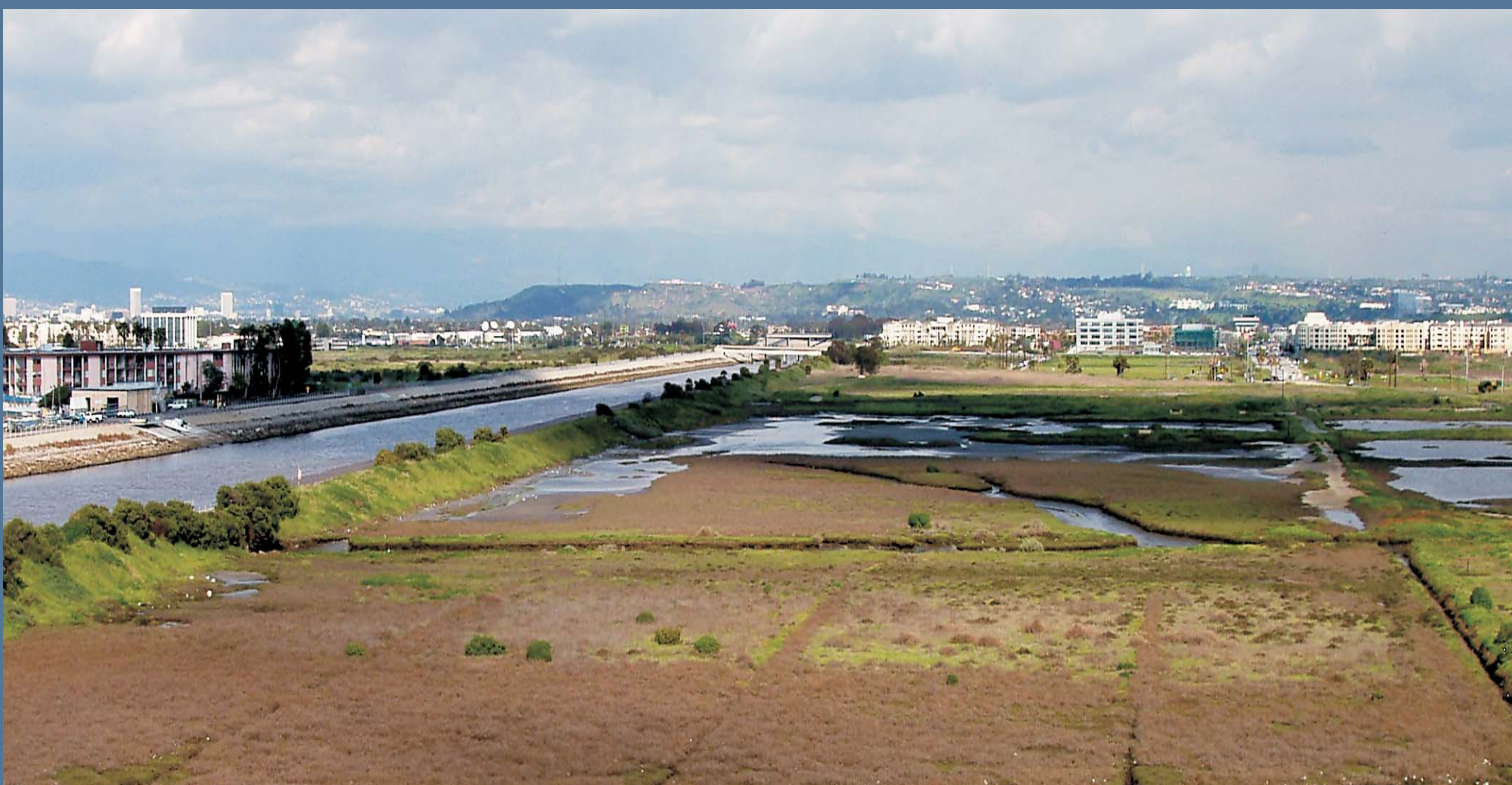
September 2008

Ballona Wetland Feasibility Report

Prepared For *California State Coastal Conservancy*



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Ballona Wetlands Restoration
Feasibility Report

Prepared for

California State Coastal Conservancy

Prepared by

Santa Monica Bay Restoration Commission
Philip Williams & Associates, Ltd.

with

EDAW
Nordby Biological Consulting
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PWA REF. # 1793.00

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1. INTRODUCTION

In 2004, the State of California took title to 600-acres of the remaining Ballona Wetlands in Los Angeles (Figure 1-1). The property is owned by two state agencies, the Department of Fish and Game (DFG) and the State Lands Commission. The State Coastal Conservancy (Conservancy) has funding for planning and restoring the property. Together, the three agencies are working with stakeholders, scientists and other agencies to develop a plan to restore this extraordinary resource. The Conservancy is providing funds for the planning effort and manages the work plan, budget, and schedule. DFG would be the applicant for any permits needed for the restoration project and the lead agency for purposes of CEQA. A restoration plan would be developed for all of the lands owned by the state. Planning is being conducted within the landscape and watershed context, incorporating adjacent and ecologically related resources.

This document characterizes the differences between five preliminary alternatives for the Ballona Wetlands Restoration Plan developed and refined by the Project Management Team (PMT), with the advice of the Ballona Wetlands Working Group, Science Advisory Committee, Agency Advisory Committee, and the consultant team. The aim is to provide a consistent set of information for each alternative using measures of change developed from the project's Goals and Objectives (Appendix A). These measures of change provide the ability to objectively determine how each alternative moves towards a specific project objective from the existing baseline conditions. The PMT would use this information to screen out infeasible or undesirable alternatives from advancing to the EIS/EIR process.

While the report is structured around five alternatives, they are discussed for each subarea within the Ballona Wetlands when appropriate, allowing the preferred alternative(s) to be developed from a combination of alternatives from different subareas. Area A refers to the portion of the Ballona Wetlands north of Ballona Creek to the west of Lincoln Boulevard. Area B refers to the portion south of Ballona Creek. Area C refers to the area north of Ballona Creek and east of Lincoln Boulevard.

Chapter 2 of the report provides an overview of the five alternatives, highlighting the changes from the existing conditions of the site, as well as the habitat restoration and public access objectives accomplished by each alternative. The alternatives encompass a reasonable range of options for restoring estuarine habitat within each of the different subareas (see Appendix B for habitat descriptions). These options include:

- Enhance existing habitat with minimal grading
- Muted tidal wetland restoration within existing constraints
- Full tidal wetland restoration, supporting all associated habitat types, and requiring significant site alteration

- Full tidal wetland and subtidal habitat restoration, providing a connection between these habitats with the project site, and requiring significant site alteration.
- Realignment of Ballona Creek, allowing interaction between the creek and wetland, and providing much more habitat and functional connectivity; and, requiring significant site alteration.

For each habitat restoration alternative, a public access alternative has been developed which includes trails, gateway entrances, overlooks and pullouts.

Chapter 3 applies information from existing sources, in particular the Existing Conditions Report and hydrodynamic modeling (Appendix C), to compare the potential effects of the restoration alternatives based on the measures of change. The main themes of the feasibility assessment are:

- Habitat Acreages
- Quality of Habitat
- Habitat Connectivity (Regional and Local)
- Biodiversity
- Hydrology (Tidal Circulation and Flood Protection)
- Sediment and Water Quality
- Sustainability
- Public Access, Recreation and Safety
- Phasing and Relative Costs

These themes are based on the goals and objectives for the project. Each theme is discussed in terms of how different site conditions might improve or effect desired characteristics of the theme. The evaluation is summarized in a Chapter 4 which describes the main characteristics of each alternative. The information provided in this section can then be used as an objective basis to determine how each of the alternatives accomplishes these project objectives. A summary is provided that compares the alternatives to each other based on a list of common, favorable characteristics. This summary also describes some of the trade-offs between the different approaches to restoration. A ranking of each alternative on a scale from 1 to 5 is given. These rankings are based on the best judgment of the Project Management Team, with input from the Science and Agency Advisory Committees.

1.1 SECTION 1 FIGURES

figure 1-1

Ballona Wetlands Restoration

Project Area

Proj. # 1793

PWA

2. DESCRIPTION OF ALTERNATIVES

2.1 ALTERNATIVE 1 - ENHANCE EXISTING HABITAT WITH MINIMAL GRADING

Alternative 1 (Figure 2-1) proposes minimal change relative to the existing conditions of the site. As such, this alternative emphasizes enhancement of existing upland habitats, in particular coastal sage scrub (CSS) and native grassland habitats, over creation or restoration of coastal wetland habitats. Alternative 1 would convert an area of freshwater marsh in the southeast portion of Area B to muted tidal marsh by replacing the existing Freshwater marsh culvert with a daylighted tidal channel that connects to Ballona Creek. This would provide one additional source of tidal influence to the project area. Existing tide gates would be modified to increase the muted tidal waters entering the southwest portion of Area B. Alternative 1 proposes little change to existing infrastructure such that the project area would remain fragmented and isolated by roads, Ballona Creek, berms and levees. Existing dune habitat, the constructed freshwater marsh and recreational facilities in Area C would be retained.

Area A would be managed to include seasonal wetland habitat, tidal low marsh and channel, transition zone and enhanced upland. The existing tidal connection to Berth H in Marina del Rey would not be changed.

Area B would remain similar to existing conditions with the following exceptions:

1. A small triangle of land located south of Culver Boulevard and west of proposed muted mid-marsh habitat that is currently mapped as non-tidal salt marsh/brackish marsh would be converted to CSS and transitional habitats.
2. The closing elevation of the tide gates that allow limited tidal influence in this area would be increased to admit lower high tides into the area. This would expand the area of muted tidal marsh.

Area C includes the highest elevations of the project area. Under Alternative 1, little excavation of this area is proposed. Instead, existing recreational facilities would be retained and enhanced CSS and native grassland habitat, and a small treatment wetland would be constructed.

In terms of Public Access (Figure 2-2), Area A would have a loop trail on the existing Gas Company access road, and a larger loop trail would provide access to the seasonal wetland area via a boardwalk. Gateway entrances, overlooks and a formal parking/staging area would be developed. For Area B, public access would include periphery trails, along Cabora Drive, and pedestrian crossings for a fully integrated trail network. Gateway entrances, overlooks and formal parking would be provided. Linkages between the east and west portions of Area B would be provided by two pedestrian crossings on Culver Boulevard. A pedestrian bridge located near the historic rail crossing would link Area B to Area A. Public access features in Area C would include two loop trails originating from the gateway entrances at La Villa Marina and near the Little League fields. A parking area would continue to be located at the Little League fields.

2.2 ALTERNATIVE 2 - A SMALLER AREA TIDAL WETLAND RESTORATION

Alternative 2 (Figure 2-3) includes a departure from existing conditions through excavation of fill to create fully tidal channels, low marsh, and mid-high salt marsh. Alternative 2 would also convert an area of freshwater marsh in the southeast portion of Area B to muted tidal marsh by replacing the existing Freshwater Marsh culvert with a daylighted tidal channel that connects to Ballona Creek. This would provide one additional source of tidal influence to the project area. Existing connections would be modified by adjusting the setting of the existing tide gates to increase the muted tidal waters entering the southwest portion of Area B. The connection under Dock 52 to Marina del Rey would be enhanced, creating a full tidal marsh in Area A. Alternative 2 proposes little change to existing infrastructure such that the project area would remain fragmented and isolated by roads, Ballona Creek, and berms and levees. Existing dune habitat, constructed freshwater marsh and recreational facilities would be retained.

Area A would be modified to include fully tidal channels, low and mid-high marsh, and associated transition zone habitats. This would be accomplished by increasing the tidal connection under Dock 52 to create an open culvert with a cross-sectional area of 100 ft^2. The remainder of Area A would be converted to enhanced CSS and native grassland habitat.

The southeast portion of Area B (Area B southeast) would be modified to include fully tidal channels, low and mid-high marsh, and associated transition zone habitats. In Area B southwest, the degree of tidal influence would be increased through modification of the existing tide gates. A new culvert with a cross-section of 100 ft^2 would provide a new fully tidal connection to Area B southwest. Like Alternative 1, a small triangle of land located south of Culver Boulevard that is currently mapped as non-tidal salt marsh/brackish marsh would be converted to CSS and transition zone habitats

Alternative 2 would create a small, deeper extension of Fiji Ditch in Area C beneath Lincoln Boulevard resulting in an incremental increase in fully tidal channel, low and mid-high marsh habitats and transition zone habitat beyond that proposed in Alternative 1. The recreational facilities, CSS and native grassland habitat would be retained and small areas of seasonal wetland and treatment wetlands created.

In Area A, a loop trail on the existing Gas Company Road, and a perimeter trail, around the new wetlands, connecting the gateway entrance along Fiji Way to the Ballona Creek Bicycle trail along the north levee would be developed (Figure 2-4). Boardwalk spur trails at the Fiji Way and Fisherman's Village gateway entrances would provide access to overlooks. Public access features in Area B would be similar to Alternative 1. Public access features in Area C would include two loop trails originating from the gateway entrances at La Villa Marina and near the Little League fields. A parking area would continue to be located at the Little League fields. An overlook would be located near the seasonal wetland area.

2.3 ALTERNATIVE 3 - A LARGER AREA TIDAL WETLAND RESTORATION

Alternative 3 (Figure 2-5) would create additional estuarine habitat relative to Alternative 2 resulting in further increases in fully tidal channel, low marsh and mid-high marsh habitats and associated transition zone habitat. Culver Boulevard, Jefferson Boulevard and the Gas Company road in Area B would be improved by raising the roads on levees or piles; these would provide greater hydraulic connectivity through larger culverts or between piles. Portions of the project area would remain fragmented and isolated by Ballona Creek and Jefferson Boulevard. Existing dune habitat, constructed freshwater marsh and recreational facilities would be retained.

Area A would be modified to include fully tidal channels, low marsh and mid-high marsh and associated transition zone habitats. This would be accomplished by increasing the tidal connection under Dock 52 to create an open culvert with a cross-sectional area of 160 ft^2. The remainder of Area A would be converted to enhanced CSS and native grassland habitat.

In Area B, Alternative 3 would increase the degree of tidal influence in the southwest wetland by replacing the SRT with a 100 foot wide breach. The alternative also includes extension of existing fully tidal channels and raising Culver Boulevard on pilings or levees and removal of the berm south of Culver Boulevard. Most available area would be converted to fully tidal habitats and transition zone habitat. The southeast wetland would be connected as in Alternative 2.

Alternative 3 would create a small, deeper extension of Fiji Ditch in Area C and excavation of a small tidal marsh resulting in an incremental increase in fully tidal channel habitat and an increase in transition zone habitat beyond that proposed in Alternative 2. The recreational facilities, CSS and native grassland habitat would be retained and two small areas of seasonal wetland would be created.

Key provisions for public access (Figure 2-6) in Area A are a looping perimeter trail along the banks of the restored wetland. This trail links gateway entrances along Fiji Way to those along the north levee. Gateway entrances would be located at the existing parking area near Fisherman’s Village, along Fiji Way, and two along the Ballona Creek Bicycle Path. Boardwalk spur trails at the Fisherman’s Village and Fiji Way gateway entrances would provide access to overlooks. These overlooks would provide both an easily accessible viewing point and a key location for interpretive and educational signage. A formal parking/staging area would be developed at the gateway entrance near Fisherman’s Village. In Area B, roadside vehicular pullouts would be provided along Culver and Lincoln Boulevards. A link between the east and west portions of Area B would be provided by a pedestrian crossing located on Culver Blvd. A pedestrian bridge located near the historic rail crossing would link Area B to Area A. Formal parking areas would be located at the gateway entrance behind Gordon’s Market and along Jefferson Blvd at the Freshwater Marsh. Public access features in Area C would include two loop trails originating from the gateway entrances at La Villa Marina and near the Little League fields. A parking area would continue to be located at the Little League fields. Overlooks would be located at viewing points for the seasonal wetland area near the Little League fields and north of Culver Blvd at the restored estuarine wetland area.

2.4 ALTERNATIVE 4 - A LARGE AREA TIDAL WETLAND RESTORATION WITH SUBTIDAL COMPONENT

Alternative 4 (Figure 2-7) resembles Alternative 3 with the exception of a larger connection with Marina del Rey and creation of shallow subtidal and intertidal habitats in Area A. This increased excavation would create a shallow subtidal basin and increased intertidal mudflats, while shifting the excavation to the northwest edge of Area A would allow for the creation of a more diverse marsh plain. Culver Boulevard and the levee system south of Culver Boulevard would be improved by raising the road on piles or a levee, these would provide greater hydraulic connectivity through larger culverts or between piles. Portions of the project area would remain fragmented and isolated by Ballona Creek and Jefferson Boulevard. Existing dune habitat, constructed freshwater marsh and recreational facilities would be retained.

Area A would be modified to include a shallow subtidal embayment, tidal channels, intertidal mudflat, low salt marsh, mid-high marsh and associated transition zone habitats. This would be accomplished by increasing the tidal connection under Dock 52 to create an open culvert with a cross-sectional area of 500 ft^2. A narrow, linear strip adjacent to Ballona Creek would be converted to enhanced CSS habitat.

In Area A there would be a loop trail on the existing Gas Company Road, and a perimeter trail along the southern edge of the restored estuarine wetland, portions of which would be boardwalk (Figure 2-8). Gateway entrances would be located at the existing parking area near Fisherman's Village and along the Ballona Creek Bicycle Path. The loop and perimeter trails would link the gateway entrance near Fisherman's Village to the Ballona Creek trail located along the north levee and the two gateway entrances along Ballona Creek. Overlooks would be located near the Fisherman's Village gateway entrance and along the perimeter trail. A formal parking/staging area would be developed at the gateway entrance near Fisherman's Village. Public access features in Area B and C would be the same as Alternative 2.

2.5 ALTERNATIVE 5 - A REALIGNMENT OF BALLONA CREEK

Alternative 5 (Figure 2-9) proposes the greatest amount of change to the project area, including the greatest degree of fully tidal wetland creation. The most obvious change would be the removal of the Ballona Creek flood control channel levees and creation of a sinuous natural creek and associated tidal basins through the site. The site would be interconnected across all areas, with shallow subtidal and mudflats grading through all marsh habitats to higher wetland-upland transition habitat. The channel would be free to migrate across the tidal floodplain, limited where necessary by buried rock protection. The existing Ballona Creek channel would be filled where necessary. The intersection of Culver and Jefferson Boulevards would be moved westward, closer to Lincoln. Culver and Lincoln Boulevard would be raised on pilings above the fully tidal marshlands. The gas/oil monitoring facilities in Area A and recreational facilities in Area C would be minimized and converted to fully-tidal channel, low, and. mid-high marsh, transition zone and enhanced CSS. The constructed freshwater marsh and existing dunes would be retained.

Phasing would be an important aspect of this alternative. Phase 1 would lower the levees and surface elevations and excavate the main channel in Area A; Phase 2 would extend the channel into Area B; Phase 3 would extend the channel into Area C following the raising of Lincoln Boulevard.

Areas A, B and C would be modified to include the reengineered fully-tidal Ballona Creek, two shallow tidal ponds, tidal channels, low salt marsh, mid-high marsh and associated transition zone habitats. The northern breakwater of Ballona Creek would be lowered to allow flood flows to spill into Marina Del Rey. Buried rock protection would be provided along the south east edge to prevent the channel meandering too far west. A narrow, linear strip in the north and west portions of the area would be converted to enhanced CSS habitat.

A perimeter trail would be constructed along Fiji Way and gateway entrances located at the existing parking area near Fisherman's Village and along Fiji Way (Figure 2-10). A boardwalk containing an overlook would link the two gateway entrances as well as overlooks located at both gateway entrances. A vehicular pullout would be located along Culver Blvd and would also provide an overlook. Linkages within Area A would be provided through two pedestrian crossings located along Lincoln Blvd. A formal parking/staging area would be developed at the gateway entrance near Fisherman's Village. Area B gateway entrances would be located behind Gordon's Market, along the southern bank of Ballona Creek, along Lincoln Blvd, and along Jefferson Blvd at the entrance to the Freshwater Marsh. Boardwalk spur trails leading to overlooks would be located along the Freshwater Marsh Trail and at a vehicular pullout along Culver Blvd. Overlooks would also be located at the existing Boy Scout Overlook Platform, at the gateway entrance along the south levee, and along the Cabora Drive trail at Pershing Drive. Linkages throughout Area B would be provided by three pedestrian crossings located on Culver Blvd. An upland area along Lincoln Boulevard provides for a possible visitor center location. Formal parking areas would be located at the gateway entrance behind Gordon's Market, at the visitor center, and along Jefferson Blvd at the Freshwater Marsh.

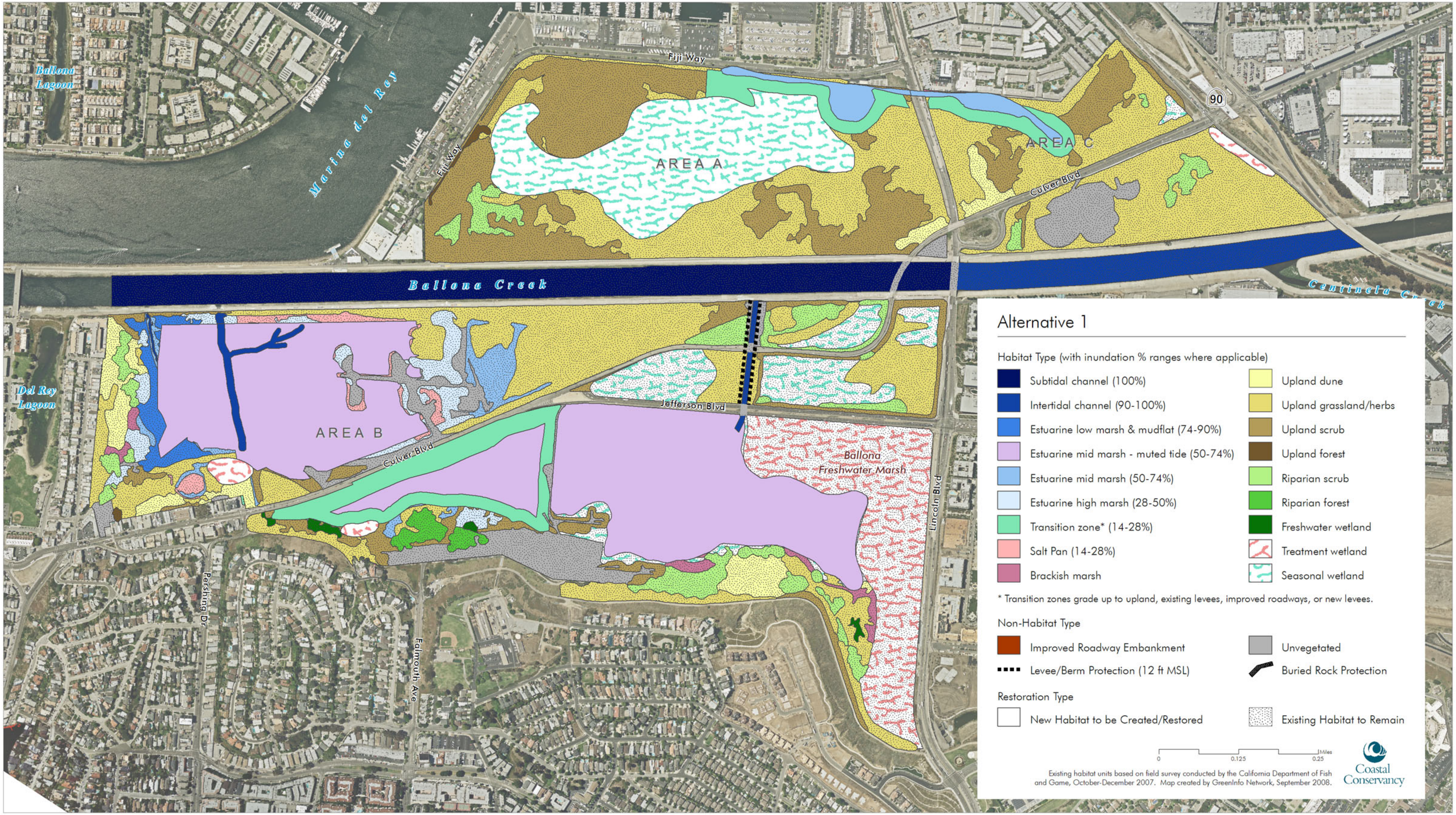
Public access features in Area C would include a perimeter trail from the La Villa Marina gateway entrance to the Lincoln Blvd pedestrian crossing to Area A. Regional trail connectivity would be preserved by connecting the Ballona Creek Bicycle Trail (previously located on the north levee) to a dual pedestrian and bicycle trail along the southern boundary of Area C. This trail would continue both to the north along Lincoln Blvd and to the south along Culver Blvd. Since both roads would be improved within this restoration alternative, improved bicycle lanes would facilitate this regional connectional. A pedestrian bridge would cross Ballona Creek connecting this new trail alignment to the existing Ballona Creek Bicycle Trail. An overlook would be located at the La Villa Marina gateway entrance.

2.6 SECTION 2 FIGURES

Ballona Wetlands
Restoration Project

FIGURE 2-1

Alternative 1 - Habitat Restoration




Ballona Wetlands
Restoration Project
FIGURE 2-2
Alternative 1 - Public Access
Range of Gateway Entrance Locations
FIJI WAY
MARINA DEL REY
AREA A
AREA C
90
MARINA EXPY
BALLONA CREEK
AREA B
CULVER BLVD
W JEFFERSON BLVD
LINCOLN BLVD
LEGEND
HABITAT TYPE
AREA (AC)
CULVERT
IMPROVE ROADWAY EMBANKMENT (TBD)
CHANNEL & LOW MARSH 2
MID MARSH (MUTED TIDE) 104
MID-HIGH MARSH (FULL TIDE) 6
TRANSITION ZONE (EURYHALINE ZONE & GRASSLAND) 48
UPLAND HABITAT (COASTAL SCRUB) 238
DUNE HABITAT 10
TREATMENT WETLAND 4
SEASONAL WETLAND 45
GRADING PLAN
CUT
FILL
GRADING CONTOUR
N
0
1,000
2,000 Feet
Gateway Entrance
Overlook
Parking Area
Pedestrian Crossing
Pedestrian Bridge
Boardwalk
Existing Regional Trail
Proposed Regional Trail
Existing Trail Network
Proposed Trail Network
Coastal Conservancy
Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, September, 2008.

Ballona Wetlands Restoration Project

FIGURE 2-3

Alternative 2 - Habitat Restoration

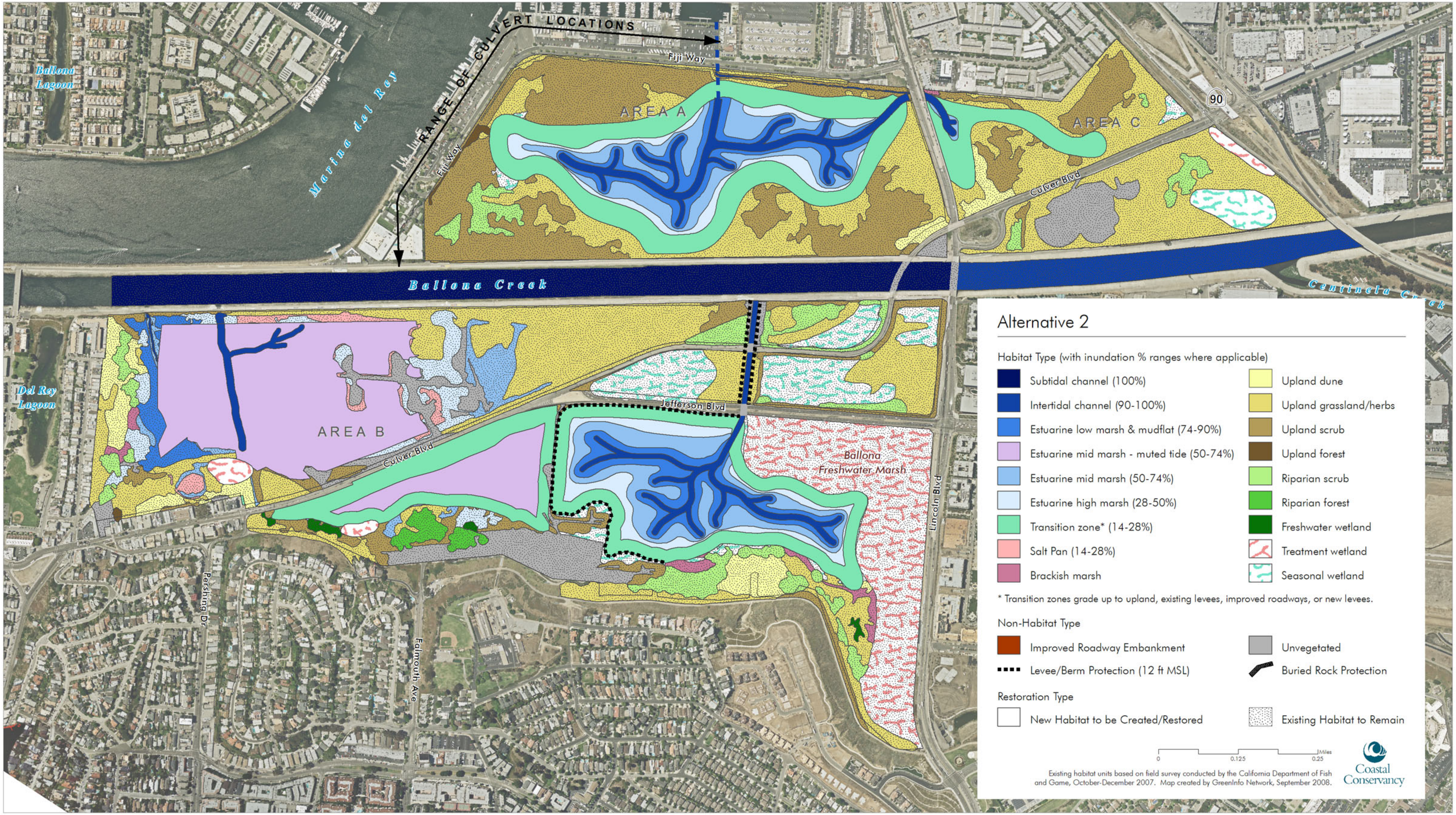
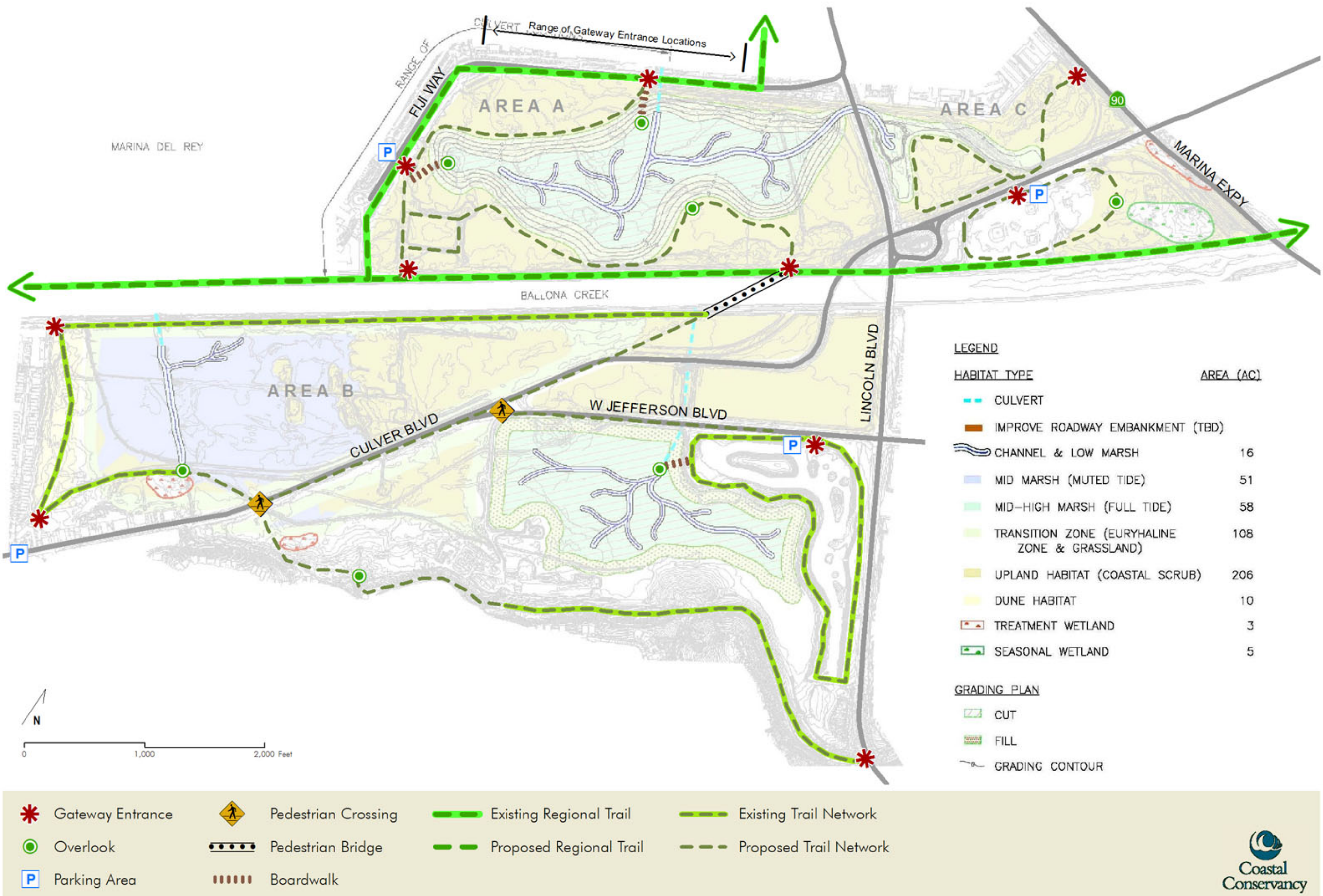


FIGURE 2-4 Alternative 2 - Public Access



Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

Ballona Wetlands
Restoration Project

FIGURE 2-5

Alternative 3 - Habitat Restoration

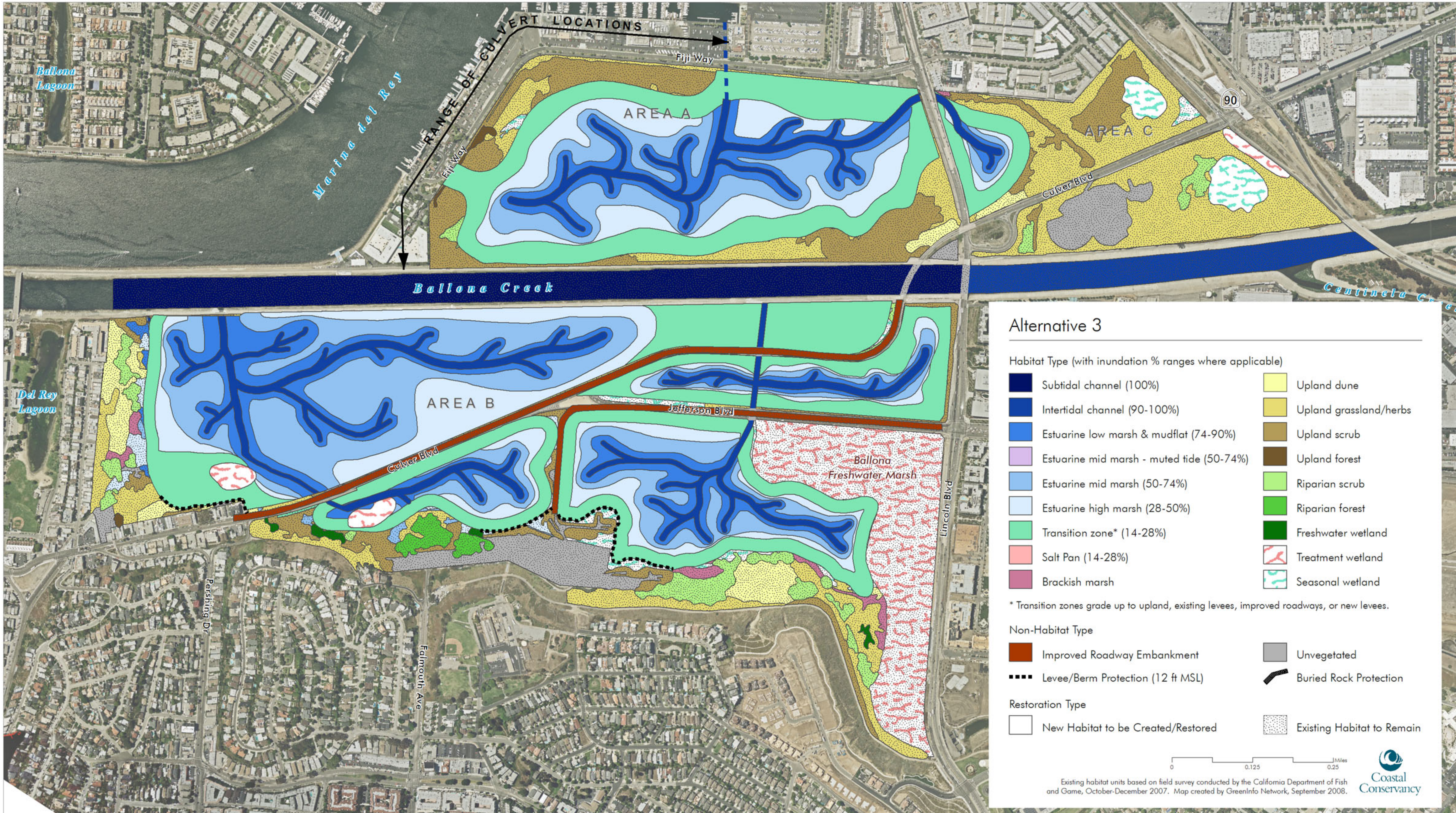
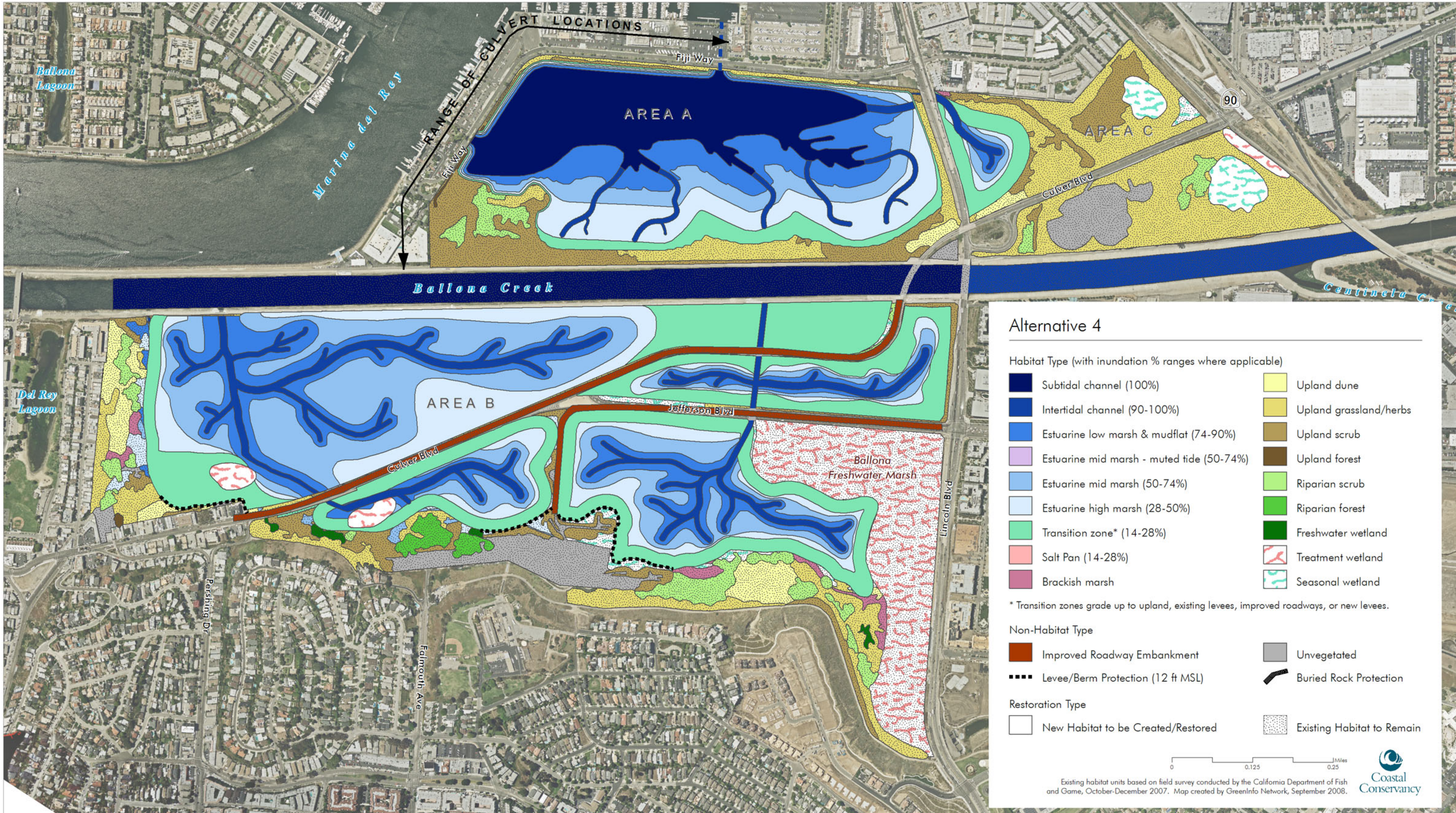


FIGURE 2-6 Alternative 3 - Public Access

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

FIGURE 2-7 Alternative 4 - Habitat Restoration



Ballona Wetlands Restoration Project

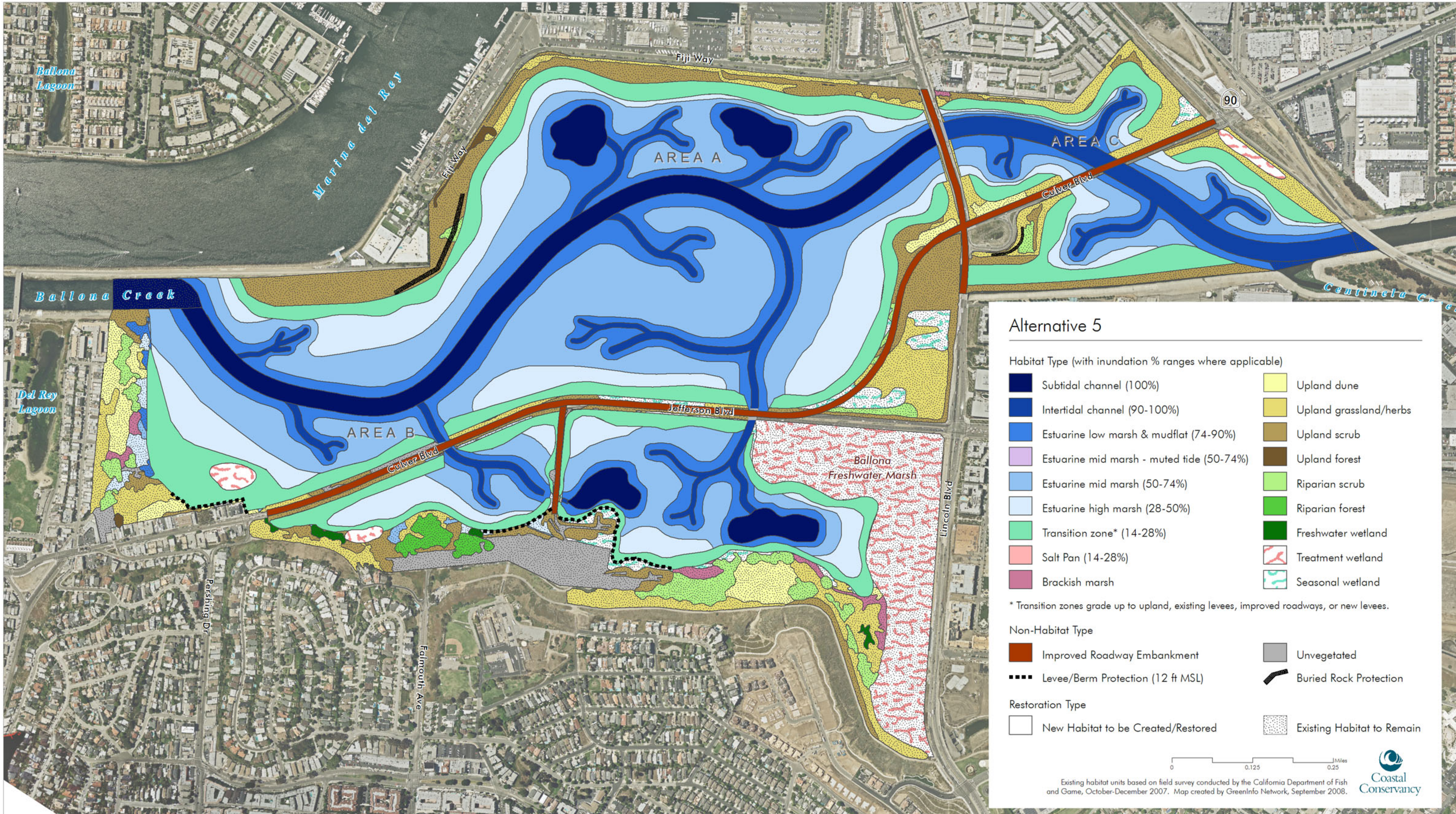
FIGURE 2-8

Alternative 4 - Public Access

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

FIGURE 2-9

Alternative 5 - Habitat Restoration



Ballona Wetlands
Restoration Project

FIGURE 2-10

Alternative 5 - Public Access

Habitat concepts created by Philip Williams and Associates (PWA) and EDAW. Map created by GreenInfo Network and EDAW, June, 2008.

3. MEASURES OF CHANGE

3.1 HABITAT

The Ballona Wetlands historically covered over 2000-acres and likely included a mix of fluvial, tidal, deltaic and dune habitat types. Today this wetland has been reduced to less than 170 acres within the project area and the hydrology of the watershed has been severely altered by extensive development. Remnant areas of the historic wetland complex include Del Rey Lagoon, Ballona Lagoon, Grand Canal, Oxford lagoon, Marina Del Rey, and the Venice Canals. Given the significant alteration, restoring Ballona Wetlands to its historic condition is infeasible; however, the opportunity to recreate a vibrant wetland system would still require consideration of the mix of habitat types that would benefit the ecological functioning.

This section provides a brief description of the different habitat types that would be restored under each of the alternatives (for more detail see Appendix B). A number of broad habitat types are identified in the alternatives: shallow subtidal and open water habitats, intertidal channels and mudflat habitats; low, mid and high marsh and salt pan habitats; wetland-upland transition habitat; brackish marsh; seasonal wetland habitat; freshwater marsh and riparian scrub habitats; and coastal dune, coastal sage scrub and native grassland habitats. Estuarine intertidal wetland habitat includes shallow subtidal, intertidal channels, mudflats, and low, middle and high marsh, salt pan, and transition zone habitats. Each component is necessary to recreate the Ballona Ecosystem and without each component the estuarine wetlands within the system would not function properly. Some components are currently absent from Ballona, and may be important additions in the restoration of Ballona Wetlands.

Tidal Wetlands

Given the estuarine location of the site, the degree of tidal inundation would be a major factor in influencing the habitat type. The period, depth, and frequency of inundation by tidal water are dependent upon the tidal range, density of soil, degree of slope, and ground elevation.

Shallow subtidal habitats include channels, embayments, basins and other features, which at extreme low water do not drain with the outgoing tides. This estuarine water regime results in permanently flooded habitats and permanent open water bodies. These habitats are generally considered truly aquatic systems and are adjacent to and downslope from tidal estuarine wetlands. Estuaries with extensive subtidal habitat areas often support extensive intertidal low marsh and mudflat habitats, providing refugia for fish during low tides, and feeding opportunities for wetland birds.

Intertidal channels and creeks play a critical role in salt marshes as they convey tidal waters and associated nutrients and dissolved gases. They also support a complex assemblage of plants and animals. Estuarine channels and creeks are subjected to a wide variety of environmental conditions. Typically, tidal flushing is greatest at the tidal inlet and decreases with distance from the inlet. This general gradient, in turn influences, water movement, salinity, temperature, nutrients, and dissolved gases. These environmental factors influence the species composition, distribution, and population dynamics of the channel fauna.

Intertidal mudflats are situated low in the intertidal zone, between subtidal open water and vegetated salt marsh (low marsh), at the open water edge and along channel banks. Mudflats are inundated and exposed during most tide cycles. Mudflat habitat support invertebrate population and provides valuable foraging habitat, particularly for shorebirds.

Intertidal salt marsh ranges from low marsh, dominated by California cordgrass (*Spartina foliosa*), to a diverse mosaic of species that comprises the mid-marsh, to very high marsh species that transition to upland. Salt marsh vegetation changes gradually with elevation. Nearly every species has its peak occurrence at its unique elevational band and the vegetation forms a continuum rather than a set of zones. However, the presence of shrub-like succulents at the uppermost elevations and tall cordgrass at the lowest elevations helps to delineate low to high marsh.

Low salt marsh is regularly inundated by tides and is dominated by California cordgrass that forms dense monotypic stands. At its lower elevation, cordgrass intergrades with mudflat habitat; at its upper elevation it intergrades with a mosaic of mid-marsh species. This highly productive species decomposes to form the base of the detrital food chain that supports many lower order estuarine consumers. Many of the animals of the low marsh are adapted to periods of frequent inundation.

Intermediate elevations within the salt marsh are inundated irregularly by tides but at a greater frequency than are higher elevations. As a result, the plant species that inhabit this elevation are adapted to highly saline soil conditions due to long periods of exposure. The animals of the mid-marsh are abundant and diverse. Food is abundant in the form of algae and the epifaunal invertebrates and insects that feed on algae. In addition, when flooded by the tides, fish move into the marsh plain to forage on these abundant invertebrates. Several bird species such as the Beldings' savannah sparrow and light footed clapper rail also forage in this zone.

High marsh habitats are also irregularly to intermittently inundated by tidal water and generally range from saline to hypersaline conditions. The vegetation varies depending on the density of the soil (i.e. ratio of clay to sand), which often is correlated with salinity.

Salt pans form in the high marsh where drainage is poor. These higher elevation areas along the upland edge are only inundated during the highest spring tides and typically have no tidal channels. As a result, ponded areas are formed that become hypersaline as water evaporates, thereby inhibiting vegetation establishment. These salt pans provide habitat diversity and have habitat value for foraging and refugia.

The wetland transitional zone represents that area where the halophytic (salt-tolerant) and hydrophytic salt marsh vegetation overlaps with upland communities. Scrub-shrub plant species of the transition zone overlap with the highest of the salt marsh species. The animals at the higher elevations of the transition zone are primarily terrestrial species. The transitional zone may also include nontidal palustrine habitats both salt influenced and non-saline types. Seeps from perched water tables on deltas and the toe of slopes and along dune transitions often support a variety of palustrine emergent and scrub-shrub types. Seasonal wetlands also occur in this area, especially in low-gradient deltaic deposits and may include salt pans. Transitional zones provide refugia during extreme weather or tides, as well as foraging opportunities. These areas also support a unique set of plant species, which may only occur or coexist in the habitat conditions provided in these transition zones.

Muted tidal habitats are created by the installation of gate structures and flow restrictions, which typically reduce tidal flows and the tide range compared to a fully tidal wetland. Muted tidal wetlands may support subtidal, mudflat, and vegetated wetland habitats. Hydraulic control structures have proven to severely limit fish passage, decrease tidal flushing, and restrict the diversity of habitat of a restored tidal wetland. A muted tidal system typically limits the creation of upper marsh and transitional habitat.

Additional habitats, which either occur on the site or are included in the alternatives consist of, brackish marsh, seasonal wetlands, freshwater and riparian habitat, and upland habitats, including coastal dune, coastal sage scrub and native grassland habitats. Some of these additional habitats are important to the restoration of the tidal wetland system; they may provide buffers from human disturbances, refugia during extreme weather or tides, or complementary habitats. These habitat types may also be significantly impacted in the region due to limited range along the coast.

Brackish conditions, with intermediate salinities, occur where freshwater mixes with seawater. This phenomenon is less frequent in southern California where many estuaries are less influenced by runoff from rainfall than in more northerly latitudes. Local influence from seeps and springs and seasonally impounded stream and river-mouths can produce brackish environments that support emergent vegetation and aquatic bed species.

Non-tidal Wetlands

Seasonal wetlands are non-tidal wetlands and transitional habitats that are flooded to varying degrees by seasonal rainfall and runoff. If there are sufficient salts in the soil, the seasonal wetland may support plant species more typical of coastal salt marsh. If the soils do not contain salts, the seasonal wetlands may support freshwater marsh species and a mixture of weedy opportunists. “Vernal pools” and seasonal saline wetlands in transition zones can occur on alluvial and deltaic deposits adjacent to estuarine habitats and are known to support special-status plants and invertebrate animals. A majority of the existing seasonal wetlands at Ballona occur on saline dredge spoils from the excavation of Marina del Rey. These habitats only support common intertidal plant species in a severely degraded state, and provide little habitat for wildlife. Some of the alternatives include the creation of seasonal wetlands in areas that do not support salt marsh plant species; in these areas freshwater seasonal wetlands may be created that could support vernal pool habitat.

Riparian scrub and woodland occurs in small groves or in riverine corridors that drain into estuaries. As with other riparian habitats, riparian scrub supports a diverse assemblage of wildlife species, especially passerine bird species. Mammal assemblages are similar to those found in freshwater marsh habitats as the two often intergrade. In an undisturbed estuarine system, wouldow scrub habitat would generally occur upstream of tidal influence as wouldows are very sensitive to salt. Like freshwater marsh, this habitat is dependent upon a constant source of freshwater.

Uplands

Most of the peripheral uplands of estuaries have been disturbed in southern California. Historically, upland communities of the systems were likely comprised of coastal dunes, scrub, or grasslands, and woodlands in some cases.

Dune habitat represents a form of transition zone between the land and the sea and includes Coastal Dune Scrub and Dune Herb vegetation. Coastal dune habitats have been largely lost due to development in southern California. Prior to development, plants stabilized the loose sand, and the dunes were thereby anchored. Following human disturbance, many of the native plants were eliminated and exotics, such as sour-fig (*Carporotus edulis*) and sea rocket (*Cakile maritima*) invaded or were planted.

Coastal sage scrub can be described as low, soft to woody shrubs and subshrubs that occur in a variety of situations and are characterized by a variety of dominant plant species. Coastal Sage Scrub is now generally rare along the coast. This vegetation community is typically dominated by coastal sagebrush (*Artemisia californica*) and California buckwheat (*Eriogonum fasciculatum*), together with laurel sumac (*Malosma laurina*), white sage (*Salvia apiana*) and others. Other forms of upland coastal scrub include, for example, Delta Scrub and Baccharis Scrub, which can be transitional to wetland scrub types. A variety of terrestrial animals, including amphibians, reptiles, mammals and birds are supported by coastal scrub habitat.

Native grasslands were a common upland vegetation associated with estuarine ecosystems in southern California. Existing conditions within coastal ecosystems often include extensive areas of non-native annual grassland and forblands generally dominated by introduced species. The function and importance of perennial and annual grasslands, however, are often similar for the support of small mammals and the raptors that prey upon them.

The proposed creation of treatment wetlands provide a means of cleaning contaminated water before it enters the wetlands. Treatment wetlands require periodic maintenance, including harvesting of wetland plants and removal of sediments as they accumulate contaminants. Thus, treatment wetlands are not considered valuable for their structure, but for their function.

3.1.1 Habitat Acreages

Each of the alternatives would make changes to the existing distribution of habitats. In some places there would be enhancement of the existing habitat, either by management or by increasing tidal inundation (for the case of muted tidal areas). In some places, there would also be replacement of existing habitat by a different habitat type, which would generally involve the regrading of the existing ground elevation and introduction of tidal flows.

For each alternative the area for each habitat type was calculated. Where the alternative did not change the existing habitat then that habitat was assumed to remain. Where a muted tidal regime has been proposed, the distribution of low, mid and high marsh has been defined by the specified tidal inundation regime.

Table 3-2 shows the acreage of each habitat type by subarea and alternative. Table 3-3 show the area of habitat type by alternative. Totals are given for estuarine, freshwater/riparian and upland habitats. These show the shift in emphasis from upland and muted tidal habitat, in the existing situation, to increasing proportion of fully tidal estuarine habitat. Alternatives 3, 4 and 5 each create over 450 acres of estuarine habitat. Included in Table 3-3 is the acreage of shallow subtidal habitat adjacent to mudflat habitat for each alternative. As noted earlier, extensive dredging and development along the southern California coastline has reduced the amount of functional subtidal habitat adjacent to mudflats and wetlands. Alternatives 4 and 5 are the only alternatives that create subtidal habitat adjacent to mudflats, each with over 40 acres.

3.1.2 Quality of Habitat

Each of the proposed restoration alternatives implies varied degrees of improvement over the current existing conditions. Alternative 1, for example, proposes minimal grading and creation of wetland habitats; however, it offers enhancement of existing uplands and seasonal wetlands, resulting in an increase in the quality of the existing habitats (CSS and palustrine wetlands on fill). For the purposes of this document, quality of habitat is described based on a variety of factors: the regional "rarity" of each habitat; the characteristics of habitat patches; the connectivity between habitats both within the project site and with adjacent complimentary habitats; the relationship to adjacent developed areas; and the degree of transition from wetland to upland habitats.

3.1.2.1 Regional Rarity

One important factor in prioritizing habitats for restoration is to identify those habitats that are rare in the region. This includes habitat types that have been lost due to development as well as habitats that require a specific combination of natural processes so that they can only be created in a few, specific places. Regional rarity, which may be considered both in terms of local (Santa Monica Bay or Los Angeles County) or regional (Southern California coast) extent of habitats, can be used to aide in this selection.

Estuarine Wetlands

Due to the dredging of wetlands and the expansion of harbors, subtidal habitat is not regionally rare; but it is often severely degraded. Shallow subtidal habitat connected to functioning wetland habitat is rare.

Estuarine wetlands, including vegetated tidal marsh, intertidal channels, mudflats and salt pans, are a regionally rare habitat that can only be restored in very specific locations. The Ballona Wetlands has long been identified as a significant regional opportunity for estuarine wetland restoration. The Southern California Wetlands Recovery Project, identifies tidal wetland restoration as a key priority in their Regional Strategy. The Regional Strategy states tidal wetlands can only be established within a small elevation range and a compatible geologic setting, and the region's rugged topography and extensive development restricts opportunities for restoration of tidal wetlands in Southern California. The project site represents the only opportunity to restore a large tidal wetland in Santa Monica Bay, and fills a large gap in the chain of wetlands along the Southern California coast.

Transitional zones provide a rare habitat due to the unique conditions created as tidal wetlands convert to uplands with increasing elevation. These habitats are regionally rare and have been significantly impacted as tidal wetlands have been lost.

Brackish marsh habitat is found at the transition of freshwater and intertidal marsh. These habitats are regionally rare and have been significantly impacted as tidal wetlands have been lost.

Non-tidal Wetlands

The seasonal wetlands in Ballona are on saline dredge spoils and are not a naturally occurring habitat type. However, seasonal wetlands may be created that could support vernal pool habitat of much more significant value. Vernal pool habitat has been nearly extirpated from Los Angeles County. These unique habitats support plant and wildlife species that rarely occur elsewhere.

Freshwater marsh and riparian scrub/woodland have also been severely degraded throughout southern California. These habitats require a consistent surface or subsurface freshwater input. While there are additional sites in the region to restore riparian and freshwater habitat, few occur in the vicinity of the Ballona Wetlands.

Upland Habitats

Coastal dunes habitats once stretched from Torrance to Santa Monica. Some of the small remaining patches are currently being restored along the south bay. Dune habitats are also rare in the sense that they require sandy substrate and specific physical processes (wind) to be maintained. Given impacts of the development surrounding the project area, there are limited opportunities to restore functioning dune systems and there may be better opportunities for coastal dune restoration adjacent to the coast.

Coastal sage scrub habitat is considered sensitive by the CDFG, but it is much more common in southern California than coastal wetland habitats. The bluffs immediately adjacent to the site and the nearby Baldwin Hills provide significant areas for potential restoration of coastal sage scrub.

Grassland habitats provide essential foraging habitat, and much of this habitat has been lost or severely impacted along the southern California coast. Restoration of upper marsh and transitional zones may provide equivalent foraging opportunities.

3.1.2.2 Habitat Patch Characteristics

The number, size and shape of habitat patches can determine the long-term stability of the created ecosystem. Restoration plans that incorporate numerous, small patches of different habitats are less likely to be self-sustaining in the long term due to edge effects. Edge effects may include colonization by invasive exotic plant species and/or competition with dominant plant species from other nearby created native habitats. Edge effects may also be reduced in habitat patches of similar area with smaller perimeters (edges). Small patches are also more susceptible to disease as fewer individual plants or clones may equate to reduced genetic diversity. Additionally, specialized pollinators may not be supported by small habitat patches. In general, larger more genetically diverse patches are more likely to survive in the long term without active management.

Edge to area ratio and edge to area index for each alternative is presented in Table 3-4. Patches have been defined by combining together all connected estuarine habitats. Edge to area ratio is simply the ratio of perimeter length to habitat patch size. Alternatives with larger patch sizes would have a lower edge to area ratio. Edge to Area Index is the ratio of the shape's edge-to-area ratio compared to the edge-to-area ratio for a circle of the same total area. The lower the index the closer patch shape is to a circle; the shape that maximizes area and minimizes edge length.

3.1.2.3 Connectivity Between Habitat Patches

Habitat connectivity includes the connection between similar habitats, as well as the connection between complementary habitats. The degree of habitat connectivity within each restoration alternative is an important factor to determine the quality of habitat which may result. Connectivity of similar habitats allows for local migration of plant and animal species providing alternative sites for these species when conditions of one site or patch become unsuitable, i.e., during drought. While bird and insect species may be able to migrate across roads and waterways, terrestrial animals, such as reptiles, amphibians and mammals, are prevented or discouraged from by these barriers. Tidal exchange is an important component of connectivity in a wetland system. Tidal exchange provides diurnal replenishment of gases and nutrients; conveys pelagic eggs and larvae of marine organisms, and distributes floating propagules of salt marsh and other plant species. Connectivity of wetland and to transitional or upland habitat is also important to the quality of a restored wetland, allowing migration terrestrial species to migrate to dry areas during high tides. Thus, habitat connectivity can be measured on at least three scales within a restoration project: 1) connectivity of similar habitats within the project area, 2) hydraulic connectivity between wetland/estuarine habitats and the ocean, and 3) connectivity between wetland habitats and the uplands or transition zones.

Roads or levees can affect the connectivity within the project area. They bisect habitat areas, restrict movement of species, increase the area of disturbed habitat and force channels through culverts. Alternatives 1 through 4 contain 3 miles of roads and 3.8 miles of levees, while Alternative 5 has 2.2 miles of roads and no levees within the project area.

3.1.2.4 Relationship to Adjacent Developed Areas

Transition zones affect the species diversity and function of both the intertidal wetland and the adjacent upland. This habitat supports a unique assemblage of both plants and animals that may not exist in either the adjacent upland or wetland. Thus, the inclusion of transitional habitats in restoration projects is highly desirable. Table 1 gives the areas of transitional habitat for each alternative. The approximate slopes for transitional habitats in the alternatives is about 1:50 to 1:100.

In addition to a wetland-upland transition zone, buffer areas are important for various wetland functions, such as area for transgression, sediment filtration or retention, pollution retention, habitat and food web support, and flood protection. These would improve the quality of the wetland habitat.

Typically, southern California wetlands are bounded by homes, roads and levees that create abrupt, narrow transitions from wetland to upland. This adjacency does not allow animal species the refugia needed during some tides and introduces human disturbances to the wetlands. For example, during extreme high tides, species like light-footed clapper rail are subjected to predation by cats as they are forced from their preferred low marsh habitat into adjacent uplands. In some cases, adjacent developed areas provide habitat for desirable species. For example, non-native cedar trees located to the north of the Area A provide nesting habitat for a small colony of great blue herons. These herons may forage in the wetland and upland habitats of Ballona, but it is the adjacent habitat that serves as the rookery.

3.1.3 Connectivity

Connectivity may be measured in terms of geographical position of the restored wetland relative to other similar or complimentary habitats, locally and regionally.

3.1.3.1 Connectivity Within the Greater Ballona Ecosystem

Within the greater Ballona system there exist areas of complimentary habitat. These include Del Rey Lagoon, Grand Canal, El Segundo Dunes, Oxford Lagoon, adjacent bluff areas, nearshore and beach habitat, Ballona Creek and Marina del Rey jetties and breakwater, and the Pacific Ocean. Some of these sites are hydraulically connected and support a limited wetland component; those that are not provide upland habitat primarily for avian and insect species.

Connectivity within the greater Ballona ecosystem can be accomplished, via improved hydraulic connection, for fish and other aquatic species and for wetland and upland plants. This allows exchange of nutrients gases; transportation of eggs, larvae, juveniles and adult aquatic organisms; provides habitat for avian species and a pathway for water-dispersed seed. Connection by air is possible for flying insects and birds, as well as wind-dispersed seeds. The ability to access similar habitats within the greater system provides refugia for animal species during times of environmental instability; provides greater genetic variation and a greater potential foraging area.

3.1.3.2 Regional Connectivity to Other Southern California Wetlands

A further measure of connectivity is the position of the restored wetland to other wetlands in southern California, such as Mugu Lagoon and Upper Newport Bay. Such connectivity applies primarily to avian and fish species. It may also apply to aquatic plankton and nekton and plant propagules, as these are transported tidally. Certain habitats, such as mudflat, may be created in order to facilitate the connectivity between these wetland systems by providing a string of mudflats along the southern Californian coast.

3.1.4 Tables

Table 3-1. Tidal Habitat Types with Elevation Limits and Inundation Regime
(Based upon Ferren et al, 2007)

Habitat Type	Lower	Upper	Lower	Upper
	NAVD ft	NAVD ft	% time tide exceeds	% time tide exceeds
Subtidal	-5.0	-3.0	100%	100%
Intertidal Channel /Mudflat	-3.0	1.0	100%	90%
Salt pan	4.5	5.5	28%	14%
Low Marsh	1.0	2.5	90%	74%
Mid Marsh	2.5	3.5	74%	50%
High Marsh	3.5	4.5	50%	28%
Transition Zone	4.5	5.5	28%	14%

Table 3-2. Acreage of each habitat type by area and alternative

Habitat Type	Existing					Alternative 1					Alternative 2					Alternative 3					Alternative 4					Alternative 5	
	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	Area A	Area B	Area C	Ballona Creek	Total	All Areas	Total
TOTAL Existing	137.6	347.5	71.4	74.0	630.5	137.6	347.5	71.4	74.0	630.5	137.6	347.5	71.4	74.0	630.5	137.6	347.5	71.4	74.0	630.5	137.6	347.5	71.4	74.0	630.5	137.6	630.5
TOTAL for Alternative						137.7	334.7	71.8	74.0	618.1	139.8	335.4	71.7	74.0	620.9	141.4	357.3	71.5	74.0	644.2	141.4	356.7	71.5	74.0	643.5	632.4	632.4
Subtidal				74.0	74.0				74.0	74.0				74.0	74.0				74.0	74.0	41.4			74.0	115.4	48.6	48.6
Intertidal Channel /Mudflat		1.7			1.7	0.3	10.2			10.4	2.9	8.7	0.1		11.7	5.6	14.5	0.3		20.4	25.7	14.5	0.3		40.6	26.2	26.2
Salt pan		22.4			22.4					0.0					0.0					0.0					0.0		0.0
Muted Low Marsh		8.5			8.5		64.7			64.7		37.0			37.0					0.0					0.0		0.0
Muted Mid Marsh		17.6			17.6		34.3			34.3		19.6			19.6					0.0					0.0		0.0
Muted High Marsh		40.6			40.6		17.8			17.8		10.2			10.2					0.0					0.0		0.0
Fully Tidal Low Marsh					0.0	1.3				1.3	14.7	14.2	0.4		29.3	27.8	72.5	1.6		102.0	13.5	72.5	1.6		87.6	131.0	131.0
Fully Tidal Mid Marsh					0.0	0.8				0.8	9.5	9.2	0.2		19.0	18.1	47.1	1.1		66.3	10.3	47.1	1.1		58.4	85.2	85.2
Fully Tidal High Marsh					0.0	0.8				0.8	9.5	9.2	0.2		19.0	18.1	47.1	1.1		66.3	10.3	47.1	1.1		58.4	85.2	85.2
Transition Zone					0.0	5.7	26.1			31.9	28.9	44.4	7.7		81.1	38.4	79.2	5.9		123.5	10.0	79.2	5.9		95.2	96.1	96.1
Brackish Marsh		3.0	0.1		3.1		2.6	0.1		2.7		2.6			2.6		2.6			2.6		2.6			2.6	2.6	2.6
TOTAL Estuarine	0.0	93.8	0.1	74.0	167.9	8.9	155.6	0.1	74.0	238.7	65.6	155.2	8.6	74.0	303.5	108.0	263.0	10.0	74.0	455.0	111.2	263.0	10.0	74.0	458.2	474.8	474.8
Fresh Water Marsh		1.1			1.1		1.0			1.0		1.0			1.0		1.0			1.0		1.0			1.0	1.0	1.0
Seasonal Wetland	10.9	74.2	0.6		85.7	10.9	2.5	0.6		14.0		2.5	4.0		6.5		2.5	5.8		8.3		2.5	5.8		8.3	2.5	2.5
Riparian Scrub	3.2	15.1	3.3		21.6		5.1	1.7		6.7		5.1	0.5		5.6		5.1	0.5		5.6		5.1	0.5		5.6	5.6	5.6
Riparian Woodland		2.9			2.9		2.9			2.9		2.9			2.9		2.9			2.9		2.9			2.9	2.9	2.9
TOTAL Freshwater/Riparian	14.1	93.3	3.9	0.0	111.3	10.9	11.5	2.2	0.0	24.6	0.0	11.5	4.6	0.0	16.0	0.0	11.4	6.3	0.0	17.7	0.0	11.4	6.3	0.0	17.7	11.9	11.9
Grassland/Herbaceous	64.0	62.7	49.7		176.4		13.3	30.0		43.4		13.3	7.3		20.7		13.2	7.3		20.5		13.2	7.3		20.5	13.5	13.5
Coastal Scrub	58.9	26.0	8.9		93.9	117.2	91.7	30.6		239.5	73.5	92.9	44.4		210.9	32.9	7.3	41.1		81.3	29.7	7.3	41.1		78.1	69.8	69.8
Coastal Dunes		9.9	2.1		12.0		8.3	2.1		10.4		8.3			8.3		8.3			8.3		8.3			8.3	8.3	8.3
Forest/Woodland	0.6	0.2			0.7		0.1			0.1		0.1			0.1		0.1			0.1		0.1			0.1	0.1	0.1
TOTAL Upland	123.5	98.8	60.7	0.0	283.0	117.2	113.5	62.7	0.0	293.4	73.5	114.7	51.8	0.0	240.0	32.9	28.9	48.4	0.0	110.2	29.7	28.9	48.4	0.0	107.0	91.7	91.7
Unvegetated/Paved		10.9			10.9	0.7	0.7			1.4	0.7	0.7			1.4	0.6	0.7			1.2	0.6				0.6	0.7	0.7
Ballfields			6.7		6.7			6.7		6.7			6.7		6.7			6.7		6.7			6.7		6.7		0.0
Gas Company		10.9			10.9		13.6			13.6		13.6			13.6		13.6			13.6		13.6			13.6	13.6	13.6
The Freshwater Marsh		39.8			39.8		39.8			39.8		39.8			39.8		39.8			39.8		39.8			39.8	39.8	39.8
TOTAL Other areas	0.0	61.6	6.7	0.0	68.3	0.7	54.1	6.7	0.0	61.5	0.7	54.1	6.7	0.0	61.5	0.6	54.0	6.7	0.0	61.3	0.6	53.4	6.7	0.0	60.6	54.0	54.0

Table 3-3. Summary of Habitat Acreages

Habitat Type	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Subtidal	74.0	74.0	74.0	115.4 (41.4†)	48.6 (48.6†)
Intertidal Channel And Mudflats	10.4	11.7	20.4	40.6	26.2
Low Marsh	66.0 (64.7††)	66.3 (37.0††)	102.0	87.6	131.0
Mid Marsh	35.1 (34.3††)	38.6 (19.6††)	66.3	58.4	85.2
High Marsh	18.6 (17.8††)	29.2 (10.2††)	66.3	58.4	85.2
Transitional Habitat	31.9	81.1	123.5	95.2	96.1
Brackish Marsh	2.7	2.6	2.6	2.6	2.6
Total Estuarine	**238.7**	**303.5**	**455.0**	**458.2**	**474.8**
Freshwater/Riparian	10.6	9.5	9.5	9.5	9.5
Seasonal Wetland	14.0*	6.5	8.3	8.3	2.5
Upland	293.4	240.0	110.2	107.0	91.7
Unvegetated	8.1	8.1	7.9	7.3	0.7

† Area of shallow subtidal habitat adjacent to mudflats
†† Area of muted tidal
* Habitat created on saline soils

Table 3-4. Edge/Area indices for Estuarine Wetland Habitats

Alternative	Edge to Area Ratio (ft/ac)	Edge to Area Index*
ALT1	218.3918	4.4645
ALT2	243.0364	4.7857
ALT3	193.1576	4.6057
ALT4	178.0851	4.4550
ALT5	111.3358	2.8696

* Edge to Area Index is the ratio of the shape's edge-to-area ratio compared to the edge-to-area ratio for a circle of the same total area.

3.2 BIODIVERSITY

Habitat restoration provides opportunities for the preservation of the region's plant and animal species as well as the opportunity for the recovery of lost or declining biodiversity. The biological communities of coastal southern California have experienced a decline in species richness, or diversity, as a result of loss of over 90% of their wetland habitat following urban and agricultural development. Declining biodiversity includes plant and animal species that are listed as threatened or endangered, many of which are associated with wetland habitats. Restoration of Ballona wetlands offers the opportunity to create refuges for these species and habitats for other species to recover locally and potentially act as a "seed" source for other nearby wetland systems. Because a major goal of this restoration project is to restore estuarine habitats and processes, diversity of species supported by estuarine habitats would be of particular interest. Therefore, for the purpose of this document, biodiversity is discussed in terms of the sustainable richness of representative interdependent native estuarine habitats along with their associated and expected species biodiversity. The diversity of species dependent upon other habitat types (eg. freshwater wetland or coastal dune habitats) included in the alternatives is also noted.

The five restoration alternatives for Ballona range from preservation and enhancement of large areas of upland habitat with limited wetland habitat to restoration and creation of large areas of wetlands with less upland habitat. Upland-dominated restoration should increase the biodiversity of the existing upland habitats. This would primarily benefit woody vascular plants and associated animals at the expense of opportunities to increase diversity of wetland plant and animal groups. Wetland-dominated restoration would benefit non-vascular aquatic plants, vascular plants, aquatic invertebrates, aquatic vertebrates, terrestrial invertebrates and terrestrial vertebrates.

Biodiversity is discussed at the level of large taxonomic groups. Some specific examples are given; however, not all species that may be supported by each of the restoration alternatives are discussed. For the purposes of this document, taxonomic groups are defined as vascular and nonvascular plants; terrestrial invertebrates (insects); terrestrial vertebrates (birds, herpetofuana, mammals); aquatic invertebrates (infauna and epifauna); and aquatic vertebrates (fish).

Estuarine Wetlands

Maximizing shallow subtidal habitat would benefit the biodiversity of the system especially for birds and fishes. Non-vascular plants (e.g., phytoplankton) would presumably be most functional in the upper water column where light penetration is greatest and thus would not necessarily benefit from deeper water. Similarly, vascular plants, insects, benthic invertebrates, herpetofuana and small mammals would not directly benefit from deeper salt water.

Fishes, primarily those associated with the nearshore ocean habitat, would be supported by deeper waters with a connection to the open coast. Such species as Queenfish (*Seriphus politus*), white croaker (*Genyonemus lineatus*), northen anchovy (*Engraulis mordax*) that inhabit the mid- to upper water column would increase the biodiversity of the system as would demersal species such as California halibut and shovel-nose guitarfish (*Rhinobatos productus*).

Gulls and terns, including California least tern and such species as double-crested cormorant (*Phalacrocorax auritus*) and brown pelican (*Pelicanus occidentalis*) would be supported by increased fish diversity and abundance. Osprey (*Pandion haliaetus*) may also forage for fish in the subtidal areas.

As more tidal wetland habitat is included in an alternative, additional taxonomic groups are supported. Creation of channel, low and mid-high marsh would support non-vascular aquatic plants, vascular plants, aquatic invertebrates, aquatic vertebrates, terrestrial invertebrates and terrestrial vertebrates.

Non-vascular plants include phytoplankton, micro-algae, and macro-algae, that are found in the channels and marsh habitats. Salt marsh micro-algae are dominated by diatoms. Macro-algae include green algae and blue-green algae. Tidal influence, light penetration and nutrients are factors that can limit salt marsh algal populations.

Vascular plants that inhabit a typical Southern California tidal salt marsh include the perennials Pacific cordgrass (*Spartina foliosa*), common pickleweed (*Sarcocornia pacifica*) and fleshy jaumea (*Jaumea carnosa*), as well as annual pickleweed (*Salicornia bigelovii*). They occur in narrow elevation zones determined by the frequency of tidal inundation, salinity, duration of saturated soil, and temperature. These plants, along with non-vascular algae, contribute to the complex food web that supports the high productivity of coastal wetlands. The detritus of vascular and non-vascular plants provides food for aquatic invertebrates, including both infauna (organisms that live within the sediment) and epifauna (those that live on the surface of the sediment).

Common infauna associated with mud or sand bottoms of channel and low marsh habitats include polychaete worms and filter-feeding bivalves, such as California jackknife clam (*Tagelus californica*), littleneck clam (*Prototheca staminea*) and bent-nose clam (*Macoma nasuta*). Common epifuana of channels include detritivores, such as California horn snail (*Cerethidia californica*), bubble snail (*Bulla gouldiana*), and *Nassarius* sp., and omnivores such as lined shore crab (*Pachygrapsus crassipes*) and yellow shore crab (*Hemigrapsus oregonensis*).

Restoring intertidal mudflat area would increase the biodiversity of benthic infauna, including polychaetes, which in turn would support a higher diversity of wading birds. Perhaps the most conspicuous animals of the intertidal mudflats are the shorebirds that feed and rest there during low tide. Many of their invertebrate prey items are widely distributed, from the subtidal channels to the lower limit of the salt marsh. Wading shorebirds, such as western sandpiper (*Calidris mauri*), semipalmated sandpiper (*C. pusilla*) and dowitchers (*Limnodromus* spp.) would be expected to forage on the mudflats during their migration.

Cordgrass associated with low marsh habitat provides structure, and possibly food, for insect species, such as the larvae of *Incertella* and *Cricotopus* species, the beetle *Coleomegilla fuscilabris* and the plant hopper (*Prokelesia* sp.). The longjaw mudsucker (*Gillichthys mirabilis*) forages in the low and mid-high marsh, especially along creek banks during high tides. Mid-high marsh habitat provides food and structure for California horn snails, amphipods, and snails of the genus *Assiminea*. Water boatmen (*Trichocorixia* spp.) feed on algae in pools and in turn provide food for California killifish (*Fundulus parvipinnis*) that feed in the marsh during high tides

The wetland-dominated restoration alternatives would create/restore large blocks of habitat that would be connected via channels and tidal flows. These large blocks of habitat would be more sustainable in the long-term as they would be less susceptible to edge effects of invasive species. They would also be less susceptible to human disturbance, as many areas would be inaccessible.

Creation of channels and mudflats provides habitat for breeding and foraging for estuarine fishes. Some, such as gobies (Gobiidae), complete their life cycle in southern California estuaries, attaching their eggs to the burrows of commensal invertebrates. Other common wetland fish species, such as topsmelt (*Atherinops affinis*), attach their eggs to filamentous algal mats that also shelter their larvae and post-larvae. Species such as California halibut spawn offshore but spend the first few years of life in protected coastal waters. Still others, such as striped mullet (*Mugil cephalus*) live their lives in protected inshore habitat but spawn offshore. In general, the channels and low marsh habitats of southern California coastal wetlands act as nursery grounds for coastal fisheries.

Larger aquatic benthic invertebrates, such as snails and crabs, as well as fish, are preyed upon by a number of bird groups, including herons and egrets, wading birds and terns and gulls. Southern California coastal wetlands support dozens of species and many thousands of individual birds that migrate along the Pacific flyway. Herons, egrets, gulls, terns, shorebirds, ducks, geese, coots, gallinules and rails occur in southern California wetlands throughout most of the year. Most of these birds appear to prefer intertidal flats to salt marsh habitats for foraging and other activities. However, marsh habitats contribute to the support of birds by: providing food (either directly or indirectly), cover from predators, and structure for nesting and roosting. Birds of the low marsh include rails, such as Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), and the endangered light-footed clapper rail (*Rallus longirostris levipes*).

Common bird species of the mid-high marsh include wading species such as willet (*Catoptrophorus semipalmatus*), marbled godwit (*Limosa fedoa*), long-billed curlew (*Numenius americanus*) and great blue heron (*Ardea herodias*). These species prey upon fishes and aquatic invertebrates and, in the case of herons, upland terrestrial animals such as small mammals and herpetofauna.

Terns and gulls observed in southern California coastal wetlands occur primarily in intertidal flats and on the adjacent beaches; however, some taxa do utilize salt marsh habitats. Western gull (*Larus occidentalis*) and ring-billed gull (*Larus delawarensis*) forage and roost in intertidal salt marsh habitats while the endangered California least tern (*Sterna antillarum browni*) forages in intertidal channels. Forster's tern (*Sterna forsteri*) and elegant tern (*S. elegans*) can use a variety of wetland habitats, including salt marsh. Most of the bird groups, with exception of a few small species, forage and roost in southern California wetlands but breed elsewhere.

The mid-high marsh provides structure for some nesting birds, including the state endangered Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*). This small songbird builds its nest low to the ground under marsh vegetation, such as pickleweed. Belding's Savannah sparrows forage on insects, often at the interface of marsh and channel.

Small mammals associated with southern California tidal wetlands include the western salt marsh harvest mouse (*Reithrodontomys megalotis limicola*) and meadow mouse (*Microtus californicus stephensi*). Harvest mice are granivorous, while meadow mice are primarily herbivorous. While little is known about their diets, neither feeds on pickleweed, the most common vascular plant species at Ballona.

Both upland-dominated and intermediate tidal restoration alternatives preserve areas that are currently muted-tidal wetlands. Muted-tidal wetlands provide functions similar to fully-tidal wetlands, but reduced in terms of biodiversity. For example, muted tidal channels may have similar species composition and densities of phytoplankton and benthic micro-algae but may support fewer salt marsh vascular plant species than do fully tidal channels. Similarly, fewer fish species might occur in muted tidal systems. With less tidal influence, muted tidal areas would be susceptible to periodic fresh water inflows. Conversely, during neap tides, muted tidal systems may be subjected to prolonged drying and increased salinity, unless they impounded water continuously, in which case, they would not support vascular plants. Thus, muted tidal systems are likely to be less sustainable than fully tidal systems.

Creation of wetland habitats allows for creation of transitional habitats, which would increase the regional diversity of vascular plants and terrestrial vertebrates. Examples of transition zone vascular plants include boxthorn *(Lycium californicum)*, bush seepweed *(Suaeda nigra)*, coast golden bush (*Isocoma menziesii*), and Parish's glasswort (*Arthrocnemum subterminale*). These overlap with the highest elevation salt marsh species including, for example, saltgrass, alkali weed *(Cressa truxillensis)*, and shoregrass *(Monanthochloe littoralis)*. Boxthorn is a common perch for birds and various small mammals and herpetofauna burrow beneath it or use it for shade.

The transition zone of southern California wetlands, such as Carpenteria salt marsh, have a euryhaline zone that fluctuates between wet season low salinities and dry season hypersaline conditions. The habitat is characterized by winter annual plant species such as salt marsh daisy (*Lasthenia glabrata* ssp. *coulteri*), salt marsh sand-spurry (*Spergularia marina*), toad rush (*Juncus bufonius*), and hutchinsia (*Hutchinsia procumbens*), which tolerate the fluctuating salinities by growing in the wet season.

The animals of the higher elevations of the transition zone are primarily terrestrial species. These include various snakes, lizards, small mammals and birds. Herpetofauna may include California kingsnake *(Lampropeltis getulus californiae)*, San Diego gopher snake *(Pituophus melanoleucus annectens)* and side-blotched lizard *(Uta stansburiana)*. Common mammals of the shrub-dominated transition zone include western harvest mouse, deer mouse *(Peromyscus maniculatus)*, pocket gopher (*Thomomys* sp.*)*, and California ground squirrel *(Spermophilus beechyi)*. The small mammals are preyed upon by a variety of birds including northern harrier *(Circus cyaneus)* and white-tailed kite *(Elaneus caeruleus)*. Ground-nesting bees that pollinate salt marsh bird's-beak (*Cordylanthus maritimus* spp. *maritimus*) live above the high tide in this habitat.

Non-tidal Wetlands

It is anticipated that brackish marsh would develop in areas where fresh water marsh and salt marsh intergrade. This habitat supports many of the taxa associated with both of those habitats, although species that cannot tolerate either extreme are likely to be absent. Brackish water marsh habitat has a range of conditions from briefly fresh to briefly hypersaline and would provide a small increase in the biodiversity of the wetlands. For example, *Juncus acutus* is regionally rare and can thrive where soil is at least briefly brackish; tall tules can provide critical cover for rails during high tide.

Seasonal wetlands would support regional biodiversity of non-vascular and vascular plant species, herpetofauna, birds and small mammals. However, much of the existing seasonal wetlands are on saline fill soils that would not support biodiversity. Vascular plants that might be supported include common pickleweed (*Sarcocornia pacifica = Salicornia virginica*), alkali weed (*Cressa truxellensis*), and alkali heath (*Frankenia salina*). Smaller areas of freshwater seasonal wetlands would provide breeding grounds for toad and frog species, such as Pacific chorus frog (*Pseudacris regilla*) and California tree frog (*Hyla cadaverina*). Ponded water provides nesting and foraging habitat for American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*) and killdeer. Small mammals common to upland habitats could also use seasonal wetlands.

Creation of vernal pool habitat has been proposed as part of upland-dominated restoration schemes. Vernal pools are regionally rare habitats, and adding water-holding depressions would increase the biodiversity of the Ballona ecosystem. Vernal pools are formed over impervious substrates, such as a soil with a subsurface clay layer that impounds seasonal rainfall. Such topography and soils are lacking from Ballona upland areas. Creation of vernal pools would benefit primarily non-vascular and vascular plants, aquatic invertebrates, and herpetofauna, although small mammals and birds may also benefit. Non-vascular species that inhabit vernal pools include diverse phytoplankton, green and blue-green micro-algae, and occasional macro-algae. These are food sources for a number of invertebrates, including fairy shrimp (*Branchinecta* spp.), several species of which are listed as endangered. Many of the vascular plants associated with vernal pools are unique in their adaptations to water levels that fluctuate widely over short periods of time. These range from fairly common species, such as isoetes (*Isoetes* spp.) to the endangered San Diego mesa mint (*Pogogyne abramsii*). Herpetofauna, such as discussed above, would benefit from vernal pools, although survival through metamorphosis depends on the amount of rainfall and the duration of impoundment.

Created vernal pools, especially those requiring importation of clay to line the pools so they would hold water for the appropriate duration, would not only be difficult build but subject to invasion by unwanted species once wetted. Imported soils often contain plant propagules, such as non-native grasses, that could invade the proposed restoration. Furthermore, small vernal pools would be subject to edge effects. Pools that dry early in the growing season of vernal pool vascular plants would be subject to invasion by non-desirable species, such as non-native grasses.

Fresh water marsh and riparian habitats would, in some way, provide support to all of the taxonomic groups. Detritus from vascular plants, such as cattail (*Typha* spp.) and bulrushes (*Scirpus* spp.), and a variety of non-vascular algae would provide food for aquatic invertebrates, including gastropods, copepods, amphipods and decapods, and insects, such as beetles (Coleoptera), flies (Diptera) and true bugs (Hemiptera). These taxa provide food for passerine birds, such as blackbirds (*Agelaius* spp.), wrens (*Cistothorus* spp.), rails (*Rallus* ssp.) and waterfowl; fishes, primarily non-native species; herpetofauna, including Pacific chorus frog and California tree frog, and snakes, such as two-striped garter snake (*Thamnophis couchi hammondi*); and small mammals. Larger mammals, such as raccoon (*Procyon lotor*), may forage directly on invertebrates and fish.

Treatment wetlands could support similar species as fresh water marsh habitat. However, these areas would require active management and removal of sediments, contaminants, and invasive plants, all of which would limit their value for biodiversity support.

<u>Upland Habitats</u>

Existing disturbed uplands would be preserved and their biota enhanced through the removal of exotic plant species and planting of native coastal sage scrub and native grassland species. Coastal sage scrub habitat (CSS) would be enhanced through planting of species such as coastal sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), deerweed (*Lotus scoparius*), sage species (*Salvia* spp.) and lemonadeberry (*Rhus integrifolia*). Planting of these vascular plant species would, in turn, provide nesting and foraging habitat for a number of migratory and non-migratory terrestrial passerine bird species, including the federally-listed threatened coastal California gnatcatcher (*Polioptila californica californica*), towhees (*Pipilo* spp), wrens (*Troglodytes* spp.), and finches (*Cardeulis* spp.). Many of these passerine birds rely on insects and seeds for food. CSS enhanced by more diverse flowering plants would support insects that provide forage for the above birds. Enhanced CSS would also support insect pollinators, including bees and flies. The diversity of other insects, such as butterflies and moths, would be enhanced by providing plant species that serve as larval foods and adult nectaring plants.

Native grassland habitat would be created from disturbed upland habitat through the removal of exotics and planting with a variety of native grasses and annual forbs. Examples include purple needlegrass (*Nassela pulchra*), nodding needlegrass (*N. cernua*), bluegrass (native *Poa* spp.) goldenstar (*Bloomeria* spp.), brodiaea (*Brodiaea* spp.), clarkia (*Clarki*a spp.) and valley tassels (*Castilleja attenuata*). Populations of these vascular plant species would enhance nesting and foraging habitat for passerine birds such as western meadowlark (*Sternella neglecta*) and grasshopper sparrow (*Ammodramus savannarum*), and also wading birds such as killdeer (*Charadrius vociferous*) and owls, including burrowing owl (*Athene cunicularia*). Grasslands are important foraging grounds for raptors including red-tailed hawk (*Buteo jamaicensis*) and white-tailed kite (*Elanus leucurus*). Like coastal sage scrub, this upland habitat would increase the diversity of flowering plants which, in turn, would support a variety of insects.

A number amphibians and reptiles occur in upland habitats, including Gilbert's skink (*Eumeces gilberti rubricaudatus*), western toad (*Bufo boreas*), spadefoot toad (*Scaphiphus hammnodi*), western fence lizard (*Sceloporus occidentalis*), side-blotch lizard (*Uta stansburiana*), rosy boa (*Charina trivirgata roseofusca*), gopher snake (*Pituophis catinefer*), horned lizard (*Phrynosoma coronatum*) and various species of rattle snake (*Crotalus* sp.). Enhancement of the existing habitat would increase foraging and breeding habitat for these and other herpetofauna.

Upland habitats also support numerous small mammals. Examples include shrews (*Sorex* sp.), deer mice (*Peromyscus* spp.), voles (*Microtus* sp.), rabbits (*Sylvilagus* spp.), and skunks (*Mephitis mephitis*). These small mammals are preyed upon by larger upland mammals, such as coyote (*Canis latrans*) and grey fox (*Urocyon* sp.), and birds of prey, such as red-tailed hawk and northern harrier (*Circus cyaneus*).

The existing disturbed upland habitats at Ballona are dominated by non-native vascular plant species, such as crown daisy (*Chrysanthemum coronarium*), mustard (*Brassic*a spp.), wild radish, fennel, castor bean, pampas grass and brazillan pepper tree. Seeds of many of these and other invasive plants are wind dispersed and off-site sources are numerous. Non-native animal species, such as Virginia opossum (*Didelphis virginianus*) and house mouse (*Mus mus*) are also common. Non-native animals that are adapted to humans are also likely to disperse into created upland habitats, competing for food with native species. Additionally, upland predators, including red fox and feral cats, can significantly affect birds nesting in the wetland as well as small mammals. Because restored upland habitats are highly susceptible to invasion by non-native plants and animals, their sustainability is constrained by the urban landscape.

All alternatives include the preservation and enhancement of coastal dune habitat at Ballona. Similar to CSS and native grassland, coastal dunes would support flowering vascular plants, such as lupines (*Lupinus* sp.), which would support and benefit from insect pollinators and provide larval and adult food sources. Coastal dune habitats provide habitat for reptiles, including horned lizard (*Phrynosoma* spp.) and California silvery legless lizard (*Anniella pulchra pulchra*). Passerine birds and small mammals could forage on seeds produced by vascular plants.

3.3 HYDROLOGY

The hydrology of each of the alternatives would have a significant impact on the functioning of the habitats. The depth and period of tidal inundations is a major influence on the type of habitats that would each alternative would support. The flow of water would erode, deposit and transport sediment. The period of time water stays on the wetlands and the amount it mixes with water from other water bodies would affect water quality. The hydrology of each alternative also affects the flood protection for existing infrastructure surrounding the wetlands. Hydrology is one of the main processes that link both the different project areas with each other and with Ballona Creek and Marina del Rey. The hydrology of the site would be sensitive to climate change and sea level rise in particular; the sustainability of the alternatives is discussed in Section 3.5.

Each restoration alternative proposed for the project has varying degrees of tidal inundation in terms of area and tidal range. Alternative 1 has minimal grading and most of the tidally inundated areas have a muted tidal range in portions of Area B. Alternative 2 and 3, by contrast, have fully tidal wetlands covering significant portions of Areas A and B. Alternative 4 has a large subtidal component connected to Marina del Rey. Alternative 5 has the greatest hydraulic connectivity with the main channel and between the restoration areas, due to the removal of levees. The degree of tidal inundation has a fundamental impact on the vertical and horizontal distribution of habitat types that would be supported.

The degree of tidal inundation inside the wetlands would also change the way the wetlands interact with Ballona Creek and Marina Del Rey. Larger, fully tidal wetlands would have larger tidal prisms which would have a greater impact on the surrounding water bodies, in particular on the amount of mixing. The location of the tidal connections is also important; a location inside Basin H, with its smaller tidal prism, would have a greater local effect on mixing than one connected to the main channel of Marina del Rey, which has a very large tidal prism.

3.3.1 Muted Tidal System versus Full Tidal System

A fully tidal wetland at Ballona would experience a tidal range equivalent to the oceanic tide in Santa Monica Bay. Mean Lower Low Water (MLLW, the long term average of the lowest tide each day) is -0.21 ft NAVD, Mean Higher High Water (MHHW, the long term average of the highest tide each day) is 5.29 ft NAVD and the diurnal tidal range (MHHW-MLLW) is 5.49 feet. The land area between the upper and lower limits of tidal range is the total area of intertidal habitat.

A muted tidal wetland experiences a more limited tidal range than a fully tidal wetland. Existing muted tidal wetlands at Ballona have Self-Regulating Tide gates (SRT), which close when the water surface elevation reaches a set height. Muted tidal systems would tend to compress the vertical range of wetland habitat types and would cause intertidal habitats to be created at lower elevations. Connections through culverts, open breaches and removal of levees are intended to allow the full oceanic tide to enter the site.

Inundation regime is the percentage of time that a given water level is exceeded during a Neap-Spring tidal cycle. It a useful parameter for characterizing the tidal inundation at a particular location with a specific elevation. The inundation regime for the unrestricted tidal system in the Santa Monica Bay is shown in Table 3-3; for example 2 ft NAVD is exceeded for 80% of the time and 4 ft NAVD for 38% of the time.

The inundation regime in some of the alternatives can be modified by setting the closure of the SRT in Area B at different elevations, which limits the maximum tidal elevation but maintains the rate of rise and fall of the tide. The inundation regimes were estimated for three SRT closure elevations using hydraulic modeling. The existing gate is set to close at 3.6 ft NAVD. Two additional closure elevations were modeled at 4.9 ft NAVD and 6.6 ft NAVD.

Table 3-3 shows how the inundation regime varies with different closure elevations. The inundation regime for lower elevations stays roughly the same between gate settings (e.g. 2 ft NAVD is exceeded about 77% of the time in all cases, which is comparable to the 80% for Santa Monica Bay). The effect of the muting is more pronounced at higher elevations (e.g. 4 ft NAVD is exceeded 38% of the time in Santa Monica Bay, but only 6% with a gate that closes at 4.9 ft NAVD). The inundation regime for intermediate closure elevations can be estimated by interpolation.

The vertical zonation of intertidal habitats can be estimated from the inundation regime. Different species would favor being inundated for different frequencies. For instance, high marshes are inundated approximately 28 to 50% of the time, while for low marsh the range of frequencies are 74 to 90%. Table 3-4 shows the inundation regime for intertidal habitats and the corresponding elevations for the oceanic tide in Santa Monica Bay (based on Ferren *et al*, 2007 in Appendix B). Each of the marsh habitat types covers a vertical range of about one foot.

Habitat zonations for the muted tidal regimes have been derived by determining the muted tidal elevation that has the same inundation regime as the open ocean. Table 3-4 shows the expected habitat distribution for different closure elevations for the SRT. Muting can also be achieved by undersized culverts that constrict the flow. These change the rate at which the tide rises in the site such that maximum elevation would not be the same on each tide. However, undersized culverts cause problems of erosion, backwater effects, and drainage.

For muted tidal systems the elevation range for the intertidal habitats is compressed which in turn limits the areal extent of these habitats compared to fully tidal alternatives. The zonation for intermediate closure elevations can be estimated by interpolation. This compression is most significant for the highest zones of the marsh (e.g. high marsh, transition zone). For instance, with the existing SRT closure elevation of 3.6 ft NAVD, mid marsh has the same vertical range as in a fully tidal system (1 foot) but occurs 0.3 feet lower. However, for the same SRT setting, the high marsh has a much reduced vertical range of 0.3 ft (between elevations 3.2 -3.5 ft NAVD).

In summary:

- varying the SRT closure elevation would mute the inundation regime in a predictable manner in Area B;
- vertical zonation of habitat would be compressed, particular at higher elevations, by muting of the tidal inundation;
- habitat area would be limited by the reduced vertical range of habitats.

3.3.2 Tidal Prism

The tidal prism is the volume of water entering the wetland on each tide. The tidal prism is a function of the topography and the tidal range of the site. For example, Alternatives 2 to 5 include substantial grading which would increase the volume of tidal water entering the site on each tide. If the tidal range is muted, the tidal prism would be reduced. The tidal prism was evaluated for each restoration area and for each of the main water connecting water bodies (Basin H, Marina Del Rey and Ballona Creek).

The tidal prism is important both within and outside the wetland:

- the tidal prism would influence the channel geometry and channel network properties.
- the tidal prism would influence the source of tidal water (as it affects the excursion length) and the residence time.

Table 3-5 shows the tidal prism of Ballona Creek in relation to the southwest wetland of Area B. In this case the main variable is the type of connection, either a SRT (Alt 1) or open breach (Alt 3). The muted tidal wetland has a tidal prism of about 30 ac-ft. Replacing muted tidal wetlands in Area B with fully tidal wetlands (Alt 3), connected to the creek by a breach, adds about 150 ac-ft to the existing tidal prism. One effect of increasing the tidal prism of Ballona Creek would be to increase the potential for scour at the mouth, in the vicinity of the jetty heads. Increased scour at the mouth has both positive and negative implications. It may reduce the need for dredging of Ballona Creek, improving the flood conveyance of the channel; however, it may also remobilize contaminated sediment that has settled at the mouth and there is the potential for undermining the breakwater as the channel readjusts to the larger tidal prism.

Table 3-6 shows the variation of tidal prism in relation to the southwest wetland of Area B. For a muted tidal wetland in this area the tidal prism is about 15 ac-ft. A tidal wetland created in this area in Alternatives 2 to 4 has a tidal prism of about 30 ac-ft.

Table 3-7 shows the variation of tidal prism for Area A. For those alternatives that connect to Marina del Rey, the tidal prism across the mouth of Basin H was used as a measure as this allows the effect of restoring the wetland tidal prism on Basin H water quality to be assessed. The larger the combined tidal prism, the greater the turnover of water in Basin H. The existing tidal prism of Basin H is about 12 acre-feet. A 38 acre wetland in Area A (Alt 2) increases the tidal prism by about 25 ac-ft, a 73 acre wetland (Alt 3) adds about 46 ac-ft, and the large subtidal pond and wetland in Alternative 4 adds about 330 ac-ft. The same alternatives connected to Marina del Rey at Via Venetia do not have a significant effect on the overall tidal prism as the tidal prism of Marina del Rey is so large.

Alternative 5 has the largest tidal prism of all of the alternatives at 600 ac-ft. This is nearly three times the existing tidal prism and it is expected that tidal flow velocities through the mouth of Ballona Creek would increase.

In summary:

- in the southwest wetland of Area B, an open breach and full tide would have a tidal prism about 100 ac-ft greater than a muted tidal option;
- southeast wetland would have a tidal prism of about 30 ac-ft;
- a tidal connection from Area A at Dock 52 has a large impact on the circulation of Basin H, but no alternative has a tidal prism sufficiently large to impact the much larger Marina del Rey channel.
- Alternative 5 has the largest tidal prism at 600 ac-ft.

3.3.3 Connections

The nature of the connection between open water and the wetland would greatly influence tidal conditions within the wetland. Four types of connections are present in at least one of the five alternatives:

- open (non-gated) culverts,
- gated culverts (e.g. self-regulating tide gate (SRT) and flood gates)
- open breach, and
- complete levee removal

The large pipes which penetrate levees to convey water between Ballona Creek and the inundated areas are referred to as culverts. Conveyance through a culvert is limited by its dimensions, particularly its cross-sectional area. Flow through culverts can be controlled by different types of gates that prevent flow through the culvert. SRT include a mechanism to close itself when water levels reach a specified elevation. Manual flood gates can be closed manually as dictated by conditions. Gated culverts can be used to prevent contaminants entering the site from Ballona Creek or Marina del Rey or to reduce peak flood elevations. The SRT has an advantage of being adaptable so that the desired water surface elevation within the site may be controlled.

The second type of connection through a levee is a breach. Breaches would be sized to the same width and depth as the connecting marsh channel and would have no top boundary. Breaches would therefore convey water with negligible restriction during normal tides and much more effectively during flood conditions. Breaches may be combined with lowering of the levee to about marsh plain elevation, thereby allowing higher tides to enter the site. This would mimic the flood routing of natural overmarsh tides and restore the hydraulic connection between the creek and the marsh plain. Controlling regular tidal flows or flood events is not possible with either a breach or levee removal.

The capacity of connections would vary. The SRT and culvert would have fixed capacity dependent upon their physical dimensions. A breach, depending on the nature of the material in which it is excavated, may be able to erode wider or deeper. Sizing levee breaches and connecting channels to the predicted tidal prism is generally necessary to limit how much the channel and breach erode. Tidal exchange and sediment supply to a wetland would be limited if the levee breaches or channels are undersized compared to the tidal prism. As the breaches or slough channels erode in response to the large tidal prism, tidal exchange and sediment supply would increase. Levee removal provides the most complete connection for water exchange and sediment supply between wetlands and the tidal source.

The location of the connections would have an impact on the evolution of the wetland, in particular the channel network. The alternatives have been developed to maximize opportunities for creating a single unified channel network within each marsh unit rather than multiple smaller networks, each with their own connection to open water. Using two connections for a hydrologic unit may increase the circulation in subtidal areas if there is sufficient head difference between the two entrances; this would be most effective in Alternative 4, which has a large open water area. For intertidal channels, flow may occur preferentially through only one of the entrances. Ideally, each marsh unit should be large enough to sustain its own network, containing a range of channel sizes and habitat. The southwest wetlands in Area B have the only remnant channel system that could be rejuvenated.

The use of structures as part of the connection, while increasing control, does have a number of issues:

- Gates and trash grilles, common on such structures, can impede the movement of sediment, seeds, fish and fish larvae. These restrictions would not be present with breaches.
- Culverts and gates generally have a smaller cross-section than natural channels and flow velocities within the structures would generally be higher. Scour would therefore be expected in the vicinity of the structure, especially in the channels leading into the wetlands.
- The potential for blockage is greater for gates and culverts, compared to an open breach, due to the smaller size of the opening and the presence of moving parts.
- Failure of a gate in the open position, due to trapping of debris or the failure of the control mechanism, may allow increase the potential for flooding. Failure of a gate in the closed position could delay drainage of tidal habitats.

3.3.4 Channel Network

Vegetated wetlands are typically drained by a complex network of dendritic and sinuous tidal channels. A dendritic sinuous tidal channel network is expected to provide better habitat and support a wider range of wetland functions than linear channels. For examples, channel bends provide sheltered foraging habitat for birds. Each tidal channel within the channel network drains and fills an area of marsh or "tidal watershed." Marsh drainage areas in natural marshes are distinguished by very subtle changes in marsh plain elevation and inundation patterns. The channel size adjusts to the flow to and from the marsh drainage area (i.e., the tidal prism of the marsh drainage area). Tidal channels may scour or fill in with sediment (shoal) in response to changes in the tidal prism and/or sediment dynamics.

In a natural system, as mudflats accrete to intertidal elevations, mudflat tidal channels form and become fixed as vegetation establishes and the marsh plain develops. Within this channel network, the tidal channel geometry at any given point is mainly dictated by the tidal prism of the watershed upstream. If the channel geometry is too small for the tidal prism, current speeds would increase and erode a larger channel. If the channel geometry is too large for the tidal prism, current speeds would decrease, allowing sedimentation to decrease the channel geometry.

Much of the natural channel system in Ballona Wetlands has been lost and a new channel networks would be constructed in tidal marsh restoration areas using the same tidal prism channel geometry relations found in natural channels. Larger tidal channels may be graded by excavating channels with dimensions that closely mimic channels in natural tidal marshes. The smallest channels may only be partially excavated, allowing these channels to develop over time through channel scour. Channel dimensions would be sized relative to the tidal prism of the marsh drainage area. Table 3-8 shows the channel network characteristics expected for each alternative, including tidal prism, channel length and order of channels. The method of calculation is described in Appendix C.

Channel networks constructed within the Ballona restoration are expected to be relatively stable, with limited potential for channel scour or shoaling. Tidal habitat would be restored by excavating fill and grading the site to elevations suitable for high, mid, and low marsh plain; mudflat; and subtidal habitat. The restored marsh plain would be graded with gentle slopes from the channel edge to upland areas to allow for the transgression of tidal habitats with sea level rise (see Section 3.5.1 below). Sedimentation rates within restored marsh areas are expected to be slow due to low sediment supply from the urbanized Ballona Creek watershed. The tidal prism of the restored marsh is therefore not expected to change rapidly after construction. The constructed tidal prism and channel dimensions are expected to maintain a relatively stable equilibrium condition. Also, as the restored marsh would be graded to higher marsh elevations, the tidal prism would be less than for lower elevation tidal areas. The potential for channels to form through channel scour is therefore expected to be low.

The presence of roads and levees within the site somewhat constrain the channel pattern as flow through this infrastructure must be routed through culverts. These culverts would set both the location and capacity of the channel at that place, reducing the ability of the channels to evolve over time. The culverts should be oversized in anticipation of larger tidal prisms in the future to increase the sustainability of the wetlands.

Permanent ponds in the marsh plain may be constructed to increase the amount of subtidal habitat. These would be connected to the channel network. These ponds would be shallow, well-defined, persistent depressions, 1 to 2 ft deep, that contain about 0.5 ft of standing water at all stages of the tide. They would receive tidal inflow on most tides.

3.3.5 Residence Time

Residence time is an estimate of how long water would remain in a flooded area before it is replaced by water from outside the wetland. A shorter residence time indicates a faster rate of turnover of the water. For this study, the residence time is estimated as the fraction of volume exchanged each tidal period, calculated by dividing the total volume in the flooded area by the tidal prism.

The residence time would depend on the proportion of tidal prism to total (subtidal plus intertidal) volume. Intertidal areas with an open connection to the ocean would have a residence time equal to the average tidal period because they dry out each tide. In areas with a large subtidal volume relative to intertidal volume (such as in Area A in Alternative 4), the residence time can be as long as several tidal periods. Short residence times indicate rapid and continuous exchange with the ocean water, with positive effects, for example, on exchange of gases, nutrients, fish larvae, sedimentation and water quality. Longer residence times indicate delayed exchange with the ocean.

The method for estimating residence time is an average for the entire flooded area and range of tides. Actual residence time would vary across the site. For example, residence times would be longer for regions of the flooded areas which are far from the exchange outlet or during periods of reduced tidal prism, such as neap tides. Similarly, actual residence times would be shorter for regions of the flooded areas which are close to the exchange outlet or during periods of increased tidal prism, such as spring tides.

3.3.6 Excursion Length

Excursion length is an estimate of the distance traveled by water during a tidal period. It is analogous to dropping a buoy in the water and measuring how far the buoy travels during a single tide. Excursion length provides an indication of the spatial extent of water movement within the tidal timeframe. As a first approximation, the water within an excursion length of a particular location is the source of inflowing water, the destination for departing water, and the volume of water that would most rapidly mix with that location's water. Water within an excursion length can be categorized as hydraulically well-connected to that location.

A major influence on excursion length is the addition of intertidal area upstream of a location which increases the flow of water past that location. In accordance with increasing flow, current speeds and hence, excursion length, also increase. Alternatives with the largest intertidal area would yield the largest excursion lengths.

Water in Ballona Creek, at the western side of the project area, exchanges with Santa Monica Bay on each tide. In contrast, water at the eastern side of the project area remains in Ballona Creek for more than a single tide. The different outlets from Area B are just a bit further than an excursion length of each other, indicating that water that exits one flooded area would typically take at least two typical tidal cycles to enter into another flooded area. The outlets from Area A to Marina del Rey and the outlets from Area B to Ballona Creek are separated by approximately three times the excursion distance and pass through a portion of Santa Monica Bay. This indicates that Area A and Area B are not well connected by Alternatives 1-4. Only Alternative 5 would closely connect Area A and Area B.

3.3.7 Flooding

Increasing tidal inundation within the Ballona wetlands may also affect the potential for flooding. Potential changes to the flood hazard as a result of the alternatives were evaluated.

Flood hazard was considered to arise from two sources – stormwater discharge from the Ballona Creek watershed and elevated ocean water levels in Santa Monica Bay. The watershed of Marina del Rey is small and its stormwater contribution is not considered a significant flood hazard. Flood events are typically characterized by their likelihood of occurrence, where the likelihood is expressed as a return interval. For this study, the selected stormwater discharge event has a return interval of 50 years or a 2% chance of occurring in any one year. The hydrograph of this 50-year stormwater discharge, which relates the rate at which water enters Ballona Creek as a function of time, was developed by the U. S. Army Corps of Engineers (2008). This hydrograph was developed by combining: (1) modeling of the transformation of rainfall into runoff and (2) frequency analysis of past discharge events.

The second source of flood hazard, elevated ocean water levels, arises from meteorological events acting at the regional or global scale. Regional meteorological events which elevate water levels include low atmospheric pressure associated with storm systems and wind setup. El Niño is the global meteorological event which leads to elevated ocean water levels along the entire western coastline. Since a detailed frequency analysis of elevated ocean water levels has not yet been conducted, this study relied upon an event selection approach to identify typical increases in ocean water level. Water levels at the Port of Los Angeles during 12 large storm events increased an average of 1.1 ft above expected water levels (USACE Hydrology Report).

These sources of water, stormwater discharge and elevated ocean water levels, interact with the ground surface elevation to determine the depth and spatial extent of flooding. Because of the existing levees which bound Ballona Creek, flooding is also a function of hydraulic connection. By adding tidal connections, the restoration alternatives alter the potential for flooding while decreasing the peak water levels within Ballona Creek. Within the flooded areas, flood exposure increases because of additional conveyance through the new tidal connections. However, the exposure within these flooded areas can be managed to acceptable levels by configuring the tidal connections and/or the flood hazard to infrastructure can be mitigated by structural means. The input of flood waters into the flooded areas acts to reduce the flood hazard within Ballona Creek itself. Because the flooded areas provide additional storage for flood waters, flood peak water levels along Ballona Creek, downstream of the tidal connection, are reduced.

Infrastructure that is exposed to flood hazard as a result of its location within or adjacent to the project area can be protected in several ways. The infrastructure itself can be raised above peak flood levels. For instance, roadways which cross the project site could be raised on structures or earthwork to elevate them above anticipated flood levels. Flood risk for infrastructure adjacent to the project area can be mitigated by constructing new levees or improving existing levees to constrain the flooded area extent.

Alternatives 1 and 2, which have muted tidal systems, have flood peaks at or below the closure elevation. If the rate at which the water level rises is rapid then the gate may close when elevations within the site are lower. For those alternatives that allow a full tide, flood peaks in the wetland channels are generally about a foot lower than in Ballona Creek. For instance, with the 50-year storm, Ballona Creek has a flood elevation of about 8.9 ft NAVD; for the same storm conditions the southeast wetland in Area B records 7.1 ft NAVD, and the southwest marsh was 7.6 ft NAVD.

Flood peaks also lower along Ballona Creek. At the seaward end of the channel, the existing peak flood elevation is predicted to be 8.9 ft NAVD. Predictions under Alternatives 1 and 2 have similar elevations as existing conditions. Alternatives 3 and 4 exhibit a 0.5 ft reduction in peak levels because of storage in the restored wetlands. Alternative 5 has slightly less of a reduction of 0.3 ft, due in part to the channel configuration and roughness of the vegetated floodplain.

3.3.8 Tables

Table 3-3. Inundation Regime of the SRT Gates in Area B, Showing Percentage of Time Tidal Water at or Above a Given Elevation

Elevation	% of time tides at or above given elevation				
ft NAVD	Santa Monica Bay (open ocean)	SRT closes at 3.6 ft NAVD	SRT closes at 4.9 ft NAVD	SRT closes at 6.6 ft NAVD	
7.5	0%				Inundation muted
7.0	1%				
6.5	4%				
6.0	8%				
5.5	14%			0%	
5.0	19%			4%	
4.5	28%		0%	16%	
4.0	38%	0%	6%	29%	
3.5	51%	23%	42%	44%	
3.0	65%	56%	58%	57%	
2.5	74%	69%	72%	70%	
2.0	80%	76%	78%	77%	Inundation similar
1.5	85%	82%	83%	82%	
1.0	90%	87%	88%	87%	
0.5	95%	100%	91%	91%	
0.0	98%	100%	97%	97%	
-0.25	100%	100%	100%	100%	

Note: all these examples use the existing 39 ft^2 culvert; with the gate set to close at 6.6ft NAVD the tide range is damped due to the lack of capacity of the culvert.

Table 3-4. Habitat Zonation in Terms of Inundation Regime and Elevation for Full and Muted Tidal Regimes

Habitat type	Inundation regime	Elevation range, ft NAVD			
	%r	Santa Monica Bay (open ocean)	SRT closes at 3.6 ft NAVD	SRT closes at 4.9 ft NAVD	SRT closes at 6.6 ft NAVD
Salt pan	14-28%	4.5-5.5	3.5-3.6	3.8-3.9	4.0-4.6
Transition Zone	14-28%	4.5-5.5	3.5-3.6	3.8-3.9	4.0-4.6
High Marsh	28-50%	3.5-4.5	3.2-3.5	3.3-3.8	3.3-4.0
Mid Marsh	50-74%	2.5-3.5	2.2-3.2	2.4-3.3	2.2-3.3
Low Marsh	74-90%	1.0-2.5	0.7-2.2	0.7-2.4	0.7-2.2
Intertidal Channel /Mudflat	90-100%	-3.0-1.0	-0.1-0.7	-0.1-0.7	-0.1-0.7
Subtidal	100%	-5.0- -3.0			

Table 3-5. Variation of Tidal Prism for Area B Southwest Wetland

	Ballona Creek tidal prism,
	ac-ft
Ballona Creek only	235
Alt 1 and 2 Area B SRT	267
Alt 3 and 4 Area B breached	386

Table 3-6. Variation of Tidal Prism for Area B Southeast Wetland

	Ballona Creek tidal prism,
	ac-ft
Ballona Creek only	235
Alt 1 Area B add muted tidal HW and tp	250
Alt 2, 3, 4 Area B fully tidal	390

Table 3-7. Variation of Tidal Prism for Area A

	Basin H tidal prism,
	ac-ft
Existing	9
Alt 2 Area A	36
Alt 3 Area A	69
Alt 4 Area A subtidal	345

Table 3-8. Channel Network Characteristics

Alt	Area	Channel length, ft			Order, no. of channels				
		Subtidal	Intertidal	Total	1	2	3	4	5
2	Area B East	1,530	13,730	15,260	43	12	4	1	
	Area A and C	1,820	14,730	16,550	43	12	4	1	
	Total	**3,350**	**28,460**	**31,810**	**86**	**24**	**8**	**2**	**0**
3	Area B East	1,530	20,270	21,800	67	20	6	1	
	Area B West	8,010	42,070	50,080	150	43	12	4	1
	Area A and C	4,770	27,030	31,800	150	43	12	4	1
	Total	**14,310**	**89,370**	**103,680**	**367**	**106**	**30**	**9**	**2**
4	Area B East	1,530	20,270	21,800	67	20	6	1	
	Area B West	8,010	42,070	50,080	150	43	12	4	1
	Area A (5 sub watersheds)	0	10,850	10,850	60	20	5		
	Total	**9,540**	**73,190**	**82,730**	**277**	**83**	**23**	**5**	**1**
5	**Total**	**17,810**	**164,650**	**182,460**	**678**	**198**	**58**	**14**	**2**

3.4 SEDIMENT AND WATER QUALITY

Water and sediment quality are key to the proper functioning of wetland systems. Contaminants associated with poor sediment and water quality can have an effect on the health of wetland plant and animal communities and to the long-term sustainability of any restoration efforts. Accumulated contaminants may also pose a human health risk. A healthy wetland depends on the continuing flow of non-impacted tidal waters and sediment into and out of the restored areas.

Contaminants that have been detected in the water column in Ballona Creek above the water quality criteria include copper, lead, zinc, bacteria indicators, polyaromatic hydrocarbons (PAHs), and several pesticides. These contaminants are generally associated with urban runoff that may contain heavy metals, PAHs and pesticides. These constituents generally are adsorbed to, and carried by, fine-grained soils (clays) and organic materials. These materials then settle out when the water flow velocity decreases such as in a wetland. Continuous flushing through adequate circulation and channel flows would reduce the accumulation of impacted sediments; in a muted tidal system there may be periods of high water slack where increased sedimentation may occur.

Evaluation of sediments in both the Ballona tidal prism and in Marina del Rey has indicated benthic impacts and in some cases toxicity responses to aquatic organism. As indicated by the toxicity testing and benthic studies, these constituents may have negative impacts to the benthic and aquatic organisms within the wetland. Certain metals such as selenium and mercury can bio-accumulate in the wetland environment and are carried up the food-chain. Organic compounds such as PAHs and pesticides such as DDT can also bio-accumulate in organisms in the wetlands resulting in a long-term impact.

Through the Total Maximum Daily Load program, pollutant load reduction is required to reduce these impacts to the benthic and aquatic communities. TMDL implementation is, however, in its initial phases which include developing an implementation plan and identifying source of pollutants. Due to the challenges of reducing pollutant loads from highly urbanized watersheds, improvements in water quality and significant reduction in potential impacts may take twenty years or more. Therefore, alternative for the wetland restoration need to consider the potential impacts from storm flows within this projected timeframe.

Water quality in Ballona Creek may improve as a result of efforts to meet TMDL targets. The need for restricted wet weather flows would diminish compared to the importance of water quality within the wetlands achieved through adequate circulation and residence time that would require less restriction of flow in and out of the wetland

Alternatives are compared by evaluating the sediment and water quality issues associated with different sources of tidal and fresh water flows, which include Ballona Creek, tidal waters and urban storm water runoff. These issues form the criteria for which the alternatives can be assessed to assure a healthy and sustainable wetland.

3.4.1 Ballona Creek Flows

Historical and current water quality data indicate that dry weather flows from Ballona Creek exceed water quality objectives for bacteria indicators, metals, and other constituents. Dry weather flows may result in pollutant loading to the restored areas. Any alternative that increases the connection of the creek to the wetlands, through larger culverts and breaches, may increase this loading.

Storm water flows frequently exceed water quality objectives for bacteria, metals, PAHs, and pesticides in Ballona Creek. Alternatives that allow for the use of flood gates can prevent the inflow of contaminated storm water into the wetlands and reduce pollutant loading. Restricted connections, for example culverts, may reduce inflow from the Creek but would also restrict drainage leading to ponding of polluted waters on the wetlands. Unrestricted storm flows from Ballona Creek, through larger breaches and levee removal, would allow the greatest exchange of water between the Creek and wetlands. Compared to muted tidal systems this would maximize the area exposed to pollutants but this may be mitigated by the improved circulation and flushing of the system.

3.4.2 Tidal Water from Ballona Estuary and Marina del Rey

In general the oceanic water quality is better than in Ballona Creek or Marina Del Rey. In Ballona Creek the tidal influence extends up to Centinela Creek and water quality reduces further away from the ocean as a result of less mixing (a function of tide and fresh water flow). Water in Marina del Rey also exceeds the water quality objectives for bacteria indicators, metals and other constituents. However, the magnitude and frequency of these exceedances are lower in comparison to Ballona Creek. The main channel of Marina del Rey has better water quality than the back basins due to greater circulation, proximity to the ocean, and less direct input from urban runoff.

Accessing the cleaner oceanic water is dependent upon the location of the tidal connection and the excursion length of the waters in the wetlands. Alternatives that have inlets or breaches closer to the ocean would provide water of higher quality to the restored areas. Alternatives that have greater excursion lengths, through larger tidal prisms, would draw from more distant, higher quality waters. Water quality within the wetlands, compared with the muted tidal systems, would also be improved by adequate circulation and lower residence time.

3.4.3 Suspended Sediment Loading

Suspended sediment and organic matter in urban runoff attract and provide the mechanism to transport constituents such as heavy metals (copper, lead, zinc), bacteria, pesticides, PAHs and other organic compounds to receiving waters. These sediments then settle out as velocity decreases when storm flows meet tidal waters or enter into the wetlands.

Historical and current data indicate long term accumulation of these constituents in sediments in Ballona estuary and at the tide gates into Area B; sediment testing has indicated toxic effects on aquatic organisms. Suspended sediments from Ballona Creek and from local resuspension during storms, may continue to enter the wetlands and impact sediment quality.

Marina del Rey also has impacted sediments in the main channel and in several of the back basins. The sources of the impacted sediments may include the Ballona estuary, resuspension of coastal sediments during storms, storm water discharges directly into Marina del Rey and human activities within the Marina.

Alternatives that restrict flows into the wetlands during and, for a period, after storm events may reduce the supply of sediment to the wetlands but increase the potential for settling of finer material due to longer slack periods. In the long term, restricted flow and import of sediment would limit sediment cycling. This may further reduce the already limited sediment supply from the urbanized watershed.

Other storm water inflows are at the ends of Falmouth and Pershing Drives and along Lincoln Boulevard and Marina Freeway. Continued loading of these constituents into the existing wetland areas has resulted in localized impacts to sediment. All the alternatives include storm water treatment wetlands to reduce the pollutant loading. Treatment wetlands can be effective in removing heavy metals, sediment and organic compounds that adsorb to fine-grain soil particles and organic matter. The effectiveness of these systems depends on the retention time that flows entering the wetlands and the maintenance of the plants and sediments. These wetlands may only be able to reduce loads from a portion of storm water flows due to the constraints of size, through flow, and number of inflow locations.

3.4.4 Sediment Impacts

Within the project area there are contaminated soils in the creek and wetland channels. Grading of the site for an alternative may make these contaminants bioavailable. All the alternatives would alter the local flow patterns within the wetlands, either by altering the path or velocity of the flow. As a result there would be localized accretion and erosion of the existing sediment as the channels adapt to the new flow regime. This may result in the mobilization of contaminated soils which may be deposited within the site or transported out to the Creek or Marina del Rey.

Culverts and other constrictions should be sized to reduce the flow velocity below that for significant erosion. Alternatives may also include structures that reduce the velocity at locations of high flow.

3.5 SUSTAINABILITY AND MAINTENANCE

All natural systems have a certain amount of variation or trends that occur over different time scales. In a tidal wetland, these variations may include floods or droughts over the short term or changes in climate over the long term. These variations can cause stress to the system, which may be anticipated and accommodated within the design of a restoration project. Climate change, for example, would affect not only sea level but also temperature and precipitation.

In addition to long term changes, there would also be individual events that would stress the system. Variations in timing and frequency of storms are difficult to predict, as is the accidental release of contaminants. The uncertainty in the timing and magnitude of these stressors makes the operation and maintenance (O&M) of the system to unexpected changes important.

3.5.1 Long-term Sustainability - Sensitivity to Climate Change

Long-term sustainability of the restored wetlands is evaluated as the sensitivity to climate change and other long-term trends, including sea level rise and also changing rainfall patterns and sediment supply within the watershed.

Tidal wetlands exist within a very narrow vertical range, set primarily by the tidal frame. A small change in the tidal frame due to sea level rise would result in movement of the vertical distribution of tidal habitats. The response of tidal wetland to sea level rise depends primarily on:

1. sediment supply to the wetland and the associated rate of wetland accretion, and
2. the availability of space for the transgression of wetland habitats to higher elevations.

If sediment is readily available, vertical accretion may keep pace with sea level rise and the spatial distribution of tidal habitats may not change significantly. If sediment supply is low, as in Ballona Creek, accretion rates may be slower than sea level rise and habitats would transgress landward. In Alternatives 2, 3, 4 and 5, tidal wetlands would be graded to elevations that support the desired vegetation, as it is assumed accretion rates would be slow.

As sea level rises, habitats that are higher in the tidal frame would be converted to habitats that are lower in the tidal frame (e.g., high marsh is converted to low marsh, low marsh is converted to mudflat, and mudflat is converted to open water). If the transitional zone has a shallow slope, higher tide levels due to sea level rise would inundate transitional and upland habitats and convert these areas to high marsh. The space provided by shallow upland slopes allows tidal habitat to transgress up the slope with sea level rise, thereby maintaining similar acreages of habitat. If the transitional slope is steep, higher elevation habitat acreages would decrease as open water and lower elevation habitats transgress landward.

The tidal wetland habitats in Alternatives 2, 3, 4 and 5 include broad transitional slopes (1:50 to 1:70) that allow habitat transgression and can accommodate 2 to 3 feet of sea level rise. These shallow slopes would also provide valuable interim transitional habitat and act as a buffer from the surrounding urban activity. Where space is constrained and shallow slopes are not feasible, particularly where wetlands are located close to levees or roads, the transgression process would still occur but the higher elevation marsh habitat would be compressed against the slope of the levee into a narrow horizontal band. There may be loss of some wetland in the future due to the steep transitional slopes in these locations.

Alternatives 1 and 2, which include culverts or gates, allow some control of the water surface elevation. In these alternatives, a muted tidal regime would be implemented that limits the maximum water surface elevation. The result would likely be a vertical and horizontal compression of the higher elevation habitats (high marsh and transition zones). The culverts and gates would be designed to accommodate expected sea level rise.

Current assessments of climate change in California do not indicate a clear trend or significant change in precipitation patterns. Higher temperatures are expected to cause a significant shift from snow to rain in the mountains, but coastal California is relatively unaffected by snow. Significant changes in precipitation and streamflow in coastal watersheds are therefore not currently predicted. There is the potential for decreased precipitation and more severe droughts. Small changes in water balance for sensitive habitats, such as seasonal wetlands and brackish marsh, may result in temporary or permanent changes in the salinity regime of these areas. Those areas that are already fully tidal wetlands may not be directly affected but they may still be influenced by changes in occasional freshwater inputs. In this respect, wetland areas connected to Ballona Creek and its watershed would be more sensitive than those connected to Marina del Rey.

3.5.2 Operations and Maintenance (O&M)

The alternatives require varying levels of ongoing operations and maintenance (O&M). Fully tidal wetlands in Alternatives 3, 4, and 5 would be designed to be self-maintaining and are expected to require little O&M. Muted tidal wetlands in Alternatives 2 and 3 would require regular and ongoing O&M of tide gates.

In addition to routine O&M for typical conditions, there would always be unforeseen or difficult to predict events – a large flood, the accidental release of a pollutant, the failure of a mechanical structure. Ideally the alternatives should be flexible enough to accommodate such unknowns and allow the opportunity for intervention. The muted tidal wetlands in Alternatives 1 and 2 provide the ability to occasionally close off the wetlands from its main tidal source, which could prevent high flows or contaminants from entering the site. A flood or tide gate may be added to a culvert with relative ease; however, it is much more difficult to close off the breaches and lowered levees in Alternatives 3, 4, and 5 from Ballona Creek. On the landward side, preventing flows from entering the site is more difficult due to the number of potential inflows and the difficulty of rerouting the flows to the ocean. For fully tidal wetlands in Alternatives 3, 4, and 5, the breaches may allow better flushing of contaminants entering from either the creek or adjacent land.

If controls are used as part of the management of the alternative, planning should include system response if the control fails. For instance, if a tide gate fails to operate then the impact it would have on the wetlands would differ depending on whether it failed open or shut, at high or low water. Ideally the tide gate should not be the only protection against excessive water levels, there should be redundant measures such as additional ebb culvert barrels and landward levees.

Another consideration is the reversibility of an alternative. All alternatives would have an adaptive management plan in which it may be desirable to manipulate conditions. Changing the operation of an existing gate has less risk than changing the tidal inundation by removing a section of the levee. If conditions change and the system does not respond as required then the ability to revert to the former state may be desirable. Another example may be the enhancement of existing uplands, where changes envisioned in Alternative 1 and 2 are mainly related to management rather than structural changes and could more easily be reversed.

3.5.3 Vectors

Mosquitoes occur in wetland ecosystems where certain species can be vectors for viral diseases such as forms of encephalitis and more recently West Nile Virus. Understanding the life cycles and habitat requirements of the species that can be disease vectors is important in their control. Mosquitoes breed in standing water. Mosquitoes rarely occur in significant numbers in areas of tidal wetlands that are regularly inundated and drained over the tide cycle. Problems can occur in areas of tidal wetlands that are not well drained, such as ponds and pans that are infrequently or seasonally inundated, densely vegetated areas that pond water between tides, or locations where tidal drainage has been interrupted. Maintenance (e.g., spraying) may be required to address vector issues for poorly drained areas of tidal marsh.

For muted tidal wetlands, the designs should provide the ability to drain areas of standing water when required. This could be accomplished by operating gated culverts to drain the wetland on an occasional basis. Open areas of standing water should be large enough to allow wind waves to disturb the surface and dense vegetation around the edges should be avoided.

Additionally, wide buffers between wetlands and residential areas can reduce the likelihood of vector issues. The design of the alternatives should provide access points for mosquito surveillance and control.

3.5.4 Invasives

Biological invasions by exotics represent one of the most serious threats to ecosystem integrity and functioning. Invaders can detrimentally alter habitats, eat native species, and act as disease agents. Millions of dollars are spent annually in combating exotic plant pests just within southern California. Managing exotic species is complicated, as invaders are living organisms that can adapt to their new environments and have diverse, cascading effects. Invasive species may become established in restored upland and wetland habitats, requiring costly removal and maintenance efforts.

Salt marshes in southern California have been relatively free from invasions of wetland plants. Some localized exceptions include a mangrove (*Avicennia marina*) intentionally introduced into Mission Bay, San Diego, a sea lavender (*Limonium ramosissimum provinciale*) in Carpinteria salt marsh in Santa Barbara and *Tamarix* which has invaded the high marsh at Tijuana Estuary in San Diego County.

Upland area in southern California have some particularly troublesome plant invaders including giant reed (*Arundo donax*), which forms dense stands in riparian, brackish and fresh water wetlands, and salt cedar (*Tamarix* spp.), which have invaded riparian habitats, uplands, transition zones and high salt marsh. The major invaders at Ballona include , wattle (*Acacia* spp.), myoporum (*Myoporum laetum*), Russian thistle (*Salsola tragus*) mustard (*Brassica* spp.), garland daisy (*Chrysanthemum coronarium*), wild radish (*Raphanus sativus*), castor bean (*Ricinis communis*), pampas grass (*Cortaderia jubata*), fennel (Foeniculum *vulgare*), brazillian pepper tree (*Schinus terebinthifolia*), slender fan pam (*Washingtonia robusta*), non-native spurge (*Euphorbia* spp.), multiple varieties of ice plant (*Aizoaceae*) and non-native grasses have invaded disturbed upland areas and continues to spread.

Important vertebrate invaders that may affect restoration efforts include cowbirds, which are nest parasites that affect the endangered Least Bell's Vireo, and predatory red fox and house cats. These primarily upland invaders can also enter the wetland areas, impacting the native species. Estuarine and marine invaders include the clam-smothering mussel (*Muscalista senhousia*) and the carnivorous yellowfin goby (*Acanthogobius flavimanus*), the "killer" alga *Caulerpa taxifolia*, the salt-marsh destroying crustacean *Sphaeroma quoyanum*, and the mud-flat invading cordgrass *Spartina alterniflora*.

Alternatives with greater area of upland habitats would have greater impacts from invasive species and provide more opportunities for them to impact the adjacent wetland habitats. Alternatives 3, 4 and 5 provide the greatest area of contiguous wetland habitat (see Table 3-3), while Alternative 5 provides a significantly smaller edge to area ratio (Table 3-4).

3.6 PUBLIC ACCESS, RECREATION AND SAFETY

The goal of the public access plan is to provide "enhanced access to and within the Ballona Ecosystem consistent with ecosystem preservation and restoration values in a safe, consistent, coherent and functional manner," as per project objectives in the Ballona Wetland Restoration Plan Goals and Objectives (Appendix A). Public access features would be developed in concert with habitat restoration efforts to ensure maximum resource protection while providing a valuable recreational experience for the community. Providing public access and interpretive features about habitat restoration in turn provides increased public education, awareness, and support of local biological and physical resources present within the Ballona Wetlands. Providing strategically-placed public access features and limiting the intensity and duration of recreational use at the Ballona Wetlands would reduce impacts to the wetlands and enhance opportunities to involve the public in restoration and monitoring efforts.

The proposed public access and recreation features include a system of trails and overlooks, gateway entrances, interpretive stations, pedestrian bridges, bicycle parking, parking areas, boardwalks, vehicular pullouts, and visitor center. These would provide a diversity of public access and recreation opportunities for a wide range of users. The goal for the future design of these features would be to integrate all aspects of the project into a coherent system of restoration and public access that provides a clear sense of place within the context of the Ballona Wetlands and surrounding landscape.

The California Fish and Game Commission has designated the majority of the project area as a State Ecological Reserve. The purpose of the designation is to provide protection for rare, threatened or endangered native species. Public entry and recreational use of ecological reserves is subject to general rules and regulations to ensure that recreation is compatible with the primary purpose of resource protection.

In order to protect natural resources on the site and limit impact to wetland areas, a controlled and appropriate level of access to the Ecological Reserve would be provided as part of restoration. The public access strategy would focus on managing and concentrating recreation use within the site. The restoration and public access design would accommodate an appropriate level of fishing, boating, walking, and other activities consistent with the Ecological Reserve designation and ecosystem restoration values:

- **Walking**. Currently, access to the Ecological Reserve for walking or hiking is authorized on a case-by-case basis, and the site is not yet open to the general public. However, there is a public trail and self-guided interpretive tour located along the perimeter of the Freshwater Marsh. Walking or hiking would likely be the predominant recreational use of the site.

- **Biking**. Several local and regional bicycle routes are located near the Ballona Wetlands. No formal off-road or trail bicycle paths exist within the wetlands. The Ecological Reserve designation permits biking only on the designated bicycle path located on the north bank of Ballona Creek. Bicycle use is not permitted within the Ecological Reserve or Freshwater Marsh area.

- **Fishing**. Fishing currently occurs on both sides of Ballona Creek and from the downstream pedestrian bridge. The Ecological Reserve designation permits fishing with barbless hooks from the shoreline of Ballona Creek or from boats within the Ballona Creek channel. Fishing within the wetland area is restricted and by permit only.

- **Boating**. The Ballona Creek channel is currently used for both motorized and non-motorized boating. The University of California Los Angeles and Loyola Marymount University rowing teams use the Ballona Creek channel for crew practice. The Ecological Reserve designation permits boating within the Ballona Creek channel. Boating within the wetland area, however, is restricted and by permit only.

- **Other Recreational Uses**. Playa Vista Little League currently plays baseball on three fields located within the Ecological Reserve (Area C).

Public access and recreation features would provide a variety of settings, including access to the estuarine environment and retreat from urbanized areas, and would provide recreation opportunities for a variety of visitors. Access would be designed to be as barrier-free as possible to provide access for visitors of varying abilities and to comply with the Americans with Disabilities Act. In some locations, trails may be designed to accommodate vehicular use in order to provide access for security or maintenance. Raised boardwalks would be strategically located to maximize interpretive and educational opportunities related to the site and ongoing restoration activities. Exact trail locations and characteristics would be further developed when the preferred alternative is identified.

Table 3-9 details the number, length and location of public access features.

The Ballona Wetlands are also an important crossroad within the regional trail network. Both the coastal South Bay Bicycle Trail and the Ballona Creek Bicycle Trail run along the boundary of the site. Running north/south, the South Bay Bicycle Trail is a 22-mile paved trail that runs from Will Rogers State Beach in the north to Torrance County Beach in the south. Running east/west, the Ballona Creek Bicycle Trail runs along the south boundary of Area A and concludes in Culver City. The project is an opportunity to increase regional connectivity by developing an integrated trail network within the project site that connects to the surrounding regional trail network. The Alternatives would both preserve and enhance regional connectivity through connections of loop trails within the project area to the regional network. These connections would provide regional and local trail users with a range of opportunities and destinations.

Providing public access and interpretive features regarding habitat restoration in turn provide increased public education, awareness, and support of local biological and physical resources present within the Ballona Wetlands. Interpretive stations would be developed at strategic locations such as at gateway entrances, overlooks, or along the trail network within the project area. Educational signage and interpretive panels would facilitate a greater understanding and appreciation of the landscape. A potential visitor center and other opportunities for outdoor education and interpretation would provide a rich diversity of public access and recreation opportunities for a wide range of users. The goal for the future design of these features would be to integrate all aspects of the project into a coherent system of restoration and public access that provides a clear sense of place within the context of the Ballona Wetlands and surrounding landscape.

The prehistoric resources within and near the Ballona project area, including LAN-54, contain human remains and other materials that are of extremely high heritage value and sensitivity to the contemporary Gabrielino/Tongva Native American groups. Efforts to enhance cultural awareness of these resources and Native American lifeways in general should therefore be closely coordinated with the California Native American Heritage Commission and those groups identified as having specific concerns for the Ballona area.

As outlined in the Ballona Wetland Early Action Plan, interpretive panels would highlight habitat characteristics and diversity, watershed history, and Native American site usage through clear, consistent and attractive displays (Conservancy 2007). Overlooks or viewing platforms would be located at vista points where important features of the landscape can be viewed and/or opportunities for wildlife viewing and birding exist. Associated interpretive information would be provided at these facilities based on the opportunities provided at the facility sites.

Public access within Ballona Wetland would be developed in a manner that is "safe, consistent, coherent and functional" for the safety of the public, long-term management, and maintenance of the site. The separation of incompatible uses, such as bikers and walkers or bikers and cars is important for public safety and security in the area. The Ballona Wetlands are located in a densely population area surrounded by busy roads and popular regional bike paths. The Ecological Reserve designation provides clear guidance on allowable recreational uses within the site.

The most common unauthorized uses within the project area are BMX biking, dog walking, homeless encampments, dumping, and off-trail walking. Unauthorized use of the site can have an adverse impact on the landscape. Therefore, controlling these uses is critical to successful habitat restoration. Wetland restoration would inherently preclude access to portions of the site by creating deepwater and wetland habitat.

Lincoln Boulevard, Jefferson Boulevard, and Culver Boulevard, as well as street ends to the west and north, provide site access for automobiles. Current on-site parking includes an unimproved lot behind Gordon's Market in Area B, paved on-street parking along Jefferson Boulevard at the Freshwater Marsh, and a paved parking lot at the Little League baseball fields in Area C. Safe traffic access would be provided by designating parking areas, creating roadside pullouts to provide formalized automobile access and viewing locations, and discouraging unauthorized roadside parking.

3.6.1 Tables

Table 3-9. Public Access Features Comparison

Public Access & Recreational Features	Alternative 1 (length/ number)	Alternative 2 (length/ number)	Alternative 3 (length/ number)	Alternative 4 (length/ number)	Alternative 5 (length/ number)
Trails					
Area A: Trails	8,800 feet	8,000 feet	9,450 feet	3,550 feet	4,450 feet
Area B: Trails	29,600 feet	29,600 feet	27,000 feet	27,000 feet	16,200 feet
Area C: Trails	7,200 feet	6,700 feet	7,150 feet	6,550 feet	2,250 feet
Boardwalks	1,900 feet	1,450 feet	1,350 feet	3,650 feet	3,850 feet
Access Points & Overlooks					
Gateway Entrances	11	11	11	10	7
Overlooks	4	6	9	9	10
Parking and Pullouts					
Formal Parking Areas	4	4	4	4	4
Vehicular Pullouts	0	0	2	2	2
Pedestrian Crossings					
Pedestrian Creek Bridge Crossing	1	1	1	1	1
Pedestrian Road Crossing	2	2	1	1	5

3.7 PHASING AND COSTS

This section describes the probable construction costs for the five selected alternatives as described in Chapter 2. In determining an opinion of probable construction costs appropriate to conceptual level design, several assumptions were required. These assumptions included:

- construction methods
- unit costs
- project sequencing and phasing
- permitting
- property acquisition

Table 3-10 is included to illustrate the level of accuracy and amount of contingency which is typically included in cost estimation for construction projects at various levels of design. This table is from the Cost Estimate Classification System, developed by the Association for the Advancement of Cost Estimating (AACE, 1997). As shown in the table, a particularly wide range in accuracy is assumed inherent for project design at the conceptual level. In addition, contingency is a large percentage of the estimated project costs, decreasing as the level of design is increased.

The "estimates of probable costs" are summarized in Table 3-11. Appendix D contains detailed cost estimates for each alternative by area and supporting information. It is important to note that these are large scale construction projects and that the alternatives involve significant intervention, and hence would require further detailed analysis and engineering design that would likely lead to additional refinements. Consequently, at this conceptual design phase, a cost contingency of 35% is included. We anticipate that actual construction costs could be reduced significantly through more detailed engineering. This is particularly true of the unit costs identified for fill placement; if a major fill element is included in the project, there is an opportunity to develop a construction methodology with a lower cost. Also, land costs are not included. At this stage, it is anticipated that all construction can be accomplished on publicly-owned land, and land and easement purchase costs are therefore not included. Also, costs associated with environmental restrictions of construction including timing and phasing are not explicitly treated.

These estimates are subject to refinement and revisions as the design is developed in future stages of the project. The cost tables summarize the cost of construction, and do not include estimated project costs for additional studies, permitting, detailed design, construction observation, monitoring and ongoing maintenance. Estimated costs are presented in 2008 dollars, and would need to be adjusted to account for price escalation for implementation in future years. This opinion of probable construction costs is based on: PWA's prior experience, prices from similar projects, and consultation with contractors and others involved in comparable projects.

Note these estimates of probable construction costs and the actual costs at the time of construction may vary. The cost of construction would be impacted by the availability of construction equipment and crews and fluctuation of supply prices at the time the work is bid. PWA makes no warranty, expressed or implied, as to the accuracy of such opinions as compared to bids or actual costs.

3.7.1 Notes on Cost Estimate Assumptions

Quantities were estimated conservatively (high). For the grading of the subtidal, mudflats and marsh plain, it is assumed the grading was to the desired elevation and volumes were calculated using the "average end area method." For channels, it is assumed that only the largest channels (order 3, 4 and 5) would be excavated, and that these channels would be excavated to their modeled, equilibrium dimensions. Quantities of material used in levees were increased to account for settlement.

Appendix D (Table D-2) includes the unit costs and assumptions used in the cost estimate. The cost of excavation is the most expensive item in Alternatives 2 to 5. The cost used for excavation is $15/CY, which may be high. The use of scrapers or other efficient construction methods may have a lower unit cost. However, in this case, over-excavation and/or ripping of the soil may be required to give a suitable substrate for wetland restoration. This additional work would increase costs. Therefore, lower unit costs are not recommended for use in the cost estimate without further analysis of engineering and constructability considerations.

Onsite trucking and placement of excavated material is included as a separate item in the cost estimate. The cost estimate assumes that as much material as possible is reused within the same area to construct levees. Even so, each alternative generates more material than can be reused on site. There is no requirement to move material from one area to another, with the exception of Alternative 1. In Alternative 1, material excavated in Area A would be trucked to Area B and used as fill for levee construction along the daylighted culvert. It is assumed that the excess quantity from each area will be placed on site in stockpiles, at least until the material is disposed of off site. Table 3-12 lists the volume of excess material to be stockpiled (Appendix D, Table D-4 includes a rough calculation of possible stockpile areas).

Options for disposal may include:

Option 1 / 2. Remove sediment, barge sediment to the Port of Los Angeles (POLA), and unload dredged material at POLA (Option 1) or dispose material at a confined disposal facility (CDF) at POLA (Option 2).

Option 3. Remove sediment, barge sediment to POLA, and truck to landfill for beneficial use as landfill cover.

Option 4. Remove sediment, barge sediment to POLA, and dispose contaminated material at a hazardous waste landfill. The level and extent of on-site contamination is presently unknown.

Option 5. Remove sediment, barge sediment offshore, and dispose sediment offshore (Offshore Disposal).

Option 6. Remove sediment and dispose sediment on a nearby beach (Beach Disposal).

POLA identified and evaluated disposal Options 1 to 4. A preliminary draft cost estimate table prepared for POLA by Weston (Weston, undated) for these options was provided. There are uncertainties associated with the preliminary draft table and conceptual-level cost estimates. Disposal costs were not estimated for this report. The POLA/Weston cost estimate information was used to estimate the costs for Options 1 to 3. Mobilization (8%) and a 35% contingency were added to the disposal cost estimates for consistency with the estimates in this report and to account for uncertainties. Cost estimates for Option 4 are not included because information on contamination is not currently available.

For offshore disposal (Option 5) and beach disposal (Option 6), a range of costs is included in the estimate. On the lower end of the range, the costs for offshore disposal (Option 5) and beach disposal (Option 6) may be as low as the costs for disposal at POLA (Option 1 / 2). The upper end of the range for offshore disposal (Option 5) may be as high as the unit cost for dredging and offshore disposal at Upper Newport Bay provided by the SCC (G. Gauthier, SCC, pers. comm.) This unit cost is $28 per cubic meter for dredging and disposal about three to five miles offshore (S. Brodeur, County of Orange, pers. comm.). For beach disposal (Option 6), the upper end of the unit cost may be about $10/CY higher than the costs for Option 1 / 2. The cost estimates for disposal options should be updated at the next opportunity. Table 3-13 summarizes the disposal option cost estimates for each alternative.

3.7.2 Phasing

Areas A and C and Area B are not hydraulically connected in Alternatives 1 to 4 and so their construction may be phased in either order. In addition, it would be possible to construct Area A prior to Area C in each of these alternatives. Since each area generates more than enough material to construct levees, there is no need to stockpile material for use in later phases.

Alternative 5 is shown as being constructed in three phases (see Figure 2-9). A breakdown of the cost estimate between phases is included in Table 3-11. Excavation of Area A and removal of the Ballona Creek levees downstream of Lincoln Boulevard would occur first. This would require the construction of a temporary levee across the northern part of Area B and adjacent to Culver Drive. This temporary levee would increase the costs of phasing Alternative 5 compared to the cost estimated for Alternative 5 without phasing. The second phase would consist of restoring the remaining portion of Area B once the first phase habitat had been successfully established. Finally, Area C would be restored in the third phase. The advantage of phasing would be to spread costs over a longer period of time and take advantage of the timing of other projects, such as the widening of Lincoln Boulevard. The project could be stopped at the end of any of the phases and still leave a functioning system.

3.7.3 Tables

Table 3-10. Levels of Cost Estimate Accuracy and Contingency for Different Levels of Design

Design Completion Level	Cost Estimate Accuracy	Contingency
Conceptual (order of magnitude costs)	-30% to +50%	35–50%
Preliminary (30%)	-15% to +30%	20-25%
40 to 70% complete	-15% to +30%	15-20%
70 to 100% complete	-5% to +15%	10-15%

Table 3-11. Summary of Engineer's Estimates[1] for Alternatives 1 to 5 (cost in Millions of Dollars)

Alternative	Area A	Area B	Area C	Total
1	$4.0	$2.6	--	**$6.6**
2	$42.6	$16.0	$3.3	**$61.8**
3	$69.3	$55.5	$5.2	**$130.0**
4	$108.4	$55.5	$5.2	**$169.0**
5	$99.8	$59.0	$50.4	**$209.3**
	Phase 1	**Phase 2**	**Phase 3**	
5 [2]	$110.4	$48.8	$50.5	$209.7

Notes:

1 - Estimated construction costs include a 35% contingency

2 - The cost estimate for phasing Alternative 5 is higher due to the construction of a temporary levee

Table 3-12. Estimated Volumes of Excess Material to Be Stockpiled.

	Stockpile Volume (ac-ft)			
	Area A	**Area B**	**Area C**	**Total**
Alternative 1	50	-	-	**50**
Alternative 2	590	120	60	**770**
Alternative 3	1,040	600	90	**1,730**
Alternative 4	1,700	600	90	**2,390**
Alternative 5	1,650	760	840	**3,250**
	Phase 1	**Phase 2**	**Phase 3**	
Alternative 5	1,790	570	830	**3,190**

Table 3-13. Summary of Estimated Costs[1] for Disposal Options. Costs in Millions of Dollars

							Alt 5 with Phasing [2]			
		Alt 1	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**Phase 1**	**Phase 2**	**Phase 3**	**Total [2]**
On-Site Work		**$6.6**	**$61.8**	**$130.0**	**$169.0**	**$209.3**	$110.4	$48.8	$50.5	**$209.7**
Disposal Volume (CY)		**86,400**	**1,241,440**	**2,789,580**	**3,853,140**	**5,231,600**	2,889,960	923,500	1,344,600	**5,158,060**
Off-Site Disposal Options										
Option 1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**	**$1.3**	**$19.1**	**$43.0**	**$59.4**	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
Option 3	**Beneficial Use - Landfill Cover**	**$4.2**	**$59.7**	**$134.1**	**$185.2**	**$252.6**	$138.9	$44.4	$64.6	**$252.6**
Option 4	**Disposal at Hazardous Waste Landfill [3]**									
Option 5	**Offshore Disposal (low end of range)**	**$1.3**	**$19.1**	**$43.0**	**$59.4**	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
	Offshore Disposal (high end of range)	**$3.6**	**$51.0**	**$114.6**	**$158.3**	**$216.**	$118.7	$37.9	$55.2	**$216.0**
Option 6	**Beach Disposal (low end of range)**	**$1.3**	**$19.1**	**$43.0**	**$59.4**	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
	Beach Disposal (high end of range)	**$2.7**	**$38.3**	**$86.0**	**$118.7**	**$162.**	$89.1	$28.5	$41.4	**$162.0**

Notes

1 - Estimated construction costs include a 35% contingency

2 - The cost estimate for phasing Alternative 5 is higher due to the construction of a temporary levee

3 - Estimate not included for Beneficial Use - Landfill Cover, contamintant report pending

4. SUMMARY

1. The project goal is to create functional estuarine habitat, including shallow subtidal, mudflats, fully tidal wetlands, salt pan and transitional habitats. Extensive enhancement of muted tidal wetlands or upland habitat, such as coastal sage scrub, grassland and saline seasonal marsh, does not achieve the project goal. However, upland habitat may provide some support for functioning estuarine habitat. Alternatives 3, 4 and 5 create the largest areas of fully tidal estuarine habitat while Alternatives 1 and 2 have larger areas of upland and muted tidal habitat. As discussed in Section 3.1, tidal estuarine habitats would benefit vascular and non-vascular plants, small mammals, a diverse community of aquatic invertebrates and many bird species known to utilize other southern California wetlands. Alternatives 4 and 5 create large areas of shallow subtidal habitat adjacent to mudflat. This would provide spawning and nursery habitat for pelagic and demersal fish species; these may disperse to the adjacent nearshore habitat and to other regional wetlands.

2. Transitional habitats, between tidal wetlands and upland, support a unique assemblage of vascular plant species and provide additional support for terrestrial species such as snakes, lizards, small mammals and birds. Transitional habitats also provide refuge for wildlife during periods of high water, serve as buffers against human activity, and allow for transgression of wetland habitats with rising sea levels. Alternatives 3, 4 and 5 provide the widest and largest area of transitional habitat. Muted tidal systems, as in Alternatives 1 and 2, have a reduced tidal range and therefore a compressed vertical range of habitats, limiting the area of transitional habitat that can be created.

3. Upland areas would support populations of vascular plants and provide foraging and nesting habitat for a number of bird species. Upland areas would also provide breeding and foraging habitat for insect pollinators, butterflies and moths, birds, herpetofauna and some mammals. All alternatives provide some upland habitat; however, there is a trade-off between the acreage of estuarine habitat and upland habitat. Alternatives 1 and 2 have the most upland habitat and the least change to the existing habitat mix. Freshwater seasonal wetlands, including vernal pool habitat, would benefit specific vascular and non-vascular plants, aquatic invertebrates and herpetofauna uniquely adapted to this environment, Alternatives 2, 3 and 4 create vernal pools.

4. Alternatives with larger, contiguous, areas of wetland habitat are more likely to sustain populations of associated species. Alternatives 3, 4 and 5 have larger areas of contiguous wetlands with fewer roads, wider transitions and more channels. These alternatives would have a higher quality of wetland habitat because they would be more remote from noise, lights, cars, and other human impacts. Alternatives with larger areas of contiguous wetland would also have fewer impacts from, and require less active management for, invasive plant and animal species.

5. Fully tidal systems allow for greater tidal circulation and reduced residence time. This would lead to a more rapid exchange of water with the ocean, and positive effects on exchange of gases, nutrients, fish larvae, sedimentation and improved water quality. Alternatives 1 and 2 have large areas of muted tidal wetland; Alternatives 3, 4 and 5 create fully tidal wetlands. The large intertidal areas of Alternative 2, 3 and 5 would have the shortest residence times, completely draining on most tidal cycles. Alternative 4 has a substantial subtidal volume, which would flush over several tidal cycles.

6. A complex tidal channel system allows water, sediment and nutrients to reach all parts of the wetland and provides diverse habitats. The complexity of the channel network depends on the area of the wetland and its tidal prism. Alternatives 3, 4 and 5 have large tidal prisms and would support an extensive and complex channel network with a large range of channels sizes.

7. The higher quality sources of tidal water are the ocean and Marina del Rey. The ability to bring this water into the wetlands would depend on the location of the tidal connection and the tidal excursion length. Alternatives 2, 3 and 4 improve tidal connections between Area A and higher quality water in Marina del Rey; this would also benefit habitat connectivity for fish species. All alternatives have some connection to Ballona Creek, which has poorer water quality. Longer excursion lengths increase the mixing of water on each tidal cycle, improving water quality. Alternatives 3, 4 and 5, with the largest tidal prism, have excursion lengths extending to the ocean.

8. The form of the tidal connection would affect the connectivity and function of habitat by influencing the movement of sediment, seeds, gases, nutrients, fish and fish larvae. Tide gates in Alternatives 1 and 2 would control water surface elevations within the wetlands but would limit connectivity with Ballona Creek and Marina del Rey, reducing diversity, and limiting primary productivity. Gates can also control pollutant loading, especially during storm events, although muted tidal systems would have a longer residence time allowing greater settling of pollutants. Gates would require regular maintenance and management as failure could impact habitat and cause flooding. Fixed structures, such as gates and culverts, need to accommodate both scour and sea level rise in their design.

Breaches in Alternatives 3 and 4 allow for full tidal range, movement of larger fish and greater seed dispersal. Open breaches would allow greater tidal circulation, reduced residence times and would be able to adapt to rising sea levels. Levee removal in Alternative 5 has the advantages of breaches and increases the interaction between the wetlands and the Creek - creating gradients of inundation and salinity across the site, letting the morphology evolve and allowing for periodic disturbance by flooding and scouring.

9. All of the alternatives would maintain the existing level of flood protection. Alternatives 1 and 2 have muted tidal systems, which would maintain the existing flood levels. These

alternatives rely on tide gates. Alternatives 3, 4 and 5 can accommodate higher flood levels by the construction of new levees and provide additional flood storage, reducing peak flood elevations.

10. All the alternatives would include principles of adaptive management in their Operation and Maintenance strategy. Alternative 1 has little change from the present situation and the risk associated with implementation is low. The restoration of wetlands in Alternative 2, 3 and 4 could be undertaken in distinct hydrologic areas which would allow for adaptive management and experimentation. Alternative 5 restores a large, contiguous area of habitat connecting a number of existing hydrologic units with Ballona Creek. This alternative makes the greatest change to the site, would be the hardest to reverse and consequently has the most risk. This risk may be mitigated to an extent by phasing the implementation.

The following tables have been developed from the above summary. They indicate favorable characteristics in terms of habitat, hydrology and public access. Check marks indicate which alternatives have these characteristics and the number of check marks indicates the relative degree. The number in brackets refers to the relevant summary paragraph above.

4.1 TABLES

Table 4-1. Summary of Habitat Characteristics

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Large areas of fully tidal estuarine habitat (1)		√	√√	√√√	√√√
Large areas of mudflat (1)			√	√√	√√
Large areas of shallow subtidal habitat, adjacent to mudflats (1)				√√	√√
Extensive channel network (6)	√	√	√√	√√	√√√
Wide transitional habitat (2)		√	√√	√√	√√
Large areas of enhanced upland habitats (3)	√√	√√	√	√	
Allows for dynamic interaction between Ballona Creek and the Wetlands					√
Larger and more hydraulic connections between wetland habitats, Ballona Creek and the ocean (5, 7, 8)		√	√√	√√	√√√
Hydraulic connection to Marina del Rey (7)		√	√	√√	
Fewer culverts and tide gates; more breaches and levee removal (7, 8)			√	√	√√
Larger contiguous areas of estuarine habitat with fewer roads and more channels (4)			√	√	√√

Table 4-2. Summary of Hydrology, Sediment and Water Quality Characteristics

	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Full tidal range (1)		√	√√	√√√	√√√
Large channel network (6)		√	√√	√√	√√√
Daylights culverts, creates breaches (8)	√	√	√√	√√	√√
Large tidal prism (5, 7)		√	√√	√√√	√√√√
Short residence time (5)		√√	√√	√	√√√
Long excursion length (7)		√	√√	√√√	√√√
Control of flows by gates (8)	√	√			
Maintains existing flood levels (9)	√	√			
Increase in flood storage (9)			√√	√√√	√√√
Stormwater wetlands	√	√	√	√	√
Hydraulic connection to Marina del Rey (7)		√	√	√√	

4.2 RANKING OF ALTERNATIVES

Ranking is based upon the ability of each alternative to meet the project goals: the creation of functioning estuarine habitats, tidal circulation, connectivity of habitat areas, ability to address sediment and water quality, sustainability and maintenance. The alternatives are ranked from 1 to 5, with 1 being the highest rank.

In order to protect natural resources on the site and limit impact to wetland areas, a controlled and appropriate level of access to the Ecological Reserve would be provided as part of restoration. The alternatives are not ranked according to public access; each alternative can be modified to accommodate varying degrees of access as described in the feasibility analysis.

<u>Alternative 1 – Rank 5</u>
Alternative 1 is ranked the lowest because this alternative:

- does not achieve the project goals of creating a functional estuarine habitat;
- maintains existing upland habitat and does not provide fully tidal habitat;
- does not address existing problems of invasive species, limited buffers, poor tidal circulation, poor connectivity between habitat areas, and supports only a limited number of targeted wetland species;
- has upland areas that would require continuous management for a muted tidal system, invasive species and human impacts; and
- accommodates sea level rise through tidal muting.

<u>Alternative 2 – Rank 4</u>
Alternative 2 is ranked 4th because this alternative:

- creates fully tidal areas with better connections to Marina Del Rey although existing muted tidal areas remain;
- maintains significant upland areas;
- does not take advantage of whole site;
- does not address existing problems of invasive species, limited buffers, tidal circulation restricted by levees, poor connectivity between habitat areas;
- has upland areas that would require continuous management for a muted tidal system, invasive species and human impacts; and
- accommodates sea level rise through tidal muting.

<u>Alternative 3 – Rank 3</u>
Alternative 3 is ranked 3rd because this alternative:

- creates fully tidal areas across the whole site;

- creates complex channel networks;
- improves tidal circulation with breaches and larger connection to Marina del Rey water;
- creates large contiguous areas of habitat and large buffer areas;
- has poor connectivity between habitat areas across the site; and
- accommodates sea level rise through transgression.

<u>Alternative 4 – Rank 2</u>

Alternative 4 is ranked 2rd because this alternative:

- creates fully tidal areas across the whole site;
- creates complex channel networks;
- improves tidal circulation with breaches and larger connection to Marina del Rey water;
- creates large contiguous areas of habitat and large buffer areas;
- has poor connectivity between habitat areas across the site;
- includes subtidal habitat adjacent to wetlands using Marina Del Rey water ;
- has longer residence time in subtidal areas; and
- accommodates sea level rise through transgression.

<u>Alternative 5 – Rank 1</u>

Alternative 5 is ranked the highest because this alternative:

- is the most likely to create a functional estuarine habitat as per the project goals;
- creates the largest complex channel network;
- improves tidal circulation through a direct connection to Ballona Creek;
- has the largest tidal prism, lowest residence time, and greatest tidal excursion;
- creates the largest contiguous area of wetland;
- has the greatest connectivity across the site;
- allows interaction between the wetlands and the Creek;
- restores gradients in salinity and inundation;
- allows periodic disturbance by flooding and scouring; and
- accommodates sea level rise through transgression.

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APPENDIX A.
GOALS AND OBJECTIVES, OPPORTUNITIES AND CONSTRAINTS

Appendix A

Ballona Wetlands Restoration Plan
Goals and Objectives,
Opportunities & Constraints

The purpose of this document is to identify key characteristics of the project area that present opportunities for achieving the restoration planning goals and objectives as well as those that may limit (or place constraints on) the achievement of those goals and objectives. The ideas listed below tend to be generalized, this document is an effort to take information about the existing conditions of the area and assess what that information tells us about achieving the project's goals and objectives.

This table does not evaluate the relative importance of specific opportunities or constraints and there are internal inconsistencies among the opportunities and constraints identified. Inherent in some of the opportunities are preferences, priorities and approaches to wetland restoration and because of these differences, some conflict with one another. The purpose of this document is not to resolve these potential conflicts, but rather to be sure there is a common understanding of the project area's potential for achieving the fullest range of goals.

Goal 1: Ecosystem Restoration: Restore, enhance, and create estuarine habitat and processes in the Ballona Ecosystem to support a natural range of habitat and functions, especially as related to estuarine dependent plants and animals.

Sub-goal 1. Habitat: Preserve, restore, enhance, and create a variety of functional wetland, estuarine and other habitats representative of the Ballona Ecosystem.

Objectives:

a. Support existing and future habitat based on identified regional needs

b. Create spatial connectivity within the site

c. Create appropriate edge habitat and connectivity to adjacent areas of the Ballona Ecosystem

d. Provide landscape-level function at a regional scale addressing habitat/landscape patches, corridors, connectivity and mosaics landscapes. Provide habitat for migratory birds, fish nurseries, etc.

Opportunities	Constraints
Preserve, restore, enhance, and create multiple habitats historically associated with both the Ballona Wetlands and the region.	Because the size of the site is limited, it may not be possible to incorporate large enough patches of all historic habitat types to ensure their viability.
Restore and create fully tidal wetland habitat	Habitats are fragmented by the existing roads, infrastructure and surrounding development
Preserve and enhance seasonal ponding areas	Existing habitats on site could be displaced by future enhancement, such as the restoration of tidal inundation
Create regional habitat linkages and corridors	Site has been filled, existing soil types may not be appropriate for reestablishment of all historic habitats
Incorporate adjacent upland habitats along with transitional habitats linking wetlands and uplands.	
Restore diverse habitats based upon gradients of elevation, hydroperiod and salinity	

Sub-goal 2. Biodiversity: Preserve and increase the native biodiversity of the Ballona Ecosystem. Identify and protect multiple levels of diversity (e.g. species, habitats, biogeographic provinces and trophic structure).

Objectives:

a. Increase diversity and populations of rare and endangered plant and animal species.

b. Establish and maintain diverse native plant communities, including vascular plants, algae, and diatoms.

c. Support a diverse complement of species including: birds, fish, amphibians, reptiles, native aquatic and terrestrial invertebrates.

Opportunities	Constraints
Restore biodiversity historically associated with the region, including common, rare and locally extirpated species.	Implementation of restoration efforts will entail impacts to existing species to some degree and may need to be mitigated in some way
Strategically design habitat to ensure recruitment and survival of targeted species	Site may too small and isolated to support some species
Restore microhabitats that support various life stages of species	May become a biological sink as a result of invaders, predators or other impacts
	Restricted tidal connection could limit the species of fish that can be established

Sub-goal 3. Physical/Chemical Processes: Maintain and establish physical and chemical processes consistent with the restoration goals.

Objectives:

a. *Improve tidal circulation and enlarge the amount of area that is tidally inundated.*

b. *Manage surface and subsurface freshwater inflows to support desired on-site habitats.*

c. *Establish and maintain a sediment transport regime that supports the desired wetland functions.*

d. *Re-establish a dynamic range of hydrologic conditions (intensity and duration) to support natural ecosystem processes.*

e. *Establish and maintain biogeochemical processes representative of natural wetland ecosystems.*

Opportunities	Constraints
Increase tidal flow into the site	Flood conveyance in Ballona Creek Channel needs to be maintained
Improve tidal connectivity within the site by enlarging existing channels and culverts, and creating new channel networks	Existing tidal connections are insufficient to create and maintain a significant area of natural tidal wetland
Improve management of tide gates to create a muted tidal system with long-term management of water levels	Elevations are too high, fill disposal will be difficult
Change the roads and berms to improve habitat connections, reduce flood hazards and accommodate sea-level rise	Existing infrastructure may limit hydrologic connections within the site
Include distributary channels in the bluff deltas for coarse sediment distribution where feasible	Urban watershed negatively impacts sediment supply, water quality and hydrograph of potential freshwater sources
Restore a more natural tidal slough system linking freshwater areas to tidal marsh	Natural channel formation may be limited due to lack of tidal scour, high elevations, soil type and absence of antecedent channel network
Enhance historic Centinela Creek in Area B by increasing freshwater flows.	Limited supply of fine sediments to the site may limit march evolution over time
Reduce current flooding problems around the project area	Low-lying properties around the periphery of the site may need to be protected from flooding
Daylight outlet culvert of the Freshwater Marsh	The upstream reach of Centinela Creek has been diverted.

Physical/Chemical Processes, continued

Opportunities	Constraints
Modify Ballona Creek levees by realignment or changing the form of the bank	
Coordinate the management of tide gates in the Ballona Ecosystem (Del Rey Lagoon, Ballona Lagoon & Ballona Wetlands)	

Sub-goal 4. Sustainability: Facilitate the conservation and restoration of natural resources in a manner that maintains and improves the ecological integrity, function, diversity and productivity for future generations.

Objectives:

- *a.* *Accommodate potential sea level rise for transitional habitat provide appropriate elevations to accommodate habitat shifts*
- *b.* *Use self-sustaining, low maintenance systems where possible*
- *c.* *Minimize future adverse effects of nuisance species, including non-native, invasive species, feral predators and disease vectors.*
- *d.* *Protect the wetlands from adverse impacts caused by contaminants in influent water or sediment.*
- *e.* *Plan for the longterm management of the site*

Opportunities	Constraints
Accommodate rising sea level by using site slope to allow habitat migration	Future development of surrounding areas
Provide sufficient tidal flow to maintain channel system	Maintenance and management resources have not been identified
Incorporate principles of adaptive management in restoration design to phase implementation and test different methods	Some sources of water and sediment to the site may be contaminated, those contaminants may accumulate in the restoration area
Utilize (or employ) existing organizations to maintain and implement stewardship activities at the site	Accumulation of contaminants or pollutants on the site: including trash and aerial deposition
Use low maintenance processes to improve water quality of urban runoff entering the wetlands	Site vulnerable to invasive species, onsite and from local area
Design site to minimize the impacts of streetlights, traffic noise and other urban characteristics on habitat values	Rising sea level may inundate low lying areas
Reduce management costs associated with tide gates	Infrastructure, such as gas facilities, needs to be maintained

Goal 2: Social and Socioeconomic Values: Create opportunities for aesthetic, cultural, recreation, research and educational use of the Ballona Ecosystem that are compatible with the environmentally sensitive resources of the area.

Sub-goal 1. Public Access: Design enhanced access to and within the Ballona Ecosystem consistent with ecosystem preservation and restoration values in a safe, consistent, coherent and functional manner.

Objectives:

a. *Develop gateway entrances that attract, welcome and inform ecosystem visitors.*

b. *Phase-out inappropriate or uncontrolled access points.*

c. *Create public outreach, education and interpretive opportunities for visitors, organizations and institutions.*

d. *Develop appropriate signage that enhances visitor understanding of wetland restoration efforts; increase public awareness of local biological and physical resources present within Ballona Wetlands.*

e. *Develop overlooks and connections accessible to pedestrian, bike and bus users and provide the appropriate signage to facilitate such access.*

f. *Provide potential opportunities for the public to participate in restoration and monitoring efforts.*

Opportunities	Constraints
Develop parking areas and designated entry points for the public on currently disturbed or developed areas.	Informal access points and associated unauthorized and uncontrolled uses
Develop interpretative components to educate the public on the values of wetland functions and habitat, build on existing educational programs	Public access areas reduce the area available for restoration
Design access with buffers between people and sensitive habitat areas	
Install facilities to serve visitors of the site	
Improve overlook points. For example, potential to use sediment material onsite to create high points	
Install consistent signage	

Public Access, continued

Opportunities	Constraints
Provide access that serves people with disabilities	
Incorporate educational and stewardship activities into the Little League program	

Sub-goal 2. Cultural Access and Preservation: Initiate formal and informal consultation with representatives of the Gabrielino/Tongva Tribal Council to develop guidelines that contribute to the preservation of sacred and cultural sites.

Opportunities	Constraints
Provide access for cultural use of the site by native people	Protection of cultural resources on site may constrain site design
Preserve cultural resources onsite	
Educate the public regarding archaeological and historic resources	

Sub-goal 3. Recreational Use: Design site to accommodate an appropriate level of fishing, boating, walking, and other activities consistent with the Ecological Reserve Designation and ecosystem restoration values.

Objectives:

a. *Provide public trails and viewing areas around the perimeter of the wetlands with interpretive displays at selected locations.*

b. *Concentrate potentially incompatible human activities in non-sensitive areas*

Opportunities	Constraints
Develop a recreational plan compatible with the Ecological Reserve designation	Existing unauthorized uses, such as BMX use and dog walking, may be incompatible with Ecological Reserve designation
Integrate existing trails, features and disturbed areas into the designated trail network.	
Integrate trail network with local and regional trails, bikeways and transportation systems	

Sub-goal 4. Public Safety and Security: Design public access so that the wetlands are a safe place to visit.

Objectives:

a. *Design access to minimize maintenance costs*

b. *Provide access points at locations responsive to the needs of law enforcement.*

c. *Create and maintain access points in a manner that minimizes safety concerns and hazards.*

Opportunities	Constraints
Provide for a safe visitor experience through site design	Major roadways cross the site, fast moving traffic, limited places for parking
Consolidate Gas Company facilities, separate from habitat areas and public access	Poorly secured site, hard to control all unauthorized access in an urban setting
Improve traffic-related safety concerns through crosswalks, walkways and safe parking areas	Unknown extent of methane or other potentially harmful substances
Improve emergency access to the site	Need to protect public health by limiting disease vectors (such as mosquitos)

APPENDIX B.
HABITAT DESCRIPTIONS FOR RESTORATION ALTERNATIVES

Draft

BALLONA WETLAND RESTORATION PROJECT: HABITAT DESCRIPTIONS FOR RESTORATION ALTERNATIVES

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I. INTRODUCTION

The Ballona Wetlands Restoration Project seeks to restore ecosystem structure, function, and processes at Ballona Wetlands, in particular those related to the support of biodiversity. A method of organizing biological diversity information for the Ballona Wetland Restoration Project is to group plants and animals by the "habitat" in which they are most likely to be sustained under improved conditions. One measure of progress toward achieving habitat restoration goals, therefore, is a determination of whether or not these targeted organisms are supported by the manipulated habitats to a measurable and acceptable level of sustained occurrence. Performance criteria can be established to measure establishment of species populations in these habitats. Physical parameters of the environmental also can be monitored and compared against data from reference sites or expected conditions to determine if the restored areas are performing within a range of anticipated values.

The following are generalized groups of habitats (organized by category and type) with information regarding characteristics such as structural feature, ecosystem function, and landscape process as well as dominant or characteristic plant species, characteristic animal species, and presumed extirpated or rare or endangered species that could be candidates for translocation and recovery experiments or goals within the Ballona Ecosystem.

The categories and subcategories of habitats are arranged from estuarine deepwater habitats and wetlands to palustrine wetlands, followed by uplands within the Ballona Ecosystem and within the estuarine category from subtidal (deepwater) and intertidal open water and non-vegetated types of habitats to vegetated types, generally going from lower elevation and hence more frequently flooded types to less frequently flooded types, an important distinction when assessing habitat characteristics. Habitat restoration design as it relates to the potential for significant sea level rise due to global climate change is an important consideration for the Ballona Wetland Restoration Science Advisory Committee during the evaluation of restoration alternatives for the Ballona Ecosystem.

II. LIST OF HABITAT CATEGORIES AND TYPES

Habitat Category I – Estuarine Open Water: Non-vegetated Habitats and Flooded Substrates:

1. Deepwater Habitats (mud and sand substrates) – Open Water Subtidal Conditions

2. Deepwater Subtidal and Wetland Intertidal Channels (cobble/gravel and riprap substrates) – Open Water Subtidal, Intertidal, and High Tide Conditions

3. Intertidal Wetland Habitats (sand and mud substrates) – Intertidal and High Tide Conditions

Habitat Category II - Estuarine Non-vegetated Intertidal Wetland Habitats

4. Intertidal Margins, Beds, Banks, and Benches (mud and sand substrates) - Low Tide Conditions

5. Intertidal Channels (cobble/gravel and riprap substrates) - Low Tide Condition

6. Mudflats

7. Hyperhaline Salt Flats

Habitat Category III - Estuarine Vegetated Wetlands:

8. Aquatic Bed Wetlands

9. Cordgrass (Low) Marsh

10. Marsh Plain (Middle Marsh)

11. High Marsh (clay/mud or sand/loam substrates)

12. High Marsh Transition Zone (including Euryhaline and Hyperhaline Habitats)

13. Brackish Marsh (an associated Open Water Habitat)

Habitat Category IV - Palustrine Nontidal Wetlands:

14. Transitional Emergent Wetlands (delta distributaries and margins of estuaries)

15. Freshwater Marsh

16. Seasonal Palustrine Wetlands (including Haline Vernal Wetlands)

17. Palustrine Scrub/Shrub Wetland (= DFG "Riparian Scrub")

18. Palustrine Forested Wetland (= DFG "Riparian Woodland"?)

Habitat Category V - Upland Habitats:

19. Grasslands (= DFG Non-native Herbaceous Vegetation)

20. Coastal Scrub (including Coastal Bluff Scrub)

21. Coastal Dune Scrub and Dune Herbs (including Foredunes)

22. Forests, Woodlands, Groves, and Tree Rows (including DFG "Eucalyptus Grove")

III. HABITAT DESCRIPTIONS

Habitat Category I – Estuarine Open Water: Non-vegetated Habitats and Flooded Substrates:

In the estuarine system, deepwater habitats are characterized by the subtidal water regime and wetlands are characterized by various non-storm-influenced intertidal water regimes including irregularly exposed, regularly flooded, and irregularly flooded regimes.

1. Deepwater Habitats (mud and sand substrates) – Open Water Subtidal Conditions

Narrative (refer to other open water habitats for additional information): Subtidal deepwater habitats include channels, bays, basins, and other features, which at extreme low water do not drain with the outgoing tides. The subtidal estuarine water regime results in permanently flooded habitats and permanent bodies of open water. These habitats are generally considered truly aquatic systems and are adjacent to and down-slope from tidal estuarine wetlands. Estuaries with extensive deepwater habitat areas often support adjacent areas of intertidal mudflat and low marsh wetland habitats.

The "plants" of channels and creeks, both intertidal and subtidal, are generally nonvascular taxa, but under brackish conditions may include various aquatic bed and emergent vascular species. The non-vascular plants include phytoplankton (e.g., diatoms) and macroalgae, which, along with the detritus from decomposed Cordgrass (*Spartina foliosa*), are often direct links in the estuarine food chain (i.e., are directly consumed by higher order consumers). Benthic invertebrates are the most visible consumers of detritus, algae and plankton. Crabs and snails graze on detritus and macroalgae, while bivalve mollusks filter feed on phytoplankton. Polychaete worms inhabit the fine sediments of tidal creeks, while fish exploit the water column and substrate surface.

Fish use of subtidal habitats can be categorized by various functional groups or guilds including, for example, (1) adult and juvenile marine fish, such as Leopard Sharks (*Triakis semifasciata*), Grey Smoothhounds (*Mustelus californicus)*, and Stripped Mullet (*Mugil cephalus*) that enter estuaries with incoming tides to forage in estuaries, (2) adult marine fish such as Round Rays that feed and mate in estuaries; (3) marine fish such as California Halibut (*Paralichthys californicus*) that use flooded estuarine habitats especially channels as nursery habitat for young-of-the-year juvenile populations; (4) estuarine restricted fish such as Long-jawed Mudsuckers (*Gillichthys mirabilis*) that spend their entire life cycle in estuaries; (5) estuarine fish such as Tidewater Gobies (*Eucyclobius newberryi*) that are restricted to particular types of estuaries with brackish water but that survive under marine conditions during floods and return to estuaries under reduced runoff conditions; (6) anadromous fish such a Steelhead Trout (*Oncorhynchus mykiss*) that live under marine conditions as adults but enter estuaries to spawn either in estuaries or in rivers and streams on adjacent watersheds. In general most estuaries do not support all of the fish guilds, but collectively, southern California estuaries as a whole provide functions for each guild.

Estuarine open water habitats such as those provided by permanently flooded conditions are important foraging areas for birds from other habitats. Of note is the endangered California Least Tern (*Sterna antillarum browni*), which breeds on sandy habitats adjacent to marine and estuarine wetlands and forages on small fish, primarily Top Smelt *(Atherinops affinis)* and Northern Anchovy *(Engraulis mordax)* in the relatively shallow water of estuaries. Shallow water habitat also is important for foraging by wading birds [e.g., Snowy and Great Egrets (*Egretta thula*, *Casmerodias albus*) and Green, Black-crown Night, and Great Blue Herons (*Butorides virescens*, *Nycticorax nycticorax*, *Ardea herodias*], wading shore birds [e.g., Willet (*Catoptrophorus semipalmatus*)], diving birds including grebes, mergansers, and many ducks. The endangered Brown Pelican (*Pelecanus occidentalis*) is a frequent forager in estuarine open water habitats such as those provided by permanently, semi-permanently flooded, and intertidal water regimes. Open waters also provide low-tide refuges for species that move on to the mudflat and marsh plain during high tide.

Structural features: bays, lagoons, channels.

Deepwater habitats: Estuarine Unconsolidated Bottom and Rocky Bottom, and Estuarine Streambed Deepwater Habitats.

Physical processes: estuarine hydrology including tidal hydraulics; fluvial hydrology in river and creek mouth estuaries; marine and shoreline processes associated with estuary mouth dynamics; sediment transport; biogeochemistry.

Water regime/hydrology: subtidal, permanently flooded (i.e., deepwater habitats).

Salinity: haline to mixohaline.

Dominant/characteristic plant(s): diatoms, algae.

Associated plant(s): *Zostera marina*, *Potamogeton pectinatus, Ruppia maritima*, *Ruppia chirrosa* in various types of Estuarine Aquatic Bed Deepwater Habitat.

Characteristic animals: perhaps over 35 species of fish depending on type of estuary and guild of fishes present; suites of benthic and epibenthic invertebrates including various mollusks, crustaceans, worms, etc.; wading birds; dabbling and diving waterfowl; foraging Osprey.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; resident and migratory bird resting and foraging habitat, source populations of marsh-plain fish species (e.g., California Killifish, Long-jaw Mudsuckers); nutrient removal (denitrification at anoxic-soil/oxic-water interface; also P removal with sediment deposition); maintain predictable environment by maintaining hydrological connectivity and reducing extremes of drought (hypersalinity) and/or freshwater flooding (hyposalinity).

Recovery opportunities: foraging habitat for California Least Tern (*Sterna antillarum browni*), California Brown Pelican (*Pelicanus occidentalis californicus*), and Osprey (*Pandion haliaetus*); flat fish nursery habitat including California Halibut (*Paralichthys californicus*), Starry Flounder (*Platichthys stellatus*), and Diamond Turbot (*Hypsopsetta guttulata*).

Management Issues: water quality.

2. Deepwater Subtidal and Wetland Intertidal Channels (cobble/gravel and riprap substrates) – Open Water Subtidal, Intertidal, and High Tide Conditions

Narrative (refer to other open water habitats for additional information): Estuarine channels and creeks play a critical role in salt marshes as they convey tidal waters and associated nutrients and dissolved gases. They also support a complex assemblage of plants and animals, and are particularly diverse when cobble beds provide surfaces for attachment by some invertebrates (e.g., mussels, oysters, barnacles, and limpets) and protective habitats for others (e.g., crabs, gobies). This substrate differences separates this habitat type (#2) from type #3 (sand and mud substrates).

Estuarine channels and creeks are subjected to a wide variety of environmental conditions including fluctuations in salinity and depth of tidal inundation. Typically, tidal flushing is greatest at the tidal inlet and decreases with distance from the inlet. This general gradient, in turn influences, water movement, salinity, temperature, nutrients, and dissolved gases. These environmental factors influence the species composition, distribution, and population dynamics of the channel fauna.

Structural features: marine cobble deltas, cobble channel beds and bars, riprap.

Deepwater Habitats and Wetlands: Estuarine Streambed and Unconsolidated Shore and Bottom (cobble/gravel) Wetlands and Estuarine Rocky Shore and Rocky Bottom (boulder) Wetlands and Estuarine Deepwater Habitats.

Physical processes: estuarine hydrology including tidal hydraulics; fluvial hydrology in river and creek mouth estuaries; marine and shoreline processes associated with estuary mouth dynamics; sediment transport; biogeochemistry.

Water regime/hydrology: subtidal, permanently flooded (i.e., deepwater habitats); intertidal irregularly exposed, regularly flooded, irregularly flooded.

Salinity: haline and mixohaline.

Dominant/characteristic plant(s): micro-algae (e.g., diatoms, cyanobacteria); macro-algae (e.g., *Ulva* and *Enteromorpha*).

Associated plant(s): none.

Characteristic animals: oysters; mussels; crustaceans including Shore, Mud, and Fiddler Crabs; possibly over 70 species of invertebrates in cobble beds; wading birds; dabbling and diving waterfowl; foraging Osprey. Many estuarine fish species also use these channels depending on the type of estuary and habitat.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; biofiltration (e.g., bivalve filtration from mussels, oysters, etc.), nutrient cycling/biogeochemistry; N and P removal as above; carbon removal by shell forming mollusks.

Recovery opportunities: *Ostreola conchaphila* (native oyster) on cobble-gravel and other hard substrates; foraging habitat for California Least Tern, California Brown Pelican, and Osprey.

Management issues: water quality including sedimentation; loss of habitat due to dredging in some estuaries; expansion of habitat in other estuaries due to ongoing accretion of marine deltas.

3. Intertidal Wetland Habitats (sand and mud substrates) – Intertidal and High Tide Conditions

Narrative (refer to other open water habitats for additional information): Intertidal channels and creeks play a critical role in salt marshes as they convey tidal waters and associated nutrients and dissolved gases. They also support a complex assemblage of plants and animals. Estuarine channels and creeks are subjected to a wide variety of environmental conditions. Typically, tidal flushing is greatest at the tidal inlet and decreases with distance from the inlet. This general gradient, in turn influences, water movement, salinity, temperature, nutrients, and dissolved gases. These environmental factors influence the species composition, distribution, and population dynamics of the channel fauna.

Structural features: intertidal channels, creeks, basins, banks, benches, marsh plain, as well as margins of deepwater habitats in bays, lagoons and subtidal channels, natural creek levees and back-levee depressions (pools).

Wetlands: Estuarine Unconsolidated Bottom, Unconsolidated Shore, Streambed, Aquatic Bed, and Emergent wetlands.

Physical processes: estuarine hydrology including tidal hydraulics; fluvial processes in tidal river and stream channels; marine and shoreline processes in estuary mouths; sediment transport; biogeochemistry.

Water regime/hydrology: intertidal – semi-permanently flooded, irregularly exposed, regularly flooded, irregularly flooded.

Salinity: haline or mixohaline.

Dominant/characteristic plant(s): diatoms.

Associated plant(s): none or *Spartina foliosa* and *Sarcocornia pacifica* (*Salicornia virginica*), and other species as appropriate on flooded habitat margins and the marsh plain; channel banks provide substrate for germination of *Ulva* spp. spores, which then grow into blades that break free and become highly productive floating mats.

Characteristic animals: perhaps over 35 species of fish depending on type of estuary and habitat; suite of benthic and epibenthic invertebrates including Ce*rithidea californica* (California Horn Snail) and various clam genera including *Tagelus, Macoma, Protothaca*; wading birds including egrets and herons; dabbling and diving waterfowl; and foraging Osprey.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; resident and migratory bird resting and foraging habitat, source populations of marsh-plain fish species (e.g., killifish, mudsuckers); nutrient cycling/biogeochemistry; N and P removal.

Recovery opportunities: flat fish habitat including California Halibut, Starry Flounder, and Diamond Turbot; foraging habitat for California Least Tern, Brown Pelican, and Osprey.

Management issues: water quality including sedimentation; loss of habitat due to dredging in some estuaries; expansion of habitat in other estuaries due to ongoing accretion of marine deltas.

Habitat Category II
Estuarine Non-vegetated Intertidal Wetland Habitats

4. Intertidal Margins, Beds, Banks, and Benches (mud and sand substrates) - Low Tide Conditions

Narrative: Within the intertidal wetland portion of estuaries and in addition to mudflat features for those estuaries that support flats, other non-vegetated structures, including channel beds, banks and benches, often occur that can have similar functions to mudflats exposed at low tide conditions. These structures are group together here when lacking aquatic bed or emergent wetland vegetation cover.

Structural features: bay and lagoon margins and beds, bottoms, banks, and benches of estuarine channels and creeks.

Wetlands: Estuarine Streambed, Unconsolidated Shore, and Unconsolidated Bottom Wetlands.

Physical Processes: estuarine hydrology including tidal hydraulics; biogeochemistry.

Water regime/hydrology: irregularly exposed, regularly flooded.

Salinity: haline and mixohaline.

Dominant/characteristic plant(s): diatoms.

Associated plant(s): none or *Spartina foliosa*, *Sarcocornia pacifica* (*Salicornia virginica*) on margins; channel banks provide substrate for germination of *Ulva* spp. spores, which then grow into blades that break free and become highly productive floating mats.

Characteristic animals: suite of benthic and epibenthic invertebrates including C*erithidea californica* (California Horn Snail) and various clam genera including *Tagelus, Macoma, Protothaca*; wading and shore birds (foraging); polychaetes; oligochaetes.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; biofiltration, food chain support and nutrient cycling, N and P removal, C removal by bivalves.

Recovery opportunities: channel bench and similar habitat for Fiddler Crabs (*Uca crenulata*).

Management issues: water quality and sedimentation issues.

5. Intertidal Channels (cobble/gravel and riprap substrates) - Low Tide Conditions

Narrative: Estuarine channels and creeks play a critical role in salt marshes as they convey tidal waters and associated nutrients and dissolved gases. They also support a complex assemblage of plants and animals, and are particularly diverse when cobble beds provide surfaces for attachment by some invertebrates (e.g., mussels, oysters, barnacles, and limpets) and protective habitats for others (e.g., crabs, gobies). Estuarine channels and creeks are subjected to a wide variety of environmental conditions including fluctuations in salinity and depth of tidal inundation. Typically, tidal flushing is greatest at the tidal inlet and decreases with distance from the inlet. This general gradient, in turn influences, water movement, salinity, temperature, nutrients, and dissolved gases. These environmental factors influence the species composition, distribution, and population dynamics of the channel fauna.

Structural features: marine cobble deltas, cobble channel beds and bars, riprap.

Wetlands: Estuarine Unconsolidated Shore and Bottom (cobble/gravel) and Estuarine Rocky Shore and Rocky Bottom (boulder).

Physical processes: estuarine hydrology including tidal hydraulics; fluvial hydrology in river and creek mouth estuaries; marine and shoreline processes associated with estuary mouth dynamics; biogeochemistry.

Water regime/hydrology: intertidal irregularly exposed, regularly flooded, irregularly flooded.

Salinity: haline and mixohaline.

Dominant/characteristic plant(s): micro-algae (diatoms, cyanobacteria); macro-algae.

Associated plant(s): none.

Characteristic animals: oysters and mussels (hard substrates) crustaceans including Shore, Mud, and Fiddler Crabs; possibly over 70 species of invertebrates in cobble beds.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; low tide resting habitat for resident and migratory birds and foraging habitat for shorebirds and clapper rail; biofiltration (by bivalves), nutrient cycling/biogeochemistry; food chain support.

Recovery opportunities: *Ostreola conchaphila* (native oyster), shore bird feeding habitat.

Management issues: water quality including sedimentation**.**

6. Mudflats

Narrative: Extensive mudflats generally occur in estuaries that have gradually sloping shorelines and are sufficiently large enough to support a extensive open water and low marsh habitats or that are flooded for long periods due to closure of the estuary mouth or reduced tidal flow, presenting development of a vegetated marsh plain. Many estuaries that lack extensive mudflat habitat support functions for shore bird foraging and maintenance of invertebrate biodiversity because tidal channel beds and banks that are exposed at low tide provide similar habitat areas.

Structural features: down slope from low marsh and the marsh plain.

Wetlands: Estuarine Unconsolidated Shore and Unconsolidated Bottom Wetlands, and Estuarine Aquatic Bed Wetland (Irregularly Exposed).

Physical processes: extended periods of inundation prevent vascular plant growth.

Water regime/hydrology: regularly (daily) flooded by high tides.

Salinity: haline.

Dominant/characteristic plant(s): micro-algae, especially diatoms (over 100 species identified at some estuaries in s. CA).

Associated plant(s): at lowest tides, Eelgrass (*Zostera marina*) may be exposed (Estuarine Aquatic Bed Wetland, Irregularly Exposed) if present in estuary; macroalgae (e.g., *Ulva* spp.).

Characteristic animals: invertebrates: crabs, shrimp, clams, etc. (some are listed above regarding intertidal creeks] and shorebirds.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; nitrogen fixation by microalgae, sediment accumulation (and P removal), nutrient cycling, denitrification, invertebrate habitat, shorebird foraging.

Recovery opportunities: shorebird feeding habitat.

Management issues: mudflat is a very limited in most southern California estuaries. Sedimentation elevates the mudflat to levels that can support vascular plants; once vascular plants are established, the habitat is less suitable for shorebird feeding.

7. Hyperhaline Salt Flats

Narrative: Whereas intertidal mudflats occur at low elevations, permanently hypersaline salt flats are an important part of continuum from upland to low marsh. Salt flats but generally form only when the elevational gradient of the marsh plain is sufficient low for this evaporate zone to form at the higher levels of infrequent tidal inundation. As with restoration of all tide influenced habitats, establishment of hyperhaline salt flat and adjacent euryhaline marsh habitats require careful consideration of elevation, frequency and duration of inundation, and substrate texture. Salt flats alternate between flooded and drought conditions, which prevent most plants from occurring or from developing closed canopies if they are present. The open flat, with an occasional subshrub (e.g., *Arthrocnemum* (*Salicornia*) *subterminale*), offers certain shore birds a rare habitat that allows both feeding and refuge from predators.

Structural features: shallow depressions of upper marsh plain, banks, upper tidal deltas

Wetlands: Estuarine Unconsolidated Shore (Irregularly Flooded)

Physical processes: Estuarine processes including tidal hydraulics; geochemical processes including formation of evaporate deposits; salt concentration so that soils prevent invasion by exotic plants.

Water regime/hydrology: irregularly flooded by tides; < 25% of high tide.

Salinity: hyperhaline **-** 200 g/L or more in dry season.

Dominant/characteristic plant(s): none; scattered *Arthrocnemum subterminale.*

Associated plant(s): none.

Characteristic animals: Staphylinid beetles; shorebirds use these areas as refugia.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; resting and foraging areas for migratory birds, especially during high tides when other habitats are inundated.

Recovery opportunities: Tiger beetles (?); Elegant Tern (*Sterna elegans*) roosting habitat.

Management issues: Naturally occurring salt flat habitats, such as along the margins of estuarine deltas, were often some of the first areas filled in and developed in southern California estuaries. The Ballona Ecosystem supports habitat on dredge spoil in areas that were previously lower elevation habitats on the marsh plain. Preservation of salt plat habitat and functions may require relocation of the habitat if existing conditions are altered as part of a restoration plan.

Habitat Category III
Estuarine vegetated wetlands:

8. Aquatic Bed Wetlands

Narrative: This habitat category as described herein includes a number of different types depending on the structure of the habitat and the dominant organism, such as algae, bluegreen algae, vascular plants, etc. For example, nutrient-rich, estuarine channels are likely to be dominated by floating *Enteromorpha intestinalis* whereas nutrient-rich, exposed mud flats may be characterized by *Enteromorpha clathrata.* Lagoons, channels, and flooded marsh depressions with haline salinities may support dense, submersed colonies of *Ruppia maritima,* whereas similar areas that are mixohaline are likely to be characterized by *Ruppia cirrhosa* and other vascular aquatic-bed species.

Structural features: depressions in marsh plain, intertidal and subtidal channels, lagoons, and bays; haline vernal wetlands.

Wetlands: Estuarine Aquatic Bed Algal; Estuarine Aquatic Bed Rooted Vascular.

Physical processes: Estuarine processes including hydraulics.

Water regime/hydrology: variable depending on class of wetland and type of estuarine system; includes permanently flooded, semi-permanently flooded; intermittently exposed, regularly flooded, irregularly flooded.

Salinity: haline; mixo-haline.

Dominant/characteristic plant(s): Algae – various species represented including Enteromorpha, *Ulva*, *Porphyra*, etc, but many examples are not large enough or provide a dense enough cover to warrant distinction as a wetland type; Rooted vascular plants – various species depending on conditions, including *Ruppia maritima* (haline or euryhaline) and *Potamogeton pectinatus*, *Ruppia cirrhosa*, and *Zannichellia palustris* (mixohaline). Floating vascular plants – e.g., *Lemna gibba* (mixohaline).

Associated plant(s): as noted above or various emergent species in adjacent wetlands.

Characteristic animals: food and habitat for aquatic invertebrate species and for small fish species, including Tidewater Goby (*Eucyclogobius newberryi*) under mixohaline conditions.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; food chain support for waterfowl such as dabbling ducks; bio-assimilation of nutrient pollution; nutrient cycling/biogeochemistry; N and P removal.

Recovery opportunities: Mixohaline (i.e., brackish) environments that support *Ruppia cirrhosa* are frequently habitat for populations of Tidewater Goby (*Eucyclogobius newberryi)*, a federal endangered and state fish of concern.

Management issues: water quality.

9. Cordgrass (Low) Marsh

Narrative: Low salt marsh is regularly and daily inundated by tides and is dominated by California Cordgrass (*Spartina foliosa*) that forms dense monotypic stands, primarily along channel edges and adjacent to mudflats. At its lower elevation, cordgrass intergrades with mudflat habitat; at its upper elevation it intergrades with a mosaic of mid-marsh species. California Cordgrass is a highly productive species. It decomposes to form the base of the detrital food chain that supports many lower order estuarine consumers. The tall canopy provides cover for birds such as Curlew and Pintail Duck, which forage during migration.

Many of the animals of the low marsh are adapted to periods of frequent inundation. These include California horn snail, Lined Shore Crab *(Pachygrapsus crassipes)*, Yellow Shore Crab *(Hemigrapsus oregonensis)*, and Fiddler Crab *(Uca crenulata)*. The best-studied animal of the low marsh is the federal and state-endangered Light-footed Clapper Rail (*Rallus longirostrus levipes*). This species generally nests in the cordgrass that grows in the low marsh and feeds on fishes and crustaceans in adjacent tidal creeks. It also nests in pickleweed on the marsh plain and in bulrushes in brackish marsh vegetation.

Structural features: lower edge of the marsh plain, tidal channel margins

Wetlands: Estuarine Emergent Persistent Wetland (Regularly Flooded)

Physical processes: Estuarine processes including tidal hydraulics; sediment accumulation.

Water regime/hydrology: regular (daily) flooding by tides

Salinity: hypersaline and saline to brackish

Dominant/characteristic plant(s): *Spartina foliosa;* also patches of *Batis maritima.*

Associated plant(s): *Salicornia bigelovii.*

Characteristic animals: *Pachygrapsus crassipes; Hemigrapsus oregonensis; Uca crenulata;* California Horn Snail (*Cerithidea californica).*

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; sediment accumulation and reduced erosion along channel edges; nutrient cycling/biogeochemistry; N and P removal; C sequestration; high rates of primary productivity and food web support; invertebrate habitat; fish habitat when flooded by tide water.

Recovery opportunities: *Spartina foliosa* (where it previously existed or to compensate for areas where its population is declining); Light-footed Clapper Rail (Fed. & State endangered bird).

Management issues: potential impacts from native and introduced predators of marsh nesting birds (Light-footed Clapper Rail); excessive sedimentation.

10. Marsh Plain (Middle Marsh)

Narrative: Intermediate elevations within the salt marsh are inundated irregularly by tides but at a greater frequency than are higher elevations. As a result, the plant species that inhabit this elevation are adapted to occasional prolonged inundation. The dominant plant is Pickleweed [*Sarcocornia pacifica* (*Salicornia virginica*)] a perennial with the broadest elevation range of all salt marsh species. Other common mid-marsh species include Saltwort (*Batis maritima*), Arrow-grass (*Triglochin concinnum*), Estero Sea-blite (*Suaeda esteroa*), and Jaumea (*Jaumea carnosa*). An important feature of the marsh plain is its topographic heterogeneity, which includes creeks, creek banks, levees, and shallow depressions. The creeks provide habitat for Longjaw Mudsucker (*Gillichthys mirabilis*);

creek levees tend to support more plant species than the plain (e.g., Estero Sea-blite is especially abundant near creeks), and the shallow depressions (5-10 cm) tend to reduce biomass of perennial pickleweed. When this dominant is subdued, the annual pickleweed (*Salicornia bigelovii*) can establish and persist. Deeper depressions (≥10 cm) retain tidal water and become feeding oases for the California Killifish (*Fungulus parvipinnus*); shallow depressions develop algal growths that support dense populations of invertebrates that are suitable prey for fish.

The animals of the mid-marsh are abundant and diverse. Food is abundant in the form of algae and vascular plant detritus. Animals that feed directly on algae include Ephydrid flies, amphipods, and snails such as the Olive Snail (*Melampus olivaceus*) in marsh vegetation and California Horn Snail (*Cerithidea californica*) in open flats and channels. A variety of birds forage in the mid-marsh, especially during higher tides when mudflats are under water, including Willet *(Catotrophorus semipalmatus)*, Marbled Godwit *(Limosa fedoa)*, Long-billed Curlew *(Numenius americanus)*, Great Blue Heron *(Ardea herodias)*, and Great Egret *(Ardea alba)*. The state endangered Belding's Savannah Sparrow *(Passerculus sandwichensis beldingii)* inhabits the marsh plain where it prefers to nest in pickleweed in mid and high marsh conditions.

Structural features: mid-marsh plain, rivulets, tidal pools, creek-side levees and back-levee depressions.

Wetlands: Estuarine Emergent Persistent Wetland (Irregularly Flooded).

Physical processes: estuarine processes including tidal hydraulics and maintenance of sediment and elevation.

Water regime/hydrology: irregularly flooded by tides (ca. 50% of high tides).

Salinity: saline to hypersaline.

Dominant/characteristic plant(s): *Sarcocornia pacifica* (*Salicornia virginica*).

Associated plant(s): *Frankenia salina, Jaumea carnosa, Distichlis spicata, Suaeda esteroa, Triglochin concinna.*

Characteristic animals: *Fundulus parvipinnis* (California Killifish); *Melampus* olivaceus; polychaetes; oligochaetes.

Ecosystem functions: plant diversity support (the mash plain is potentially diverse in native halophytes), habitat for rare, endangered, and special interest species; insect support, nutrient cycling/biogeochemistry; N and P removal; primary productivity and detrital food web support.

Recovery opportunities: Belding's Savannah Sparrow (State endangered bird); Long-billed Curlew (*Numenius americanus*); Estero Seep-weed (*Suaeda esteroa*); Northern Harrier (*Circus cyaneus*).

Management issues: sedimentation (increase in elevation and loss of shallow depressions that form pools and create feeding oases, or erosion (decrease in elevation); potential impacts to marsh nesting birds (Belding's Savannah Sparrow).

11. High Marsh (clay/mud or sand/loam substrates)

Narrative: High marsh habitats are irregularly to intermittently inundated by tidal water and generally range from saline to hypersaline conditions. Plants that comprise the high marsh include the Parish's Glasswort [*Arthrocnemum subterminale* (*Salicornia subterminalis*)], Shoregrass (*Monanthochloe littoralis)*, Alkali Heath (*Frankenia salina*), and Sea Lavender *(Limonium californicum)*. The vegetation varies depending on the drainage and density of the soil (i.e., ratio of clay to sand), which often is correlated with salinity. Vegetation in dense, hypersaline (salinity greater than seawater) or euryhaline (fluctuating salinity, seasonal hypersalinity) is quite different than loose, sandy soils. The endangered Salt Marsh Bird's Beak *(Cordylanthus maritimus* spp. *maritimus)* occurs in high marsh and is more abundant in sandy soils. Likely the open canopies of sandy areas allow seeds to germinate after rainfall while also offering roots for this hemiparasite to parasitize. High marsh vegetation provides habitat for Belding's Savannah Sparrow, staphylinid beetles, the snail *Assiminea transluscens*, and other estuarine restricted species.

Structural features: upper marsh plain, slopes of berms and banks; upper tidal deltas.

Wetlands: Estuarine Emergent Persistent Wetland (Irregularly Flooded).

Physical processes: Estuarine processes including tidal hydraulics; also Aeolian-influenced processes if adjacent to dune systems, or fluvial-influenced if on a delta.

Water regime/hydrology: Irregularly flooded by tides (< 50% of high tides.

Salinity: saline, hyperhaline, euryhaline.

Dominant/characteristic plant(s): *Arthrocnemum subterminale*; *Monanthochloe littoralis.*

Associated plant(s): *Sarcocornia pacifica, Limonium californicum, Distichlis spicata, Spergularia macrotheca, Atriplex watsonii, Frankenia salina*

Characteristic animals: *Asiminea transluscens* (snail); Belding's Savannah Sparrow; Cottontail; Ground Squirrels.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; high tide refuge for Light-footed Clapper Rail and Belding's Savannah Sparrow.

Recovery opportunities: Light-footed Clapper Rail (Fed. & State endangered bird); Belding's Savannah Sparrow (State endangered bird); Northern harrier (*Circus cyaneus*) foraging habitat; *Cordylanthus maritimus* ssp. *maritimus* (Fed. & State endangered plant)

Management issues: Loss of historic habitat due to filling and development. Vulnerable to invasion by many introduced invasive plant species including introduced species of *Limonium* (Sea Lavender), are less likely to invade lower elevations habitats, and introduced grass species such as Rabbit's Foot Grass (*Polypogon monspeliensis*), Sicklegrass (*Parapholis incurva*), Italian Ryegrass (*Lolium multiflorum*) because it is rarely tidal and can have very low salinities at least seasonally.

12. High Marsh Transition Zone (including Euryhaline and Hyperhaline Habitats)

Narrative: The transition zone represents that area where the halophytic and hydrophytic salt marsh vegetation overlaps with upland communities. Storm-surge high tides may flood habitats transitional to upland habitats, including various palustrine wetlands adjacent to high marsh estuarine wetlands; however, they are generally considered to be located beyond the limits of estuarine wetlands, but within the more broadly defined "estuarine" ecosystem (e.g., the Ballona Ecosystem). At relatively undisturbed southern California estuaries, examples of Estuarine Scrub Shrub Wetland may occur in the transition zone and may include Boxthorn *(Lycium californicum)*, Bush Seepweed *(Suaeda nigra)*, Coast Golden Bush (*Isocoma menziesii*), Parish's Glasswort (*Arthrocnemum subterminale*), and Quail Bush (*Atriplex lentiformis*). These overlap with the highest elevation salt marsh species including, for example, Saltgrass *(Distichlis spicata)*, Alkali Weed *(Cressa truxillensis)*, and Shoregrass *(Monanthochloe littoralis)*. *Lycium* is a common perch for birds and various small mammals burrow under it. The fact that it is deciduous shrub that greens up whenever there is water available makes it an indicator of sewage spills or other off-season sources of water.

The animals of the higher elevations of the transition zone are primarily terrestrial species. Those associated with shrubby uplands such as portions of the transition zone include, for example, various species of snakes, lizards, small mammals and birds. Herpetofauna may include California Kingsnake *(Lampropeltis getulus californiae)*, San

Diego Gopher Snake *(Pituophus melanoleucus annectens)* and side-blotched lizard *(Uta stansburiana)*. Common mammals of the shrub-dominated uplands include Western Harvest Mouse *(Reithrodontomys megalotis)*, Deer Mouse *(Peromyscus maniculatus)*, Pocket Gopher (*Thomomys* sp.), Opossum *(Didelphis virginianus)*, Striped Skunk (*Mephitis mephitis)*, and California Ground Squirrel *(Spermophilus beechyi)*. The small mammals are preyed upon by a variety of birds including Short-eared Owl *(Asio flammeus)*, Northern Harrier *(Circus cyaneus)*, and White-tailed Kite *(Elaneus caeruleus)*. Ground-nesting bees that pollinate Salt Marsh Bird's-Beak (*Cordylanthus maritimus* spp. *maritimus*) live above the high tide in this habitat. Boxthorn (*Lycium californicum*) offers a tall perch site for various birds, and its thorns can deter human intrusion.

One of the more interesting habitats is the euryhaline zone with fluctuating salinities between wet season low salinities and dry season hypersaline conditions. The habitat is characterized by winter annual plant species such as Salt Marsh Daisy (*Lasthenia glabrata* ssp. *coulteri*), Salt Marsh Sand-sperry (*Spergularia marina*), Toad Rush (*Juncus bufonius*), and Hutchinsia (*Hutchinsia procumbens*), which are adapted to the fluctuating salinities. The euryhaline zone is generally located upslope from hyperhaline salt flats and down-slope from nontidal palustrine wetland or grassland habitats and is perhaps the habitat most representative of Mediterranean climate estuarine wetlands.

The transition zone may also include nontidal palustrine habitats both salt influenced and non-saline types. Seeps from perched water tables on deltas and the toe of slopes and along dune transitions often support a variety of palustrine emergent and scrub-shrub types. Characteristic non-saline or slightly brackish species may include shrubs such as Mule Fat (*Baccharis salicifolia*) and herbaceous species such as spiny-rush (*Juncus acutus*), Willow-Dock (*Rumex salicifolia)*, and Alkali Ryegrass (*Leymus triticoides*). Seasonal palustrine wetlands also occur in this area, especially in low-gradient deltaic deposits and may include salt-influenced types supporting a variety of native annual species such as Alkali Barley (*Hordeum depressum*). Belding's Savannah Sparrows use the taller shrubs of this habitat during the non-nesting season.

Structural features: alluvial plain, upper deltas, banks.

Wetlands: Estuarine Emergent Persistent and Nonpersistent Wetland (Irregularly Flooded); Estuarine Scrub Shrub Wetland (Broadleaved Deciduous and Evergreen).

Physical processes: estuarine processes including tidal hydraulics; fluvial-influenced if on a delta; geochemical processes including formation of evaporate deposits.

Water regime/hydrology: (irregularly flooded by tides; i.e., < 20% of tides); and adjacent storm-tide influenced wetlands, palustrine wetlands, and uplands.

Salinity: fluctuating from mixohaline and saline to hyperhaline (more saline than sea water) and euryhaline (fluctuating salinity) and upslope to potentially non-haline.

Dominant/characteristic plant(s): *Arthrocnemum subterminale, Monanthochloe littoralis, Lycium californicum.*

Associated plant(s): winter annuals including *Spergularia marina, Juncus bufonius, Hordeum depressum, Lasthenia glabrata* ssp. *coulteri, Hutchinsia procumbens.*

Characteristic animals: (see animals discussed above regarding the high marsh habitat).

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; foraging areas for upland animals; resting areas for migratory birds; high tide refuge for Light-footed Clapper Rail; pollination support.

Recovery opportunities: *Lasthenia glabrata coulteri* (CNPS rare); *Hutchinsia procumbens* (locally extirpated); Tiger beetles (?); Northern Harrier (*Circus cyaneus*) foraging areas.

Management issues: Loss of historic habitat due to filling and development. Vulnerable to colonization by many introduced invasive plant species. This transitional habitat [and the high marsh as noted above] is highly susceptible to invasive species such as Rabbit's Foot Grass (*Polypogon monspeliensis*), Sicklegrass (*Parapholis incurva*), Italian Ryegrass (*Lolium multiflorum*), and other grasses because it is rarely tidal and can have very low salinities at least seasonally, especially during unusually wet winters and in areas that receive substantial anthropogenic freshwater inputs.

13. Brackish Marsh (and associated Open Water Habitat)

Narrative: Sites where freshwater mixes with saline seawater produce brackish conditions with intermediate salinities. This phenomenon is less frequent in southern California where many estuaries are less influenced by runoff from rainfall than in more northerly latitudes. In southern California, brackish sites vary seasonally, with dilution during the wet season and concentration of salts during the dry season. Local influence from seeps and springs and seasonally impounded stream and river-mouths can produce brackish environments that support emergent vegetation characterized, for example, by Prairie Bulrush [*Bolboschoenus* (*Scirpus*) *maritimus*], and Southern Cattail (*Typha domingensis*), and aquatic bed species including (*Potamogeton pectinatus)* and Ditchgrass (*Ruppia* spp.). The biggest difference in plant composition between brackish and salt marshes is often at the lower elevations in the marsh -- higher elevation areas of Mediterranean-climate brackish marshes tend to be similar to the mid-marsh plain or high marsh habitats of salt marshes. Tidewater Goby (*Eucyclogobius newberryi),* a Federal listed endangered species, occurs in systems or habitats within systems characterized by brackish water conditions.

Structural features: channels, depressions, basins, seeps and springs.

Wetlands: Estuarine Emergent Persistent and Nonpersistent Wetland (Semi-permanently Flooded); estuarine Aquatic Bed Wetland (Floating and Rooted Vascular; Algal).

Physical processes: Estuarine processes including tidal hydraulics; also fluvial-influenced if associated with a river channel and artesian-influenced if associated with seeps or springs from groundwater.

Water regime/hydrology: Tidally influenced with a wide range of tidal inundation frequencies depending on elevation and distance from the tidal inlet; seasonal dilution from surface water (runoff).

Salinity: brackish (mixohaline).

Dominant/characteristic plant(s): Prairie Bulrush [*Bolboschoenus* (*Scirpus*) *maritimus*]; California Bulrush, Tule [*Schoenoplectus* (*Scirpus*) *californicus*]; American Bulrush [*Schoenoplectus* (*Scirpus*) *americanus*]; Southern Cattail (*Typha domingensis*).

Associated plant(s): Salt Marsh Bulrush [*Bolboschoenus* (*Scirpus*) *robustus*] (unknown from Ballona?); Spiny Rush (*Juncus acutus*).

Characteristic animals: rails; bittern; wrens, Redwing Blackbird.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; biofiltration of freshwater runoff; nutrient cycling/biogeochemistry; N and P removal; C sequestration; sediment accumulation; very high rates of primary productivity in the lower portions of brackish and freshwater marsh areas; food web support.

Recovery opportunities: Light-footed Clapper Rail (Fed. & State endangered); Tidewater Goby (threatened); Brackish Water Snail (*Tyonia imitator*).

Management issues: Influence of stormwater runoff on formation of and impacts to brackish marshes; water quality; excessive sedimentation from upstream disturbances.

Habitat Category IV
Palustrine Nontidal Wetlands:

14. Transitional Emergent Wetlands (delta distributaries and margins of estuaries)

Narrative: The toe of slopes along estuary margins often provide opportunities for the formation of fresh or brackish water seeps and springs, including examples with well-developed dune fields containing freshwater lenses, deltas of rivers with shallow aquifers, and alluvial fans with artesian wells. These features can be the sites of estuarine brackish marshes and palustrine freshwater marshes. They also can support the development of palustrine emergent wetlands that are transitional in nature and similar to habitat type No 12 – High Marsh Transition Zone, but are distinctly palustrine and adjacent to estuarine habitats within coastal ecosystems.

Structural features: margins of dunes, deltas, banks, bluffs, alluvial fans and plains.

Wetlands: Palustrine Emergent Persistent Wetland.

Physical processes: Fluvial and/or groundwater hydrology.

Water regime/hydrology: (Permanently?), seasonally, temporarily, or intermittently saturated; temporarily or intermittently flooded.

Salinity: Freshwater to euryhaline. Due to brackish nature of water, salt spray, or rare storm-tide influences, or even concentration of salts by plants, soil salinity may increase during dry periods and may include formation of surface precipitates.

Dominant/characteristic Plant(s): Alkali Ryegrass (*Leymus triticoides*); Saltgrass (*Distichlis spicata*); Western Goldenrod (*Euthamia occidentalis*); Salt Marsh Baccharis (*Baccharis douglasii*).

Associated plant(s): Alkali Barley (*Hordeum depressum);* Seaside Heliotope (*Heliotropium curassavicum);* Coast Golden Bush (*Isocoma menziesii);* Western Sea-Purslane (*Sesuvium verrucosum);* Common Sedge (*Carex praegracilis*); Yerba Mansa (*Anemopsis californica*); Baltic Rush (*Juncus balticus*); Small-leaved (Petunia parvifolia); Sticky Conyza (*Conyza coulteri*).

Characteristic animals: small mammals including voles, harvest mice, field mice, gophers; herpetofauna.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; hydrology (seasonally saturated, temporarily flooded).

Recovery opportunities: foraging habitat for White-tailed Kite and other raptors; potential habitat for Ventura Marsh Milk-vetch (*Astragalus pycnostachys* var. *lanosissimus* - Fed and State listed endangered plant); Wandering Skipper (butterfly); Southern Salt Marsh Shrew (*Sorex ornatus salicornicus*).

Management issues: invasion by Giant reed (*Arundo donax*) and Myoporum (*Myoporum laetum*).

15. Freshwater Marsh

Narrative: Freshwater marshes occur in saturated, organic rich or sometime mineral soils. The dominant plants are generally emergent monocots such as cattails (*Typha* spp.) and bulrushes [e.g., *Schoenoplectus (Scirpus) californicus*], although aquatic-bed species, such as pondweeds (*Potamegeton* spp.), may also be common. Redwing Blackbirds (*Agelaius phoeniceus*) and Marsh Wrens (*Cistithorus palustris*) commonly breed in the tall, dense vegetation. Common mammals include Raccoon (*Procyon lotor*), Striped Skunk and Opossum. Freshwater marsh habitat may also support the Light-footed Clapper Rail, although this is not considered optimal breeding or foraging habitat. These marshes may provide refugia for rails and other bird species during extreme high tides and rive floods. Creation and maintenance of freshwater marsh habitat is dependent upon a continual source of freshwater. Some coastal wetland restoration plans have incorporated freshwater and brackish marshes due to historical evidence of springs adjacent to intertidal areas

Structural features: river and stream channels; ponds; seeps and springs

Wetlands: Riverine Nonpersistent Emergent Wetland; Palustrine Emergent Persistent Wetland (Permanently or Semi-permanently Flooded, Irregularly Exposed).

Physical processes: Fluvial and/or groundwater.

Water regime/hydrology: Permanently flooded; intermittently flooded; seasonally flooded; permanently and seasonally saturated.

Salinity: fresh water to slightly brackish (groundwater conditions).

Dominant/characteristic Plant(s): Broadleaved Cattail (*Typha latifolia*); Bur-reed (*Sparganium eurycarpum*); California Bulrush (*Schoenoplectus californicus*); Southern Cattail (*Typha domingensis*).

Associated plant(s) - Representative: Basket Rush (*Juncus textilis*); Spiny Rush (*Juncus acutus*); Spike-rush (*Eleocharis spp*.), Hooker's Evening Primrose (*Oenothera elata* ssp. *hookeri*); Horsetails – Common Scouring Rush (*Equisetum hyemale* ssp. *affine*), Smooth Scouring Rush (*E. levigatum*), Giant Horsetail (*E. telmateia*); Western Goldenrod (*Euthamia occidentalis*); Willow Dock (*Rumex salicifolius* vars. *crassus*); Willow Herb (*Epilobium ciliatum* ssp. *ciliatum*); Yerba Mansa (*Anemopsis californica*); American Bulrush (*Schoenoplectus americanus*); Three-square Bulrush (*Schoenoplectus pungens*); Cinquefoil (*Potentilla anserina*); Monkey-flower (*Mimulus guttatus*).

Characteristic animals: Western Pond Turtle, Red-legged Frog; rails, waterfowl, Red-winged Blackbird (*Agelaius phoeniceus*); many passerine birds.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; nutrient cycling/biogeochemistry; N and P removal; C sequestration; sediment accumulation; high rates of primary productivity; habitat for breeding birds.

Recovery opportunities: Western Pond Turtle (*Clemmys marmorata*); California Red-Legged Frog (*Rana aurora draytonii*); Light-footed Clapper Rail and other rail species known to use freshwater marshes adjacent to estuaries in southern California; Least Bittern (*Ixobrychus exilis*); Northern Harrier (*Circus cyaneus*); Spiny Rush (*Juncus acutus*).

Management issues: excessive sedimentation; subject to shrub invasion (e.g., willow invasion). Sites that are less frequently flooded can have substantial problems with non-native grasses such as Rabbitsfoot Grass. Also, Giant Reed and Pampas Grass are large perennial grasses that can be problematic.

16. Seasonal Palustrine Wetlands (including Haline Vernal Wetlands)

Narrative: Seasonal wetlands are non-tidal wetlands and transitional habitats that are flooded to varying degrees by seasonal rainfall and runoff. If there are sufficient salts in the soil, the seasonal wetland may support plant species more typical of coastal salt marsh, such as Pickleweed [*Sarcocornia pacifica* (*Salicornia virginica*)], Saltgrass (*Distichlis spicata*), and Alkali Weed (*Cressa truxillensis*). If the soils do not contain salts or alkaline substances, the seasonal wetlands may support freshwater marsh species and a mixture of weedy opportunists. "Vernal pools" and saline vernal wetlands of transition zones can occur on alluvial and deltaic deposits adjacent to estuarine habitats and are known to support special concern plants and invertebrate animals (e.g., fairy shrimp species).

Seasonal wetlands can be important to a number of bird species that feed on the insects, algae and aquatic invertebrates that develop in these temporary habitats. Amphibians, such as western toad (*Bufo boreas*) and Pacific Tree Frog (*Pseudacris regilla*) have been noted to breed in this habitat. These areas also attract mammals, such as Coyote, Raccoon, Striped Skunk and Opossum. In areas where water pools deeply enough, waterfowl species such as Mallard (*Anas platyrhynchos*), Cinnamon Teal (*Anas cyanoptera*) and American Coot (*Fulica Americana*) have been observed. Seasonal wetlands may also used by shorebirds such as Killdeer (*Charadrius vociferus*) and Black-necked Stilts (*Himantopus mexicanus*).

Structural features: depressions in deltas and fill deposits often associated with other palustrine wetlands adjacent to estuarine wetlands

Wetlands: Palustrine Emergent Wetland, persistent and non-persistent types, seasonally flooded and generally euryhaline

Physical processes: natural examples influenced by fluvial and coastal (storm) processes and anthropogenic effects from disturbances including infilling, dredging, grading, etc.

Water regime/hydrology: Seasonally flooded

Salinity: Fresh water or euryhaline (low salinity when flooded and higher salinity when dry)

Dominant/characteristic Plant(s): Haline vernal wetland examples – Alkali Barley (*Hordeum depressum*); Pickleweed (*Sarcocornia pacifica*); Salt Marsh Daisy (*Lasthenia glabrata* ssp. *coulteri*); Salt Marsh Sand-Sperry (*Spergularia marina*); Toad Rush (*Juncus bufonius* ssp. *halophilus*?). Freshwater examples – Meadow Barley (*Hordeum brachyantherum* ssp. *brachyantherum).*

Associated plant(s): Alkali Mallow (*Malvella leprosa*); Alkali Weed (*Cressa truxillensis*); Sea-Purslane (*Sesuvium verrucosum*); Horned Sea-blite (*Suaeda calceoliformis*); Seaside Heliotrope (*Heliotropium curassavicum*); Slim Aster (*Symphyotrichum subulatum*); Sticky Conyza (*Conyza coulteri*).

Characteristic animals: planktonic (e.g., rotifers, crustaceans including copepods, cladocerans) and macroscopic (e.g., aquatic insect larvae) invertebrates.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; shorebird foraging habitat.

Recovery opportunities: Silver Scale (*Atriplex argentea* var. *mohavensis*) (extirpated?); Hutchinsia (*Hutchinsia procumbens*) (extirpated?); Southern Tarweed (*Centromadia*. *parryi* ssp. *australis*); fairy shrimp species?

Management issues: impacts (e.g., cover and thatch) from introduced annual weeds including Brass Buttons (*Cotula coronopifolia*), Mediterranean Barley (*Hordeum marinum*), Italian Ryegrass (*Lolium multiflorum*), Rabbitsfoot Grass (*Polypogon monspeliensis*), and Sicklegrass (*Parapholis incurva*).

17. Palustrine Scrub/Shrub Wetland (= DFG "Riparian Scrub")

Narrative: Willow scrub is characterized by dense broad-leafed, winter-deciduous riparian thickets dominated by several willow shrub and tree species (*Salix* spp.). Riparian trees also may occur with the association and may include, for example, scattered Fremont's Cottonwood (*Populus fremontii*), and Western Sycamore (*Platanus racemosa*). Riparian woodland also may occur in small groves or in riverine corridors that drain into estuaries. As with other riparian habitats, riparian scrub supports a diverse assemblage of wildlife species, especially passerine bird species. The endangered Least Bell's Vireo (*Vireo bellii pusillus*) and Southwestern Willow Flycatcher (*Epidonax traillii extimus*) as well as other sensitive species, such as Yellow Warbler (*Dendroica petechia brewsteri*) and Yellow-breasted Chat (*Icteria virens*) all depend on riparian woodlands for breeding. Mammal assemblages are similar to those found in freshwater marsh habitats as the two often intergrade. In an undisturbed estuarine system, willow scrub habitat would generally occur upstream of tidal influence as willows are very sensitive to salt. Like freshwater marsh, this habitat is dependent upon a constant source of freshwater.

Structural features: bluff and dune seeps or spring, floodplains.

Wetlands: Palustrine Scrub/Shrub Wetland (Broadleaved Deciduous and Evergreen).

Physical processes: fluvial and/or groundwater hydrology; sediment transport.

Water regime/hydrology: seasonally and permanently saturated; temporarily flooded; phreatophytic.

Salinity: fresh water.

Dominant/characteristic Plant(s): Arroyo Willow (*Salix lasiolepis*); Mule Fat (*Baccharis salicifolia*); Sandbar Willow (*Salix exigua*).

Associated plant(s): Basket Rush (*Juncus textlis*); California Rose (*Rosa californica*); Coyote Brush (*Baccharis pilularis*); Salt Marsh Baccharis (*Baccharis douglasii*); American Dogwood (*Cornus sericea* ssp. *occidentalis*)?; Hoary Nettle (*Urtica dioica* ssp. *holosericea*).

Characteristic animals: resident and migratory passerine birds, such as Common Yellowthroat (*Geothlypis trichas*) and Blue grosbeack (*Guiraca caerulea*), and those listed herein (habitat no. 18); herpetofauna and mammals of various guilds.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; refuges for estuarine wildlife species and wildlife corridors linking upland sites with coastal wetlands.

Recovery opportunities: Least Bell's Vireo (*Vireo bellii pusillus*) and Southwestern Willow Flycatcher (*Epidonax traillii extimus*) as well as other sensitive species, such as Yellow Warbler (*Dendroica petechia brewsteri*) and Yellow-breasted Chat (*Icteria virens*).

Management issues: Impacts from invasive plant species including Giant reed (*Arundo donax*), Pampas Grass (*Cortaderia selloana*); Myoporum (*Myoporum laetum*).

18. Palustrine Forested Wetland (= DFG "Riparian Woodland"?)

Narrative: Palustrine Forested Wetland as discussed herein is generally characterized by isolated stands of trees or tall shrubs that occur at seeps, toe-of-slopes, ponded areas, along streams and rivers, and at other sites with shallow water tables. Arroyo Willow (*Salix lasiolepis*) is the most common representative but other native species such as additional willow species, Black Cottonwood (*Populus balsamifera* ssp. *trichocarpa*), and Western Sycamore (*Platanus racemosa*) are also represented. Riparian corridors along streams and rivers are no longer well developed due to impacts from urbanization, but portions of the original drainage of Centinela Creek still support riparian vegetation. In the riparian setting, trees in upland and wetland habitats may be included in mapped examples of this vegetation where the distinction among hydric (i.e., wetland), mesic, and xeric (i.e., upland) types of riparian vegetation are often not distinguished. A number of exotic species also may be represented including Myoporum (*Myoporum laetum*) and various species of *Eucalyptus,* especially Blue Gum (*Eucalyptus globulus*).

Structural features: bluff seeps, floodplains, margins of dunes and dune swales.

Wetlands: Palustrine Forested Broadleaved Deciduous Wetland.

Physical processes: fluvial and/or groundwater hydrology; sediment transport.

Water regime/hydrology: permanently, seasonally, temporarily, or intermittently flooded; permanently, seasonally saturated; phreatophytic.

Salinity: freshwater.

Dominant/characteristic Plant(s): Black Cottonwood (*Populus balsamifera* ssp. *trichocarpa*); Western Sycamore (*Platanus racemosa*); Arroyo (*Salix lasiolepis*).

Associated plant(s): Blue Elderberry (*Sambucus mexicana*); Coast Live Oak (*Quercus agrifolia*); White Alder (*Alnus rhombifolia*); Red Willow (*Salix laevigata*); Shining Willow (*Salix lucida* ssp. *lasiandra*); Black Willow (*Salix goodingii*); California Walnut (*Juglans californica*); various riparian shrubs and vine species and herbaceous plants including Stinging Nettle (*Urtica dioica* ssp,. *holosericea*).

Characteristic animals: Passerine birds including resident and migratory birds such as those sensitive species listed below; herpetofauna; shelter and corridor for mammals including raccoon, skunk, and coyote.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; breeding bird habitat.

Recovery opportunities: Southwestern Willow Flycatcher (*Empidomax trallii extimus*); Least Bell's Vireo (*Vireo belli pusillus*); Western Yellow Warbler (*Dendroica petechia brewsteri*); Yellow-breasted Chat (*Icteria virens*).

Management issues: vulnerable to invasion by Giant Reed (*Arundo donax*) and various exotic vines (e.g. Cape Ivy), shrubs (Tamarisk), and tree species (e.g., *Eucalytus* spp.); restore connectivity of stands when appropriate and feasible.

Habitat Category V
Upland Habitats:

19. Grasslands (= DFG Non-native Herbaceous Vegetation)

Narrative: Grasslands are illustrated on historic maps of the Ballona region and are likely to have occurred on alluvial deposits on the periphery of the coastal wetland ecosystem, mixed with various forms of coastal scrub. DFG recently used the designation "non-native herbaceous" for the category of vegetation that represents the existing conditions of "grassland", "meadow", or "prairie" vegetation within the Ballona Ecosystem. In a restored state, the vegetation could include native grass species and a diverse number of native herbaceous and sub-shrub species as noted above, with small colonies and scattered individuals of coastal scrub species to provide perches and shelter for animals that characterize grassland and adjacent scrub and wetland habitats.

Structural features: upland alluvial deposits, graded spoil deposits,

Physical processes: potentially a fire-maintained community.

Dominant/characteristic Plant(s): in an upland context - California Barley (*Hordeum brachyantherum* ssp. *californicum*); Purple Needlegrass (*Nassella pulchra*); Salt Grass (*Distichlis spicata*); Alkali Ryegrass (*Leymus triticoides*).

Associated plant(s): Alkali Heath (*Frankenia salina*); Coast Golden Bush (*Isocoma menziesii*); Common Tarweed (*Dienandra fasciculata*); Telegraph Weed (*Heterotheca grandiflora*); Deerweed (*Lotus scoparius*), Spanish Clover (*Lotus purshianus*), Owl's Clover (*Castilleja exerta*); White Cudweed (*Gnaphalium canescens*); Common Verbena (*Verbena lasiostachys*); California Poppy (*Eschschulzia californica*); Pitseed Goosefoot (*Chenopodium berlandieri*); Arroyo Lupine (*Lupinus succulentus*); Bicolor Lupine (*Lupinus bicolor* var. *microphyllus*); Fascicled Milkweed (*Asclepias fasciculata*); Bush Aster (*Lessingia filaginifolia*); Fiddleneck (*Amsinckia menziesii*); Western Ragweed (*Ambrosia psilostachya*); Gum Plant (*Grindelia robusta*); California Goldenrod (*Solidago californica*); Popcorn Flower (*Cryptantha inermedia*); Miniature Sun Cup (*Camissonia micrantha*); Rattlesnake Weed (*Euphorbia albomarginata*); Pygmy Stonecrop (*Crassula connata*).

Characteristic animals: resident and migratory grassland bird species including Horned Lark; herpetofauna including lizards and snakes, such as California King Snake and Gopher Snake; and small mammals including voles, mice, shrews, and moles.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; host plants for butterfly larvae including the Wandering Skipper Monarch (*Danaus plexippus*) butterflies; habitat for native small mammals; foraging habitat for raptors such as White-tailed Kite and Northern Harrier and egrets (Great Egret) and herons (Great Blue Heron).

Recovery opportunities: South Coast Marsh Vole (*Microtus californicus stephensi*); San Diego Black-tailed Jackrabbit (*Lepus californicus bennettii*); California Horned Lark (*Eremophila alpestris*); White-tailed Kite (*Elanus caeruleus*); Northern Harrier (*Circus cyaneus*).

Management issues: Maintenance of grassland habitat to prevent it becoming coastal scrub (using fire, grazing, or mowing techniques?); control of invasive plant species.

20. Coastal Scrub (including Coastal Bluff Scrub)

Narrative: The general category "coastal scrub" includes a number of shrub-dominated plant communities in the context of a variety of land forms. Coyote Brush and California Sage Brush form colonies on alluvial and disturbed soils and can occur within the context of grassland and other herbaceous vegetation. Upland delta scrub can be quite rich in shrub species and occurs in alluvium adjacent to wetland forms of delta scrub often dominated by Mulefat (*Baccharis salicifolia*). Coastal Bluff Scrub is limited to coastal bluffs where salt tolerant species including Wooly Sea-Blite (*Suaeda taxifolia*) and Quail Bush (*Atriplex lentiformis*) are characteristic but occurs in different forms depending on proximity to salt spray. Within the bluff community, sparsely-vegetated areas or areas with low vegetation also can support a wide variety of herbaceous species, some of which are also associated with coastal dunes. Coastal Dune Scrub is treated separately herein. No Maritime Chaparral occurs in the Ballona Ecosystem.

Other forms of upland coastal scrub include, for example, Delta Scrub and Baccharis Scrub, which can be transitional to wetland scrub types.

A variety of terrestrial animals, including amphibians, reptiles, mammals and birds are supported by coastal scrub habitat. For instance, Coastal Sage Scrub is the preferred breeding habitat of the coastal California Gnatcatcher (*Pilioptila californica californica*).

Structural features: alluvial deposits, berms and banks; coastal bluffs.

Physical processes: fluvial, erosional, (and anthropogenic).

Dominant/characteristic Plant(s): Coyote Brush (*Baccharis pilularis*); California Sagebrush (*Artemisia californica*); *Mugwort (Artemisia douglasiana***);** Quail Bush (*Atriplex lentiformis*); Douglas' Nightshade (*Solanum douglasii*); Lemonade Berry (*Rhus integrifolia*); Seacliff or Dune Buckwheat (*Eriogonum parvifolium*).

Associated plant(s): Laurel Sumac (*Malosma laurina*); Cliff Aster (*Malacothris saxatilis*); Deerweed (*Lotus scoparius*); Black Sage (*Salvia mellifera*); Wild Morning-glory (*Calystegia macrostegia*); Melic Grass (*Melica imperfecta*); Foothill Needlegrass (*Nassella lepida*); California Brome (*Bromus carinatus*); Mock Heather (*Ericameria ericoides*); Bladderpod (*Isomeris arboreus)*; Elderberry (*Sambucus mexicanus*); Wild Cucumber (*Marah macrocarpus*); Giant Ryegrass (*Leymus condenstatus*); California Encelia (*Encelia californica*); Suffrutescent Wallflower (*Erysimum insulare* ssp *suffrutescens*); Coastal Prickly Pear (*Opuntia littoralis*); California Buckwheat (*Eriogonum fasciculaum*); Milk Vetch (*Astragalus trichopodus*); Branching Phacelia (*Phacelia ramosissima* var.

austrolittoralis); Bush Mallow (*Malacothamnus fasciculatus*); Lewis' Evening Primrose (*Camissonia lewisii*); Toyon (*Heteromeles arbutifolia*); Chaparral Nightshade (*Solanus xanti*); Wooly Sea-blite (*Suaeda taxifolia*).

Characteristic animals: Loggerhead Shrike (Lanius ludovicianus) perching; California Gnat Catcher (*Polioptila californica californica*) endangered; resident and migratory passerine birds including Luzuli Bunting (*Passerina amoena*) and Blue Grosbeak (*Guiraca caerulea*); small mammals.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; breeding bird habitat; refuge for resident estuarine birds.

Recovery opportunities: Pacific Pocket Mouse (*Perognathus longimembris pacificus*); Loggerhead Shrike (*Lanius ludovicianus*) perching; California Gnat Catcher (*Polioptila californica californica*) breeding habitat; Suffrutescent Wallflower (*Erysimum insulare* ssp. *suffrutescens*); Lewis' Evening Primrose (*Camissonia lewisii*); Coastal Dunes Milkvetch (*Astragalis tener* var. *titi*).

Management issues: plan for connectivity among sites; invasive species such as Pampas Grass.

21. Coastal Dune Scrub and Dune Herbs (including Foredunes)

Narrative: Dune habitat represents a form of transition zone between the land and the sea and includes Coastal Dune Scrub and Dune Herb vegetation. Coastal dune habitats have been largely lost due to development in southern California. Prior to development, plant species such as dune lupine (*Lupinus chamissonis*), Mock Heather (*Ericameria ericoides*), dune primrose *(Camissonia cheiranthifolia)*, sand verbena *(Abronia maritima)* and dune ragweed *(Ambrosia chamissonis)* stabilized the loose sand, and the dunes where thereby anchored. Following human disturbance, many of the native plants were eliminated and exotics, such as sour-fig *(Carporotus edulis)* and sea rocket *(Cakile maritima)* invaded or were planted.

Dunes are important habitats for several species of rare insects including Globose Dune Beetle *(Coelus globosus)*, the Sandy Beach Tiger Beetle *(Coelus hiticollis gravida)*, and Sand Dune Tiger Beetle *(C. latesignata latesignata)*. The San Diego Horned Lizard and Silvery Legless Lizard *(Anniella pulchra pulchra)* were once common; the later still occurs within the Ballona Ecosystem. The endangered California Least Tern *(Sterna antillarum browni)* and Western Snowy Plover *(Charadrius alexandrinus nivosus)* are associated with dune habitat but generally nest in the upper beach environment, which is no longer connected to the dunes.

Structural features: coastal dunes

Physical processes: aeolian transport and deposition of sands; storm influenced.

Dominant/characteristic Plant(s): Dune Lupine **(***Lupinus chamissonis*); Dune Buckwheat **(***Eriogonum parvifolium***)**; Beach Bur (*Ambrosia chamissonis*); Beach Evening Primerose (*Camissonia cheiranthifolia*); Common Sand Verbena (*Abronia umbellata*).

Associated plant(s): California Croton (*Croton californicus*), Tall Stephanomeria (*Stephanomeria virgata*), Mock Heather (*Ericameria ericoides*), Yellow Pincushion (*Chaenactis glabriuscula*), California Sun Cup (*Camissonia bistorta*), Lewis' Evening Primrose (*Camissonia lewisii*), Miniature Sun Cup (*Camissonia micrantha*), Coastal Dunes Milkvetch (*Astragalis tener* var. *titi*).

Characteristic animals: Silvery Legless Lizard (*Anniella pulchra pulchra*); Globose Dune Beetle (*Coelus globosus*); Ciliated Dune Beetle.

Ecosystem functions: maintenance of biodiversity; habitat for rare, endangered, and special interest species; source of freshwater seeps along interface with salt marsh habitat.

Recovery or protection opportunities: Silvery Legless Lizard (*Anniella pulchra pulchra*); El Segundo Blue Butterfly (*Euphilotes battoides allyni*); Dorothy's El Segunda Dune Weevil (*Trigonoscuta dorothea dorothea*); Globose Dune Beetle (*Coelus globosus*); Lande's El Segundo Dune Weevil (*Onychobaris langei*); Suffrutescent Wallflower (*Erysimum insulare* ssp. *suffutescens*); Beach Spectaclepod (*Dithyrea maritima*), Lewis' Evening Primrose (*Camissonia lewisii*)

Management issues: Remnant dunes are disjunct from coastal processes that formed them hence no natural disturbance regime, and beach related habitats are missing from the complex. Vulnerable to introduced invasive plant species.

22. Forests, woodlands, groves, and tree rows (including DFG "Eucalyptus Grove")

Narrative: Oak woodlands, characterized by Coast Live Oak (*Quercus agrifolia*), are characteristic along slopes, bluffs, and banks adjacent to various estuaries in southern California but may not have been located within or in proximity to the Ballona Ecosystem. Nonetheless, Coast Live Oaks may have been in the more xeric portions of riparian forests that included stands of Western Sycamore (*Platanus racemosa*). Current conditions include a number of groves and stands of planted or naturalized, largely exotic trees (e.g., Blue Gum, *Eucalyptus globulus*) within the Ballona Ecosystem. Some of these sites have important ecosystem functions such as nesting areas for great Blue Herons, whereas others (e.g., Myoporum and Acacia) may be less important depending on the site and role in the ecosystem.

Structural features: cultivated areas; roadsides; yards; banks and bluffs.

Physical processes:

Dominant/characteristic Plant(s): *Eucalyptus* spp.; Myoporum (*Myoporum laetum*).

Associated plant(s): numerous species of planted and naturalized trees including Acacia (*Acacia baileyana*); California Walnut (*Juglans californica*); Peruvian and Brazilian Pepper Trees (*Schinus molle* and *S. terebinthifolia*); Canary Island Date Palm (*Phoenix canariensis*); Slender Fan Palm (*Washingtonia robusta*); Carob (*Ceratonia siliquia*); Sweet Gum (*Liquidambar styraciflua*); Olive (*Olea europea*); Velvet Ash (*Fraxinus velutina*); Fremont Cottonwood (*Populus fremontii*); Chinese Elm (*Ulmus parvifolia*).

Characteristic animals: resident and migratory passerine birds; roosting and possibly nesting raptors; roosting and nesting herons.

Ecosystem functions: habitat for rare, endangered, and special interest species; perches for raptors.

Recovery opportunities: Preservation/expansion of Great Blue Heron rookery; potential for Monarch Butterfly over-wintering habitat in groves of Blue Gum (*Eucalyptus globulus*).

Management issues: Monarch Butterflies use exotic Eucalyptus trees as winter roosts. Need to retain butterfly habitat (if Eucalyptus trees are targeted as butterfly habitat at Ballona), while not encouraging spread of exotic tree species.

APPENDIX C.
HYDRODYNAMIC MODELING

APPENDIX C – NUMERICAL MODELING OF BALLONA WETLAND RESTORATION ALTERNATIVES TECHNICAL APPENDIX

Hydrodynamic modeling was conducted in support of the development and evaluation of restoration alternatives for the Ballona Wetlands Restoration Project. The Environmental Fluid Dynamics Code (EFDC) hydrodynamic model was selected because of its capacity to model the relevant physical processes, its compliance with regulatory standards, and its availability in the public domain at no cost.

This appendix documents the development, calibration, and alternative implementation of the EFDC model. It also provides supporting documentation for specific model results discussed in the Feasibility Report. This appendix is not a stand-alone report and should be reviewed in conjunction with Section 3.3 (Hydrology) of the Feasibility Report.

Because the EFDC model uses metric units, some of the model results in this appendix are presented using metric units. However, the discussion in the Feasibility Report uses English units to follow local convention. As a result, this appendix presents some results in metric units and some in English units.

Sections C-1 and C-2 were prepared as stand-alone memos. Section C-1 discusses the EFDC model development and calibration. Section C-2 discusses the representation of marsh channel networks within the model. Section C-3 shows overview plots of model bathymetry for each alternative. Section C-4 provides supporting documentation for model results discussed in Section 3.3 (Hydrology) of the Feasibility Study.

C-1. LOWER BALLONA CREEK MODELING – EFDC MODEL DEVELOPMENT AND CALIBRATION

1. INTRODUCTION

This section presents the calibration process for the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model developed for the Ballona Creek Wetland Restoration Project. The EFDC model was configured such that predicted water levels accurately replicate observed water levels from a two-week calibration period. Typically, predicted water levels agree to within 5 cm of the observed water levels. Having calibrated the EFDC model, it is ready to characterize the hydrologic response of the proposed restoration actions for feasibility assessment purposes.

This section includes details of the model development and calibration. The section on model development describes the EFDC model in general and summarizes how the model was configured to represent the Lower Ballona Wetland system. The section on calibration describes the calibration approach and compares model predictions and field observations.

2. MODEL DEVELOPMENT

The EFDC model was chosen to simulate the Lower Ballona Wetland system after discussion between the Project Management Team, the Science Advisory Committee and the LA District, Corps of Engineers. Benefits of this model include its capacity to model the relevant physical processes, its compliance with regulatory standards, and its availability in the public domain at no cost.

After briefly describing EFDC's general characteristics, this section describes the application of the model to the Lower Ballona Wetland system, including the model's domain, boundary conditions, initial conditions and model execution. The linked Lower Ballona Wetland system includes lower Ballona Creek; Ballona Wetland Restoration Areas A, B, and C; Marina Del Rey; Del Rey Lagoon; Ballona Lagoon; the Grand Canal; and a portion of Santa Monica Bay. The uncertainties with respect to the model predictions are discussed.

2.1. MODEL DESCRIPTION

EFDC is a numerical model designed for simulating flows in open water systems. The model was originally developed at the Virginia Institute of Marine Science and receives continuing support from the U.S. EPA. A complete description of the model assumptions, governing equations and approximations, including the space discretization, time integration, and numerical solution methods is presented in Hamrick (1992). Tetra Tech (2002) provides guidance in using the model as well as references to successful applications of EFDC for a variety of tidally-influenced systems.

The physical processes represented in the model include important aspects of the Lower Ballona Wetland system:

- unsteady tidal flow,

- boundary wetting and drying, and
- hydraulic control structures.

EFDC solves the physical equations for fluid flow on a staggered, finite-difference grid. The modeling domain is defined by a curvilinear flexible mesh, enabling the grid to follow dominant terrain features. At present, the model has been configured to predict two-dimensional (2D) depth-averaged flow. Although not implemented for this study, the model can be extended to simulate three-dimensional (3D) flows and the transport of salt, sediment, and/or contaminants.

2.2. MODEL DOMAIN

The model domain defines the portion of the physical environment that is included in the model. Its extent should include the system's relevant components and processes between these components. Additionally, the boundaries of the system should be sufficiently far from the region of interest such that boundary conditions do not overly constrain flow in the region of interest. When constructing the model's horizontal grid that defines the domain, these factors must be balanced against model execution time. The vertical component of the model domain is defined by the system's bathymetry. Further information about the physical setting within the model domain can be found in PWA (2006).

2.2.1. Model extent

The model domain extends from where Ballona Creek passes under Sawtelle Boulevard to Santa Monica Bay, as shown in Figure 1. The upstream boundary is beyond the range of tidal influence and coincides with a discharge monitoring station. Placing the downstream boundary within Santa Monica Bay provides ample distance and tidal volume between the specified tidal boundary condition and the region of interest. Between the upstream and downstream boundaries, the model domain includes:

- lower Ballona Creek;
- Ballona Wetland Restoration Areas A, B and C;
- Marina Del Rey, including Oxford Basin;
- Del Rey Lagoon;
- Ballona Lagoon, including the Grand Canal downstream of Washington Boulevard; and
- a portion of Santa Monica Bay roughly 1.3 km by 2.5 km.

2.2.2. Horizontal grid generation

EFDC employs a curvilinear orthogonal grid to represent the physical domain. The grid is analogous to a rubber sheet of graph paper. Its curvilinear aspect allows the grid to be stretched and transformed so that it aligns with the major topographic features of the model domain. However, orthogonality requirements dictate that the grid maintains nearly perpendicular intersections at cell boundaries.

The grid generation tools available within the EFDC modeling environment are somewhat limited in their functionality. Instead, DELFT3D's grid generation software (WL | Delft Hydraulics, 2006b) was used to create the grid. DELFT3D's graphical user interface provides robust tools for grid orthogonalization, manipulation, and merging. After creating the grid with the DELFT3D software, the grid files were converted to EFDC format using MatLab programs. The grid cell sizes average 10 m across in most of the model domain, resulting in approximately 42,000 active cells within the domain.

2.2.3. Bathymetry

The bathymetry, or spatial map of surface elevations, is represented in the model as a single elevation value at the center of each grid cell. Multiple sources of bathymetric data were compiled to cover the entire model domain. The sources of bathymetry data for each region are listed below:

- *Ballona Creek:* Channel centerline elevations and width from the channel's design drawings (Los Angeles County Flood Control District, 1959).

- *Ballona Wetland Areas A, B and C*: Ground surface elevations from the R.J. Lung & Associates aerial survey in April 1998, supplemented with spot elevations, marsh channel cross sections, and culvert invert elevations collected by PWA in 2006.

- *Marina Del Rey*: Elevations in the main stem of the marina from unpublished USACE dredging surveys in March 2006 and elevations in the mooring basins extrapolated from the adjacent main channel elevations.

- *Del Rey Lagoon:* Spot elevations from bathymetric survey drawings (City of Los Angeles, 2003) interpolated across the lagoon.

- *Ballona Lagoon and the Grand Canal*: Elevations from cross section surveys (Coastal Frontiers Corporation, 1989) and Ballona Lagoon Enhancement Project design drawings (City of Los Angeles, 1997).

- *Santa Monica Bay*: Bathymetric survey data from the National Oceanic and Atmospheric Administration (1997).

All elevation data were converted to the same horizontal datum (UTM Zone 10N) and vertical datum (NAVD88) using Corpscon software (U.S. Army Corps of Engineers, 2004). The data sets were then imported into the DELFT3D bathymetry generation software (WL | Delft Hydraulics, 2006a) and smoothly interpolated at the boundaries between data sets. The compiled bathymetric surface was converted into EFDC-specific input files using the EFDC_Explorer graphical user interface (Criag, 2004). To refine features such as wetland channels and elevated road bed that have widths on the order of the 10 m grid cell size, a MatLab program was used to inscribe these features into the bathymetry. This procedure ensures that these features are hydraulically contiguous, but yields a stair-step appearance as the features traverse diagonally across the grid. The compiled bathymetry for the model extent is shown in Figure 1. Figure 2 displays a portion of the bathymetry within the western portion of Area B that includes wetland channels and road bed. This figure demonstrates the implementation of these features as contiguous sets of grid cells.

2.3. BOUNDARY AND INITIAL CONDITIONS

Boundary and initial conditions describe the external forcing applied to the model and starting values for the predicted variables, respectively. Boundary conditions consist of:

- the tidal boundary within Santa Monica Bay,
- the freshwater inflows from the Ballona Creek watershed,
- culvert discharges, and
- bed roughness.

Initial conditions must be specified for the water surface elevation and velocity field when the model begins a simulation.

2.3.1. Tidal boundary

Comparison between the NOAA continuous tide gauge station at the Port of Los Angeles (Station ID 9410660) and water surface measurements in Ballona Creek collected by Nearshore and Wetland Surveys (2006) show good agreement with minimal amplitude differences or phase lag. For example, observations in Ballona Creek (Nearshore and Wetland Surveys, 2006) and at the Port of Los Angeles are shown in Figure 3. Because of the agreement between the two data sets, the Port of Los Angeles water surface elevation data was applied as the open tidal boundary condition at the model's western edge in Santa Monica Bay. This tide station is well established and it can provide boundary condition data for a wide range of time periods. The northern and southern boundaries of the model grid in Santa Monica Bay are linked by a periodic boundary condition. This type of boundary condition minimizes the influence of these boundaries on model results.

2.3.2. Freshwater inflow

The primary freshwater inflow into the Lower Ballona system comes from Ballona Creek itself. The upstream model boundary coincides with the County of Los Angeles, Department of Public Work's discharge station at Sawtelle Blvd (Station ID F38C-R). Observations from this station were used as a discharge boundary condition into the model.

2.3.3. Culvert and gate discharges

Culverts and gates regulate flow into and out of the Area B wetland, Fiji Ditch, Del Rey Lagoon, and Ballona Lagoon. Culvert flow is represented in the model as water-level-dependent discharge between a pair of grid cells. Discharges through all but one culvert are implemented in the EFDC model through an input file that specifies the discharge as a function of the difference in water levels at the ends of each culvert.

A slightly more complex specification was used for the gate that conveys water from Ballona Creek to the Area B wetland. Flow through this gate is governed by a self-regulating tide gate that closes automatically once the water level in Ballona Creek reaches a predetermined level. For this culvert, the discharge was modeled as a function of both the upstream and downstream water levels and the discharge was set to zero when the upstream water level in Ballona Creek equal or exceeds the water level which triggers gate closure.

Observed water levels within the Area B wetland (Nearshore and Wetland Surveys, 2006) slowly increase even after the self-regulating tide gate has closed. This increase may result from leakage through either of the tide gates and/or seepage from the headlands to the south of the wetland. The exact source remains a point of discussion. To replicate these slowly increasing water levels, a constant discharge of 0.16 m^3/s was added as a source to the wetland. This rate was estimated from the observed rate of water level increase after the self-regulating tide gate has closed (Figure 5) and the area of inundated wetland during higher high water. If future investigation clarifies and quantifies the source of this water level increase, it can be more explicitly included in the model.

2.3.4. Bed roughness

Bed roughness relates the flow velocity to the frictional loss of momentum as the flow moves over the bed. EFDC parameterizes the bed friction's effect on flow through a roughness height, z_0, based on the assumption of a logarithmic velocity profile. A typical, constant z_0 value of 0.002 m was applied across the entire domain (Blumberg and Mellor, 1987). Sensitivity analysis of water levels to variations in z_0 confirms that water levels are relatively insensitive to this parameter.

2.3.5. Initial conditions

Model start times were selected to coincide with slack tide when current speeds can be initialized to zero. Initial water levels throughout the model domain were set to a uniform value equal to the open boundary condition. The model was spun up for four days of simulation time to remove initial transients from the model results and enable water levels and velocities to equilibrate to the prescribed boundary conditions.

2.4. MODEL EXECUTION

For the model configuration described above, model testing indicates that stable and accurate predictions are achieved with a time step of two seconds. With this time step, simulations execute on a 3.6 GHz PC workstation at speeds approximately eight times faster than real time.

2.5. MODEL UNCERTAINTY

EFDC is a widely used modeling tool for estuarine simulations and has been validated in numerous studies (Tetra Tech, 2002). However, numerical models inherently rely on approximations that introduce sources of uncertainty in the model results. Uncertainties may be present both spatially and temporally, and may result from a variety of factors, including:

- physical characteristics of the model domain,
- specification of boundary conditions, or
- limitations in the model's numerical formulation.

For the specific application of a hydrodynamic model of the Lower Ballona system, it is important to assess the modeling uncertainties and assumptions made in applying the model to understand the extent to which these uncertainties affect model predictions.

The largest uncertainties affecting model performance for the Lower Ballona model are the accuracy and resolution of available bathymetry and the grid resolution used in the model to resolve this bathymetry. To the extent possible, the model has made use of the most recent and best available bathymetric data and datum conversion tools (Section 2.2.3). However, when the bathymetric data is sampled onto the model grid, additional filtering of the bathymetric data occurs which limits the capacity of the model to resolve small-scale bathymetric features. The grid resolution for the model was selected to be as fine as possible, subject to the computation time restraints. The nominal grid cell size of 10 m prevents the model from accurately resolving the bathymetry in the smallest channels. However, since the volume of these small channels represents a small fraction of the overall domain, their exclusion is not likely to significantly alter the model's predictions.

The model solves the 2D depth-averaged approximation of the hydrodynamic flow equations. The use of 2D simulations significantly reduces the computational time required for the model simulations but also introduces additional model uncertainty in the hydrodynamic predictions. This uncertainty is constrained because the wetland's shallow depths and limited freshwater inputs minimize the impact of 3D flow effects.

Model uncertainties are also introduced through the specification of boundary conditions and model parameterizations, such as bed roughness. Additionally, any field data used either to force the model or to calibrate the model has some associated uncertainty due to instrument calibration and errors, instrument location, field corrections, and data noise.

3. MODEL CALIBRATION

The model was calibrated to observed water levels, primarily by adjustment of culverts and gate discharge rates. As presently calibrated, the model predicts water levels to within 5 cm of observations for nearly all of the calibration period. The sections below describe the calibration approach, summarize the observation data, compare predicted and observed water levels, and outline future refinements to the model.

3.1. CALIBRATION APPROACH

Calibrating a model involves adjusting model parameters or model formulation in order to match model predictions and field observations at known locations. Initially, the calibration process can verify that each of the specified model inputs and boundary conditions are working properly. Subsequent iterations of the calibration process enhance agreement between model predictions and observations. The model is run for a known set of input conditions, and its output is compared to a known set of observations. The discrepancies between the model predictions and the observation data help determine which aspects of the model are not adequately capturing the physical processes. This may lead to adjusting some model parameters to improve agreement between predictions and observations.

Adjustments to model parameters are made until the model's response to the specified inputs replicates the field measurements as closely as possible. The goal of the calibration process is to identify the areas and processes of highest interest, and maximize the model's predictive capability in those areas, while ensuring reasonable behavior in the rest of the model predictions.

The model was calibrated to optimize agreement between observations and predictions of water levels. Calibration to water levels indicates that the model is correctly predicting the volumes of water that are exchanged between each region of the model. Calibration of Ballona Creek water levels required no adjustments to model parameters beyond the model setup described above in Section 0. To calibrate water levels at the other four observation stations, all of which are upstream of culverts, a coefficient scaling the discharge through the culverts was adjusted. Comparison between this calibrated discharge and the discharge estimated by the U.S. Geological Survey Culvert Analysis Program (CAP; Fulford, 1998) exhibit good agreement.

3.2. OBSERVATION DATA

The water level observations used for calibration were collected by PWA and Nearshore and Wetland Surveys (2006) in July and August, 2006. A representative spring-neap cycle from July 5 to July 20 was selected from this observation record as the calibration period to simulate. The five locations at which water levels were observed are shown in Figure 1. In addition to water levels in Ballona Creek, which is directly exposed to the tidal action, the other four stations are located in regions where the tidal flows are controlled by flow through gates and culverts.

3.3. WATER LEVEL COMPARISON

Time series of predicted water levels at five stations and the corresponding observed water levels are plotted in Figure 4 to Figure 8. For most of the two-week simulation period, these time series demonstrate agreement within 5 cm between the model predictions and observations. Differences larger than 5 cm between predictions and observations are typically caused by mechanisms beyond the scope of the model that are insignificant in comparison to the changes expected from restoration. Explanation for these larger differences between observations and predictions are discussed below:

- During several of the lowest tides in the middle of the simulation period, the observations bottom out at constant values that are above the predicted values (Figure 4 to Figure 7). This is because the instruments were mounted such that water levels during these lowest tides fell below their sensors and exposed the sensors to the atmosphere during these periods.
- As discussed above in Section 2.3.3, an unknown water source causes water levels to rise in the Area B wetland after the tide gates between Ballona Creek and the wetland close. The observed water levels consist of a rapidly rising section while the tide gate is open and then a slowly rising section once the tide gate closes (Figure 5). In the absence of data, the unknown source was modeled as a constant discharge to the wetland. This approximation of the source is sufficient to

reproduce the typical rising water levels during high tides. However, the source's actual discharge rate probably varies in time, causing the differences between the observed and the modeled water levels.

- In Fiji Ditch (Figure 6), high frequency oscillations in the water level observations are consistent with the 6 to 8 second water level oscillations observed visually during instrument installation. It is hypothesized that these water level oscillations result from ocean swell that propagates through the marina and culvert. The model does not include the physical processes which create this type of water level oscillation since this process does not transport significant amounts of water.
- Below 0.25 m NAVD, predicted water levels in Del Rey Lagoon fall more rapidly than observed water levels (Figure 7). This difference may be the result of the representation of the lagoon's bathymetry in the model, which was created by interpolation from relatively few spot elevations. Since the predictions at all other times and locations otherwise demonstrate good agreement with the observed water levels and the lagoon is only a small feature located outside the project area, the current implementation is sufficient for assessment of the restoration alternatives. If specific questions regarding circulation within the lagoon are of interest, the model's representation of the lagoon's bathymetry should be improved.
- The tide gates regulating flow into Ballona Lagoon (Figure 8) are manually adjusted to restrict flow during spring tides, e.g. from July 7 to July 14. This operational practice prevents flooding upstream of the gates. Since records of the actual gate settings are not maintained (Mariposa Landscaping, personal communication), no attempt was made to model the Lagoon's water levels during this period. Hence, during the spring tides, the predicted water level continues to span nearly the full range of water levels in Ballona Creek while the observed water level within Ballona Lagoon was muted.

3.4. FUTURE WORK

Although the model is sufficiently calibrated to provide a feasibility assessment of the proposed restoration alternatives, additional calibration should be conducted for future stages of alternative design or evaluation of more complex processes, such as sediment transport or water quality. These additional steps include:

- Calibration to observed current velocity data
- Calibration to observed salinity data
- Validation to water levels during high Ballona Creek discharge

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WL | Delft Hydraulics. 2006b. 3D-RGFGRID User Manual: Generation and manipulation of curvilinear grids for FLOW and WAVE. Rotterdam, The Netherlands.

5. FIGURES

Source: R.J. Lung & Associates aerial survey (1998) and PWA (2006) channel cross sections

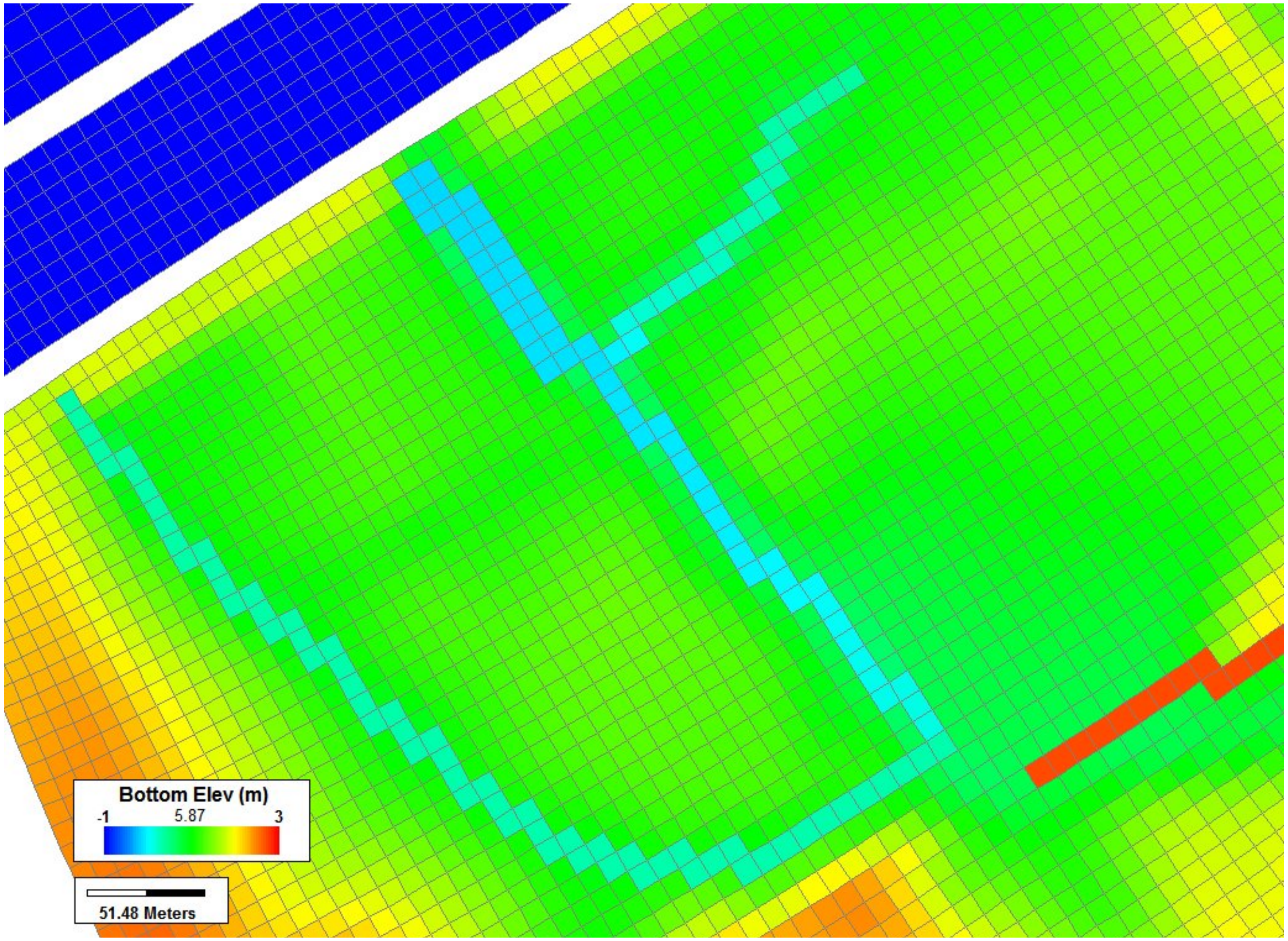
figure 1

Lower Ballona Modeling

Model Bathymetry, Full Extent

PWA Ref# 1793.01

PWA



Source: R.J. Lung & Associates aerial survey (1998) and PWA (2006) channel cross sections

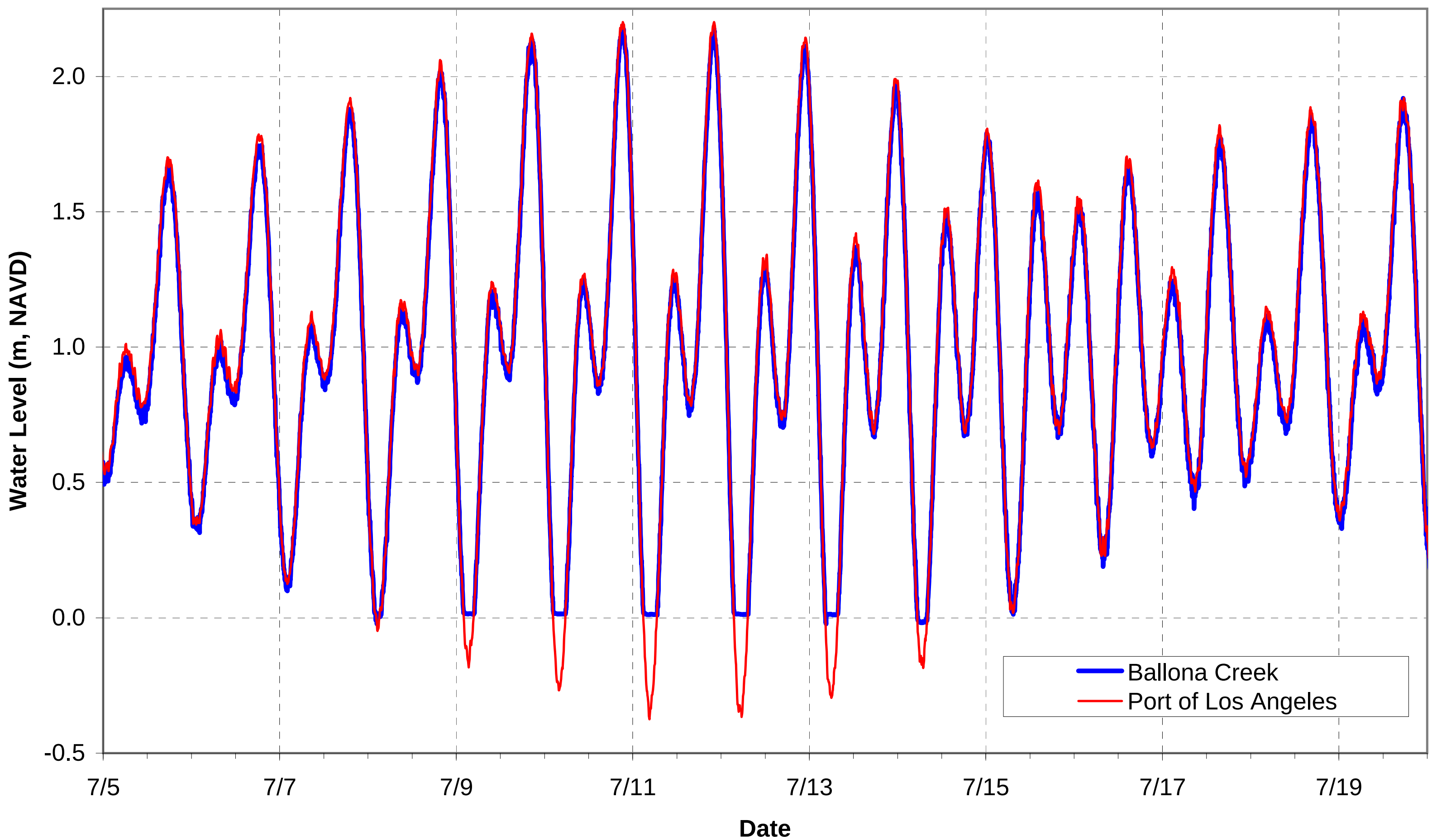
figure 2

Lower Ballona Modeling

Model Bathymetry, Area B Wetland

PWA Ref# 1793.01

PWA



Source: NOAA (Station ID 9410660) and Nearshore and Wetland Surveys (2006)

figure 3

Lower Ballona Modeling

Port of Los Angeles and Ballona Creek Observed Water Levels

PWA

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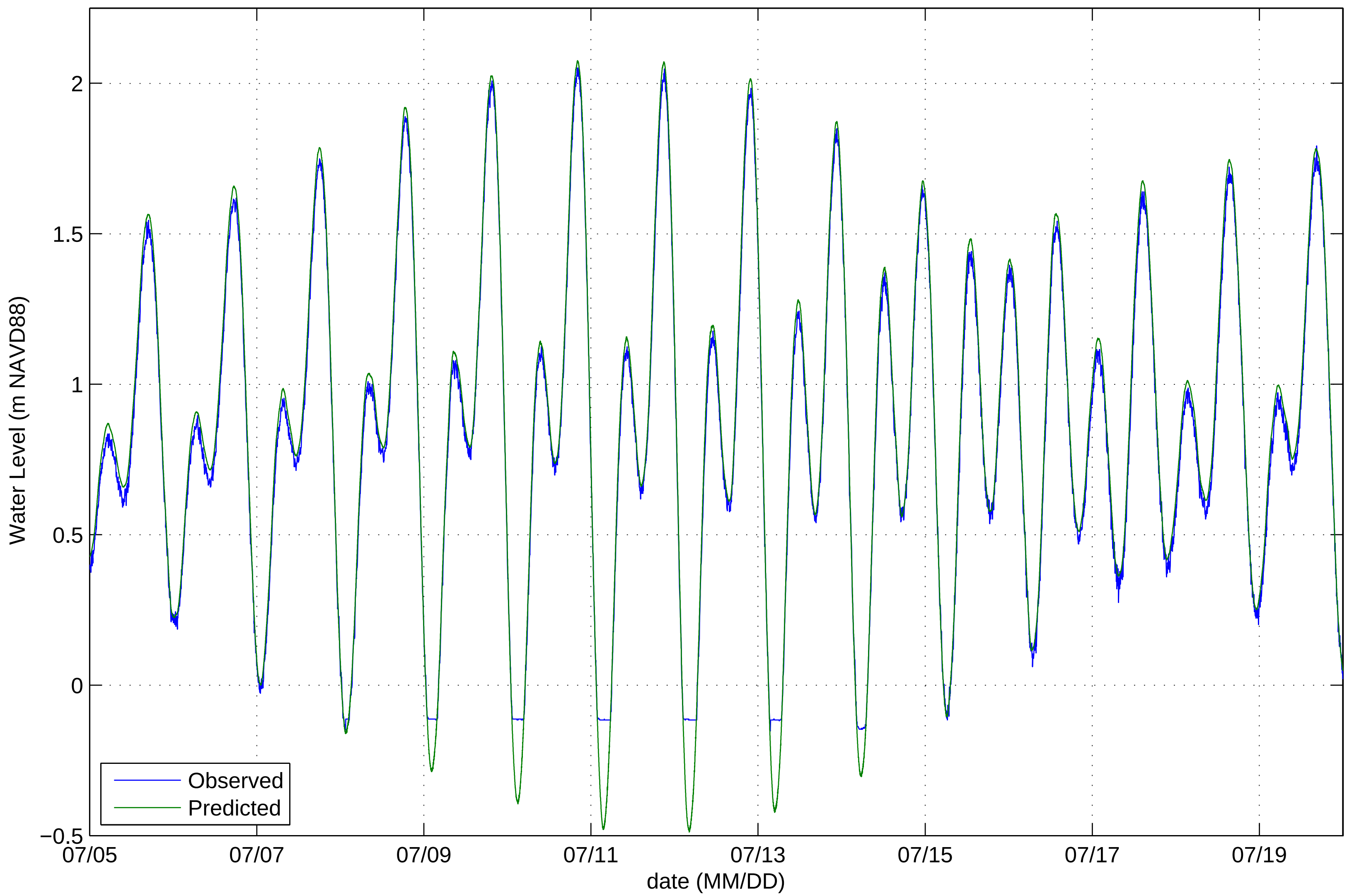

Source: USACE field observations and EFDC model predictions

Figure 4
Lower Ballona Modeling

Predicted vs. Observed Water levels, 2006 – Ballona Creek

PWA Ref# 1793.1

PWA

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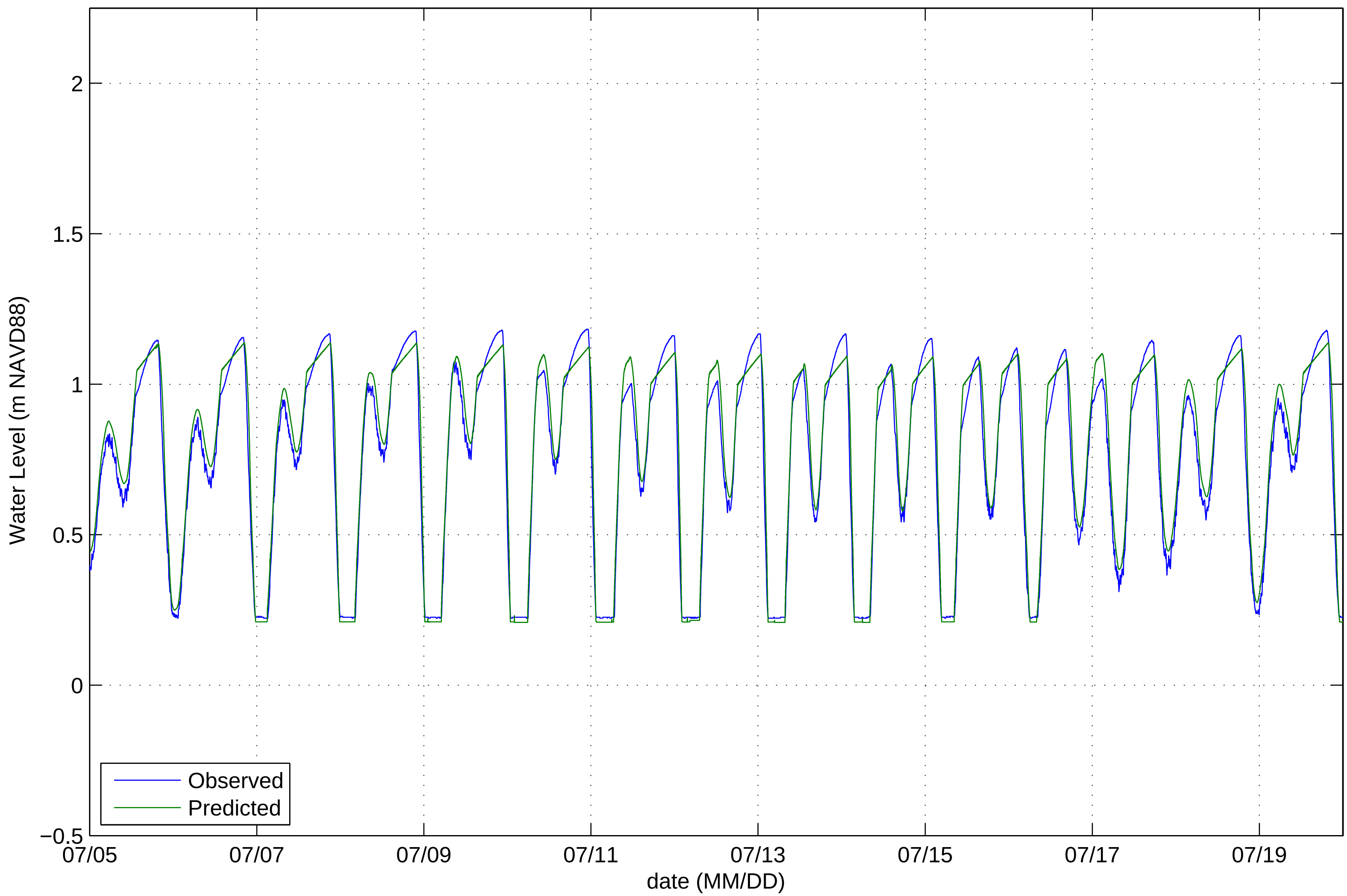

Source: USACE field observations and EFDC model predictions

Figure 5
Lower Ballona Modeling

Predicted vs. Observed Water levels, 2006 – Area B Wetland

PWA Ref# 1793.1

PWA

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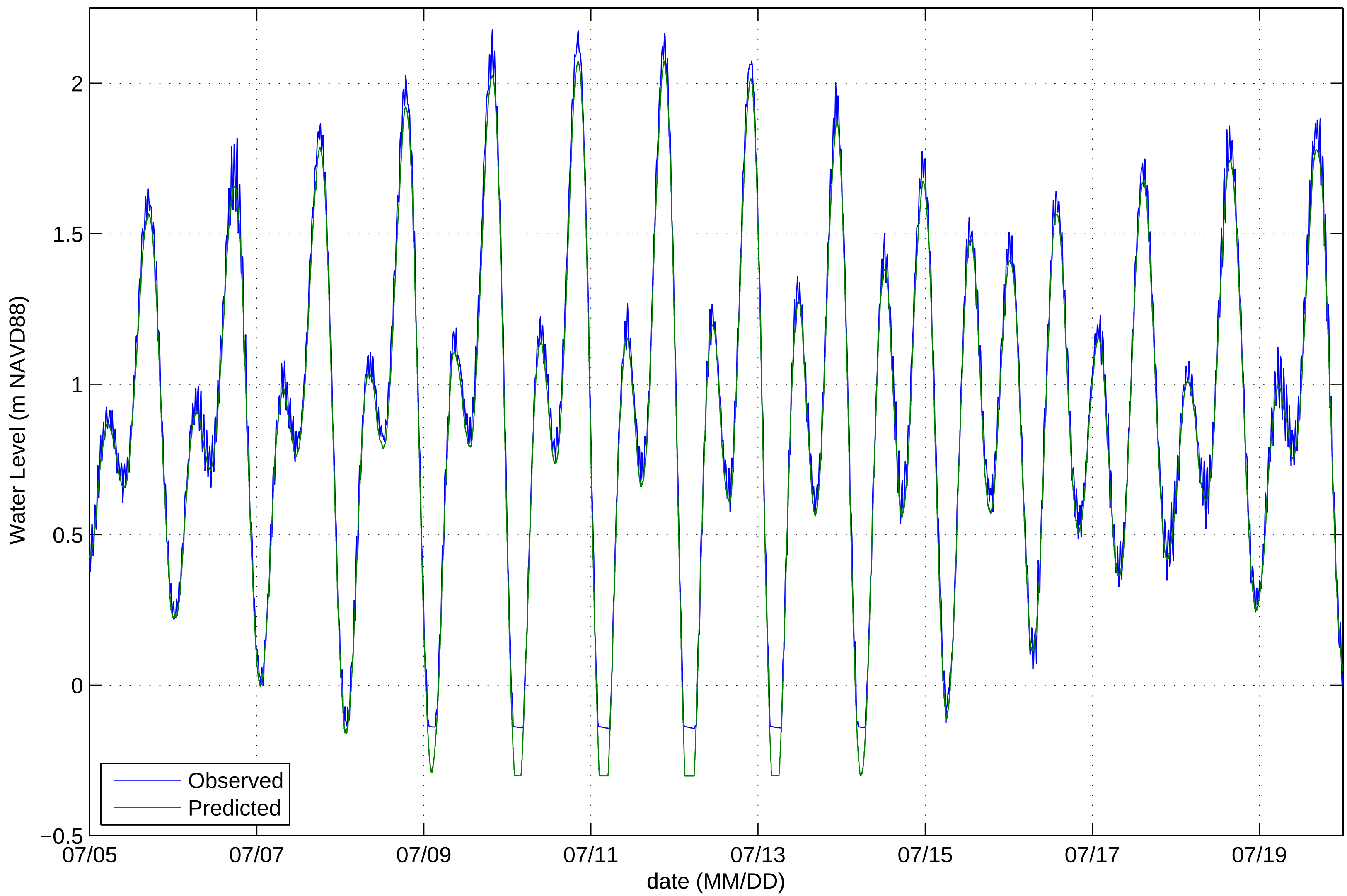

Source: PWA field observations and EFDC model predictions

Figure 6
Lower Ballona Modeling

Predicted vs. Observed Water levels, 2006 – Fiji Ditch

PWA Ref# 1793.1

PWA

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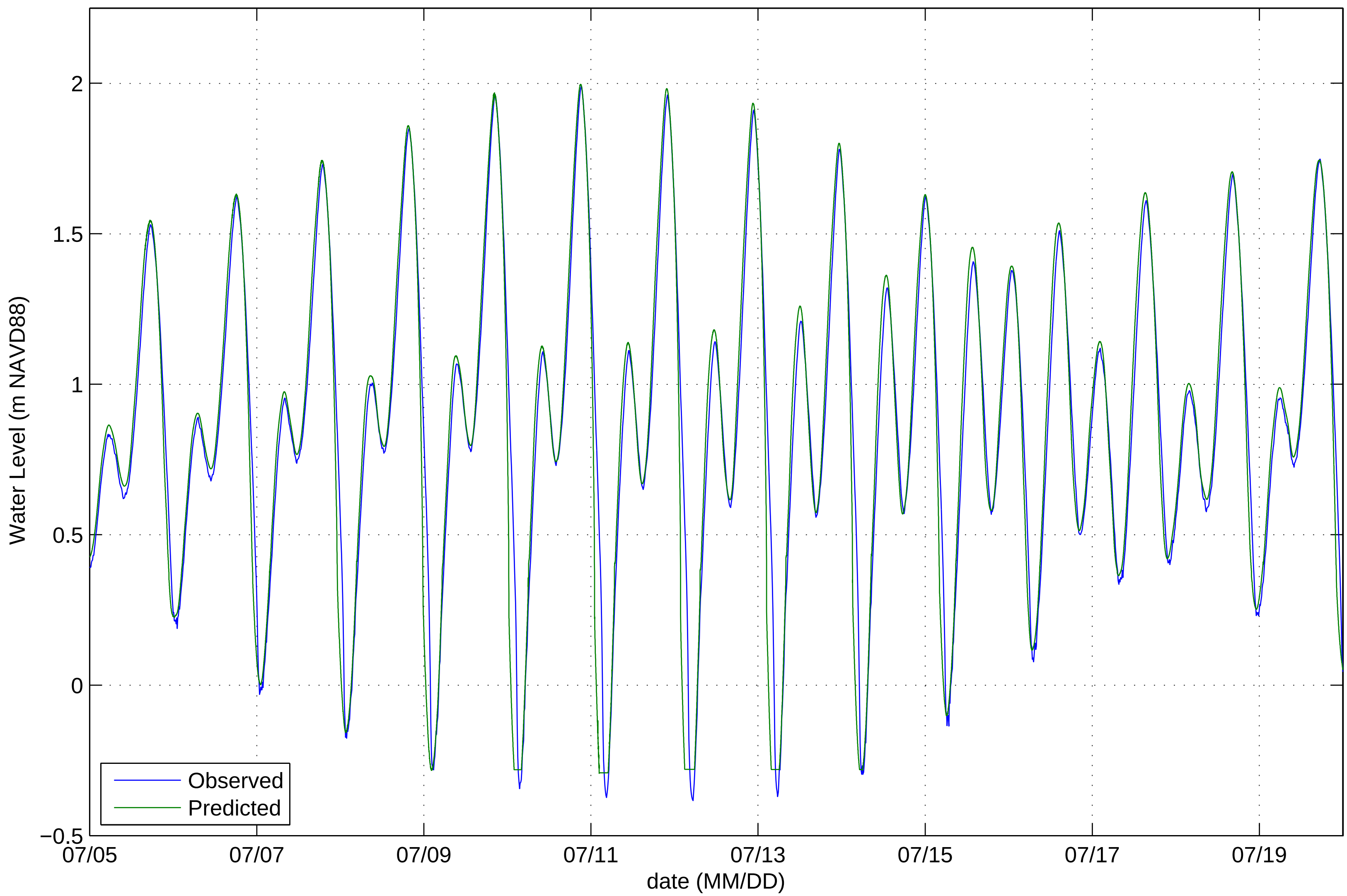

Source: PWA field observations and EFDC model predictions

Figure 7
Lower Ballona Modeling

Predicted vs. Observed Water levels, 2006 – Del Rey Lagoon

PWA Ref# 1793.1

PWA

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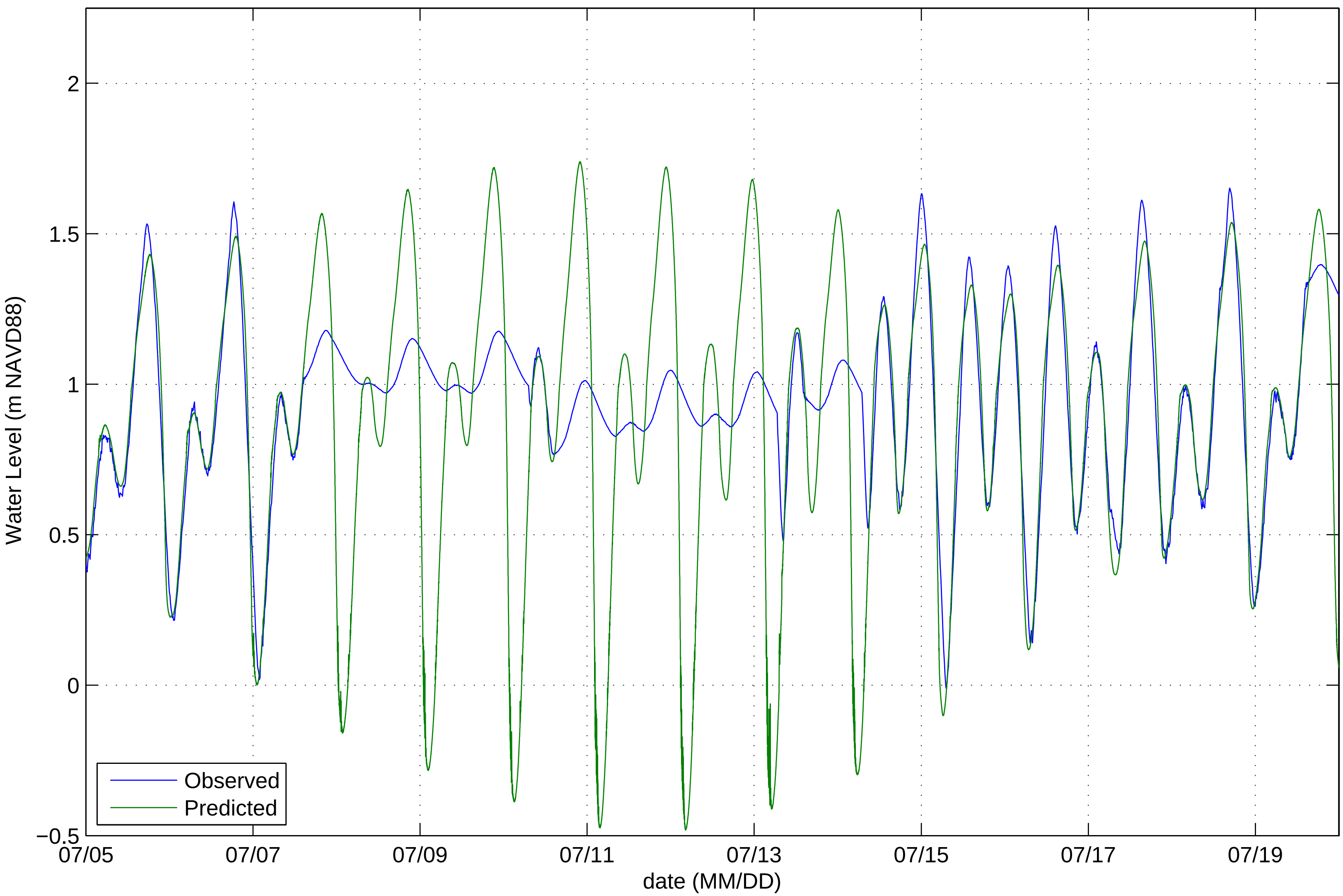


Source: PWA field observations and EFDC model predictions

Figure 8
Lower Ballona Modeling

Predicted vs. Observed Water levels, 2006 – Ballona Lagoon

PWA Ref# 1793.1

PWA

P:\Projects\1793_Ballona_Wetlands\1793.01_Modeling\Reporting\Model calib memo\Figs\ballona_wse_BLagoon.pdf

C-2. MARSH CHANNEL REPRESENTATION IN LOWER BALLONA EFDC MODEL

1. INTRODUCTION

This section outlines the methodology implemented to represent tidal channel morphology and layout in the Lower Ballona Wetlands EFDC numerical model. The purpose of the numerical model is not to model fine scale hydrodynamics or velocities in the tidal channels (existing or future), but to describe the hydraulic characteristics and flushing of each restoration parcel. The procedure is based on the methods presented in the "Design Guidelines for Tidal Channels in Coastal Wetlands," prepared by PWA in January 1995 for the U.S. Army Corps of Engineers. The guidelines present empirical relationships between morphologic characteristics of marsh channels (channel top width, depth, and cross sectional area) and diurnal tidal prism. Characteristics of marsh morphometry (channel order, length, sinuosity, drainage density, etc.) are also tabulated. The tidal prism dataset includes sites from San Diego Bay (Chula Vista) and San Francisco Bay (Novato, Corte Madera, and Newark Slough). The marsh morphometry dataset includes a more extensive analysis of sites from southern California, north San Francisco Bay, and south San Francisco Bay.

The approach taken to implement the appropriate channel characteristics in the model was to first determine what the detailed tidal channel characteristics would be, and then to aggregate these for inclusion into the model, given the grid cell size limitations. A general outline of the procedure is presented below:

1. Approximate channel order, length, and number of channels based on channel morphometry relationships with marsh area (Section 2).
2. Approximate channel geometry (width and thalweg depth) based on tidal prism using hydraulic geometry relationships (Section 3).
3. Aggregate channel morphology and morphometry for inclusion into the model (Section 4).

2. CHANNEL MORPHOMETRY

Marsh morphometry refers to the plan view features of tidal marshes, such as channel length, sinuosity, channel order, and density of channels. The general outline presented in the Design Guidelines is reproduced below:

1. Determine the order of the drainage system that can be accommodated within the site based on the marsh area.
2. Calculate the total channel length based on an assumed drainage density (typically 0.01-0.02 ft/ft^2).
3. Estimate the number of channels of each order.
4. Partition the length among the different order channels.

The results for Area B East Wetland are presented below as an example of the methodology and assumptions used in the analysis.

1. For a given marsh area of approximately 35 acres, Figure 7.1-4 of the design guidelines was used to select a maximum channel order of 4 for the parcel.
2. Drainage densities at numerous California marshes tend to fall between 0.01-0.02 ft/ft^2. A drainage density of 0.01 ft/ft^2 was selected to minimize construction costs and allow for natural evolution of the site. From this drainage density, a total length of channels of 15,250 ft was determined.
3. The number of channels of each order was determined assuming a bifurcation ratio of 3.5. This ratio predicts 1 fourth-order channel, 4 third-order channels, 12 second-order channels, and 43 first-order channels, although not all orders can be represented in the model due to grid cell size limitations.
4. Table 7-6 and Figure 7.3-1 of the Design Guidelines give typical channel distributions for California marshes. The following distribution of channel length was assumed for the 4th through 1st order channels: 10%, 15%, 30%, and 45%. The total length of channels was used with the channel order distributions to determine the length of each order channel.

3. HYDRAULIC GEOMETRY

The term hydraulic geometry refers the empirical relationships between channel discharge and channel geometry. The hydraulic geometry relationships presented in the Design Guidelines relate diurnal tidal prism with channel width, depth, and cross sectional area. A predicted tidal prism of 25 acre-ft was determined to represent the diurnal tidal prism for the 35-acre Area B East Wetland parcel using Figure 5.2-1. The top width and depth of the 4th order channel were determined assuming this tidal prism. For the lower order channels, the total tidal prism was distributed incrementally based on the bifurcation ratio, after subtracting out the intertidal storage volume of the next higher order channel. The partitioned tidal prism was used in the hydraulic geometry relationships for each channel order.

4. IMPLEMENTATION OF CHANNEL MORPHOLOGY IN MODEL BATHYMETRY

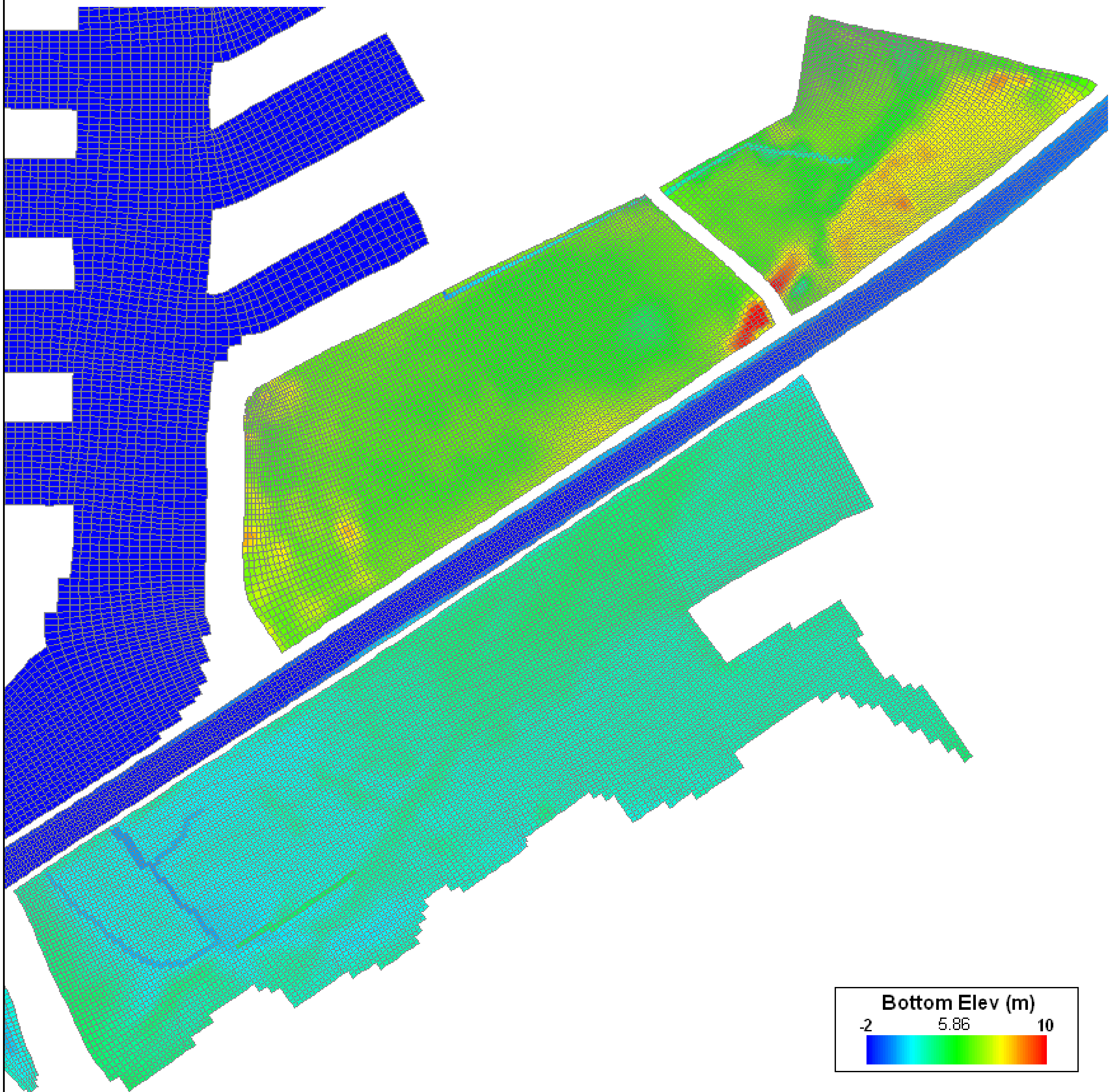
For each channel order, the predicted top width was compared to the grid cell size of the EFDC model grid, nominally equal to 9 m (29.5 ft). The predicted top widths of the 3rd and 4th order channels were 28 ft and 54 ft, roughly equivalent to one and two cell widths, respectively. The model tidal prism was calculated as the total intertidal channel storage volume for a diurnal tide range of 5.49 ft (LA tide gage, #9410660). The resulting tidal prism was 19 acre-ft, 24% less than the predicted tidal prism of 25 acre-ft. This is due to the lack of first and second order channels in the model. To account for the remaining 6 acre-ft, 4 of the 12 second-order channels were implemented at a width of one grid cell. The number of grid cells for each channel order was determined by dividing the length per channel by the nominal grid size. An idealized channel layout was then overlaid on the existing topography grid based on the widths, depths, and lengths determined from the Design Guidelines. The bed elevation of the highest-order channel is constant along its length. Along-channel bed elevations of lower-order channels were linearly interpolated from the channel junction to the channel end (i.e., from the predicted elevation of the higher-order channel to the predicted elevation of the lower-order channel). Elevations of the future marshplain (non-channel regions within the wetland footprint) were set at MHHW (1.61 m NAVD).

The channel layout was adjusted iteratively to correctly reproduce the expected future tidal prism for the marsh restoration parcel. The model tidal prism was confirmed by comparing the total intertidal channel storage volume to the predicted diurnal tidal prism for the given marsh area. Future model refinement could be to develop a more detailed bathymetry grid in the region of tidal channels.

C-3. LOWER BALLONA EFDC MODEL – ALTERNATIVES BATHYMETRY

Sections C-1 and C-2 above describe the model development and calibration procedures. Figure 9 through Figure 14 show the model bathymetries for each alternative.

Figures



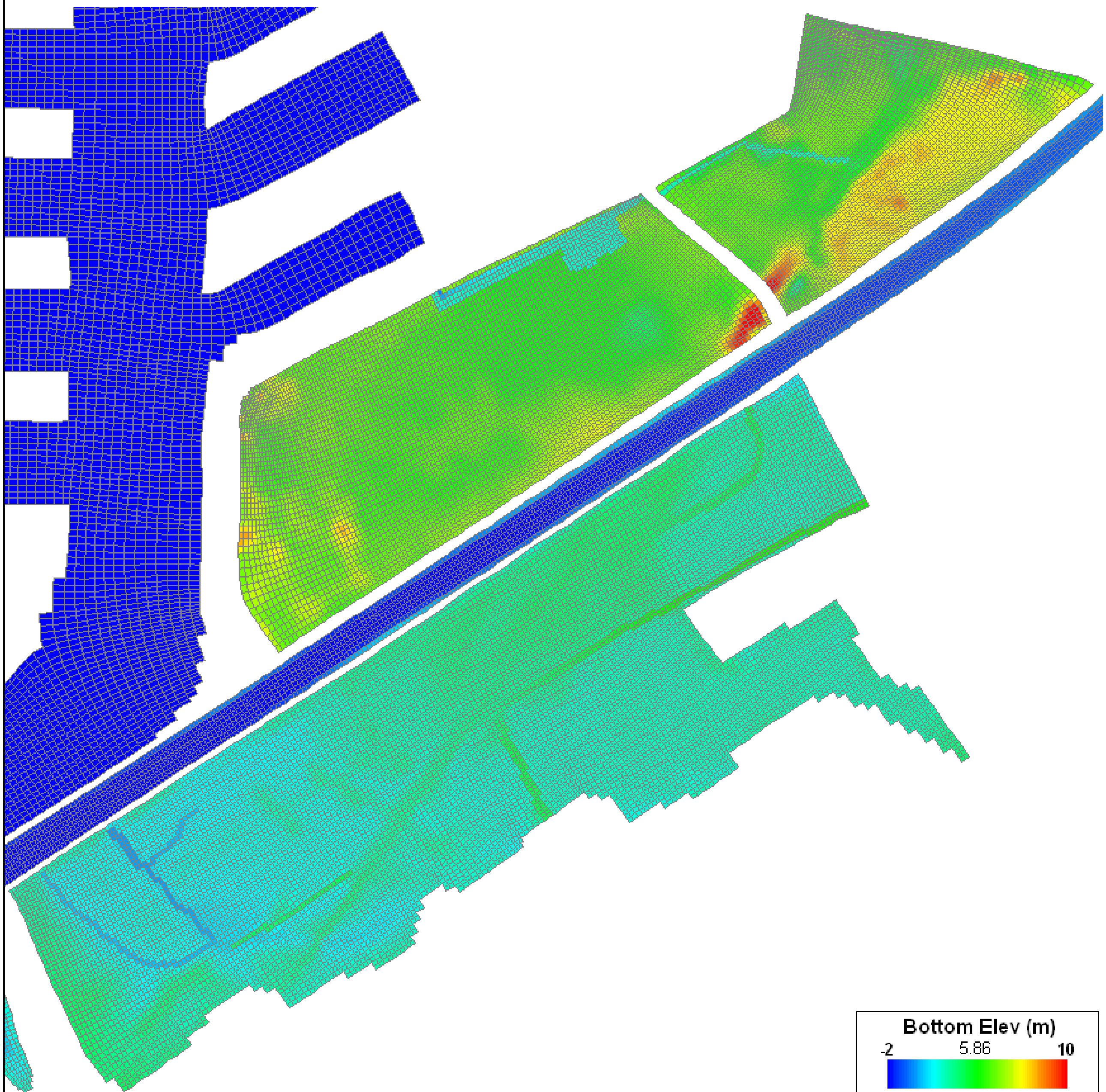
Source: EFDC model setup.
Notes: Bottom elevations shown in meters NAVD.

figure 9
Ballona Wetlands Restoration Project

Existing Conditions (No Action) Bathymetry

PWA Ref# 1793

PWA



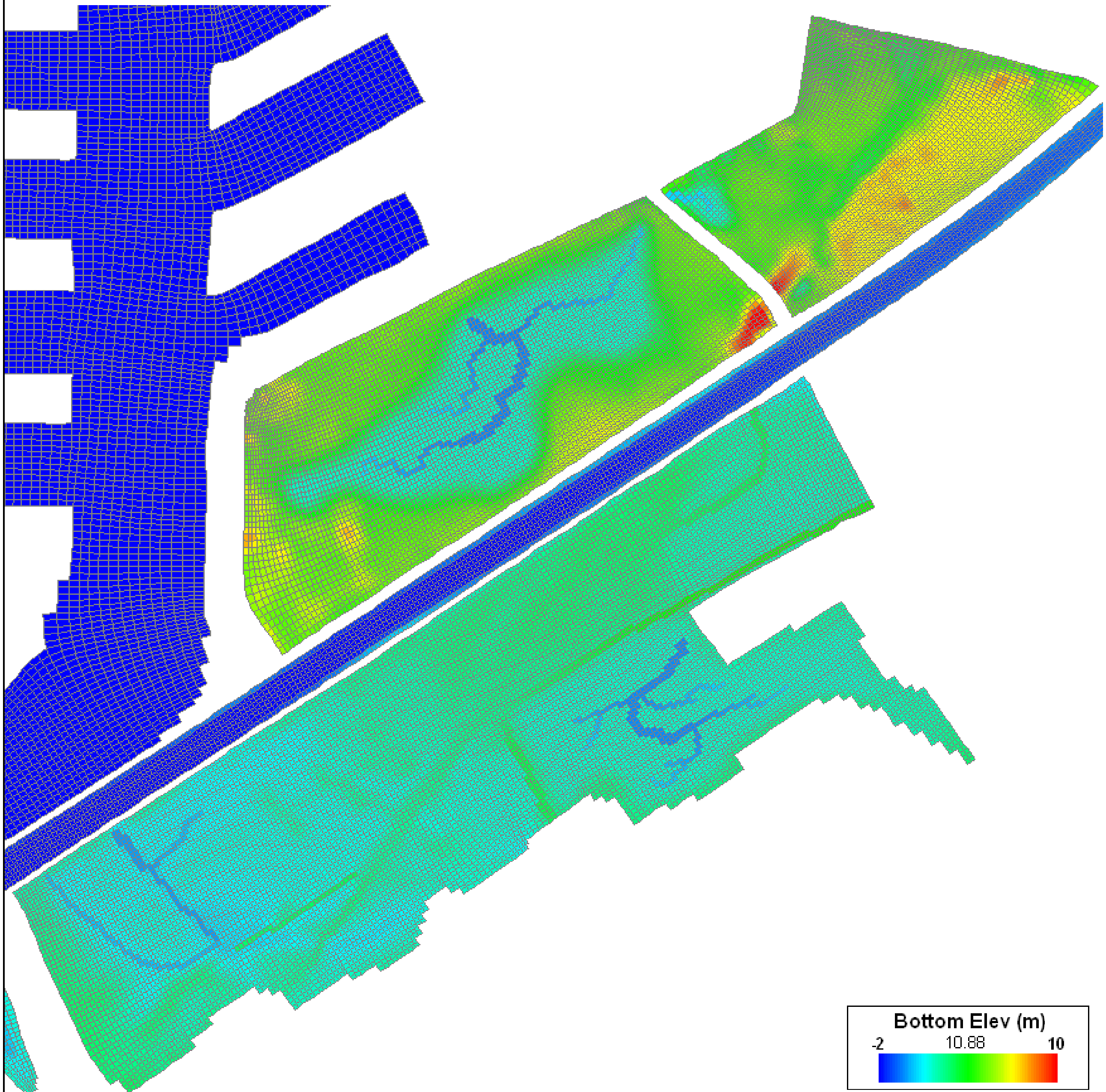
Source: EFDC model setup.
Notes: Bottom elevations shown in meters NAVD.

figure 10
Ballona Wetlands Restoration Project

Alt 1 – Muted Tidal Bathymetry

PWA Ref# 1793

PWA

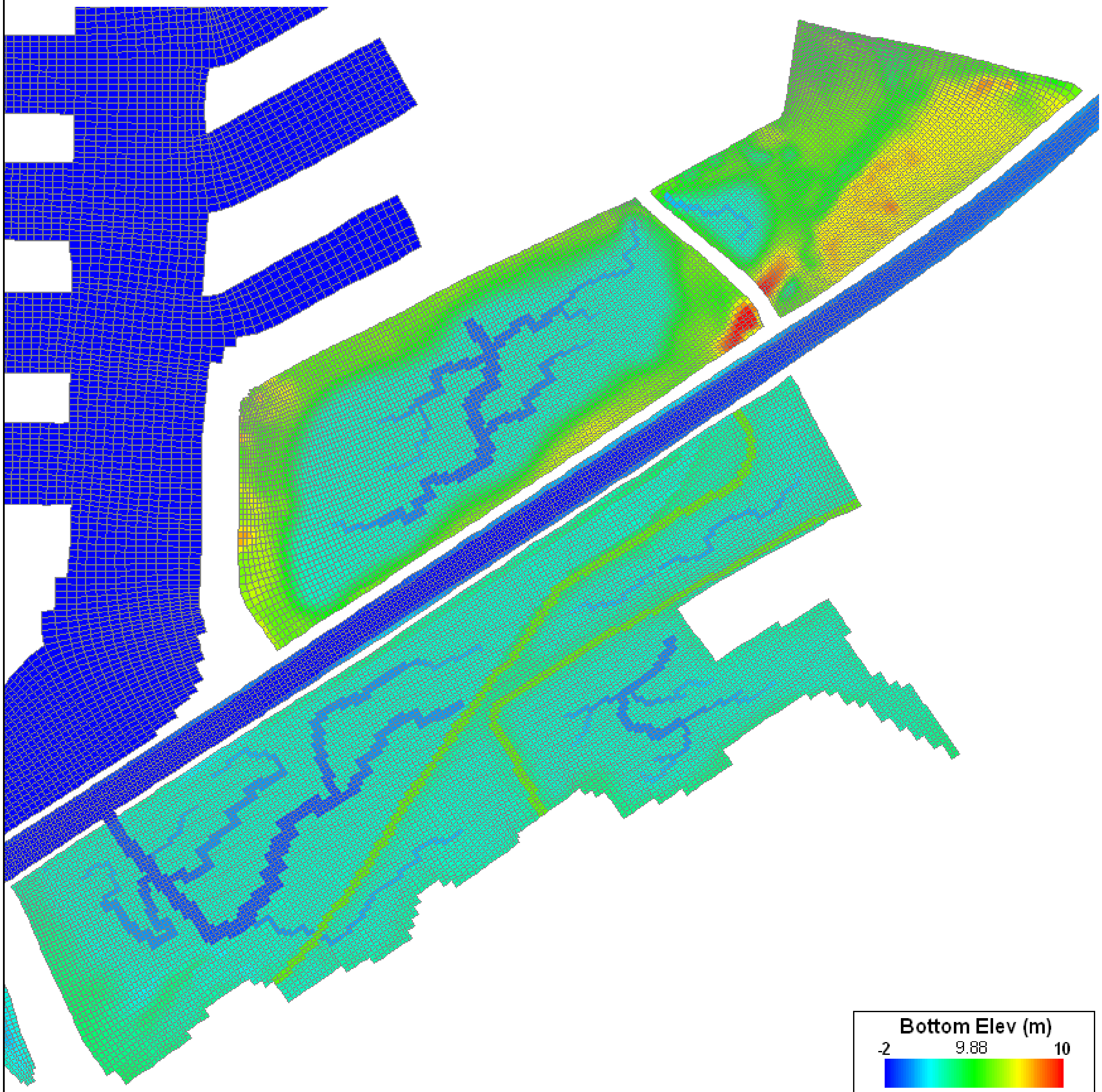


Source: EFDC model setup.
Notes: Bottom elevations shown in meters NAVD.

figure 11
Ballona Wetlands Restoration Project

Alt 2 – Partial Tidal Bathymetry

PWA Ref# 1793



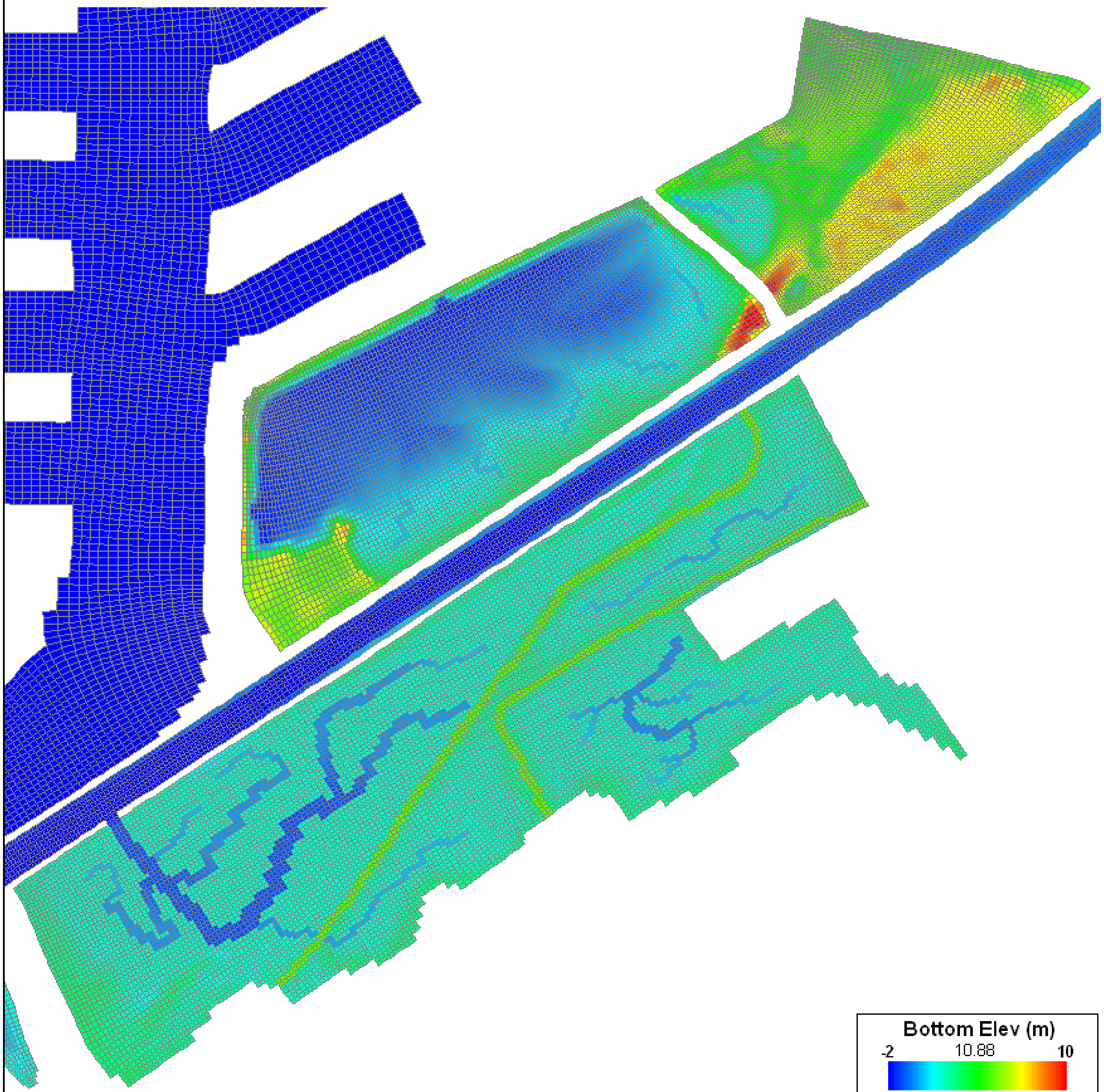
Source: EFDC model setup.
Notes: Bottom elevations shown in meters NAVD.

figure 12
Ballona Wetlands Restoration Project

Alt 3 – Full Tidal Bathymetry

PWA Ref# 1793

PWA



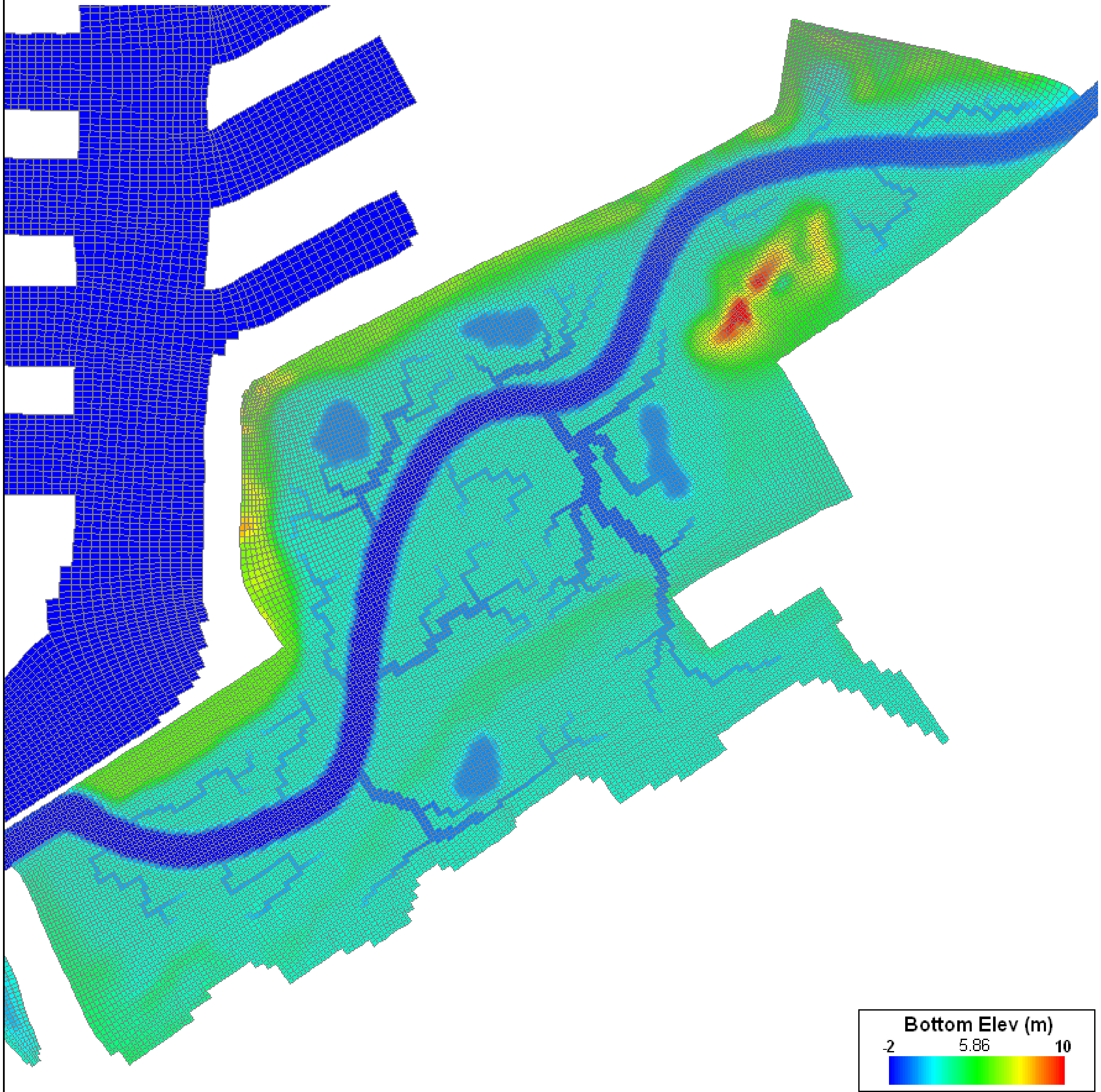
Source: EFDC model setup.
Notes: Bottom elevations shown in meters NAVD.

figure 13
Ballona Wetlands Restoration Project

Alt 4 – Area A Subtidal Bathymetry

PWA Ref# 1793

PWA



Source: EFDC model setup.
Notes: Bottom elevations shown in meters NAVD.

figure 14
Ballona Wetlands Restoration Project

Alt 5 – New Creek Bathymetry

PWA Ref# 1793

PWA

C-4. SUPPORTING DOCUMENTATION FOR SECTION 3.3 HYDROLOGY

Section 3.3 of the Lower Ballona Creek Restoration Feasibility Study discusses the expected hydrology for each proposed alternative. The text and figures below provide supporting documentation for the specific model results discussed in the report as well as related model results not explicitly discussed in the Feasibility Study. The section numbers below correspond to the relevant subsections of Section 3.3 (Hydrology).

Section 3.3.1 - Muted Tidal System versus Full Tidal System

Inundation regime is the percentage of time that a given water level is exceeded during a neap-spring tidal cycle. It is a useful parameter for characterizing the tidal inundation at a particular location with a specific elevation. The inundation frequency curves corresponding to Table 3-7 are shown in Figure 15.

Section 3.3.2 - Tidal prism

Tidal prism is the volume of water passing through a channel cross section on each tide (ebb or flood). Tidal prism was evaluated for each restoration area at four cross sections: (1) mouth of Ballona Creek, (2) mouth of Marina Del Rey, (3) Basin H entrance, and (4) Marina del Rey above Basin H. Tidal prism was estimated by integrating the discharge time series at each cross section for each tide (flood or ebb). The mean tidal prism of all floods and all ebbs was estimated for all runs that spanned the full spring-neap cycle. The results are shown in Table 1.

Section 3.3.3 – Connections

Area B southwest wetland SRT and culvert connection

Figure 16 shows a sample water level comparison for the culvert sizing and SRT optimization for the Area B southwest wetland. Two culvert geometries are tested: (1) 2 x 5 ft culverts and (2) 3 x 5 ft culverts. Three elevations are tested for the SRT: 3.6 ft, 4.9 ft, and 6.6 ft NAVD. Increasing the culvert area increases the tide range within the wetland and improves drainage from the wetland to Ballona Creek. The effect of the SRT in limiting high water within the site is seen once the Ballona Creek water levels reach the closure elevation.

Area B southeast wetland, Area A small marsh, Area A large marsh, Area A subtidal

Figure 17 illustrates the procedure adopted to size the culvert connections to each wetland. The number of culverts was increased until the tide range within the wetland approximately matched that of Ballona Creek. As can be seen in Figure 17, once the number of culverts increases beyond six 5-ft culverts, there are very small incremental gains in tide range for relatively large increases in culvert cross sectional area. The same procedure was followed to size the culverts for the small and large marshes and subtidal portion of Area A, shown in Figure 18, Figure 19, and Figure 20, respectively.

Area B southwest breach

The Area B breach was sized with a similar objective to the culvert sizing described above. The breach was sized to allow full conveyance of the tidal signal to the wetland (i.e. no tidal damping or muting). A sample water level comparison is shown in Figure 21.

Section 3.3.4 - Channel Network

Section 3.3.4 of the Feasibility Report discusses the expected channel network characteristics for each alternative. See Appendix C-2 (Marsh channel representation in Lower Ballona EFDC model) for a more detailed explanation of the methodology used to develop the channel networks.

Section 3.3.6 - Excursion Length

Section 3.3.6 of the Feasibility Report provides a qualitative discussion of tidal excursion lengths and implications for hydraulic connectivity and mixing in Ballona Creek. Excursion length was examined at the same cross sections locations as for the tidal prism analysis: (1) mouth of Ballona Creek, (2) mouth of Marina del Rey, and (3) Entrance to Basin H. For this application, excursion length was calculated by integrating the velocity time series over each tidal cycle to obtain the tidal excursion for each flood or ebb tide. The median tidal excursion lengths for flood and ebb were then tabulated for each model run. The results are shown in Table 2.

Section 3.3.7 – Flooding

50-yr hydrograph

The Ballona Creek Ecosystem Restoration Feasibility Study Hydrology Appendix (USACE 2008) presents results of a flood frequency analysis and rainfall-runoff model for the Ballona Creek watershed. A discharge-frequency relationship for Ballona Creek at Sawtelle Boulevard for the period 1928-2005 was developed to predict the hydrograph for the 50-yr discharge event (Figure 22). Ballona Creek hydrographs for the 50-year event were provided to PWA by the USACE. PWA then used these hydrographs to estimate the discharge from Sepulveda Channel and from Centinela Channel. These estimates were used as boundary conditions for the model.

50-yr flood water levels

The restoration alternatives were evaluated under flood conditions by using the EFDC model to predict water levels resulting from the 50-yr flood. The predicted peak water levels near the SRT for existing conditions (Figure 23) compare well with the USACE predictions at the same location. Overall changes to the system under Alternative 1 and Alternative 2 are minimal, resulting in nearly identical water level predictions in Ballona Creek as for Existing Conditions (Figure 24, Figure 25). Because of flow through the culverts is limited, water levels within the southeast wetlands peak at lower values than within Ballona Creek and also take longer to drain off with the falling flood water levels (Figure 25). Alternative 3's peak water levels in Ballona Creek were lower than the Existing Conditions peak because the large expanse of wetlands in this alternative provides storage for the flood waters (Figure 26). For floods under Alternatives 1-3, predicted water levels in Area A are not altered since these wetlands are not connected to Ballona Creek. Therefore, Alternative 4, which is identical to Alternative 3 except for the subtidal region of Area A, was not modeled with flood conditions. For Alternative 5, water levels were assessed both upstream near Area C and at the SRT. While the upstream water levels are higher as a consequence of the channel and water surface slope, Alternative 5's upstream water levels are below that of existing conditions (Figure 27). This suggests that flood hazard is unlikely to increase with restoration.

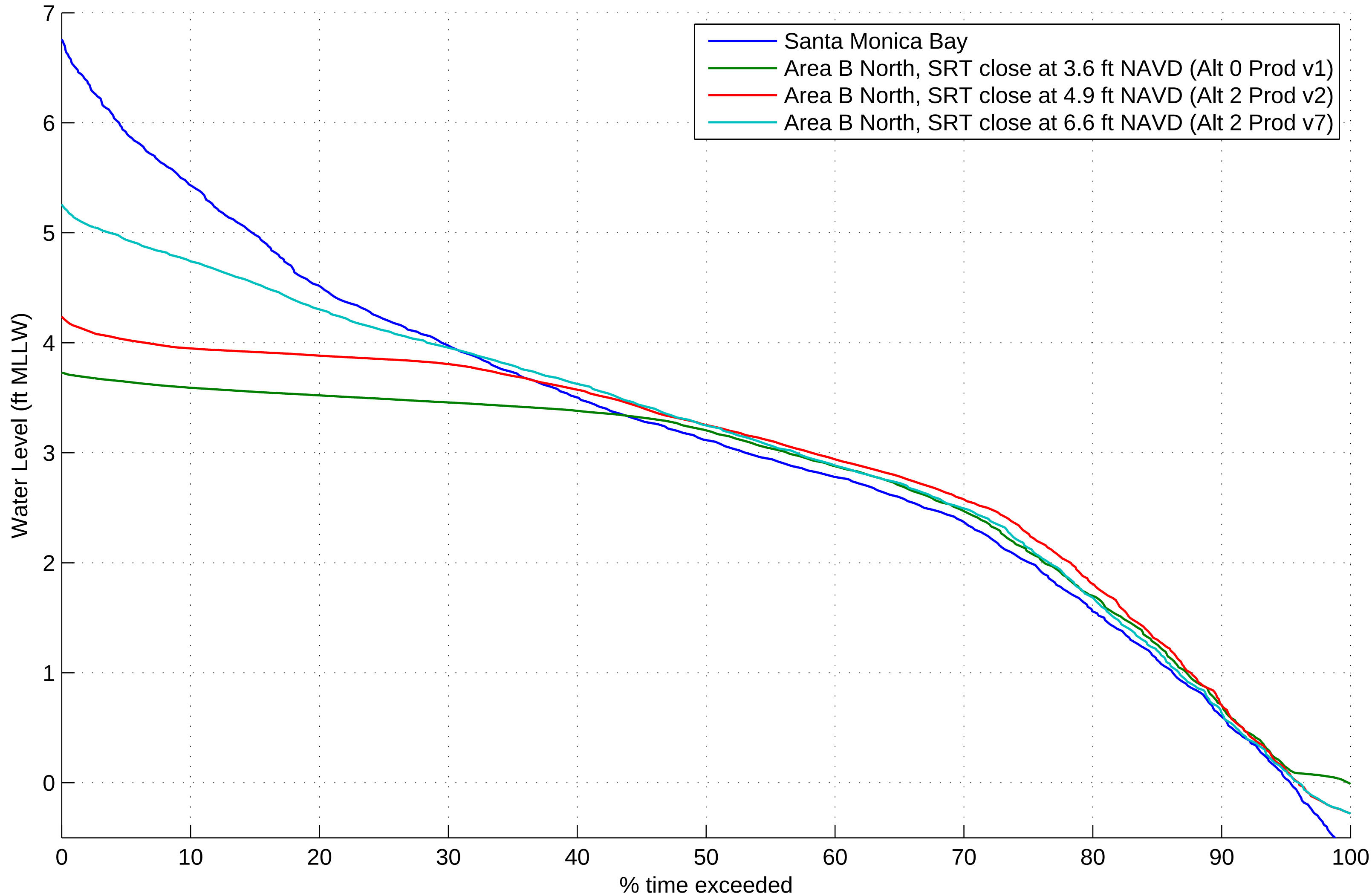
Storm Surge Analysis

Water levels at the Port of Los Angeles were examined using an event selection approach to identify typical storm surge events (super-elevation of water levels above astronomical tides). Events were selected based on events identified in the Ballona Creek Ecosystem Restoration Feasibility Study Hydrology Appendix (USACE 2008), since coastal storms often exhibit high precipitation and storm surge. Typical surges ranged from 0.5 to 1.5 ft above astronomical tides, with a maximum of 1.65 ft during the 1997-1998 El Niño winter. Storm surge events lasted approximately 3-7 days. Table 3 shows a summary of the event-based analysis.

Additional Model Runs

Additional model runs were conducted for each alternative to inform the culvert sizing, SRT closure elevations, and other aspects of the model setup. The full run catalog is shown in Table 4.

Figures



Source: EFDC model predictions

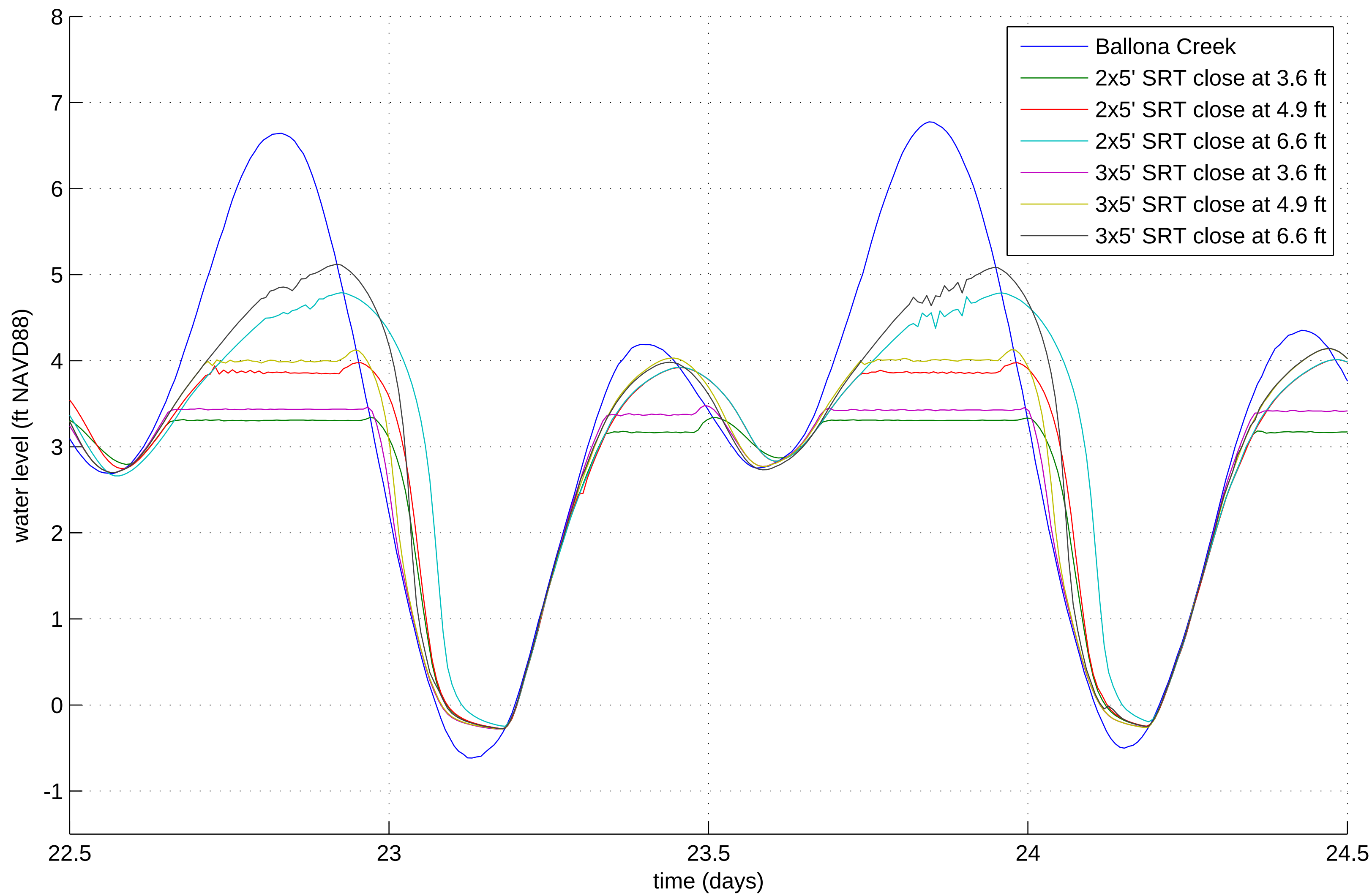
Figure 15
Lower Ballona Wetlands

Inundation frequency, Area B southwest SRT

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Water levels\plot_inun_freq_AreaB_north_SRT.m



Source: EFDC model predictions

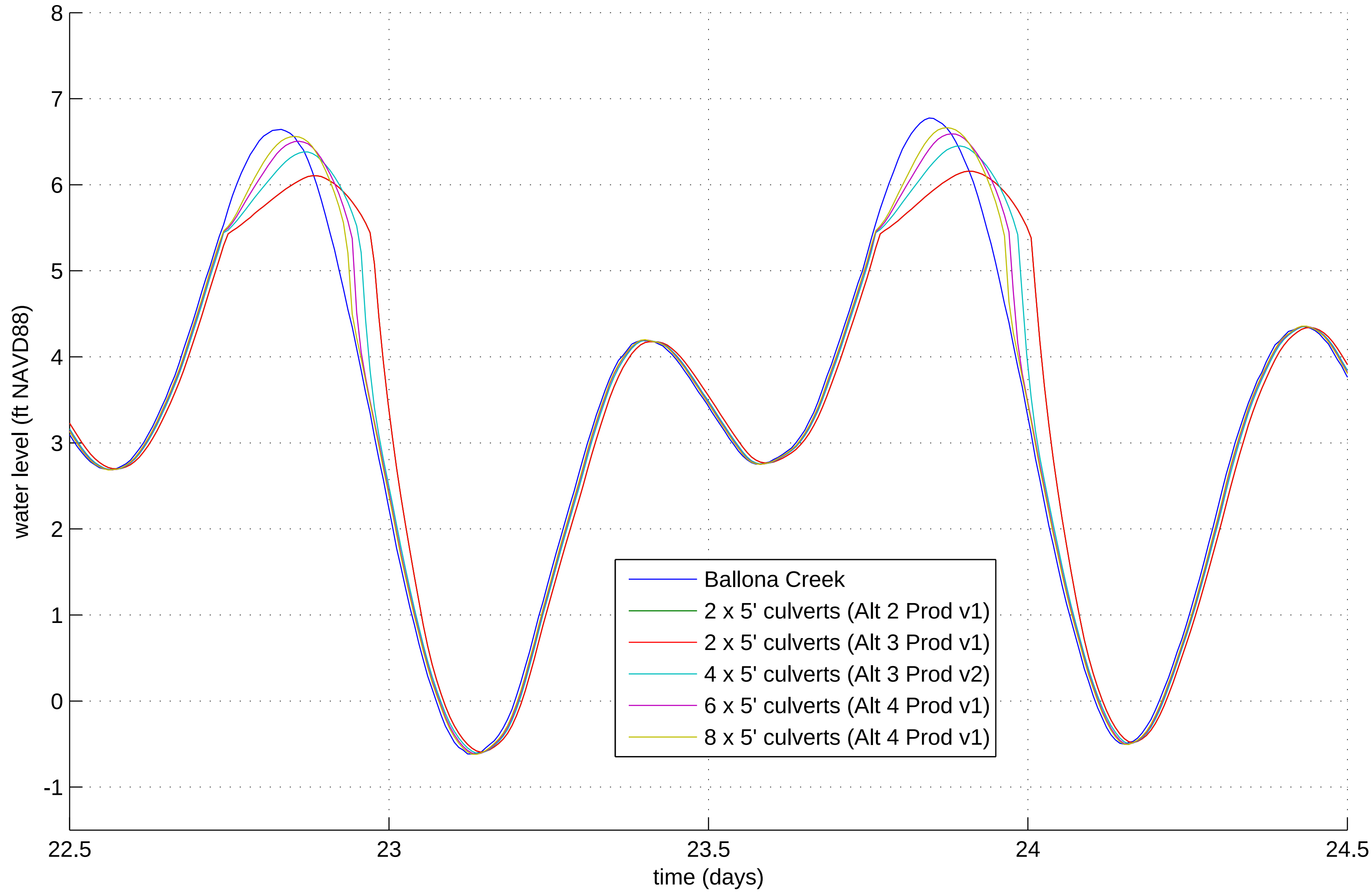
Figure 16
Lower Ballona Wetlands

Culvert sizing and SRT optimization, Area B southwest

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Culvert sizing\compare_culverts_AreaB_north_SRT.m



Source: EFDC model predictions

Figure 17
Lower Ballona Wetlands

Culvert Sizing, Area B SE Marsh

PWA Ref# 1793.1

PWA

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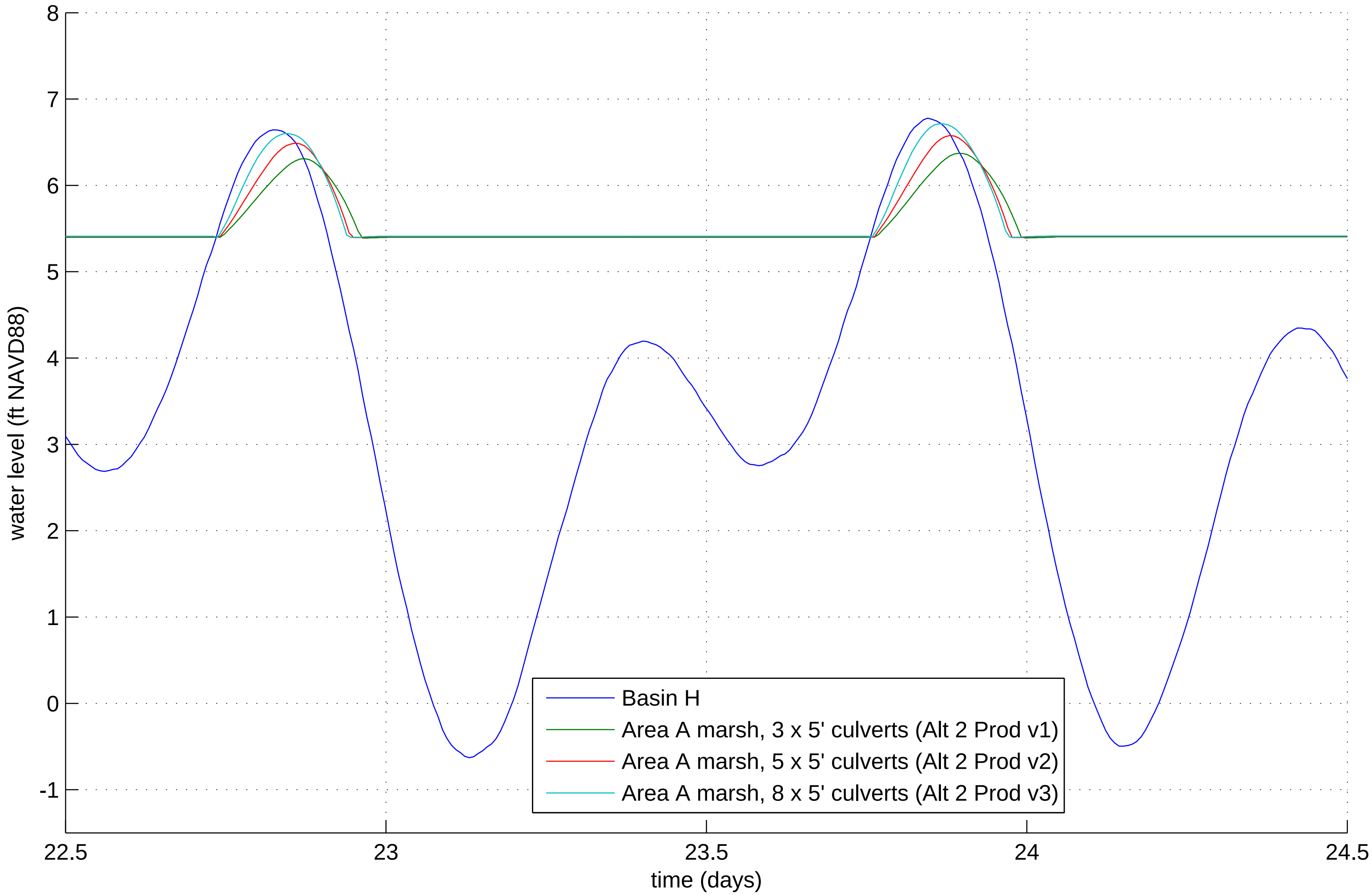


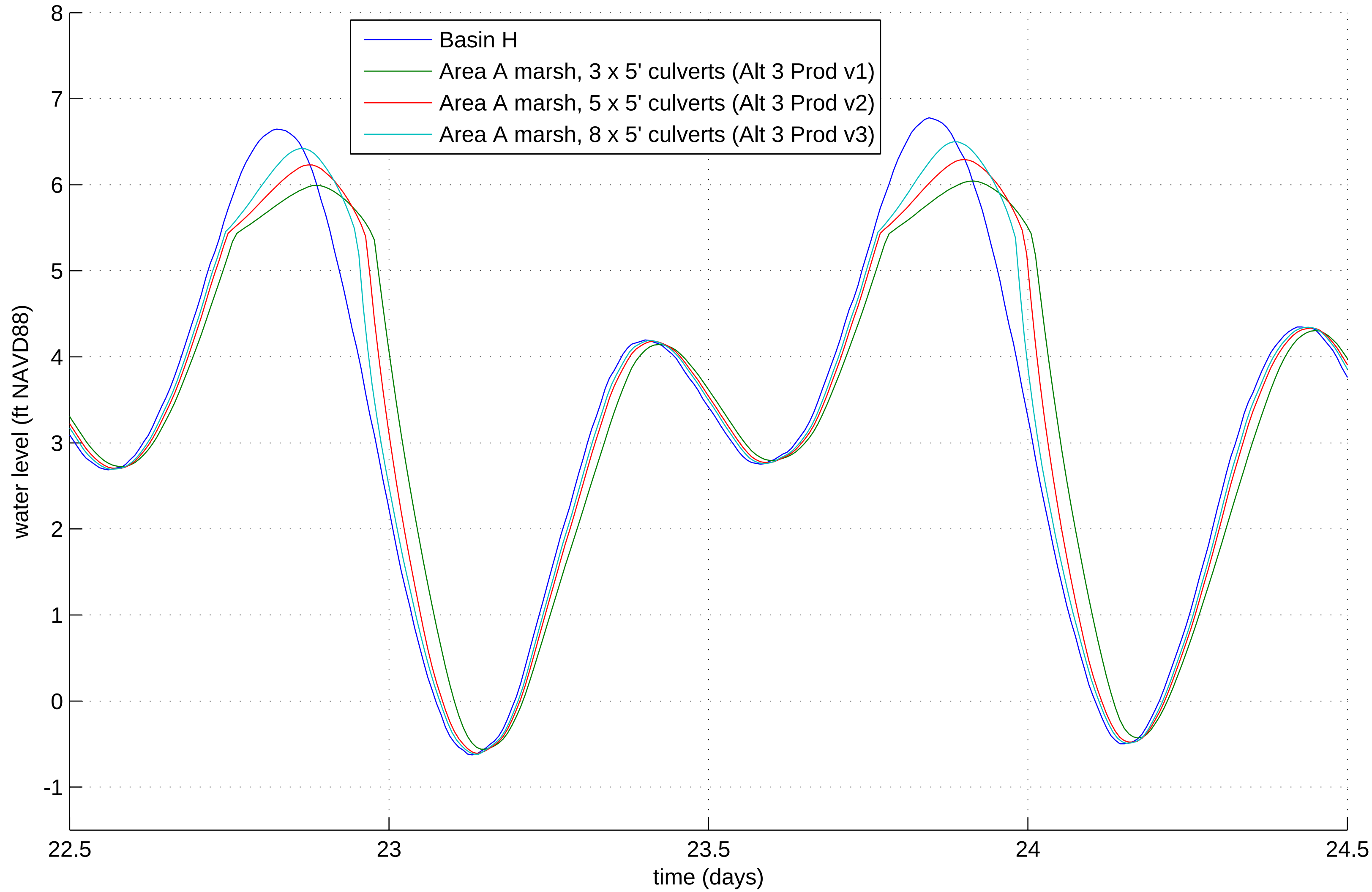
Source: EFDC model predictions

Figure 18
Lower Ballona Wetlands

Culvert Sizing, Area A Small Marsh

PWA Ref# 1793.1

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Culvert sizing\compare_culverts_AreaA_small_marsh.m



Source: EFDC model predictions

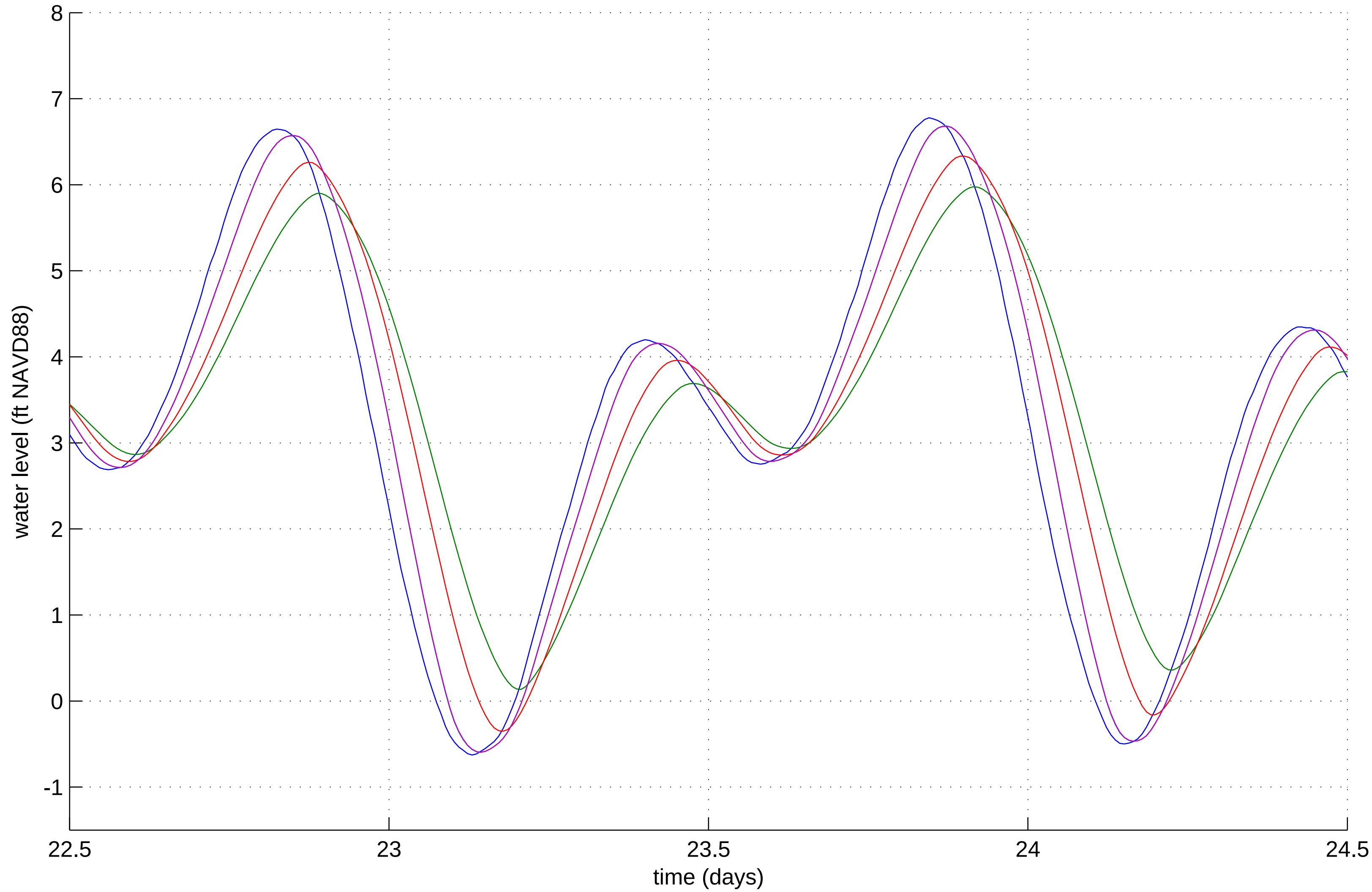
Figure 19
Lower Ballona Wetlands

Culvert Sizing, Area A Large Marsh

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Culvert sizing\compare_culverts_AreaA_large_marsh.m



Source: EFDC model predictions

- Basin H
- Area A subtidal, 8 x 5' culverts (Alt 4 Prod v1)
- Area A subtidal, 12 x 5' culverts (Alt 4 Prod v2)
- Area A subtidal, 2x(12 x 5') culverts (Alt 4 Prod v5)
- Area A subtidal, 2x(12 x 5') culverts @ Via Venetia (Alt 4 Prod v6)

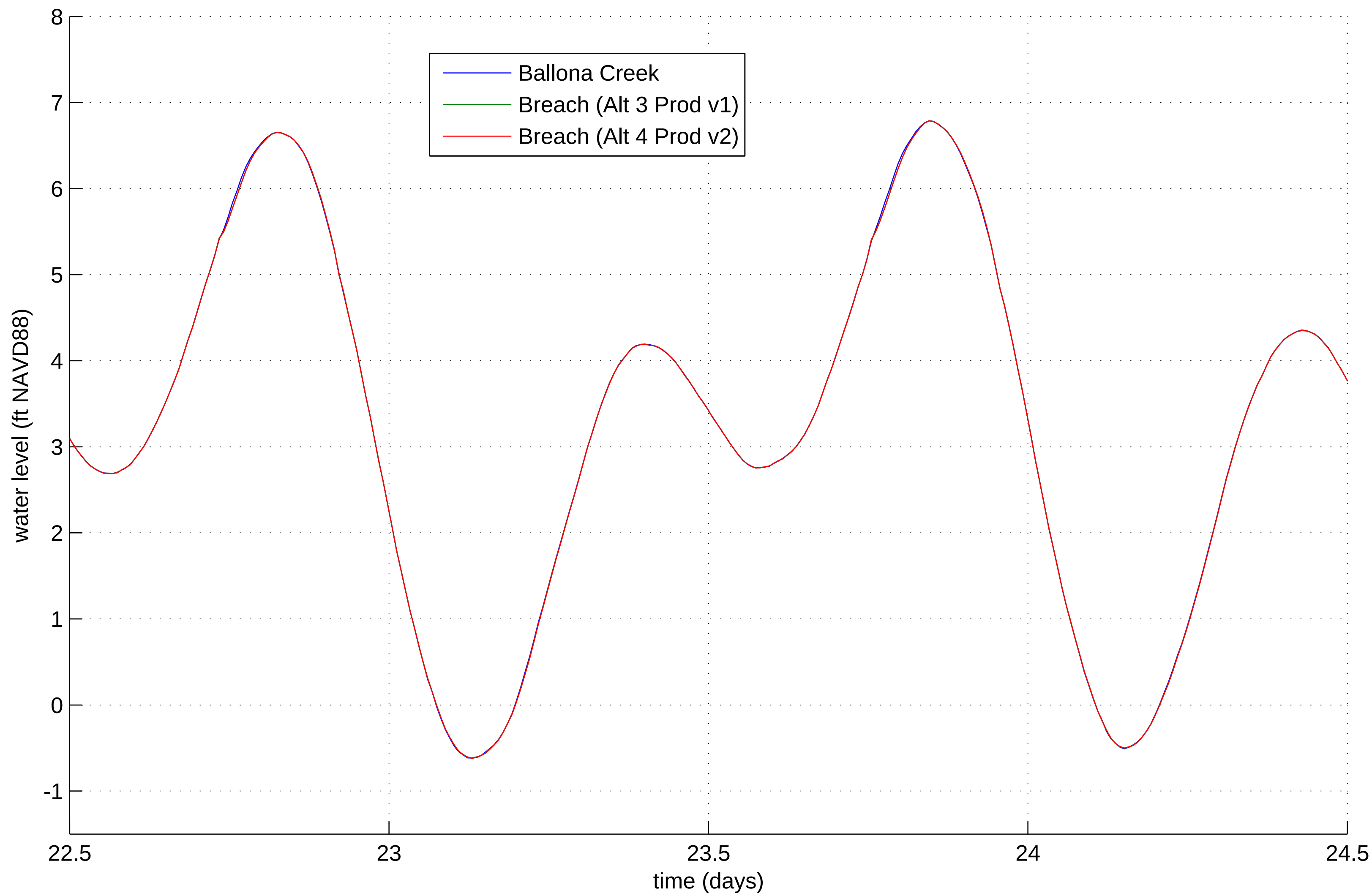
Figure 20
Lower Ballona Wetlands

Culvert Sizing, Area A Subtidal

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Culvert sizing\compare_culverts_AreaA_subtidal.m



Source: EFDC model predictions

Figure 21
Lower Ballona Wetlands

Culvert Sizing, Area B Southwest Breach

PWA Ref# 1793.1

PWA

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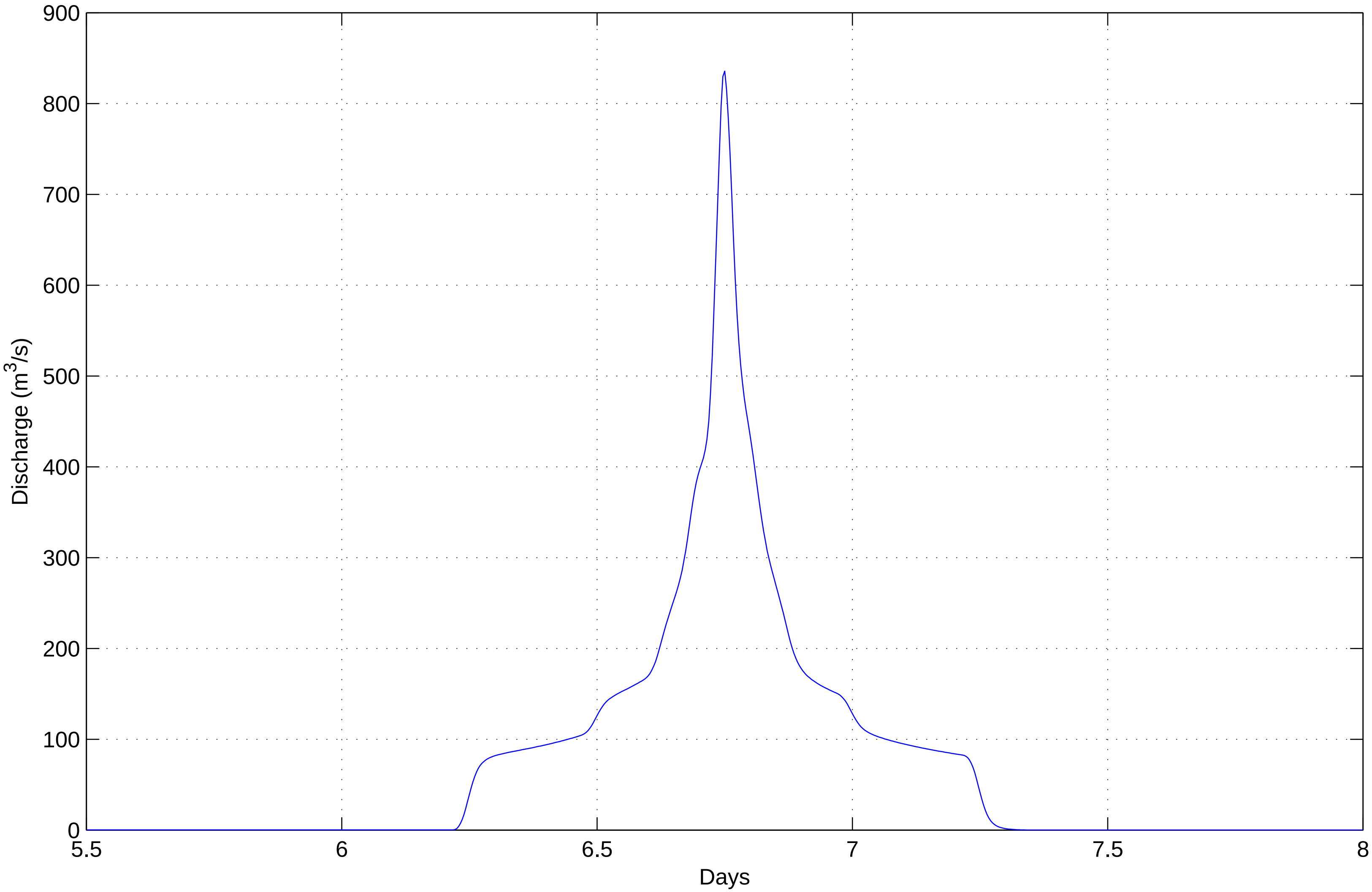


Source: Ballona Creek Ecosystem Restoration Feasibility Study Hydrology Appendix F3 - Without Project Hydrologic Analysis. January 2008. U.S. Army Corps of Engineers, South Pacific Division, Los Angeles District

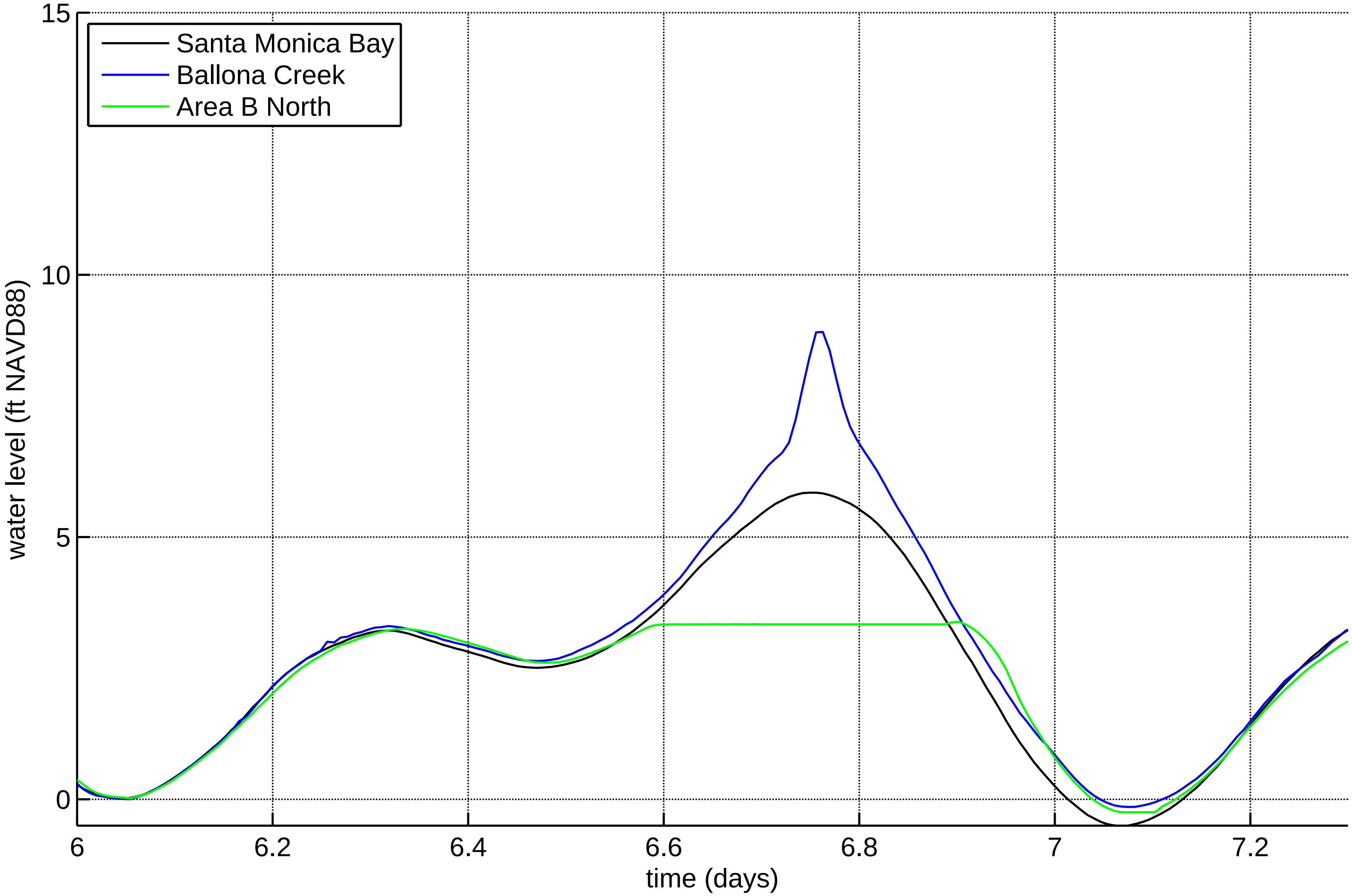
Figure 22
Ballona Wetlands Restoration Project

Ballona Creek 50-yr hydrograph at Sawtelle Blvd

PWA Ref# 1793

PWA

J:\1793_Ballona_Wetlands\1793.01_Modeling\Reporting\Modeling appendix\Flooding\plot_50yr_hydrograph.m



Source: EFDC model predictions

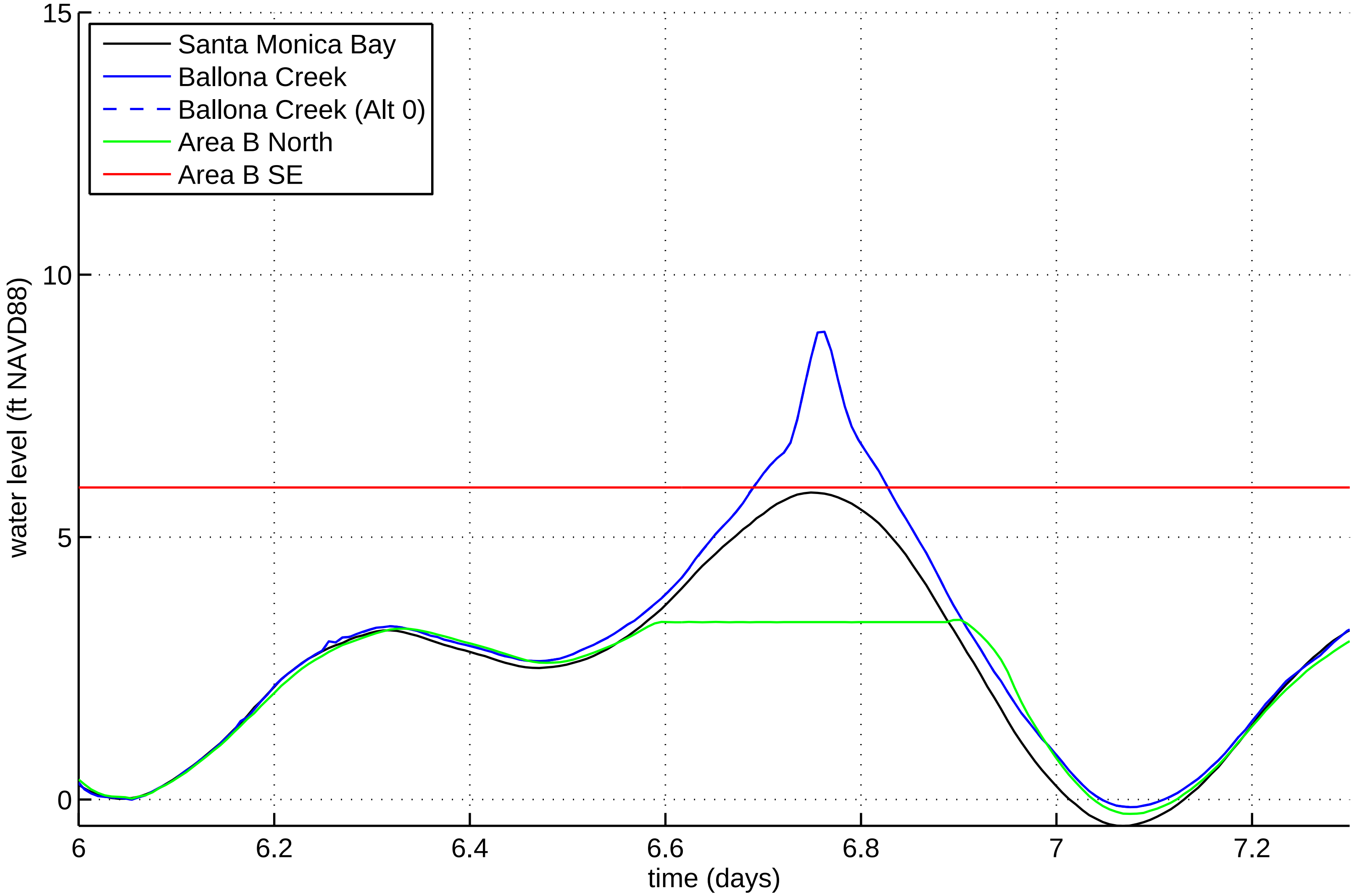
Figure 23
Lower Ballona Wetlands

Existing Conditions: Water Levels, 50-yr Flood

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Flooding\plot_alt0_flood.m



Source: EFDC model predictions

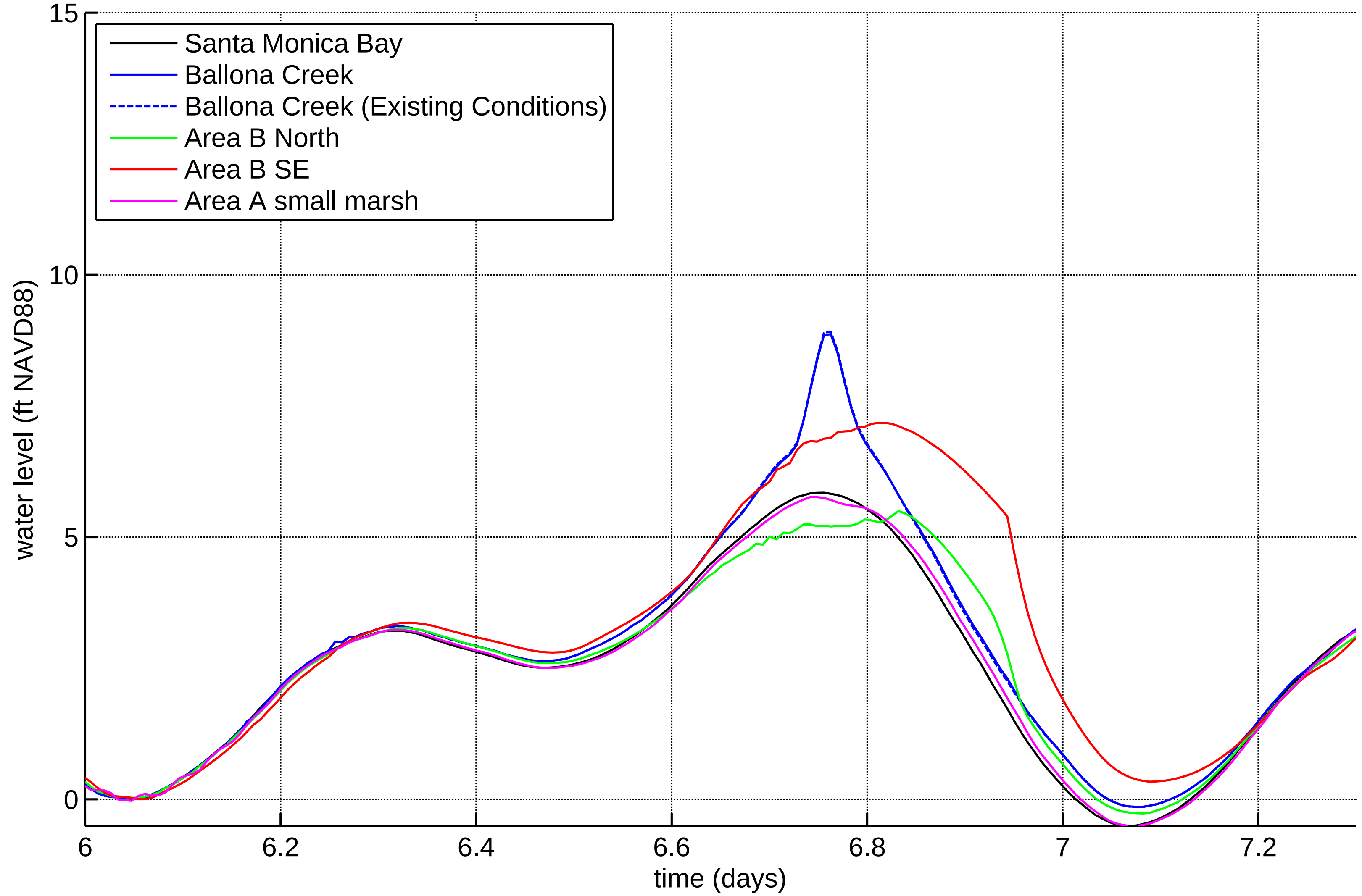
Figure 24
Lower Ballona Wetlands

Alt. 1: Water Levels, 50−yr Flood

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Flooding\plot_alt1_flood.m



Source: EFDC model predictions

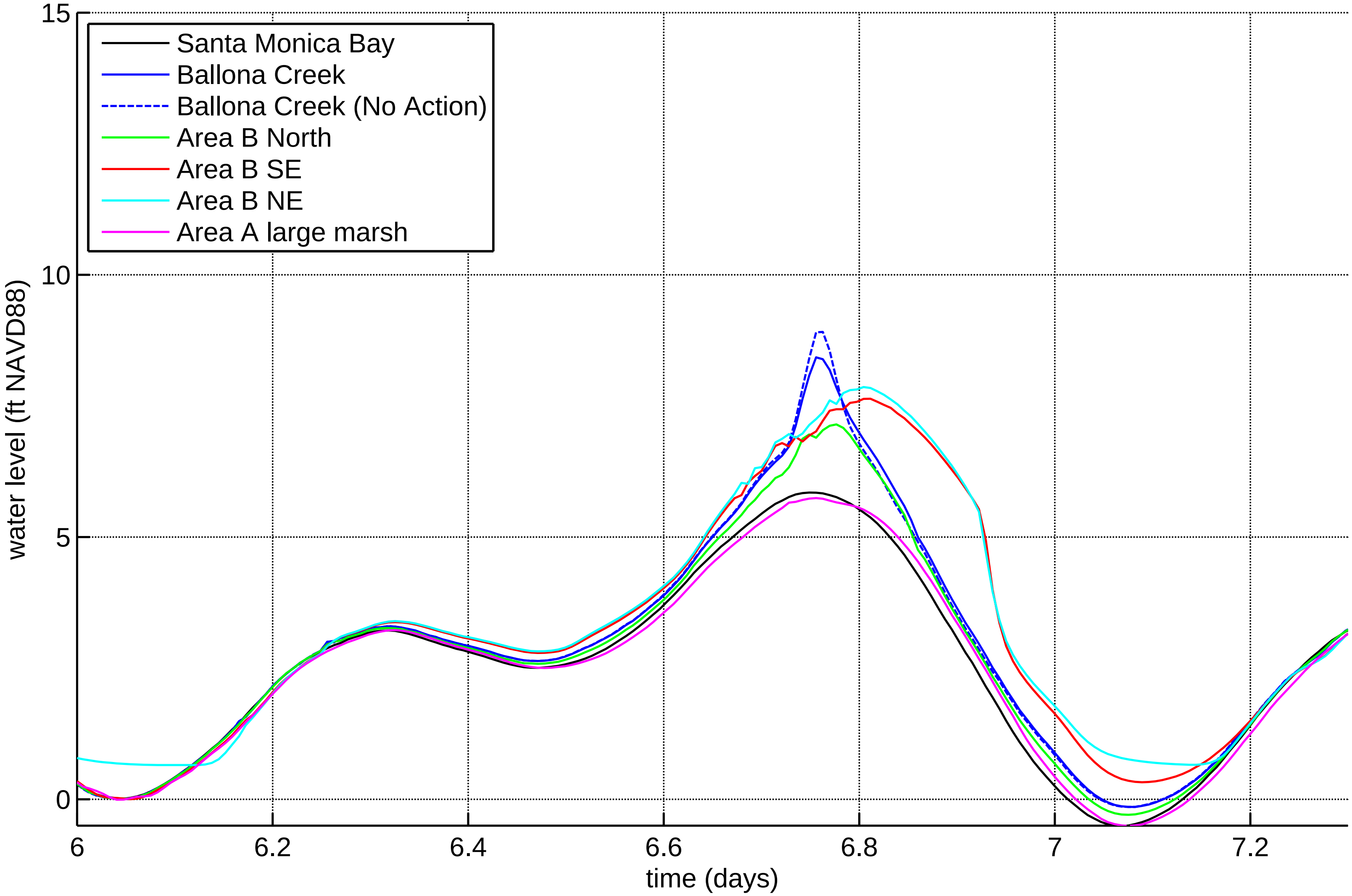
Figure 25
Lower Ballona Wetlands

Alt. 2: Water Levels, 50-yr Flood

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Flooding\plot_alt2_flood.m



Source: EFDC model predictions

Figure 26

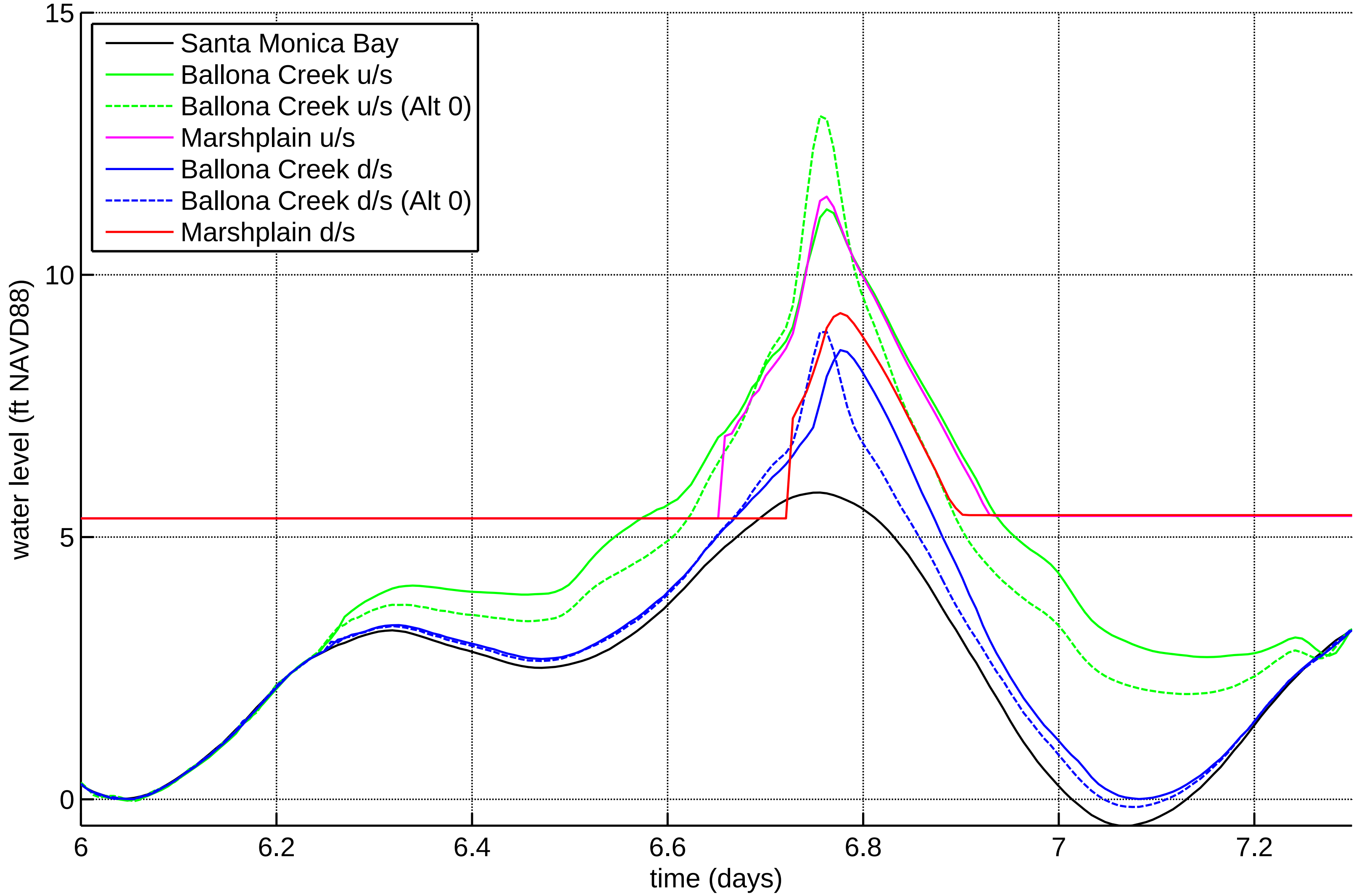
Lower Ballona Wetlands

Alt. 3: Water Levels, 50-yr Flood

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Flooding\plot_alt3_flood_2.m



Source: EFDC model predictions

Figure 27
Lower Ballona Wetlands

Alt. 5: Water Levels, 50-yr Flood

PWA Ref# 1793.1

PWA

C:\m.brennan\Projects\1793_Ballona\Modeling\Alternatives\Analysis\Flooding\plot_alt5_flood.m

Table 1. Modeled Tidal Prism at Selected Cross Sections
1793.01 Ballona Wetlands Restoration Project
Tidal prism in ac-ft

	Mouth of Ballona Creek		**Mouth of Marina del Rey**		**Entrance to Basin H**		**Marina del Rey above Basin H**	
Model Run*	mean flood	mean ebb	mean flood	mean ebb	mean flood	mean ebb	mean flood	mean ebb
Alt 0 Prod v1	231	-243	1291	-1400	9	-10	382	-350
Alt 1 Prod v1	235	-279	1402	-1287	12	-14	364	-416
Alt 2 Prod v1	267	-314	1384	-1343	31	-35	376	-432
Alt 2 Prod v2	274	-306	1348	-1383	36	-44	382	-440
Alt 2 Prod v3	277	-405	1221	-1418	48	-53	464	-529
Alt 2 Prod v7	284	-331	1281	-1385	43	-47	394	-424
Alt 3 Prod v1	386	-416	1404	-1362	54	-55	388	-431
Alt 3 Prod v2	390	-419	1409	-1367	60	-68	382	-409
Alt 3 Prod v4	396	-427	1477	-1438	69	-70	380	-456
Alt 4 Prod v1	391	-421	1625	-1488	294	-298	376	-448
Alt 4 Prod v2	392	-421	1701	-1651	345	-348	414	-448
Alt 4 Prod v5	392	-421	1765	-1714	381	-371	461	-466
Alt 4 Prod v6	392	-421	1764	-1713	10	-10	509	-516
Alt 5 Prod v1	599	-627	1400	-1284	11	-12	381	-409

* See run catalog for more detailed description of model setup for each run.

Table 2. Median tidal excursions lengths

1793.01 Ballona Wetlands Restoration Project

	Ballona Creek		Marina del Rey		Basin H Entrance	
Model Run*	flood (mi)	ebb (mi)	flood (mi)	ebb (mi)	flood (mi)	ebb (mi)
Alt 0 - No action\Prod v1	0.63	-0.71	0.75	-0.52	0.01	-0.01
Alt 1 - Muted tidal\Prod v1	0.64	-0.72	0.67	-0.57	0.01	-0.02
Alt 2 - Partial tidal\Prod v1	0.69	-0.76	0.69	-0.58	0.04	-0.03
Alt 2 - Partial tidal\Prod v2	0.71	-0.82	0.69	-0.58	0.06	-0.02
Alt 2 - Partial tidal\Prod v7	0.79	-0.83	0.69	-0.58	0.04	-0.02
Alt 3 - Full tidal\Prod v1	1.03	-0.95	0.70	-0.59	0.07	-0.05
Alt 3 - Full tidal\Prod v2	1.03	-0.95	0.70	-0.59	0.12	-0.04
Alt 3 - Full tidal\Prod v4	1.03	-0.95	0.70	-0.59	0.11	-0.04
Alt 4 - Area A subtidal\Prod v1	1.03	-0.95	0.78	-0.65	0.37	-0.10
Alt 4 - Area A subtidal\Prod v2	1.03	-0.95	0.81	-0.69	0.41	-0.18
Alt 4 - Area A subtidal\Prod v5	1.03	-0.95	0.85	-0.72	0.47	-0.20
Alt 4 - Area A subtidal\Prod v6	1.03	-0.95	0.84	-0.72	0.01	-0.01
Alt 5 - New creek\Prod v1	1.52	-1.43	0.67	-0.57	0.01	-0.02

* See run catalog for more detailed description of model setup for each run.

Note: mi = miles

Table 3. Storm Surge Event-based Analysis for Ballona Creek Mouth
1793.01 Ballona Wetlands Modeling
J. Vandever (PWA)
Date: April 10, 2008

Event*	Description	Storm Dates	Peak Surge (ft)**	Date/Time***	Approx. Duration (days)****
1	Series of winter storms tracked eastward from North Pacific	27 February - 3 March 1938	0.76	3/2/38 15:40	3
2	Winter storm, combination of warm Pacific cyclone and cold coastal storm	21-23 January 1943	1.35	1/22/43 21:10	3.5
3a	Low-latitude north Pacific cyclone	3-4 March 1943	0.54	3/3/43 18:00	2.5
3b			0.75	2/22/43 20:00	4
4	Combination of cold low pressure system moving down coast and subtropical cyclone	19-21 November 1967	0.64	11/21/67 19:10	4
5a	Series of unusually intense low latitude Pacific storms	18-26 January 1969	0.86	1/21/69 5:00	4.5
5b	Series of unusually intense low latitude Pacific storms	18-26 January 1969	0.80	1/25/69 7:00	5.5
6	Pacific cyclone cold front	3-4 December 1974	-	-	-
7	Persistent series of warm, subtropical Pacific storms from SW	5-13 February 1978	1.58	2/10/78 1:30	6
8	Persistent series of warm, subtropical Pacific storms from SW	27 February - 5 March 1978	1.32	3/1/78 2:00	7
9a	1982-83 El Nino Winter	1982-83 Winter	1.64	3/2/83 1:20	7
9b	1982-83 El Nino Winter		1.23	2/2/83 15:30	7
10	High storm event in SF Bay	3 December 1983	-	-	-
11	1997-1998 El Nino Winter	1997-98 Winter	1.65	2/3/1998 9:30	3

Average Surge	**1.1**

* Events were selected based on the COE Ballona Creek Ecosystem Study Appendix F3 Hydrology.
* Peak surge determined from the max residual between observed and predicted water level at NOAA Station #9410660 Los Angeles
** Dates and times are given in local standard time (LST)
*** Approximate storm durations were determined by visually examining the residual time series for each event

Table 4. Ballona Wetlands Modeling Run Catalog					
Restoration alternatives	**Run name**	**Status P=planned S=setup R=running C=complete A=analyzed**	**Tide or Flood**	**Run period, days**	**Project area configuration**
No Action					
	Calibration v1	C	Tide	0.1-19.1	Area B N: Existing SRT (2x5' culverts)
	Alt 0 - Prod v1	C	Tide	10.88-28.88	Area B N: Existing SRT (2x5' culverts)
	Alt 0 - Prod fld v6	C	Flood	5.86-7.36	Area B N: Existing SRT (2x5' culverts)
Alt 1- Muted tidal					
	Alt 1 - Prod v1	A	Tide	10.88-28.88	Area B N: Existing SRT (2x5' culverts, cutoff at 1.1 m NAVD) Area B SE: 2x5' culverts, cutoff at 2 m NAVD
	Alt 1 - Prod v2	A	Tide	10.88-21.1	Area B N: Modified SRT (4x5' culverts, cutoff at 1.5 m NAVD) Area B SE: 4x5' culverts, cutoff at 2.25 m NAVD
	Alt 1 - Prod fld v2	R	Flood	5.28-6.78	Area B N: Existing SRT (2x5' culverts, cutoff at 1.1 m NAVD) Area B SE: 2x5' culverts, cutoff at 2 m NAVD
	Alt 1 - Prod fld v3	R	Flood	5.86-7.36	Area B N: Existing SRT (2x5' culverts, cutoff at 1.1 m NAVD) Area B SE: 2x5' culverts, cutoff at 2 m NAVD
Alt 2 - Partial tidal					
	Alt 2 - Prod v1	A	Tide	10.88-28.88	Area B N: Existing SRT (2x5' culverts, cutoff at 1.1 m NAVD) Area B SE: 2x5' culverts Area A: 3x5' culverts, Dock 52
	Alt 2 - Prod v2	A	Tide	10.88-28.88	Area B N: Modified SRT (2x5' culverts, cutoff at 1.5 m NAVD) Area B SE: 2x5' culverts Area A: 5x5' culverts, Dock 52
	Alt 2 - Prod v3	A	Tide	21.8-24.8	Area B N: Modified SRT (2x5' culverts, cutoff at 2.0 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 2 - Prod v4	A	Tide	21.8-24.8	Area B N: Modified SRT (3x5' culverts, cutoff at 2.0 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 2 - Prod v5	A	Tide	21.8-24.8	Area B N: Modified SRT (3x5' culverts, cutoff at 1.5 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 2 - Prod v6	A	Tide	21.8-24.7	Area B N: Modified SRT (3x5' culverts, cutoff at 1.1 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 2 - Prod v7	A	Tide	10.88-28.88	Area B N: Modified SRT (3x5' culverts, cutoff at 2.0 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 2 - Prod fld v2	C	Flood	5.28-6.78	Area B N: Modified SRT (2x5' culverts, cutoff at 2.0 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 2 - Prod fld v3	C	Flood	5.86-7.36	Area B N: Modified SRT (2x5' culverts, cutoff at 2.0 m NAVD) Area B SE: 2x5' culverts Area A: 8x5' culverts, Dock 52
Alt 3 - Fully tidal					
	Alt 3 - Prod v1	A	Tide	10.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 2x5' culverts Area A: 3x5' culverts, Dock 52
	Alt 3 - Prod v2	A	Tide	10.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 4x5' culverts Area A: 5x5' culverts, Dock 52
	Alt 3 - Prod v3	A	Tide	21.8-24.7	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 4x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 3 - Prod v4	A	Tide	9.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 4x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 3 - Prod fld v4	C	Flood	5.86-7.36	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 2x5' culverts Area A: 3x5' culverts, Dock 52

Alt 4 - Subtidal					
	Alt 4 - Prod v1	A	Tide	10.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 6x5' culverts Area A: 8x5' culverts, Dock 52
	Alt 4 - Prod v2	A	Tide	10.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 8x5' culverts Area A: 12x5' culverts, Dock 52
	Alt 4 - Prod v3	A	Tide	10.88-11.2	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 8x5' culverts Area A: 8*(12x5' culverts), Dock 52
	Alt 4 - Prod v4	A	Tide	10.88-11.2	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 8x5' culverts Area A: 4*(12x5' culverts), Dock 52
	Alt 4 - Prod v5	A	Tide	10.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 8x5' culverts Area A: 2*(12x5' culverts), Dock 52
	Alt 4 - Prod v6	C	Tide	10.88-28.88	Area B N: Breach to Creek Area B NE: 2x5' culverts Area B SE: 8x5' culverts Area A: 2*(12x5' culverts), Via Venetia
Alt 5 - New creek					
	Alt 5 - Prod v1	C	Tide	10.88-28.88	Phase 3
	Alt 5 - Prod fld v4	P	Flood	5.86-7.36	Phase 3
SLR / Storm surge					

APPENDIX D.
DETAILED COST ESTIMATES AND SUPPORTING INFORMATION

Table D-1. Summary of Engineer's Estimates[1] for Alternatives 1 to 5. Costs in Millions of Dollars

Alternative	Area A	Area B	Area C	Total
1	$4.0	$2.6	--	**$6.6**
2	$42.6	$16.0	$3.3	**$61.8**
3	$69.3	$55.5	$5.2	**$130.0**
4	$108.4	$55.5	$5.2	**$169.0**
5	$99.8	$59.0	$50.4	**$209.3**
	Phase 1	**Phase 2**	**Phase 3**	
5 [2]	$110.4	$48.8	$50.5	**$209.7**

Notes

1 - Estimated construction costs include a 35% contingency

2 - The cost estimate for phasing Alternative 5 is higher due to the construction of a temporary levee

Table D-2. Estimated Volumes of Excess Material to Be Stockpiled and Rough Calcuation of Possible Stockpile Areas and Number of Truck Loads.

	Stockpile Volume (CY)				Stockpile Volume (ac-ft)				5-ft High Stockpile Areas (ac) [1]				10-ft High Stockpile Areas (ac) [1]				No. Truck Loads [2]
	Area A	**Area B**	**Area C**	**Total**	**Area A**	**Area B**	**Area C**	**Total**	**Area A**	**Area B**	**Area C**	**Total**	**Area A**	**Area B**	**Area C**	**Total**	**Total**
Alternative 1	86,400	-	-	86,400	50	-	-	**50**	11	-	-	**11**	6	-	-	**6**	**8,640**
Alternative 2	955,900	196,040	89,500	1,241,440	590	120	60	**770**	120	25	13	**158**	62	14	7	**83**	**124,144**
Alternative 3	1,684,880	963,700	141,000	2,789,580	1,040	600	90	**1,730**	211	122	19	**352**	108	63	10	**182**	**278,958**
Alternative 4	2,748,440	963,700	141,000	3,853,140	1,700	600	90	**2,390**	344	122	19	**485**	176	63	10	**249**	**385,314**
Alternative 5	2,665,700	1,218,100	1,347,800	5,231,600	1,650	760	840	**3,250**	334	155	171	**659**	170	80	88	**338**	**523,160**
	Phase 1	**Phase 2**	**Phase 3**		**Phase 1**	**Phase 2**	**Phase 3**		**Phase 1**	**Phase 2**	**Phase 3**		**Phase 1**	**Phase 2**	**Phase 3**		
Alternative 5	2,889,960	923,500	1,344,600	5,158,060	1,790	570	830	**3,190**	362	116	169	**647**	185	60	87	**332**	**515,806**

Notes

1- Assumes circular stockpile with 5:1 (h:v) side slopes. Area calculation uses insitu volume and does not account for losses, bulking, or compaction.

2- Assumes 10 CY per truck load as an order of magnitude index

Table D-3. Summary of Estimated Costs[1] for Disposal Options. Costs in Millions of Dollars

		Alt 1				Alt 2				Alt 3				Alt 4				Alt 5				Alt 5 with Phasing [2]			
		Area A	Area B	Area C	Total	Area A	Area B	Area C	Total	Area A	Area B	Area C	Total	Area A	Area B	Area C	Total	Area A	Area B	Area C	Total	Phase 1	Phase 2	Phase 3	Total [2]
On-Site Work		$4.0	$2.6	--	**$6.6**	$42.6	$16.0	$3.3	**$61.8**	$69.3	$55.5	$5.2	**$130.0**	$108.4	$55.5	$5.2	**$169.0**	$99.8	$59.0	$50.4	**$209.3**	$110.4	$48.8	$50.5	**$209.7**
Disposal Volume (CY)		86,400	0	0	**86,400**	955,900	196,040	89,500	**1,241,440**	1,684,880	963,700	141,000	**2,789,580**	2,748,440	963,700	141,000	**3,853,140**	2,665,700	1,218,100	1,347,800	**5,231,600**	2,889,960	923,500	1,344,600	**5,158,060**
Off-Site Disposal Options																									
Option 1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**	$1.3	--	--	**$1.3**	$14.7	$3.0	$1.4	**$19.1**	$26.0	$14.8	$2.2	**$43.0**	$42.3	$14.8	$2.2	**$59.4**	$41.1	$18.8	$20.8	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
Option 3	**Beneficial Use - Landfill Cover**	$4.2	--	--	**$4.2**	$45.9	$9.4	$4.3	**$59.7**	$81.0	$46.3	$6.8	**$134.1**	$132.1	$46.3	$6.8	**$185.2**	$128.1	$58.5	$64.8	**$252.6**	$138.9	$44.4	$64.6	**$252.6**
Option 4	**Disposal at Hazardous Waste Landfill [3]**																								
Option 5	**Offshore Disposal (low end of range)**	$1.3	--	--	**$1.3**	$14.7	$3.0	$1.4	**$19.1**	$26.0	$14.8	$2.2	**$43.0**	$42.3	$14.8	$2.2	**$59.4**	$41.1	$18.8	$20.8	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
	Offshore Disposal (high end of range)	$3.6	--	--	**$3.6**	$39.3	$8.1	$3.7	**$51.0**	$69.2	$39.6	$5.8	**$114.6**	$112.9	$39.6	$5.8	**$158.3**	$109.5	$50.0	$55.4	**$216.0**	$118.7	$37.9	$55.2	**$216.0**
Option 6	**Beach Disposal (low end of range)**	$1.3	--	--	**$1.3**	$14.7	$3.0	$1.4	**$19.1**	$26.0	$14.8	$2.2	**$43.0**	$42.3	$14.8	$2.2	**$59.4**	$41.1	$18.8	$20.8	**$81.0**	$44.5	$14.2	$20.7	**$81.0**
	Beach Disposal (high end of range)	$2.7	--	--	**$2.7**	$29.5	$6.0	$2.8	**$38.3**	$51.9	$29.7	$4.3	**$86.0**	$84.7	$29.7	$4.3	**$118.7**	$82.1	$37.5	$41.5	**$162.0**	$89.1	$28.5	$41.4	**$162.0**
Grand Totals for Disposal Options																									
Option 1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**	$5.4	--	--	**$5.4**	$57.3	$19.0	$4.7	**$81.0**	$95.3	$70.4	$7.4	**$173.0**	$150.7	$70.4	$7.4	**$228.4**	$140.9	$77.8	$71.2	**$290.3**	$155.0	$63.1	$71.2	**$290.7**
Option 3	**Beneficial Use - Landfill Cover**	$8.2	--	--	**$8.2**	$88.5	$25.4	$7.6	**$121.5**	$150.3	$101.8	$12.0	**$264.1**	$240.4	$101.8	$12.0	**$354.2**	$227.9	$117.6	$115.2	**$461.9**	$249.3	$93.2	$115.1	**$462.3**
Option 4	**Disposal at Hazardous Waste Landfill [3]**																								
Option 5	**Offshore Disposal (low end of range)**	$5.4	--	--	**$5.4**	$57.3	$19.0	$4.7	**$81.0**	$95.3	$70.4	$7.4	**$173.0**	$150.7	$70.4	$7.4	**$228.4**	$140.9	$77.8	$71.2	**$290.3**	$155.0	$63.1	$71.2	**$290.7**
	Offshore Disposal (high end of range)	$7.6	--	--	**$7.6**	$81.9	$24.0	$7.0	**$112.9**	$138.6	$95.1	$11.0	**$244.6**	$221.3	$95.1	$11.0	**$327.4**	$209.3	$109.1	$105.8	**$425.2**	$229.2	$86.8	$105.7	**$425.7**
Option 6	**Beach Disposal (low end of range)**	$5.4	--	--	**$5.4**	$57.3	$19.0	$4.7	**$81.0**	$95.3	$70.4	$7.4	**$173.0**	$150.7	$70.4	$7.4	**$228.4**	$140.9	$77.8	$71.2	**$290.3**	$155.0	$63.1	$71.2	**$290.7**
	Beach Disposal (high end of range)	$6.7	--	--	**$6.7**	$72.1	$22.0	$6.0	**$100.1**	$121.3	$85.2	$9.5	**$216.0**	$193.1	$85.2	$9.5	**$287.8**	$181.9	$96.6	$92.0	**$371.2**	$199.5	$77.3	$91.9	**$371.7**

Notes

1 - Estimated construction costs include a 35% contingency

2 - The cost estimate for phasing Alternative 5 is higher due to the construction of a temporary levee

3 - Estimate not included for Beneficial Use - Landfill Cover, contamintant report pending

Table D-4. Summary of Unit Costs and Cost Estimate Assuptions

Item	Description	Unit	Unit Cost	Notes
	Unit Costs			
	Mobilization			
1	Mobilization	LS		8% of subtotal used as a typical value. This value may be high.
	Demolition			
2	Demo culvert, daylight channel	LF	$1,000	
	Excavation	CY		Excavation of material only. Transportation included in Item 9.
3	Excavate to Marshplain	CY	$15	Excavate material from existing grade to marshplain elevation.
4	New Ballona Creek	CY	$15	Excavate material to create new Ballona Creek channel.
5	Channels Order 5	CY	$15	Excavate material to create large channels
6	Channels Order 4	CY	$15	Excavate material to create medium channels
7	Channels Order 3	CY	$15	Excavate material to create small channels
8	Breach	CY	$15	Excavate material to create breach
	Transportation	CY		Transportation of excavated material only. Placement of material in stockpile included in Item 12.
9	Onsite trucking	CY	$5	Truck transportation of excavated material to locations of fill and stockpile in each sub-area. Does not include transportation between sub-areas.
	New Levees	CY		
10	Levee Fill - no road	CY	$10	Levee construction using earth fill from material excavated onsite in each sub-area
11	Levee Fill - with road	CY	$17	Levee construction per above and paved roadway.
	Stockpile	CY		
12	Place material at stockpile	CY	$5	Placement of excavated material in excess of fill material in a stockpile in each sub-area. Excavation (Items 3-8) and transporation (Item 9) included separately.
	Levee Lowering and Ballona Creek Fill			
13	Levee Lowering	CY	$5	Excavation of earth material from existing levees along Ballona Creek. Removal and salvage of rip rap included in Item 15.
14	Ballona Creek Fill	CY	$5	Fill placement in existing Ballona Creek channel by sidecasting excavated material from levee lowering to fill Ballona Creek and using some excavated material (Items 2-8)
15	Salvage Rip Rap	CY	$10	Removal of rip-rap from existing levees
16	Buried rock protection	CY	$20	Assumes half the salvaged volume is used for protection and remainder is taken off-site for use by contractor
	Water Control Structures			
17	Culvert	SF	$2,010	New culvert
18	Tide Gate	LS	$100,000	New tide gate for culvert
	Subtotal			
	Contingency			35% contingency included for concept-level cost estimate.
	Total			
	Disposal Options - Cost Estimates from POLA / Weston and SCC			
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**			
	Mobilization	LS		8% of subtotal used as a typical value. This value may be high.
	Sediment Removal	CY	$3	From POLA / Weston
	Barge Sediment (approx. 30 NM)	CY	$4.50	From POLA / Weston
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	CY	$3	From POLA / Weston
	Subtotal			
	Contingency			35% contingency included for concept-level cost estimate.
	Total for Option 1			
3	**Beneficial Use - Landfill Cover**			
	Mobilization	LS		8% of subtotal used as a typical value. This value may be high.
	Sediment Removal	CY	$3	From POLA / Weston
	Barge Sediment (approx. 30 NM)	CY	$5	From POLA / Weston
	Stockpiling & Staging Material at POLA	CY	$1	From POLA / Weston
	Truck Material to Site (100 mi at $0.20/cy)	CY	$20	From POLA / Weston
	Placement, grading, compaction at Site	CY	$4.25	From POLA / Weston
	Subtotal			
	Contingency			35% contingency included for concept-level cost estimate.
	Total for Option 2			
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**			
5	**Offshore Disposal [1]**			
	Mobilization	LS		8% of subtotal used as a typical value. This value may be high.
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	CY	$28	Based on $28 per cubic meter cost from Upper Newport Bay project for dredging and disposal about three miles offshore provide by SCC
	Subtotal			
	Contingency			35% contingency included for concept-level cost estimate.
	Total for Option 3			
6	**Beach Disposal [1]**			
	Mobilization	LS		
	Sediment Removal and Beach Disposal	CY	$21	Based on cost for Option 1 / 2 with additional $10/CY premium for beach disposal
	Subtotal			
	Contingency			
	Total for Option 4			

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 1 Area A

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$240,000**
1	Mobilization	1	LS	$240,000	$240,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**109,500**	CY		**$1,642,500**
3	Excavate to Marshplain	109,500	CY	$15	$1,642,500
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	0	CY	$15	$0
7	Channels Order 3	0	CY	$15	$0
8	Breach	0	CY	$15	$0
	Transportation	**109,500**	CY		**$547,500**
9	Onsite trucking	109,500	CY	$5	$547,500
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**86,400**	CY		**$547,500**
12	Place material at stockpile	109,500	CY	$5	$547,500
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$2,977,500**
	Contingency	35%			**$1,042,200**
	Total				**$4,019,700**

Disposal Options - Cost Estimates from POLA / Weston and SCC

1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$79,000	$79,000
	Sediment Removal	86,400	CY	$3	$259,200
	Barge Sediment (approx. 30 NM)	86,400	CY	$4.50	$388,800
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	86,400	CY	$3	$259,200
	Subtotal				**$986,200**
	Contingency	35%			**$345,200**
	Total for Option 1				**$1,331,400**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$247,000	$247,000
	Sediment Removal	86,400	CY	$3	$259,200
	Barge Sediment (approx. 30 NM)	86,400	CY	$4.50	$388,800
	Stockpiling & Staging Material at POLA	86,400	CY	$1	$86,400
	Truck Material to Site (100 mi at $0.20/cy)	86,400	CY	$20	$1,728,000
	Placement, grading, compaction at Site	86,400	CY	$4.25	$367,200
	Subtotal				**$3,076,600**
	Contingency	35%			**$1,076,900**
	Total for Option 2				**$4,153,500**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$211,000	$211,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	86,400	CY	$28	$2,419,200
	Subtotal				**$2,630,200**
	Contingency	35%			**$920,600**
	Total for Option 3				**$3,550,800**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$158,000	$158,000
	Sediment Removal and Beach Disposal	86,400	CY	$21	$1,814,400
	Subtotal				**$1,972,400**
	Contingency	35%			**$690,300**
	Total for Option 4				**$2,662,700**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$5,351,100**
3	**Upland Disposal**	**$8,173,200**
5	**Offshore Disposal [1]**	**$7,570,500**
6	**Beach Disposal [1]**	**$6,682,400**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 1 Area B

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$160,000**
1	Mobilization	1	LS	$160,000	$160,000
	Demolition				**$1,400,000**
2	Demo culvert, daylight chan	1,400	LF	$1,000	$1,400,000
	Excavation	**0**	CY		**$0**
3	Excavate to Marshplain	0	CY	$15	$0
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	0	CY	$15	$0
7	Channels Order 3	0	CY	$15	$0
8	Breach	0	CY	$15	$0
	Transportation	**23,100**	CY		**$115,500**
9	Onsite trucking	23,100	CY	$5	$115,500
	New Levees	**23,100**	CY		**$231,000**
10	Levee Fill - no road	23,100	CY	$10	$231,000
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**0**	CY		**$0**
12	Place material at stockpile	0	CY	$5	$0
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$1,906,500**
	Contingency	35%			**$667,300**
	Total				**$2,573,800**

Disposal Options - Cost Estimates from POLA / Weston and SCC

1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$0	$0
	Sediment Removal	0	CY	$3	$0
	Barge Sediment (approx. 30 NM)	0	CY	$4.50	$0
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	0	CY	$3	$0
	Subtotal				**$0**
	Contingency	35%			**$0**
	Total for Option 1				**$0**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$0	$0
	Sediment Removal	0	CY	$3	$0
	Barge Sediment (approx. 30 NM)	0	CY	$4.50	$0
	Stockpiling & Staging Material at POLA	0	CY	$1	$0
	Truck Material to Site (100 mi at $0.20/cy)	0	CY	$20	$0
	Placement, grading, compaction at Site	0	CY	$4.25	$0
	Subtotal				**$0**
	Contingency	35%			**$0**
	Total for Option 2				**$0**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$0	$0
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	0	CY	$28	$0
	Subtotal				**$0**
	Contingency	35%			**$0**
	Total for Option 3				**$0**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$0	$0
	Sediment Removal and Beach Disposal	0	CY	$21	$0
	Subtotal				**$0**
	Contingency	35%			**$0**
	Total for Option 4				**$0**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$2,573,800**
3	**Upland Disposal**	**$2,573,800**
5	**Offshore Disposal [1]**	**$2,573,800**
6	**Beach Disposal [1]**	**$2,573,800**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 2 Area A

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$2,530,000**
1	Mobilization	1	LS	$2,530,000	$2,530,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**955,900**	CY		**$14,338,500**
3	Excavate to Marshplain	951,700	CY	$15	$14,275,500
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	2,430	CY	$15	$36,450
7	Channels Order 3	1,770	CY	$15	$26,550
8	Breach	0	CY	$15	$0
	Transportation	**955,900**	CY		**$4,779,500**
9	Onsite trucking	955,900	CY	$5	$4,779,500
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**955,900**	CY		**$4,779,500**
12	Place material at stockpile	955,900	CY	$5	$4,779,500
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$5,125,000**
17	Culvert	2,500	SF	$2,010	$5,025,000
18	Tide Gate	1	LS	$100,000	$100,000
	Subtotal				**$31,552,500**
	Contingency	35%			**$11,043,400**
	Total				**$42,595,900**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$873,000	$873,000
	Sediment Removal	955,900	CY	$3	$2,867,700
	Barge Sediment (approx. 30 NM)	955,900	CY	$4.50	$4,301,550
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	955,900	CY	$3	$2,867,700
	Subtotal				**$10,909,950**
	Contingency	35%			**$3,818,500**
	Total for Option 1				**$14,728,450**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$2,723,000	$2,723,000
	Sediment Removal	955,900	CY	$3	$2,867,700
	Barge Sediment (approx. 30 NM)	955,900	CY	$4.50	$4,301,550
	Stockpiling & Staging Material at POLA	955,900	CY	$1	$955,900
	Truck Material to Site (100 mi at $0.20/cy)	955,900	CY	$20	$19,118,000
	Placement, grading, compaction at Site	955,900	CY	$4.25	$4,062,575
	Subtotal				**$34,028,725**
	Contingency	35%			**$11,910,100**
	Total for Option 2				**$45,938,825**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$2,328,000	$2,328,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	955,900	CY	$28	$26,765,200
	Subtotal				**$29,093,200**
	Contingency	35%			**$10,182,700**
	Total for Option 3				**$39,275,900**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$1,746,000	$1,746,000
	Sediment Removal and Beach Disposal	955,900	CY	$21	$20,073,900
	Subtotal				**$21,819,900**
	Contingency	35%			**$7,637,000**
	Total for Option 4				**$29,456,900**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$57,324,350**
3	**Upland Disposal**	**$88,534,725**
5	**Offshore Disposal [1]**	**$81,871,800**
6	**Beach Disposal [1]**	**$72,052,800**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 2 Area B

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$950,000**
1	Mobilization	1	LS	$950,000	$950,000
	Demolition				**$1,400,000**
2	Demo culvert, daylight chan	1,400	LF	$1,000	$1,400,000
	Excavation	**277,970**	CY		**$4,169,550**
3	Excavate to Marshplain	274,400	CY	$15	$4,116,000
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	2,040	CY	$15	$30,600
7	Channels Order 3	1,530	CY	$15	$22,950
8	Breach	0	CY	$15	$0
	Transportation	**277,970**	CY		**$1,389,850**
9	Onsite trucking	277,970	CY	$5	$1,389,850
	New Levees	**81,930**	CY		**$819,300**
10	Levee Fill - no road	81,930	CY	$10	$819,300
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**196,040**	CY		**$980,200**
12	Place material at stockpile	196,040	CY	$5	$980,200
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$2,110,000**
17	Culvert	1,000	SF	$2,010	$2,010,000
18	Tide Gate	1	LS	$100,000	$100,000
	Subtotal				**$11,818,900**
	Contingency	35%			**$4,136,700**
	Total				**$15,955,600**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$179,000	$179,000
	Sediment Removal	196,040	CY	$3	$588,120
	Barge Sediment (approx. 30 NM)	196,040	CY	$4.50	$882,180
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	196,040	CY	$3	$588,120
	Subtotal				**$2,237,420**
	Contingency	35%			**$783,100**
	Total for Option 1				**$3,020,520**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$559,000	$559,000
	Sediment Removal	196,040	CY	$3	$588,120
	Barge Sediment (approx. 30 NM)	196,040	CY	$4.50	$882,180
	Stockpiling & Staging Material at POLA	196,040	CY	$1	$196,040
	Truck Material to Site (100 mi at $0.20/cy)	196,040	CY	$20	$3,920,800
	Placement, grading, compaction at Site	196,040	CY	$4.25	$833,170
	Subtotal				**$6,979,310**
	Contingency	35%			**$2,442,800**
	Total for Option 2				**$9,422,110**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$478,000	$478,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	196,040	CY	$28	$5,489,120
	Subtotal				**$5,967,120**
	Contingency	35%			**$2,088,500**
	Total for Option 3				**$8,055,620**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$358,000	$358,000
	Sediment Removal and Beach Disposal	196,040	CY	$21	$4,116,840
	Subtotal				**$4,474,840**
	Contingency	35%			**$1,566,200**
	Total for Option 4				**$6,041,040**

Grand Totals with Disposal Options

Item	Description	Total Cost
1 / 2	**Disposal at POLA**	**$18,976,120**
3	**Upland Disposal**	**$25,377,710**
5	**Offshore Disposal [1]**	**$24,011,220**
6	**Beach Disposal [1]**	**$21,996,640**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 2 Area C

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$200,000**
1	Mobilization	1	LS	$200,000	$200,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**89,500**	CY		**$1,342,500**
3	Excavate to Marshplain	89,500	CY	$15	$1,342,500
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	0	CY	$15	$0
7	Channels Order 3	0	CY	$15	$0
8	Breach	0	CY	$15	$0
	Transportation	**89,500**	CY		**$447,500**
9	Onsite trucking	89,500	CY	$5	$447,500
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**89,500**	CY		**$447,500**
12	Place material at stockpile	89,500	CY	$5	$447,500
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$2,437,500**
	Contingency	35%			**$853,200**
	Total				**$3,290,700**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$82,000	$82,000
	Sediment Removal	89,500	CY	$3	$268,500
	Barge Sediment (approx. 30 NM)	89,500	CY	$4.50	$402,750
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	89,500	CY	$3	$268,500
	Subtotal				**$1,021,750**
	Contingency	35%			**$357,700**
	Total for Option 1				**$1,379,450**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$255,000	$255,000
	Sediment Removal	89,500	CY	$3	$268,500
	Barge Sediment (approx. 30 NM)	89,500	CY	$4.50	$402,750
	Stockpiling & Staging Material at POLA	89,500	CY	$1	$89,500
	Truck Material to Site (100 mi at $0.20/cy)	89,500	CY	$20	$1,790,000
	Placement, grading, compaction at Site	89,500	CY	$4.25	$380,375
	Subtotal				**$3,186,125**
	Contingency	35%			**$1,115,200**
	Total for Option 2				**$4,301,325**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$218,000	$218,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	89,500	CY	$28	$2,506,000
	Subtotal				**$2,724,000**
	Contingency	35%			**$953,400**
	Total for Option 3				**$3,677,400**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$164,000	$164,000
	Sediment Removal and Beach Disposal	89,500	CY	$21	$1,879,500
	Subtotal				**$2,043,500**
	Contingency	35%			**$715,200**
	Total for Option 4				**$2,758,700**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$4,670,150**
3	**Upland Disposal**	**$7,592,025**
5	**Offshore Disposal [1]**	**$6,968,100**
6	**Beach Disposal [1]**	**$6,049,400**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 3 Area A

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$4,110,000**
1	Mobilization	1	LS	$4,110,000	$4,110,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**1,684,880**	CY		**$25,273,200**
3	Excavate to Marshplain	1,673,700	CY	$15	$25,105,500
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	3,540	CY	$15	$53,100
6	Channels Order 4	4,240	CY	$15	$63,600
7	Channels Order 3	3,400	CY	$15	$51,000
8	Breach	0	CY	$15	$0
	Transportation	**1,684,880**	CY		**$8,424,400**
9	Onsite trucking	1,684,880	CY	$5	$8,424,400
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**1,684,880**	CY		**$8,424,400**
12	Stockpile	1,684,880	CY	$5	$8,424,400
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$5,125,000**
17	Culvert	2,500	SF	$2,010	$5,025,000
18	Tide Gate	1	LS	$100,000	$100,000
	Subtotal				**$51,357,000**
	Contingency	35%			**$17,975,000**
	Total				**$69,332,000**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$1,539,000	$1,539,000
	Sediment Removal	1,684,880	CY	$3	$5,054,640
	Barge Sediment (approx. 30 NM)	1,684,880	CY	$4.50	$7,581,960
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	1,684,880	CY	$3	$5,054,640
	Subtotal				**$19,230,240**
	Contingency	35%			**$6,730,600**
	Total for Option 1				**$25,960,840**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$4,799,000	$4,799,000
	Sediment Removal	1,684,880	CY	$3	$5,054,640
	Barge Sediment (approx. 30 NM)	1,684,880	CY	$4.50	$7,581,960
	Stockpiling & Staging Material at POLA	1,684,880	CY	$1	$1,684,880
	Truck Material to Site (100 mi at $0.20/cy)	1,684,880	CY	$20	$33,697,600
	Placement, grading, compaction at Site	1,684,880	CY	$4.25	$7,160,740
	Subtotal				**$59,978,820**
	Contingency	35%			**$20,992,600**
	Total for Option 2				**$80,971,420**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$4,103,000	$4,103,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	1,684,880	CY	$28	$47,176,640
	Subtotal				**$51,279,640**
	Contingency	35%			**$17,947,900**
	Total for Option 3				**$69,227,540**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$3,077,000	$3,077,000
	Sediment Removal and Beach Disposal	1,684,880	CY	$21	$35,382,480
	Subtotal				**$38,459,480**
	Contingency	35%			**$13,460,800**
	Total for Option 4				**$51,920,280**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$95,292,840**
3	**Upland Disposal**	**$150,303,420**
5	**Offshore Disposal [1]**	**$138,559,540**
6	**Beach Disposal [1]**	**$121,252,280**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 3 Area B

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$3,290,000**
1	Mobilization	1	LS	$3,290,000	$3,290,000
	Demolition				**$1,400,000**
2	Demo culvert, daylight chan	1,400	LF	$1,000	$1,400,000
	Excavation	**1,259,910**	CY		**$18,898,650**
3	Excavate to Marshplain	1,229,400	CY	$15	$18,441,000
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	5,560	CY	$15	$83,400
6	Channels Order 4	9,390	CY	$15	$140,850
7	Channels Order 3	8,180	CY	$15	$122,700
8	Breach	7,380	CY	$15	$110,700
	Transportation	**1,252,530**	CY		**$6,262,650**
9	Onsite trucking	1,252,530	CY	$5	$6,262,650
	New Levees	**288,830**	CY		**$4,336,600**
10	Levee Fill - no road	81,930	CY	$10	$819,300
11	Levee Fill - with road	206,900	CY	$17	$3,517,300
	Stockpile	**963,700**	CY		**$4,818,500**
12	Stockpile	963,700	CY	$5	$4,818,500
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$2,110,000**
17	Culvert	1,000	SF	$2,010	$2,010,000
18	Tide Gate	1	LS	$100,000	$100,000
	Subtotal				**$41,116,400**
	Contingency	35%			**$14,390,800**
	Total				**$55,507,200**

Disposal Options - Cost Estimates from POLA / Weston and SCC

1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$880,000	$880,000
	Sediment Removal	963,700	CY	$3	$2,891,100
	Barge Sediment (approx. 30 NM)	963,700	CY	$4.50	$4,336,650
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	963,700	CY	$3	$2,891,100
	Subtotal				**$10,998,850**
	Contingency	35%			**$3,849,600**
	Total for Option 1				**$14,848,450**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$2,745,000	$2,745,000
	Sediment Removal	963,700	CY	$3	$2,891,100
	Barge Sediment (approx. 30 NM)	963,700	CY	$4.50	$4,336,650
	Stockpiling & Staging Material at POLA	963,700	CY	$1	$963,700
	Truck Material to Site (100 mi at $0.20/cy)	963,700	CY	$20	$19,274,000
	Placement, grading, compaction at Site	963,700	CY	$4.25	$4,095,725
	Subtotal				**$34,306,175**
	Contingency	35%			**$12,007,200**
	Total for Option 2				**$46,313,375**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$2,347,000	$2,347,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	963,700	CY	$28	$26,983,600
	Subtotal				**$29,330,600**
	Contingency	35%			**$10,265,800**
	Total for Option 3				**$39,596,400**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$1,760,000	$1,760,000
	Sediment Removal and Beach Disposal	963,700	CY	$21	$20,237,700
	Subtotal				**$21,997,700**
	Contingency	35%			**$7,699,200**
	Total for Option 4				**$29,696,900**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$70,355,650**
3	**Upland Disposal**	**$101,820,575**
5	**Offshore Disposal [1]**	**$95,103,600**
6	**Beach Disposal [1]**	**$85,204,100**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 3 Area C

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$310,000**
1	Mobilization	1	LS	$310,000	$310,000
	Demolition				**$0**
2	Demo culvert, daylight ch	0	LF	$1,000	$0
	Excavation	**141,000**	CY		**$2,115,000**
3	Excavate to Marshplain	141,000	CY	$15	$2,115,000
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	0	CY	$15	$0
7	Channels Order 3	0	CY	$15	$0
8	Breach	0	CY	$15	$0
	Transportation	**141,000**	CY		**$705,000**
9	Onsite trucking	141,000	CY	$5	$705,000
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**141,000**	CY		**$705,000**
12	Stockpile	141,000	CY	$5	$705,000
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$3,835,000**
	Contingency	35%			**$1,342,300**
	Total				**$5,177,300**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$129,000	$129,000
	Sediment Removal	141,000	CY	$3	$423,000
	Barge Sediment (approx. 30 NM)	141,000	CY	$4.50	$634,500
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	141,000	CY	$3	$423,000
	Subtotal				**$1,609,500**
	Contingency	35%			**$563,400**
	Total for Option 1				**$2,172,900**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$402,000	$402,000
	Sediment Removal	141,000	CY	$3	$423,000
	Barge Sediment (approx. 30 NM)	141,000	CY	$4.50	$634,500
	Stockpiling & Staging Material at POLA	141,000	CY	$1	$141,000
	Truck Material to Site (100 mi at $0.20/cy)	141,000	CY	$20	$2,820,000
	Placement, grading, compaction at Site	141,000	CY	$4.25	$599,250
	Subtotal				**$5,019,750**
	Contingency	35%			**$1,757,000**
	Total for Option 2				**$6,776,750**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$344,000	$344,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	141,000	CY	$28	$3,948,000
	Subtotal				**$4,292,000**
	Contingency	35%			**$1,502,200**
	Total for Option 3				**$5,794,200**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$258,000	$258,000
	Sediment Removal and Beach Disposal	141,000	CY	$21	$2,961,000
	Subtotal				**$3,219,000**
	Contingency	35%			**$1,126,700**
	Total for Option 4				**$4,345,700**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$7,350,200**
3	**Upland Disposal**	**$11,954,050**
5	**Offshore Disposal [1]**	**$10,971,500**
6	**Beach Disposal [1]**	**$9,523,000**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 4 Area A

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$6,430,000**
1	Mobilization	1	LS	$6,430,000	$6,430,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**2,748,440**	CY		**$41,226,600**
3	Excavate to Marshplain	2,748,000	CY	$15	$41,220,000
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	0	CY	$15	$0
7	Channels Order 3	440	CY	$15	$6,600
8	Breach	0	CY	$15	$0
	Transportation	**2,748,440**	CY		**$13,742,200**
9	Onsite trucking	2,748,440	CY	$5	$13,742,200
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**2,748,440**	CY		**$13,742,200**
12	Stockpile	2,748,440	CY	$5	$13,742,200
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$5,125,000**
17	Culvert	2,500	SF	$2,010	$5,025,000
18	Tide Gate	1	LS	$100,000	$100,000
	Subtotal				**$80,266,000**
	Contingency	35%			**$28,093,100**
	Total				**$108,359,100**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$2,510,000	$2,510,000
	Sediment Removal	2,748,440	CY	$3	$8,245,320
	Barge Sediment (approx. 30 NM)	2,748,440	CY	$4.50	$12,367,980
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	2,748,440	CY	$3	$8,245,320
	Subtotal				**$31,368,620**
	Contingency	35%			**$10,979,100**
	Total for Option 1				**$42,347,720**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$7,828,000	$7,828,000
	Sediment Removal	2,748,440	CY	$3	$8,245,320
	Barge Sediment (approx. 30 NM)	2,748,440	CY	$4.50	$12,367,980
	Stockpiling & Staging Material at POLA	2,748,440	CY	$1	$2,748,440
	Truck Material to Site (100 mi at $0.20/cy)	2,748,440	CY	$20	$54,968,800
	Placement, grading, compaction at Site	2,748,440	CY	$4.25	$11,680,870
	Subtotal				**$97,839,410**
	Contingency	35%			**$34,243,800**
	Total for Option 2				**$132,083,210**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$6,692,000	$6,692,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	2,748,440	CY	$28	$76,956,320
	Subtotal				**$83,648,320**
	Contingency	35%			**$29,277,000**
	Total for Option 3				**$112,925,320**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$5,019,000	$5,019,000
	Sediment Removal and Beach Disposal	2,748,440	CY	$21	$57,717,240
	Subtotal				**$62,736,240**
	Contingency	35%			**$21,957,700**
	Total for Option 4				**$84,693,940**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$150,706,820**
3	**Upland Disposal**	**$240,442,310**
5	**Offshore Disposal [1]**	**$221,284,420**
6	**Beach Disposal [1]**	**$193,053,040**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 4 Area B

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$3,290,000**
1	Mobilization	1	LS	$3,290,000	$3,290,000
	Demolition				**$1,400,000**
2	Demo culvert, daylight chan	1,400	LF	$1,000	$1,400,000
	Excavation	**1,259,910**	CY		**$18,898,650**
3	Excavate to Marshplain	1,229,400	CY	$15	$18,441,000
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	5,560	CY	$15	$83,400
6	Channels Order 4	9,390	CY	$15	$140,850
7	Channels Order 3	8,180	CY	$15	$122,700
8	Breach	7,380	CY	$15	$110,700
	Transportation	**1,252,530**	CY		**$6,262,650**
9	Onsite trucking	1,252,530	CY	$5	$6,262,650
	New Levees	**288,830**	CY		**$4,336,600**
10	Levee Fill - no road	81,930	CY	$10	$819,300
11	Levee Fill - with road	206,900	CY	$17	$3,517,300
	Stockpile	**963,700**	CY		**$4,818,500**
12	Stockpile	963,700	CY	$5	$4,818,500
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$2,110,000**
17	Culvert	1,000	SF	$2,010	$2,010,000
18	Tide Gate	1	LS	$100,000	$100,000
	Subtotal				**$41,116,400**
	Contingency	35%			**$14,390,800**
	Total				**$55,507,200**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$880,000	$880,000
	Sediment Removal	963,700	CY	$3	$2,891,100
	Barge Sediment (approx. 30 NM)	963,700	CY	$4.50	$4,336,650
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	963,700	CY	$3	$2,891,100
	Subtotal				**$10,998,850**
	Contingency	35%			**$3,849,600**
	Total for Option 1				**$14,848,450**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$2,745,000	$2,745,000
	Sediment Removal	963,700	CY	$3	$2,891,100
	Barge Sediment (approx. 30 NM)	963,700	CY	$4.50	$4,336,650
	Stockpiling & Staging Material at POLA	963,700	CY	$1	$963,700
	Truck Material to Site (100 mi at $0.20/cy)	963,700	CY	$20	$19,274,000
	Placement, grading, compaction at Site	963,700	CY	$4.25	$4,095,725
	Subtotal				**$34,306,175**
	Contingency	35%			**$12,007,200**
	Total for Option 2				**$46,313,375**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$2,347,000	$2,347,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	963,700	CY	$28	$26,983,600
	Subtotal				**$29,330,600**
	Contingency	35%			**$10,265,800**
	Total for Option 3				**$39,596,400**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$1,760,000	$1,760,000
	Sediment Removal and Beach Disposal	963,700	CY	$21	$20,237,700
	Subtotal				**$21,997,700**
	Contingency	35%			**$7,699,200**
	Total for Option 4				**$29,696,900**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$70,355,650**
3	**Upland Disposal**	**$101,820,575**
5	**Offshore Disposal [1]**	**$95,103,600**
6	**Beach Disposal [1]**	**$85,204,100**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 4 Area C

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$310,000**
1	Mobilization	1	LS	$310,000	$310,000
	Demolition				**$0**
2	Demo culvert, daylight cl	0	LF	$1,000	$0
	Excavation	**141,000**	CY		**$2,115,000**
3	Excavate to Marshplain	141,000	CY	$15	$2,115,000
4	New Ballona Creek	0	CY	$15	$0
5	Channels Order 5	0	CY	$15	$0
6	Channels Order 4	0	CY	$15	$0
7	Channels Order 3	0	CY	$15	$0
8	Breach	0	CY	$15	$0
	Transportation	**141,000**	CY		**$705,000**
9	Onsite trucking	141,000	CY	$5	$705,000
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**141,000**	CY		**$705,000**
12	Stockpile	141,000	CY	$5	$705,000
	Levee Lowering and Ballona Creek Fill				**$0**
13	Levee Lowering	0	CY	$5	$0
14	Ballona Creek Fill	0	CY	$5	$0
15	Salvage Rip Rap	0	CY	$10	$0
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$3,835,000**
	Contingency	35%			**$1,342,300**
	Total				**$5,177,300**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$129,000	$129,000
	Sediment Removal	141,000	CY	$3	$423,000
	Barge Sediment (approx. 30 NM)	141,000	CY	$4.50	$634,500
	Material (hydraulic unloader) or Disposal at CDF	141,000	CY	$3	$423,000
	Subtotal				**$1,609,500**
	Contingency	35%			**$563,400**
	Total for Option 1				**$2,172,900**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$402,000	$402,000
	Sediment Removal	141,000	CY	$3	$423,000
	Barge Sediment (approx. 30 NM)	141,000	CY	$4.50	$634,500
	Stockpiling & Staging Material at POLA	141,000	CY	$1	$141,000
	Truck Material to Site (100 mi at $0.20/cy)	141,000	CY	$20	$2,820,000
	Placement, grading, compaction at Site	141,000	CY	$4.25	$599,250
	Subtotal				**$5,019,750**
	Contingency	35%			**$1,757,000**
	Total for Option 2				**$6,776,750**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$344,000	$344,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	141,000	CY	$28	$3,948,000
	Subtotal				**$4,292,000**
	Contingency	35%			**$1,502,200**
	Total for Option 3				**$5,794,200**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$258,000	$258,000
	Sediment Removal and Beach Disposal	141,000	CY	$21	$2,961,000
	Subtotal				**$3,219,000**
	Contingency	35%			**$1,126,700**
	Total for Option 4				**$4,345,700**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$7,350,200**
3	**Upland Disposal**	**$11,954,050**
5	**Offshore Disposal [1]**	**$10,971,500**
6	**Beach Disposal [1]**	**$9,523,000**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 5 Area A

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$5,920,000**
1	Mobilization	1	LS	$5,920,000	$5,920,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**2,674,100**	CY		**$40,111,500**
3	Excavate to Marshplain	2,649,400	CY	$15	$39,741,000
4	New Ballona Creek	16,500	CY	$15	$247,500
5	Channels Order 5	1,200	CY	$15	$18,000
6	Channels Order 4	3,300	CY	$15	$49,500
7	Channels Order 3	3,700	CY	$15	$55,500
8	Breach	0	CY	$15	$0
	Transportation	**2,674,100**	CY		**$13,370,500**
9	Onsite trucking	2,674,100	CY	$5	$13,370,500
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**2,665,700**	CY		**$13,328,500**
12	Stockpile	2,665,700	CY	$5	$13,328,500
	Levee Lowering and Ballona Creek Fill				**$1,189,400**
13	Levee Lowering	85,700	CY	$5	$428,500
14	Ballona Creek Fill	94,100	CY	$5	$470,500
15	Salvage Rip Rap	14,520	CY	$10	$145,200
16	Buried rock protection	7,260	CY	$20	$145,200
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$73,919,900**
	Contingency	35%			**$25,872,000**
	Total				**$99,791,900**

Disposal Options - Cost Estimates from POLA / Weston and SCC

1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$2,434,000	$2,434,000
	Sediment Removal	2,665,700	CY	$3	$7,997,100
	Barge Sediment (approx. 30 NM)	2,665,700	CY	$4.50	$11,995,650
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	2,665,700	CY	$3	$7,997,100
	Subtotal				**$30,423,850**
	Contingency	35%			**$10,648,400**
	Total for Option 1				**$41,072,250**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$7,592,000	$7,592,000
	Sediment Removal	2,665,700	CY	$3	$7,997,100
	Barge Sediment (approx. 30 NM)	2,665,700	CY	$4.50	$11,995,650
	Stockpiling & Staging Material at POLA	2,665,700	CY	$1	$2,665,700
	Truck Material to Site (100 mi at $0.20/cy)	2,665,700	CY	$20	$53,314,000
	Placement, grading, compaction at Site	2,665,700	CY	$4.25	$11,329,225
	Subtotal				**$94,893,675**
	Contingency	35%			**$33,212,800**
	Total for Option 2				**$128,106,475**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$6,491,000	$6,491,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	2,665,700	CY	$28	$74,639,600
	Subtotal				**$81,130,600**
	Contingency	35%			**$28,395,800**
	Total for Option 3				**$109,526,400**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$4,868,000	$4,868,000
	Sediment Removal and Beach Disposal	2,665,700	CY	$21	$55,979,700
	Subtotal				**$60,847,700**
	Contingency	35%			**$21,296,700**
	Total for Option 4				**$82,144,400**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$140,864,150**
3	**Upland Disposal**	**$227,898,375**
5	**Offshore Disposal [1]**	**$209,318,300**
6	**Beach Disposal [1]**	**$181,936,300**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 5 Area B

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$3,500,000**
1	Mobilization	1	LS	$3,500,000	$3,500,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**1,440,000**	CY		**$21,600,000**
3	Excavate to Marshplain	1,398,600	CY	$15	$20,979,000
4	New Ballona Creek	27,700	CY	$15	$415,500
5	Channels Order 5	2,000	CY	$15	$30,000
6	Channels Order 4	5,500	CY	$15	$82,500
7	Channels Order 3	6,200	CY	$15	$93,000
8	Breach	0	CY	$15	$0
	Transportation	**1,440,000**	CY		**$7,200,000**
9	Onsite trucking	1,440,000	CY	$5	$7,200,000
	New Levees	**209,300**	CY		**$3,558,100**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	209,300	CY	$17	$3,558,100
	Stockpile	**1,218,100**	CY		**$6,090,500**
12	Stockpile	1,218,100	CY	$5	$6,090,500
	Levee Lowering and Ballona Creek Fill				**$1,783,600**
13	Levee Lowering	128,500	CY	$5	$642,500
14	Ballona Creek Fill	141,100	CY	$5	$705,500
15	Salvage Rip Rap	21,780	CY	$10	$217,800
16	Buried rock protection	10,890	CY	$20	$217,800
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$43,732,200**
	Contingency	35%			**$15,306,300**
	Total				**$59,038,500**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$1,113,000	$1,113,000
	Sediment Removal	1,218,100	CY	$3	$3,654,300
	Barge Sediment (approx. 30 NM)	1,218,100	CY	$4.50	$5,481,450
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	1,218,100	CY	$3	$3,654,300
	Subtotal				**$13,903,050**
	Contingency	35%			**$4,866,100**
	Total for Option 1				**$18,769,150**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$3,469,000	$3,469,000
	Sediment Removal	1,218,100	CY	$3	$3,654,300
	Barge Sediment (approx. 30 NM)	1,218,100	CY	$4.50	$5,481,450
	Stockpiling & Staging Material at POLA	1,218,100	CY	$1	$1,218,100
	Truck Material to Site (100 mi at $0.20/cy)	1,218,100	CY	$20	$24,362,000
	Placement, grading, compaction at Site	1,218,100	CY	$4.25	$5,176,925
	Subtotal				**$43,361,775**
	Contingency	35%			**$15,176,700**
	Total for Option 2				**$58,538,475**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$2,966,000	$2,966,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	1,218,100	CY	$28	$34,106,800
	Subtotal				**$37,072,800**
	Contingency	35%			**$12,975,500**
	Total for Option 3				**$50,048,300**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$2,225,000	$2,225,000
	Sediment Removal and Beach Disposal	1,218,100	CY	$21	$25,580,100
	Subtotal				**$27,805,100**
	Contingency	35%			**$9,731,800**
	Total for Option 4				**$37,536,900**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$77,807,650**
3	**Upland Disposal**	**$117,576,975**
5	**Offshore Disposal [1]**	**$109,086,800**
6	**Beach Disposal [1]**	**$96,575,400**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 5 Area C

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$2,990,000**
1	Mobilization	1	LS	$2,990,000	$2,990,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**1,352,000**	CY		**$20,280,000**
3	Excavate to Marshplain	1,324,700	CY	$15	$19,870,500
4	New Ballona Creek	21,800	CY	$15	$327,000
5	Channels Order 5	800	CY	$15	$12,000
6	Channels Order 4	2,200	CY	$15	$33,000
7	Channels Order 3	2,500	CY	$15	$37,500
8	Breach	0	CY	$15	$0
	Transportation	**1,352,000**	CY		**$6,760,000**
9	Onsite trucking	1,352,000	CY	$5	$6,760,000
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**1,347,800**	CY		**$6,739,000**
12	Stockpile	1,347,800	CY	$5	$6,739,000
	Levee Lowering and Ballona Creek Fill				**$595,200**
13	Levee Lowering	42,900	CY	$5	$214,500
14	Ballona Creek Fill	47,100	CY	$5	$235,500
15	Salvage Rip Rap	7,260	CY	$10	$72,600
16	Buried rock protection	3,630	CY	$20	$72,600
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$37,364,200**
	Contingency	35%			**$13,077,500**
	Total				**$50,441,700**

Disposal Options - Cost Estimates from POLA / Weston and SCC

1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$1,231,000	$1,231,000
	Sediment Removal	1,347,800	CY	$3	$4,043,400
	Barge Sediment (approx. 30 NM)	1,347,800	CY	$4.50	$6,065,100
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	1,347,800	CY	$3	$4,043,400
	Subtotal				**$15,382,900**
	Contingency	35%			**$5,384,100**
	Total for Option 1				**$20,767,000**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$3,839,000	$3,839,000
	Sediment Removal	1,347,800	CY	$3	$4,043,400
	Barge Sediment (approx. 30 NM)	1,347,800	CY	$4.50	$6,065,100
	Stockpiling & Staging Material at POLA	1,347,800	CY	$1	$1,347,800
	Truck Material to Site (100 mi at $0.20/cy)	1,347,800	CY	$20	$26,956,000
	Placement, grading, compaction at Site	1,347,800	CY	$4.25	$5,728,150
	Subtotal				**$47,979,450**
	Contingency	35%			**$16,792,900**
	Total for Option 2				**$64,772,350**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$3,282,000	$3,282,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	1,347,800	CY	$28	$37,738,400
	Subtotal				**$41,020,400**
	Contingency	35%			**$14,357,200**
	Total for Option 3				**$55,377,600**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$2,462,000	$2,462,000
	Sediment Removal and Beach Disposal	1,347,800	CY	$21	$28,303,800
	Subtotal				**$30,765,800**
	Contingency	35%			**$10,768,000**
	Total for Option 4				**$41,533,800**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$71,208,700**
3	**Upland Disposal**	**$115,214,050**
5	**Offshore Disposal [1]**	**$105,819,300**
6	**Beach Disposal [1]**	**$91,975,500**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 5 Phase 1

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$6,550,000**
1	Mobilization	1	LS	$6,550,000	$6,550,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**2,924,300**	CY		**$43,864,500**
3	Excavate to Marshplain	2,882,500	CY	$15	$43,237,500
4	New Ballona Creek	31,400	CY	$15	$471,000
5	Channels Order 5	1,500	CY	$15	$22,500
6	Channels Order 4	4,200	CY	$15	$63,000
7	Channels Order 3	4,700	CY	$15	$70,500
8	Breach	0	CY	$15	$0
	Transportation	**2,924,300**	CY		**$14,621,500**
9	Onsite trucking	2,924,300	CY	$5	$14,621,500
	New Levees	**49,240**	CY		**$492,400**
10	Levee Fill - no road	49,240	CY	$10	$492,400
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**2,889,960**	CY		**$14,449,800**
12	Stockpile	2,889,960	CY	$5	$14,449,800
	Levee Lowering and Ballona Creek Fill				**$1,828,500**
13	Levee Lowering	163,100	CY	$5	$815,500
14	Ballona Creek Fill	148,200	CY	$5	$741,000
15	Salvage Rip Rap	27,200	CY	$10	$272,000
16	Buried rock protection	0	CY	$20	$0
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$81,806,700**
	Contingency	35%			**$28,632,400**
	Total				**$110,439,100**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$2,639,000	$2,639,000
	Sediment Removal	2,889,960	CY	$3	$8,669,880
	Barge Sediment (approx. 30 NM)	2,889,960	CY	$4.50	$13,004,820
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	2,889,960	CY	$3	$8,669,880
	Subtotal				**$32,983,580**
	Contingency	35%			**$11,544,300**
	Total for Option 1				**$44,527,880**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$8,231,000	$8,231,000
	Sediment Removal	2,889,960	CY	$3	$8,669,880
	Barge Sediment (approx. 30 NM)	2,889,960	CY	$4.50	$13,004,820
	Stockpiling & Staging Material at POLA	2,889,960	CY	$1	$2,889,960
	Truck Material to Site (100 mi at $0.20/cy)	2,889,960	CY	$20	$57,799,200
	Placement, grading, compaction at Site	2,889,960	CY	$4.25	$12,282,330
	Subtotal				**$102,877,190**
	Contingency	35%			**$36,007,100**
	Total for Option 2				**$138,884,290**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$7,037,000	$7,037,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	2,889,960	CY	$28	$80,918,880
	Subtotal				**$87,955,880**
	Contingency	35%			**$30,784,600**
	Total for Option 3				**$118,740,480**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$5,278,000	$5,278,000
	Sediment Removal and Beach Disposal	2,889,960	CY	$21	$60,689,160
	Subtotal				**$65,967,160**
	Contingency	35%			**$23,088,500**
	Total for Option 4				**$89,055,660**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$154,966,980**
3	**Upland Disposal**	**$249,323,390**
5	**Offshore Disposal [1]**	**$229,179,580**
6	**Beach Disposal [1]**	**$199,494,760**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 5 Phase 2

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$2,900,000**
1	Mobilization	1	LS	$2,900,000	$2,900,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**1,192,500**	CY		**$17,887,500**
3	Excavate to Marshplain	1,165,500	CY	$15	$17,482,500
4	New Ballona Creek	15,500	CY	$15	$232,500
5	Channels Order 5	1,700	CY	$15	$25,500
6	Channels Order 4	4,600	CY	$15	$69,000
7	Channels Order 3	5,200	CY	$15	$78,000
8	Breach	0	CY	$15	$0
	Transportation	**1,192,500**	CY		**$5,962,500**
9	Onsite trucking	1,192,500	CY	$5	$5,962,500
	New Levees	**209,300**	CY		**$3,558,100**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	209,300	CY	$17	$3,558,100
	Stockpile	**923,500**	CY		**$4,617,500**
12	Stockpile	923,500	CY	$5	$4,617,500
	Levee Lowering and Ballona Creek Fill				**$1,253,500**
13	Levee Lowering	51,000	CY	$5	$255,000
14	Ballona Creek Fill	110,700	CY	$5	$553,500
15	Salvage Rip Rap	8,200	CY	$10	$82,000
16	Buried rock protection	18,150	CY	$20	$363,000
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$36,179,100**
	Contingency	35%			**$12,662,700**
	Total				**$48,841,800**

Disposal Options - Cost Estimates from POLA / Weston and SCC

1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$844,000	$844,000
	Sediment Removal	923,500	CY	$3	$2,770,500
	Barge Sediment (approx. 30 NM)	923,500	CY	$4.50	$4,155,750
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	923,500	CY	$3	$2,770,500
	Subtotal				**$10,540,750**
	Contingency	35%			**$3,689,300**
	Total for Option 1				**$14,230,050**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$2,630,000	$2,630,000
	Sediment Removal	923,500	CY	$3	$2,770,500
	Barge Sediment (approx. 30 NM)	923,500	CY	$4.50	$4,155,750
	Stockpiling & Staging Material at POLA	923,500	CY	$1	$923,500
	Truck Material to Site (100 mi at $0.20/cy)	923,500	CY	$20	$18,470,000
	Placement, grading, compaction at Site	923,500	CY	$4.25	$3,924,880
	Subtotal				**$32,874,630**
	Contingency	35%			**$11,506,200**
	Total for Option 2				**$44,380,830**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$2,249,000	$2,249,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	923,500	CY	$28	$25,858,000
	Subtotal				**$28,107,000**
	Contingency	35%			**$9,837,500**
	Total for Option 3				**$37,944,500**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$1,687,000	$1,687,000
	Sediment Removal and Beach Disposal	923,500	CY	$21	$19,393,500
	Subtotal				**$21,080,500**
	Contingency	35%			**$7,378,200**
	Total for Option 4				**$28,458,700**

Grand Totals with Disposal Options

1 / 2	**Disposal at POLA**	**$63,071,850**
3	**Upland Disposal**	**$93,222,630**
5	**Offshore Disposal [1]**	**$86,786,300**
6	**Beach Disposal [1]**	**$77,300,500**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)

Alternative 5 Phase 3

Item	Description	Quantity	Unit	Unit Cost	Total Cost
	Mobilization				**$2,990,000**
1	Mobilization	1	LS	$2,990,000	$2,990,000
	Demolition				**$0**
2	Demo culvert, daylight chan	0	LF	$1,000	$0
	Excavation	**1,352,000**	CY		**$20,280,000**
3	Excavate to Marshplain	1,324,700	CY	$15	$19,870,500
4	New Ballona Creek	21,800	CY	$15	$327,000
5	Channels Order 5	800	CY	$15	$12,000
6	Channels Order 4	2,200	CY	$15	$33,000
7	Channels Order 3	2,500	CY	$15	$37,500
8	Breach	0	CY	$15	$0
	Transportation	**1,352,000**	CY		**$6,760,000**
9	Onsite trucking	1,352,000	CY	$5	$6,760,000
	New Levees	**0**	CY		**$0**
10	Levee Fill - no road	0	CY	$10	$0
11	Levee Fill - with road	0	CY	$17	$0
	Stockpile	**1,344,600**	CY		**$6,723,000**
12	Stockpile	1,344,600	CY	$5	$6,723,000
	Levee Lowering and Ballona Creek Fill				**$620,200**
13	Levee Lowering	42,900	CY	$5	$214,500
14	Ballona Creek Fill	50,300	CY	$5	$251,500
15	Salvage Rip Rap	8,160	CY	$10	$81,600
16	Buried rock protection	3,630	CY	$20	$72,600
	Water Control Structures				**$0**
17	Culvert	0	SF	$2,010	$0
18	Tide Gate	0	LS	$100,000	$0
	Subtotal				**$37,373,200**
	Contingency	35%			**$13,080,700**
	Total				**$50,453,900**

Disposal Options - Cost Estimates from POLA / Weston and SCC

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1 / 2	**Unload Dredged Material at POLA / Disposal at CDF at POLA**				
	Mobilization	1	LS	$1,228,000	$1,228,000
	Sediment Removal	1,344,600	CY	$3	$4,033,800
	Barge Sediment (approx. 30 NM)	1,344,600	CY	$4.50	$6,050,700
	Unload Dredged Material (hydraulic unloader) or Disposal at CDF	1,344,600	CY	$3	$4,033,800
	Subtotal				**$15,346,300**
	Contingency	35%			**$5,371,300**
	Total for Option 1				**$20,717,600**
3	**Beneficial Use - Landfill Cover**				
	Mobilization	1	LS	$3,830,000	$3,830,000
	Sediment Removal	1,344,600	CY	$3	$4,033,800
	Barge Sediment (approx. 30 NM)	1,344,600	CY	$4.50	$6,050,700
	Stockpiling & Staging Material at POLA	1,344,600	CY	$1	$1,344,600
	Truck Material to Site (100 mi at $0.20/cy)	1,344,600	CY	$20	$26,892,000
	Placement, grading, compaction at Site	1,344,600	CY	$4.25	$5,714,550
	Subtotal				**$47,865,650**
	Contingency	35%			**$16,753,000**
	Total for Option 2				**$64,618,650**
4	**Disposal at Hazardous Waste Landfill - estimate not included, contamintant report pending**				
5	**Offshore Disposal [1]**				
	Mobilization	1	LS	$3,274,000	$3,274,000
	Sediment Removal and Offshore Disposal (approx. 3 mi offshore)	1,344,600	CY	$28	$37,648,800
	Subtotal				**$40,922,800**
	Contingency	35%			**$14,323,000**
	Total for Option 3				**$55,245,800**
6	**Beach Disposal [1]**				
	Mobilization	1	LS	$2,456,000	$2,456,000
	Sediment Removal and Beach Disposal	1,344,600	CY	$21	$28,236,600
	Subtotal				**$30,692,600**
	Contingency	35%			**$10,742,400**
	Total for Option 4				**$41,435,000**

Grand Totals with Disposal Options

Item	Description	Total Cost
1 / 2	**Disposal at POLA**	**$71,171,500**
3	**Upland Disposal**	**$115,072,550**
5	**Offshore Disposal [1]**	**$105,699,700**
6	**Beach Disposal [1]**	**$91,888,900**

Notes

1 - For Options 5 and 6, costs may range from the cost for Option 1 / 2 (lower end) up to the costs listed for Options 5 and 6 (upper end)