

ALISO CREEK ESTUARY RESTORATION

Conceptual Restoration Plan

Prepared for
Laguna Ocean Foundation

March 2018



Long-term restoration plan rendering for the Aliso Creek Estuary

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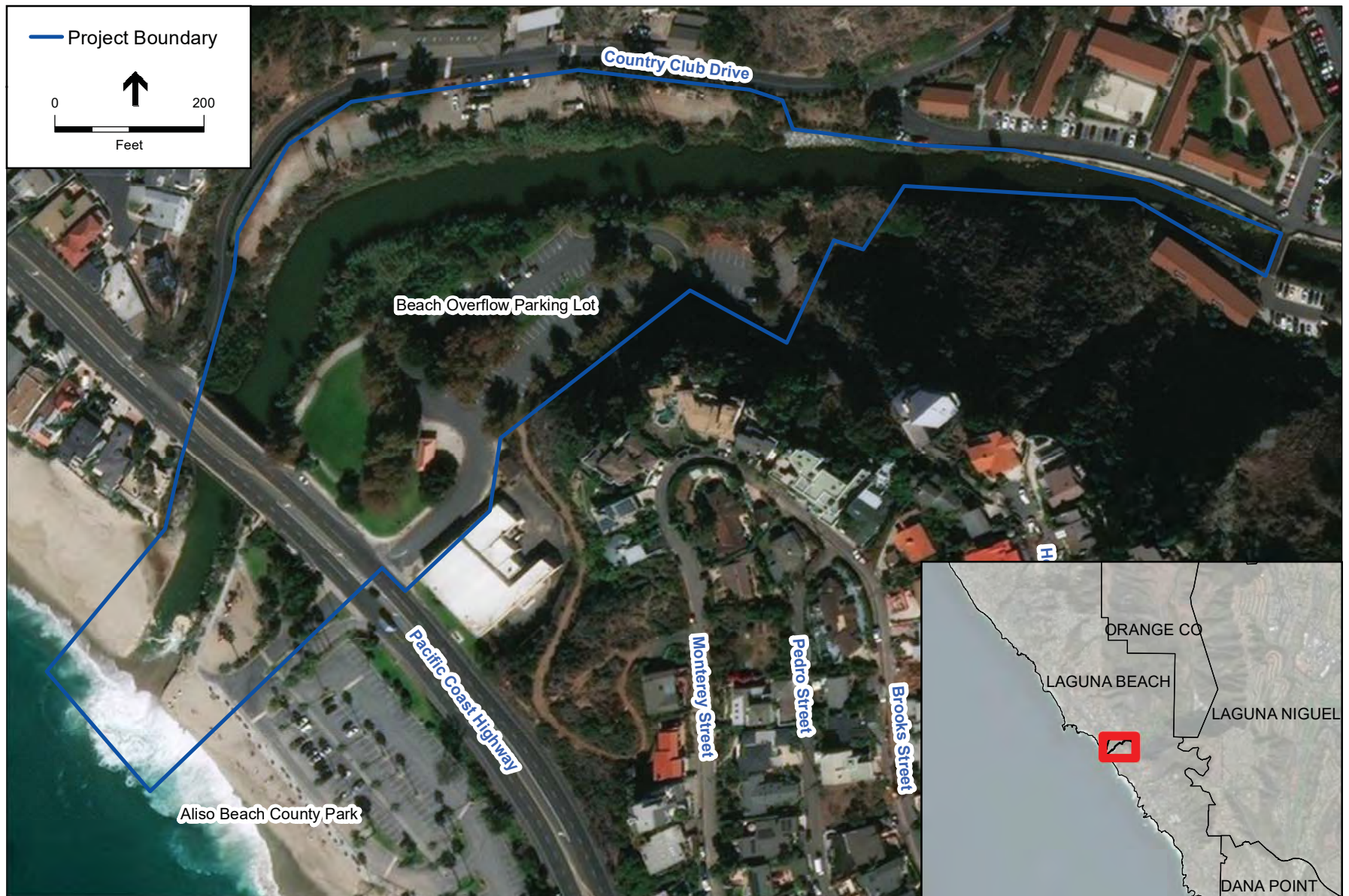
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SECTION 1

Introduction

The Aliso Creek Estuary is a coastal lagoon estuary located at the mouth of Aliso Creek at the Pacific Ocean in southern Laguna Beach, California (**Figure 1-1**). Aliso Creek and its watershed extend approximately 18 miles inland into southern Orange County. Ocean waves regularly push sand into the mouth of Aliso Creek, forming a beach berm that closes the mouth and forms an enclosed estuary. Historically, prior to development, the Aliso Creek Estuary supported wide swaths of wetland habitat, including vegetated marsh, along the banks of Aliso Creek and was a critical ecosystem for estuary plants and wildlife. The mouth of the estuary likely only opened during periods of high rainfall, when high creek flows broke through the beach berm. Over time, these wetlands were filled in and developed, destroying habitat and leaving a channelized estuary with minimal native vegetation along its steep banks. Urban development within the upstream watershed increased creek flows to the estuary during dry weather and degraded the estuary's water quality, largely through irrigation runoff. The mouth of the Aliso Creek is also now regularly breached and opened illegally during dry weather by people using the beach for recreation and less frequently by the County of Orange as permitted for public safety. These impacts to estuary wetlands, creek inflow, and natural mouth closure have resulted in the loss of estuary habitat, function, and wildlife, degrading the estuary ecosystem. Sensitive species such as the tidewater goby (an endangered fish endemic to this type of estuary) have been lost from the ecosystem.

The Aliso Creek Estuary Restoration Plan seeks to restore the estuary ecosystem by expanding the channelized estuary, creating new wetland habitats, reducing dry-weather creek inflows, improving water quality, and reducing artificial breaching of the estuary mouth. These restoration actions are expected to restore the estuary ecosystem such that it will support native estuary plants and wildlife and a range of estuary ecosystem functions. Laguna Ocean Foundation (LOF) has led the development of this Conceptual Restoration Plan for the Aliso Creek Estuary. This estuary ecosystem restoration plan, which is funded by the California Coastal Conservancy (SCC) and others, identifies a feasible plan to restore the lagoon at the mouth of Aliso Creek to a healthy estuary. The plan was developed with the assistance of a technical consultant team (Environmental Science Associates [ESA] with Coastal Restoration Consultants [CRC]) and input from various stakeholders. The restoration plan includes analyses of existing site conditions, opportunities and constraints, and potential future conditions. Restoration goals and concepts were defined by the Science Advisory Team, a multi-disciplinary group of professional experts with knowledge of similar systems in Southern California and the dynamics and functions of such systems. The product is a CEQA/NEPA-ready plan, developed with strong local support and well-positioned to seek funding for implementation.



SOURCE: ESRI

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Figure 1-1

Aliso Creek Estuary Project Site Location



The first step in developing the Aliso Creek Estuary Restoration Plan was to gather and review existing data on hydrology, water quality and physical conditions, ecology, biology and other topics relevant to the lagoon (current, historic and future conditions), including studies of upstream watershed conditions that might be relevant to estuary restoration planning. In addition to reviewing available technical data, representatives of the principal private landowners and agencies with land uses or facilities in the vicinity of the lagoon were consulted to learn about existing land use constraints and opportunities. The landowners, public agencies and utility providers were asked for site specific information on facilities, pipelines, ownerships, easements and rights-of-way, etc., from which a GIS database of existing land use and infrastructure within the study area was developed. The study area generally extends from the Pacific Ocean to the property boundary of The Ranch at Laguna Beach (a privately owned inn and golf course) a few hundred yards upstream and inland of Coast Highway, and includes Orange County's Aliso Beach Park (inland and coastal sides) and adjacent properties (Figure 1-1). Information gathered through this process is summarized in Section 2 for the purpose of providing background information that informed the development of the restoration plan and will support the subsequent phases of the project including environmental review (i.e., CEQA/NEPA).

As the restoration team finalized the development of the conceptual restoration plan, key elements of the plan were shared with stakeholders, and their feedback further informed and shaped the plan's development. The first key product was to define restoration goals and objectives (Section 3) based on current conditions, a study of historical conditions and ecosystem functions, and regional planning and strategies provided through the Southern California Wetland Recovery Project (WRP, see Section 2 for further discussion). The project's restoration goals were shared with stakeholders and the general public in January 2016.

Following the identification of goals and objectives, in-depth planning and technical analyses were performed to develop and evaluate restoration alternatives (Section 5). The Science Advisory Team provided input on the selection of a preferred restoration alternative that would best meet the restoration goals and opportunities within the constraints. This preferred alternative involves restoring the extent, processes, and functions of the estuary to as close to historic conditions as possible within the constraints of current conditions. Restoration planning also considered alternatives and options for reconfiguring existing public uses within and adjacent to the Aliso Beach Park to accommodate the expansion and restoration of the estuary and to create and enhance opportunities for the public to experience the restored estuary and surrounding natural beauty of the Aliso Canyon and Aliso Beach. A preferred set of public use options was identified and explored with key land owners and stakeholders.

The identified preferred restoration alternative and public use options (summarized below) were detailed and used to form the conceptual restoration plan. The conceptual restoration plan was presented to the public in a workshop in October 2017 and includes the following key components:

- **Near-term restoration plan (Figure 1-2):** expansion of the estuary on the east and west side of the Aliso Creek Coast Highway Bridge, restoration of habitats including vegetated marsh and upland coastal sage scrub, reduction of artificial breaching of the estuary mouth, reduction of dry-weather creek inflow and improvement in water quality through increased operation of the South Coast Water District's (SCWD) Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project at the upstream Coastal Treatment Plant (CTP), and an

adaptive management program to refine management of the restored estuary based on restoration monitoring.

- **Long-term restoration plan (Figure 1-3):** expanding (i.e., lengthening) the Coast Highway Bridge when the opportunity arises (e.g., in conjunction with transportation improvements and/or other projects) in order to further restore, connect, and improve the function of estuary habitats; and relying on long-term watershed management to reduce dry-weather creek inflow and improve water quality (e.g., implementation of water quality improvement plans for the Aliso Creek watershed)
- **Public use options (Figure 1-4, in conjunction with the near-term restoration plan):** removing/reconfiguring the Aliso Beach Park's inland parking lot to facilitate estuary expansion east of Coast Highway; creating a new visitor center and parking lot on the north side of Aliso Creek along Village Lane; installing a network of trails, boardwalks, and interpretive features for the public to experience the restored estuary; a range of potential options for an enhanced crossing (e.g., bridge) between new public use features on the north side of Aliso Creek and Aliso Beach; and relocation of the picnic area and playground as well as narrowing the existing Aliso Beach Park's beach parking lot entrance to facilitate estuary expansion west of Coast Highway.

Focused hydrology and water quality studies were performed for the preferred restoration alternative to analyze key feasibility issues for the restoration (Section 6). These feasibility studies include modeling high flows through the Aliso Creek Estuary, dynamics and changes in estuary water levels due to creek mouth opening and closure throughout the year, and resulting changes in estuary water quality. The water quality data collection and assessment for the restoration plan focuses on salinity, temperature, dissolved oxygen, and residence time as key parameters that affect the types of estuary habitats that can be restored in the Aliso Creek Estuary. The feasibility studies also include modeling and assessment of the potential response of the restored estuary to sea-level rise and climate change.

Conceptual restoration planning details were further developed for the preferred alternative to finalize the plan (Section 7), including grading, re-vegetation, public use, and monitoring and adaptive management plans. The restored estuary is expected to create and support vegetated brackish marsh habitat dominated by tules, with the potential for cattail freshwater marsh, salt marsh, and riparian habitats. These restored wetland habitats would transition down to restored open water channels and seasonally exposed unvegetated flats, and up to restored coastal sage scrub and foredune scrub. Restored habitats would also connect with and enhance adjacent existing creek channel and hillslope habitats. The restored estuary is expected to provide habitat conditions that could support a range of estuary species, including shorebirds and the endangered tide water goby. Based on the conceptual restoration plan, the conceptual-level opinion of probable implementation costs ("cost estimate") totals approximately \$11.4 million, including design and permitting (approximately \$1 million), construction (approximately \$10.1 million), and operations and maintenance over the first 5 years after construction (approximately \$300,000).

The restoration plan also identifies and discusses next steps for the process to plan, permit, design, implement, and manage the restoration (Section 8). As a key first step, landowners and potential project partners, which likely include LOF, SCC, SCWD, Orange County, the City of Laguna Beach, and South Orange County Wastewater Authority (SOCWA), will need to reach agreements on the process and roles for the next steps.



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 1-2
Conceptual Restoration Plan
Near-term Phases



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 1-3
Conceptual Restoration Plan



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 1-4
 Conceptual Public Use Options

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SECTION 2

Existing Conditions

2.1 Aliso Creek Estuary and Regional Context

Aliso Creek is a 19-mile long stream, with an approximately 35 square mile watershed that includes both heavily urbanized areas and large open space areas in South Orange County. The Creek once drained to the Pacific through a broad, expansive estuary with extensive wetlands, as evidenced in historical photographs and maps (see Section 2.1.4). The creek's estuarine habitat has suffered degradation through modification of its hydrologic regime (from urbanization of the watershed) and physical modification of the mouth of the creek and its banks. The Aliso Estuary is a site of extremely high restoration value, due to its key geographic location between two regionally significant ecosystem reserve systems: the terrestrial greenbelt, or 'super park' comprised of ~15,000 acres of preserved natural habitats in the San Joaquin Hills, and the blue belt of the coastal and offshore Laguna Beach State Marine Conservation Area recently established through the Marine Life Protection Act. The Aliso Creek Estuary is the only location where a viable habitat linkage between these two systems can be developed. It is also the only location between San Mateo Creek (to the south) and Newport Back Bay (to the north) where the possibility exists to link protected freshwater and coastal ecosystems.

2.1.1 Southern California Coastal Wetlands

The Aliso Creek Estuary ecosystem is one of several small coastal creek mouth estuarine lagoon wetlands in Southern California. There are approximately 40 coastal wetlands along the 99 mile (160 km) coastline of the U.S. portion of the Southern California bight, between Point Conception and the border with Mexico (Southern California Wetlands Inventory 1998). Historically, Southern California wetlands naturally occurred across a wide range of conditions, from larger systems that were almost always under tidal influence to smaller systems, like Aliso Creek, that were intermittently or often closed and non-tidal. Most of these wetlands have been modified by human activity, resulting in losses of natural wetland habitat. The modern wetlands generally exist under disturbed conditions and are often surrounded by extensive urban development (Zedler 1982; 2001). The remaining natural coastal wetlands comprise a variety of environments including saline lagoons, embayments, river mouth marshes, and saltmarshes, depending on their physiographic location along the coast (Ferren et al. 1995).

Most of the Southern California wetlands are small and isolated, being confined to narrow river valleys and separated by coastal hills and mountains. They occur within two distinct groups of tidally-influenced estuaries and coastal lagoons (Macdonald 1988). Aliso Creek falls within the group made up of smaller, shallower estuaries and lagoons that can periodically close at the inlet

due to longshore transport of sand forming a sand bar across their mouths, smaller tidal prisms, and lower downstream freshwater flows. Generally, the longshore transport of sediment is stronger than the stream discharges at the inlet and the entrance to the coastal wetland is closed for long periods, only to be opened again when stream discharges increase during floods in winter. The other group of estuaries includes relatively deep water lagoons and ocean inlets with tidal prisms large enough to maintain frequent or permanent tidal exchange throughout the system.

The Mediterranean climate provides low levels of precipitation (occurring seasonally during wet winters) and, depending on the inflow of freshwater and salt water, the soils may vary considerably in salinity during the year (Zedler 1982). Soil salinity, in turn, directly affects the distribution of plants within the wetland (Hendrickson 1991; Zedler 1982; 2001).

Zedler (1982) reported 19 dominant species of plant within the saltmarshes of Southern California. The general composition of plant communities changes with elevation (although most species have broad ranges of distribution and a degree of overlap occurs) with cordgrass (*Spartina foliosa*) typical of the lower elevations. Open mudflat within the stands is often colonized by *Salicornia bigelovii* and *Batis maritima* while pickleweed (*Sarcocornia pacifica* syn: *Salicornia virginica*) dominates in the low to middle elevations. Pickleweed has the broadest distribution, occurring throughout most of the elevational range of cordgrass as well as being capable of becoming established on disturbed soils. Common species in the middle to high elevations include fleshy jaumea (*Jaumea carnosa*), salt grass (*Distichlis spicata*), and alkali heath (*Frankenia salina*). Although the flora of Southern California wetlands is limited, the tolerant species form highly dynamic communities both within wetland, and between wetlands that respond to both natural and anthropogenic environmental changes.

The smaller marshes are more likely to be dominated by pickleweed because environmental conditions become more extreme when ocean inlets close or narrow and tidal influence is absent or decreased for extended periods. If freshwater inputs dominate the water levels and salinity regimes, brackish marsh can become dominant. Brackish marsh plant species include tule (*Schoenoplectus californicus*), spiny rush (*Juncus acutus*), bulrush (*Bolboschoenus robustus* and/or *Bolboschoenus maritimus*) and alkali rye grass (*Elymus triticoides*). Upper marsh species might remain well represented, and large numbers of opportunistic weed species are usually present.

In general, the Southern California saltmarshes with a long history of good tidal flushing tend to have more native saltmarsh plant species than marshes with inlets that are closed (PERL 1990). Drought and hypersalinity due to limited tidal flushing or mouth closure can lead to the elimination of the less tolerant halophytes, such as cordgrass, while promoting the more tolerant species, like pickleweed (Boland and Zedler 1991; Callaway and Zedler 2004).

2.1.2 Historic Changes to Southern California Coastal Wetlands

Many Southern California coastal wetlands have been altered or eliminated by human activities. Over the past approximately 150 years, Southern California is estimated to have lost roughly 80% of its coastal estuarine habitats (SCCWRP 2014).

The California Coastal Commission, in its Procedural Guidance for the Review of Wetland Projects in California's Coastal Zone (CCC 1994) identified a variety of human activities that have caused losses and impacts to coastal wetlands. These activities include: draining wetlands and converting to agricultural uses; deposition of fill on top of wetlands to construct urban areas, roads, railways, or oil development; dredging new and expanded channels to create marinas; filling wetlands to increase the area of shoreline support facilities; and constructing flood control projects that result in the dredging, filling, and channelization of wetlands to prevent the natural dissipation of water and sediment into low-lying areas.

Such activities lead to significant changes to the wetland processes and the geomorphological and ecological linkage between coastal watersheds, wetlands, and the marine system. The main changes to these systems include draining, filling, and converting wetlands, hydrological modification, alterations to sediment transport processes and degradation of water quality (Wetlands Recovery Project 2001). Freshwater inflows to many Southern California estuaries have been substantially altered and tidal inlets have been restricted. Although dams have reduced sediment inputs, increased freshwater inflows and storm inputs have led to sediment accumulation and infilling of many estuarine systems (e.g. Greer and Stow 2003).

In recognition of the losses of coastal wetlands and the importance of these resources for habitat, water quality, and other benefits, there are several efforts underway to protect and restore wetlands. Due to the changes in wetland processes and ecological linkages described above, there are many challenges and constraints to wetland restoration. In many cases, these projects involve creating a functioning wetland system, but not necessarily re-creating the historic conditions.

In the late 1990s, the Southern California Wetlands Recovery Project (WRP) was formed to develop a regional strategy for wetland recovery in the U.S. portion of the Southern California Bight (WRP 2001). The WRP's Working Agreement was signed by fourteen state and federal agencies in 1997 and amended in 2017. Led by the California Natural Resources Agency and supported by the State Coastal Conservancy (SCC) and the Earth Island Institute, the WRP is a broad collaboration of non-profits, local communities, state agencies, and scientists engaged in wetland science and restoration. The focus of the WRP is preservation and restoration of coastal wetland ecosystems, aquatic and riparian habitat, and re-establishment of ecosystem functions such as hydrological processes, sediment transport, and water quality. The Aliso Creek Restoration was included as a proposed project in the 2015 WRP Work Plan.

The WRP identified six regional goals to achieve its vision to re-establish functioning wetland systems that support a diverse range of fauna and flora, while providing socio-economic benefits. These are:

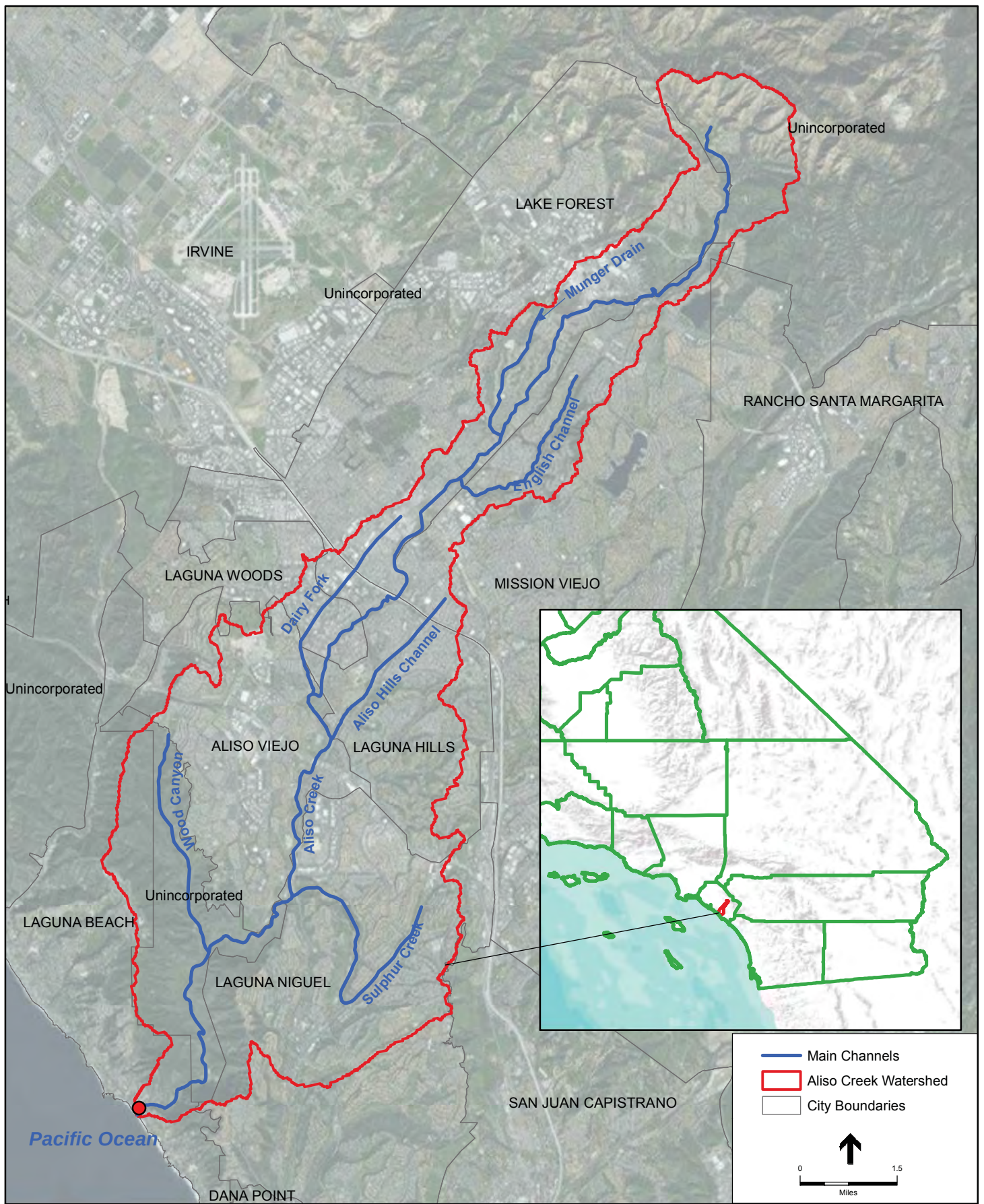
- Preserve and restore coastal wetland systems.
- Preserve and restore stream corridors and wetland ecosystems in coastal watersheds.
- Recover native habitat and species diversity.
- Integrate wetlands recovery with other public services.
- Promote education and compatible access related to coastal wetlands and watersheds.
- Advance the science of wetland restoration and management in Southern California.

The WRP is currently in the process of developing an updated Regional Strategy that will both inform and be informed by restoration planning for the Aliso Creek Estuary.

2.1.3 Aliso Creek Watershed

The Aliso Creek Watershed is approximately 35 square miles and is located in southern Orange County approximately 50 miles south of Los Angeles (**Figure 2-1**). The watershed includes portions of the cities of Aliso Viejo, Laguna Beach, Laguna Hills, Laguna Niguel, Laguna Woods, Lake Forest, Mission Viejo, and County unincorporated areas including the 6 square mile Aliso and Wood Canyons Wilderness Park. Aliso Creek watershed, like other watersheds in Orange County, has been significantly affected by development. Aliso Creek, once an intermittent stream before the region became heavily urbanized, now flows year-round through many sections as flow has been augmented by significant increases in upstream urban runoff. The watershed has a population of approximately 144,000 people divided among the seven cities and unincorporated areas and this number is expected to grow to approximately 160,000 people by the year 2020.

The creek is a 19-mile long watercourse that drains a long, narrow coastal canyon with headwaters in the Cleveland National Forest, which ultimately discharges to the Pacific Ocean at Aliso Beach in the City of Laguna Beach (**Figure 2-2**). For much of its course, the creek is channelized and confined by urban development and only flows freely in several stretches in its far upper and lower course. The main branch of Aliso Creek is fed by seven major tributaries and over forty minor drains and streams. Major tributaries to Aliso Creek include Wood Creek, Sulphur Creek, Aliso Hills Channel, Dairy Fork, Munger Creek, and English Canyon (Figure 2-1). Several of these tributaries including Dairy Fork, Aliso Hills Channel, Munger Creek, and other smaller channels have been replaced by storm drains. Wood Canyon Creek remains unchannelized, whereas Sulphur Creek has been channelized and diverted into culverts in several stretches, and English Canyon Creek has several sections of riprap stabilization and bank protection.



SOURCE: ESRI; USGS; Orange County Public Works

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-1

Aliso Creek Watershed



SOURCE: ESRI

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Figure 2-2
Aliso Creek Project Site

2.1.4 History of Aliso Creek

2.1.4.1 Prehistoric Site Evolution

Aliso Creek formed as a drainage when the Santa Ana Mountains began their uplift along the Elsinore fault. Along the coast, the uplift of the San Joaquin Hills, approximately 1.4 million years ago, formed around the creek as it cut through the hills to reach the ocean (Gath et al. 2001). During the end of the last glacial period (31,000 to 10,000 years ago), the climate of Southern California became wetter, and the increased rainfall, as well as the lower sea level, increased the power of the rivers, which cut through the San Joaquin Hills even more dramatically. As the sea level rose again and the dry climate returned (20,000 to 18,000 years ago), the rivers began to deposit sediment in the basin (Byrd 1998 as referenced in LSA 2008).

2.1.4.2 Historic Ecology and Habitats

The general emergence of the California coastline, in addition to changing sea levels and climatic conditions in the more recent past, suggests there occurred drowned valleys and creek and river mouths along the coast, with sand spits and dune fields at the ocean interface of the coastal wetland ecosystems and developing alluvial fans and deltas within the inland portions of these ecosystems from intermittent rivers as they grade towards the coast. This complex interplay of marine, estuarine, and riverine/fluvial processes made for a dynamic system in portions of the coastal wetland subject to periods of storm-related runoff, deposition, and erosion and oceanic wave action that among other effects produced marine deltas at the mouths of estuaries and wherever dune systems failed. The interplay of freshwater from the landscape and salt water from the ocean also influenced the relationship and distribution of habitats within the ecosystem.

Historical topographic surveys (t-sheets) of the Aliso Creek Estuary area have been used to map historic habitats in the area (**Figure 2-3**; Grossinger et al. 2011). Based on the 1885 T-sheet, the Aliso Creek Estuary used to be a larger lagoon with areas of salt vegetated wetland unvegetated flat (labeled as river island/bar in Figure 2-3). The 1885 T-sheet shows the mouth of the lagoon closed to the ocean. **Figure 2-4** shows the historic habitats overlaid on current conditions, which shows that almost all of the historic wetland habitat except the open water channel have been converted to developed land uses. Additional historic photos are shown and discussed below.



SOURCE: Source: SFEI, SCCWRP, CSUN

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-3

Historic Map and Ecology, 1885



SOURCE: ESRI, SoCal Atlas

Aliso Creek Estuary Conceptual Restoration Plan . 150108

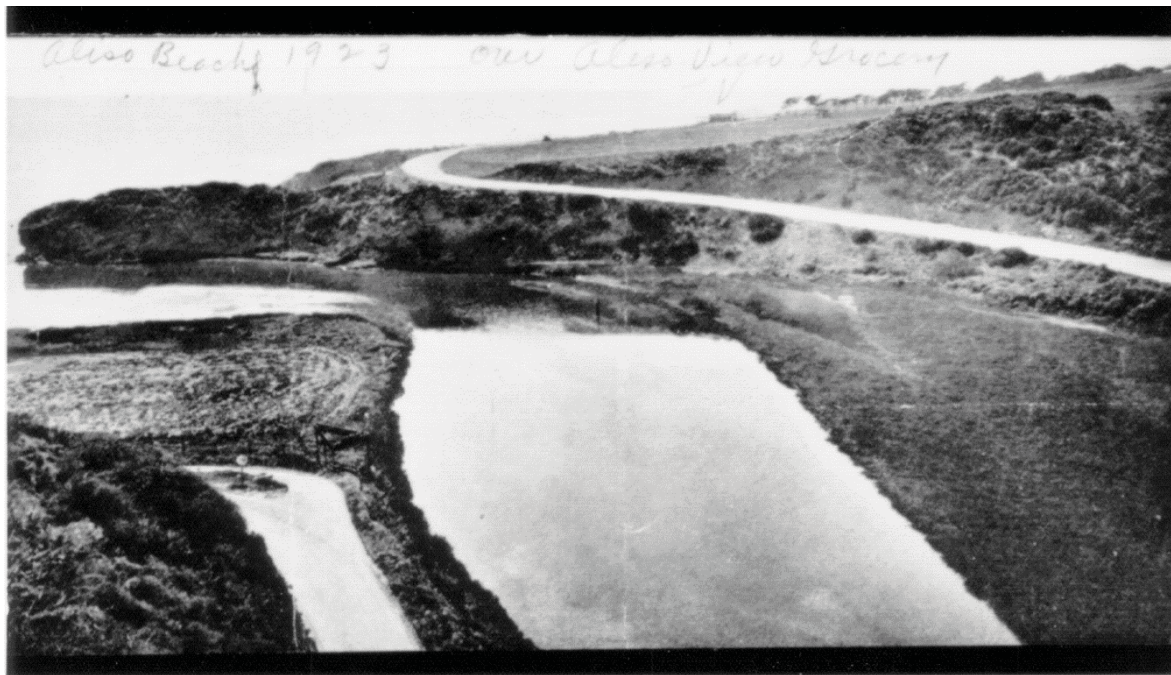
Figure 2-4
Historic Ecology

2.1.4.3 Post-European Colonization Changes

Over the past two centuries, there have been significant changes to the Aliso Creek watershed. European settlers brought livestock to graze in the watershed in the early 1800s, and by the mid-1800s, much of the land was barren, which contributed to increased erosion. Trees were used for construction, and much of the historic riparian habitat was destroyed. Erosion rates peaked in the mid-late 1800s and much of this material settled into the channel downstream (Tetra Tech 2010).

Figures 2-5 through 2-9 show historic photos of Aliso Creek and Lagoon circa 1920-1940 and illustrate some of the development of the area. Figure 2-5 is looking north and shows the Old Coast Road in the 1923 photo (top), which later became Coast Highway and crossed over the lagoon mouth, as shown in the 1935 photo (bottom). Historic photos indicate that a bridge was present across Aliso Creek upstream of the current Aliso Creek Coast Highway Bridge (Coast Highway Bridge) before the Coast Highway bridge was constructed (Figure 2-9). The Coast Highway bridge was constructed in 1926 with a center arch and two half-arches at the ends of the bridge (Figure 2-6). As-built bridge plans from 1932 (California Department of Transportation [Caltrans], see Appendix A) indicate that the Aliso Creek Bridge was widened in 1932. The plans show that new bulkheads (walls) and other bridge-support structures were constructed on both sides of the prior bridge, with the new bulkheads at different angles than the existing bulkheads, which therefore changed the orientation of the prior bridge. The new bulkheads closed off the two half-arches, leaving only a center arch. The Aliso Creek Bridge fixed the location of the lagoon inlet, which likely meandered previously. Figures 2-7 and 2-8 show the Aliso Beach Campground and the mouth of the lagoon, which is closed to the ocean in all of the photos. Figure 2-9 shows a view of the creek from further up in the canyon. The top photo is looking east into the canyon, while the bottom photo is looking west toward the lagoon and ocean.

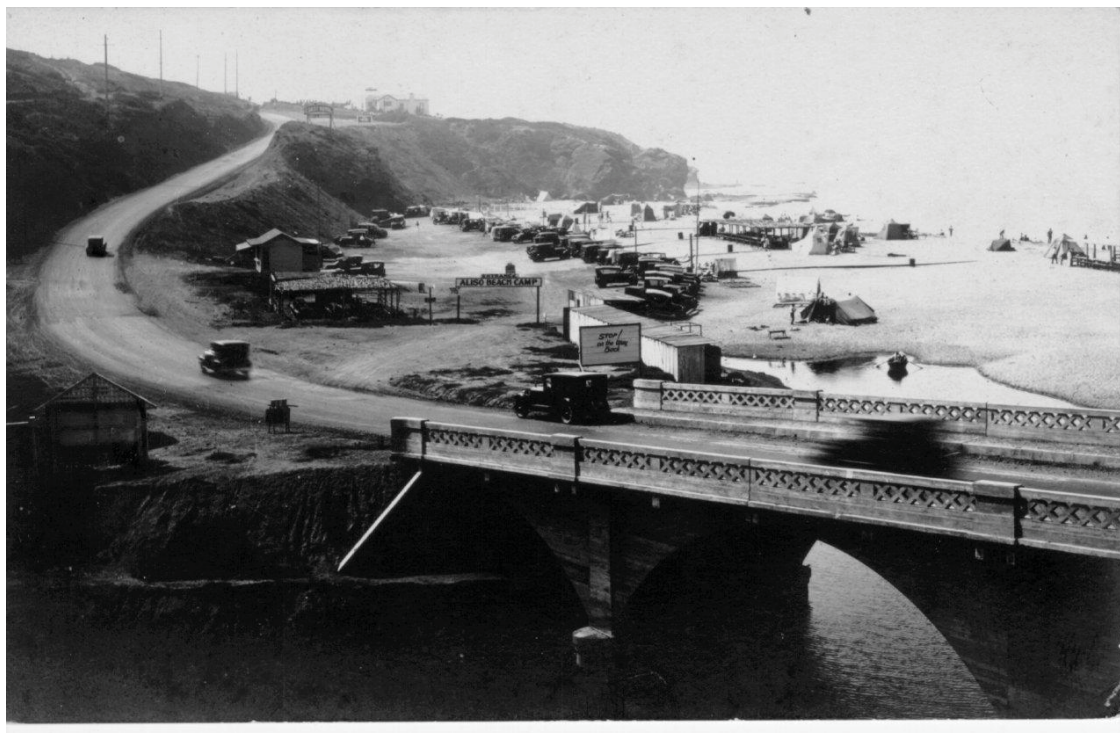
Approximately 30 major bridges have been constructed across the creek. Additionally, the development of the watershed starting in the 1960s increased runoff to the creek and peak flows, which has caused creek incision. The construction of the beach overflow parking lot on the south side of the lagoon has reduced the size of the lagoon from its much larger, historic extent. As a result of these changes, the historic Aliso Creek Estuary habitats have been largely lost, leaving only a channelized creek channel with steep banks that are dominated by non-native vegetation and whose natural hydrology is modified.



Source: Laguna Beach Historical Society

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-5
Aliso Beach 1923 and 1935



Source: Laguna Beach Historical Society

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-6
Aliso Creek Bridge



Source: Laguna Beach Historical Society

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-7
Aliso Beach



Source: Laguna Beach Historical Society

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-8
Aliso Beach



Source: Laguna Beach Historical Society

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-9
Aliso Beach Canyon

2.2 Land Use

2.2.1 Existing Land Use

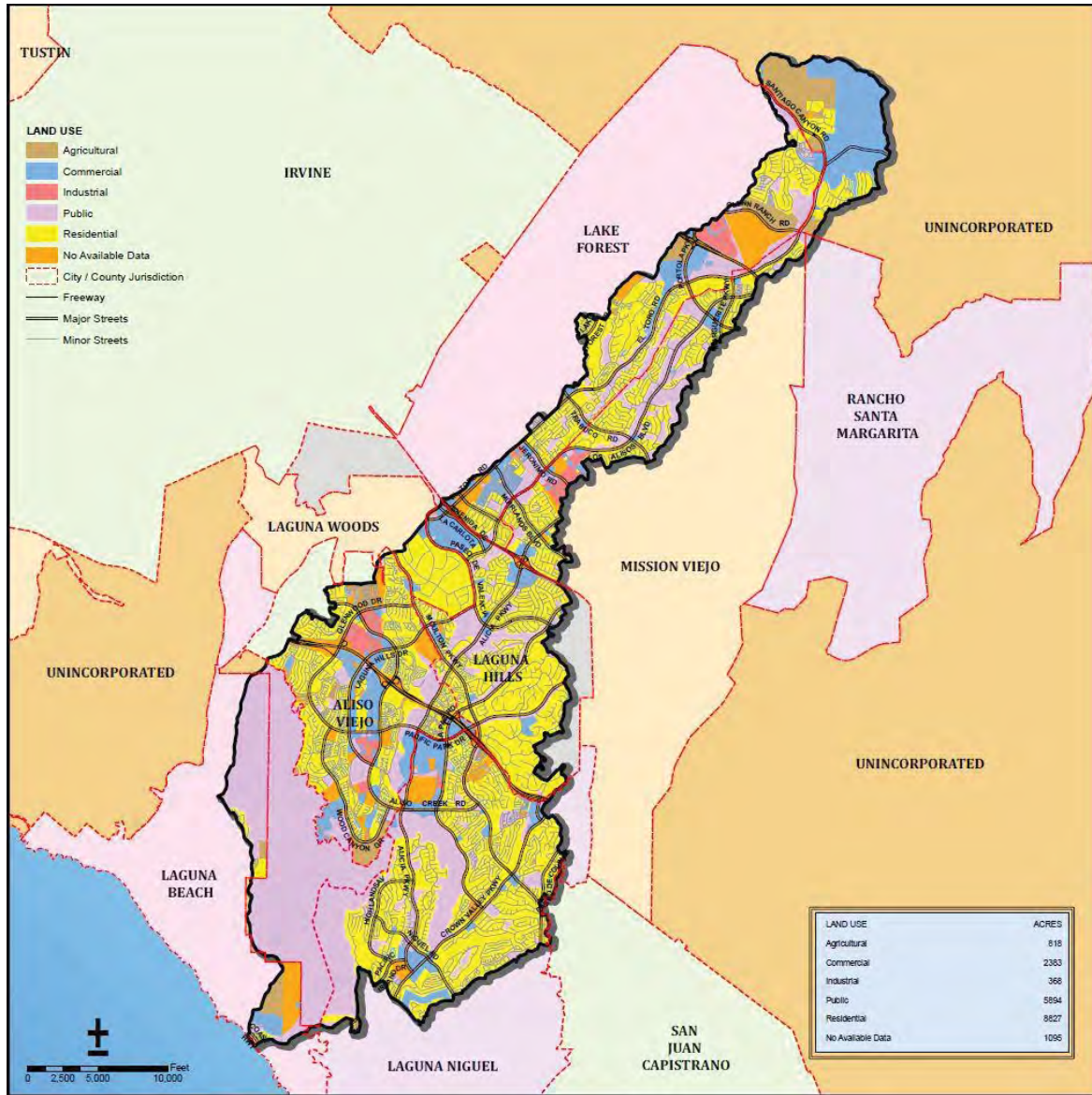
The Aliso Creek Watershed is mostly dominated by urban land use and is primarily a mix of residential, public, and commercial zoning with the remaining undeveloped land area comprised of National Forest and Community Wilderness Park (**Figure 2-10**). **Table 2-1** illustrates that as of 2009 just under 90% of the watershed was comprised of residential, (45.5%), public facilities (30.4%), and commercial (12.3%) land use.

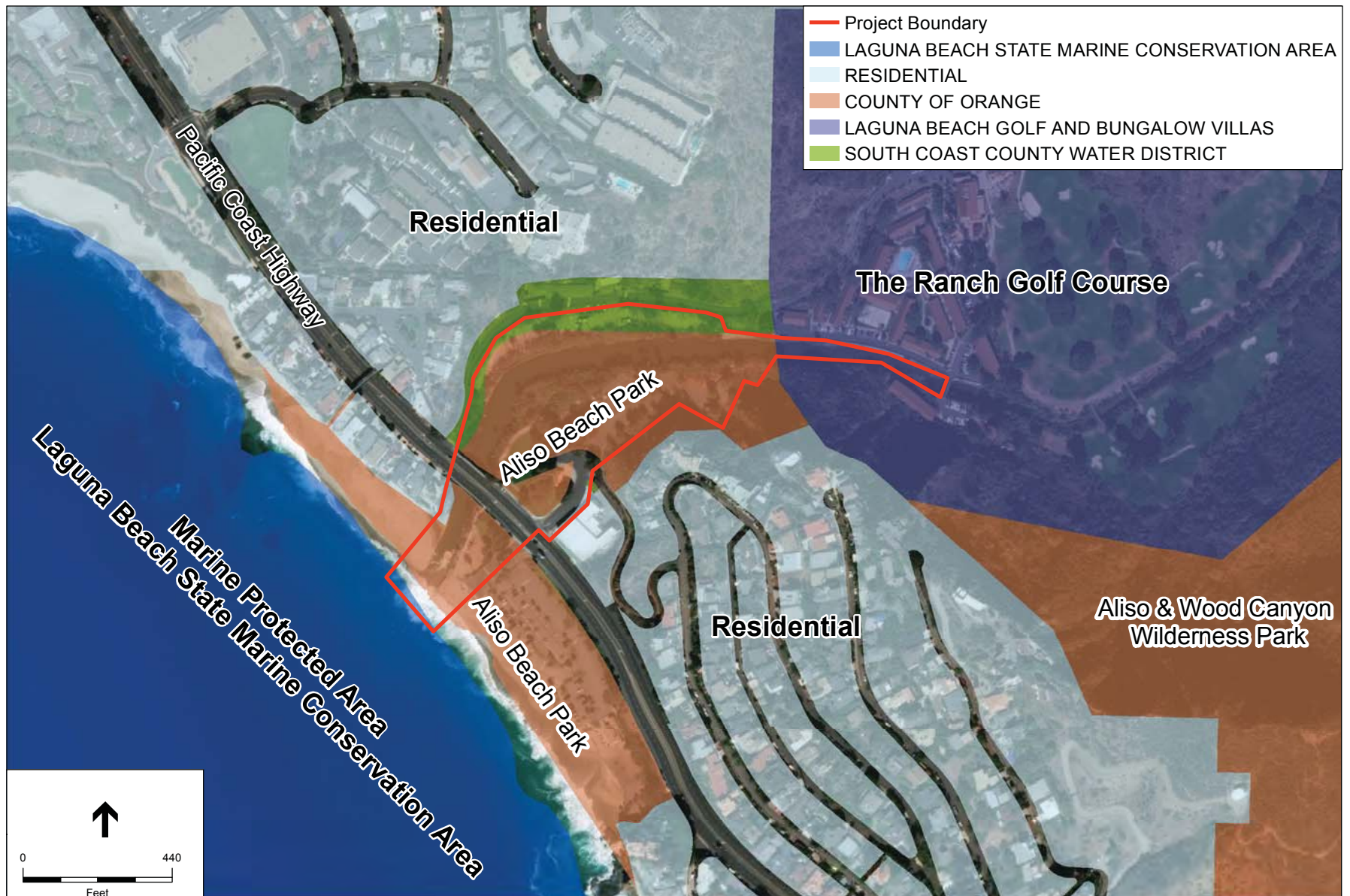
TABLE 2-1
LAND USE IN THE ALISO CREEK WATERSHED

Land Use	Area (acres)	Percent (%)
Agriculture	818	4.3
Commercial	2,383	12.3
Industrial	368	1.9
Public	5,894	30.4
Residential	8,827	45.5
No Data	1,095	5.6
Total	19,395	100

SOURCE: OCPW (2009)

Most of the project site is included in the Aliso Beach County Park (Figure 2-11), with the Park's overflow parking lot and grass area along the south bank (Figure 2-2). A dirt lot is located along the north bank and is planned for use as a construction staging area, after which it may be available for restoration. The Ranch at Laguna Beach Hotel and Ben Brown's Golf Course are along the north bank and extend across to the south bank at the upstream end of the project area. Upstream of the golf course, Aliso Creek runs through the approximately 4,500-acre Aliso and Woods Canyon Wilderness Park, which extends along the southern hillside. Residential development is located along the coast north and south of the site.





SOURCE: ESRI

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-11
Land Use Map

2.2.2 General Plan Policies

The City of Laguna Beach's General Plan Open Space and Conservation Element includes land use and conservation policies that relate to protection and restoration of Aliso Creek. These policies were provided by the LOF and demonstrate the project's consistency with local policy.

- *Watershed Protection and Restoration* – Promote the protection and restoration of offshore, coastal, lake, stream or wetland waters and habitats and preserve them to the maximum extent practicable in their natural state. (Policy 4I)
- Promote the preservation and restoration of Laguna's natural drainage channels, freshwater streams, lakes and marshes to protect wildlife habitat and to maintain watershed, groundwater and scenic open space. (Policy 9A)
- Where possible, require restoration of deteriorated significant natural drainage courses that have been disturbed by development, but which retain potential for natural function. (Policy 9F)
- Develop standards for maintenance of free and adequate flow in natural drainage channels. (Policy 9G)
- Coordinate, wherever possible, natural and man-made drainage structures so that natural channels will contribute to transport a volume of runoff equal (or as close as possible) to that which would have occurred if the watershed were in its natural condition before development. (Policy 9H)
- Promote preservation and enhancement of the natural drainage of Laguna Beach. (Policy 9K)
- Restore and retain **Aliso Creek** in a natural state and protect the Creek from infringement of new development. (Policy 9T)
- Protect **Aliso Creek** Area from any increase in flow which might have adverse impacts on the water quality in Aliso Creek and prevent excessive erosion and sedimentation and emphasize the prevention of siltation from adversely impacting the South Laguna Marine Life Refuge. (Policy 9U)
- Actively work with the County on approval of Aliso Viejo Drainage Plan to ensure the integrity of water quality in **Aliso Creek**. (Policy 9V)

2.3 Infrastructure

2.3.1 Creek Infrastructure

There is a rock jetty along the south side of the creek channel west of Coast Highway. Both sides of the creek are armored immediately upstream of the Coast Highway bridge. The existing north creek bank east of the Coast Highway is armored in places; however, some of the armoring is old and deteriorating. Armoring is not visible for most of the south bank and portions of the north bank; however, older armoring that is overgrown with vegetation has been observed in some locations on the south and north bank when the lagoon drains out and water levels are low. Older armoring that is overgrown may therefore be buried along both creek banks.

Although there are no major flood control structures on Aliso Creek there are 19 drop structures (i.e., grade control structures) upstream of the Estuary. These drop structures serve to mitigate erosion and degradation of the channel that have resulted from increased urbanization and storm runoff in the watershed. Aliso Creek is crossed by approximately 30 major bridges, several of which carry major transportation arteries through the watershed, including California State Route 7, California State Route 241 and Interstate 5 in addition to Coast Highway.

2.3.2 Transportation and the Aliso Creek Bridge

The Aliso Creek Estuary is bordered to the west by the California State Route 1/Pacific Coast Highway (Coast Highway or Highway 1), to the north by Country Club Drive, and to the south by Aliso Way and the beach overflow parking lot operated by OC Parks. Country Club Drive extends from Coast Highway inland to The Ranch property line just north of Aliso Creek, and Aliso Way extends from Highway 1 to the beach overflow parking lot just south of the lagoon.

Coast Highway runs primarily north/south along the California coast and provides a connection between beach communities. Near the creek, the highway is a four lane road and crosses over the creek near the mouth of the lagoon at the Aliso Creek Bridge. The highway supports approximately 36,000 trips daily (County of Orange Transportation Authority 2017).

As discussed in Section 2.1.4.3, the Aliso Creek Bridge was originally constructed in 1926 with a center arch and two half-arches and widened in 1932, which altered the original orientation of the bridge due to the addition of new bulkheads and bridge-support structures. The widening effort closed off the two half-arches (Caltrans 1938). The most recent Aliso Creek Bridge inspection was performed by Caltrans on September 5, 2013. The Aliso Creek bridge received a sufficiency rating of 81.0, which exceeds the upper threshold of bridge sufficiency ratings that qualify for the Highway Bridge Replacement and Rehabilitation Program (HBP, USDOT 1995). Similarly, the 2013 inspection gave the deck, superstructure, and substructure a 7 rating, indicating good condition with some minor problems. The channel and channel protection received a 6 rating, with the Caltrans inspection indicating: "...bank is beginning to slump. River control devices and embankment protection have widespread minor damage. There is minor stream bed movement evident. Debris is restricting the channel slightly (USDOT 1995)." Based on the structure inventory and appraisal report of the 2013 inspection, the bridge is structurally sound and no work recommendations were noted.

2.3.2 Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project

The SCWD operates an Urban Runoff Recovery Unit (Recovery Unit) on Aliso Creek at the CTP as part of the Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project (eGIS 2008b). The Recovery Unit is intended to divert a portion of the dry-weather flow from Aliso Creek for treatment and reuse for CTP operations and/or recycled water supply. The Recovery Unit also provides the capability and benefit of reducing anthropogenic dry-weather flows and pollutants in Aliso Creek and to the estuary and ocean.

The Recovery Unit is capable of diverting 1.23 cfs (800,000 gallons per day) from Aliso Creek; however, the Recovery Unit is not operated during high flows or during very low flows. Current operational plans and regulatory permits allow SCWD to operate the Recovery Unit when the flow in Aliso Creek is between 6 and 20 cfs (eGIS 2008b). Flows above 20 cfs are considered to be high or wet-weather flows, whereas the Recovery Unit is intended for dry-weather flows. The Recovery Unit is not permitted to operate when Aliso Creek flows are below 6 cfs, apparently to maintain low flows below 6 cfs for the purposes of avoiding potential effects to Aliso Creek habitats and ecology (e.g., potentially drawing down creek water levels such that isolated pools form that could potentially leave fish stranded). During recent drought conditions, the dry-weather flow in Aliso Creek has often been less than 6 cfs and the Recovery Unit has not been operated.

2.3.3 Utilities

Several public utilities occur within the Aliso Creek Restoration project area. These include infrastructure from the City of Laguna Beach, the SCWD, SoCal Gas Company, Cox, Frontier, and Southern California Edison.

2.3.3.1 City of Laguna Beach

The North Coast Interceptor (NCI) serves as the primary transmission pipeline to deliver wastewater from the City of Laguna Beach to SOCWA's Coastal Treatment Plant. The city transmits over 2,000,000 gallons a day to the Coastal Treatment Plant. Two lift stations, the Laguna SOCWA Lift Station and the Bluebird SOCWA Lift Station facilitate transport to the Coastal Treatment Plant (**Figure 2-12**).

The existing alignment of the NCI is within the creek for most of its length. Planning is currently underway to move the NCI out of the creek to a new alignment. This project is being done in coordination with the SCWD, and both the NCI and the SCWD force main are expected to be realigned by 2020.

2.3.3.2 SCWD

The SCWD has a 20-inch primary transmission pipeline that delivers wastewater to the Coastal Treatment Plant, which is partially aligned within Aliso Creek (**Figure 2-12**). As mentioned in Section 2.3.3.1, SCWD and the City of Laguna Beach are planning to move the force main and the NCI to a new alignment. The force main is a metal pipeline, which has been found to be adversely affected by soil conditions.

The clear-treated effluent from the Coastal Treatment Plant is discharged into an ocean outfall transmission main that parallels the creek and discharges to the ocean 7,900 feet offshore (**Figure 2-12**).



Note: Outfall Location
is approximate based on
Weston Solutions 2015

SOURCE: ESRI, Orange County, City of Laguna Beach, Weston Solutions 2015

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-12
SOCWA, NCI, and SCWD Mains

2.3.3.3 SOCWA

SOCWA has two wastewater gravity sewer pipes that cross Aliso Creek (Figure 2-12 and 2-13). The pipe that is within the channel upstream of the site in the Aliso and Woods Canyon Wilderness Park has become exposed in recent years due to channel down-cutting, and SOCWA has tentative plans to relocate the pipes north of the creek in the future.

2.3.3.4 SoCal Gas Company

The SoCal Gas Company has a gas line running under Country Club Road to the north of the Creek. A 1 ¼ inch line cuts across the creek at the bridge south of The Ranch at Laguna Beach (Ranch). A 4-inch gas line runs along Coast Highway and crosses the lagoon at the bridge. Another 16-inch gas line runs across the lagoon just upstream of the Coast Highway bridge.

2.3.3.5 Cox

Cox has two 2 inch conduits for fiber cables that cross the creek at the bridge south of the Ranch (Figure 2-14). The conduits may also include fiber for a phone system or other internal connections for the Ranch.

2.3.3.6 Frontier

Frontier owns the property just south of the park and parking lot along the south bank of Aliso Creek near the mouth of the lagoon. The northwest corner of this lot was granted to SCWD in 1981 for construction of a pump station.

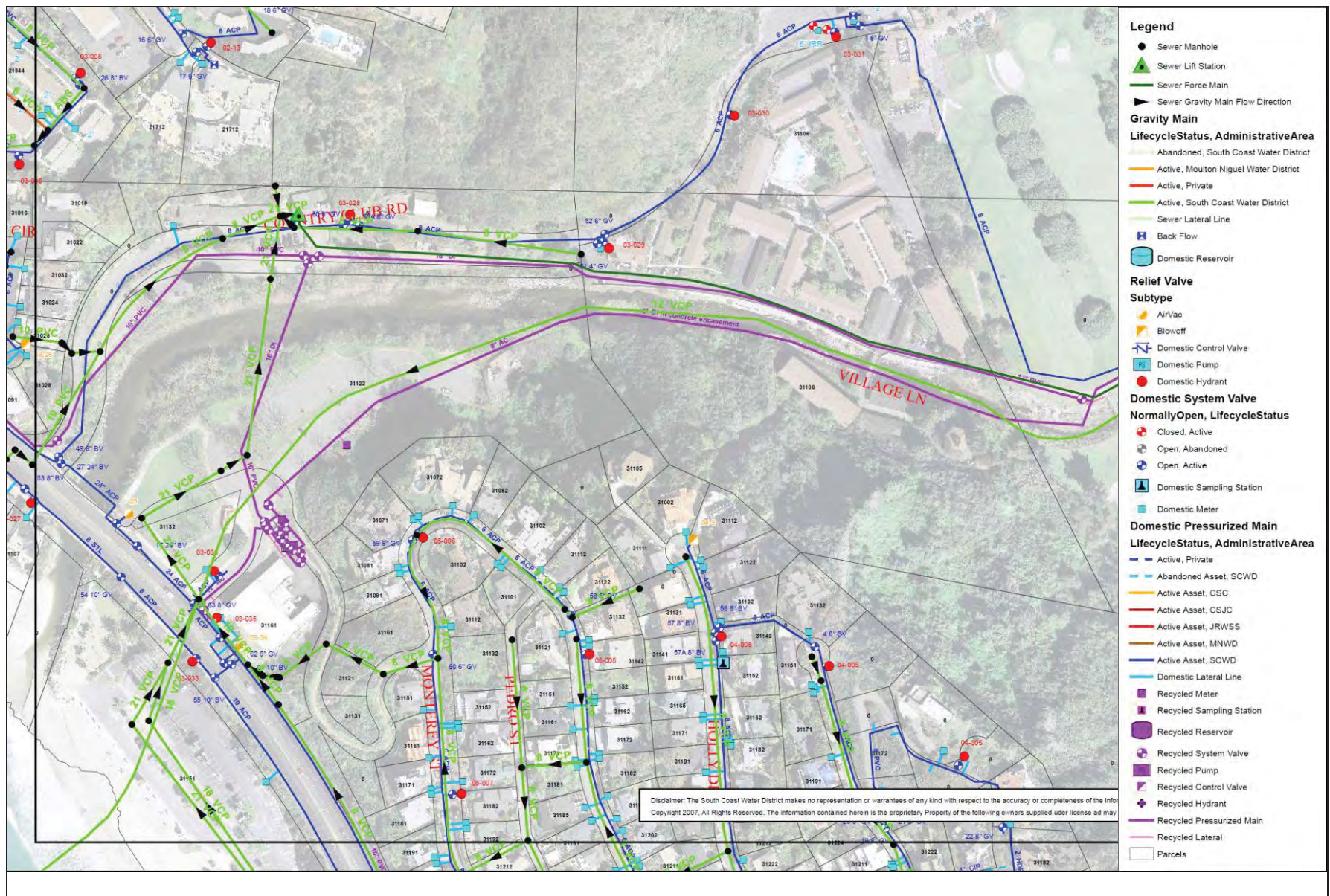
2.4 Physical Setting

2.4.1 Geology and Soils

The project site is near two active faults: The Newport-Inglewood Fault, located offshore, and the Elsinore Fault, located 20 miles northeast of the site. The Newport-Inglewood Fault is thought to have the potential for generating a larger earthquake at the site than the Elsinore Fault.

The bedrock of the San Joaquin Hills is composed of Tertiary-age marine sedimentary rocks. Bedrock in the northeastern portion of the watershed consists of rocks from the Capistrano and Monterey Formations. In the southwestern portion of the watershed, these formations overlie the Topanga Formation and the San Onofre Breccia Formation (Tetra Tech 2010). The bed of Aliso Creek is underlain by Quaternary age unconsolidated alluvial deposits, consisting of hard sandy clay and loose to dense sand and silt (USACE 2009). A map of the existing soils of the site is shown in Figure 2-15.

The Aliso Creek Estuary is confined by San Onofre Breccia bedrock, which limits the scour elevation at the mouth. The San Onofre Breccia deposit is overlaid with fine to coarse sand that increases in compaction with depth (Moffat & Nichol 1994). Figure 2-16 shows the bedrock contours at the Aliso Creek Estuary. The bedrock elevation contours were determined using a high pressure water-jet probe in 1994.

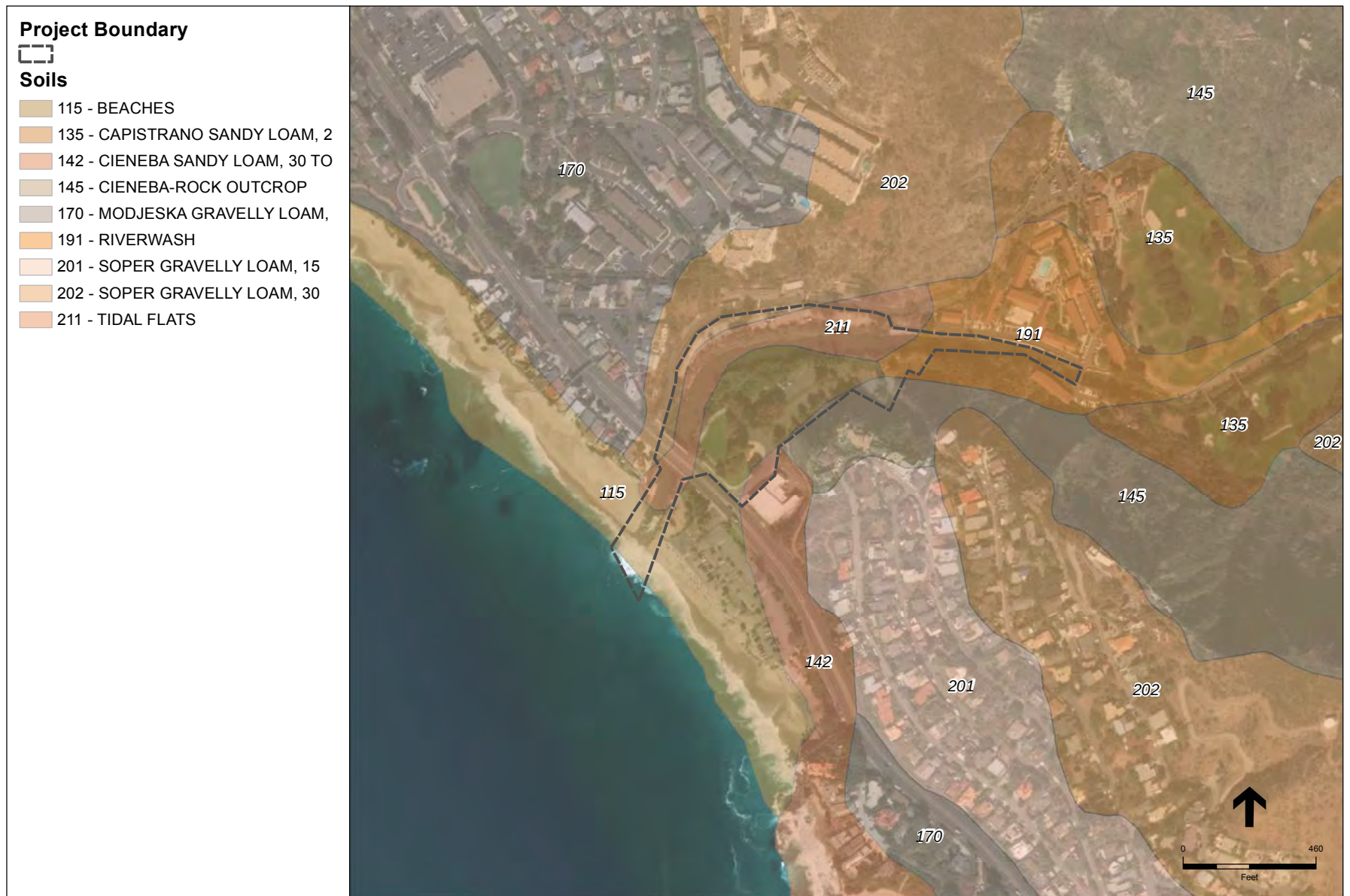


Aliso Creek Estuary Conceptual Restoration Plan . 150108

Source: SCWD

Figure 2-13

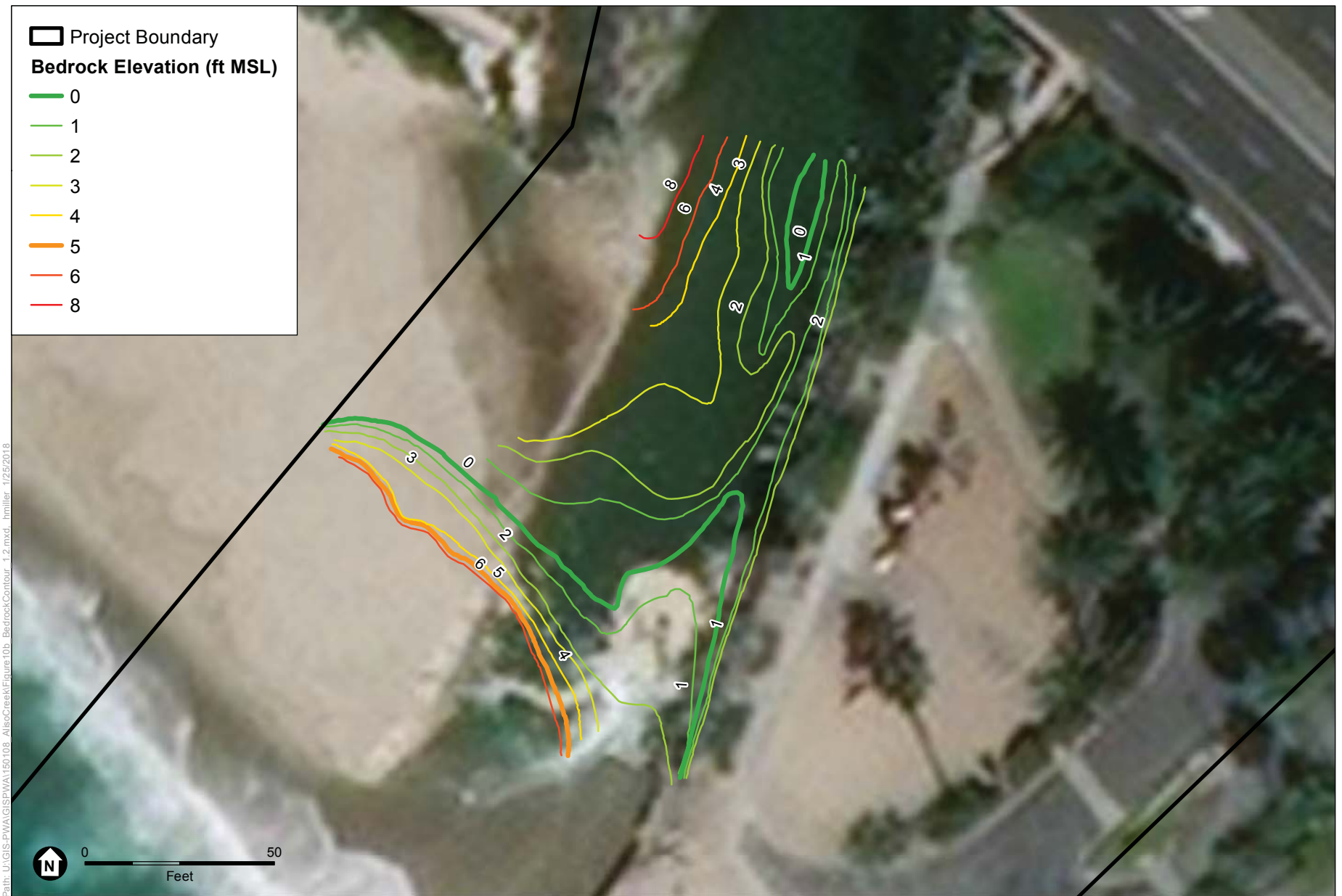
Aliso Creek Composite Utility Map



SOURCE: ESRI, USDA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-15
Soils Map



SOURCE: Moffat and Nichol 1994

NOTE: Bedrock contours shown are in ft MSL, which differ from the vertical datum ft NAVD used throughout the report. The approximate conversion is:
ft NAVD = ft MSL + 2.6.

However MSL is a moving tidal datum and exact conversions were not determined for this report

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-16
Bedrock Contours

2.4.2 Climate

The project site has a Mediterranean climate, characterized as warm, dry summers and mild, wet winters. Average daily temperatures range from lows of 35-48 °F to highs of 80-84 °F. Along the coast, the annual average relative humidity is 71% (County of Orange 2009).

More than 90% of rainfall at the site occurs between November and April. The San Joaquin Hills receive an average annual precipitation of 14 to 18 inches. Annual rainfall totals from 1974 to the present for the County of Orange rainfall station #216 (Laguna Nigel -Sulphur Creek Dam) are presented in **Figure 2-17**.

2.4.3 Topography and Bathymetry

Existing topography at Aliso Creek is available from the California State Coastal Conservancy Coastal LiDAR Project Digital Elevation Model (DEM; **Figure 2-18**; 2009-2011). Aliso Creek bathymetry data collected for the Aliso Creek Conceptual Restoration Plan is included in Appendix B-2.

2.5 Hydrology

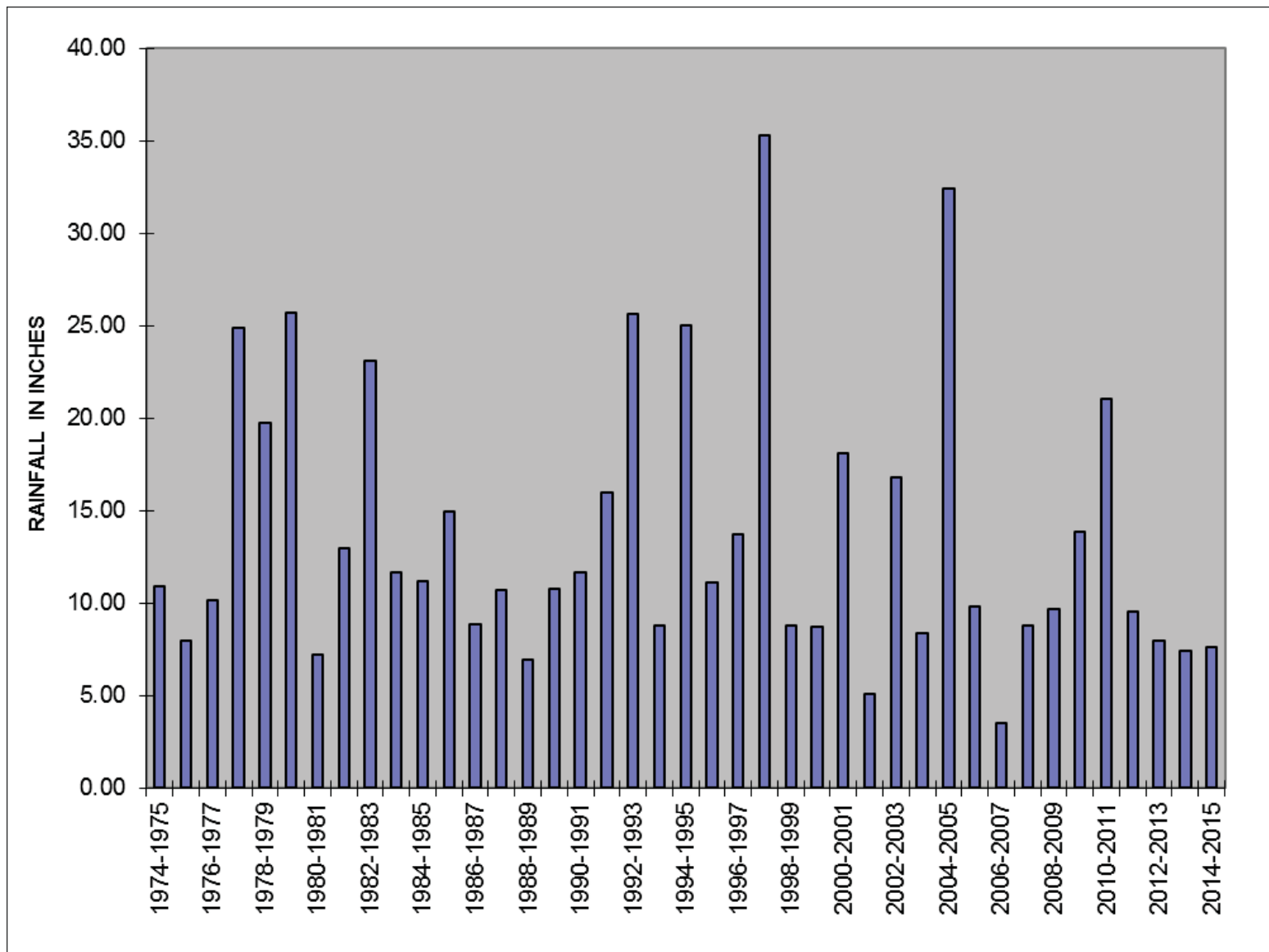
2.5.1 Tides

When the Aliso Creek Estuary is open to the ocean, tides propagate through the mouth of the lagoon back through the channel. The Laguna Beach coast experiences mixed semidiurnal tides, with two high and two low tides of unequal heights each day. In addition, the tides exhibit strong spring-neap tide variability; spring tides exhibit the greatest difference between high and low tides while neap tides show a smaller than average range. The spring-neap tides also vary on an annual cycle, with the highest spring tides occurring in June-July and December-January and the weakest neap tides occurring in March-April and September-October.

2.5.1.1 Tidal Datums

The closest long-term tide gage to Laguna Beach is in Newport Beach. The NOAA tidal datums for the 1983-2001 epoch for the Newport Beach tide gage are summarized in **Table 2-2**. This table also provides a conversion from the older National Geodetic Vertical Datum of 1929 (NGVD) to the current North American Vertical Datum (NAVD). The mean tide range, defined as mean high water (MHW) minus mean low water (MLW) is 3.81 ft, and the diurnal tidal range, defined as mean higher high water (MHHW) minus mean lower low water (MLLW) is 5.49 ft.

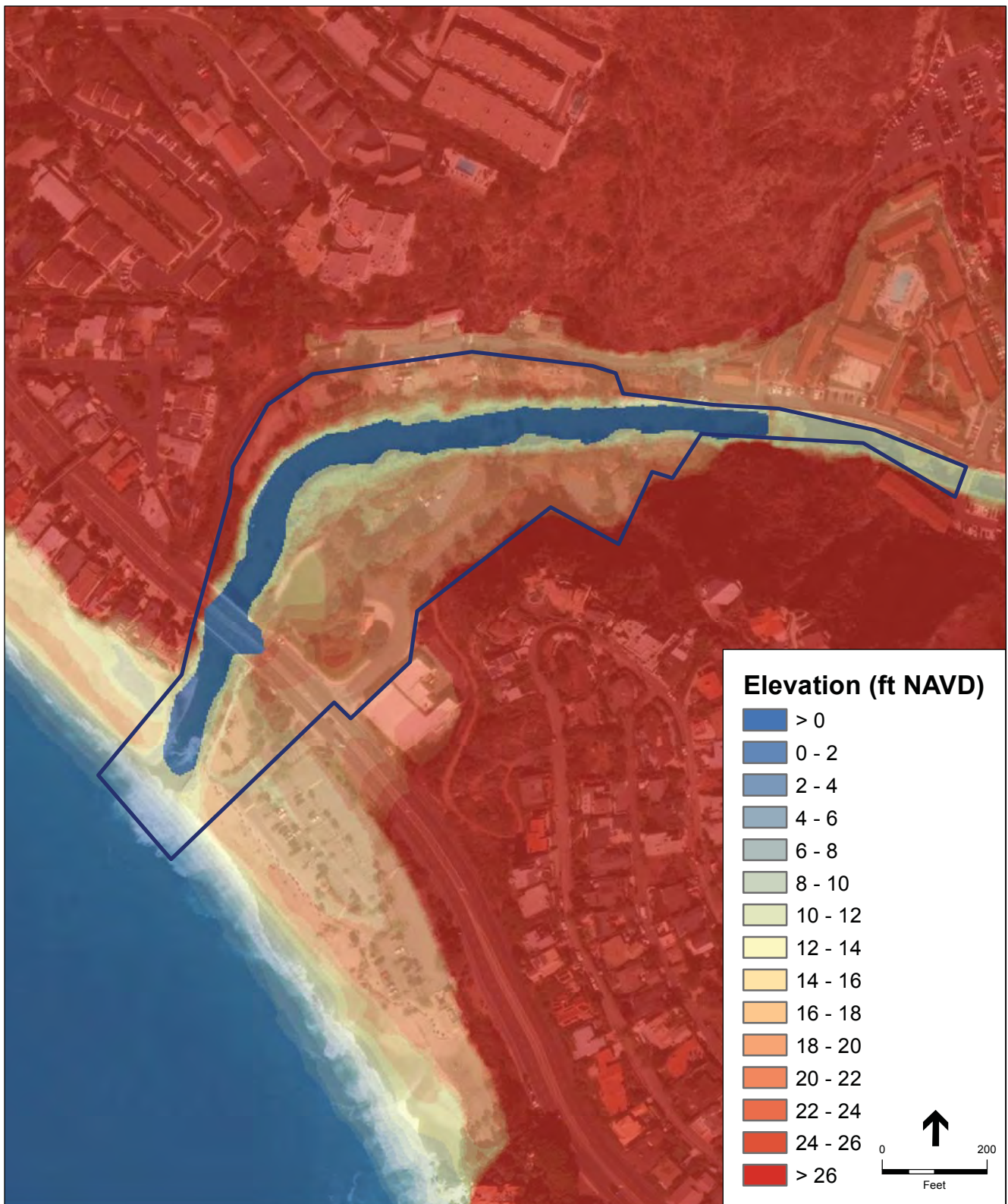
As described above, when the Aliso Creek Estuary is open to the ocean, tides propagate through the mouth of the lagoon back through the channel. However, tides within the Lagoon are usually limited or cut off by the beach berm at the mouth of the lagoon. After the lagoon has been mechanically breached, the resulting straight and deep mouth channel allows tides to partially enter the lagoon. However, even after breaches, low tides are likely cut off by the perched channel bed, so that tides in the lagoon are muted.



Source: OC Watersheds.com, 2015

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Figure 2-17
Orange County Annual Rainfall



Source: CA Coastal Conservancy 2009-2011

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-18
Project Site Topography

In addition to mechanical breaching, the Aliso Creek Estuary experiences unauthorized and smaller-scale breach events by beach users, which can also impact the tide within the lagoon (See Section 2.5.5.1 for discussion on breaching events).

**TABLE 2-2
NEWPORT BEACH TIDAL DATUMS**

Tidal Datum	ft MLLW	ft NAVD
Maximum recorded water level (1/28/1983 8:06)	7.67	7.49
Highest Astronomical Tide (HAT)	7.18	7.00
Mean Higher High Water (MHHW)	6.41	6.23
Mean High Water (MHW)	4.68	4.50
Mean Tide Level (MTL)	2.80	2.62
Mean Sea Level (MSL)	2.78	2.60
Mean Low Water (MLW)	0.92	0.74
North American Vertical Datum of 1988 (NAVD)	0.18	0
Mean Lower Low Water (MLLW)	0	-0.18
Lowest Astronomical Tide (LAT)	-1.92	-2.10
Minimum recorded water level (1/20/1988 16:30)	-2.35	-2.53
NOAA Tides and Currents, 1923-present		

Water level data collected within the Aliso Creek Conceptual Restoration Plan are included in Section 6.

2.5.1.2 Sea Level Rise

Historical trends in relative sea level are measured at tide gages, which capture relative vertical movements of land as well as changes in the global or eustatic sea level. These records measure the local rates of sea level rise relative to the coast. NOAA estimates that relative sea levels have been rising at a rate of 0.88 mm/yr at the Los Angeles tide gage (1924-2006).

The State of California Sea-Level Rise Guidance Document (CO-CAT 2013) provides guidance for California projects on how to use predictions of global sea level rise for long-term planning purposes. The document recommends using the estimates provided by the National Research Council's (NRC) report on *Sea-Level Rise for the Coasts of California, Oregon, and Washington* (2012) as a starting place to select values. These predictions for Los Angeles are:

- 2 to 12" of sea level rise by 2030
- 5 to 24" of sea level rise by 2050
- 17 to 66" of sea level rise by 2100

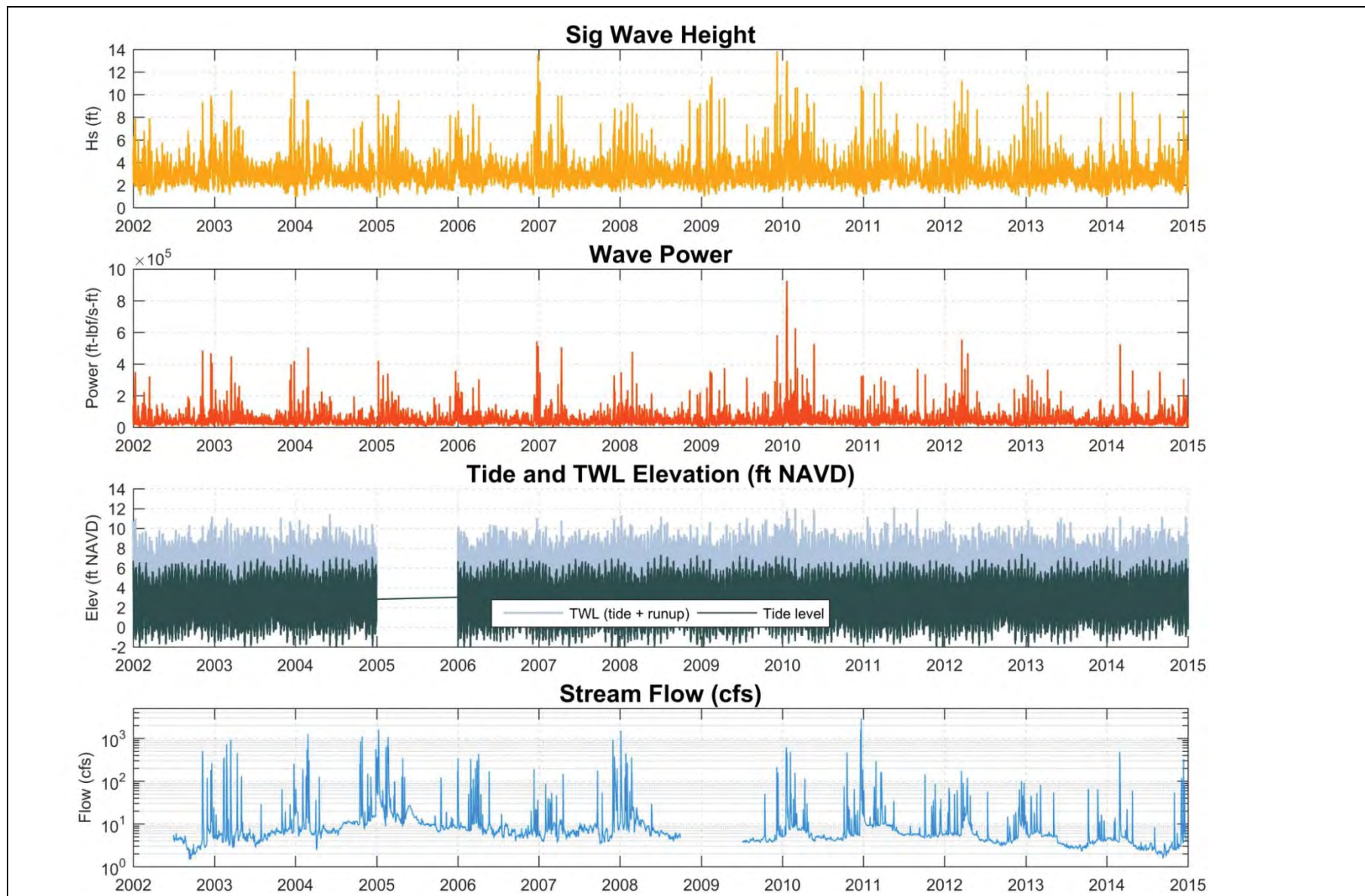
The ranges in sea level rise represent the range in sea level rise for low and high global greenhouse gas emission scenarios (B1 and A1FI) identified by the Intergovernmental Panel on Climate Change (IPCC) (NRC 2012).

2.5.2 Waves

Figure 2-19 summarizes the wave climate, offshore tides, and stream flows to the lagoon. Wave data were collected from the National Data Buoy Center (NDBC) Dana Point buoy (#46223), managed by the Coastal Data Information Program (CDIP). The buoy is located 4 miles south of the site in deep water. Wave data are representative of deepwater conditions, and do not account for the wave refraction and shoaling that alter wave characteristics in the nearshore coastal zone. Wave power and total water level (TWL), taken as the sum of tide levels and wave runup on the beach (ESA 2015), are also shown in Figure 2-19. Wave power is directly related to sediment transport, powering both the shore-parallel littoral drift and cross-shore placement of sand in the mouth of lagoons (ESA 2015). TWL influences beach height and the likelihood of wave overwash spilling into the lagoon.

Given the narrow, incised setting of the Aliso Creek Estuary, the tidal prism of the site is small, and tides likely play a relatively small role on the lagoon hydrology and mouth morphology. The tidal prism is especially small compared with those of sites to the south such as Los Peñasquitos and San Dieguito lagoons, which have different geological settings that have allowed for greater space to accommodate tides (Jacobs et al. 2010). Tides in these larger sites have a significant influence on mouth morphology.

The Aliso Creek Estuary is a perched system (see classification of Jacobs et al. 2010) with a heightened beach berm that typically exceeds the high tide level and prevents significant influence of tidal action in the lagoon. Although the mouth of the lagoon is mechanically opened throughout the year, wave action builds up the berm elevation back up near or above high tide by delivering more sand than can be removed by stream input, therefore hydrologically isolating the lagoon from tidal influence. At Aliso Creek, seasonal shifts in the wave climate and stream flow shown in Figure 2-19 likely dominate the hydrology of the lagoon, and thus the state of the mouth. Waves are generally weakest in the summer months, whereas stream flows are low for a longer period, typically below 5 cfs from May through mid-October (Figure 2-19). However, wave overwash over the berm into the lagoon during the winter months may be an important source of water to the lagoon. The Aliso Creek mouth inlet is discussed further in Section 2.5.5.



NOTE: Wave data from CDIP Dana Pt Buoy. Stream flow data provided by County.

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-19

Time series of environmental forcing conditions at Aliso Creek lagoon

2.5.3 Stream Flows

2.5.3.1 Historic and Current Flow Data

Historically the United States Geological Survey (USGS) has operated two stream gage stations on Aliso Creek, USGS Station 11047700 and USGS Station 11047500. Station 11047700 was located on Lower Aliso Creek approximately 0.3 miles upstream of Coast Highway and was in operation between 1982 and 1987, and Station 11047500, which was operated by the USGS for the period of 1930 to 1980 is now operated by the Orange County Watersheds Program (OCWP), as OC #4. The OCWP also operated a gage (OC #1146) in the lower Aliso Creek reach at the South Orange County Watershed Authority (SOCWA) treatment plant approximately 1.2 miles upstream of the Pacific Ocean. **Table 2-3** provides a brief description of each gage and **Figure 2-20** provides a map showing the location of each gage.

TABLE 2-3
ALISO CREEK STREAM GAGES

Gage ID	Gage Name	Drainage Area (mi ²)	Period of Record
USGS 11047500	Aliso Creek at El Toro (Jeronimo Road)	7.9	1930-1980
USGS 11047700	Aliso Creek at South Laguna (Lower Aliso Creek)	34.4	1982-1987
OC #4	Aliso Creek at Jeronimo Road	8.1	1980-present
OC #1146	Lower Aliso Creek at Treatment Plant	30.4	2002-present

SOURCE: USACE (2010)

The stream gage at Jeronimo Road is located approximately 300 feet upstream of Jeronimo Road; the USGS gage at El Toro was located adjacent to Second Street, approximately 800 feet upstream of Jeronimo Road. Due to the similar location of these two gages, their records can be considered as a single continuous record for the purpose of a historic flood record and low flow conditions analysis. The relatively short period of record of the USGS gage at South Laguna and the County of Orange gage at the SOCWA treatment plant limits the gages' usefulness for considering the long-term flood and long-term low flow record in the creek. **Table 2-4** provides the annual peak flow and the annual total runoff volume for each water year since 1932 from a prior analysis of the historical flood record and changes in low flow conditions for flows measured upstream of Jeronimo Road (USACE 2010). Major flood events, defined for comparison purposes as floods having peak flows of at least 1,500 cfs, are identified in Table 2-4 in bold text.

Trends in the data show an increase in annual runoff volume within the Aliso Creek watershed, especially in the mid-1970s. Prior to 1978, the annual runoff volume exceeded 650 acre-feet only six of the 46 years of record (13%). Since 1978, the annual runoff volume has exceeded 650 acre-feet in every year. The magnitude of peak flows has also increased since 1978. Prior to 1978, the magnitude of the annual peak flow exceeded 1,500 cfs only twice, whereas since 1987, nine years have had peak flows in excess of 1,500 cfs.

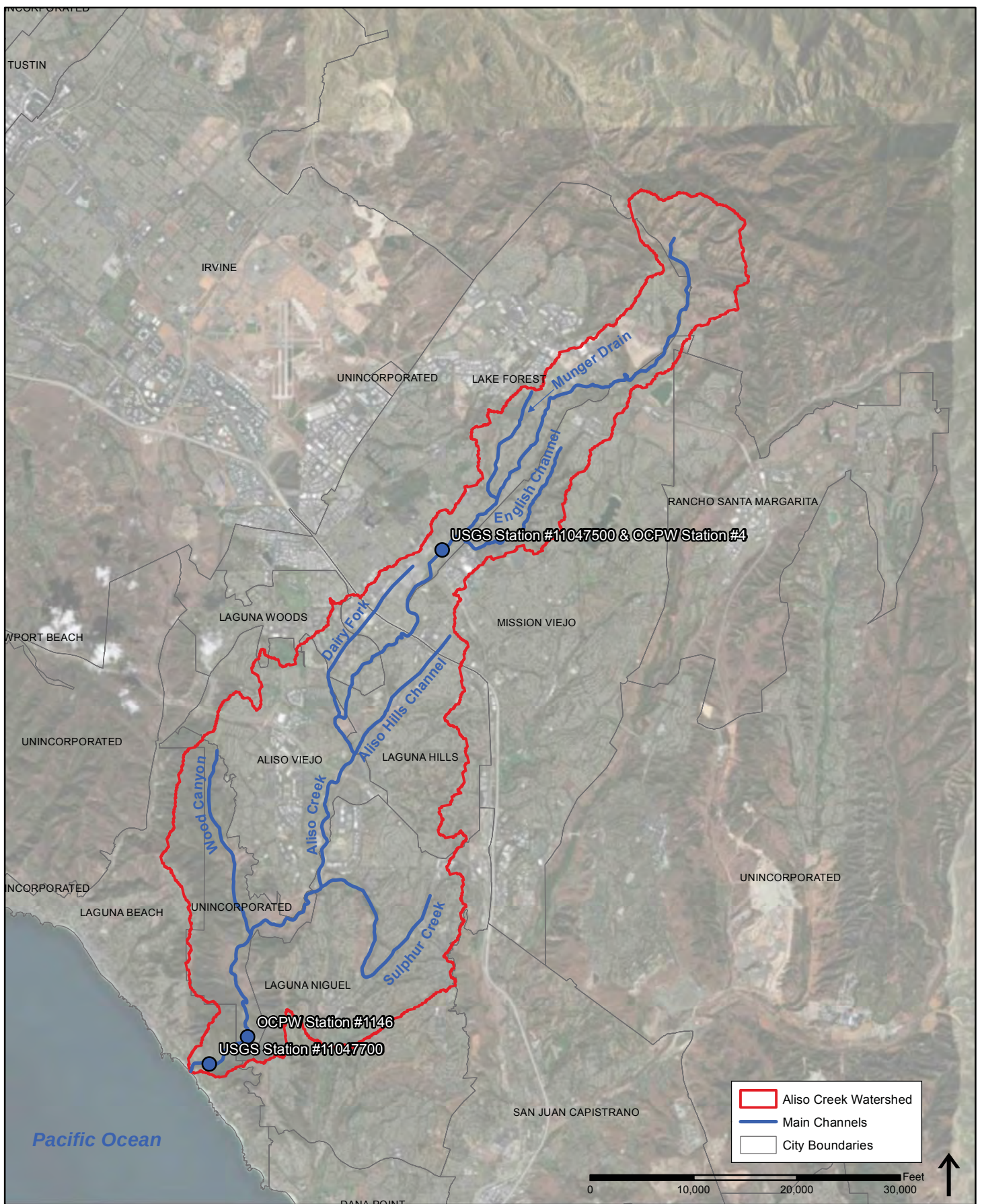


TABLE 2-4
ALISO CREEK ANNUAL PEAK FLOW AND ANNUAL RUNOFF VOLUME

Water Year	Peak Flow(cfs)	Annual Runoff Volume (ac-ft)	Water Year	Peak Flow(cfs)	Annual Runoff Volume (ac-ft)	Water Year	Peak Flow(cfs)	Annual Runoff Volume (ac-ft)
1932	508	558	1958	964	1,380	1984	519	1,310
1933	352	165	1959	2	2	1985	442	1,530
1934	494	155	1960	32	13	1986	508	1,950
1935	1,240	633	1961	0	0	1987	190	372
1936	1,420	353	1962	73	177	1988	321	1,910
1937	1,950	618	1963	88	62	1989	315	2,780
1938	1,280	1,610	1964	67	24	1990	260	1,060
1939	231	386	1965	81	391	1991	610	1,290
1940	547	301	1966	277	404	1992	3,000	2,290
1941	632	2,550	1967	333	571	1993	2,090	7,150
1942	20	28	1968	35	174	1994	459	1,360
1943	943	1,910	1969	2,500	4,320	1995	2,120	5,340
1944	879	613	1970	95	49	1996	387	1,750
1945	678	365	1971	35	47	1997	1,070	1,760
1946	182	111	1972	81	212	1998	4,500	6,920
1947	90	156	1973	636	508	1999	254	1,490
1948	102	130	1974	223	373	2000	772	2,750
1949	2	1	1975	300	325	2001	572	3,130
1950	85	11	1976	58	54	2002	254	1,160
1951	0	0	1977	57	200	2003	1,690	3,280
1952	950	1,520	1978	324	1,270	2004	330	1,620 ¹
1953	133	45	1979	245	1,870	2005	2,470	8,020
1954	122	79	1980	2,100	6,420	2006	934	1,600
1955	15	6	1981	225	973	2007	402	1,150
1956	505	425	1982	161	1,040	2008	1,580	2,180
1957	2	1	1983	1,670	2,980	2009	909	1,628 ¹

NOTE: Bold Text indicates flood events with peak flows of at least 1,500 cfs.

¹ denotes partial annual volume

Source: USACE (2010)

The trend in low-flow conditions is also illustrated in the plot of cumulative annual flow volume shown in **Figure 2-21** below. The major storm events from Table 2-4 are labeled in Figure 2-21, which cause steep increases in the cumulative flow plot. Between these major storm events, the slope of the cumulative flow plot indicates the average trend in total stream flow, including typical storm flows and base flows. The slope of the cumulative flow plot remains fairly flat from the 1940's through the late 1970's, which is indicative of little or no flow due to watershed and climatic conditions (e.g., pre-urban development and drought). In the late 1970's the slope becomes noticeably steeper, indicating an increase in low-flows from the earlier time period. This corresponds to years of increased urbanization in the Aliso Creek watershed. **Figure 2-22** further illustrates the change in low-flow conditions. Figure 2-22 shows both the low flows (i.e., flows less than 5 cfs) and changes in average dry-weather flows from 1930-2014 at the Jeronmio street gage. Average dry-weather flows were calculated using streamflow data for June-September of each year. From 1930 until around 1970, the low flow is approximately 0 cfs, indicative of little to no flow. Starting in the 1970s, the average-low flow increased and has been approximately 1 cfs since the early 2000s (Figure 2-22).

Mean monthly flow data from 1930 to 1980 is presented for the USGS #11047500 gage at Jeronimo Road in **Figure 2-23**. Prior to the 1970s, many years had months where there was little to no mean monthly flow. Although there was a gap in data collection between 1978 and 2002, the increase in low flow can be seen from data collected over the past 12 years. Data from the same gage, now operated by OCWP (Station #4), shows that over the past 12 years, mean monthly flows exceed zero in every month (**Figure 2-24**). As the watershed has developed and become more urbanized, flows in the creek have become more consistent. The creek's steady baseflow is likely from irrigation throughout the watershed increasing the water available to infiltrate into subsurface and emerge as baseflow in the creek (USACE 2009).

Although the period of record is much shorter for the gaging stations in the lower reach of Aliso Creek, the same trends in increased low-flows is evident. At USGS gage #11047700 the mean monthly flows exceeded zero in every month over the five-year period of record from 1982 through 1987 (**Figure 2-25**). The same holds true for the OCWP gauging station at the Coastal Treatment Plant, where again, for the entire period of record from 2002-present mean monthly flows in each month always exceeds zero (**Figure 2-26**).

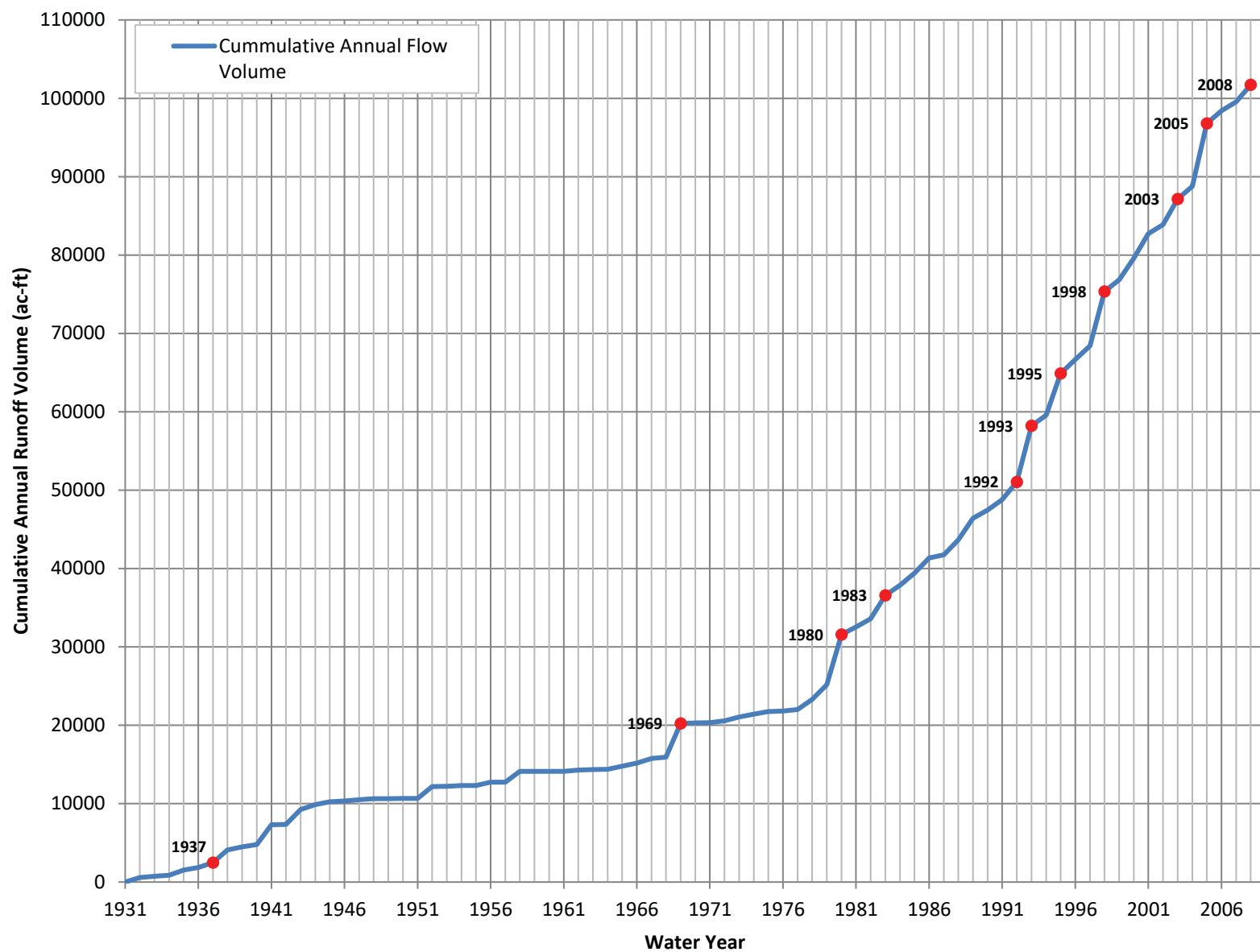
2.5.3.2 Estimated Peak Discharge

In 2010, Tetra Tech Inc. calculated peak discharges throughout the watershed by extrapolation of flood frequency curves plotted at areas of interest. These values compared favorably with the FEMA FIS (1993) and local agency values and are presented for 2-, 5-, 10-, 25-, 50-, 100- and 500-year return periods in **Table 2-5** for select locations.

TABLE 2-5
ALISO CREEK ESTIMATED PEAK DISCHARGE

Location	Drainage Area (mi ²)	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	25-yr (cfs)	50-yr (cfs)	100-yr (cfs)	500-yr (cfs)
Jeronimo Gage	8.6	670	1,300	1,760	2,400	2,820	3,320	4,600
Pacific Coast Highway	34.6	1,620	3,110	4,270	5,390	7,130	8,480	11,500

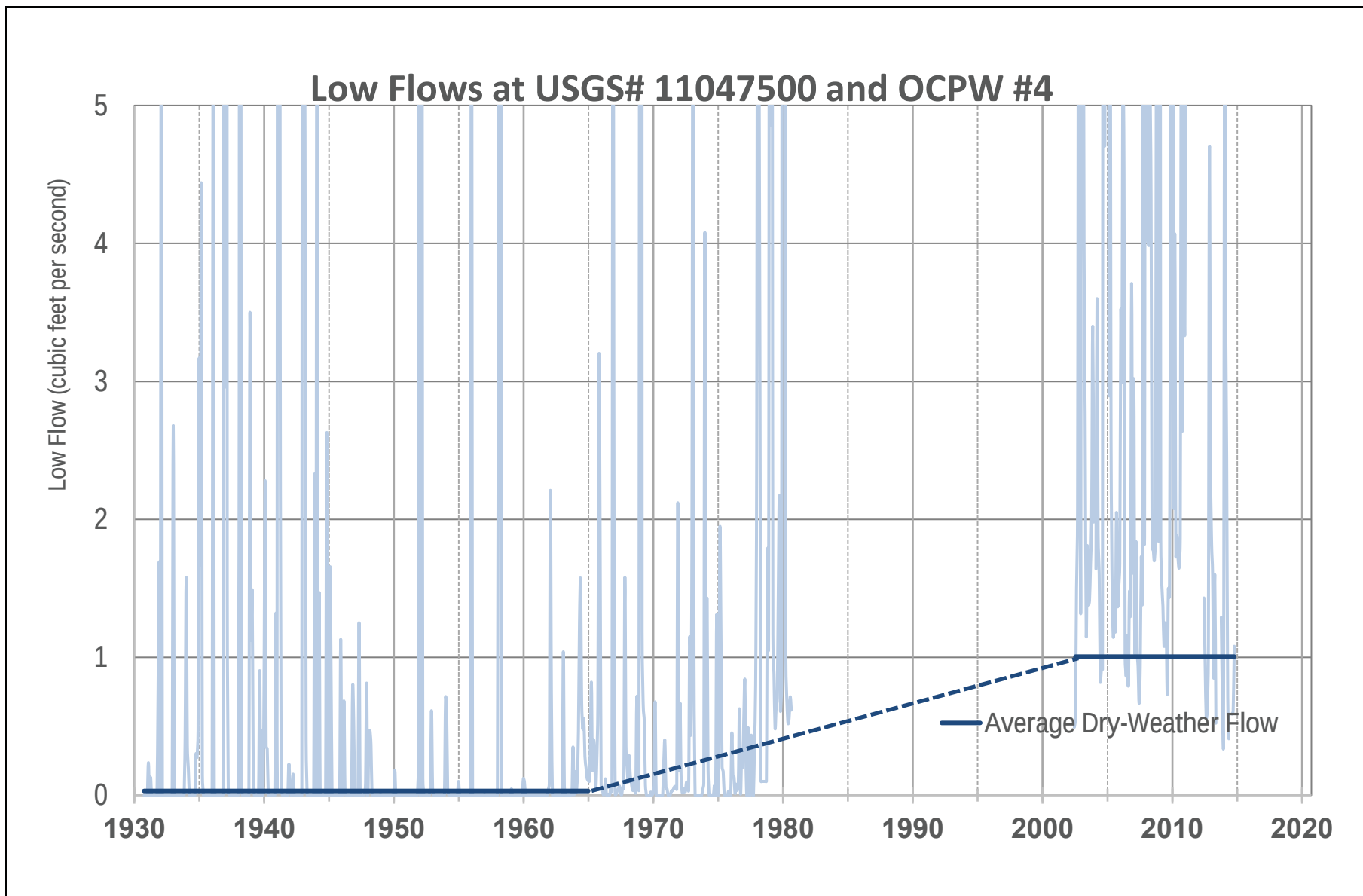
SOURCE: USACE (2010)



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Figure 2-21

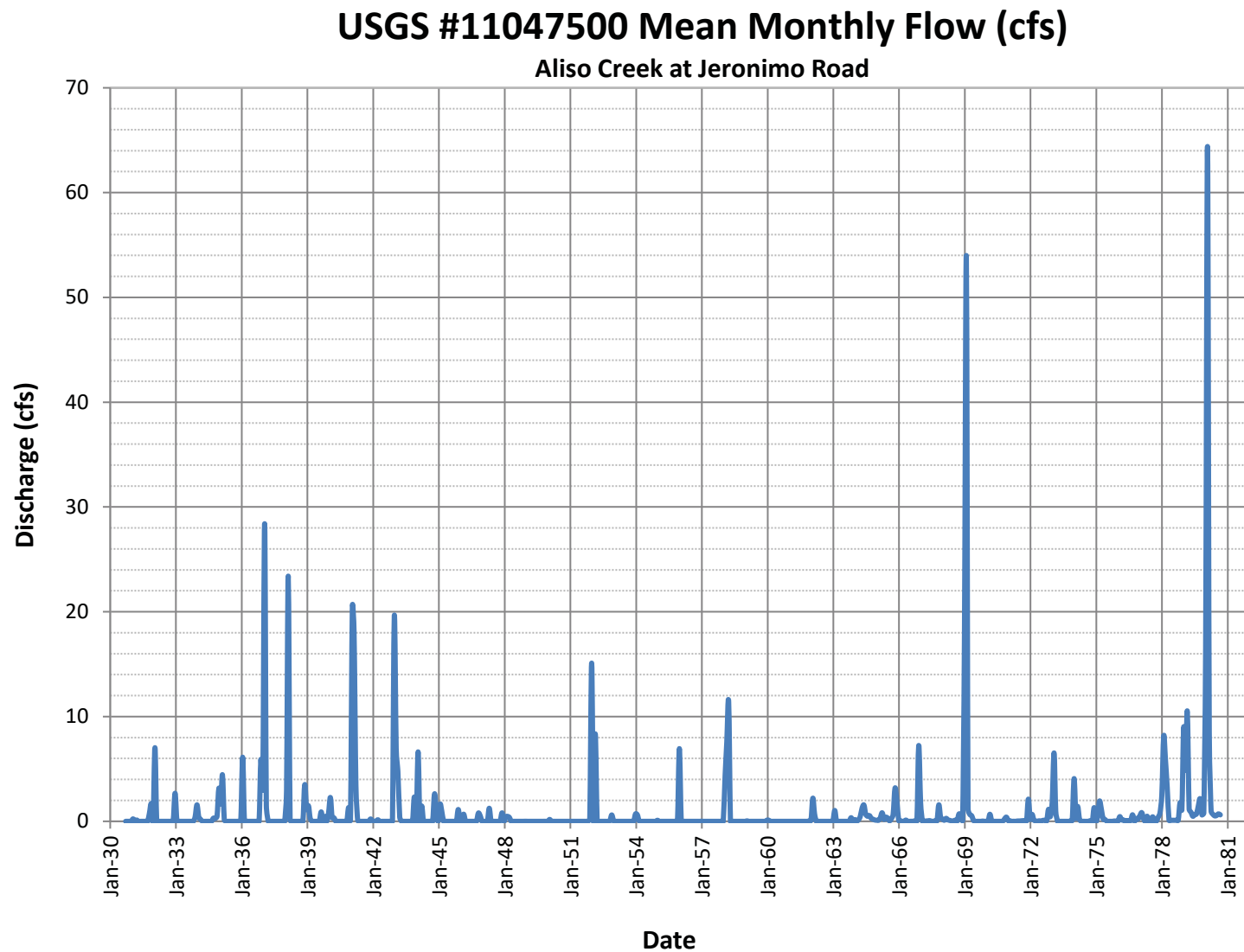
Total Cumulative area-weighted flow volume for Aliso Creek at Jeronimo Road Gauge



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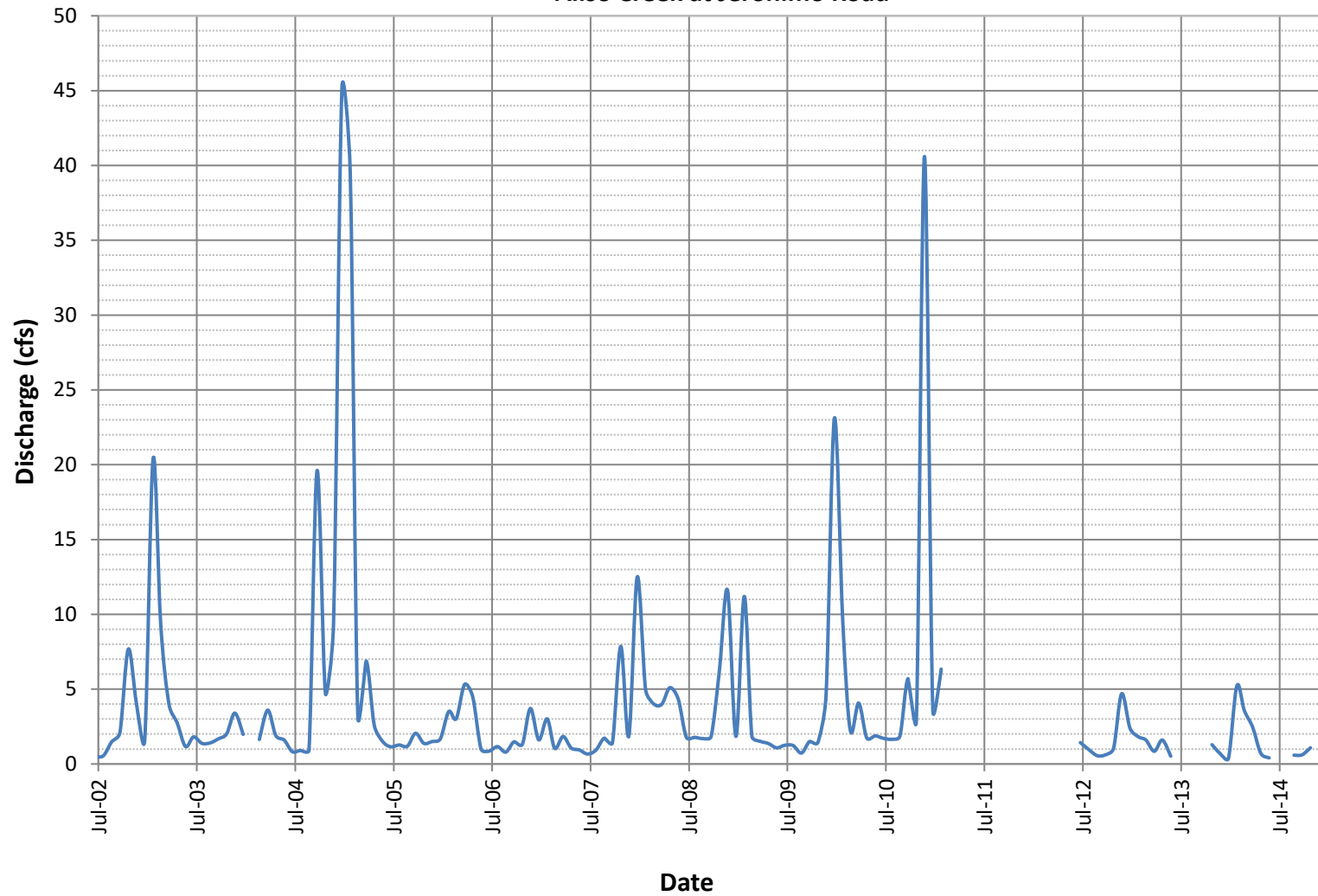
Figure 2-22

Average Dry-Weather Flow (cfs)



Orange County Station #4 Mean Monthly Flow (cfs)

Aliso Creek at Jeronimo Road



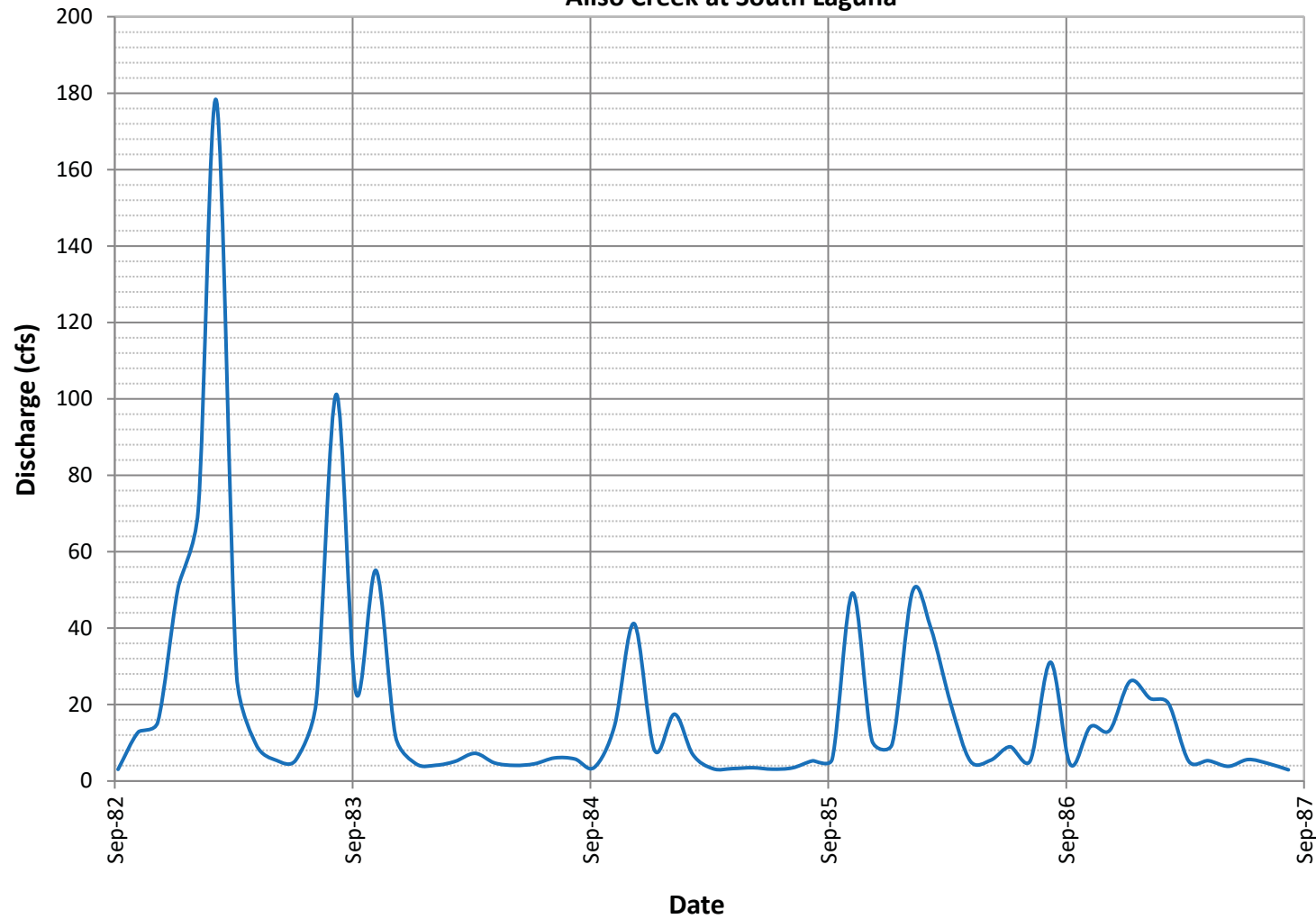
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Figure 2-24

OCPW #4 Mean Monthly Flow (cfs)

USGS #11047700 Mean Monthly Flow (cfs)

Aliso Creek at South Laguna



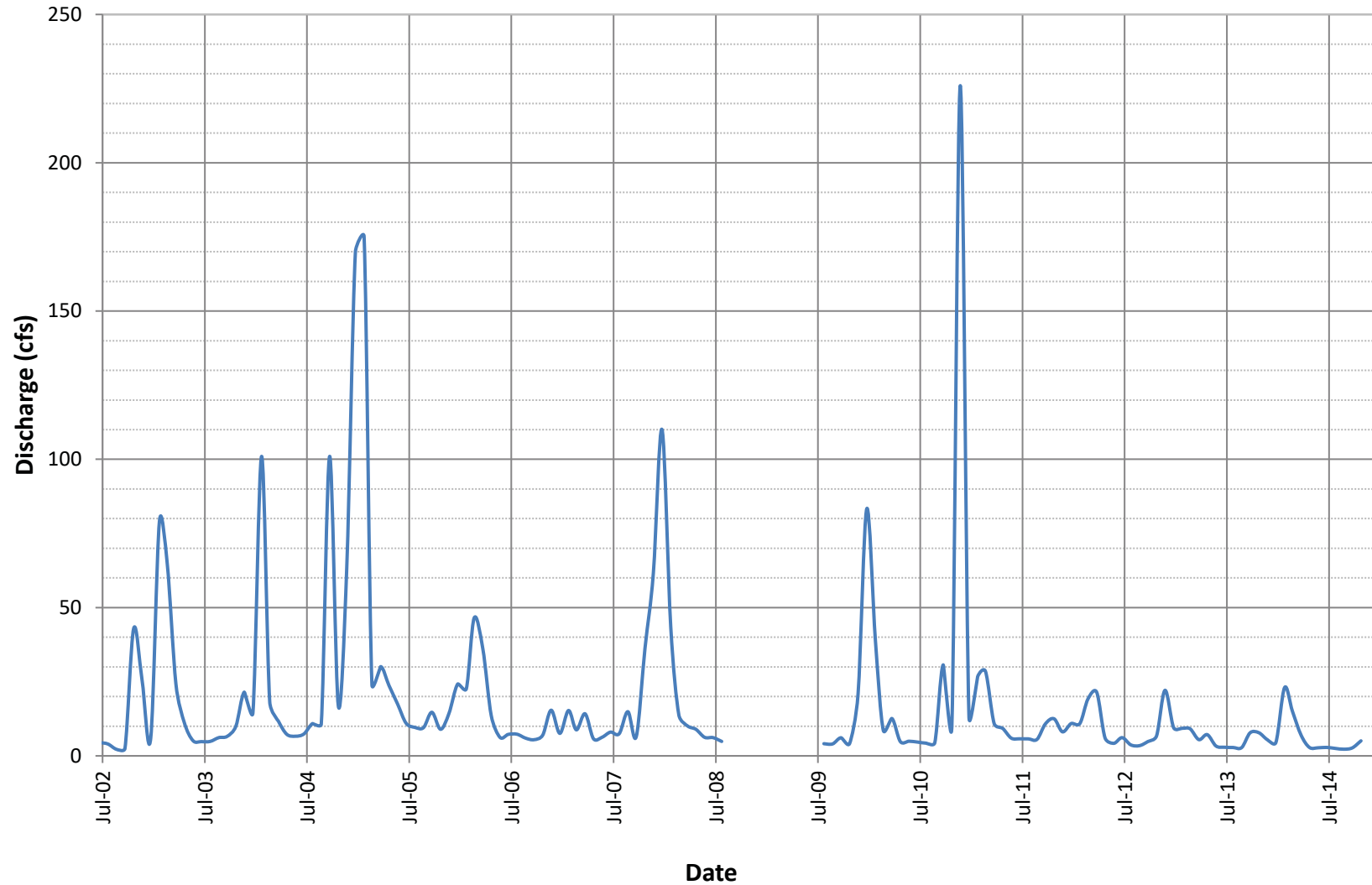
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Figure 2-25

USGS #11047700 Mean Monthly Flow (cfs)

Orange County Station #1146 Mean Monthly Flow (cfs)

Aliso Creek at Treatment Plant



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Figure 2-26

OCWP Station #1146 Mean Monthly Flow (cfs)

2.5.3.3 Flooding

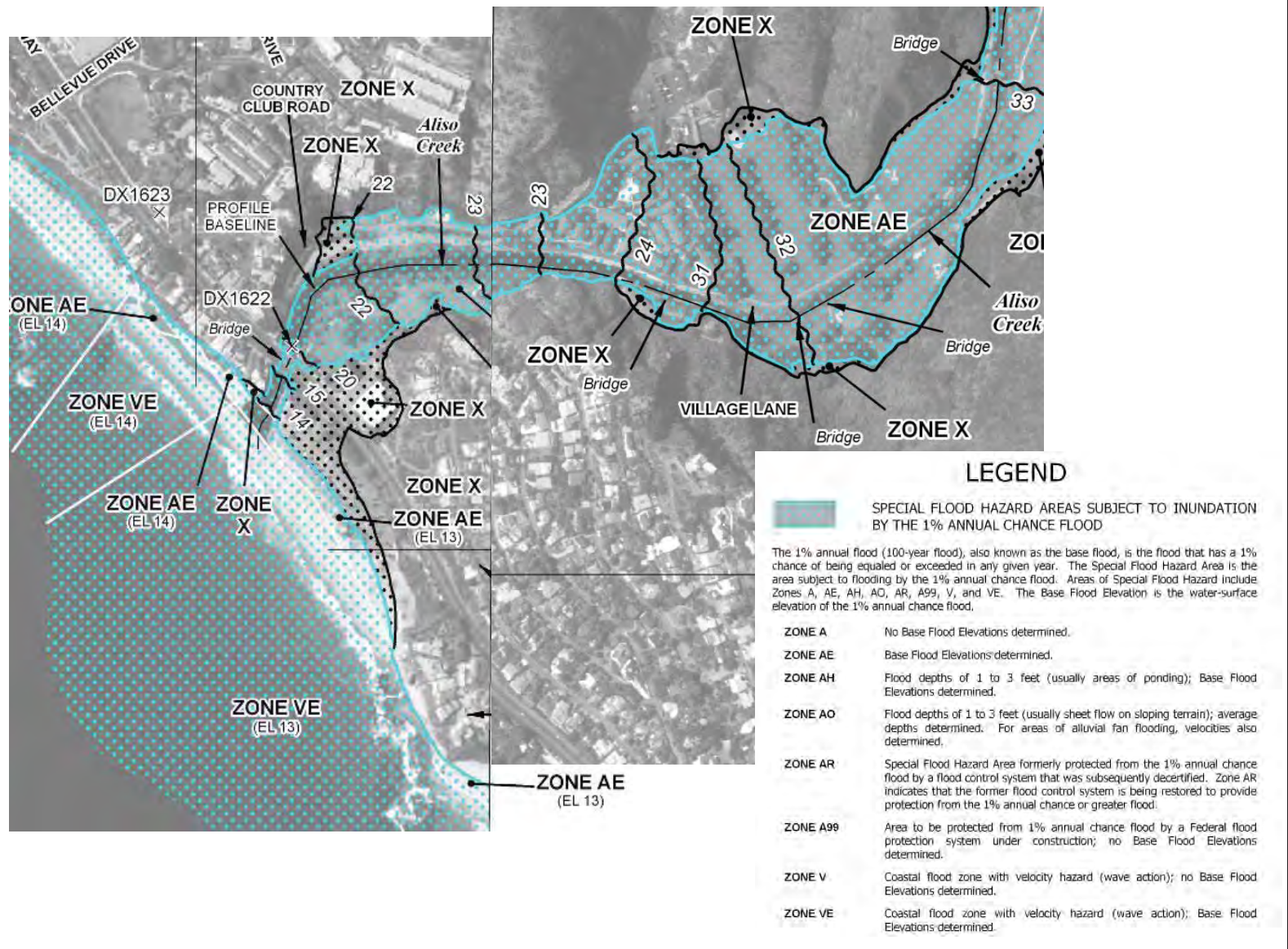
The FEMA Flood Insurance Study and Flood Insurance Rate Maps analyze and map flooding along Aliso Creek and along the coast (**Figure 2-27**). FEMA maps flood zones and elevations for the 1% -annual-chance-of-occurrence storm event (100-year flood) as well as the 0.2%-annual-chance-of-occurrence event (500-year) flood zone. The FEMA flood map indicates that the parking lot along the south bank and portions of the north bank, as well as the golf course upstream, are flooded by the 1%-chance creek (fluvial) flood event. The entire beach and portions of the Aliso Beach parking lot are subject to the 1%-chance coastal flood event.

2.5.4 Fluvial Sediment Transport and Upstream Creek Erosion

Tetra Tech (2009) modeled erosion and deposition in Aliso Creek using the U.S. Army Corps of Engineers (USACE) SAM Hydraulic Design Package for Channels. Results from sediment transport modeling showed that the creek reaches directly upstream of the lagoon are erosional and result in deposition in the lagoon. However, Tetra Tech (2009) also reported that actual surveys of the lagoon indicated that it was erosional as well, possibly due to the backwater effects of the Coast Highway bridge.

Tetra Tech (2009) calculated sediment yields from the watershed using two different methods. Using the Modified Universal Soil Loss Equation, they derived an average annual sediment yield at the Coast Highway bridge, and the results showed 42,300 cy of sediment transport per year with approximately 2,900 cy/yr of gravel (>2mm), 11,500 cy/yr of sand (<2mm and >0.75mm), and 27,900 cy/yr of silt/clay. A second method, the Los Angeles Debris Method, provided similar results with an average annual sediment yield of 40,700 cy/yr, comprised of 2,800 cy/yr of gravel, 11,100 cy/yr of sand, and 26,800 cy/yr of silt/clay. The USACE 1997 sediment budget analysis calculated a sand volume of 12,000 cy/yr from Aliso Creek. In 2010, Tetra Tech added another method to compare the possible watershed sediment yields. The PSIAC method, which uses scoring for factors that affect sediment yield, resulted in a total sediment yield of 14,700 – 29,500 cy/yr.

Tetra Tech also estimated sand delivery to the ocean from creek erosion to be approximately 18,000 cy/yr based on the modeled mean annual transport capacity of various reaches and the modeled volume changes to channel cross sections. This channel erosion is due to the urbanization and resulting hydromodification that has occurred in the watershed since the 1970s. As the channel approaches equilibrium conditions, the amount of erosion and sediment yield will decrease.



Source: FEMA, 2009

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Figure 2-27

FEMA Flood Map for Aliso Creek

Upstream of the project area and the golf course within the Aliso and Woods Canyon Wilderness Park, Aliso Creek has undergone significant erosion and incision. Over the past few decades the channel of Aliso Creek in the Wilderness Park has deeply incised into its former floodplain along with widening, thus leaving the floodplain abandoned above the new active flow area to form a relict alluvial terrace. Between the edges of the terrace the channel has started to create a new floodplain, by migrating from side to side and laterally eroding into the toe of the alluvial terrace to create floodplain sidewalls. These sidewalls are steep, mostly unvegetated and appeared to be actively eroding through scour at the toe and mass failure (landslides or slumps) above. This process of erosion and slumping has broken utility pipes and undercut the adjacent road in several places (PWA 2009). It is anticipated that further erosion of these slopes is likely in the future, and that infrastructure located on the terrace (the access road and the utilities) is at risk in its current location.

The County of Orange and USACE are planning the Aliso Creek Ecosystem Restoration Project in the Wilderness Park to restore creek habitat and protect utilities and infrastructure. USACE, in partnership with the County of Orange, developed a range of alternatives to stabilize the creek and protect utilities and infrastructure in the Wilderness Park. Treatments considered include excavating the sidewalls to create a wider floodplain, placing soil to raise the Creek back up to the floodplain, and balancing sidewall excavation and channel fill (all in conjunction with multiple grade control structures to stabilize the channel bed). The combined Draft Integrated Feasibility Report and Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was released for public review in September 2017 (USACE 2017). As of March 2018 the report has not been finalized.

2.5.5 Mouth Inlet

The Aliso Creek Estuary is a perched system (see classification of Jacobs et al. 2010) that drains Aliso Creek to the Pacific Ocean over a heightened beach berm that typically prevents tides from having a strong influence in the lagoon (Section 2.5.2). Although the mouth of the lagoon is mechanically opened throughout the year, waves elevate the berm near or above high tides by delivering more sand than can be removed by stream inputs.

2.5.5.1 Mouth Management

The urban setting of Aliso Creek creates some important management issues common to southern California tidal lagoons: the natural geomorphic processes of mouth closure and mouth migration expose nearby properties to flooding and/or erosion, and the perched (elevated) setting of the lagoon behind the partially blocked beach means that effluent of waterborne nutrients and pollutants into the lagoon are potentially retained for extended periods of time. The mouth has been breached periodically since at least the 1920s (Everts Coastal 1997). Breaching entails grading of a channel in the beach, either with shovels or with heavy equipment, to artificially create a channel in the beach barrier and thus drain the lagoon. A report commissioned by The County of Orange in 1994 (Moffatt & Nichol 1994) outlined a series of recommendations to prevent closing and migrating of the mouth across the beach south of Highway 1. These actions were intended to mitigate risks of erosion to the former Aliso Pier and properties to the north, to

improve beach access, and to limit the exposure of beachgoers to poor-quality ponded waters in the lagoon.

In addition to permitted breaching events, which are performed to manage the outlet for public safety, the lagoon also periodically experiences unauthorized breaching by beach users who use shovels or their bare hands to drain the estuary for recreation purposes. Beach users breach the outlet so that the outflow scours the outlet and forms a standing wave, which they ride/surf (e.g., on body boards). Beach users also apparently breach the outlet so that the sand scoured from the inlet deposits in surf zone, forming a shoal that improves the shape of breaking waves for riding/surfing. Though these events are on a smaller scale than the authorized County breaching, they still affect estuary conditions and therefore present a management issue that is important to the success of the estuary's restoration.

Available historical information indicates that the lagoon has historically been perched, with the mouth typically closed or with flows spilling over the beach. The mouth condition in aerial photographs provided by the County, the California Coastal Records Project (CCRP), DigitalGlobe (hosted by Google Earth), the USGS, and the US Department of Agriculture (USDA) are summarized in **Table 2-6**.

TABLE 2-6
SUMMARY OF AVAILABLE AERIAL AND OBLIQUE COASTAL IMAGES AT ALISO CREEK

Date	Source	Mouth Condition	Date	Source	Mouth Condition
1947	Orange County	Closed	Jun 11, 2005	USDA	Open-Perched
1959	Orange County	Closed	Dec 31, 2005	DigitalGlobe	Open-Perched
1970	Orange County	Closed	Sep 16, 2006	CCRP	Open-Perched
1972	CCRP	Open-Perched	Feb 28, 2007	USGS	Open-Perched
1986	Orange County	Closed	Sep 19, 2008	CCRP	Closed
Nov 3, 1986	CCRP	Closed	May 24, 2009	USDA	Open-Perched
1987	CCRP	Open-Perched	Nov 14, 2009	DigitalGlobe	Closed
Apr 14, 1993	CCRP	Open-Perched	Apr 24, 2010	USDA	Open-Perched
May 31, 1994	USGS	Open-Perched	Sep 23, 2010	CCRP	Closed
Jun 4, 2002	USGS	Open-Perched	Mar 7, 2011	DigitalGlobe	Closed
Sep 23, 2002	CCRP	Open-Perched	Apr 16, 2013	DigitalGlobe	Open-Perched
Dec 31, 2002	USGS	Open-Perched	Sep 29, 2013	CCRP	Open-Perched
Mar 6, 2004	DigitalGlobe	Open-Perched	Apr 23, 2014	DigitalGlobe	Closed
Oct 23, 2004	CCRP	Open-Perched	Mar 24, 2015	DigitalGlobe	Closed
Apr 1, 2005	Digital Globe	Open-Perched			

At present, the County of Orange has permits to perform routine semi-annual or more frequent mouth breaching. Breaching is typically performed by a bulldozer, and excavated sand is placed on the beach above the high tide line, but within the area that the mouth typically migrates through during subsequent weeks or months. The number of breaches has recently varied from as few as two in 2012 to as many as eight in 2009 and 2011 (**Table 2-7**).

TABLE 2-7
ALISO CREEK BEACH MANAGEMENT ACTIONS: 2006-2014¹

Date	Cubic Yards	Date	Cubic Yards	Date	Cubic Yards
Nov 2, 2006	1,520	Jun 22, 2009	<213	Apr 15, 2011	<213
Nov 22, 2006	10	Aug 7, 2009	<213	May 3, 2011	<213
Jun 26, 2006	<213	Oct 28, 2009	<37,000	Jun 23, 2011	<213
Oct 10, 2007	50	May 28, 2010	<213	Jun 28, 2011	<213
Apr 10, 2008	30,000	Jun 18, 2010	<213	Sep 15, 2011	<213
May 1, 2008	3,500	Jun 29, 2010	<213	Mar 27, 2012	10,000
Jun 6, 2008	3,600	Aug 6, 2010	<213	Dec 27, 2012	<213
Dec 8, 2008	28,000	Aug 12, 2010	<213	Apr 4, 2013	<213
Feb 13, 2009	<213	Nov 10, 2010	<213	May 23, 2013	<213
Mar 6, 2009	<213	Dec 8, 2010	<213	Nov 5, 2013	<213
Mar 27, 2009	<213	Jan 28, 2011	<213	Dec 11, 2013	<213
Apr 8, 2009	<213	Feb 7, 2011	<213	Apr 14, 2014	<213
May 22, 2009	<213	Feb 22, 2011	<213	May 14, 2014	10,000

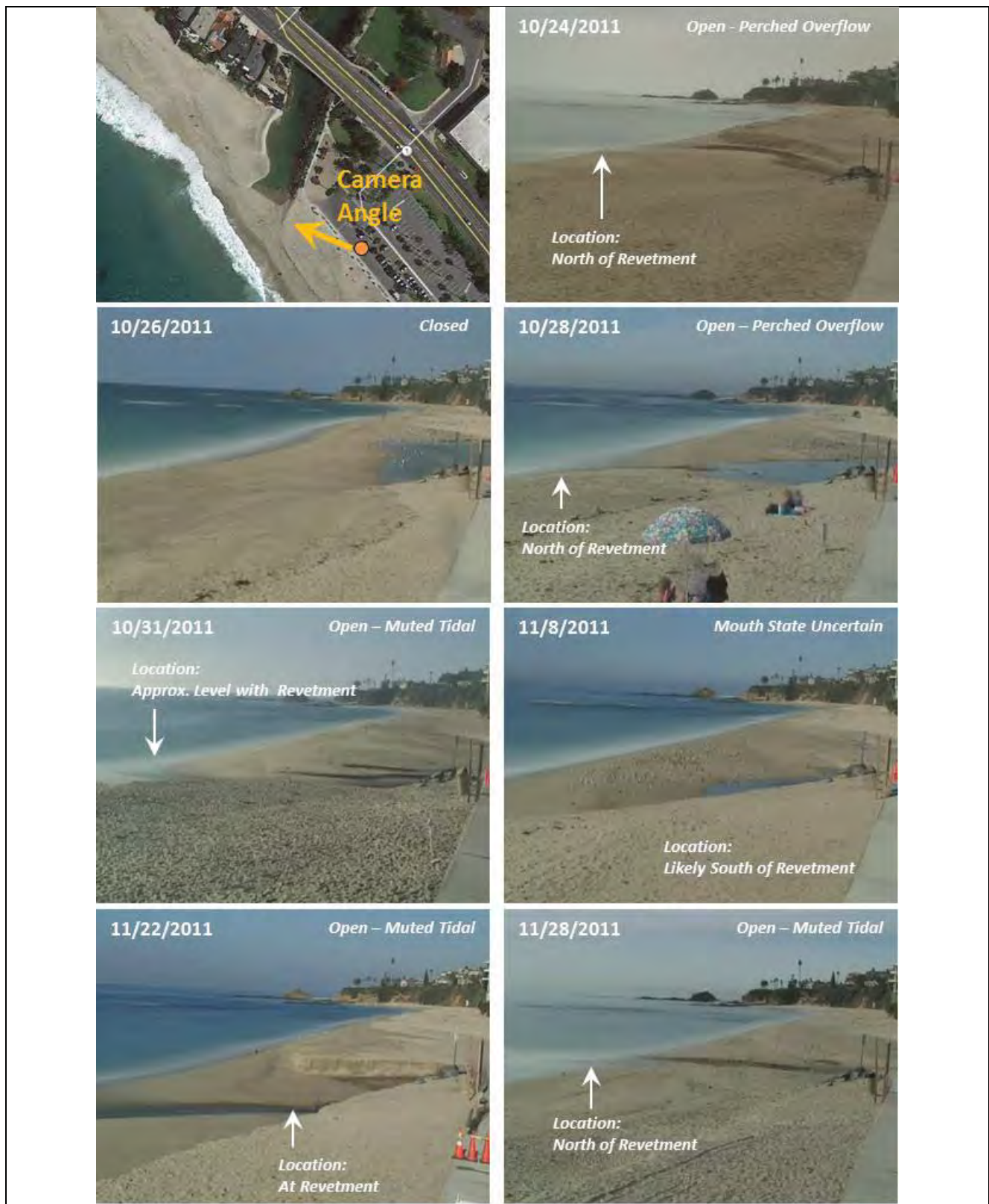
NOTE: 213 cubic yards is the maximum allowable volume for berm-breaching excavation

¹SOURCE: County of Orange 2007-2014

2.5.5.2 Mouth Morphology Response

Daily time-exposure photographs of the beach and creek mouth were provided by CoastalCOMS from October 2011 to the present and used to classify the condition of the mouth. These generally portray a dynamic lagoon mouth, undergoing extensive lateral movement along the beach. **Figure 2-28** shows a sequence of photographs from 2011 that illustrate both the typical lateral migration and also differences in lagoon water levels for open and closed mouth conditions. Photographs taken after County breach events generally show a deep, straight channel, and a fully drained lagoon, followed by 1-2 weeks in which the accretion re-forms the barrier and the inlet begins to migrate again. As discussed previously by Moffatt & Nichol (1994), the inlet migration can be either to the north or south. Inlet migration increases friction in the channel, and encourages perched or closed conditions (Behrens et al. 2009), so this is often a transitional state preceding closure at the site. High stream flow events sometimes appeared to cause the mouth to breach, but these were infrequent given the especially dry conditions of the years when the photographs were taken.

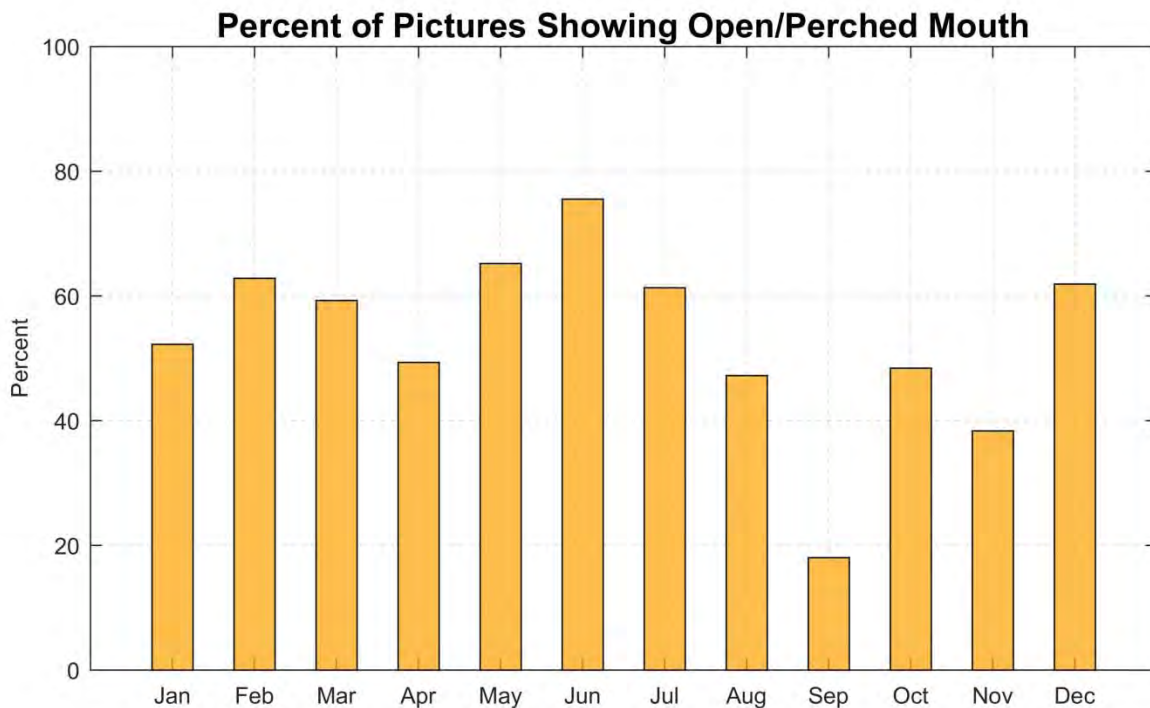
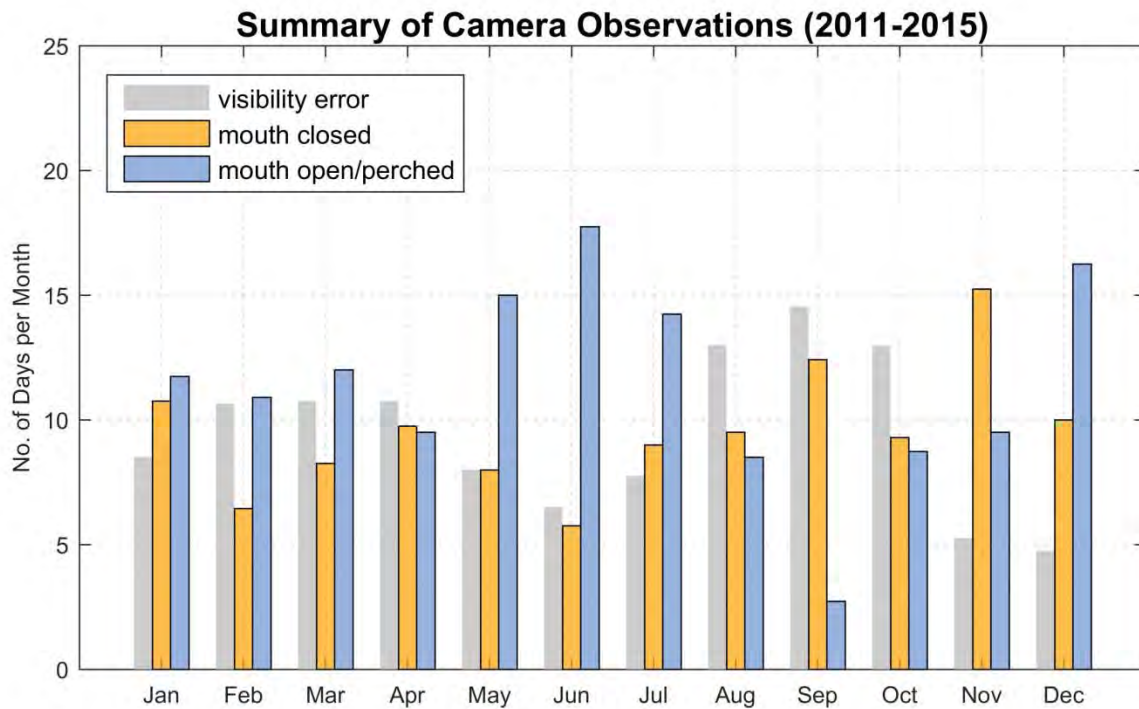
The available photographs suggest that beachgoers play a significant role in lagoon and mouth conditions. Often, the mouth was shown to be closed during weekdays, and then open during the weekend. This was especially true during the summer months and during holidays, when dozens of beachgoers were visible on the beach. This is reflected in **Figure 2-29**. From 2011 to 2015, the mouth was open most often in the winter months (52-62% of the time) and the months of May-July (61-75% of the time). The mouth was open the least in the fall (18-46% of the time), with September being the month when mouth closure was most common. Overall, the mouth was typically closed for 40-60 percent of the year from 2011 to 2015, and is otherwise characterized by perched overflow.



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Figure 2-28

Mouth morphology of Aliso Creek: October 14 – November 28, 2011.



NOTE: Mouth condition interpreted from CoastalCOMS time exposures.

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Figure 2-29
 Summary of mouth conditions at Aliso Creek from
 2011 to 2015.

Figure 2-30 looks at the mouth condition in more detail, by examining average daily conditions from 2011 to 2015. Mouth closure was most likely in mid-late spring and the fall, from September to November. This may coincide with the moderate wave power and relatively low flows in those months. However, the high percentage of ‘open-inlet’ conditions from May to August are not explained by these processes, and may be tied to unauthorized breach events.

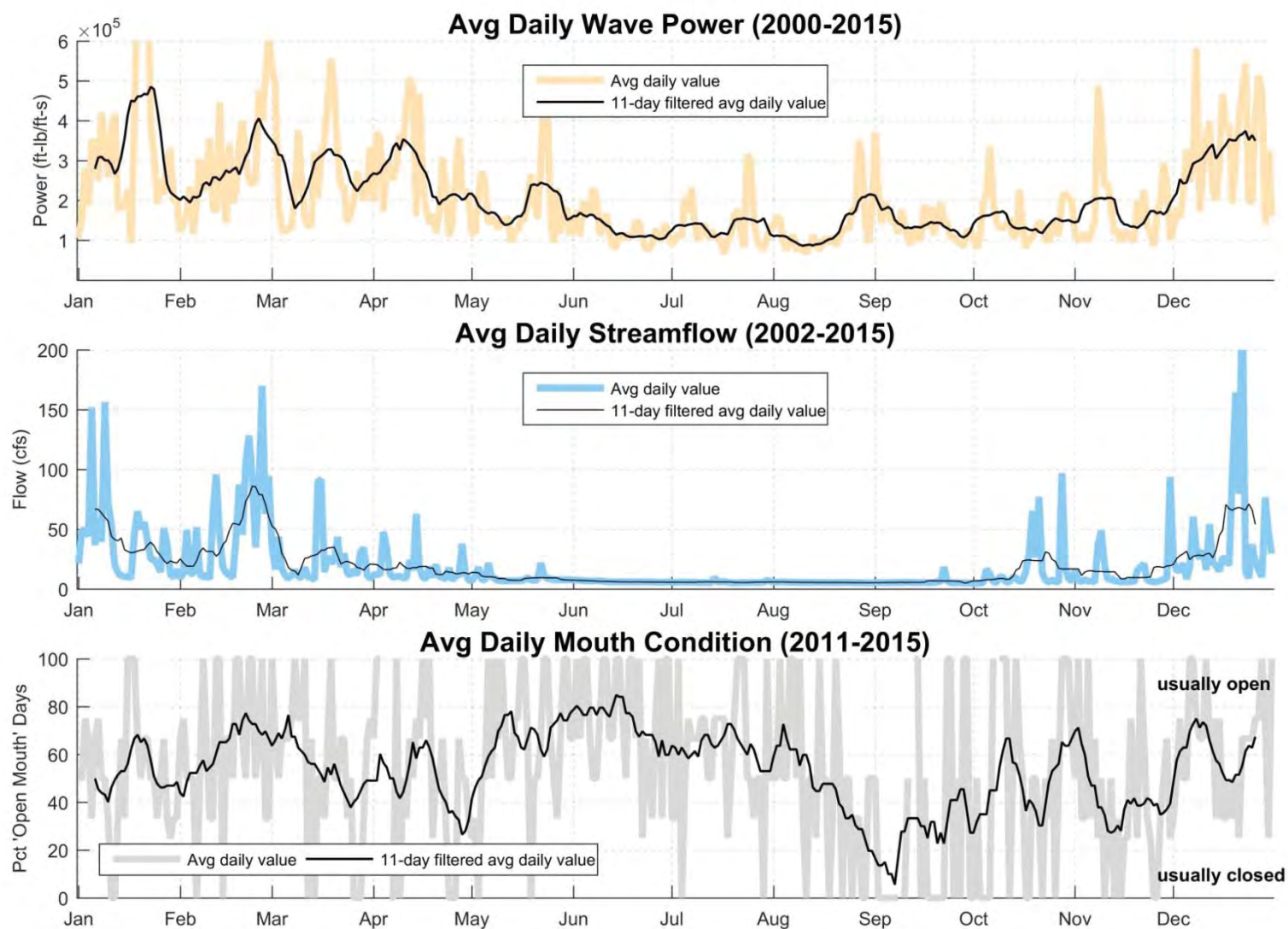
Aliso Creek Estuary and mouth form a dynamic system that responds strongly to stream flows and local wave conditions. Tides are likely a weaker influence given the small size of the lagoon, and because the available camera data portray a lagoon that is usually closed or perched above tide levels. Camera data indicate that periodic unauthorized breaches are likely a strong influence on lagoon hydrology, preventing ponding in the lagoon during summer. This leads to relatively frequent open-mouth conditions in summer, when flows would otherwise likely be too weak to keep the mouth open. Under natural (pre-development) conditions, it is possible that the lagoon would have been closed seasonally for several months at a time.

2.5.6 Coastal Sediment Transport

Aliso Beach is part of a dynamic littoral sub-cell with a constantly changing shoreline (Moffatt & Nichol 1994). The beach is approximately 3000 ft long and confined by Camel Point headland to the north and Aliso Point to the south, both of which influence alongshore and longshore sediment transport. Moffatt & Nichol (1994) acknowledge multiple sediment sources and sinks influence coastal processes and beach width, but note that sediment supplied by Aliso Creek and alongshore transport are the most significant factors influencing sediment movement. The net movement of alongshore and longshore sand transport is towards the south; the northern headland acts as a barrier to northward movement. Similarly, the beach orientation (approximately 145°) and the average wave approach direction (270°) also play a role in the net sediment transport towards the south (Moffatt & Nichol 1994). Though Aliso/Camel Point can also impede alongshore transport, the point generally only acts as a barrier when beach sand levels are low. Alongshore transport generally is south from November through April and towards the north from May to October.

2.6 Water and Sediment Quality

The Aliso Creek Watershed is within the San Diego Regional Water Quality Control Board (SDRWQCB) area (Region 9). The SDRWQCB is responsible for adopting and implementing water quality control plans, issuing waste discharge requirements, and performing other functions concerning water quality control within their region. The Aliso Creek watershed has been designated by the SDRWQCB as a target watershed for priority water quality enhancement efforts. Numerous issues have been identified within the watershed and are related to both human actions and natural processes, including degraded water quality and loss of fish and wildlife habitat, with non-point source pollution being the primary causes of impairment. Residential and commercial use of fertilizers and pesticides, and pet and waterfowl waste are most likely the key contributors to the nutrient and stormwater impacts, as well as elevated bacteria loads, observed in the watershed.



NOTE: Wave data from CDIP Dana Pt Buoy. Stream flow data provided by County. Mouth condition interpreted from CoastalCOMS time exposures.

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Figure 2-30
Average daily conditions for (top) wave power, (middle) stream flow, and (bottom) frequency of open-mouth conditions from 2011 to 2015

These factors along with high water temperatures all play a role in contributing to poor water quality in the Aliso Creek watershed (USACE 2009). Water and sediment quality data collection from within the Aliso Creek Estuary has previously been limited, with little to no data available. Salinity, temperature, and dissolved oxygen (DO) data were collected for the Aliso Creek Conceptual Restoration Plan and are discussed in Section 6.3. The following sections focus on upstream and ocean water quality.

2.6.1 Water Quality Improvement Efforts

Dating back to the late 1990s, water quality, particularly fecal indicator bacteria (FIB) contamination, has been a priority issue in the watershed. Numerous efforts beginning in the 1990s have been made to improve water quality in the watershed (**Table 2-8**). Since 2000, improvement efforts in the watershed have exceeded \$23 million in expenditures (OCPWa 2015).

TABLE 2-8
LIST OF KEY WATER QUALITY IMPROVEMENT EFFORTS

Year	Water Quality Efforts
1997	County receives Clean Water Act Section 205(j) grant to conduct Aliso Creek water quality studies.
1998	Aliso Creek 205(j) Water Quality Planning Study Report completed laying out framework for water quality improvement.
2000	County initiates focused Aliso Creek water quality monitoring investigations on FIB contamination.
2001	San Diego Water Board issues 13225 Directive to the County and watershed cities to continue to investigate and refine plan to address FIB contamination within Aliso Creek.
2001	Monitoring program expanded to weekly bacteriological testing at all major stormdrain outfalls to Aliso Creek (over 100 monitoring stations throughout the watershed).
2002	Laguna Niguel source investigation finds non-human origin of FIB in J03P02 stormdrain.
2002	Constructed wetlands completed in J05 channel as mitigation for Laguna Hills Community Center project.
2003	J01P28 Media Filter and UV Light Disinfection Treatment System constructed to treat drainage from Aliso Viejo Town Center area.
2004	Wetland Capture and Treatment project (Wet CAT) completed to clean runoff from Laguna Niguel J03P02 stormdrain.
2005	South Orange County Integrated Regional Water Management Plan (IRWMP) developed with focus on water quality and restoring watershed biological diversity.
2006	J01P08 subwatershed irrigation controller pilot study in Lake Forest shows meaningful reductions in stormdrain flow.
2006	Aliso FIB monitoring program revised to focus on the summer when concentrations in the watershed are at their highest.
2007	Watershed wide SmarTimer Edgescape Evaluation Project (SEEP) study on benefits of enhanced irrigation controllers and landscape retrofits to reduce irrigation runoff and pollutant loads.
2007	Channel restoration project completed in segment of J04 (Narco) channel in Laguna Niguel achieves significant FIB reductions.
2010	San Diego Water Board adopts FIB Total Maximum Daily Load (TMDL) for south Orange County including Aliso Creek, its tributaries and Aliso Beach.
2012	Aliso Creek Watershed Comprehensive Load Reduction Plan (CLRP) developed identifying watershed BMPs needed to meet FIB TMDLs. (updated in 2014)

Source: OCPW (2015)

In addition to the designation of the Aliso Creek Watershed as a target watershed for priority water quality enhancement efforts, the entire main branch and mouth of Aliso Creek, along with the major watershed tributaries, have been listed on the California 303(d) list of Water Quality Limited Segments under the Clean Water Act (CWA). In 2010, the State of California published an updated list of impaired water bodies pursuant to provisions of Clean Water Act Section 303(d). Aliso Creek, its major tributaries, and Aliso Creek mouth are listed as impaired for various constituents, as shown in **Table 2-9**. The Clean Water Act requires states to establish Total Maximum Daily Loads (TMDLs) for waters that are placed on the CWA 303(d) List. TMDLs for the listed constituents have been developed to address exceedances in Aliso Creek, its major tributaries, and the Aliso Creek mouth. The TMDLs define the waste load allocations and implementation timelines to meet these goals. The purpose of the TMDL is to restore the beneficial uses and to attain the water quality objectives in the waterbody.

TABLE 2-9
CALIFORNIA 303(D) LIST OF WATER QUALITY LIMITED SEGMENTS

Water Body	Pollutant	Estimated Area Assessed	First Year Listed	TMDL Completion Date
Aliso Creek	Indicator Bacteria ¹	19 Miles	2002	2005
	Phosphorus ¹	19 Miles	2002	2019
	Selenium	19 Miles	2010	2021
	Total Nitrogen as N	19 Miles	2010	2019
	Toxicity ¹	19 Miles	2002	2019
Aliso Creek (mouth)	Indicator Bacteria	0.29 Acres	1990	2019

¹ These listings apply to the Aliso Creek mainstem and all the major tributaries of Aliso Creek which are Sulphur Creek, Wood Canyon, Aliso Hills Canyon, Dairy Fork, and English Canyon.

SOURCE: Waterboards.ca.gov, 2015

In 2001, the SDRWQCB issued a directive, by authority of California Water Code Section 13225, to the County of Orange, the Orange County Flood Control District, and the cities of Laguna Beach, Laguna Hills, Laguna Niguel, Laguna Woods, Lake Forest, Mission Viejo, and Aliso Viejo (the Permittees) to investigate urban runoff in the Aliso Creek watershed. The directive found that the Permittees may be discharging waste with high indicator bacteria concentrations from municipal storm drain outfalls into Aliso Creek and its tributaries. The Directive required the Permittees to conduct weekly monitoring at all major outfalls to Aliso Creek, to evaluate the effectiveness of structural and non-structural Best Management Practices (BMPs) currently being implemented in the watershed, and to identify future measures that would eliminate levels of high bacteria from outfalls (OCPW 2015)

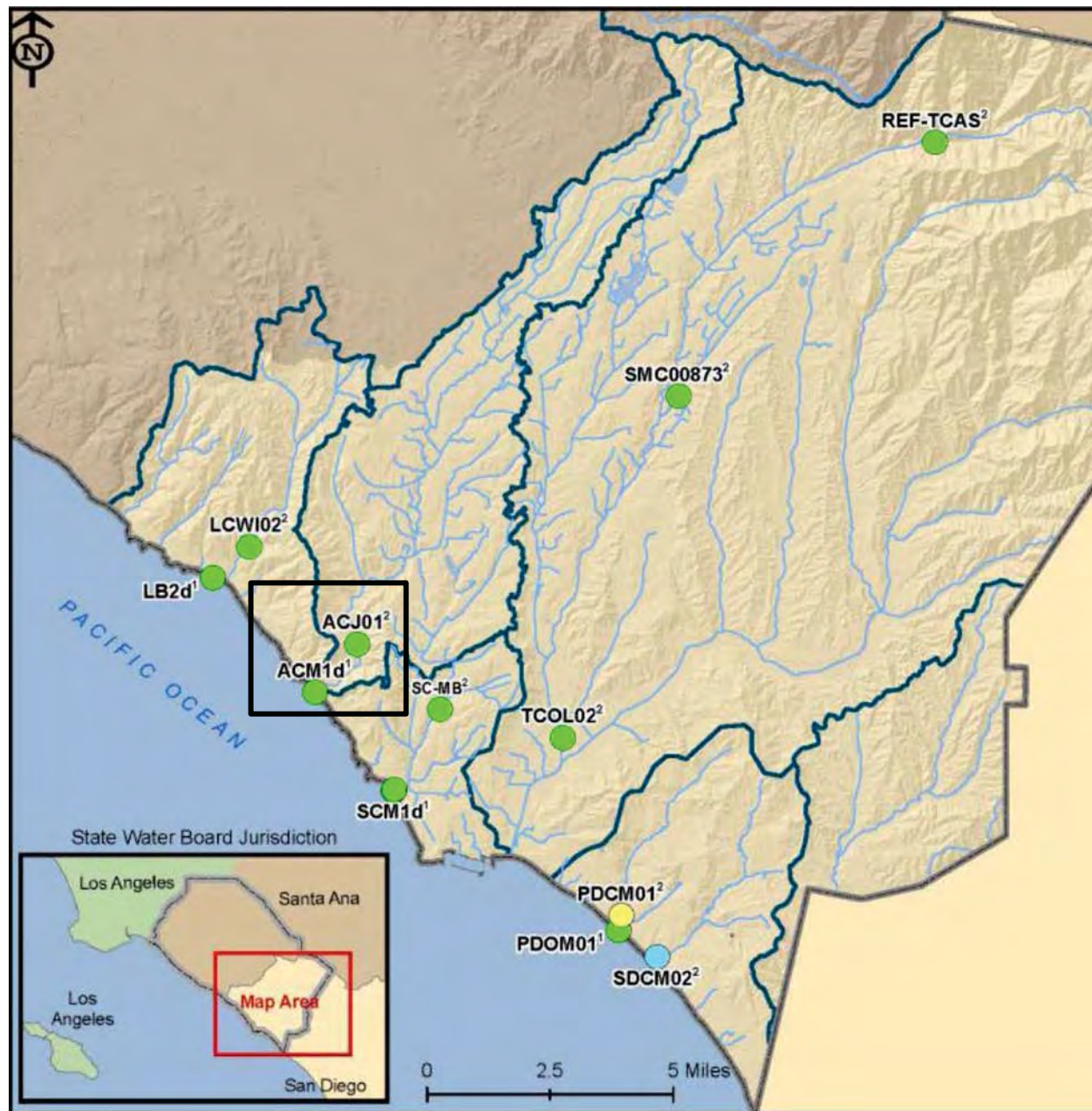
Over the years there have been several revisions to the monitoring program as a result of ongoing monitoring and improved knowledge about overall patterns of bacteria in the watershed and localized responses to specific BMPs. Current monitoring efforts focus on sites near the bottom of the watershed and BMP evaluation sites at high-priority drains throughout the watershed (**Figure 2-31** and **2-32**). Monitoring at the status and trends monitoring sites occurs on a more frequent basis than in prior years but is only conducted in the summer months when bacteria concentrations are the highest.

As part of the San Diego Regional Water Quality Control Board's Municipal Separate Storm Sewer System (MS4) Permit for South Orange County, the County of Orange and cities in South Orange County (the co-permittees) have developed a Water Quality Improvement Plan (WQIP). The WQIP identifies priority water quality conditions, sources of pollutants, quantifiable goals, improvement strategies and schedules, and monitoring and assessment plans for the South Orange County subregion. The Highest Priority Water Quality Conditions (HPWQCs) identified in the Southern Orange County WQIP are pathogen health risk at beaches due to bacteria carried by creek flows, channel erosion and associated geomorphic impacts, and unnatural water balance and flow regime. Additional Priority Water Quality Conditions identified are eutrophication, nuisance conditions (turbidity, trash, and nutrient loads), and water quality conditions related to biology (toxicity, pesticides). The WQIP anticipates restoration of the Aliso Creek Estuary and explicitly acknowledges the need for water quality management within the watershed to be consistent with estuary restoration objectives. Implementation of the WQIP over time has the potential to improve water quality conditions in the watershed and the Estuary.

2.6.2 Fecal Indicator Bacteria

On February 10, 2010 the Regional Board adopted TMDLs for indicator bacteria to address impaired beaches and creeks in the San Diego region (Beaches and Creeks Indicator Bacteria TMDLs) including Aliso Creek and its tributaries, the Aliso Creek mouth, and Aliso Beach. In addition to the Directive Monitoring efforts, management efforts on indicator bacteria have been generally shifted to the implementation of the Beaches and Creeks TMDL (OCPW 2012 and 2018).

The Beaches and Creeks TMDLs define the allowable indicator bacteria loads from the storm drain system that will still allow attainment of water quality standards. The modeled reductions required to meet these loads in south Orange County range from 73-99% during dry weather to 91-100% during wet weather depending on the location and indicator bacteria species. A 22% wet weather allowable exceedance frequency of TMDL number target is also included in the TMDLs to account for natural sources of bacteria. Compliance with the TMDLs must occur by April 4, 2021 with a possible extension to April 4, 2031 for wet weather load reductions (OCPW website). The development of a watershed Comprehensive Load Reduction Plan targeting all watershed pollutants of impairment has been developed outlining the specific BMPs needed to meet TMDL targets and special studies to identify sources of indicator bacteria in the watershed (OCPW 2014).



Source: OCPW (2014)

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Figure 2-32

Aliso Creek Toxicity Monitoring Program Water Sampling
Location Map

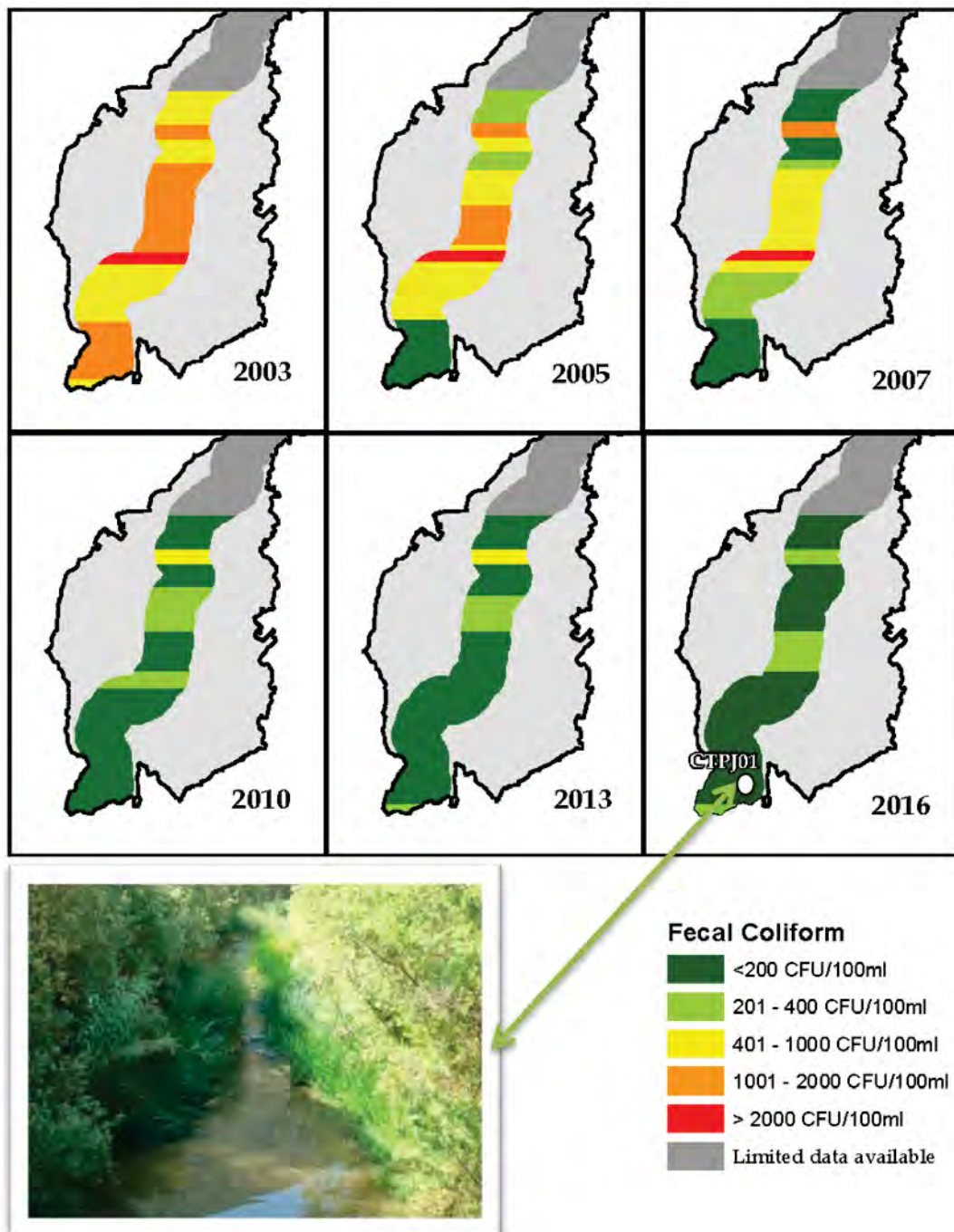
The WQIP provides wet and dry weather baseline bacteria loads and target load reductions for fecal coliforms. The baseline loads were determined using the Structural BMP Prioritization and Analysis Tool (SBPRAT) based on the 1993 water year. In Aliso Creek, the WQIP plan identified the baseline fecal coliform load as 4765×10^{12} most probable number (MPN) with a target load reduction of 1268×10^{12} MPN, or 26.62% for wet weather flows. For dry weather, the annual baseline fecal coliform load was 65.6×10^{12} MPN with a target reduction of 62.9×10^{12} MPN or a 95.58% total reduction. Total coliform and *Enterococcus* annual baseline loads and percent load reductions for dry and wet weather conditions can be found in Table 3-2 and 3-3 of the WQIP.

Results from the monitoring effort associated with the Aliso Creek Revised 13225 Directive Monitoring Program are reported annually as part of the Aliso Creek Runoff Management Plan Water Quality Data Assessment Annual Report. Historic water quality data suggests that there has been a dramatic reduction in FIB concentrations throughout the watershed at multiple sampling sites and the greatest reduction in concentrations is observed in the lower portion of the watershed which has the highest potential for human health impacts (**Figure 2-33**).

SOCWA has two bacteriological water quality monitoring programs at Aliso Creek. The first monitoring program collects weekly water samples at three locations at the Aliso County Beach (Aliso Creek North, Aliso Creek Middle, Aliso Creek South). From 2005-2016, the three Aliso Creek monitoring sites complied with Assembly Bill 411 (AB 411) bacteriological water quality standards 98.6% of the time (OCHCA 2017). The AB 411 monitoring period is from April 1 to October 31.

In 2015, SOCWA expanded its AB 411 monitoring to include an additional “Point-Zero” monitoring program, which consists of sampling at and near the location where urban runoff enters the ocean (“point-zero”). Point Zero monitoring evaluates water samples taken at the surf zone at three locations: point-zero, 75 ft upcoast and 75 downcoast of the point-zero location. These locations differ from the Aliso Creek monitoring sites mentioned above. The upcoast and downcoast samples are only taken when there is urban runoff flow to the ocean. During the 2016 AB 411 “dry-season” monitoring period, there were no Point-Zero monitoring program samples that exceeded allowable standards; however, during the “wet weather” non-monitoring period of 2016 (January-March and November-December), there were 4 samples (out of 25 total samples) across the three monitoring locations that exceeded the AB 411 standards (OCHCA 2017).

The non-profit environmental organization Heal the Bay uses the results of beach water quality samples collected by the SOCWA to provide a weekly letter grade based on the results of three indicator bacteria: *Enterococcus*, total coliform, and fecal coliform. The weekly grade is used to summarize the health risks of swimming or surfing at the Aliso County Beach. The annual report grades for dry and wet periods are found below in **Table 2-10**. The Aliso County Beach has closed fourteen times since 2002 due to sewage spills (Heal the Bay 2017).



SOURCE: OPCW, 2016

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Figure 2-33
Historical Fecal Coliform Concentration in Aliso Creek

TABLE 2-10
HEAL THE BAY REPORT CARD GRADES

Year	Dry	Wet	AB411
2016	C	B	A
2015	B	F	A
2014	A	F	A
2013	B	B	A
2012	A	F	A
2011	A	F	A
2010	A	F	A
2009	A	F	A+
2008	A	B	A
2007	A	D	A
2006	A	F	A
2005	A	F	A
2004	A	F	A
2003	A	F	A
2002	A	F	A
2001	A	F	A
2000	B	F	N/A

NOTES: Dry weather grades are calculated for days of no rain and at least 3 days after it stops raining. Wet weather grades are calculated for samples collected on rainy days and the following three days following rain.

SOURCE: Heal the Bay 2017 (beachreportcard.org)

Although Aliso Creek and its tributaries are currently designated as having a beneficial use of Non-Contact Recreation (REC-2), the analysis presented in the Aliso Creek 13255 Directive Monitoring Program focuses on tracking trends and comparing those to the more stringent beneficial use of Contact Water Recreation (REC-1), water quality objectives and bacteria TMDL dry weather numeric targets.

For the 2014 sampling season, there was an overall increase in bacteria concentrations at most sampling sites as compared to 2013. Although there was an increase at most sites, the concentrations still remained below the REC-1 fecal coliform objective of 400 CFU/100ml (OCPWa 2015). The seasonal geometric mean of fecal coliform concentration was also studied for sampling years between 2001 and 2014 for all five status and monitoring sites. The levels at most sites increased from 2013 to levels similar to those observed in 2012. A running 30-day geometric mean for fecal coliform was also looked at in comparison to the REC-1 water quality objective of 200 CFU/100ml and this objective was met at three of the five sites (OCPWa 2015). The sites that recorded values above the objective were still below historic levels.

Using the more stringent REC-1 objectives for single sample maximum allowable density, (61 CFU/100ml for designated beach areas, 108 CFU/100ml for moderately or slight used areas and 151 CFU/100ml for infrequently used areas) and the geometric mean objective of 33 CFU/100ml, concentration of enterococci at the five status and monitoring sites was also looked at to determine current trends and to compare against previous year data. 2014 results showed that the median enterococci concentrations were below the 61 CFU/100 ml water quality objectives for

most sites (OCPWa 2015). The enterococci concentration seasonal geometric mean of years 2001 thru 2014 was also analyzed and showed that over the past decade the seasonal geometric mean has decreased by an order of magnitude at all sites. For the 2014 sampling year the geometric mean fluctuated around historic lows with a slight increase at only one site. The 2014 results for the 30-day geometric mean concentrations showed that all sites showed exceedances of the REC-1 objective of 33 CFU/100ml (OCPWa 2015).

2.6.3 Copper, Cadmium, and Selenium

Results from the 2013-2014 dry weather monitoring effort gave the Ambient Coastal Monitoring Site (ACM1) at the mouth of Aliso Creek a “Very Good” rating (less than 15% of all samples exceeded the California Toxic Rules (CTR) thresholds for copper, cadmium, and selenium. The Mass Loading and Bioassessment monitoring site (ACJ01) located above the ACWHEP structure in the Aliso and Woods Canyon Wilderness Park upstream of the estuary and the Golf Course at The Ranch also received a “Very Good” rating for copper and cadmium, but “Poor” rating for selenium (76-100% of samples exceeded the selenium CTR threshold) during dry-weather (County of Orange 2014). ACJ01 similarly received a “Poor” rating for wet weather selenium sampling (County of Orange 2014).

2.6.4 Toxicity

In order to provide a cumulative perspective of pollutant effects on receiving waters aquatic species toxicity, aqueous toxicity testing of water samples from the ACM1 and ACJ01 monitoring site was also conducted for dry and wet weather flows. The toxicity testing evaluated reproduction, chronic survival, acute survival, growth, and cell density. A sample was considered toxic if the organism response was less than 80% effect (i.e., if testing for chronic survival and less than 80% of organisms survived, the sample was considered toxic). For the 2013-2014 sampling season toxicity was assessed at the mouth of Aliso Creek (ACM1) and at the status and trends monitoring site ACJ01 (County of Orange 2014).

During sampling, both monitoring sites along the main branch and at the mouth of the creek showed a “Very Good” Toxicity score, indicating less than 15% of samples were found toxic for both dry weather (ACM1 and ACJ01) and wet weather (ACJ01). There were no toxic samples at either Aliso Creek monitoring sites during dry weather sampling. During wet weather, only one sample (*Americamysis bahia* growth test) was found to be toxic at the ACJ01 location. Station toxicity scores are based on the percentage of total samples that are found toxic; despite one toxic sample, ACJ01 still was given a “Very good” toxicity score.

Aqueous toxicity at the Ambient Coastal monitoring site was evaluated using the marine coastal organisms *Mysidopsis bahia* and *Stronglyocentrotus purpuratus* and aqueous toxicity at the Mass Loading and Bioassessment monitoring sites were evaluated using two fresh water organisms *Ceriodaphnia dubia*, *Hyallela azteca*, and two marine organism *Mysidopsis bahia* and *Stronglyocentrotus purpuratus* (County of Orange 2014). Since the Aliso Creek Estuary is brackish with limited direct tidal inputs, the fresh and salt water species used for toxicity testing are appropriate to assess toxicity in Aliso Creek. Sediment toxicity data are not available.

2.6.5 Nutrients

Nutrients, specifically Nitrogen and Phosphorus are also a priority water quality concern for the Aliso Creek watershed and both are listed as pollutants on the 2010 303(d) list. The contribution of nutrients such as nitrogen and phosphorus can be both point and non-point source as well as from both natural (decomposing organic materials, sediments, wildlife feces, groundwater chemistry) and anthropogenic (fertilizers, cleaning products, septic systems, recycled water).

Although nitrogen and phosphorus are identified as “medium” priority pollutants, current monitoring within the Aliso Creek watershed provides limited data on these constituents at a watershed scale. Additional monitoring and data analysis is needed to calculate pollutant loads, identify hotspots, and better define human risks and habitat impacts (OCPWa 2015).

As part of the Aliso Creek Watershed Comprehensive Load Reduction Plan the Watershed Permittees have been developing and implementing several structural and non-structural BMP initiatives to reduce and eliminate Total Nitrogen and Total Phosphorus loads in the watershed (County of Orange 2012). These BMP initiatives are intended to reduce or eliminate the creation of pollutants, reduce pollutants at their source and remove pollutants from runoff. **Table 2-11** below lists the type of BMP implemented and the associated Watershed Project.

2.6.6 Aliso Creek Ocean Outfall

The SOCWA operates the Aliso Creek Ocean Outfall (ACOO), a pipe that extends approximately 1.5 miles (7,900 ft) offshore and discharges treated effluent from four wastewater treatment plants (SOWCA Coastal Treatment Plant, SOCWA Joint Regional Treatment Plant, the Los Alisos Water Reclamation Plant, and the El Toro Water Reclamation Plant, Figure 2-12). The ACOO also conveys brine discharge from the Aliso Creek Water Harvesting Project and the Irvine Desalter Project. As part of the SDRWQCB Order No. R9-2012-0013 and NPDES Permit No. CA0107611, the SOCWA coordinates a sampling program to measure the effects of ocean receiving water characteristics and resident biota and ensure compliance with permit standards. During the 2013-2014 monitoring year, SOWCA took monthly water samples at seven nearshore monitoring stations and seven offshore monitoring locations to test the bacterial, physical, chemical, and biological characteristics of receiving waters. Nearshore sampling evaluated total and fecal coliforms and enterococci; offshore sampling evaluated temperature, salinity, light transmittance, dissolved oxygen, total and fecal coliforms, enterococci, water color and clarity, and pH. During the 2013-2014 monitoring year there were no permit exceedances for total coliform and fecal coliform (permit limits of 10,000 CFU/100 ml and 400 CFU/100 ml, respectively) at both the nearshore and offshore monitoring sites. There was one exceedance of the *Enterococcus* permit limit of 104 CFU/100 ml in September 2013 at nearshore sampling location 5, which registered 130 CFU/100 ml. For the additional water constituents monitored at the offshore locations there were two samples that did not meet compliance criteria (dissolved oxygen and pH in September 2013), but neither were interpreted as an outfall effect based on reference station values (Weston Solution 2015).

TABLE 2-11
BMP TYPES AND TARGETED POLLUTANTS IN THE ALISO CREEK WATERSHED

BMP Type/Category	Watershed Project
Structural BMPs	
Treatment Wetland	Wood Canyon Emergent Wetland at J02P08 (2005) Laguna Hills Wetland at J05 (2003) Wetland Capture and Treatment WetCAT (1991) Glenwood Wetland J06P03 (2011) Oso Parkway Southside Wetland (2012) Dairy Fork Wetland & Habitat Restoration (2016)
UV and Media Filter	J01P28 Urban Runoff Treatment Facility (2012)
Sand Filter	Munger Drain Sand Filter (2005)
Channel Restoration/Retrofitting	Narco Channel Restoration (2007) Upper Sulphur Restoration (2007) English Creek Aquatic Restoration (2015)
Landscape Retrofits	Sulphur Solutions "Green Back" Water Conservation and Pollution Prevention (2006) Alicia Parkway Median Island Landscape Rehabilitation Project (2008) El Toro Road Parkway Project (2009) Pollution Reduction Conservation Retrofit Program J01P08 Sub-watershed (2008) El Toro Traffic and Landscape Project (2006) Water District "Smart Landscape" Rebate Program (2014)
Catchbasin Retrofits	Sulphur Solution "Control" Subproject (Debris Gates 2008) La Paz Sports Park Catchbasin Filters and Bioretention Basins (2003) KristarFlogard Filters (2007) El Toro Frontage Road Storm Drain Improvement Project (2006) Future Aliso Viejo Litter Control Project (2013) Top of the World Catch Basin Retrofit (2014) Catch Basin Debris Gates (M2 Tier 1 Project 2012)
Low Impact Development (Projects with WQMP/Local Standard Stormwater Mitigation Plan (SSMP) and Treatment Control BMPs	Watershed Wide (Since 2001)
Irrigation Controllers	SmartTimer Edgescape Evaluation Project (SEEP 2008)
Trash Bin Enclosure Retrofits	Watershed Wide
Non-structural BMPs	
Street Sweeping	Watershed LIP Programs
Integrated Pest Management	Watershed LIP Programs
Fertilizer Management	Watershed LIP Programs
Education and Outreach	Watershed LIP Programs
SOURCE: OCPW (2014)	

In addition to water sampling, SOWCA also monitors benthic sediment chemistry and benthic infaunal communities. Sediment sampling in October 2013 found no exceedances of the Effects Range-Low concentration (the threshold above which concentrations are detrimental to the environment, [Long et al. 1995]). Similarly, benthic infaunal sampling conducted in October 2013 noted “overall the taxa and abundance values for the ACOO stations still represent a highly diverse community with moderate abundances and indicate a healthy habitat for infaunal organisms” (Weston Solutions 2015).

There were no NPDES permit violations for all constituents at the ACOO monitoring sites (SOCWA 2014) in 2014. Additional monitoring at each of the facilities that discharge to the ACOO during 2014 showed two NPDES violations of settleable solids in October 2014 at the Los Alisos Water Reclamation Plant due to a pond maintenance project. There were no other NPDES permit violations at remaining ACOO facilities (SOCWA 2014).

2.7 Biological Resources

The goal of this section is to characterize the current conditions of natural resources within the Aliso Creek Estuary project area. This section covers existing vegetation, special status species and jurisdictional wetlands and waters of the US and State. This section is intended to guide the development of conceptual restoration strategies for the Aliso Creek Estuary. Further field and literature investigations will be needed to refine these preliminary findings to provide sufficient detail for use in environmental review or permitting.

The vegetation within the project area is strongly dominated by invasive and horticultural non-native species. Despite the dominance of non-natives, 26 native plant species were found on a site visit in November 2015. Additional species could be added to this total by visiting in other times of the year when annual species, for instance, might be more prevalent. Coastal sage scrub habitat was identified within the project area, though it is generally heavily degraded by disturbance and invasive non-native species. It may nevertheless be considered an Environmentally Sensitive Habitat Area (ESHA) and potentially protected under the Coastal Act. Alteration of the vegetation in these areas may trigger the need for mitigation of coastal sage scrub.

Consultation with the California Natural Diversity Database (CNDDDB) revealed that there are over 150 special status species that might have the potential to occur on site. The overwhelming majority of those (110) have a very low probability of occurring. Eight special status birds were identified that could be expected to use the site, though none of those are likely breeding on site. Monarch butterflies were observed but there is no known roost at the site. Southwestern pond turtles are known to occur not far up-stream, though none were observed within the project area during our site visit in November 2015. About 30 additional species of special status plants and animals have a moderate potential to occur on site. It will likely take additional field visits, surveys and literature searches in subsequent planning stages to determine whether these species occur within the project area.

The project site contains considerable areas that are likely to be jurisdictional waters and wetlands of the US and State. These areas are all associated with the lagoon; no potential jurisdictional

areas away from the immediate vicinity of the lagoon itself were identified. Alterations to these jurisdictional areas will require permits and all project designs should seek to be self-mitigating for such impacts.

2.7.1 Vegetation

In order to give a general characterization of the vegetation within the project site, ESA team member CRC conducted reconnaissance-level vegetation mapping in November 2015. Reconnaissance level mapping was done in order to inform the development of a conceptual restoration plan for the site and is not robust enough for use in CEQA or permitting. Our goal with this mapping effort is to generally characterize the on-site vegetation. Reconnaissance level mapping does not include detailed GPS based data collection of community polygons. Instead, community polygons are estimated based on the most recent high-resolution aerial photos and on the ground investigation by CRC staff. This vegetation mapping is sufficient for providing general guidance as to where potentially sensitive habitats (*e.g.*, coastal sage scrub) might occur and to provide a general idea of the quality of habitat on site in its current state.

A vegetation survey of the project area was conducted by CRC Principal Matt James on November 15, 2015. The survey identified nine general vegetation communities at the site (Fig 26). The vegetation was classified into communities based primarily on their dominant species except in landscaped areas. Due to the prevalence of non-native and horticultural species at the site, our classification scheme does not strictly follow the California Native Plant Society's (CNPS) scheme (Sawyer et al. 2009), though there is some overlap in terminology.

2.7.1.1 Existing Vegetation

The project area is dominated primarily by non-native vegetation. Despite the dominance of non-natives, 26 native plant species were found on the site in November 2015 (**Table 2-12**). Native plants are found in relatively low numbers and with minimal cover compared to invasive and horticultural non-natives (**Table 2-13**). The nine vegetation communities and two unvegetated cover types identified during mapping are explained below (**Figure 2-34**).

***Arundo donax* community**

Arundo donax (giant reed) dominates this vegetation community. *Arundo donax* is a common invasive along creeks and rivers in southern California and often excludes native riparian trees and shrubs and forms monotypic stands. Within the project area, dense *Arundo donax* patches occur on both the northern and southern banks of the lagoon (Figure 2-34). The only two willow trees seen on site, both *Salix lasiolepis* (arroyo willow), were found within the *Arundo donax* community. Generally, there is very little plant diversity within the *Arundo* patches and native cover is estimated to be between 5% and 10% overall.



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Figure 2-34

Vegetation Communities within the Project Area

TABLE 2-12
NATIVE PLANTS FOUND WITHIN THE PROJECT AREA IN NOV. 2015

Species	Common Name
<i>Ambrosia psilostachya</i>	Western ragweed
<i>Anemopsis californica</i>	Yerba mansa
<i>Artemisia californica</i>	California sagebrush
<i>Artemisia douglasiana</i>	Mugwort
<i>Baccharis pilularis</i>	Coyote brush
<i>Baccharis salicifolia</i>	Mulefat
<i>Conyza canadensis</i>	Horseweed
<i>Distichlis spicata</i>	Salt grass
<i>Elymus condensatus</i>	Giant rye grass
<i>Elymus triticoides</i>	Creeping wild rye
<i>Encelia californica</i>	California sunflower
<i>Eriogonum fasciculatum</i>	Common buckwheat
<i>Frankenia salina</i>	Alkali heath
<i>Heliotropium curassavicum</i>	Seaside heliotrope
<i>Heteromeles arbutifolia</i>	Toyon
<i>Isocoma menziesii</i>	Coast goldenbush
<i>Jaumea carnosa</i>	Fleshy jaumea
<i>Malacothamnus fasciculatus</i>	Chaparral mallow
<i>Malosma laurina</i>	Laurel sumac
<i>Opuntia littoralis</i>	Coast prickly pear
<i>Platanus racemosa</i>	Western sycamore
<i>Rhus integrifolia</i>	Lemonade berry
<i>Salix lasiolepis</i>	Arroyo willow
<i>Sambucus mexicana</i>	Elderberry
<i>Schoenoplectus pungens</i>	Common threesquare
<i>Solanum spp.</i>	Nightshade
<i>Toxicodendron diversilobum</i>	Poison oak

TABLE 2-13
NON-NATIVE PLANTS FOUND WITHIN THE PROJECT AREA IN NOV.2015

Species	Common Name
<i>Acacia cyclops</i>	Coastal wattle
<i>Aptenia cordifolia</i>	Heartleaf iceplant
<i>Arundo donax</i>	Giant reed
<i>Asparagus aethiopicus</i>	Asparagus fern
<i>Atriplex semibaccata</i>	Australian saltbush
<i>Bromus diandrus</i>	Rip-gut brome
<i>Bromus madritensis</i>	Madrid brome

Species	Common Name
<i>Carpobrotus edulis</i>	Hottentot fig
<i>Chenopodium album</i>	Lamb's quarters
<i>Cortedaria selloana</i>	Pampas grass
<i>Cynodon dactylon</i>	Bermuda grass
<i>Cyperus umbellatus</i>	Umbrella sedge
<i>Echium candicans</i>	Pride of madeira
<i>Erodium cicutarium</i>	Storksbill
<i>Eucalyptus globulus</i>	Tasmanian bluegum
<i>Eucalyptus</i> spp.	Eucalyptus
<i>Euphorbia chamaesyce</i>	Prostrate spurge
<i>Foeniculum vulgare</i>	Fennel
<i>Hedera helix</i>	English ivy
<i>Hirschfeldia incana</i>	Slender-pod mustard
<i>Hordeum marinum</i>	Seaside barley
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Malva parviflora</i>	Cheese weed
<i>Mesembryanthemum crystallinum</i>	Crystalline iceplant
<i>Nerium oleander</i>	Oleander
<i>Nicotiana glauca</i>	Tree tobacco
<i>Opuntia ficus-indica</i>	Nopal
<i>Oxalis pes-caprae</i>	Bermuda buttercup
<i>Paspalum dilatatum</i>	Dallisgrass
<i>Phoenix canariensis</i>	Date palm
<i>Pinus muricata</i> ¹	Bishop pine
<i>Piptatherum miliaceum</i>	Smilo grass
<i>Pittosporum undulatum</i>	Australian cheesewood
<i>Plantago lanceolata</i>	English plantain
<i>Ricinus communis</i>	Castor bean
<i>Rubus armeniacus</i>	Himalayan blackberry
<i>Salsola</i> spp.	Russian thistle
<i>Schinus terebinthifolius</i>	Brazilian pepper tree
<i>Tecomaria capensis</i>	Cape honeysuckle
<i>Tropaeolum majus</i>	Nasturtium
<i>Vinca major</i>	Periwinkle
<i>Washingtonia robusta</i>	Mexican fan palm
<i>Yucca</i> spp.	Yucca

¹ Species native to California but not native to this area

Lawn with horticultural trees

Maintained *Pennisetum clandestinum* (kikuyu grass) lawns occur around the parking lot on the southern side of the lagoon (Figure 2-34). At least three species of trees are planted within these lawns: *Erythrina* spp. (coral tree), *Magnolia grandiflora* (southern magnolia) and *Platanus* spp. (sycamore, plane tree or hybrid). The majority of the trees are some species of *Platanus*, though definite identification at the time of our site visit was not possible (no fruits present and most leaves shriveled). Most or all of the trees appear to be *P. hybrida* (London plane tree), however possibility that some or all of the trees are the native *P. racemosa* (western sycamore) or hybrids of the two species cannot be ruled out. Assuming the *Platanus* trees are not native, it is estimated that the native cover in this community is essentially zero percent.

Coastal sage scrub

Coastal sage scrub is a plant community that is endemic to coastal California and northern Baja Mexico. In southern California this habitat has become especially rare over the last century, primarily due to development. Coastal sage scrub is characterized primarily by drought tolerant shrubs and subshrubs and many different “versions” are recognized in different areas (*e.g.*, Diegan, Riversidian, Venturan, etc.). Within the project site, areas of coastal sage scrub were a mix of typical coastal sage scrub species, including *Isocoma menziesii* (coast goldenbush), *Baccharis pilularis* (coyote brush), *Rhus integrifolia* (lemonade berry), *Artemisia californica* (coastal sage), *Eriogonum fasciculatum* (buckwheat), *Sambucus mexicana* (elderberry), *Encelia californica* (California sunflower) and *Elymus condensatus* (giant rye grass). Many non-natives species were mixed with these natives, especially *Foeniculum vulgare* (fennel), *Carpobrotus edulis* (hottentot fig) and annual grasses such as *Bromus* spp. (bromes). It is estimated that the overall native cover in the coastal sage scrub areas ranges between 10% and 75%. Coastal sage scrub is typically considered an ESHA by the Coastal Commission. More detailed investigations and consultation with the Commission will be needed to determine whether or not some or all of the areas identified as coastal sage scrub would meet their criteria.

***Baccharis salicifolia*/*Acacia cyclops*/*Rhus integrifolia* scrub community**

This plant community is found along the southern bank of the lagoon (Figure 2-34) and is comprised primarily of non-native shrubs and vines with some native shrubs mixed in. It is estimated that this community has >80% cover in the tree/shrub layer and >80% cover in the herbaceous layer. The dominant non-native is *Acacia cyclops* (coastal wattle), a large shrub or small tree that is most likely a horticultural escapee that has naturalized on the moist banks of the lagoon. Other common non-natives in this community include *Carpobrotus edulis* (iceplant), *Myoporum laetum* (Ngaio tree), *Tropaeolum majus* (nasturtium) and a variety of typical non-native annual weeds. *Baccharis salicifolia* (mulefat) is the most common native species in this community and *Rhus integrifolia* (lemonade berry) is dominant in a few small areas. Other native species found scattered throughout this community include *Ambrosia psilostachya* (western ragweed), *Isocoma menziesii* (coast goldenbush), *Toxicodendron diversilobum* (poison oak) and *Heteromeles arbutifolia* (toyon). Overall, this community is characterized by 5-20% cover by native plants.

Horticultural shrubs and trees

Several areas, especially around the Coast Highway bridge, are characterized almost exclusively by horticultural species (Figure 2-34). Some of these areas seem to be maintained (trimmed and weeded) while others seem to be semi-natural (immediately adjacent to the lagoon east of the Coast Highway bridge). Dominant shrubs and trees include *Acacia cyclops* (coastal wattle), *Echium candicans* (pride of Madeira), *Washingtonia robusta* (Mexican fan palm), *Myoporum laetum* (Ngaio tree), *Carissa macrocarpa* (natal plum) and *Nerium oleander* (oleander).

Understory species include *Carpobrotus edulis* (hottentot fig), *Tropaeolum majus* (nasturtium) and *Vinca major* (periwinkle) along with various annual non-native weeds.

***Carpobrotus edulis* community**

In addition to forming the understory to shrubs and trees in some areas, there are a few nearly monotypic stands of *Carpobrotus edulis* (hottentot fig) on the northern and southern banks of the lagoon (Figure 2-34). Three native salt marsh plant species are intermixed in the patch of *C. edulis* on the southern bank in small amounts. Small amounts of *Jaumea carnosa* (fleshy jaumea), *Frankenia salina* (alkali heath) and *Distichlis spicata* (salt grass) are found here. Overall, the estimated native cover is between 1% and 5% in the *Carpobrotus edulis* community.

***Baccharis salicifolia* scrub community**

Several relatively small areas along the margins of the lagoon were classified as *Baccharis salicifolia* scrub. *Baccharis salicifolia* (mulefat) is the dominant species in these areas. A wide variety of non-natives are also found in these areas, including many weedy annual species and invasive vines found through the project area. Several native shrub species are found in the community as well, including *Isocoma menziesii* (coast goldenbush), *Baccharis pilularis* (coyote brush), *Rhus integrifolia* (lemonade berry), *Artemisia douglasiana* (mugwort) and *Toxicodendron diversilobum* (poison oak). Overall, the estimated native cover in this community is between 20% and 50%.

***Cynodon dactylon* community**

Cynodon dactylon (Bermuda grass) forms monotypic stands right at the waterline along two stretches of the lagoon (Figure 2-34). It is possible that some *Distichlis spicata* (salt grass), which is very similar in appearance to *C. dactylon*, is mixed in to this community, but it was not detected during the November vegetation survey.

***Cortaderia selloana* community**

Cortaderia selloana (pampas grass) occurs in a few areas near the eastern end of the lagoon where it is growing out of cracks in the concrete retaining wall on the north bank. There is evidence that annual species may also grow in these cracks adjacent to the large *C. selloana* plants but difficulty with access prohibited closer inspection during our survey.

Unvegetated beach

An area surrounding the mouth of the lagoon is unvegetated beach (Figure 2-34). The substrate here is prone to regular erosion and accretion depending on weather and waves. At the time of our visit, there was no vegetation within the project area on the sandy beach around the mouth of the

lagoon. At a different time of year this area could support some plants. The extent of unvegetated beach within the project area will vary in size and shape depending on how recently the mouth has breached, water level in the lagoon, recent wave climate, etc.

Developed areas and rip-rap/retaining walls

There are large areas within the project area that are not vegetated. These include the parking lot, bathroom and concrete paths on the southern bank (Figure 2-34). A dirt parking/staging area on the northern bank is also unvegetated. There are also several areas along the margins of the lagoon that are unvegetated due to rip-rap and retaining walls.

2.7.2 Special Status Species

A wide range of special status species could be found within or near the project area. It is important to understand how restoration of the Aliso Creek Estuary might potentially impact and/or benefit all of these species. In order to get a general understanding of which species might currently occur within or near the project site, the CNDDDB was consulted. Using the CNDDDB, a list of all special status species that have been reported to occur within the Laguna Beach USGS Quad and the other eight adjacent USGS Quads that surround the Laguna Beach Quad was compiled.

This approach of compiling a complete species list of the nine quads (for this project there are only five adjacent quads due to the coastal location) is standard practice in assessing the potential for special status species to occur on or near a project during environmental review and permitting. This preliminary assessment is intended only to inform the conceptual restoration design and provide guidance as to the potential impacts to special status species and to highlight certain species that might benefit from different restoration designs for the Aliso Creek Estuary Restoration.

2.7.2.1 CNDDDB List of Special Status Species

Our search of the CNDDDB yielded 154 special status plants, animals and communities that could potentially occur within the project area (Appendix C). These species fall in to a wide range of different regulatory statuses that all have different potential levels of protection. Species that are listed as endangered or threatened by California or the federal government generally receive the highest level of protection. Plants listed as 1B (considered very rare and threatened with extinction) by the CNPS generally receive careful protection as well. CNPS also rates different levels of rarity and several other state, federal and international agencies have myriad statuses as well. Any species that is included on any special status list, if found on a site, may trigger regulatory scrutiny. Similarly, any restoration actions that can benefit these species is of particular interest to the extent that the project could help lead to their recovery and/or protection.

We have assigned preliminary estimates of the potential for each species or community to occur within the project area. Species with a “high” potential to occur (11 total) include those for which (1) the site has appropriate and sufficient habitat to support for at least part of their life cycle and (2) are expected to commonly occur in the region. Species with “moderate” potential to occur (33 total) include those for which potential habitat may be present within or near the project site but

more research is needed as to their potential to occur on site. Species with “low” potential to occur (110 total) include those for which (1) appropriate habitat does not exist on site or (2) were not found during the vegetation survey (perennial plants only).

Several of the species that currently have low or moderate potential to occur on site could benefit from ecological restoration. If appropriate habitat is restored, in sufficient amounts, some special status species might be able to colonize the site naturally or be re-introduced. Restoration designs could be tailored to meet the needs of certain target species. However, the relatively large number of potential species that could be targeted must be balanced by the relatively small size of the project area.

Tidewater Goby

Aliso Creek Estuary once supported an estimated 10,000-15,000 tidewater goby in the late summer and early fall (Swift et al. 1989). Tidewater goby were last collected in Aliso Lagoon in 1978 (USFWS 2005). Known and potential contributors to this extirpation include point-source and non-point-source pollution, artificial breaching of the lagoon mouth, encroachment by development, channelization, reduction or modification of habitat, recreational activity in the lagoon and non-native fish predators (USFWS 2005). While it was most likely a combination of these factors that led to the extirpation of this species from Aliso Lagoon, channelization and loss of habitat area are probably the most critical factors. The lagoon currently has little or no off-channel refugia with emergent vegetation where tidewater goby can forage and seek shelter from predators. Restoration actions within the lagoon that include expansion of emergent vegetation and the total flooded area would likely benefit this species and allow for reintroduction. It has long been suspected that tidewater goby populations south of Los Angeles are genetically differentiated from northern populations (Dawson et al. 2001). A recent DNA and morphological study of tidewater goby (Swift et al. 2016) has confirmed that the gobies found historically in Aliso Lagoon belonged to a newly described species (*Eucyclogobius kristinae*) that is currently found in only three lagoon systems (all in San Diego County). Given the rarity of the new species, re-establishing extirpated populations in systems where it once occurred (like Aliso Lagoon) should become a high priority for wildlife managers.

Southern California Steelhead

The historical status of southern California steelhead (*Oncorhynchus mykiss*) in Aliso Creek has varied in recent history. In their 2007 Southern California Coast Steelhead recovery plan, the National Marine Fisheries Service indicated that Aliso Creek had no evidence of historical populations of steelhead (NMFS 2007). However, by the mid-2000s, NMFS identified sufficient information to reverse the prior Aliso Creek designation, and today the lower Aliso Creek is recognized as historic steelhead habitat (USACE 2017). The most recent edition of the NOAA South-central California Steelhead Recovery Plan (National Marine Fisheries Service 2013) does not include Aliso Creek as a targeted watershed for steelhead recovery. There are currently significant man-made barriers to upstream migration within the watershed that probably preclude steelhead from reaching breeding areas even if they were to enter the lagoon. Recent surveys for this species up-stream revealed no steelhead (Dudek 2012).

Southwestern Pond Turtle

In southern California, southwestern pond turtles (*Emys marmorata*) occur primarily along creeks with more-or-less permanent surface water. Aliso Creek, upstream of the project site, is known to support one of the few remaining viable populations of this species south of Ventura County (OC Parks 2009). This species may already occur within the project area though they were not observed by field biologists during two site visits performed for the Aliso Creek Estuary Conceptual Restoration Plan. Southwestern pond turtles are known to occur in coastal lagoons where there is sufficient freshwater inflow and floating or emergent woody vegetation to bask on (Abel 2010). The potential presence of non-native turtles, especially red-eared sliders (*Trachemys stricta*), which are common in perennial water in urban southern California, within the Aliso Creek Estuary should be assessed since this species can outcompete pond turtles, exclude them, and potentially introduce exotic diseases (Spinks et al. 2003). Determining the status of non-native turtles and inclusion of coarse woody debris and restoration of riparian habitats could benefit this species at the Aliso Creek Estuary.

Endangered and Threatened Birds

Even in a restored state, Aliso Creek Estuary will probably not support breeding of any of the threatened or endangered avian species found throughout the region. Salt marsh specialists such as Belding's savanna sparrow typically need larger swathes of pickleweed (*Salicornia pacifica*) than the lagoon could support and Ridgway's rail (formerly Light-footed clapper rail) are found almost exclusively in permanently tidal salt marshes with cordgrass (*Spartina foliosa*). It is unlikely that sufficient acreage of coastal sage scrub could be restored to attract coastal California gnatcatcher. Western snowy plover and least tern may use the beach and open water respectively for foraging, but the high public usage of the beach area will probably exclude this species from nesting in or near the lagoon mouth. Limited potential for riparian restoration will probably keep yellow-billed cuckoo, southwestern willow flycatcher and least Bell's vireo from nesting on the site. Nevertheless, a restored lagoon will provide potential habitat for a wide diversity of birds, many of which are considered special status by various state, federal and international agencies and could provide important habitat for migratory shorebirds and waterfowl moving along the Pacific flyway.

Rare Plants

No special status plant species were observed during the site visit in November 2015. Though no specific, directed searches for any special status species were conducted, it is likely that any present perennial species would have been observed during the course of the vegetation mapping efforts. Despite the apparent lack of rare plants at the site, there is great potential to establish several species through restoration. These include most of the plant species listed with a "moderate" potential to occur on site in Appendix C.

2.7.3 Jurisdictional Assessment including Wetlands and Waters

A preliminary assessment of potential jurisdictional areas within the project area was conducted, which is shown in **Figure 2-35**. This preliminary assessment is meant only to help inform the development of the conceptual restoration plan for the Aliso Creek Estuary and should not be used for any other purpose, including environmental review, permitting or final project design. This is not a jurisdictional delineation. The assessment is based only on cursory observations on-site and observations of aerial photographs by CRC Principal and certified wetland delineator Matthew James. The potential for hydric soil or quantify vegetation cover was not investigated

The “ordinary high water” line and the “top of bank” that typically help to define Army Corps and California Department of Fish and Wildlife (CDFW) jurisdiction respectively were estimated. There may also be jurisdictional wetlands on the beach and on a low-lying bar on the south side of the lagoon (Fig 27) that may be under Army Corps, CDFW and/or Coastal Commission jurisdiction.

2.8 Public Access and Recreation

2.8.1 Introduction

The majority of the project site is located within Aliso Beach County Park. Aliso Beach Park is a coastal regional park which is owned and operated by the County of Orange Harbors, Beaches and Parks (HBP) Department.

2.8.2 Existing Facilities

Aliso Beach is a popular park in southern Orange County and has two primary use areas that are separated by the Pacific Coast Highway. The beach front portion of the park includes a 146 space parking lot, picnic area, playground, concession stand, restrooms, accessible paved paths, fire pits, and the beach. The Aliso Creek lagoon is located at the north end of these park facilities, adjacent to the picnic and playground areas (Figure 1-1).

The inland portion of the park can be accessed by a pedestrian underpass, which crosses under the Coast Highway bridge at the south end, or by vehicle entry from Coast Highway to the inland parking lot. The inland park facilities are located on the south side of the creek. There is a paved inland parking lot providing approximately 120 spaces, with recreational amenities including picnic tables, restrooms, open manicured lawn for unstructured play, and shade trees.

There is also a gravel parking lot on the north side of the creek, part of which is within the park boundary and part of which is owned by SCWD. SCWD is currently using the gravel lot for construction staging/equipment storage. This gravel lot is connected to the inland portion of the park on the south side of Aliso Creek by a sidewalk along the Coast Highway bridge and a stairway down into the park.

DRAFT Aliso Lagoon Jurisdictional Assessment - **Not a Jurisdictional Delineation**



Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-35

Preliminary Jurisdictional Assessment of the Project Area

2.8.3 Recreation Benefit

Aliso Beach Park was evaluated in the Facilities Inventory Assessment prepared for the Resources and Development Management Department (RDMD) in support of the HBP Strategic Plan adopted in 2007. It was found to comply with five criteria developed from the goals and objectives in the Recreation Element of the County of Orange General Plan:

1. The park is 27 acres and of sufficient size to accommodate large numbers of visitors. Park attendance estimates are over 1.1 million visitors annually.
2. The park has sufficient parking to provide public access and accommodate the number of visitors, with 266 parking spaces total between the two paved lots.
3. Aliso Beach Park is a significant local and regional attraction with the majority of visitors from within the county, although over 40% live outside the county.
4. The park is able to satisfy recreation needs of a variety of residents with diverse aquatic recreation opportunities as well as a playground, picnicking and trails.
5. And, the park is readily accessible to law enforcement and emergency services if needed.

Aliso Beach Park is referenced multiple times within the Aliso and Woods Canyon Wilderness Park (AWCWP) Resource Management Plan (June 2009). This plan identified several public access points to the AWCWP from Aliso Beach Park including Access #6 along Village Lane to the AWMA Road/ Coastal Treatment Plant Road and Access #7 Toovet Trail. A formal trail has not been developed along Village Lane. Public access is currently restricted for the private road through the golf course. There is a trail connection from the south side of the inland parking lot, which connects to Monterey Street and the neighborhood south of the park. This trail can be used as a connection to the Toovet Trail within AWCWP by travelling approximately one mile on surface streets within the neighborhood between the two parks.

The inland portion of Aliso Beach Park was specifically evaluated for the County of Orange Environmental Management Agency in the Aliso Beach Inland Area General Development Plan in 1977. In the time since this report was prepared both the park and the surrounding area have changed substantially. At that time, the inland area was identified as underutilized and anecdotal evidence indicates that the same is true today, with minimal use of the inland parking lot and restroom by park attendees except in peak use periods. The General Development Plan is still the County's most recently adopted planning document for the site and is thus the most relevant source for understanding the intended development and use of the site

The planning process resulted in development of a preferred alternative, which became the basis of the General Development Plan. Several elements from that plan have been developed over the subsequent years, including redevelopment of the parking lot and restroom, and development of the open turf areas for unstructured play and family picnicking. These existing elements adhere closely to the graphic concept in the General Development Plan. Other elements that were included in the plan that have not been developed to date include a boardwalk along the stream/lagoon buffer zone, educational amenities, trails and park amenities on the north side of the creek, and a pedestrian bridge connecting the north and south areas of the inland portion of the park. The fishing pier, which was a major component of the 1977 plan, is no longer a feature

of the park (having been removed due to storm damage). As indicated in the 1977 plan, the inland parking lot was designed to accommodate parking demand associated with the pier, a use that no longer exists.

2.8.4 Recreation Potential

Aliso Beach Park currently offers common recreation activities include swimming, surfing, picnicking, fishing, structured and unstructured play. The inland area, creek and estuary are underutilized and provide limited recreation opportunities. Restoration of Aliso Creek could provide some new recreation opportunities within Aliso Beach Park. The park does not currently offer significant quiet natural areas, which is another planning goal in the General Plan. This goal could be achieved through the estuary restoration, with improved floodplain connectivity and native plant community establishment. The restoration, combined with the potential addition of pedestrian boardwalks, bridge and trails would provide opportunities for enjoyment, education, and interpretation and would fulfill elements of the Aliso Beach Inland Area General Development Plan that have not been executed to date.

Several local planning documents, including the AWCWP Management Plan, the Orange County Long Range Transportation Plan, and the Parks Strategic Plan, identify Aliso Beach Park as a staging area for a regional riding and hiking trail that links Aliso Beach Park to Aliso and Wood Canyons Regional Park. The trail connection through the private property of The Ranch Inn and Golf Course does not yet exist.

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SECTION 3

Restoration Goals and Objectives

This section outlines the four restoration goals developed to reflect the overarching desire of ensuring long-term resiliency and health in the Aliso Creek Estuary through a process-driven restoration that respects local constraints and opportunities and is cognizant of regional objectives. The goals and restoration recommendations were developed by local scientists and planners during a focused two-day workshop convened in Laguna Beach on December 9 and 10, 2015. Appendix D (Aliso Creek Estuary Restoration Workshop summary report, prepared by Dr. Eric Stein, Southern California Coastal Water Research Project) documents the workshop and provides the basis for the Aliso Creek Estuary Restoration goals and objectives included below.

Historically, small estuaries and lagoons such as Aliso Creek have not received as much restoration focus as larger coastal systems, partly because their value and importance to regional ecology has been less well-documented than larger systems. Small lagoons and estuaries provide a broad suite of ecological and social functions and services, including nutrient sequestration, sediment control, coastal water quality, species habitat, and recreational value. However approximately 80% of all small lagoons in California have been lost entirely, and much of the remaining systems are significantly degraded.

The WRP has identified quantifiable restoration objectives for a suite of varying coastal systems, including small lagoons and estuaries. Small lagoons and estuaries differ in their relationship to landscapes, watersheds, and the ocean, and restoration planning and long-term management should reflect the unique characters of these small coastal systems. Restoration of the Aliso Creek Estuary is an opportunity to implement the goals of the WRP regional strategy while also considering local opportunities and constraints. With this backdrop, the workshop participants determined goals and objectives for the Aliso Creek Estuary Restoration by considering the best possible ecologically sound strategy in consideration of the natural setting of the estuary and regional WRP restoration goals. The four identified goals are the following:

1. Promote resiliency by basing restoration on historically-informed ecosystem processes in consideration of climate change effects
 - Allow mouth closure to occur on a seasonal to annual cycle consistent with hydrodynamic forcing and historical conditions
 - Minimize dry season freshwater inputs to the estuary
2. Develop a long-term management strategy that is proactive, adaptive, minimally intrusive, and process based
3. Develop restoration priorities that support the WRP regional strategy
4. Promote the use of Aliso Estuary for research, education, and community engagement

To achieve these goals, the workshop participants developed additional long and short-term recommendations.

- The narrow Pacific Coast Highway bridge across the lagoon mouth that restricts mouth migration and tidal flow into the estuary
- Adjacent confinement and fill of the historical estuary associated with the beach parking lot that limits the opportunity for migration or marsh transgression
- The upstream channel that accelerates flow velocities into the estuary and increases the likelihood of scour
- Increased watershed discharge that results in higher wet and dry weather flows, increased sediment loading, and delivery of high levels of nutrients and bacteria.
- Invasive plant and animal species
- Lack of local recognition of the importance of the Aliso Estuary as a wetland resource
- Public opinion and concerns about changes in land use that may be associated with the estuary restoration (e.g. loss of parking areas)

SECTION 4

Opportunities and Constraints

Opportunities and constraints for the restoration of the Aliso Creek Estuary to meet the goals and objectives (Section 3) were developed based on existing conditions (Section 2; the Aliso Creek Estuary Restoration Workshop [Appendix D]); coordination and a series of meetings with key stakeholders including the County of Orange, SCWD, SOCWA, the City of Laguna Beach, and The Ranch at Laguna Beach. Additional opportunities and constraints related to modifying public access features within the Aliso Beach Park to accommodate estuary restoration were identified based on analysis of existing conditions, local development codes, and the requirements of potential recreational elements.

The opportunities and constraints frame the development of restoration alternatives (Section 5.1) and public use options (Section 5.2) and the selection of a preferred restoration alternative and public use options (Section 5.1.2 and Section 5.2.2). These opportunities and constraints are listed and summarized in **Tables 4-1** and **4-2**.

TABLE 4-1
RESTORATION OPPORTUNITIES AND CONSTRAINTS

Opportunities
Increase diversion of dry-season inflows through cooperation with the SCWD
Eliminate or reduce artificial breaching of the estuary by beach users through outreach and education in cooperation with County enforcement
Expand estuary habitat by relocating public park features on publically-owned land
Re-establish estuarine plant and wildlife species including rare and endangered species
Restore ecological connectivity and wildlife corridors between the coast and the Aliso Creek Watershed, including the upstream Aliso and Woods Canyon Wilderness Park and proposed Aliso Creek Mainstem Ecosystem Restoration (planned by the County of Orange and USACE), as well as other inland habitat
Plan and implement the restoration as a nature-based climate change and sea-level rise adaptation measure
Provide public access, interpretation, and education opportunities in conjunction with the restoration
Restore the Aliso Creek Estuary and enhance public use as a “gateway” feature and scenic resource to/for South Laguna Beach
Constraints
Land is owned by public agencies (County of Orange and SCWD) with missions and land-use objectives other than habitat restoration
Expanding estuary habitat requires removal of existing parking and park features, which need to be relocated or balanced with habitat restoration
Current creek water quality is impaired and the long-term restoration of the Aliso Creek Estuary is dependent on the timeline for implementing improvement measures
Re-establishing native plant and wildlife species may require management of non-native and invasive species
The restoration must maintain or improve the existing level of flood management
The restoration needs to consider County management of the Aliso Creek mouth and Aliso Beach for public safety to avoid potentially increasing the need for County management activities

TABLE 4-2
PUBLIC USE OPPORTUNITIES AND CONSTRAINTS

Opportunities
Providing a loop trail through the restoration will serve park users and neighbors. There are numerous view opportunities from various locations around the site. Enhancing the existing creek and riparian corridor will improve habitat, water quality, and visitor experience, and may provide opportunities for environmental education and interpretation The Inland park area and parking lot are underutilized except for a few peak days per year.
Constraints
Coast Highway is a barrier that divides the beach and inland portions of the park. Village Lane is not built within the easement for the road to The Ranch.

SECTION 5

Restoration Alternatives and Public Use Options

Estuary restoration alternatives were developed to identify different approaches to achieve the restoration goals and objectives (Section 3) and address the opportunities and constraints (Section 4). Restoration phases were also identified and planned within each alternative. The restoration alternatives were evaluated relative to restoring ecological function and achieving other restoration goals. Based on this evaluation, a preferred alternative was selected with input from the Science Advisory Team.

Once a preferred restoration alternative was selected, public use options and alternatives were developed to enhance public access and interpretation for the restored estuary and to reconfigure existing public uses to accommodate the preferred estuary restoration alternative. A preferred set of public use options was selected; however, the Conceptual Restoration Plan anticipates that further public use planning will likely be required to select the preferred approach among these options. The Conceptual Restoration Plan presents the preferred set of public use options to show a feasible set of options that would enhance and accommodate the preferred restoration alternative proposed and detailed in this plan.

The Restoration alternatives are discussed in Section 5.1 and the public use options are discussed in Section 5.2.

5.1 Restoration Alternatives

In order to restore the system dynamics for the “perched lagoon small river mouth estuary” (as classified by the WRP) per the goals and objectives, alternatives were developed to restore physical and ecological processes and habitats similar to historic conditions. The restoration alternatives and phasing summarized in **Table 5-1** were developed based on input from the conceptual design meeting with the Science Advisory Team on August 8, 2016.

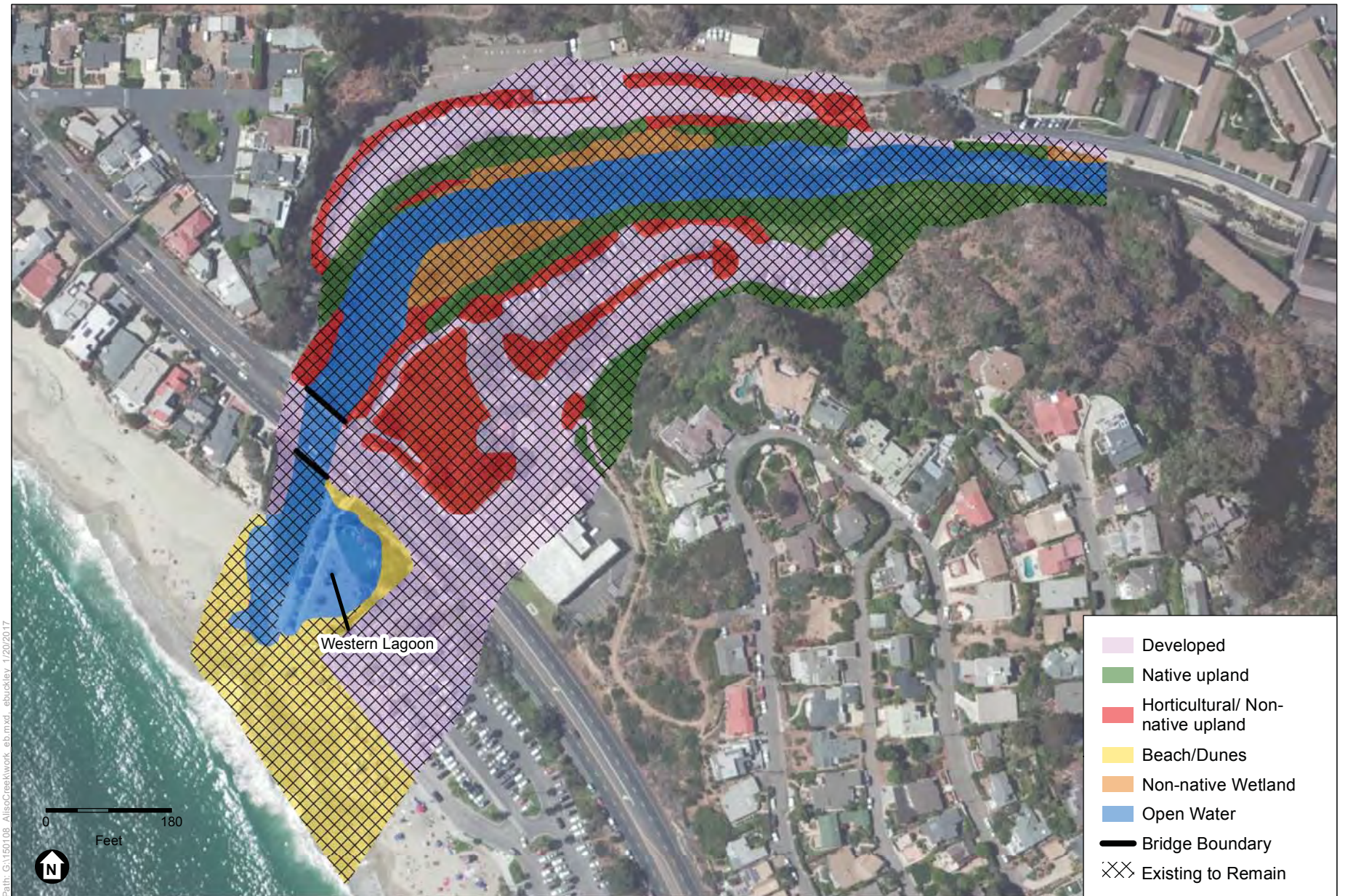
TABLE 5-1
SUMMARY OF RESTORATION ALTERNATIVES, PHASES, AND KEY BENEFITS.

	Phase 1	Phase 2	Phase 3	Phase 4	Key benefits (by Alternative)
Alternative 1	Inflow & mouth management Reduce low flows Reduce artificial/ manual breaching	Western lagoon restoration (Figure 5-1)	Partial restoration of eastern lagoon (Figure 5-2)		Maintains ½ of existing parking in E lagoon Provides area for future wetland restoration with sea level rise
Alternative 2			Full restoration of eastern lagoon (Figure 5-3)		Approaches historic habitat acreage & mouth closure within project area/constraints
Alternative 3				Expand Coast Highway bridge (Figure 5-4)	Enhances channel dynamics Provides habitat connectivity between W and E lagoon
Key benefits (by Phase)	Increases mouth closure	Expands shallow, sandy-bottom, open water habitat	Recreates vegetated marsh and unvegetated flat habitat	Recreates vegetated marsh and unvegetated flat habitat	

Figures 5-1, 5-2, 5-3, and 5-4 show draft conceptual habitat restoration alternatives for the following restoration phases and alternatives:

- Phase 2: Western Lagoon Restoration (which is common to Alternatives 1, 2, and 3) (Figure 5-1)
- Alternative 1 (Figure 5-2), which consists of
 - Phase 1: Inflow and mouth management to reduce dry-season low flows and artificial/manual breaching
 - Phase 2: Western lagoon restoration
 - Phase 3: Partial restoration of eastern lagoon
- Alternative 2 (Figure 5-3), which consists of:
 - Phase 1: Inflow and mouth management to reduce dry-season low flows and artificial/manual breaching (same as Alternative 1)
 - Phase 2: Western Lagoon Restoration (same as Alternative 1)
 - Phase 3: Full restoration of eastern Lagoon
- Alternative 3 (Figure 5-4), which consists of:
 - Phase 1: Inflow and mouth management to reduce dry-season low flows and artificial/manual breaching (same as Alternatives 1 and 2)
 - Phase 2: Western lagoon restoration (same as Alternatives 1 and 2)
 - Phase 3: Full restoration of eastern Lagoon (same as Alternative 2)
 - Phase 4: Expansion of the Coast Highway bridge

The restoration phases are described further below.



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Figure 5-1
Western Lagoon Restoration
Phase 2 of Alternatives 1, 2 & 3



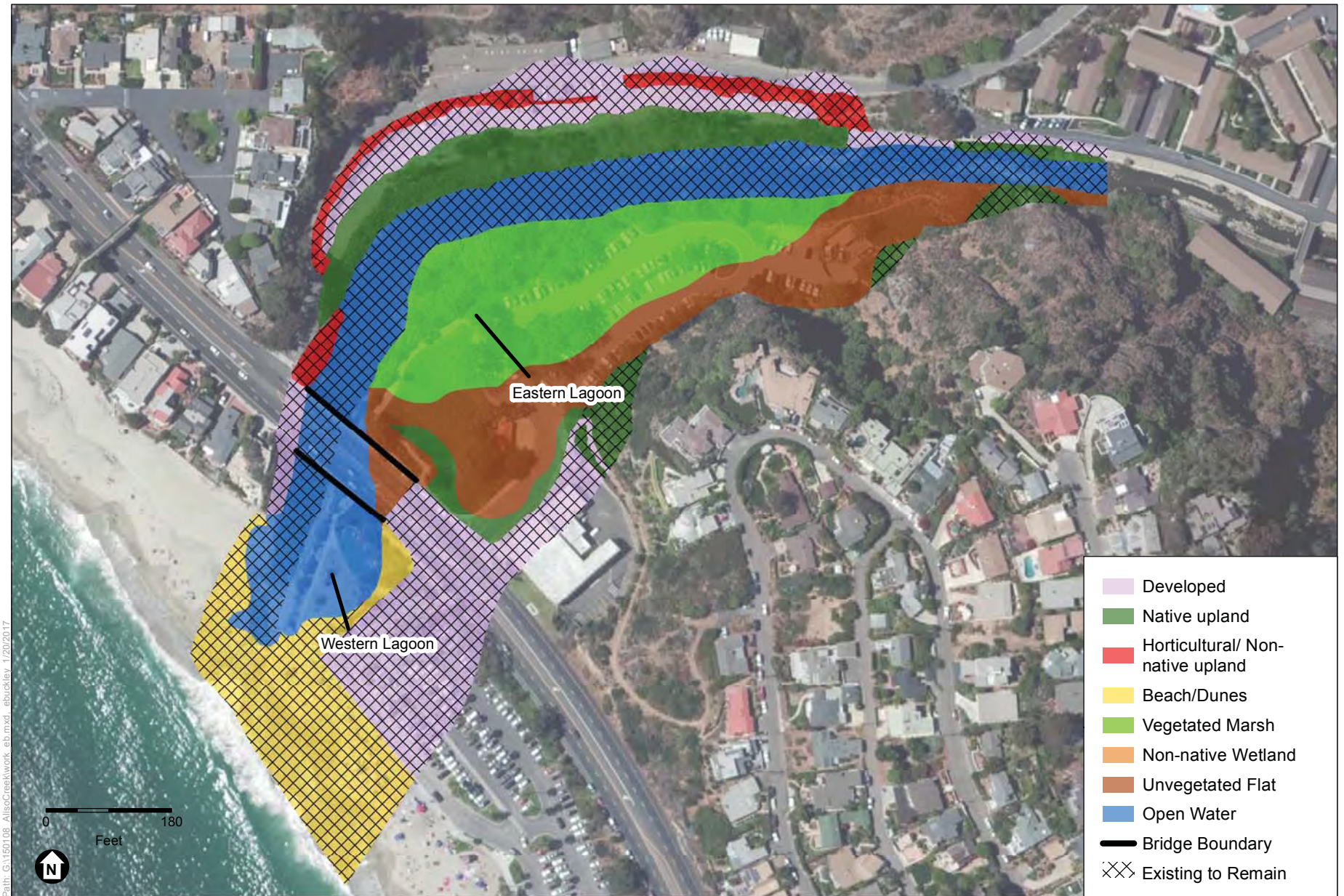
Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-2
Partial Restoration of Eastern Lagoon
Alternative 1, Phase 3 (Final Phase)



Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-3
Full Restoration of Eastern Lagoon
Alternative 2, Phase 3 (Final Phase)



Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-4
PCH Bridge Expansion
Alternative 3, Phase 4 (Final Phase)

5.1.1 Restoration Phases

5.1.1.1 Phase 1: Inflow and Mouth Management

The first phase for all three alternatives is inflow and mouth management. Reducing flow in Aliso Creek and ceasing artificial/manual mouth breaching would allow for the Lagoon to remain closed for longer periods of time. These management measures meet the goal to restore the predominantly closed mouth condition and system dynamics that were characteristic of the historic lagoon habitat system. Under typical existing conditions, the mouth breaches frequently, undergoing closure-breach cycles that can often take place in a single day. Each time that a mouth breach occurs, the lagoon partially drains and the water level drops by several feet. Decreasing dry-season runoff into the Lagoon is predicted to raise water levels on average, because the Lagoon would not fill to the beach crest elevation as rapidly, so mouth breach events would be delayed, and the number of breach events would likely decrease. Based on model results discussed below, a 2.5 cfs reduction in low flows could at times result in a balance between inflow (gains) and evaporation and seepage (losses), allowing for Lagoon water levels to remain constant or increase slowly as the beach berm builds, reducing the likelihood of breaching.

The mouth has also been manually breached periodically by the County for management purposes and by beach users who dig out a channel and surf the standing wave caused by outflow in the channel. Phase 1 of the restoration would include coordination, outreach, and management measures to support the County's recent efforts to prohibit breaching of the lagoon by beach users and reduce the need for the County to breach the mouth for management purposes.

5.1.1.2 Phase 2: Western Lagoon Restoration

In Phase 2, the lagoon on the west side of Coast Highway would be expanded (Figure 5-1). The playground and grass area north of the beach parking lot on the west side of the Highway would be restored into an open water lagoon surrounded by beach and dunes. The existing rock jetty on the south side of the channel would be removed. If needed, new rock armor or similar would be installed around the perimeter of the restored western lagoon to protect adjacent areas from erosion. New armoring could be buried with cobble and/or sand to provide a more natural transition and habitat between the open water and beach/dune habitat and the parking lot. The restored open water lagoon would be constructed as a bench sloping up from the channel bank through intertidal and supratidal elevations, providing a range of open water depths and sand flats. The channel would be allowed to dynamically erode and deposit sand within the restored western lagoon and the confines of any new armoring.

5.1.1.3 Phase 3: Eastern Lagoon Restoration

Phase 3 involves expansion of the eastern lagoon and revegetation of the non-native wetland areas. For Alternative 1, the lagoon would be expanded into part of the parking lot on the east side of Coast Highway (Figure 5-2). Vegetated marsh and un-vegetated flat habitats would be restored. In Alternatives 2 and 3, the full parking lot would be restored to a combination of vegetated marsh and un-vegetated flat (Figure 5-3). Additionally, the north side of the lagoon/north channel bank would be revegetated to restore a natural transition from the open water to the developed areas. Large areas of wetland restoration are not proposed along the north

side/bank of the lagoon because the channel meanders against the hill slope as it did historically. Wetland restoration on the outside bend of the channel may not be sustainable or feasible given that restoration would require excavation of the hillside.

Parking removed to restore wetlands in the eastern lagoon could be partially replaced with parking within the SCWD's dirt lot on the north side of the lagoon, if agreements are secured with SCWD. As included in the public use options (Section 5.2), parking in this location could be combined with interpretive and overlook features and access could be provided to the beach via the bridge and existing stairs and tunnel under the bridge.

5.1.1.4 Phase 4: Coast Highway Bridge Expansion (Alternative 3 Only)

Phase 4 would be implemented only for Alternative 3. In this phase, the Coast Highway bridge would be expanded or lengthened to accommodate a wider channel and lagoon near the mouth (Figure 5-4).

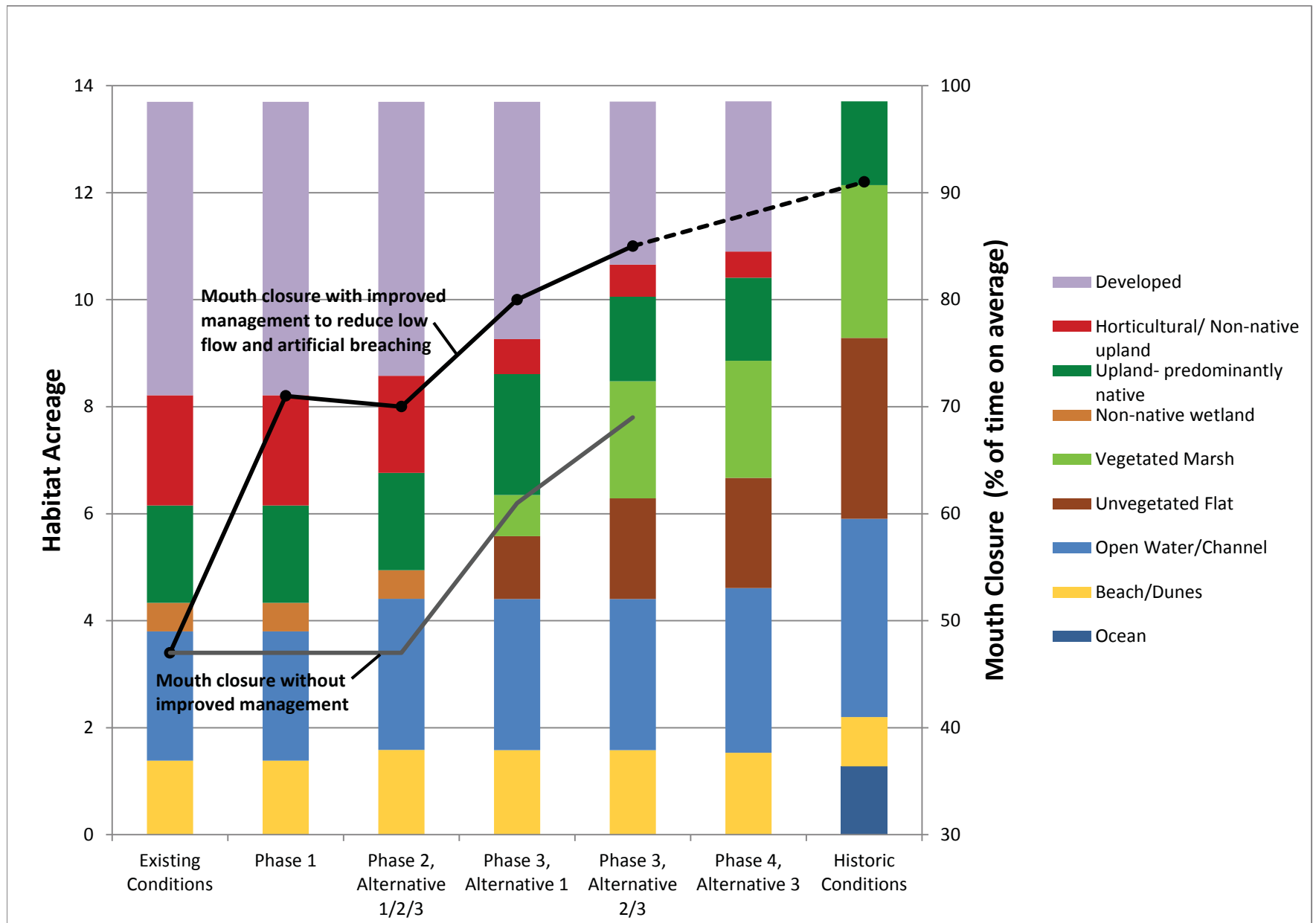
5.1.2 Selection of a Preferred Restoration Alternative

5.1.2.1 Alternatives Evaluation

The restoration alternatives were evaluated based on expected ecological function of the restored estuary and how well the alternatives meet the project goals. Ecological function was evaluated by quantifying and assessing the acreage of restored habitat and increase in mouth closure for each alternative. **Figure 5-5** shows the habitat acreages for each restoration phase/alternative with the predicted increase in mouth closure.

The Aliso Creek Estuary QCM model described in Section 6.2 was used to predict the increase in mouth closure and evaluate the effects of the different restoration phases and alternatives. The model was run for the period from January 20, 2011 to April 30, 2016. Restored conditions were modeled for each phase and alternative as follows:

- To simulate dry-season inflow management, ESA reduced dry-season low flow inflow (defined as Creek discharges less than 20 cfs) by 2.5 cfs. This is twice the existing capacity of the SCWD's upstream low flow diversion and recycling system at the CTP. This low flow reduction could be accomplished by doubling the low flow diversion capacity and storage at the CTP (including permits that would allow for this) and/or implementation of low-flow reduction measures within the watershed.
- To simulate improved mouth management to cease artificial/manual breaching, ESA eliminated artificial/manual breaching of the mouth by the County and/or beach users from the model. The model was trained to simulate past breaching practices by forcing the mouth to breach when the beach berm built to an elevation of 10 ft NAVD. The forced breaching was removed from the model so that the beach berm is allowed to be naturally built by waves to higher elevation.
- Restored topography was developed to represent each alternative and phase as well as historic conditions (as a hypsometric curve). Restored marsh and flat habitats were set at an elevation of 8 ft NAVD, which is around the typical water level expected when the mouth is closed based on monitoring data and previous modeling. For the historic conditions model run, the marsh and flat habitat was set at 5 to 7 ft NAVD.



SOURCE: ESA

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Figure 5-5
Habitat Acreages and Mouth Closure

While the historic marsh elevation is not known, this elevation represents a best guess based on water levels and experience from other predominantly-closed lagoon systems. The modeled elevation for the restored marsh and flat habitats is higher than the historic habitat elevation based on the expectation that the restored marsh and flat will be designed slightly higher to function in response to both current and future sea-level rise.

- A range in the magnitude of sea-level rise was modeled since the effects of higher oceanic tides and extreme wave events will likely be felt long before the 50- or 100- year horizons. The oceanic tides in the model were progressively increased to produce a curve of the expected range in Lagoon water levels.

Note that the model was initially developed using water level data collected from January to April 2016 (see Section 6-2) for the purposes of evaluating alternatives during the data collection effort. The model was refined based on additional water level data collected in the summer of 2016 to further analyze the conceptual restoration plan. As discussed in Sections 6.2 and 6.3.2.1, the refined model gives less mouth closure than the estimates discussed below; however, the relative changes between the closure estimates for existing conditions and restoration alternatives are not expected to be significantly different than discussed below.

Inflow and mouth management

Reducing dry-weather inflow and ceasing artificial/manual breaching have the potential to significantly increase mouth closure compared to existing conditions, independent of expanding lagoon habitats (e.g., from 41% under existing conditions to 71% with Phase 1: Inflow and Mouth Management) (Figure 5-5 and **Table 5-2**). Reducing inflow causes the lagoon to fill more slowly. Ceasing artificial breaching allows waves to naturally build the beach berm to a higher elevation. As a result, the water level reaches, overtops, and breaches the beach berm less frequently.

Lagoon Habitat Expansion

Expanding lagoon wetland habitats that are above tidal elevations increases the volume of the lagoon when it is closed and causes the lagoon to fill more slowly and breach less often. Restoring and expanding the eastern lagoon is expected to significantly increase mouth closure. In combination with inflow and mouth management, Alternative 1: Partial Restoration of Eastern Lagoon is expected to be closed about 80% of time and Alternative 2: Full Restoration of Eastern Lagoon (and Alternative 3, Phase 3) is expected to be closed about 85% of the time in comparison to 90% closure modeled for historic conditions (and about 50% closure for existing conditions).

Expanding lagoon wetlands and volume within the tide range increases tidal volume. This can lead to greater flows and currents through the mouth when it is open, thereby slowing down deposition from waves and potentially preventing or slowing down closure. Restoring open water habitat in Phase 2: Western Lagoon Restoration (before restoring higher elevation wetland habitats in the eastern lagoon in Phase 3) expands the intertidal volume (Figure 5-5 and Table 5-2). The model therefore predicts that mouth closure will not increase in Phase 2; however, the model does predict an increase in mouth closure in Phase 3 per above.

TABLE 5-2
MODELED MOUTH CLOSURE AND LAGOON WATER LEVEL AVERAGED SEASONALLY AND ANNUALLY

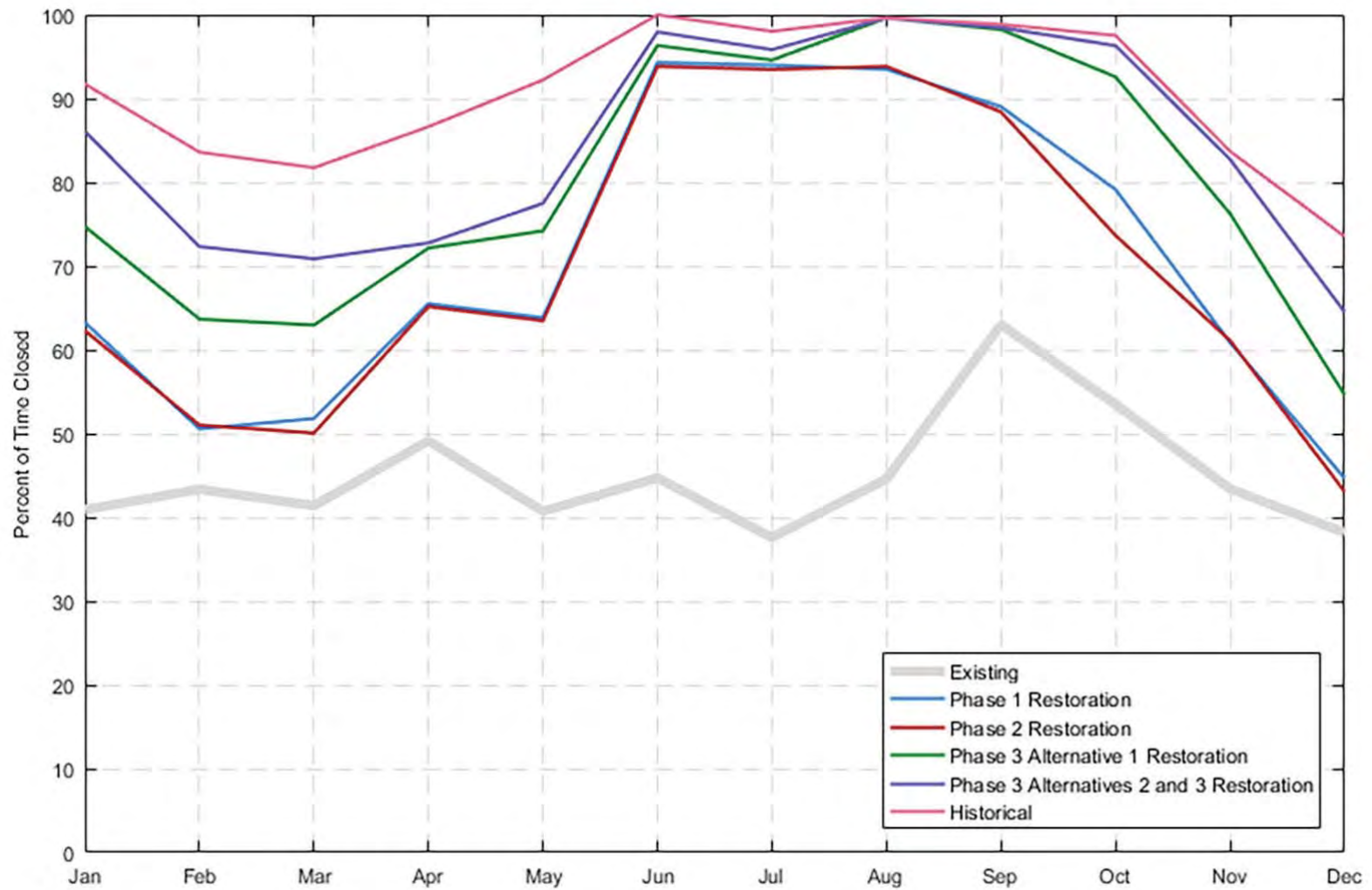
Scenario	% Time Mouth Closed					Average Lagoon Water Level (ft NAVD)				
	Dec – Feb	Mar - May	Jun - Aug	Sep - Nov	Full year	Dec – Feb	Mar - May	Jun - Aug	Sep – Nov	Full year
Existing	39	45	43	60	47	7.57	8.08	8.21	8.84	8.18
Existing w/ SLR	45	47	30	60	46	10.72	10.68	9.76	11.33	10.62
Phase 1	53	60	94	76	71	9.54	9.89	8.99	8.50	9.23
Phase 2	52	59	94	74	70	9.61	9.88	9.00	8.44	9.23
Phase 3, Alternative 1	65	69	97	89	80	9.73	9.31	9.35	9.30	9.42
Phase 3, Alternatives 2,3	75	74	98	93	85	10.06	9.88	9.34	9.47	9.69
Historic	83	87	99	93	91	9.66	8.89	8.64	8.52	8.93

NOTE: Sea Level Rise is noted as SLR in table

Dry- and Wet-season Dynamics

Based on the model results (**Figure 5-6**), the mouth is anticipated to be mostly closed during the dry-season from June to October for Alternatives 1, 2, and 3, with modeled closure of about 95% or greater, which is close to the estimated historic closure. While Phase 1: Inflow and Mouth Management are expected to significantly increase dry-season mouth closure, it is the cumulative effect of the eastern lagoon expansion in Phase 3 of Alternatives 1, 2, and 3 that is expected to increase mouth closure to near historic levels.

For the wet-season months of October to April, the model results indicate that the Phase 1: Inflow and Mouth Management and Phase 2: Western Lagoon Restoration would result in less of an increase in closure. The results suggest that eastern lagoon restoration and expansion would have a progressively greater effect on increasing closure, with more closure in Alternative 3: Full Restoration of Eastern Lagoon than in Alternative 2: Partial Restoration of Eastern Lagoon. None of the restoration alternatives are as close to the predicted historic mouth closure during the wet season as the dry season. This model result is due to the added lagoon volume, which captures enough of the wet-season runoff to delay breaching enough to have a measureable effect on the length of closure events during the wet-season. Thus, with an expanded lagoon, wet-season runoff and discharge events fill and breach the lagoon less frequently. Note that the model does not account for the increase in peak discharge from historic conditions due to hydromodification and the modeled increase in wet-season closure is solely due to the lagoon expansion.



SOURCE: ESA

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Figure 5-6
Modeled Mouth Closure Averaged by Month

During the dry season, there are few precipitation-driven runoff and discharge events. The reduction in low flow and artificial breaching is expected to restore a system that is mostly closed as the low flow reduction is enough to keep the lagoon from overtopping the berm when the berm is allowed to build to natural height. During the wet season, storm discharge events can fill and breach the lagoon. A great amount of storm discharge is required to fill and breach the lagoon for restoration alternatives with greater extents of restoration and larger lagoon volumes. Thus, Alternative 3: Full Restoration of Eastern Lagoon is expected to lead to the mouth being closed more often in the wet season than in Alternative 2: Partial Restoration of Eastern Lagoon. Neither alternative is expected to lead to mouth closure as often as historic conditions, given that the historic lagoon area and volume were greater than can be restored within current constraints.

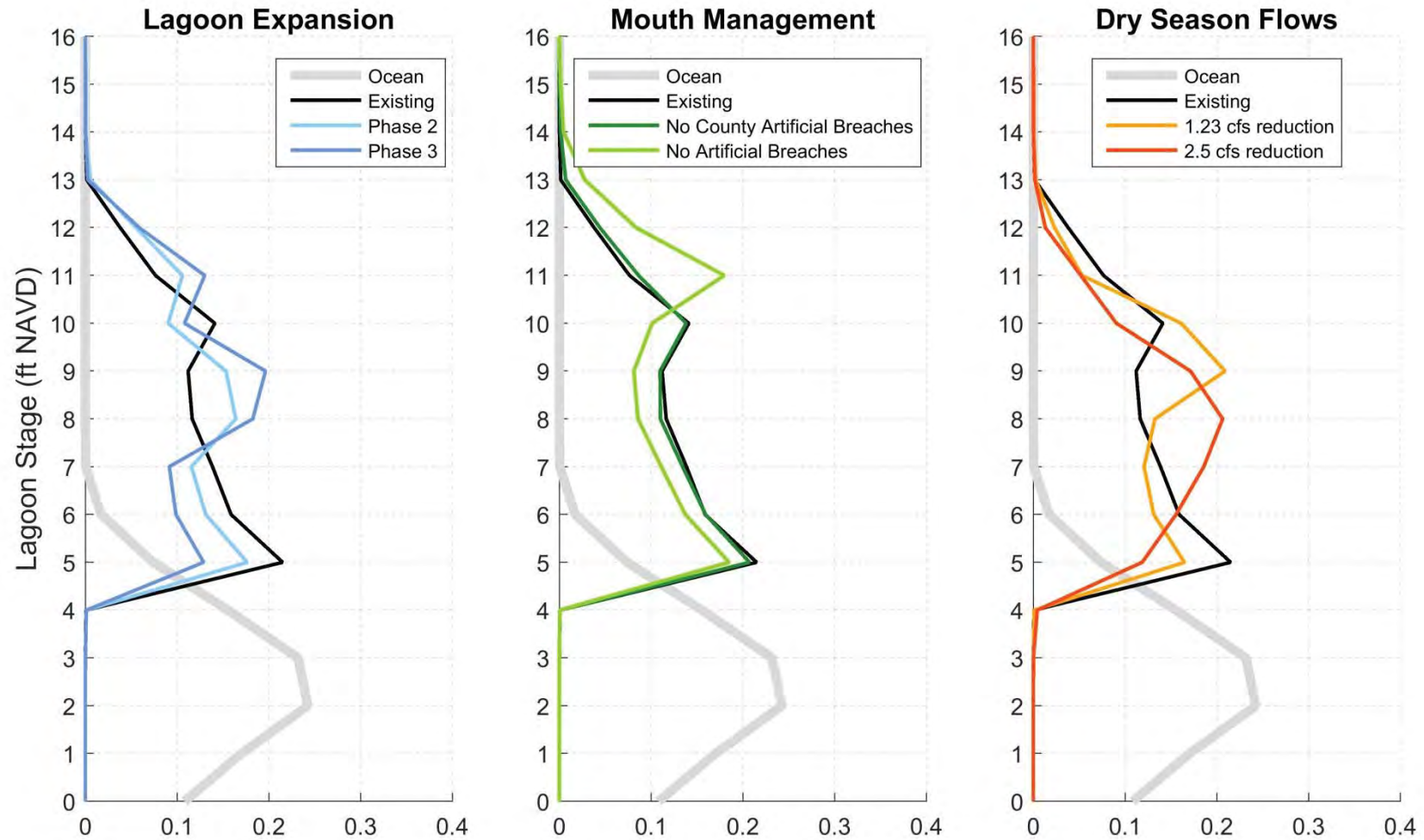
Lagoon Water Levels

The water level inundation frequency within the Lagoon was also examined to understand both the effects of the alternatives, and also some of the phased components. **Figure 5-7** shows expected water level probability density functions for a range of conditions. As described above, altering mouth management practices, reducing dry season inflows, and expanding the lagoon were all predicted to lead to increases in lagoon water level on average.

The results for the conceptual restoration alternatives are also summarized in Table 5-2. Lagoon water levels are generally modeled to progressively increase with Phase 1: Inflow and Mouth Management, Alternative 2: Partial Restoration of Eastern Lagoon, and Alternative 3: Full Restoration of Eastern Lagoon.

Sea-level Rise

Model results for both existing conditions and Alternative 3 with sea-level rise indicate that mouth closure is expected to remain relatively unchanged and that lagoon water levels are expected to increase by the same amount/at the same rate as sea-level rise. These modeling results indicate that the height of the wave-built beach berm is likely to increase with sea levels, causing similar increase in the lagoon water levels. Sedimentation within the lagoon is a key process to consider in assessing the effects of sea-level rise and is further discussed in Section 6.2.



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-7
Predicted Water Level Changes



5.1.2.2 Preferred Alternative Selection

In summary, the restoration alternatives have the following key benefits and tradeoffs:

Alternative 1: Partial Restoration of Eastern Lagoon

- Restores approximately half of the potential wetlands that can be re-created in the eastern lagoon.
- Maintains half of the existing parking in the eastern lagoon, which could possible provide area for future wetland restoration and transgression with sea-level rise.
- Significantly increases mouth closure during the dry-season, but less so in the wet-season.

Alternative 2: Full Restoration of Eastern Lagoon

- Maximizes the restoration of historic habitats in the eastern lagoon (Goal 3).
- Mouth closure frequency approaches estimated historic conditions.
- Leaves the Coast Highway bridge in place.

Alternative 3: Expand the Coast Highway bridge

- Enhances channel dynamics by allowing for greater channel migration and reduced channel scour at the bridge (Goal 1).
- Provides habitat connectivity between the western and eastern lagoon through the restoration of a channel bank with unvegetated flat habitat that shorebirds and other species could use for passage under the Coast Highway bridge between the western and eastern lagoon.
- Involves the complexity, cost, and uncertainty in the timing for the Coast Highway bridge modifications.

Table 5-3 evaluates the alternatives relative to the restoration goals. Based on the evaluation of alternatives relative to ecological function and the restoration goals and input from the Science Advisory Team, Alternative 3 was selected as the preferred restoration alternative that would provide the highest ecological function and best meets the restoration goals. Alternative 3 was selected as the preferred restoration alternative with the understanding that Phase 4: Expand the Coast Highway Bridge can be opportunistically implemented in the longer-term, if and when the Coast Highway bridge is retrofitted or modified for other reasons. Alternative 3 achieves significant benefits in Phase 3: Full Restoration of Eastern Lagoon and provides the opportunity for additional enhancement to occur through the Coast Highway bridge expansion in the future.

Alternative 3 was further analyzed (Section 6) and detailed (Section 7) to develop the conceptual restoration plan.

TABLE 5-3
EVALUATION OF RESTORATION ALTERNATIVES AGAINST GOALS AND OPPORTUNITIES

Alternatives Evaluation		Goals and Alternatives Evaluation Summary (in italics)
Alternative 1	+	1. Promote resiliency by basing restoration on historically-informed ecosystem processes. Allow mouth closure to occur on a seasonal to annual cycle consistent with hydrodynamic forcing and historical conditions. Minimize dry season freshwater inputs to estuary. <i>Summary: All alternatives meet this goal. Alternative 3 restores conditions most similar to historic conditions.</i>
Alternative 2	++	
Alternative 3	+++	
Alternative 1	+	2. Develop a long-term management strategy that is proactive, adaptive, minimally intrusive, and process based. <i>Summary: All alternatives meet this goal by including management actions to reduce artificial breaching and dry-weather inflows that promote native habitats, community involvement, and watershed management.</i>
Alternative 2	+	
Alternative 3	+	
Alternative 1	0	3. Develop restoration priorities that support the WRP regional strategy. <i>Summary: Alternative 3 expands the estuary by a greater amount than other alternatives and uses the “maximum capacity” of the site to support wetland habitat per the WRP. Alternative 1 falls short of fully achieving restoration objectives for the sake of preserving the existing parking lot at its present location, and therefore does not meet this goal.</i>
Alternative 2	++	
Alternative 3	+++	
Alternative 1	+	4. Promote the use of Aliso Estuary for research, education, and community engagement. <i>Summary: All alternatives meet this goal; however, Alternatives 2 and 3 promote restoration and therefore better promote research, education, and community engagement than Alternative 1, which achieves only partial restoration in order to maintain the existing parking lot at its present location.</i>
Alternative 2	++	
Alternative 3	++	
NOTE: The number of + signs indicates the degree to which the alternative meets the goal relative to other alternatives. 0 indicates that the alternative does not meet the goal.		

5.2 Public Use Options

5.2.1 Preliminary Alternatives

Three public use alternatives were developed to explore relocation and replacement options for existing park elements impacted by the preferred habitat restoration alternative. The preferred restoration alternative is designed to provide the maximum habitat restoration benefit within the available area, which results in impacts to the picnic area and playground on the beach side of the park, and the parking lot, restroom, picnic area, and open play field on the inland side of the park.

5.2.1.1 Alternative 1

Alternative 1 (**Figure 5-8**) proposes to shift the inland parking lot to the north side of Aliso Creek in the gravel pad between Village Lane and the creek. This location could accommodate up to 110 parking spaces and replace all of those removed by the restoration, with a separate two-way drive aisle serving head-in parking on both sides. A restroom could be included at the west end of the parking lot. The new parking lot connects to the beach by following the sidewalk along the east side of Coast Highway to the existing stairs and tunnel. This alternative condenses the picnic and playground areas by narrowing the entry drive and north end of the beach side parking lot and reducing the landscaping buffer.

5.2.1.2 Alternative 2

Alternative 2 (**Figure 5-9**) also proposes to shift the inland parking lot to the north side of Aliso Creek. In this alternative, Village Lane is shifted south into the easement for the road. The parking would be divided into two sections of head in parking, one on each side of the road, replacing up to 80 of the existing parking spaces. New sidewalks would be built along Village Lane to connect the new parking areas to the east side of the Coast Highway, the existing stairs and tunnel. This alternative also proposes to reorganize the picnic and playground elements on the beach side. The north end of the parking lot and entry are unchanged.

5.2.1.3. Alternative 3

Alternative 3 was developed as a refinement to Alternative 1 that incorporates elements of Alternative 1 and advances the concept of developing a destination and gateway (**Figure 5-10**). A visitor center and restroom were added to create a destination and further expand on the gateway concept. This alternative includes a small additional parking lot at the location of the current inland parking lot entry drive and a short boardwalk loop to provide opportunities for public access and enjoyment of the restoration areas.

5.2.2 Preferred Public Use Options

Alternative 3 was selected as the tentatively preferred set of public use options for the Conceptual Restoration Plan and the alternative that best meets the goals and public use opportunities and constraints. The alternatives and the preferred alternative/set of public use options were presented and discussed with key stakeholders, including the County of Orange, SCWD, SOCWA, the City of Laguna Beach, and The Ranch at Laguna Beach. Alternative 3 was then carried forward and

further developed into the public use options for the Conceptual Restoration Plan (Section 7 and 7.4). The criteria that guided the selection of Alternative 3 included:

- Developing a single, self-contained parking lot was desirable for public safety, and to control and minimize traffic impacts to other users on Village Lane.
- Relocating Village Lane into the designated easement would be expensive and could negatively affect other adjacent users such as SCWD.
- Placing the parking lot and public use options on the north bank of the creek provides education and interpretive opportunities and views of the restored estuary, habitats, and the ocean in the distance.
- Alternative 3 begins to develop a sense of place and has the opportunity to create a gateway to Laguna Beach.



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-8
Parking Lot Relocation
Alternative 1



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-9
Parking Lot Relocation
Alternative 2



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 5-10
 Parking Lot Relocation
 Alternative 3

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SECTION 6

Hydrology and Water Quality Feasibility Studies

Focused hydrology and water quality feasibility studies were performed for the preferred restoration alternative and Conceptual Restoration Plan to assess the key processes that support restoration of habitats and functions to the Aliso Creek Estuary. These feasibility studies include assessments of hydrodynamics and sediment transport (Section 6.1), estuary water balance and mouth morphology (Section 6.2), water quality (Section 6.3), and climate change and sea-level rise (Section 6.4). These feasibility studies focus on Phase 3 of Alternative 3 (Full restoration of eastern Lagoon) as the near-term phase of the Conceptual Restoration Plan, rather than focusing on Phase 4 (Expansion of the Coast Highway bridge), which is the long-term phase of the Conceptual Restoration Plan.

6.1 Hydrodynamic Assessment

As part of the Aliso Creek Estuary Restoration project, ESA developed a hydrodynamic model using the USACE's HEC-RAS software program (version 5.0.3). The model was used to simulate flow depth, velocity, and shear stress for existing conditions and for the conceptual restoration plan. The following sections document the model development, results, and next steps.

6.1.1 Model Overview

The model domain (i.e., the area covered by the model) extends from the mouth of Aliso Creek downstream of California State Route 1 (CA-1) to approximately 5,800 feet upstream as shown in 6-1. The model is horizontally projected to NAD 83, CA State Plane Zone 6, and vertically referenced to NAVD88. The model combines one-dimensional (1D) geometry representing the channel geometry with two-dimensional (2D) geometry representing overbank floodplain topography. The 1D/2D model was used to analyze an existing conditions scenario and the conceptual restoration plan for the 10- and 100-year flood events. The 100-year flood, which can also be characterized as a flood which has a 1% chance of occurring every year, represents an extreme event that is most relevant to evaluating flood potential and effects to flooding conditions for the restoration. The 10-year event (i.e. a flood which has 10% chance of occurring each year) is expected to occur more frequently and is more relevant to evaluating sediment transport dynamics and associated habitat responses (e.g. erosion, deposition, sediment sorting) under pre- and post-project conditions. This section describes the model inputs and assumptions and the next section describes results for these scenarios.

6.1.1.1 Model Geometry

The 1D channel geometry was represented using a combination of surveyed bathymetric cross-sections and LiDAR sections. **Figure 6-1** shows the cross-section locations and labels the cross-sections by the distance from the mouth in feet. These cross-sections are also shown and labeled in subsequent model results figures using these distances. Cross-sections were surveyed in 2016 by ESA. The LiDAR cross-sections were used to reduce the spacing between cross-sections to provide higher model resolution in areas that were above the water level during the LiDAR survey. However, one potential model refinement would be to replace these sections with more detailed cross-sectional information collected either through additional channel surveys or by developing a more detailed topographic surface in CAD from the channel survey already collected.

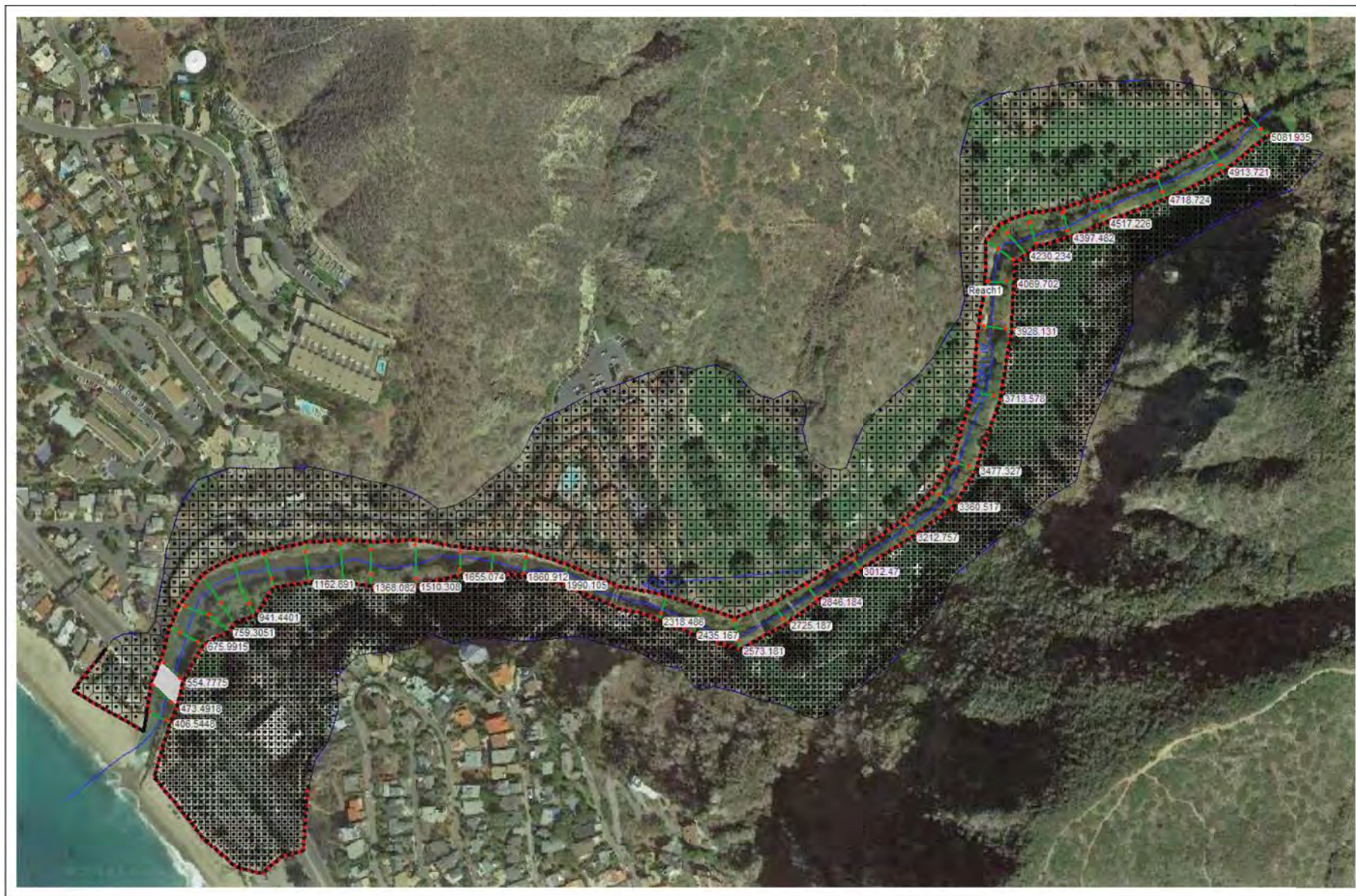
Roughness for the 1D model was selected based on engineering judgement and typical values for this type of open channel setting. Values for the channel, which does not contain vegetation below the water line, is relatively sinuous, and is comprised of fine grain material, range from 0.025 to 0.032.

The 2D channel geometry in HEC-RAS is represented using two components (1) a topographic surface and (2) a computational mesh which overlays the surface. The topographic surface is input as gridded data with higher resolution than the computational mesh. The mesh samples the underlying topography and generates a stage-storage table for each mesh element and tables of stage and conveyance and other hydraulic properties at each mesh face. The topographic surface was generated from a 1-meter resolution coastal LiDAR dataset (NOAA 2012). The computational mesh was set to 20-ft by 20-ft cells.

For restored conditions, a floodplain and tidal marsh area was incorporated into the left bank (left side of channel looking downstream) from Coast Highway to approximately 1,100 feet upstream. A topographic surface for this project component was generated in CAD and spliced into the existing surface using the RAS Mapper tool in HEC-RAS.

Roughness for the 2D model was geospatially distributed based on manually delineated landcover data. Landcover was delineated from aerial imagery data and assigned a roughness value based on professional judgement and typical roughness values for overbank landcover. For existing conditions, the roughness categories included roads ($n = 0.017$), tree cover and forest ($n = 0.1$), grass ($n = 0.03$) for areas primarily covering the golf course, beach ($n = 0.02$), and buildings ($n = 0.5$). The high roughness value for buildings was selected to reflect that some flow can enter a building but the majority will be diverted around the structure. For the conceptual alternative, a category was added for the graded floodplain area representing vegetated conditions with tidal marsh species ($n = 0.05$).

The HEC-RAS feature connecting flow between 1D and 2D areas is the lateral structure. The flow equation governing exchange across these structures is a standard weir equation $Q = C * L * H^{3/2}$, where flow (Q) is a function of a weir coefficient (C), the weir length (L), and the head over the weir (H). The HEC-RAS manual (USACE 2016) recommends a weir coefficient for a natural bank of 0.5, which was selected for the model.



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Figure 6-1
Aliso Creek Estuary Hydrodynamic Model Domain

6.1.1.2 Boundary Conditions

Two flow scenarios were analyzed using the model (1) the 100-year or 1%-annual chance event and (2) the 10-year or 10% annual chance event. Tetra Tech (1999) conducted hydrologic modeling for the Creek and produced hydrographs for these events. ESA was provided the model and hydrographs and used these to define the inflow boundary to the hydraulic model. The peak flows for the 10-, and 100-year events are 4,338 and 8,104 cfs, respectively.

The downstream boundary condition was set to normal depth. Energy slope for this boundary condition was set equal to the bed slope at 0.003 (ft/ft). The bed elevation for the downstream-most cross-section in the model was set to 4.4 ft NAVD to represent a typical elevation at the lagoon mouth without scoured conditions. Although scouring would occur during the modeled events, the fixed bed elevation likely represents a conservative condition with respect to flooding (i.e., causes higher water levels than may actually occur). A future refinement to the model could include lowering the channel bed elevation at the mouth to analyze potentially higher velocity and scour conditions.

6.1.2 Model Results

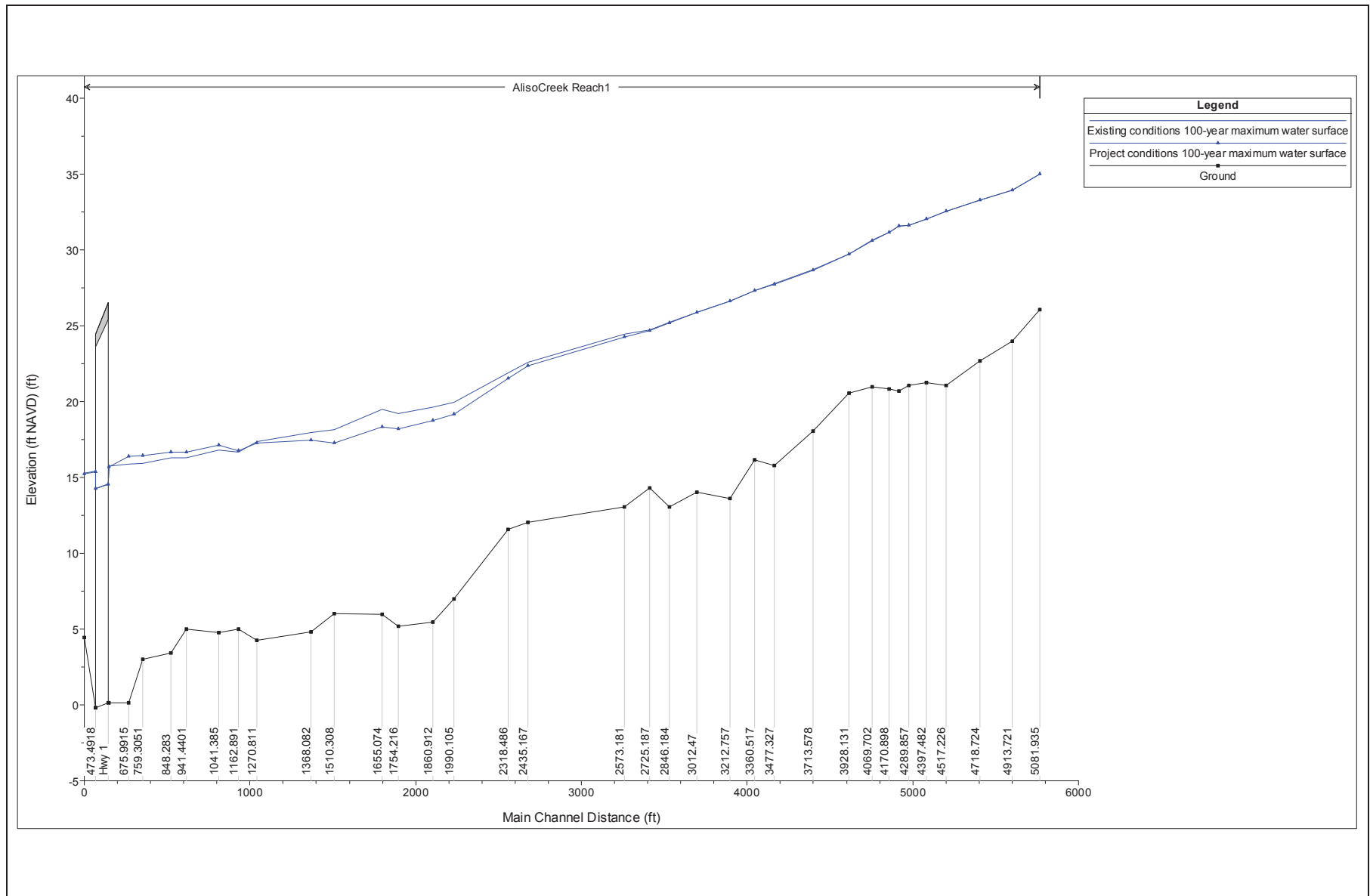
The model was used to simulate hydrodynamic flood conditions for an existing conditions scenario and the conceptual restoration plan for the 10- and 100-year events for a total of four model runs. This section describes the key model results for these scenarios.

6.1.2.1 Hydrodynamic

6.1.2.1.1 100-year event

The 100-year event was simulated to examine how the conceptual restoration plan would affect flow dynamics, focusing particularly on potential effects to water surface and flood extent. A comparison of the water surface elevations for existing and project conditions is shown in **Figure 6-2**, respectively. The maximum flood depth and extent for 100-year existing and project conditions is shown in **Figure 6-3** and **6-4**, respectively.

The water surface profiles show that under the proposed project the flood water surface elevation is lowered along the channel from approximately 1,800 feet upstream of the project site, to approximately river station 1,000—a distance of approximately 2,400 feet. The reduction in flood elevation ranges from 0.1 to 1.1 feet (0.5 ft on average). Downstream of river station 1,000 to Coast Highway, the flood width increases significantly as water extends across the restored floodplain, reducing channel velocities and increasing depths slightly above existing conditions. This results in an increase in flood water elevation ranging from 0.1 to 0.5 feet (0.3 ft on average) over around 660 linear feet of channel and floodplain. This slight increase should be evaluated as a potential effect of the project, which would need to be addressed during design. One potential option to address this during design would be to raise grades around the perimeter of the restored habitats (i.e., the edge between restored habitats and adjacent development) to offset the increase in flood levels.



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-2
100-year maximum water surface elevation profiles





SOURCE: DigitalGlobe (Aerial Imagery, 10/18/2016)

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Figure 6-3
Existing Conditions Max Depth 100-yr Event



SOURCE: DigitalGlobe (Aerial Imagery, 10/18/2016)

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-4
Project Conditions Max Depth 100-yr Event

The inundation extents show slight reductions as a result of the reduced water surface elevation in the vicinity of The Ranch at Laguna Beach. Inundation on the golf course, the private drive parallel to the creek, the guest buildings, and on Village Lane could be somewhat reduced relative to existing conditions.

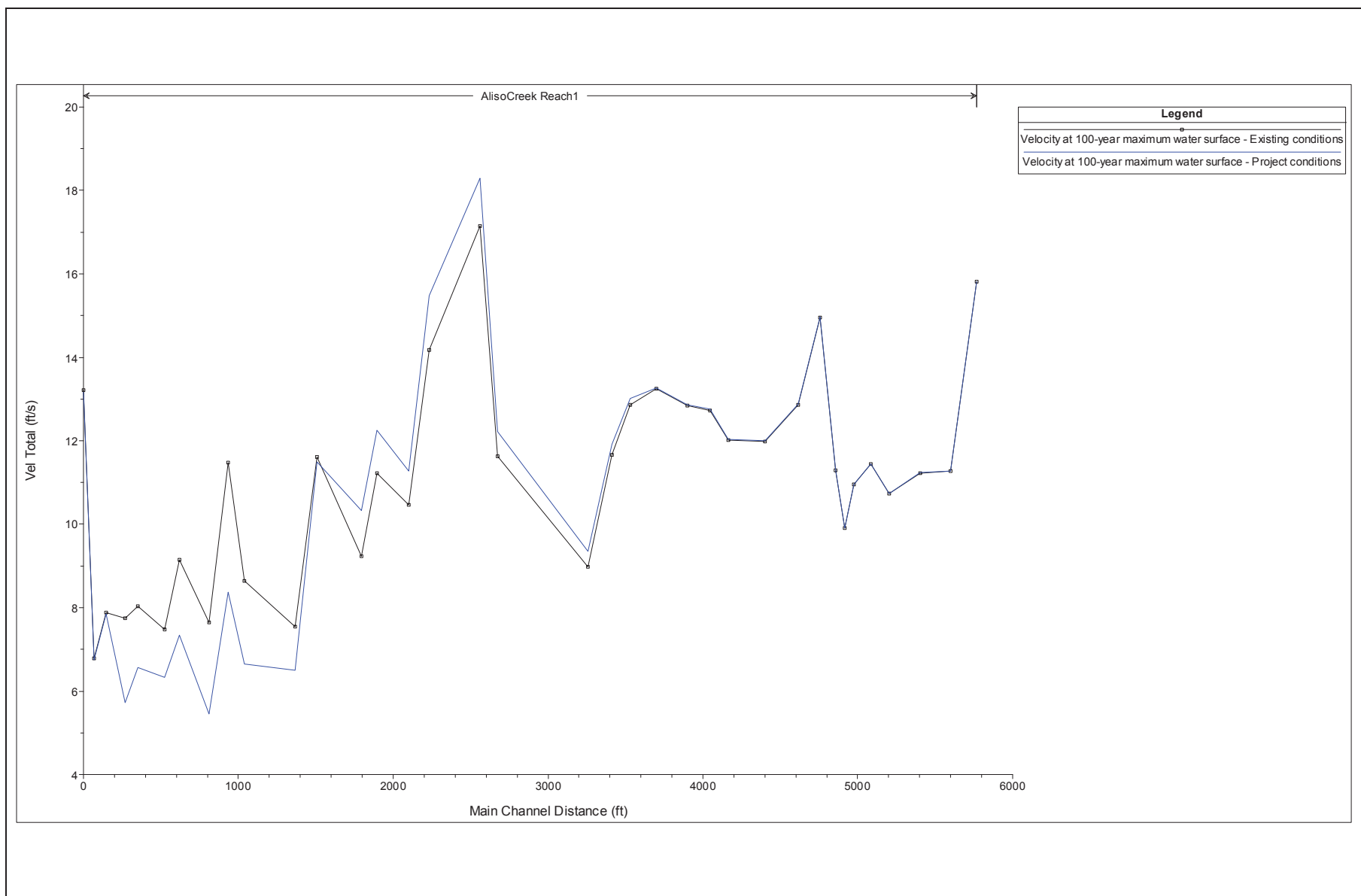
A comparison of the existing and project conditions velocity is shown in **Figure 6-5**. This figure shows that the average velocity in the channel would be reduced by an average of 1.5 ft/s just upstream of Coast Highway for approximately 1,200 feet, at which point the velocity then increases by an average of 0.7 ft/s for approximately 1,700 feet. This increase is caused by the flow expansion into the floodplain which drops water levels and causes a locally steeper water surface profile.

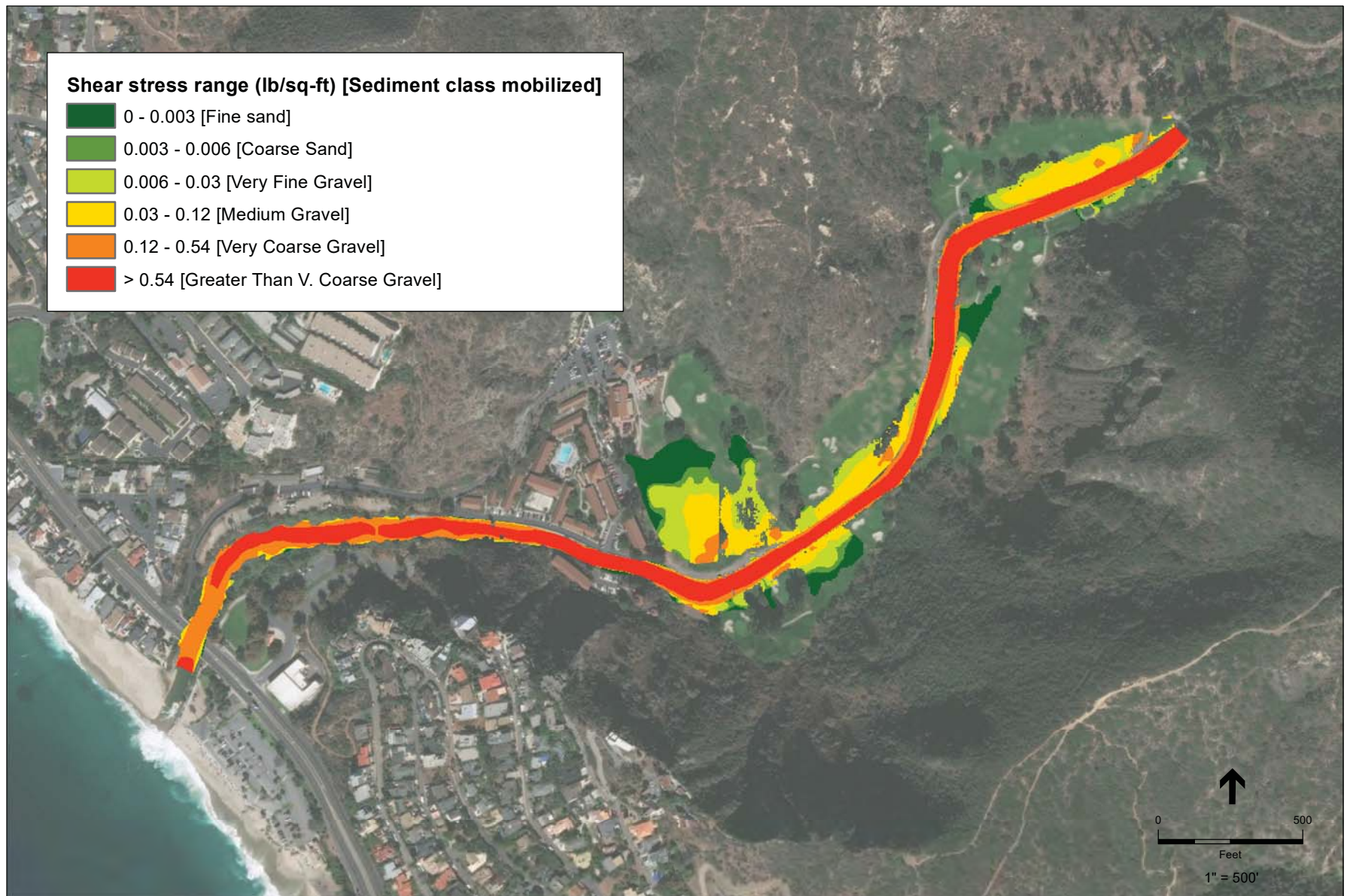
Comparison to FEMA 100-year Flood

FEMA has conducted a detailed study for lower Aliso Creek and has mapped the 100-year floodplain. The results from this analysis differ in a few important ways. The FEMA model was run with a steady flow assumption (i.e., a constant discharge that represents the peak of the 100-year flood). This does not account for the dynamics of floodplain overtopping and storage, and peak flow attenuation in the channel, which are captured in our analysis of a flood hydrograph. Additionally, the FEMA model is represented entirely using 1D cross-sections and no 2D floodplain routing is incorporated. The FEMA 100-year floodplain map shows significantly more inundation than the model developed by ESA. This is attributable in part to the differences in steady versus unsteady flow, and the inclusion of the 2D floodplain routing in the ESA model. The models are not directly comparable due to these differences in model setup. A potential comparison could be developed by running a continuous steady flow in the ESA model. This analysis could be incorporated into future studies to compare the ESA and FEMA models (e.g., for the purposes of revising the FEMA map for the restoration).

6.1.2.2 Sediment Transport Assessment

The 10-year event was simulated to examine how the conceptual restoration plan would affect flow dynamics, focusing particularly on impacts to velocity, shear stress, and erosion potential in the channel and across the graded floodplain. Since flows at the 10-year magnitude are anticipated to occur more frequently than the 100-year event, this event is expected to play a more critical role in cumulatively driving the sediment regime and morphology of the channel, and its associated habitat. The shear stress model output from HEC RAS was used to map the corresponding sediment size that could be mobilized by the 10-year event. Fischenich (2001) presents shear stress ranges that would mobilize the relevant sediment size classes. This table was used to convert the shear stress results to maps of 10-year sediment transport potential shown for existing and restored project conditions in **Figure 6-6** and **6-7**, respectively.



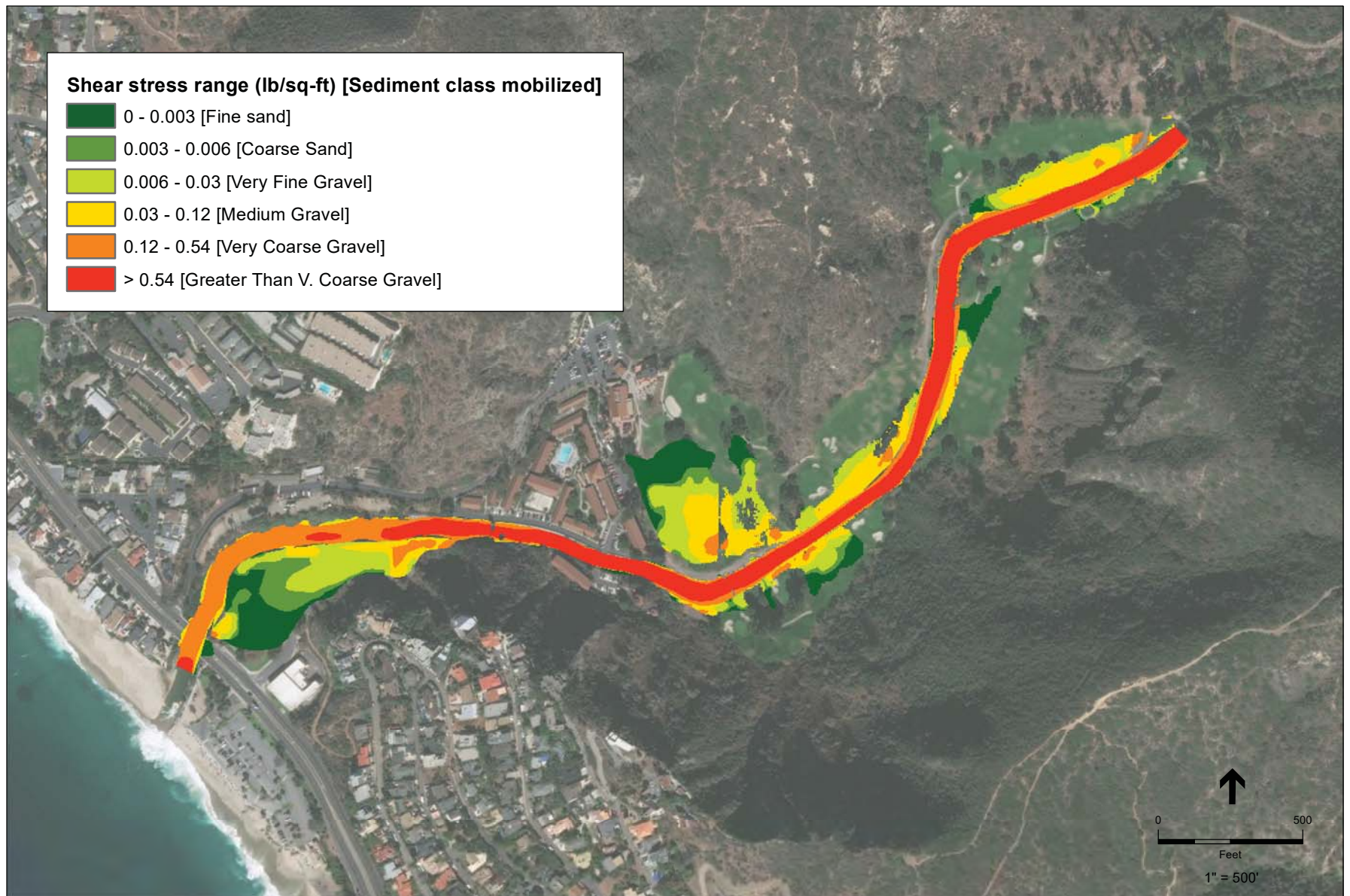


SOURCE: DigitalGlobe (Aerial Imagery, 10/18/2016)

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-6

Potential sediment mobilization for 10-year event - Existing conditions



SOURCE: DigitalGlobe (Aerial Imagery, 10/18/2016)

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-7

Potential sediment mobilization for 10-year event - Project conditions

Note that the analysis is not a full sediment transport mode and only focusses on entrainment of exposed sediment particles. The figures show the largest particle size that would be entrained in a given location at the time of maximum shear stress (which sometimes, but not always, coincides with the peak flow). Shear stress for a given location would be lower before and after this, so sediment could be entrained at peak flow and subsequently redeposited downstream or on the floodplain at lower flows. Entrainment and deposition would also be strongly affected by vegetation on the banks and floodplain. For example, the analysis assumes that sediment is bare, but a vegetated surface would have a shear stress resistance similar to that needed to entrain 6-inch cobble.

These figures show that the restored floodplain exhibits significantly lower shear stress than the channel. This is intuitive as flow is much shallower and slower in this area. The map shows that while gravel is likely to be transported through the creek channel, it would likely be deposited (or at least not eroded) from much of the floodplain area. It can be inferred from this that sand would likely be transported from the channel onto the floodplain at peak flows, where it could be trapped by vegetation or deposited on the falling limb of the hydrograph. The results also indicate that sediment transport capacity is slightly reduced in the channel as a result of diversion of flow from the channel to the floodplain under project conditions. Overlaying these results onto known areas of erosion or deposition allows us to infer the likely project effect. For example, surveys of the lagoon by Tetra Tech 2009 suggest that it is not depositional (though the sediment transport modeling from the same study suggested it was depositional). Field evidence and comparison of as-built surveys at the Coast Highway bridge to current surveys suggests that the Aliso Creek Estuary is stable (i.e., transports sediment through the estuary) to somewhat erosional (e.g., evidence of bed scour at the bridge). If the field evidence of stable to erosional conditions is accepted, the hydraulic model results showing lower shear stress would suggest that the lagoon would become slightly less erosive or slightly depositional under restored project conditions. Tetra Tech (2009) found the reach upstream of the lagoon to be erosional; under project conditions this area would be similar or slightly less erosive. While the model shows that the channel would continue to be the main conduit for sediment, the proposed floodplain does have the potential to trap some sand that would otherwise be transported to the beach: a sediment budget of the beach, channel and floodplain would shed light on the likely magnitude of that effect. If required, a full sediment transport model that captures erosion and deposition processes as well as vegetation effects could be used to assess this process in more detail during design.

6.1.3 Summary and Next Steps

The 1D/2D hydrodynamic model developed by ESA was used to evaluate the effects on hydraulics and sediment transport of restoring floodplain area in the estuary of Aliso Creek. The modeling analysis showed the following key results:

- For the 100-year event:
 - The water surface elevation is reduced by an average of 0.5 feet over a length of approximately 2,400 feet and extending approximately 1,800 feet upstream of the restored floodplain. The reduction in water surface elevation may reduce flooding in an area of the golf course of approximately 16,000 square feet (0.4 acre).
 - For approximately 660 feet upstream of Coast Highway, the water surface is increased by an average of 0.3 feet. Because flood levels are contained within the channel and the restored floodplain, the increase in water surface elevation does not appreciably increase the inundated area.
- Channel velocity for the 100-year event is reduced upstream of the bridge by an average of 1.5 ft/s for approximately 1,200 feet, at which point velocity is increased by an average of 0.7 ft/s for 1,700 feet. Velocity does not change at the bridge. This pattern is the same for the 10-year event.
- For the 10-year event, creek flows would not entrain, and might deposit gravel and sand over much of the restored floodplain. This would support natural habitat functions and deposition that may maintain the restored floodplain into the future with sea-level rise, but could somewhat slightly reduce sediment delivery to the beach.

Potential model refinements that could be implemented to improve the model for future simulations include:

- Refine the channel cross-sections through the project site by interpolating sections or developing an integrated CAD surface of surveyed data. Some of the sections through this area are based on LiDAR and are fairly coarse. This improvement would be recommended to enhance future model runs but it is not expected to have a significant effect on the current version of the model runs.
- Include additional model scenarios with a deeper amount of scour assumed at the mouth of the Creek. These scenarios could be used as a more conservative representation of potential peak velocities and scour conditions.
- Improve the configuration of the computational mesh. Break lines, which could be added to capture high ground elements such as berms which affect flow routing, and other mesh edits could be incorporated to improve the model results.
- Simulate a continuous flow in the ESA model to develop a more valid comparison to the FEMA model. This model scenario could be included in a future study to test how closely the two models compare for the 100-year inundation for the purposes of revising the FEMA map for the restoration.
- Develop a full sediment transport model, and/or develop a sediment budget to assess the magnitude of sand trapping on the floodplain relative to sand delivery from the channel and from coastal sediment transport processes.

The model results suggest that the restoration alternative would provide flood reduction benefits to adjacent properties with minimal increases in water levels in parts of the channel. Flow velocity and scour potential would be reduced at Coast Highway and the restored floodplain would be capable of depositing sediment and supporting ecological functions, enhancing the estuary condition as a result of the restoration.

6.2 Estuary Water Balance and Mouth Morphology Assessment

This section describes the results of a quantified conceptual model (QCM) for Aliso Creek, which was used to assess the effects of the conceptual restoration alternatives and sea-level rise on the future mouth morphology and lagoon hydrology. The use of the model to evaluate the different alternatives is described in Section 6.1. This section focuses in more detail on the effects of the preferred alternative.

The QCM consists of a water balance for the lagoon tied to a sediment balance for the lagoon mouth and beach. It uses time series of coastal and fluvial conditions to drive time series of beach-building from waves, resulting mouth conditions (open/closed/perched), and lagoon water levels. It incorporates gauged freshwater inflows to the lagoon and evapotranspiration losses from the surface, and estimates hydrologic terms that complete the water balance, such as flows through the mouth, wave overwash into the lagoon, and seepage from the lagoon to the ocean. The benefit of this approach is that once a period of several years has been successfully hindcasted to match observations, the same period of time can be run with any number of hypothetical sea level rise scenarios or restoration/management alternatives, to understand their direct influence on lagoon conditions over that same period of time. The goal is typically to find a time period with sufficient data and range of environmental conditions, in order to add confidence in predictions of how the system would behave in the future.

The model was used in this case to hindcast observed mouth closure conditions from 2010 to 2016, and water level conditions measured in 2016. The QCM was developed to better understand lagoon hydrology under existing conditions, to help inform the development of the conceptual restoration alternatives, and to evaluate their potential effects on lagoon habitat.

6.2.1 Existing Conditions Modeling

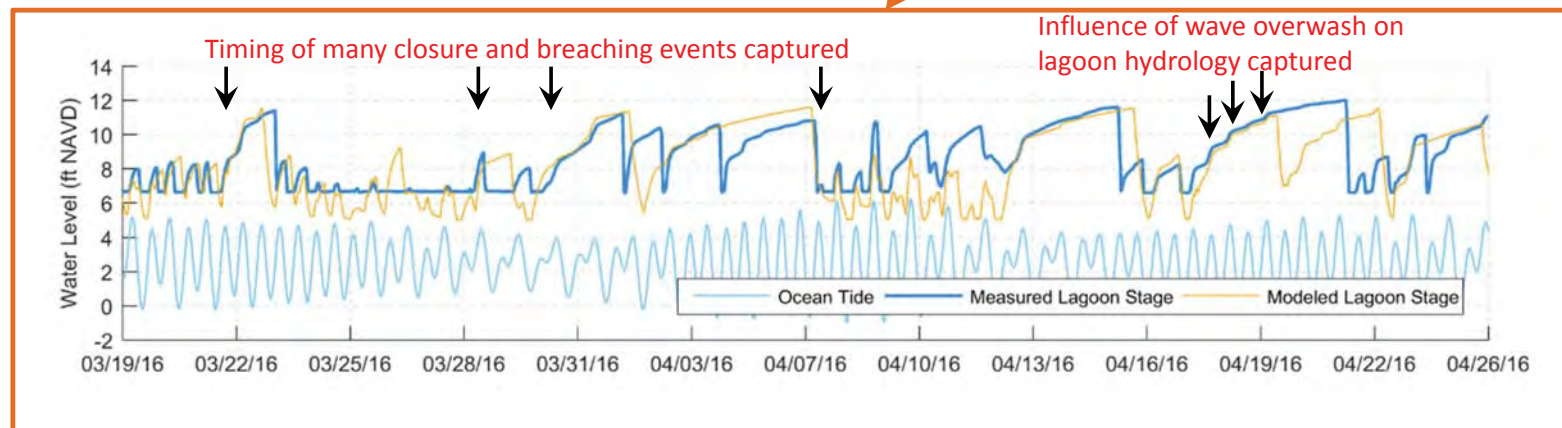
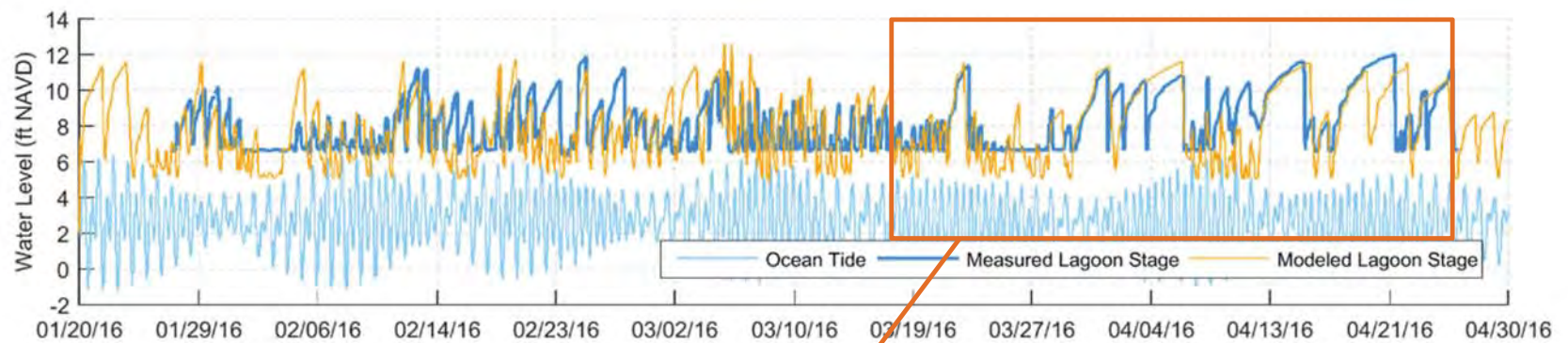
The period from January to April 2016 was used to hindcast conditions in the lagoon. Sources of data used to provide boundary conditions for the model, and used to test its accuracy, are given in **Table 6-1**. To account for breaching by beach users, a cap of 10 feet NAVD was set for the months of May through September. This is a simple approach, but modeling unauthorized breaches from beach users is difficult since it does not follow a specific pattern, other than being more frequent during summer months and during weekends.

**TABLE 6-1
DATA SOURCES**

Parameter	Source/Location	Measurement Period
Coastal Influences		
Offshore Waves	CDIP Model Output OC221	2000-present
Tide Stage	NOAA LA Outer Harbor (#9410660)	1923-present
Beach and Lagoon Mouth		
Inlet Condition (Open/Closed)	Lagoon water level logger and CoastalCOMS photography	2011-present
Beach Crest/Profile	Coastal Conservancy Lidar and ESA survey	2009-2011, 2016
Lagoon Hydrology		
Runoff	OCPW Gage (#1146)	2011-present
Evapotranspiration	CIMIS #75	1987-present
NOTE: CIMIS is California Irrigation Management Information System		

Figures 6-8 and 6-9 show how the model compares against the Lagoon water level data from January to April 2016. Although the exact timing of the closure and breaching events are not always captured, the model reproduces a number of important aspects, such as (1) periods of inlet scour during high watershed runoff, (2) mouth closure during high wave events, (3) the impact of wave overwash on Lagoon hydrology, and (4) inlet breaching. Given the complexity of Aliso Creek Estuary and other similar estuaries, the QCM is best used to reproduce the seasonality of the closures and the expected distribution of water levels in the Lagoon, and not the exact timing of closure or breach events.

Despite the complexity of the system, the model accurately identifies that Lagoon water levels are generally lower during periods of high watershed runoff, indicating that runoff drives inlet breaching, causing water to drain from the Lagoon. Wave overwash is also a driver of mouth breaching, and is thus also related to lagoon draining. Examining conditions in early February 2016 in **Figure 6-10**, a series of short-lived mouth closure events is visible during a period of high wave power from February 7th to 14th. Although these waves likely deposited sediment in the bed, causing the mouth closure events, significant wave overwash is the likely cause of the rapid lagoon breaching since watershed runoff was low at this time and beach users were generally not visible in the site photographs. The model also captures an extended period of closures in late March through April when streamflow was very low. Wave power was relatively low during this period; however, small oscillations can be seen in the rising portion of the April 18 closure, which correspond to a series of high tides. These events are indicative of elevated Lagoon water levels caused by wave overwash.



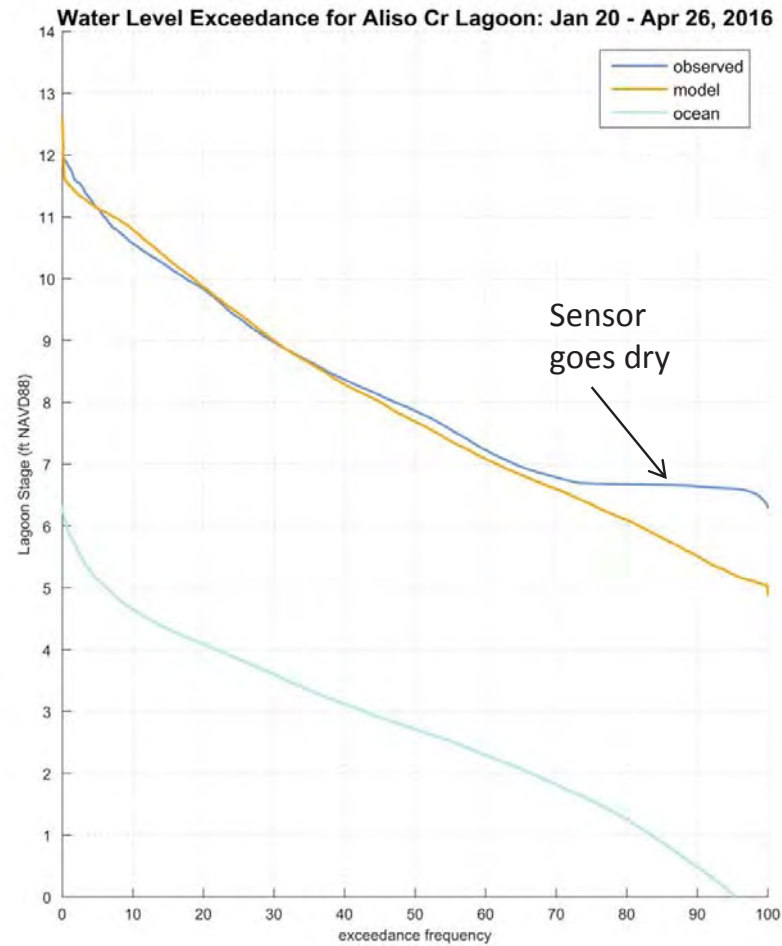
SOURCE: ESA

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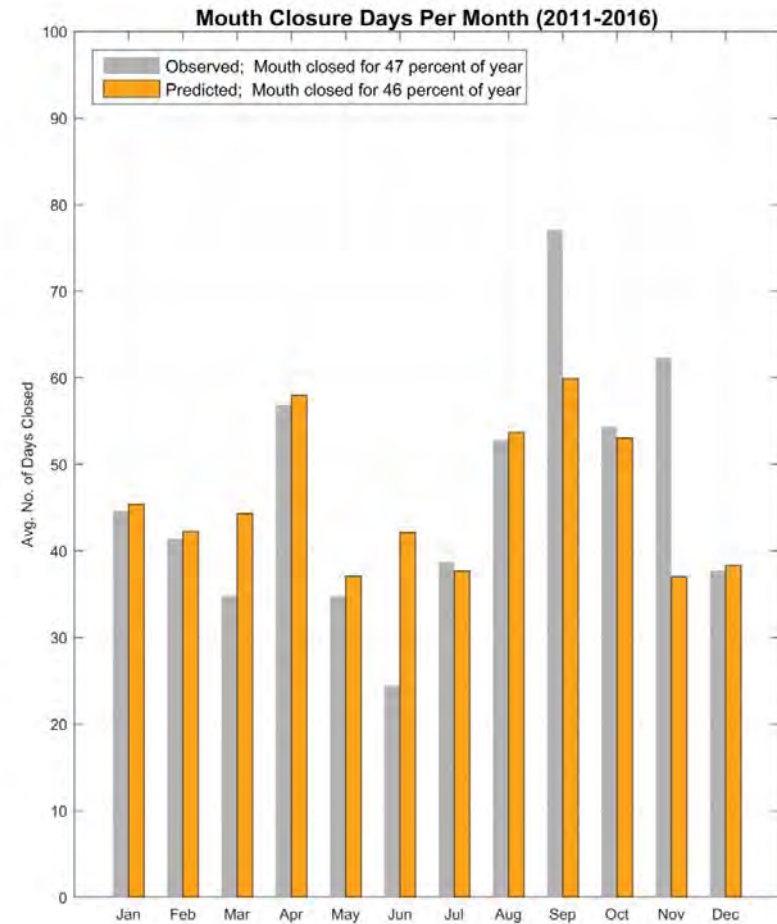
Figure 6-8

Detail of modeled closure events from March-April 2016

Lagoon Water Levels



Mouth Closure Seasonality

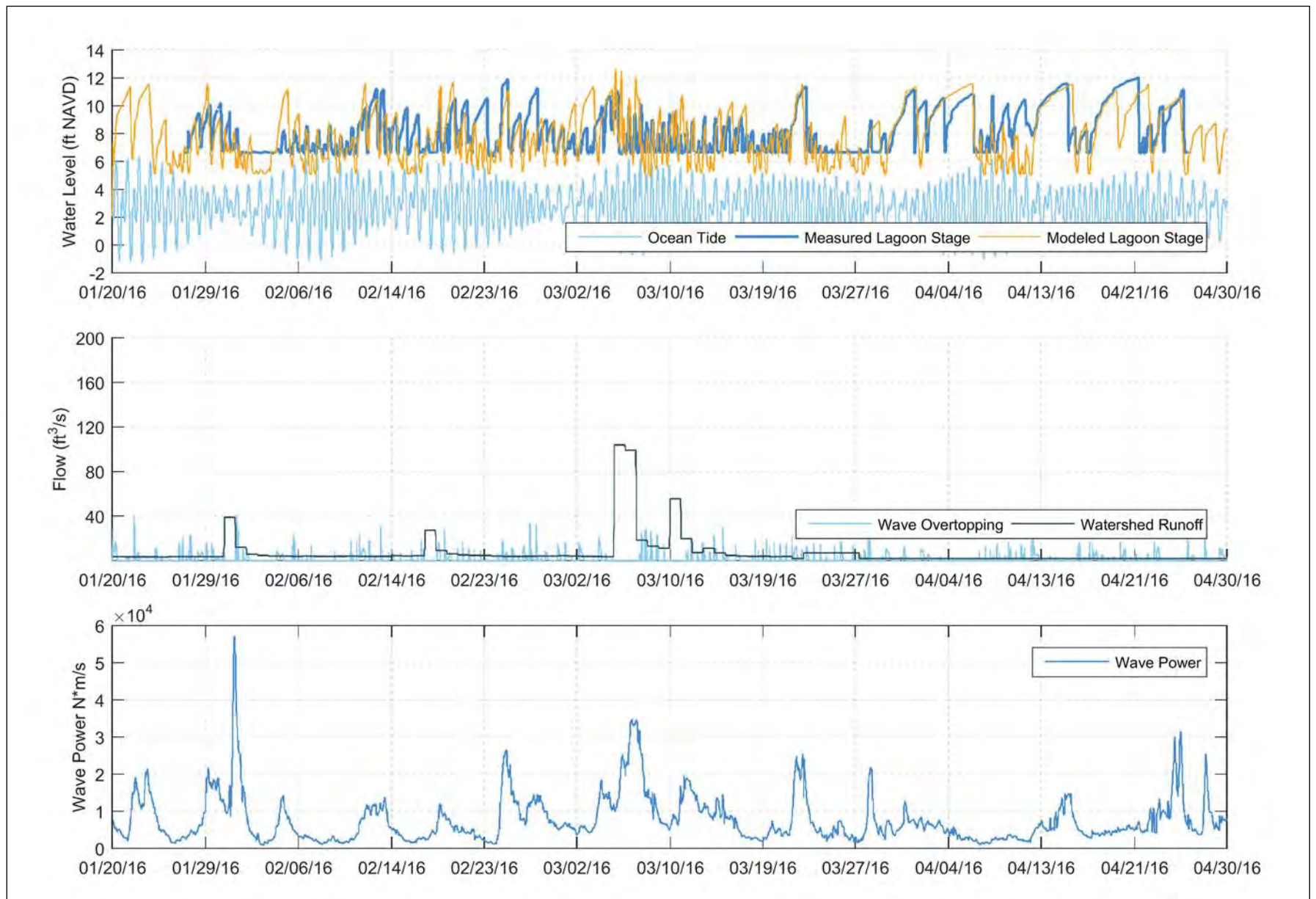


SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-9

Comparison of model and observations:
 (Left) Water level exceedance: 1/2016-4/2016
 (Right) Closure days per month: 2011-2016



SOURCE: See Table 2 for data sources

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-10

Example of modeled closure events from early 2016, showing (top) water levels, (middle) river flow, and (bottom) wave power

Note that the model was initially developed using water level data collected from January to April 2016 as discussed above for the purposes of evaluating alternatives during the data collection effort (see Section 5.1.2.1). The model was refined based on additional water level data collected in the summer of 2016 to further analyze the conceptual restoration plan as discussed in Sections 6.2.2 and 6.3.2.1.

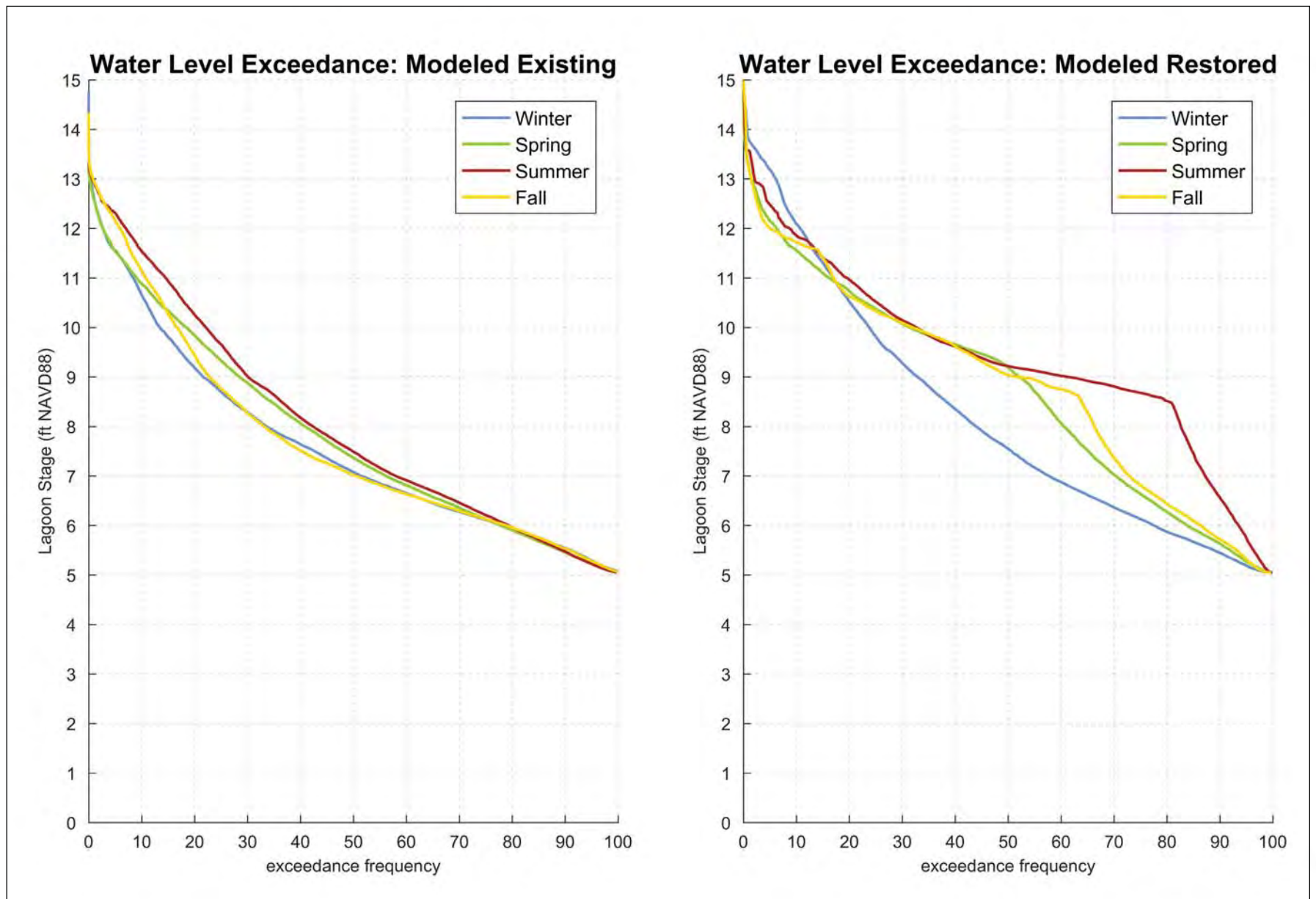
6.2.2 Restored Conditions Modeling

To explore how future changes could influence the behavior of the Lagoon, the same 2011–2016 time series was run with sea level rise and several restoration and management options, as discussed in Section 6.1. As described in Section 6.1, the preferred alternative combines several actions that were found to best meet the restoration goals and objectives. These include cessation of artificial breaching, reduction of freshwater inflows, and expansion of the lagoon volume through removal of artificial fill placed to construct the inland parking lot. The model predicted that each of these changes would contribute to longer seasonal closure events, higher average water levels, and ultimately a greater amount of brackish habitat in the lagoon.

Figure 6-11 shows modeled water level exceedance frequencies for 2011–2016, for both existing conditions and for the preferred alternative. In all seasons, the restoration was predicted to produce higher water levels. The change is greatest from spring through fall. This is because the restoration was shown to increase the likelihood of seasonal closure events (i.e., decrease the frequency of breaching events), which tended to begin in spring and end in late fall during the first major rainfall event of the year.

6.2.3 Sea-level Rise Modeling

A range in the magnitude of future sea level rise was examined since the effects of higher oceanic tides and extreme wave events will likely be felt long before the 50- or 100- year horizons. The same 2011–2016 time period was run with progressively higher oceanic tidal levels for both existing and restored conditions. Since lagoon water levels vary greatly over time, modeled water level results were analyzed to provide the distribution of water levels. **Figure 6-12** (top panel) plots the increase in water levels over time with sea-level rise for existing and restored conditions. The water level distribution is shown in **Figure 6-12** (top panel) by plotting the average water level as well as variation of the water level around the average (i.e., water levels exceeded 25% and 75% percent of the time, which provide a statistical measure of water levels above and below the average). **Figure 6-12** (bottom panel) also shows the expected change in mouth closure frequency with sea-level rise for both existing and restored conditions.

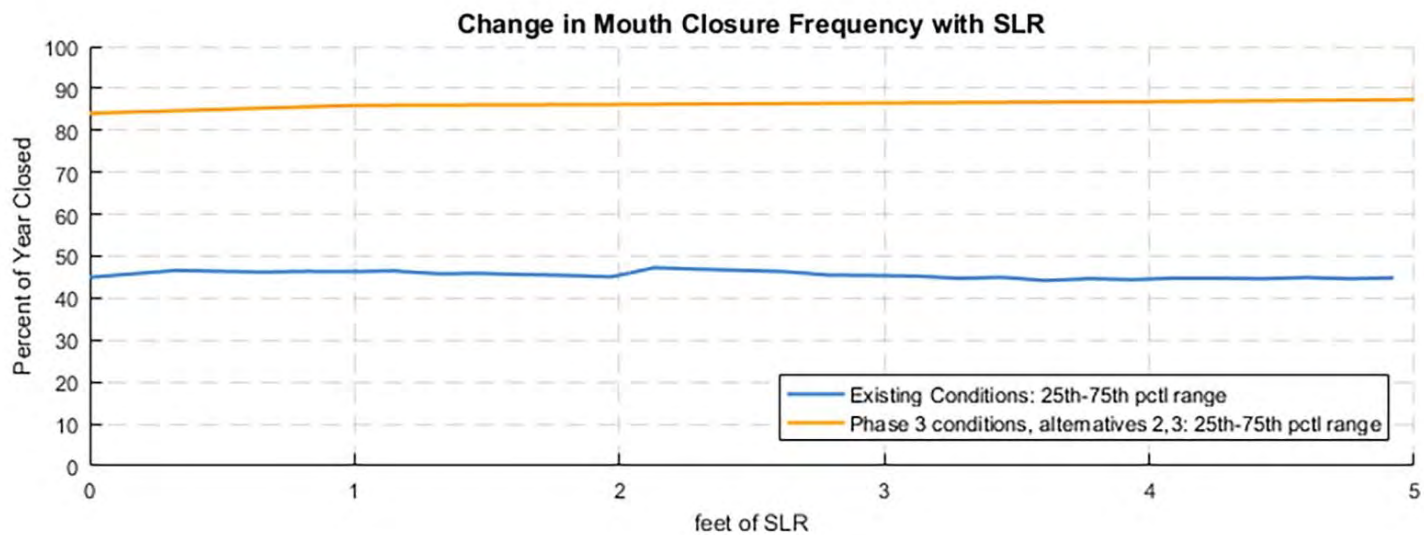
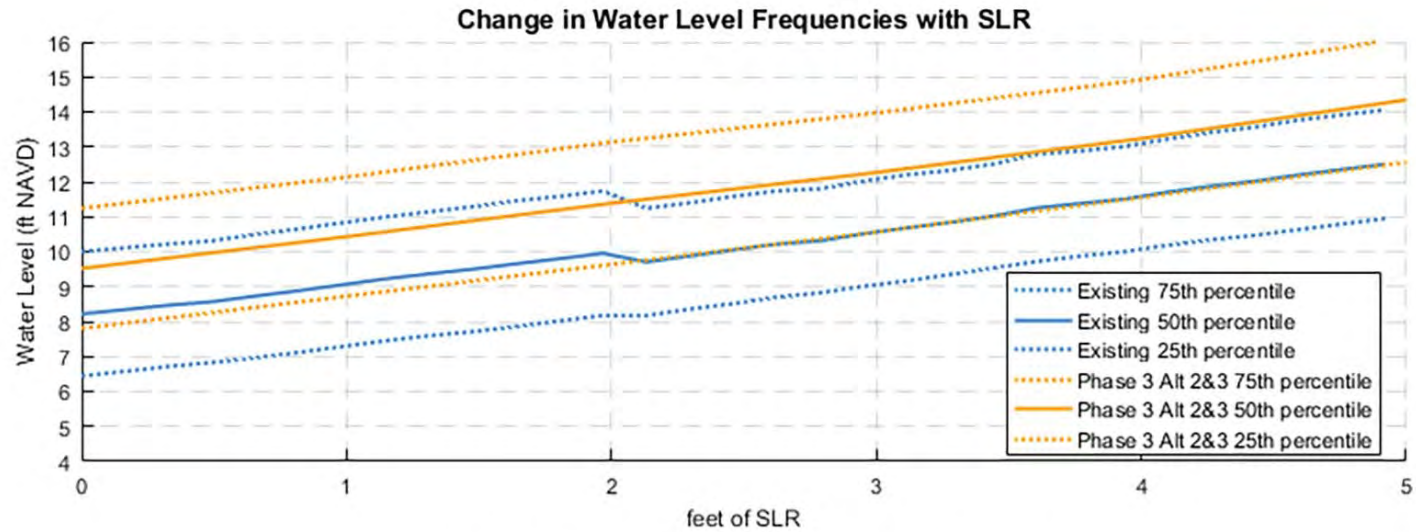


SOURCE: ESA QCM Model

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Figure 6-11

Modeled seasonal water level exceedance from 2011 to 2016 for (left) existing conditions and (right) the preferred alternative



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-12

Modeled Water Level and Mouth Closure with Sea-level Rise
Existing Conditions and Full Restoration of Eastern Lagoon
(Phase 3 of Alternatives 2 and 3)

Since the existing Lagoon is largely confined within a channel with high banks, sea level rise is not expected to change the frequency of closure. In systems with shallower channel banks and adjacent marsh networks, sea level rise could potentially drown parts of the floodplain, adding a large amount of intertidal volume (tidal prism), which would in turn increase the amount of flow through the mouth and thus increase the amount of time that the mouth is scoured open by tides. Mouth closure is not expected to decrease with sea-level rise at the Aliso Creek Estuary unless much of the site is excavated to add marshplain within the tide range. The preferred restoration plan and conceptual restoration alternative include restoration of wetland floodplain that is perched or higher than the tide range. Model results for restored conditions also show that sea level rise is not expected to significantly change or decrease the frequency of mouth closure. Since the model did not show a significant change in closure frequency with sea-level rise for both existing and restored conditions, the water level range was not expected to change substantially for either existing or restored conditions, aside from moving upward with sea level rise.

6.3 Water Quality Assessment

ESA collected water level data at the Aliso Creek Coast Highway Bridge from March – July 2016. Salinity, temperature, dissolved oxygen, and pH data were collected using moored stationary sondes at the top and bottom of the water column near the Coast Highway Bridge, and by collecting periodic vertical profiles at multiple locations in the estuary using water quality sondes. Stationary sondes provide continuous time series of parameters, but have a fixed location. The vertical sonde profiles supplement this by giving a fuller picture of how each of these water constituents vary spatially from upstream to downstream. These data are analyzed and discussed in Section 6.3.1 as the basis for this assessment of the potential influence of restoration on water quality.

Section 6.3.2 assesses the potential influence of restoration on water quality, focusing on residence time, seepage, salinity, and vertical water column conditions. These are all key factors to understanding the influence of restoration on water quality. As discussed in the conclusions of this section (Section 6.3.1.3) and Section 8.2, more detailed assessment of other water quality constituents, including nutrients, could be performed based on the understanding of these key factors from this assessment.

6.3.1 Observed Conditions

Figure 6-13 summarizes the lagoon conditions from February to November 2016. It was found that water quality conditions in the lagoon were strongly dependent on the seasonal hydrology, which can be segmented from the observations as follows:

- 1) **February to March:** Relatively wet conditions with at least three rainfall events and predominantly open-mouth (draining toward the ocean) conditions. Tides and wave runup on the beach entered the open mouth and caused muted ‘tidal’ fluctuations in the lagoon. Watershed runoff was 5-150 cubic feet per second (cfs) and water levels were typically below 10 ft NAVD88.
- 2) **April to May:** Runoff began to decline and wave action started to raise the sill (i.e., build up the beach and sand berm) in the mouth. Runoff was typically below 5 cfs during this time. A series of at least ten short-lived mouth closure events occurred in sequence over 2 months. Water levels began to rise to 12 ft NAVD88 during closure events before the mouth breached and drained the lagoon.
- 3) **June to September:** Runoff declined below 3 cfs, and a 3-week closure event began at the end of May. The mouth breached in mid-June and immediately closed again, followed by a series of partial breach events that did not fully drain the lagoon in late June. The mouth then remained closed from July to mid-August. Water levels were steady at 12-12.5 ft NAVD. The time lapse camera observed a mouth breach event in mid-August. The mouth drained to the ocean for roughly one day, and the camera showed that it had been closed by wave action the following day.

The sections below describe how salinity, temperature, dissolved oxygen, and pH in the lagoon responded to these hydrologic conditions.

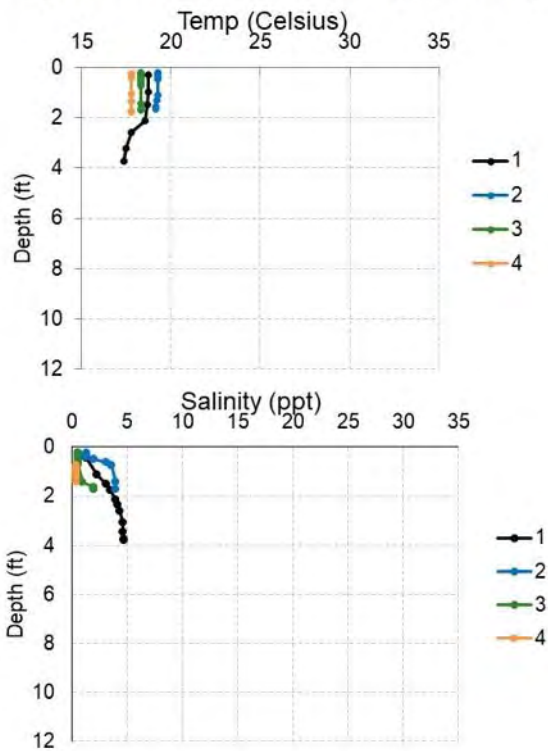
6.3.1.1 Observed Vertical Water Column Conditions

Vertical sonde profiles were taken at four locations throughout the lagoon on March 2nd and July 22nd, 2016. The former captured wet and well-mixed conditions. The latter captured vertically salt-stratified conditions during dry conditions when the mouth was closed.

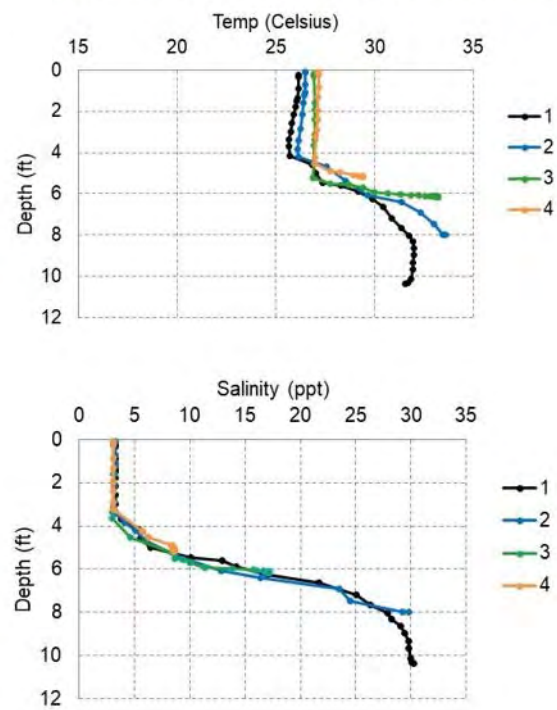
During the relatively wetter February-March period, the lagoon was shallow and relatively well-mixed, as shown in **Figure 6-14**. The profiles show that salinity was below 5 parts per thousand (ppt) at all depths, even at the relatively deep pool under the Coast Highway bridge near the mouth. This implies that freshwater runoff made up the majority of lagoon water, and that tidal or wave overwash influences were limited. The bridge was the only location where salinity varied with depth, increasing from 1 ppt at the surface to 5 ppt at 4 feet of depth. Overall, salinity increased from zero ppt at the upstream end of the lagoon to 1-5 ppt at the bridge. Temperature also increased from about 17 °C at the upstream end to about 19 °C at the bridge, and only varied with depth at the bridge pool, where it was 2 °C cooler at 4 ft depth than at the surface. Dissolved oxygen was above 8 mg/L at all sites, meaning that the lagoon was well oxygenated. These results are typical of wet conditions in shallow lagoons (e.g. Largier 1991; Williams and Stacey 2016).

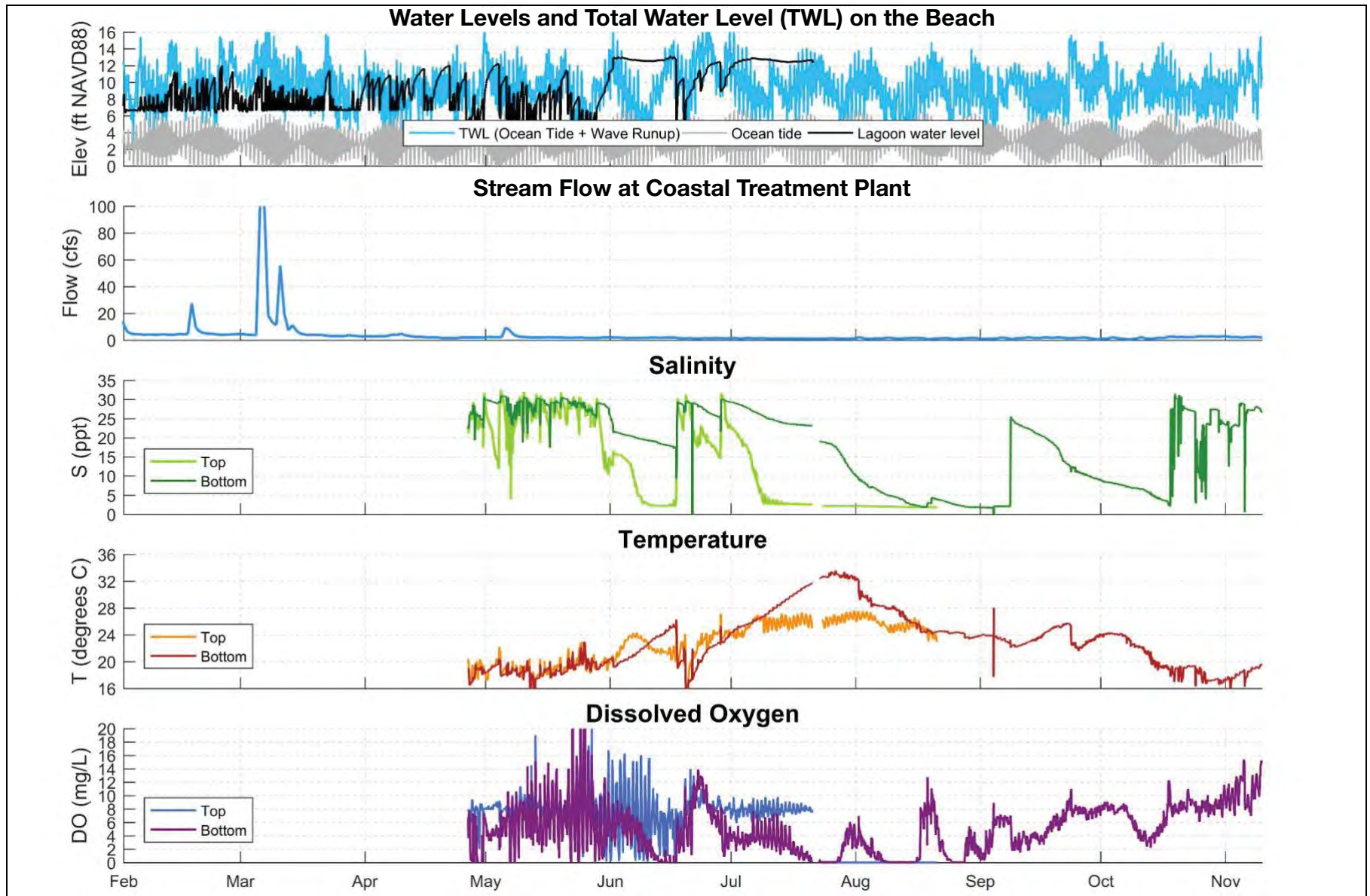


Open-Mouth Conditions (3/2/2016)



Closed-Mouth Conditions (7/21/2016)





SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-14
Water Quality Time Series

At the time of the July 22nd profiles, the lagoon mouth had been either partially or fully closed from the ocean for almost two months. Inflows were less than 2 cfs, and the lagoon water level had been steady at 12.0-12.5 feet NAVD88 for several weeks. The salinity profiles show that the water column was vertically stratified at all four locations, with:

- A 4-foot layer of relatively fresh (3 ppt salinity) water at the top,
- A transition zone from 4 to 8 feet of depth where salinity increased from 3 ppt to 30 ppt, and
- A salty (30 ppt) bottom layer below 8 ft depth.

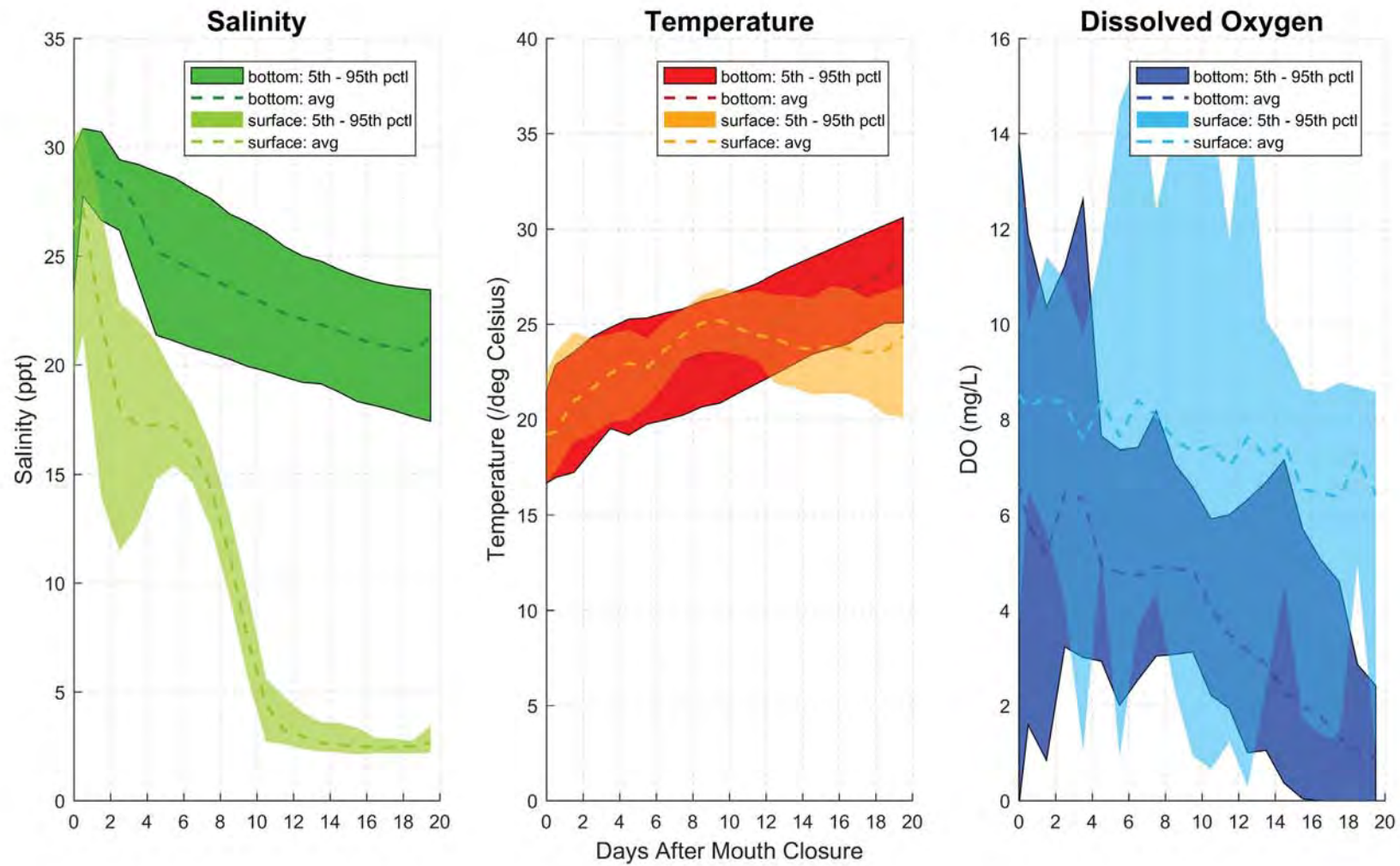
This type of vertical structure is very common in small California lagoons that experience mouth closure (e.g. Williams and Stacey 2016). Many of these systems are classified as ‘salt-trap’ estuaries because the seasonally closed-mouth holds this trapped saltwater in the lagoon until the next major rainfall event breaches the mouth and allows the water column to mix (pers. comm. J. Largier).

The lack of vertical mixing between the bottom and surface layers inhibited the exchange of heat and dissolved oxygen with the fresher upper layer. Water temperatures were 26-27 °C in the surface layer and increased to 32-35 °C at the salty bottom layer. Dissolved oxygen profiles were not taken on July 22nd, but the stationary sondes at the bridge location showed that the bottom layer had very low (<1 mg/L) dissolved oxygen at depth, compared to relatively-oxygenated (8 mg/L) conditions in the surface layer. Dissolved oxygen in the lower salty layer was originally high, but depleted over several weeks in June and July (Figure 6-13). These conditions are common in salt-stratified lagoons after mouth closure, as contact with the atmosphere allows replenishment of dissolved oxygen in the relatively-fresh upper layer, whereas the lower layer experiences depletion of oxygen over time resulting from decomposition of organic matter in the water column. The difference in salinity between the upper and lower layers inhibits mixing, effectively preventing re-oxygenation of the lower layer.

6.3.1.2 Observed Water Quality Changes Over Time

Bottom and surface sondes located at the Coast Highway bridge (see Figure 6-14) were installed in late April 2016, and collected hourly salinity, temperature, dissolved oxygen, and pH until December 2016.

As shown in Figures 6-13 and **6-15**, water quality conditions were strongly influenced by the condition of the lagoon mouth. In May, the mouth was open and measured water levels in the lagoon suggest that wave runup and possibly some high tides were entering the lagoon. During this time, surface and bottom salinity, temperature, and dissolved oxygen are very similar, and experienced daily fluctuations. The water column was mixed, oxygenated (dissolved oxygen > 7 mg/L), relatively cool (temperature of 16-22 °C), and salty (salinity of 20-32 ppt) at the bridge.



SOURCE: ESA

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 6-15

Water Quality Time Series, Closure

After the mouth closed in May, salinity immediately began to decline, and temperature increased. Dissolved oxygen at the surface fluctuated daily while it declined sharply at the bottom, becoming anoxic (zero dissolved oxygen) within about three weeks of mouth closure. The mouth briefly opened several times in mid-June, allowing the lagoon to partially drain each time. However, the mouth was closed by high wave runup (see Figure 6-13 upper panel) each time, indicated by abrupt increases in lagoon water level. These drainage events briefly allowed the lagoon to mix, which can be inferred from the fact that measured values of salinity, temperature, and dissolved oxygen were the same at the top and bottom of the water column each time. After closing a final time on June 28th, the same patterns emerged as before: salinity and dissolved oxygen declined and temperature increased, especially in the lower salty layer.

Surface salinity dropped from oceanic levels to less than 5 ppt within one week of closure. Bottom salinity declined through the summer until mid-August when it was essentially the same as surface salinity levels. Throughout the month of July, while the lower salty layer was still present in the lagoon, temperatures increased until peaking at 28°C and 33°C in the surface and bottom layers, respectively. As the saltwater layer disappeared in August, temperatures started to decline again. As with the June mouth closure event, dissolved oxygen in the lower layer became anoxic within 2-3 weeks.

When the mouth breached and closed again in mid-August, saltwater was deposited in the lagoon, shown by a spike in bottom sonde salinity. As with the July closure event, this salt declined over time and the bottom and surface salinity were the same after 5-6 weeks.

6.3.1.3 Conceptual Model

Closed Lagoon Mouth

When watershed runoff is low during the spring, summer, and fall, the lagoon mouth closes due to wave action, meaning that surface flows do not carry waterborne constituents out of the lagoon through the mouth. This type of morphology is described in more detail in Section 2. Under these closed-mouth conditions, seepage through the beach berm and uptake by wetland plants are the only viable mechanisms for removing waterborne constituents from the water column. Among these, seepage is likely the dominant route for exporting constituents, since existing wetland areas are small. Nearby California Irrigation Management Information System (CIMIS) measurements suggest that evapotranspiration losses are likely to be very small in comparison.

During periods of mouth closure, saltwater from previous tides and from wave overwash is trapped in the lagoon, and settles to form a bottom salty layer. This is evident from the bottom and surface sonde time series (Figure 6-13), and from a number of studies at similar lagoons by ESA (e.g., ESA 2017). The sharp vertical transition between the denser saltwater at the bottom and the freshwater at the surface inhibits vertical mixing (Largier 1991; Behrens et al. 2016). This usually leads to much different temperature and dissolved oxygen conditions at the surface and bottom, since the surface layer is subjected to re-oxygenation and daily fluctuations in air temperature, while the bottom layer is relatively isolated. If the surface layer is clear of surface vegetation, solar radiation can penetrate into the lower layer, which accumulates heat over time

since the sharp salinity interface with the upper layer inhibits heat transfer (pers. comm. J. Largier).

Transport of water constituents out of the lagoon via seepage may be significant over time. This is possible because water levels are typically higher than the ocean tides during closure (Figure 6-13, upper panel). Water levels measured during the July-August closure event of 2016 reached a plateau at 12-12.5 feet NAVD, when Creek flows measured at the upstream Coastal Treatment Plant were roughly 1.0-1.5 cfs. For water levels to reach a plateau, 1.0-1.5 cfs had to be lost to seepage out of the lagoon. Bottom sonde salinity measurements during this event, and during the later August-September event showed that 4-6 weeks was enough time to completely remove the trapped saltwater.

Open Lagoon Mouth

When watershed runoff is high, flows draining out of the mouth remove sediment and cause the mouth to scour to relatively low elevations (bed elevation < 8 ft NAVD). This is clear from the water level record and from the available mouth time lapse photographs. During these events, waterborne constituents are flushed from the lagoon. In these cases, the flows spilling out of the mouth are likely the main determinant of residence time, as these are much larger than seepage through the beach.

After flood flows recede, the pooled runoff in the lagoon may continue to spill out to the ocean for a period of days to weeks until waves close the mouth again. During this time, the lagoon may either be fresh, as was observed during March 2nd, 2016 (Figure 6-14), or collected wave overwash and tides could dominate inflows and give relatively salty conditions. This was shown by the bottom and surface sondes in April-May 2016. Under these conditions, a thin layer of water at the surface may exit through the mouth, but bottom waters are trapped and subjected to seepage losses over time.

6.3.2 Potential Influence of Restoration on Water Quality

As discussed in Section 5, the restoration is expected to change the dry-season hydrology of the lagoon, which could in turn affect water quality. The sections below examine how the residence time (Section 6.3.2.1) and vertical water column stratification (Section 6.3.2.2) could change with the restoration. This assessment focuses on residence time and vertical stratification as key physical parameters that affect water quality. The Conceptual Restoration Plan also includes reducing dry-weather creek inflow and pollutant loading to the estuary (see Section 7.7), which is a key restoration/management action that is expected to improve water quality in the restored estuary. The potential benefits of reducing dry-weather creek inflow and pollutant loading and the results of the residence time and stratification assessments are discussed further in the water quality assessment conclusions (Section 6.3.2.3).

6.3.2.1 Residence Time

For conservative waterborne constituents, such as fecal indicator bacteria, nutrients, and metals, residence time is a key consideration, as it represents the amount of time that these will be present in the lagoon. Since the lagoon mouth is intermittently closed, the pathway for these constituents to exit the lagoon is constantly changing.

To better understand how the restoration could affect residence time in the lagoon, hydrologic outputs from the lagoon QCM model were used (see Section 6.2). Changes in residence time were examined for (1) periods of mouth closure, and (2) for periods of relatively high watershed runoff with an open lagoon mouth. For each, differences between modeled conditions were evaluated for:

- Existing conditions
- Restored estuary with expansion of lagoon habitats to the extent included in the Preferred Restoration Alternative (Alternative 3), with dry season inflows reduced by 1.25 cfs, and
- Restored estuary with expansion of lagoon habitats to the extent included in the Preferred Restoration Alternative (Alternative 3), with dry season inflows reduced by 2.5 cfs.

Closed Lagoon Mouth

As discussed above, under closed lagoon mouth conditions, seepage and evaporation are the main pathways for water to leave the lagoon. Evaporation leaves behind waterborne constituents, and is predicted to be small (< 0.1 cfs) for Aliso Creek based on the small lagoon surface area and the nearest CIMIS data. Therefore, it was assumed that seepage losses are the main pathway for constituents to leave the lagoon. Uptake by wetland plants was not considered.

Table 6-2 outlines the QCM model results for the three scenarios. Seepage losses tended to be 0.5 – 2 cfs, depending on the lagoon stage, but averaged between 0.5 and 0.8 cfs across all modeled closure events from 2011 to 2016. A bulk residence time for water in the lagoon was estimated by dividing the average lagoon volume by the average seepage loss rate during modeled closure events. Residence time is likely to be different in the upper fresh layer than in the lower salty layer, which is not reflected in this simple bulk measure. Our intent is simply to illustrate the overall change in residence time of the lagoon for the different cases.

Under existing conditions, the residence time is estimated at about 14 days, and the mouth is closed for 110 days per year. Residence times were slightly lower for both of the restored cases. This is because the mouth was closed for longer periods of time (167 and 222 days per year for flow reductions of 1.25 and 2.5 cfs, respectively), which allowed the beach to build higher and thus for larger amounts of ponding in the lagoon, forcing seepage to leave the lagoon more quickly. Combining the shorter residence times and longer closure events, the salinity of the lagoon would be expected to be lower on average for the restored cases compared to existing conditions.

TABLE 6-2
ESTIMATED RESIDENCE TIMES FOR ALISO CREEK ESTUARY UNDER CLOSED-MOUTH CONDITIONS

Scenario	Avg Seepage Loss Rate (cfs) ¹	Avg Lagoon Volume (Acre-ft) ¹	Bulk Residence Time (days) ²	Days of Mouth Closure per Year ¹
Existing	0.55	16	14.1	110
Full Restoration, 1.25 cfs low-flow diversion	0.78	19	12.3	167
Full Restoration, 2.5 cfs low-flow diversion	0.62	17	13.4	222

¹ Estimated from ESA lagoon QCM model for closure events from 2011 to 2016.

² Estimated as: Bulk Residence Time = (Avg Lagoon Volume / Avg Seepage Loss Rate)

For this residence time analysis, the QCM was refined using additional water level data collected in the summer of 2016 as discussed in Section 6.2.1. The additional water level data collected for the months of June through August 2016 encompassed several long-term closure events that when paired with water quality data greatly helped to understand residence time in the lagoon. Refining the model with this additional data led to the estimated days of closure per year from 2011 to 2016 included in Table 6-2, which are lower than the percent closure initially estimated for existing conditions and restoration alternatives (see Section 5.1.2.1). The closure results in Table 6-2 are refined estimates; however, note that the relative changes between existing and restored conditions for both the initial closure estimates and the refined closure estimates in Table 6-2 are similar.

Open Lagoon Mouth, High Runoff

Under high runoff conditions, the mouth is open and spilling to the ocean. Under these conditions the mouth erodes and the March 2nd, 2016 sonde profiles (Figure 6-13) show that water column is relatively homogeneous. As a result, residence time is based on the size of the lagoon and the rate that freshwater inflows can transport them out of the lagoon.

Residence times are expected to increase with restored conditions, but the change for open mouth conditions is likely to be small. Residence time was estimated by dividing the lagoon volume by the watershed runoff rate. This assumes that water exits the mouth at the same rate that it arrives upstream under wet season conditions. During typical winter baseflows of 10-20 cfs, the residence time was the same for both the existing and restored cases, at 6-12 hours. During relatively common storm event flows of 100-200 cfs, the residence time was estimated at 0.7 – 1.4 hours for existing conditions, and 0.8 – 1.6 hours for restored conditions. This is because the restored lagoon would have a larger volume at flood elevations, so the same inflows would take longer to remove a larger volume of water, although the change is small, and within the level of uncertainty of the model.

TABLE 6-3
ESTIMATED RESIDENCE TIMES FOR ALISO CREEK ESTUARY UNDER WINTER AND STORM RUNOFF CONDITIONS

Scenario	Watershed Runoff (cfs) ¹	Avg Lagoon Volume (Acre-ft) ²	Bulk Residence Time (hours) ³
Existing	10-20	10	6-12
Full Restoration	10-20	10	6-12
Existing	100-200	12	0.7 - 1.4
Full Restoration	100-200	13	0.8 - 1.6

¹ Runoff of 10-20 cfs is representative of typical winter baseflow; 100-200 cfs is representative of a typical storm event.

² Estimated from ESA lagoon QCM model for closure events from 2011 to 2016.

³ Estimated as: Bulk Residence Time = (Avg Lagoon Volume / Watershed Runoff Rate)

6.3.2.2 Vertical Water Column Conditions

Although the restoration would enlarge the lagoon and potentially reduce flows during the dry season, water column conditions during wet conditions are likely to be similar to existing conditions. Under closed-mouth conditions it is expected that the water column will still have a vertical structure dominated by a lower salty layer and an upper fresh or brackish layer during closure events. This is based on some key findings from the monitoring and QCM modeling:

- As waves build up the bed of the lagoon mouth during closure events, they also spill into the lagoon. The amount of saltwater transported into the lagoon in the days leading to closure is significant. Sonde data showed that the entire water column at the bridge was salty at the beginning of closure events in 2016.
- Any freshwater that arrives at the lagoon will be trapped behind the beach berm, and because of its buoyancy will rest on top of the trapped saltwater.
- Observed closure events in 2016 tended to happen when sand in the mouth filled in to at least 6-7 ft NAVD88. This was reinforced by the findings of the QCM. When paired with the 2016 salinity data this means that the water column was initially salty below 6-7 ft NAVD88 (initially trapped saltwater), and brackish or fresh at higher elevations when trapped freshwater began to accumulate in the lagoon.
- As water seeps out of the lagoon over time, it will be replaced by any incoming freshwater, meaning that the lagoon will become fresher over the duration of closure events.
- Wave overwash can contribute additional saltwater after closure.

The QCM model runs for 2011-2016 predicted that for existing conditions from 2011 to 2016, closure events were too short to experience much seepage of saltwater out of the lagoon, so most closure events likely had a salty lagoon with a very thin brackish or fresh layer at the top during closed conditions. For restored conditions, the key finding from the QCM (see Section 6.2) is that reduced inflows would lead to longer mouth closure events. The QCM showed that seepage losses tend to be in the range of 0.5 – 1.5 cfs, so it is expected that the salinity in the lagoon during closure events will depend on whether the inflows surpass this amount.

The following is expected:

- **For dry season flows above approximately 1.5 cfs:** freshwater will accumulate in the lagoon and the water column will freshen over time. The QCM predicts water levels will be above 10 ft NAVD88 during closure events. Salinity would be expected to be at least 30 ppt below 6-7 ft NAVD88 initially, and 0-3 ppt in the surface layer. Over time the entire water column would be 0-3 ppt and would be well-mixed after seepage removes the lower layer.
- **For dry season inflows below approximately 1.5 cfs:** the lagoon will likely still freshen over time, but this would take longer, since seepage would balance out or overpower inflows. Water levels may reach 10 ft NAVD88, but the QCM predicts that they would lower over time due to combined seepage and evaporative losses. Salinity would be expected to be at least 30 ppt below 6-7 ft NAVD88 initially, and 0-3 ppt at the surface. The lower layer would persist for a longer period of time.

These salinity conditions will dictate the dissolved oxygen and temperature in the water column. Whenever the lower layer is present for several weeks, it is expected that bottom waters would have lower dissolved oxygen and higher temperature than the surface.

6.3.2.3 Conclusions

The Conceptual Restoration Plan includes reducing dry-weather inflows and loading of nutrients and other constituents through upstream management actions (i.e., increased operation of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project in the near-term and watershed management in coordination with the WQIP in the long-term, as described further in Section 7.7). Reducing dry-weather inflows and pollutant loading is expected to improve and enhance water quality in the restored estuary. In particular, reducing dry-weather loading of nutrients has the potential to reduce eutrophication in the estuary, which includes reducing the potential for algae blooms and low dissolved oxygen conditions. The potential water quality effects and benefits of the restoration could be further assessed, including a nutrient cycling assessment, as discussed in Section 8.2. However, nutrient and other water quality constituent data is not available from the estuary. These data would need to be collected to inform further assessments of water quality. As discussed in Section 8.3.1, testing increased operation of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project in conjunction with water quality data collection would also inform and reduce uncertainties for further water quality assessments (e.g., uncertainties related to groundwater influences).

The assessments in the above sections were performed to quantify and assess changes in mouth closure, residence time, salinity, and vertical water column stratification as key physical factors that govern estuary water quality. These factors are important to understand as they effect the type of habitat and vegetation that will establish in the restored estuary and influence other water quality processes. The results of these assessments are summarized and discussed below.

Under both existing and restored conditions, salinities are likely to be mostly brackish when the mouth of the estuary is closed. At present, saltwater largely appears to enter the estuary from tides and wave runup when the mouth is open, and from wave overwash events when the mouth is closed. In both cases, a bottom saline layer forms and a portion of the saltwater mixes with trapped freshwater, causing a transition from fresher water at the surface to brackish or saline

conditions in the lower layer. This vertical salinity structure moderates the water quality in the lagoon, since it inhibits mixing between the fresher upper layer and the trapped saltier lower layer. This lack of vertical mixing allows oxygen to decay steadily in the lower layer, resulting naturally from the breakdown of organic material in the water column. The relatively fresh upper layer typically maintains higher levels of dissolved oxygen because of its exposure to the atmosphere. As creek inflows fill the closed estuary, the estuary water level rises above the ocean tide level and forces water from the estuary to flow (seep) through the sand berm from the estuary to the ocean. This seepage eventually removes enough salt from the lower layer that typical winds can once again fully mix the water column and restore high levels of dissolved oxygen.

The results of this assessment indicate that during the dry-season, the restoration will increase the amount of time that the mouth is closed as intended to restore conditions that are similar to historic estuary conditions. Water levels in the restored estuary are expected to increase once the estuary is closed more often. These increases in the period of time the estuary is closed and in the water level are expected to increase seepage and flushing of trapped salt water from the bottom of the estuary, potentially leading to lower salinity brackish conditions, less vertical stratification, and less potential for low dissolved oxygen conditions to form in the bottom of the channel. Also, restored wetland areas are expected to be shallowly inundated and well oxygenated. In combination with reduced dry-weather creek inflows and nutrient loading to the estuary, these physical effects of the restoration are expected to have the potential to improve dissolved oxygen conditions in the estuary, which has the potential to benefit estuary ecology (e.g., for benthic invertebrate and fish species).

In conclusion, restored water quality conditions are expected to support brackish closed-mouth estuary and wetland conditions, habitats, and wildlife. The restoration includes reducing dry-weather creek inflows and pollutant loads, which is expected to have the potential to improve and enhance water quality for the restored estuary. The restoration is also expected to increase mouth closure during the dry season, but would actually reduce the residence time of water in the estuary due to increase water levels and seepage through the sand berm to the ocean. The combined effect of reducing dry-weather pollutant loads to the estuary and physical and ecological restoration of the estuary is expected to have the potential to improve the existing water quality in the estuary. These conclusions are based on the planning-level hydrology and water quality feasibility assessments performed for this Conceptual Restoration Plan. Further water quality assessment could be performed based on the results on the results of these assessments to confirm these conclusions as discussed in Section 8.2.

6.4 Climate Change and Sea-level Rise Assessment

6.4.1 Sea-level Rise Assessment

Historical trends in relative sea level are measured at tide gages, which capture relative vertical movements of land as well as changes in the global or eustatic sea level. These records measure the local rates of sea level rise relative to the coast. NOAA estimates that relative sea levels have been rising at a rate of 0.88 mm/yr at the Los Angeles tide gage (1924-2006).

The State of California Sea-Level Rise Guidance Document (CO-CAT 2013) provides guidance for California projects on how to use predictions of global sea level rise for long-term planning purposes. The document recommends using the estimates provided by the NRC's report on *Sea-Level Rise for the Coasts of California, Oregon, and Washington* (2012) as a starting place to select values. These predictions for Los Angeles are:

- 2 to 12" of sea level rise by 2030
- 5 to 24" of sea level rise by 2050
- 17 to 66" of sea level rise by 2100

The ranges in sea level rise represent the range in sea level rise for low and high global greenhouse gas emission scenarios (B1 and A1FI) identified by the IPCC [NRC 2012].

The sea-level rise modeling performed for the Conceptual Restoration Plan (see Section 6.2.3) shows that sea-level rise is not expected to change mouth closure frequency, assuming adequate sand supply to build up the sand berm at the mouth. Water levels in the estuary are expected to increase at the same or similar rate as the rate of sea-level rise. This is because the elevation of the beach berm at the creek mouth inlet is controlled by wave processes, which transport/deposit sand and build the beach berm to an elevation near or above the high tide level (see additional discussion in Section 2). In response to sea level rise, the beach is expected to erode and move back, but the beach and inlet berm will also move up in elevation with adequate sand supply. The increase in elevation of the beach berm is expected to increase water levels in the Aliso Creek Estuary under both typical and fluvial storm discharge conditions.

With future sea level rise projected to accelerate due to climate change, coastal flooding and the rate of coastal erosion are also projected to increase. Projected coastal erosion and flooding results from the USGS Coastal Storm Modeling System 3.0 (CoSMoS) Phase 2.0 for the Southern California region were reviewed for the Conceptual Restoration Plan; however, the results do not appear to accurately represent Aliso Beach (see Appendix E). Based on the review and interpretation of these results, it appears that Aliso Beach could erode back to the edge of the Aliso Beach parking west of Coast Highway with less than 1 meter (3.3 feet) of sea-level rise, which could occur within the next 50 years. The Aliso Beach parking lot is already subject to 100-year Creek flooding as shown in the FEMA flood map (Figure 2-27) and has experienced coastal flooding and damage in the past. Creek and coastal flooding are expected to increase in intensity and frequency due to sea-level rise and coastal erosion.

A site-specific analysis of future coastal erosion and flooding could be performed to further assess the vulnerability of Aliso Beach and the Aliso Beach Park to sea-level rise. This assessment and adaptation planning to reduce the vulnerability of Aliso Beach Park to sea-level rise could be coordinated with the Aliso Creek Estuary Restoration.

6.4.2 Changes in Rainfall and Creek Flows

Several studies have been conducted to estimate the potential impact of climate change on specific climate stressors including temperature and rainfall, and secondary impacts of those stressors such as wildfires, droughts and flooding. With respect to rainfall trends, the majority of climate models indicate that annual average rainfall will decrease in California particularly in the lower latitude Southern California region (Thorne et al. 2012) as a result of increased temperatures. However, extreme rainfall events are expected to increase given the greater moisture availability anticipated under a warmer atmosphere. In particular, atmospheric rivers (narrow corridors in the atmosphere that transport water vapor and are the most significant driver of extreme rainfall events in California) are projected to increase by most current climate models (Gershunov et al. 2013). This increase in atmospheric river frequency is expected to change flood frequency, intensity, and timing depending on the season, flood type, and location.

Though inherently uncertain, studies increasingly show that over the southwest, drying conditions are expected to persist while extreme rainfall events are expected to increase. Whang and Zhang (2008) estimated that over much of North America, extreme rainfall events over the past half century with an average recurrence interval of once in twenty years are projected to occur twice as frequently in the future. Downscaled climate model results support this result. Dominguez et al. (2012) projected an increase in intensity in wintertime extreme events with 20- to 50-year return periods of 13-14% by 2050. In the southern portion of the Southwest US, climate models project that extreme rainfall events will increase in severity and timing even as total precipitation decreases (Groisman et al. 2005). Existing studies generally converge on expected trends, for California in general and Southern California in particular, of dryer conditions on average with more intense and more frequent extreme events driven by an increase in atmospheric rivers.

For the Aliso Creek Estuary Restoration, dryer conditions with climate change could reduce dry-weather creek inflows to the estuary. This is not necessarily expected to negatively affect the restored estuary: the existing dry-weather flow to the estuary is elevated above historic levels due to watershed development, and reducing dry-weather inflows through management actions is part of the Conceptual Restoration Plan. For wet-weather conditions with climate change, more intense and more frequent extreme rainfall and creek flow events could increase sediment delivery from upstream to the estuary. Warmer, drier summers could also lead to increased fire frequency, further increasing sediment loads. Upstream watershed management planned for the WQIP (e.g., hydromodification management) and proposed upstream creek restoration and stabilization (e.g., the Aliso Creek Mainstem Ecosystem Restoration) could decrease sediment delivered to the estuary by reducing channel erosion. There is uncertainty in the implementation and effects of upstream watershed and creek management and the net effect of these potential management measures with future climate change. The restored estuary is expected to be a dynamic ecosystem that may change over time in response to infrequent extreme creek flow events, similar to how the historic estuary ecosystem may have functioned. Future climate change and potential increases in extreme wet-weather, drought, temperature, and wildfire could potentially increase the frequency and magnitude of changes or “natural” disturbances to the restored estuary ecosystem.

SECTION 7

Conceptual Restoration Plan

The Conceptual Restoration Plan was developed for the preferred restoration alternative and preferred set of public use options (see Section 5). The Conceptual Restoration Plan includes near-term phases (Figure 1-2) and a long-term phase that would extend the length of the Coast Highway bridge and restore the estuary through the bridge (Figure 1-3). The following conceptual plan elements were developed and are described in the following sections: proposed habitats (Section 7.1), grading plan (Section 7.2), re-vegetation plan (Section 7.3), utility modifications (Section 7.4), bank erosion protection (Section 7.5), reducing artificial breaching (Section 7.6), dry-weather flow reduction (Section 7.7), public use options (Section 7.8), extending the length of the Coast Highway bridge (Section 7.9), adaptive management and monitoring (Section 7.10), and a conceptual planning-level opinion of probable construction costs (Section 7.11).

7.1 Proposed Habitats

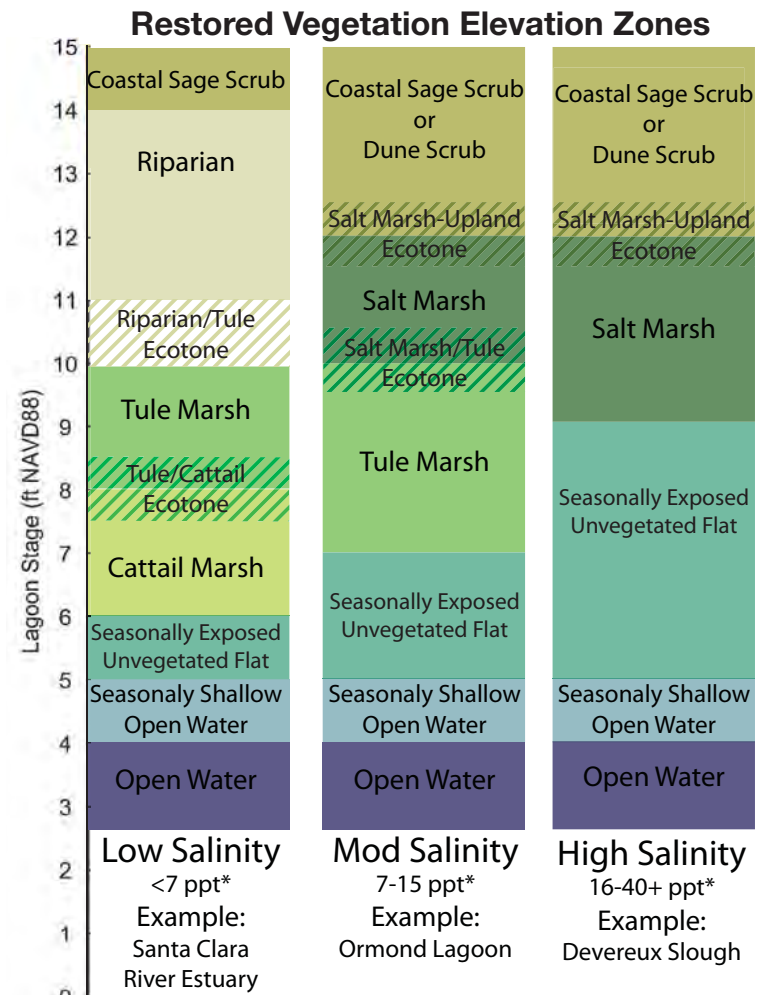
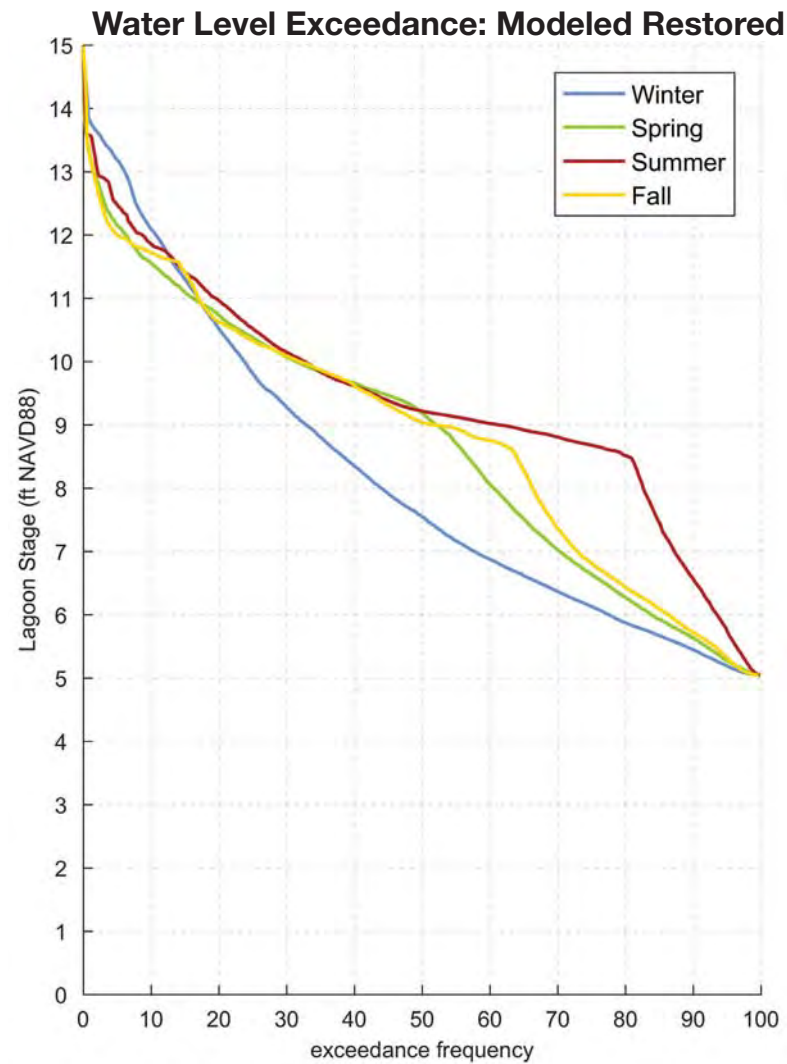
The proposed restoration project will result in a substantial expansion of wetland habitats at the site. The expansion of wetlands is primarily a result of lowering topography through grading. The reduction of manual breaching and dry-season freshwater inflows will alter the hydrology and salinity in the lagoon. The hydrology of the site (see Section 6.3) will consist of closed-mouth lagoon conditions most of the time with short periods of open-mouth conditions during and immediately after rainfall events. Under closed conditions, the water level elevations in the lagoon will generally be about 9 – 11 feet NAVD with low brackish salinity levels (e.g., 4 ppt in the surface water/lens that inundates wetland vegetation). Under open-mouth conditions, water level will roughly coincide with tidal elevations and salinity will be close to that of seawater (~34 ppt). The lagoon west of the Coast Highway will probably have some seawater influence under closed-mouth conditions due to wave overwash events and seepage of sea water through the beach berm. Under this hydrologic regime and with the proposed grading plan (see Section 7.2), it is expected that the restored lagoon will support brackish marsh, riparian, open water, foredune scrub and coastal sage scrub habitats in distinct elevation zones (**Figures 7-1** and **7-2**). The restored lagoon is expected to function as a “low salinity” lagoon east of Coast Highway and a “moderate salinity” lagoon west of Coast Highway; however, actual conditions may differ from these expectations and will vary seasonally and annually. Vegetation patterns will evolve over time in reaction to these variations. **Table 7-1** shows the estimated habitat acreages east and west of Coast Highway. Table 7-1 shows habitat acreages expected for both low salinity and moderate salinity (east of Coast Highway) and low to high salinity (west of Coast Highway), which provide a range in the potential acreage of habitat depending on salinity and other conditions. The general habitat types are described in the following sections.



SOURCE:

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 7-1
Habitat Zones



* = Typical max salinity during growing season (April-Sept) excluding any deep salt wedge, i.e., closed conditions

Coastal
Restoration
Consultants

**TABLE 7-1
HABITAT ACREAGES**

Ecotone	Low Salinity (<7ppt)	Moderate Salinity (7-15 ppt)
East of Coast Highway		
Open Water (Existing)	1.502	1.502
Open Water (Restored)	0.186	0.186
Seasonably Shallow Open Water	0.201	0.201
Seasonably Exposed Unvegetated Flat	0.642	0.954
Cattail Marsh	0.658	-
Tule Marsh	1.443	1.241
Salt Marsh	-	0.968
Riparian	0.838	-
Upland	1.296	1.715
Subtotal	6.767	6.767
West of Coast Highway		
		High Salinity (16-40+ppt)
Open Water (Existing)	0.368	0.368
Open Water (Restored)	0.007	0.007
Seasonably Shallow Open Water	0.004	0.004
Seasonably Exposed Unvegetated Flat	0.075	0.244
Cattail Marsh	0.074	-
Tule Marsh	0.133	-
Salt Marsh	-	0.080
Riparian	0.070	-
Dune/Upland	0.028	0.055
Subtotal	0.758	0.758
Total	7.526	7.526

7.1.1 Fresh/Brackish and Brackish/Salt Marsh

Brackish marsh is a general term used to describe the types of wetlands that occur where typical water salinities are between 0.5 ppt and 30 ppt. Brackish conditions are also referred to as mixohaline by Cowardin et al. (1979), and distinct from limnetic (<0.5 ppt), euhaline (30-40 ppt) and hyperhaline (>40 ppt). Cowardin et al. (1979) distinguish three types of wetlands within mixohaline class, oligohaline (0.5-5 ppt), mesohaline (5-18 ppt) and polyhaline (18-30 ppt). In southern California, brackish marshes within these three subclasses generally have different vegetation associations. The restored Aliso Creek Estuary is expected to be oligohaline (referred to in this plan as fresh/brackish marsh) landward of the Coast Highway bridge and mesohaline (referred to as brackish/salt marsh) seaward of the bridge.

Different brackish marsh species occur at different elevations within a given marsh. The stratification of vegetation is due to differing stress tolerances of different species and

interspecific competition. Using the results of the hydrology modeling and salinity assessment for restored conditions, the estimated elevation ranges for East of the Coast Highway bridge, fresh/brackish marsh is expected to extend down to about 6 feet NAVD, below which will be open water. Cattail (*Typha* spp.) is expected to dominate between 6 and 7 feet NAVD and be co-dominant with tule (*Schoenoplectus californicus*) between about 7 and 8 feet NAVD. Tule will likely dominate between about 8 and 10.5 feet NAVD with other fresh/brackish species (Table 7-2) mixed in.

TABLE 7-2
TYPICAL OLIGOHALINE FRESH/BRACKISH MARSH SPECIES^A

Species	Common Name	Preferred Conditions
<i>Anemopsis californicus</i>	Yerba mansa	Saturated soil
<i>Bolboschoenus robustus</i>	Robust bulrush	Seasonally flooded
<i>Elymus triticoides</i>	Alkali rye grass	Seasonally saturated soil
<i>Equisetum hymale</i>	Scouring rush	Saturated soil
<i>Euthamia occidentalis</i>	Western goldenrod	Seasonally saturated soil
<i>Juncus balticus</i>	Baltic rush	Saturated soil
<i>Juncus textilis</i>	Basket rush	Saturated soil
<i>Schoenoplectus californicus</i>	Tule	Seasonally flooded
<i>Typha domingensis</i>	Southern cattail	Permanently flooded
<i>Typha latifolia</i>	Broadleaf cattail	Permanently flooded

NOTES:

^a Species typical of oligohaline fresh/brackish marsh in coastal southern California. These would be east of the Coast Highway Bridge

SOURCE: Coastal Restoration Consultants 2018

West of the Coast Highway bridge, the brackish/salt marsh is expected to be dominated by tule between about 8 and 10 feet NAVD. Tule is expected to co-occur with a mix of brackish/salt marsh species (Table 7-3) between 9 and 10.5 feet NAVD. Brackish/salt marsh species other than tule are expected between about 10.5 and 12 feet NAVD.

7.1.2 Riparian

Riparian habitats occur primarily along streams and rivers in southern California. The habitat is made up of small to large trees, shrubs and herbaceous understory species, many of which are phreatophytic (having roots that reach down to the water table). Along the coast, oligohaline lagoons can support a subset of species that are characteristically riparian (Table 7-4), yet have some tolerance to salt.

In the restored Aliso Creek Estuary, riparian species are expected to establish between about 10.5 and 14 feet NAVD east of the Coast Highway bridge. At this elevation they will very rarely be flooded. When these elevations are flooded, the water salinity should be very low.

**TABLE 7-3
MESOHALINE BRACKISH/SALT SPECIES^a**

Species	Common Name	Preferred Conditions
<i>Baccharis glutinosa</i>	Salt marsh baccharis	Seasonally saturated soil
<i>Bolboschoenus maritimus</i>	Saltmarsh bulrush	Seasonally flooded
<i>Distichlis spicata</i>	Salt grass	Seasonally saturated soil
<i>Frankenia salina</i>	Alkali heath	Seasonally saturated soil
<i>Jaumea carnosa</i>	Fleshy jaumea	Seasonally flooded
<i>Juncus acutus</i>	Spiny rush	Saturated soil
<i>Salicornia pacifica</i>	Pickleweed	Seasonally flooded
<i>Schoenoplectus californicus</i>	Tule	Seasonally-permanently flooded

NOTES:

^a Species typical of a mesohaline brackish/salt marsh in southern California. These would be west of the Coast Highway bridge

SOURCE: Coastal Restoration Consultants 2018

**TABLE 7-4
RIPARIAN HABITAT SPECIES**

Species	Common Name	Preferred Conditions
<i>Baccharis douglasii</i>	Mugwort	Sub-shrub
<i>Baccharis pilularis</i>	Coyote brush	Shrub
<i>Baccharis salicifolia</i>	Mulefat	Shrub
<i>Elymus condensatus</i>	Giant rye grass	Grass
<i>Elymus triticoides</i>	Alkali rye grass	Rhizomatous grass
<i>Juncus patens</i>	Common rush	Graminoid
<i>Salix exigua</i>	Sandbar willow	Rhizomatous shrub
<i>Salix lasiolepis</i>	Arroyo willow	Tree
<i>Salicornia pacifica</i>	Pickleweed	Seasonally flooded

NOTES:

^a Typical species of riparian habitat along the edges of a brackish lagoon in Southern California

SOURCE: Coastal Restoration Consultants 2018

7.1.3 Coastal Sage Scrub

The upland areas east of the Coast Highway bridge above about 14 feet NAVD will support coastal sage scrub habitat. Coastal sage scrub (sometimes called soft chaparral) was one of the dominant upland habitat types in much of coastal Orange County before development restricted its occurrence severely. It is a highly diverse community dominated by drought-tolerant shrubs and sub-shrubs. Coastal sage scrub occurs on a range of different slope aspects and soil types, which, along with distance from the coast, determine what species are dominant at a given location. Species expected to do well at the project site are listed in **Table 7-5**.

TABLE 7-5
COASTAL SAGE SCRUB HABITAT SPECIES

Species	Common Name	Preferred Conditions
<i>Artemisia californica</i>	California sagebrush	Shrub
<i>Atriplex lentiformis</i>	Saltbush	Shrub
<i>Baccharis pilularis</i>	Coyote brush	Shrub
<i>Encelia californica</i>	California encelia	Shrub
<i>Eriogonum fasciculatum</i>	California buckwheat	Sub-shrub
<i>Eschscholzia californica</i>	California poppy	Annual
<i>Isocoma menziesii</i>	Coast goldenbush	Shrub
<i>Lupinus succulentus</i>	Arroyo lupine	Annual
<i>Mimulus aurantiacus</i>	Sticky monkey flower	Sub-shrub
<i>Salvia leucophylla</i>	Purple sage	Shrub
<i>Salvia mellifera</i>	Black sage	Shrub

SOURCE: Coastal Restoration Consultants 2018

7.1.4 Foredune Scrub

Upland areas with sandy soil west of the Coast Highway bridge (>12 feet NAVD) will support dune scrub habitat. Foredune scrub species (**Table 7-6**) are adapted to well-drained soils, occasional inundation by sea or lagoon water and blowing sand.

TABLE 7-6
FOREDUNE SCRUB HABITAT

Species	Common Name	Preferred Conditions
<i>Abronia maritima</i>	Red sand verbena	Sub-shrub
<i>Ambrosia chamissonis</i>	Beach bur	Sub-shrub
<i>Atriplex leucophylla</i>	Beach saltbush	Sub-shrub

SOURCE: Coastal Restoration Consultants 2018

7.1.5 Open Water and Seasonally Exposed Unvegetated Flat

The lowest areas of the project (below 6 feet NAVD) will be too deep for cattail and will be flooded almost all the time. The open brackish water could support algae and aquatic plants (**Table 7-7**). Aquatic algae such as *Ulva* spp. are an important part of natural estuarine food webs and often act as an indicator of water quality. Under low-nutrient natural conditions, aquatic algae should be present in relatively small amounts. However, if there are high levels of nutrients (phosphorus and nitrogen) in the water, algae blooms may become a nuisance. When algae becomes abundant and then dies, the microorganisms that consume the dead algae can severely deplete the available oxygen in the water column, leading to die offs of fish and other aquatic species.

TABLE 7-7
AQUATIC SPECIES FOUND IN BRACKISH LAGOONS

Species	Common Name	Preferred Conditions
<i>Ruppia maritima</i>	Ditch grass	Floating vascular plant
<i>Ulva intestinalis</i>	Sea lettuce	Floating algae
<i>Ulva lactuca</i>	Sea lettuce	Floating algae

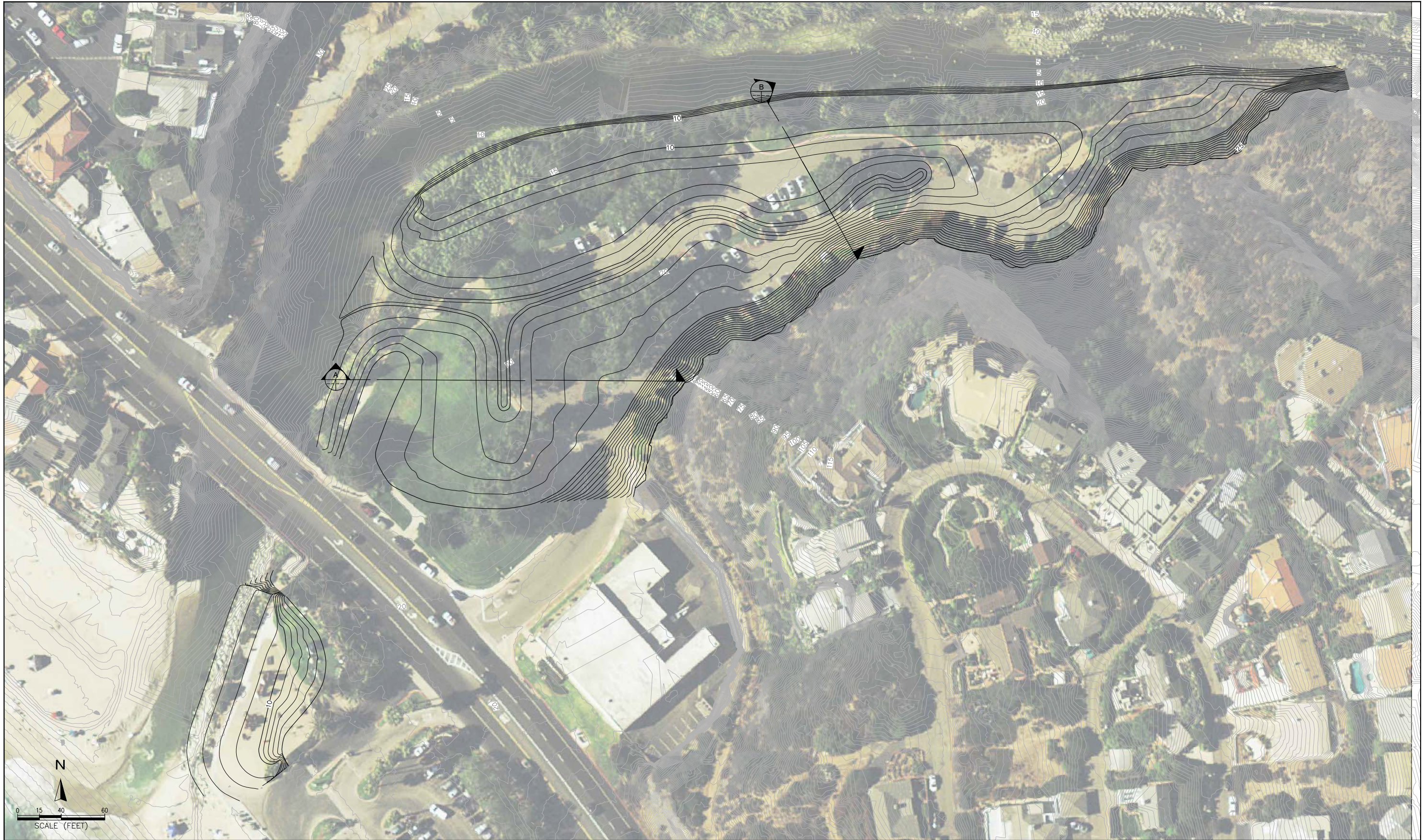
SOURCE: Coastal Restoration Consultants 2018

7.2 Grading Plan

The conceptual grading plan is shown in plan view and cross-section in **Figures 7-3** and **7-4**, respectively. New wetland areas would be created by removing, excavating, and grading the existing inland parking lot and associated park features east of Coast Highway and the existing playground/picnic area west of Coast Highway. These new wetland areas would be connected to the existing channel. Along the northern edge of the new wetland marshplain east of Coast Highway, a low channel habitat berm at elevation 10.5' NAVD would separate the marsh from the main estuary channel. This berm would support restored habitat and vegetation. The berm feature is intended to mimic natural berms that form along marsh channels, and to shield parts of the marsh from high velocity flows in the main estuary channel during mouth breach events. The berm would run east along the main channel and transition up to existing grade near the upstream extent of the planned grading area. At this eastern extent, the grade would slope from 10.5' up to 15' and provide riparian habitat.

A lagoon wetland basin would be located immediately south of the habitat berm. This would grade from approximately 10' at the edge of the berm down to 6' along an interior wetland channel. The marsh channel would have two branches: an east-west oriented main channel roughly 500 feet long, and a secondary channel roughly 100 feet long branching off of the main channel. At elevation 6 feet the marsh channel would have a width of 5 to 10 feet. Landward of the marsh channel to the east and south, the marsh would slope upward gradually to the bluff/canyon slope, where it would meet the existing grade at about 10 ft NAVD.

West of Coast Highway, the existing playground area and rock revetment would be excavated to elevations consistent with back-barrier lagoonal open water and sand flat habitat, and slope up to 15 ft NAVD along the southern boundary of the new trail area (Figures 7-1 and 7-2). The slope between 10 and 15 ft NAVD at the upper edge of this area may provide high salt marsh habitat. If sediment sampling collected in future phases of the project design were to indicate that the soil below the open water and sand flat habitat was not native sand, these areas may be over-excavated down to the potential channel scour depth and backfilled with sand.

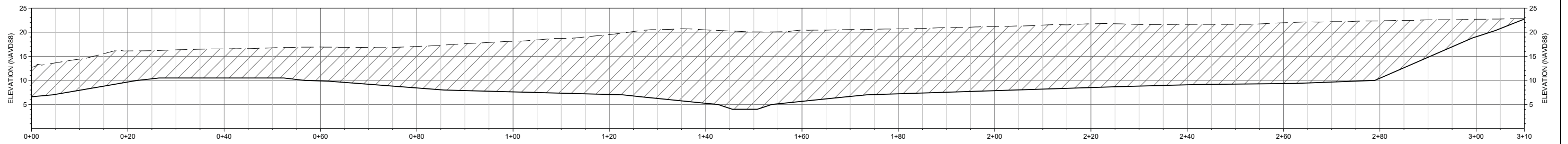


SOURCE: ESA

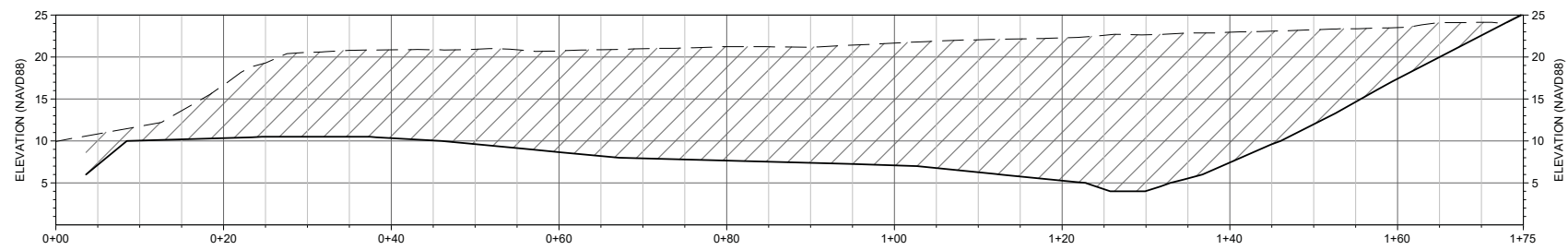
Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 7-3
Design Grade Concept 1

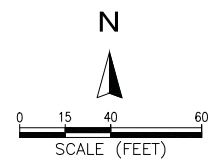




Section A



Section B



7.3 Re-vegetation Plan

Re-establishment of native vegetation communities is a crucial aspect of implementing the Aliso Creek Estuary Restoration and ecological restoration projects in general. Native plants provide many important ecosystem services, including:

- Stabilization of soils and erosion control,
- The basis for the food web and nutrient cycling,
- Physical structure that supports wildlife,
- Increasing resistance to invasion by non-native plants, and
- Improving water quality.

A crucial component in estuary restoration is an understanding of the physical conditions and site-specific factors that influence successful re-vegetation. Achieving the desired vegetation outcomes, including target plant community cover and diversity, requires knowledge of each species and its appropriate physical growing conditions.

Important physical factors vary widely by habitat, but some important processes that effect patterns in southern California's coastal lagoons include soil moisture dynamics, hydrology, scour and sedimentation, soil salinity, soil texture, slope steepness and aspect, and climate. In order for re-vegetation to be successful at a restoration site, these physical growing conditions must be understood across different areas of the site. This allows appropriate native plant communities and species to be matched to the appropriate areas. Or, conversely, allows the design of a restoration project to support target habitats.

In southern California's coastal wetlands, relatively small differences in elevation can lead to very different vegetation communities. This is due to the fact that important stressors on plants (e.g., flooding duration and depth, soil salinity, etc.) vary strongly with elevation. Tidal estuaries have highly variable but fairly predictable water levels and salinities; therefore, the elevation ranges for typical plant communities are fairly well understood in these systems. In contrast, water levels and salinities vary considerably both within and between years in intermittently-open estuaries like Aliso Creek Estuary. Further, given the myriad differences between these small estuary systems, it is generally expected that any two will not necessarily be alike. Therefore, predicting the exact elevation band for each expected plant community is difficult in these systems.

The conceptual grading plan (Section 7.2, Figures 7-3 and 7-4) for this project was developed to meet the project goals and objectives, including those related to target plant communities. Hydrologic modeling (Section 6.2) was used to both develop the grading plan and provide a guide to predicting the suite of species that will be likely thrive at different elevations. Using the inundation-versus-elevation curves (Figure 7-2) from the modeling and an assessment of salinity under restored conditions (Section 6.2), predictions as to what species and communities will occur where were made (Figure 7-1). This re-vegetation plan lays out a plausible path towards establishing native wetland, riparian, and upland plant communities within the project area.

However, given the uncertainty associated with projected elevation distributions in a small intermittently-open estuary system, it will be important to develop and employ an adaptive management framework to guide the re-vegetation efforts and refine re-vegetation strategies to accomplish the project goals (see Section 7.5).

7.3.1 Re-Vegetation Guidelines

A set of general guidelines (below) were developed for planting and weeding the site in order to provide a rough cost estimate for re-vegetation efforts. A detailed implementation plan will need to be developed for the project that will refine these strategies. That plan will need to be developed concurrently with both the final grading plan and include any special conditions set forth in project permits issued by the regulatory agencies. A restoration ecologist familiar with implementing restoration and/or mitigation projects in coastal southern California should prepare the plan.

7.3.1.1 Planting and Seeding

Planting palettes for the different habitats should be based on Tables 7-2 to 7-7 (“planting” aquatic species in the open water areas is not recommended). These lists will likely need to be adjusted and/or expanded as project planning proceeds through the next stages. Only species native to coastal Orange County should be used. Horticultural cultivars of native species should never be used. Plant material (seed and nursery stock) should only be sourced from firms who are able to document the geographic area where propagules were collected for each species. This will help assure appropriate genotypes are introduced. For most of the common species, propagules should be sourced from natural stands (not restoration/mitigation sites) along the coast between Los Angeles and San Diego Counties. Special attention should be paid to local collection of propagules for species and sub-species endemic to the Laguna Beach area (*e.g.*, *Dudleya* spp.) if they are used.

Wetland and riparian areas should be planted with nursery stock. Small nursery containers (*e.g.*, 2-inch pots or plugs) are preferred for most species. Trees (willows) and larger wetland plants (tule and cattail) should be planted from standard 1-gallon nursery stock. Planting in these areas should take place in spring so new plantings can experience a full growing season (spring and summer) and establish extensive root systems capable of stabilizing soil and mechanically anchoring the plants during winter flooding. Planting densities will vary by species (see **Table 7-8**).

Foredune and coastal sage scrub areas should be re-vegetated with a combination of small nursery stock and seed (Table 7-1). Planting and seeding in these areas should occur in early winter to take advantage of natural rain. Temporary irrigation should be installed in these areas and used only to the extent necessary. Over-irrigation may lead to plants growing less extensive root systems than those required to survive once irrigation has ceased. There should be a plan and funding in place to remove the irrigation after plants are established (1-3 years). Table 7-8 includes re-vegetation quantity estimates and opinions of probably implementation costs (“cost estimate”). These cost estimates are included in the overall opinions of probably construction costs for the project included in Section 7.11.

**TABLE 7-8
REVEGETATION COSTS**

Planting Type	Area (Ft ²)	Planting Density (feet on center)	Total # of Plants	Average Cost per plant	Cost
Cattail/Tule Marsh					
1-gallon pot	78,000	3	10,000	\$4.00	\$40,000
Subtotal					\$40,000
Tule/Salt Marsh					
1-gallon pot	6,500	3	830	\$4.00	\$3,320
2-inch pot	2,700	1.5	1,350	\$3.00	\$4,050
Subtotal					\$7,370
Riparian					
1-gallon pot	36,500	2.5	6,750	\$5.00	\$33,750
Subtotal					\$33,750
Foredune Scrub					
2-inch pot	2,400	2	700	\$4.00	\$2,800
Seed	2,400	N/A	N/A	N/A	\$200
Subtotal					\$3,000
Coastal Sage Scrub					
1-gallon pot	6,500	3	830	\$4.00	\$40,500
2-inch pot	2,700	1.5	1,350	\$3.00	\$2,000
Subtotal					\$42,500
TOTAL FOR PLANT MATERIAL					\$124,820

7.3.1.2 Weeding

Weeds are not expected to be a major problem in flooded wetland areas. However, elsewhere on site invasive annual species will be a management issue. If not controlled, they can out-compete natives and cause the re-vegetation effort to fail. If possible, at least one grow-kill cycle before planting in the riparian and coastal sage scrub areas is recommended. This is typically done by irrigating the site briefly to sprout weeds from seed and then killing seedlings using an aquatic-approved herbicide, hand weeding, solarization or similar method. Weeding is much more efficient before native plants are installed or native seed is spread. Weeding non-native annuals will need to continue after planting (spot herbicide or hand removal). Minimizing irrigation will generally favor natives and discourage annual non-native plants. As native shrubs and trees grow larger, they will shade the ground and discourage many of the most problematic annual weeds from germinating.

Non-native perennial plant species are often a long-term maintenance issue at restoration sites. Detecting and removing these species (*e.g.*, *Arundo donax*, *Cynodon dactylon*, *Pennisetum clandestinum*, *Nicotiana glauca*, *Cortaderia selloana*, and *Tamarix ramosissima*) should be a priority during the installation phase (the first three to five years) and beyond. These species typically require treatment with herbicide or mechanical removal. Early detection, when plants

are still small, makes control efforts much easier. A detailed weeding strategy for annual and perennial non-natives should be part of the final implementation plan and should be tailored to achieve goals for non-native cover, if laid out in regulatory permits.

7.3.1.3 Site Preparation and Short Term Maintenance

Future studies and permit conditions will dictate specific measures that need to be undertaken to assure the re-vegetation effort is successful. These will include at least, an erosion control plan, soil texture and salinity analyses to assess the possible need for soil amendments, short-term fencing to protect new plantings from trampling and, signage to inform the public about the sensitivity of the restoration site to trampling and other disturbance. Plantings should also be monitored for herbivory by gophers, rabbits, squirrels, deer, etc. If plants are being killed or damaged, herbivore protection will need to be installed. This would likely only be a problem in the coastal sage scrub and riparian areas. These issues should all be addressed in the implementation plan, which should be prepared in conjunction with final project design and permitting phases.

7.4 Utility Modifications

Several buried utilities cross the project site, Aliso Creek, the Aliso Beach inland parking lot proposed for restoration, and the SCWD staging area on the north side of Aliso Creek. Approximately 5 to 20 ft of excavation is proposed to restore the parking lot to wetland. Information on the depth of the buried utilities was not available for the Conceptual Restoration Plan. Further assessment, planning, design, and coordination with the utility owners will be required in the next phases of the project to determine if utilities can be protected-in-place and/or which utilities would need to be relocated/realigned. For the purposes of this Conceptual Restoration Plan and conceptual opinion of likely construction costs in Section 7.11, it is assumed that utilities may need to be relocated and realigned around restored wetland areas (e.g., to preserve access for maintenance), including sewer mains and recycled water pipelines.

It may be possible to protect the utilities running under Aliso Creek in place given that channel excavation is not proposed. The proposed new visitor center, parking, access, and interpretive features on the SCWDs staging area north of the Creek would be constructed “at grade” with resurfacing, but without excavation to lower grades. The proposed improvements may therefore not conflict with existing utilities; however, further assessment and coordination would be required to confirm this.

Final design can include a surveyor review of property boundaries and easements and potential utility locations and constraints to the project. Field work can then be used to confirm locations via noting ground penetrations and, if needed, potholing (excavation) to locate buried utilities. For utilities to remain, construction-period actions can be taken to protect-in-place or modify the utilities, as appropriate. These actions can be taken with notifications so that the utility owners are engaged to confirm constraints and protection measures.

7.5 Bank Erosion Protection

Along the south side of Aliso Creek through the restored estuary, new wetland areas will be restored with shallow, natural, vegetated slopes adjacent to the existing creek channel. These vegetated transitions from the channel to restored wetland will provide some level of natural erosion protection during storm events and high creek flows. Some bank erosion and deposition is expected, which is part of natural estuary dynamics and ecosystem processes and can benefit the restored estuary.

The existing north creek bank east of the Coast Highway is armored in places; however, some of the armoring is old and deteriorating. The restoration plan includes revegetating the north bank with native plants. If future design studies indicate bank erosion protection is needed, the restoration may install new bank erosion protection along the north bank. This could include some combination of biotechnical bank stabilization techniques, which incorporate native vegetation, and/or traditional armoring. Traditional armoring, such as rip rap, could be buried with soil and revegetated to provide both protection and habitat.

The jetty along the south side of the creek channel west of Coast Highway would be removed to expand and restore the estuary to the south. If future design studies indicate that bank erosion protection is needed along the new edge of the restored estuary at this location, the restoration would install new bank erosion protection. This could include buried armoring and/or surface armoring that is designed to allow for public access (e.g., a seating wall or steps). New armoring could be buried with cobble and/or sand to provide a more natural transition and habitat between the open water and beach/dune habitat and the parking lot.

7.6 Reduce Artificial Breaching

The restoration plan includes reducing artificial breaching of the mouth. Currently, the mouth is artificially breached by beach users for recreation and, less frequently, by the County of Orange for management of Aliso Beach and public safety (County of Orange Parks, Beach and Coastal Facilities staff, pers. comm.). To reduce breaching by beach users, a program for public outreach, education, and enforcement would be developed, implemented, and refined through monitoring and adaptive management (see Section 7.10). This program could include signage, tours, a social media campaign, and increased patrolling and enforcement by lifeguards, volunteers, and/or others. The restoration may also allow for the County of Orange to reduce their breaching and beach management activities by expanding the mouth of the estuary. However, the restoration would seek to allow for the County of Orange to continue to breach as currently permitted if needed.

7.7 Dry-weather Flow Reduction

The restoration plan includes reducing dry-weather flows and pollutant loading from the Aliso Creek watershed to the restored estuary. Historically, dry-weather flows in Aliso Creek were likely minimal (see Section 2.5.3). Dry-weather flows have increased due to watershed development and anthropogenic sources (e.g., dry-weather runoff from over irrigation). The restoration plan includes increasing operation of the SCWD's Aliso Creek Urban Runoff

Recovery, Reuse, and Conservation Project (Section 2.3.2) as a near-term measure to divert dry-weather flows. In the long-term, the restoration plan relies on the South Orange County WQIP (Section 7.7.2) to reduce dry-weather flows and improve water quality from the Aliso Creek watershed. These near-term and long-term components of the restoration plan are further discussed below.

7.7.1 Increased Operation of SCWD Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project (Near-term Plan)

SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project currently allows for the diversion of 1.23 cfs from Aliso Creek at the CTP during dry-weather when flows in the creek are between 6 and 20 cfs (see Section 2.3). During recent drought conditions, the flow in Aliso Creek has been below 6 cfs and SCWD has not diverted water. The near-term restoration plan includes increasing operation of the Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project within a monitoring and adaptive management plan (see Section 2.3) to confirm that increased diversions enhance the estuary. Increasing operations and diversion through adaptive management would likely involve incrementally lowering the 6 cfs threshold for diversion (e.g., lowering the threshold to 5 cfs, so that flow is diverted when creek flows are between 5 and 20 cfs). The adaptive management plan would also include collecting and assessing monitoring data against established thresholds and a decision process for either further increasing diversions (e.g., lowering the threshold to 4 cfs) or changing management.

7.7.2 Watershed Management through South Orange County WQIP (Long-term Plan)

The South Orange County WQIP seeks to reduce pollutants and dry-weather flows in Aliso Creek through watershed management measures (see Section 2.6.1). Implementation of the WQIP provides the opportunity to enhance the estuary over the long-term. With implementation of the WQIP, it is possible that increased operation of SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project may not be necessary.

The South Orange County WQIP may consider developing strategies and targets for managing and enhancing estuaries. This effort could be coordinated with the Aliso Creek Estuary Restoration, including subsequent phases of planning, monitoring, and adaptive management.

7.8 Public Use Options

The conceptual public use options (Figure 1-4) were developed to accommodate habitat restoration, reduce the potential effects of recreational use on the restored habitat, and expand opportunities for nature enjoyment, education, and interpretation to meet the goals of the Aliso Creek Estuary Restoration and also fulfill elements of the Aliso Beach Inland Area General Development Plan.

The Conceptual Public Use Options further expands on the preferred public use alternative (Alternative 3, see Section 5.2). It includes several new amenities including a Visitor Center,

interpretive and educational opportunities, restored natural areas, and a network of trails and boardwalks with different options for a new pedestrian bridge, in addition to replacing the existing parking, restroom, playgrounds and picnic areas impacted by the restoration.

The existing entry to the inland parking lot is preserved to allow access to the adjacent building which shares the park access drive. The driveway will be shortened to end just past this parcel. A new parking lot will be added along this driveway providing for direct access to the network of trails in the restored estuary and to the soft surface trail connection south to the neighborhood and Toovet Trail within the AWCWP. A second new parking lot will be developed on the north side of the creek, served from Village Lane. This new parking lot will provide up to 76 parking spaces to support beach users, as well as a proposed Visitor Center. It could also accommodate potential future trail users connecting along Village Lane to the AWMA Road / Coastal Treatment Plant Road trail in AWCWP. In addition to the new parking facilities, the existing beach side parking lot could be reorganized to provide an additional 20 parking spaces, for a combined total of 108 new parking spaces between the three lots to replace the existing 113 parking spaces removed from the inland parking lot.

A new Visitor Center is located at the west end of the north parking lot and is sited to provide views over the restoration area and west to the Pacific Ocean and beach, as well as being a visible destination to draw visitors in. It could provide educational and interpretive opportunities regarding site history, restoration objectives, sensitive species and other relevant information. The Visitor Center will also include a restoration overlook patio on the bank of the Creek and replace existing restroom facilities for the inland parking lot proposed for removal in the conceptual restoration plan.

A new sidewalk and trail will connect the north parking lot and Visitor Center to the beach and new interpretive trail(s) adjacent to or through the restoration area. Several potential trail connection options were identified, which could be executed individually or in combination to benefit park users:

- Option A provides a signaled pedestrian crossing at the intersection of Village Lane and Coast Highway. It is intended to provide a safe crossing to reduce pedestrian vehicular conflicts. Sidewalks would be maintained on both sides of the bridge, preserving access to the stairs and tunnel underpass at the southeast end of the bridge.
- Option B adds a new pedestrian bridge parallel to the existing road bridge. It would provide a separate, safe pedestrian route from the parking lot to the beach. The new bridge could serve dual purposes of increasing safety and providing an opportunity for visitors to view the restoration areas. It would connect to the stairs and tunnel underpass at the southeast end of the bridge.
- Option C includes a boardwalk section through the restoration area and a new pedestrian bridge across Aliso Creek. It would provide a loop trail around and through the restoration area to allow visitors to access and experience the natural area.
- Option D also includes a boardwalk through the restoration and pedestrian bridge across the creek to return to the parking lot. Option D provides a longer trail loop. It limits restoration area fragmentation by following the toe of the slope along the south edge of the park and shifts the crossing point upstream where a shorter bridge may be possible.

7.8.1 Traffic and Trip Generation

The conceptual public use options shift the traffic dynamics slightly from the current condition. Currently, the inland parking lot provides 113 spaces on the southeast side of the creek and exits directly onto Coast Highway with a right turn only exit. The Ranch at Laguna Beach utilizes Village Lane for access on the northeast side of the creek, also with a right turn only exit onto the Coast Highway. The existing inland parking lot driveway and Village Lane are separated by approximately 400 feet.

The conceptual public use options reduce parking on the southeast side of the creek to twelve spaces, utilizing the current driveway access to Coast Highway with right only exit. A new parking lot (76 spaces) and visitor center are proposed along Village Lane on the northeast side of the creek to replace the remaining parking. Traffic will access these facilities on Village Lane, and maintain the current right turn only exit onto Coast Highway.

The conceptual public use options do not substantially increase the traffic entering Coast Highway within this area, but it would increase the traffic on Village Lane and at the intersection of Village Lane and Coast Highway. Current baseline parking use information is not available for the inland parking lot. It is estimated to be approximately 10 to 20 cars entering and exiting per hour on weekdays, with holiday and weekend use likely to be higher. The Visitor Center will be a new amenity and is likely to increase the level of regular daily trip generation. The precise size and character of the facility is as yet to be determined and will have an effect on the parking demand associated with it. Based on other similar facilities, it is initially estimated that it will generate 10 to 20 vehicle trips in and out per hour. This is anticipated to be a relatively constant flow of traffic for all hours and days of operation, trending toward the low end on weekdays and the high end during holidays and weekends.

The conceptual public use options are not anticipated to generate concentrated traffic increases at peak hours due to the minimal change in park uses, and the dispersed in and out flow of current park uses. A traffic study is recommended during subsequent phases to further evaluate traffic and parking demand.

7.9 Extend Length of the Coast Highway Bridge (Long-term Plan)

The long-term restoration plan would involve extending the length of the Coast Highway bridge to enhance the restored estuary by reducing channelization of the estuary at the bridge and improving connectivity between restored estuary habitats bisected by the bridge. Open water, unvegetated flat, and possibly vegetated wetland habitats would be restored under the expanded bridge. Public access would be modified to maintain a bridge under-crossing. This component of the long-term plan would be pursued opportunistically, for example in collaboration with transportation projects and/or bridge improvements if needed in the future. ESA has not assessed the feasibility of extending the Coast Highway Aliso Creek Bridge. Additional assessment of the bridge would be necessary in future phases of the Aliso Creek Estuary Restoration Project.

7.10 Adaptive Management and Monitoring

Adaptive management is a tool for achieving success where there is uncertainty as to what actions will be needed to accomplish specific goals. Ecological restoration is inherently uncertain. There are simply too many variables to control, especially in systems such as Aliso Creek Estuary with its complex hydrology. Designing and implementing this project using an adaptive management approach will lead to better outcomes and help the project meet its goals.

The Aliso Creek Estuary Restoration will consider using adaptive management for the following components of the restoration:

- Dry-weather creek inflow reduction
- Reducing artificial breaching
- Ecological restoration including re-vegetation
- Public access

The first step in the adaptive management process will be to develop a detailed adaptive management and monitoring plan. The detailed plan will establish the process and parameters for monitoring, evaluating, and refining management actions through an iterative science-based process. The purpose is to improve management of the restored estuary and overall restoration outcomes by performing focused monitoring that will feedback into an evaluation and decision-making process to reduce uncertainties and confirm restoration success. As part of this process, the detailed plan will establish thresholds or triggers for continuing or modifying management actions. The plan would also establish an adaptive management working group (e.g., including restoration managers, proponents, experts, and/or regulatory agency representatives). This working group would evaluate monitoring results against triggers and decide whether to continue or modify management actions and then proceed with the iterative process of implementing management actions, monitoring, evaluating, and deciding on how to proceed with subsequent management. The detailed adaptive management plan and implementation of adaptive management within the Aliso Creek Estuary Conceptual Restoration Plan could include the following process and steps:

1. Perform baseline monitoring as specified in the Adaptive Management Plan to establish baseline conditions for comparison to monitoring of restored conditions with management actions.
2. Implement initial management actions
3. Perform monitoring of conditions after implementation of the initial management action
4. Evaluate the monitoring results to assess the response of the restored estuary to the management action
5. Compare the response and/or performance of the restored estuary against:
 - a. Models and predictions (e.g., modeling and predictions included in this Conceptual Plan). Refine models and predictions based on monitoring results
 - b. Thresholds or triggers established in the adaptive management plan

6. Decide whether to continue or refine/modify management actions based on the above comparison.
7. Implement continued or refined management actions and repeat steps 3 to 7.

This adaptive management process could be continued until it is determined through this process that the restoration is meeting established success criteria. The detailed adaptive management plan would establish these success criteria based on the project goals and objectives and any environmental requirements identified through the environmental review (e.g., CEQA) and regulatory permitting process. These success criteria may be based on restoring and achieving:

- Physical processes similar to historic dynamics and support restored habitats (e.g., mouth closure, lagoon water level, water quality)
- Habitat structures and functions
- Resilient and diverse native wetland vegetation communities
- Wildlife use
- Public access, education, and stewardship that support the restored estuary

The detailed adaptive management plan may need to be periodically updated based on results and/or for subsequent phases of restoration.

As ecological restoration is the central component and goal of adaptive management, ecological adaptive management and monitoring are discussed further below (Sections 7.10.1 and 7.10.2, respectively). The near term restoration plan includes reducing dry-weather creek inflows to the estuary by increasing operation of the SCWD's Also Creek Urban Runoff Recovery, Reuse, and Conservation Project, which would likely be implemented incrementally through an adaptive management process. This near-term dry-weather flow reduction plan is described further in Section 7.7 and discussed as a next step in Section 8.3.

7.10.1 Ecological Adaptive Management

The importance of using an adaptive management approach in ecological restoration has long been recognized. There is an inherent level of uncertainty in habitat development following restoration. Adaptive management allows restoration efforts to be fine-tuned as naturally functioning habitats continue to develop and evolve over time. Careful analysis of as-built conditions and continuous hydrologic and salinity monitoring will provide guidance on early revegetation efforts in the wetlands. Revegetation zones may need to be adjusted for different species and communities. Pilot planting efforts (e.g., using a limited number of plants to assess survival at different elevations) can help fine tune planting strategies before large numbers of plants are installed.

This Conceptual Restoration Plan provides a possible path towards developing more naturally functioning habitats at the site. The site will support these habitats, though the exact locations and proportions of habitat are uncertain. Careful monitoring and adaptive management approaches should be used to help understand how the site is evolving and predict future conditions. Data

should be used to inform changes to initial implementation strategies for all aspects of the restoration implementation, including erosion control, planting and weeding.

7.10.2 Ecosystem Monitoring

A detailed monitoring plan will need to be developed for the project as plans are finalized and permits are issued. Most restoration project measure a few fairly simple vegetation metrics (*e.g.*, percent cover of natives and non-natives, diversity, stature, etc.). While these usually are valuable metrics for assessing a project, other biological factors like general wildlife usage (*e.g.*, bird surveys) or efforts directed at target species (*e.g.*, tide water goby) are often more effective at demonstrating project benefits and impacts. Collection of data on physical metrics is equally important. Surface water measurements of parameters such as salinity, water level, depth, dissolved oxygen levels, nutrient levels and temperature are recommended as these are underlying factors that can explain processes such as wildlife usage and plant zonation. Other physical factors such as erosion and sedimentation dynamics, mouth dynamics and soil salinity are also useful in explaining biological patterns.

The comprehensive ecosystem monitoring program should serve three primary purposes. First, monitoring is used to assess progress towards project goals and performance criteria. This might include specific requirements that come with funding sources for the actual implementation of the project. For instance, an in-lieu fee mitigation or other off-site mitigation funding source might come with much more complex performance criteria requirements than typical grant funding sources would. Second, monitoring should be used to support decision-making in the adaptive management program (see details below). Third, monitoring reports should contribute knowledge to the greater restoration community on the efficacy of the techniques and approaches used to implement the restoration project (*i.e.*, the reports should be publicly available). This is especially important for projects in small estuarine systems like Aliso Creek Estuary, which are so far not common in southern California. “Lessons learned” in early projects like the Aliso Creek Estuary Restoration could contribute greatly to the success of future work in the region.

7.11 Cost Estimate

The conceptual planning-level opinion of probable construction costs (“cost estimate”) included in this section is considered a rough order of magnitude estimate, and has an anticipated accuracy range of +50% to -30%. Further design efforts are needed to reduce uncertainties and improve the accuracy of the cost estimate.

In providing opinions of probable construction costs, ESA has no control over the actual costs at the time of construction. The actual cost of construction may be effected by external economic factors and market forces, which include the availability of construction equipment and crews, fuel costs, and fluctuation of supply prices at the time the work is bid.

ESA makes no warranty, expressed or implied, as to the accuracy of such opinions as compared to bids or actual costs. It is recommended that the estimate be updated in concert with the design/preparation of construction documents and consideration of restrictions and requirements that may arise as part of approvals and as required by permits yet to be secured.

7.11.1 Summary of Opinion of Probable Construction Costs

A summary of the opinion of probable construction costs for the near-term restoration phases (Figure 1-2) is given in **Table 7-9** below, which includes a contingency, soft costs (such as engineering, design, and permitting), and operations and maintenance over the first 5 years after implementation. These costs are discussed further in the following sections. The cost estimate assumes that excess excavated soil material will be off-hauled to a nearby landfill and disposed of as cover material. Costs for off-hauling are included and it is assumed that soil can be disposed of as cover material at no cost. (See Section 7.11.1.2 for additional discussion of soil disposal). Appendix F details the cost estimate and assumptions in further detail. The costs of extending the length of the Coast Highway bridge in the long-term restoration plan was not estimated or included in the cost estimate in Table 7-9 below. Extending the Coast Highway bridge may cost on the order of roughly \$10 million (see the discussion at the end of Section 7.11.1.2).

TABLE 7-9
SUMMARY OF ESTIMATED CONSTRUCTION COSTS

Item	Amount
Division 01 General Conditions	\$450,000
Mobilization	\$510,000
Division 02 Existing Conditions	\$2,630,000
Division 31 Earthwork	\$2,230,000
Division 32 Exterior Improvements	\$870,000
Construction Costs (subtotal)	\$6,690,000
General Contractor's Overhead & Profit	\$670,000
Surety	\$130,000
Contingency	\$2,570,000
Construction Costs, Adjusted (subtotal)	\$10,060,000
Soft costs (Engineering, Permitting, and CEQA)	\$1,000,000
Operations and Maintenance (5 years)	\$300,000
Total	\$11,360,000

7.11.1.1 Factors Affecting Unit Prices

Market Conditions and Location

The time of the year that the project is advertised or constructed often affects prices and, if this changes for the project, the unit prices for the contract items may need revision. The costs presented in this estimates are valid in 2018. All costs presented in this estimate are adjusted to reflect cost trends applicable in Santa Ana, CA (i.e., Orange County). Location adjustments were provided by RSMeans. No further adjustments were made to unit costs, unless specifically indicated in this section and in the cost estimate spreadsheet.

Quantities of Work (Economies of Scale)

Smaller quantities of work usually carry a higher unit cost compared to larger volumes. That is because mobilization, drayage, overhead and other costs are distributed over a smaller base. Additionally, production rates can be negatively affected by smaller volumes, which in turn increases unit costs. Whenever applicable, unit costs in RSMeans database were selected to correspond to the anticipated volume of work.

Traffic and Accessibility

According to CALTRANS guidelines, material hauling uphill rather than downhill, and work on the top of slopes or retaining walls are always more expensive to construct than work that is easy to accomplish on level or gentle slopes. The ease of accessibility to the work will affect the cost to do the work. In this particular case, it is anticipated that hauling will require additional considerations: few opportunities may exist to stage trucks and set up loading operations. No water-based construction work is anticipated to take place.

Construction Season

The timing of bidding is an important factor affecting prices. CALTRANS guidelines suggest that “the time of the year that the project is advertised and constructed affects the unit cost for items of work. Contractors are usually more readily available for work early in the spring and will therefore bid conservatively at that time. Later in the spring and during the summer, many contractors have ongoing projects that keep them busy; therefore, they tend to bid higher or not at all.”

7.11.1.2 Assumptions

Basis of Unit Prices

RSMeans Online Database 2018 unit costs adjusted for Santa Ana were used to estimate construction costs. All unit costs include labor, equipment, and material, with a basic overhead and profit provided by RSMeans. Each line item costed in this manner was assigned a database reference number. Consistent with RSMeans recommended practice, an additional 10% was carried out for General Contractor’s overhead and profit. It is assumed that the project will be exempt from sales taxes.

Contingency Rate

The cost estimate includes a 35% contingency to allow for uncertainties related to the following: anticipated multiple phases for earthwork and excavation, which will require the placement of erosion control measures in the interim; type and final dimensions of pedestrian bridge and boardwalk; costs of disposal, among others.

Engineering and Permitting (Soft) Costs

Soft costs related to the development of contract documents, engineering studies, assessment, regulatory compliance, contract administration, and support were not included in the construction cost estimate. Based on experience and project history, it is estimated that engineering costs may be on the order of \$500,000; costs will fluctuate as a function of scope of work and project

features. These uncertainties are carried out in the final contingency. Permitting and CEQA costs may vary significantly depending on potential restrictions associated with the project. If an EIR is required, costs may be on the order of \$500k. The latter value was included in the cost estimate.

Operations and Maintenance

An allowance for 5 years of maintenance and operations was included for reducing dry-weather creek inflows through increased operation of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project. The program is anticipated to last for five years, and includes the following components: monitoring gauges (4 total), monthly water quality testing and sampling; and yearly environmental and maintenance support as skilled labor at \$150/hr (loaded). Maintenance costs for re-vegetation during the vegetation establishment period are included with re-vegetation costs under Exterior Improvements (Table 7-9).

Further Considerations

Select items may warrant further consideration and/or design refinement, which may reduce their total price. These items are discussed further below.

- **Hauling & disposal:** As currently stated, the project requires that approximately 75,000 bank (i.e., in place) cubic yards (BCY) be removed and hauled off-site. Disposal may be possible at the Prima Desecha Landfill, which is located 15 miles from the site. The cost estimate assumes that the total volume of the excavated material can be disposed of as cover material at no cost (other than testing). Soil testing would need to be performed to assess whether the material is suitable for disposal as cover material (as discussed in Section 8, Next Steps). If soil testing were to indicate that soil is not suitable for cover material, costs of disposal could be significantly higher than assumed for this cost estimate. (For example, estimated costs for disposal could possibly be over \$1M, with a unit cost of \$70 to \$75 per loose (i.e., excavated) cubic yard (LCY) including tipping fee).

Trucking costs included in the cost estimate are predicated upon the following: 15 min load/wait/unload, 12 cubic yards (CY, approx. 15 ton) truck, 30-mile trip, 35 MPH, no allowance for loading equipment; this corresponds to an anticipated daily output of 84 LCY per day per truck. Based on initial estimates, and assuming that 10 tri-axle trucks with a 15-ton payload capacity are used, it may take up to 100 working days to transport the material to the disposal site. It was assumed that the use of larger trucks may be challenging due to (1) impact on congestion and air quality and (2) existing capacity on the Coast Highway bridge. This needs to be verified in subsequent design phases.

In generally, balancing cut and fill of soil on site is more cost effective than off-hauling excavated material. Based on the Conceptual Restoration Plan, on-site balance of cut and fill is not expected to be achievable for the Aliso Creek Estuary Restoration because the scale of restoration and grading and the size of the site limit opportunities for placing excavated soil on site. If a local/nearby site can be identified for beneficial re-use of excavated soil, costs could possibly be greatly reduced. The Conceptual Restoration Plan has not identified local opportunities for beneficial re-use; however, it is possible that at least some of the excavated soil could be beach-quality sand that could be placed on Aliso Beach. Soil testing, planning, and design is recommended as a next step to further assess the opportunity to place excavated sand on Aliso Beach (see Section 8).

- **Pedestrian Bridge:** the cost estimate assumes the placement of a pre-fabricated laminated wood bridge, 130-ft span. Given the uncertainty surrounding the type and dimensions of the bridge, a unit cost of \$250 per square foot (SF), along with a 10-ft width, was selected.
- **Boardwalk:** the estimate for unit cost was based on existing studies and historical prices. At this point, details regarding the type and actual features of the boardwalk have not been developed. For that reason, a conservative estimate of \$500/SF was used, which includes all labor, equipment, and material. It is noted that the maximum documented unit price is \$55/SF for materials plus 80% of material costs in labor and equipment. These uncertainties are accounted for in the contingency.
- **Phased Execution and Erosion control:** due to limited production rate anticipated from the trucking and hauling operations, it is anticipated that only part of the excavation process may be achieved in a given construction year. Two years are envisioned at this conceptual level to complete the work. Therefore, it is anticipated that the construction sequence will include more stringent provisions for erosion control during the interim wet season. The erosion control methods anticipated at the site include: hydro-seeding/mulching of bare slopes, installation of fiber rolls, etc. These costs were included in the Division 01, which was rounded up to 15%. Note that these erosion control measures will be in addition to regular BMPs and other mitigation measures during construction period.
- **Mobilization:** mobilization costs were estimated conservatively at 10% of construction costs, in addition to the 15% carried out for Division 01. This estimate is considered conservatively high.
- **Rock armor:** along the northern bank, rock armor will be installed. This item was included in our estimate. The unit cost is \$200 per cubic yard (CY). This unit cost incorporates labor, material, and equipment, and includes all components anticipated for this type of structures, including geotextile fabric, sub-base layer, and primary armor stone (1/4 Ton, typically).
- **Visitor center:** a unit price of \$300/SF was assumed for the visitor center. This unit price assumed a slab-on grade concrete/steel building based on commercial per SF data, adjusted for inflation. Additional anticipated costs for connections to utilities, including water and sewage, were included as separate lines in the cost estimate. The unit costs were estimated using RSMeans 2018.
- **Bridge replacement costs:** while not included in the total cost estimate for the near-term restoration phases in Table 7-9, an order of magnitude estimate for the probable costs of construction associated with a new CALTRANS bridge is provided for the long-term restoration plan. Per CALTRANS, the average cost per SF includes all bid items, including: time related overhead, mobilization, bridge removal, approach slabs, slope paving, sound-walls or retaining walls. Prices were escalated to adjust for inflation (3.6%, based on CALTRANS construction cost data). With this in mind, the estimated cost of replacement is approximately \$9.5M.

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SECTION 8

Next Steps

Key next steps needed to advance the Conceptual Restoration Plan to the subsequent phases of CEQA/NEPA environmental review, permitting, detailed restoration design, implementation, and long-term management are discussed below.

8.1 Land owner and project proponent agreements

A high-priority next step for moving the Aliso Creek Estuary Restoration Project into the next phase of CEQA/NEPA environmental review is to reach agreements between the key landowners and project proponents on the process and roles for environmental review, design and permitting, implementation/construction, and long-term operations and management (O&M). The key proponents likely include LOF, SCC, SCWD, Orange County, the City of Laguna Beach, and SOCWA. The proponents will need to meet and coordinate, possibly through a facilitated process, to reach and document agreements, for example through one or more memoranda of understanding (MOUs), on the process, roles, responsibilities, and terms for moving the project forward. This process may address topics such as:

- Additional studies and/or planning desired by the project proponents to inform their agency's decisions regarding the restoration project
- Lead agency/agencies for CEQA/NEPA review
- Possible formation of a new entity to lead planning, implementation, and/or O&M of the restoration, such as a joint powers authority and/or a local conservancy
- Possible property sales or transfers and easement modifications
- Need and process for entering into safe harbor agreements with regulatory agencies (e.g., U.S. Fish and Wildlife Service [USFWS] and CDFW) regarding the recovery of listed species and assurances from agencies that additional or different management activities will not be required without the project proponents' consent (USFWS 2017).

This process should also help to identify both possible sources of funding and proponents that can lead funding pursuits and manage funds (e.g., submitting grant applications and managing grant funding). Establishing agreements on how proponents will collaborate to implement the project should help position the proponents and the restoration for funding.

8.2 Potential additional studies and/or planning

As discussed above, the project proponents may desire additional studies and/or planning before initiating the CEQA/NEPA environmental review phase. Alternatively, if proponents decide to move forward with CEQA/NEPA, these studies could be initiated concurrently with the CEQA/NEPA phase as discussed in subsequent sections. These potential additional studies and/or planning may include:

- Utility modification/relocation planning (e.g., for water and wastewater pipes under the Aliso Beach Park inland parking lot, including the SOCWA main pipe line for effluent from the CTP)
- Public use planning (e.g., further consideration and refinement of the preferred public use options such as pedestrian bridge crossings identified in this Conceptual Restoration Plan with possible additional public outreach to inform planning)
- Further analysis and/or assessment of potential benefits and effects of the restoration on Aliso Beach coastal processes and management of the Aliso Creek mouth by Orange County.
- Development of a public outreach, education, and implementation/enforcement plan and program for reducing artificial breaching of the mouth by beach users.
- Further water quality assessment and coordination with the WQIP, possibly including a WQIP workshop to explore how water quality for the Aliso Creek estuary and possibly other estuaries can be managed and enhanced through the WQIP and/or more detailed water quality assessment including nutrient cycling (see Section 8.5.2).
- Coordinate with other restoration projects and management actions within the Aliso Creek Watershed to ensure consistency with estuary restoration objectives and management practices.

8.3 Potential Initial Monitoring and Adaptive Management Phase

An initial phase of monitoring and adaptive management could potentially proceed ahead of, or in conjunction with, planning for other components of the near-term restoration plan. This initial phase could inform and benefit further restoration planning by providing additional information to reduce restoration uncertainties and evaluate the effectiveness of management actions included in the restoration plan. This initial phase could include one or both of the following:

1. Physical, water quality, and ecological monitoring in conjunction with an initial adaptive management plan to test the effects and effectiveness of increasing operations of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project to reduce dry-weather creek inflows and improve water quality for the estuary.
2. Pilot program for public outreach, education, and enforcement to reduce artificial breaching of the mouth by beach users for recreation in conjunction with monitoring of breaching and a process to evaluate and refine the program.

Performing both of these restoration/management actions together within an adaptive management framework would allow for testing, evaluation, and refinement of these components of the restoration ahead of planning and implementing the full near-term restoration. A detailed adaptive management plan would need to be developed and implemented to guide this initial phase and achieve its goal of informing and progressing the overall restoration plan.

A CEQA/NEPA and permitting strategy would need to be developed and implemented for the initial phase of monitoring and adaptive management. It may be necessary for environmental clearances to consider the initial phase and the overall restoration together (e.g., through a tiered project-level CEQA/NEPA review for the initial phase and program-level review for the overall restoration). It is also possible that project proponents could reach agreement and secure environmental clearances for this initial phase more quickly than for the overall near-term restoration; however, the initial phase would likely need to be linked to milestones that move the restoration towards full implementation. The two potential components of this initial monitoring and adaptive management phase listed above are further discussed below.

8.3.1 Increased operation of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project

Increased operation of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project could be incrementally implemented as described in Section 7.7 in conjunction with an initial adaptive management and monitoring phase to pilot and evaluate this component of the near-term restoration plan. An adaptive management and monitoring plan would need to be developed specifically for this component of the initial phase to specify the process and parameters for incrementally increasing diversion and monitoring physical, water quality, and ecological responses as discussed in Section 7.10.

The CEQA/NEPA and permitting for this component of an initial phase may include revisiting the SCWD's current permits for the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project. It may be possible to amend SCWD's permits to incorporate increased operations as part of the initial adaptive management and monitoring phase of the Aliso Creek Estuary Restoration. Alternatively, new or additional environmental clearances could be prepared and secured that would replace SCWD's existing permits and include other components of an initial phase.

The CEQA/NEPA and permitting strategy will likely need to integrate, link, and/or evaluate increased operation of SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project with implementation of the Aliso Creek Aliso Creek Estuary Restoration, as further decreasing dry-weather Creek flow without implementation of other components of the near-term restoration plan is not necessarily expected to enhance the existing estuary. It is possible that further decreasing dry-weather inflow could have adverse impacts to the existing estuary (e.g., lowering water levels and reducing habitat extent); however, if decreasing dry-weather inflow is implemented in conjunction with the near-term restoration plan, the combined effect is expected to result in an ecological benefit to the restored estuary.

8.3.2 Program to Reduce Artificial Breaching of the Mouth by Beach Users

A program for public outreach, education, and enforcement to reduce artificial breaching of the mouth by beach users for recreation, as discussed in Section 7.6, could possibly be initiated immediately. This program could be coupled with monitoring of breaching and physical, water quality, and ecological responses in the estuary and a process to evaluate and refine the program as part of an initial adaptive management and monitoring phase of the restoration. Coordination and collaboration with Orange County Parks would likely be required to develop and implement the program within the Aliso Beach Park. Once the program and an accompanying adaptive management and monitoring plan are developed, the need for CEQA/NEPA review and regulatory permits could be evaluated. It is possible that environmental clearances would not be required for activities associated with this type of public outreach, education, and enforcement program.

8.4 CEQA/NEPA, Permitting, and Design

CEQA/NEPA review, permitting, and design can be initiated based on this Conceptual Restoration Plan as described below. One or more lead agencies will need to be identified for the CEQA process and, if needed, NEPA process. There may be a federal nexus for NEPA review if the project is funded with federal funding or requires a federal authorization (e.g., USACE Section 404 permit). The restoration site is included in the USFWS's Recovery Plan for the Tidewater Goby and USFWS may have discretionary permitting authority if the project would impact tidewater goby Critical Habitat or result in "take" of the species. Depending on if there is a federal nexus, consultation with USFWS under Section 7 or Section 10 may be necessary, and a supporting NEPA analysis may be required.

The restoration project is likely to require individual permits from regulatory agencies, which may include the following:

- USACE Section 404 and possibly Section 10
- USFWS biological consultation under either Section 7 (if there is a federal nexus) or Section 10 (for no federal nexus) for tidewater gobies
- CDFW streambed alteration agreement and possibly 2081 incidental take permit
- Coastal Development Permit
- Regional Water Quality Control Board Section 401 certification
- FEMA Letter of Map Revision (LOMR)
- Local municipal permits from the City of Laguna Beach and County of Orange.

Restoration design will include detailed engineering and landscape architecture design and collaboration with restoration ecologists, CEQA/NEPA and permitting leads and agencies, and

other specialists. The restoration design can proceed in stages, with reviews by agencies at specified levels of completion. These stages may include:

- Concept design: this Conceptual Restoration Plan provides the basis for a concept design and a project description for CEQA/NEPA review. Additional design information may be needed for CEQA/NEPA review, which could be documented in the form of a concept design memorandum.
- 30%-complete preliminary design for agency review and to support the regulatory permitting process. The 30%-complete preliminary design could include a Preliminary Design Report, a partial set of design drawings, outline specifications, and a refined opinion of likely implementation costs. Alternatively, 30%-complete construction documents can be provided as a separate deliverable.
- 60%-complete final design, which could include a complete draft set of design drawings, draft specifications, and a further refined opinion of likely implementation costs.
- 90%- and 100%-complete final design with the final draft and final package of design plans, specifications, and opinion of likely construction costs to support final permits and bidding and contracting the construction/implementation.

Additional information needed for design includes:

- Preparation of a base map including topographic and boundary surveys by a licensed surveyor
- Coordination and agreements with owners of utilities to be modified and/or protected in place by the restoration
- Surface and sub-surface soil sampling and testing to provide information on soil characteristics and quality for planning, design and permitting, including for beneficial reuse and/or off-haul of excess soil excavated to restore the estuary. This may also include geotechnical engineering evaluation and mapping the horizon of shallow bedrock.

Other additional studies that are likely needed to support CEQA/NEPA, permitting, and design are discussed below.

8.5 Additional Studies to Support CEQA/NEPA, Permitting, and Design

In addition to the potential need for additional studies/and or planning to inform decision making and agreements for how to move the project forward discussed in Section 8.2, additional studies will be needed to support CEQA/NEPA, permitting, and design. These studies may include:

- Ecological studies (see Section 8.5.1 below)
- Baseline water and sediment quality data collection from within the existing estuary
- Further water quality assessment including nutrient cycling and indicator bacteria (see Section 8.5.2)
- Additional hydrodynamic modeling of flooding to support design, a FEMA LOMR, and other permits

- Further modeling of mouth closure dynamics and assessment of estuary and coastal sediment processes
- A cultural resources study
- Other environmental resource studies.

Additional ecological studies and further water quality assessment are discussed in the following sections.

8.5.1 Ecological Studies

Ecological studies will need to be completed as the project moves towards more detailed restoration plans, CEQA and permitting and implementation. These studies will generally serve multiple purposes, including 1) improving the understanding of existing conditions to guide future restoration planning, 2) identifying sensitive resources on and near the site, 3) assessing potential impacts of the project to sensitive resources, and 4) developing mitigation and minimization measures to protect sensitive resources during construction. Important studies that will likely be needed moving forward include a formal wetland delineation, wildlife surveys, and vegetation surveys.

A wetland assessment done as part of this planning effort identified potential and probable jurisdictional wetlands and waters within the project site. These likely include wetlands regulated by USACE under Section 404, the SDRWQCB under CWA Section 401, and CDFW under California Fish and Game Code Section 1600 (i.e., three-parameter wetlands) and additional California Coastal Commission (CCC) wetlands (i.e., one-parameter wetlands). A formal delineation following USACE protocols will need to be done for the site. The regulatory agencies generally prefer that delineations be done within no more than a year or two before CEQA and permitting.

It is expected that various types of wildlife surveys ranging from reconnaissance-level to protocol) may need to be conducted as part of the CEQA/NEPA and permitting process. Though tidewater goby or other federal and state threatened or endangered species are not thought to currently occur on site, it may be necessary to conduct presence/absence surveys for special-status species with potential to occur in the project area. If threatened or endangered species (or their habitat) are potentially present, it may be required by CDFW and/or USFWS) to conduct species-specific/protocol-level surveys to support CEQA/NEPA review. The bridge over PCH and the cliffs adjacent to the site have potential to support roosting bats. Bat emergence surveys should be undertaken to identify use patterns in and around the site. General reconnaissance-level surveys for other wildlife, such as amphibians and birds should also be done to support CEQA/NEPA and permitting as well.

The vegetation surveys conducted for this planning effort did not identify any special status plants on site. It is known that one or more special status species of liveforever (*Dudleya* spp.) probably are growing on adjacent cliffs. Even though the cliffs are outside of the project area, they may be considered as a buffer area that would need to be surveyed as part of the CEQA and permitting process. The trees in the parking lot south of Aliso Creek should be surveyed by an arborist to

determine whether or not they might be protected under the City of Laguna Beach's Heritage Tree Ordinance.

There may be other biological surveys that will be necessary to support CEQA/NEPA and project permitting. The best approach to determine what surveys are necessary is to consult with local representatives of the permitting agencies. Conducting a CEQA and/or permitting kick-off meeting at the site with LOF and the representatives from the various agencies can be an efficient way to get input on what studies will be needed given the specifics of the restoration plan and potential resources on site. For example, the approach to considering coastal rainbow trout/steelhead can be explored at that time.

8.5.2 Further Water Quality Assessment

The water quality assessment completed for this Conceptual Restoration Plan (Section 6.3) is focused on estuary salinity, stratification, and residence time. This is because understanding these parameters and how they are expected to change with restoration provides the basis for understanding the type of estuary habitat that the restoration will support and how other estuary water quality functions may change with the restoration. It may also be beneficial to further assess other estuary water quality functions such as nutrient cycling and indicator bacteria processes. Assessing these processes may help to inform CEQA/NEPA, permitting, and design. This assessment could also help to further understand existing conditions as a baseline for monitoring and interpreting post-restoration water quality conditions, which would be valuable for both informing adaptive management and restoration practices and science for intermittently-open creek mouth estuaries.

A nutrient cycling assessment would address nutrient loading from the watershed and nutrient cycling process within the estuary, which may include the potential for algal growth, eutrophication, and nutrient uptake by restored vegetation. An assessment of indicator bacteria processes would need to consider watershed loading and the potential for decay and regrowth within the estuary. These studies would need to further assess existing conditions in order to further understand how water quality may change with restoration.

Additional water quality data collection in the estuary would likely be needed to support the assessment. Data collection could be performed in conjunction with an initial adaptive management and monitoring phase of the restoration that includes decreasing dry-weather flows and water quality loads to the estuary through increased operation of the SCWD's Aliso Creek Urban Runoff Recovery, Reuse, and Conservation Project and a pilot program to reduce artificial breaching of the mouth (as discussed in Section 8.3). Doing so would likely provide information that would greatly improve the ability to understand the effects of these restoration actions and predict restored water quality for the full restoration plan.

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SECTION 9

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SECTION 10

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Appendix A

Aliso Creek Bridge As-Built Drawings (Selected Drawings)



*California Department of Transportation
Division of Maintenance*

Structure Maintenance and Investigations

B_{RIDGE}

I_{NSPECTION}

R_{ECORDS}

I_{NFORMATION}

S_{YSTEM}

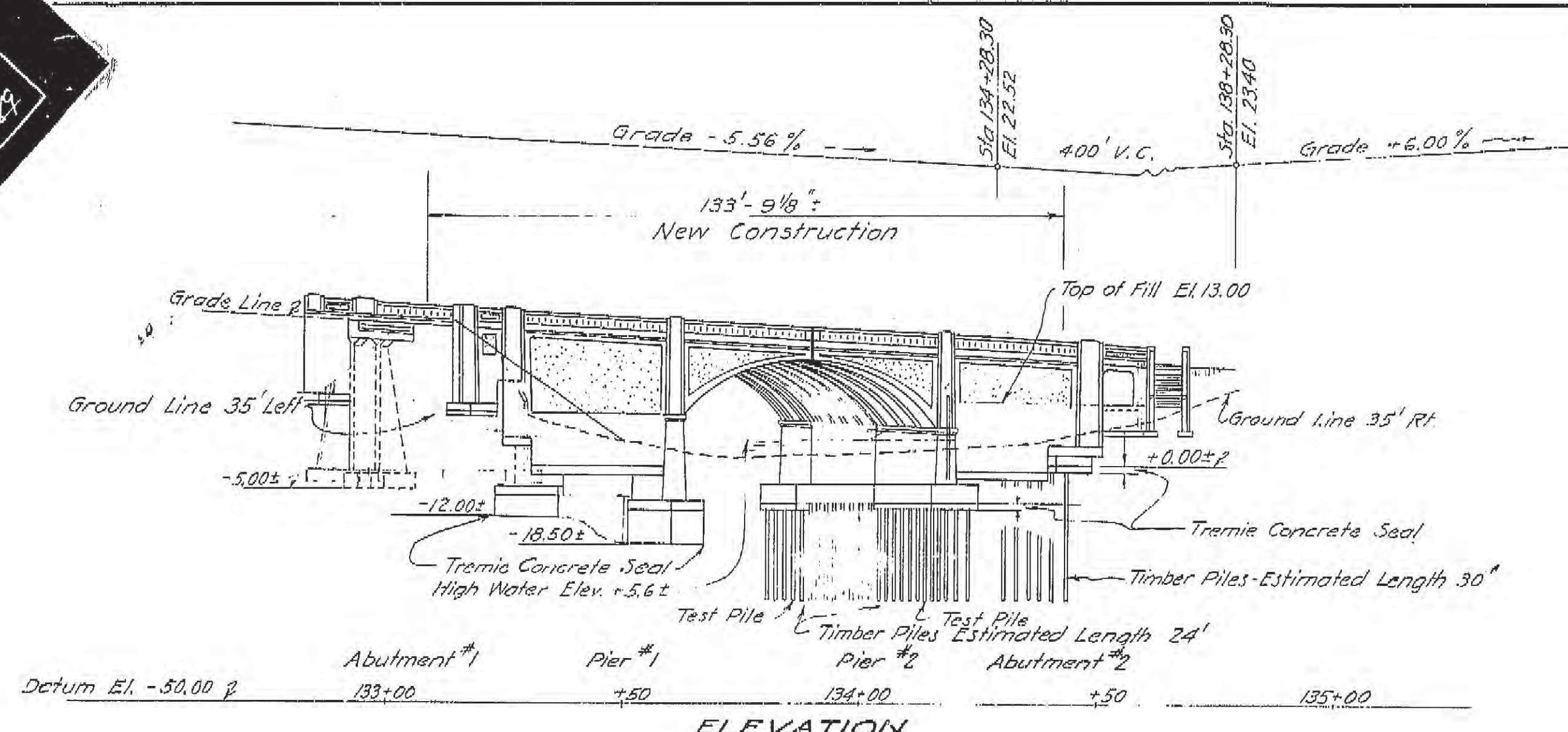
The requested documents have been generated by BIRIS.

These documents are the property of the California Department of Transportation and should be handled in accordance with Deputy Directive 55 and the State Administrative Manual.

Records for “Confidential” bridges may only be released outside the Department of Transportation upon execution of a confidentiality agreement.

Rte. 1
P.M. 0.5

AS BUILT PLANS
Contract No. 27VC12
Date Completed
Document No. 70002569



Notes:
Tremie concrete seals may be omitted if they are found unnecessary. No allowance will be made if seals are not used.

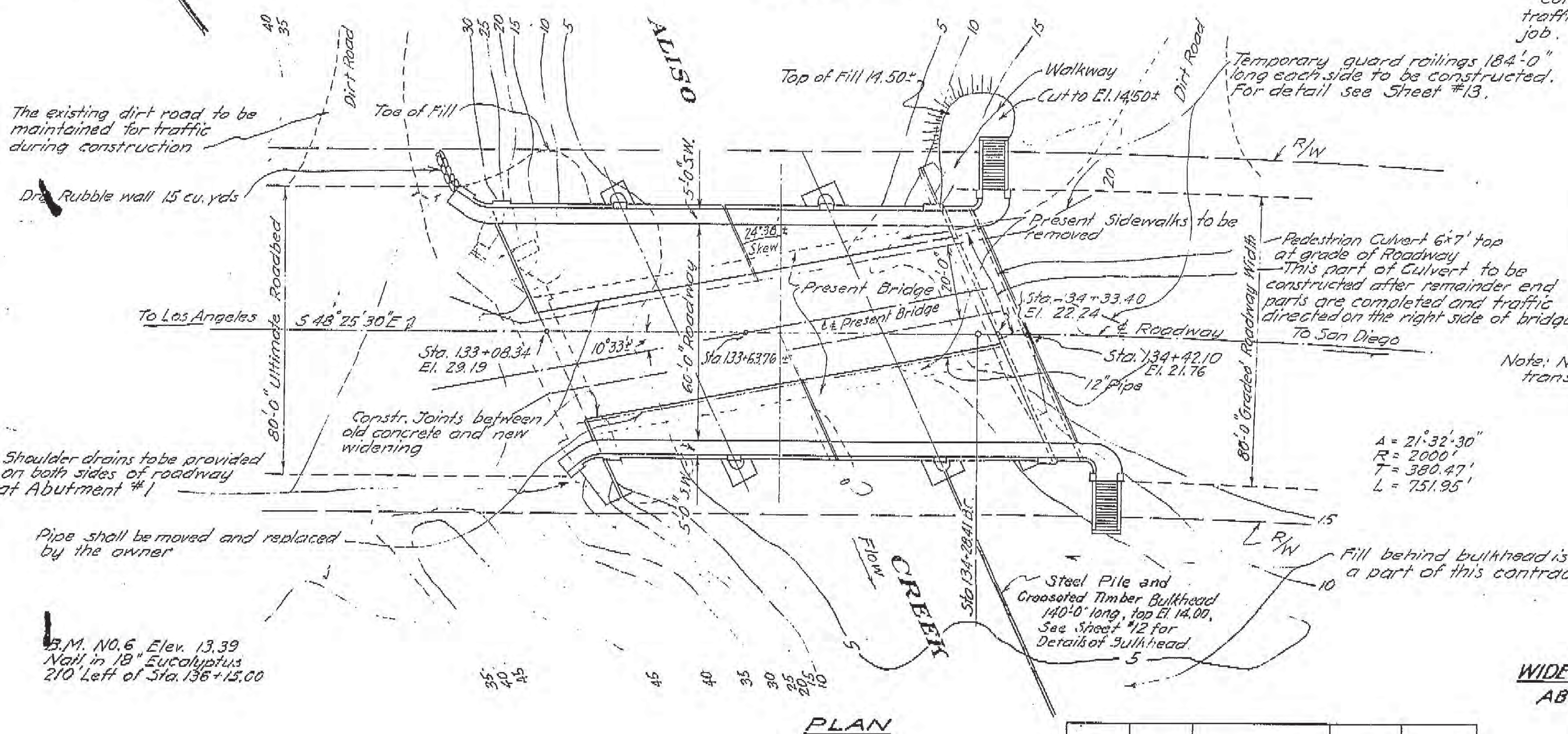
Contractor shall check dimensions of the present bridge during construction prior to ordering reinforcing steel. Adjustments to discrepancies and irregularities in the present construction shall be made in the field.
The exact depth of foundation and thickness of tremie concrete seals will be determined by the Engineer.
The exact length of piles will be determined by the Contractor with test piles.
The existing structure shown in pale lines.

Contractor shall maintain 2-way traffic over present bridge throughout job.

TITLE	SHEET NO.
GENERAL PLAN	1
SUPERSTRUCTURE	2
SIDE ELEVATIONS	3
ABUTMENT NO. 1	4
ABUTMENT NO. 2	5
PIER NO. 1	6
PIER NO. 2	7
ISOMETRIC VIEWS	8
DETAILS-GIRDERS	9
DETAILS	10
PEDESTRIAN CULVERT	11
DETAILS OF BULKHEAD	12
DETAILS OF WINGWALLS	13

Note: New construction on super-elevation transition see Sheets #2 & #8

A = 21°32'30"
R = 2000'
T = 380.47'
L = 751.95'



Cont. # 27VC12

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
WIDENING OF BRIDGE ACROSS ALISO CREEK
ABOUT 3 MILES SOUTH OF LAGUNA BEACH
IN ORANGE COUNTY
GENERAL PLAN
Scale: 1"=20'
BRIDGE NO. 5503 DRAWING NO. C-27-1

FOR GENERAL NOTES ON THIS SET OF PLANS SEE SHEET NO. 10.

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ORIGINAL AS TAKEN BY ME OR UNDER MY CLOSE PERSONAL SUPERVISION AND CONTROL ON THE DATE IN THE ATTACHED CERTIFICATE PURSUANT TO AN ORDER OF THE BOARD OF PUBLIC WORKS.

DATE _____ SIGNATURE _____ TITLE _____

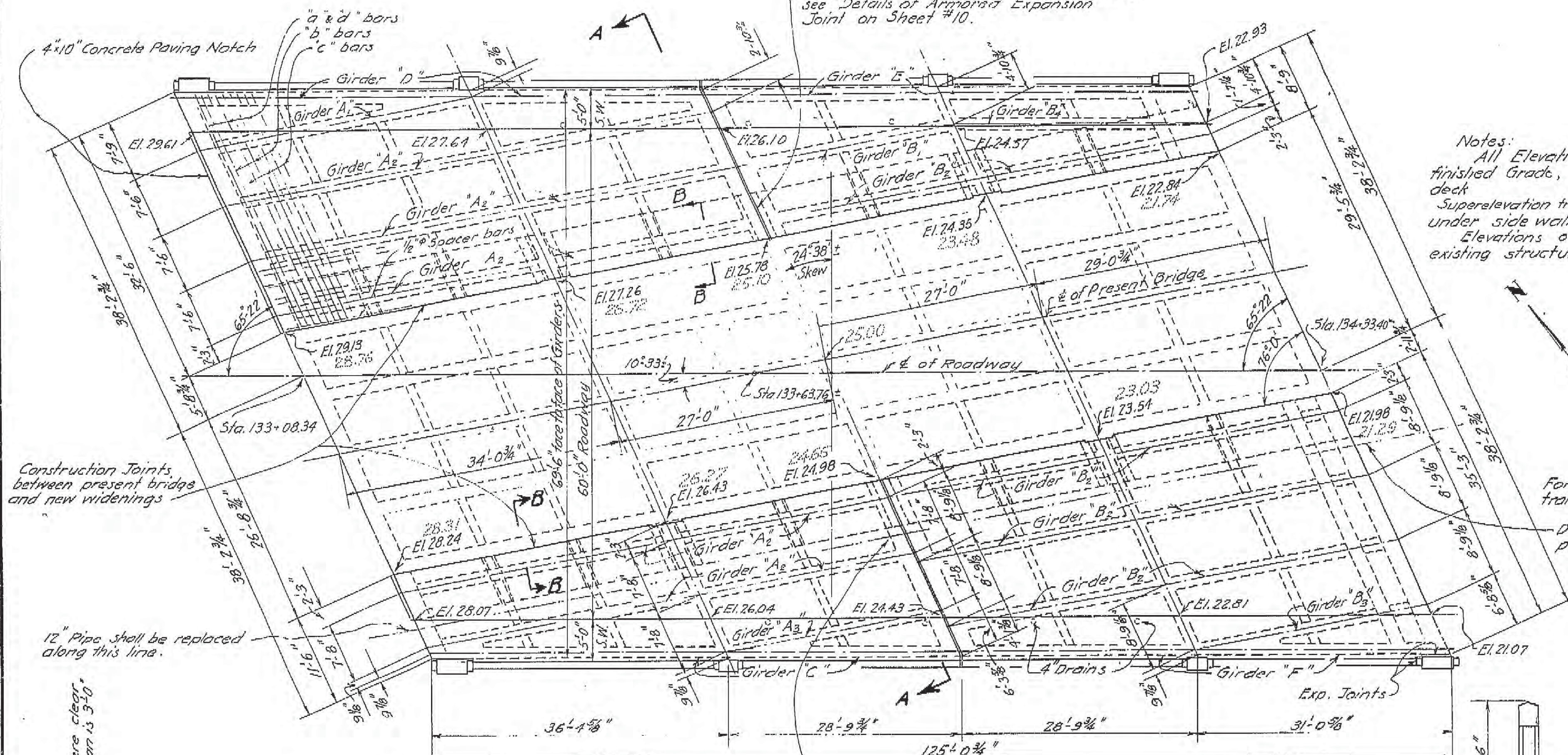
Notes:
All Elevations given to 2" below finished grade, being top of concrete deck.
Superelevation transition continued under side walk.
Elevations of roadway deck of existing structure are shown thus 21.74

For detail of superelevation transition see Sheet #8.

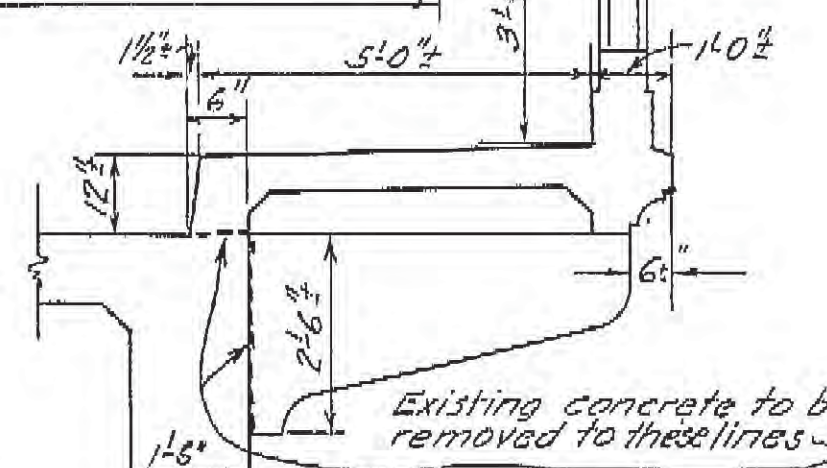
Drop pipe under pedestrian culvert

AS BUILT PLANS
Contract No. 27412
Date Completed
Document No. 7000249

1/4" Expansion Joint and Expansion Angles, see Details of Armored Expansion Joint on Sheet #10.



DECK PLAN
Scale: 1/8"=1'-0"



SECTION B-B Showing old Sidewalk to be removed
Scale: 1/2"=1'-0"

WIDENING OF BRIDGE ACROSS
ALISO CREEK

ABOUT 3 MILES SOUTH OF LAGUNA BEACH
IN ORANGE COUNTY

SUPERSTRUCTURE

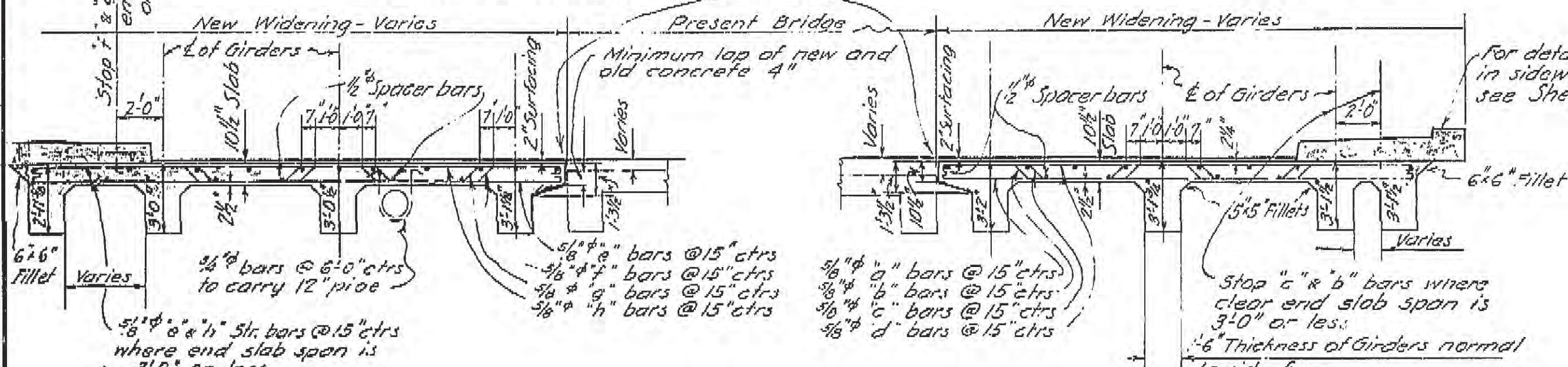
Scales as shown.

BRIDGE NO. 5503 DRAWING NO. C-27-2

Revised By	Checked By	Description	Location	Date

Construction Joint between new and old concrete. The exposed steel from present structure shall be embedded into new concrete.

Provide 16"x16" Openings in diaphragms for pipe



SECTION A-A
Scale: 1/4"=1'-0"

For detail of Reinforcement in sidewalks and railings see Sheet #10

Stop "a" & "b" bars where clear end slab span is 3'-0" or less.
6" Thickness of Girders normal to side face.

Drawn By	Checked By	Date

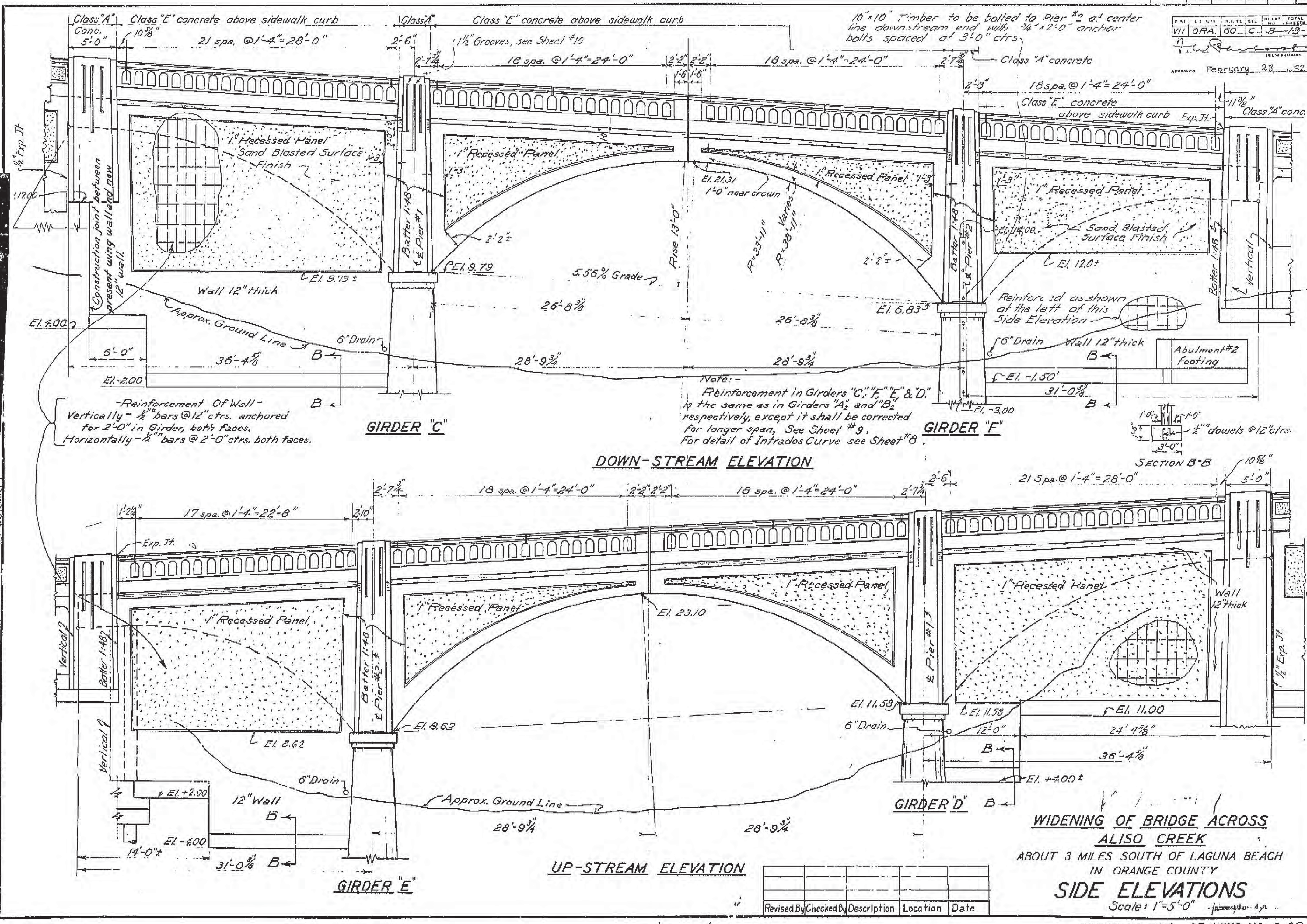
AS-BUILT PLANS

Contract No. 27012
Date Completed
Document No. 7000239

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
2	CAL.	203-D	1933	25	39

DATE	BY	REVISION	NO.	TOTAL
VII	ORA.	60	C	13

APPROVED February 23, 1932



WIDENING OF BRIDGE ACROSS ALISO CREEK
ABOUT 3 MILES SOUTH OF LAGUNA BEACH
IN ORANGE COUNTY
SIDE ELEVATIONS
Scale: 1"=5'-0"

BRIDGE NO 5503 DRAWING NO C-27-3

I HEREBY CERTIFY THAT THIS IS A TRUE AND ACCURATE COPY OF THE ABOVE DOCUMENT TAKEN UNDER MY DIRECTION AND CONTROL ON THIS DATE IN SACRAMENTO, CALIFORNIA PURSUANT TO AUTHORIZATION BY THE DIRECTOR OF PUBLIC WORKS.

DATE _____ SIGNATURE _____ TITLE _____

Appendix B

Aliso Field Data

B-1 Field Data Collection Plan

ALISO CREEK ESTUARY RESTORATION

Field Data Collection Plan

Prepared for
County of Orange

November 2015

Customer Care/Permit Services
P.O. Box 4048
Santa Ana, CA 92702



ESA prepared the following field data collection plan to collect data to support the development of the Aliso Creek Estuary Conceptual Restoration Plan. The field data collection plan was prepared to apply for and obtain an encroachment permit from the County of Orange.

Project Background and Location

The Laguna Ocean Foundation has received a grant from the California State Coastal Conservancy to develop a Restoration Plan for the estuary at Aliso Creek. ESA, as the lead consultant, has begun the process of initial background data collection and through this process will develop an understanding of current physical, hydrological, biological and water quality conditions of the existing lagoon and its upstream influences. To support this data collection process, ESA is requesting a permit to perform a baseline topographic/bathymetric survey as well as sediment grain size, water quality and water level data collection in the Aliso Creek Estuary and upstream channel. The work will take place on the following parcels, APN 056-020-34 and 056-240-36 and the information provided below is a more detailed description of the proposed work to aid Orange County staff in the application review process. Please refer to Figure 1 at the end of the document for a general location map.

Topographic/Bathymetric Survey

ESA is proposing to collect baseline topographic/bathymetric survey data to support development of a topographic base map. ESA will survey approximately 8 channel cross-sections and a channel thalweg (a longitudinal profile at the deepest part of the channel) from a canoe or similar small, non-motorized boat. An optical total station and/or an RTK (Real Time Kinematic) GPS unit will be used to record locations and surface elevations along each transect. The survey will be tied into at least one site benchmark established nearby. Additionally, ground transects will be surveyed in areas adjacent to the channel and at Aliso Beach to supplement and verify available LiDAR topographic data. Figure 2 illustrates the approximate location of the topographic/bathymetric transects.

Water Level Data Collection

ESA is also proposing to install a water level recorder in the Estuary to measure water level fluctuations near the Estuary mouth (i.e., tidal fluctuations when the mouth is open and fluctuations due to Creek inflow, wave overtopping and seepage when it is closed) for a period of 12 months. ESA will install a pressure transducer inside a stilling well (perforated aluminum or PVC pipe). The stilling well will be vibrated into the mud until refusal above the highest water level and the pressure transducer will be placed inside. The data logger will be programmed to record one sample every ten minutes. Additionally, a barometric logger will be installed onsite to adjust the pressure data for changes in the barometric pressure throughout the time of measurement. During installation, data download, and removal, the water surface elevation will be surveyed in to calibrate the pressure measurements. Figure 2 illustrates the approximate location of the water level data recorder deployment. The water level recorder will be accessed using a canoe or similar boat. The water level recorder will be maintained for up to two years, after which the equipment and stilling well would be removed; however, the water level recorder could be maintained for longer to provide a long-term data set if allowed by the County of Orange.



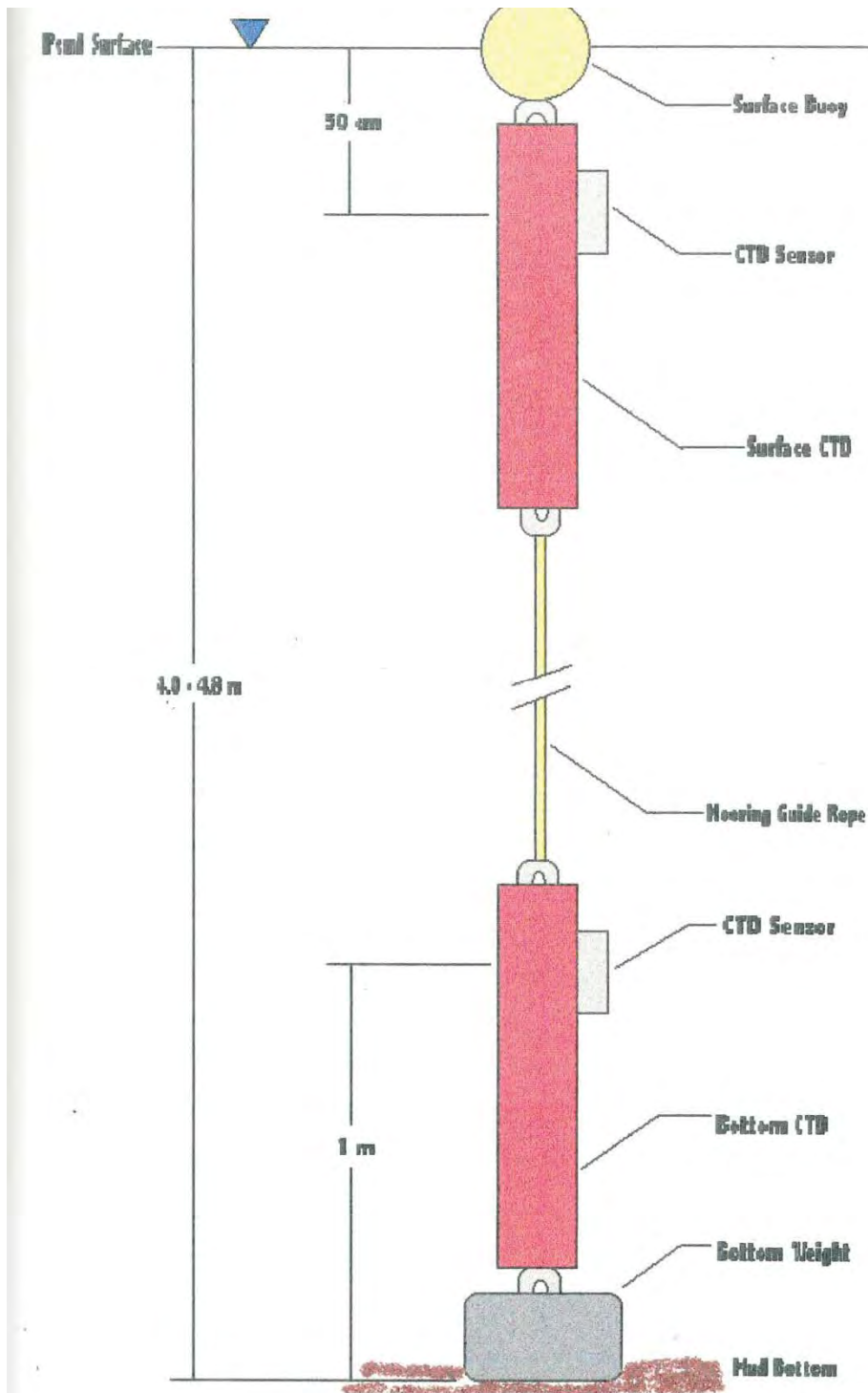
Picture of water level recorder in a stilling well taken at low tide.

Sediment Grain Size Data Collection

In support of the background data collection ESA will collect approximately 4 sediment grab samples. Sediment collected in the field will be sent to the lab to be analyzed for grain size.

Water Quality Data Collection

ESA would also like to deploy two water quality instruments to measure salinity, temperature, and dissolved oxygen for a period of 12 months. The two instruments will be deployed in one location, with one instrument to measure the water quality parameters at the water surface and one at the bottom of the Estuary, in order to characterize stratification processes. The gages will be deployed either in a vertical array attached to a buoy, or in a stilling well, similar to the water level pressure gage installation, depending on site conditions. The instruments would be accessed by canoe or a similar boat. Figure 2 illustrates the approximate location of the water quality data recorder deployment.



Example schematic drawing for deployment of surface and bottom water quality instruments

Canoe/Boat Storage

ESA requests permission to access and store a canoe or similar small, non-motorized boat in the Aliso Beach Park storage area at the northern end of the parking lot. ESA would need a key or combination to access the storage area for the purpose of retrieving and storing the canoe/boat only. The gate would be locked after retrieving and storing the canoe so that the gate would be locked at all times when staff are not present.

Contact Information

Project Owner/Company Name

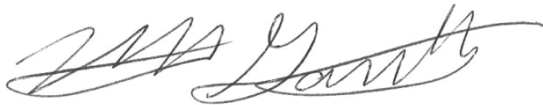
The Ocean Foundation
1320 19th Street, NW, Suite 500
Washington, DC 20036
202-887-8996 phone
202-887-8987 fax

Engineer/Contractor Name

ESA
Nick Garrity, PE
626 Wilshire Boulevard, Suite 1100
Los Angeles, CA, 90017-2934
213-599-4326 phone
213-599-4301 fax
ngarrity@esassoc.com

If additional information is needed or you require clarification regarding the proposed work please feel free to contact me at your convenience.

Sincerely,

A handwritten signature in black ink, appearing to read "Nick Garrity", with a stylized flourish at the end.

Nicholas Garrity, P.E.
ESA | Environmental Hydrology
ngarrity@esassoc.com
213-599-4326 direct
562-296-5679 cell



Figure 1. General Location of Proposed Work

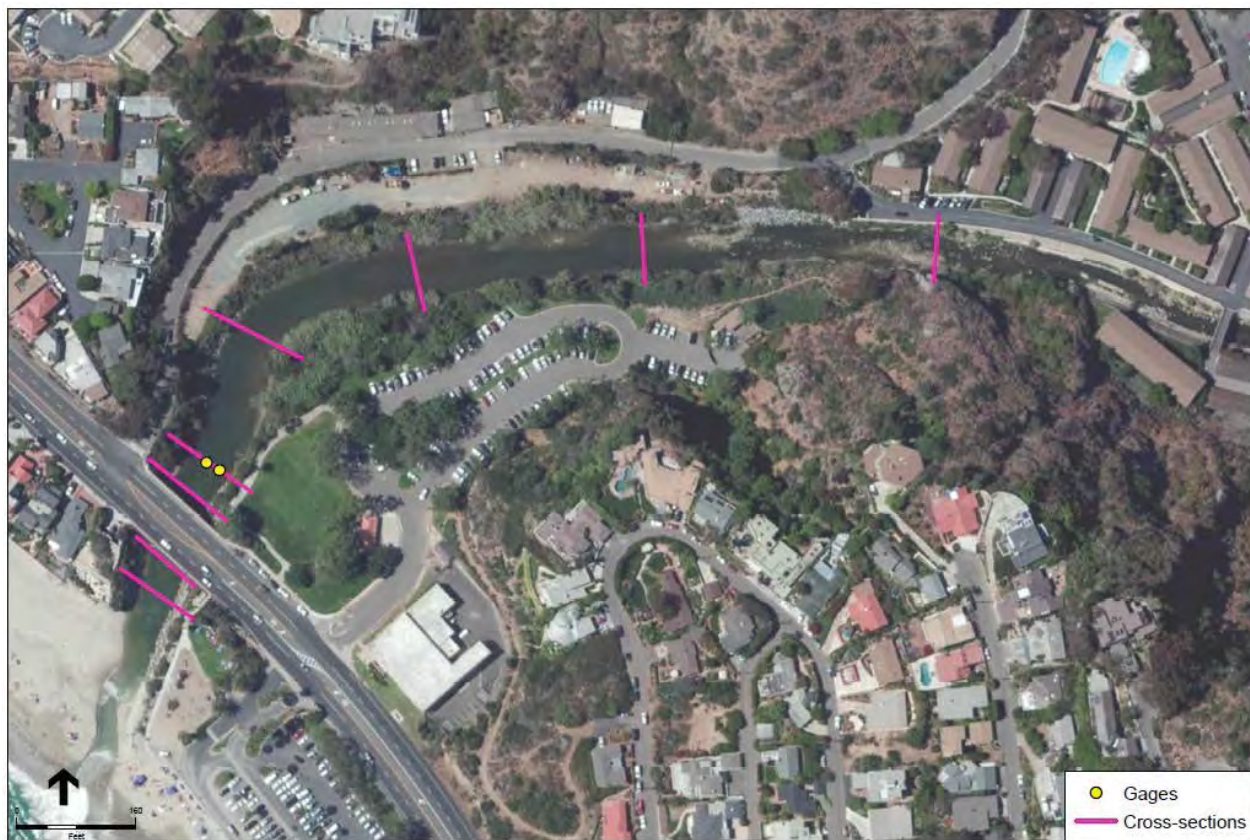


Figure 2. Location of Topographic/Bathymetric Survey Transects, Water Level and Quality Monitoring Sites

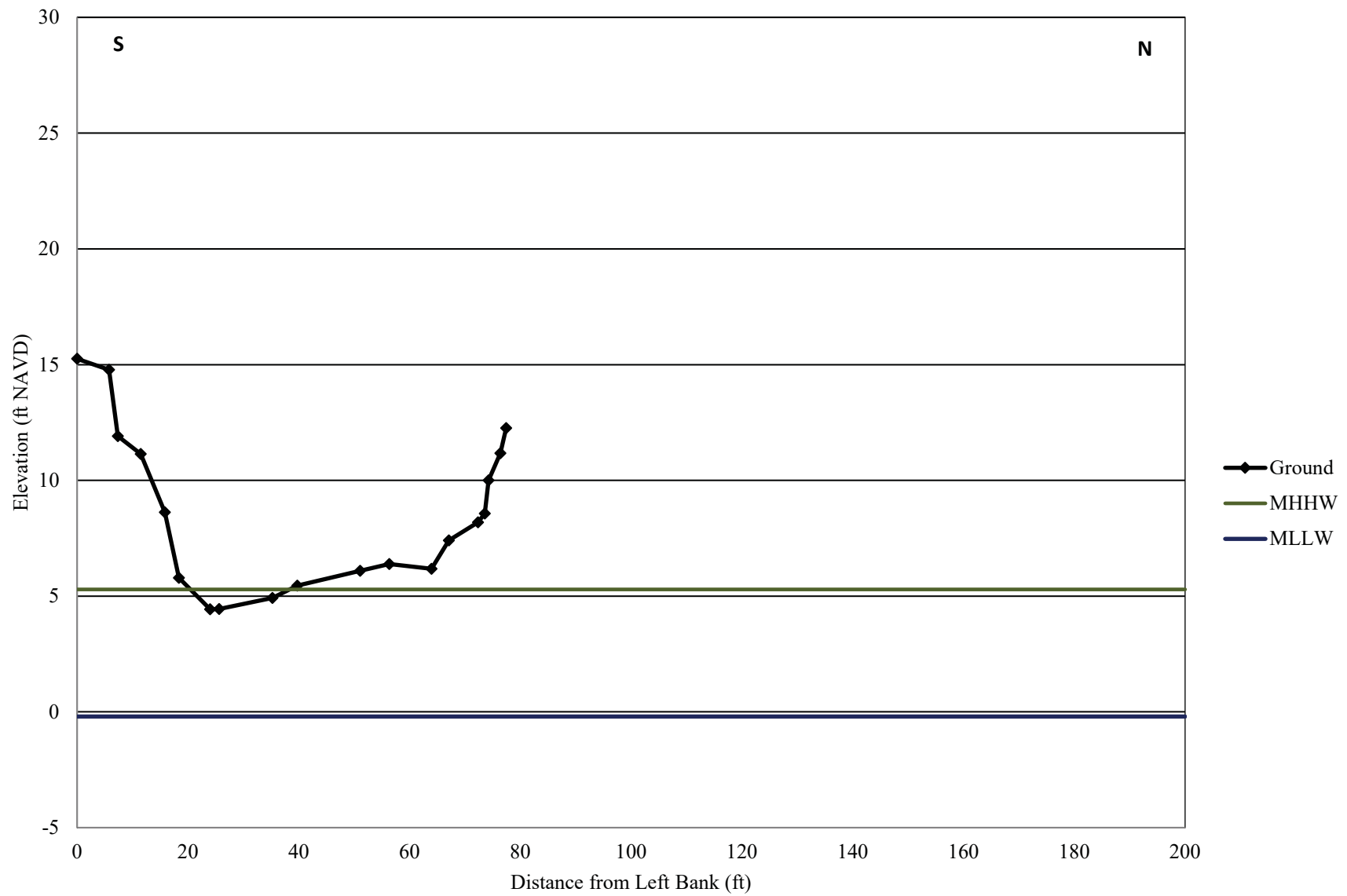
B-2 Topography and Bathymetry



SOURCE: Esri, ESA

Aliso Creek Estuary Restoration .150108.

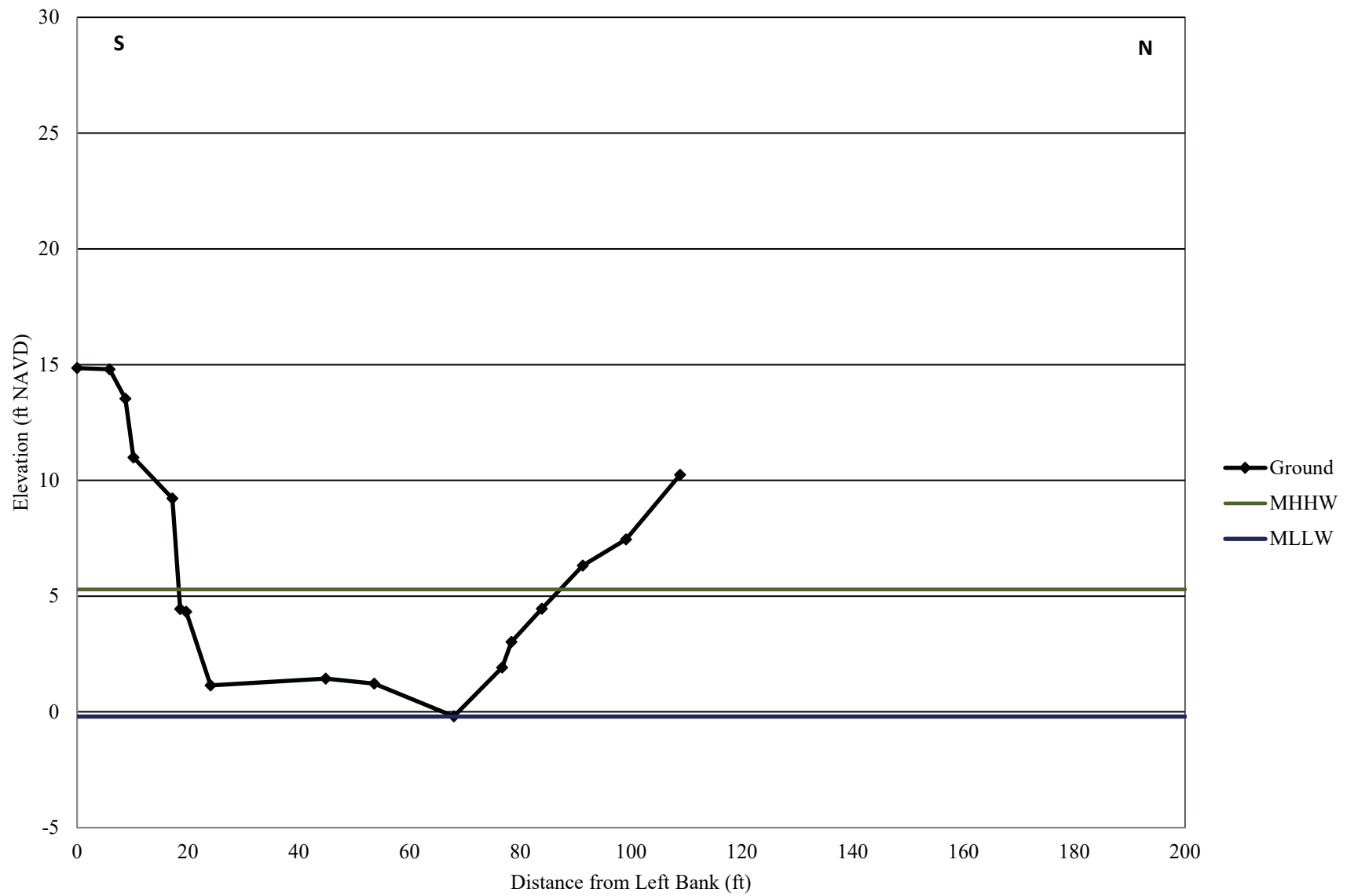
Figure B-1
Aliso Creek Cross-Sections and Longitudinal Thalweg Profile



SOURCE: ESA Survey 1/28/2016

Aliso Creek Estuary Restoration . D150108.00

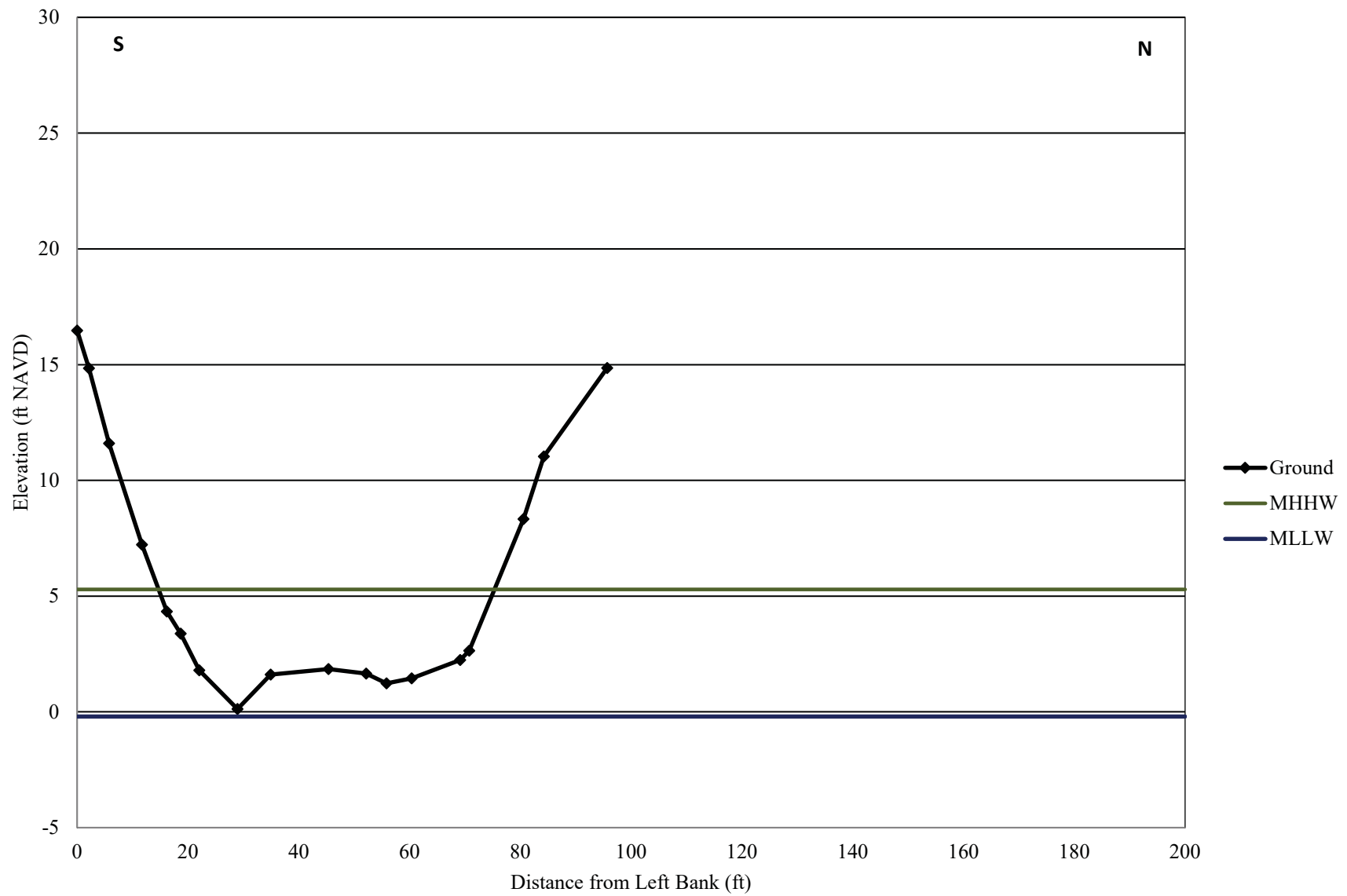
Figure B-2
Cross Section 1



SOURCE: ESA Survey 1/28/2016

Aliso Creek Estuary Restoration . D150108.00

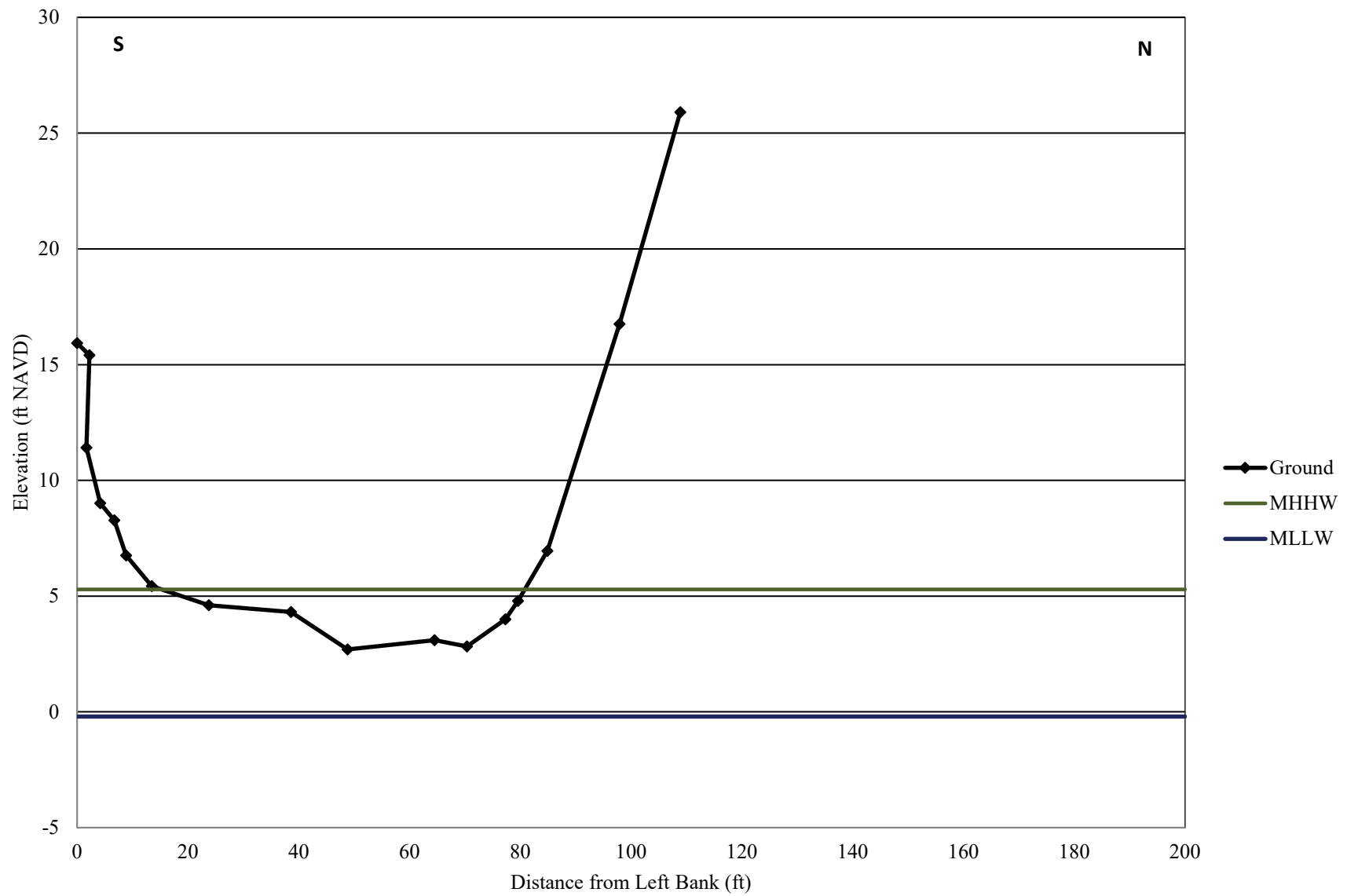
Figure B-3
Cross Section 2



SOURCE: ESA Survey 1/28/2016

Aliso Creek Estuary Restoration . D150108.00

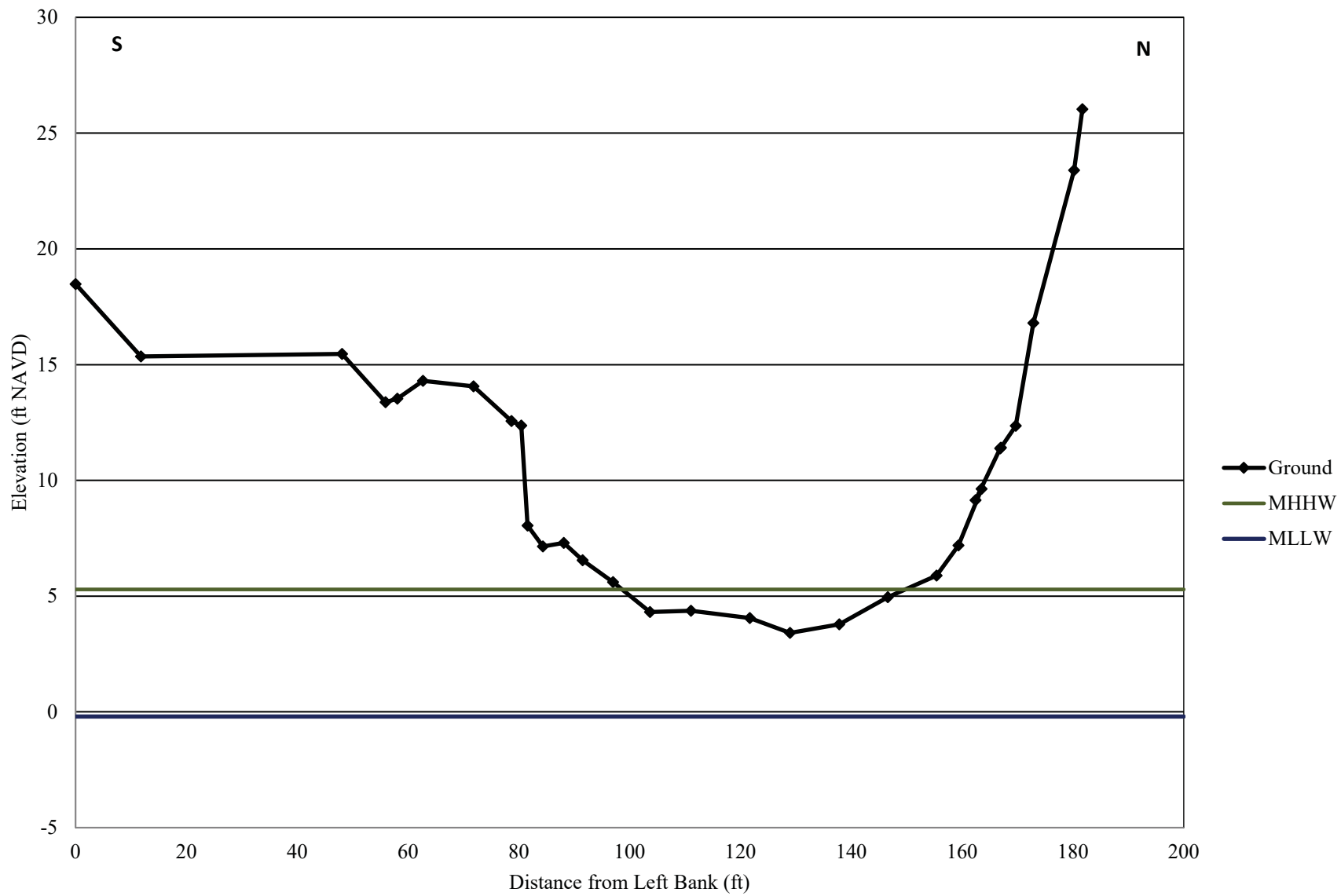
Figure B-4
Cross Section 3



SOURCE: ESA Survey 1/28/2016

Aliso Creek Estuary Restoration . D150108.00

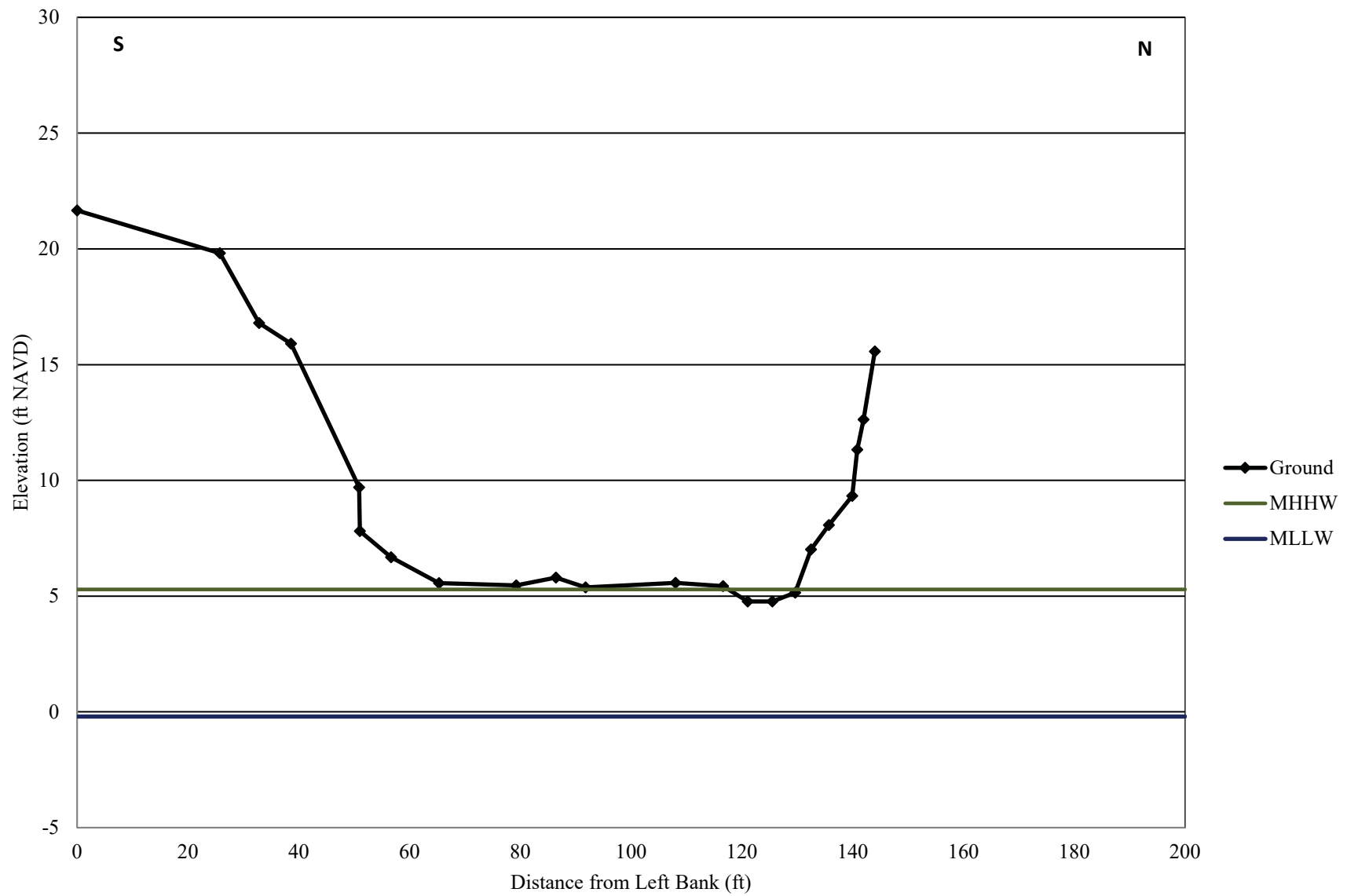
Figure B-5
Cross Section 4



SOURCE: ESA Survey 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

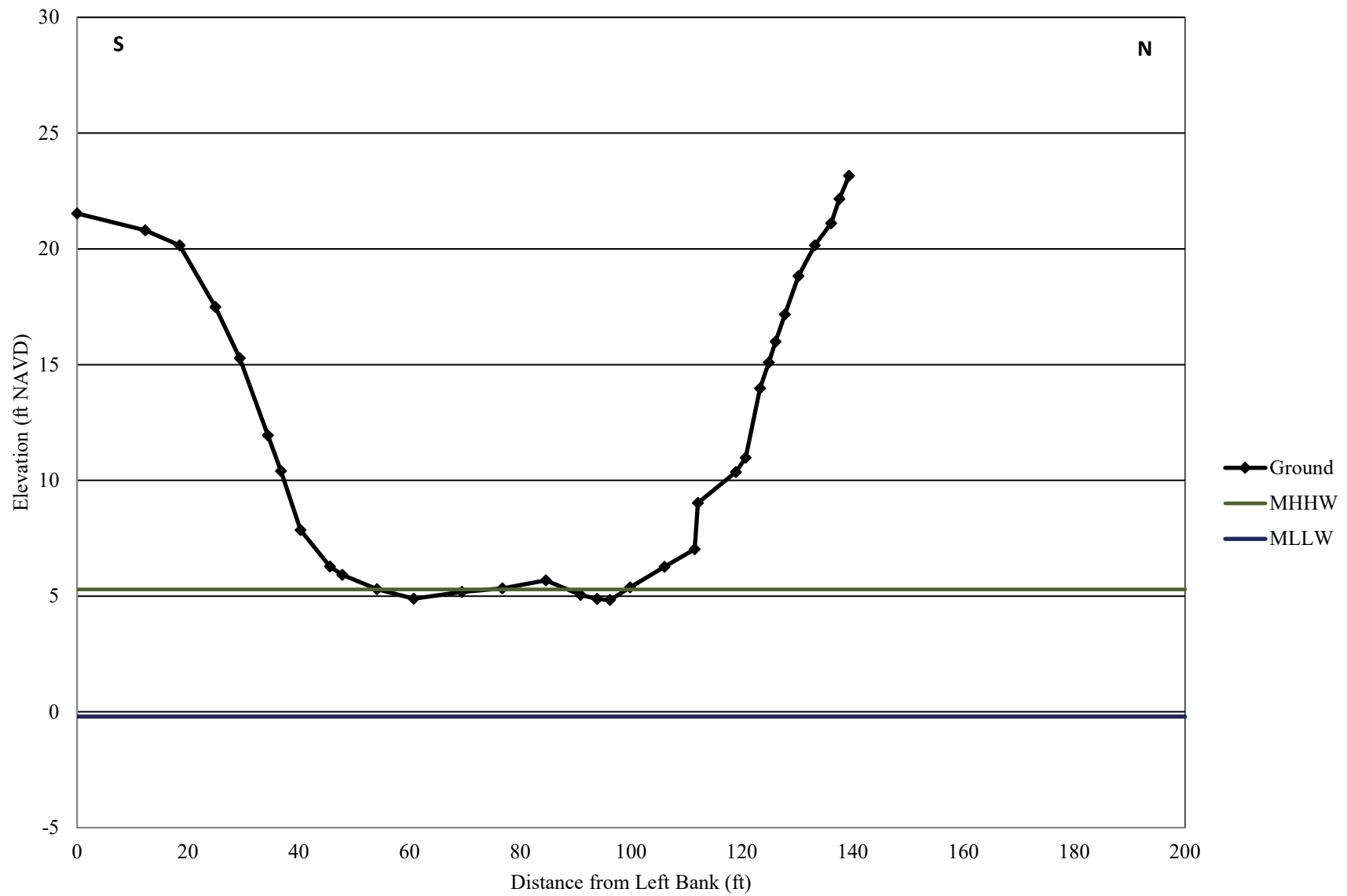
Figure B-6
Cross Section 5



SOURCE: ESA Survey 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

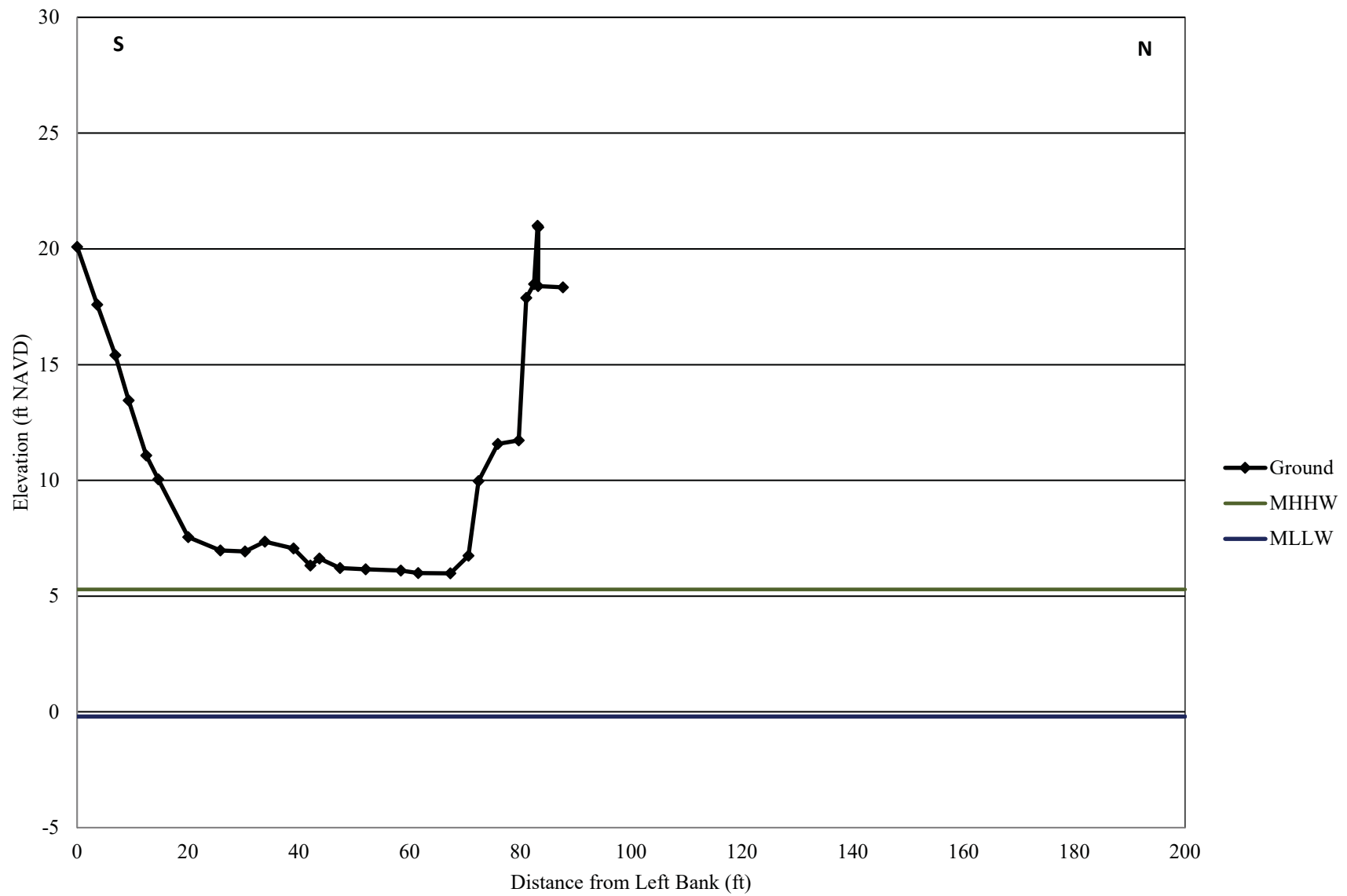
Figure B-7
Cross Section 6



SOURCE: ESA Survey 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

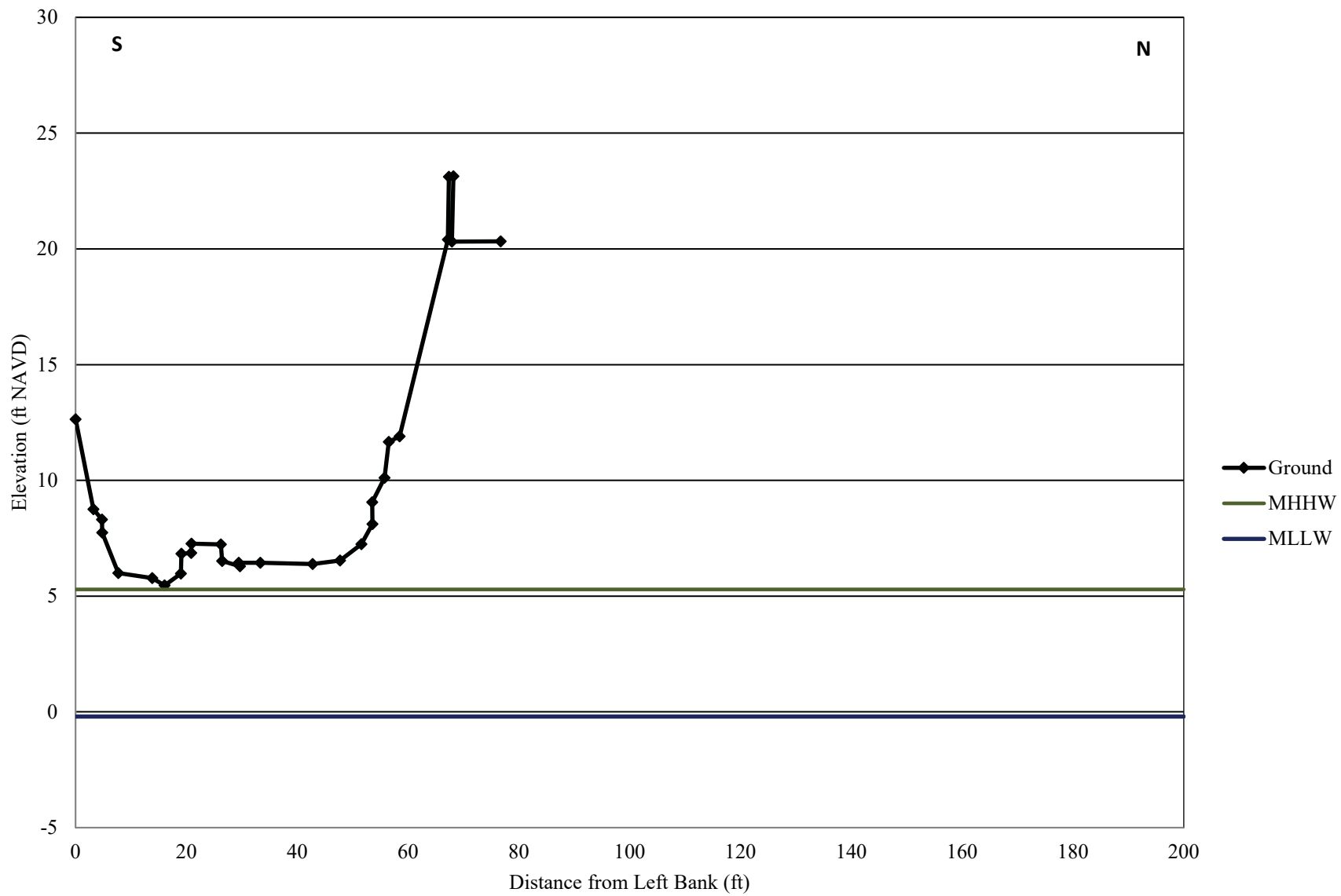
Figure B-8
Cross Section 7



SOURCE: ESA Survey 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

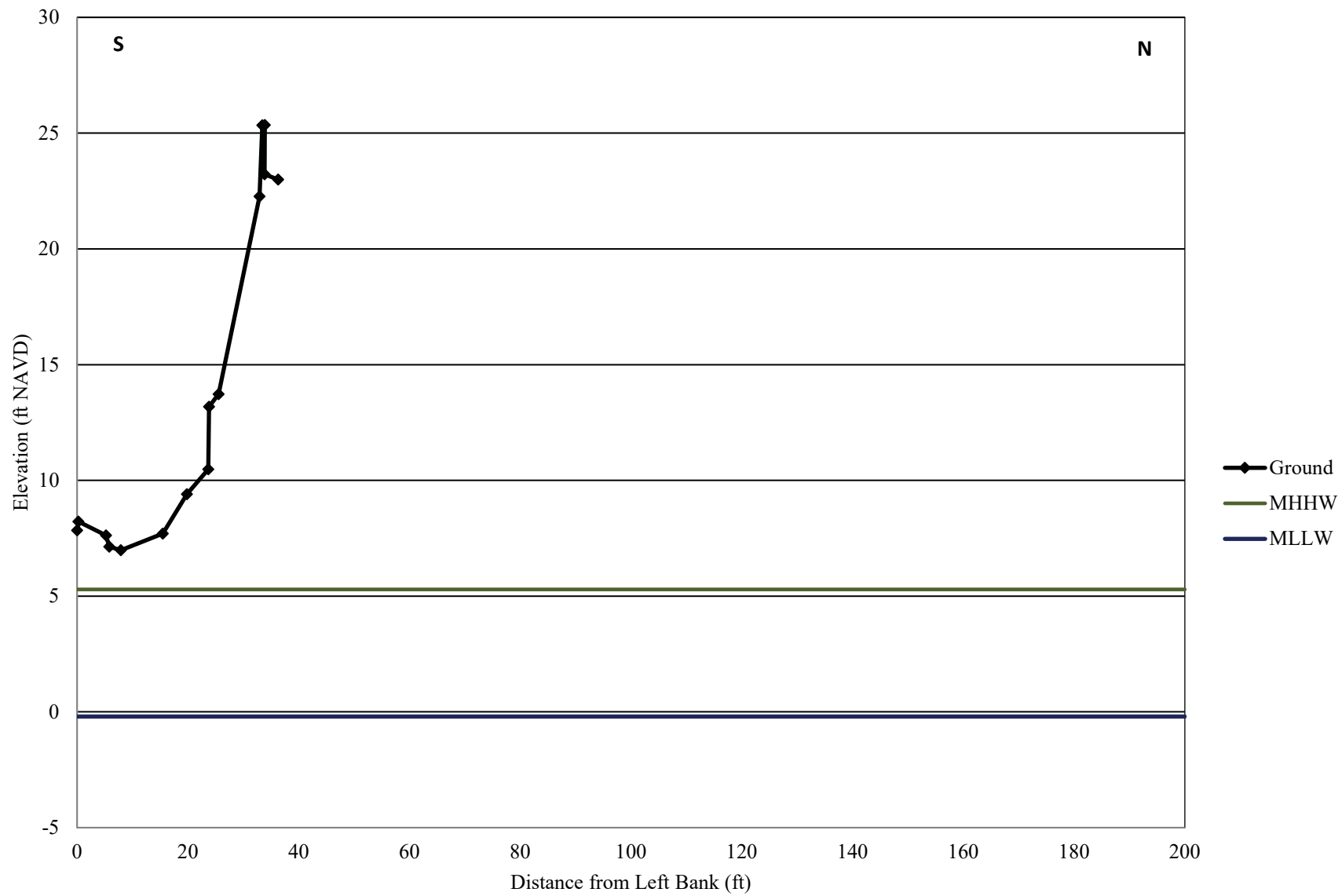
Figure B-9
Cross Section 8



SOURCE: ESA Survey 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

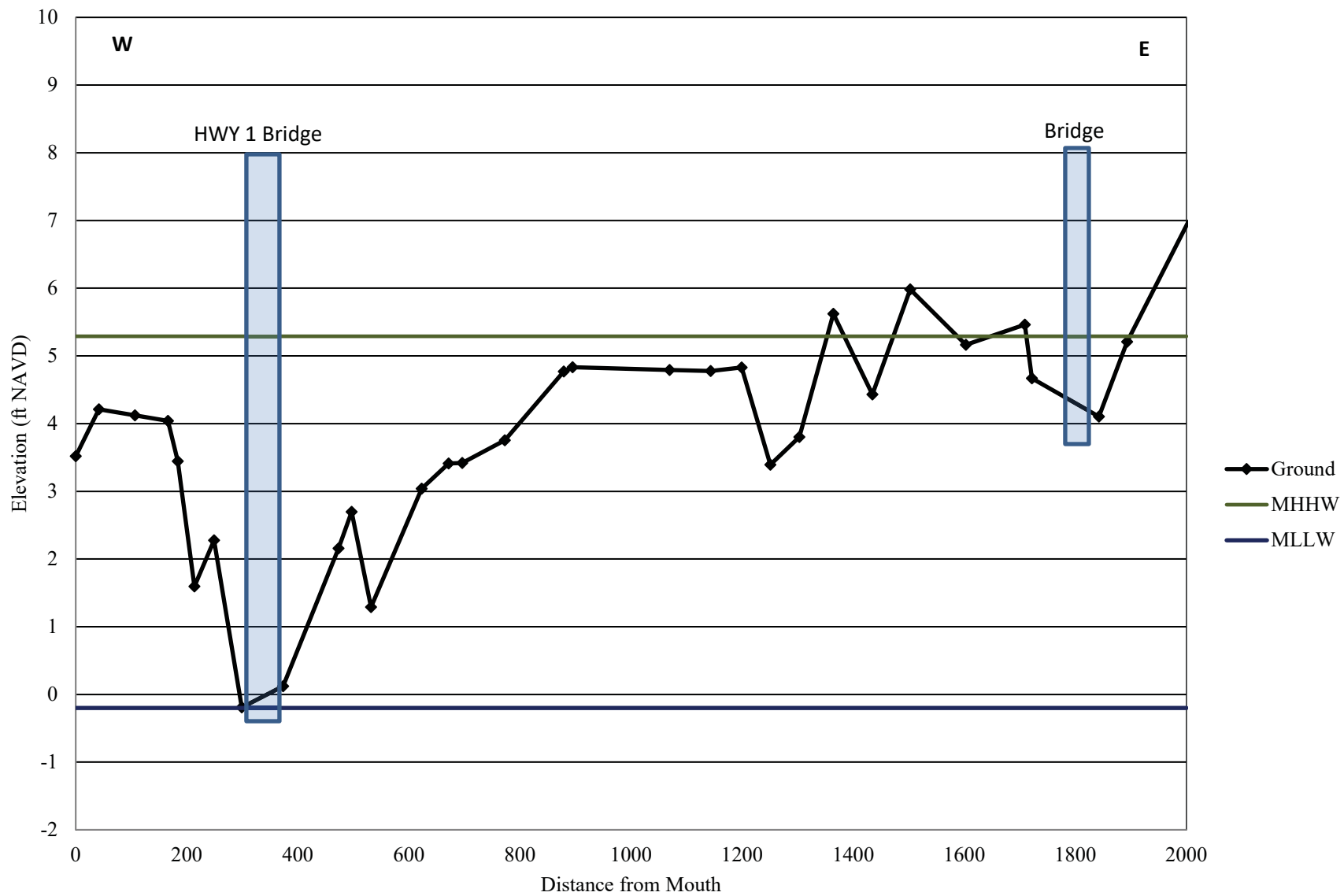
Figure B-10
Cross Section 9



SOURCE: ESA Survey 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

Figure B-11
Cross Section 10



SOURCE: ESA Survey 1/28/2016 & 3/1/2016

Aliso Creek Estuary Restoration . D150108.00

Figure B-12
Longitudinal Thalweg Profile

B-3 Sediment Sampling

WALLACE LABORATORIES Sand and Gravel Sieve Analysis

365 Coral Circle

date Apr. 13, 2016

El Segundo, CA 90245

location Environmental Science Associates

(310) 615-0116

requested by Ellen Buckley

	material	Soil ID	16-103E-1		16-103E-2		16-103E-3		16-103E-4		16-103E-5		16-103E-6	
			Aliso Creek Beach		Aliso Mouth 12/16		Aliso 2-1		Aliso CK Sed 3		Aliso Sed 4		Aliso Sed 5	
	mesh	millimeter	percent passing	percent retained	percent passing	percent retained	percent passing	percent retained	percent passing	percent retained	percent passing	percent retained	percent passing	percent retained
coarse gravel	2	12.5	100.0%	0.0%	100.0%	0.0%	98.2%	1.8%	88.3%	11.7%	83.9%	16.1%	91.4%	8.6%
	4	4.75	100.0%	0.0%	100.0%	0.0%	96.7%	1.5%	81.4%	6.9%	72.4%	11.4%	84.6%	6.8%
fine gravel	10	2.00	99.8%	0.2%	99.6%	0.4%	87.2%	9.5%	55.2%	26.1%	49.5%	22.9%	67.1%	17.5%
	14	1.41	99.0%	0.8%	98.5%	1.1%	71.4%	15.8%	45.5%	9.8%	39.9%	9.6%	55.4%	11.7%
	16	1.19	98.1%	0.9%	98.0%	0.5%	63.4%	7.9%	39.0%	6.5%	34.2%	5.7%	46.3%	9.1%
coarse sand	20	0.84	96.7%	1.4%	97.4%	0.6%	57.2%	6.2%	31.9%	7.1%	29.2%	4.9%	37.5%	8.8%
	28	0.59	89.4%	7.2%	94.3%	3.1%	45.3%	12.0%	18.7%	13.2%	19.9%	9.3%	19.4%	18.1%
	32	0.50	80.9%	8.5%	90.6%	3.7%	41.2%	4.0%	13.9%	4.8%	16.0%	3.9%	13.5%	5.9%
medium sand	40	0.42	70.0%	11.0%	85.3%	5.3%	36.6%	4.7%	10.8%	3.2%	13.1%	2.9%	9.9%	3.6%
	48	0.30	37.3%	32.7%	63.8%	21.5%	28.6%	8.0%	7.1%	3.7%	9.5%	3.6%	6.1%	3.8%
fine sand	60	0.25	23.5%	13.8%	49.1%	14.7%	23.0%	5.6%	6.0%	1.1%	8.2%	1.3%	5.0%	1.1%
	80	0.177	13.1%	10.4%	29.3%	19.8%	16.0%	7.0%	4.9%	1.1%	7.0%	1.2%	4.0%	1.0%
	100	0.149	2.5%	10.6%	10.3%	19.0%	9.0%	7.0%	3.6%	1.2%	5.8%	1.2%	3.0%	1.0%
very fine sand	150	0.104	0.5%	2.0%	2.8%	7.5%	4.4%	4.6%	2.5%	1.1%	3.5%	2.3%	2.0%	1.0%
	200	0.074	0.2%	0.3%	1.3%	1.5%	2.2%	2.2%	1.8%	0.7%	2.4%	1.1%	1.3%	0.7%
	270	0.053	0.1%	0.1%	0.5%	0.8%	0.6%	1.6%	0.9%	0.9%	1.1%	1.2%	0.6%	0.7%
pan				0.1%		0.5%		0.6%		0.9%		1.1%		0.6%
Texture			sand		sand		sand		gravelly sand		gravelly sand		gravelly sand	
Sand			97.0%		95.0%		92.4%		92.2%		89.8%		94.0%	
Silt			0.6%		2.8%		5.4%		6.0%		8.2%		4.0%	
clay			2.4%		2.2%		2.2%		1.8%		2.0%		2.0%	



SOURCE: ESA 2016

Aliso Creek Estuary Restoration

Figure A-3.1
Sediment Sample Locations

Appendix C

CNDDDB List of Special Status Species



Appendix C

Scientific Name	Common Name	Group	Federal List	Calif. List	Global Rank	State Rank	CNPS Status	Other Status *	Potential to Occur on Site
<i>Anaxyrus californicus</i>	arroyo toad	Amphibians	Endangered	None	G2G3	S2S3		SSC, EN	Low
<i>Rana draytonii</i>	California red-legged frog	Amphibians	Threatened	None				SSC	Low
<i>Spea hammondi</i>	western spadefoot	Amphibians	None	None	G3	S3		S, SSC, NT	Moderate
<i>Accipiter cooperii</i>	Cooper's hawk	Birds	None	None	G5	S4		WL, LC	High
<i>Accipiter striatus</i>	sharp-shinned hawk	Birds	None	None				WL	High
<i>Charadrius alexandrinus nivosus</i>	western snowy plover	Birds	Threatened	None	G3T3	S2		SSC, RWL, BCC	High
<i>Larus californicus</i>	California gull	Birds	None	None				WL	High
<i>Numenius americanus</i>	long-billed curlew	Birds	None	None				WL	High
<i>Pelecanus occidentalis californicus</i>	California brown pelican	Birds	Delisted	Delisted				FP	High
<i>Phalacrocorax auritus</i>	double-crested cormorant	Birds	None	None				WL	High
<i>Sternula antillarum browni</i>	California least tern	Birds	Endangered	Endangered	G4T2T3Q	S2		FP, RWL	High
<i>Accipiter gentilis</i>	northern goshawk	Birds	None	None				SSC	Low
<i>Agelaius tricolor</i>	tricolored blackbird	Birds	None	None				SSC	Low
<i>Aimophila ruficeps canescens</i>	southern California rufous-crowned sparrow	Birds	None	None	G5T3	S2S3		WL	Low
<i>Ammodramus savannarum</i>	grasshopper sparrow	Birds	None	None	G5	S3		SCC, LC	Low
<i>Aquila chrysaetos</i>	golden eagle	Birds	None	None				FP, WL	Low
<i>Asio flammeus</i>	short-eared owl	Birds	None	None				SSC	Low
<i>Asio otus</i>	long-eared owl	Birds	None	None				SSC	Low
<i>Athene cunicularia</i>	burrowing owl	Birds	None	None	G4	S3		S, SSC, LC, BCC	Low
<i>Bucephala islandica</i>	Barrow's goldeneye	Birds	None	None				SSC	Low
<i>Buteo regalis</i>	ferruginous hawk	Birds	None	None	G4	S3S4		WL, LC, BCC	Low
<i>Campylorhynchus brunneicapillus sandiegensis</i>	coastal cactus wren	Birds	None	None	G5T3Q	S3		SSC, S, BCC	Low
<i>Chaetura vauxi</i>	Vaux's swift	Birds	None	None				SSC	Low
<i>Charadrius montanus</i>	mountain plover	Birds	None	None				SSC	Low
<i>Circus cyaneus</i>	northern harrier	Birds	None	None				SSC	Low
<i>Cistothorus palustris clarkae</i>	Clark's marsh wren	Birds	None	None				SSC	Low
<i>Coccyzus americanus occidentalis</i>	western yellow-billed cuckoo	Birds	Threatened	Endangered	G5T2T3	S1		S, RWL, BC C	Low
<i>Coturnicops noveboracensis</i>	yellow rail	Birds	None	None				SSC	Low
<i>Cypseloides niger</i>	black swift	Birds	None	None				SSC	Low

<i>Elanus leucurus</i>	white-tailed kite	Birds	None	None	G5	S3S4		S, FP, LC	Low
<i>Empidonax traillii</i>	willow flycatcher	Birds	None	Endangered					Low
<i>Empidonax traillii extimus</i>	southwestern willow flycatcher	Birds	Endangered	Endangered					Low
<i>Eremophila alpestris actia</i>	California horned lark	Birds	None	None	G5T3Q	S3		WL, LC	Low
<i>Grus canadensis canadensis</i>	lesser sandhill crane	Birds	None	None					Low
<i>Haliaeetus leucocephalus</i>	bald eagle	Birds	None	Endangered					Low
<i>Icteria virens</i>	yellow-breasted chat	Birds	None	None	G5	S3		SSC, LC	Low
<i>Ixobrychus exilis</i>	least bittern	Birds	None	None				SSC	Low
<i>Lanius ludovicianus</i>	loggerhead shrike	Birds	None	None				SSC	Low
<i>Laterallus jamaicensis coturniculus</i>	California black rail	Birds	None	Threatened	G3G4T1	S1		S, FP, NT, RWL, BCC	Low
<i>Passerculus sandwichensis beldingi</i>	Belding's savannah sparrow	Birds	None	Endangered	G5T3	S3			Low
<i>Phoebastria albatrus</i>	short-tailed albatross	Birds	Endangered	None				SSC	Low
<i>Plegadis chihi</i>	white-faced ibis	Birds	None	None				WL	Low
<i>Polioptila californica californica</i>	coastal California gnatcatcher	Birds	Threatened	None	G3T2	S2		SSC, YWL	Low
<i>Pyrocephalus rubinus</i>	vermillion flycatcher	Birds	None	None				SSC	Low
<i>Rallus longirostris levipes</i>	light-footed clapper rail	Birds	Endangered	Endangered	G5T1T2	S1		FP, RWL	Low
<i>Riparia riparia</i>	bank swallow	Birds	None	Threatened	G5	S2		S, LC	Low
<i>Rynchops niger</i>	black skimmer	Birds	None	None				SSC	Low
<i>Vireo bellii pusillus</i>	least Bell's vireo	Birds	Endangered	Endangered	G5T2	S2		NT, YWL	Low
<i>Xanthocephalus xanthocephalus</i>	yellow-headed blackbird	Birds	None	None				SSC	Low
<i>Pandion haliaetus</i>	osprey	Birds	None	None	G5	S4		S, WL, LC	Moderate
<i>Pelecanus erythrorhynchos</i>	American white pelican	Birds	None	None				SSC	Moderate
<i>Progne subis</i>	purple martin	Birds	None	None				SSC	Moderate
<i>Southern Riparian Scrub</i>	Southern Riparian Scrub	Community	None	None	G3	S3.2			High
<i>Southern Coast Live Oak Riparian Forest</i>	Southern Coast Live Oak Riparian Forest	Community	None	None	G4	S4			Low
<i>Southern Coastal Salt Marsh</i>	Southern Coastal Salt Marsh	Community	None	None	G2	S2.1			Low
<i>Southern Cottonwood Willow Riparian Forest</i>	Southern Cottonwood Willow Riparian Forest	Community	None	None	G3	S3.2			Low

<i>Southern Dune Scrub</i>	Southern Dune Scrub	Community	None	None	G1	S1.1			Low
<i>Southern Foredunes</i>	Southern Foredunes	Community	None	None	G2	S2.1			Low
<i>Southern Sycamore Alder Riparian Woodland</i>	Southern Sycamore Alder Riparian Woodland	Community	None	None	G4	S4			Low
<i>Valley Needlegrass Grassland</i>	Valley Needlegrass Grassland	Community	None	None	G3	S3.1			Low
<i>Branchinecta sandiegonensis</i>	San Diego fairy shrimp	Crustaceans	Endangered	None	G2	S2		EN	Low
<i>Streptocephalus woottoni</i>	Riverside fairy shrimp	Crustaceans	Endangered	None	G1G2	S1S2		EN	Low
<i>Eucyclogobius newberryi</i>	tidewater goby	Fish	Endangered	None	G3	S3		AFS-EN, SSC, VU	Low
<i>Oncorhynchus mykiss irideus</i>	steelhead - southern California DPS	Fish	Endangered	None					Low
<i>Rhinichthys osculus ssp. 3</i>	Santa Ana speckled dace	Fish	None	None	G5T1	S1		TH, SSC, S	Low
<i>Gila orcuttii</i>	arroyo chub	Fish	None	None	G2	S2		VU, SSC, S	Moderate
<i>Danaus plexippus pop. 1</i>	monarch - California overwintering population	Insects	None	None	G4T2T3	S2S3		S	High
<i>Euphydryas editha quino</i>	quino checkerspot butterfly	Insects	Endangered	None					Low
<i>Panoquina errans</i>	wandering (=saltmarsh) skipper	Insects	None	None	G4G5	S2		NT	Low
<i>Bombus crotchii</i>	Crotch bumble bee	Insects	None	None	G3G4	S1S2			Moderate
<i>Cicindela gabbii</i>	western tidal-flat tiger beetle	Insects	None	None	G2G4	S1			Moderate
<i>Cicindela hirticollis gravida</i>	sandy beach tiger beetle	Insects	None	None	G5T2	S1			Moderate
<i>Cicindela latesignata latesignata</i>	western beach tiger beetle	Insects	None	None	G2G4T1T2	S1			Moderate
<i>Coelus globosus</i>	globose dune beetle	Insects	None	None	G1G2	S1S2		VU	Moderate
<i>Antrozous pallidus</i>	pallid bat	Mammals	None	None				SSC	Low
<i>Chaetodipus californicus femoralis</i>	Dulzura pocket mouse	Mammals	None	None	G5T3	S3		SSC	Low
<i>Chaetodipus fallax fallax</i>	northwestern San Diego pocket mouse	Mammals	None	None				SSC	Low
<i>Choeronycteris mexicana</i>	Mexican long-tongued bat	Mammals	None	None	G4	S1		SSC, NT, H	Low
<i>Lasiurus cinereus</i>	hoary bat	Mammals	None	None	G5	S4		LC, M	Low
<i>Myotis yumanensis</i>	Yuma myotis	Mammals	None	None	G5	S4		S, LC, LM	Low

<i>Neotoma lepida intermedia</i>	San Diego desert woodrat	Mammals	None	None	G5T3T4	S3S4		SSC	Low
<i>Nyctinomops femorosaccus</i>	pocketed free-tailed bat	Mammals	None	None				SSC	Low
<i>Nyctinomops macrotis</i>	big free-tailed bat	Mammals	None	None	G5	S3		SSC, LC, MH	Low
<i>Perognathus longimembris brevinasus</i>	Los Angeles pocket mouse	Mammals	None	None				SSC	Low
<i>Perognathus longimembris pacificus</i>	Pacific pocket mouse	Mammals	Endangered	None	G5T1	S1		SSC	Low
<i>Sorex ornatus salicornicus</i>	southern California saltmarsh shrew	Mammals	None	None	G5T1?	S1		SSC	Low
<i>Taxidea taxus</i>	American badger	Mammals	None	None	G5	S3		SSC, LC	Low
<i>Eumops perotis californicus</i>	western mastiff bat	Mammals	None	None	G5T4	S3S4		S, SSC, H	Moderate
<i>Tryonia imitator</i>	mimic tryonia (=California brackishwater snail)	Mollusks	None	None	G2	S2			Moderate
<i>Abronia maritima</i>	red sand-verbena	Plants	None	None			4.2		Low
<i>Abronia villosa</i> var. <i>aurita</i>	chaparral sand-verbena	Plants	None	None	G5T2T3	S2	1B.1	S	Low
<i>Aphanisma blitoides</i>	aphanisma	Plants	None	None	G3G4	S2	1B.2		Low
<i>Atriplex coulteri</i>	Coulter's saltbush	Plants	None	None	G2	S2	1B.2		Low
<i>Brodiaea filifolia</i>	thread-leaved brodiaea	Plants	Threatened	Endangered	G2	S2	1B.1		Low
<i>Calochortus catalinae</i>	Catalina mariposa-lily	Plants	None	None			4.2		Low
<i>Calochortus weedii</i> var. <i>intermedius</i>	intermediate mariposa-lily	Plants	None	None	G3G4T2	S2	1B.2	S	Low
<i>Camissoniopsis lewisii</i>	Lewis' evening-primrose	Plants	None	None			3		Low
<i>Chaenactis glabriuscula</i> var. <i>orcuttiana</i>	Orcutt's pincushion	Plants	None	None	G5T1T2	S1	1B.1	S	Low
<i>Chloropyron maritimum</i> ssp. <i>maritimum</i>	salt marsh bird's-beak	Plants	Endangered	Endangered	G4?T1	S1	1B.2		Low
<i>Cistanthe maritima</i>	seaside cistanthe	Plants	None	None			4.2		Low
<i>Comarostaphylis diversifolia</i> ssp. <i>diversifolia</i>	summer holly	Plants	None	None	G3T2	S2	1B.2	S	Low
<i>Dichondra occidentalis</i>	western dichondra	Plants	None	None			4.2		Low
<i>Eleocharis parvula</i>	small spikerush	Plants	None	None			4.3		Low
<i>Eryngium aristulatum</i> var. <i>parishii</i>	San Diego button-celery	Plants	Endangered	Endangered	G5T1	S1	1B.1		Low
<i>Harpagonella palmeri</i>	Palmer's grapplinghook	Plants	None	None	G4	S3	4.2		Low
<i>Helianthus nuttallii</i> ssp. <i>parishii</i>	Los Angeles sunflower	Plants	None	None	G5TH	SH	1A		Low

<i>Hordeum intercedens</i>	vernal barley	Plants	None	None			3.2		Low
<i>Horkelia cuneata</i> var. <i>puberula</i>	mesa horkelia	Plants	None	None	G4T1	S1	1B.1	S	Low
<i>Juncus acutus</i> ssp. <i>leopoldii</i>	southwestern spiny rush	Plants	None	None			4.2		Low
<i>Lasthenia glabrata</i> ssp. <i>coulteri</i>	Coulter's goldfields	Plants	None	None	G4T2	S2	1B.1	S	Low
<i>Lepidium virginicum</i> var. <i>robinsonii</i>	Robinson's pepper-grass	Plants	None	None	G5T3	S3	4.3		Low
<i>Microseris douglasii</i> ssp. <i>platycarpa</i>	small-flowered microseris	Plants	None	None			4.2		Low
<i>Monardella hypoleuca</i> ssp. <i>intermedia</i>	intermediate monardella	Plants	None	None	G4T2T3	S2S3	1B.3		Low
<i>Nama stenocarpa</i>	mud nama	Plants	None	None	G4G5	S1S2	2B.2		Low
<i>Nasturtium gambelii</i>	Gambel's water cress	Plants	Endangered	Threatened	G1	S1	1B.1		Low
<i>Navarretia prostrata</i>	prostrate vernal pool navarretia	Plants	None	None	G2	S2	1B.1		Low
<i>Nemacaulis denudata</i> var. <i>denudata</i>	coast woolly-heads	Plants	None	None	G3G4T2	S2	1B.2		Low
<i>Nolina cismontana</i>	chaparral nolina	Plants	None	None	G3	S3	1B.2	S	Low
<i>Orcuttia californica</i>	California Orcutt grass	Plants	Endangered	Endangered			1B.1		Low
<i>Pentachaeta aurea</i> ssp. <i>allenii</i>	Allen's pentachaeta	Plants	None	None	G4T1	S1	1B.1		Low
<i>Pentachaeta aurea</i> ssp. <i>aurea</i>	golden-rayed pentachaeta	Plants	None	None			4.2		Low
<i>Polygala cornuta</i> var. <i>fishiae</i>	Fish's milkwort	Plants	None	None			4.3		Low
<i>Pseudognaphalium leucocephalum</i>	white rabbit-tobacco	Plants	None	None	G4	S2	2B.2		Low
<i>Quercus dumosa</i>	Nuttall's scrub oak	Plants	None	None	G3	S3	1B.1	S	Low
<i>Senecio aphanactis</i>	chaparral ragwort	Plants	None	None	G3?	S2	2B.2		Low
<i>Suaeda esteroa</i>	estuary seablite	Plants	None	None	G3	S2	1B.2		Low
<i>Symphyotrichum defoliatum</i>	San Bernardino aster	Plants	None	None	G2	S2	1B.2	S	Low
<i>Tetracoccus dioicus</i>	Parry's tetracoccus	Plants	None	None			1B.2		Low
<i>Verbesina dissita</i>	big-leaved crownbeard	Plants	Threatened	Threatened	G2G3	S1	1B.1		Low
<i>Atriplex pacifica</i>	south coast saltscale	Plants	None	None	G3G4	S2	1B.2		Moderate
<i>Atriplex parishii</i>	Parish's brittle-scale	Plants	None	None	G1G2	S1	1B.1	S	Moderate
<i>Atriplex serenana</i> var. <i>davidsonii</i>	Davidson's saltscale	Plants	None	None	G5T1	S1	1B.2		Moderate
<i>Centromadia parryi</i> ssp. <i>australis</i>	southern tarplant	Plants	None	None	G3T2	S2	1B.1		Moderate
<i>Convolvulus simulans</i>	small-flowered morning-glory	Plants	None	None			4.2		Moderate

<i>Deinandra paniculata</i>	paniculate tarplant	Plants	None	None			4.2		Moderate
<i>Dudleya blochmaniae</i> ssp. <i>blochmaniae</i>	Blochman's dudleya	Plants	None	None	G3T2	S2	1B.1		Moderate
<i>Dudleya multicaulis</i>	many-stemmed dudleya	Plants	None	None	G2	S2	1B.2	S	Moderate
<i>Dudleya stolonifera</i>	Laguna Beach dudleya	Plants	Threatened	Threatened	G1	S1	1B.1		Moderate
<i>Euphorbia misera</i>	cliff spurge	Plants	None	None	G5	S2	2B.2		Moderate
<i>Isocoma menziesii</i> var. <i>decumbens</i>	decumbent goldenbush	Plants	None	None	G3G5T2T3	S2	1B.2		Moderate
<i>Lycium californicum</i>	California box-thorn	Plants	None	None			4.2		Moderate
<i>Malacothrix saxatilis</i> var. <i>saxatilis</i>	cliff malacothrix	Plants	None	None			4.2		Moderate
<i>Phacelia ramosissima</i> var. <i>australitoralis</i>	south coast branching phacelia	Plants	None	None			3.2		Moderate
<i>Suaeda taxifolia</i>	woolly seablite	Plants	None	None			4.2		Moderate
<i>Emys marmorata</i>	western pond turtle	Reptiles	None	None	G3G4	S3		S, SSC, VU	High
<i>Chelonia mydas</i>	green turtle	Reptiles	Threatened	None					Low
<i>Plestiodon skiltonianus</i> <i>interparietalis</i>	Coronado Island skink	Reptiles	None	None				SSC	Low
<i>Anniella pulchra pulchra</i>	silvery legless lizard	Reptiles	None	None			SSC		Moderate
<i>Aspidoscelis hyperythra</i>	orangethroat whiptail	Reptiles	None	None	G5	S2		SSC, LC, S	Moderate
<i>Aspidoscelis tigris stejnegeri</i>	coastal whiptail	Reptiles	None	None	G5T3T4	S2S3			Moderate
<i>Crotalus ruber</i>	red-diamond rattlesnake	Reptiles	None	None	G4	S3		SSC, S	Moderate
<i>Phrynosoma blainvillii</i>	coast horned lizard	Reptiles	None	None	G3G4	S3S4		S, SSC, LC	Moderate
<i>Salvadora hexalepis virgulata</i>	coast patch-nosed snake	Reptiles	None	None	G5T4	S2S3		SSC	Moderate
<i>Thamnophis hammondi</i>	two-striped garter snake	Reptiles	None	None	G4	S3S4		S, SSC, LC	Moderate

* SSC = CDFW Species of Special Concern; S = BLM and/or USFS Sensitive; WL = CDFW Watch List; FP = CDFW Fully Protected; RWL = NABCI Red Watch List; YWL = NABCI Yellow Watch List; EN = IUCN Endangered; VU = IUCN Vulnerable; LC = IUCN Least Concern; NT = IUCN Near Threatened; H = BWBG High Priority; MH = BWBG Medium-high priority; M = BWBG Medium priority; TH = AFS Threatened; AFS-EN = AFS Endangered; BCC = USFWS Birds of Conservation Concern

Appendix D

Aliso Creek Estuary Restoration Workshop



Aliso Estuary Design Workshop

December 9-10, 2015

Laguna Beach, CA



Prepared by:

Eric D. Stein – Southern California Coastal Water Research Project

Introduction and Background

“That’s just a pool of sewage”. This characterization of the Aliso Creek Estuary by a local teenager reflects the challenges and the imperative to restore small tidal estuaries and lagoons along the southern California coast. Many of the region’s large wetlands are currently in various phases of restoration planning, design or implementation. Until recently, small estuaries and lagoons have not received as much focus, partly because their value and importance to regional ecology has not been as well documented as their larger counterparts. . . as reflected in the perceptions of the local Laguna Beach resident quoted above. Small coastal systems have different relationships with their local landscape, their watersheds, and the ocean than larger systems. As such, the way we approach goal setting, restoration planning, and long-term management should accommodate the unique character of these systems. The Aliso Creek Estuary provides an opportunity to develop and demonstrate a process tailored to the challenges and opportunities provided by restoration of small coastal lagoons and estuaries.

Most small lagoons and estuaries periodically close to the tides at frequencies varying from daily to annually and can remain closed for periods of hours to decades, depending on factors such as wave energy, river flow and sediment supply. In Australia, such estuaries are referred to as ICOLLS (Intermittently Closed Open Lakes and Lagoons (Roy et al. 2001), in South Africa the term TOCE’s (temporarily open/closed estuaries) is favored (Whitfield 1992), with ICEs (intermittently closed estuaries) and IOEs (intermittently open estuaries) applied to differentiate the entrance regimes (Whitfield and Bate 2007). In the United States, where such systems are primarily limited to the coasts of California and Oregon, they are typically called “lagoons” or “bar-built estuaries” (Heady et al. 2014).

Contrary to common perceptions, bar-built estuaries provide a broad suite of ecological functions and social services. Local and endemic fish may use these systems for spawning, rearing, refugia, or passage. In addition to fisheries values, healthy bar-built estuaries can support a variety of amphibian, reptile, bird and mammal species. They also can serve to sequester and cycle nutrients, trap sediment and protect coastal water quality (Barbier et al. 2011). Although not always appreciated, bar-built estuaries also provide aesthetic and recreational value to their local communities.

Once numbering over 300 distinct systems (between Pt. Conception and the US-Mexico border), over 80% of historic bar-built estuaries have been lost (Stein et al. 2014). The remaining are often degraded due to manipulation of mouth conditions, excessive discharge or constituent loading from watersheds, encroachment, invasive species infestation, or direct impact. Furthermore, reductions in lagoon volume from berm retreat could lead to more frequent breach-drain-fill cycles, destabilizing estuarine water levels and threatening the integrity of dependent ecosystems. In these cases, salinity-driven shifts from freshwater-brackish vegetation to salt marsh vegetation could result in a net decrease in the production of below-ground biomass, impeding the ability of the marsh plain to keep pace with rising sea levels (Schile et al. 2014). Restoration and management of these systems is complicated due to their small size, typically constrained setting, relatively lower capacity to assimilate watershed inputs, and general lack of attention and prioritization.

Against this backdrop, the southern California Wetlands Recover Project (WRP) is updating their regional strategy for coastal wetland restoration. The overarching goal of the regional strategy is to:

Reestablish a mosaic of fully-functioning and resilient wetland systems with a diversity of habitat types and connections to upland and marine communities, which preserves and recovers self-sustaining populations of species

The regional strategy envisions a series of quantifiable objectives specific to wetland types and locations that will guide decisions about where and how to restore coastal wetlands over the next several decades. Restoration and management of bar-built estuaries along appropriate portions of the southern California coast is part of the WRP's regional strategy. The Aliso Creek Estuary provides an early opportunity for implementing the concepts of the regional strategy through a planning process that is based on local opportunities and constraints, and is consistent with a regional vision of how this site relates to the long-term ecological health of the region.

Purpose and Goals of the Workshop

Past wetland restoration planning has suffered from the lack of a regional vision. Consequently, many plans reflect a desire to achieve as much as possible in every individual project. This may be manifested as goals for high habitat diversity and support for many sensitive species in areas that are much smaller than their historic footprint and subject to a suite of constraints and pressures not historically present. Such an ambitious approach may be even more problematic in small bar-built estuaries which have less available area and proportionately higher constraints. In these cases a regional perspective is imperative as it allows sites to be designed based on expectations that are reasonable for the size and landscape orientation of the site, even if the result is less complexity and richness. The goal of the Aliso Estuary Design Workshop was to develop preliminary project goals and priorities for restoration and management of the estuary. Specific workshop objectives included:

- Identify key drivers that affect development of restoration alternatives
- Develop conceptual options for habitat restoration given certain constraints
- Identify target habitats, functions, species for the restoration plan
- Identify unreasonable or inadvisable expectations for restoration
- Identify key constraints that would need to be addressed for various options to proceed
- Ensure consistency with the WRP regional recovery objectives
- Provide a template for early planning that can be applied to other projects

We adopted a “non-traditional” approach to accomplishing these objectives by convening a focused two-day charrette in which a small group of local scientists and planners met to develop preliminary goals and priorities from a relatively unconstrained perspective (See Appendix A for a list of the participants and the workshop agenda). ***The group was charged with considering the best possible ecologically sound strategy for restoration in consideration of the natural setting of the estuary.*** Regulatory, cost, and logistic considerations, although important, were not emphasized during the workshop. These real-world considerations will shape the ultimate goals and design of the project; however, the desire was to begin with a less constrained perspective. The products of the charrette will become the starting point of a process in which local stakeholders, funders, and permitting entities will shape the ultimate trajectory for the restoration process through additional analysis and discussions. The hope is that this process can provide additional benefits of:

- Accelerating initial development of goals, objectives, and priorities

- Allowing design priorities to be formed in consideration of regional objectives and activities in adjacent or nearby wetlands whose functions and services may augment those of this system
- Demonstrating a process that can be replicated for restoration planning in other small bar-built estuaries



Figure 1: Workshop participants deliberating design options

Overview of Aliso Creek Estuary

The Aliso Creek Estuary is a small creek mouth lagoon, approximately 1 ha in size, located in Laguna Beach, Orange County California (Figure 2). The lagoon closes in the high intertidal range and would naturally be closed from mid-late spring through the first winter storm large enough to breach the mouth (typically November time frame). However, the lagoon is mechanically opened by the county of Orange for water quality purposes several times a year, and much more frequently by local residents, largely for recreational or aesthetic reasons (personal communications). Current vegetation within the project area is strongly dominated by invasive and horticultural non-native species, with small patches of mulefat scrub and degraded coastal sage scrub (Figure 3). Despite the dominance of non-natives, recent biological surveys reported 26 native plant species on a site visit in November 2015 (ESA Associates 2015). Historically, the Aliso Creek estuary used to be a larger lagoon with vegetated wetlands, sandbars, areas of salt marsh and salt pan to the north and south, and coastal dunes across and adjacent to the estuary mouth (Figure 3; Grossinger et.al. 2011).



Figure 2: Aliso Creek Estuary project location

The Aliso Creek Estuary is at the terminus of the 31 km long Aliso Creek, which drains an approximately 90 km² watershed that includes both heavily urbanized areas and large open space areas. The creek's estuarine habitat has suffered degradation through modification of its hydrologic regime (from urbanization of the watershed) and physical modification of the mouth of the creek and its banks. In particular, the existing Pacific Coast Highway Bridge and adjacent beach parking lots constrain the footprint of the estuary and limit its ecological function. Watershed discharge of dry and wet weather flow and contaminants have also contributed to the degradation of the physical processes and habitats of the estuary. Major water quality concerns include bacteria, nutrients, and selenium. Hydrologic and water quality impacts are expected to decrease over time as proposed watershed management actions are implemented. However, projected sea level rise will likely inundate the lower portion of the lagoon and erode the adjacent beach habitat. Additional details on the existing conditions for the estuary can be found in the ESA Associates "Existing Conditions Report" (ESA Associates 2016).

The Aliso Estuary is a site of extremely high restoration value, due to its key geographic location between two regionally significant ecosystem reserve systems: the terrestrial greenbelt, or 'superpark' comprised of ~6,100 ha of preserved natural habitats in the San Joaquin Hills, and the bluebelt of the coastal and offshore Laguna State Marine Reserve recently established through the Marine Life Protection Act. The Aliso Creek estuary is the only location where a viable habitat linkage between these two systems can be developed. It is also the only location between San Mateo Creek (to the south) and Newport Back Bay (to the north) where the possibility exists to link protected freshwater and coastal ecosystems (ESA Associates 2016).



Figure 3: Current (top) and historical (bottom) habitats of the Aliso Creek Estuary

Proposed Restoration Goals

Four restoration goals were developed to reflect the overarching desire of ensuring long-term resiliency and health through a process-driven restoration that respects local drivers and is cognizant of regional objectives. The goals acknowledge the need to try and balance potentially competing desires and the importance of active and adaptive management through ongoing community engagement.

Goal 1: Promote resiliency by basing restoration on historically-informed ecosystem processes in consideration of climate change effects

- a. Allow mouth closure to occur on a seasonal to annual cycle consistent with hydrodynamic forcing and historical conditions
- b. Allow lateral mouth migration to minimize destructive scour patterns when the lagoon drains
- c. Minimize dry season freshwater inputs to the estuary
- d. Promote nitrogen sequestration and denitrification to minimize development of eutrophic conditions
- e. Allow episodic events to provide periodic disturbance, recovery, and rejuvenation
- f. Provide topography that allows channel migration, anastomization, erosion and accretion within the lagoon
- g. Provide topographic complexity that supports a diversity of habitat types
- h. Provide adequate area and variety of elevations to allow recruitment and refugia for appropriate plant and animal taxa.
 - i. Look for short term opportunities to provide suitable habitat for highly endangered tidewater goby sub-population (including possibly serving as a laboratory for reintroduction). *However, over the long term, the design would aim to support diverse fish assemblages and not establish specific targets for any given species.*
- i. Provide adjacent and upstream, accessible transition zones. These may serve as buffer habitats in the short-term but become transgression opportunities in the long-term.

Goal 2: Develop a long-term management strategy that is proactive, adaptive, minimally intrusive and process based

- j. Minimize actions that promote development of habitat (conditions) that are conducive to supporting invasive, non-native plants and animals
- k. Promote community involvement as active partners in long-term management of the estuary
- l. Support and promote watershed management actions that facilitate the ecological health of the estuary

Goal 3: Develop restoration priorities that support the WRP regional strategy

- m. Use the WRP regional strategy approach to develop habitat targets for the Aliso estuary (i.e. historical distributions x maximum capacity to support wetland habitat)
- n. Promote information exchange and coordination with other small river mouth estuary projects
- o. Target restoration management in consideration of the role of adjacent wetlands that may provide regional connectivity and allow for migration and genetic exchange

Goal 4: Promote the use of Aliso Estuary for research, education and community engagement

- p. Use the restoration and management approaches developed at Aliso as a template to inform restoration planning at similar small river mouth estuaries along the southern California coast

- q. Encourage community based restoration by including local stakeholder groups in the planning process and by making them active members of the long-term management plan.
- r. Create partnerships with upstream land managers (e.g. Orange County Parks) to coordinate management of the estuary in the context of the surrounding landscape and watershed
- s. Coordinate estuary restoration and management actions and documented benefits with those of adjacent wetland and the offshore marine protected area (e.g. water quality, fisheries, bird usage)
- t. Create education and outreach opportunities that highlight the importance of small river mouth estuaries (in terms of functions and services) and highlight the ecological interactions between the estuary, surrounding upland landscapes, and the ocean.
- u. Encourage the use of Aliso Estuary as a laboratory to inform future projects in similar type systems.

Restoration Recommendations

The workshop participants developed a set of recommendations aimed at achieving the four goals for the estuary restoration. Recommended actions are divided into short vs. long term endeavors, with the short term actions intended to be pursued proactively and the long term actions intended to be more opportunistic. Achieving a resilient estuarine system requires addressing several key constraints:

- The narrow Pacific Coast Highway bridge across the lagoon mouth that restricts mouth migration and tidal flow into the estuary
- Adjacent confinement and fill of the historical estuary associated with the beach parking lot that limits the opportunity for migration or marsh transgression
- The upstream channel that accelerates flow velocities into the estuary and increases the likelihood of scour
- Increased watershed discharge that results in higher wet and dry weather flows, increased sediment loading, and delivery of high levels of nutrients and bacteria.
- Invasive plant and animal species
- Lack of local recognition of the importance of the Aliso Estuary as a wetland resource
- Public opinion and concerns about changes in land use that may be associated with the estuary restoration (e.g. loss of parking areas)

Restoration recommendations were developed with minimal consideration of cost or logistical constraints (as discussed above) and are presented in order of their importance in achieving the restoration goals (Figure 4). Specific restoration activities would support mainly Goal #1, while Goals #2-4 would be achieved through development of management, education, and stakeholder coordination activities.



Figure 4: Summary of recommended restoration actions

1. **Widen PCH Bridge** as the opportunity arises. Ideally a new bridge would completely span with width of the estuary to maximize the opportunity for tidal access and mouth migration.
 - a. Look at local bridge assessment report and coordinate with CalTrans
2. **Remove fill and grade back slopes on north side of estuary.** Include transition zone habitat for longer term wetland transgression
3. **Revise project boundary to allow reconfiguration of beach parking lot area** to improve mouth dynamics
 - a. Create opportunities for dune restoration to improve sand management
 - b. Would need to provide replacement parking options
 - c. Potentially connect with sea level rise adaptation planning
4. **Remove historical fill on south side of estuary** in overflow parking area, and reconfigure remaining parking area to allow for long term transgression
 - a. This area provides the area of greatest restoration opportunity
 - b. Create zones of intertidal marsh, transitional habitats, secondary channels and backwater ponds
 - c. Retain some of this area for future transgression zones
5. **Retrofit flood control/bank protection in upper channel reach** below the golf course transition

- a. Stabilize banks in a way that promotes additional creek bottom habitat

The recommended restoration actions could be phased in over time based on opportunities to leverage other efforts and funding sources (Table 1).

Table 1: Phasing of restoration recommendations

	Action	Time frame
1	Widen PCH bridge	long-term
2	Remove fill and grade back north side slopes	short-term
3	Reconfigure beach parking lot area	long-term
4	Remove historical fill on south side of estuary	short-term
5	Retrofit channel flood control/bank protection	short-term

Restoration of urban estuaries is not a static process. Active and ongoing maintenance is necessary to ensure long-term success at achieving agreed upon goals. Community engagement is an important element of long-term management and stewardship (Goal #2). Few community members recognize or appreciate the importance of the Aliso Estuary or the opportunities its restoration provides. This is one of the few areas along the southern California coast where natural uplands (i.e. Aliso Canyon Wilderness Park), a dynamic estuary, and a marine reserve can function as an integrated resource. Local participation is key for agreeing on tradeoffs with existing land uses (e.g. parking) that will be required for the estuary restoration. Furthermore, local stakeholders should be active participants in management of the estuary and mitigation of upstream stressors (Figure 5). Incorporation of education and outreach into every phase of planning and implementation will be an important strategy for achieving the long-term project goals.

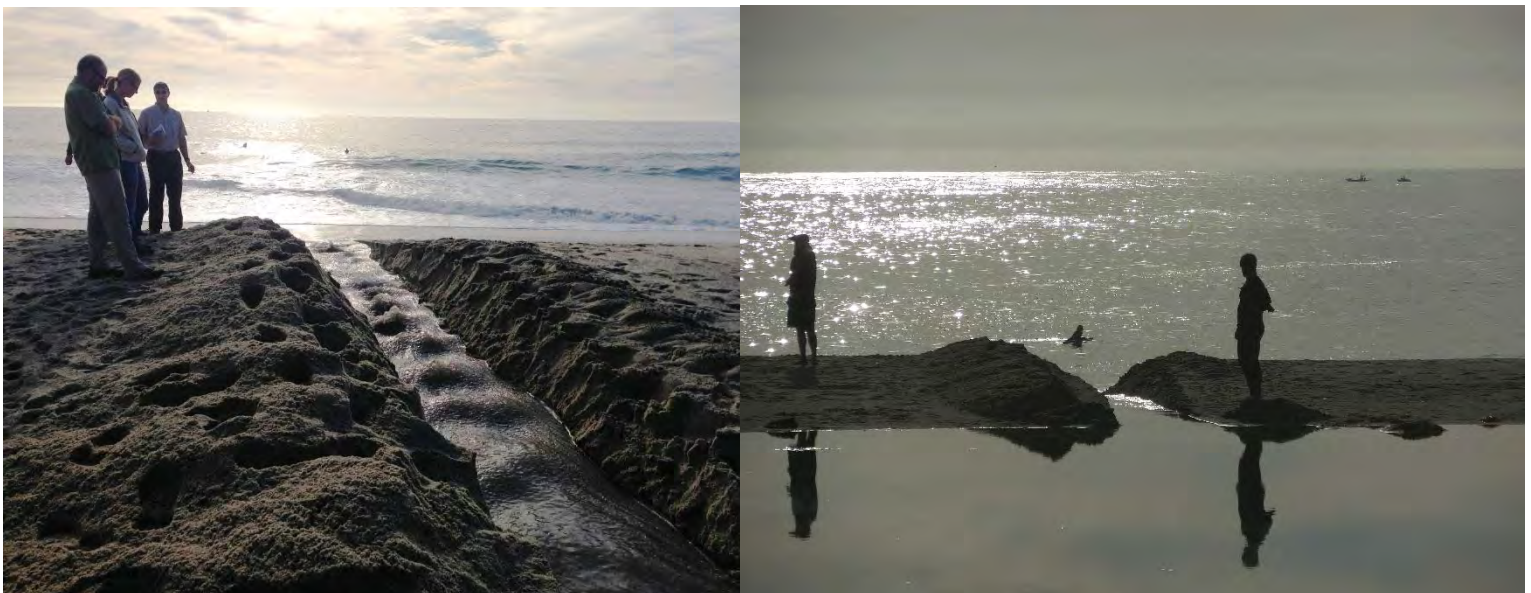


Figure 5: Stakeholders should be involved in management decisions such as lagoon breaching

Next Steps and Lessons Learned

The goals and recommendations produced during the workshop are intended to be a starting point for further detailed discussions with stakeholders and agency staff. We expect that restoration goals and alternatives will be iteratively refined based on local desires, regulatory considerations, and cost and logistic constraints. Next steps in project planning may include the following:

- A. Filling current knowledge gaps through additional investigation and data collection, which may include:
 - Conducting estuary and creek fish surveys
 - Collecting water quality and water level data from the estuary
 - Conducting bathymetric surveys of the estuary
 - Mapping the type and distribution of upstream invasive species
 - Summarizing the plans for future water and runoff management
- B. Identifying and coordinating with key partners for next phases of the planning process (e.g. CalTrans, City of Laguna Beach, Orange County, key landowners, community groups, San Diego Regional Water Board, WRP managers group)
- C. Presenting the findings of this workshop to key partner groups. Through these discussions and investigations, proposed project actions should be related to key ecological functions and services that may be provided through the restoration
- D. Iteratively refining goals and developing alternatives based on continued investigation and discussions, including an outline of necessary long-term management actions. This may include refining the project boundary as proposed above
- E. Developing roadmaps to connect this project (both restoration and long-term management) with the WRP regional strategy, proposed watershed management actions, MPA management, and beach management programs (among others)

This focused design workshop was an experiment in an alternative approach for initial restoration planning. The workshop was largely successful in that we were able to achieve the following stated objectives through a relatively streamlined process:

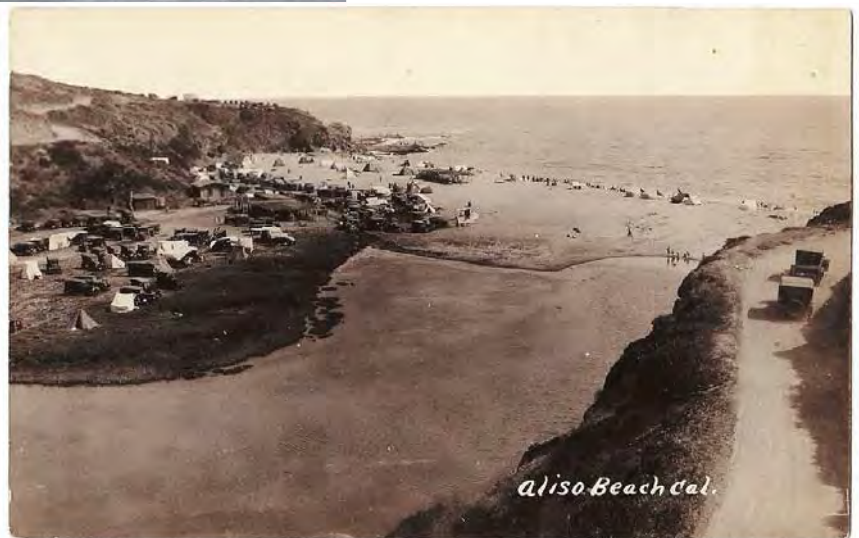
- Identify key drivers that affect development of restoration alternatives
- Develop conceptual options for habitat restoration given certain constraints
- Identify target habitats, functions, species for the restoration plan
- Identify unreasonable or inadvisable expectations for restoration
- Identify key constraints that would need to be addressed for various options to proceed

It is premature to evaluate success at achieving the final objectives of ensuring consistency with the WRP regional recovery objectives and providing an example process that could be applied for initial planning of other small estuary restoration projects. Discussion of the WRP regional strategy during the workshop was useful in that it provided a backdrop for detailed discussions about restoration of the

Aliso Estuary and helped create the expectation that this project should be considered in the regional context and would not be expected to provide all estuarine functions and services in isolation from other systems. Planning of future projects will likely benefit from having a complete regional strategy to refer to, including the anticipated quantifiable objectives.

The overall process was successful and we suggest that this model be applied to other restoration projects, particularly those involving small estuary or lagoon restoration. We suggest the following considerations, if this process were to be replicated for other systems:

- Retain the two-day format
- Include the site visit. If possible, solicit input/perspectives from local stakeholders or scientists on typical conditions and local management
- Add additional scientists (only 50% of our invited scientist were able to participate, if all 6 had attended, it would have improved the depth and breadth of the discussions)
- Include time for individuals to independently sketch out alternatives on aerial photos or maps and then compare various ideas



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Aliso Creek Estuary Conceptual Design Charrette

December 9-10, 2015

Laguna Beach, CA

Overview and Objectives

Aliso Creek estuary is a small lagoonal river mouth estuary at the terminus of the mostly urbanized Aliso Creek watershed. The Laguna Oceans Foundation (LOF) is in the initial phase of a restoration planning effort for the estuary that will consider the natural process expected to occur in this type of system and the associated habitats that can be supported. Moreover, the LOF would like to design and plan the project in consideration of the Wetland Recovery Project's (WRP) emerging regional strategy and goals.

We are proposing a design charrette to support restoration planning for the Aliso Estuary. The goal of the charrette is to provide general input on potential goals for the restoration in terms of inherent structural considerations and natural processes, and the associated habitats that could be supported under restoration. The charrette will outline a set of reasonable expectations in terms of general hydrologic/tidal conditions and the associated habitat, features or habitats expected to occur in the system and major management considerations that should be addressed through restoration planning.

The Aliso Creek estuary restoration project provides an important early opportunity to couple local objectives with the emerging regional wetland restoration goals. The conceptual design charrette will help ensure that design for Aliso Creek estuary is consistent with the larger regional goals being developed through the WRP Science Panel effort. It will support development of a conceptual approach that reflects not only the functions inherent in small coastal lagoons, but also considers the contribution of such systems to overall regional wetland function. This process will also serve as case-study to demonstrate how local-region coordination can be accomplished.

Goals for the Charrette

1. Provide input on potential goals for the restoration in terms of inherent structural considerations and natural processes, and the associated habitats that could be supported under restoration.
2. Identify key drivers that affect development of restoration alternatives (e.g. mouth conditions, adjacent land use, PCH bridge retrofit).
3. Develop conceptual options for habitat restoration given certain constraints? For example, if you remove PCH bridge, what could you do? If you remove the parking lot, what could you do?
4. Produce recommendations for potential restoration options to pursue based on understanding of drivers and constraints, and in consideration of the regional goals for this area. This may be phased goals.
5. Identify unreasonable or inadvisable expectations for restoration, i.e. things that you should not consider.

6. Provide basis for drafting a restoration goals and objectives report that will guide development and evaluation of restoration alternatives.

General Structure and Agenda

The charrette would occur over two days and include a combination of presentations, field visit, and group discussions.

Day 1 AM – Review of available information on the Aliso Creek estuary including historical conditions, current stressors/constraints from the watershed and surrounding areas, and relevant watershed or regional plans.

Day 1 PM – Field visit by panel to explore the estuary and relevant upstream land use.

Day 2 AM – Group discussion of main themes that should be considered in response to overarching issues such as physical/hydrological drivers, appropriate habitats, management needs (Note: the full list of issues would be generated by the panel).

Day 2 PM – outline report and list next steps.

Expected outcomes

We will produce a short report that outlines key goals, objectives and considerations in moving forward with the restoration planning. These recommendations are not meant to be prescriptive, but rather to serve as a starting point for discussions with stakeholders and agency representatives through the detailed design and alternatives analysis processes.

Participants

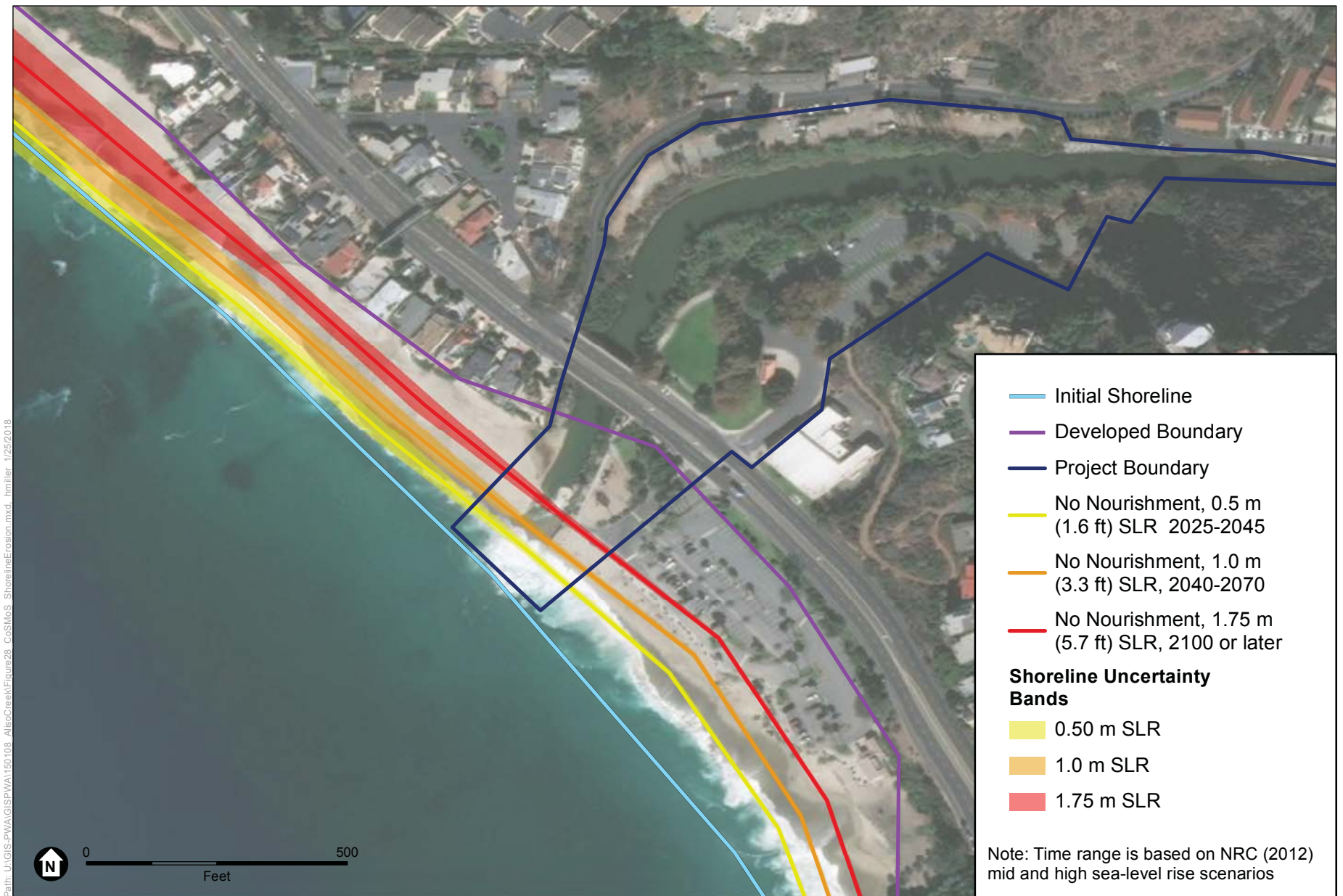
- Eric Stein – Southern California Coastal Water Research Project (SAP) – Facilitator
- Christine Whitcraft – California State University Long Beach (SAP)
- David Jacobs – University of California Los Angeles
- Stacie Fejtek Smith – NOAA Restoration Center
- Deborah Ruddock – State Coastal Conservancy
- Nick Garrity – ESA Associates
- Matt James - Coastal Restoration Consultants, Inc.
- Ed Almanza - Laguna Ocean Foundation
- Robin Zur Schmiede – Laguna Ocean Foundation
- Amber Sanderson – Laguna Ocean Foundation

Appendix E

Review of USGS Coastal Storm Modeling System 3.0, Results for Aliso Beach



The USGS Coastal Storm Modeling System 3.0 (CoSMoS) Phase 2.0 for the Southern California region provides a regional-level assessment and preliminary maps of coastal flooding and erosion with future sea level rise projections. Figure C-1 shows modeled shoreline change and coastal erosion under different sea level rise scenarios. The CoSMoS modeling results indicate that with 1.0 m (3.3 ft), which is projected to occur between 2070 and 2100 based on the NRC (2012) mid and high sea-level rise scenarios., Aliso Beach would erode back to the edge of the Aliso Beach parking lot south of the Creek. However, note that in Figure C-1 the initial shoreline used in the model is more than 100 ft offshore of the shoreline shown in the aerial photo from October 2016. This likely indicates that the CoSMoS model uses an initial shoreline from a year in which the beach was significantly wider than it is currently. The CoSMoS model results therefore do not appear to adequately account for annual fluctuations in beach width (as evidenced by the model results' narrow uncertainty bands shown in Figure C-1. The existing Aliso Beach could therefore erode back to the edge of the Aliso Beach parking lot sooner than indicated by the CoSMoS model results.



SOURCE: ESRI, USGS

Aliso Creek Estuary Conceptual Restoration Plan . 150108

Figure 2-36
CoSMoS Results
Shoreline Erosion

Appendix F

Cost Estimate

Table of Costs

LINE NUMBER	LINE ITEM	QTY	UNIT OF MEASURE	UNIT PRICE	TOTAL PRICE	NOTES	RS Means Source
					\$	-	
Division 01	General Conditions				\$	-	
Ad hoc	Mobilization	1	LS	\$ 450,000.00	\$ 450,000	Estimated as a fraction of construction costs(approx. 10%, generally considered conservative)	No
					\$	-	
Division 02	Existing Conditions				\$	-	
	Removal				\$	-	
02 41 13.70 0100	Remove Existing Rock Armor and Stockpile	1000	CY	\$ 69.50	\$ 69,500	Remove existing riprap, surface area approx. Disposal NOT included	Yes
G 1020 210 1100	Existing South Parking structure	9000	SY	\$ 10.00	\$ 90,000	Remove bituminous surface and haul it out 3 miles	Yes
G 1020 205 1060	Remove underground water pipe including earthwork	1500	LF	\$ 28.72	\$ 43,080	Assume that utilities are not impacted in North parking lot	Yes
G 1020 206 1070	Remove underground sewer pipe including earthwork	1500	LF	\$ 30.84	\$ 46,260	Assume that utilities are not impacted in North parking lot	Yes
Ad hoc	Construction waste disposal (no haz mat)	1000	CY	\$ 25.00	\$ 25,000	Tipping fee to be worked out, allowance; 1 TON is about \$75 (tipping), excl. hauling	
					\$	-	
	Clearing and grubbing				\$	-	
31 11 10.10 7160	Selective large tree removal 24"	100	EA	\$ 978.02	\$ 97,802	Tree removal operations	Yes
G 1010 120 1990	Clearing and grubbing	7.0	AC	\$ 11,494.00	\$ 81,007	Clearing and grubbing, including trees, total footprint	Yes
					\$	-	
	Relocations				\$	-	
Ad hoc	Playground Relocation	1	LS	\$ 17,868.80	\$ 17,869	Labor and basic equipment, crew B-3A; 5 shifts	Yes
Ad hoc	Relocate Picnic Area	1	LS	\$ 17,868.80	\$ 17,869	Labor and basic equipment, crew B-3A; 5 shifts	Yes
Ad hoc	Narrow Existing Park Entrance	1	LS	\$ 17,868.80	\$ 17,869	Labor and basic equipment, crew B-3A; 5 shifts	Yes
					\$	-	
Division 31	Earthwork				\$	-	
					\$	-	
	North embankment shore protection (soil covered)				\$	-	
Ad hoc	Install and furnish rock erosion control at Northern bank	1900	CY	\$ 180.00	\$ 342,000	Lumped cost per CY of protection, including labor, geo-fabric, and bedding; placement is land-based; assume 1/41	No
31 23 16.42 0250	Load with 1.5 CY hydraulic excavator, crawler mounted from borrow l	1100	LCY	\$ 2.56	\$ 2,821	Borrow soil from stockpiled area and load onto trucks (15% carried out)	Yes
31 23 23.20 0014	Import soil stockpiled from vegetated marsh restoration (no cost for fi	1100	LCY	\$ 3.00	\$ 3,300	Assume 2 ft (embankment) of soil, trucked with 12CY DT, less than a mile (on-site)	Yes
31 23 16.42 0250	Place with 1.5 CY hydraulic excavator	1100	LCY	\$ 2.23	\$ 2,453	Place and spread; 85 CY/hr based on R312316-45 Excavating Equipment	Yes
					\$	-	
	Excavate fill and haul to laydown yard				\$	-	
G 1030 120 2200	Site wide allowance based on net cut requirements	86000	LCY	\$ 9.43	\$ 810,980	Calculated from CAD surface	Yes
					\$	-	
	Load onto trucks and haul to landfill						
31 23 16.42 0250	Process extra material at laydown yard	86000	LCY	\$ 2.56	\$ 220,547	Borrow soil from stockpiled area and load onto trucks (15% carried out)	Yes
31 23 23.20 1069	Hauling to Prima Desecha Landfill	86000	LCY	\$ 14.19	\$ 1,220,340	See assumptions for disposal	Yes
Ad hoc	Disposal costs (tipping fee)	86000	LCY	\$ -	\$ -	Assume that soil cover material is disposed of at no charge at Prima Desecha Landfill (subject to acceptance)	No
					\$	-	
	Grading						
	Rough grading (30,000 lb grader)						
31 22 13.20 0280	Vegetated marsh: 166,700 SF	166700	SF	\$ 0.07	\$ 11,836	Use unit cost per SF from RS Means	Yes
31 22 13.20 0280	Upland Coastal Sage (steep embankment): 49,500 SF	49500	SF	\$ 0.07	\$ 3,515	Use unit cost per SF from RS Means	Yes
31 22 13.20 0280	Low growing upland: 31,200 SF	31200	SF	\$ 0.07	\$ 2,215	Use unit cost per SF from RS Means	Yes
	Final grading (30,000 lb grader)				\$	-	
31 22 16.10 3300	Vegetated marsh: 166,700 SF	18522	SY	\$ 0.22	\$ 4,075	Use unit cost per SF from RS Means	Yes
31 22 16.10 3300	Upland Coastal Sage (steep embankment): 49,500 SF	5500	SY	\$ 0.27	\$ 1,485	Use unit cost per SF from RS Means	Yes
31 22 16.10 3300	Low growing upland: 31,200 SF	3467	SY	\$ 0.22	\$ 763	Use unit cost per SF from RS Means	Yes
					\$	-	
	Erosion and Sediment Control (SWPPP/BMP)				\$	-	
	This item is included in Division 01 General Conditions				\$	-	

LINE NUMBER	LINE ITEM	QTY	UNIT OF MEASURE	UNIT PRICE	TOTAL PRICE	NOTES	RS Means Source
					\$	-	
Division 32	Exterior Improvements				\$	-	
	Discrete Elements						
Ad hoc	Visitor center and restrooms	2100	SF	\$ 300.00	\$ 630,000	ROM estimate buildings	No
G 3010 124 3000	Waterline	500	LF	\$ 47.05	\$ 23,525	Connect to water system 12" HDPE	Yes
G 3020 114 3000	Sewerline	500	LF	\$ 85.25	\$ 42,625	Connect to sewerline 18" HDPE	Yes
Ad hoc	Restoration overlook	1	LS	\$ 15,600.00	\$ 15,600	Allowance for 50x50 lawn and \$10k for panel, with 2 day crew time (B-1)	No
Ad hoc	Interpretive node	1	EA	\$ 15,600.00	\$ 15,600	Allowance for 50x50 lawn and \$10k for panel, with 2 day crew time (B-1)	No
					\$	-	
					\$	-	
	Parking Lots				\$	-	
G 2020 214 1570	Parking Lot, 80 space (see assumptions)	1	EA	\$ 168,800.00	\$ 168,800	Use RS Means Assemblies Cost	Yes
G 2020 214 1510	Parking Lot, 12 spaces (see assumptions)	1	EA	\$ 42,000.00	\$ 42,000	Use RS Means Assemblies Cost	Yes
					\$	-	
	Pedestrian Paving/Trails				\$	-	
	<i>Option C</i>				\$	-	
G 2030 120 2280	Sidewalk, 5-ft wide	2300	LF	\$ 41.90	\$ 96,370	Use RS Means Assemblies Cost	Yes
Ad hoc	Boardwalk 5' clear width min. (6' design width)	475	LF	\$ 500.00	\$ 237,500	Unit cost assessed based on published data (see documentation)	
					\$	-	
	Landscaping and Planting				\$	-	
32 93 43.10 0758	Furnish and install tree at North parking lot	50	EA	\$ 436.00	\$ 21,800	Average price ea, and install using backhoe loader 48 HP; tree count proposed after figures and schematics	Yes
	<i>Permanent Irrigation</i>				\$	-	
Ad hoc	Vegetated marsh: 166,700 SF	166700	SF	\$ 1.00	\$ 166,700	Use ESA go-by for high-end unit costs	No
Ad hoc	Upland Coastal Sage: 49,500 SF	49500	SF	\$ 1.00	\$ 49,500	Use ESA go-by for high-end unit costs	No
Ad hoc	Low growing upland: 31,200 SF	31200	SF	\$ 1.00	\$ 31,200	Use ESA go-by for high-end unit costs	No
	<i>Planting</i>				\$	-	
Ad hoc	Total planting needs	1	LS	\$ 362,000.00	\$ 362,000	Per cost estimate provided by CRC	No
					\$	-	
	Bridge (Pedestrian) Pre-fabricated				\$	-	
	OPTION C				\$	-	
32 34 20.10 1600	Wood, laminated type, CIP, 130' span	1200	SF	\$ 250.00	\$ 300,000	Estimate for wood based bridge; 10 ft wide; does not include allowance for foundation work	Yes
03 30 53.40 4000	Allowance for foundation work	40	CY	\$ 600.00	\$ 24,000	Foundation mat, wing wall, includes labor	Yes
					\$	-	
SUBTOTAL					\$	5,809,804	

Division 01	General Requirements	15%	\$	5,809,804	\$	871,471	Potential complexities about: traffic, erosion control, potential offsite staging area
	Estimated as fraction of construction costs		LS				

Estimate Subtotal					\$	6,681,274	
Sales Tax					\$	-	Assume state-funded project exempt from sales taxes
Subtotal A					\$	6,681,274	
GC O&P					\$	668,127	See assumptions for rates
Subtotal B					\$	7,349,402	
Contingency					\$	2,572,291	See assumptions for rates
Subtotal C					\$	9,921,692	
Bond					\$	130,966	See assumptions for rates
Subtotal D					\$	10,052,659	
Location			Index:	100	\$	-	Location adjustment is automatically included in RS Means Online 2018
Total Project Costs					\$	10,052,659	

Note that soft costs (design, engineering, permitting, etc.) are not included in this estimate.

Operations and Maintenance (Creek Inflow Management, 5-year plan)

LINE NUMBER	LINE ITEM	QTY	UNIT OF MEASURE	UNIT PRICE	TOTAL PRICE	NOTES
Ad hoc	Monitoring gauge	4	EA	\$ 1,000.00	\$ 4,000	Includes installation and data retrieval
02 91 10.00 010	Water quality sampling and testing	60	EA	\$ 3,500.00	\$ 210,000	Assume monthly testing (costs per RS Means Online Data 2018, Santa Ana)
Ad hoc	Yearly environmental and maintenance support @150/hr	600	HRS	\$ 150	\$ 90,000	Assume 120 man-hours per year, for 5 years
Total					\$ 304,000	

Assumptions

Crews and Labor

B-1 crew	\$	1,481	Day rate (including O&P)
B-3A	\$	3,574	Day rate (including O&P)

Operations

All operations	Land-based
Excavating and hauling assumptions: 1.5 CY hyd. Exc., eight 8-CY dump trucks, 3 mile round trip. Costs of disposal NOT included	
Swelling factor	15%
Soil	Mostly sand

Division 01 Requirements

Division 01 incorporates all general conditions including potential complexities associated with site access restrictions, sensitive habitats, mobilization, and monitoring, BMP, etc. - does not cover O&P for GC

Boardwalk Design

Unit cost for boardwalk was assessed from recent Schaaf and Wheeler study in the Bay Area (similar cost indices) and 2006 cost estimate from the Association of State Wetland Managers			
Unit cost is consistent and ranges from \$160 to 200 per LF. This estimate uses \$180/LF			
Boardwalk cost study prepared by Tracy Johnson indicates cost of \$55/SF plus 80% cost of material for installation			
Boardwalk: 6' minimum width, and an ADA minimum clear width of 5'			
Unit cost	\$	500	LF
alternative		594	LF

Marsh/Restored Land Elevation Adjustment

Excavate and hauling: assume that material is transported to laydown yard within site

Misc. Construction Items

Riprap length	1000	Average length (LF) of riprap coverage needed for the site
All sidewalks are assumed to be concrete, and 5' wide		

CALTRANS Unit Costs for Bridge

The "TOTAL AMOUNT" and "AVERAGE COST/SQFT" includes all bid items, including:
Time related overhead, mobilization, bridge removal, approach slabs, slope paving, soundwalls or retaining walls

Hauling and Disposal

Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 15 min load/wait/unload, 12 C.Y. truck, cycle 30 miles, 35 MPH, excludes loading equipment; 84 CY/day output

Parking Lots

The Parking Lot System includes: compacted bank-run gravel; fine grading with a grader and roller; and bituminous concrete wearing course

Units and Constants

Contingency	35.00%
Planning	35.00%
Conceptual Stage	20.00%
Schematic Stage	15.00%
Preliminary Working Dr	10.00%
Final	3.00%
Time Value of Money	
Interest Rate ("cost of n	6%
Escalation Rate	4.20%
Location-based Adjustment	
Sales Tax	0.00%
O&P (GC)	10.00%
Bond structure	
\$12/1000+10%O&P	1.32%

Instructions

General
This worksheet is based on RS Means approach. Other approaches are possible. Any departure from the RS Means approach may impact the way adjustments are calculated.

GC O&P
This entry represents the general contractor's markup on material, labor, equipment, and subcontractor costs. The standard markup is 10%, but can vary between 5-15% depending on the type of work performed.

Sales Tax
If the work is subject to state or local sales taxes, the amount must be added to the estimate. Sales tax may be added to material costs, equipment costs, and subcontracted work. For subcontracted work, sales tax may be added to part of the amount only.

Contingency
A factor for contingency may be added to any estimate to represent the cost of unknowns that may occur between the time the project is constructed. The amount of the allowance will depend on the stage of design at which the estimate is done, and contractor's assessment of the risk involved.
See Section 01 21 16.50 Contingencies in RS Means

Location Adjustment
Use the City Cost Index to adjust the costs

Escalation
Rate of escalation was estimated using CALTRANS 2015 Bridge Project Cost Indices

Division 01 Requirements
This is the first division numerically, but the last division estimated. Division 1 includes project-wide needs provided by the General Contractor.
These requirements vary by project, but may include temporary facilities and utilities, security, testing, project cleanup, etc.
For small projects, a percentage can be used, typically between 5% and 15% of project cost. For large projects, the costs may be itemized and priced individually.

Estimate Breakdown Structure

Item	Amount
Mobilization	\$ 450,000
Division 02	\$ 506,255
Division 31	\$ 2,626,329
Division 32	\$ 2,227,220
Division 01	\$ 871,471
Construction Costs	\$ 6,681,274
GC O&P	\$ 668,127
Surety	\$ 130,966
Contingency	\$ 2,572,291
Construction Costs, Adjus	\$ 10,052,659
Soft costs	\$ 1,000,000
O&M	\$ 304,000
Total	\$ 11,356,659

