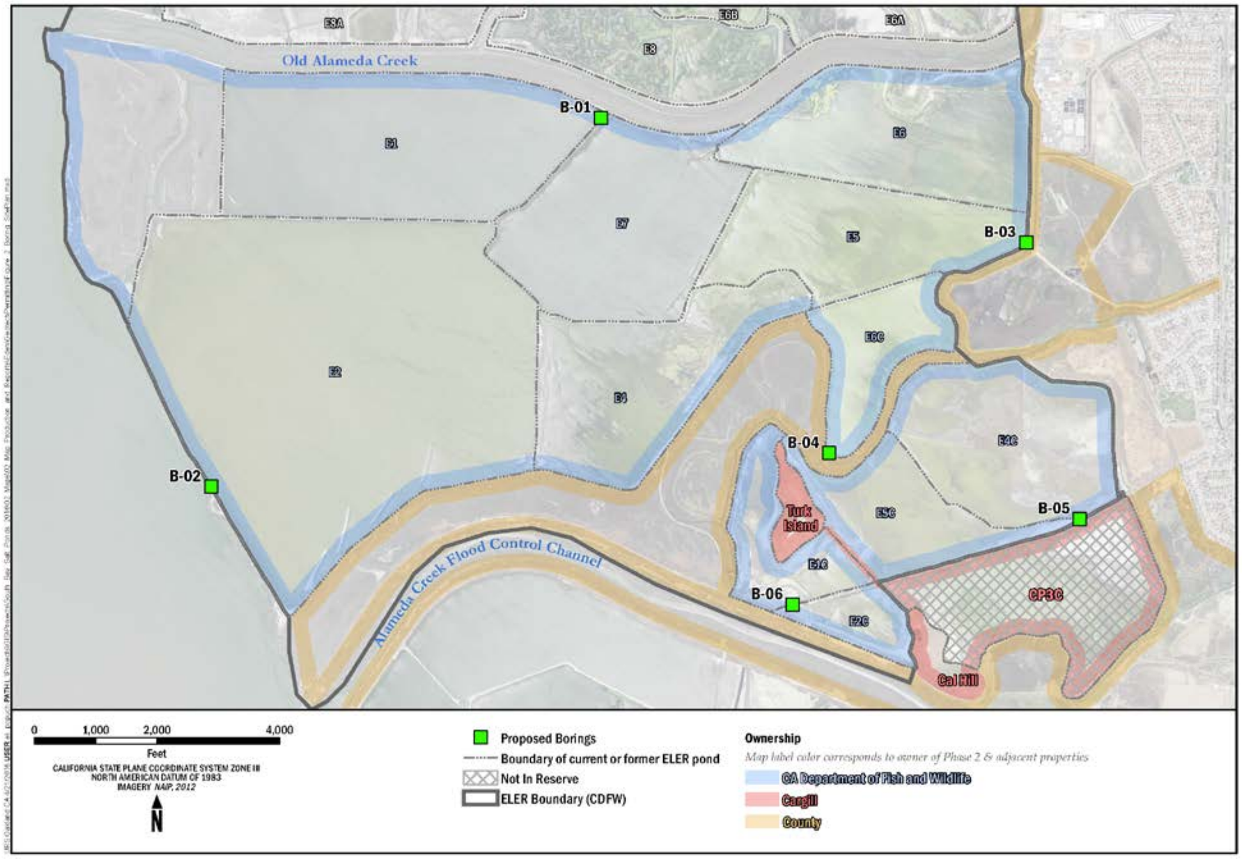

Figure 3.4. Boring Locations

During future design phases, this geotechnical data will be used to assess the existing levees' ability to support construction equipment, to perform seepage and slope stability analysis for raised levees, to evaluate the potential magnitude of consolidation settlement induced by placement of additional levee fill, and to design foundation elements for water control structures, bridge abutments, and boardwalks. Consolidation settlement will also be evaluated in areas designated for habitat transition zone fill; placement of additional fill may be required to account for settlement and achieve the proposed finished grade.

For this preliminary design, conservative assumptions were made for proposed slopes and bulking factors. Later design phases will be based off the geotechnical investigation results.

4. PRELIMINARY DESIGN

The preliminary design elements of the Eden Landing ponds are discussed in the sections below.

4.1 Preliminary Design Components

4.1.1 Site Clearance and Demolition Activities

Prior to performing construction activities, existing vegetation in areas that will be disturbed will be cleared and disposed of off-site. Similarly, sensitive vegetation located in the immediate construction areas will be handpicked, salvaged and replanted elsewhere, as appropriate.

Southern Eden Landing contains two stretches of existing power distribution lines, shown in Figure 4.1:

- Approximately 9,500 feet of power lines and 30 power poles located along the southern OAC levee.
- Approximately 8,000 feet of power lines and 35 power poles located in and near the C-Ponds, not including the span crossing the ACFCC.

In Alternatives B, C and D, the power lines and poles located along the southern OAC levee will be demolished as they currently power the pump between the OAC and Pond E1, which will be removed as part of the restoration project (in all alternatives). All other power lines and poles, including those located in and near the C-Ponds, will remain in place and operational. Proposed breaches (described in Section 4.1.4) in the C-Pond levees will not impact the current location of these lines and poles.

Existing water control structures are also shown in Figure 4.1 and detailed in Table 4.1. Two water control structures in the Island Ponds (E6 – E5 and E5 – E6C) and two water control structures in the C-Ponds (ACFCC – E2C and E2C – CP3C) will be replaced or repaired as necessary for continued operation. All remaining water control structures and associated support structures will be demolished. Demolished materials will be salvaged for re-use elsewhere, or disposed or recycled off-site. Levee breaches will be created where water control structures are removed, except at the E2-Bay, E6C-E4C, ACFCC-E1C, and E2C-E5C water control structures where the levee will be backfilled to match pre-removal heights and widths. Locations where the levees will be backfilled are noted in Table 4.1, and are a result of either maintaining flood control protection or access to Cargill or Alameda County property.

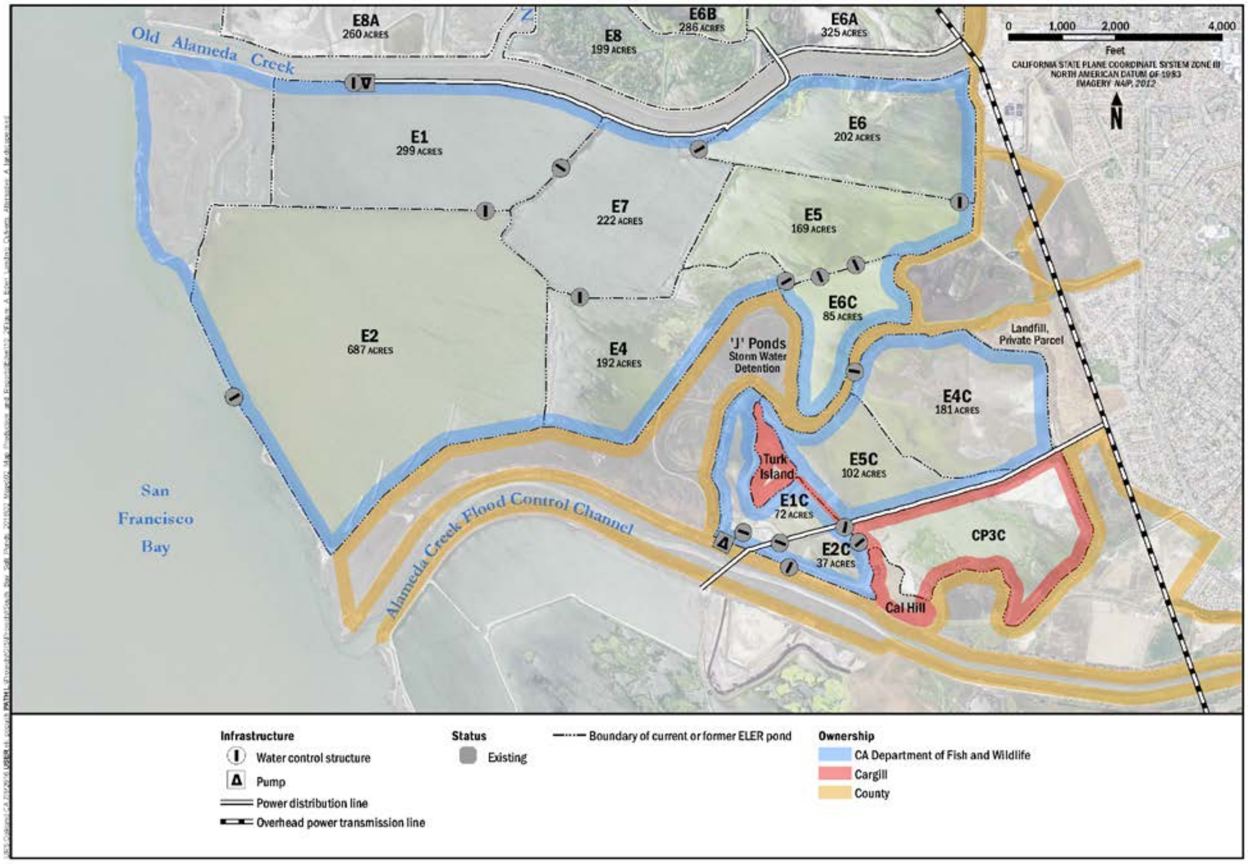

Figure 4.1. Existing Infrastructure

Table 4.1. Existing Water Control Structures Proposed Action

Location	Quantity	Size	Type	Action
E2 - Bay	2	48 in.	Intake/discharge gates	Demolish (backfill levee)
OAC - E1	4	48 in.	(2) Intake/discharge open pipes/combo gates	Demolish
			(2) Intake/discharge slide gates/flap gates	
OAC - E1	1	10,000 gpm	Pump (#1 Baumberg Intake)	
E1 - E2	1	48 in.	Slide gate	
E1 - E7	1	48 in.	Slide gate	
E7 - E4	1	48 in.	Slide gate	
E7 - E6	1	48 in.	Slide gate	
E4 - E5	1	48 in.	Combo gate	
E6 - E5	4	30 in.	Wood gates	Demolish (Alt. B) or Replace/repair (Alt. C & D)
E5 - E6C	2	36 in.	Combo gates	
E6C - E4C	2	30 in.	Siphons (not operable)	Demolish (backfill levee)
E2C - E5C	1	36 in.	Combo gate	
ACFCC - E1C	1	7,660 gpm	Pump (Cal Hill Intake) (not operable)	
ACFCC - E2C	2	48 in.	Intake/discharge combo gates	Replace/repair
E2C - CP3C	1	48 in.	Slide gate	
E2C - E2C donut	1	36 in.	Unknown (open)	Demolish
E1C - E2C donut	1 1	24 in. 10,000 gpm	Unknown (not operable) Pump (Call Hill Transfer) (not operable)	

4.1.2 Levee Raising

The design goals of levee raising include providing an equal or improved level of flood protection relative to existing conditions, providing support for Bay Trail construction, and providing support for high refuge habitat and adjacent habitat transition zones. Table 4.2 summarizes the location and length of raised levees for each alternative. Based on the hydrodynamic flood modeling summarized in Attachment 1, a raised levee elevation of 12 feet NAVD88 will provide equal or better flood protection, compared to existing conditions, thereby meeting the project flood protection objective. This is 5 feet above MHHW and provides a freeboard of about 1.5 to 2.5 feet above the maximum water surface elevation within the ponds during the design hydrologic events. Some levees will be raised also to 12 feet NAVD88 for construction of recreational trails and adjacent habitat transition zones, which are detailed in Section 4.1.9 and Section 4.1.5, respectively. Appendix A, Figures A-3, A-4, and A-5 contain plan views of these levee improvements.

Table 4.2. Proposed Raised Levees

Levee Raising Location	**Alternative B** Linear Feet	**Alternative C** Linear Feet	**Alternative D** Linear Feet	**Purpose**
Inland Ponds Landside Levee	6,000	-	6,000	Flood Protection
C-Pond Landside Levee	10,500	-	10,500	Flood Protection
Bay Trail Levee (E6C-ACFCC)	7,500	-	-	Bay Trail
Bay Levee	-	5,900	10,900	Habitat
Mid Complex Levee	-	12,900	12,900	Habitat
Total	24,000	18,800	40,300	

Design:

- Top elevation: Raised levees will have a minimum crest elevation of 12 feet NAVD88.
- Top width: Raised levees will have a minimum crest width of 12 feet.
- Side slope: The improved levees will have side slopes of 4:1 (H:V).

A typical cross-section of the proposed levee raising is shown in Figure 4.2.

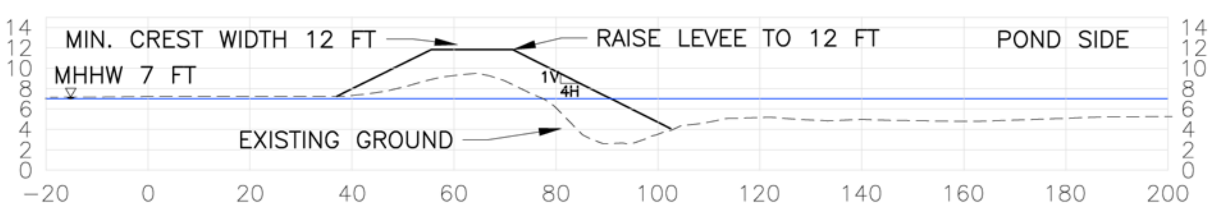

Figure 4.2. Proposed Levee Raising – Typical Section

Material for levee raising may be sourced on-site from levee lowering, levee breaching, pilot channel excavations, existing levee reshaping, and/or from off-site upland re-use materials. Levee lowering to MHHW may coincide with levee raising, without significant volumes of water entering the Bay and Inland Ponds (which will not be drained for construction).

Additional detail on the raised levees follows. Plan views are clipped from Figures A-3, A-4, and A-5 in Appendix A.

Inland Ponds Landside Levee

(Alternative B and D) Approximately 6,000 feet of perimeter levee raising, spanning from the northeast corner of Pond E6, to the south and west along Ponds E5 and E6C, and ending at the eastern corner of Pond E6C. The levees to be raised all border Alameda County property. Figure 4.3 shows the plan view (of Alt. B only), and Figure 4.4 shows profile with the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

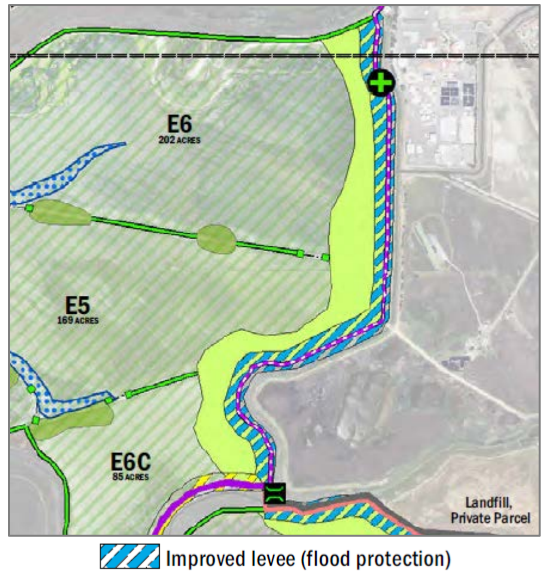

Figure 4.3. Plan of Inland Ponds Landside Levee (Alt. B)

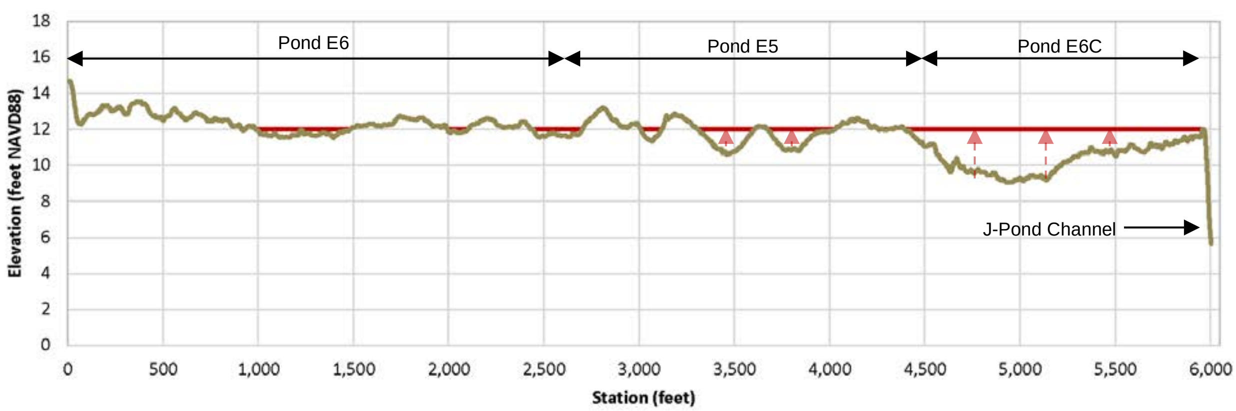

Figure 4.4. Raised Levee Profile of Inland Ponds Landside Levee

C-Ponds Landside Levee

(Alternative B and D) Approximately 10,500 feet of perimeter levee raising along the landside portion of the C-Ponds, spanning from the northern corner of Pond E4C (where the E6C levee raising ends), to the south and east around Pond E4C and then west and south along Pond CP3C ending at Cal Hill. Also includes the existing Cargill access levee to Turk Island. The eastern levee to be raised near Ponds E4C borders Alameda County property. The southern levees to be raised near Ponds E4C, E5C, and E2C border Cargill's Pond CP3C. Figure 4.4 shows the plan view (of Alt. B only) and Figure 4.6 shows the profile with the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

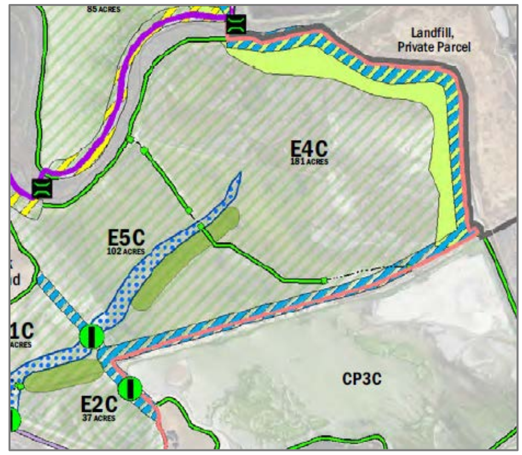

Figure 4.5. Plan of C-Ponds Landside Levee (Alt. B)

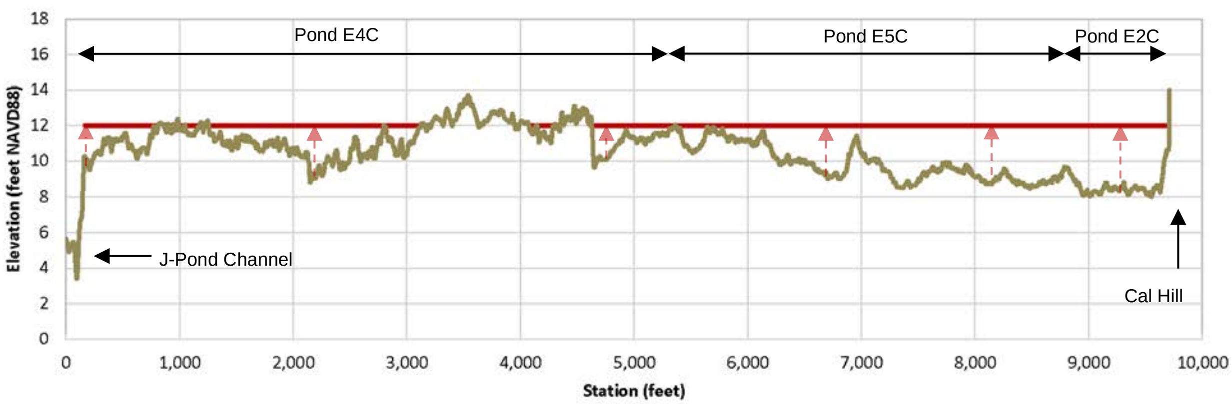

Figure 4.6. Raised Levee Profile of C-Ponds Landside Levee

Bay Trail Levee (E6C – ACFCC)

(Alternative B) Approximately 7,500 feet of perimeter levee raising along the southern E6C levee and northern E5C and E1C levees will provide a raised base levee for the Bay Trail; this levee improvement provides no flood protection. The proposed levee alignment falls all on CDFW property, except for a connecting bridge over Alameda County's J-Ponds. Figure 4.7 shows the plan view and Figure 4.8 shows the profile with the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

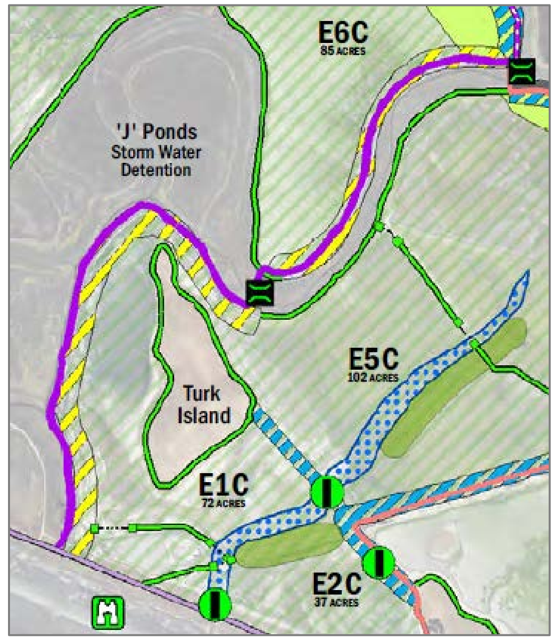

Figure 4.7. Plan of Bay Trail Levee (E6C – ACFCC) (Alt. B)

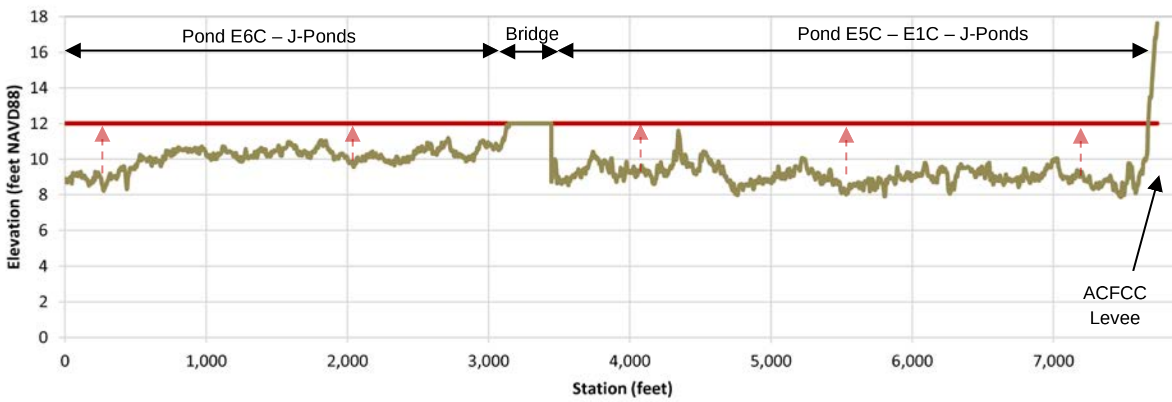

Figure 4.8. Raised Levee Profile of Bay Trail Levee (E6C – ACFCC)

Bay Levee

(Alternative C and D) Approximately 5,900 (Alt. C) and 10,900 (Alt. D) feet of perimeter levee raising along the western bay front levees of Ponds E1 and E2. The levees to be raised border the Cargill Mitigation Marsh, Southern Whale's Tale Marsh, and San Francisco Bay. Figure 4.9 shows the plan views and Figure 4.10 shows the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88. The profile view shows that in Alternative C, little raising will be performed because the existing levee is near or above the 12-foot design elevation.

The Bay Levee will be raised for habitat enhancement, not flood protection. The Eden Landing Preliminary Alternatives Analysis (URS 2014a) proposed raising the levee located between the Bay and Ponds E1 and E2. Hydrodynamic modeling results described in Attachment 1 show that tide waters will enter southern Eden Landing through the OAC breaches and lowered levees, and therefore increasing the height of the Bay levee will not reduce the water surface elevation within the Bay and Inland Ponds. Raising this Bay levee may reduce wave overtopping, however the segments lower than 12 feet NAVD88 are protected behind 1,000 to 2,500 feet of fringing marsh (and the partial Cargill Mitigation Marsh western levee).

Figure 4.9. Plan of Bay Levee (Alt. C left, Alt. D right)

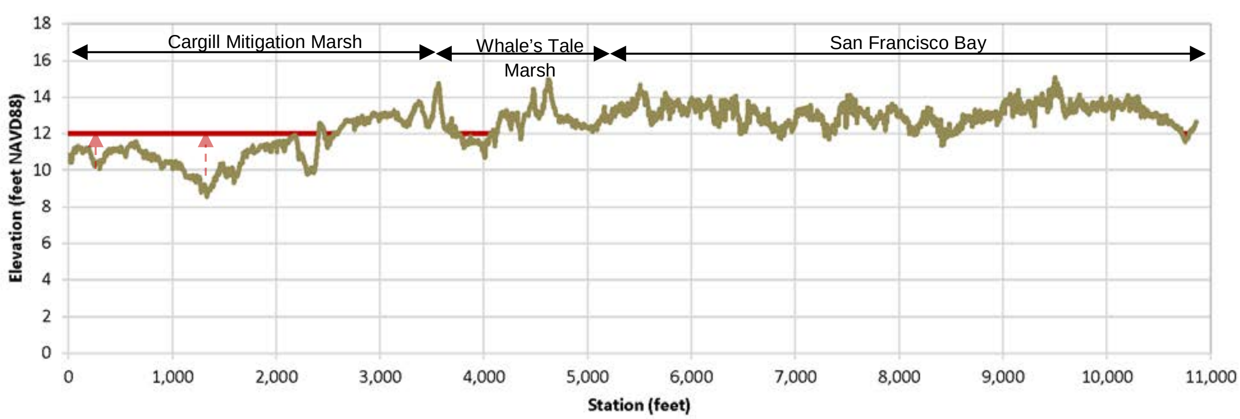

Figure 4.10. Raised Levee Profile of Bay Levee

Other approaches may also be taken for habitat enhancement, such as placing small tree trunks strategically in the ponds near or on the islands. In Alternative B, tree roots are proposed to be placed along the outer Bay levee to help create high tide refuge and help protect the levee from wave erosion. Tree "rootwads" are a natural slope stabilization technique often used in stream restoration design.

<u>Mid-Complex Levee</u>

(Alternative C and D) Approximately 12,900 feet of perimeter levee raising along a mid-complex levee spanning from the southwest corner of Pond E6, between Ponds E7, E5, and E4, across the Alameda County's "J" Ponds, connecting to the ACFCC levee near the southwest corner of Pond E1C. For Alternative C, the levee will be permanently raised. For Alternative D, the levee will be temporarily raised and a later Project Phase would breach and may also lower or remove sections of the levee to restore tidal influence to the Inland and C Ponds. Figure 4.12 shows the existing levee (as of the 2010 LiDAR) with the proposed height increase to 12 feet NAVD88.

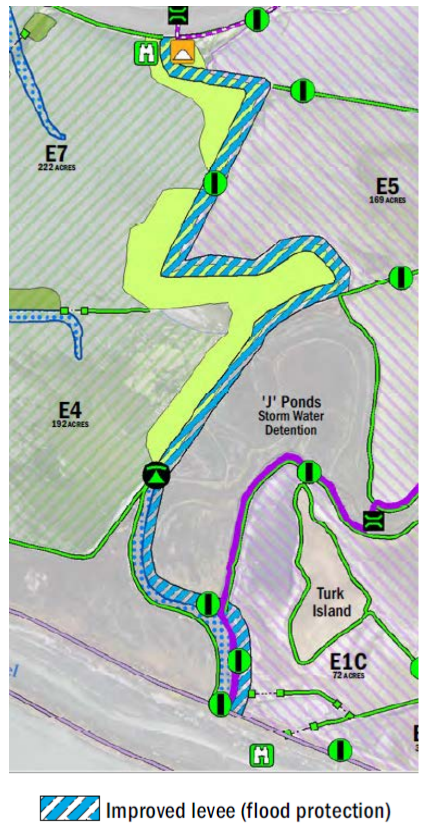

Figure 4.11. Plan of Mid-Complex Levee (Alt. C)

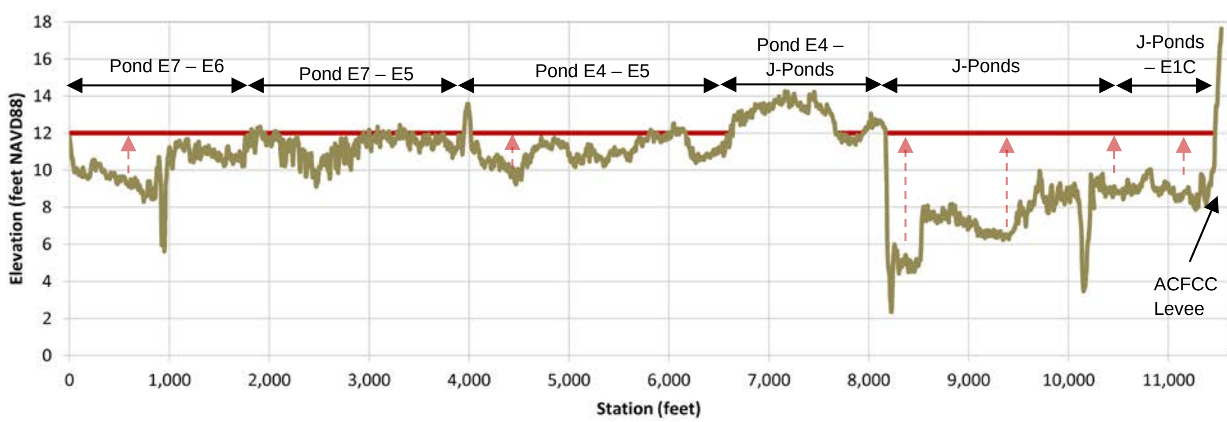

Figure 4.12. Raised Levee Profile of Mid Complex Levee

4.1.3 Levee Lowering

The design goals of levee lowering include providing an increased frequency of levee overtopping to help provide an equal or improved level of flood protection relative to existing conditions, as well as to promote increased hydraulic connectivity between channels and marshes. Table 4.3 and Figure 4.13 show the location and length of lowered levees for each alternative. Based on the hydrodynamic flood modeling summarized in Attachment 1, a lowered levee elevation to MHHW (7 feet NAVD88) will help provide equal or better flood protection by large ACFCC discharge events to overtop the lowered levees into the Bay Ponds and exit through the OAC to the Bay. This will in turn reduce flood levels traveling upstream through the J-Ponds and into inland Alameda County properties. With this approach, the restored ponds can support temporary detention of flood waters to benefit inland low-lying regions. As the ponds accrete over time and begin to support marsh habitat, the periodic tidal overtopping of the highest tides will create new breaches along these lowered levees and will increase hydraulic and habitat connectivity.

Table 4.3. Proposed Lowered Levees

Levee Lowering Location	**Alternative B** Linear Feet	**Alternative C** Linear Feet	**Alternative D** Linear Feet
OAC/E1 & E7 Levee	5,400	5,400	5,400
Fringing Marsh/E1&E2	3,800	3,800	-
ACFCC/E2 Levee	3,600	3,600	3,600
Total	12,800	12,800	9,000

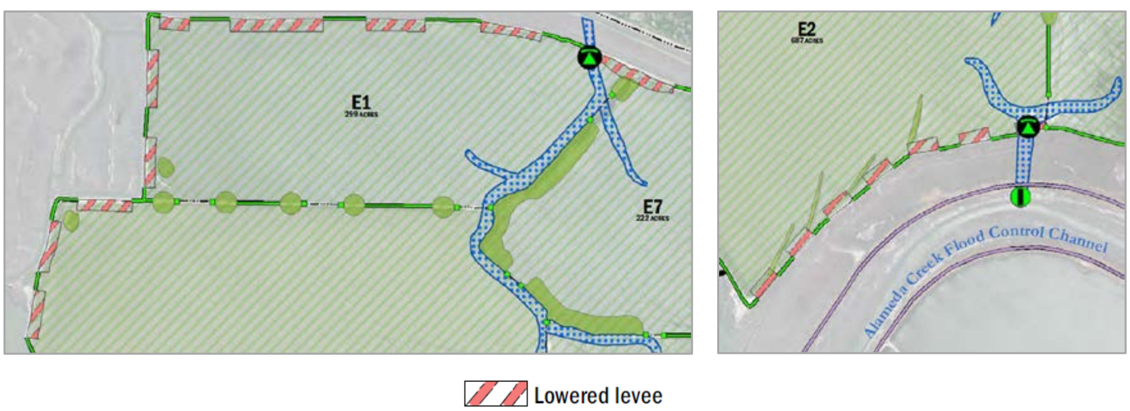

Figure 4.13. Plan of Lowered Levees (Alt. B)

Design:

- Top elevation: Lowered levees will be lowered to MHHW, 7 feet NAVD88.
- High Tide Refuge Habitat: Portions of lowered levees will remain at two feet above MHHW, or 9 feet NAVD88 to provide high tide refuge habitat.

A typical cross-section of the proposed levee lowering is shown in Figure 4.14.

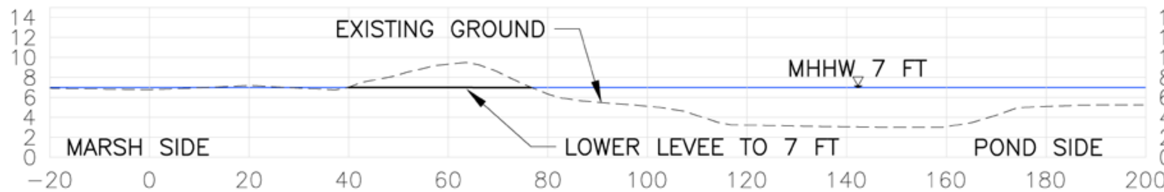

Figure 4.14. Proposed Levee Lowering – Typical Section

Material excavated from levee lowering will be reused onsite to raise levees and/or build habitat transition zones. Additional detail on the lowered levees follows.

OAC – Pond E1 and E7 Levee

(Alternatives B, C, and D) Along the 7,000-foot long northern levee of Pond E1 and E7 bordering the OAC, approximately 75% of the length (5,400 feet) will be lowered. The remaining 25% of the levee length will be left at existing elevations to provide high water refuge habitat at intervals along the levee alignment. Figure 4.15 shows the existing levee (as of the 2010 LiDAR) with the proposed levee lowering to MHHW (7 feet NAVD88).

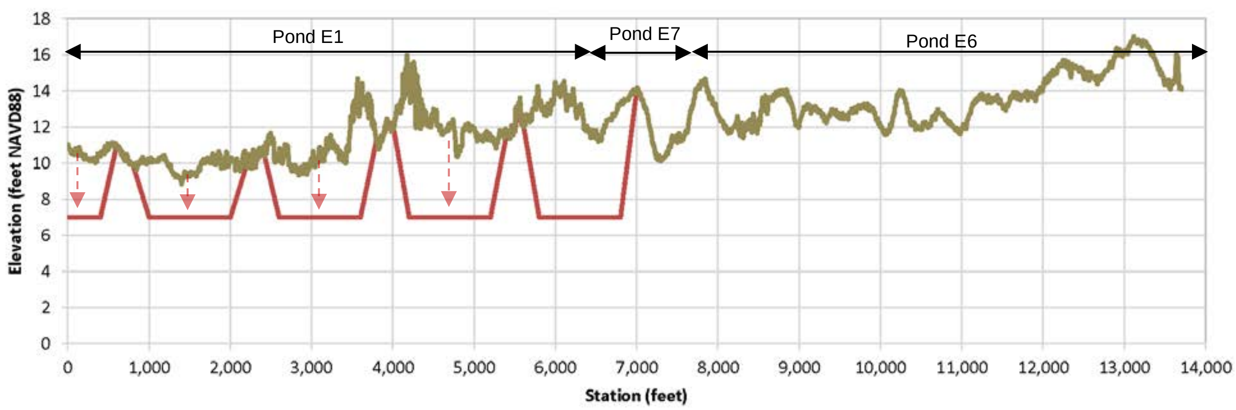

Figure 4.15. Lowered Levee Profile of OAC and Pond E1 and E7 Levees

Fringing Marsh – Pond E1 & E2 Levee

(Alternatives B and C) Along the 5,000-foot long western levee of Pond E1 and E2 bordering the Bay, approximately 75% of the length (3,800 feet) will be lowered. The remaining 25% of the levee length will be left as existing conditions to provide high water refuge habitat at intervals along the levee length. Figure 4.16 shows the existing levee (as of the 2010 LiDAR) with the proposed levee lowering to MHHW (7 feet NAVD88).

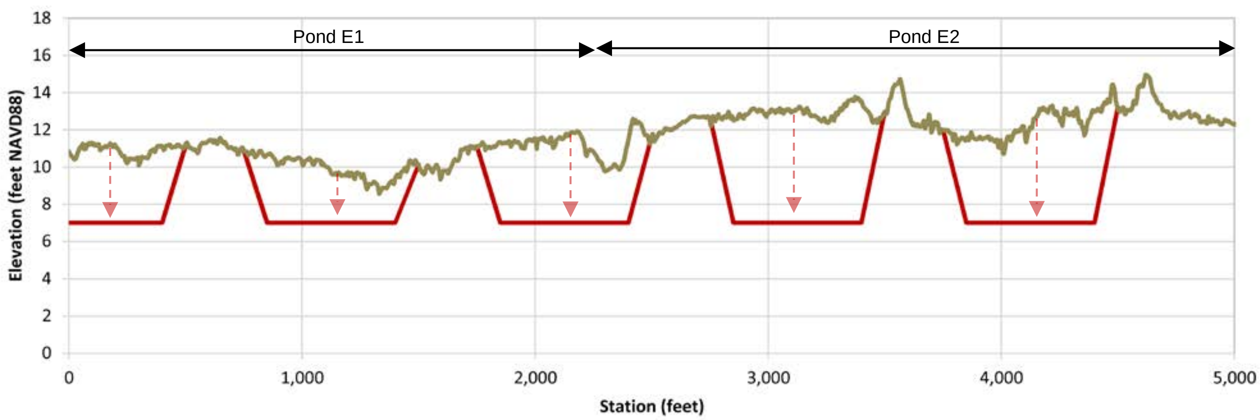

Figure 4.16. Lowered Levee Profile of Bay and Pond E2 and E1 Levee

<u>ACFCC – Pond E2 Levee</u>

(Alternatives B, C, and D) Along the 4,900-foot long southern levee of Pond E2 bordering Alameda property adjacent to the ACFCC, approximately 75% of the length (3,600 feet) will be lowered. The remaining 25% of the levee length will be left as existing conditions to provide high water refuge habitat at intervals along the levee length. Figure 4.17 shows the existing levee (as of the 2010 LiDAR) with the proposed levee lowering to MHHW (7 feet NAVD88).

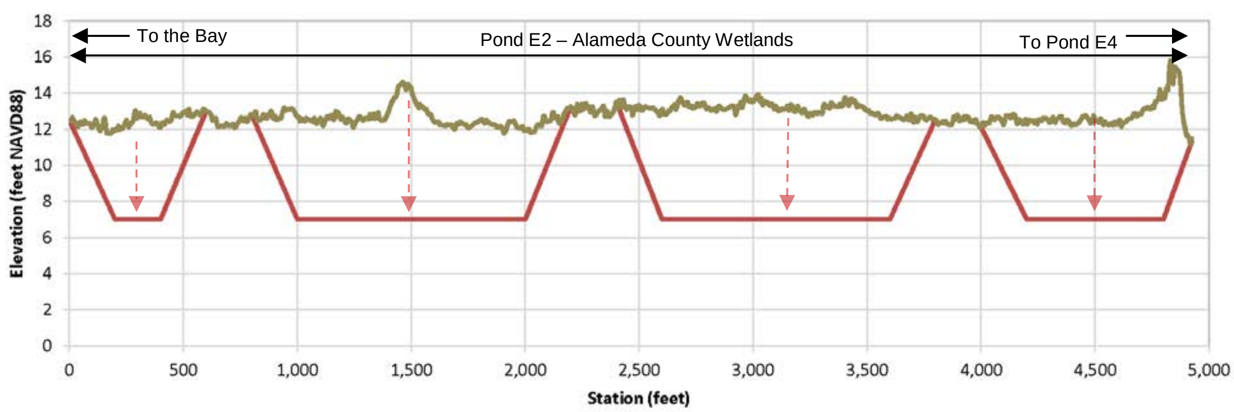

Figure 4.17. Lowered Levee Profile of Pond E2 and Alameda County Wetland Levee

4.1.4 Levee Breach

The design goal of levee breaching was to increase hydraulic connectivity between nearby sloughs and ponds. Levee breach locations were selected based on the historical slough locations and proposed pilot channel locations to maximize hydraulic connectivity between ponds. Breaches were classified as being either external or internal; external defined as a connection to an adjoining property not owned by CDFW, and internal defined as a connection between ponds (owned by CDFW). Breach locations, design details, and associated alternatives are summarized in Table 4.4 for external breaches and in Table 4.5 for internal breaches. Locations of the breaches can be seen in Appendix A Figures A-3, A-4, and A-5.

Table 4.4. External Levee Breach Design

Location	Width (ft.) (perpen. crest)	Length (ft.) (parallel crest)	Bottom Elev. (ft. NAVD88)	Slope	Purpose	Applicable Alternatives
OAC/E6	200	160	-4	3H:1V	Hydraulic connectivity	B
OAC/E1 (east)	150	380	-4			B, C and D
OAC/E1 (west)	150	30	0		Remove existing pump	B, C and D
Alameda County Wetlands/E2/E4	100	50	2.7 or higher		Fish passage	B
Alameda County Wetlands/E2	100	50	2.7 or higher			C

Table 4.5. Internal Levee Breach Design

Location	Width (ft.) (perpen. crest)	Length (ft.) (parallel crest)	Bottom Elev. (ft. NAVD88)	Slope	Purpose	Applicable Alternatives
E1/E2 (west)	50	120	-4	3H:1V	Hydraulic connectivity	B, C and D
E1/E2 (mid)	50	120	-4			B, C and D
E1/E2 (east)	50	120	-4			B, C and D
E1/E7	75	50	-4			B, C and D
E2/E7	75	50	5 (EG)			B, C and D
E7/E4	75	100	-4			B, C and D
E2/E4 (north)	50	50	-4			B, C and D
E2/E4 (south)	50	50	6 (EG)			B, C and D
E7/E6 (west)	25	25	5 (EG)			B
E7/E6 (east)	75	100	-4			B
E5/E7	75	110	-4			B
E4/E5	75	50	5 (EG)			B
E6/E5 (west)	50	50	0			B
E6/E5 (east)	50	50	0			B
E5/E6C	100	50	-4			B
E1C/E2C Donut	100	100	2.7			B, C and D
E2C Donut (west)	50	50	2.7			B, C and D
E2C Donut (east)	50	50	2.7			B, C and D
E4C/E5C (mid)	20	50	2.7			B and D
E4C/E5C (south)	20	50	2.7			B and D

Note: EG = Existing Ground

Levee breach design bottom elevations range from -4 feet to about 6 feet NAVD88. The elevation of -4 feet was chosen to align with the pilot channel depths, which were designed to allow for about one foot of water in the channels during the lowest spring tide (approximately -2.8 feet NAVD88) to prevent fish stranding. Levee breaches not connected to a pilot channel have design bottom elevations near existing grade of the ponds, or if they border a channel (as in the case of the Pond E6/E5 east and west breaches) an average elevation of 0 feet was proposed.

Levee breach widths (perpendicular to the levee crest) were based on existing topography to connect breach bottoms to pond bottoms or adjoining pilot channels. Levee breach lengths (parallel to the levee crest) were initially sized based on empirical hydraulic geometries of historic marshes in San Francisco Bay (PWA et al. 2004), and confirmed and modified as needed with MIKE21 model results (as described in Attachment 1). PWA et al.'s empirical relationships correlate equilibrium channel depth, top width, and cross-sectional area with tidal prism. As detailed in Appendix B, the potential diurnal tidal prism was calculated for each breach using the anticipated marsh area that will receive tide waters from each breach. Using the estimated tidal prism, the average channel cross-sectional area was estimated and informed the breach length when used in combination with the desired breach depth. Both the short term (immediately after the breach) and long term (future accreted marsh) tidal prisms were analyzed. The breach lengths were sized based on the channel depth assumptions, and will increase in length if the bottom channel elevation increases.

Breaches will not be armored and are expected to evolve naturally with erosion or deposition from incoming and outgoing tidal flows. The side slopes for these breaches are recommended for construction stability only. Breaches will be excavated with long reach excavators positioned on the existing levee crests. The material will be hauled to or directly placed onto locations identified to receive fill for levee raising, island or mound creation, or construction of habitat transition zones.

A typical cross-section of the proposed levee breach is shown in Figure 4.18.

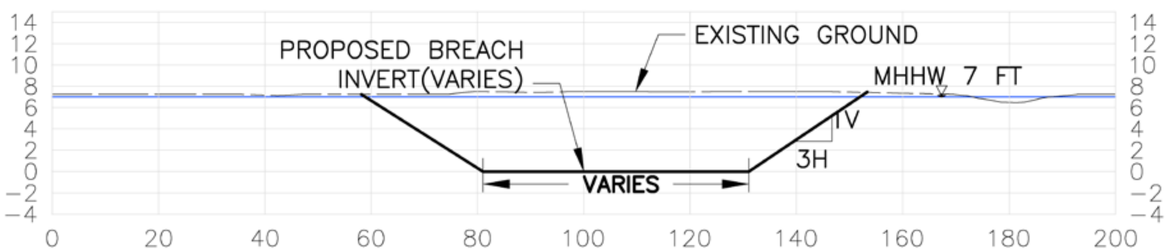

Figure 4.18. Proposed Levee Breach – Typical Section

4.1.5 Habitat Transition Zone

Habitat transition zones are areas with a wide transition in elevation from upland zones to tidal marsh zones. Low marsh, high marsh, tidal fringe, and upland habitats will develop over a habitat transition zone. The design goal of habitat transition zones is to provide areas varying in elevation to increase habitat diversity and complexity.

Table 4.6 summarizes the location and length of habitat transition zones for each alternative. Habitat transition zones will be constructed of material generated on-site from excavations of pilot channels, levee breaches, and lowered levees. Upland fill material may also be used if available from off-site construction projects, assuming it meets suitability requirements. In the case of Alternative B, material should first be utilized to construct the habitat transition zone in the Inland Ponds, as opposed to in the C-Ponds, because Pond E4C is relatively high and will be exposed to already muted tides.

Table 4.6. Proposed Habitat Transition Zones

Habitat Transition Zone Location	Alternative B Linear Feet	Alternative C Linear Feet	Alternative D Linear Feet
Inland Ponds Landside Levee	6,000	-	-
C-Pond Landside Levee	4,500	-	-
Mid Complex Levee	-	7,800	-
Bay Levee	-	-	10,900
Total	10,500	7,800	10,900

The preliminary design assumes a slope of 30:1 (H:V), which is the flattest slope that will be considered for construction, and thus the maximum fill volume and footprint for the habitat transition zones. Future designs may include slopes as steep as 10:1 (H:V), but these will require less fill material and have a smaller footprint. Habitat transition zones will be sized based on the amount of material available. Slopes varying from 10:1(H:V) to 30:1(H:V) will provide both a wide habitat transition zone as well as a gentle slope for dissipating wave energy and reducing erosion potential; all important design features for increasing sea level rise resiliency of the future marshes.

Design:

- Top elevation and slope: The top of habitat transition zone will begin at an elevation of 9.0 feet NAVD88 and extend down to pond bottom with slopes between 10:1(H:V) and 30:1(H:V).
- Slope protection: Hydroseeding with native seed mix and/or a planting schema will speed establishment of a range of vegetation, transiting from tidal marsh to upland vegetation.

Figure 4.19 shows a typical cross-section of the proposed habitat transition zone slopes along the proposed levee alignments.

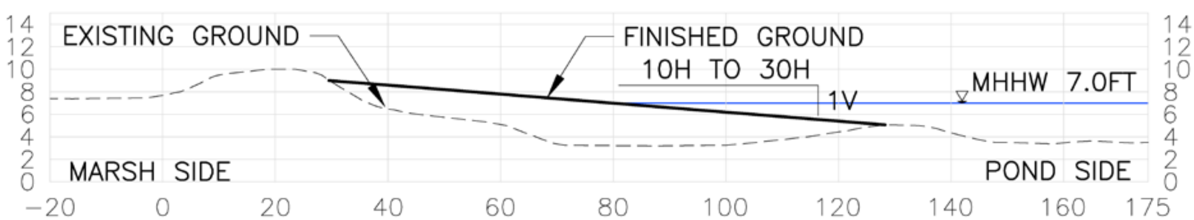

Figure 4.19. Proposed Habitat Transition Zone – Typical Section

4.1.6 Pilot Channel

The design goal of pilot channels is to facilitate draining and filling of the ponds. Without the channels, the low-lying pond depressions in the center of the ponds will not drain, slowing vegetation growth in the restored marsh. As depicted in Figure 3.2, about half of the project site historically drained towards the ACFCC or directly out to the Bay, which is currently not possible given existing property lines, levees and flood concerns. As an alternative, new main channel alignments will be constructed adjacent to existing levees in order to utilize the higher ground of the levees to support equipment access during construction, as well as to utilize the existing borrow ditch geometry to limit excavation. Channel “spurs” will offshoot the main channels into the deeper pond centers where necessary to reach pond depressions. These channel spurs will be minimized as they are more time-consuming (i.e. expensive) to construct.

Pilot channel locations, design details, and applicable alternatives are summarized in Table 4.7 and correspond to channels shown in Figures A-3, A-4 and A-5 found in Appendix A.

Table 4.7. Pilot Channel Design Details

Location	Top Channel Width (ft.)	Length (ft.)	Existing Elev. (ft. NAVD88)	Design Bottom Elev. (ft. NAVD88)	Design Slope	Applicable Alternatives
Bay Ponds Channel						
OAC island cut near E1 breach	15	250	7	0	1H:1V	B, C and D
E1 borrow ditch	30	2,500	6	-4		B, C and D
E2 borrow ditch	30	2,600	6	-4		B, C and D
E4 borrow ditch	30	1,400	6	-4		B, C and D
E1 spur	15	600	4.5	0		B, C and D
E2 spur	15	2,200	4	0		B, C and D
E7 spur	15	900	4.5	0		B, C and D
E4 spur	15	300	5	0		B, C and D
Inland Ponds Channel						
OAC island cut near E6 breach	15	250	7.5	0	1H:1V	B
E6 borrow ditch	30	2,000	5	-4		B
E7 borrow ditch	30	1,000	6	-4		B
E5 borrow ditch	30	3,400	6	-4		B
E6 spur	15	1,300	5	0		B
OAC island cut near E7 culvert	15	250	7.5	0		C and D
E6 borrow ditch (culvert route)	30	2,000	5	0		D
E5 borrow ditch (culvert route)	30	4,400	5.5	0		D
C-Ponds Channel						
E2C-E1C channel	30	1,600	5.5	2.7	1H:1V	B and D
E5C channel	30	2,000	5.5	2.7		B and D
E4C channel	30	700	5.5	2.7		B and D
Fish Passage Channel						
ACFCC to E2 and E4	15	3,100	7.5	0	1H:1V	B
ACFCC to E4 borrow ditch	15	3,100	7	2.7		C

The smaller spur channels, island cuts, and fish passage channels have design widths of 15 feet and slopes of 1:1 (H:V) with the assumption that future scouring will widen and create stable marsh slopes over time (although marsh channel slopes are relatively steep). The larger main channels have design widths of 30 feet and slopes of 1:1 (H:V), which can be constructed with a long reach excavator positioned on existing levees and reaching to the side of the levee. Excavated material will be deposited nearby to create island habitats.

In the Bay and Inland Ponds, a main channel bottom elevation of -4 feet NAVD88 was chosen to allow for about one foot of water in the channels during the lowest spring tide (approximately -2.8 feet NAVD88) to prevent fish stranding. During a MLLW tide (-1.1 feet NAVD88), about three feet of water will remain in the channels. Some sedimentation and scouring is anticipated to occur in and near the channels as they equilibrate, however, by excavating to a relatively low elevation, natural channel morphology will not be slowed by hard sills. (Hard sills created by the weight of historic levees were encountered in the northern Eden Landing Phase 1 ponds).

In the C-Ponds, a main channel bottom elevation of 2.7 feet NAVD88 was chosen to match the existing culvert invert elevation located between the ACFCC and Pond E2C. In the Inland Ponds, a main channel bottom elevation of 0 feet NAVD88 was chosen in Alternative D to align with the proposed culvert invert elevations in those ponds.

The OAC channel is comprised of a large northern stream and a smaller southern stream separated by a middle island of existing marsh. As part of Alternatives B, C and D, three different "island cuts" are proposed in the existing marsh within the OAC to connect the flow through the proposed external breaches and culverts into the larger and deeper northern stream of the OAC. If not constructed, the scouring power of the restored tidal prism will scour the southern stream, as opposed to the northern stream that is the main conveyance for flood flows. Scouring of the southern stream may cause accretion in the northern stream, which is undesired. The island cuts are narrow and intended to begin the erosion process towards a stable channel equilibrium that would develop over time.

A typical cross-section of the proposed pilot channel is shown in Figure 4.20.

Figure 4.20. Proposed Pilot Channel – Typical Section

4.1.7 Island Habitat

The design goal of the island habitats is to provide high tide refuge habitat and a means to beneficially reuse excavated material onsite. Island habitats will be constructed throughout the pond complex where existing levees will remain, separated by new levee breaches. Material excavated from the levee breaches and nearby pilot channels will be used to improve the remnant levees (island habitat) in footprint and height. The islands will be built to an elevation above MHHW to minimize exposure to tidal waters. Given the islands will be constructed from remnant levees and adjacent pilot channels, the islands will be linear in nature and the majority will be located significant distances from recreational trails to avoid habitat disturbance.

The island in Ponds E5C and E4C will be located in the middle of the pond adjacent to the pilot channel, as these ponds are relatively higher than others in the pond complex and the pond bottoms are believed accessible with heavy equipment. All other islands will be constructed from existing levees.

A select group of islands will be treated to create nesting habitat for western snowy plover, California least tern, or other bird species. The top surface of the islands will be treated with a 12-inch thick sand layer underlain by a 6-inch thick crushed rock to minimize weed establishment. The sand layer will include oyster shells or other materials to provide a primarily unvegetated, diverse landscape that is typically preferred by nesting birds.

Design:

- Top elevation: The islands will have a minimum crest elevation of 9 feet NAVD88, not including sand and rock substrate placed for habitat on top of the levee crest.
- Side slope: The nesting island will have side slopes no steeper than 7:1 (H:V) to the pond bottom.

A typical cross-section of the island habitats is shown in Figure 4.21.

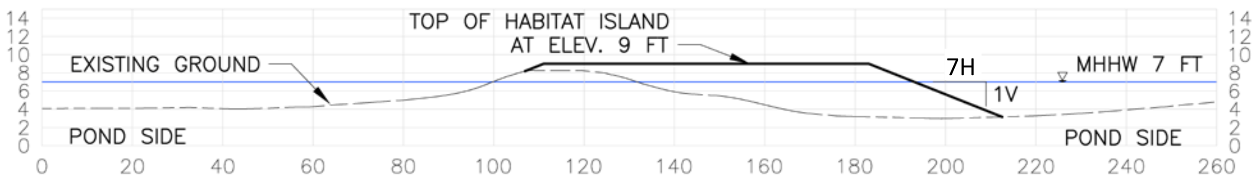

Figure 4.21 Island Habitat – Typical Section

4.1.8 Water Control Structures

The design goal of new water control structures is to facilitate the controlled movement of water between the ponds. Redundancy is desired in the proposed culvert system to provide reliability. The water control structures will have combination gates at both the inlets and outlets for maximum flexibility in water level control. A combination gate can be operated as a slide gate to allow flow in both directions, or may act as a tide gate in both directions when closed.

The design details of the proposed water control structures (new and modifications to existing) are shown in Table 4.8.

Table 4.8. Water Control Structure Design Details

Location	(Number), Size, Type	Length (ft.)	Existing Invert Elev. (ft. NAVD88)	Design Invert Elev. (ft. NAVD88)	Purpose	Applicable Alternatives
ACFCC/E2C (existing)	(2) 48 in. dia. HPDE/CMP	170	2.7	-	Hydraulic connectivity (Alt. B) or Pond management (Alt. C and D)	B, C and D
ACFCC/E2C	(2) 48 in. dia. HPDE/CMP	170	-	2.7		
E1C/E5C (south)	(2) 48 in. dia. HPDE/CMP	60	-	2.7		
E1C/E5C (north)	(1) 48 in. dia. HPDE/CMP	50	-	2.7		C and D
E2C/CP3C (existing)	(1) 48 in. dia. HPDE/CMP	60	Unknown	-		B and D
OAC/E6	(2) 48 in. dia. HPDE/CMP	150	-	0		C and D
E6/E5 (west)[1]	(1) 48 in. dia. HPDE/CMP	40	-	0		
E6/E5 (east)[1] (existing)	(1) 48 in. dia. HPDE/CMP	40	-	0		
E5/E6C (west)[2] (existing)	(1) 36 in. dia. HDPE/CMP	60	Unknown	0		
E5/E6C (east)[2] (existing)	(1) 36 in. dia. HDPE/CMP	60	Unknown	0		
ACFCC/E2&E4 via Alameda County Wetlands	(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP	200	-	2.7	Fish passage	B
E7/E5	(1) 48 in. dia. HPDE/CMP	50	-	0	Culvert redundancy	C
ACFCC/Alameda County Wetlands	(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP	200	-	2.7	Fish passage	
Alameda County Wetlands/E1C	(1) 48 in. dia. HPDE/CMP	30	-	2.7	Fish passage/pond management	
Alameda County Wetlands/J-Ponds	(1) 48 in. dia. HPDE/CMP	50	-	2.7	Detention basin management	

Note 1: E6/E5 (west) and (east) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

Note 2: E5/E6C (west) and (east) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

Water control structures will include prefabricated box culverts or circular high density polyethylene (HDPE) or corrugated metal pipe (CMP) installed through levees with either headwalls or T-shaped bridge structures to operate gate valves. For the larger water control structures, a concrete box culvert may be used to mitigate corrosion concerns typically expected in estuarine water. Alternatively, solid wall HDPE pipes may be employed as they provide a longer service life (greater than 50 years) but are typically more expensive.

A culvert, as opposed to a bridged beach, was proposed to join Ponds E1C and E5C (Cargill-owned levee) because a culvert is believed to be more cost effective than a bridge able to support maintenance vehicle access. Some of the culverts that require coordination with either Cargill or the ACFCWCD may be phased in at a later time in the project to allow for stakeholder involvement and agreement.

Additional Design Details:

- Cover: Concrete box culverts will have a minimum of 1.0 foot of cover. HDPE and CMP will require more cover than that of concrete box culverts and will be based on the diameter of the pipe and future cover analysis calculations.
- Fish Passage: Culverts intended for fish passage will consider adult and juvenile life stages and associated low and high passage flow criteria in future design phases. Because these culverts are in both a tidal and riverine system environment, different culvert heights will be considered to limit the time the culvert is flowing full. A natural culvert bottom will also be considered to encourage fish passage into the Bay Ponds from ACFCC.
- Seepage Control: Culverts will be designed to prevent through seepage along the pipe trench alignment. Engineered seepage prevention collars may be required.
- Floatation: Culverts (pipe material and wall thickness) will be designed to prevent floatation when fully inundated. Engineered concrete collars on the pipe may be required.

4.1.9 Recreational Trails

The design goal of recreational trails is to meet the recreation objectives of the project. Table 4.9 includes the trail locations and lengths. Each action alternative includes continuing the Bay Trail from its existing extent in the northern Eden Landing Ponds to the southeast corner of Pond E6C; from there three routes are proposed to connect the trail to the ACFCC levee. Plan views of the proposed trail routes are shown in Appendix A Figures A-3, A-4, and A-5.

Table 4.9. Trail Details

<table>
<tr><th>Location</th><th>Length (ft.) (parallel crest)</th><th>Purpose</th><th>Applicable Alternatives</th></tr>
<tr><td>N. Eden Landing Ponds to E6C</td><td>16,000</td><td rowspan="7">Public Access / Recreation</td><td>B, C and D</td></tr>
<tr><td>E6C to ACFCC</td><td></td><td></td></tr>
<tr><td>Route 1: CDFW Property only</td><td>7,400</td><td rowspan="3">B, C and D</td></tr>
<tr><td>Route 2: CDFW & Cargill Property</td><td>10,500</td></tr>
<tr><td>Route 3: CDFW & Alameda County Property</td><td>11,900</td></tr>
<tr><td>Alvarado Salt Works Loop</td><td>13,500</td><td>C</td></tr>
<tr><td>S. ACFCC levee connection</td><td>NA (bridge)</td><td>C</td></tr>
</table>

The trail though the Northern Eden Landing Ponds to Pond E6 includes crossing the existing tide gate structure located along the OAC. Handrails and appropriate access features would be included in the design to modify this existing, operating tide gate structure for pedestrian access.

Design:

- Width: trails designed to be part of the Bay Trail will follow Bay Trail design guidelines and may be at least 12 feet wide with a three-foot shoulder on either side, totaling to 18 feet. Trails not designated as part of the Bay Trail will be a minimum of 10 feet wide with a one-foot should on either side, totaling to 12 feet.

- Surfacing: trails will be built on improved or existing levees. Erosion or uneven surfaces on existing levees will be regraded for ADA compliance. Surfacing materials may be compacted gravel, decomposed granite, and/or native soil with stabilizing agents.
- Bridges: all bridges will be passable by pedestrians, and depending on bridge length and location may also be passable by maintenance or emergency vehicles. Maintenance and emergency vehicles currently have access to all levees via existing access routes.

4.1.10 Bridges

The design goal of bridges is to meet the recreation objectives of the project. Table 4.10 details bridge locations and lengths. Plan views of the proposed bridges are shown in Appendix A Figures A-3, A-4, and A-5.

Table 4.10. Bridge Details

Location	Length (ft.)	Purpose	Applicable Alternatives
Across J-Ponds from E6C to E4C	250	Public Access / Recreation	B, C and D
Across J-Ponds from E6C to E5C	310		B, C and D
Across OAC to Alvarado Salt Works	500		C
Across ACFCC at Cal Hill	600		C

Design Details:

- Bridge Loading: all bridges will be passable by pedestrians and bicycles. The two shorter bridges across the J-Ponds will also be accessible by maintenance and emergency vehicles. The two longer bridges across the OAC and ACFCC already have existing nearby vehicle access (i.e. the OAC tide gate structure and Union City Blvd. over ACFCC).
- Bridge Support: Given the long spans, bridges may be supported by numerous driven piles in the channels.
- Bridge Bottom Elevation: bridges spanning the OAC and ACFCC will allow for the 100-year flood event to pass underneath the bridges with sufficient freeboard. Floating structures (such as maintenance dredging and Coast Guard equipment) must also pass under, or a portion of the bridge removed for passage past, the bridge at MHHW tide. Bridges spanning the J-Ponds will be constructed to allow for Alameda County equipment access under the bridge.
- Abutment Scour: bridge abutments will be protected against scour.

Figure 4.22 depicts a typical light-duty bridge suitable for pedestrians and bicycles.

Figure 4.22 Representative Light-duty Bridge with Abutment Armoring
Source: Questa 2011

4.1.11 Interpretive Signage and Benches

Interpretive signage and benches will support the recreation objective of the project. One interpretive sign and bench may be placed near the proposed viewing platform near the intersection of the C-Ponds and the ACFCC levee (Alternatives B, C, and D). The interpretive sign will be similar to that shown in Figure 4.23. Benches will be approximately 7 or 8 feet long with coated steel supports and wood slat finished surfaces, similar to that shown in Figure 4.23.

Figure 4.23 Representative Interpretive Sign and Bench (located at northern Eden Landing Ponds)

4.1.12 Viewing Platform

Viewing platforms will provide a scenic lookout area to support the recreation objective of the project. A viewing platform will be comprised of asphalt or similar surfacing material as the proposed recreational trails and may be built near the intersection of the C-Ponds and the ACFCC levee (Alternatives B, C, and D) as well as near the Alvarado Salt Works (Alternative C). The viewing platforms will be constructed on or near levee crests and may vary in size to accommodate the existing space. Access to the platforms will be ADA accessible. A typical viewing platform is shown in Figure 4.24.

Figure 4.24 Proposed Viewing Platform

4.1.13 Union Sanitary District Connection

Union Sanitary District (USD) provides wastewater collection, treatment, and disposal services to Fremont, Newark and Union City. USD's wastewater treatment plant is located immediately east of Pond E6. Given the close proximity to the plant, southern Eden Landing may be a suitable location for wet-weather detention storage or a treated freshwater discharge. The SBSP Restoration Project team and USD are currently discussing such options and applicable permits. Alternative B contains an approximate location of a USD connection to Pond E6.

4.2 Construction Implementation

Construction will be implemented by procuring the services of a general contractor with experience in performing restoration activities, levee improvements, and working within and near tidal waters and bay mud. Site access information, along with a preliminary analysis of the schedule and cost estimate to complete the construction activities, is discussed below.

4.2.1 Access

Primary access to southern Eden Landing is near the Union Sanitary District Headquarters at the end of Horner Street, which can be reached from Dyer/Whipple Road or Alvarado-Niles exits off I-880, and Union City Blvd. Alternative access to the southern portion of southern Eden Landing is at the end of Westport Way via Carmel Way (near Sea Breeze Park) off Union City Blvd. Access routes are shown on Figure 4.25. Access throughout the pond complex is via former salt pond levee maintenance roads. Public foot and road access is permitted within some locations within the northern pond complex and along the ACFCC levees currently.

Construction vehicles shall avoid crossing any structures if the vehicle exceeds the weight-bearing capacity. If this is not possible, engineer-approved precautions shall be taken to avoid damaging the structures.

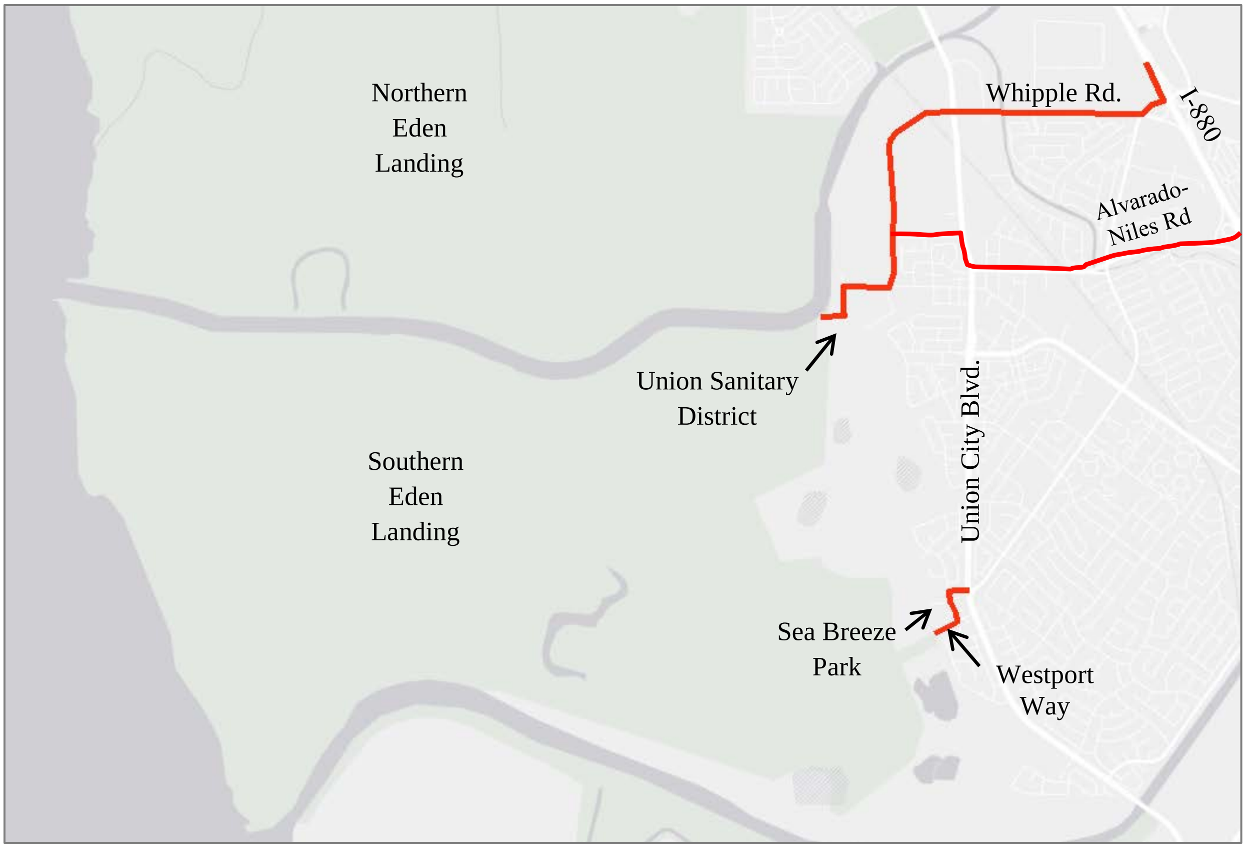

Figure 4.25 Site Access

4.2.2 Earthwork Volumes

Based on the preliminary design, estimated volumes of earthwork proposed for the Eden Landing alternatives are detailed in Table 4.11. Quantities were measured using AutoCAD Civil3D software based on terrain models of the existing and proposed ground surfaces. A bulking factor of 30% was included in both cut and fill volumes, as well as a 20% contingency.

Because the levees are comprised of dry, compacted material, material excavated from levee lowering and external breaches is most suitable for construction of raised levees. Wet bay mud generated from pilot channel excavation will be used to construct the habitat islands. Excavation of internal levee breaches will also be used to construct habitat islands to minimize hauling small amounts of material far distances around the site. Habitat transition zones will be constructed with any excess excavation from levee breaches and lowered levees, and will be supplemented with imported material if needed.

Table 4.11 shows that in Alternative B, approximately 155,000 CY of dry material will be excavated, of which 91,000 CY will be placed on levees to raise them. The remaining 64,000 CY will help build habitat transition zones and trails, although an additional 92,000 CY of material will need to be imported to construct the Alternative B habitat transition zones. Lastly, approximately 240,000 CY of wet material will be excavated and used to create habitat islands throughout the complex in this Alternative.

Table 4.11. Preliminary Earthwork Volumes

Dry Material Excavation and Placement	Alternative B		Alternative C		Alternative D	
	Cut (CY)	**Fill (CY)**	**Cut (CY)**	**Fill (CY)**	**Cut (CY)**	**Fill (CY)**
Levee Raising						
Inland Ponds Landside Levee	-	9,000	-	-	-	9,000
C-Pond Landside Levee	-	44,000	-	-	-	44,000
Bay Trail Levee	-	38,000	-	-	-	-
Bay Levee	-	-	-	2,000	-	9,000
Mid Complex Levee	-	-	-	81,000	-	81,000
Levee Lowering						
OAC/E1 & E7 Levee	-28,000	-	-28,000	-	-28,000	-
Fringing Marsh/E1&E2	-17,000	-	-17,000	-	-	-
ACFCC/E2 Levee	-25,000	-	-25,000	-	-25,000	-
Levee Breaches						
External	-85,000	-	-42,000	-	-41,000	-
Total	-155,000	91,000	-112,000	83,000	-94,000	143,000
Net Dry Material		**-64,000**		**-29,000**		**49,000**
Wet Material Excavation and Placement						
Pilot Channels						
Bay Ponds	-80,000	-	-80,000	-	-80,000	-
Inland Ponds	-71,000	-	-2,000	-	-39,000	-
C-Ponds	-13,000	-	-	-	-13,000	-
Fish Passage Channel	-18,000	-	-1,000	-	-	-
Levee Breaches						
Internal	-58,000	-	-37,000	-	-38,000	-
Habitat Islands						
Throughout Complex		240,000		120,000		170,000
Total	-240,000	240,000	-120,000	120,000	-170,000	170,000
Net		**0**		**0**		**0**
Imported Upland Fill Placement						
Habitat Transition Zones						
Inland Ponds Landside Levee	-	101,000	-	-	-	-
C-Ponds Landside Levee	-	46,000	-	-	-	-
Mid Complex Levee	-	-	-	75,000	-	-
Bay Levee	-	-	-	-	-	96,000
Trails						
Imported Trail Base	-	9,000	-	13,000	-	9,000
Total	0	156,000	0	88,000	0	105,000
Excess Dry Material Excavation		-64,000		-29,000		49,000
Net Fill Import		**92,000**		**59,000**		**154,000**

Note: Levee raise volumes assume a conservative levee crest width of 16 feet, as opposed to a minimum 12 feet.

4.2.3 Construction Methods and Equipment

Probable construction equipment includes:

- Long reach excavator(s) and drag-line excavator (working off crane mats in soft areas)
- Amphibious excavator(s) (for channel excavation)
- End dump trucks (for onsite and offsite hauling)
- Low-ground pressure (LGP) trucks (for onsite hauling)
- LGP dozer(s) (for material pushing around site)
- LGP loader(s) (for material loading into trucks)
- LGP backhoe (for trenching)
- Motor grader (for levee road leveling and upkeep)
- Temporary matting (wood or plastic for equipment support)
- Water truck(s) (dust control, moisture conditioning)
- Compactor(s) (material compaction)
- HDPE pipe fuser (culvert construction)
- Crane(s) (equipment/material loading/unloading)
- Auger drill (bridge and/or water control structure foundation piles)

This equipment list does not include smaller items such as fuel service, maintenance service, personal vehicles, small tools and equipment.

Currently, the Bay and Inland Ponds are hydraulically separated from the C-Ponds. Almost all construction at the C-Ponds may therefore be phased separately than the Bay and Inland Ponds (with levee raising in the C-Ponds being the exception because it requires excavated material from levee lowering in the Bay Ponds). Assuming construction is performed in the Bay, Inland, and C-Ponds concurrently (un-phased throughout the site) the sequence of construction tasks for Alternative B may include the following:

- <u>Pre-construction Pond Management</u>: Lower pond water levels to lowest possible levels for improved site access.
- <u>Mobilization</u>: develop submittals, staging areas, and other facilities. Mobilize equipment to the site via ground transportation.
- <u>Site Preparation</u>: Where necessary, clear and grub work areas, scarify slopes, and repair/raise low access roads in preparation of work.
- <u>Demolition</u>: Demolish existing structures and backfill as identified.
- <u>USD Connection:</u> Construct, if included in project.
- <u>Bridges:</u> Construct pedestrian bridges. Construction methods may include cofferdams, foundation piles, cast in-place concrete abutments, and placement of riprap scour protection.
- <u>Water Control Structures:</u> Excavate trenches and temporarily store material. Install HDPE or CMP pipe using flatbed trucks for delivery, loaders for lowering pipe in place, and HDPE pipe fuser to connect pipe sections (if necessary). Install valves.

- Internal Breaches, Channels & Habitat Islands: Excavate internal breaches and channels. Place material nearby to create habitat islands. Dozers would move material laterally as necessary to construct habitat islands with excavated material.
- OAC Island Cuts: Construct limited temporary roads (with mats and material) as necessary to excavate island cuts in existing OAC marsh. Load material on trucks and place onsite as habitat islands/habitat transition zones.
- Habitat Transition Zones: Utilize excess onsite material as it becomes available, or import material from offsite locations to place and grade for construction of habitat transition zones. Scarify slopes prior to placement. Shape material with a dozer.
- Lower & Raise Levees: Working from the levee top, excavate material, load onto trucks, transport onsite and place at levee raising locations. If excess material is available, use material to build habitat transition zones.
- External Breaches & Raise Levees: Excavate external breaches with long reach excavators. Haul material onsite to complete levee raises. Import material to raise levees as needed.
- Trails and Viewing Platforms: Grade and compact proposed trail pathways. Import, place and compact trail base material. Geotextile fabric may be laid out, gravel compacted in-place, and quarry fines compacted on top to create an accessible surface. Create viewing platforms at-grade off-set from the main trail pathway; or if elevated, drill platform foundations and assemble onsite using small power tools.
- Signage and Benches: Install trails, signage, and benches on identified levees.
- Demobilization: Demobilize equipment via ground transportation.

A similar task construction sequence may be performed if Alternatives C and D are selected; however with the construction of a mid-complex levee, the contractor may choose to phase tasks between the Bay Ponds (planned to be tidal habitat) and the Inland and C-Ponds (planned to be managed ponds). For instance, if the Inland and/or C-Ponds are desired managed pond habitat for species, their project features may be constructed after completion of the features within the Bay Ponds (including the mid-complex levee). Some sequence constraints in these options, such as constructing the habitat transition zones before lowering access levees (Alternative D).

It is assumed that the bottom of the Bay and Inland Ponds will not support LGP equipment without temporary access road construction. It is also assumed that the bottom of the C-Ponds, with the exception of possibly Pond E2C, will support LGP equipment for the construction of channels within the pond bottoms. It is also assumed that fill will be imported as a rate that ensures an efficient construction operation. All fill is assumed to be imported from a dirt broker at no cost to the project.

The final equipment and sequencing will be developed by the selected contractor based on the contractor's detailed work plan.

4.2.4 Schedule

The construction schedule will be driven by the volume of earthwork, construction work windows, weather conditions, and contractor means and methods.

4.2.4.1 *Construction Work Windows*

Construction activities will occur within permitted work windows to avoid impacts to special-status and other sensitive species. The dates provided were developed based on the Eden Landing Pond E12/13 Restoration Preliminary Design (PWA 2009) and the Alviso-Island Ponds A19, A20, and A21 Preliminary Design Memorandum (URS 2014b). Permits for this project may have different construction limitations.

In-channel construction will likely be limited between April 15 to October 15 when water levels are lowest. Considerations include:

- Steelhead could be present from December 15 to April 30. In-channel work between April 15 and April 30 should have an approved biological monitor present and should be done at low tides whenever possible.
- Longfin smelt and sturgeon could be present year-round. In-channel work should have an approved biological monitor present and should be conducted at low tide if possible.

Construction activities in bird nesting areas could be limited during the following periods listed for each species:

- March 1 to September 15 for western snowy plover
- February 1 to September 1 for terns, avocets, and stilts
- February 1 to September 1 or earlier (as allowed) for California Ridgway's rail

Negative results of pre-construction surveys and monitoring efforts could lengthen the permitted construction periods. Work in the spring and summer (March - August) is not prohibited, but approved buffer zones could be implemented to allow work to continue during nesting seasons.

4.2.4.2 *Construction Schedule*

Construction is expected to begin in 2018. Assuming a construction window of September 1 through March 1, a preliminary estimate of the overall duration of construction is shown in Table 4.12.

Table 4.12. Preliminary Project Construction Durations

Alternative	Duration (months) *
Alternative Eden B	29
Alternative Eden C	27
Alternative Eden D	27

*Duration is from initiation of mobilization to final demobilization and includes sequential, seasonal down time.

The construction durations for habitat transition zone creation will be primarily controlled by the availability of upland fill material that can be imported to the project site. Durations assume that sufficient fill material is available to allow for continuous operation during the construction windows, but that the quantity available will only allow for one habitat transition zone construction crew at a time. Habitat transition zone construction durations range from 7, 3.5, to 5 months (five 8-hour working days per week, with 4.35 weeks/month) for Alternatives B, C, and D (assuming single crews), which is a significant portion of the project duration. These durations also assume upland material is hauled onsite at the rate of possible placement, although road capacity will likely restrict delivery of material, possibly doubling the time required to build the habitat transition zones. Based on experiences at Inner Bair Island, if fill material will be provided by an independent dirt broker at no cost to the project, it is recommended that the above durations be increased if used for permitting or scheduling.

Other construction elements were allowed to occur concurrently with multiple crews provided that they made reasonable sense. The estimate is based on the assumption that some heavy construction activities may be permitted to occur during the nesting habitat window under the watch of a biological monitor.

4.2.5 Preliminary Cost Estimate

Table 4.13, Table 4.14, and Table 4.15 contain preliminary rough order of magnitude construction cost estimates for the three Eden Landing action alternatives. Each estimate depends on distinct features that may or may not be included in the final preferred alternative. Unit costs were developed based on a combination of similar AECOM project experience, unit construction costs from a contractor experienced in salt marsh restoration construction, the R.S. Means estimate guide, and vendor quotes.

Item #	Line Item	Quantity	Unit	Unit Cost	Amount
1	Mobilization & Demobilization				$1,881,300
1.1	Mobilization & Demobilization	1	LS	15%	$1,881,300
2	Site Preparation				$413,400
2.1	Clear & Grub	39	ACRE	$4,000	$156,000
2.2	Demolition Water Control Structures	16	EACH	$8,900	$142,400
2.3	Demolition Electrical Lines	1	LS	$115,000	$115,000
3	Earthwork				$6,728,000
3.1	Levee Raising (haul, fill)	91,000	CY	$17	$1,547,000
3.2	Levee Lowering (cut)	56,000	CY	$3	$168,000
3.3	Levee Breaches - External (cut)	68,000	CY	$7	$476,000
3.4	Levee Breaches - Internal (cut, haul, fill)	47,000	CY	$13	$611,000
3.5	Channels & Islands (cut, fill)	110,000	CY	$9	$990,000
3.6	Channel spurs (access road, cut, haul, fill)	36,000	CY	$27	$972,000
3.7	Habitat Transition Zones (haul, fill)	147,000	CY	$12	$1,764,000
3.8	Hydroseeding	20	ACRE	$10,000	$200,000
4	Structures				$4,450,000
4.1	Water Control Structures	-	-	-	-
4.1.1	ACFCC/E2C (add to existing; two 48" pipes, 170 lf with headwalls & gates)	1	EACH	$670,000	$670,000
4.1.2	ACFCC/E2&E4 via Alameda County Wetlands (6'x6' concrete box, 200 lf with headwalls & gates)	1	EACH	$630,000	$630,000
4.1.3	E2C/CP3C (replace existing one 48" pipe, 75 lf, with gates)	1	EACH	$375,000	$375,000
4.1.4	E1C/E5C (south) (one 48" pipe, 75 lf, with gates)	1	EACH	$375,000	$375,000
4.2	Bridges (~300 ft long)	2	EACH	$1,600,000	$3,200,000
4.3	Bridges (~500 ft long)	0	EACH	$2,100,000	$0
5	Public Access Features				$950,300
5.1	Recreational Trails	311,200	SF	$3	$933,600
5.2	Interpretive Signage	1	EACH	$3,900	$3,900
5.3	Benches	1	EACH	$6,800	$6,800
5.4	Viewing Platform	1,000	SF	$6	$6,000
	Subtotal				$15,343,000
	Design & Unit Cost Contingency			25%	$3,835,800
	Total Direct Construction Cost				$19,178,800
	Construction Contingency			30%	$5,753,700
	Total				**$24,932,500**

Table 4.13. Preliminary Cost Estimate for Eden Landing – Alternative B

Item #	Line Item	Quantity	Unit	Unit Cost	Amount
1	Mobilization & Demobilization				$2,554,100
1.1	Mobilization & Demobilization	1	LS	15%	$2,554,100
2	Site Preparation				$353,800
2.1	Clear & Grub	33	ACRE	$4,000	$132,000
2.2	Demolition Water Control Structures	12	EACH	$8,900	$106,800
2.3	Demolition Electrical Lines	1	LS	$115,000	$115,000
3	Earthwork				$4,145,000
3.1	Levee Raising (haul, fill)	82,000	CY	$17	$1,394,000
3.2	Levee Lowering (cut)	56,000	CY	$3	$168,000
3.3	Levee Breaches - External (cut)	34,000	CY	$7	$238,000
3.4	Levee Breaches - Internal (cut, haul, fill)	29,000	CY	$13	$377,000
3.5	Channels & Islands (cut, fill)	48,000	CY	$9	$432,000
3.6	Channel spurs (access road, cut, haul, fill)	18,000	CY	$27	$486,000
3.7	Habitat Transition Zones (haul, fill)	75,000	CY	$12	$900,000
3.8	Hydroseeding	15	ACRE	$10,000	$150,000
4	Structures				$11,075,000
4.1	Water Control Structures	-	-	-	-
4.1.1	ACFCC/E2C (add to existing; two 48" pipes, 170 lf with headwalls & gates)	1	EACH	$670,000	$670,000
4.1.2	ACFCC/Alameda County Wetlands (6'x6' concrete box, 200 lf with headwalls & gates)	1	EACH	$630,000	$630,000
4.1.3	OAC/E6 (two 48" pipes, 150 lf with gates)	1	EACH	$430,000	$430,000
4.1.4	E1C/E5C (south) (one 48" pipe, 60 lf with gates)	1	EACH	$370,000	$370,000
4.1.5	E1C/E5C (north) (one 48" pipe, 50 lf with gates)	1	EACH	$365,000	$365,000
4.1.6	Wetlands/E1C (one 48" pipe, 30 lf with gates)	1	EACH	$355,000	$355,000
4.1.7	Wetlands/J-Ponds (one 48" pipe, 50 lf with gates)	1	EACH	$365,000	$365,000
4.1.8	E6/E5 (west) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.9	E6/E5 (east, replace existing) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.10	E5/E6C (west, repair gates only)	1	EACH	$100,000	$100,000
4.1.11	E5/E6C (east, repair gates only)	1	EACH	$100,000	$100,000
4.1.12	E7/E5 (one 48" pipe, 50 lf with gates)	1	EACH	$370,000	$370,000
4.2	Bridges (~300 ft long)	2	EACH	$1,600,000	$3,200,000
4.3	Bridges (~500 ft long)	2	EACH	$2,100,000	$4,200,000
5	Public Access Features				$1,453,000
5.1	Recreational Trails	473,200	SF	$3	$1,419,600
5.2	Interpretive Signage	2	EACH	$3,900	$7,800
5.3	Benches	2	EACH	$6,800	$13,600
5.4	Viewing Platform	2,000	SF	$6	$12,000
	Subtotal				$20,500,900
	Design & Unit Cost Contingency			25%	$5,125,300
	Total Direct Construction Cost				$25,626,200
	Construction Contingency			30%	$7,687,900
	Total				**$33,314,100**

Table 4.14. Preliminary Cost Estimate for Eden Landing – Alternative C

Item #	Line Item	Quantity	Unit	Unit Cost	Amount
1	Mobilization & Demobilization				$1,955,700
1.1	Mobilization & Demobilization	1	LS	15%	$1,955,700
2	Site Preparation				$450,700
2.1	Clear & Grub	55	ACRE	$4,000	$220,000
2.2	Demolition Water Control Structures	13	EACH	$8,900	$115,700
2.3	Demolition Electrical Lines	1	LS	$115,000	$115,000
3	Earthwork				$5,867,000
3.1	Levee Raising (haul, fill)	143,000	CY	$17	$2,431,000
3.2	Levee Lowering (cut)	42,000	CY	$3	$126,000
3.3	Levee Breaches - External (cut)	33,000	CY	$7	$231,000
3.4	Levee Breaches - Internal (cut, haul, fill)	30,000	CY	$13	$390,000
3.5	Channels & Islands (cut, fill)	89,000	CY	$9	$801,000
3.6	Channel spurs (access road, cut, haul, fill)	17,000	CY	$27	$486,000
3.7	Habitat Transition Zones (haul, fill)	96,000	CY	$12	$1,152,000
3.8	Hydroseeding	25	ACRE	$10,000	$250,000
4	Structures				$5,770,000
4.1	Water Control Structures	-	-	-	-
4.1.1	ACFCC/E2C (add to existing; two 48" pipes, 170 lf with headwalls & gates)	1	EACH	$670,000	$670,000
4.1.2	E2C/CP3C (replace existing one 48" pipe, 75 lf, with gates)	1	EACH	$375,000	$375,000
4.1.3	OAC/E6 (two 48" pipes, 150 lf with gates)	1	EACH	$670,000	$670,000
4.1.4	E1C/E5C (south) (one 48" pipe, 60 lf with gates)	1	EACH	$370,000	$370,000
4.1.5	E1C/E5C (north) (one 48" pipe, 50 lf with gates)	1	EACH	$365,000	$365,000
4.1.6	E6/E5 (west) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.7	E6/E5 (east, replace existing) (one 48" pipe, 40 lf with gates)	1	EACH	$360,000	$360,000
4.1.8	E5/E6C (west, repair gates only)	1	EACH	$100,000	$100,000
4.1.9	E5/E6C (east, repair gates only)	1	EACH	$100,000	$100,000
4.2	Bridges (~300 ft long)	2	EACH	$1,600,000	$3,200,000
4.3	Bridges (~500 ft long)	0	EACH	$2,100,000	$0
5	Public Access Features				$950,300
5.1	Recreational Trails	311,200	SF	$3	$933,600
5.2	Interpretive Signage	1	EACH	$3,900	$3,900
5.3	Benches	1	EACH	$6,800	$6,800
5.4	Viewing Platform	1,000	SF	$6	$6,000
	Subtotal				$15,913,700
	Design & Unit Cost Contingency			25%	$3,978,500
	Total Direct Construction Cost				$19,892,200
	Construction Contingency			30%	$5,967,700
	Total				**$25,859,900**

Table 4.15. Preliminary Cost Estimate for Eden Landing – Alternative D

Note: LS = lump sum; CY = cubic yards; apparent errors in table totals due to rounding.

The following assumptions were made in developing this preliminary cost estimate.

- Pond bottoms of the Bay and Inland Ponds will be wet during construction and will not support low ground pressure equipment without matting and road construction out into the ponds. Pond bottoms of the C-Ponds will be dry during construction and have the ability to support low ground pressure equipment.
- Building temporary roads out into the ponds to excavate channels requires construction sequencing considerations because fill material will have to be brought into the site, and efficient management of this fill material could reduce costs.
- Import fill is assumed to be provided to the projects by a dirt broker at no cost to the project and in a quantity that does not limit typical equipment production rates.
- Significant culvert costs include T-shaped bridge structures (on both sides) to operate gates, sheet piling, dewatering, trenching, HDPE piping, and combination gates on either side of the pipe. (HDPE pipe is assumed in this estimate as opposed to CMP.)
- Significant concrete box culvert costs include concrete headwalls (both sides), sheet piling, dewatering, trenching, cast-in-place concrete, and combination gates on either side of the culvert.
- Approximately half of the disturbed acreage from levee raising and cutting is assumed to be hydroseeded, as areas exposed to tidal waters are anticipated to be naturally seeded once tidal exchange is returned to the ponds.
- Each Alternative contains optional Trail Routes 1, 2, and 3. An average distance of Trail Routes 1, 2, and 3 (approximately 10,000 linear feet) was used in cost estimates.
- The estimate includes a design and unit cost contingency of 25 percent to cover changes to the design assumptions and components and uncertainty in material unit costs.
- The estimate includes a construction contingency of 30 percent to cover changes to the project costs during construction.
- The contingencies do not include costs for engineering design, environmental documentation, permits, or contract and construction administration.

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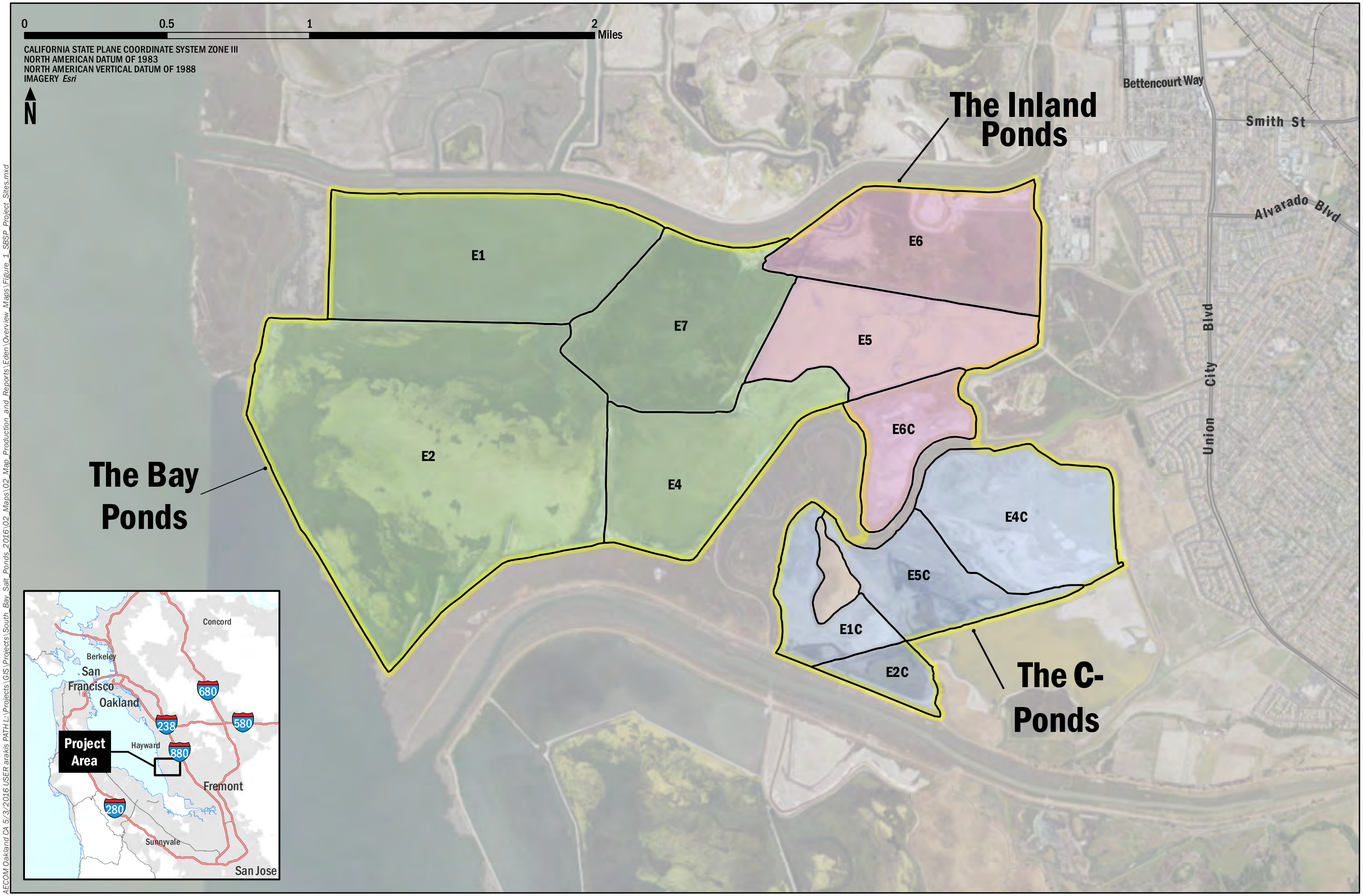
Appendix A

Eden Landing Figures



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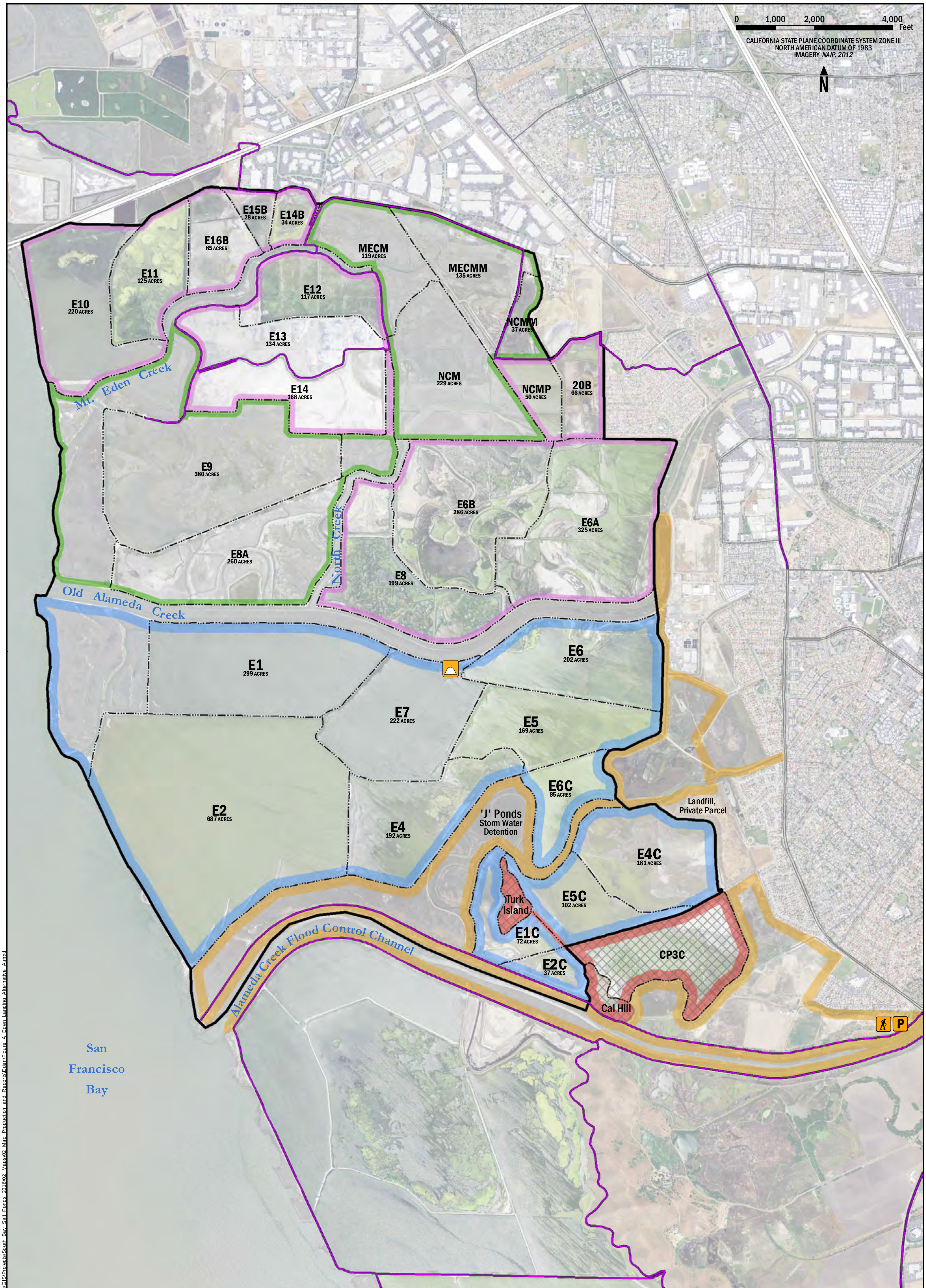
LEGEND

- Phase 2 Eden Landing Project Area
- The Bay Ponds
- The C Ponds
- The Inland Ponds

AECOM

South Bay Salt Pond Restoration Project
Eden Landing Phase 2: Project Area

Figure A-1
Eden Landing Phase 2: Project Area



Existing Alvarado Salt Works

Existhing Trailhead

Existing Parking lot

Existing trail

Boundary of current or former ELER pond

Phase 2 Project area

Phase 1

Enhanced managed pond

Tidal marsh

Ownership

CA Department of Fish and Wildlife

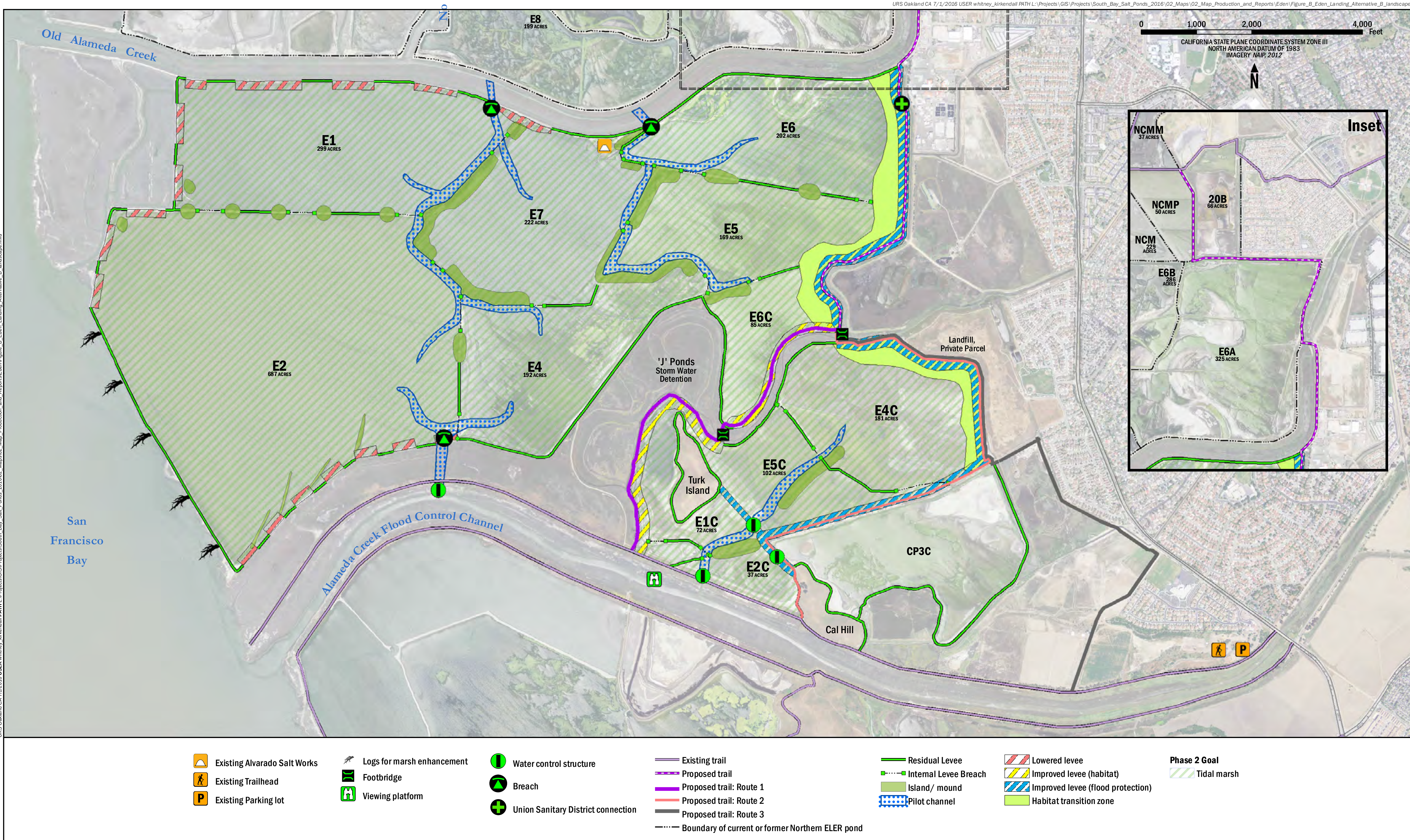
Cargill

County

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden A



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden B

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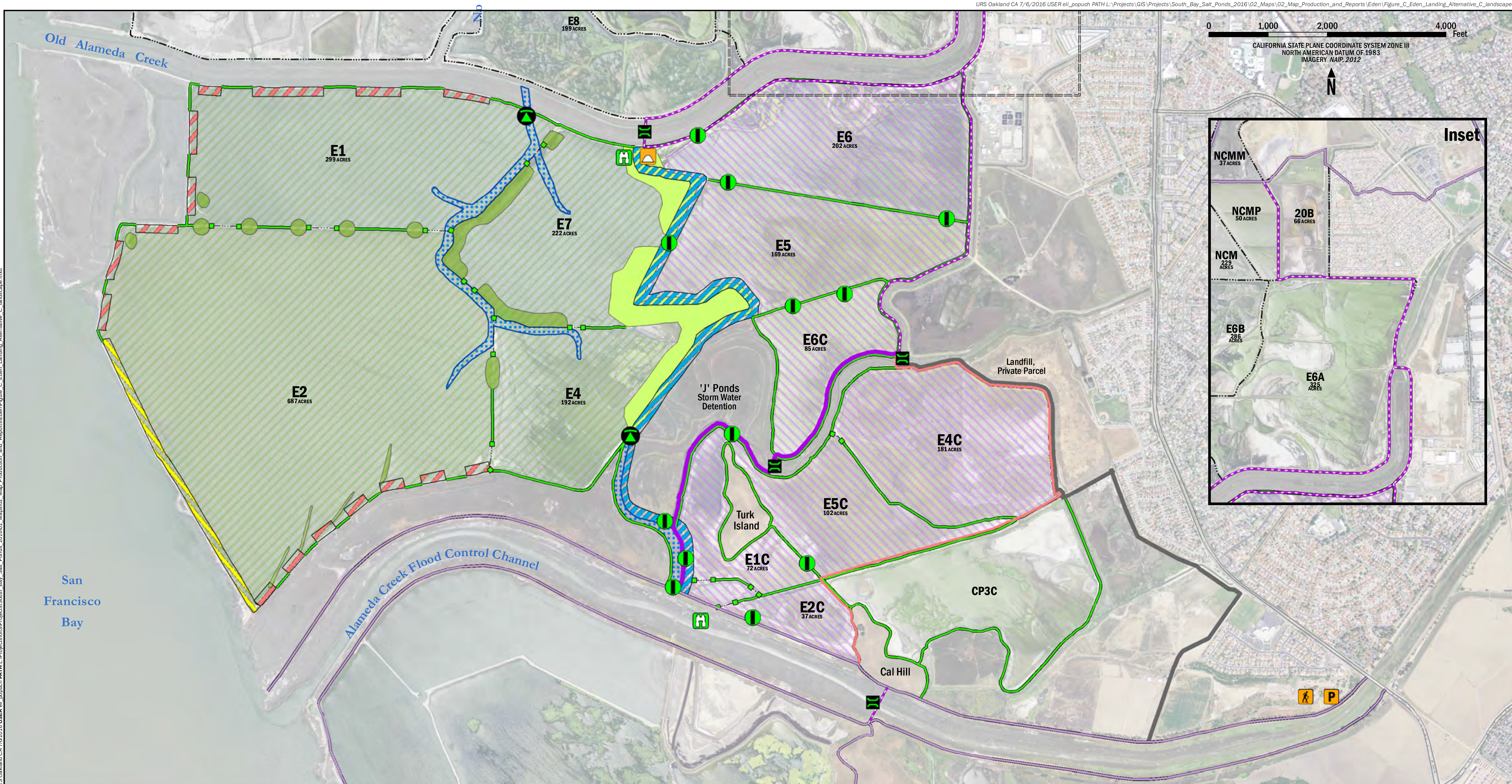
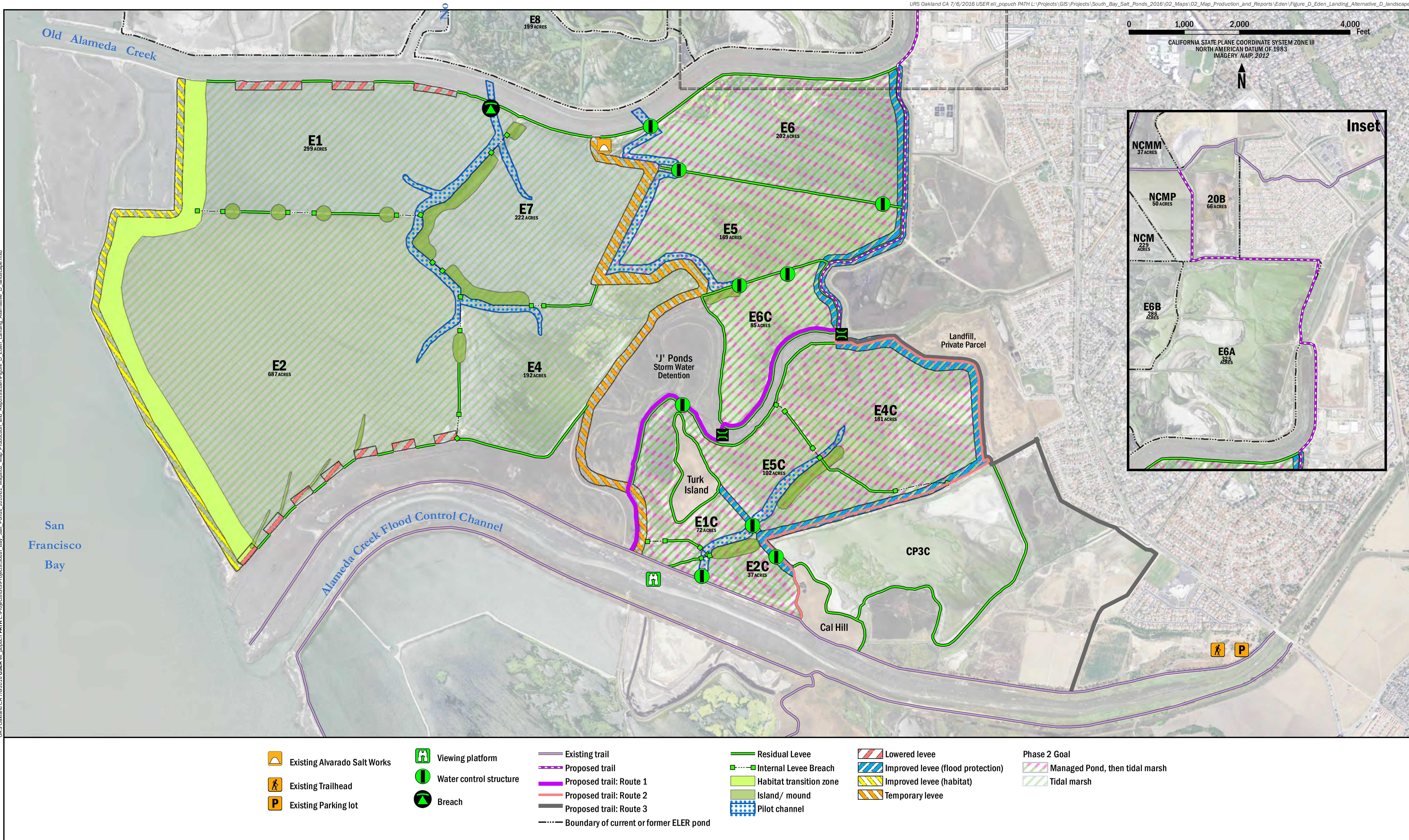


Existing Alvarado Salt Works
Existing Trailhead
Existing Parking lot
Footbridge
Viewing platform
Water control structure
Breach
Existing trail
Proposed trail
Proposed trail: Route 1
Proposed trail: Route 2
Proposed trail: Route 3
Boundary of current or former ELER pond
Residual Levee
Internal Levee Breach
Island/ mound
Pilot channel
Lowered levee
Improved levee (flood protection)
Improved levee (habitat)
Habitat transition zone
Phase 2 Goal
Managed Pond, Permanent
Tidal marsh

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden C



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden D

Infrastructure

- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status

- Existing

Boundary of current or former ELER pond

Ownership

- CA Department of Fish and Wildlife
- Cargill
- County

URS Oakland CA 7/8/2016 USER eli_popuch PATH L:\Projects\GIS\Projects\South_Bay_Salt_Ponds_2016\02_Maps\02_Map_Production_and_Reports\Eden\10_2\Figure_A_Eden_Landing_Culverts_Alternative_A_landscape.mxd

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative A

Infrastructure

- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status

- New
- Demolish
- Replace/Repair

Boundary of current or former ELER pond

Phase 2 Goal

- Tidal marsh

Ownership

- CA Department of Fish and Wildlife
- Cargill
- County

Note: Levee breaches will be created where infrastrcture is demolished, except at the Bay-E2 water control structue where the levee will be backfilled after structure removal.

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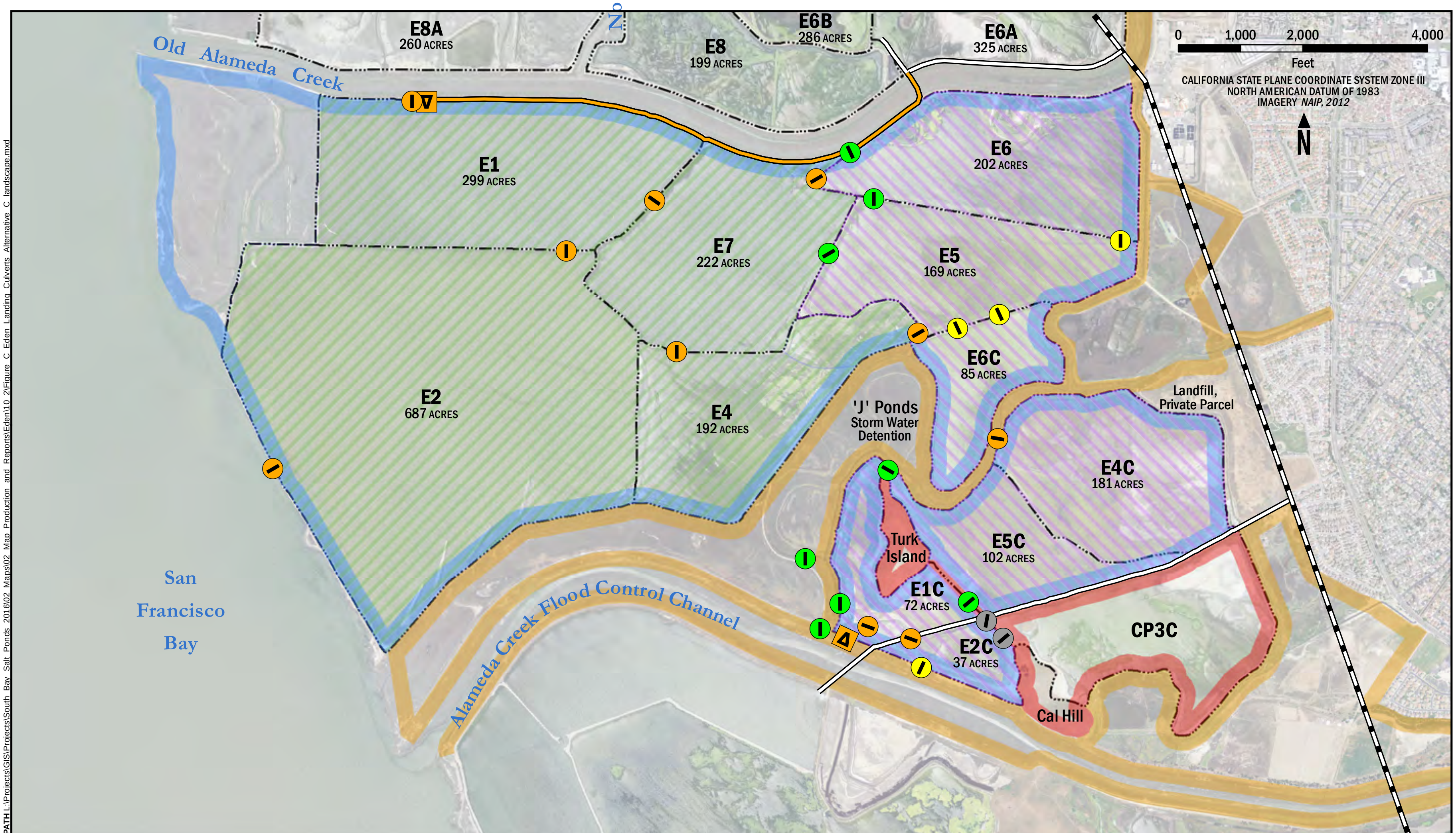
AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative B



Infrastructure
- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status
- New
- Demolish
- Replace/Repair
- Existing

Boundary of current or former ELER pond

Phase 2 Goal
- Managed Pond, Permanent
- Tidal marsh

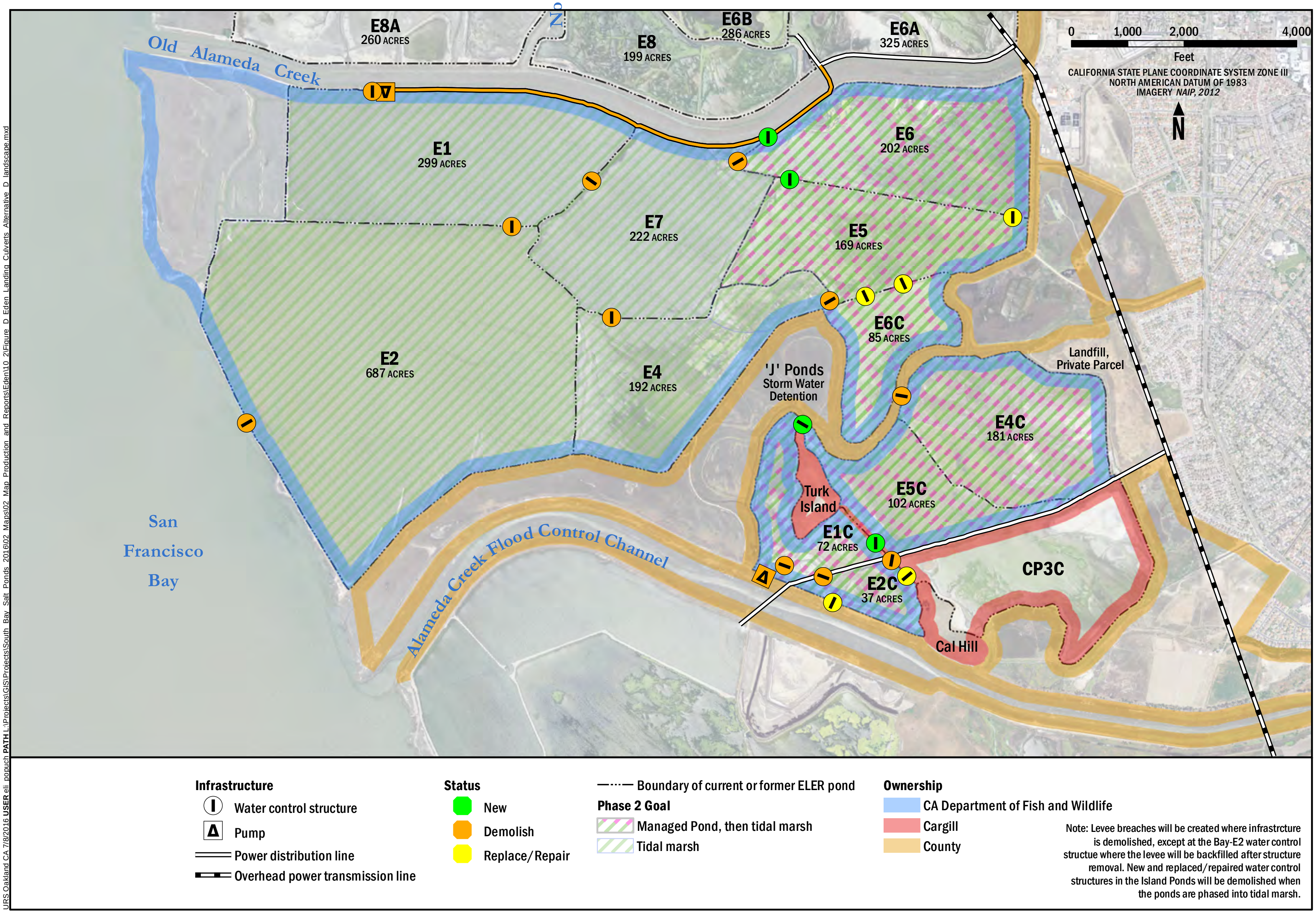
Ownership
- CA Department of Fish and Wildlife
- Cargill
- County

Note: Levee breaches will be created where infrastrcture is demolished, except at the Bay-E2 water control structue where the levee will be backfilled after structure removal.

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative C



AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative D

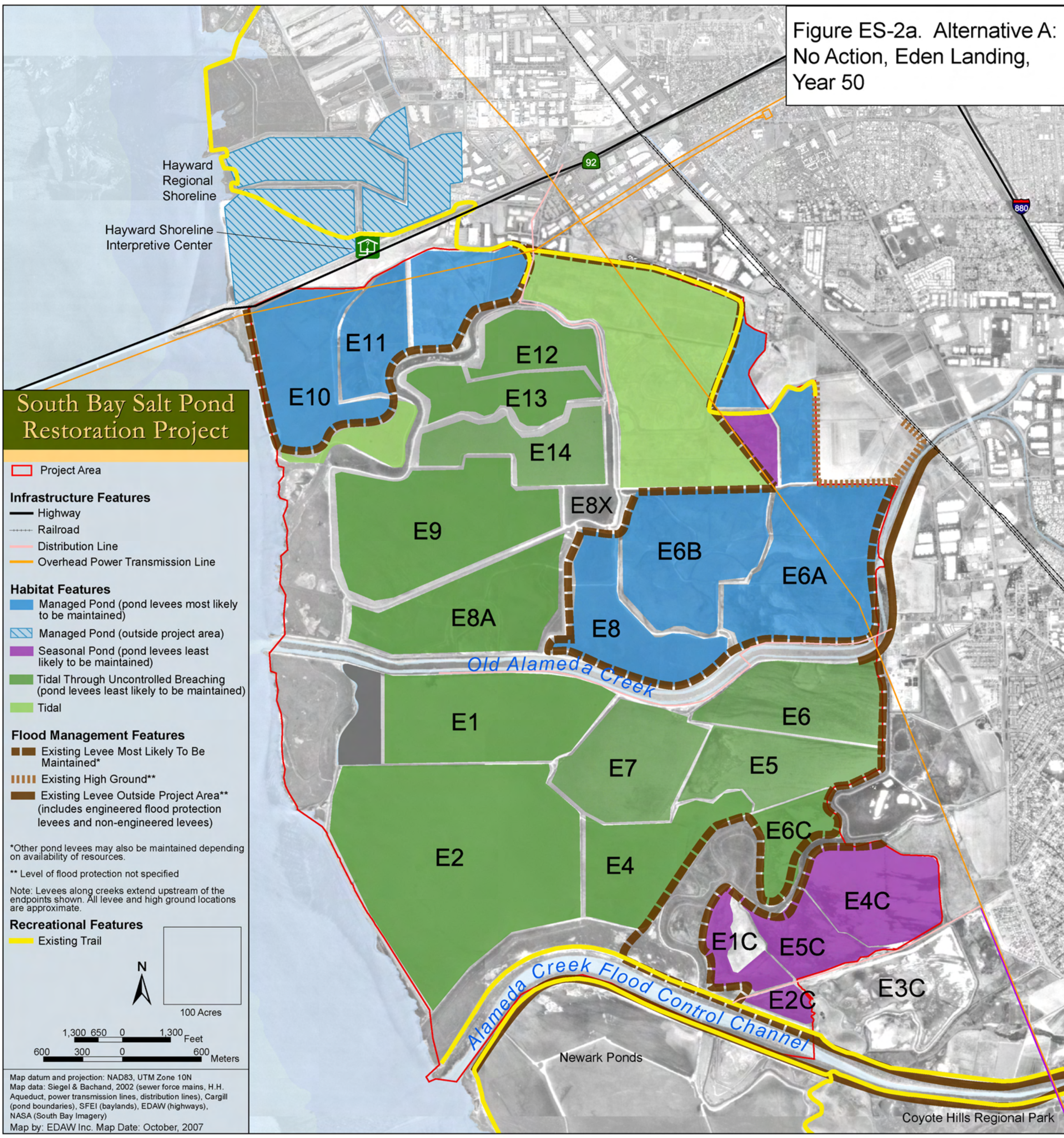


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Figure A-6. Programmatic EIS/R Alternative A: No Action

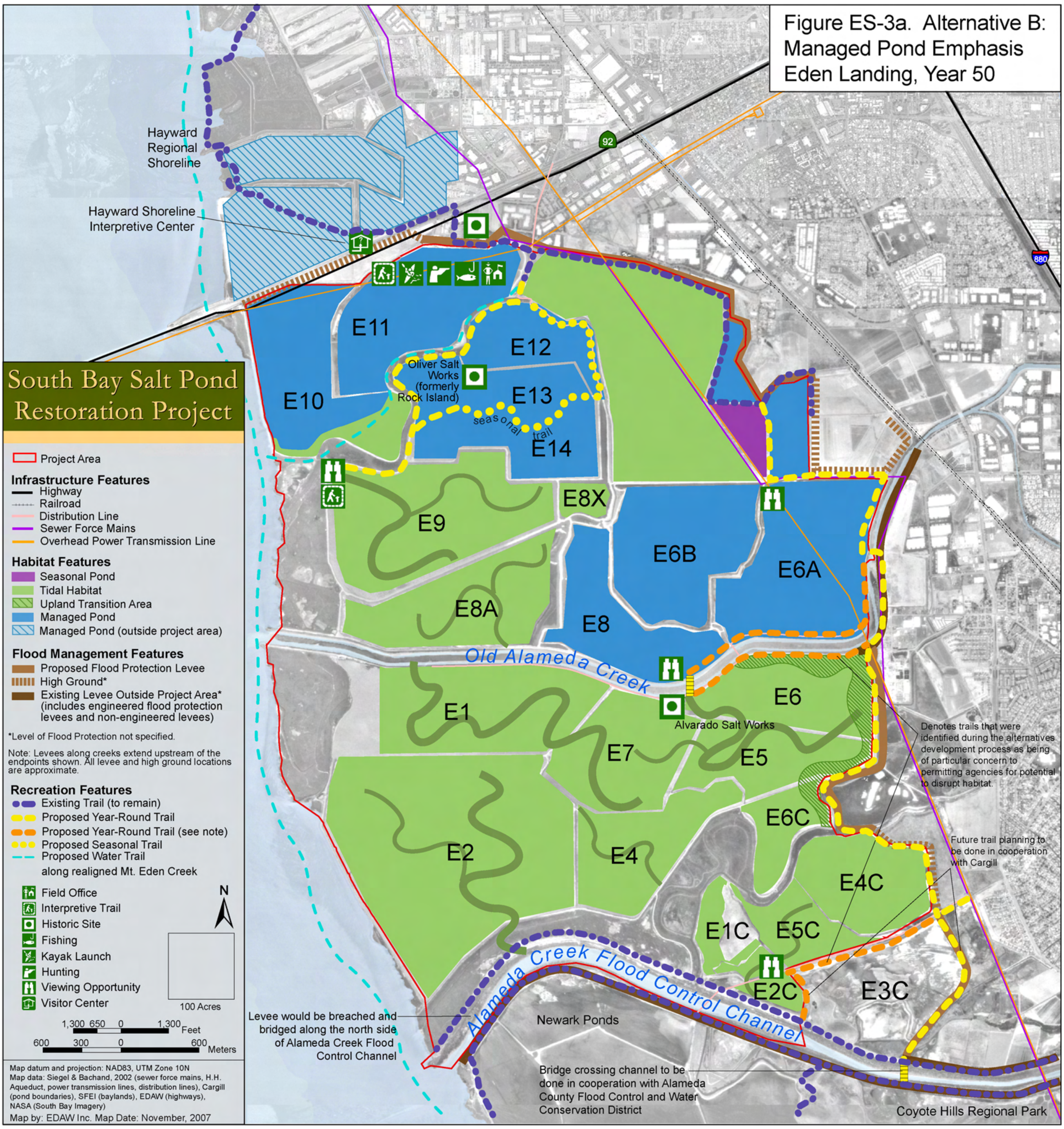

Figure A-7. Programmatic EIS/R Alternative B: Managed Pond Emphasis

Figure A-8. Programmatic EIS/R Alternative C: Tidal Habitat Emphasis

Appendix B

Levee Breach Design

Table A.1. External Breach Design: Empirical Relationships

Location	Pond Area (acres)	Avg. Pond Bottom Elev. (ft. NAVD88)	Potential Diurnal Tidal Prism (ac-ft)	Avg. Channel Cross-sectional Area (ft^2)	Bottom Elev. (ft. NAVD88)	Channel Top Width or Breach Length (ft.) (parallel crest)	Applicable Alternatives
OAC/E1 (west)	Note 1				0	30	B, C and D
OAC/E1 (east)	1,375 (E1, E2, E4, E7)	4.9 (E1) 4.8 (E2) 5.6 (E4) 5.2 (E7)	1,000	2,750	-4	380	B, C and D
OAC/E6	445 (E5, E6, E6C)	5.1 (E5, E6) 5.5 (E6C)	280	1,200	-4	160	B
Alameda County Wetlands/E2/E4	Note 2				2.7 or higher	50	B
Alameda County Wetlands/E4	Note 2				2.7 or higher	50	C

Note 1: Not applicable. Breach included due to structure removal and not designed with empirical relationships.

Note 2: Not applicable. Breach included to provide fish passage downstream of a culvert. Not designed with empirical relationships.

Table A.2. Internal Breach Design: Empirical Relationships

<table>
<tr><th>Location</th><th>Pond Area (acres)</th><th>Avg. Pond Bottom Elev. (ft. NAVD88)</th><th>Potential Diurnal Tidal Prism (ac-ft)</th><th>Avg. Channel Cross-sectional Area (ft^2)</th><th>Bottom Elev. (ft. NAVD88)</th><th>Channel Top Width or Breach Length (ft.) (parallel crest)</th><th>Applicable Alternatives</th></tr>
<tr><td>E1/E2 (west)</td><td rowspan="3">680 (E2)</td><td rowspan="3">4.8 (E2)</td><td>180</td><td>900</td><td>-4</td><td>120</td><td>B, C and D</td></tr>
<tr><td>E1/E2 (mid)</td><td>180</td><td>900</td><td>-4</td><td>120</td><td>B, C and D</td></tr>
<tr><td>E1/E2 (east)</td><td>180</td><td>900</td><td>-4</td><td>120</td><td>B, C and D</td></tr>
<tr><td>E1/E7</td><td colspan="4">Note 1</td><td>-4</td><td>50</td><td>B, C and D</td></tr>
<tr><td>E2/E7</td><td colspan="4">Note 1</td><td>5 (EG)</td><td>50</td><td>B, C and D</td></tr>
<tr><td>E7/E4</td><td>190 (E4)</td><td>5.6 (E4)</td><td>120</td><td>700</td><td>-4</td><td>100</td><td>B, C and D</td></tr>
<tr><td>E2/E4 (north)</td><td colspan="4">Note 1</td><td>-4</td><td>50</td><td>B, C and D</td></tr>
<tr><td>E2/E4 (south)</td><td colspan="4">Note 1</td><td>6 (EG)</td><td>50</td><td>B, C and D</td></tr>
<tr><td>E7/E6 (west)</td><td colspan="4">Note 1</td><td>5 (EG)</td><td>25</td><td>B</td></tr>
<tr><td>E7/E6 (east)</td><td>200 (E6)</td><td>5.1 (E6)</td><td>130</td><td>730</td><td>-4</td><td>100</td><td>B</td></tr>
<tr><td>E5/E7</td><td>245
(E5, E6C)</td><td>5.1 (E6)
5.5 (E6C)</td><td>150</td><td>780</td><td>-4</td><td>110</td><td>B</td></tr>
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<tr><td>E6/E5 (west)</td><td colspan="4">Note 1</td><td>0</td><td>50</td><td>B</td></tr>
<tr><td>E6/E5 (east)</td><td colspan="4">Note 1</td><td>5 (EG)</td><td>50</td><td>B</td></tr>
<tr><td>E5/E6C</td><td>80 (E6C)</td><td>5.5 (E6C)</td><td>20</td><td>230</td><td>-4</td><td>50</td><td>B</td></tr>
<tr><td>E1C/E2C Donut</td><td colspan="4">Note 2</td><td>2.4</td><td>100</td><td>B, C and D</td></tr>
<tr><td>E2C Donut (west)</td><td colspan="4" rowspan="2">Note 2</td><td rowspan="2">2.4</td><td>50</td><td>B, C and D</td></tr>
<tr><td>E2C Donut (east)</td><td>50</td><td>B, C and D</td></tr>
<tr><td>E4C/E5C (mid)</td><td rowspan="2">95 (E5C)</td><td rowspan="2">6.1 (E5C)</td><td rowspan="2">60</td><td rowspan="2">410</td><td>2.7</td><td>50</td><td>B and D</td></tr>
<tr><td>E4C/E5C (south)</td><td>2.7</td><td>50</td><td>B and D</td></tr>
</table>

Note 1: Not applicable. Breach included to promote water exchange between ponds and not designed with empirical relationships.

Note 2: Not applicable. Culvert causes muted tides; therefore, breaches not designed with empirical relationships.

ATTACHMENT 1. SOUTHERN EDEN LANDING RESTORATION PRELIMINARY DESIGN: 1D AND 2D HYDRODYNAMIC MODELING

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MEMORANDUM

TO: Members of the South Bay Salt Pond Restoration Project Management Team

FROM: AECOM

DATE: July 2016

RE: **Attachment 1. Southern Eden Landing Restoration Preliminary Design: 1D and 2D Hydrodynamic Modeling**

1. INTRODUCTION

This memorandum documents the one- and two-dimensional hydrodynamic modeling performed in support of the Southern Eden Landing Restoration Preliminary Design (AECOM 2016a). The preliminary design is of the South Bay Salt Pond (SBSP) Restoration Project's Phase 2 actions at the southern half of the Eden Landing Ecological Reserve (ELER). For the purposes of this document, these ponds are referred to as the southern Eden Landing Ponds.

The southern Eden Landing Ponds includes 11 ponds that are described in three groups in this memorandum, based on their location within the complex and their proximity and similarity to each other. The groups are as follows and as shown in Figure 1.1:

- The Bay Ponds: Ponds E1, E2, E4, and E7 are the four relatively large ponds closest to San Francisco Bay, bordered to the north by the Old Alameda Creek (OAC) and to the south by

Alameda County-owned property including the Alameda County Wetlands and the Alameda County Flood Control Channel (ACFCC).

- The Inland Ponds: Ponds E5, E6, and E6C are somewhat smaller ponds in the northeast portion of the complex. They are bordered to the north by OAC, to the east by the Union Sanitary District Waste Water Treatment Plant and Cargill owned property (used by the Southern Alameda County Radio Controllers Aircraft Club), and to the south by an Alameda County-owned freshwater outflow channel and diked marsh areas known collectively as the "J-Ponds".
- The Southern Ponds or C-Ponds: Referred to by both names, Ponds E1C, E2C, E4C, and E5C are in the southeastern portion of the complex. They are separated from the Inland Ponds and the Bay Ponds by the J-Ponds.

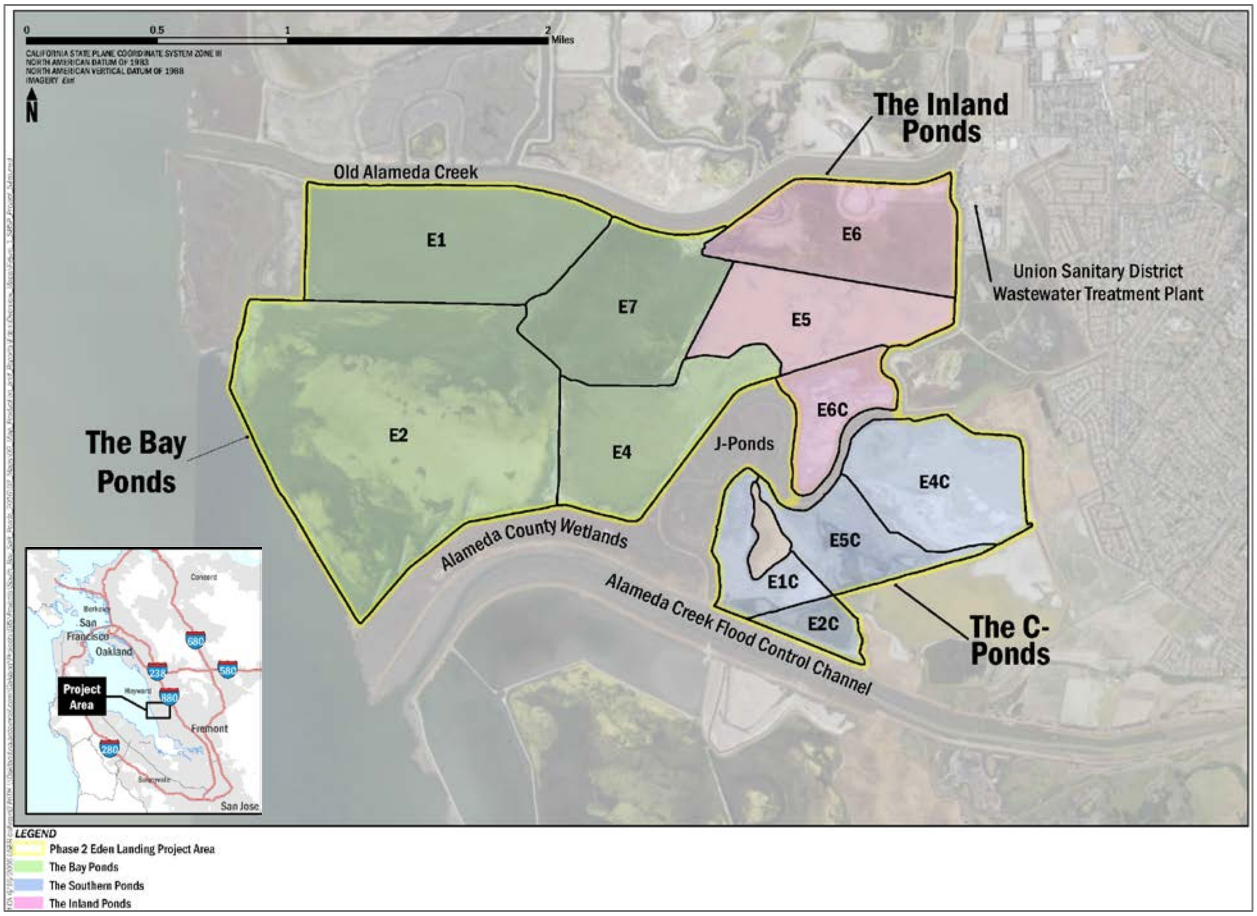

Figure 1.1. Project Vicinity Map

The Phase 2 southern Eden Landing alternatives include one no-action (Alternative Eden A) and three action project alternatives (Alternatives Eden B, C and D) as graphically depicted in Appendix A on Figures A-2, A-3, A-4, and A-5. Each of these alternatives also includes new infrastructure and repair of existing structures as shown in Figures A-6, A-7, A-8, and A-9. Figure 1.2 below shows no-action infrastructure alternative map (Figure A-6) which details existing infrastructure (culverts, pumps, and electrical lines) within southern Eden Landing. Table 1.1 summarizes these existing culverts and pumps and the proposed action. Proposed actions include demolishing or repairing/replacing structures. Demolished materials will be salvaged for re-use elsewhere, or disposed or recycled off-site.

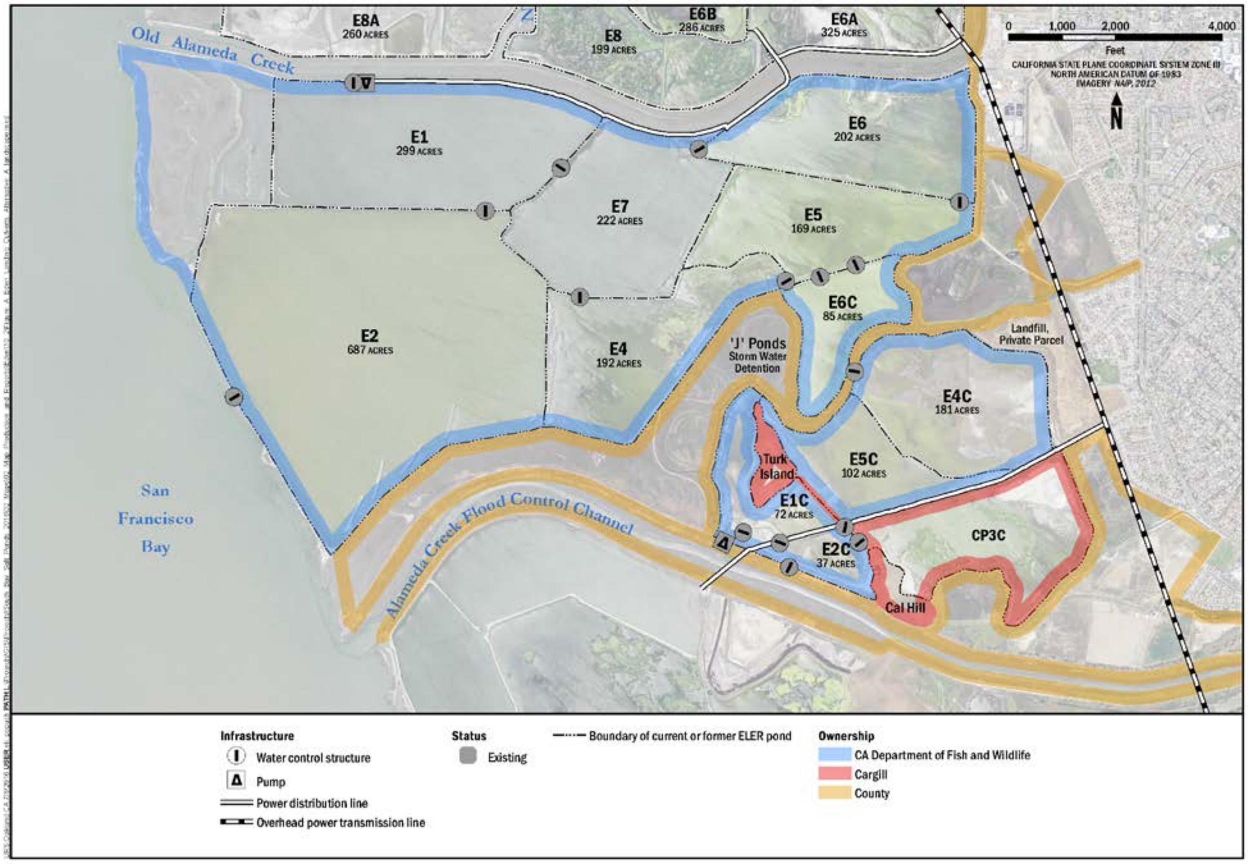

Figure 1.2. Existing Infrastructure

Table 1.1. Existing Water Control Structures

Location	Quantity	Size	Type	Action
E2 - Bay	2	48 in.	Intake/discharge gates	Demolish (backfill levee)
OAC - E1	4	48 in.	(2) Intake/discharge open pipes/combo gates (2) Intake/discharge slide gates/flap gates	Demolish
OAC - E1	1	10,000 gpm	Pump (#1 Baumberg Intake)	
E1 - E2	1	48 in.	Slide gate	
E1 - E7	1	48 in.	Slide gate	
E7 - E4	1	48 in.	Slide gate	
E7 - E6	1	48 in.	Slide gate	
E4 - E5	1	48 in.	Combo gate	
E6 - E5	4	30 in.	Wood gates	Demolish (Alt. B) or Replace/repair (Alt. C & D)
E5 - E6C	2	36 in.	Combo gates	
E6C - E4C	2	30 in.	Siphons (not operable)	Demolish (backfill levee)
E2C - E5C	1	36 in.	Combo gate	
ACFCC - E1C	1	7,660 gpm	Pump (Cal Hill Intake) (not operable)	
ACFCC - E2C	2	48 in.	Intake/discharge combo gates	Replace/repair
E2C - CP3C	1	48 in.	Slide gate	
E2C - E2C donut	1	36 in.	Unknown (open)	Demolish
E1C - E2C donut	1 1	24 in. 10,000 gpm	Unknown (not operable) Pump (Cal Hill Transfer) (not operable)	

2. METHODOLOGY

AECOM developed a two-dimensional hydrodynamic model using MIKE21 to refine the design of restoration features including levee breach and pilot channel dimensions, levee raising and lowering heights and locations, and culvert locations and numbers. A one-dimensional hydraulic model using HEC-RAS was also developed to efficiently analyze culvert sizes for the C-Ponds and Inland Ponds, as HEC-RAS has a more robust culvert routine and the model runtime is minutes instead of hours with MIKE21. Analyses were performed on the three project action alternatives (Alternatives Eden B, C and D). These alternatives are graphically depicted in Appendix A on Figures A-3, A-4, and A-5.

The following sections include a description of the model methodology (model type, domain, restoration feature design criteria, modeling scenarios, and inputs). Because there were no available flow or pond water surface elevation data, neither of the models were calibrated.

2.1 Model Types

MIKE21 FM Model

AECOM used MIKE21 Flexible Mesh Flow Model version 2016 (MIKE21 FM) for this study. MIKE21 FM simulates changes in water levels and velocities in response to tides, wind, and freshwater inflows. It solves the time-dependent, vertically integrated equations of continuity and conservation of momentum in two horizontal dimensions. The equations are solved using a cell-centered finite volume method. Water levels and flows are resolved using a spatial domain comprised of triangles and/or quadrilateral elements. Inputs include topography and bathymetry, structure geometry, bed resistance, structures, and hydrographic boundary conditions (e.g. tides and river discharge). Outputs include water surface elevation, total water depth, velocities, and discharge through structures.

HEC-RAS Model

USACE's Hydrologic Engineering Center's River Analysis System (HEC-RAS) was used to develop a model of the Eden Landing managed pond system. Existing and potential culverts were modeled to measure their effectiveness at filling the ponds during typical management activities and flood conditions. As mentioned above, HEC-RAS is the preferred model for culvert design as model runtimes are on the scale of minutes instead of hours with MIKE21, and HEC-RAS allows for more comprehensive culvert design. Inputs include topography and bathymetry, bed resistance, structures, and hydrographic boundary conditions (e.g. tides and river discharge). Outputs include water surface elevation and discharge velocities through structures.

2.2 Site Topography and Project Datum

Table 2.1 lists the three sources of topographic and bathymetric data used in this modeling analysis and the associated preliminary design.

Table 2.1. Topographic and Bathymetric Data

Data Source	Year Collected	Horizontal Datum	Vertical Datum	Projection
USGS 2010 SBSP Project LiDAR	2010	NAD83	NAVD88	UTM-10 10N
USGS 2005 SBSP Project Bathymetry	2003-2004	NAD83	NAVD88	CA State Plane III
USGS 2007 South San Francisco Bay Bathymetry	2005	NAD83	NAVD88	UTM-10 10N

The available site topography is high-accuracy LiDAR from the 2010 USGS San Francisco Coastal LiDAR project (San Francisco, Marin, Solano, Contra Costa, Alameda, San Mateo, Santa Clara counties, California). The LiDAR data was collected between June 11, 2010 and July 11, 2010.

USGS (2005) also conducted a bathymetric survey of the SBSP Project pond complexes between August 2003 and March 2004 using a shallow-water sounding system to measure water depths with a precision of 1 cm. The system was comprised of a single beam echosounder, a differential global positioning system (DGPS) unit, and a laptop computer on a shallow-draft kayak with a trolling motor. Sample depths were converted to elevation based on water surface elevations recorded every 15-20 minutes at the ponds. Transects were made at 100 meter intervals.

The below water elevations in the Bay adjacent to the project site were obtained from 2005 Hydrographic Survey of South San Francisco Bay, California by USGS, published in 2007. These data consisted of xyz data collected using a single beam acoustic sampler.

The digital elevation point files used in the hydrodynamic model were generated by merging the three sets of data using the horizontal spatial reference system of NAD83, CA State Plane III meters and vertical datum NAVD88, meters.

The data from the bathymetric survey of the SBSP pond complexes and the bathymetric survey of the South Bay were inserted into areas with no LiDAR coverage (to prevent overlapping points between the datasets). To reduce the number of LiDAR points for use in CADD and the hydrodynamic model, the LiDAR datasets were down sampled using a “model key point” algorithm. “Model key points” are points selected to represent local topography and are not removed during a point thinning process. This algorithm thins the ground class within a user-specified vertical tolerance. Areas which exhibit a greater variation in the terrain have more model key points than in areas with a smaller variation in terrain (for example a parking lot). The vertical tolerance parameter required for the algorithm mandates that a triangulated irregular network (TIN) surface generated from the model key points would be within the user-specified distance of a TIN surface generated from the original ground points. The algorithm vertical tolerance parameter was set to 6 inches (0.15 meters) for this study.

In general, the project site is comprised of fairly flat pond bottoms separated by levees. Many of the levees have borrow ditches directly adjacent to them. Figure 2.1 depicts the distribution of pond bottom elevations of the three groups of ponds, most of which are between MSL and MHW. About half of the pond bottoms are 1 ½ to 2 feet or more below MHW and less than 10% are higher than MHW. The C-Ponds are the highest group of ponds, followed by the Inland and Bay Ponds.

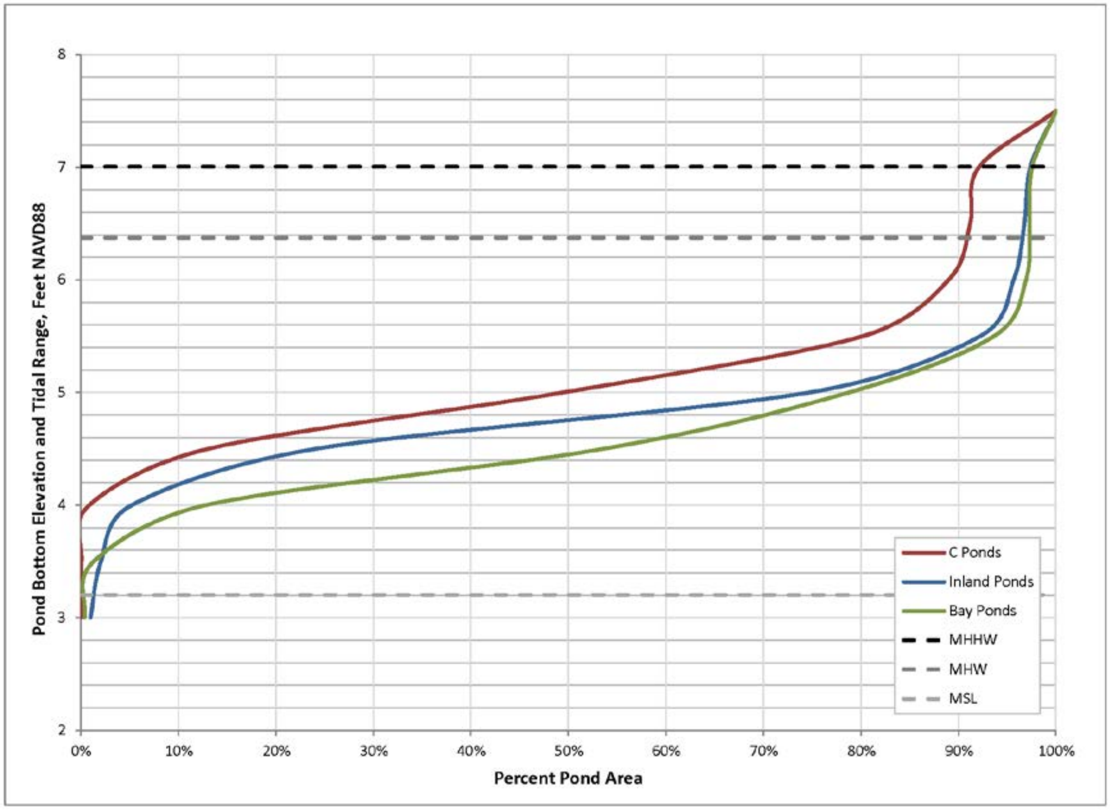

Figure 2.1. Average Pond Group Bottom Elevations

2.3 MIKE21 Model Domain

As mentioned in the previous section, the topographic and bathymetric data used to develop the model domain included three separate data sources. The final elevation grid used as input to the MIKE21 FM model is shown in Figure 2.2. (Please note, all MIKE21 model plan views are shown in metric coordinate systems and units, as the model runs most efficiently in metric.)

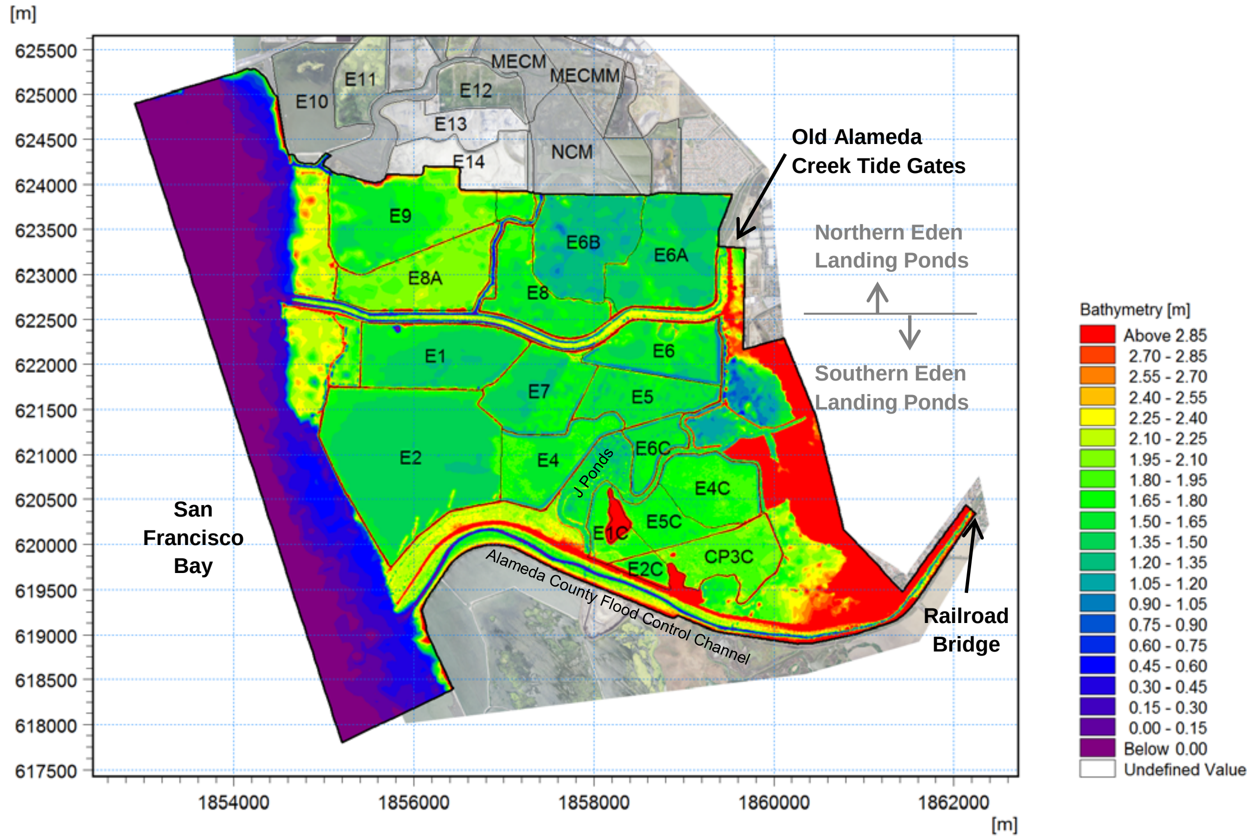

Figure 2.2. Model Elevation Grid (m NAVD88)

The model extent is as shown in Figure 2.2; bounded by the Bay to the west, the northern Eden Landing Ponds to the north, Alameda County property to the east, and ACFCC to the south. Along the OAC, the model extends to the tide gates located approximately 3.5 miles (18,500 feet) upstream from the Bay. Along the ACFCC, the model extends to the point of tidal influence approximately 4.7 miles (25,000 feet) upstream to the railroad bridge. The eastern boundary was determined with iterative modeling, which indicated that all modeled flood waters were contained by relatively high ground to the east. Of the northern Eden Landing Ponds, the three southwestern ponds (E8A, E9, and E8X) were included in the model extent because they were breached in September 2011 (SCC, 2012). The three southeastern managed ponds (E8, E6B, and E6A) were also included in the model, as they are overtopped during the 100-year flood event and therefore provide some storage capacity for the system.

The southern levee of the ACFCC was chosen as the southern extent of the model; however, it is likely overtopped during the 100-year flood event, allowing water to flow into Cargill's currently-operating salt ponds to the south. This is because, although the southern ACFCC levee is slightly higher than the northern levee near the Bay (by approximately 1 foot), the momentum of the flow will direct the water against the northern levee first, potentially overtopping and breaching it. Therefore, the southern model extent assumption is considered a realistic, conservative approach for determining flood levels in the project area.

The spatial domain of the MIKE21 FM model is represented by a system of triangular sections called a mesh, which is composed of nodes and elements. A “node” is a point in space that has both horizontal coordinates and vertical elevation assigned to it. An “element” is a triangular or quadrilateral area bounded by three or four nodes, varied throughout the mesh, which allows the area of interest to be modeled at variable resolution.

For construction of the MIKE21 FM mesh, the node points from the LiDAR were imported into the MIKE21 FM Mesh Generator utility. The Mesh Generator develops the unstructured grid that is used as the model domain. The elevations of each mesh element were interpolated from the LiDAR point cloud.

The final mesh is shown in Figure 2.3. Denser areas indicate finer mesh. In general the mesh elements range in size from 100 to 5,000 m^2 (approximately 15 to 100 meters tall and wide triangular elements). Smaller elements down to 10 m^2 are located on many of the narrow levee crests. In general, the most impacted ponds (C-Ponds), creeks, and County lands have refined element sizes of 200 m^2. The larger, flatter ponds have element sizes of 1,250 m^2. Time was taken to construct the mesh such that the critical topographic features, such as levee crests and borrow ditches, were accurately captured in the model with connected paths of at least one element.

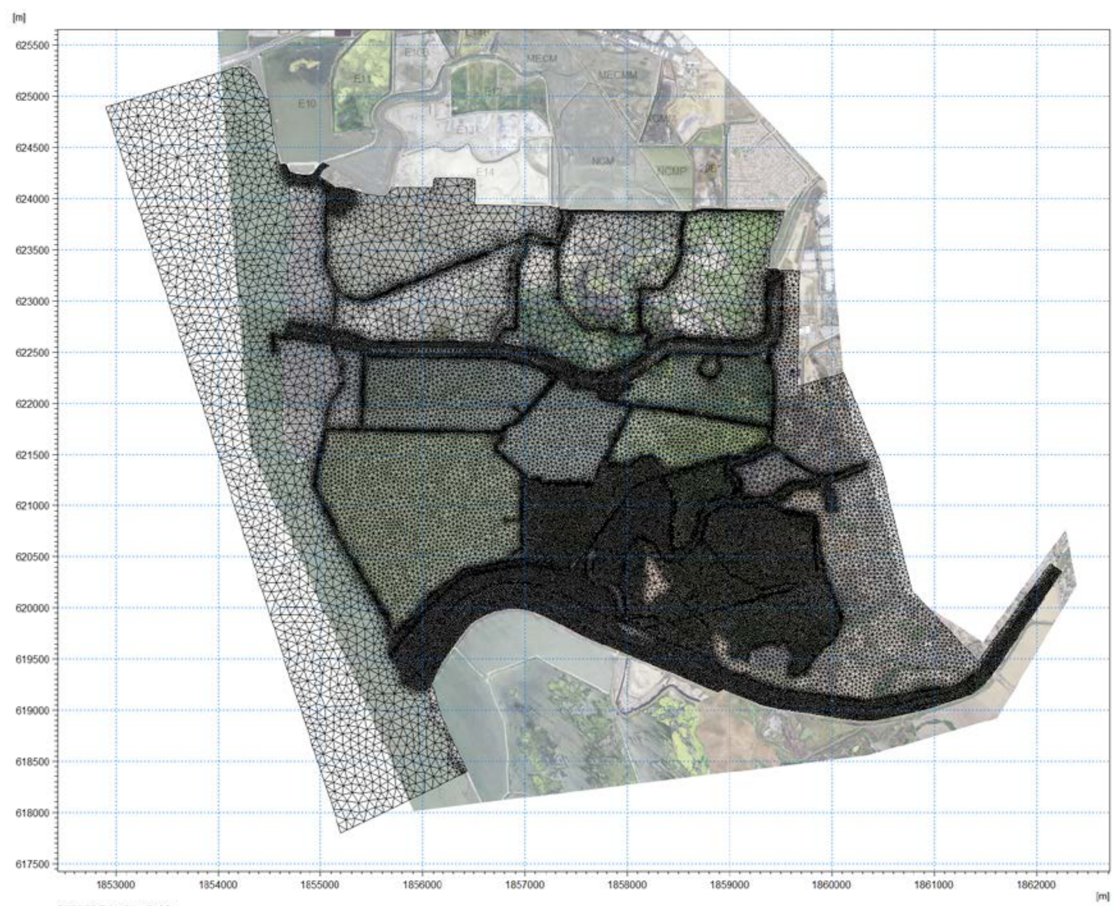

Figure 2.3. Model Mesh

Several modifications to the mesh and elevation grid were made in the Mesh Generator to improve the accuracy of the modeling results. These modifications include:

- The Northern Eden Landing Ponds were breached in September 2011 (SCC, 2012). The 2010 LiDAR data was modified to include levee breaches based on aerial imagery. Levee breach bottom elevations were estimated at about 5 feet NAVD88, similar to the surrounding pond bottom elevations.
- Borrow ditches and small channels visible in aerial imagery were included in the mesh to a greater detail than what was captured with the 100-meter bathymetry transects. Since limited bathymetry was available in these smaller ditches and channels, AECOM used nearby elevations that captured channel depths, and applied those elevations along the visible length of the channels (as determined by historic aerial images).
- Bathymetry was not available for the OAC or ACFCC, however, only the deepest portions of the channels were not captured with the 2010 LiDAR. As described in the results section, the OAC proved to be a major constriction in flow during the restoration scenarios. Because the OAC is comprised of a larger north and smaller south stream, separated by a marsh island in the middle, the smaller south stream was modified to resemble the larger north stream during some model runs. The southern stream in the OAC is anticipated to quickly, naturally increase in size and depth with the restoration project, and therefore this modification is believed to accurately represent the future conditions after restoration.

2.4 Modeling Configurations

Three general layout configurations were modeled to analyze how the different alternative configurations would function given certain boundary conditions. The features within each of these configurations were refined during the modeling analysis, resulting in the final restoration alternatives and modeling configurations as listed below. The habitat transition zones and habitat islands were not included in the analysis since they do not significantly affect the hydrodynamics. Specifics of the design of all of these alternatives can be found in the Preliminary Design Memo (AECOM 2016a).

1. Alternative A (Appendix A, Figure A-2): Existing conditions with all existing culverts closed (see Table 1.1). Given the limited conveyance of the culverts and the short duration of the peak flood (several hours), having the culverts open or closed has limited impact on flood levels; however the slightly more conservative “closed” scenario (resulting in a greater level of flood protection) was chosen of the two options.
2. Alternative B (Appendix A, Figure A-3): Full tidal restoration of the southern Eden Landing Ponds with improvements to the landside levee. The proposed fish passage channel from the ACFCC to Ponds E2 and E4 was not included in this configuration (it was originally included in a different alternative); it was however included in the Alternative C & D configuration described below. Given the relative limited conveyance through the proposed ACFCC culvert in this fish passage channel, (especially during 100-year fluvial and tidal events when levees are overtopped), the inclusion or exclusion of this fish passage channel has minimal, if any, effect on model results.

3. Alternative C & D (Appendix A, Figure A-4 and A-5): Construction of a mid-complex levee, allowing tidal restoration of the Bay Ponds and management of the Inland and C-Ponds. The future phased tidal restoration of the Inland and C-Ponds in Alternative D was assumed to be similar to Alternative B, and was therefore not modeled separately. This Alternative C & D configuration included Alternative B's fish passage culvert and channel from ACFCC to Ponds E2 and E4. Either of the fish passage channels could have been selected for use in the model, as both have limited relative conveyance through the proposed ACFCC culverts as described above.

2.5 Design Criteria of Restoration Features

The modeling objective was to inform the design of restoration features. The prominent design criteria of the restoration features were:

1. Tidal Propagation: Restoration features were designed to create adequate filling and draining of the ponds during tidal cycles. Adequate filling was defined as when the vast majority pond surface was flooded (greater than 6") during a flood tide. Adequate draining was defined as when the vast majority of the pond surface was dry (less than 6" based on model accuracy and data) during an ebb tide.
2. Flood Control: Restoration features were designed to provide at a minimum the same level of tidal and fluvial flood protection as exists under current conditions.

Additional criteria were also taken into consideration, such as limiting adverse erosion or accretion of nearby features such as existing marsh, levees and channels.

2.6 Hydrologic Scenarios

Design criteria were applied to the restoration features during two hydrologic scenarios: a typical tide scenario with no riverine discharge, and a flood scenario with a combination of 10- and 100-year riverine and tidal events. Both are described in detail below.

Tide Scenario: This hydrologic scenario included three weeks of a typical summer tide from May 4, 2015 7:00 AM to June 2, 2015 7:00 AM with no channel discharge. The first week was a "warmup" week for model equilibration, followed by two to three weeks as needed. The ponds initially were started with a water surface elevation of 2.5 feet in the ponds (about half a foot below MSL). The initial water surface elevation in the ponds was chosen to be near MSL, but because the model had a week of warmup, the initial water surface elevation had a minor impact on the modeling results. Figure 2.4 shows the time series of water levels in relation to the local tidal datums obtained from the Redwood City tide gauge (NOAA gauge 9414523), located roughly 7 miles (11 kilometers) west of Eden Landing.

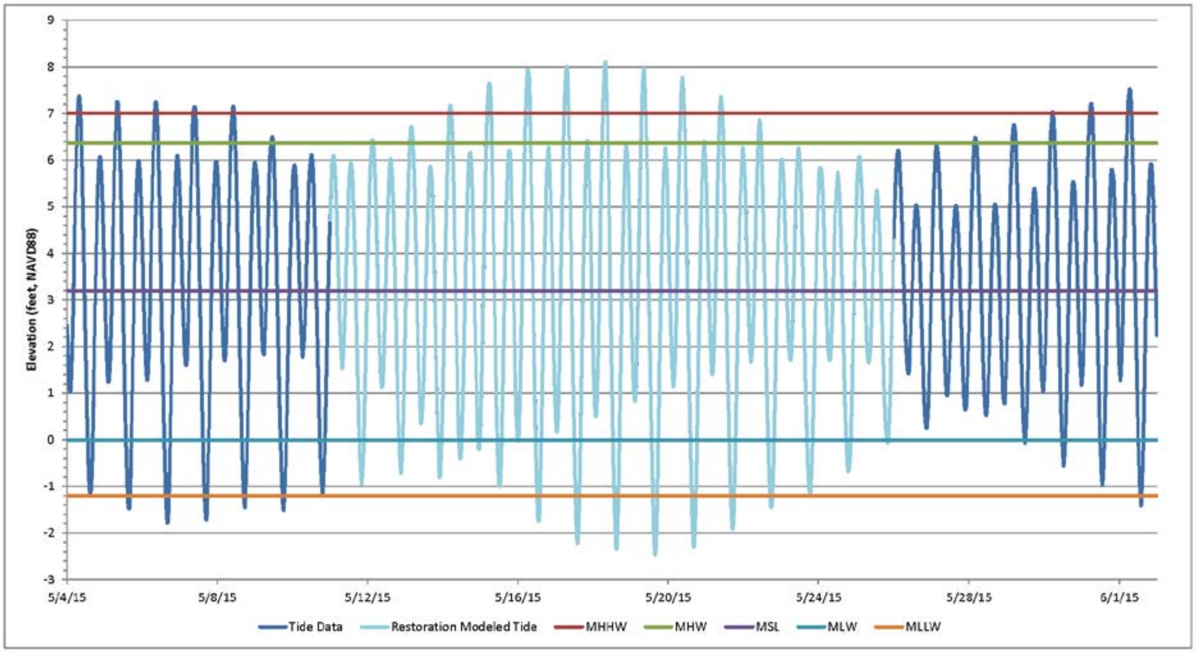

Figure 2.4. Typical Tide used as Input for Model Scenarios (Maximum Elevation 8.1 feet)

The 6 minute daily tide data from the Redwood City gauge were obtained from National Oceanic Atmospheric Administration's Tides and Currents website (NOAA 2016) and converted to NAVD88 using NOAA conversions listed in AECOM 2016. Table 2.2 summarizes the tidal datums for the three NOAA tide gauges near the project site, showing that the mixed-semidiurnal tides are amplified in the South Bay from a MHHW elevation of 6.9 feet at San Mateo Bridge up to 7.2 feet at Dumbarton Bridge and MLLW from -0.8 to -1.4 feet. Sources of conversions from tidal to geodetic (NAVD88) datum are listed in Table 2.2.

Table 2.2. Tidal Statistics for the South Bay

	San Mateo Bridge West, CA Station ID 9414458	**Redwood City, CA Station ID 9414523**	**Dumbarton Bridge, CA Station ID 9414509**
	Feet, NAVD88	Feet, NAVD88	Feet, NAVD88
100-year[1]	10.4	10.7	10.9
10-year[1]	9.3	9.4	9.6
MHHW	6.92	7.10	7.20
MHW	6.29	6.47	6.59
MSL	3.31	3.30	3.27
MTL	3.34	3.28	3.22
NAVD88	0	0.00	0
MLW	0.39	0.10	-0.15
MLLW	-0.80	-1.10	-1.41
NAVD88 Datum Source	Foxgrover et al. 2007	AECOM 2016	NOAA 2016

[1]Extreme still water tide levels from the *San Francisco Bay Tidal Datums and Extreme Tides Study Final Report* (AECOM 2016b).

Flood Scenario: This scenario included the following two combinations of flood events:

1. 100-year tide with 10-year riverine discharge from the OAC and ACFCC (coinciding tide and discharge peaks)
2. 10-year tide with 100-year riverine discharge from the OAC and ACFCC (coinciding tide and discharge peaks)

This is more conservative than recommended in the Alameda County Hydrology and Hydraulics Manual (2003) where for primary facilities the highest of the following scenarios is to be used:

- The FEMA 100-year water surface elevation; or
- The 5-year recurrence peak discharge combined with a 100-year tide elevation in the Bay; or
- The 15-year recurrence peak discharge with a MHHW elevation in the Bay.

These flood scenarios included seven days of a 10- and 100-year tide from May 15, 2015 7:00 AM to May 21, 2015 7:00 AM. Figure 2.5 and Figure 2.6 show the time series of the 10- and 100-year tide levels in relation to the local tidal datums. The 10- and 100-year tides were generated by shifting the typical tide shown in Figure 2.4 (maximum elevation of 8.1 feet) up to the extreme elevations of 9.4 feet and 10.7 feet NAVD88 (AECOM 2016b), respectively.

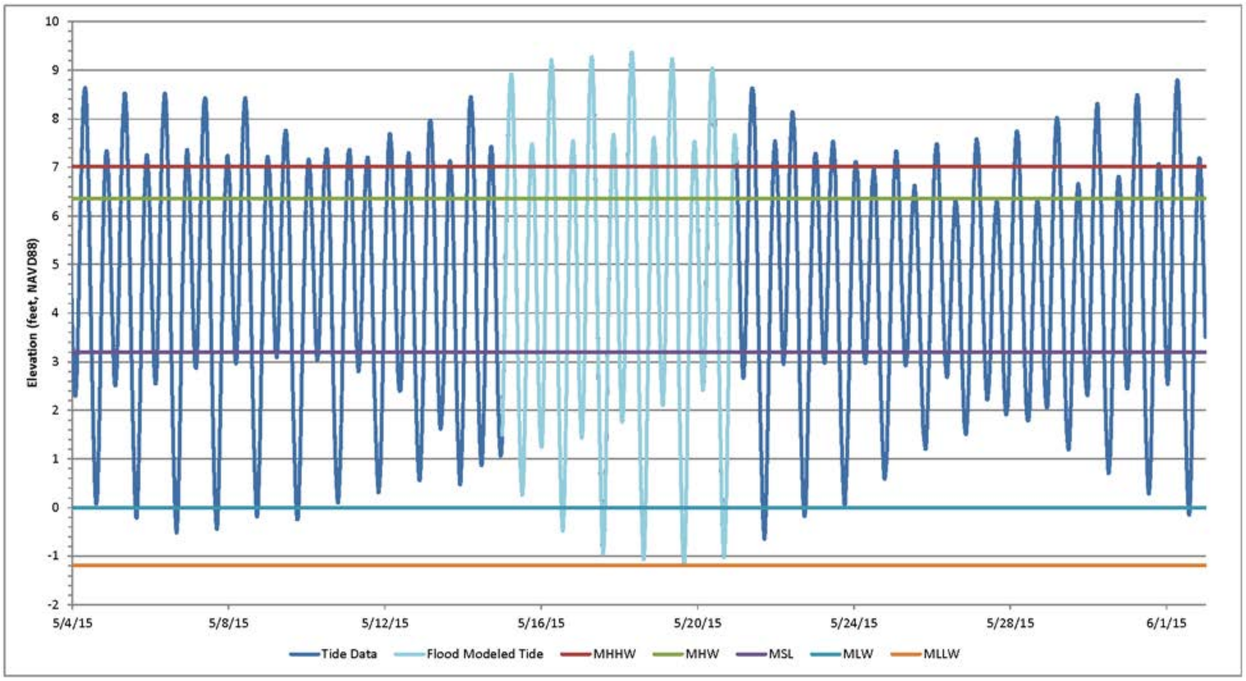

Figure 2.5. 10-year Tide (Extreme Elevation 9.4 feet)

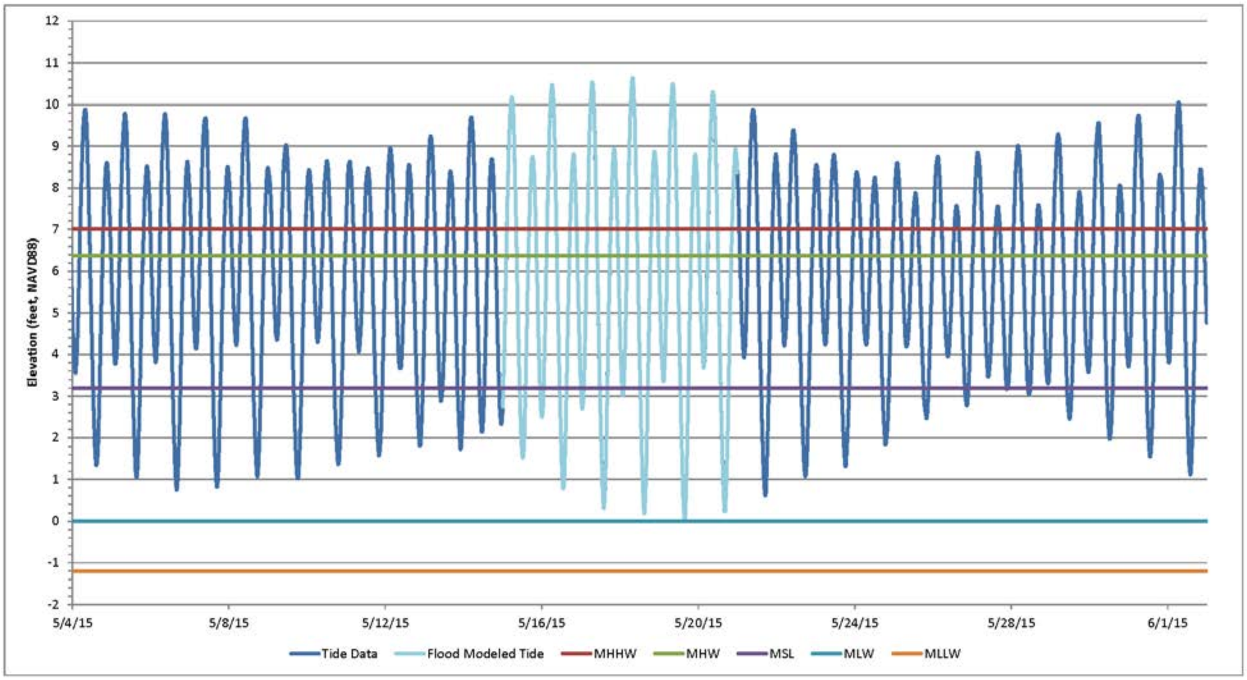

Figure 2.6. 100-year Tide (Extreme Elevation 10.7 feet)

The hydrographs for the 10- and 100-year discharge events from OAC and ACFCC are shown in Figure 2.7. The hydrographs were obtained from DHI (2015). To confirm that the hydrographs represent reasonable approximations to the 10- and 100-year events, HEC-SSP V2.0 was used to analyze 56 years of peak flow data collected in the ACFCC at Union City (USGS # 11180700, located 0.2 mi upstream of Interstate 880 crossing). The analysis resulted in a 100-year peak flow of 30,410 cfs and a 10-year flow of 14,116 cfs, which are consistent with the hydrographs in DHI (2015). Sufficient data were not available for the OAC so the DHI (2015) values were assumed to also be sufficiently accurate for preliminary design.

All flood scenarios had an initial water surface elevation of 6.5 feet NAVD88 throughout the model mesh, conservatively assuming the ponds were starting “full” about a half of a foot below MHHW. This is conservative for all alternatives because the available flood storage in the ponds is minimized. (The internal water level in the pond has no impact on the whether the external levees are overtopped during a flood event; the initial water surface elevation does however have an impact on if the internal levees are overtopped.) If this elevation were to be decreased to MSL, the maximum water surface elevation reached within the ponds (and used to design the levee heights) may decrease. At the 6.5 feet NAVD88 elevation, portions of the low-lying areas east of the complex also began with ponded water; however the *difference* in water surface elevation between existing and restored conditions was used as the indicator of meeting or exceeding existing flood control in this area, not the total water surface elevation. For this reason, these flood criteria results were not sensitive to the initial water surface elevation.

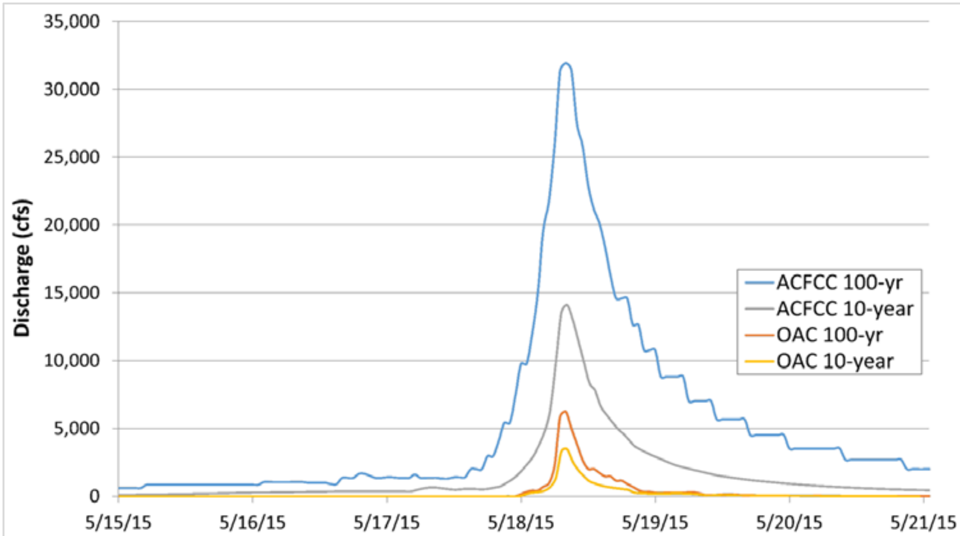

Figure 2.7. 10- and 100-year Discharge Event Hydrographs of ACFCC and OAC

2.7 Bed Resistance

In MIKE21 FM, the bed resistance is specified using a Manning number "M", which is the inverse of the more commonly used Manning's n. Typically the roughness coefficient is used as a calibration parameter, and the lower the Manning's number the higher the roughness. Figure 2.8 shows the chosen Manning's numbers based on vegetation observed or lack thereof in available imagery.

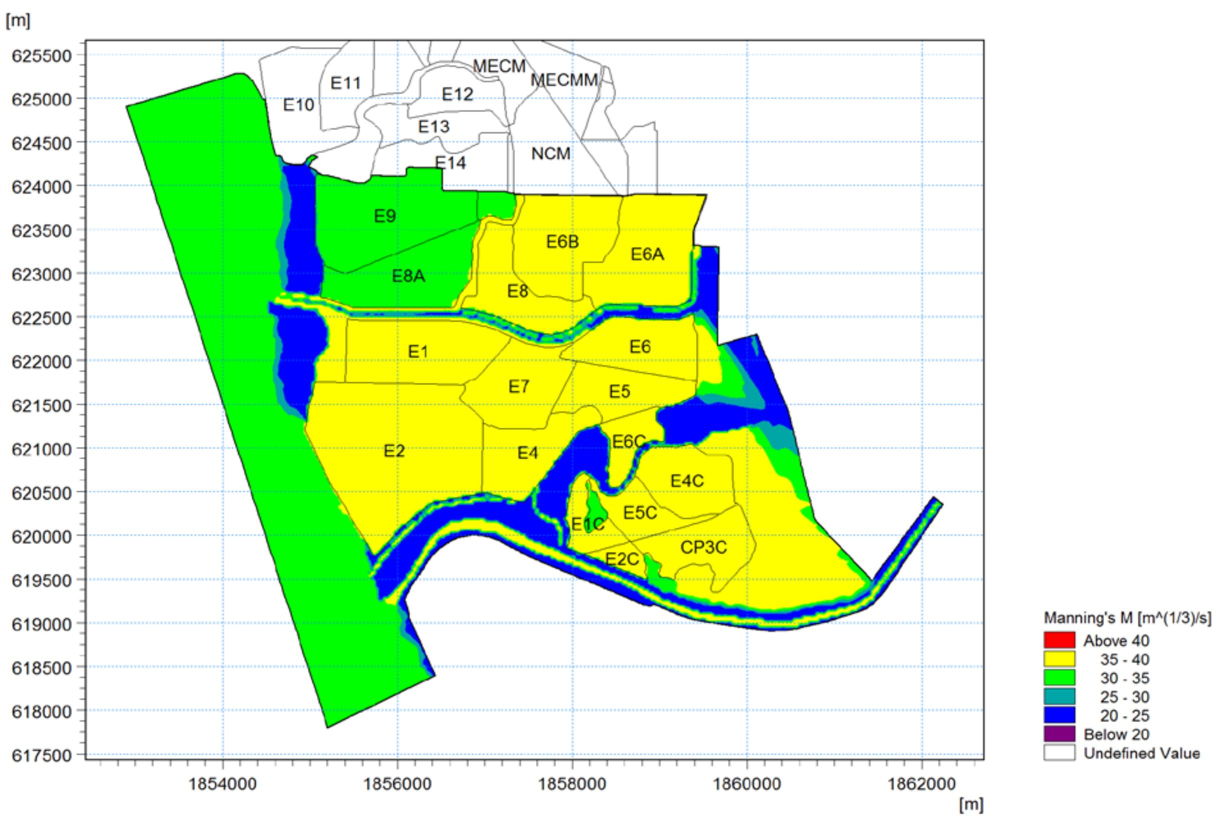

Figure 2.8. Bed Resistance

2.8 Approach

Various locations and quantities of levee breaches, pilot channels, culverts, and levee raising and lowering were modeled to refine the design features. The Preliminary Design Memo (AECOM 2016a) contains details on initial design choices for feature dimensions and locations. For instance, initial levee breach sizes were sized based on empirical hydraulic geometries of historic marshes in San Francisco Bay (PWA et al. 2004), and initial pilot channels were sized and located based on equipment capabilities and cost considerations.

In general, tidal filling and draining criteria were first met with the addition of levee breaches and pilot channels, then flooding criteria were applied to the features and levee raising and lowering design details were determined. The greatest water surface elevation resulting from the two Flood Scenario combinations was used to design the restoration features.

All of the southern Eden Landing Ponds are within areas inundated by the 1% annual chance flood on FEMA's Flood Insurance Rate Maps (FIRMs) due to coastal flooding sources from extreme high tide (as opposed to riverine sources) (see Figure 2.9). None of the existing levees are accredited to meet Federal standards to reduce risk from a 100-year flood. The 1% annual chance Still Water Level (SWL), or flood level not including the effects of waves or tsunamis but including storm surge and astronomical tide, of the ponds is 10 feet NAVD88. FEMA is currently updating its maps, and preliminary results indicate the 1% SWL will increase to 11 and 12 feet within southern Eden Landing pending additional considerations proposed by Alameda County. Because the uncertified levees in and around the pond complex do not influence the 1% SWL in FEMA's typical approach, breaching the existing ponds does not change FEMA's current FIRMs depicting 1% SWL.

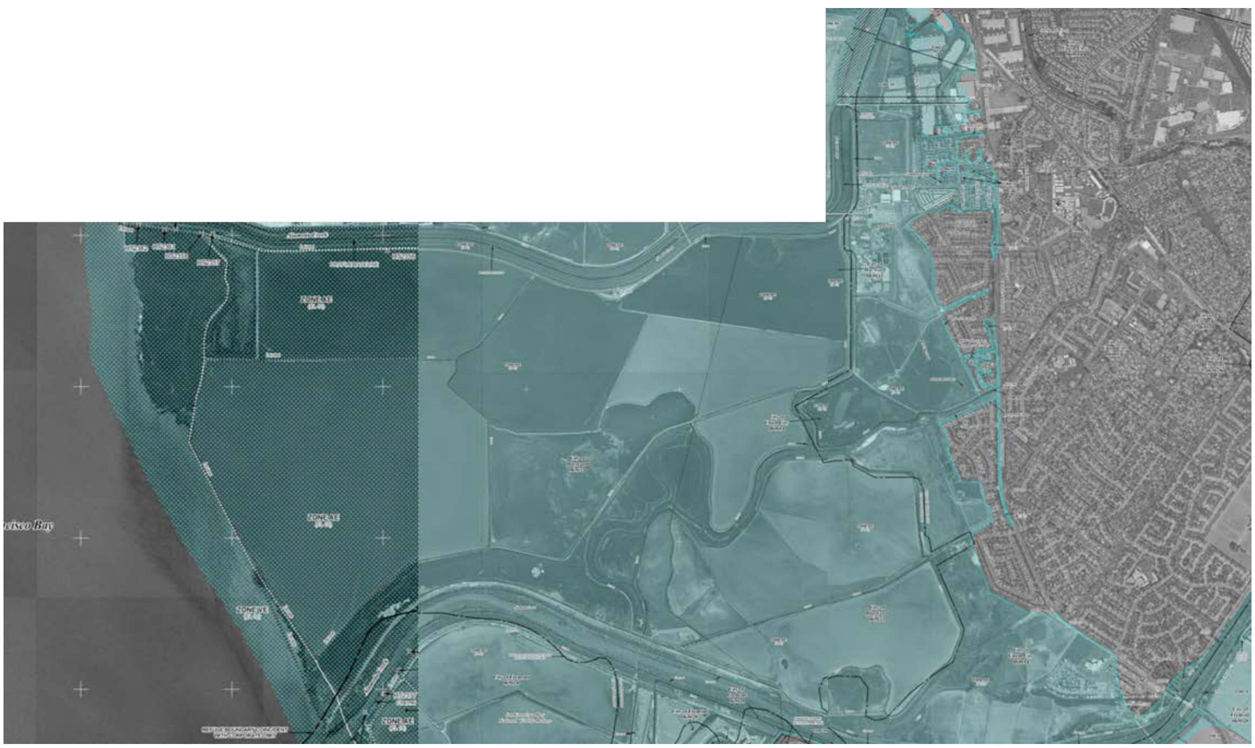

Figure 2.9. Existing FEMA Flood Insurance Rate Map Extent (Effective 2009, pending update)

FEMA also calculates the Total Water Level (TWL), which includes the effects of waves (wave setup and runup) on top of the SWL. All of the levee improvements and habitat transition zones proposed in the restoration design could lower FEMA’s calculated TWL, as the TWL does take into consideration berms or levees that knock down waves or reduce fetch lengths.

The Federal levees surrounding the ACFCC are accredited levees, and therefore may need to be unclassified as an “accredited” levee in order to install breaches. Because this process is likely to conflict with the Phase 2 restoration timeline, the restoration design was constrained to installing only gated culverts in the ACFCC Federal levees. Although not ideal for the full tidal restoration alternative for the C-Ponds, additional culverts will improve tidal exchange and maintain or improve the existing flood protection. Restoration Alternatives B and D also included a culvert through the ACFCC Federal levee to allow fish passage from the ACFCC into the Bay Ponds.

Lastly, during model development Dr. David Schoellhamer from the USGS performed an external review of the model and modeling approach. His comments are listed in Appendix B and were incorporated into subsequent versions of the model and analysis.

3. MODEL RESULTS

The following is a summary of the MIKE21 and HEC-RAS modeling results.

3.1 MIKE21 Tide Scenario Results

The extent of tidal waters and total water depth within Alternative B (full tidal restoration) configuration is shown in Figure 3.1 and Figure 3.2 (on the following page) during the spring and neap tides, respectively. During the peak of the spring tide, the majority of the ponds contain ponded water except for the areas of highest elevation. The ponds may not drain completely at low tides during the peak spring tide and may contain ponded water for several days. When the peak tides recede the ponds do not fill as high and they drain more fully. During the neap tide, the majority of the ponds are drained with patches of water remaining in the ponds due to the uneven nature of the pond bottoms. These patches of ponded water are anticipated to shrink in size over time as small channels form in the pond bottoms; the model does not include geomorphic changes such as these.

Figure 3.3 (on the following pages) shows the water surface elevations in the Bay Ponds and channels of the Inland Ponds, which fill up to about 5.6 feet. The ponds receive water from the muted tide in the OAC, also shown in the figure. The majority of the pond bottoms of the Inland Ponds are only flooded during peak tidal elevations, however deeper channels transport water around the ponds. Figure 3.4 shows the water surface elevations in the C-Ponds, which fill up to about 6.3 feet (in E2C). The C-Ponds receive water from the slightly muted tide in ACFCC, also shown in the figure. In general, the ponds become more muted the farther the distance from the connection to ACFCC.

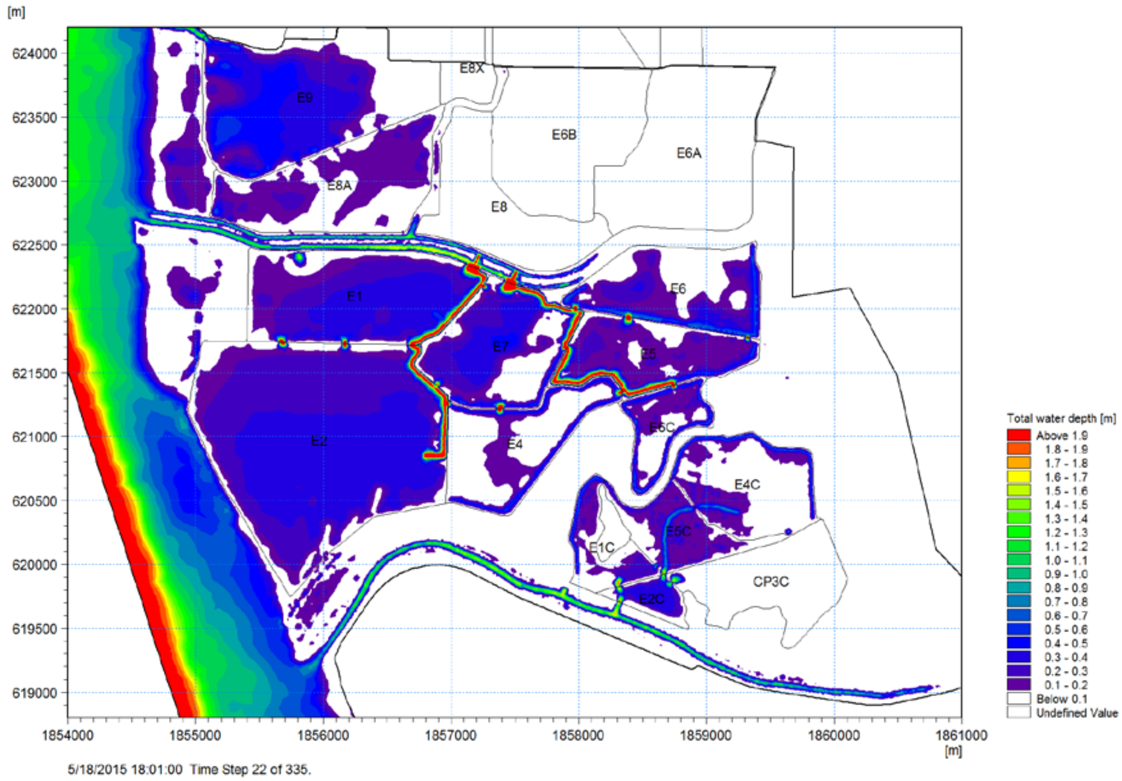

Figure 3.1. Alternative B Total Water Depth during Spring Tide

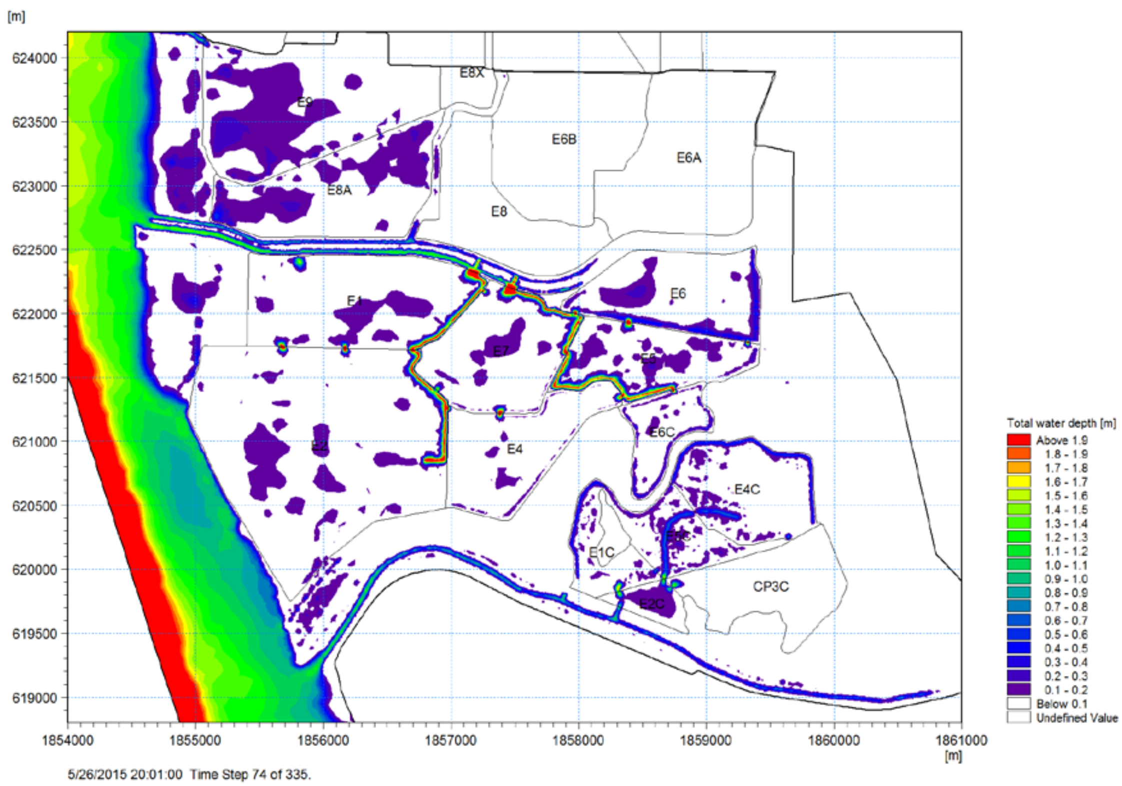

Figure 3.2. Alternative B Total Water Depth during Neap Tide

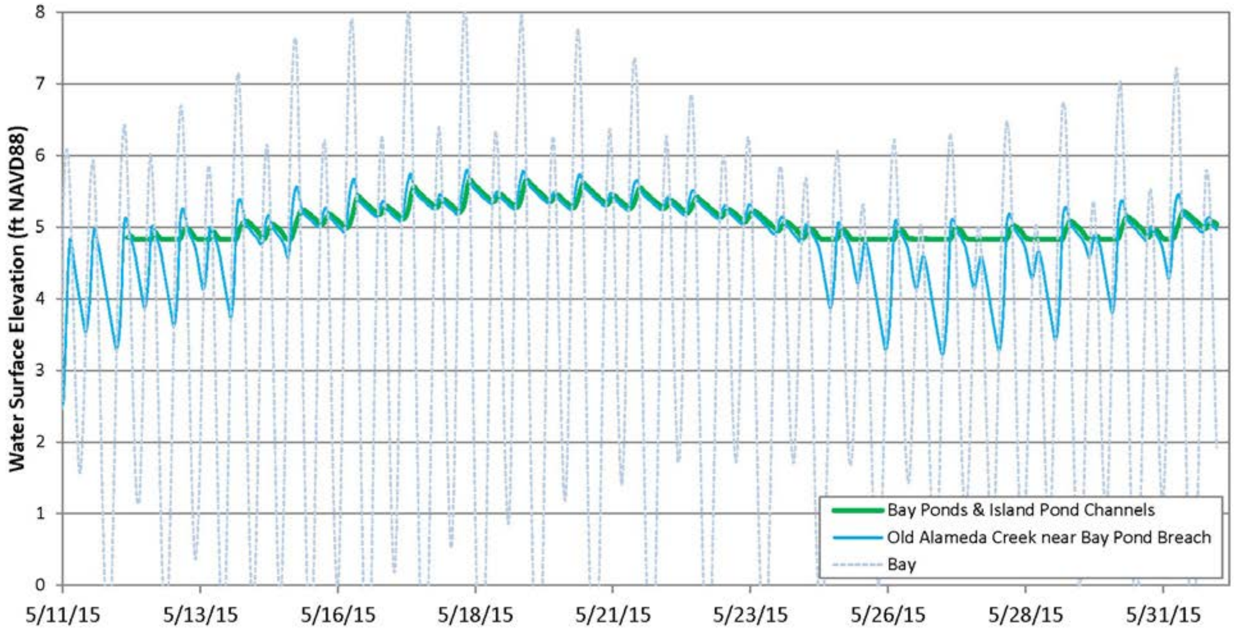

Figure 3.3. Tidal Elevations in the Bay and Island Ponds

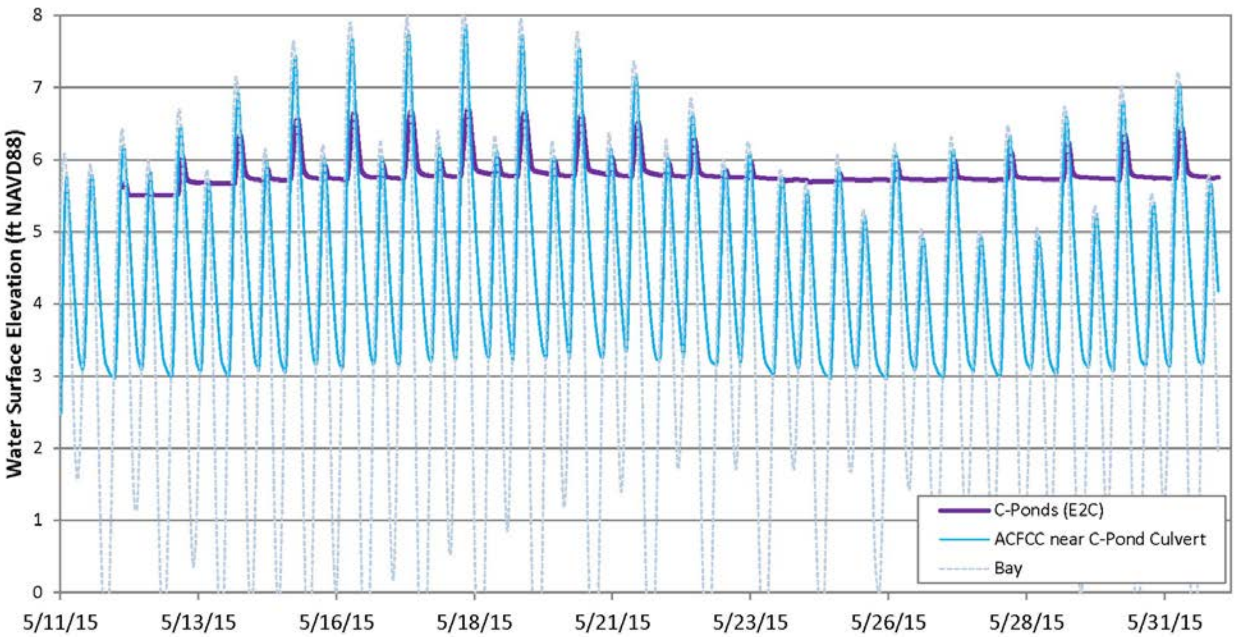

Figure 3.4. Tidal Elevations in the C-Ponds

The major Tide Scenario modeling results include:

- The OAC constricts conveyance into the ponds; therefore increasing the number of breaches above those already included along the OAC would not significantly increase conveyance into the ponds. The OAC is anticipated to scour over time with the restoration project, thereby increasing the tidal prism in the Bay and Inland Ponds.
- "Natural" channels constructed in the center of the wet pond bottoms were modeled, however eliminated due to anticipated construction cost (except for in the C-Ponds where the ponds may be dried sufficiently to support low ground pressure equipment). More economical "borrow ditch" channels were included in the Bay and Inland Ponds where equipment can excavate to the side while on existing levees. Both channel types enhance draining of low depressions in the ponds; without constructed channels, the ponds do not fully drain.
- Because the design is constrained to including a culvert through the ACFCC Federal levee (as opposed to a breach), the channel through the Alameda County Wetlands to Ponds E2 and E4 should only be as large as the volume that may be conveyed through the culvert. Model results show the hydraulic conveyance into the Bay Ponds through this culvert and channel is minimal. Fish habitat and passage is an important goal of this restoration design, therefore this connection culvert and channel remains in the restoration alternatives to predominately support fish passage into the Bay Ponds, as opposed to hydraulic connectivity.
- The C-Ponds are the highest elevation ponds of the southern Eden Landing Ponds, and although the restoration design proposes to double the existing culverts and construct a channel in the pond bottom, the tide will remain muted in the C-Ponds. The proposed additional culverts and channel will increase management flexibility, if the ponds remain managed permanently or temporarily (Alternatives C and D).

3.2 MIKE21 Flood Scenario Results

The results of the Flood Scenarios informed the levee crest elevation design in all three action alternatives and allowed for comparison of pre- and post-project flood levels. For each of the Flood Scenarios and model configurations, maximum water depth was analyzed along the four proposed raised levees found in Alternatives B, C, and D, as well as three areas of potential flooding outside the complex, as listed in Table 3.1 and shown in Figure 3.5.

Table 3.1. Flood Scenario Areas of Analysis

	Flood Scenario Areas of Analysis	Applicable Alternative
Levee Alignments	Inland Ponds Landside Levee	B & D
	C-Ponds Landside Levee	B & D
	Bay Levee	C & D
	Mid Complex Levee	C & D
Areas of Potential Flooding Outside of Complex	J-Ponds	B, C, & D
	Alameda County East Property	B, C, & D
	Alameda County South Property	B, C, & D

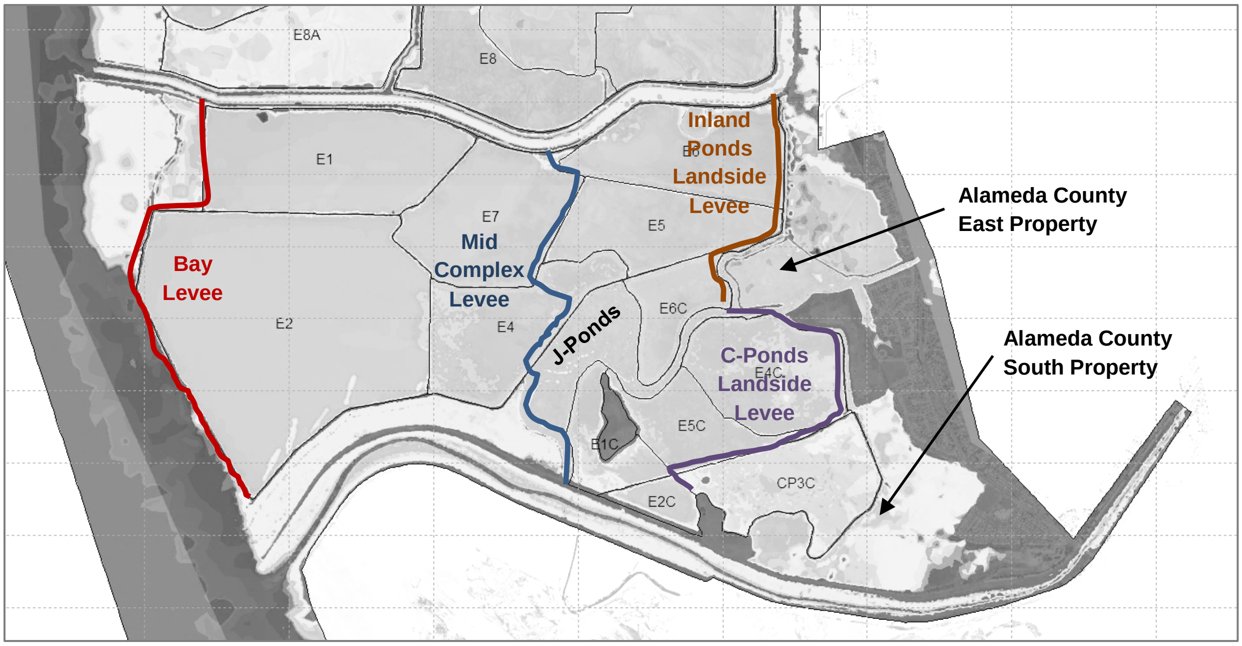

Figure 3.5. Flood Scenario Areas of Analysis for Alternatives A, B, C & D

The following is a summary of the Flood Scenario results in each of these areas of interest, discussed in the context of each model configuration: Alternative A (existing conditions), Alternative B (full tidal restoration), and Alternative C & D (partial tidal restoration and pond management).

Alternative A Configuration (Existing Conditions)

Figure 3.6 and Figure 3.7 show the maximum water surface elevations reached during the 10-year tide and 100-year discharge and the 100-year tide and 10-year discharge Flood Scenarios.

During the 10-year tide and 100-year discharge, the blue arrows in Figure 3.6 indicate the general flow path of the water. The 100-year discharge event overtops the ACFCC levee near the Bay and travels back upstream through the Alameda County Wetlands, J-Ponds, Pond E6C, C-Ponds, and to the Alameda County East Property and South Property.

During the 100-year tide and 10-year discharge, the blue arrows in Figure 3.7 also indicate the general flow path of the water. In this case, the 100-year tide overtops the pond levees via the OAC and Alameda County Wetlands. The Alameda County East Property is flooded by water traveling upstream through the J-Ponds and overtopped levees of Pond E6C (also fed by the J-Ponds). The FEMA FIRMs (see Figure 2.9) project the 100-year tide elevation farther inland than shown in Figure 3.7 because FEMA assumes non-accredited levees do not prevent water from traveling inland.

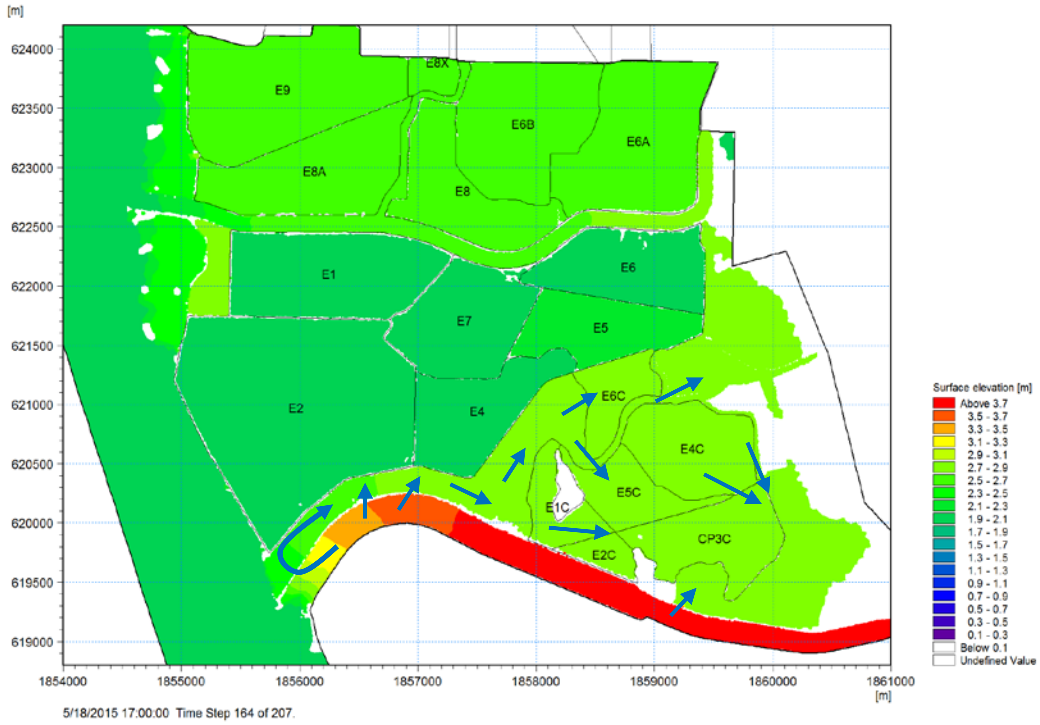

Figure 3.6. Alternative A Existing Conditions, Maximum Water Surface Elevation, Flood Scenario 10-year Tide & 100-year Discharge

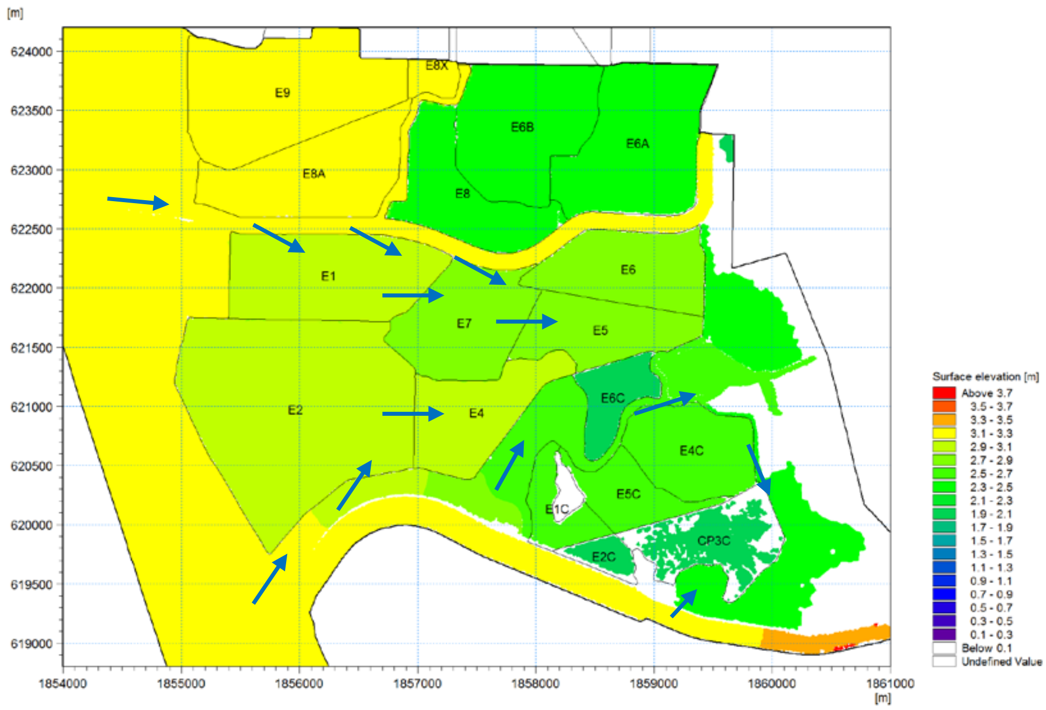

Figure 3.7. Alternative A Existing Conditions, Maximum Water Surface Elevation, Flood Scenario 100-year Tide & 10-year Discharge

The peak water surface elevations near the four proposed levee improvements for the Alternative A configuration (existing condition) are shown in Figure 3.8. Figure 3.8 shows that maximum water surface elevations near most proposed levees are near 9.5 feet, or about 10.2 feet in the case of the Bay Levee. The J-Ponds and Alameda County East and South Properties have a maximum water surface elevation of about 9 to 9.5 feet. In general, the C-Ponds, J-Ponds, and Alameda County Wetlands are most influenced by a large flood discharge down the ACFCC, whereas the Bay Ponds are much more influenced by a large tide. The Inland Ponds generally reach the same maximum water surface elevations during either Flood Scenario.

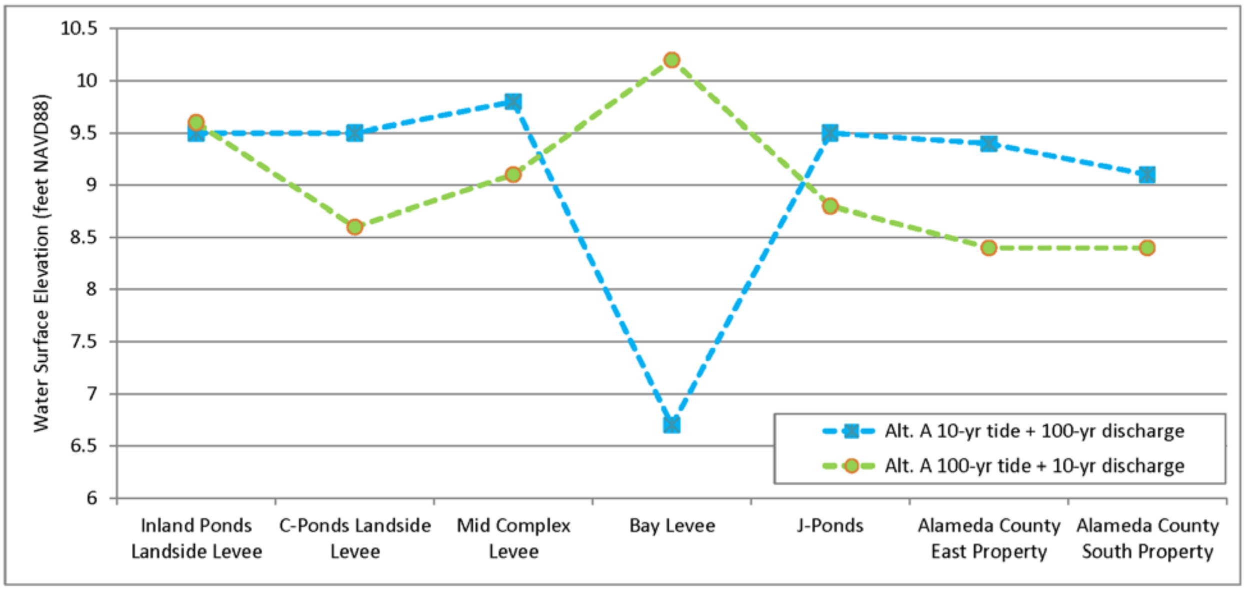

Figure 3.8. Alternative A Existing Conditions, Flood Scenarios, Maximum Water Surface Elevations in Vicinity of Improved Levees

Alternative B Configuration (full tidal restoration)

In the case of the Alternative B configuration, Figure 3.9 and Figure 3.10 (on the following page) show the maximum water surface elevations reached during the 10-year tide and 100-year discharge and the 100-year tide and 10-year discharge Flood Scenarios.

During the 10-year tide and 100-year discharge, the blue arrows in Figure 3.9 indicate the general flow path of the water. The 100-year discharge event overtops the ACFCC levee near the Bay similar to the Alternative A configuration, however with the proposed levee lowering to MHHW along the southern Pond E2 and northern Pond E1 levees, the majority of the water passes into the Bay and Inland Ponds and out through the OAC. With this restoration design, the ponds act as detention during peak discharge events, reducing the maximum water depths and extents experienced in the J-Ponds and Alameda County East and South Properties compared to existing conditions (see Figure 3.6).

During the 100-year tide and 10-year discharge, the blue arrows in Figure 3.10 indicate that the 100-year tide overtops the pond levees via the OAC and Alameda County Wetlands, similar to the Alternative A Configuration. Because the restoration design includes pilot channels, the maximum water surface elevation experienced is of shorter duration because the water can more quickly recede with the outgoing tide. The maximum water surface elevation is slightly increased about half a foot in the Bay Ponds (as one would expect with tidal restoration) due to the 100-year tide entering the Bay Ponds over the lowered levees along the OAC and Alameda County Wetlands; the maximum water surface elevation does however remain below the maximum occurring during the 10-year tide and 100-year discharge hydrologic scenario.

The peak water surface elevations for this configuration compared to existing conditions are summarized in Figure 3.11 (on the following pages). (Please note, in comparison to Figure 3.8, Figure 3.11 does not include the extraction points near the Mid-complex and Bay Levees, as those levee raises are not included in Alternative B and this information was extracted to inform levee height design.)

Within the J-Ponds, Alameda County East and South Properties, the maximum water surface elevations of the Alternative B configuration are all maintained or less than the peak elevation of about 9 to 9.5 feet in these areas. The maximum water surface elevation near the Inland Ponds and C-Ponds landside levees increase less than a half of foot. This slight increase is the driver for improving the Inland and C-Ponds Landside Levees between 2 and 2.5 feet in this Alternative, thereby increasing flood protection beyond existing conditions.

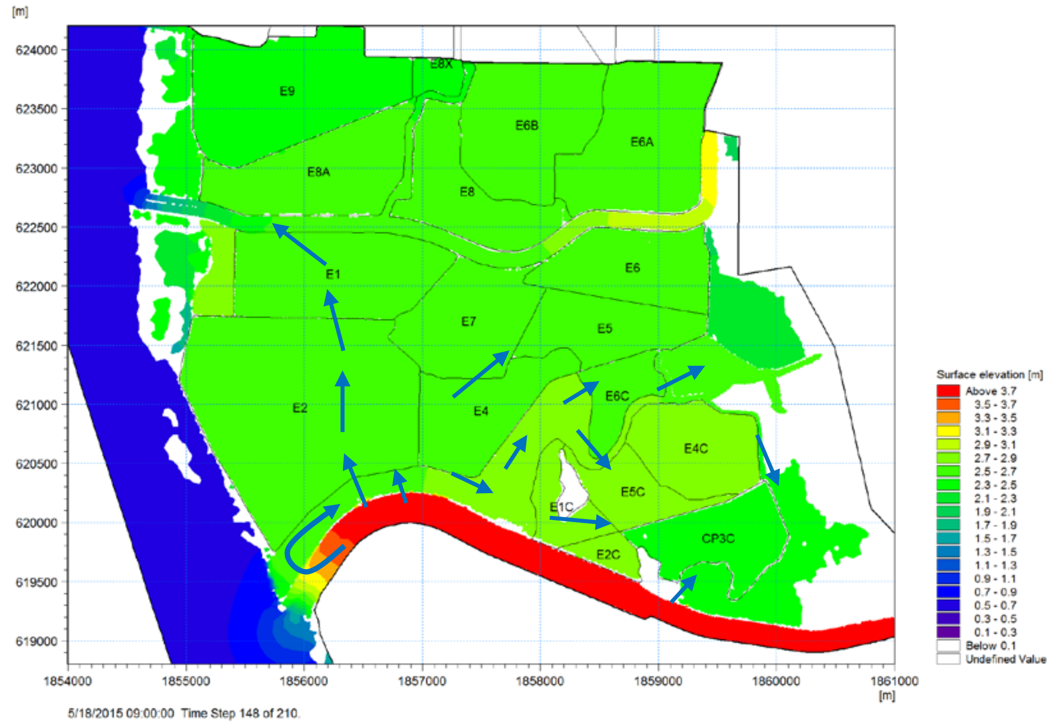

Figure 3.9. Alternative B Tidal Restoration, Maximum Water Surface Elevation, Flood Scenario 10-year Tide & 100-year Discharge

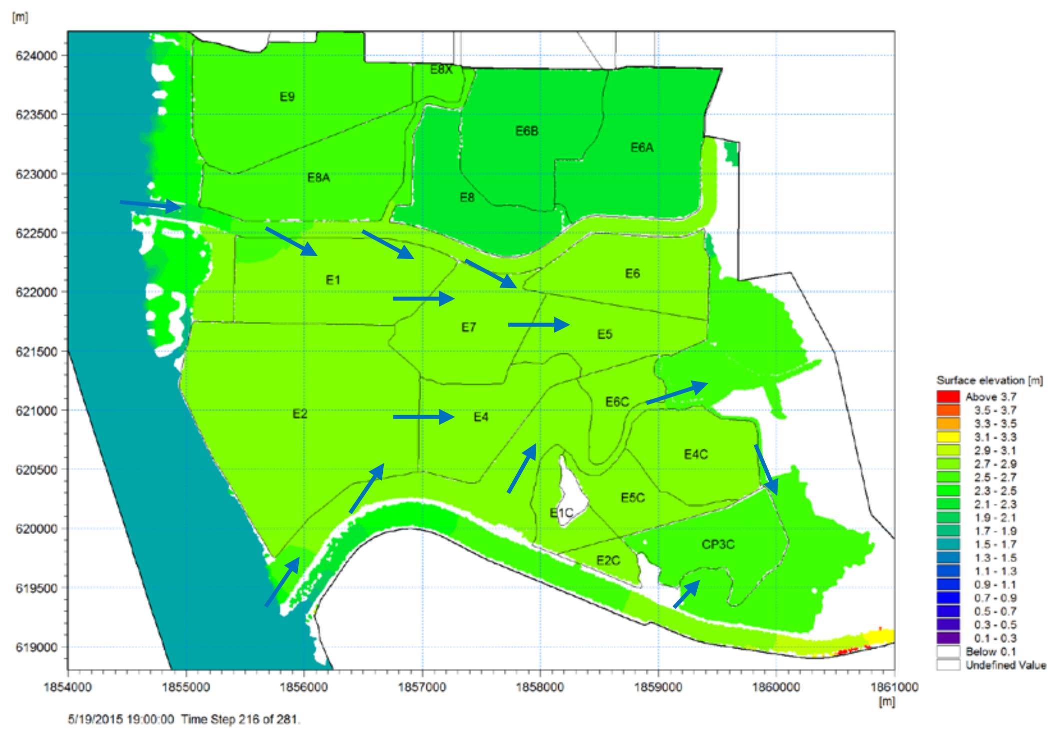

Figure 3.10. Alternative B Tidal Restoration, Maximum Water Surface Elevation, Flood Scenario 100-year Tide & 10-year Discharge

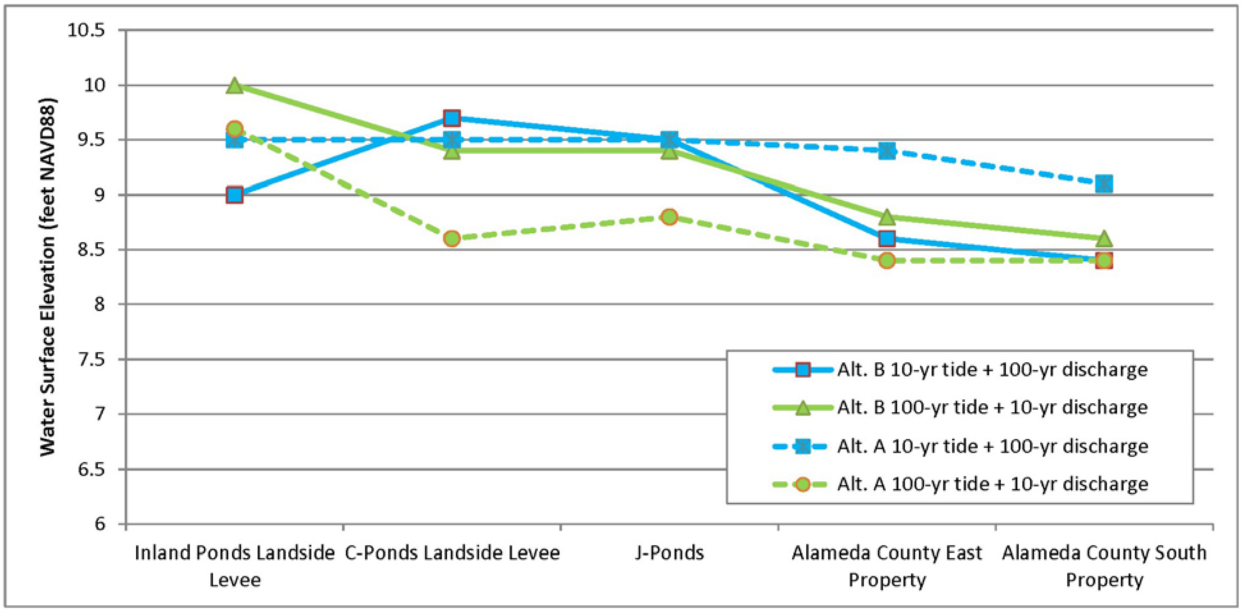

Figure 3.11. Alternative B Tidal Restoration, Flood Scenarios, Maximum Water Surface Elevations in Vicinity of Improved Levees

Additional general results from the Alternative B tidal restoration include:

- If the northern Pond E1 and southern Pond E2 levees were not lowered in Alternative B, the maximum water surface elevation in the J-Ponds increases over two feet, and the water surface elevation in the Alameda County East and South Properties increase about a foot. Levee lowering is an important flood control method necessary in the design to allow for flood waters from the ACFCC to travel through the ponds and out through the OAC.
- A levee breach into the C-Ponds from either the ACFCC or the J-Ponds would result in significantly higher water surface elevations in the C-Ponds compared to existing conditions. A breach in either of these locations allows for the ACFCC large discharge event to travel directly into the C-Ponds, and would require additional levee raising than what is proposed in the Preliminary Design to prevent levee overtopping into Alameda County South Property via Cargill's Pond CP3C.
- To investigate the potential fish passage culvert along ACFCC, a relatively small 3,500 cfs (less than the 10-year event) was discharged from ACFCC during a model run with a dye tracer in it. Dye concentration results indicate water travels from ACFCC through the proposed fish passage culverts and into the Bay Ponds. Little to no tidal water extend up to the fish passage culverts during such an event. The ACFCC discharge enters the Bay and Inland Ponds, indicating that a percentage of juvenile fish traveling with flow would be transported into the Bay and Inland Ponds and then out the OAC.

Alternative C & D Configuration (mid complex levee and phased restoration)

In the case of the Alternative C & D configuration, Figure 3.12 and Figure 3.13 (on the following page) show the maximum water surface elevations reached during the 10-year tide and 100-year discharge and the 100-year tide and 10-year discharge Flood Scenarios.

During the 10-year tide and 100-year discharge, the blue arrows in Figure 3.12 indicate the general flow path of the water. The 100-year discharge event overtops the ACFCC levee near the Bay similar to the Alternative A configuration, however with proposed levee lowering to MHHW along the southern Pond E2 and northern Pond E1 levees, the majority of the water passes into the Bay Ponds, and is blocked by the Mid Complex levee from entering the Inland and C-Ponds, and travels out through the OAC. With this restoration design, the ponds act as detention during peak discharge events, reducing the maximum water surface elevations and extents experienced in the Inland Ponds, C-Ponds, J-Ponds and Alameda County East and South Properties compared to existing conditions (see Figure 3.6).

During the 100-year tide and 10-year discharge, the blue arrows in Figure 3.13 indicate that the 100-year tide overtops the pond levees via the OAC and Alameda County Wetlands, similar to the Alternative A Configuration. The Mid Complex Levee prevents the high tide from entering the all ponds and properties east of the Bay Ponds.

The peak water surface elevations for this configuration compared to existing conditions are summarized in Figure 3.14 (on the following pages). The maximum water surface elevations in the J-Ponds and Alameda County East and South Properties are reduced between 0.5 to one foot compared to the peak flood elevation. The water surface elevation at the Mid Complex Levee increases from about 9.7 to 10.4 feet, and the Bay Levee water surface elevation remains about the same compared to Alternative A existing conditions. The Mid Complex Levee is not overtopped, and therefore the increase in water surface elevation at this location is anticipated as all the water previously allowed to flood the Inland Ponds, J-Ponds, C-Ponds, and Alameda County Properties is now contained only within the Bay Ponds.

Additional general results from the Alternative C & D partial tidal restoration and managed pond configuration include:

- The maximum water surface elevations in the OAC and ACFCC near the model extents do not increase in Alternative C & D compared to Alternative A (existing conditions). The same is true for the Northern Eden Landing Ponds, which reach a maximum water surface elevation of about 8 feet, which does not flood into the property immediately behind the existing Pond E6A levee.

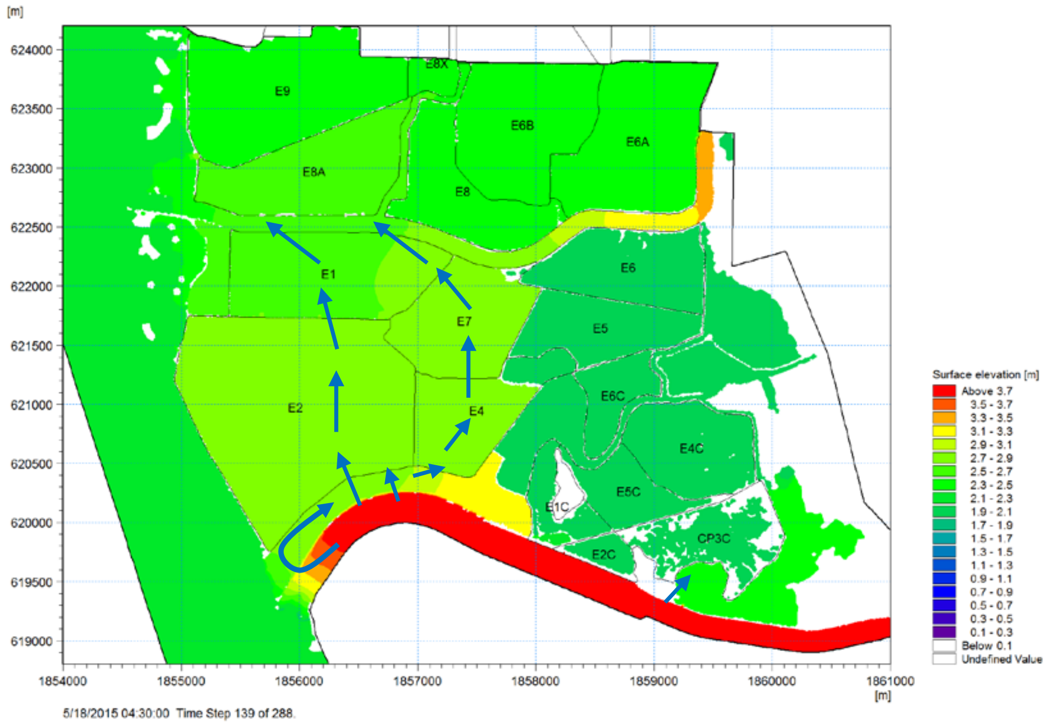

Figure 3.12. Alternative C & D Partial Tidal Restoration and Managed Ponds, Maximum Water Surface Elevation, Flood Scenario 10-year Tide & 100-year Discharge

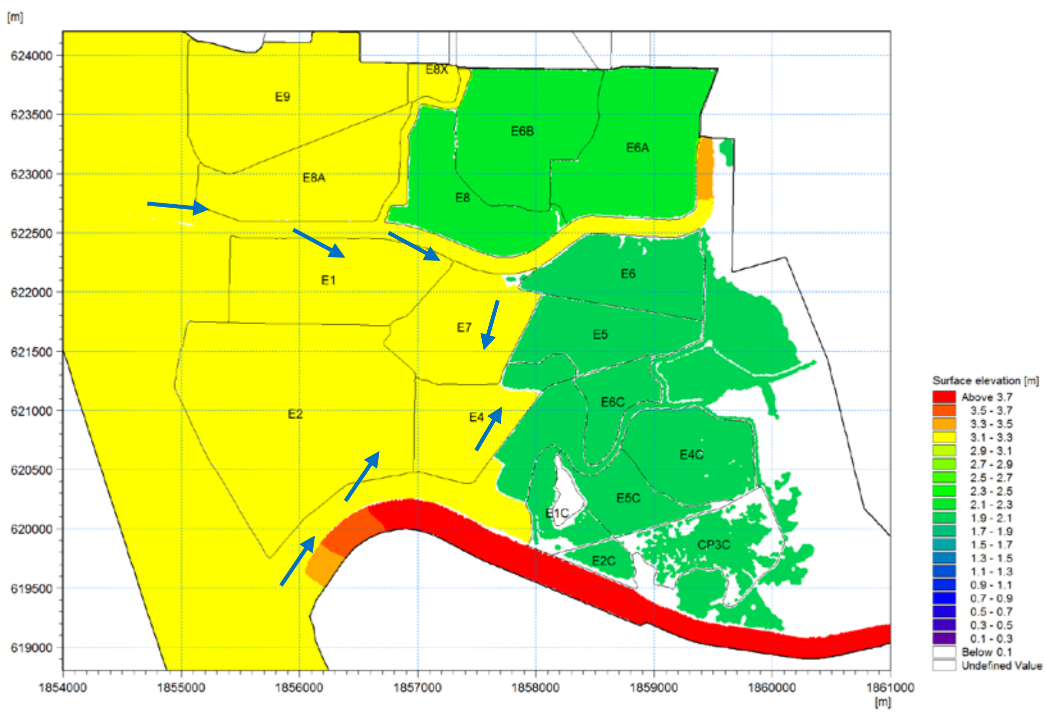

Figure 3.13. Alternative C & D Partial Tidal Restoration and Managed Ponds, Maximum Water Surface Elevation, Flood Scenario 100-year Tide & 10-year Discharge

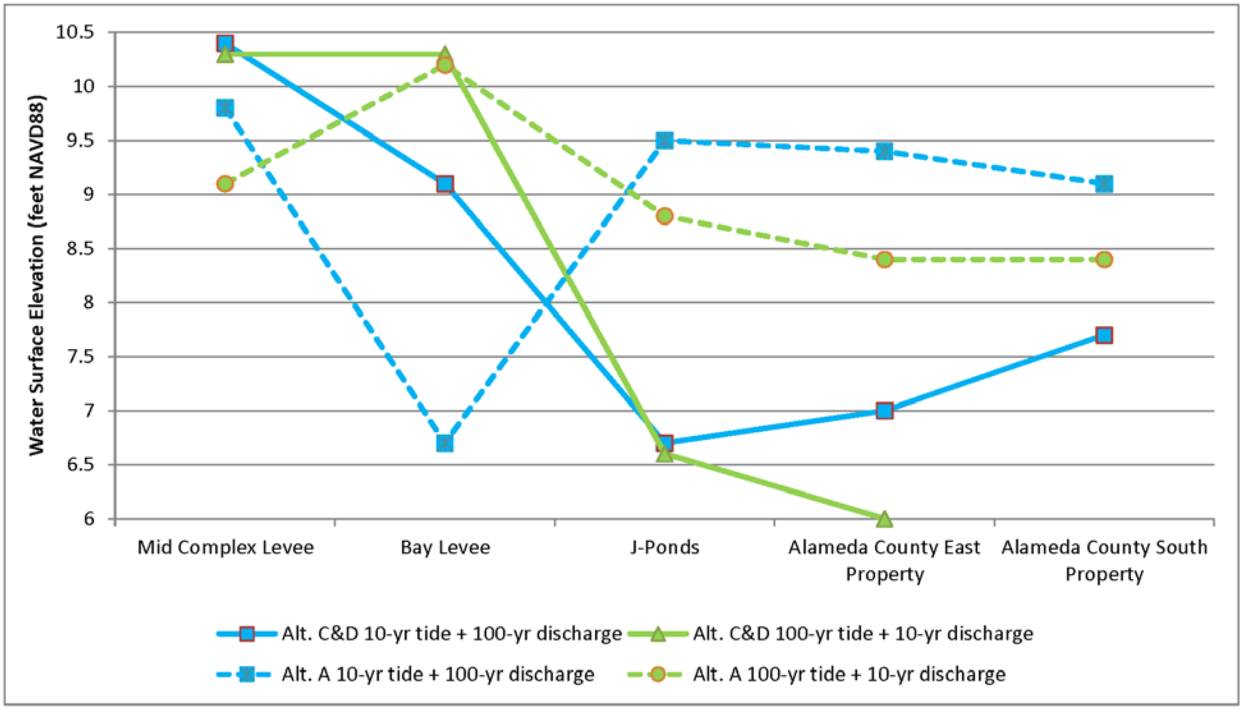

Figure 3.14. Alternative C & D Tidal Restoration and Pond Management, Flood Scenarios, Maximum Water Surface Elevations in Vicinity of Improved Levees

<u>Flood Scenario Conclusions</u>

Based on results from all Flood Scenarios, a consistent 12 foot NAVD88 levee improvement elevation was included in the Preliminary Design for all proposed levee improvements to provide over 1.5 feet of freeboard at all locations. Further analysis may allow the Inland and C-Ponds Landside Levees to be reduced to 11 feet NAVD88, however the higher elevation, greater volume, and larger environmental impact is appropriate to assume at this stage in the design. The Bay Levee may also be eliminated from improvement if habitat value is added elsewhere, as the Bay Levee currently provides wave protection; no flood protection. Of note, these maximum water surface elevations do not include wave setup and runup, therefore a freeboard is recommended.

Table 3.2. Preliminary Design Levee Improvement Elevations

	Max. Water Surface Elev. (feet NAVD88)			Freeboard	Preliminary Design Elevation
	Alt. A	Alt. B	Alt. C & D	(feet)	(feet NAVD88)
Inland Ponds Landside Levee	9.6	10.0	-	2.0	12.0
C-Ponds Landside Levee	9.5	9.4	-	2.5	12.0
Mid Complex Levee	9.8	-	10.4	1.6	12.0
Bay Levee	10.2	-	10.3	1.7	12.0

3.3 HEC-RAS Water Control Structure Results

New water control structures will facilitate the controlled movement of water between the ponds. The number, location, sizes, and operation of these water control structures differs by Alternative. Below is a summary of the results obtained from the HEC-RAS modeling analysis performed on the Inland and C-Ponds. Proposed water control structures (new and existing) are shown in Table 3.3, as well as Appendix A Figures A-7, A-8, and A-9. Additional information can be found in the Eden Landing Preliminary Design (AECOM 2016a).

Table 3.3. Design Criteria of Water Control Structures

Location	(Number), Size, Type	Length (ft.)	Existing Invert Elev. (ft. NAVD88)	Design Invert Elev. (ft. NAVD88)	Purpose	Applicable Alternatives
ACFCC/E2C (existing)	(2) 48 in. dia. HPDE/CMP	170	2.7	-	Hydraulic connectivity (Alt. B) or Pond management (Alt. C and D)	B, C and D
ACFCC/E2C	(2) 48 in. dia. HPDE/CMP	170	-	2.7		
E1C/E5C (S)	(2) 48 in. dia. HPDE/CMP	60	-	2.7		
E1C/E5C (N)	(1) 48 in. dia. HPDE/CMP	50	-	2.7		C and D
E2C/CP3C (existing)	(1) 48 in. dia. HPDE/CMP	60	Unknown	-		B and D
OAC/E6	(2) 48 in. dia. HPDE/CMP	150	-	0		C and D
E6/E5 (W)[1]	(1) 48 in. dia. HPDE/CMP	40	-	0		
E6/E5 (E)[1] (existing)	(1) 48 in. dia. HPDE/CMP	40	-	0		
E5/E6C (W)[2] (existing)	(1) 36 in. dia. HDPE/CMP	60	Unknown	0		
E5/E6C (E)[2] (existing)	(1) 36 in. dia. HDPE/CMP	60	Unknown	0		
ACFCC/E2&E4 via Alameda County Wetlands	(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP	200	-	2.7	Fish passage	B
E7/E5	(1) 48 in. dia. HPDE/CMP	50	-	0	Culvert redundancy	C
ACFCC/Alameda County Wetlands	(1) 6 ft. x 6 ft. concrete box or (3) 48 in. diam. HDPE/CMP	200	-	2.7	Fish passage	
Alameda County Wetlands/E1C	(1) 48 in. dia. HPDE/CMP	30	-	2.7	Fish passage/pond management	
Alameda County Wetlands/J-Ponds	(1) 48 in. dia. HPDE/CMP	50	-	2.7	Detention basin management	

Note 1: E6/E5 (W) and (E) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

Note 2: E5/E6C (W) and (E) could be combined into a single set of culverts to reduce costs as opposed to two separate culverts.

3.3.1 Inland Ponds

In Alternatives C and D (the managed pond alternatives), two culverts will connect the OAC and Pond E6. One culvert could provide the desired conveyance over a longer period, however redundancy in the system is desired. The water level in the Inland Ponds may be increased up to the high tide level in the OAC by operating the combination gate on the inside of Pond E6 as a tide gate, and leaving open the outside gate on the OAC end.

Figure 3.15 shows the water surface elevations in the Inland Ponds with the proposed culverts for Alternatives C and D listed in Table 3.3. The results in the figure indicate sufficient capacity to convey water between the ponds.

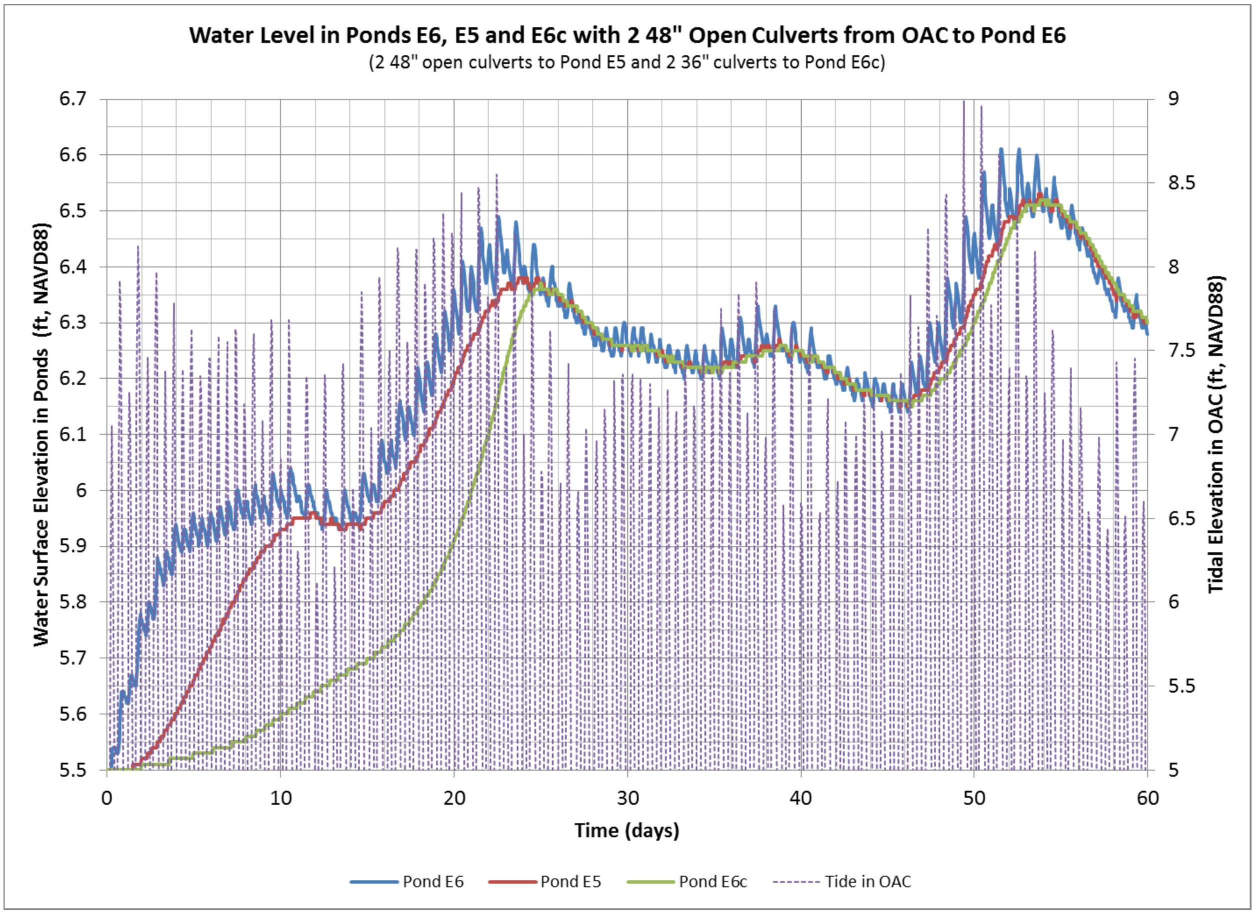

Figure 3.15 Water Surface Elevations in Inland Ponds with Proposed Water Control Structures

Figure 3.16 shows the predicted water surface elevations in the OAC near the Pond E6 culverts relative to the Bay tides. When the OAC is flowing during rain events, the limited conveyance capacity of the OAC causes water surface elevations in the OAC to rise. With a 10 cfs base flow in the OAC, the low tide in the OAC just outside the Inland Ponds is about one to two feet higher than that experienced in the Bay. With a higher base flow of about 100 cfs, the low tide in the OAC is about three to four feet higher than the low tide in the Bay. After the breach is constructed connecting the OAC and Pond E1

(Alternatives B, C and D), the OAC is anticipated to scour and increase its conveyance capacity; however the OAC reach from Pond E1 to the culvert at Pond E6 is not anticipated to scour.

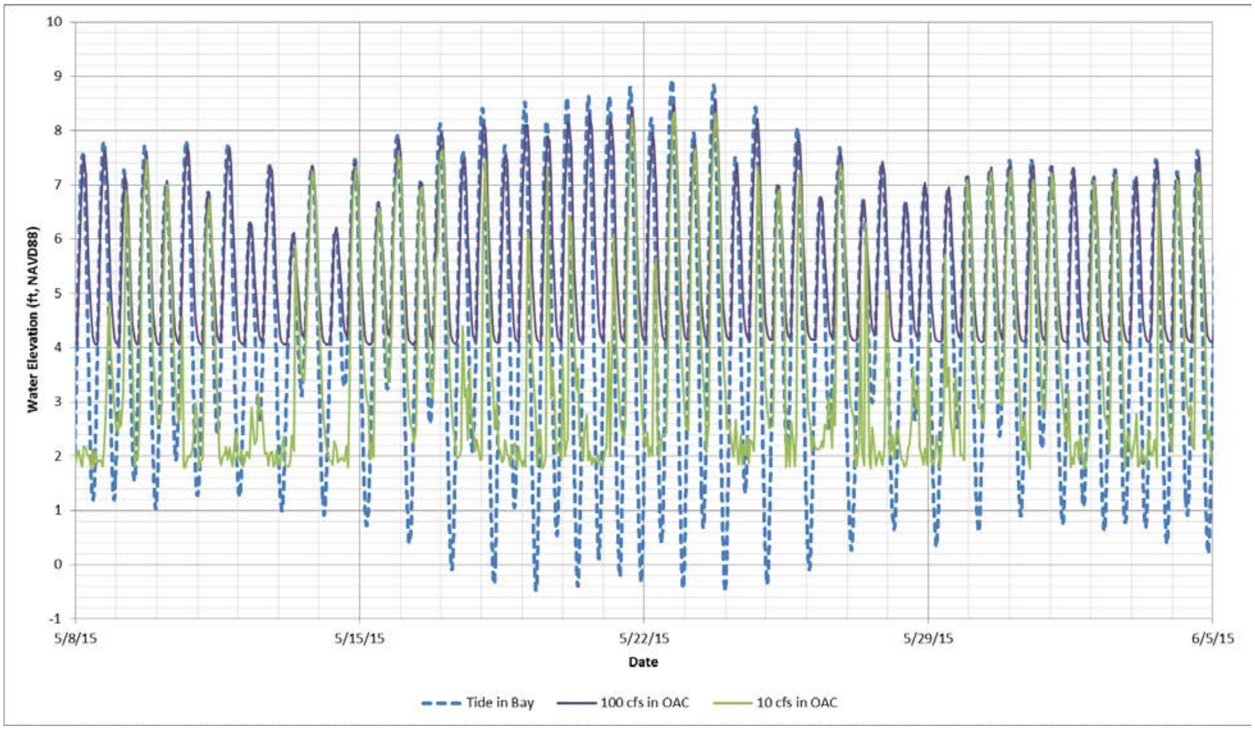

Figure 3.16 Tidal Elevations in the Bay and OAC (near Pond E6)

3.3.2 C-Ponds

Presently there are two 48 inch gates culverts connecting Pond E2C to the ACFCC. Adding two more culverts raises the maximum water level in the ponds by about a half a foot in Pond E2C and about 0.1 feet in Ponds E5C and E4C. This assumes that a 48 inch culvert is installed between Ponds E1C and E5C.

4. LIMITATIONS

This memorandum summarizes a modeling study based on information available at the time and our professional judgment pending future analyses. Future design decisions or additional information may change the findings, and corresponding professional judgments presented in this report. In the event that conclusions or recommendations based on the information in this memorandum are made by others, such conclusions are not the responsibility of AECOM, or its subconsultants, unless we have been given an opportunity to review and concur with such conclusions in writing

5. REFERENCES

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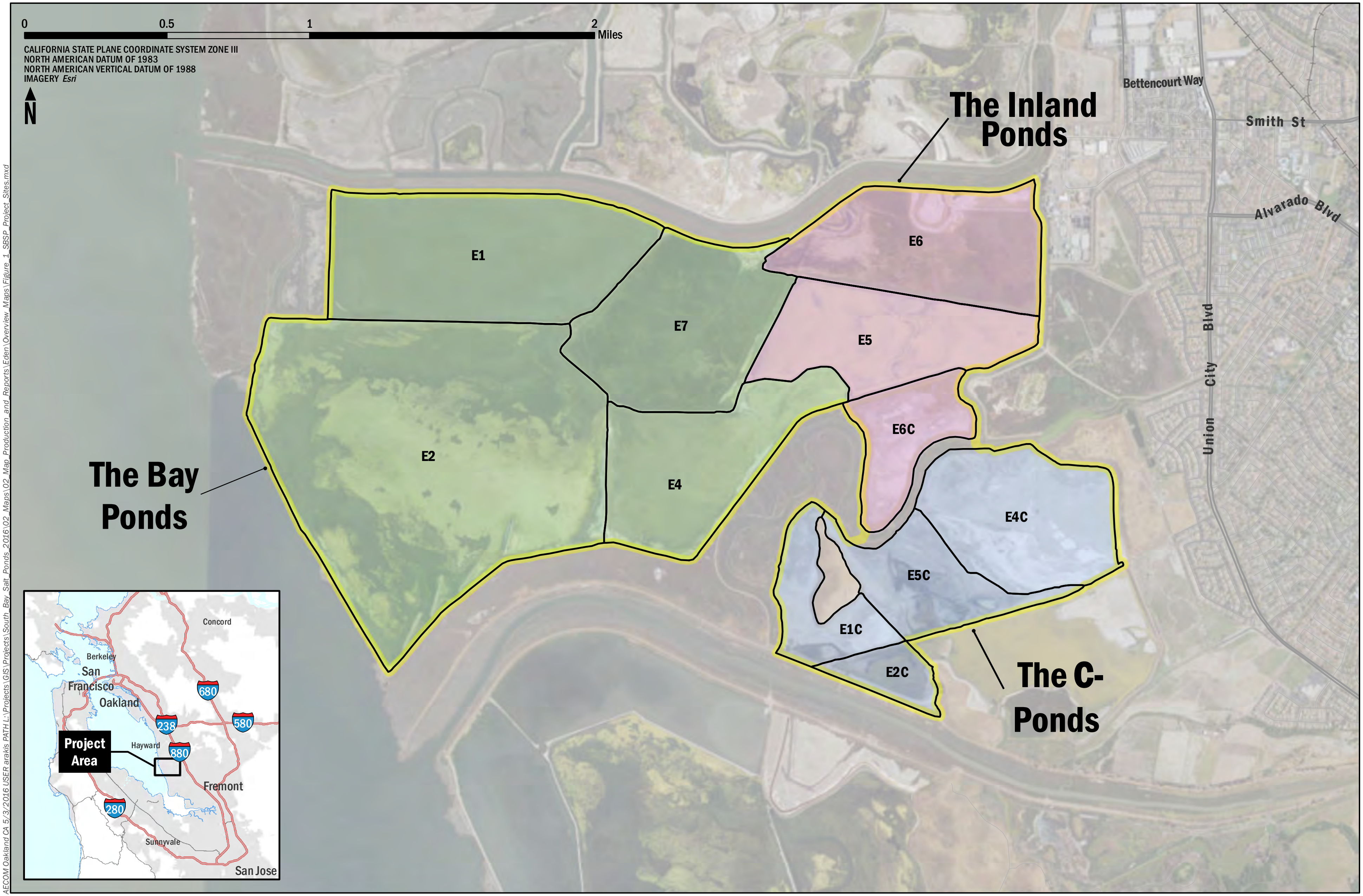
Appendix A

Eden Landing Figures



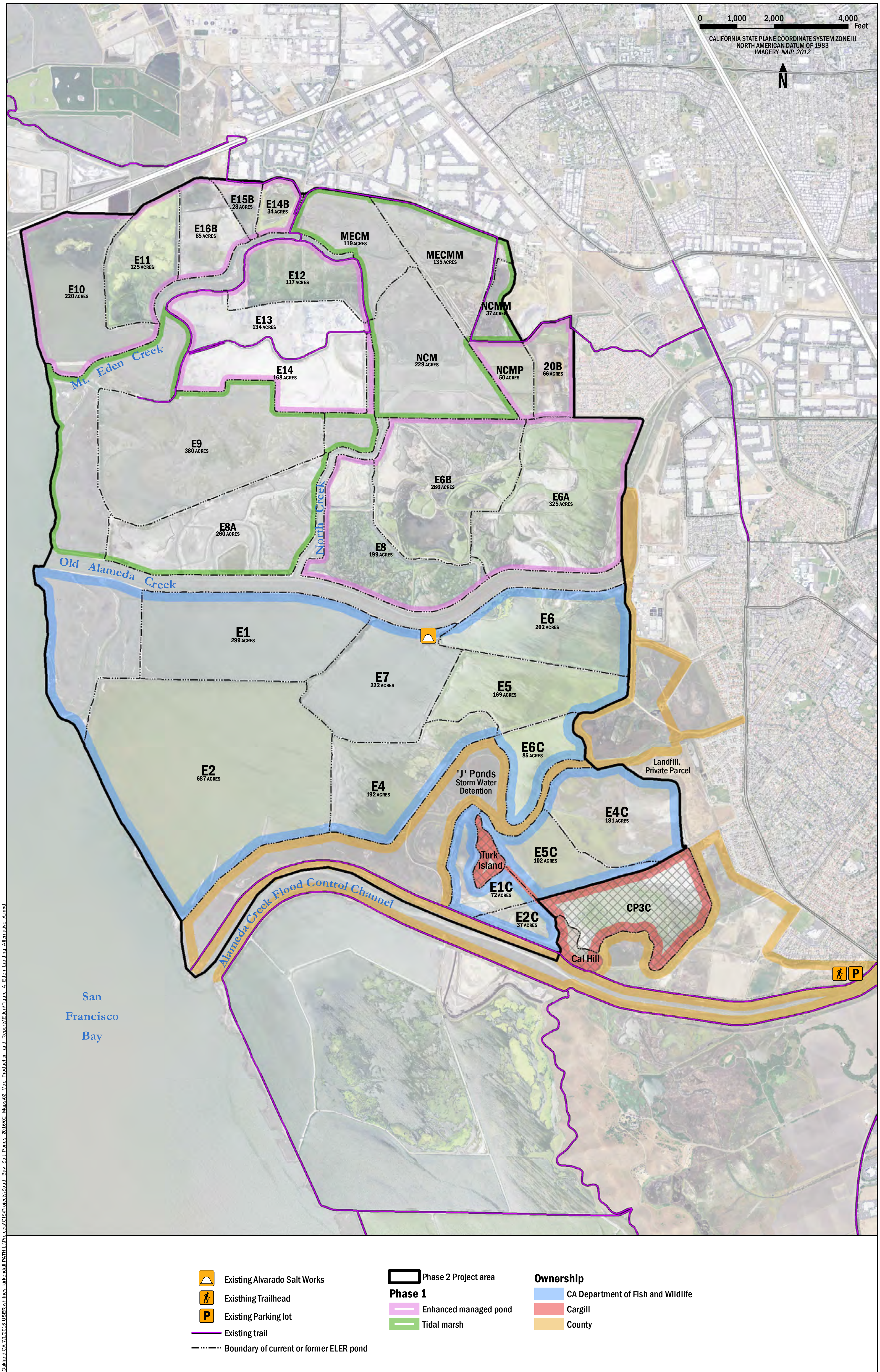
LEGEND

- Phase 2 Eden Landing Project Area
- The Bay Ponds
- The C Ponds
- The Inland Ponds

AECOM

South Bay Salt Pond Restoration Project
Eden Landing Phase 2: Project Area

Figure A-1
Eden Landing Phase 2: Project Area



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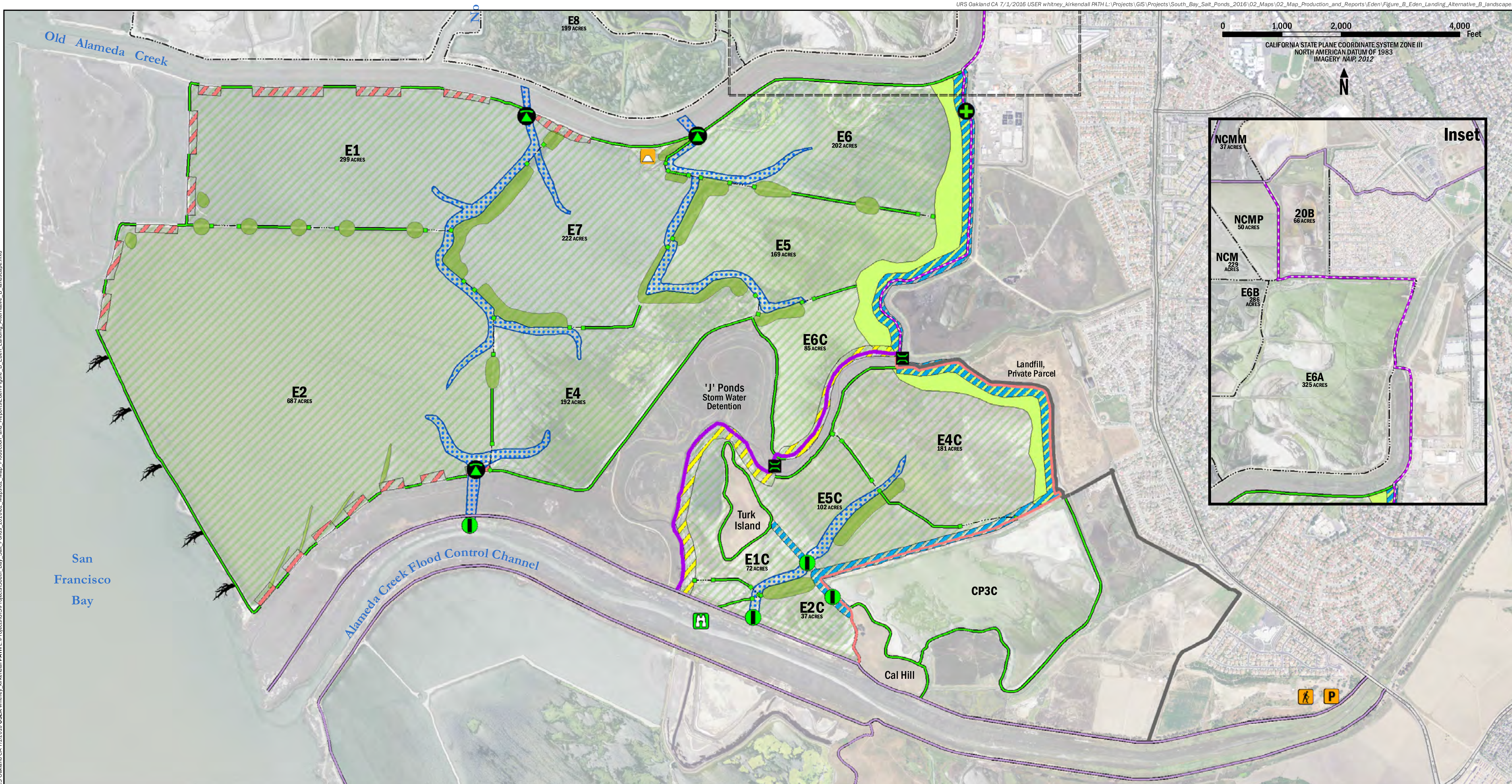
South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden A

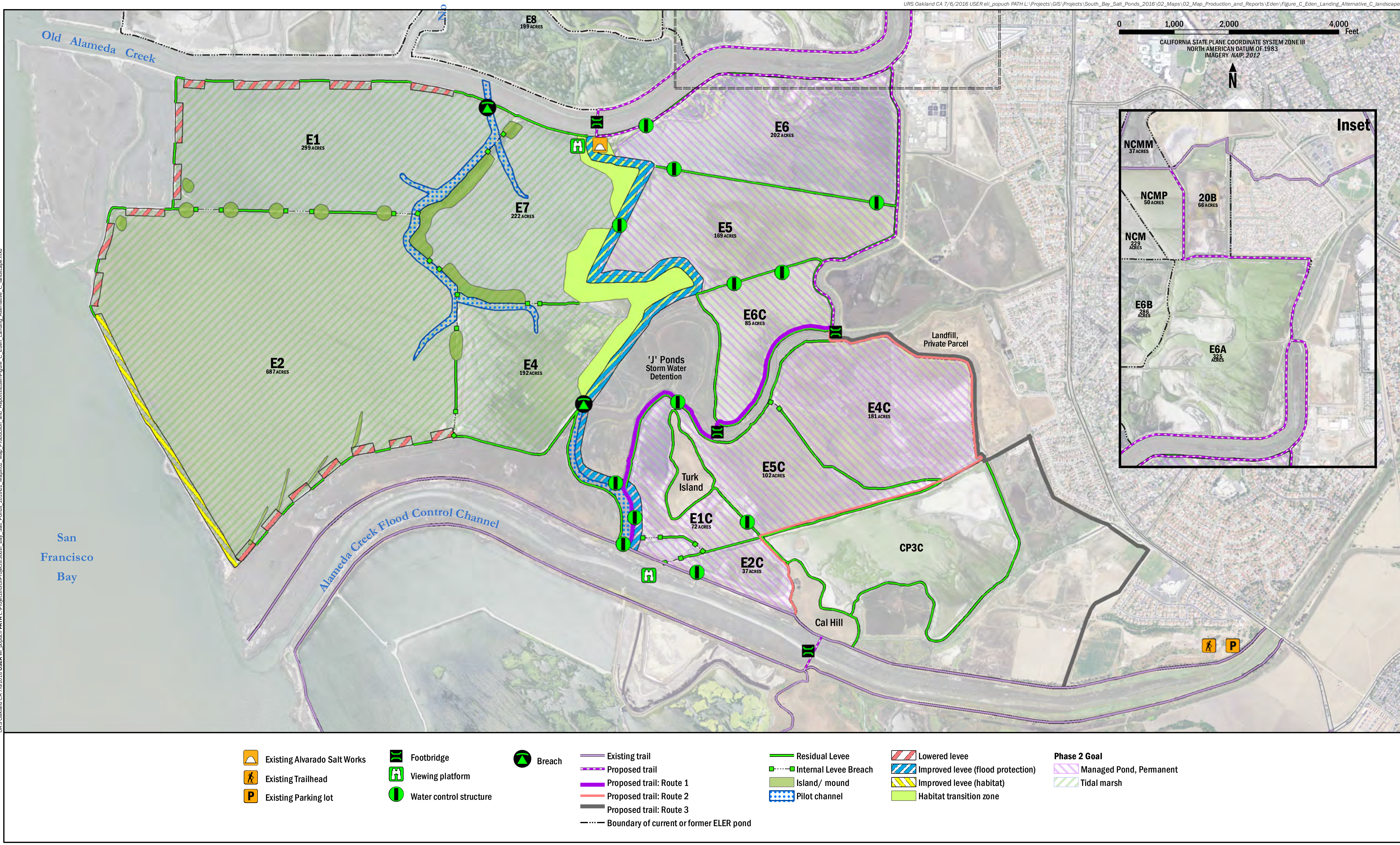


Existing Alvarado Salt Works
Existing Trailhead
Existing Parking lot
Logs for marsh enhancement
Footbridge
Viewing platform
Water control structure
Breach
Union Sanitary District connection
Existing trail
Proposed trail
Proposed trail: Route 1
Proposed trail: Route 2
Proposed trail: Route 3
Boundary of current or former Northern ELER pond
Residual Levee
Internal Levee Breach
Island/ mound
Pilot channel
Lowered levee
Improved levee (habitat)
Improved levee (flood protection)
Habitat transition zone
Phase 2 Goal
Tidal marsh

AECOM

South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden B



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South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Alternative Eden C

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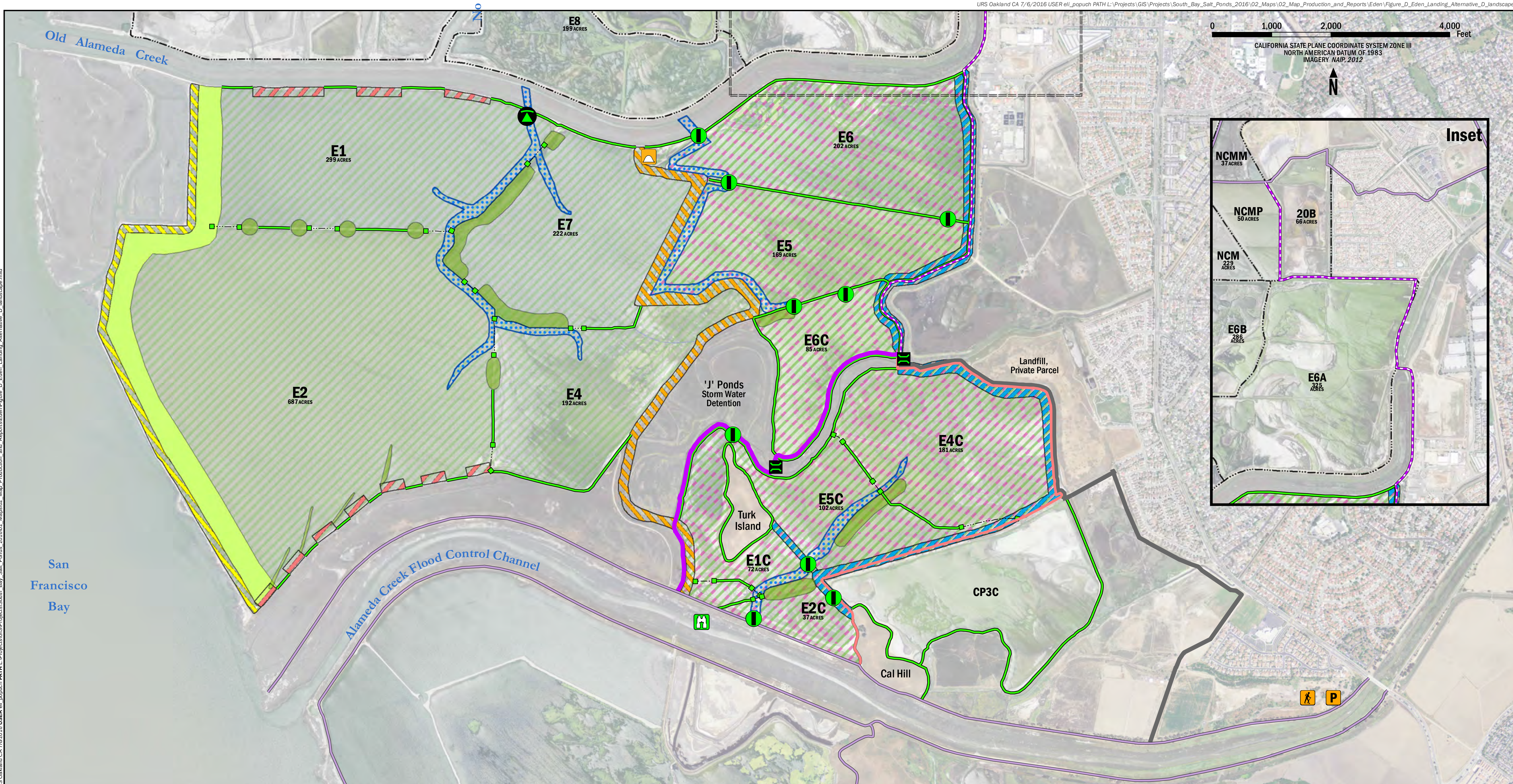

Existing Alvarado Salt Works
Existing Trailhead
Existing Parking lot

Viewing platform
Water control structure
Breach

Existing trail
Proposed trail
Proposed trail: Route 1
Proposed trail: Route 2
Proposed trail: Route 3
Boundary of current or former ELER pond

Residual Levee
Internal Levee Breach
Habitat transition zone
Island/ mound
Pilot channel

Lowered levee
Improved levee (flood protection)
Improved levee (habitat)
Temporary levee

Phase 2 Goal
Managed Pond, then tidal marsh
Tidal marsh

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South Bay Salt Pond Restoration Project
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Alameda County, CA

Alternative Eden D

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Infrastructure

- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status

- Existing

Boundary of current or former ELER pond

Ownership

- CA Department of Fish and Wildlife
- Cargill
- County

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South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

Infrastructure Alternative A

Infrastructure

- Water control structure
- Pump
- Power distribution line
- Overhead power transmission line

Status

- New
- Demolish
- Replace/Repair

Boundary of current or former ELER pond

Phase 2 Goal

- Tidal marsh

Ownership

- CA Department of Fish and Wildlife
- Cargill
- County

Note: Levee breaches will be created where infrastrcture is demolished, except at the Bay-E2 water control structue where the levee will be backfilled after structure removal.

URS Oakland CA 7/8/2016 **USER** eli_popuch **PATH** L:\Projects\GIS\Projects\South_Bay_Salt_Ponds_2016\02_Maps\02_Map_Production_and_Reports\Eden\10_2\Figure_B_Eden_Landing_Culverts_Alternative_B_landscape.mxd

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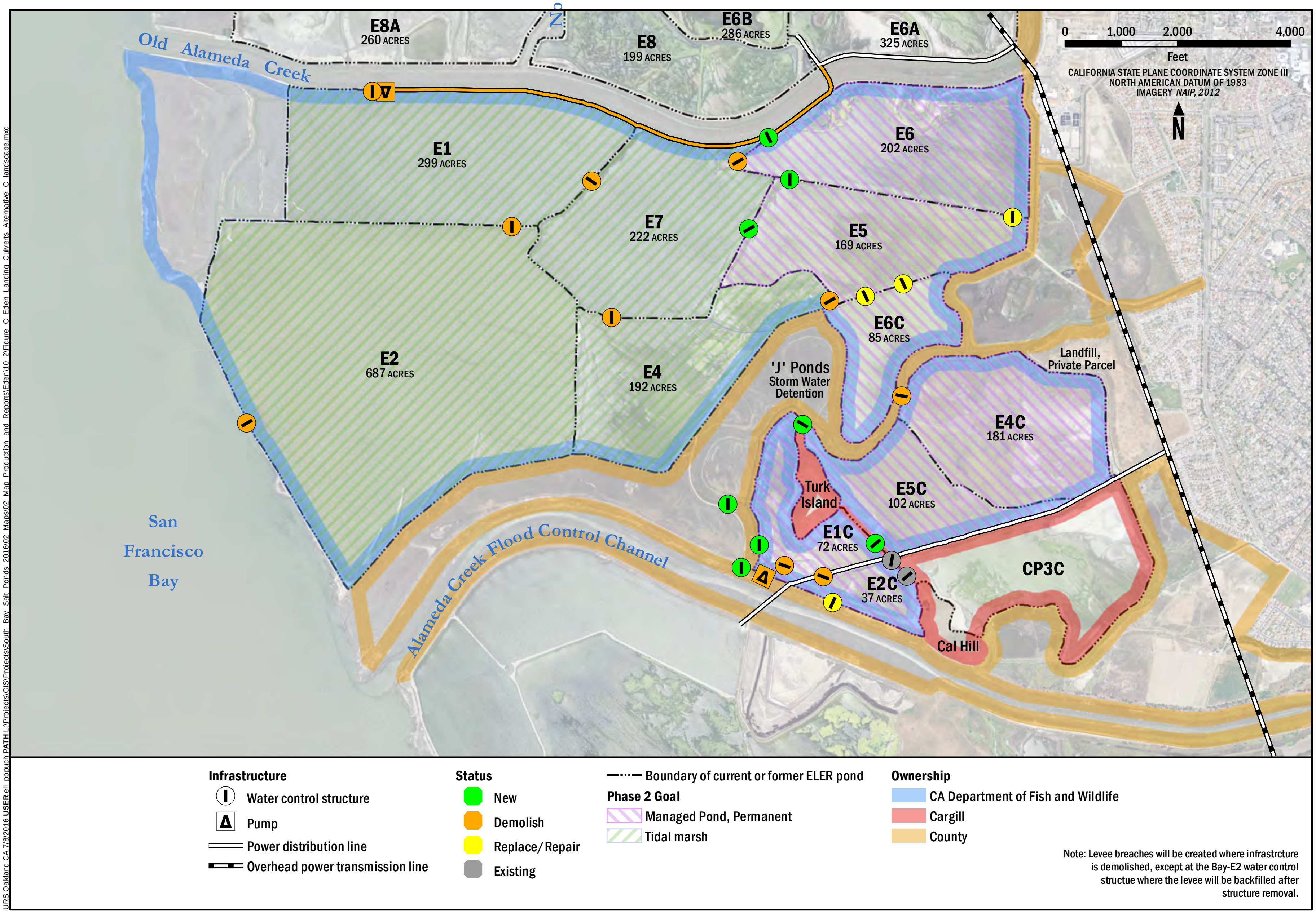
Infrastructure Alternative B



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South Bay Salt Pond Restoration Project
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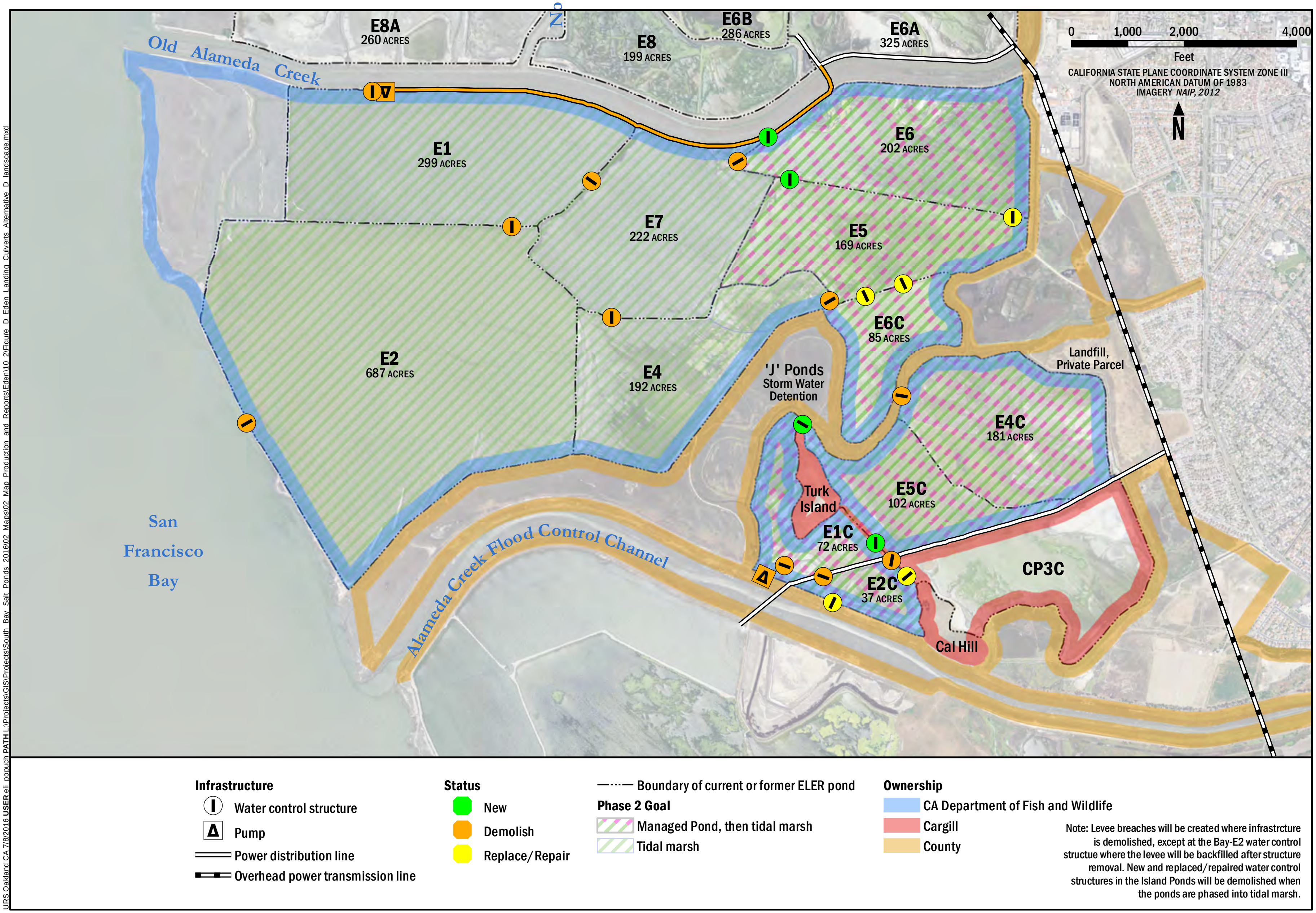
Alameda County, CA

Infrastructure Alternative C



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South Bay Salt Pond Restoration Project
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Infrastructure Alternative D

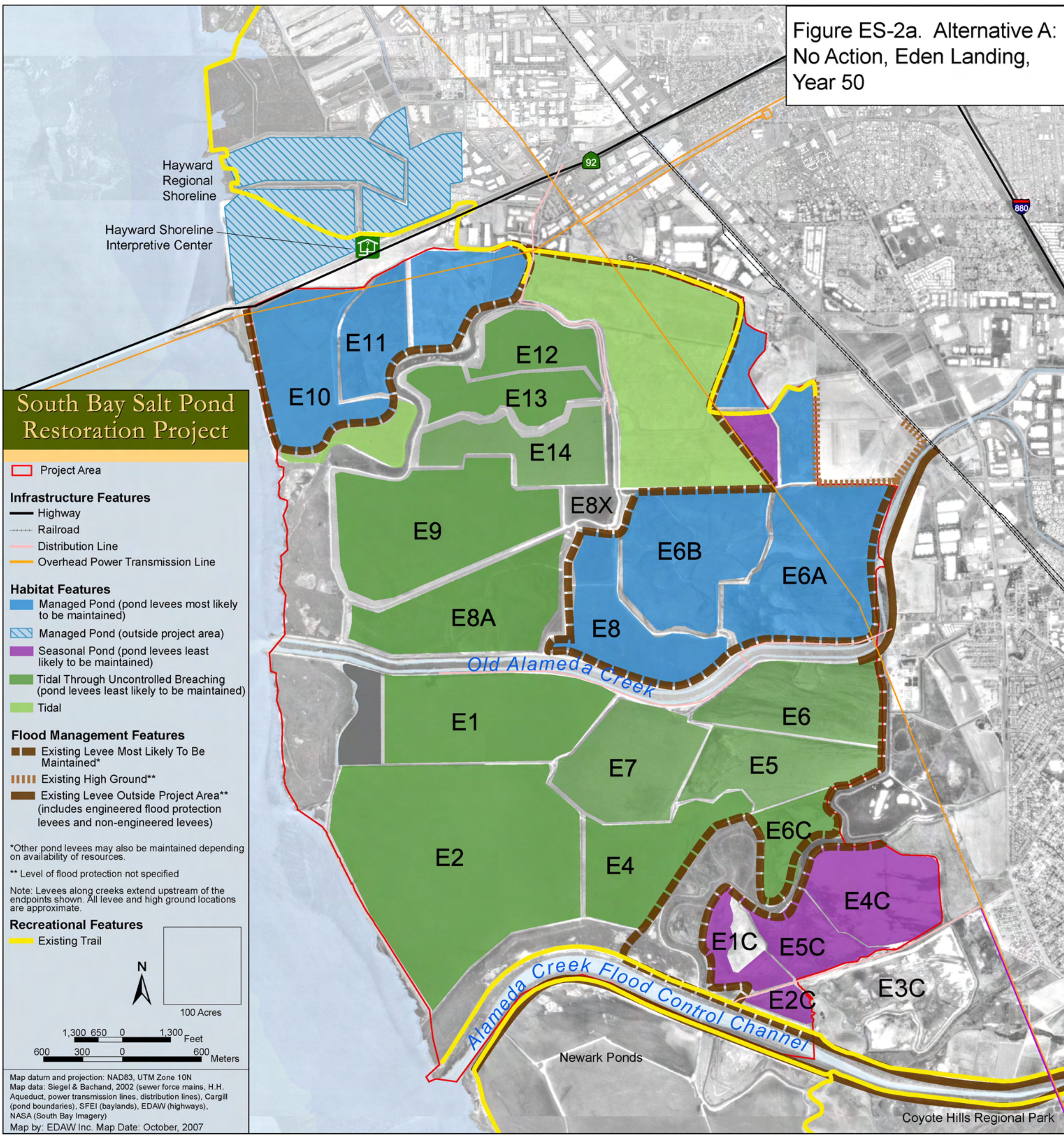

Figure A-6. Programmatic EIS/R Alternative A: No Action

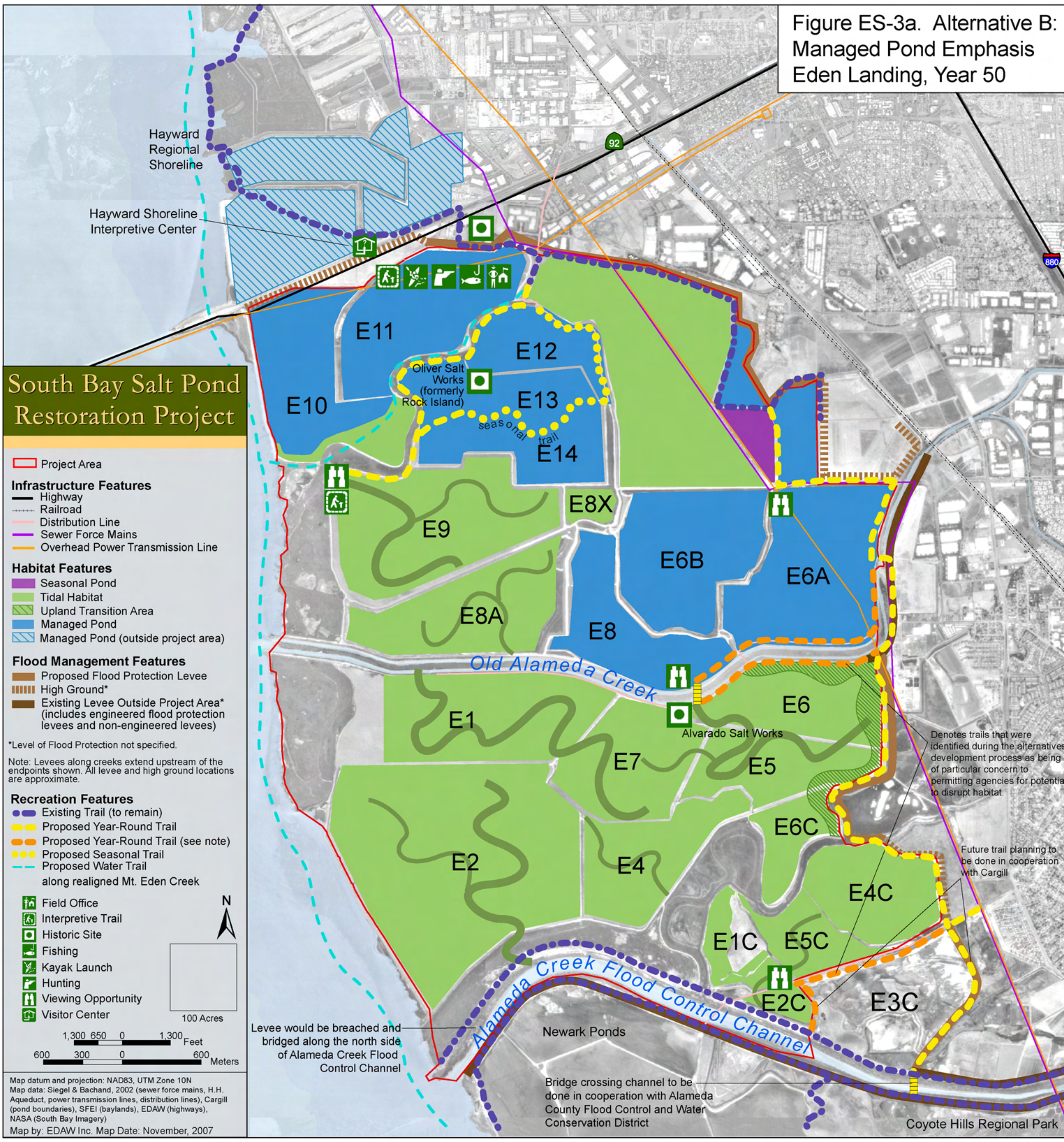

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Figure A-7. Programmatic EIS/R Alternative B: Managed Pond Emphasis

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Figure A-8. Programmatic EIS/R Alternative C: Tidal Habitat Emphasis

Appendix B

David Schoellhamer (USGS) comments on AECOM modeling of Eden Landing Ponds

David Schoellhamer comments on AECOM modeling of Eden Landing Ponds

March 18, 2016

On March 17, 2016, Phil Mineart and Megan Collins of AECOM presented their modeling of the Eden Landing Ponds to me via a webinar. The objective of the modeling at this 10% design stage is to conceptually determine how to obtain water levels in the ponds that meet management objectives without increasing flood risk. AECOM is applying the MIKE21 model, a commonly used model that simulates depth-averaged flow varying in time and varying horizontally. This is an appropriate model for the task and overall the modeling is appropriate for the task. Specific comments follow.

- Accurate bathymetry data are essential and they have utilized the latest and best data available.
- Boundary conditions of Bay tides and the 100-year flood are also essential and well-defined. For flood simulations they have aligned the arrival of the flood peak with a high tide which is a good conservative approach. Perhaps now or a later design stage the effect of sea level rise on the flood scenario should be considered. *[AECOM insert: The SBSP Project's approach is to maintain existing flood protection and work with external partners as practicable to improve existing conditions. Designing for sea level rise would improve existing conditions, and is therefore not an incorporated component of the Eden Landing design at this time.]*
- There is no water level data that I know of that could be used for model calibration. Ideally, such data would exist and be used to calibrate the model. Fortunately water level is the easiest model variable to predict (compared to velocity, salinity, sediment, water quality), the model domain is small, bathymetry is well-defined, and the boundary conditions are well-defined. So lack of data adds uncertainty to the model but is not a fatal flaw.
- The management objective for restoration is to maximize pond area that is wetted and dried during a tidal cycle. A different management objective would likely lead to a different restoration design.
- AECOM will double check that there is no overtopping of the levee on the landward side of the model domain that protects an urban area. *[AECOM insert: The model extent was expanded to the east to capture the full flood extent.]*
- The model does not consider bathymetric change created by restoration actions. The simulation of a scoured OAC was a good idea to test what could happen with increased tidal prism and potential scour. OAC at the E7 breach (I am 90% sure I have the right one) has a mid-channel marsh island. The E7 breach to the south channel could increase scour there. The south channel would then take more tidal prism, reducing tidal flows in the north channel that could lead to deposition there (similar to deposition in Steinberger Slough when the Port of Redwood City was deepened). The north channel presently takes most of the flood flow, so deposition in it would have the potential to make flooding worse. AECOM proposed making a cut in the mid-channel island at the E7

breach to try to better balance the increased flow in the north and south channels, which makes sense to me.   I expect this would also improve wetting and drying of E7. I also expect it would reduce erosion of seaward fringe marsh in OAC along the south channel and so the cut may preserve some seaward marsh and may not result in a net loss of marsh. *[AECOM insert: OAC island cuts are proposed for external breaches connecting Ponds E1 and E7 to the OAC.]*

ATTACHMENT 2. EDEN LANDING GEOTECHNICAL INVESTIGATION AND ANLYSES

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Memorandum

To	State Coastal Conservancy	Pages 5
Subject	Eden Landing Geotechnical Investigation and Analyses	
From	Seth Gentzler, PE, Project Manager Kanax Kanagalingam, PE, GE, Benjamin Choy, PE	
Date	November 8, 2016	

This memorandum presents geotechnical data collected from the recent AECOM geotechnical field investigation and results of the geotechnical analyses performed for the conceptual restoration design of the southern half of the Eden Landing Ecological Reserve (ELER).

1.0 AECOM Geotechnical Investigation

In June 2016, AECOM planned and executed a subsurface field investigation in order to collect geotechnical field data, and to perform laboratory testing on the samples collected during the investigation. The investigation consisted of six soil borings, B-01-through B-06. Table 1 summarizes the approximate locations of these borings and the boring depths. Figure 1 shows the locations of these boring on the project vicinity map. The field investigation was performed between June 20 and 22, 2016.

Pitcher Drilling Company of East Palo Alto, California drilled the exploratory borings using a truck-mounted Failing 1500 drill rig. The borings were advanced using rotary wash drilling techniques to depths ranging from 56.5 to 63 feet. An AECOM geologist on site during drilling, visually classified the soils encountered during the drilling, and logged the borings. The draft boring logs are included as Attachment 1. The borings were backfilled with a neat cement-bentonite grout in accordance with the appropriate county permits.

Samples were collected at five foot intervals using a split-spoon sampler during standard penetration testing (SPT), a 2.5-inch Modified California (ModCal) sampler, or a 2.8-inch Shelby tube sampler. The sampler utilized in the field was determined based on the encountered materials.

Samples collected during the exploration were transferred to Cooper Testing Laboratories in Palo Alto, California for testing. Tests were performed on select samples and included moisture content and density, sieve analysis, Atterberg limits, unconsolidated-undrained triaxial tests (TXUUs), consolidated-undrained triaxial tests (TXCUs) with pore pressure measurements, and consolidation tests. The geotechnical laboratory test results are presented in Attachment 2.

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2.0 Geotechnical Analyses

As part of the restoration of the southern half of the ELER, existing levees in the Eden Landing pond complex are proposed to be raised to a design crest elevation of 12 feet (NAVD88). Based on hydrodynamic modeling results, the proposed raise is expected to provide equal or better flood protection compared to existing conditions. Based on the subsurface soil conditions and the levee geometry after the proposed raise, representative levee cross sections were selected for geotechnical analyses.

The details of the representative analysis sections, material characterization, analysis procedures, and the results of the analyses are discussed in the following sections.

2.1 Representative Analysis Sections and Material Characterization

The selected representative analysis cross sections and their idealized soil profiles are shown on Figures 2 and 3. The section shown on Figure 2, named as Section A, represents the existing levees that will be raised by about 2 feet. Section A represents the majority of the levees that will be raised as part of the ELER restoration. The section shown on Figure 3, named as Section B, represents a relatively short levee section where the levees will be raised by about 4 feet to meet the design crest elevation of 12 feet. This section is located along the Mid-Complex Levee between approximate Stations 81+00 and 115+00. Considering the thickness of the soft bay mud (as described below) at the project site, the levee side slopes of 4H:1V were assumed for the geotechnical evaluation.

The idealized profiles and material properties for the analyses were developed based on the geotechnical data collected from the recent AECOM investigation, available historical data collected by others (Geo/Resource Consultants, INC. 2008, AMEC 2010, Wood Rodgers, CE&G and GEI 2011), past similar projects, and engineering judgement. In general, the existing levees are underlain by a soft compressible Young Bay Mud (YBM). The YBM is underlain by stiff old bay clay (OBC). The thickness of the YBM at the project site ranges from 15 to 35 feet. The idealized soil profile modeled the YBM as a 30-foot–thick layer underlying the existing levee. It is recommended that a more comprehensive field investigation program shall be performed to refine the subsurface conditions for final design.

Since the source of the new levee fill material is not yet determined, conservative strengths were assigned to the new levee fill in performing the slope stability analysis. It is recommended that a test fill be constructed to confirm that the strengths and densities assumed in this analysis are attainable. Due to the difficulty in working with the YBM, it is recommended that the levee test fill be constructed near the site of the future levee in an area with similar subsurface conditions as the foundations for the future levees. Depending on the results of the test fill, modifications of the design may be warranted. For now, the strengths assigned to the levee fill in this analysis are judged to be sufficiently conservative to achieve in the field.

Table 2 summarizes the idealized soil profile and the material parameters selected for the settlement and stability analyses.

2.2 Analysis Procedures

The stability of the levees was analyzed for two cases: the end of construction case and the long-term steady state seepage during a potential high water event. Rapid drawdown was judged to not be applicable since the tidal fluctuations would not allow the levees to fully saturate.

As the levee raises will, in general, be constructed over soft compressible YBM, one dimensional settlement analysis was performed for the selected representative sections using the geometry determined to be stable for the target design crest elevation. Slope stability analysis was then performed with the levee crest height selected at a higher elevation to approximately compensate for the estimated settlement.

As provided in Table 2, the soft YBM layer was modeled using undrained shear strength. For the end of construction case, the undrained shear strength was first estimated using the current effective stresses and the undrained strength ratio (Su/σ_v') of 0.27, and then modeled using a depth-dependent strength model. For the long term steady state case, the undrained strength was modeled directly using the undrained strength ratio to represent the long term consolidated stress conditions. In both cases the lower bound of the undrained strength was limited to 200 psf.

Finite element seepage analyses were performed using SEEP/W (2012 Version 8.15), a two-dimensional, finite element analysis software program developed by GEO-SLOPE International, Ltd. SEEP/W analyzes groundwater seepage and excess pore water pressure dissipation conditions in porous materials, such as soil and rock. Slope stability analyses were completed using SLOPE/W (2012 Version 8.15), a slope stability analysis program also developed by GEO-SLOPE International, Ltd. Pore water pressures calculated in SEEP/W analyses, assuming steady-state seepage conditions, were imported and used in the static slope stability.

2.3 Analysis Results and Discussion

2.3.1 Section A

The anticipated settlement of the raised levee crest was first estimated by performing a settlement analysis on Section A with the design crest elevation of 12 feet. The estimated immediate settlement is on the order of 1-inch, and the consolidation settlement is on the order of 17-inches. The consolidation settlement is expected to occur over 20 to 85 years. In order to compensate for the consolidation settlement the constructed crest elevation will be 13.4 feet, which is assumed to be sufficient to maintain the levee crest at or above elevation of 12 feet. It is noted that along the alignment of the levee, differential settlement is likely to occur due to differences in the subsurface materials.

Slope stability analyses were performed on the levee section with the increased crest height (elevation 13.4 feet). The results of the stability analyses are summarized in Table 3, and in Figures 4 and 5. The section calculated a factor of safety of 1.2 for end of construction, and 1.3 for long term stability. Based on the results of the slope stability analyses performed as part of the 30 percent design of the levees at Alviso and Ravenswood Pond Complexes (not included in this memorandum), the calculated factors of safety were judged to be adequate for both the end of construction and long term conditions. Based on these analysis results, 4H:1V or flatter side slopes and the construction crest elevation of 13.4 feet are recommended for the levee construction.

2.3.2 Section B

Similar to Section A, the anticipated settlement of the raised levee crest was first estimated by performing a settlement analysis on Section B with the design crest elevation of 12 feet. The estimated immediate settlement is on the order of 2-inches, and the consolidation settlement is on the order of 36-inches. The consolidation settlement is expected to occur over 20 to 85 years. In order to compensate for the consolidation settlement, the proposed constructed crest elevation will be 15 feet, which is assumed to be sufficient to maintain the levee crest at or above elevation of 12 feet. It is noted that along the alignment of the levee, differential settlement is likely to occur due to differences in the subsurface materials.

Slope stability analyses were performed on the levee section with the increased crest height (crest elevation 15 feet). The results of the stability analyses showed that the factor of safety calculated for the end of construction case was judged to be not adequate for construction.

Three alternatives were considered for raising the levee to provide a long term crest elevation at 12 feet or above:

(1) Construct to elevation 15 feet with flattened side slopes of 5H:1V,
(2) Excavation and replacement of the top 10 feet thick soft YBM and construct to elevation 15 feet with 4H:1V side slopes, and
(3) Staged construction with first stage construction to elevation 12 feet following by periodic maintenance to keep crest at elevation 12 feet.

The factors of safety calculated for the end of construction stability of both (1) and (2) did not meet the assumed adequate factors of safety of 1.2 for end of construction case. The alternative involving the excavation and replacement of deeper than 10-foot thick soft YBM is considered to be an expensive alternative, and therefore not considered for evaluation. The results of analysis for staged construction are summarized in Table 3, and in Figures 6 and 7. The section with the crest elevation at 12 feet calculated a factor of safety of 1.2 for end of construction, and 1.4 for long term stability. The calculated factors of safety for this scenario were judged to be adequate for construction.

Based on these analysis results, 4H:1V or flatter side slopes and the construction crest elevation of 12 feet are recommended for the levee construction. In addition to the alternatives discussed above, an alternate levee alignment closer to nearby existing levees could also be considered for Section B.

3.0 Limitations

This memorandum was developed in accordance with the standard of care commonly used as state-of-practice in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period. No warranty is either expressed or implied that actual encountered site and subsurface conditions will conform exactly to the conditions described herein; nor is it expressed or implied that this memorandum’s recommendations will be sufficient for all construction planning aspects of the work. The conclusions presented in this memorandum are professional opinions based on the indicated project criteria and data available at the time this report was prepared.

The conclusions presented in this memorandum are intended only for the purpose, site location, and project indicated. The recommendations made in this report are based on the assumption that the subsurface soil and groundwater conditions do not deviate appreciably from those disclosed in the site-specific exploratory borings, including those performed by others. Additional borings are recommended for final design.

4.0 References

Geo/Resource Consultants, INC., 2008. Geotechnical Investigation Report, SBSP Eden Landing Ponds E8A, E9, and E8X Phase 1 Action Tidal Restoration/ New E10 Levee, Report.

AMEC, 2010. Geotechnical Study, South Bay Salt Pond Restoration Project, Eden Landing Restroations, Ponds E8/E9 and E12/13, Report.

Wood Rodgers, CE&G and GEI, 2011. Alameda County Category 1 Levee Evaluation, Flood Control Zone 5, Site Plan and Exploration Data.

TABLES

Table 1 AECOM Boring Locations and Depths

Boring	Location	Approximate Latitude	Approximate Longitude	Depth (ft)
B-01	Eden Landing – near Pond E6/E7	37.590270°	-122.116008°	61.5
B-02	Eden Landing – Pond E2	37.573452°	-122.137606°	56.5
B-03	Eden Landing – Pond E6C	37.584964°	-122.091962°	61.5
B-04	Eden Landing – Pond E6C/J Ponds	37.575561°	-122.103004°	61.5
B-05	Eden Landing – Pond E5C	37.572686°	-122.088808°	63
B-06	Eden Landing – Pond E2C	37.568414°	-122.105628°	61.5

Table 2 Idealized Soil Profile and Material Properties Used for Analyses

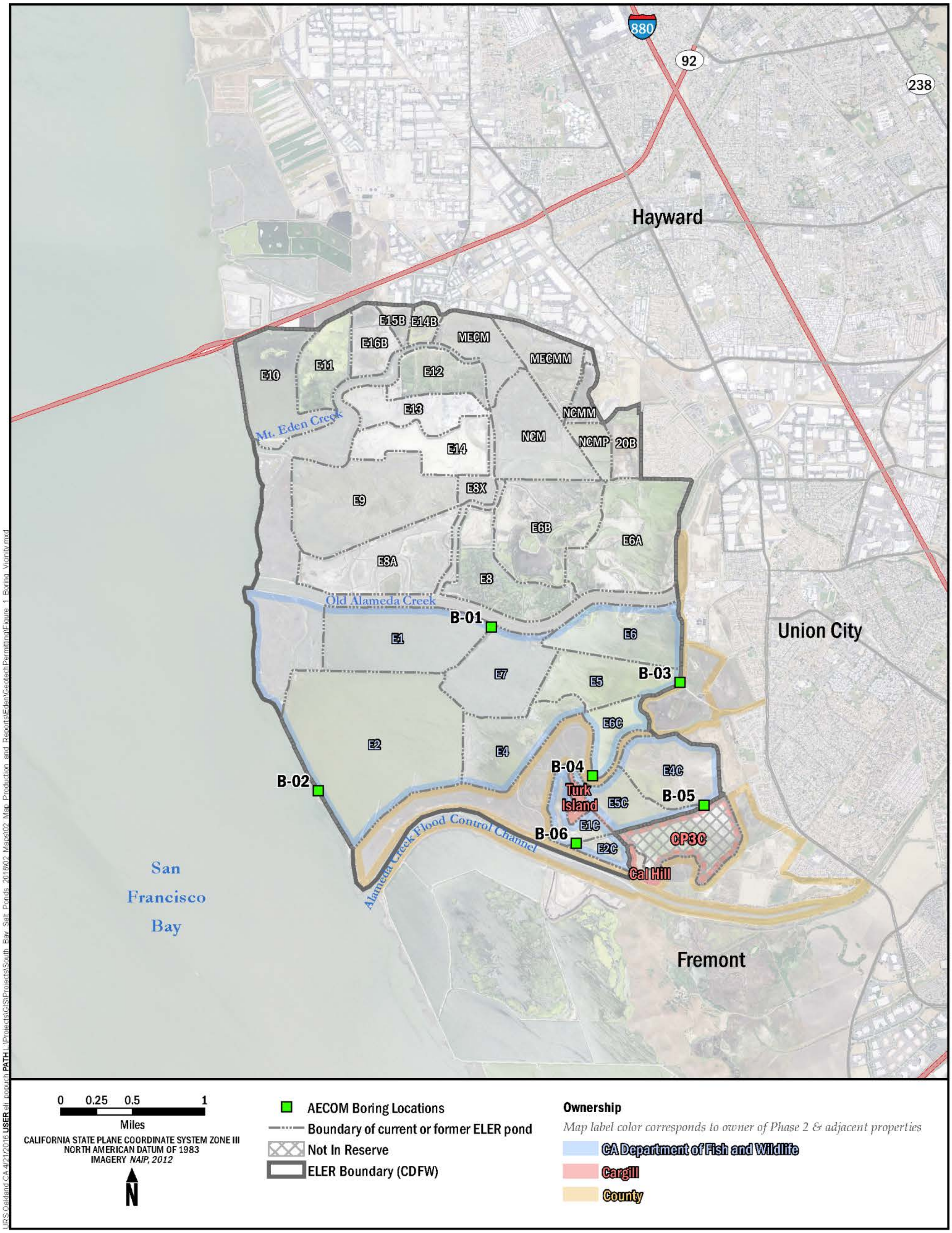
Material Layer	Elevation Below Levee Centerline (ft)				Unit Weight (pcf)	Soil Strength Parameters					Settlement Analysis Parameters			
	Section A		Section B											
	Top	Bottom	Top	Bottom		c' (psf)	ϕ' (deg.)	Su (psf)	Su/σ_v'	Su,min (psf)	OCR	Cc	Cr	e_0
New Fill	12.0	10.3	12	7.6	125	100	32	-	-	-	-	-	-	-
Existing Fill	10.3	5.3	7.6	5	120	50	28	-	-	-	-	-	-	-
Young Bay Mud (YBM)	5.3	-24.8	5	-25	95	-	-	-	0.27	200	1.2	1.1	0.2	2.5
Old Bay Clay (OBC)	-24.8	-50.0	-25	-50	120	-	-	1000	-	-	3.0	0.3	0.1	0.8

Table 3 Slope Stability Analysis Results for Sections A and B

Slope Stability Analysis Case	Analysis Water Surface Elevation (ft)		Assumed Adequate Factor of Safety[3]	Calculated Factor of Safety	
	Assumed Waterside[4]	Assumed Landside		Section A[1]	Section B[2]
End of Construction	10.5	Dry	1.2	1.2	1.2
Long Term Steady State	10.5	Dry	1.3	1.3	1.4

Notes: [1]Crest elevation 13.4 ft, [2] Crest elevation 12 ft.
[3]Assumed factors of safety are based on the results of the slope stability analyses performed as part of the 30 percent design of the levees at Alviso and Ravenswood Pond Complexes (not included in this memorandum).
[4]Assumed based on 100-yr flood level and regional typical tidal high water.

FIGURES



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South Bay Salt Pond Restoration Project
EDEN LANDING
Alameda County, CA

FIGURE 1. VICINITY MAP

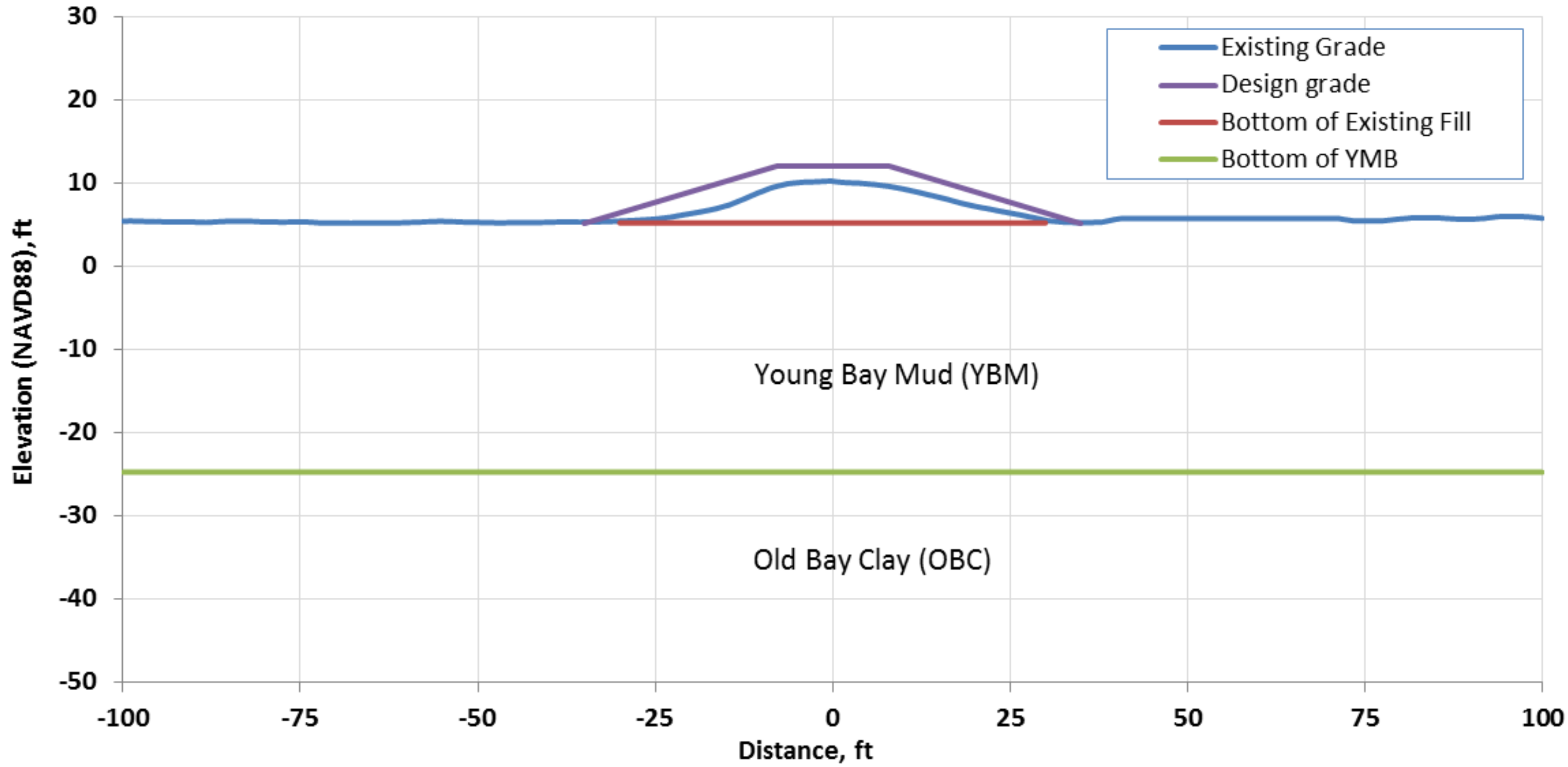


Figure 2 Idealized Cross Section – Section A

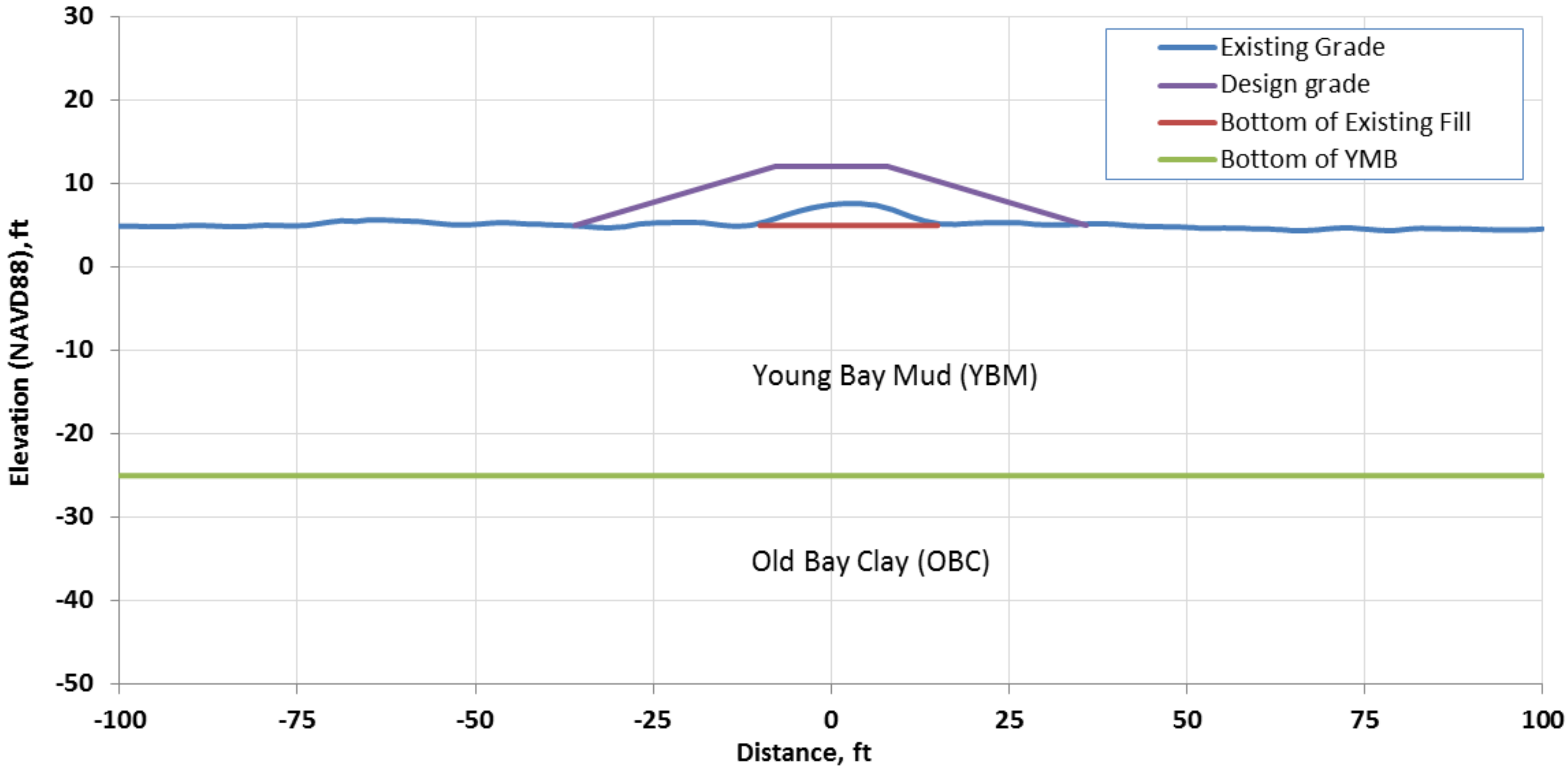


Figure 3 Idealized Cross Section – Section B

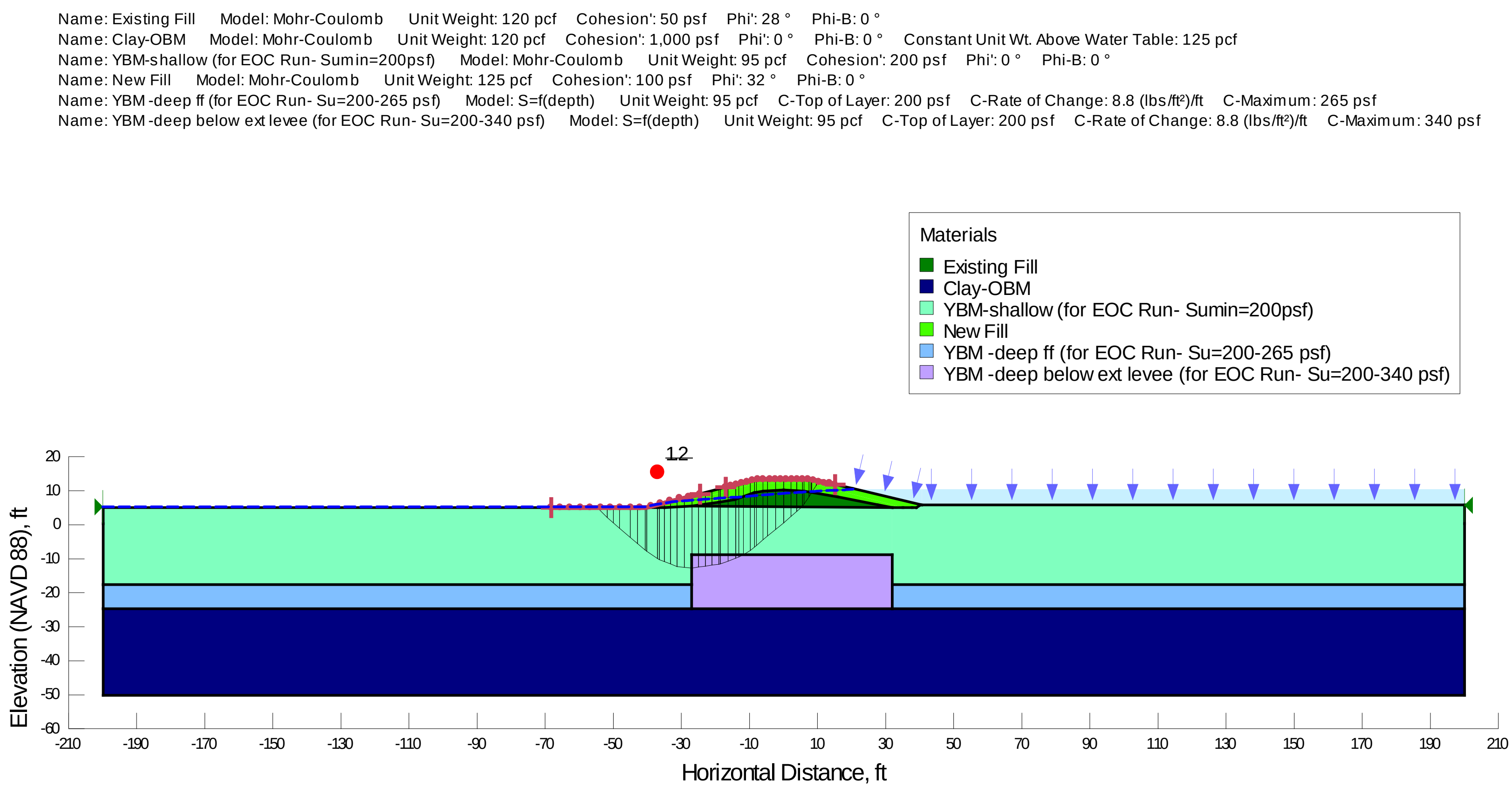


Figure 4 End of Construction Stability - Section A

Name: Existing Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 50 psf   Phi': 28 °   Phi-B: 0 °
Name: Clay-OBM   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 1,000 psf   Phi': 0 °   Phi-B: 0 °   Constant Unit Wt. Above Water Table: 125 pcf
Name: YBM   Model: S=f(overburden)   Unit Weight: 95 pcf   Tau/Sigma Ratio: 0.27   Minimum Strength: 200 psf
Name: New Fill   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 100 psf   Phi': 32 °   Phi-B: 0 °

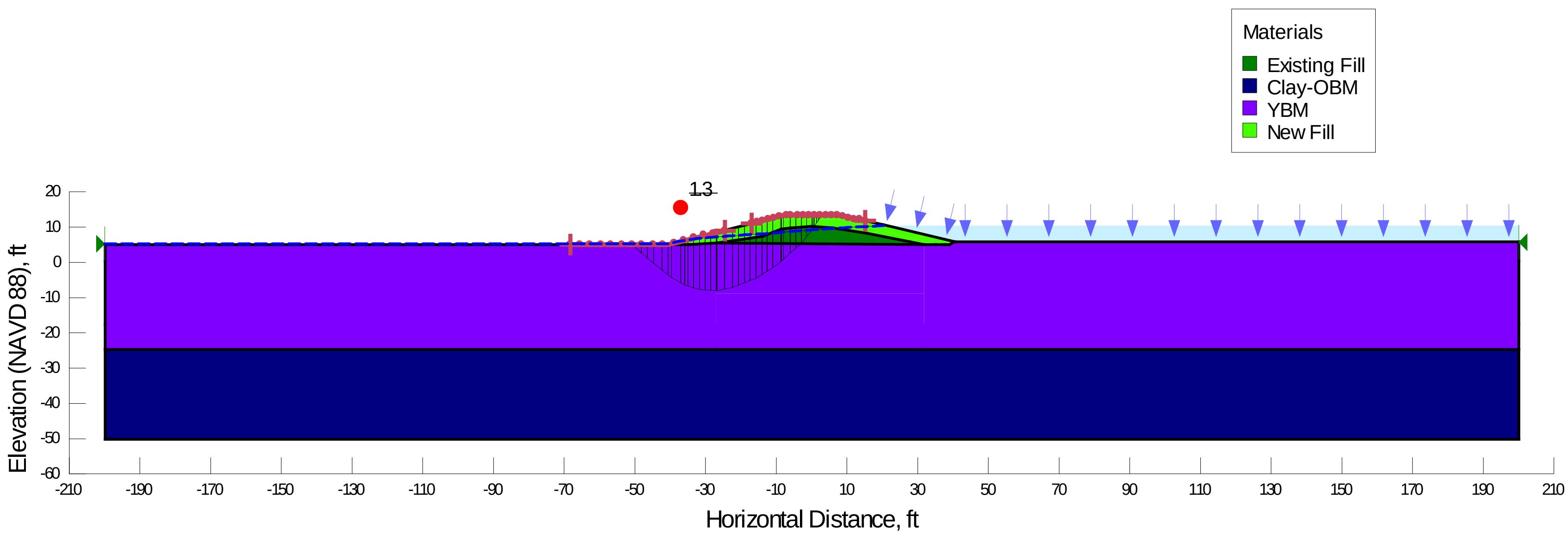


Figure 5 Long Term Steady State Stability - Section A

Name: Existing Fill   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 50 psf   Phi': 28 °   Phi-B: 0 °   Piezometric Line: 1
Name: Clay-OBM   Model: Mohr-Coulomb   Unit Weight: 120 pcf   Cohesion': 1,000 psf   Phi': 0 °   Phi-B: 0 °   Constant Unit Wt. Above Water Table: 125 pcf   Piezometric Line: 1
Name: YBM-shallow (for EOC Run- Sumin=200psf)   Model: Mohr-Coulomb   Unit Weight: 95 pcf   Cohesion': 200 psf   Phi': 0 °   Phi-B: 0 °   Piezometric Line: 1
Name: New Fill   Model: Mohr-Coulomb   Unit Weight: 125 pcf   Cohesion': 100 psf   Phi': 32 °   Phi-B: 0 °   Piezometric Line: 1
Name: YBM -deep (for EOC Run- Su=200-265 psf)   Model: S=f(depth)   Unit Weight: 95 pcf   C-Top of Layer: 200 psf   C-Rate of Change: 8.8 (lbs/ft²)/ft   C-Maximum: 265 psf   Piezometric Line: 1

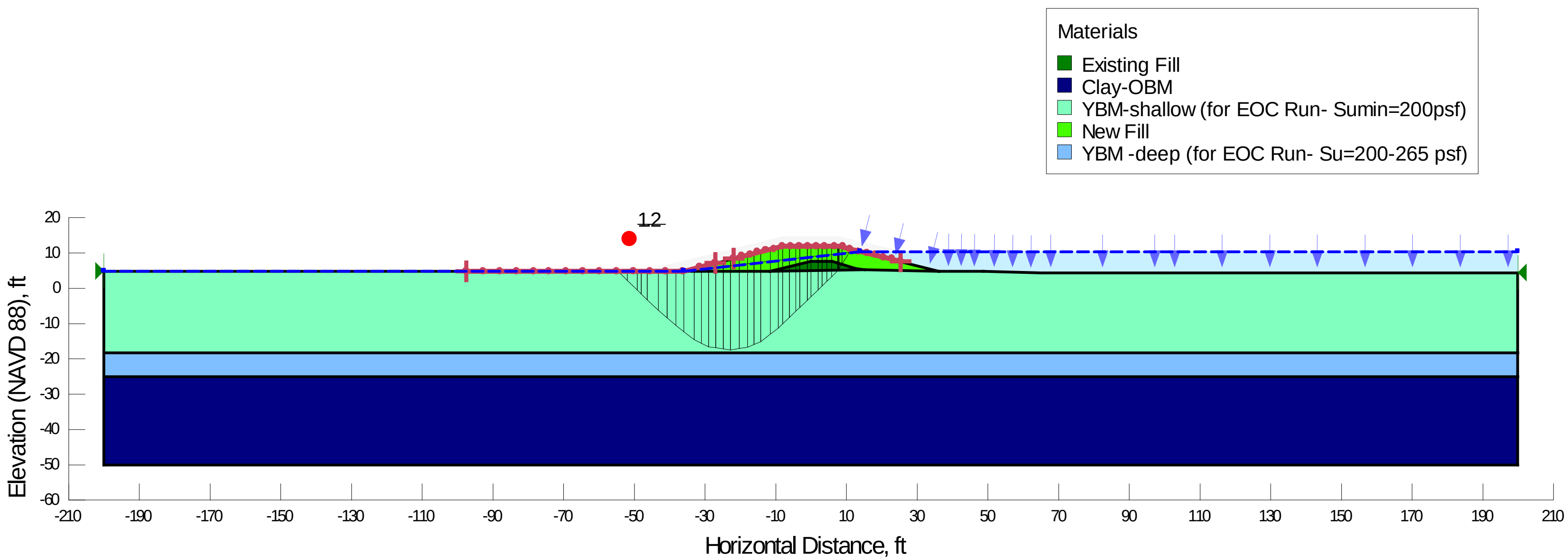


Figure 6 End of Construction Stability - Section B

Name: Existing Fill Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 50 psf Phi': 28 ° Phi-B: 0 ° Piezometric Line: 1
Name: Clay-OBM Model: Mohr-Coulomb Unit Weight: 120 pcf Cohesion': 1,000 psf Phi': 0 ° Phi-B: 0 ° Constant Unit Wt. Above Water Table: 125 pcf Piezometric Line: 1
Name: YBM Model: S=f(overburden) Unit Weight: 95 pcf Tau/Sigma Ratio: 0.27 Minimum Strength: 200 psf Piezometric Line: 1
Name: New Fill Model: Mohr-Coulomb Unit Weight: 125 pcf Cohesion': 100 psf Phi': 32 ° Phi-B: 0 ° Piezometric Line: 1

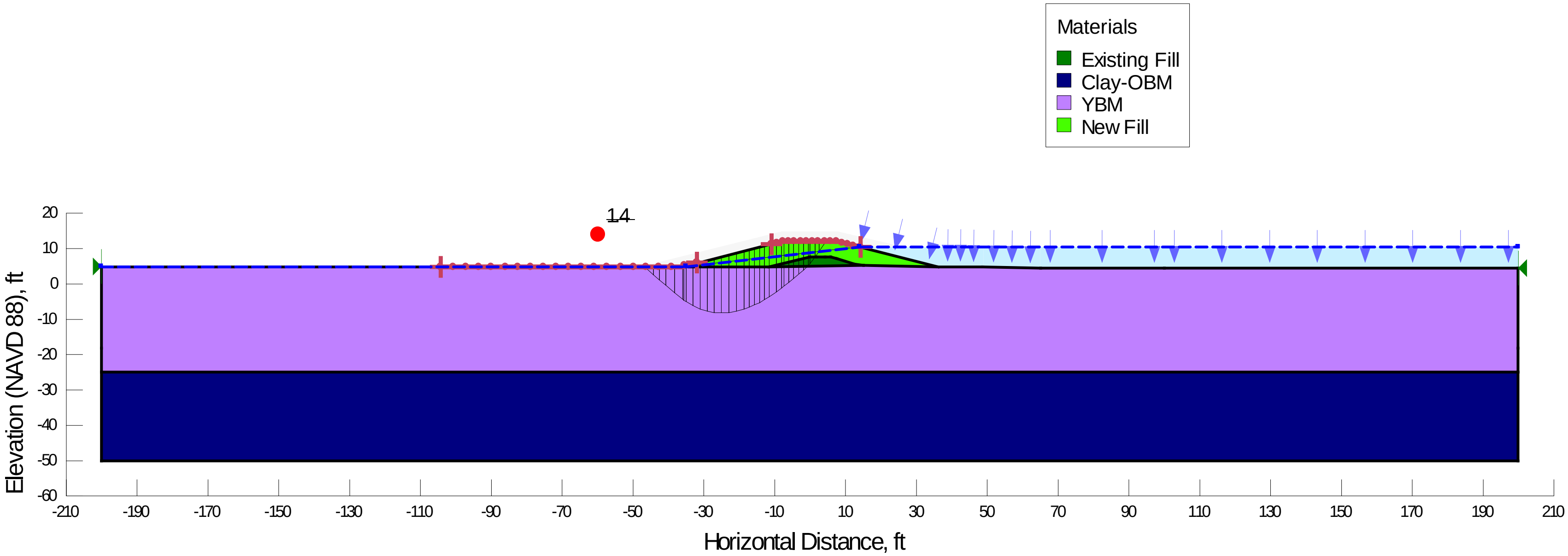


Figure 7 Long Term Steady State Stability - Section B

ATTACHMENT-1

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Key to Log of Boring

Sheet

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11	12

COLUMN DESCRIPTIONS

1 **Elevation:** Elevation in feet referenced to specified datum.

2 **Depth:** Depth in feet below the ground surface.

3 **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below.

4 **Sample Number:** Sample identification number.

5 **Sampling Resistance:** Number of blows required to advance driven sampler 12 inches beyond first 6-inch interval, or distance noted, using a 140-lb hammer with a 30-inch drop; or down-pressure for pushed sampler.

6 **Recovery:** Percentage of driven or pushed sample length recovered; "NA" indicates data not recorded.

7 **Graphic Log:** Graphic depiction of subsurface material encountered; typical symbols are explained below.

8 **Material Description:** Description of material encountered; may include density/consistency, moisture, color, and grain size.

9 **Water Content:** Water content of soil sample measured in laboratory, expressed as percentage of dry weight of specimen.

10 **Dry Unit Weight:** Dry weight per unit volume of soil measured in laboratory, expressed in pounds per cubic feet (pcf).

11 **Unconfined Compressive Strength:** Unconfined compressive strength of soil sample measured in laboratory, expressed in psf.

12 **Remarks and Other Tests:** Comments and observations regarding drilling or sampling made by driller or field personnel. Other field and lab test results, using the following abbreviations:

LL	Liquid Limit (from Atterberg Limits test), percent
PI	Plasticity Index (from Atterberg Limits test)
SA	Sieve analysis, percent passing #200 sieve
WA	Wash on #200 sieve, percent passing #200 sieve
UC	Unconfined compressive strength (qu), psf
CONS	Consolidation test
TX-UU	Unconsolidated undrained triaxial compression test, peak deviator stress and confining pressure, psf
TX-CU	Consolidated undrained triaxial compression test
PP	Pocket penetrometer

TYPICAL MATERIAL GRAPHIC SYMBOLS

POORLY GRADED SAND (SP)

POORLY GRADED SAND WITH SILT (SP-SM)

SILTY SAND (SM)

CLAYEY SAND (SC)

WELL-GRADED SAND (SW)

LEAN CLAY (CL)

FAT CLAY (CH)

SILTY CLAY (CL)

POORLY GRADED GRAVEL (GP)

POORLY GRADED GRAVEL WITH SILT (GP-GM)

SILT (ML)

CLAYEY SILT (ML)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Standard Penetration Test (SPT) unlined split spoon

Shelby tube (3-inch OD, thin-wall, fixed head)

Modified California (2.5-inch OD) with brass liners

Pitcher barrel with Shelby tube liner

California (3-inch OD) split barrel

Bulk (5-gallon bucket)

OTHER GRAPHIC SYMBOLS

First water encountered at time of drilling and sampling (ATD)

Static water level measured after drilling and sampling completed

Change in material properties within a lithologic stratum

Inferred or transitional contact between lithologies

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive; actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.

2. Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Figure A-1

Project: SBSP, Eden Landing

Project Location: South Bay

Project Number: 60423372

Log of Boring B-01

Date(s) Drilled	**6/21/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2041436.29 E 6093467.52**

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, blows / foot	SAMPLES Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						SILTY CLAY (CL-ML), medium stiff, Olive brown (2.5Y 4/4), moist, medium plasticity				
							ELASTIC SILT (MH), soft to medium stiff, very dark grayish brown (2.5Y 3/2), wet, high plasticity [Young Bay Mud]				set casing at 3.5 feet
	5		1		95						mud rotary 50 to 75 psi
							At 6.5 feet, as above except black (2.5Y 2.5/1)				
	10		2		80						50 to 85 psi
							At 11.5 feet, as above except very dark gray (2.5Y 3/1)				
	15		3		95						consolidation test 50 to 75 psi
	20		4	0 0 0	100		- grades to medium stiff				PP: 0.5 tsf PP: 0.75 tsf
							- color changes to dark greenish gray (gley 4/5GY)				
	25		5	0 0 0	100		- trace find sand				PP: 0.5 tsf
	30										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-01

Elevation feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance, blows / foot	Samples: Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	30		6	0 0 0	100						PP: 0.75 tsf
							FAT CLAY (CH), very stiff to hard, dark greenish gray (gley 3/10Y). At 33.5 feet, shells and sand transition				
	35		7	5 14 20	70						PP: 4.25 tsf
							- grades to light olive brown with white and yellowish brown mottling				
	40		8	7 9 12	55		FAT CLAY with fine Sand (CH), very stiff, high plasticity				PP: 3.25 tsf
							- becomes stiff				
	45		9	0 4 4	70		- becomes soft to medium stiff				PP: 2.0 tsf
											driller notes soil becomes sandy, soft
	50		10	1 2 9	60		Poorly-Graded SAND with CLAY (SP-SC), very loose to loose, olive brown (2.5Y 4/3), fine grained sand.				
			SPT-1	1 3 8							
	55		11	5 4 3	100		LEAN CLAY with Sand (CL), medium stiff, olive brown (2.5Y 4/3), fine grained sand.				
							SILTY CLAY (CL-ML), stiff, olive brown (2.5Y 4/3).				
	60		12	3 6 7	60						PP: 1-1.5 tsf
											End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

Project: SBSP, Eden Landing **Project Location: South Bay** **Project Number: 60423372**	**Log of Boring B-02** Sheet 1 of 2

Date(s) Drilled	**6/21/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**56.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2035422.39 E 6087103.51**

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						LEAN CLAY (CL) with trace fine sand, medium stiff, very dark grayish brown (10YR 3/2), medium to high plasticity fines.				
											set casing at 3.5 feet
	5						ELASTIC SILT (MH), soft, dark greenish gray (gley 3 10Y), medium to high plasticity fines [Young Bay Mud]				mud rotary at 5 feet
			1		95						weight of hammer to 50 psi
	10										50 psi
			2		95						
	15										50 psi
			3		95						
	20						- with shells				50 psi ICU triaxial test PP: 0 tsf ICU triaxial test
			4		95						
							- increasing fine sand				
	25		5	0 0 0	80						PP: 0-0.25 tsf
	30										

DRAFT

Report: GEO_10B1_OAK; File: 20161103_EDEN_BORINGS.GPJ; 11/4/2016 02

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-02

Elevation feet	Depth, feet	Samples: Type	Samples: Number	Samples: Sampling Resistance, blows / foot	Samples: Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	30		6	0 0 0	90						PP: 0 tsf
	35		7	0 0 0							
	40		8	6 17 22	50		LEAN CLAY (CL), very stiff, dark greenish gray (gley 4 10G), medium to high plasticity fines. - gravel at tip of sample				PP: 2.75 tsf PP: 3.25 tsf
	45		9	7 12 12	55		- color changes to olive brown (2.5Y 4/4)				PP: 3.25 tsf PP: 5.5 tsf
	50		10	0 0 4	75		- soft to medium stiff, light olive brown (2.5Y 5/4)				PP: 1.25 tsf
	55		11	4 7 8			- becomes stiff to very stiff, - becomes low to medium plasticity SILT (ML)				PP: 1.75 tsf PP: 2.0 tsf End of boring at a depth of 56.5 feet; Grout boring with portland cement
	60										
	65										

Project: SBSP, Eden Landing

Project Location: South Bay

Project Number: 60423372

Log of Boring B-03

Date(s) Drilled	**6/20/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2037620.45 E 6099203.59**

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						LEAN CLAY (CL), medium stiff, brown (7.5YR 4/2), medium to high plasticity fines.				
							- some organics, dark grayish brown (10YR 4/2) with dark red mottling (2.5YR 3/6)				set casing at 3.5 feet
	5		1		85		ELASTIC SILT (MH), soft to medium stiff, dark greenish gray (gley 3/1 10Y), high plasticity fines [Young Bay Mud]				mud rotary at 5 feet ICU triaxial test 50-85 psi water at a depth of 8 feet on 6-12-16
	10		2		35						75-85 psi sample started to slip out, contractor pushed it back in shelby tube
	15		3		80						50-85 psi
	20		4		50		SILTY CLAY (CL-ML), very stiff, dark greenish gray (gley 4/2 10Y).				PP: 2.75 tsf 50-125 psi, and refusal at a depth of 21.5 feet
	25		5	3 3 2	65		- becomes stiff with fine sand, dark greenish gray (gley 3/10Y)				PP: 1.5 tsf
	30										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-03

Elevation feet	Depth, feet	Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND - OTHER TESTS -
	30		6	0 2 2	75						UU Triaxial test PP: 1.5 tsf
	35		7	0 0 0	? -		- little organics -				PP: 1.25 tsf
	40		8	3 5 5	65 -		SILTY CLAYEY SAND (SC-SM), loose, dark greenish gray - (gley3/10Y), fine-grained sand				
							SILTY CLAY (CL-ML) with fine Sand.				
	45		9	2 5 5	65 -		- becomes soft to medium stiff -				PP: 1.25 tsf
							SILTY CLAY (CL-ML), very stiff, olive gray (5Y 5/2) with light olive brown (2.5Y 5/4)				
	50		10	4 7 8	65						PP: 2.75 tsf end of the day resume drilling
	55		11	15 22 19			Well-Graded SAND with Silty Clay and Gravel (SW-SC), dense, dark grayish brown (2.5Y 4/2) with multi color gravel, gravel up to 1/2", well graded.				
							Well-Graded GRAVEL with Sand (GW), loose, multi color.				
	60		12	4 5 4	partial		SILTY CLAY with Sand (CL-ML), medium stiff to stiff, light olive brown (2.5Y 5/4).				End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

DRAFT

Report: GEO_10B1_OAK; File: 20161103_EDEN_BORINGS.GPJ; 11/4/2016 03

Project: SBSP, Eden Landing	Log of Boring B-04
Project Location: South Bay	Sheet 1 of 2
Project Number: 60423372	

Date(s) Drilled	**6/20/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2036016.57 E 6097143.01**

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						LEAN CLAY (CL), medium stiff, dark grayish brown (2.5Y 4/2) with brown mottles, medium plasticity fines.				Native Fill
							- organics				set casing at 3.5 feet
	5		1	0 0 0	100		ELASTIC SILT (MH), soft to medium stiff, dark greenish gray (gley 5/1 10Y), medium to high plasticity [Young Bay Mud]				mud rotary at 5 feet PP: 0.5 tsf
							- becomes moist to very moist, organics				
							- transitions to soft				
	10		2		95						weight of bar (50 psi) 15 minutes wait for sample expansion
	15		3		90						50 psi; last 6" with 75 psi
							Poorly-Graded SAND (SP), fine-medium grained, shells and gravel.				
							LEAN CLAY with Silt (CL), medium stiff to stiff, mottled yellowish brown (10YR 5/4) and greenish gray (gley 6/5 BG), medium plasticity.				
	20		4	3 5 8	40						PP: 2.5 tsf
							SILTY CLAY (CL-ML), medium stiff to stiff, dark greenish gray (gley 3/1 10Y), medium to high plasticity				
	25		5	0 4 4	65						
	30										

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND - OTHER TESTS -
	30		6	2 7 7	80						UU Triaxial test PP: 1.5 tsf
	35		7	0 5 9	?		- with brown mottling				PP: 0.75 tsf PP: 3.0 tsf
							SILTY SAND (SM), medium dense, grayish brown.				
	40		8	7 8 8	75						
							SILTY CLAY (CL-ML), medium stiff, very dark gray (2.5Y 3/1).				
	45		9	3 7 18	85						PP: 0.75 tsf
			SPT-9	0 1 2	?		Poorly-Graded SAND with SILT (SP-SM), very loose, fine-grained sand, dark olive gray (5Y 3/2).				
							- clay lens				
	50		10	9 22 17	95		SILTY SAND (SM) with Well-Graded GRAVEL lenses (GW), medium dense, very dark grayish brown, fine to medium multi colored gravel up to 1/4".				PP: 1.5 tsf
			SPT-10	8 11 25	95?						
							Well-Graded SAND with Gravel (SW), medium dense, dark grayish brown (2.5Y 4/2), multi colored gravel.				
	55		SPT-11	7 14 12	65						
							- becomes dense				
	60		SPT-12	17 24 24							Grout inspection at 1 PM End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-05

Date(s) Drilled	**6/22/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**63.0 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2034043.71 E 6098580.55**

Elevation feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Sampling Resistance, blows / foot	SAMPLES Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						SILTY CLAY (CL-ML), medium stiff, Olive brown (2.5Y 4/4) and olive gray (5Y 4/2) with reddish brown mottling, moist, medium to high plasticity fines.				
							ORGANIC SILT (OH) with trace fine sand, very soft, black (7.5YR 2.5/1), medium plasticity with organics [Young Bay Mud]				set casing to 3.5 feet
	5		1		50						mud rotary at 5 feet PP: 0 tsf 50-75 psi
	10						- becomes dark gray (5Y 4/1)				
			2		90		- becomes medium stiff				50,125,185 psi
							SILT with Sand (ML), stiff, light olive brown with gray (2.5Y 5/3 with 2.5Y 5/1) and dark yellowish brown mottling				PP: 1.5 tsf
	15		3	2 3 3	70						PP: 1.25 tsf
							SILT (ML), stiff, dark gray (2.5Y 4/1), medium to high plasticity fines				
	20		4		90						50-95 psi
	25		5		90						50-100 psi PP: 1.75 tsf
	30										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-05

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS -
	30		6	0 5 7	70						PP: 1.5 tsf
							FAT CLAY (CH) with trace fine sand, stiff, dark gray, high plasticity fines.				
	35		7	0 4 4	40		- becomes very stiff, with white and dark yellowish brown mottling				PP: 3.0 tsf
	40		8	6 12 17	40						PP: 3.75 tsf PP: 3.0 tsf
	45		9	8 21 26	40		- becomes very stiff to hard				PP: 3.0 tsf PP: 4.5 tsf
							Well-Graded GRAVEL with Sand (GW), very dense, olive brown (2.5Y 4/4) with multi colored sand and gravel, coarse sand.				
							Well-Graded SAND with SILT and GRAVEL (SW-SM), very dense, olive brown (2.5Y 4/4) with multi colored sand and gravel, coarse sand.				
	50		10	18 25 30	80						losing circulation , add bentonite
	55		11	17 18 15	0		- becomes dense				sample - slough?
											caving back up to 55 feet
	60		12	20 22 36							
			SPT-12	11 22 21							
											End of boring at a depth of 63 feet; Grout boring with portland cement
	65										

Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-06

Date(s) Drilled	**6/22/2016**	Logged By	**Stacy Ball**	Checked By	
Drilling Method	**Mud Rotary**	Drill Bit Size/Type	**6-inch OD Core Barrel/ 6-inch OD Auger/ 4.75-inch OD Drag bit**	Total Depth of Borehole	**61.5 feet**
Drill Rig Type	**Failing 1500**	Drilling Contractor	**Pitcher Drilling Co.**	Surface Elevation	**feet (NAVD88)**
Groundwater Level(s)		Sampling Method(s)	**SPT, Modified California, Shelby**	Hammer Data	**140 lb/30-inch drop Auto Hammer**
Borehole Backfill	**Neat Cement Grout**	Location		Coordinates	**N 2033102.70 E 6096899.46**

Elevation feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Sampling Resistance, blows / foot	SAMPLES: Recovery, %	Graphic Log	MATERIAL DESCRIPTION	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS
	0						SILTY CLAY with sand and gravel (CL-ML), very stiff, dark brown (7.5Y 3/4), moist				
							FAT CLAY to ORGANIC CLAY(CH-OH), medium stiff, black, moist, high plasticity fines, petroleum smell, greasy.				set casing to 3.5 feet
	5		1		90		ORGANIC SILT (OH), soft, very dark grayish brown (10YR 3/2), medium plasticity fines [Young Bay Mud]				mud rotary at 5 feet 50 psi PP: 0.25 tsf
							- becomes very soft, very dark gray (10YR 3/1), medium to high plasticity fines, no visible organics				
	10		2								weight of bar (300 lbs) PP: 0.0 tsf
	15		3								consolidation test weight of bar (300 lbs)
							ORGANIC SILT with Sand (OH), very soft, very dark gray (10YR 3/1), low to medium plasticity fines with organics, shells.				
	20		4								
							ELASTIC SILT (MH), very soft, very dark gray, medium to high plasticity.				weight of bar (300 lbs) PP: 0.75 tsf
	25		5		90						weight of bar (50 psi) PP: 0.75 tsf
							- becomes stiff				
	30										

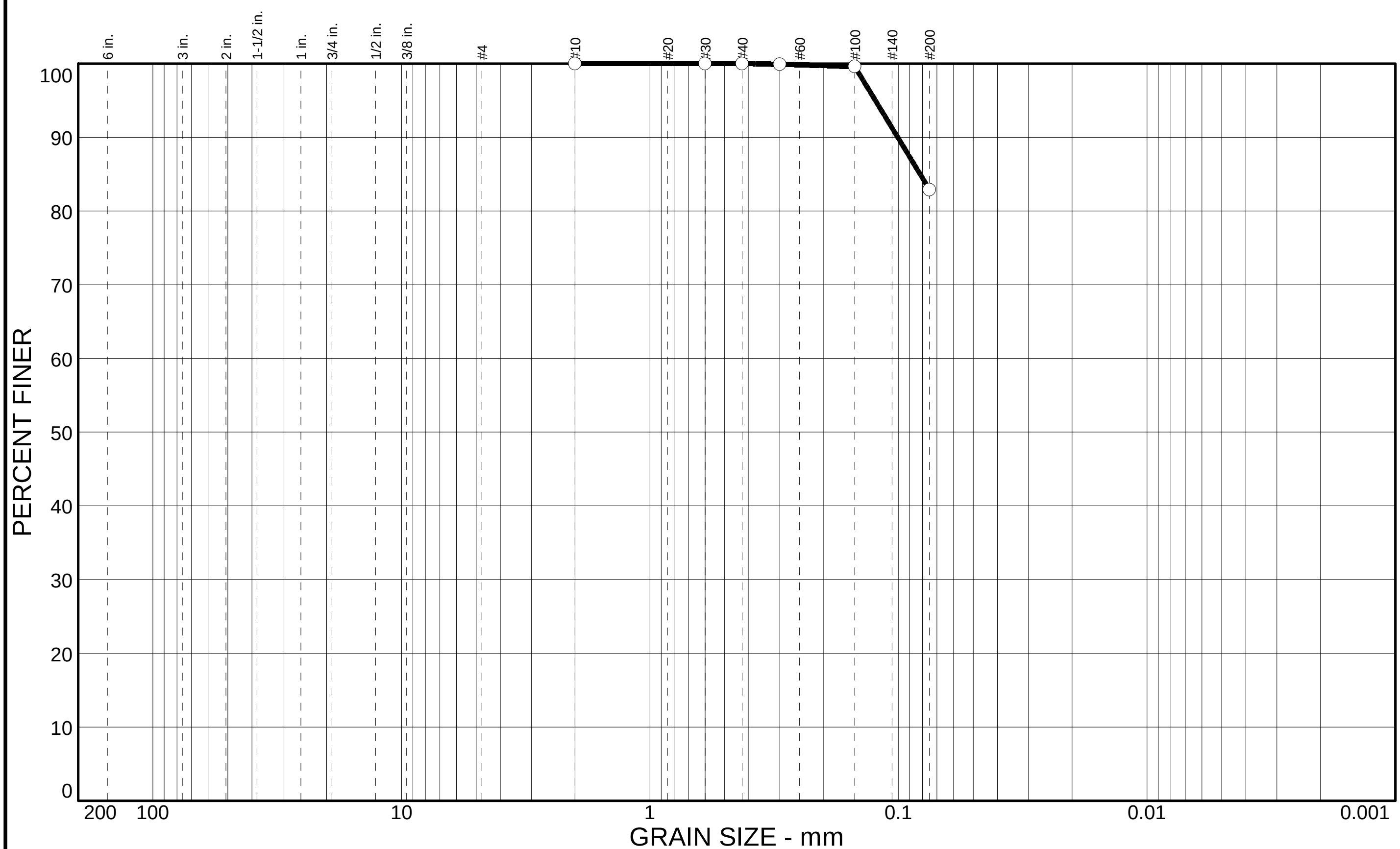
Project: SBSP, Eden Landing
Project Location: South Bay
Project Number: 60423372

Log of Boring B-06

Elevation feet	Depth, feet	SAMPLES Type	Number	Sampling Resistance, blows / foot	Recovery, %	Graphic Log	MATERIAL DESCRIPTION -	Water Content, %	Dry Unit Weight, pcf	Unconfined Compressive Strength, psf	REMARKS AND OTHER TESTS -
	30		6		60		LEAN CLAY with Sand (CL), hard, olive brown (2.5Y 4/3).				UU Triaxial test 75 to 200 psi, and refusal for pushing at 52 feet consolidation test PP: 2.0 tsf
	35		7	0 4 5			SILTY SAND TO SANDY SILT (SM-ML), loose, olive brown (2.5Y 4/3).				
			SPT-7	1 2 3							
	40		8	2 3 5							
							- becomes very dark gray (2.5Y 3/1)				
	45		9	7 12 12			- becomes medium dense				
							SILTY CLAY (CL-ML), very stiff.				PP: 3.0 tsf
							- becomes black (2.5Y 2.5/1)				
	50		10	4 8 12			SANDY SILT TO SILTY SAND(ML-SM), medium dense, fine sand.				
			SPT-10	2 5 9							
							SILTY SAND with Gravel (SM), dense, olive brown (2.5Y 4/4), fine to coarse sand, multi colored fine gravel.				
	55		11	14 20 22							
							SILTY SAND (SM), medium dense, olive brown and dark olive brown (2.5Y 4/3 and 2.5Y 3/3), fine grained sand.				
	60		12	6 9 14							
											End of boring at a depth of 61.5 feet; Grout boring with portland cement
	65										

ATTACHMENT-2

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			17.1	82.9					

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#10	100.0		
#30	100.0		
#40	100.0		
#50	99.9		
#100	99.6		
#200	82.9		

SOIL DESCRIPTION

○ Light Olive Brown CLAY w/ Sand

REMARKS:

○

○ Source: B-06-7

Elev./Depth: 35'

COOPER TESTING LABORATORY

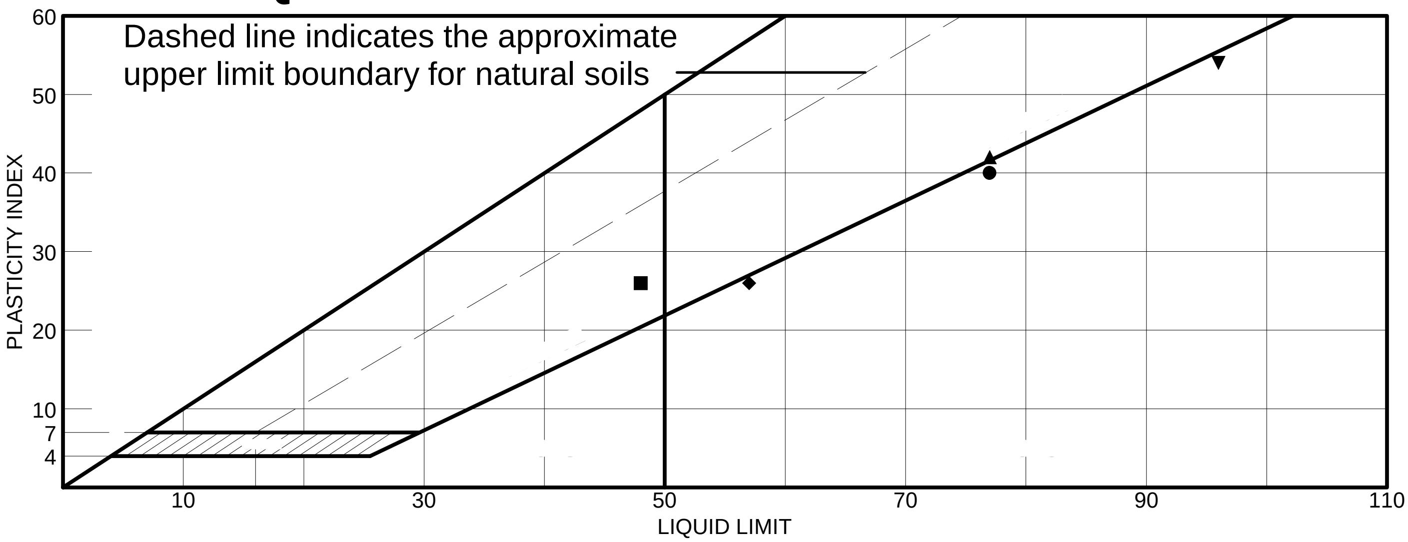
Client: AECOM

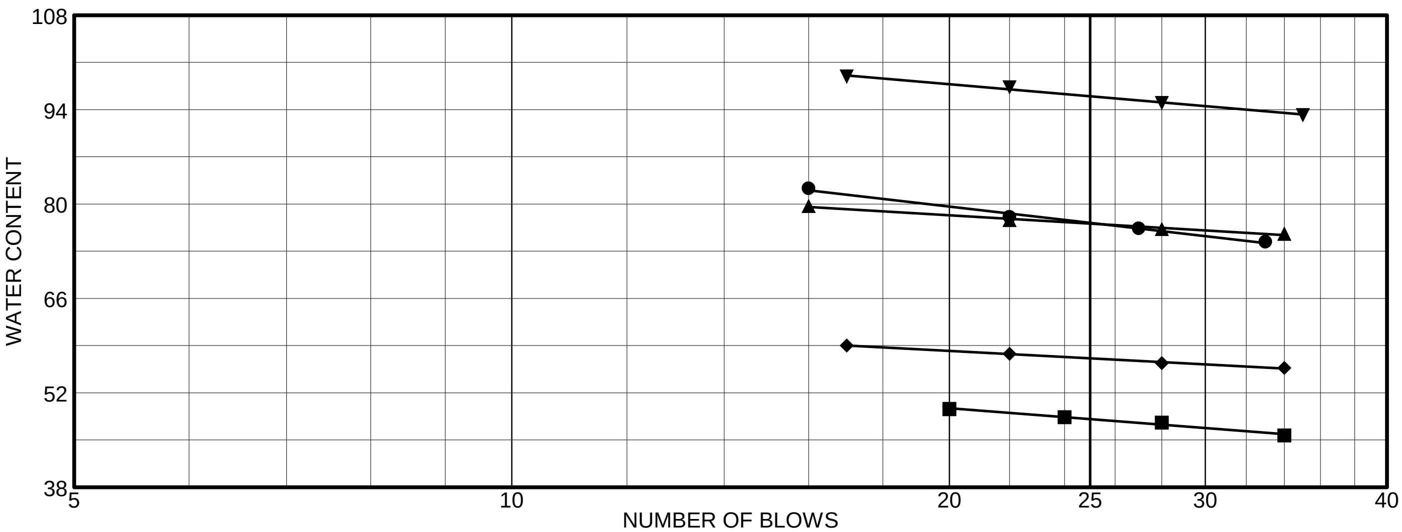
Project: Eden Landing - 60423372

Project No.: 020-209

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Gray Elastic SILT (Bay Mud)	77	37	40			
■	Greenish Gray Lean CLAY w/ shells	48	22	26			
▲	Greenish Gray Fat CLAY	77	35	42			
◆	Greenish Gray Elastic SILT (Bay Mud)	57	31	26			
▼	Greenish Gray Elastic SILT (Bay Mud)	96	42	54			

Project No. 020-209 **Client:** AECOM

Project: Eden Landing - 60423372

● **Source:** B-01-3 **Elev./Depth:** 15-17.5'
■ **Source:** B-01-7 **Elev./Depth:** 35-36'
▲ **Source:** B-02-2 **Elev./Depth:** 10-12.5'
◆ **Source:** B-02-4 **Elev./Depth:** 20.5-23(Tip-1/2")
▼ **Source:** B-03-1 **Elev./Depth:** 5-7.5(Tip-1")

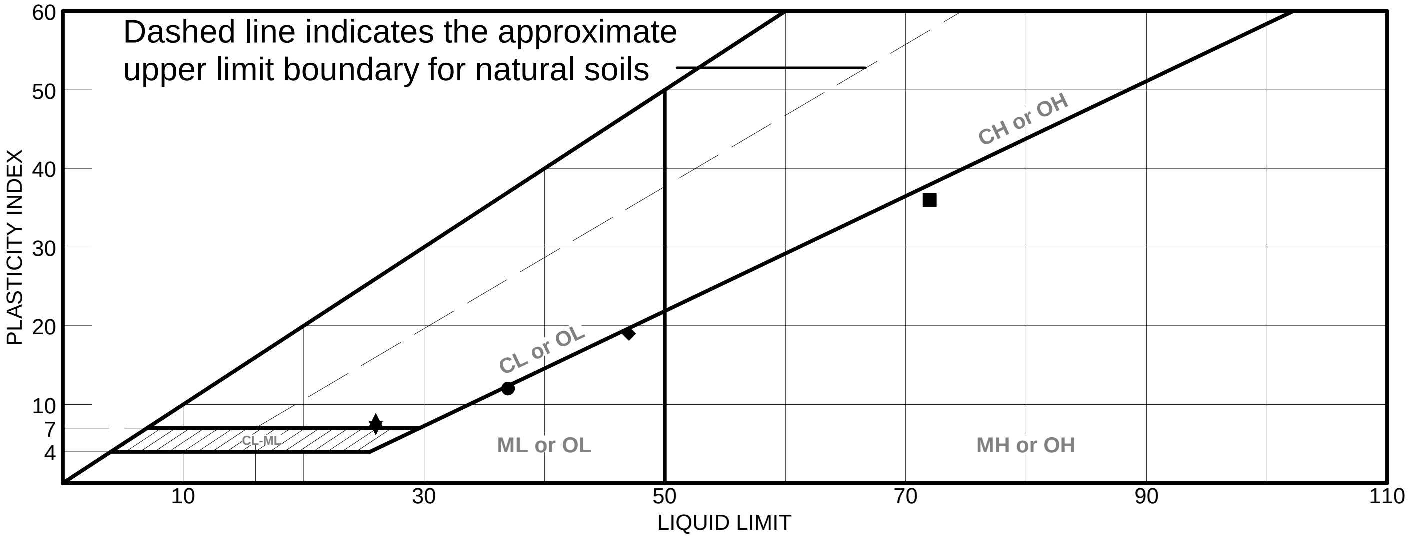
Remarks:
●
■
▲
◆
▼

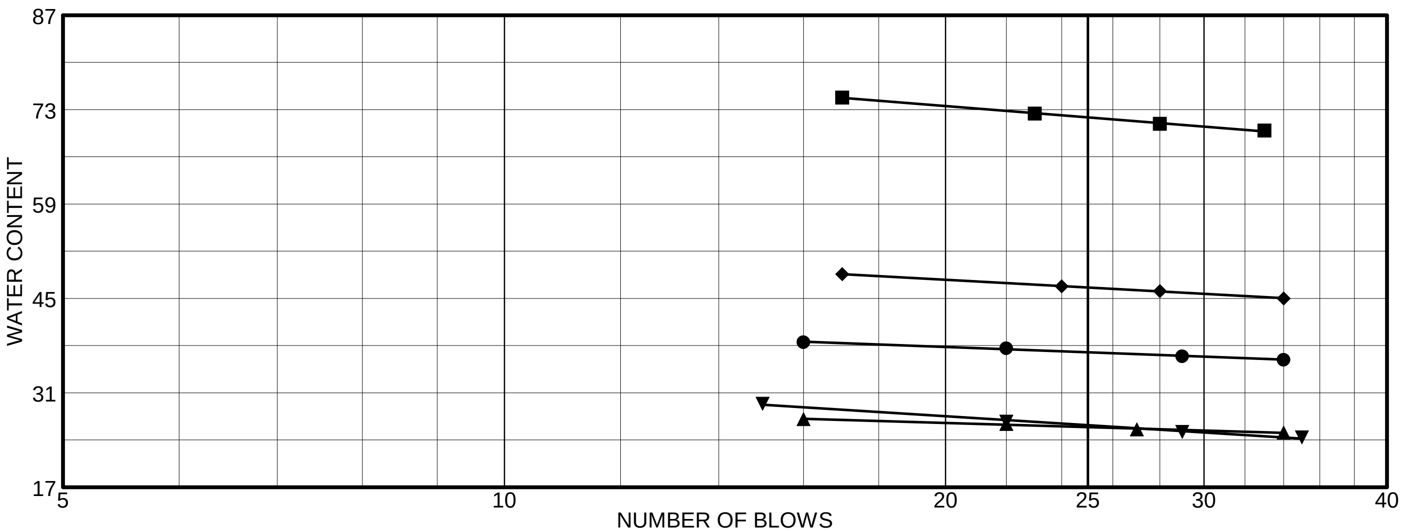
LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Bluish Gray SILT	37	25	12			
■	Bluish Gray Elastic SILT	72	36	36			
▲	Light Greenish Gray Sandy Lean CLAY	26	18	8			
◆	Bluish Gray SILT	47	28	19			
▼	Dark Gray Silty, Clayey SAND w/ shell fragments	26	19	7			

Project No. 020-209 **Client:** AECOM

Project: Eden Landing - 60423372

● **Source:** B-03-4 **Elev./Depth:** 20-21.5'

■ **Source:** B-04-2 **Elev./Depth:** 10-12.5'

▲ **Source:** B-05-2 **Elev./Depth:** 10-12.5(Tip-1")

◆ **Source:** B-05-4 **Elev./Depth:** 20-22.5'

▼ **Source:** B-06-3 **Elev./Depth:** 15-17.5(Tip-8")

Remarks:

●

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LIQUID AND PLASTIC LIMITS TEST REPORT

COOPER TESTING LABORATORY

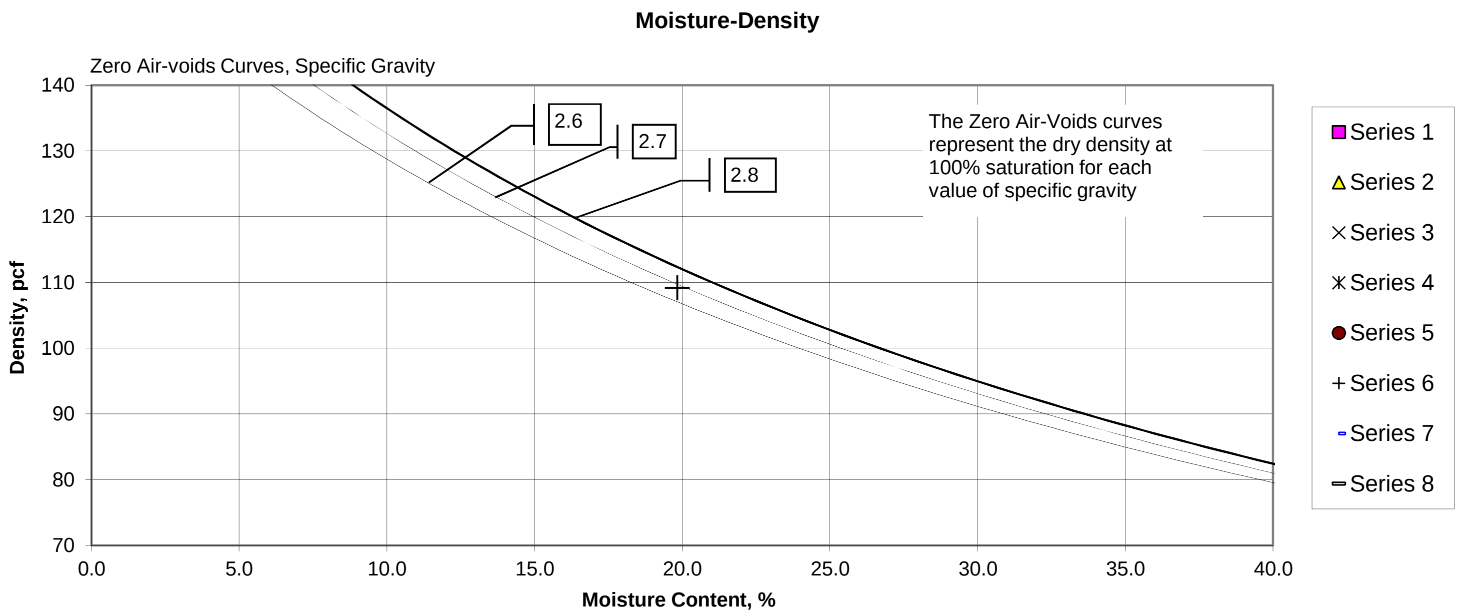
Figure

Moisture-Density-Porosity Report
Cooper Testing Labs, Inc. (ASTM D7263b)

CTL Job No:	020-209	**Project No.**	60423372	**By:**	RU
Client:	AECOM	**Date:**	08/05/16		
Project Name:	Eden Landing	**Remarks:**			

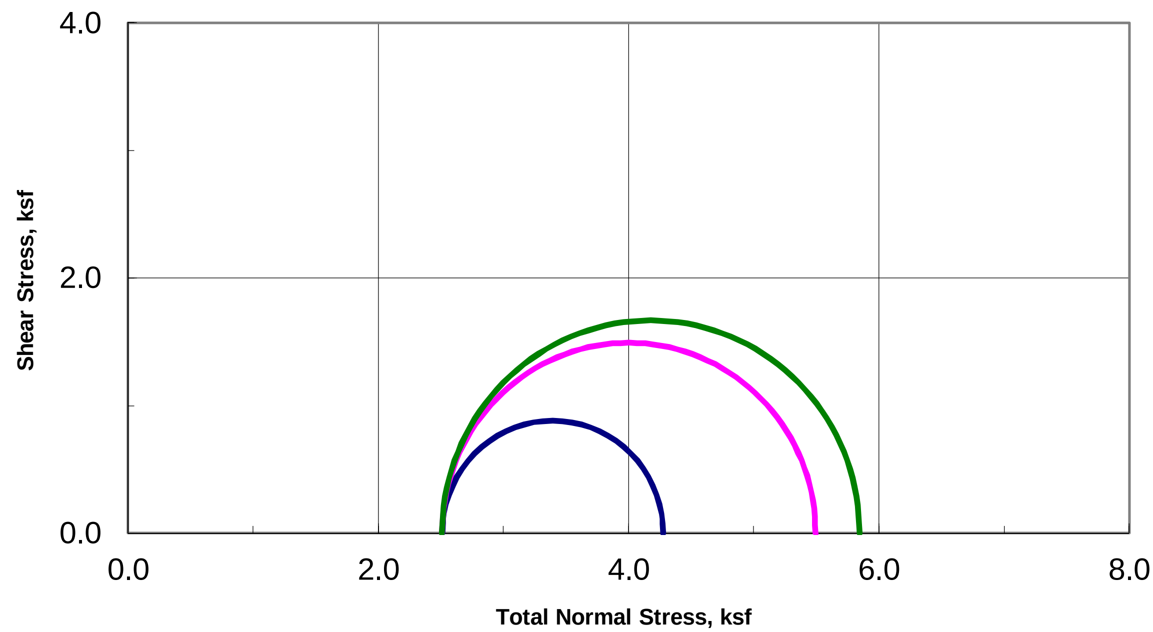
Boring:	B-01	B-02	B-03	B-04	B-05	B-05		
Sample:	7	2	4	2	4	2		
Depth, ft:	35-36	10-12.5	20-21.5	10-12.5	20-22.5	10-12.5(Tip-1")		
Visual Description:	Greenish Gray Lean CLAY w/ shells	Greenish Gray Fat CLAY	Bluish Gray SILT	Bluish Gray Elastic SILT	Bluish Gray SILT	Light Greenish Gray Sandy Lean CLAY		
Actual G_s								
Assumed G_s						2.70		
Moisture, %	55.7	81.2	30.1	86.3	40.5	19.8		
Wet Unit wt, pcf						130.8		
Dry Unit wt, pcf						109.1		
Dry Bulk Dens.pb, (g/cc)						1.75		
Saturation, %						98.1		
Total Porosity, %						35.3		
Volumetric Water Cont,Өw,%						34.6		
Volumetric Air Cont., Өa,%						0.7		
Void Ratio						0.55		
Series	1	2	3	4	5	6	7	8

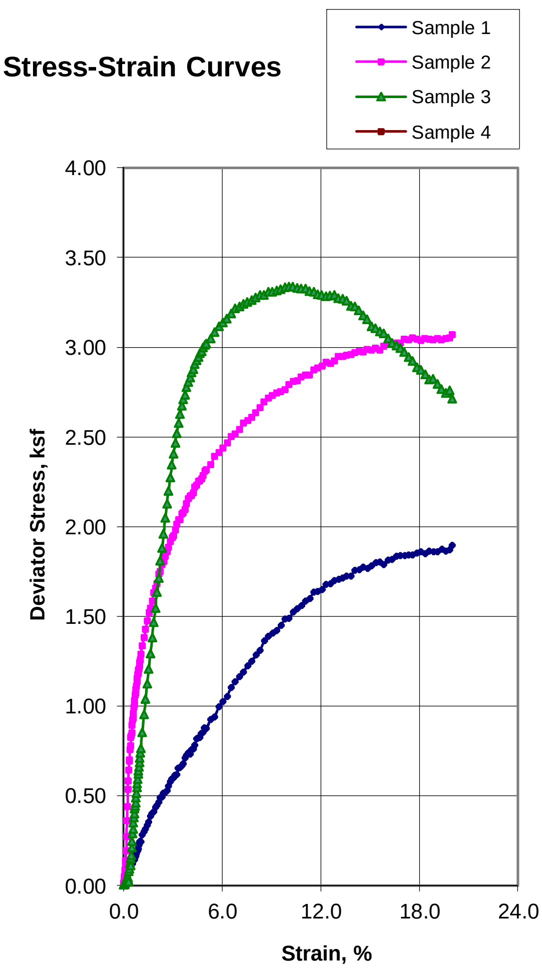
Note: All reported parameters are from the as-received sample condition unless otherwise noted. If an assumed specific gravity (Gs) was used then the saturation, porosities, and void ratio should be considered approximate.



Cooper Testing Labs, Inc.
937 Commercial Street
Palo Alto, CA 94303

Unconsolidated-Undrained Triaxial Test
ASTM D2850





Sample Data				
	1	2	3	4
Moisture %	34.4	28.1	28.0	
Dry Den,pcf	87.3	94.8	95.3	
Void Ratio	0.931	0.777	0.769	
Saturation %	99.9	97.6	98.3	
Height in	4.98	4.98	6.07	
Diameter in	2.41	2.41	2.87	
Cell psi	17.4	17.4	17.4	
Strain %	15.00	15.00	10.31	
Deviator, ksf	1.766	2.987	3.337	
Rate %/min	1.00	1.00	1.00	
in/min	0.050	0.050	0.061	
Job No.:	020-209			
Client:	AECOM			
Project:	Eden Landing - 60423372			
Boring:	B-03-6	B-04-6	B-06-6	
Sample:				
Depth ft:	30-31.5	30	30-32(Tip-4")	

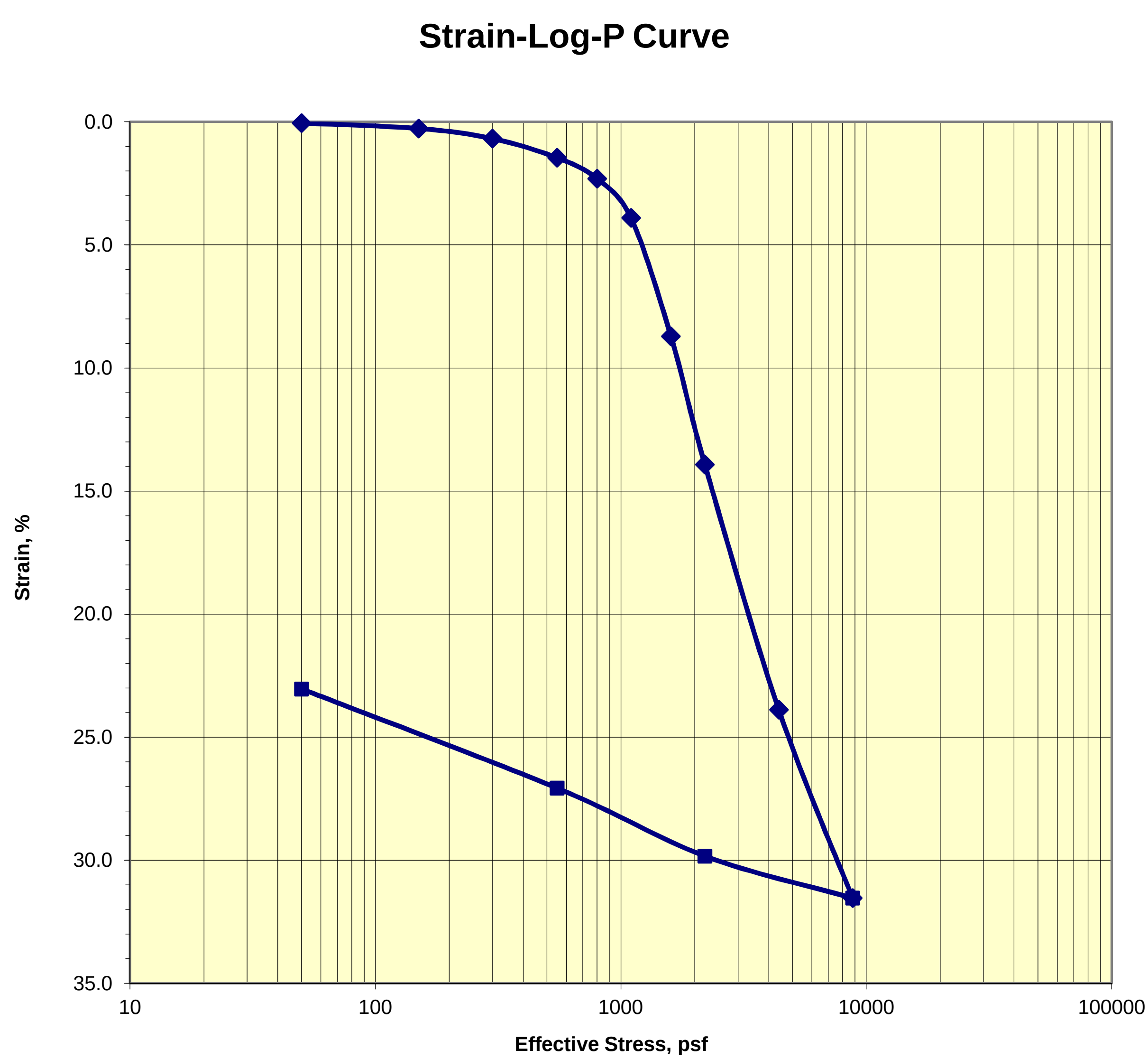
Visual Soil Description	
Sample #	
1	Gray CLAY
2	Gray CLAY
3	Olive Gray CLAY
4	

Remarks:

Note: Strengths are picked at the peak deviator stress or 15% strain which ever occurs first per ASTM D2850.

Consolidation Test
ASTM D2435

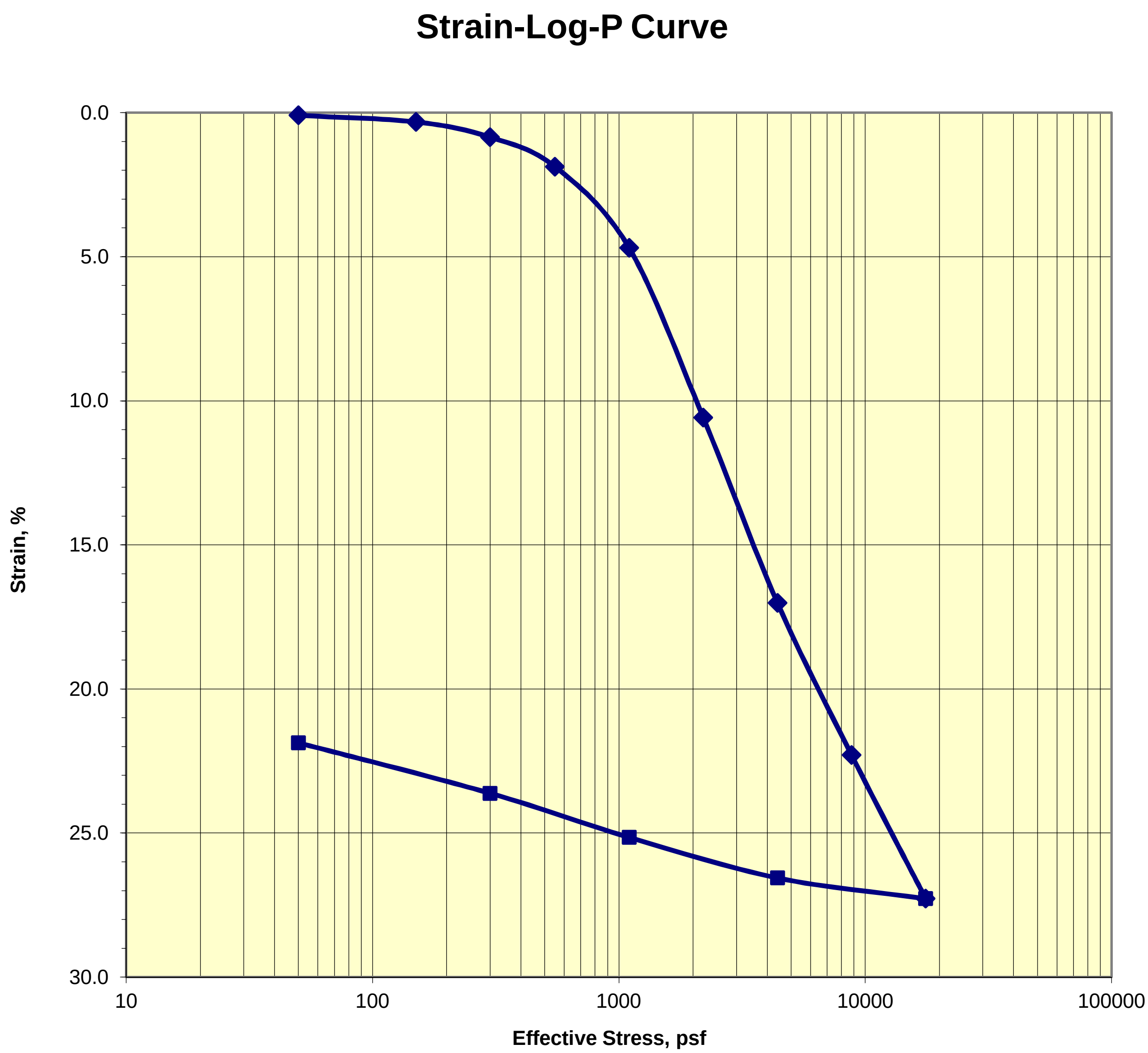
Job No.:	020-209	**Boring:**	B-01-3	**Run By:**	MD
Client:	AECOM	**Sample:**		**Reduced:**	PJ
Project:	60423372	**Depth, ft.:**	15-17.5(Tip-9")	**Checked:**	PJ/DC
Soil Type:	Gray Elastic SILT (Bay Mud)			**Date:**	8/9/2016



Assumed Gs 2.7	Initial	Final
Moisture %:	90.2	60.3
Dry Density, pcf:	49.0	64.1
Void Ratio:	2.438	1.628
% Saturation:	99.9	100.0

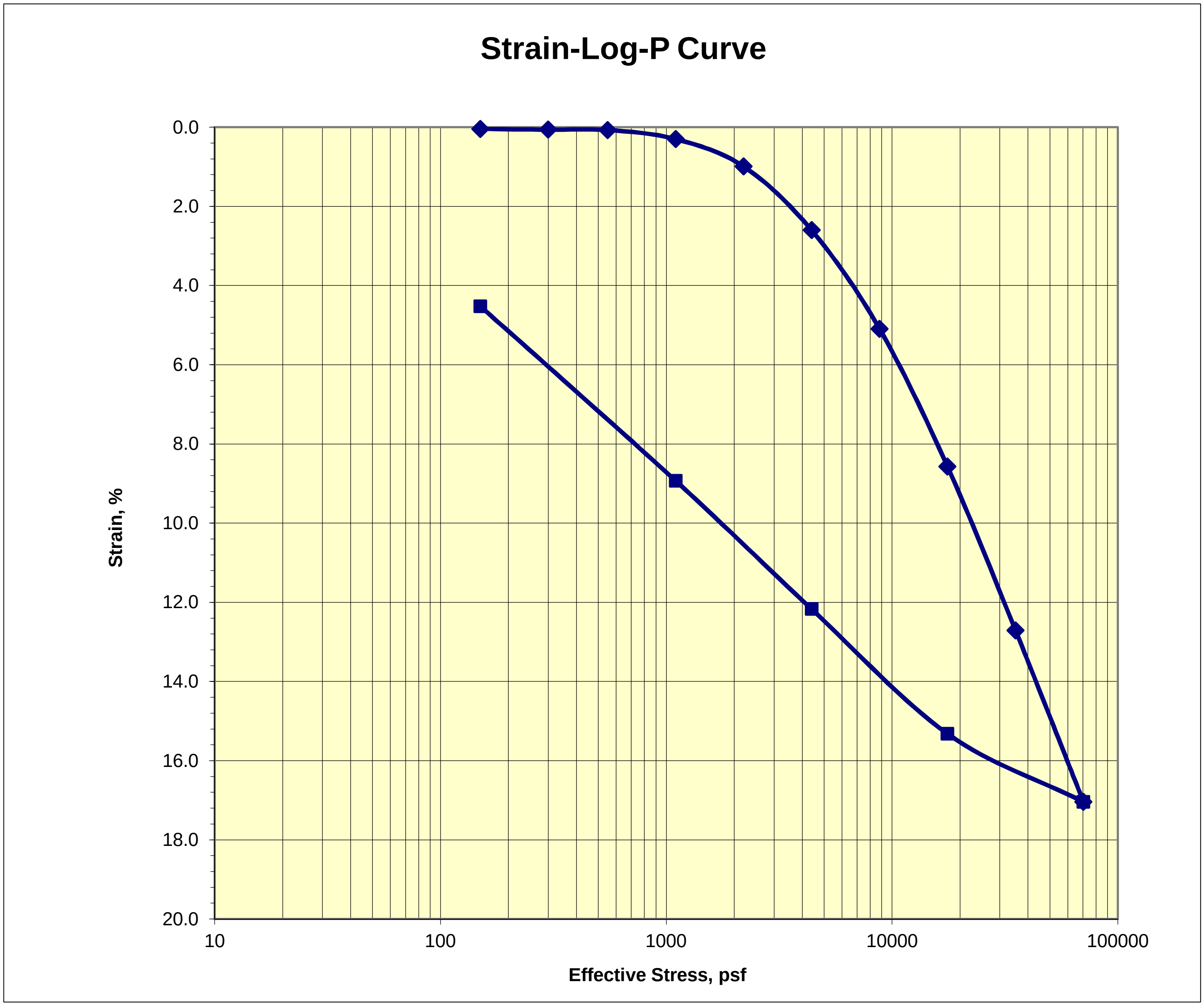
Consolidation Test
ASTM D2435

Job No.:	020-209	**Boring:**	B-06-3	**Run By:**	MD
Client:	AECOM	**Sample:**		**Reduced:**	PJ
Project:	60423372	**Depth, ft.:**	15-17.5(Tip-7")	**Checked:**	PJ/DC
Soil Type:	Dark Gray Silty, Clayey SAND w/ shell fragments			**Date:**	8/9/2016



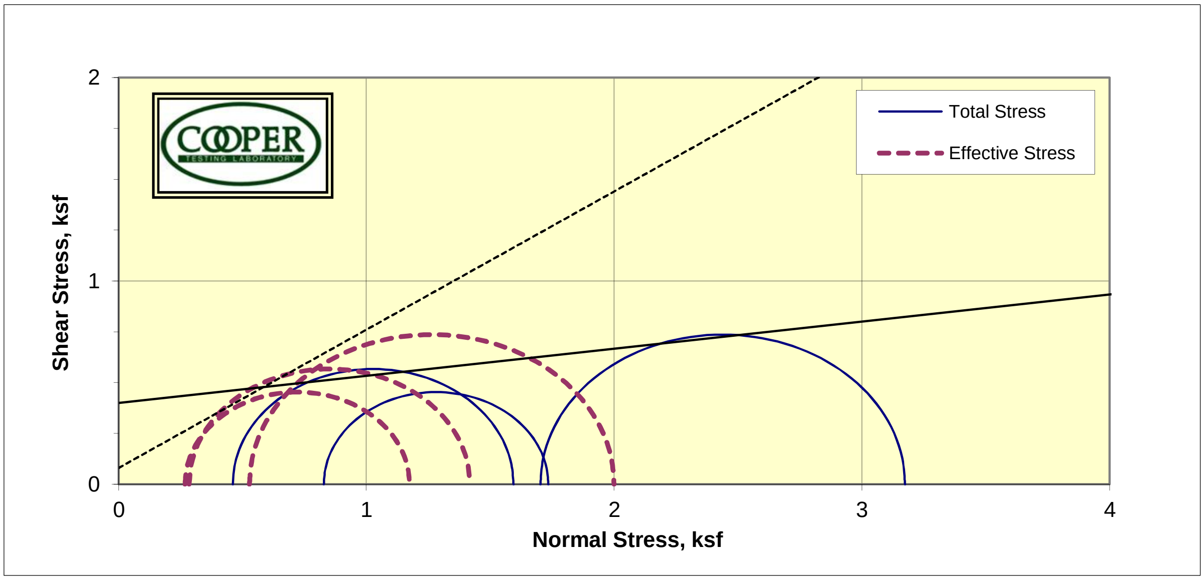
Assumed Gs 2.7	**Initial**	**Final**
Moisture %:	50.3	31.1
Dry Density, pcf:	71.3	91.6
Void Ratio:	1.364	0.840
% Saturation:	99.6	100.0

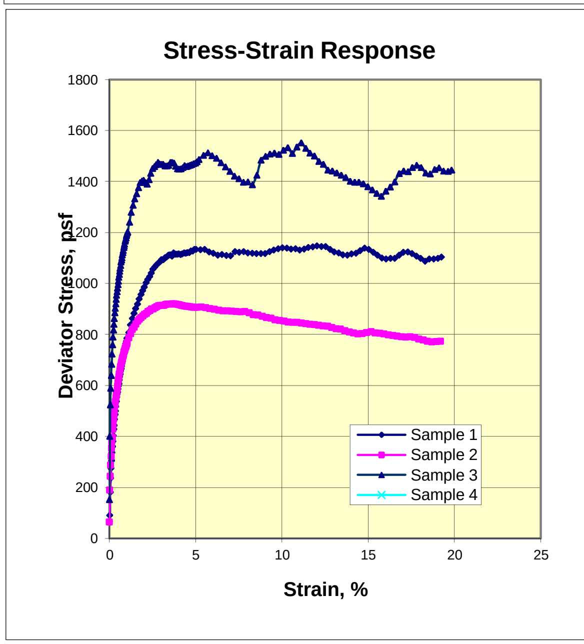
Job No.:	020-209	**Boring:**	B-06-6	**Run By:**	MD
Client:	AECOM	**Sample:**		**Reduced:**	PJ
Project:	60423372	**Depth, ft.:**	30-32(Tip-3")	**Checked:**	PJ/DC
Soil Type:	Olive CLAY			**Date:**	8/9/2016



Assumed Gs 2.75	Initial	Final
Moisture %:	28.3	26.3
Dry Density, pcf:	95.2	99.5
Void Ratio:	0.804	0.725
% Saturation:	96.7	100.0

Triaxial Consolidated Undrained with Pore Pressure
ASTM D4767





Sample:	1	2	3	4
MC, %	74.6	71.2	65.6	
DD, pcf	53.8	57.0	59.6	
Sat. %	94.6	98.4	97.0	
Void Ratio	2.130	1.954	1.827	
Diameter in	2.87	2.87	2.87	
Height, in	6.11	6.10	6.10	
	Final			
MC, %	75.1	65.9	53.8	
DD, pcf	55.6	60.6	68.7	
Sat. %	100.0	100.0	100.0	
Void Ratio	2.028	1.779	1.452	
Diameter, in	2.83	2.80	2.71	
Height, in	6.10	6.05	5.92	
Cell, psi	62.9	66.0	71.4	
BP, psi	59.7	60.3	59.6	
	Effective Stresses At:			
Strain, %	5.0	5.0	5.0	
Deviator ksf	1.133	0.906	1.472	
Excess PP	0.176	0.560	1.174	
Sigma 1	1.418	1.175	2.000	
Sigma 3	0.285	0.268	0.528	
P, ksf	0.851	0.721	1.264	
Q, ksf	0.567	0.453	0.736	
Stress Ratio	4.979	4.379	3.787	
Rate in/min	0.0001	0.0001	0.0001	

Total C	**0.4**	**ksf**
Total phi	**7.6**	**degrees**
Eff. C	**0.1**	**ksf**
Eff. Phi	**34.2**	**degrees**

©

Job No.:	020-209	**Date:**	8/12/2016
Client:	AECOM		BY:DC
Project:	Eden Landing - 60423372		
Sample 1)	B-03-1 @ 5-7.5(Tip-1")	Greenish Gray Elastic SILT (Bay Mud)	
Sample 2)	B-02-4 @ 20.5-23(Tip-7")	Greenish Gray Elastic SILT (Bay Mud)	
Sample 3)	B-02-4 @ 20.5-23(Tip-1/2")	Greenish Gray Elastic SILT (Bay Mud)	
Sample 4)			

The strength of sample #2 was the lowest and is shown in order as the second Mohr circle. Interestingly the pore pressure responded as it should have when comparing to the other samples. It is assumed that the strengths didn't plot as expected because sample #1 was a different boring and depth than samples #2 & #3.