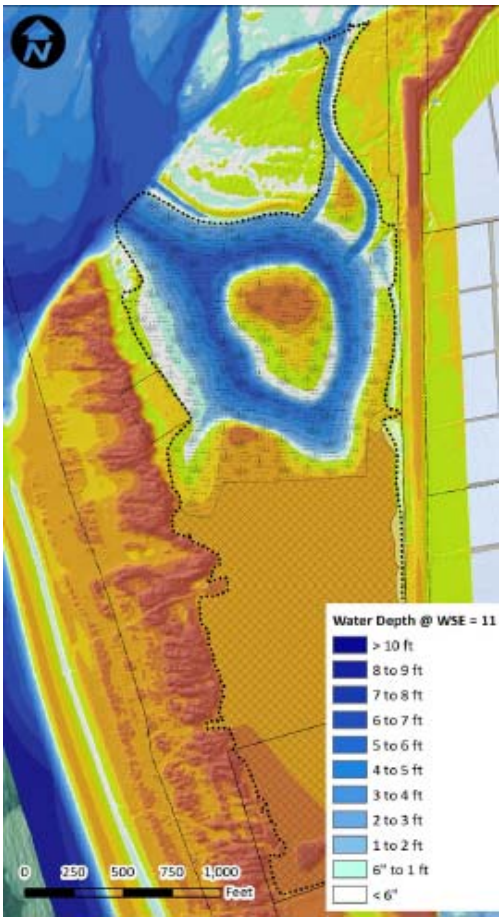
SANTA CLARA RIVER ESTUARY HABITAT RESTORATION AND ENHANCEMENT FEASIBILITY STUDY



California Department of Fish and Wildlife
Fisheries Restoration Grant Program Agreement # P1350015
August 7, 2015

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ENVIRONMENTAL CONSULTANTS

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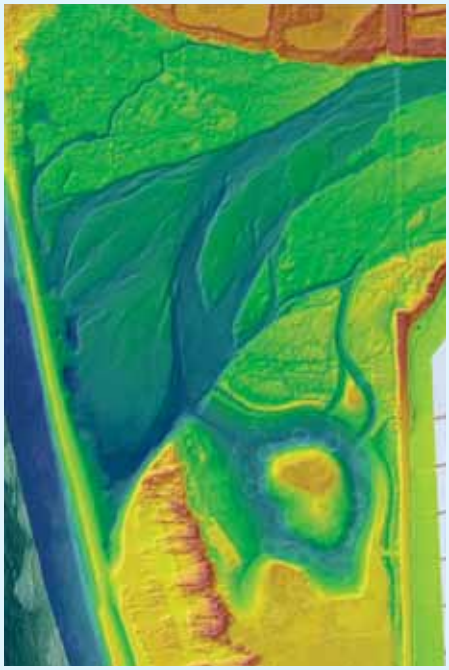
Hydrology | Hydraulics | Geomorphology | Design | Field Services



Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Prepared for:
Wishtoyo Foundation and Wishtoyo Foundation's Ventura Coastkeeper Program

Wishtoyo

VENTURA COASTKEEPER

Prepared by:
cbec, inc. with assistance from WRA, Inc. and Mike Podlech

July 2015
Project Number: 14-1023

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EXECUTIVE SUMMARY

Background

The Santa Clara River Estuary (SCRE) is located at the interface of the Santa Clara River (SCR) and the Pacific Ocean in Ventura County, California (see Figure 1 and Figure 2). Historically, the SCRE was an expansive intertidal ecosystem that included unrestrained channels, marshes, and riparian habitats that supported a vast array of aquatic species including the endangered southern California steelhead (steelhead). Since the 1850's, land development and hydrologic modifications within the watershed have dramatically reduced the overall size and quality of the habitat within the SCRE (Figure 3 and Figure 4). While historically home to one of the largest steelhead runs in southern California with an estimated annual run of over 8,000 steelhead returning adults prior to the 1950s (Moore, 1980), very few adult steelhead currently return to the SCR and its tributaries. A recovery plan for the species published in January 2012 identified the SCR as one of the highest priority sites for recovery actions, as one of the most likely to sustain independently viable populations, and critical for ensuring viability of the species as a whole (NMFS, 2012). In addition to steelhead, many other special-status wildlife, fish, and invertebrate species have also been documented (or have the potential to occur) within the vicinity of the SCRE including but not limited to: tidewater goby, California least tern, and western snowy plover.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

The Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study (Project) was initially created to explore the feasibility of expanding and enhancing estuarine habitat for steelhead and other native and protected species by restoring approximately 15 to 35 acres of the SCRE by providing lagoon, side channel, contiguous wetland, and/or additional upland riparian habitat within the space currently occupied by the McGrath State Beach and Campground (campground). As preliminary campground and restoration design concepts evolved, it became clear that additional restoration acreage (up to approximately 42 acres) may be possible and desirable. The campground is located on the southern margin of the SCRE and, in recent years, has often been closed to the public because of shallow flooding caused by high water levels in the estuary (Stillwater Sciences, 2011).

While portions of the campground have transitioned into wetland conditions due to the regular flooding, these areas are dominated by non-native wetland species and are dissected by the paved campground roads, facilities, and campsites. The area currently provides no steelhead habitat when water levels in the SCRE are low (i.e., below an elevation of approximately 9 ft, NAVD88). When inundated, the area provides limited, poor-quality steelhead habitat, degraded water quality, and dramatically reduced recreational opportunities. The Project provided for a number of deliverables including this Feasibility Study and a design plan set for the restoration of the estuary at the 30% completion level (Appendix F).

Project Funding

The Project was principally funded through the California Department of Fish and Wildlife (CDFW) Fisheries Restoration Grant Program (FRGP), with additional funds granted by the U.S. Fish & Wildlife Service (USFWS) Coastal Program and the McGrath Trustee Council. California State Parks (State Parks) and the Wishtoyo Foundation's Ventura Coastkeeper Program provided in kind contributions.

Feasibility Study

The purpose of this Feasibility Study is to provide CDFW, State Parks, USFWS, the McGrath Trustee Council, the Wishtoyo Foundation, its Ventura Coastkeeper Program, Project partners, interested parties, stakeholders, and regulatory agencies with information and analysis regarding the viability of the estuary and habitat restoration. Another Project deliverable, the Existing Conditions Technical Report (ECTR)(cbec et. al, 2015), which was released in January 2015, provided a focused technical assessment of the existing conditions and functionality of the SCRE and the adjacent campground. This Feasibility Study builds on the ECTR and documents the work done by the Project team, the four independent technical advisers retained for the Project, and participating stakeholders to develop a Preferred Restoration Concept for the SCRE within the Project property and within the scope of the available funding.

This Feasibility Study represents the culmination of many efforts including:

- A preliminary restoration concept design, modeling, and feasibility effort enabled by the USFWS Coastal Program
- Targeted field studies, surveys, and assessments
- A synthesis of existing studies and research
- A number of concept brainstorming sessions
- A full-day design charrette workshop which included the participation of numerous inter-disciplinary stakeholders, the independent technical advisers, a variety of other restoration experts, and agency representatives
- The development of two distinct preliminary restoration alternatives
- A suite of hydrodynamic and sediment transport model simulations and physical water quality considerations
- Another design workshop to facilitate review of the simulation results and to allow for input into refined restoration concepts
- Final development and analysis of the Preferred Restoration Concept (Figure 14).

This Feasibility Study describes the development of the Preferred Restoration Concept and discusses the anticipated benefits and comparative advantages of the Preferred Restoration Concept over the existing conditions, with specific considerations for steelhead habitat creation and benefits to other native wildlife species. It includes a description of the topographic grading, plans for reestablishing appropriate vegetation communities and ecological functions, and an assessment of how the preferred restoration of the estuary may function under a variety of anticipated and potential scenarios. Scenarios include SCR flood runoff events (2-year and 10-year), open-mouth / tidal conditions, closed-berm conditions, sea level rise, and a range of potential reductions in the flow of treated wastewater discharged into the

north end of the estuary by the City of San Buenaventura's Ventura Water Reclamation Facility (VWRF). The report also includes temporary irrigation considerations, an opinion of probable cost for the construction of the project, and a list of recommendations that may be helpful as the project moves beyond the 30% level of completion.

Restoration Objectives

The broad objective of the Project is to restore ecological functions within the constraints of the existing hydrology and to provide for species and habitat resiliency with anticipated future hydrologic changes including sea level rise and potential VWRF discharge reductions. The goal is not restoration of the estuary to some fixed, historical condition, but rather, to jump-start the estuary back to a more natural and dynamic site that is allowed to evolve naturally with changing hydrologic and geomorphic conditions while providing a variety of suitable habitats for steelhead and other native species.

Preferred Restoration Concept

The Preferred Restoration Concept includes two distinct areas, the Restoration Area (approximately 42 acres) which is envisioned to be almost exclusively for restoration activities and low-impact interpretive trails, and the adjacent Mixed Use Area (approximately 43 acres) to the south which would include new campground facilities potentially interspersed with other dune, wetland and riparian habitats (Figure 14 and Figure 27). Though this report primarily focuses on the development and benefits of the Restoration Area, these two areas are mutually-enabling[1] and together form one continuous, integrated site that collectively provides substantial improvements to the crucial ecological functions of the estuary and the recreational value of the campground.

The Preferred Restoration Concept provides expanded and enhanced habitat for endangered steelhead and reflects the synthesis of a wide array of stakeholder-generated ideas, a diverse set of professional perspectives, and efforts to realize an appropriate balance between a number of often competing considerations including: different estuary water levels during open-mouth (Figure 16) and closed-berm conditions (Figure 17 and Figure 25), sea level rise, potential changes to the local hydrology, expanded and enhanced endangered species habitat, continued public coastal access, and overall project cost. The Preferred Restoration Concept includes the following key components:

- Removal of the existing campground and all associated hard infrastructure including pavement, buildings, and underground utilities.
- Approximately 42 acres of Restoration Area including the creation of two different fluvial side channels, a large, well-connected network of estuarine lagoon and seasonal tidal sloughs, and enhanced riparian, wetland, and dune habitats.
- Conversion of the existing shallow and fragmented disturbed wetland within the campground footprint into a deeper water feature capable of supporting aquatic habitat under a greater range of potential water levels due to open-mouth and closed-berm conditions.

[1] The Mixed Use Area and the Restoration Area are considered mutually enabling as it is considered unlikely that either portion would be acceptable to the majority of stakeholders as a standalone project.

- Gradually sloped aquatic and terrestrial habitat features and improved estuarine ecological functions that accommodate seasonal water level changes and variable hydrologic inputs.
- A new higher-elevation campground to maintain current recreational opportunities and public access to the coast and to reduce the hazards and risks associated with extreme events and changing climate.
- Preservation of large stands of existing riparian and marsh habitat.
- Enhancement and restoration of disturbed and degraded habitat areas.

The Preferred Restoration Concept provides a mix of deep and shallow aquatic habitats with a range of marsh and riparian vegetation types suitable for a wide variety of bird, fish, and invertebrate species associated with coastal estuaries and freshwater marsh. The habitat mosaic will support variable life stages and life history components for a diversity of animal species. The Preferred Restoration Concept is also expected to provide improved site drainage to reduce potential for salinity stratification or the stranding of steelhead and tidewater goby following breach events, velocity refugia for juvenile steelhead and tidewater goby during storm events, and up to a 2 °C decrease in peak daily water temperatures in the portion of the SCRE currently occupied by the campground (Figure 26).

The dynamic nature of the SCRE was a fundamental consideration for the development of the Preferred Restoration Concept. While expected to provide significant habitat (and recreational) improvements in the short term, the Preferred Restoration Concept is also anticipated to provide enhanced ecological resiliency as the site continues to evolve in response to changing (and variable) climatic inputs and uncertain hydrologic inputs. Adaptive management of the SCRE should allow for an evolving system (the natural condition), so that the estuary will continue to provide habitat for native and endangered species for many years to come.

Next Steps

The design geometry and the other concept information included in this report (and in the planset included in Appendix F) represent the Preferred Restoration Concept at a robust 30% level of design, but additional rounds of stakeholder engagement, public input, integration planning, engineering design, and geometry refinement are required. Important next steps include permitting, review of additional estuary studies, and final restoration and campground design.

Permitting

Because the Project will occur within habitats that are potentially under the jurisdiction of the U.S. Army Corps of Engineers (Corps), the Los Angeles Regional Water Quality Control Board (LARWQCB), the California Department of Fish and Wildlife (CDFW), and the California Coastal Commission (CCC), the following permits will be required:

- Clean Water Act Section 404 Nationwide or Individual Permit
- Clean Water Act Section 401 Water Quality Certification
- California Fish and Game Code Section 1602 Lake and Streambed Alteration Agreement
- Coastal Development Permit

As the landowner and likely lead agency for future efforts, State Parks will also need to demonstrate compliance under the California Environmental Quality Act (CEQA). Other permits may also be required.

Additional Studies and Final Design

Given the dynamic nature of the SCRE and the uncertainty of future hydrologic conditions (sea level rise, climate change, and potential VWRF discharge reductions), the Preferred Restoration Concept was designed to provide enhanced ecological functions and suitable habitat for the focal native and endangered species at a wide range of estuary water levels while also maintaining and improving public recreational opportunities at the coast.

However, as the design of the Preferred Restoration Concept moves past the 30% level, it will be necessary to review the City of Ventura's Phase 3 Special Studies (due in draft form in September 2017, with datasets potentially available at an earlier time), which will include an expanded water budget analysis, a Nutrient and Toxicity Special Study, and a Groundwater Special Study (LARWQCB, 2013; City of Ventura, 2014). In the face of climate change and the potential reduction of VWRF discharge into the estuary, the temperature, quantity, and seasonality of groundwater inflows to the SCRE may have important design considerations that should be incorporated into the final grading and vegetation designs for the Preferred Restoration Concept.

While the sensitive ecology and specific coastal location of the Project site will likely make the acquisition of environmental and construction permits more challenging, the existing condition of the campground portion of the site (intermittent shallow flooding) provides poor-quality steelhead habitat and meager recreational opportunities. Similarly, the adjacent parcel to the south (evaluated for campground relocation as part of the Mixed Use Area) has been previously disturbed by oil exploration and development activities, and is primarily dominated by invasive plant species. The Preferred Restoration Concept proposes improvements to both of these sites that are crucial, urgently needed, and which will have ecological, recreational, and socioeconomic benefits.

DISCLOSURE STATEMENT

This document and all supporting studies and reports were prepared through an agreement with the California Department of Fish and Wildlife (CDFW) through the Fisheries Restoration Grant Program (FRGP) as a Project deliverable in accordance with Agreement P1350015. The total Project budget was $947,314. Grant funds allocated to this Project from the CDFW FRGP were limited to a total amount of $663,282 and included compensation for the preparation of multiple Project deliverables including: several written reports, spreadsheets, draft design plan sets, field-work activities, and expenses. Grant funds from the U.S. Fish and Wildlife Service Coastal Program and McGrath Trustee Council, and in kind contributions from California State Parks and Wishtoyo Foundation's Ventura Coastkeeper Program, were also utilized for the Project deliverables.

The contents of this document do not necessarily reflect the views and policies of the California Department of Fish and Wildlife, U.S. Fish and Wildlife Service, California State Parks, the Wishtoyo Foundation, or the Wishtoyo Foundation's Ventura Coastkeeper Program. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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GLOSSARY OF ACRONYMS

Acronym	Meaning
2D	Two dimensional
APN	Assessor's Parcel Number
CCC	California Coastal Commission
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
cfs	cubic feet per second
Corps	United States Army Corps of Engineers
cy	cubic yards
CNPS	California Native Plant Society
CWA	Clean Water Act
DO	Dissolved Oxygen
DPS	Distinct Population Segment
ECTR	Existing Conditions Technical Report (previous grant deliverable)
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FRGP	Fisheries Restoration Grant Program
ft	feet
fps	feet per second
GIS	Geographic Information System
LARWQCB	Los Angeles Regional Water Quality Control Board
LCP	Local Coastal Program
LIDAR	Light Detection and Ranging - remotely sensed topographic data acquired using a laser
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MTL	Mean Tide Level
NAVD88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
OPC	Ocean Protection Council
RPR	Rare Plant Rank
SCR	Santa Clara River
SCRE	Santa Clara River Estuary
SWPPP	Stormwater Pollution Prevention Plan
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
VCWPD	Ventura County Watershed Protection District
WSE	Water Surface Elevation

1 INTRODUCTION

1.1 PURPOSE

This report was prepared as a key project deliverable for the Santa Clara River Estuary (SCRE) Habitat Restoration and Enhancement Feasibility Study (Project). The Project was principally funded through the California Department of Fish and Wildlife (CDFW) Fisheries Restoration Grant Program (FRGP), with additional funds granted by the U.S. Fish & Wildlife Service (USFWS) and the McGrath Trustee Council. California State Parks (State Parks) and the Wishtoyo Foundation's Ventura Coastkeeper Program provided in kind contributions. The Project was initially created to explore the feasibility of creating expanded and enhanced estuarine habitat for southern California steelhead (steelhead) and other native and protected species by restoring approximately 15 to 35 acres of the SCRE by providing lagoon, side channel, contiguous wetland, and/or additional upland riparian habitat within the space currently occupied by the McGrath State Beach and Campground (campground) and the adjacent areas (Figure 1). As preliminary campground and restoration design concepts evolved, it became clear that additional restoration acreage (up to approximately 42 acres) may be possible and desirable.

The purpose of this Feasibility Study is to provide CDFW, State Parks, USFWS, the McGrath Trustee Council, the Wishtoyo Foundation, its Ventura Coastkeeper Program, Project partners, interested parties, stakeholders, and regulatory agencies with information and analysis regarding the viability of the estuary and habitat restoration. Another Project deliverable, the Existing Conditions Technical Report (ECTR)(cbec et al., 2015), provided a focused technical assessment of the existing conditions and functionality of the SCRE and the adjacent campground. This Feasibility Study builds on the ECTR and documents the work done by the Project team, the four independent technical advisers retained for the Project, and participating stakeholders to develop a preferred restoration alternative for the SCRE within the Project property and within the scope of the grant funding.

This Feasibility Study represents the culmination of a preliminary restoration concept design, modeling and feasibility effort enabled by the USFWS Coastal Program; targeted field studies, surveys, and assessments; a synthesis of existing studies and research; a number of concept brainstorming sessions; a full-day design charrette which included the participation of numerous stakeholders, the independent technical advisers, a variety of other restoration experts, and agency representatives; the development of two distinct preliminary restoration alternatives (referred to as Alternative 1 and Alternative 2); a suite of hydrodynamic and sediment transport model simulations and physical water quality analyses; another design workshop to facilitate review of the simulation results and to allow for input into refined restoration concepts; and final development and analysis of the Preferred Restoration Concept. This Feasibility Study is primarily intended to describe the development of the Preferred Restoration Concept and to document the anticipated benefits and comparative advantages of the Preferred Restoration Concept over the existing conditions (with specific considerations for steelhead habitat creation and benefits to other native wildlife species), but it also provides a summary of earlier efforts as necessary to support the wider objectives of the Project.

Source: 2014 NAIP aerial. Property parcel boundaries from Ventura County GIS – "County View". Inset from ESRI.

cbec eco engineering

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Site location

Project No. 14-1023	Created By: DM/DT	**Figure 1**

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7/27/2015

As developed by the Project, the Preferred Restoration Concept includes two distinct areas, the Restoration Area which was envisioned to be almost exclusively for restoration activities and low impact interpretive trails, and the Mixed Use Area to the south which would include new campground facilities potentially interspersed with other dune, wetland and riparian habitats (Figure 1). This report primarily focuses on the development and benefits of the Restoration Area, but includes interrelated preliminary draft plans for the Mixed Use Area and the elements of the proposed campground (see Appendix F).

1.2 MOTIVATIONS

There are a number of motivations behind the Project. To provide context and impetus for the Preferred Restoration Concept, several of the main motivations are described in more detail below.

As described in the National Marine Fisheries Service (NMFS) Southern California Steelhead Recovery Plan, natural and anthropogenic factors have caused precipitous steelhead population declines and have reduced the distribution of steelhead within southern California (NMFS, 2012). Prior to 1950, the annual returning adult steelhead run on the Santa Clara River (SCR) was estimated to be over 8,000 steelhead per year and was home to one of the largest steelhead runs in southern California (Moore, 1980). Now, very few adult steelhead are observed returning to the SCR and its tributaries. As a distinct population segment (DPS), southern California steelhead were first listed as an endangered species under the Endangered Species Act (ESA) in 1997 and the listing was reaffirmed again in 2006 (NMFS, 2012). NMFS estimates that only 15% of the historical estuarine habitat within the watershed remains and designated the SCR and the SCRE as critical habitat (NMFS, 2012). The SCR was further identified as one of the highest priority sites for recovery actions and one of the most likely to sustain independently viable populations. As estuaries can provide rearing habitat for juvenile steelhead and also function as the gateway used by both immigrating adults and emigrating juveniles moving between marine and freshwater environments, steelhead revitalization efforts within the watershed will benefit from ecologically suitable estuarine habitat. More detailed information pertaining to the current steelhead use of the estuary and the suitability of the SCRE for steelhead habitat and restoration activities is provided in the ECTR.

The Project is also motivated by the long history of flooding (and the subsequent closure) of McGrath State Beach and Campground. Established as a State Park in 1962 when the site was purchased from the McGrath family, the area has been a popular recreation site for over fifty years. Flooding concerns from the seasonally closed mouth berm were observed even in 1962 as evidenced by breaching easements granted to Hugo McGrath and Associates to protect nearby agricultural productiveness (State Parks, 1979). An earthen levee between the campground and the southern boundary of the main estuary provided some protection from surface water flooding (groundwater flooding was still a concern) until it was effectively destroyed in the 1990's (Swanson et al., 1990; ESA, 2003; Stillwater Sciences, 2011). This has increased the susceptibility of the campground to surface flooding from the estuary. In recent years, higher water levels in the estuary have caused more frequent flooding, significantly damaged campground infrastructure, and resulted in intermittent closures. In addition to reduced recreational opportunities on the coast, the ECTR indicated that the shallow flooding of the campground may reduce

the suitability of the estuary habitat for steelhead and other native aquatic species because of the potential for increases in maximum daily water temperatures and low dissolved oxygen levels.
Another motivation is manifest in the mission of Wishtoyo Foundation's Ventura Coastkeeper Program: "to protect, preserve, and restore the ecological integrity and water quality of Ventura County's inland water bodies, coastal waters, and watersheds, which are vital natural resources for the citizens and all inhabitants of Ventura County, and are the lifeblood of Chumash Native American culture." The SCRE is a complex system both in the way it functions ecologically and hydraulically, but also in the way it is part of the cultural and economic landscape of the local community. Beyond expanded and improved habitat for listed and endangered species, other co-benefits are anticipated for the project including: improved recreational opportunities, expanded avenues for environmental and Native American cultural education, and economic benefits to the local and regional economies.

1.3 LOCATION

The SCRE is located at the interface of the Santa Clara River and the Pacific Ocean in Ventura County, California (Figure 1). On the south side of the SCRE is McGrath State Beach and Campground. To the north is the Ventura Water Reclamation Facility (VWRF) operated by the City of San Buenaventura (City of Ventura). North Harbor Boulevard crosses over the eastern side of the estuary. For much of the year, the SCRE is separated from the sea to the west by a narrow sand bar or mouth berm formed by wave action and local sediment. The water level within the estuary fluctuates seasonally, primarily in response to river flows, groundwater flows, treated wastewater discharge volumes, and the height, width, and location of the mouth berm. The inundation extents within the estuary can be limited to just the deeper areas within the lower estuary at low tide with an open mouth or can extend over a thousand feet eastward of the Harbor Blvd bridge at high estuary stage with a closed mouth berm. For the purposes of this report, the SCRE is generally defined to include contiguous areas where the ground surface is less than an elevation of approximately 11 ft (NAVD88). Ecological discussion of the estuary also generally includes the surrounding riparian areas.

The majority of the central estuary is on a parcel of land owned by State Parks and is within the city limits of Oxnard, California. As contemplated by the FRGP funding, restoration concept development was limited to the Project Area (Figure 1) which included the northern part of this parcel (APN 138008006) and the adjacent parcel to the south which is also owned by State Parks (APN 138008008). Two private inholdings exist (APN 138008003 and APN 138008002) but were not included in the restoration planning. The Project Area corresponds to the Study Area used previously for the wildlife and habitat assessments and the wetland delineations which were completed as part of the ECTR and covers an area of approximately 250 acres.

The sensitive ecology and specific coastal location of the Project site may make the acquisition of environmental and construction permits for the restoration and new campground areas more challenging. But, as recent site assessments and the ECTR have confirmed, the existing condition of the campground portion of the site (i.e., shallow flooding) provides poor-quality steelhead and native species habitat and meager recreational opportunities. The adjacent parcel to the south of the existing

campground, previously disturbed by oil exploration and development activities, is primarily dominated by invasive plant species.

1.4 KEY ESTUARY STUDIES

The SCRE and surrounding area have been studied for decades by many different agencies and consultants. In addition to supporting the data collection and synthesis efforts associated with the Project, local, state and federal agencies have also provided many years of insight into the function of the SCRE through ecological monitoring programs, data collection efforts, historical research, habitat analyses, site observations, and financial support for many related efforts (e.g., State Parks, 1979; Swanson et al., 1990; USFWS, 1999; Kelley, 2008; Beller et al. 2011; Stillwater Sciences, 2011; and many others). This section describes a few of the key estuary studies and datasets that significantly informed the Project, the ECTR, and the development of the Preferred Restoration Concept. A complete list of the references, scientific papers, and supporting materials consulted through the course of the Project is included in Section 9.

One landmark report, entitled "Historical Ecology of the lower Santa Clara River, Ventura River, and Oxnard Plain: an analysis of terrestrial, riverine, and coastal habitats" (Beller et al., 2011), which was funded by the California Coastal Commission (CCC) and completed by the San Francisco Estuary Institute synthesized over two centuries of local documents, maps, photographs, and historical accounts. This work provided the Project with the crucial understanding of what the site conditions and the historical ecology of the estuary were prior to European settlement and thereby formed the starting point for the development of restoration concepts for the SCRE. This Feasibility Study makes repeated use of the graphics and historical ecological research completed in those efforts and expressly recognizes the importance of that type of scholarship in protecting, restoring, and making accessible the lands and waters of the California coast.

Another resource used by the Project team was the Coastal Resilience Ventura project developed by The Nature Conservancy (TNC) and partner agencies in order to support coastal adaptation planning and climate/disaster risk reduction using nature-based solutions. In addition to an online interactive mapping application (http://maps.coastalresilience.org/ventura) the TNC efforts also included a detailed technical report which described the hazards analysis mapping approach (including planning horizons for sea level rise projections) for the local coastline including the SCRE (ESA/PWA, 2013). The analysis and scenarios used to develop the Preferred Restoration Concept for the Project built on these broader planning efforts with a site specific analysis.

A key recent scientific study, titled the "Estuary Subwatershed Study – Assessment of the Physical and Biological Condition of the Santa Clara River Estuary" (Estuary Subwatershed Study), prepared by Stillwater Sciences for the City of Ventura in 2011, synthesized many of the earlier estuary studies, provided a majority of the recent water quality data and interpretation, and also provided a significant portion of the technical understanding related to the current and historical functions of the SCRE. An independent review of the Estuary Subwatershed Study, performed by Richard Ambrose, Ph.D. (Director and Professor of the UCLA Environmental Science and Engineering Program) and Sean Anderson, Ph.D.

(Assistant Professor of Environmental Science and Resource Management at California State University – Channel Islands) at the request of the Wishtoyo Foundation and its Ventura Coastkeeper Program, also provided important perspectives on the health and functions of the SCRE. Nonetheless, the Estuary Subwatershed Study is a wide-ranging and detailed synthesis report, and the long-term monitoring data collected in the study formed the basis for many of the sections within the ECTR.

In addition to the studies summarized above, a substantial dataset of environmental water quality data is available for the SCRE because the VWRF currently discharges approximately 7 to 9 million gallons per day of treated municipal wastewater into the northern end of the SCRE under waste discharge and monitoring requirements established by the Los Angeles Regional Water Quality Control Board (LARWQCB) as required by the Clean Water Act (CWA) and the National Pollutant Discharge Elimination System (NPDES). As background, in 1975, the LARWQCB adopted the Water Quality Control Policy for the Enclosed Bays and Estuaries of California, which was intended to phase out discharges like the VWRF unless it was demonstrated that the discharge "enhanced the quality of receiving waters above that which would occur in the absence of the discharge" (LARWQCB, 2008). The enhancement finding supporting the City of Ventura NPDES permit was questioned in 2008. The Estuary Subwatershed Study, which the City of Ventura was ordered to complete by the LARWQCB in 2008, was intended to provide the LARWQCB with enough information to resolve the scientific disagreement related to whether the VWRF effluent was an enhancement to the SCRE. Definitive conclusions have yet to be made, but there is agreement on performing additional focused studies. Such studies are mandated by the City of Ventura's current NPDES permit. The additional studies, referred to as the Phase 3 Special Studies, include an expanded water budget analysis, a Nutrient and Toxicity Special Study, and a Groundwater Special Study (LARWQCB, 2013; City of Ventura, 2014).

The data for many of the previous estuary studies are the water quality monitoring and reporting requirements associated with the City of Ventura's NPDES VWRF discharge permit (NPDES permit No. CA0053651). Revised most recently by the LARWQCB in 2013, the permit requires continuous sonde and periodic grab sampling within the effluent and the SCRE (the 'receiving waters'). A number of associated Time Schedule Orders issued by the LARWQCB, have also resulted in additional data collection efforts and several special focused studies (Stillwater Sciences, 2011; Nautilus Environmental, 2005; Entrix, 2002a/b; and others). This data was instrumental in preparation of the ECTR and supported the development of the Preferred Restoration Concept.

The Project, this Feasibility Study, and the Preferred Restoration Concept are not intended to address any specific scientific controversies related to the health of the estuary as it pertains to the VWRF effluent discharge or legal responsibility for costs of implementation, and should not be construed as suggesting or recommending any specific VWRF discharge or reduction. This Feasibility Study is only intended to describe and support the Preferred Restoration Concept as an important and resilient step towards the much-needed improvements in the SCRE.

1.5 REPORT ORGANIZATION

This Feasibility Study is organized into ten sections and is supported by several technical appendices. A brief summary of each section and technical appendix is provided below:

Section 1 provides a general overview of the Project, the purpose and scope of this Feasibility Study, and the motivations for the Project. This section also describes a number of key previous estuary studies, related local studies, and regional analyses that provide historical data and technical support for many of the topics discussed in the report.

Section 2 summarizes the findings of the surveys, studies, and assessments completed for the Project, which were previously documented in the ECTR, and provides a review of the existing conditions within the Project Area and the estuary including assessments of the existing habitat distribution and quality, vegetation surveys, water quality considerations, hydraulic and hydrologic conditions, and the overall geomorphic setting.

Section 3 describes the design process, the development and assessment of the two preliminary restoration alternatives, and the considerations for the preferred concept development that emerged from the preliminary efforts.

Section 4 provides a detailed description of the topographic grading and key features included the Preferred Restoration Concept and also includes preliminary estimates of earthwork quantities.

Section 5 describes the methods used to evaluate the hydraulic functioning and overall suitability of the Restoration Area under the three primary existing hydrologic regimes (river runoff events, open-mouth / tidal conditions, and closed-berm conditions), and also for several future and potential conditions including sea level rise and several VWRF discharge reductions scenarios.

Section 6 describes the biological aspects of the enhanced and expanded estuarine, marsh, and riparian habitats created within the Restoration Area of the Preferred Restoration Concept including improved ecological functions, considerations and plans for reestablishing appropriate vegetation, a discussion of how specific target aquatic species (i.e., steelhead and tidewater goby) and other native species will benefit, and a discussion of the possible impacts associated with the construction of the project. In addition, this section also discusses restoration habitat resilience in the face of climate change and sea level rise, species migration considerations, and some potential methods for evaluating the ecological success of the project.

Section 7 provides an opinion of the probable cost for construction of the Preferred Restoration Concept.

Section 8 provides a list of recommendations and next steps for the project including considerations for the regulatory permits and the environmental review processes that may be required.

Section 9 provides a full list of reference materials (cited and uncited) directly relevant to the Project.

Section 10 lists the people involved in the preparation of this Feasibility Study.

Appendix A provides a detailed technical description of the work done to build the hydrodynamic models and the scenarios which were used to provide for comparative evaluations between the existing conditions, the two preliminary restoration alternatives, and the Preferred Restoration Concept.

Appendix B documents a spreadsheet-based water balance model developed and refined for the Project and used to explore additional design scenarios including further potential VWRF discharge reduction values, and seasonally variable subsurface flows.

Appendix C includes all comments received on the preliminary restoration alternatives and the results of the hydrodynamic and water quality modeling.

Appendix D is the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) for the Project site and vicinity which shows the mapped regulatory 100-year floodplain and other flood hazards.

Appendix E provides the key components of a Stormwater Pollution Prevention Plan (SWPPP) for the construction of the Preferred Restoration Concept.

Appendix F is a draft construction planset for the Preferred Restoration Concept at the 30% completion level. The plan set includes the main components of the design (plan, profile, and typical sections) for both the physical grading of the site as well as the establishment of native wetland and riparian vegetation. Erosion and sediment control plan considerations (perimeter control, key areas for protection, etc.) are also included on the grading plans at the 30% level.

Appendix G includes the geotechnical and analytical results for the sediment sampling (surficial and subsurface) performed to support the Project.

Appendix H includes the Cultural, Archaeological, and Paleontological Resources Study (Topanga Anthropological Consultants, 2015) prepared to provide a detailed assessment of the potential for cultural, archaeological, and paleontological resources and remains to exist on or below the surface of the Project Area. This report also includes a detailed description of the cultural history of the Chumash Native American Peoples within the Project Area, historical landscape changes, oil field developments, and subsurface conditions.

Appendix I includes stakeholder comments received on the draft version of this Feasibility Study and a list of responses and revisions.

Appendix J provides suggested elements and designs for the Natural and Cultural Resources Interpretative Area which is anticipated to be an important feature of the Mixed Use Area.

Appendix K contains a letter from California State Parks which provides support for the Preferred Restoration Concept and describes State Parks participation in the Project and efforts completed related to the feasibility of relocating the campground, alternatives, and 30% concept designs.

1.6 UNITS AND DATUMS

For simplicity, data presented in this report are generally given in only one unit system, typically the unit system used by the analytical lab, the hydrodynamic modeling software, or the field/sampling equipment, which includes both U.S. customary and SI units. All vertical elevations are provided in feet relative to the North American Vertical Datum of 1988 (NAVD88). Where provided, horizontal coordinates use the North American Datum of 1983 - California State Plane Zone IV in feet.

2 SUMMARY OF EXISTING CONDITIONS AND STUDY SURVEYS

The following eight sections provide useful context for the Preferred Restoration Concept including the existing topographic conditions (Section 2.1), the historical ecology and the geomorphic setting (Section 2.2), the current and anticipated hydrologic regimes (Section 2.3), water quality considerations (Section 2.4), subsurface conditions (Section 2.5), the results of the cultural, archaeological, and paleontological resources study (Section 2.6), the character and location of the existing biological communities and special-status plant species (Section 2.7), and assessments of the existing wildlife habitats (Section 2.8). These sections form a brief summary of the more detailed Existing Conditions Technical Report (ECTR) previously developed for the Project.

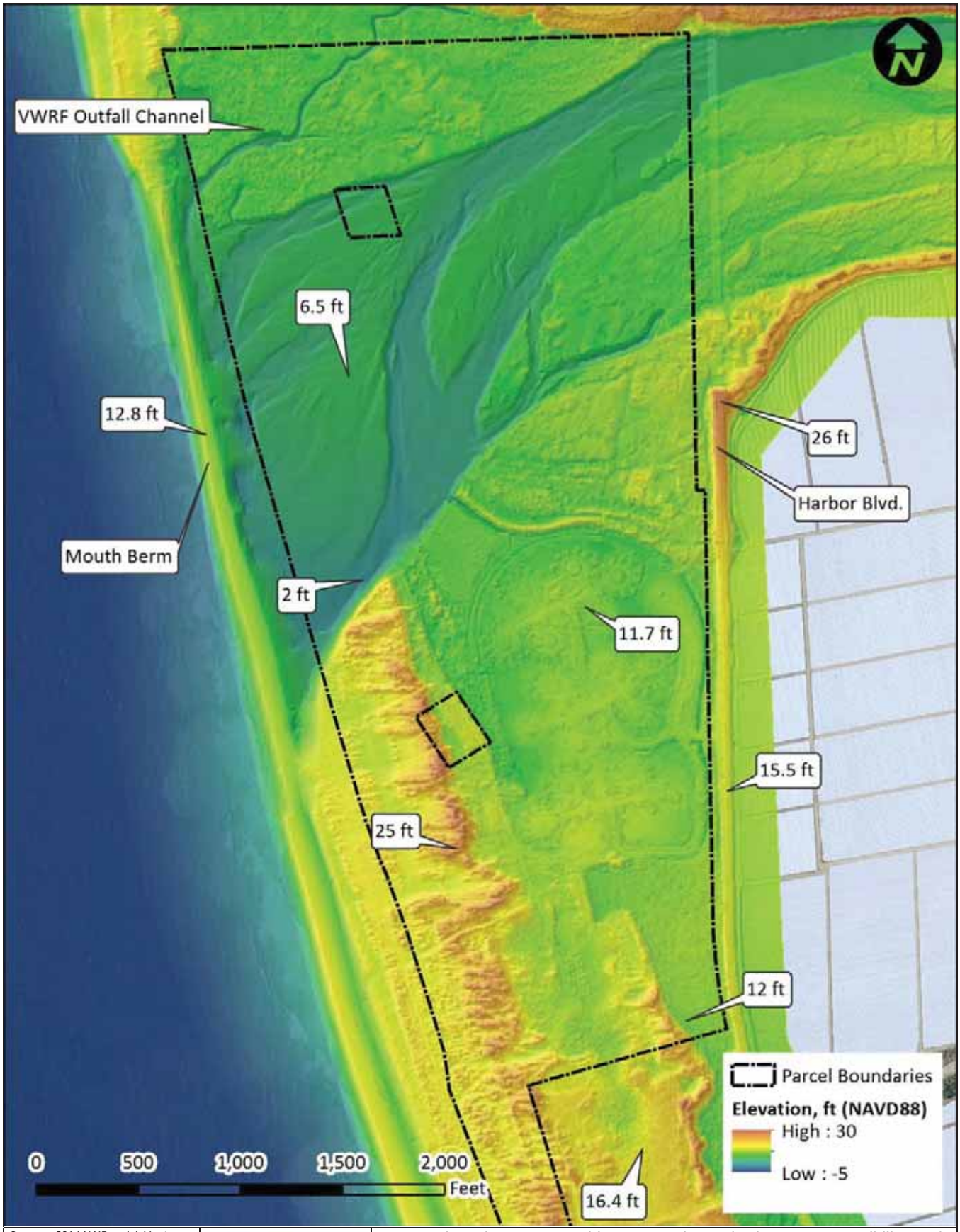
While many areas of the SCRE provide suitable habitat, these sections generally focus on the deficiencies of the existing conditions (as impetus and rationale for the Project) and on the important feasibility considerations that directly influenced the development of the Preferred Restoration Concept. For more detailed and wide-ranging descriptions of the existing conditions within the estuary refer to the ECTR and the cited reference materials.

2.1 TOPOGRAPHY

This section describes some key elevations for the existing physical topography of the Project site (see Figure 2). These elevations provide important context for the subsequent sections that summarize the existing conditions and were fundamental considerations in the development of the Preferred Restoration Concept. As discussed in more detail in Appendix A, the site topography used for the project was developed from a combination of 2009-2011 LIDAR, multi-beam bathymetry (2012), and limited field surveys (2014).

The majority of the site is separated from the Pacific Ocean by a set of elevated, sand dunes (ranging from 14 ft up to 27 ft) that mostly parallel the coast. The central portion of the main SCRE extends from Harbor Blvd to the seasonal mouth berm and is primarily below 7 ft with deeper channels as low as 1 ft. The elevation of the existing campground area is relatively flat and is mostly between 9 ft and 13 ft with an overall average elevation of 11.4 ft. Loss of use begins to occur when the water surface elevation in the SCRE is around 9 ft. The campground as a whole is generally forced to close when water levels increase above 10 ft. To the east of the site, Harbor Blvd ranges from a low point of around 13 ft at the southern end of the site near the intersection with West Gonzales Road, to 15.5 ft at the current campground entrance, to a high point above 20 ft at the southern estuary bridge embankment.

The area to the south of the existing campground exhibits significantly more topographic variability and reflects previous oil exploration and site grading activities. A detailed history of oil exploration activities and site grading changes is in included in Appendix H. Elevations vary from just under 10 ft in low areas at the southeast corner to raised areas above 27 ft with an overall average of 14.7 ft.



Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry
Notes: All elevations relative to NAVD88

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Existing conditions topography

Project No. 14-1023	Created By: DT	**Figure 2**

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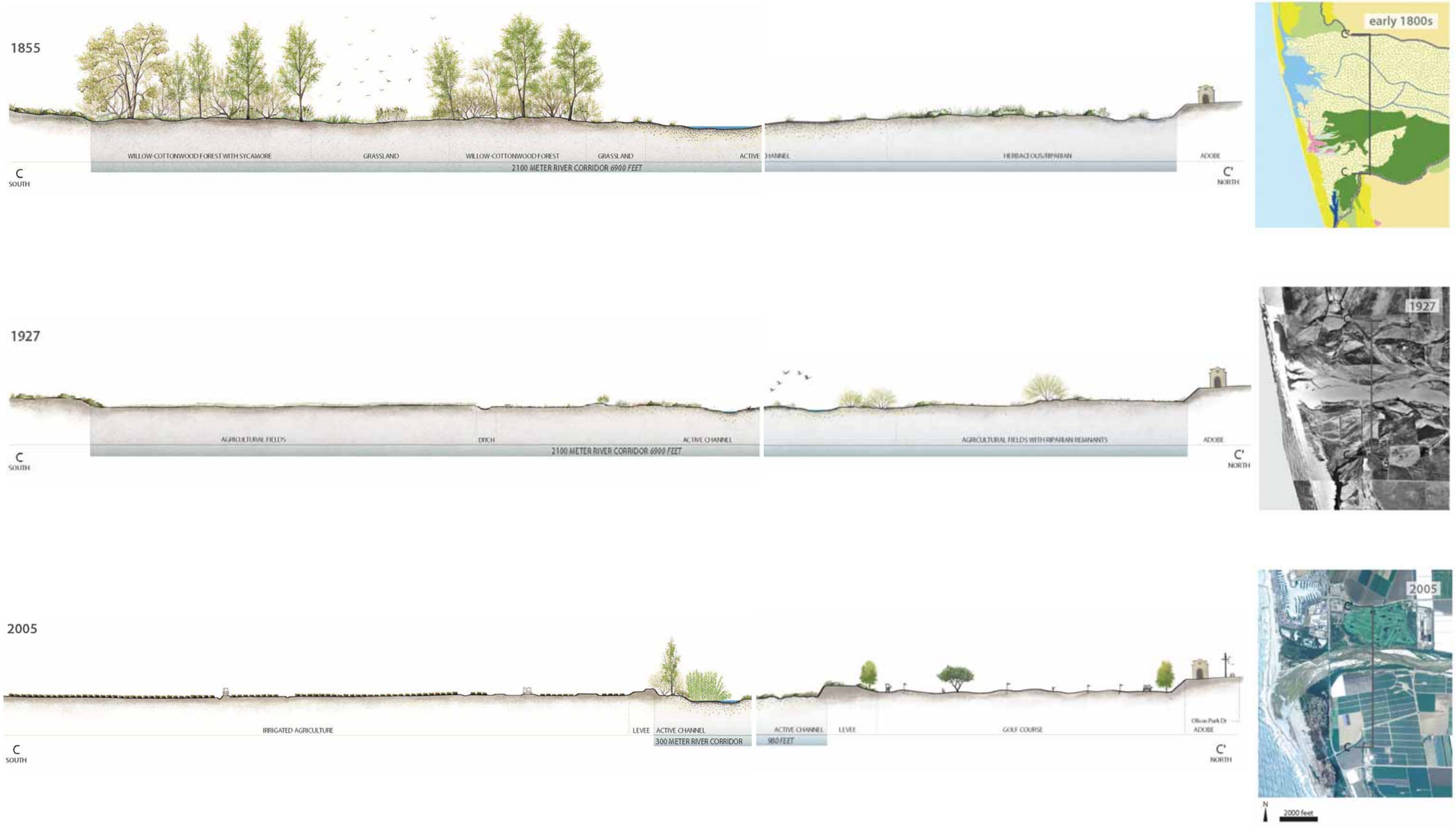
2.2 HISTORICAL ECOLOGY AND GEOMORPHOLOGY

Prior to the significant anthropogenic watershed modifications that began in the 1850's, the SCR was an unconstrained meandering river that supported a rich array of aquatic habitats including ponds, sloughs, freshwater marshes, and perennial reaches (Beller et al., 2011). As shown in Figure 3, the river corridor just upstream of the estuary was expansive and included extensive riparian forests and herbaceous riparian communities. At the river mouth, the SCRE featured open sand dunes, willow-cottonwood forested riparian habitats, and a diverse suite of freshwater, saline, and brackish aquatic habitats including willow swamps, salt flats, and a seasonally open tidal lagoon (Figure 4) (Beller et al. 2011). Though the position of the SCR corridor remained relatively stable during the 19th and early 20th century, in the relatively recent geologic past the lower SCR is known to have shifted from an outlet near present day Point Hueneme to its present location (Figure 5). These shifts, caused by large historic floods coupled with sediment deposition on the Oxnard Plain, created a dynamic landscape with ecological habitats and vegetation patterns reflective of the migrating river courses. The ever-changing nature of the river and estuary, the large variety of historic aquatic, riparian, and terrestrial habitats, and the importance of geomorphic events at causing landform changes, were key considerations for the development of appropriate restoration concepts.

The present day geomorphic constraints on the SCR and the SCRE also offered important feasibility considerations for the development of the preliminary restoration alternatives and significantly influenced the Preferred Restoration Concept. Today, flood protection levees, irrigation withdrawals, diversion dams, and land use changes within the watershed have significantly altered the fluvial and geomorphic processes influencing the SCR and the SCRE. With the significantly reduced width of the lower river corridor, which is now laterally constrained by the flood control levees that extend eastward from the Harbor Blvd bridge embankments, there has been a reduction in overbank sediment deposition relative to historic conditions. This increases the potential for bed scour and sediment transport efficiency due to increases in flow velocity and water depth. The scour (and depositional) patterns were of particular concern for the Project as the development of appropriate and sustainable restoration concepts depends on an understanding of the likely future trajectory of the system.

The current geomorphic regime is described in more detail in the ECTR. A detailed technical description of the hydrodynamic and sediment transport modeling done for the Project is included in Appendix A. Key model output and the geomorphic considerations of the Preferred Restoration Concept are discussed in Section 5.



Source: Adapted from Beller et al., 2011.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Historical river cross sections, 1855-2005

Project No. 14-1023	Created By: DT	**Figure 3**

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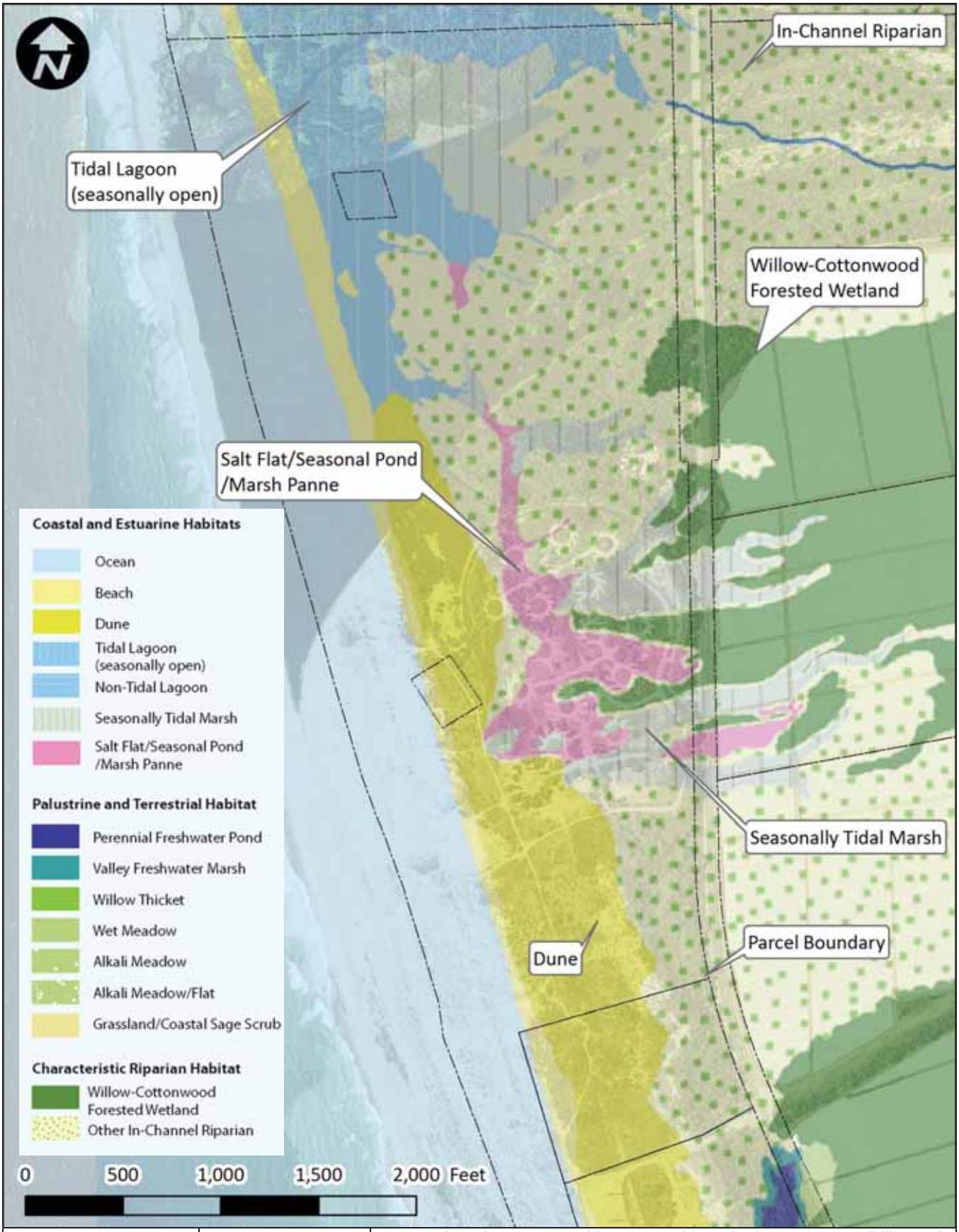

Source: 2014 NAIP. Adapted from Beller, et al. 2011.

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Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Historical habitat mapping

Project No. 14-1023 | Created By: DM | **Figure 4**

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Source:2014 NAIP. Adapted from Beller, et al. 2011.	cbec	Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study **Historical Santa Clara River channels**		
		Project No. 14-1023	Created By: DT	**Figure 5**

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2.3 HYDROLOGY

The hydrologic regime of the SCRE is complex and is affected by a number of factors: changing and uncertain precipitation patterns, surface water storage and diversions within the SCR watershed, agricultural drainage, relatively poorly characterized or quantified groundwater flows[2], VWRF effluent discharges, tidal exchanges during open-mouth conditions, and coastal wave action. While less disturbed than many other rivers in southern California, the overall hydrology of the SCR has been permanently and significantly altered from historical conditions through anthropological developments within the watershed including flood control levees, flow diversions, land use changes, and dams. The Preferred Restoration Concept does not purport to restore the hydrological regime of the estuary. The objective is to restore ecological functions within the constraints of the existing hydrology and to provide for species resiliency with anticipated future hydrologic changes (sea level rise and potential VWRF discharge reductions). This section focuses on the key hydrologic feasibility considerations that significantly influenced the development of the Preferred Restoration Concept including river runoff from storm events, the VWRF discharge, the location and elevation of the mouth berm, observed estuary water levels during closed-berm conditions, current tide levels, and projections for sea level rise. The existing hydrology of the SCRE is described in more detail in the ECTR.

River Runoff During Storm Events

The climate of the approximately 1,620 square mile SCR watershed (Figure 6) is characterized by a semi-arid, two-season Mediterranean climate typical of the southern California coastline. There are cool wet winters and warm/hot summers with around 80% of the annual precipitation occurring between November and March (ESA, 2003). Despite the flow diversions upstream, which often leaves the lower SCR dry or at flow rates below 1 cfs (Stillwater Sciences, 2011), the lower SCR can respond quickly to high-intensity precipitation events and reach flow rates well above 100,000 cfs. The recent 2005 flood event had an estimated flow of 136,000 cfs. A flood frequency analysis (plotted graphically in Figure 7) of historical peak river flows from 1955-2012 (USGS #11114000 for peak flows in 1955-2004 and VCWPD #723 for peak flows in 2008-2012, see gage locations Figure 6), indicates that the 2-year recurrence flow event is approximately 12,800 cfs and the 10-year recurrence event is approximately 86,600 cfs[3]. A review of recent flow hydrographs, available at 15-minute intervals for VCWPD gage #723 through the VCWPD Hydrologic Data Server(VCWPD, 2012), indicates these high-intensity flows events are often characterized by a relatively short-duration (less than 2 days).

[2] The City of Ventura's Phase 3 Special Studies (due in draft form in September 2017) will include a Groundwater Special Study (LARWQCB, 2013; City of Ventura, 2014) which is anticipated to provide additional information on the volume, quality, and seasonal nature of groundwater flows for the SCRE.

[3] Recurrence intervals are often misunderstood. The statistical analysis of the streamflow data for the SCR indicates that, in any given year, there is a 50% chance that the river will have an event larger than 12,8000 cfs. Similarly, there is a 10% chance, in any given year, that the river will have an event larger than 86,600 cfs. A different, but useful way to think about the statistical likelihood of these events when considering the Preferred Restoration Concept, is that there is a 75% chance a 2-year event will occur in the next two years and a 65% chance that a 10-year event will occur in the next ten years. The analysis also assumes that the fundamental distribution of the extreme events that cause large runoff is not changing (and follows a theoretical value of an idealized distribution) which though currently common practice, may become a less valid assumption as ongoing climate changes impact local precipitation patterns. For simplicity, in this Feasibility Study, these events are referred to as the 2-year and 10-year event.

Source: ESRI base aerial.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Santa Clara River watershed and gaging stations

Project No. 14-1023	Created By: DT	**Figure 6**

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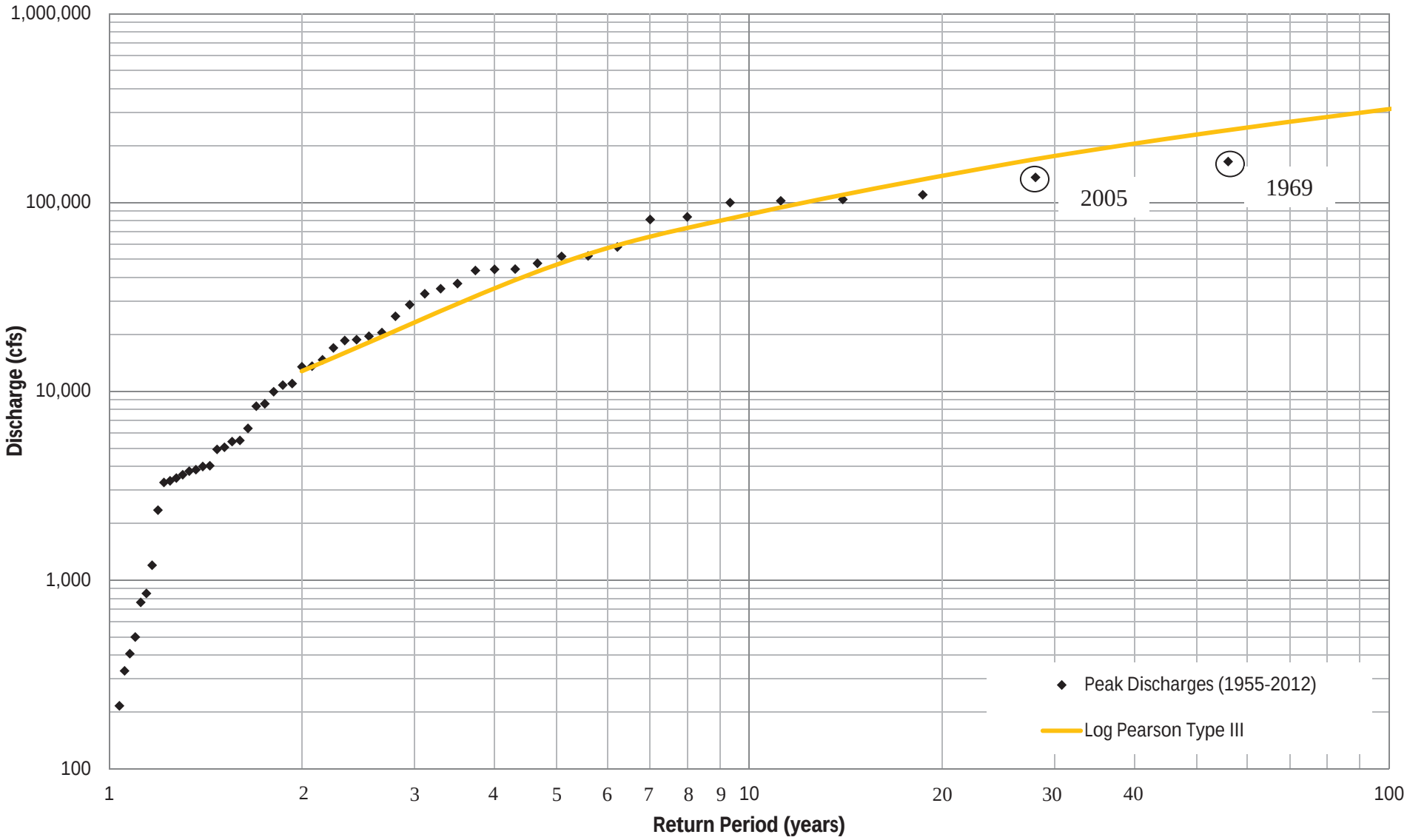

Source:USGS gage #11114000 Santa Clara River at Montalvo and VCWPD gage #723 Santa Clara River at Victoria Av.
Notes: Annual peak discharges for 1955-2012. No data for WY 1989, 2006, 2007. 1995 flow estimated from Flood Protection Report (1995-1996). 2005 flow estimated from VCWPD gage #724.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Santa Clara River flood frequency analysis

Project No. 14-1023	Created By: DT	**Figure 7**

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Though fleeting, the river runoff from storm events significantly impacts the physical setting and ecological suitability of the estuary. The 2-year event has ecological significance because of the frequency at which it occurs and the breaching of the mouth berm. The less frequent, but more powerful 10-year event has geomorphic significance because of the potential for significant scour/deposition and the re-working of estuary sediments. The current, persistent flooding of the campground is not associated with the 2-year or 10-year runoff events. Rather, these events tend to alleviate the campground flooding associated with closed-berm conditions by breaching the mouth berm and allowing the estuary to drain. While the flood hazard for the area is high due to the low-lying elevations and proximity to the SCR, the recent and regular flooding of the campground has occurred during dry years without significant storm events.

VWRF Discharge

Between river runoff events, the principal source of water for the SCRE during closed-berm conditions is the treated effluent of the Ventura Water Reclamation Facility (VWRF). Discharging into the northern side of the SCRE via the Wildlife Ponds and VWRF outfall channel (Figure 1), the VWRF provides a relatively continuous flow of treated wastewater into the estuary with monthly average daily mean rates between 10.5 and 13 cfs (Stillwater Sciences, 2011). Though not the sole determinant of the water level in the estuary, which is also influenced by the configuration of the mouth berm, seasonally variable groundwater inflows, and climate (e.g., evaporation), the VWRF effluent may cause high water levels within the SCRE during the summer and fall months, and increase the likelihood that the mouth berm can be overtopped and/or breached during the dry season (Stillwater Sciences, 2011). As the dominant source of water during closed-berm conditions, the VWRF also has significant effects on the water quality within the estuary (see also Section 2.4).

The Consent Decree entered into between the City of Ventura, Wishtoyo Foundation, Wishtoyo Foundation's Ventura Coastkeeper Program, and Heal the Bay, requires that the City of Ventura reclaim up to 100% of the VWRF effluent by 2025 as a first priority, but no less than 50% by 2025, subject only to limitations on reclamation specified in the Decree (United States District Court, 2012). It is pertinent to note that the Consent Decree does not require the City to cease or reduce its discharge of VWRF effluent if resource agencies, as informed by scientific experts, determine a particular amount of VWRF effluent flow is needed to sustain the native and endangered species within the estuary (United States District Court, 2012). The Project and this Feasibility Study do not suggest or recommend any specific VWRF discharge or reduction percentages. The Preferred Restoration Concept was developed to provide enhanced ecological functions and suitable habitat for the focal native and endangered species at a wide range of potential estuary water levels while also maintaining and improving public recreational opportunities on the coast. However, as the VWRF discharge rate directly and significantly influences water levels within the SCRE during extended closed-berm conditions, analyzing the full range of potential VWRF discharge reduction scenarios was a crucially important feasibility consideration for the development of the Preferred Restoration Concept.

Mouth Berm Configuration

The seasonal mouth berm is an important feasibility consideration as the water level within the estuary is essentially limited by the elevation of the berm. The configuration of the mouth berm (and the duration of open-mouth or closed-berm conditions within the estuary) are influenced by many processes including river sediment transport, the length of time since a major storm event, the bathymetry of the estuary and nearshore, surface water inflows, groundwater levels, tidal cycles, wave energy and littoral sediment transport. An analysis of recent aerials (2005 – 2014) suggests that the location and the configuration of the mouth berm for the SCRE may depend largely on the length of time following the last storm event capable of transporting sediments. As shown in Figure 8, the 2005 flood event formed a delta and reformed the mouth berm more than 800 ft westward into the Pacific Ocean from its previous position. Since 2005, littoral transport, wave and tidal action, combined with the lack of any major discharge events in the SCR, have caused the mouth berm to steadily retreat to the east. Future flood events in the SCR can be expected to produce similarly-sized changes in the location and configuration of the mouth berm. The west to east shift in the location of the mouth berm since 2005 has also resulted in substantial estuary volume and surface area reductions (Figure 9).

The elevation of the berm varies from season to season and along its length, but recent topographic surveys found that the crest elevation varied between 12 ft and 17ft. While breaches have been previously observed when the SCRE surface water elevation reached 10 ft (Stillwater Sciences, 2011), the persistent recent inundation of the northern portion of the campground, which is mostly at an elevation of between 9.5 ft and 11 ft, indicates higher water levels (up to nearly 12 ft) may not cause a breach to occur. The bathymetric survey, which was performed in the fall of 2014 during a several month period of closed-berm and flooded conditions, found SCRE water levels were around 11 ft (and had not caused a breach to occur).

Estuary Water Levels

Estuary water levels during closed-berm conditions are primarily influenced by the location and height of the mouth berm (which affects the volume and surface area of the estuary while also setting the maximum elevation to which the estuary can fill before overtopping the berm), the VWRF discharge rate, seasonally variable groundwater inflows, and the rate at which water seeps through the berm to the Pacific Ocean. Following a breach event, and subsequent berm closure, water levels in the SCRE can quickly (sometimes within a few days) increase to a pseudo-equilibrium summer water level (currently observed to be around 11 ft), reflecting a dynamic balance between current inflows (VWRF discharge and groundwater sources) and outflows (evaporation, evapotranspiration and subsurface flows to the Ocean and to McGrath Lake).

Source: 2014 NAIP aerial.
Notes: banklines digitized from Google Earth

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Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Recent berm trends

Project No. 14-1023	Created By: DT	**Figure 8**

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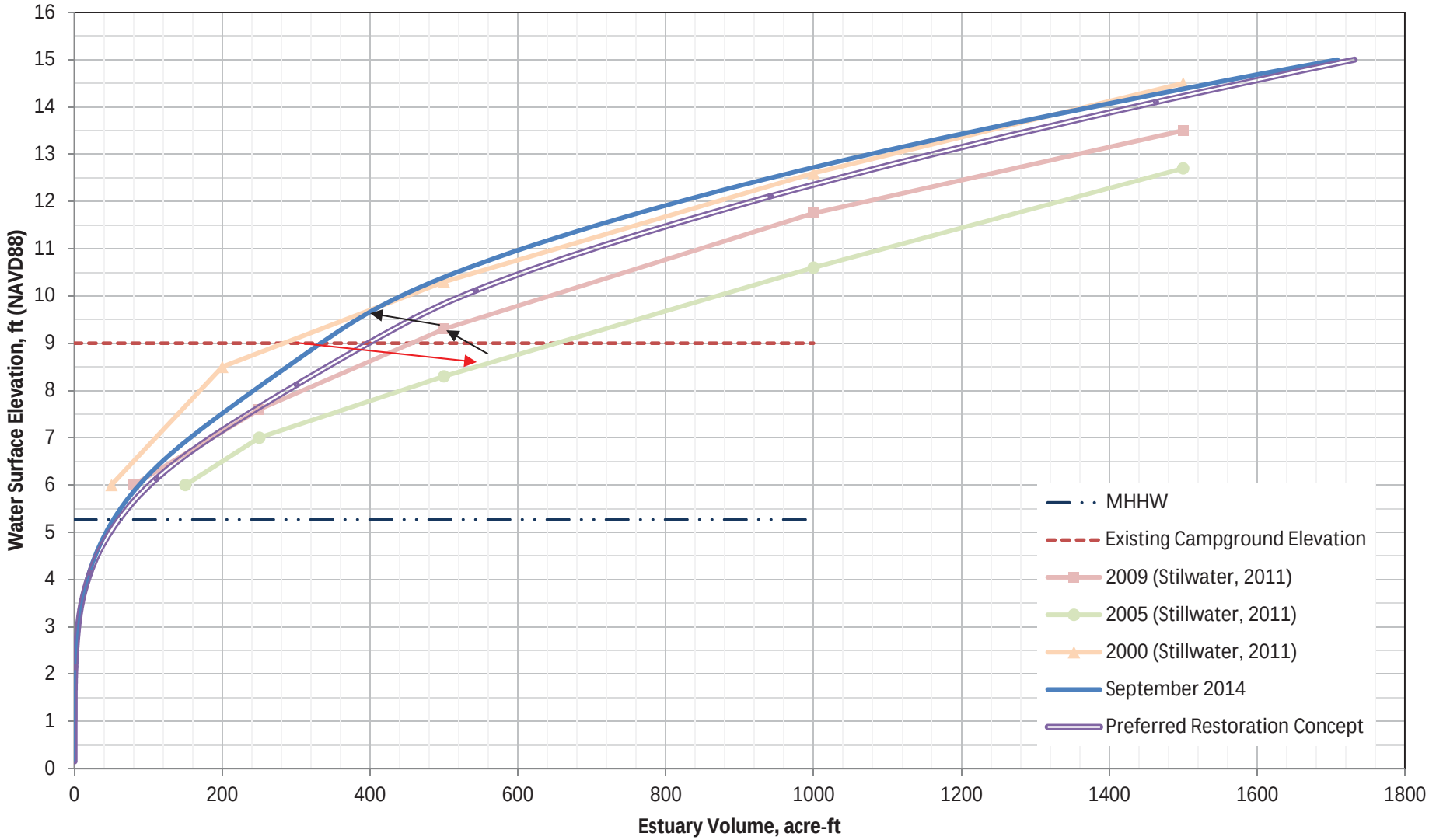

Notes:Curve data estimated for 2000, 2005 and 2009 and adapted from Stillwater 2011. Campground elevation is an approximate average. MHHW from average of bounding NOAA tidal gage stations. Red arrows indicateschange after 2005 event. Black arrows indicate changes since 2005 event.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Hypsometric analysis and recent trends

Project No. 14-1023	Created By: DM	**Figure 9**

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It is important to note that the pseudo-equilibrium summer water level is not generally expected to be the highest water level observed in any given year because the monthly average VWRF discharge rate has historically increased from September to December while at the same time, the average monthly evaporation rate decreases. Water levels in the estuary are therefore expected to, on average, increase slightly heading into the fall and winter months. With current VWRF discharge patterns, the effect is small (less than 1 ft) and the pseudo-equilibrium summer water elevation is a useful point of comparison. As described in more detail in Section 5 and Appendix B, a spreadsheet-based water balance model was set up to help determine how water levels may vary during closed-berm conditions with construction of the Preferred Restoration Concept and with anticipated future hydrologic changes.

Tide Levels

Historical tidal measurements are available from two nearby NOAA tide stations: the Santa Barbara Station (ID: 9411340) established in 1974, and the Santa Monica Station (ID: 9410840) established in 1932 (Figure 6). The tides are mixed semidiurnal tides, with approximately two low tides and two high tides per day. Using an average of the data from the two surrounding stations, the current mean tide level (MTL) at the SCRE is approximately 2.7 ft and the mean higher high water (MHHW) is approximately 5.3 ft. Other key tidal datums are included in Table 1.

Table 1 — Tidal datums

Tidal Datum (ft, NAVD88)	Santa Barbara	Santa Monica	SCRE
MHHW	5.27	5.24	**5.26**
MHW	4.51	4.50	**4.51**
MTL	2.68	2.62	**2.65**
MLW	0.85	0.74	**0.80**
MLLW	-0.13	-0.19	**-0.16**

Note: Station datums were converted to NAVD88. Santa Barbara used 3.29 ft and Santa Monica used 2.63 ft. (NOAA, 2014). These values may not match previous studies exactly due to ongoing data collection at each site which is updated on the NOAA site regularly.

The extent and volume of the tidal exchange with the estuary during open-mouth conditions has changed significantly over the past twenty years and varies in large part on the bathymetry of the SCRE. Though not a common occurrence in the past few years (which were dominated by closed-berm conditions), open-mouth conditions can persist for extended periods following a breach event and therefore also form an important design condition for the restoration of the estuary.

Sea Level Rise

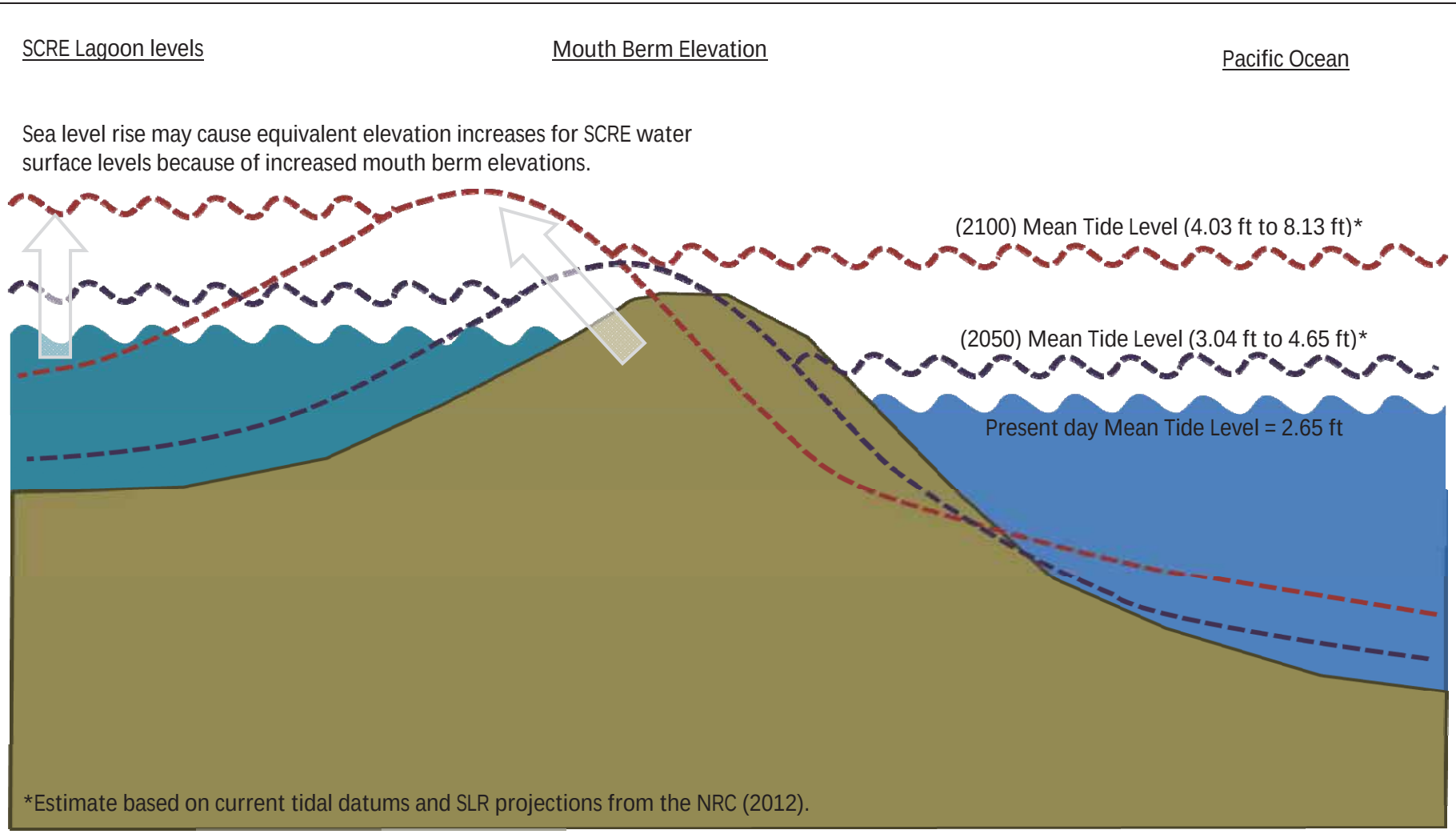
The most recent regional sea level rise projections were published in the 2012 National Research Council (NRC) report on Sea Level Rise for the Coasts of California, Oregon and Washington. Based on the Intergovernmental Panel on Climate Change (2007) findings on global sea level changes and on regionally specific published research results related to vertical land motions, the NRC (2012) report summarized the processes contributing to sea level rise for the west coast, and provided updated projections for sea level rise. Projections and ranges applicable to the SCRE were slightly lower than previous estimates (see the ECTR for a more detailed discussion) and include:

A rise in mean sea level (relative to 2000)

- by 2030 – 0.43 ft with a range of 0.13 to 0.98 ft;
- by 2050 – 0.92 ft with a range of 0.39 to 2.0 ft; and
- by 2100 – 3.02 ft with a range of 1.38 to 5.48 ft.

These projections were also recommended by the March 2013 update to the State of California Sea-Level Rise Guidance Document prepared by the Ocean Protection Council (OPC), the California Climate Action Team, and the California Ocean Science Trust. These sea level projections were also recognized by the draft Sea-Level Rise Policy Guidance issued by the California Coastal Commission (CCC) in 2013 and the recently released revised draft (CCC, 2015). These reports also stress that there are uncertainties within climate change projections and emphasize the use of the best available science, scenario-based analysis, the incorporation of adaptive management techniques, and the selection of appropriate risk and planning timeframes.

Mouth berms like the one observed at the mouth of the SCRE are depositional features, resulting from the accumulation of sediment at the landward extreme of incident wave run-up. As such, sea level rise is anticipated to generate a landward shift in the location of the berm and a corresponding increase in the elevation of the mouth berm (Hanslow, 2000; SCOR, 1991). This may increase water levels within the SCRE during extended closed-berm conditions (see Figure 10), though mouth berm formation is also dependent on many other poorly-quantified factors (which may also change with sea level rise) including: sediment particle size, littoral transport, beach slope, nearshore sediment transport, local wave shape, and tidal cycles.



Source: Adapted from Hanslow, 2000 after Dean &Maurmeyer (1983). Current mean tide levels from average of Santa Monica and Santa Barbara tide gages NOAA (2014). Sea level rise projections based on the National Research Council 2012 projection ranges for the Southern California Coast for the years 2050 and 2100. Concept only. N.T.S.

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Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Sea level rise and mouth berm elevation

Project No. 14-1023	Created By: DM	**Figure 10**

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2.4 WATER QUALITY

Restoration concepts formulated as part of the Project were limited to mostly physical modifications (e.g., improved grading, natural substrates, and enhanced vegetation) to create expanded and enhanced habitat within the area currently occupied by the campground. While the Preferred Restoration Concept is actually anticipated to indirectly provide some limited improvements to the water quality (see Section 4 and Section 5.3), the Project was not set up to investigate supplemental treatment of source waters or other remediation efforts aimed at directly changing the water quality in the SCRE.

To inform the feasibility of the project it was important to assess the existing water quality of the SCRE to determine overall site suitability for a restoration effort and to help guide the development of the restoration concepts. Water quality conditions within the SCRE have been observed to change on many different time scales, are influenced by many factors, and are not solely determined by any single variable or inflow. A more comprehensive discussion regarding the existing water quality of the estuary was prepared for the ECTR. Recent field and laboratory measurements, for a variety of water quality parameters (temperature, pH, dissolved oxygen (DO), nitrogen and phosphorous, etc.), suggest that overall water quality conditions are generally acceptable during open-mouth conditions (when the estuary volume is either dominated by river flow or tidally influenced with cooler ocean waters), but less than ideal during extended closed-berm conditions (when the inflow into the estuary is dominated by the VWRF discharge). A few of the key water quality considerations that pertain to the feasibility of the Preferred Restoration Concept are described in more detail below.

Water Temperature

Because of the relatively shallow water depths within the SCRE (predominantly less than 8 ft), the central portion of the lagoon is relatively well-mixed and does not generally exhibit thermal stratification. Water temperatures in the existing estuary vary from lows around 13 °C during open-mouth winter conditions, to peak daily values around 25 °C during extended closed-berm summer conditions (although higher observations up to 29 °C have been recorded). Estuary water temperatures are influenced by many factors (solar exposure, shading, air temperature, wind conditions, groundwater inflows, etc.), but are closely linked to the temperature of the VWRF discharge. Isolated areas of the estuary and areas with asphalt substrate like the campground currently exhibit higher diurnal water temperature fluctuations because of increased solar absorption and shallow water depths.

Rearing juvenile steelhead generally prefer water temperatures between 10-13 °C and have an upper lethal limit of about 24 °C (Bjornn and Reiser, 1991). However, a growing body of recent literature describes the increasing temperature tolerances of steelhead when the associated increases in metabolic rates are supported by adequate food supplies (Hayes et al., 2008). As described in Section 5.4, the Preferred Restoration Concept is expected to provide a 1 to 2 °C reduction in the maximum daily summer water temperatures within the current campground area and anticipated to provide slightly reduced water temperatures within the SCRE overall.

Dissolved Oxygen

With closed-berm conditions, DO levels in the estuary (at least near the surface and during daylight hours) are often supersaturated, but DO levels below those necessary to sustain most fish life have been observed at depth, at night, and in certain poorly-connected portions of the estuary (particularly the flooded campground and the VWRF outfall channel). This is likely due to the commonly eutrophic conditions within the estuary and the decay of plant material. As described in Section 4 and Section 6, the proposed grading within the Restoration Area is expected to reduce the potential for low DO events through increased wind-driven circulation and the establishment of more appropriate wetland and marsh vegetation species.

2.5 SUBSURFACE CONDITIONS

The nature and quality of the subsurface sediments (and the local groundwater) within the Project Area had been studied and analyzed prior to the efforts associated with the Project. These previous studies, summarized in the ECTR, suggested that surface and buried sediments within the existing campground are primarily unconsolidated alluvial soils, with elevated salinity levels possibly due to historical salt flat conditions (Figure 4) or tidal influences. These studies, though limited, indicated that the subsurface sediments below the existing campground did not appear to exhibit widespread hydrocarbon or pesticide contamination which might have limited the feasibility of estuary restoration efforts.

However, discussions with State Parks and Wishtoyo during the development of the preliminary alternatives established that additional targeted sampling was appropriate to support this Feasibility Study given that the restoration concepts generally involved substantial quantities of excavation within the footprint of the existing campground and the limited amount of subsurface data. As the Preferred Restoration Concept was being developed, specific excavation depths and design elevations were used to guide a limited, but targeted subsurface sampling effort. Due to the history of the nearby McGrath Lake site, the 1993 oil spill, nearby agricultural lands, and the VWRF effluent, composite hand-augured subsurface samples collected at three locations were analyzed for metals, pesticides, and oil and grease in addition to some basic geotechnical analyses. These results are included in Appendix G and generally confirm that contaminants in the subsurface sediments do not appear to limit the feasibility of the Preferred Restoration Concept from a habitat suitability standpoint. Laboratory results were either generally below the Environmental Screening Level (ESL) (SFBRWQCB, 2013), below the detection limit, or near the practical quantification limit. Horticultural soil suitability was also studied for the Project and is discussed in Section 6.2.

2.6 CULTURAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES STUDY

The Project included a Cultural, Archaeological, and Paleontological Resources Study (Topanga Anthropological Consultants, 2015) in order to inventory archaeological resources, to identify sensitive areas, to provide a detailed assessment of the potential for archaeological sites to occur within the buried sediment surfaces of the Project Area, and to provide recommendations for mitigation. The Cultural, Archaeological, and Paleontological Resources Study (provided in full in Appendix H) also provided additional (and detailed) information on the subsurface conditions observed within the Project

Area[4]. Key findings related to the feasibility of the Preferred Restoration Concept are summarized below:

- Surface observations did not detect evidence of Chumash Native American cultural sites, archaeological sites, or paleontological sites. The present ground surface of the Project Area includes historic stream deposits and areas of disturbed dunes.
- Buried Native American cultural and archaeological campsite deposits have been identified in similar coastal areas.
- No evidence of human burials was found.
- Paleontological fossils are not expected.
- The sediments beneath the existing campground reflect the scour and deposition of recent alluvium associated with large floods and are less likely to contain buried surfaces.
- Monitoring for Chumash cultural and archaeological sites is recommended if undisturbed soils over 160 years old are disturbed.
- Plants and animals significant to Chumash Native American Peoples are present (e.g., *Juncus acutus* and *Anemopsis californica*) and should be protected or transplanted to ensure their long-term presence at the site (see Section 6.2).

2.7 BIOLOGICAL COMMUNITIES AND SPECIAL-STATUS PLANTS

This section provides a targeted summary of the vegetation types observed on site (Section 2.7.1), the protected biological communities (Section 2.7.2), and the special-status plant species determined to have the potential to occur within the Project Area (Section 2.7.3). A more detailed and wide-ranging description of the existing ecological conditions within the estuary was provided in the ECTR. Feasibility considerations for Preferred Restoration Concept given these plant and biological communities are discussed in Section 6.2.

2.7.1 EXISTING VEGETATION

A variety of vegetation types are found within the SCRE. Found in seasonal wetlands, marsh, and riparian habitats, the vegetation reflects greatly varying degrees of inundation and saturation. Plant communities are influenced by variable flows from the SCR, seasonal estuary openings to the Pacific Ocean, and treated wastewater inflow from the VWRF. This section provides a description of the plant communities observed at many locations within the SCRE, but focuses on the areas within and adjacent to the campground to provide context for the Preferred Restoration Concept.

[4] Observations during the subsurface auger program suggested that some remediation actions were taken in portions of the former oil field in the Project Area. Evidence for affected soils was not encountered during augering, and sediments and groundwater brought up in the auger lacked any sign of discoloration or smell associated with affected soils. (Topanga Anthropological Consultants, 2015).

Where plant communities occur close to the SCR, they are subject to seasonal flooding with high flow velocities from the river which can result in substantial shifts in plant cover and distribution. These areas are dominated by marsh and riparian woodland habitats. Marsh vegetation is dominated by a mix of hardstem bulrush (*Schoenoplectus acutus* var. *occidentalis*) and cattails (*Typha* sp.) interspersed with un-vegetated channels and other deep water habitats. Riparian habitats are shrub- or tree-dominated areas which develop along the edges of ephemeral, intermittent, or permanent streams or rivers. In the Project Area, riparian habitat occurs within and along the edges of the SCR at elevations ranging from approximately 11 to 16 ft and is dominated by willows (*Salix* spp.). Both marsh and riparian woodland habitats at the site contain large stands of the non-native and invasive giant reed (*Arundo donax*). Giant reed is an invasive species classified by the California Invasive Plant Council as noxious. It provides no habitat benefits for steelhead and outcompetes native species which do provide such benefits. Within the SCRE, giant reed is primarily present in large stands on the northern shoreline, in areas with ground elevations between 7 ft and 11 ft. Giant reed is also common upstream within the watershed of the SCR (Stillwater Sciences and URS, 2007). Giant reed spreads vegetatively by rhizomes or fragments that float in from upstream sources.

In the campground and other areas that are protected from high flows by woody riparian vegetation, biological communities are subject to a more gradual ebb and flow of flood waters, resulting in more stable wetland communities. Where plant communities are exposed to less frequent inundation, wetland communities are dominated by a mix of weedy, non-native species and native salt marsh species such as pickleweed (*Salicornia pacifica*). These drier, less-frequently inundated wetlands are dissected by the paved campground roads, campsites, and are subject to regular mowing and active public uses associated with the operation of the campground.

The campground contains a mix of upland and wetland habitats dominated by weedy, non-native species. Areas around roads and campsites have been planted with non-native ornamental species such as myoporum (*Myoporum laetum*) and several species of bottlebrush (*Melaleuca* spp.). Areas managed as lawn are dominated by non-native grasses such as Bermuda grass (*Cynodon dactylon*). While large portions of the campground have developed wetland conditions due to the regular flooding, these areas are dominated by non-native wetland species such as fathen (*Atriplex prostrata*) or brass buttons (*Cotula coronopifolia*), with some areas containing native wetland species such as pickleweed. Wetland habitat that has developed within the campground is regularly disturbed by campground management activities.

To the west, the campground is bordered by foredune habitat. Foredunes are a dynamic, shifting landscape that is formed by wind-blown deposits of beach sand. At McGrath State Beach, foredune habitat is characterized by dune mat vegetation (*sensu* Sawyer et al., 2009), which is dominated by native species such as pink sand verbena (*Abronia umbellata* var. *umbellata*), beach evening-primrose (*Camissoniopsis* [*Camissonia*] *cheiranthifolia* ssp. *suffruticosa*), and beach morning glory (*Calystegia soldanella*). Foredunes and dune mat vegetation and have high potential to support rare plants, such as red sand verbena (*Abronia maritima*), or rare wildlife, such as silvery legless lizard (*Anniella pulchra*).

To the east, the campground is bordered by a narrow band of riparian woodland surrounding an existing drainage ditch. This riparian vegetation is dominated by a mix of willow and non-native trees such as myoporum and bluegum (*Eucalyptus globulus*). These areas represent relatively low-quality riparian habitat because of the proximity of Harbor Blvd. and the campground entrance road, but this area provides an important physical and visual buffer.

To the south, the campground is bordered by a large area of upland habitat that has been graded and disturbed by historic oil exploration activities. The majority of this area is dominated by invasive species such as short-podded mustard (*Hirschfeldia incana*), ripgut brome (*Bromus diandrus*), ice plant (*Carpobrotus edulis*), and myoporum, although small stands of native species are present, including stands of coyote brush (*Baccharis pilularis* ssp. *consanguinea*) and western ragweed (*Ambrosia psilostachya*). Two seasonal wetlands occur in this disturbed area. One occurs in the northern end in an area that ponds water adjacent to a manmade berm. This wetland appears to fill with water only when the campground is entirely flooded. The other seasonal wetland occurs in the southeast corner of the site in a depression that appears to collect stormwater runoff from the highway and runoff from irrigated farm fields on the opposite side of Harbor Blvd. This area drains to the south toward McGrath Lake.

2.7.2 BIOLOGICAL COMMUNITIES

Within the Project Area, fifteen biological communities were identified at the general community (i.e., Holland, 1986) and alliance (i.e., Sawyer et al., 2009) levels, including several communities not described at either level. Six of these communities are considered sensitive, either because they are identified as sensitive plant communities by the CDFW or as Environmentally Sensitive Habitat Areas under the City of Oxnard Coastal Land Use Plan, or because they occur in wetlands and non-wetland waters and are regulated as such by the Corps, the LARWQCB, CCC, and/or the CDFW. The sensitive plant communities are listed below.

<u>Sensitive Plant Alliances</u>

- Arroyo willow thickets (*Salix lasiolepis* Shrubland Alliance)[5]
- Black cottonwood forest (*Populus trichocarpa* Forest Alliance)
- Dune mat (*Abronia latifolia – Ambrosia chamissonis* Herbaceous Alliance)

<u>Wetlands and Non-Wetland Waters</u>

- Freshwater marsh (multiple alliances)
- Seasonal wetlands (multiple alliances)
- Non-wetland waters (i.e., open water)

[5] This alliance is considered sensitive only when found in wetland or riparian settings.

The remaining communities identified at the site in the ECTR are not considered sensitive by the regulatory agencies because they are either dominated by common native species such as coyote brush or western ragweed or because they are dominated by non-native and invasive species such as ice plant or myoporum. These communities are highly degraded and primarily occur within the campground footprint or within the southern portion of the site, which was substantially disturbed during historic oil exploration activities. Although wetland habitat within the campground is considered sensitive due to regulatory definitions, in reality these areas are highly degraded and subject to on-going maintenance and use by campers. Wetlands within the campground are largely dominated by non-native species and are subject to regular disturbance such as mowing and vehicular and pedestrian traffic during the portion of the year when they are not inundated by floodwaters.

Due to the irregularity of inundation, much of the wetland vegetation that has developed within the campground is of marginal quality, dominated by weedy, non-native species such as fat hen and brass buttons. Some areas within the campground are dominated by native wetland species such as pickleweed or salt grass (*Distichlis spicata*); however, these species may be more indicative of saline conditions than wetland hydrology. The lowest-lying portions of the campground, primarily along the north and west, contain water for longer durations and support more robust marsh and riparian vegetation indicative of long-duration inundation.

Within the southern portion of the Project Area (i.e., the Mixed Use Area), habitats are dominated by non-native and invasive species such as ice plant, myoporum, tamarisk (*Tamarix* sp.), shortpod mustard, and non-native annual grasses. These areas have relatively poor-quality habitat compared to the wetland and riparian communities closer to the SCR.

2.7.3 SPECIAL-STATUS PLANT SPECIES

This section provides a brief summary of the special-status plant species that have the potential to occur within the Project Area. A more detailed and wide-ranging description of the special-status plant species is provided in the ECTR. A literature and database review (CDFW, 2014; CNPS, 2014; County of Ventura, 2014; Swanson et al., 1990; ESA, 2003; Stillwater Sciences and URS, 2007; Stillwater Sciences, 2011; Google Earth, 2014; USDA, 2014) determined that 26 special-status plant species, including four Locally Important species (Ventura County 2014), have been documented within the vicinity of the Project Area. Based on the types and condition of habitats observed at the site, 19 of these species have a moderate to high potential to occur within the Project Area, including four species that were observed on the site:

- Red sand verbena (*Abronia maritima*; CNPS Rare Plant Rank [RPR] 4.2) was observed in small patches on the foredunes at the southwestern edge of the Project Area.
- Coast dudleya (*Dudleya caespitosa*; Locally Important) was observed at the far southern end of the Project Area in habitat disturbed by previous oil exploration activities.
- Sand dune sedge (*Carex pansa*; Locally Important) was observed south of the campground on a sandy berm.
- Fragrant flatsedge (*Cyperus odoratus*; Locally Important) was observed in disturbed wetland habitat at the north side of the campground.

The remaining 15 special-status plant species determined to have potential to occur at the site were determined to primarily have potential to occur within the intact foredune habitat along the western edge of the Project Area or in association with undisturbed marsh habitat along the edges of the SCR. Although some of the disturbed habitats at the site (e.g., the campgrounds and the disturbed upland areas to the south) may contain elements of suitable habitat for one or more of these species, prior and current disturbances in these areas greatly limit the potential for these species to occur there. Similarly, the dense overstory canopy and high levels of non-native, invasive species within the arroyo willow and other scrub-shrub and woodland habitats at the site limit the potential for rare plant species to occur there.

2.8 WILDLIFE HABITAT ASSESSMENT

As discussed in more detail in the wildlife habitat assessments included with the ECTR, the Project Area contains the terminus of the SCR, which forms a large and dynamic estuary that provides a diverse range of aquatic and terrestrial habitats. The current habitat complexity supports many rare and protected fish and wildlife species. Approximately 50 special-status wildlife, fish, and invertebrate species including: steelhead (*Oncorhynchus mykiss*), tidewater goby (*Eucyclogobius newberryi*), California least tern (*Sterna antillarum browni*), and western snowy plover (*Charadrius alexandrinus nivosus*) have been documented or have the potential to occur within the vicinity of the SCRE (see detailed list in the ECTR). This section provides a summary of the existing wildlife habitats present within the SCRE and the existing campground area. Some wildlife considerations are also provided as context for the habitat and vegetation components of the Preferred Restoration Concept which are discussed in Section 6.

SCRE

Many areas within the SCRE provide suitable year-round aquatic estuarine habitat for several species of fish. The federally endangered tidewater goby relies upon the estuary for all life stages including breeding and rearing habitat. The Southern California Distinct Population Segment (DPS) of steelhead occur within the SCR, and currently utilize the SCRE during migration to and from the ocean and for short-term (i.e., a few days) juvenile rearing prior to outmigration as smolts (Kelley, 2008) when the mouth berm is open, or for extended seasonal rearing when the estuary mouth is closed. Steelhead in this DPS are designated as federally endangered. For both of these species, the estuary has been designated as Critical Habitat under the Endangered Species Act by NMFS and USFWS. These designations are a clear indication that the estuarine habitat of the SCRE is vital for the continued existence of these species.

In addition to several species of fish, the SCRE provides important nesting and rearing habitat for waterfowl. During closed-berm conditions, the SCRE is typically characterized by a large expanse of open water which allows waterfowl and diving avian species to forage on fish, invertebrates, and aquatic plants. The area also provides an important sheltered natural resting location for migratory avian species.

Dune habitat to the south of the SCRE (the western and southern portion of the Project Area) provides suitable nesting and foraging habitat for several special-status wildlife species, including the western snowy plover, California least tern, silvery legless lizard (*Anniella pulchra pulchra*), and globose dune beetle (*Coelus globosus*). Higher quality dune habitat occurs along the western boundary of the Project Area compared to the southern portion which has large patches of the non-native ice plant and disturbed fill material from historic oil exploration activities.

The SCRE also supports riparian vegetation, which include dense arroyo willow thicket, and provides nesting and foraging habitat for many resident and migratory avian species, including the state and federal endangered least bell's vireo (*Vireo bellii pusillus*) and southwestern willow flycatcher (*Empidonax traillii extimus*). The riparian canopy also supports roosting and foraging habitat for bats, such as the western red bat (*Lasirurs blossevillii*).

Existing Campground Area

When flooded, the campground is part of the estuary and is accessible to both native and invasive aquatic species. In contrast to many areas of the SCRE, the habitat provided within the footprint of the campground is generally poor-quality[6]. The campground provides mostly shallow water areas which receive direct solar exposure, have minimal circulation, and support algal blooms. The low oxygen and high temperatures observed in the shallowly flooded areas of the campground are largely unsuitable for sensitive species, such as steelhead. In contrast, non-native species that occur in the SCRE, such as common carp (*Cyprinus carpio*) and Western mosquitofish (*Gambusia affinis*) have the potential to thrive in this habitat.

While the flooded campground may be frequented by a number of protected shorebird species (e.g., western snowy plover and California least tern), it is of limited quality and it is expected that use of the site by these protected species would be enhanced with the Preferred Restoration Concept.

[6] As discussed in the ECTR, the shallow flooding of the campground is likely worsening the short-term water quality and habitat suitability of the southern and western portion of the main SCRE lagoon when breach events occur and the stagnant, warm, low dissolved oxygen water of the campground is allowed to drain northward into the main estuary and out through the breach opening. While the draining of the estuary can occur quickly following a breach event (i.e., in a matter of hours), these are crucial stages in steelhead migration into and out of the SCR and water quality considerations at these times may influence smolt survivability and may have consequences for juvenile steelhead rearing in the estuary. It should be noted that once tidal exchange is established, water quality conditions in the estuary generally improve due to the influx of cooler, well-oxygenated ocean water.

3 PRELIMINARY RESTORATION ALTERNATIVES AND CONCEPT DEVELOPMENT

This section lists the general restoration considerations for enhancement features which were identified in the beginning stages of the Project, describes the overall design process used to create the two preliminary restoration alternatives (Figure 11 and Figure 12), briefly explains the habitat components and grading approach used by each alternative, and also summarizes the additional design considerations that emerged from the hydrodynamic and ecological analyses of the alternatives. The preliminary restoration alternatives formed an important step towards the development of the Preferred Restoration Concept which is discussed in detail in Sections 4, 5, and 6.

3.1 GENERAL CONSIDERATIONS FOR ENHANCEMENT FEATURES

To support concept development, a number of general (and sometimes conflicting) considerations for estuary and habitat enhancement were identified early in the Project. These are listed below and may be worth reexamining as the restoration designs continue beyond the feasibility concept level.

- Provide for adequate site drainage to reduce potential for salinity stratification or stranding of steelhead and tidewater goby following breach events
- Increase the estuary volume and surface area to provide more expansive habitat and to potentially reduce the frequency of unseasonal breaching[7]
- Promote enhanced wind mixing and circulation through well-connected channels designed to take advantage of the prevailing westerly winds
- Include an appropriate range of water depths for focal species with a focus on gradual slopes rather than benches at specific elevations (to provide wetted habitat under uncertain future hydrologic regimes including sea level rise and potential VWRF discharge reductions)
- Size channels and sloughs to provide appropriate flow velocities for a range of conditions and to provide areas of velocity refugia for steelhead during river runoff and breach events
- Consider the potential benefits of increased salinity through larger tidal prism (when open to ocean) for invasive species control
- Provide for a diversity of habitat types and elevations with both freshwater and brackish areas
- Provide side channel habitat for steelhead
- Incorporate an appropriate amount of topographic complexity
- Provide gradual slopes to allow vegetation and habitat structures to evolve as sea level rises
- Allow for adaptive management
- Integration with historical and present day cultural resources
- Consider compatibility with recreation and site access

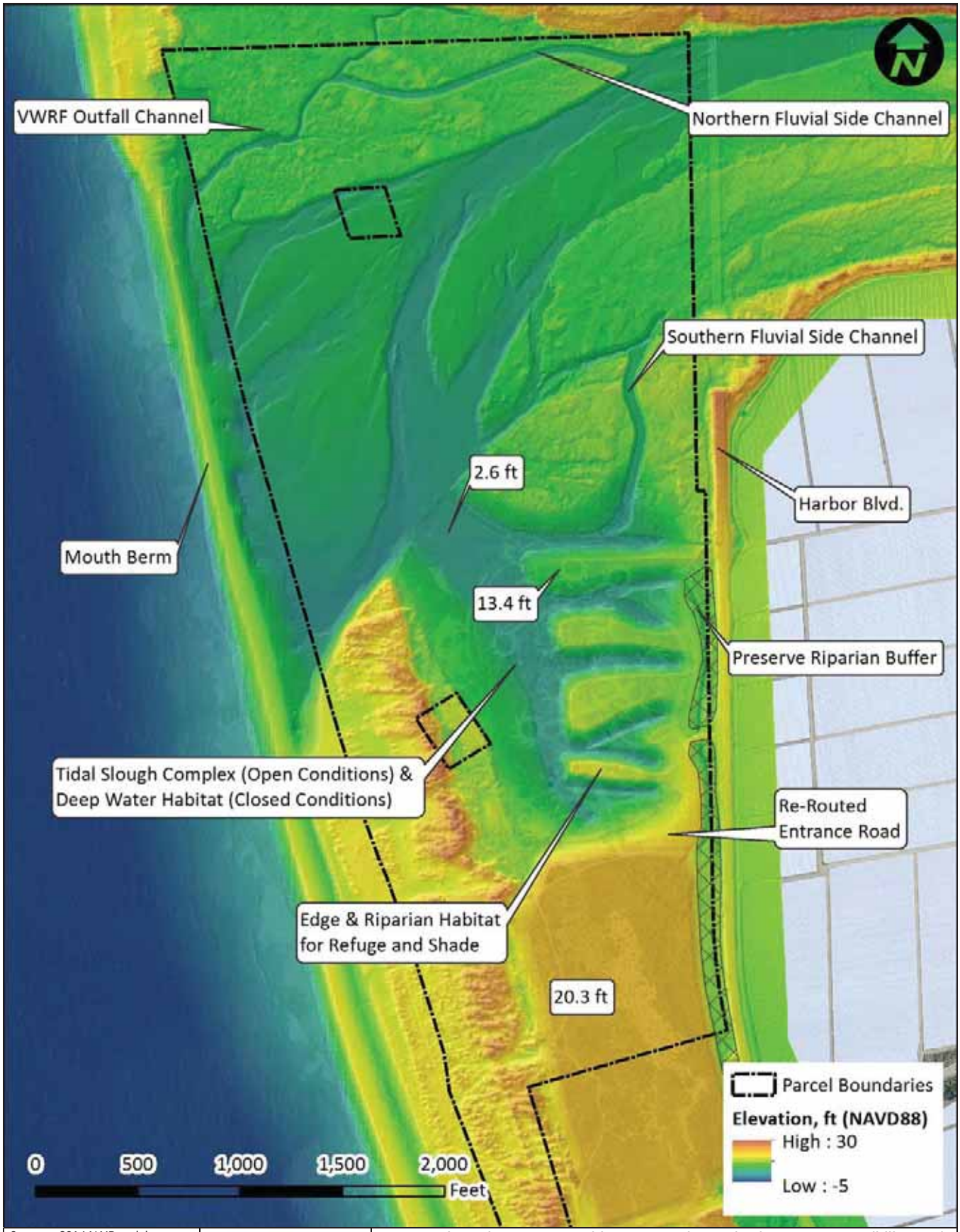
[7] It is uncertain whether the reduction would be appreciable given the moderate increase in estuary volume created with the Preferred Restoration Concept. This is primarily due to the unpredictable nature of future storm events and because the hypsometric relationship of the estuary has been observed to change significantly over time.

- Consider vegetation and grading options that might potentially offer lower water temperatures through shading
- Select deep enough side channel elevations to prevent vegetation recruitment
- Consider sediment transport and depositional patterns

3.2 DESIGN PROCESS

The design process for the Project started with an initial SCRE restoration and enhancement feasibility study, supported by USFWS (Agreement No.: 81440-B-J317), which included preliminary development of estuary restoration concepts, a limited hydrodynamic modeling effort, and initial development of a spreadsheet-based water balance model for the estuary. Building on this initial effort, were several focused site assessments (see the ECTR) followed by an intensive full-day workshop and design charrette which included the participation of numerous stakeholders and agency personnel representing a diverse set of interests and expertise in multiple disciplines. Facilitated by a number of large-scale site aerials and topographic elevation maps, the design charrette group was tasked with reviewing the previous ideas for the restoration of the estuary, brainstorming an extensive list of concept ideas, and synthesis of the ideas into two distinct preliminary restoration alternatives for the consultant team to evaluate further. This was largely successful, but prior to further development, several follow-up coordination and alternative refinement meetings were also held with CDFW, State Parks, and the independent technical advisers to confirm the funding agency, the landowner, and the independent technical advisers approved of the general direction the concepts were headed. Both preliminary alternatives included retaining the existing intersection location at Harbor Blvd but re-routed the entrance road to the south. Both preliminary alternatives included the preservation and enhancement of the existing riparian buffer that parallels Harbor Blvd.

After the preliminary restoration alternatives were developed into the hydrodynamic model, a suite of simulation scenarios (see Section 5.2 and Appendix A for more details) were created to allow for comparative evaluations under a number of different potential situations. After the modeling was complete, the design charrette participants were invited to a follow-up meeting to discuss the hydrodynamic and water quality results and to provide initial input into the creation of the Preferred Restoration Concept. In addition, a three-week input and comment period was provided to allow for additional written input into the concept design. Comments received on the preliminary restoration alternatives are included in Appendix C for reference and future consideration. A list of the specific considerations that emerged for the development of the Preferred Restoration Concept is included in Section 3.5.



Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Preliminary alternative 1

Project No. 14-1023 | Created By: DT | **Figure 11**

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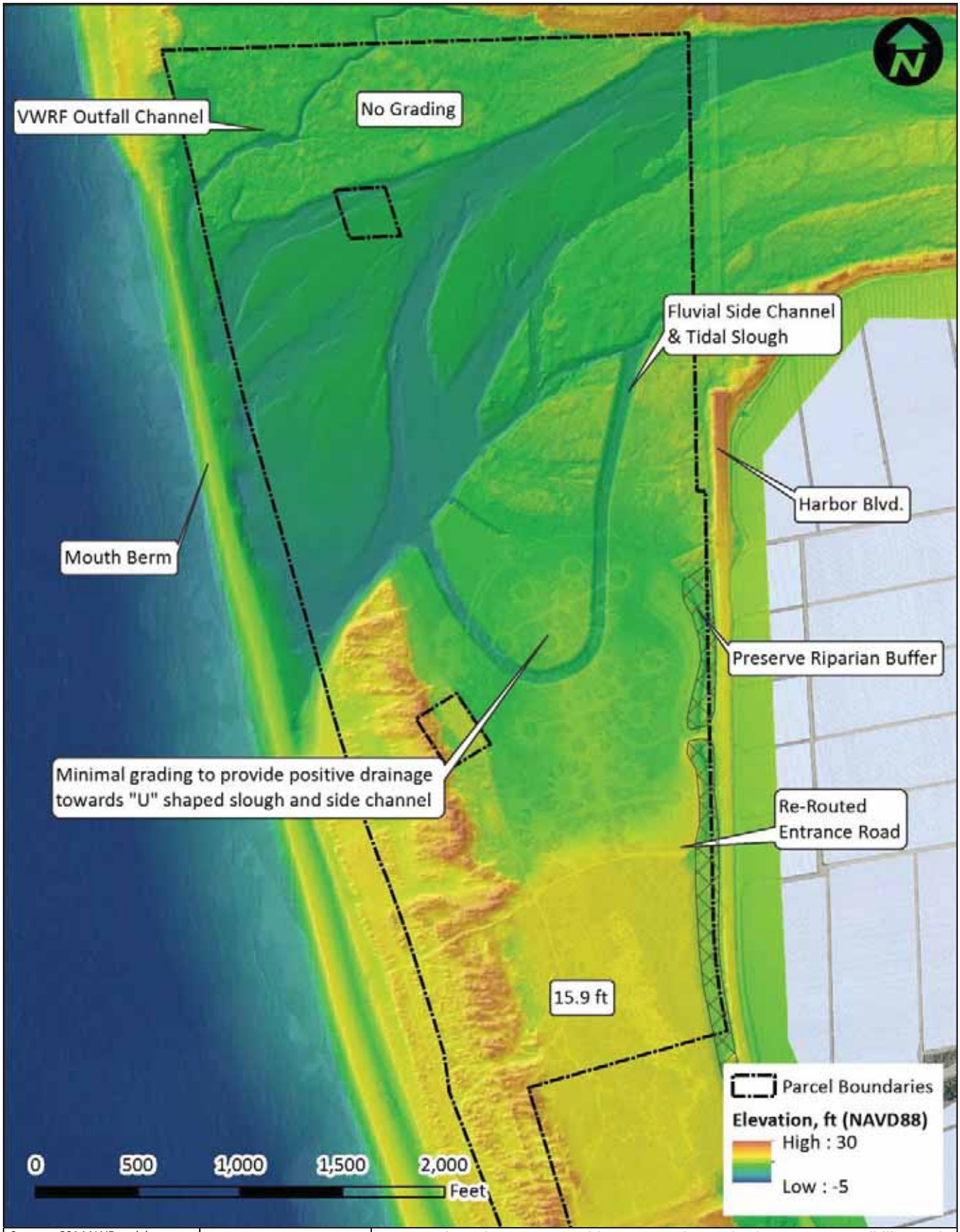

Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development	cbec eco engineering	Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study **Preliminary alternative 2**		
		Project No. 14-1023	Created By: DT	**Figure 12**

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3.3 PRELIMINARY ALTERNATIVE 1

This section briefly describes Preliminary Alternative 1, one of the two interim preliminary restoration alternatives developed by the Project team as part of the overall restoration design process. The Preferred Restoration Concept (Section 4) built on the lessons learned from analysis and review of the simulation results for the preliminary restoration alternatives (Section 3.5). This section is provided for reference only; the Preferred Restoration Concept supersedes these preliminary alternatives.

Preliminary Alternative 1 (Figure 11) was proposed as a relatively more extensive overhaul of the existing campground site to include a number of East-West oriented deeper-water tidal slough channels and new fluvial side channels on both the north and south side of the main estuary. The northern fluvial side channel was intended to provide water quality and habitat benefits in the northern portion of the estuary by providing a connection between the existing outfall channel and the deeper area of the estuary near the north side of the Harbor Blvd Bridge. The idea was to create an open, un-vegetated channel, parallel to an existing remnant channel, which would provide juvenile steelhead with velocity refugia and an 'off-ramp' from the high velocities of the main channel during a river runoff event. During closed conditions the channel was intended to provide shaded edge habitat by taking advantage of existing and established vegetation on the north side of the estuary.

The tidal slough channels and deeper water habitat on the south side of the estuary were envisioned to provide a significant increase in the intertidal volume of the estuary (increasing the tidal prism may increase the duration of open-mouth conditions) and expansive open water habitat surrounded by sloped marsh with higher elevation peninsulas between slough channels to support riparian vegetation for shading. The East-West alignment of the slough channels was intended to maximize opportunities for the prevailing winds to increase slough mixing and improve water quality, as well as mimicking the historic configuration of tidal marsh channels within the area (Figure 4).

Like the northern fluvial channel, the southern fluvial channel proposed for Preliminary Alternative 1 was intended to provide flow refugia during river runoff events and shaded edge habitat during closed-berm conditions. In addition, the southern fluvial channel was anticipated as a way of improving water quality within the tidal slough by frequent introduction of water from upstream during flood events.

As developed by the Project team, Alternative 1 included an approximate total excavation volume of 328,000 cy and would have generated enough fill material to increase the average elevation of the southern portion of the Project site by roughly 5.6 ft to approximately 20.3 ft.

3.4 PRELIMINARY ALTERNATIVE 2

This section briefly describes Preliminary Alternative 2, one of the two interim preliminary restoration alternatives developed by the Project team as part of the overall restoration design process. The Preferred Restoration Concept (Section 4) built on the lessons learned from analysis and review of the simulation results for the preliminary restoration alternatives (Section 3.5). This section is provided for reference only; the Preferred Restoration Concept supersedes the preliminary alternatives.

Preliminary Alternative 2 (Figure 12) was proposed as a comparatively less extensive overhaul of the existing campground site to explore the ecological suitability of a concept with less earthwork grading. On the south side of the estuary, this approach included removing the existing campground infrastructure (pavement, buildings, etc.), removal of the old remnant levee and other high ground near the existing maintenance yard and the north side of the campground, and minor re-grading of the remainder of the main campground area to provide positive drainage to a new "U" shaped fluvial side channel and tidal slough. The "U" shaped channel was intended to provide water quality and habitat benefits by allowing freshwater from upstream into the restoration area during flood events, by providing additional edge habitat (water-vegetation interface), and through the potential for juvenile steelhead to find refuge in the estuary during high flow events rather than being swept out to the ocean. Channel inverts at the east and west end were selected to match existing elevations within the main estuary, generally at the upper end of the current tidal range for the eastern connection and at the lower end of the tidal range for the western connection. The high point of the "U" channel was at the southern end at an elevation of about 7.0 ft so that both arms would drain northward to the main estuary. The concept envisioned providing both channelized flow into the restoration area via the "U" channel and sheet flow via the removal of the higher ground.

In contrast to Preliminary Alternative 1, the approach did not include any proposed modifications to the north side of the estuary.

As developed by the Project team, Alternative 2 included an approximate total excavation volume of 120,000 cy and would have generated enough fill material to increase the average elevation of the southern portion of the Project site by roughly 1.2 ft to an elevation of approximately 15.9 ft

3.5 CONSIDERATIONS FOR PREFERRED CONCEPT DEVELOPMENT

This section lists some of the additional considerations for the development of a preferred concept that emerged through the review and analysis of the hydrodynamic and water quality simulations done for the preliminary restoration alternatives. While some uncertainties and different professional viewpoints remained, a set of consistent themes emerged from the comments received on the two preliminary alternatives. These comments (included in full in Appendix C) were instrumental in development of the Preferred Restoration Concept which includes some aspects of both Preliminary Alternative 1 and Preliminary Alternative 2. The considerations that were specifically incorporated in the development of the Preferred Restoration Concept are summarized below.

- Some comments advised against, (or were neutral on), the inclusion of the northern fluvial channel, either from a cost/benefit perspective, habitat suitability concerns (model results suggested that the northern fluvial channel allowed the prevailing winds to create a circulation pattern such that VWRF discharge volumes would flow east and impact the eastern/upper portions of the estuary rather than being more contained to the outfall channel), or proximity to levees that protect important infrastructure coupled with uncertainties in the scour and depositional sediment transport modeling.

- A simpler slough complex was recommended. It was suggested that this would include a reduced number of re-oriented slough finger channels, with more pronounced end-tapering, while still maintaining long uninterrupted wind areas ('fetch'), with additional and varied connectivity at different water levels. Several comments suggested increased slough and channel connectivity along the eastern side of the site which might also reduce the tendency for flotsam to accumulate at the eastern end of the slough fingers.
- It was recommended that southern end of the southern fluvial channel be extended further to the south into the slough complex and to engage more area during high flow events.
- It was recommended that larger and enhanced island type habitat features be incorporated into the grading concepts to provide protection for nesting birds and establishment of riparian vegetation and shading.
- It was recommended that the fluvial channels (and the other habitat types) include varying widths, meanders, slopes and other 'microhabitat' complexities which could include large woody material.
- It was recommended that the target excavation quantity be selected at an intermediate level (somewhere between the preliminary alternatives) to keep the cost of the restoration project within appropriate limits, and to keep the majority of the finished campground closer to the level of the principal access route (i.e., Harbor Blvd).
- It was advised that restoration concepts include removal of the existing stands of invasive giant reed (*Arundo donax*) (which offers little habitat value). In addition, it was recommended that the site grading be strategically developed to reduce the likelihood of future giant reed colonization by reducing that amount of area between elevation 7 ft and 10 ft (recent vegetation elevation survey mapping within the SCRE suggested that giant reed favors this elevation range).
- It was suggested that an additional model scenario (sea level rise concurrent with a potential VWRF discharge reduction) was appropriate for evaluating and refining restoration concepts.
- It was recommended that the design reduce impacts to existing vegetation by strategically creating new restoration features in areas currently supporting existing infrastructure slated for removal.

4 PREFERRED RESTORATION CONCEPT: TOPOGRAPHY AND FEATURES

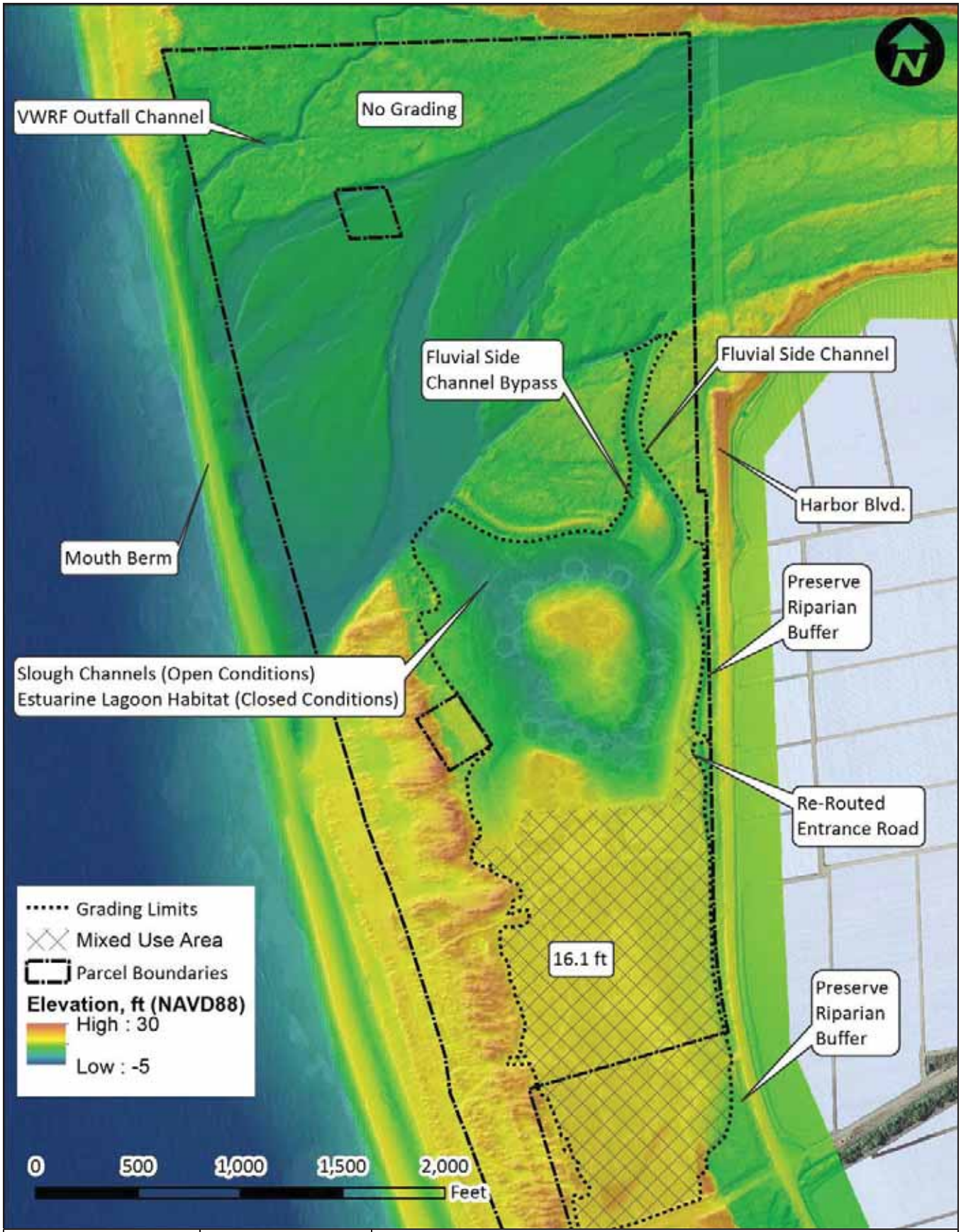
This section, together with Section 5 and Section 6, provides a detailed description of the Preferred Restoration Concept as developed and refined by the Project team through meetings with participating stakeholders and based on the lessons and considerations that emerged from the preliminary restoration alternatives (see Section 3). The Preferred Restoration Concept includes design elements adapted from both of the preliminary alternatives as well as a few additional features. The Preferred Restoration Concept provides expanded and enhanced habitat for endangered steelhead and reflects the synthesis of a wide array of stakeholder-generated ideas; a diverse set of local and regional professional perspectives; and efforts to realize an appropriate balance between a number of often competing considerations including: different estuary water levels during open-mouth and closed-berm conditions, resiliency to sea level rise and local hydrology changes, expanded and enhanced endangered species habitat, continued public coastal access, and overall project cost. The design geometry and the other concept information included in this report (and in the planset included in Appendix F) represent the Preferred Restoration Concept at a robust 30% level of design, but additional engineering design, geometry refinement, and integration planning will be required as the project moves forward in the future.

The Preferred Restoration Concept (depicted in Figure 13, Figure 14, and as detailed in Appendix F) includes two distinct but contiguous areas, the Restoration Area which is envisioned to be almost exclusively for habitat restoration and enhancement (and potentially some interpretive trails), and the Mixed Use Area to the south which will include the new campground facilities potentially interspersed with additional dune, wetland, and riparian habitats. Though discussed separately for accounting and logistical purposes (this report focuses primarily on the specific design concepts for the Restoration Area with only some basic grading and impact considerations for the Mixed Use Area), these two areas are mutually-enabling and together form one contiguous, integrated site that collectively provides substantial improvements to the crucial ecological functions of the estuary and the recreational value of the campground.

Section 4.1 provides an overview of the topographic grading and the key physical features of the Preferred Restoration Concept. Sections 4.2 – 4.5 provide more detailed descriptions of each component. Estimated earthwork quantities and cut/fill areas for the Preferred Restoration Concept are discussed in Section 4.6.

4.1 TOPOGRAPHIC OVERVIEW

Within the grading limit of the Restoration Area (an overall area of approximately 42 acres), the Preferred Restoration Concept includes a fluvial side channel with an inset bench; a shorter, and slightly higher, fluvial side channel bypass; an elevated riparian and dune area between the fluvial channels; a simple two-pronged network of gradually sloped estuarine and tidal slough channels; a larger, partially elevated central marsh and riparian area; and a diversely graded set of marsh, wetland and riparian areas around the site periphery (see Figure 13, Figure 14, and Appendix F). The Preferred Restoration Concept does not include any work on the northern side of the main SCRE lagoon.



Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development

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Preferred restoration concept: expanded SCRE

Project No. 14-1023 | Created By: DM | **Figure 13**

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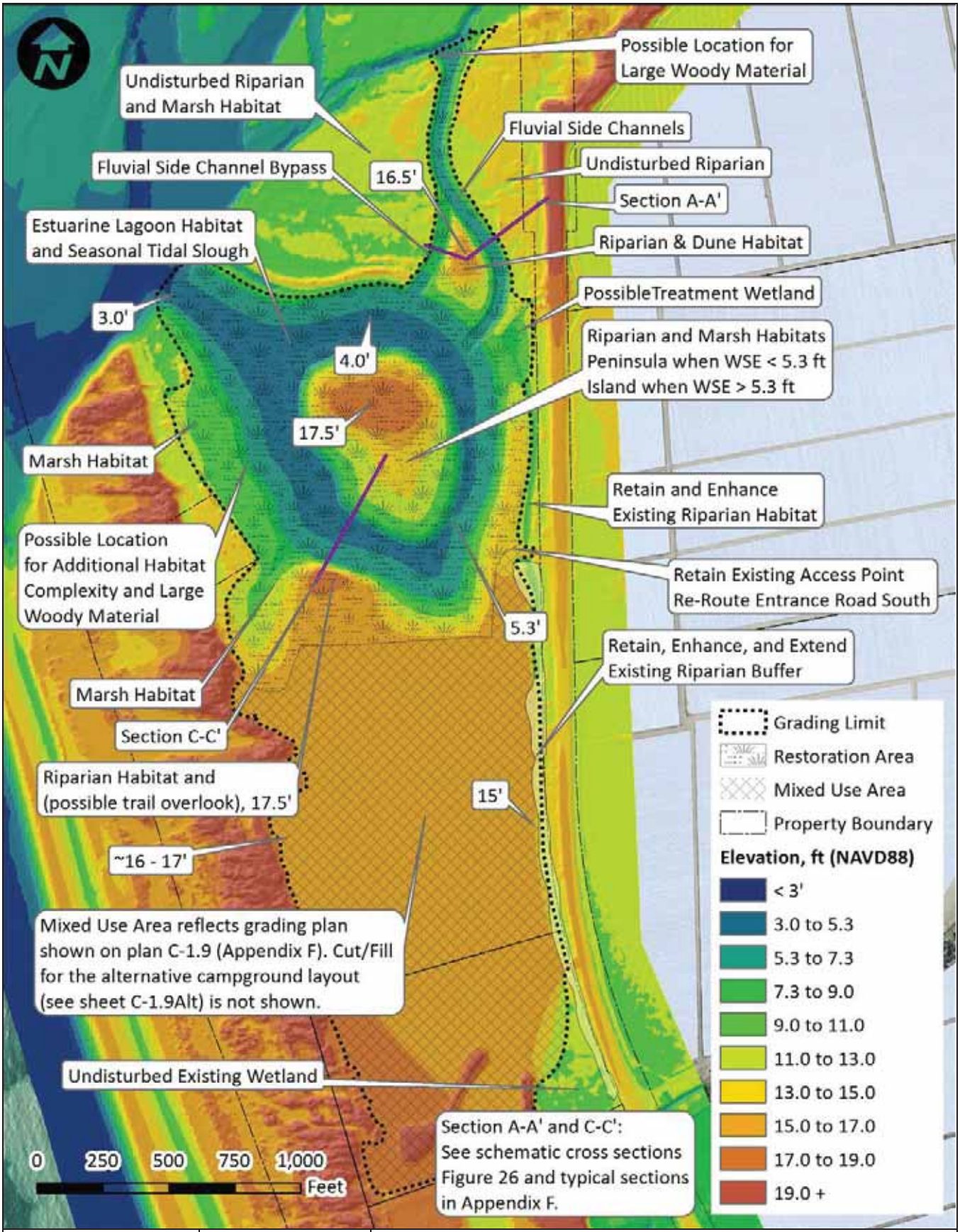

Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development

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Preferred restoration concept: grading and key features

Project No. 14-1023 | Created By: DM | **Figure 14**

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The topographic changes proposed within the SCRE will affect the hypsometric relationship currently observed within the estuary by providing additional volume at any given estuary water level (Figure 9). Additional habitat complexity beyond topographic site grading (e.g., large woody material or larger, engineered log structures) could be considered for inclusion at a number of locations within the Restoration Area (e.g., at the inlet to the fluvial side channels, within the broad slopes of the marsh and wetland areas), but these details were not included in the 30% design of the Preferred Restoration Concept prepared for this Feasibility Study.

4.2 FLUVIAL SIDE CHANNELS – WATER QUALITY BENEFITS AND STEELHEAD HABITAT

Similar to the preliminary alternatives, the Preferred Restoration Concept includes fluvial side channels to provide steelhead habitat benefits by providing 'off-ramps' from the high velocities of the main river corridor during a river runoff event. Instead of being swept out to the ocean, juvenile steelhead may find velocity refuge in the calmer waters of the slough channels via the additional access routes provided by the fluvial side channels. The fluvial side channels are also intended to provide water quality benefits by allowing frequent[8] introduction of freshwater from upstream into the restoration area.

To address comments from a number of Project stakeholders, the fluvial side channel extends further south into the restoration area than previous concepts to engage more of the slough area during river flow events. As designed, the fluvial side channel is approximately 1300 ft long, includes a gradually flared connection to the river corridor at an existing channel with an invert elevation of 6.8 ft, has an average longitudinal slope of 0.1%, and meets the northern branch of the tidal slough complex at an elevation of 5.2 ft (just below the MHHW). With current estuary water levels during closed-berm conditions (approximately 11 ft), the bottom bed of this channel would likely remain predominantly un-vegetated. Existing established vegetation on both sides of the channel would provide shaded estuarine edge habitat for steelhead with water depths from 3 to 6 ft. The fluvial side channel includes an appropriate amount of sinuosity, is 30 ft wide at the base, and includes an inset, 10 ft wide bench on the inside of each channel bend to mimic natural riverine channel sections and to provide areas for appropriate in-channel vegetation. The bench elevation ranges from 9.5 ft to 10.8 ft (chosen to provide suitable elevations for vegetation planting, see Section 6).

In addition to the fluvial side channel, a fluvial side channel bypass is also included in the Restoration Area. Located just to the west of the other channel, and at bed elevations selected to be above the 2-year event, the bypass provides for additional habitat complexity and additional flow into the Restoration Area during the larger, but less frequent, river runoff events. By allowing some flow to bypass the longer route, the bypass channel is intended to function as a sort of relief valve for the other channel during larger, more energetic events, without reducing the effectiveness of the lower channel at refreshing the water in the slough channels for the smaller, more frequent events. The bypass channel is

[8] Though hydrodynamic simulations were only performed for the 2-year and 10-year events, the hydrology of the SCR suggests that, as designed, the fluvial side channel will be activated by most river runoff events (i.e., several times per year).

approximately 430 ft long, 40 ft wide at the base, has an average longitudinal slope of 0.6%, connects to the other fluvial channel at an invert of approximately 9.1 ft, and ties in to the northern branch of the slough complex at 6.5 ft. With current estuary water levels during closed-berm conditions, the higher bed of this channel will likely support small, mostly flexible, marsh vegetation. This was incorporated into the roughness assumptions of the hydraulic modeling and is not anticipated to reduce the effectiveness of the channel during large events. Side slopes for both fluvial channels were developed at 4:1 to allow for the establishment of native riparian vegetation.

As the existing and proposed riparian vegetation along the fluvial channels matures, the north-south alignment of these channels may also provide areas of cooler water temperatures because of increased morning and afternoon riparian shading, and the relatively deep water of the eastern channel during closed-berm conditions. The alignment of these channels was also designed to reduce the disturbance of the existing well-established riparian in this area of the site by locating the new fluvial channels in the area currently occupied by the maintenance yard, dump station, and access road.

4.3 ESTUARINE AND TIDAL SLOUGH CHANNELS

In addition to the aquatic habitat created by the fluvial side channels, the Restoration Area includes a bifurcated, but uncomplicated network of gradually-sloped estuarine and tidal slough channels. The alignments of the slough channels were slightly refined from previous concepts and were set up to take advantage of the strong on-shore winds common in the afternoons and to allow for the establishment of regular diurnal circulation patterns to promote mixing.

During open-mouth conditions the slowly-tapered slough channels were designed to be mostly in the upper half of the intertidal zone (between MTL and MHHW) and characterized by tidally inundated sand/mud flats surrounded by low marsh habitats. Though the slough channels could potentially drain entirely during a low tide, existing sills at the opening of the mouth berm and within the lagoon itself have generally prevented a complete dewatering of the estuary though the formation, elevation, and persistence of the sill is poorly understood and may change in the future as the bathymetry of the estuary evolves.

As designed, slough channel elevations range from a low point of 3 ft at the northwest corner at the connection with the main lagoon to a high point of 5.3 ft at the southeast corner of the central island complex. At water levels above the current MHHW of 5.3 ft the slough channels would connect and the central habitat island would become a true island with water on all sides. At water levels below MHHW, two separate slough channels would exist and the central habitat complex would be connected to the high ground to the east with a marshy peninsula. The dual behavior as peninsula/island provides seasonally varying habitat complexity in addition to well-defined flow directions during tidal exchange periods. As the side slopes of the gradual slough channels continue above the MHHW, the tidal flats would transition into supratidal high marsh habitat and riparian areas.

With the current estuary water levels typically observed during closed-berm conditions (approximately 11 ft), the lower elevation areas of the slough channels would provide large areas of relatively deep water estuarine lagoon habitat with water depths over 5 ft surrounded by narrower swaths of gradually shallower water.

Gentle slopes around 2.5% were provided in most areas of the slough channels to allow for anticipated future changes in estuary water levels. Slough slopes gradually vary across the site from a minimum value of approximately 1% along the western margin of the site (a minimum value for adequate drainage), to an upper value of approximately 17% on the north shores of the central island complex. The steeper slopes were strategically developed in key areas (the north sides of the central and fluvial islands) to reduce the amount of area between 7 ft and 10 ft to reduce the potential for giant reed colonization which appears to favor these elevations where present in the current estuary (see also Section 6.2 and Section 2.7.1).

To reduce disturbance to existing beneficial vegetation which has become established on the old remnant levee evident in the topography, and a functioning micro slough, the northern slough extents were adjusted slightly to the south from previous concepts. The width of the slough connection to the central estuary was also reduced from previous concepts to provide slightly higher tidal scour velocities to help maintain the inlet.

4.4 RIPARIAN AND DUNE ISLANDS/PENINSULAS

Within the area partially surrounded by the slough channels, and the area surrounded by the fluvial side channels, the Restoration Area includes mounded riparian and elevated dune areas. These areas provide topographic variability and are intended to support dense riparian vegetation for slough and channel shading surrounding slightly higher elevations with more sparse vegetation and the potential for protected, but open sandy areas. With the current estuary water levels typically observed during closed-berm conditions (approximately 11 ft), these terrestrial habitats areas would become true island refuge areas (and considerably less anthropologically-accessible than at low estuary water levels). Elevations for these riparian and dune islands areas vary from the upper end of the slough channels to elevations of approximately 17.5 ft for the central island and 16.5 ft for the fluvial island. Slopes vary from around 1% at the top of the islands, to the typical 2.5% of the slough channels, up to the higher 17% slopes designed for the northern side of the islands between 7 ft and 10 ft to discourage giant reed colonization.

These riparian and dune island areas represent a fill situation, with design elevations above existing ground levels. In addition to the habitat considerations, this reduces the quantity of the material created through the excavation of the slough and fluvial channels which would need to be transported south to the Mixed Use Area. Approximate excavation and transport quantities for the grading proposed with the Preferred Restoration Concept are discussed in Section 4.6.

4.5 ADDITIONAL WETLANDS, MARSH AND RIPARIAN AREAS

Around the western, southern, and eastern periphery of the estuarine slough channels, the Restoration Area includes large swaths of additional wetlands, marsh, and riparian areas with a variety of mostly gentle slopes and elevations between 9 ft and 15 ft. These areas are intended to provide a variety of wildlife habitats and vegetation communities and to create a substantial buffer zone between the center of the Restoration Area and the Mixed Use Area to the south and Harbor Blvd to the east. On the west side are broad bands of gently sloped (1% to 1.5%) marsh habitats at elevations mostly between 9 ft and 11.5 ft. The east side is graded to avoid disturbing the existing drainage path and established vegetative corridor along Harbor Blvd, to provide additional riparian through removal of the existing entrance road and design elevations between 11 ft and 14.5 ft, and to provide a small partially separated treatment wetland area to receive intercepted agricultural drainage from the other side of Harbor Blvd and runoff from the Mixed Use Area. This wetland area will require additional design and coordination as drainage plans for the Mixed Use Area and campground concepts are refined.

On the south side of the slough channels, the design includes two lobed-marsh habitats separated by an elevated riparian area. The lobed marsh habitat design is intended to provide pockets of additional wetland habitat complexity with a variety of slopes and aspects, to create for a wide area suitable for transitional marsh species (Section 6.2.3), and to provide a visual and physical buffer separating the Mixed Use Area and the central portion of the Restoration Area. The elevated riparian area is intended to support dense riparian vegetation and provide shading to the slough channel to the north and the adjacent areas of the lobed marsh habitats to the east and west. The proximity of this high point to the entrance area of the Mixed Use Area makes this a logical location for an interpretive trail and overlook to highlight the restoration areas, the established vegetation communities, and focal wildlife species.

4.6 EARTHWORK QUANTITIES

The Preferred Restoration Concept includes an approximate total excavation volume of 250,800 cy (249,000 cy of excavation to reach design grades plus 1,800 cy of over-excavation for the transitional marsh area) and generates enough fill material to increase the average elevation of the Mixed Use Area by around 1.5 ft to an overall elevation of approximately 16.2 ft[9]. This is consistent with the recommendation that the Preferred Restoration Concept be developed with excavation quantities at an intermediate level (somewhere between the two preliminary alternatives) to keep the cost of the restoration project within reasonable limits, and to keep the majority of the finished campground closer to the level of the principal access route (i.e., Harbor Blvd).

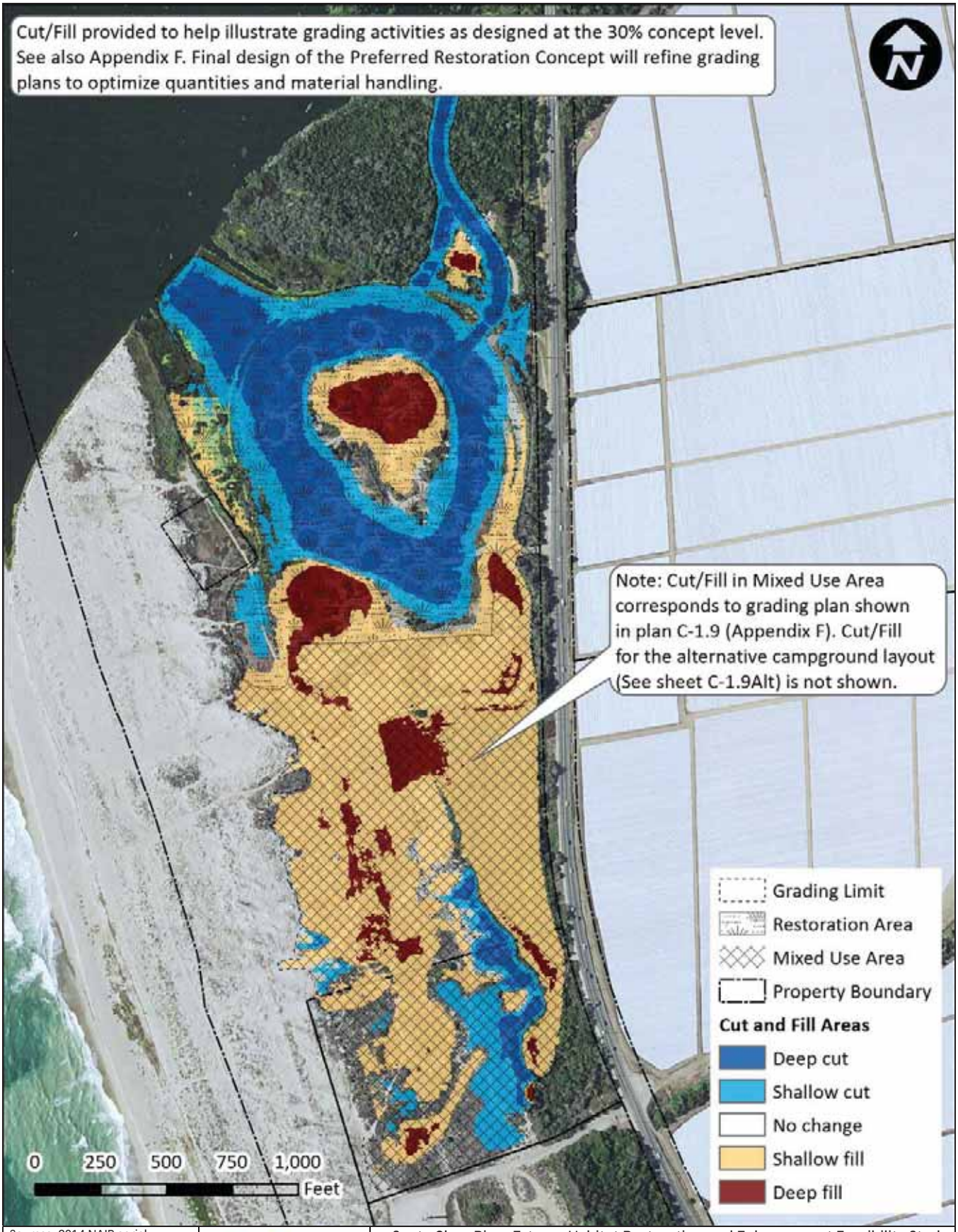
The grading of the Preferred Restoration Concept creates an approximate cut/fill balance (within 3.5%) for the Project Area. Earthwork volumes are included in Table 2. As concept plans evolve for the Mixed

[9] This elevation is provided for reference only. The existing topography within the Mixed Use Area is highly variable and includes areas with higher and lower elevations. This elevation is not a grading recommendation for building, road, or campsite design. It merely reflects the average elevation increase anticipated through excavation of the Restoration Area and placement of the material within the Mixed Use Area. Concept grading plans for the Mixed Use Area necessarily include areas above and below this elevation.

Use Area, the overall excavation volume may potentially be reduced (by up to 29,000 cy) by not removing/re-grading the existing higher ground in the center of the Mixed Use Area. Areas of cut/fill for the Preferred Restoration Concept are shown in Figure 15.

Table 2 — Preferred Restoration Concept: cut/fill quantities

Category	Quantity	*Unit*	*Notes*
Total Excavation Volume:	**250,800**	*cy*	
Excavation within Restoration Area:	220,000	*cy*	*Slough channels, fluvial channels, etc.*
Excavation within Mixed Use Area :	29,000	*cy*	*Remnant high ground in Mixed Use Area. Final design may reduce this quantity.*
Over-excavation:	1800	*cy*	*For transitional marsh. Estimated from acreage and 12" over-excavation.*
Total Fill Placement on Site:	**242,000**	*cy*	
Fill placement within Restoration Area:	72,000	*cy*	*Riparian islands.*
Fill placement within Mixed Use Area:	170,000	*cy*	
Cut/Fill Balance:	8800	cy	*(long) Final design and grading will reduce further.*
	3.5%	*% of total*	



Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development

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Preferred restoration concept: cut and fill areas

Project No. 14-1023	Created By: DT	**Figure 15**

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5 PREFERRED RESTORATION CONCEPT: HYDROLOGY AND HYDRAULICS

This section describes the methods used to evaluate the hydraulic functioning and overall suitability of the Restoration Area portion of the Preferred Restoration Concept under the three primary existing hydrologic regimes (river runoff events, open-mouth / tidal conditions, and closed-berm conditions), and also for several future and potential conditions including sea level rise and a range of VWRF discharge reductions scenarios. This section, together with Section 4 and Section 6, provides a detailed description of the Preferred Restoration Concept.

Section 5.1 summarizes the assumptions, limitations, and uncertainties associated with these methods. While useful, the model simulations developed for the Project were based on a number of important assumptions and have some inherent limitations.

Section 5.2 and 5.3 describe the two different and largely independent methods which were employed for the Project to explore the feasibility and suitability of the various conceptual restoration alternatives for a wide range of anticipated hydrologic, hydraulic, and geomorphic considerations and conditions.

The principal analytical method was a commercially available, two-dimensional (2D), hydrodynamic numerical model capable of unsteady flood routing, sediment transport, and temperature modeling capabilities. Hydrodynamic scenario development, rationale, and key results for the Preferred Restoration Concept are discussed in more detail in Section 5.2 (additional technical details are presented in Appendix A).

In addition, a spreadsheet-based water balance model was developed to explore potential estuary water levels for additional closed-berm design scenarios including VWRF discharge rates below those which could be simulated with the hydrodynamic model and the inclusion of a number of estimated, seasonally variable groundwater flows, and subsurface exchanges with McGrath Lake. Though the specific data sources and overall approach of the two models varied, the water balance model and the hydrodynamic model provided reasonably consistent water level estimates for the closed-berm scenarios considered. A basic overview of the spreadsheet model and a discussion of notable results for the Preferred Restoration Concept are included in Section 5.3 (technical details are presented in Appendix B).

Section 5.4 provides a focused comparative analysis to highlight areas where the Preferred Restoration Concept addresses specific deficiencies present in the existing conditions. The Preferred Restoration Concept is generally anticipated to provide improved and expanded habitat for steelhead habitat and tidewater goby for the range of open-mouth, closed-berm, and river runoff conditions considered. The results also suggest that the Preferred Restoration Concept will continue to provide ecological benefits with the anticipated future hydrologic changes (potential VWRF discharge reductions and sea level rise).

5.1 ASSUMPTIONS, LIMITATIONS, AND UNCERTAINTY

While useful in assessing the feasibility and suitability of the various restoration and topography options considered, the hydrodynamic model simulations and the spreadsheet-based water balance model developed for the Project were both based on a number of important assumptions and have some inherent limitations. There is also a considerable amount of uncertainty involved in anticipating and simulating potential future conditions, especially for a natural site as complex and as dynamic as the SCRE. Scenarios were developed with the best available data to provide the Project team with a method for comparatively evaluating different alternatives and as an objective tool to progressively refine the restoration concepts. Results should be viewed relative to results for other scenarios and not as an absolute prediction of future conditions. Scenario formulations and model results do not represent a risk assessment and should not be used to set final building elevations or other potential campground infrastructure. Appendix A provides a detailed technical description of the work done to build the hydrodynamic models and the technical assumptions made to create each scenarios. Appendix B describes the water balance model. A few key general caveats are included below.

- The hydrodynamic simulations developed for the Project utilized a 2D, depth-integrated numerical model. In this type of model, depth-dependent variables (velocity, sediment concentration, temperature, etc.) are characterized by a single value. Model results do not characterize the vertical distribution of sediment within the water column and do not indicate the potential for thermal or salinity stratification.
- Though the hydrodynamic simulations provided results that appear to agree well with recent inundation patterns and previous hydraulic modeling, models were not calibrated or verified.
- Sediment transport modeling is a tool for assessing potential geomorphic changes: results should be interpreted as probable trends (not absolutes) with order-of-magnitude levels of accuracy.
- Hydrodynamic model results are derived from simplified, depth-integrated, two-dimensional representations of complex, three-dimensional processes.
- Hydrodynamic model scenarios did not include wave action, littoral transport, and did not simulate the initial breaching or the subsequent rebuilding of the mouth berm.
- Closed-berm scenarios (both the hydrodynamic model and the water balance model) were developed with observed (and estimated) relationships between closed-berm water levels and groundwater flows to the ocean. Though results are within anticipated ranges and seem to agree reasonably well with recent estuary stage observations, these relationships may change in the future.
- Distributed and seasonally variable groundwater flows were not included in the hydrodynamic simulations because of model limitations (not set up for subsurface flows) and data gaps related to groundwater patterns and temperatures[10]. With current VWRF discharge rates this is a reasonably appropriate assumption, and water temperatures predicted for the estuary for

[10] The City of Ventura's Phase 3 Special Studies (due in draft form in September 2017) will include a Groundwater Special Study (LARWQCB, 2013; City of Ventura, 2014) which is anticipated to provide additional information on the volume, quality, and seasonal nature of groundwater flows for the SCRE.

extended closed-berm simulations were consistent with the range of observed temperature measurements for the estuary. Similarly, water levels predicted by the hydrodynamic model were generally consistent with the results of the water balance model. However, this assumption (i.e., excluding groundwater flows) becomes progressively less valid as lower potential VWRF discharge rates are simulated and groundwater flows become a significant percentage of the flow into the estuary. Therefore, hydrodynamic simulations were not performed for potential VWRF discharge reduction scenarios beyond a 50% reduction.

- Both models used data averaged over different time periods (rather than instantaneous data which is generally unavailable) for each hypothetical scenario (e.g., monthly average VWRF discharge). Actual hydrological inflows and conditions fluctuate and may change from observed historical averages. These models are intended to be comparative, not predictive.

5.2 HYDRODYNAMIC MODEL SCENARIOS

Sections 5.2.1-5.2.3 briefly describe the three primary types of hydrodynamic scenarios used to support development of the Preferred Restoration Concept including river runoff from storm events, open-mouth / tidal exchange conditions, and closed-berm conditions.

Section 5.2.4 and Section 5.2.5 summarize the modifications made to the base scenarios to simulate restoration concepts with sea level rise and a range of potential VWRF discharge reduction scenarios.

These scenarios were developed based on hydrologic analyses and the assessments of the ECTR. Technical details for the hydrodynamic model scenarios are included in Appendix A. Several rounds of interim scenario results for the preliminary alternatives were analyzed by the Project team and were used to inform the design and development of the Preferred Restoration Concept but are not included in this report. Key final simulation results and comparisons with the existing conditions simulations are discussed in Section 5.4

5.2.1 RIVER RUNOFF FROM STORM EVENTS

River runoff scenarios were developed to simulate the flows within the estuary when a significant precipitation event occurs within the watershed, and the SCR conveys large volumes of flood runoff water and sediment to the SCRE. The purpose of these scenarios was to allow for the qualitative and comparative evaluation of flow velocities, inundation extents, water surface elevations, and sediment trends for a relatively frequent and ecologically important flow event (2-year) and a larger geomorphic flood event (10-year). While larger river runoff events will occur, the 2-year and 10-year events bracket a wide range of anticipated (and historically observed) flow conditions (see Figure 7) and provide useful and appropriate simulation results for ecological restoration planning and design.

The model was developed to provide answers to the following types of questions:

- What peak flow velocities are expected? Are there areas that provide velocity refuge?
- Which areas will be inundated? What water depths are anticipated?
- What types of bathymetry changes are expected? Do sediment transport patterns suggest that certain features will fill in with sediment? Where is scour expected to occur?
- Does the event provide mixing and circulation in areas outside of the main river corridor?

Initial conditions for the runoff event scenarios included an estuary water surface elevation of 11 ft to simulate the inundated conditions generally observed prior to a breach event. However, as accurate breaching of the berm proved to be beyond the capabilities of this effort, the scenarios were run with a pre-opened breach geometry. The 2-year breach was based on a limited breach-section survey and the 10-year breach was estimated from aerial photographs. As a result, simulation results may reflect isolated and/or perched wet areas due to the pre-breach water levels (not necessarily associated with the event itself). Key river runoff scenario results are discussed in Section 5.4

5.2.2 OPEN-MOUTH / TIDAL EXCHANGE CONDITIONS

This scenario was developed to simulate the flows within the estuary during open-mouth conditions when the estuary is influenced by periods of tidal exchange, and VWRF effluent discharge, but without significant river or groundwater inputs such as might occur during an extended open-mouth period after a breach event. The purpose of this scenario was to determine whether tidal exchange velocities, inundation areas, or water depths, posed any specific feasibility challenges. While other tidal conditions may occur, this scenario reflects the primary water surface elevations and tidal patterns (typical spring and neap tides, etc.) observed for the Pacific Ocean near the SCRE and also provided useful simulation results for the restoration planning and design.

To help guide concept development and refinement, the model was set up to provide answers to the following general types of questions:

- What ebb tide flow velocities are expected? What flood tide velocities are expected?
- What is the volume of the tidal prism?
- How well will the estuary drain between tide cycles?
- Which areas are expected to remain inundated?
- What water depths will be available under different tidal conditions?

Wave action and littoral transport were not included so the model simulations were not capable of assessing breach persistence via tidal scour at the mouth or berm building processes.

Simulation results for the Preferred Restoration Concept suggested that the tidal volumes and velocities were likely not large enough to create significant scour or sedimentation within the SCRE. This is generally consistent with recent observations of the existing estuary during open-mouth conditions. This is also not unanticipated since the elevations of the proposed slough channels are within the upper half

of the intertidal range (MTL=2.7 ft, MHHW=5.3 ft) (see also Section 2.3). As shown in Figure 16, relatively shallow water depths (below 2 ft) are expected within the slough channels at the MHHW (5.3 ft). Spring tides would provide deeper depths, but some smaller neap tides may not create water levels high enough to cause tidal exchange. Low sills currently exist at the breach opening and within the western edge of the SCRE lagoon and have been observed to prevent the complete dewatering of the SCRE even at very low tides.

5.2.3 CLOSED-BERM CONDITIONS

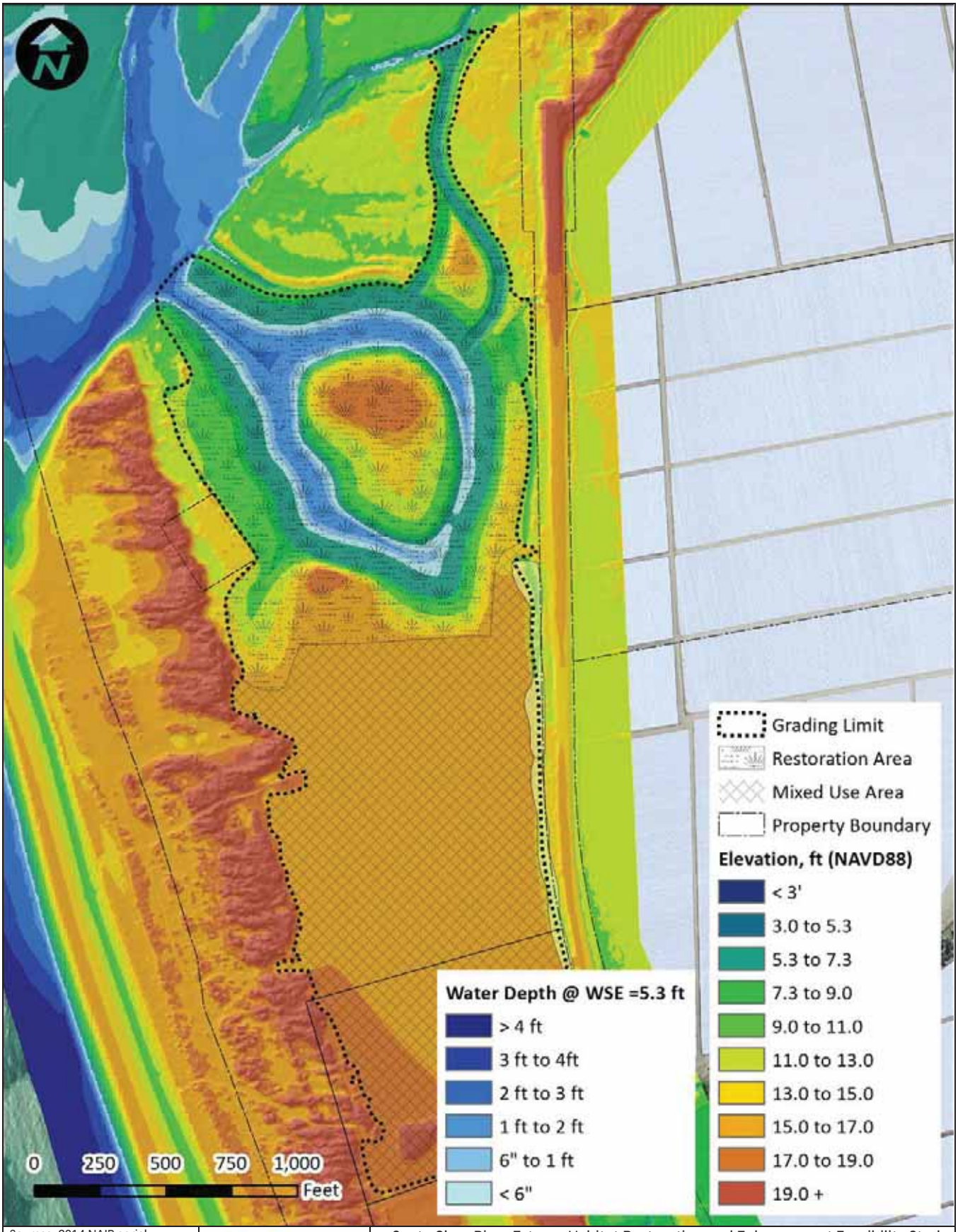
This scenario was developed to simulate circulation patterns, and temperature fluctuations within the estuary during extended closed-berm conditions when the estuary is primarily influenced by the VWRF effluent discharge, wind-driven mixing, evaporation, diurnal thermal fluctuations, and subsurface flows. The hypothetical, but typical scenario was developed to begin on March 1st (as though a breach event occurred in February with subsequent berm closure as has occurred in recent years) and end on October 1st (after estuary water temperatures have been observed to stabilize or decrease as cooler fall weather begins). While the actual behavior of the SCRE in closed-berm conditions will vary depending on actual climate patterns, recent breach history, actual VWRF discharge rates, etc., this scenario reflects the average climatic and discharge conditions observed in recent years and provided useful comparative simulation results which supported development and refinement of the Preferred Restoration Concept.

The model was set up to provide answers to the following general types of questions:

- What is the anticipated pseudo-equilibrium summer water level?
- How long on average would it take for the estuary to fill to a pseudo-equilibrium water level?
- How could water temperatures vary across the estuary? With the season?
- What wind-driven circulation patterns are anticipated within the estuary?

As shown in Figure 17, a variety of water depths (up to approximately 7 ft) are expected within the slough channels at the pseudo-equilibrium water level (11 ft) anticipated for the summer months.

Though using a vertically-integrated approach, closed-berm scenarios produced water temperatures that agree reasonably well with recent observed temperatures (high values around 25 °C possible in summer months and low values around 12 °C with open-mouth conditions). Key closed-berm scenario results are discussed further in Section 5.4



Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Preferred restoration concept: water depths at MHHW

Project No. 14-1023 | Created By: DM | **Figure 16**

C:_WORK\14-1023_SCRE_Feasibility_Study\Reports\FSR (Task 2.2)\FinalFigures\Fig16_PreferredAlt_WaterDepths.docx
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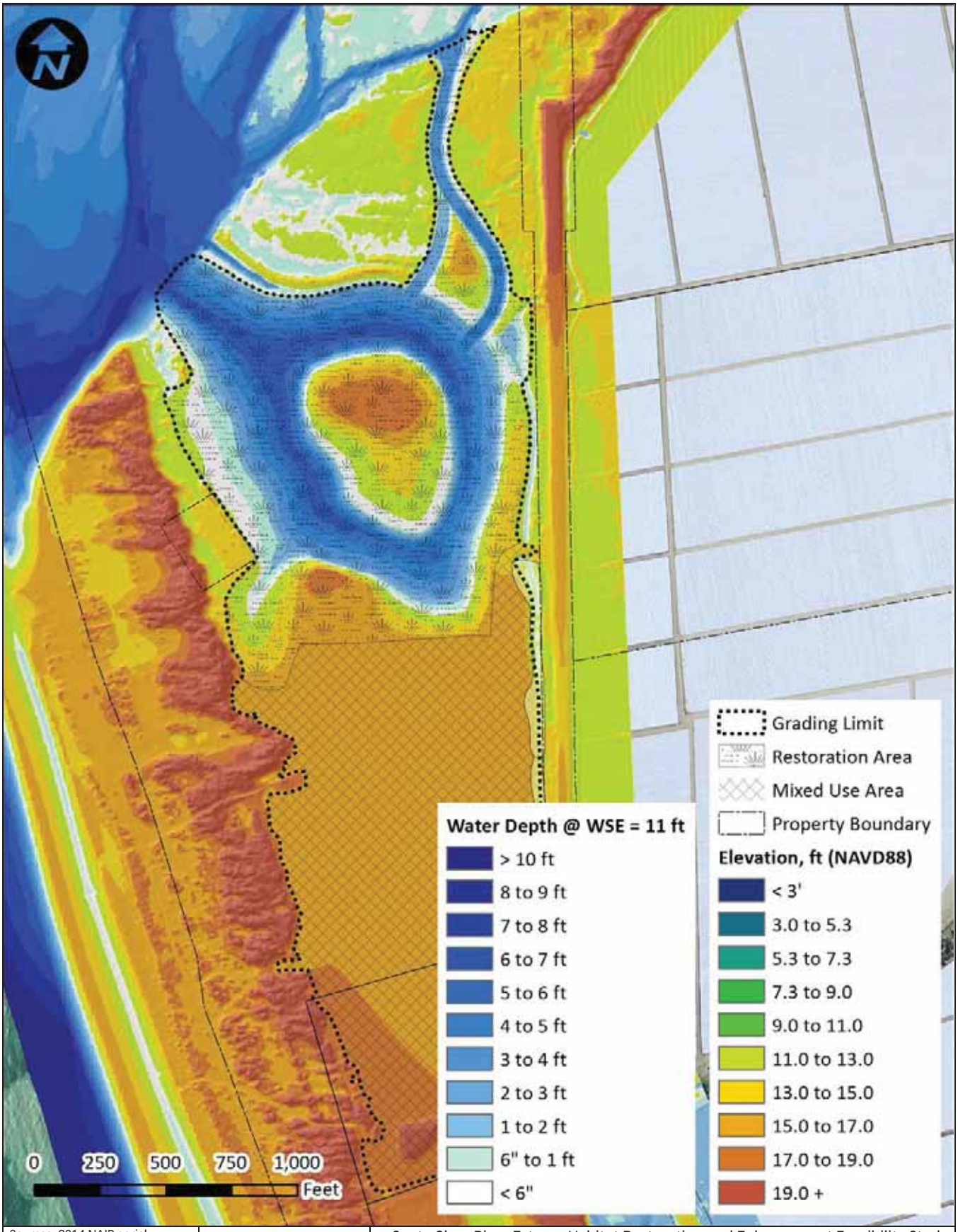

Sources: 2014 NAIP aerial, Ventura County GIS, 2009-2011 NOAA DCSC LIDAR, 2012 CSUCI bathymetry, 2014 cbec survey, 2015 cbec concept development

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Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Preferred restoration concept: water depths at WSE = 11ft

Project No. 14-1023	Created By: DM	**Figure 17**

C:_WORK\14-1023_SCRE_Feasibility_Study\Reports\FSR (Task 2.2)\FinalFigures\Fig17_PreferredAlt_WSE11ft_2.docx
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5.2.4 CLIMATE CHANGE - SEA LEVEL RISE

Each of the simulation scenarios described above were modified to include sea level rise to determine how higher mean and extreme sea levels would affect the functioning of the restoration concepts under each general type of hydrologic regime (i.e., open-mouth, closed-berm, and river runoff event). The purpose of the simulations was not to predict the actual amount of future sea level rise, nor to recommend the use of a specific planning number over another, but to allow for overall concept feasibility analysis and comparative evaluations of each restoration concept. Scenario modifications for the open-mouth and river runoff scenarios included a vertical shift in the downstream boundary conditions corresponding to an increase in the mean tide level (MTL) of 2 ft corresponding to the upper range of the most recent NRC (2012) projections for the year 2050. A more detailed discussion of sea level rise projections and considerations for the SCRE was included in the ECTR.

As sea level rise continues and the elevations of the intertidal range move upward, the amount of intertidal (and potentially subtidal) habitat within the Restoration Area may be anticipated to increase. Open-mouth simulations with +2 ft of sea level rise included did not suggest substantially different results; tidal volumes and velocities were still not large enough to create significant scour or sedimentation within the SCRE, and river runoff events only produced slightly higher water surface elevations, slightly lower velocities, and a minor reduction in estuary scour.

The sea level rise modification for the closed-berm condition scenarios was included through a revised rating curve to reflect that with a higher MTL, less water would be expected to flow from the estuary to the ocean at a given water level. This approach was incorporated into both the hydrodynamic models and the spreadsheet-based water balance model. Technical details are included in Appendix A (hydrodynamic model) and Appendix B (water balance model). Key sea level rise simulation results for closed-berm conditions are discussed further in Section 5.4.

5.2.5 POTENTIAL WASTEWATER FLOW REDUCTIONS

As discussed in the ECTR and summarized in Section 2.3, the VWRF discharge rate directly and significantly influences the water levels within the SCRE during extended closed-berm conditions. As established and discussed by the Project team during restoration development, and as previously shown by Stillwater Sciences (2011), a reduction in the VWRF discharge rate will result in closed-berm water levels in the estuary that are lower than observed presently. To estimate the potential estuary water levels and to evaluate the suitability and overall feasibility of the Preferred Restoration Concept with such conditions, the closed-berm condition scenarios were modified to model the full range of anticipated potential VWRF discharge rates. No changes to the effluent temperature or seasonal patterns were included. This effort was not intended to determine if a particular amount of effluent is needed to sustain the native and endangered species within the estuary or to provide support for any particular discharge reduction. Rather, this scenario was limited to providing estimates for the pseudo-equilibrium summer water level that might be anticipated with varying levels of VWRF discharge to allow the Project team to develop appropriate and flexible topographic grading plans for restoration concepts.

A 50% VWRF discharge reduction was evaluated with the hydrodynamic model. As described in more detail in Appendix A/B, groundwater flows become relatively more important in the scenario as the VWRF discharge is reduced. Because of limitations in the surface-based hydrodynamic approach, additional VWRF discharge reduction scenarios (up to complete removal of VWRF surface discharge) were instead simulated with the spreadsheet-based water balance model (Section 5.3).

As with other simulations completed for the Project, the VWRF discharge reduction scenarios were not intended as predictive models. These models simulations were useful tools, used by the Project team to inform and refine restoration concepts based on comparative results. Simulation results are discussed in Section 5.4.

5.3 WATER BALANCE MODEL

To support the initial development of preliminary restoration alternatives and to subsequently refine the Preferred Restoration Concept, the spreadsheet-based water balance model of the SCRE (initially developed through the feasibility effort supported by USFWS) was expanded to include additional VWRF discharge reduction capabilities, basic seasonal assumptions for groundwater inflows, elevation-dependent rating curves for flows to the ocean and to McGrath Lake, sea level rise functionality, and updated estuary hypsometric relationships. The water balance model was developed using monthly averages for evaporation rates, VWRF flow rates, and estimated seasonal groundwater flows. The water balance model used a simple water-in/water-out 'bathtub' approach to determining daily estuary water levels by adding up all the inflows and outflows (some based on monthly averages and others based on the previous water level), calculating the change in volume, determining the increase in surface area (using the hypsometric curve), and then calculating the corresponding change in the water surface elevation within the estuary. The water balance model was calibrated to a limited set of recently recorded estuary water levels by adjusting the inflow with the most uncertainty (upstream groundwater inflows).

As the water balance model primarily provides an estimate of the water level trends over the course of a closed-berm period, which are directly linked to the magnitude of the VWRF, only a few VWRF discharge reduction runs were needed to generally bracket the full range of potentially anticipated water levels. As the spreadsheet model was modified to include both sea level rise and VWRF discharge reduction capabilities, this tool was also used by the Project team to determine potential water levels assuming sea level rise and a VWRF discharge reduction occur concurrently.

Unlike the hydrodynamic model which directly simulates flow and circulation patterns (i.e., movement) within the estuary (including water temperatures), the spreadsheet approach only provides an estimate of the water level in the estuary for each day. Technical details for the development of the water balance model are discussed in Appendix B.

Water level predictions from the spreadsheet-based model are discussed in Section 5.4.

5.4 SIMULATION RESULTS AND COMPARISONS

This section discusses the key simulation results including the 2-year event, the 10-year event, potential pseudo-equilibrium summer water levels (possible during extended closed-berm conditions), and estuary water temperatures. These results are also presented in Figure 18 - Figure 26. The discussion intends to highlight the improved hydraulic and ecological functions the Preferred Restoration Concept provides relative to the existing conditions.

Scenario Results: 2-Year Event

Figure 18 shows the water depth and flow velocity simulation results for the Preferred Restoration Concept at the peak of the 2-year event. Water depths in the Restoration Area are anticipated to vary from shallow water at the margins of the slough channels, 2 to 4 ft in the activated fluvial side channel and at the point where the ends of the slough channels connect, and up to about 6 ft near the connection with the existing estuary. Velocities in the fluvial side channel reach a maximum of 2-3 fps and lead in to slower slough channel velocities below 0.5 fps. The event creates water levels that connect the slough channels and creates mild circulatory flow around the north and south sides of the central island. Water surface elevations at the peak of the event (Figure 19) show water levels mostly around 8.5 ft within the Restoration Area.

The sediment transport simulation results (Figure 20) indicate that the 2-year event will cause only minor bed level changes within the existing estuary (mostly associated with the main river thalweg near Harbor Blvd and at the breach in the mouth berm) and minimal changes to the new features of the Restoration Area.

Direct comparison with the depth and velocity results for the existing conditions simulation (Figure 21) shows how the Preferred Restoration Concept provides additional areas of velocity refuge for steelhead and increased freshwater flows into the area currently occupied by the campground. Velocity and depth within the main estuary remains essentially unchanged. Whereas the current situation does not allow for frequent freshening flows into the stagnant areas of the campground, the fluvial channel of the Preferred Restoration Concept allows for the more regular introduction of fresh water flows.

Scenario Results: 10-Year Event

Figure 22 shows the water depth and flow velocity simulation results for the Preferred Restoration Concept at the peak of the 10-year event. Water depths in the Restoration Area ranged from 5 to 8 ft in the activated fluvial side channel, 2 to 3 ft in the fluvial side channel bypass, 5 ft at point where the ends of the slough channels connect, and up to 8 ft near the connection with the existing estuary. Velocities in the center of the fluvial side channel reach a maximum of 7 fps (with lower velocities observed at the sides of the channel and in the inset benches) and lead in to slower slough channel velocities below 2 fps. The event creates water levels that connect the slough channels and generates heightened circulatory flow around the island (with velocities around 2 fps observed even at the southern side of the island). Simulated water surface elevations at the peak of the event (Figure 19) show water levels range from 14 ft at the entrance of the fluvial channel to 10.5 ft at the connection with the main estuary.

The sediment transport simulation results (Figure 23) indicate that the 10-year event is capable of causing extensive bed level changes within the existing estuary. Deep scour is possible in areas that concentrate flow while significant sedimentation is possible in overbank, sheltered areas, and in the Pacific Ocean where runoff velocities begin to decrease. Within the Restoration Area however, the model results suggests much more limited scour and deposition is possible, with scour anticipated along the interior sections of the fluvial channel and depositional areas at both the inlet connection with the river corridor at the upper end of the estuary and at the outlet into the slough. A comparison of the bed topography before and after the storm suggests that the fluvial side channel generally persists and is not anticipated to fill in with one such event.

Figure 24 allows direct comparison of the depth and velocity results for the existing conditions and the Preferred Restoration Alternative during the peak of the 10-year event.

Pseudo-equilibrium Summer Water Levels (see Figure 25)

As described in more detail in Section 2.3, the SCRE often exhibits a pseudo-equilibrium water level during extended closed-berm conditions. As the predominant condition observed during the summer months (which influences the vegetation patterns and ecological functioning of the estuary), it was important to consider how the pseudo-equilibrium water level could change with the expanded estuary of the Preferred Restoration Concept and with a range of future hydrological changes including potential VWRF discharge reductions and sea level rise.

While the increased estuary volume of the Preferred Restoration Alternative is expected to fill more slowly following a breach and drain event, it is a small effect and both models indicate the currently observed water level trends will likely persist unless hydrologic changes occur. Figure 25 shows the water surface elevations predicted by the simplified water balance model (which does not include any subsurface flows beyond the losses to the Pacific Ocean through the mouth berm) and the enhanced water balance model (which includes seasonally variable groundwater flows and exchange with McGrath Lake).

Key observations related to the simulated water level results are discussed below.

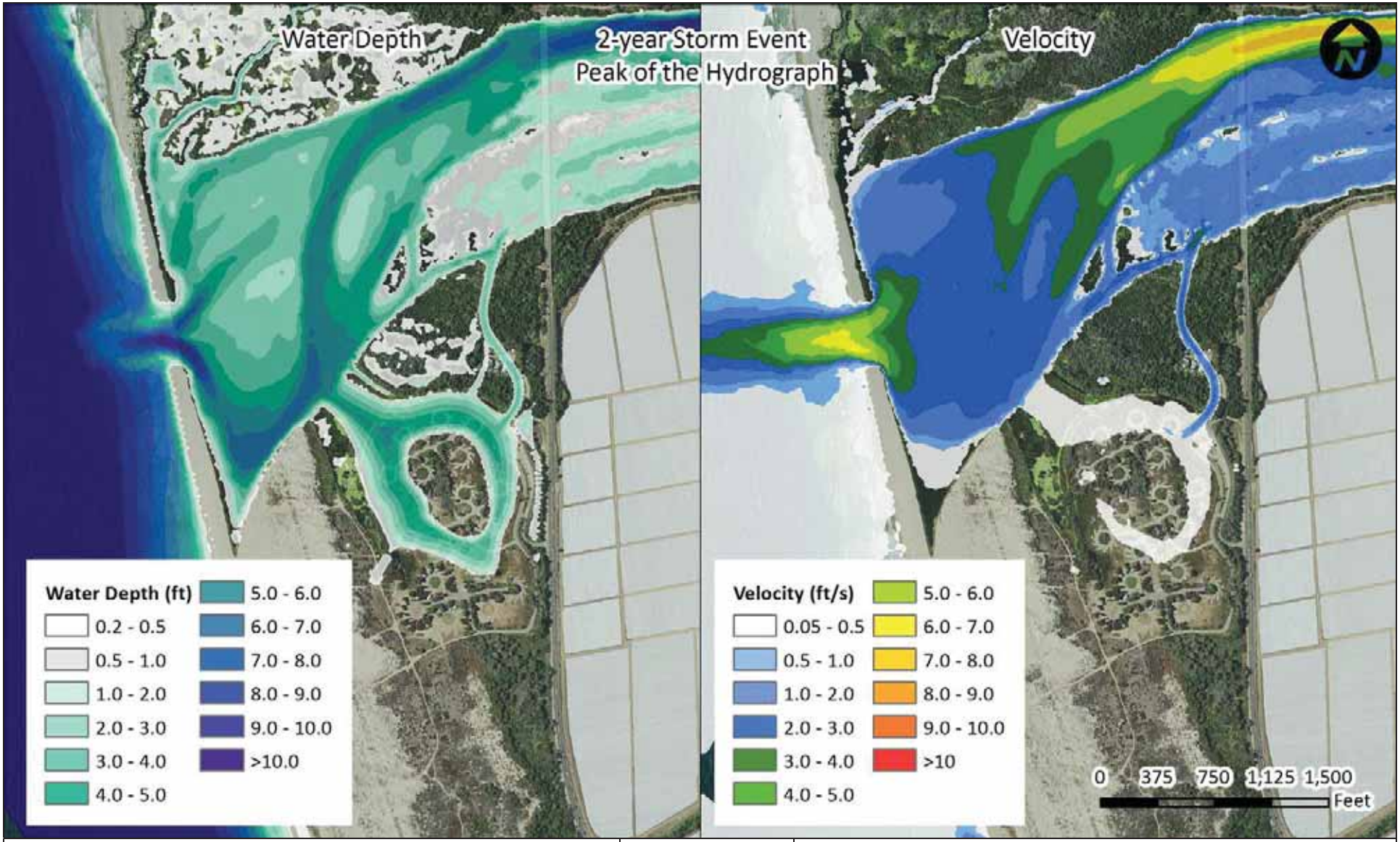
- Anticipated future hydrologic changes (sea level rise) and the range of potential VWRF discharge reductions could result in a wide range of summer time water levels for the SCRE (as low as 6 ft and as high as 13 ft). The grading of the Preferred Restoration Concept was designed to provide enhanced ecological functions and resiliency in the face of a dynamic system and uncertainty related to the future hydrology.
- With the existing hydrology, scenarios suggest pseudo-equilibrium summer water levels around 11 ft (consistent with recent observations and field measurements) for both the existing conditions and for the Preferred Restoration Alternative.
- Water levels in the estuary, though stable in the summer months because of relatively uniform VWRF and groundwater inflows, may be higher in the spring and fall months corresponding to higher VWRF discharge rates, lower evaporation rates, and increased groundwater flows. The effect becomes more pronounced as the VWRF discharge rates are reduced and other terms become more important.
- Sea level rise is anticipated to increase the water levels observed during closed-berm conditions. The water balance model predicted that 2 ft of sea level rise, absent other hydrologic changes, would result in an increase of approximately 1-2 ft with pseudo-equilibrium summer water levels in the estuary around 12 ft. The overall feasibility of the restoration project may decrease if sea level rise occurs without any changes in the VWRF discharge as the site could become progressively wetter and more deeply inundated.
- With a 50% reduction in the VWRF surface discharge rate, corresponding to an average annual discharge of approximately 3.0 million gallons per day, the models predicted a summer water level around 8 ft. While this might reduce the frequency of campground inundation, no additional habitat for steelhead would be realized without the topography modifications proposed by the Preferred Restoration Concept. However, as discussed in Section 4 and 5, the gradually sloped grading of the Preferred Restoration Concept would still allow the Restoration Area to provide suitable aquatic habitat and important ecological functions at this water level. If the Preferred Restoration Concept is built before any final determinations are made on the amount of VWRF discharge, a gradual reduction in the VWRF discharge may be advisable to allow vegetation to adapt (i.e., colonize lower elevation areas, and extend roots to lower elevations). If a VWRF reduction regime is adopted before the restoration proceeds, final design grading and vegetation plans should be revised to account for the adjusted estuary water levels which could then be anticipated with greater certainty.
- To provide some estimate of what a lower water level in the SCRE could be, the water balance model was modified to include a 100% removal of the VWRF surface discharge while retaining the subsurface flow rates from the VWRF wildlife ponds (estimated at approximately 1 million gallons per day)(Stillwater Sciences, 2011). This approach yielded pseudo-equilibrium summer water levels around 6 ft. As could be expected, this is just above the current MHHW (5.3 ft). At this water level, the slough channels of the Preferred Restoration Concept would still have 2-3 ft of water whereas, at these water levels, the existing topography of the campground would not provide any aquatic habitat. It was determined that a complete removal of all VWRF discharge into the SCRE (including the subsurface flow from the wildlife ponds) could not be accurately simulated with the presently available data source because of the limited groundwater data

available and the number of other uncertainties related to this scenario. The City of Ventura's Phase 3 Special Studies are expected to provide groundwater data, including seasonal flow patterns and groundwater temperatures, which should be used to refine these scenarios.

- With a 50% reduction in the VWRF discharge rate and 2 ft of sea level rise, the models suggest water levels around 10 ft. As sea level rise and the VWRF discharge reductions have the opposite effect on water levels within the SCRE, it might be possible to manage water levels in the estuary at preferred levels by carefully controlling VWRF discharge rates as sea level rise continues.

Summer Water Temperatures (see Figure 26)

- The Preferred Restoration Concept is not anticipated to change the seasonal temperature pattern within the main estuary (as summarized by Location A), but is expected to provide around a 2 °C decrease in peak daily water temperatures in the portion of the SCRE currently occupied by the campground (Location B). The benefit is largely due to increased connectivity to the central estuary and greater water depths.
- The simulations suggest that a 50% reduction in the VWRF discharge rate (without any sea level rise) could create a slight (approximately 0.5 °C) increase in maximum daily water temperatures in the estuary due to slightly lower water depths. The temperature increase was not observed when sea level rise was also included in the simulation. It should be noted that the modeled seasonal temperature patterns do not reflect groundwater inflows into the estuary. A reduction in the VWRF discharge rate would change the relative percentage of the estuary volume coming from groundwater sources and will have temperature effects beyond those characterized in this modeling effort. The objective of this effort was not to determine or suggest any particular VWRF discharge rate, but to evaluate the feasibility of the Preferred Restoration Concept under a range of potential future conditions.
- Temperature increases associated with climate change were not modeled, but the effect of increased air temperatures on the already warm SCRE water temperatures will clearly be detrimental to habitat conditions. Establishing high-quality vegetative shading was a crucial consideration for the development of the Restoration Area. Without the grading and vegetation improvements of the Preferred Restoration Concept, water temperature conditions in the estuary will likely deteriorate.



Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results. Water Depth (left) shows inundation extents more accurately than velocity (right).

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Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Depth and velocity for a 2-year storm event

Project No. 14-1023	Created By: DT	**Figure 18**

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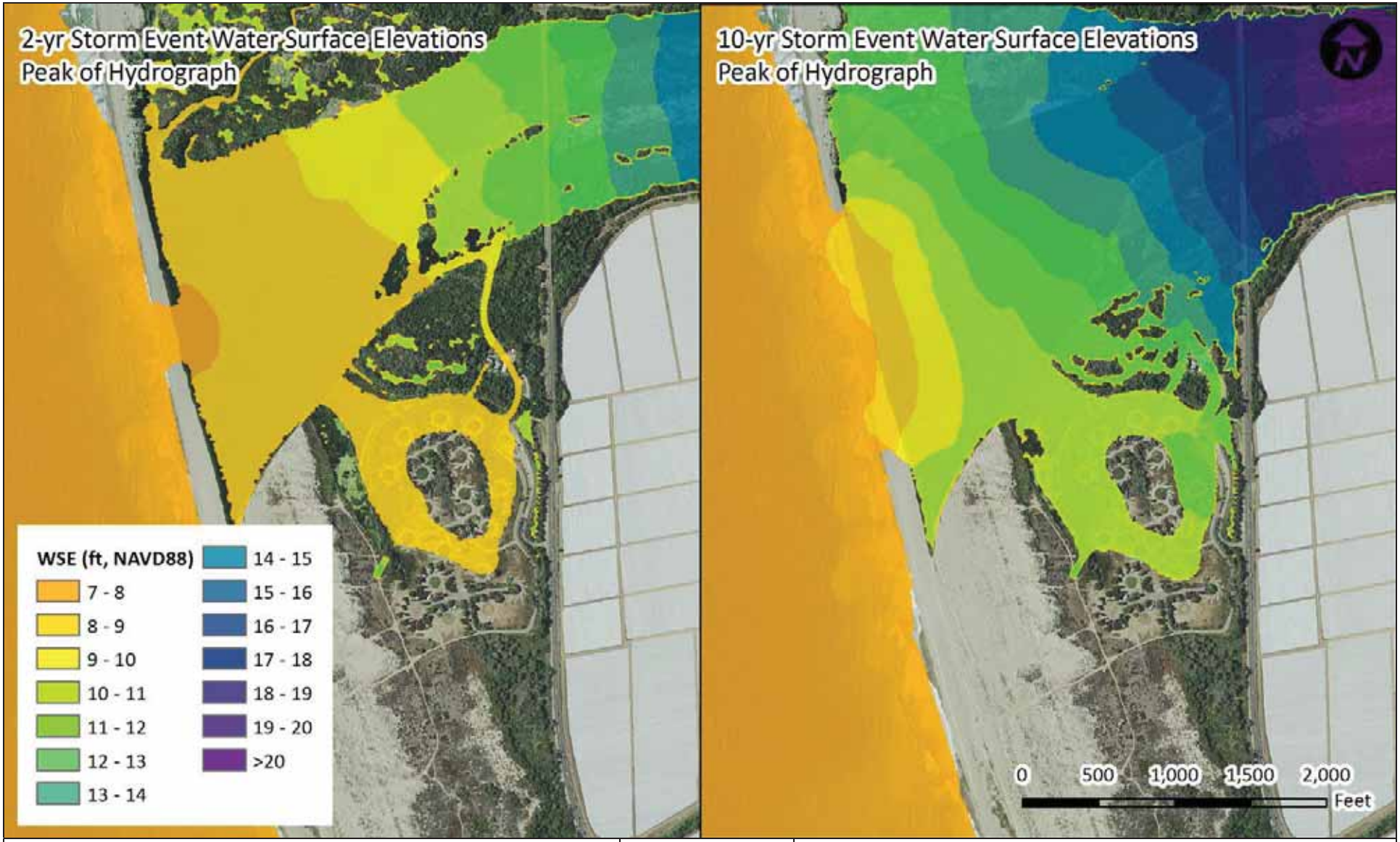
7/27/2015



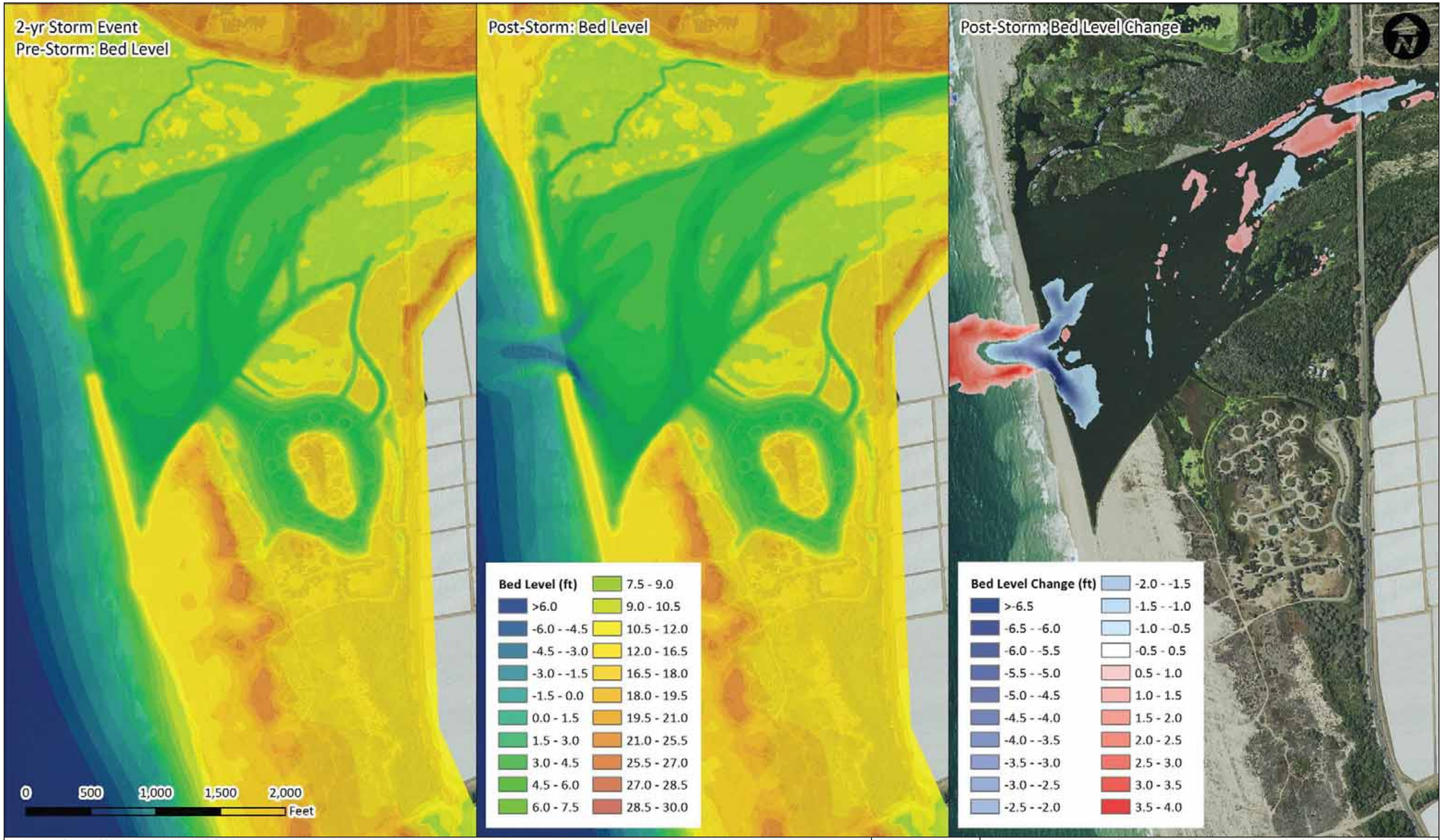
Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Water surface elevations for 2- and 10-year events

Project No. 14-1023	Created By: DT	**Figure 19**

C:_WORK\14-1023_SCRE_Feasibility_Study\Reports\FSR (Task 2.2)\FinalFigures\Fig19_2and10yr_WSE.docx
7/27/2015



Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results.

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Bed level changes for a 2-year storm event

Project No. 14-1023	Created By: DT	**Figure 20**

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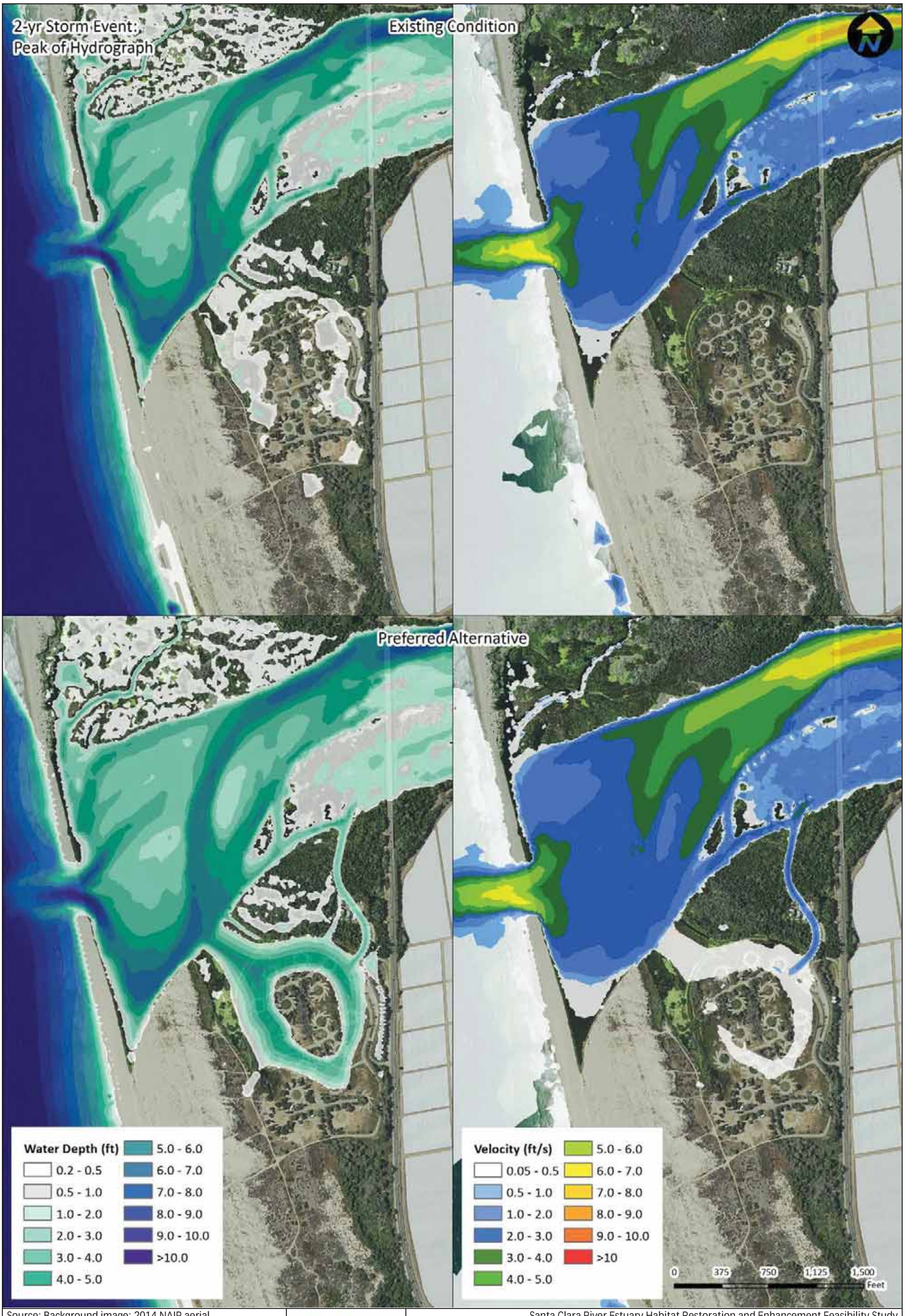

Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Preferred restoration concept vs existing conditions for a 2-year storm event

Project No. 14-1023	Created By: DT	**Figure 21**

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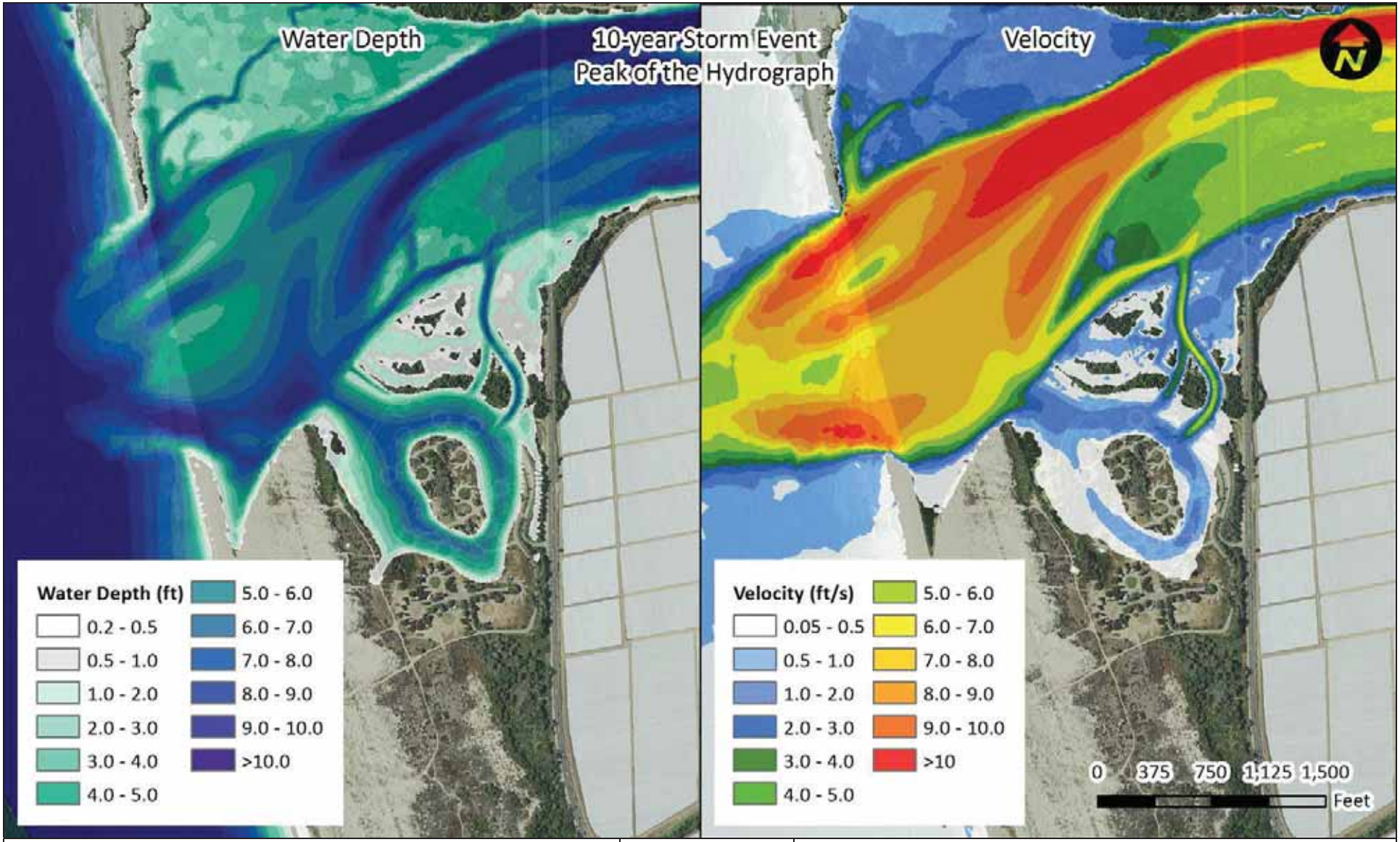
7/27/2015



Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results. Water Depth (left) shows inundation extents more accurately than velocity (right).

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Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Depth and velocity for a 10-year storm event

Project No. 14-1023	Created By: DT	**Figure 22**

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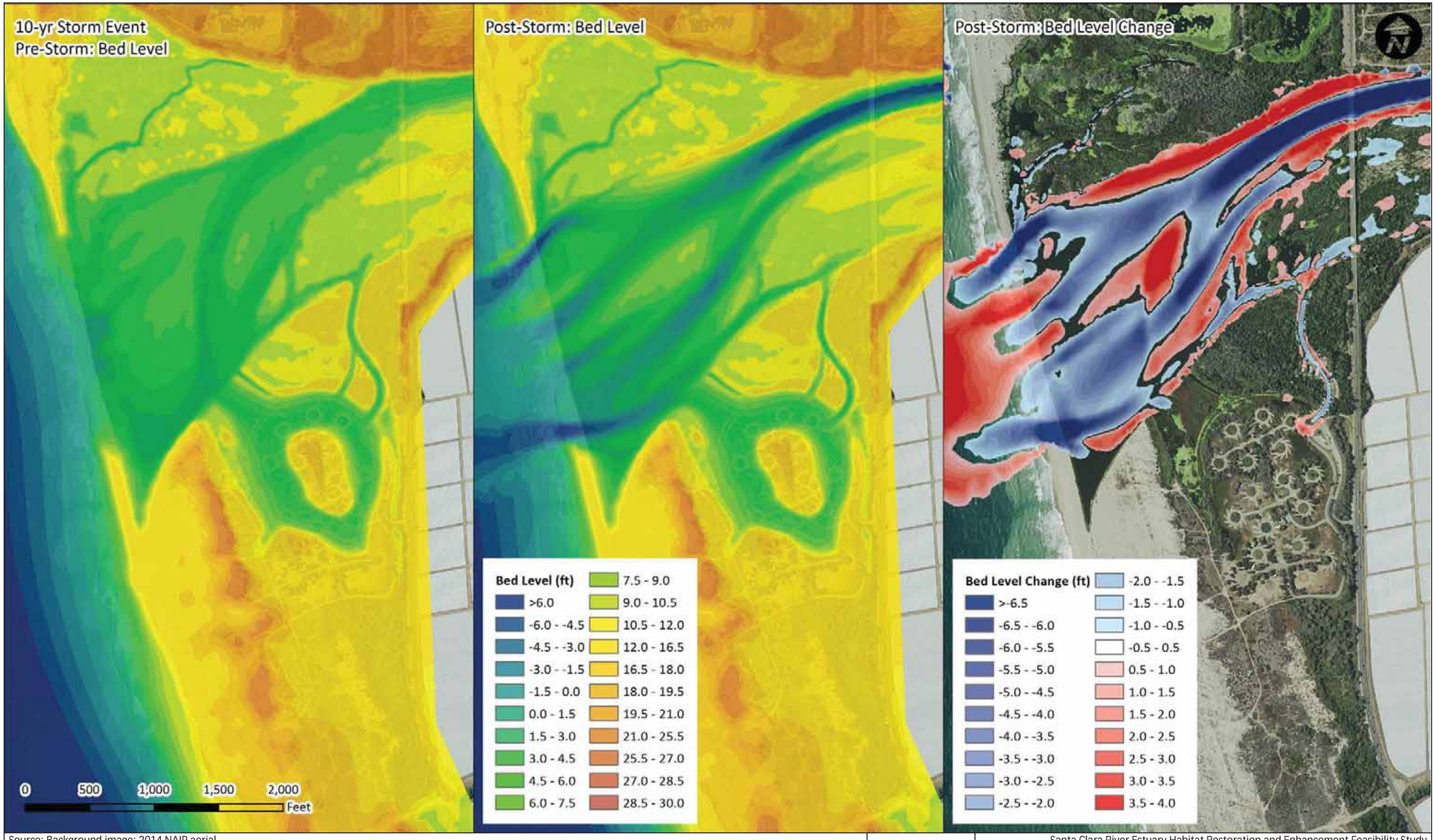
7/27/2015



Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Bed level changes for a 10-year storm event

Project No. 14-1023	Created By: DT	**Figure 23**

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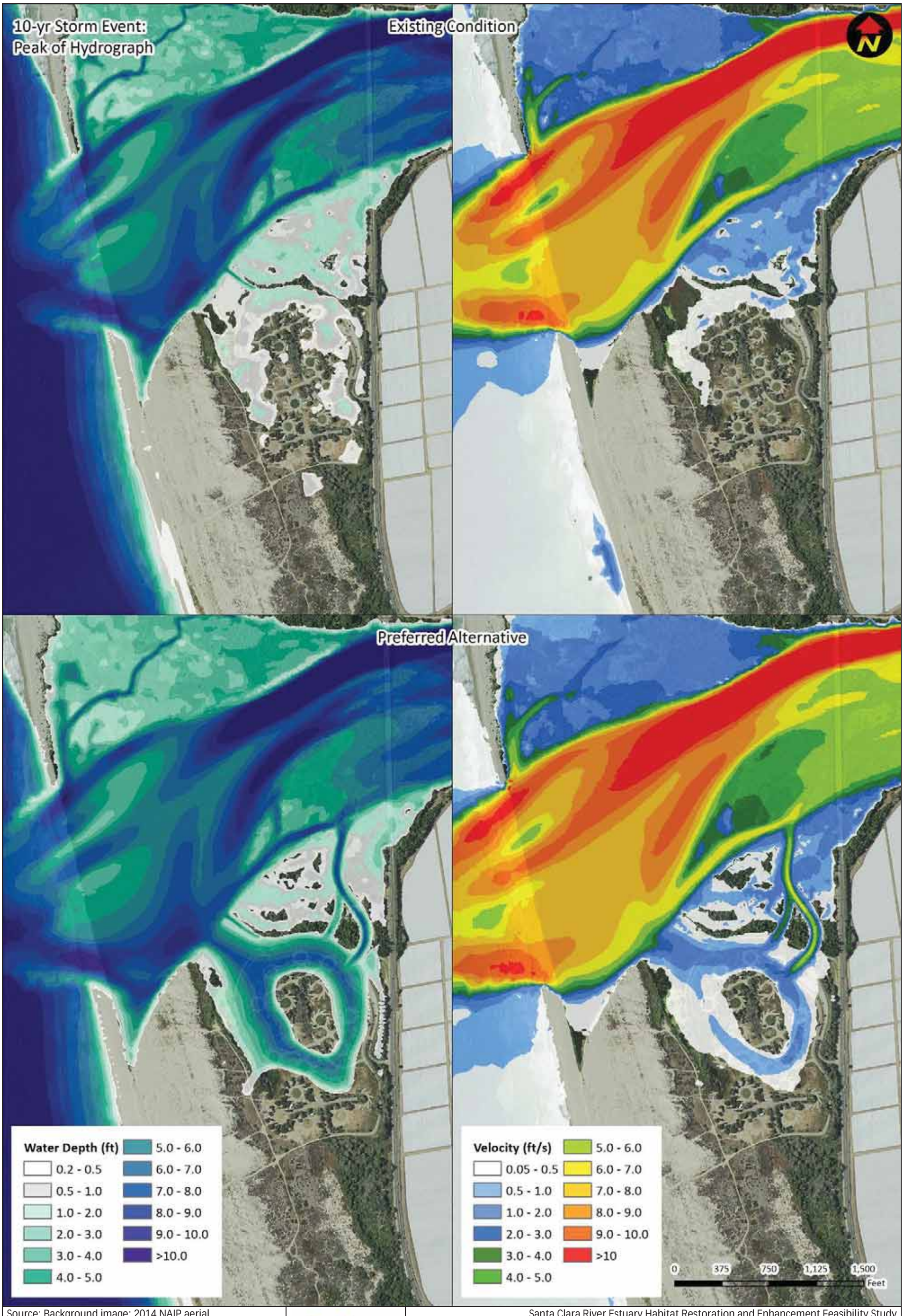
7/27/2015



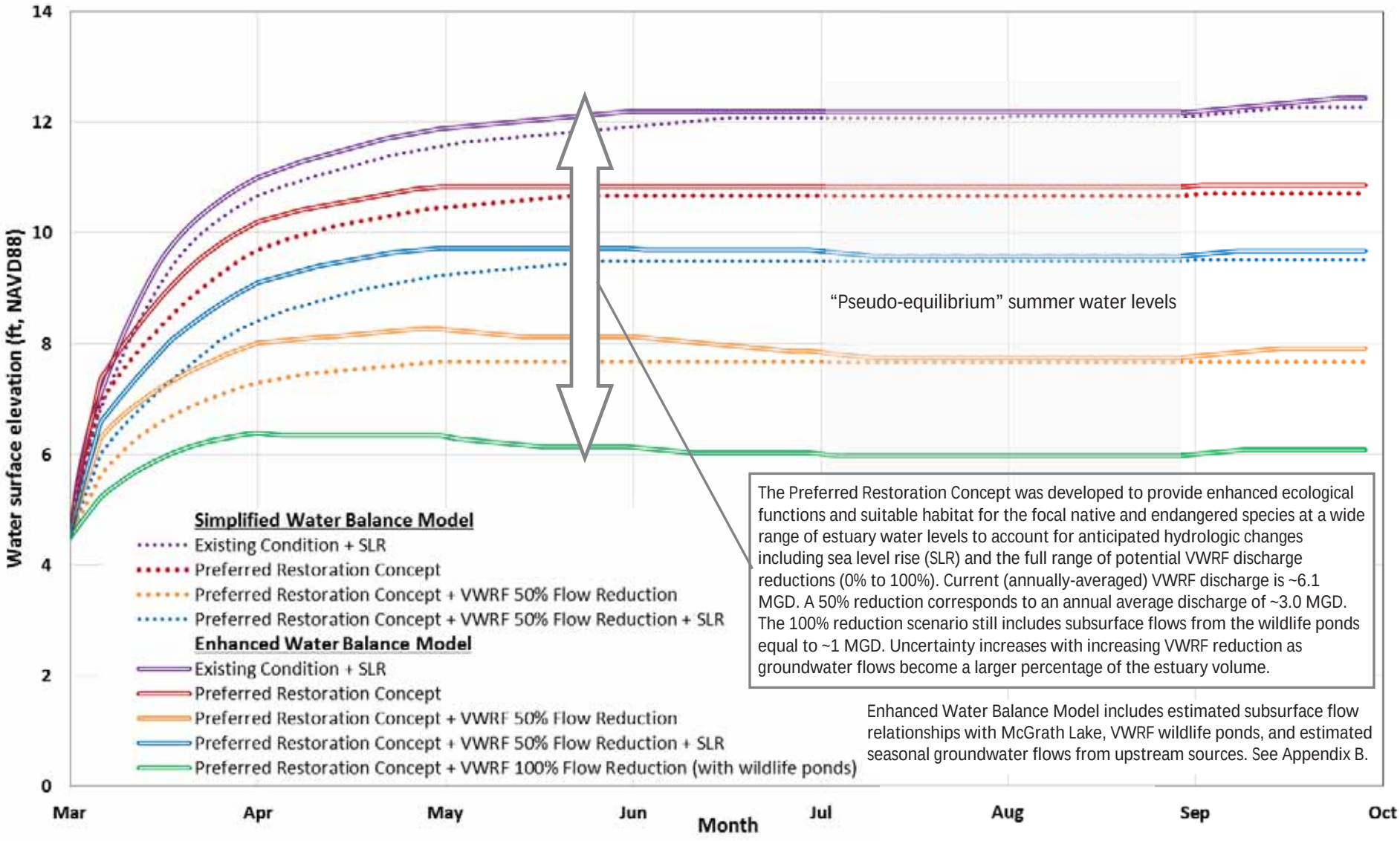
Source: Background image: 2014 NAIP aerial
Notes: Rasters derived from MIKE 21 FM model results.

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Preferred restoration concept vs existing conditions for a 10-year storm event

Project No. 14-1023	Created By: DT	**Figure 24**

C:_WORK\14-1023_SCRE_Feasibility_Study\Reports\FSR (Task 2.2)\FinalFigures\Fig24_ECPrefAltComp_10yr_2.docx
7/27/2015



Notes: Water surface elevations reflect the results of a spreadsheet-based water balance model based on monthly average historical VWRF flows (Stillwater Sciences, 2011), monthly average evaporation rates (VCWPD, 2015), and estimated subsurface flow relationships which were calibrated to a limited set of water levels recorded in the fall of 2014. See Appendix B.

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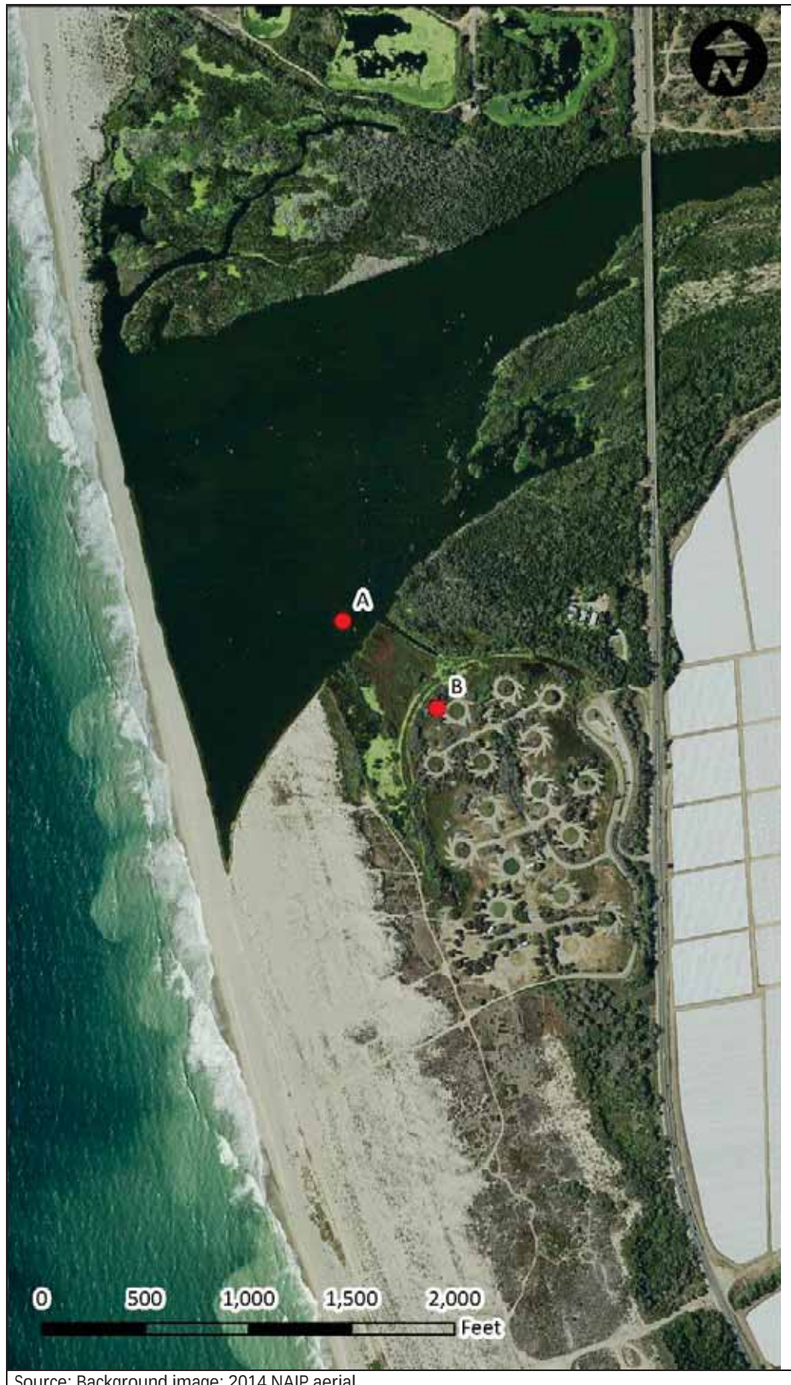
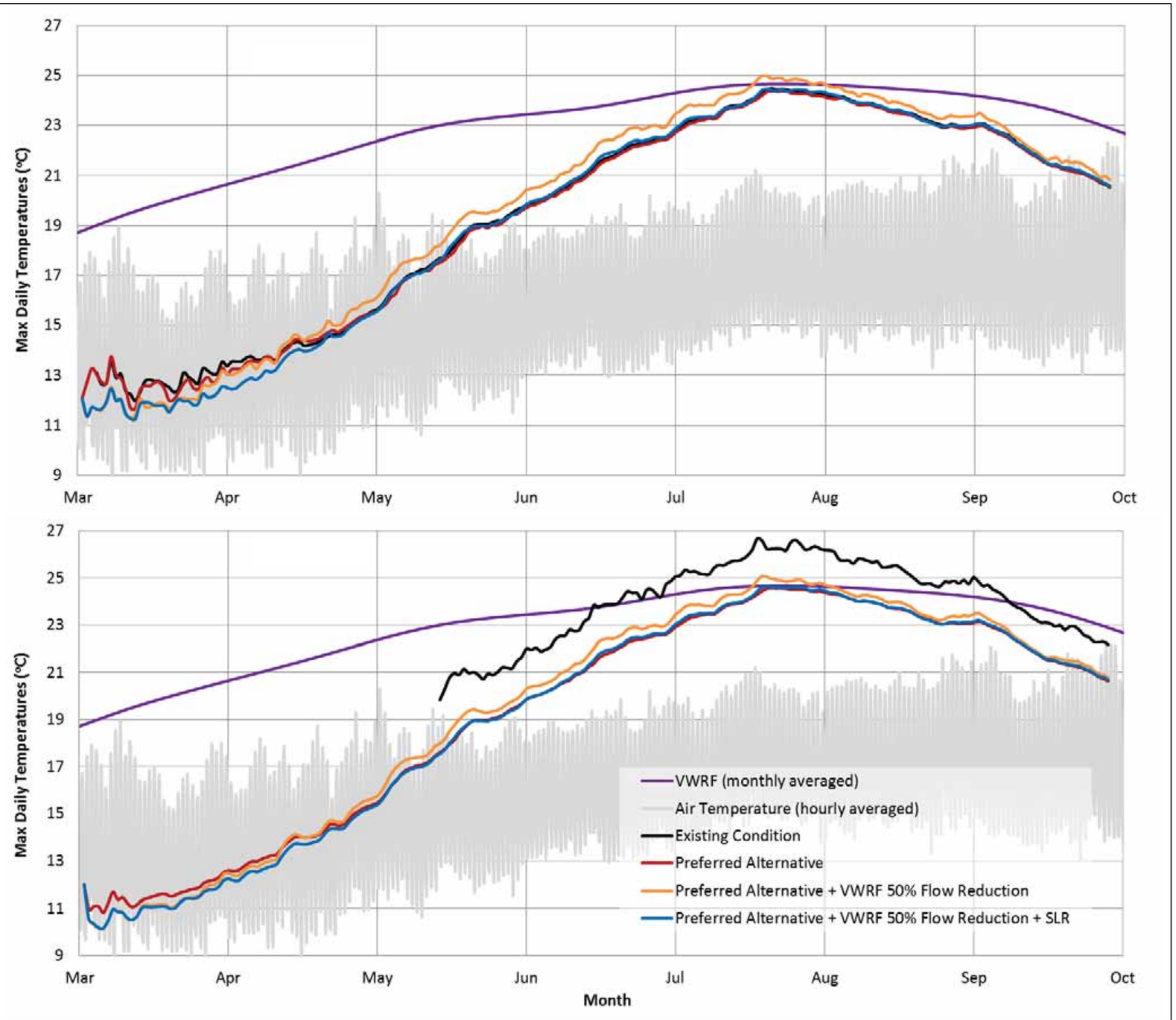
Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Water surface elevations for closed-berm conditions

Project No. 14-1023	Created By: DM	**Figure 25**

C:_WORK\14-1023_SCRE_Feasibility_Study\Reports\FSR (Task 2.2)\FinalFigures\Fig25_WSEClosedBerm.docx
7/27/2015





Source: Background image: 2014 NAIP aerial

Notes: Time series derived from MIKE 21 FM model results. Air temperature data derived from CIMIS #156 station. VWRF temperature data derived from VWRF annual reports (2002-2009).

Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study

Seasonal water temperatures

Project No. 14-1023 | Created By: DT | **Figure 26**

C:_WORK\14-1023_SCRE_Feasibility_Study\Reports\FSR (Task 2.2)\FinalFigures\Fig26_SeasonalWaterTemperature.docx
7/27/2015

6 PREFERRED RESTORATION CONCEPT: HABITAT AND VEGETATION

This section, together with Section 4 and Section 5, provides a detailed description of the Preferred Restoration Concept. Sections 6.1 and 6.2 describe the biological aspects of the enhanced and expanded estuarine, marsh, and riparian habitats created within the Restoration Area of the Preferred Restoration Concept including improved ecological functions, considerations and plans for reestablishing appropriate vegetation, and a discussion of how specific target aquatic species (steelhead and tidewater goby) and other native species will benefit. Section 6.3 includes a discussion of the possible impacts associated with the construction of the project. Section 6.4 discusses restoration habitat resilience in the face of climate change and sea level rise. Finally, Section 6.5 provides potential methods for evaluating the ecological success of the project. This report does not discuss habitat and vegetation considerations or designs for the Mixed Use Area.

6.1 HABITAT DEVELOPMENT

The Restoration Area of the Preferred Restoration Concept focuses on creating expanded and enhanced habitat for endangered steelhead. Although the Preferred Restoration Concept also includes some upland habitat restoration, the primary focus is on the restoration of estuarine habitats by converting the existing marginal habitat within the campground into high-quality estuarine, marsh, and riparian habitats. Due to the combined influence of salt water from the Pacific Ocean and freshwater inputs from the SCR and the VWRF, the habitats proposed in the Restoration Area include elements of both salt marsh and freshwater marsh. The following sections provide more detail on the types and benefits of the habitats (open water, marsh, and riparian) included in the Restoration Area. Two schematic cross sections (see Figure 27) are provided to help illustrate the different habitat types proposed within the Restoration Area.

6.1.1 OPEN WATER

At water levels recently observed during extended closed-berm conditions, the fluvial side channel and the slough channels in the center of the Restoration Area will create an expansive area of open water habitat (see Figure 17). These open water areas will allow for the improved circulation of water within marsh and riparian habitats throughout the Restoration Area as well as increased habitat connectivity with the SCR. This estuarine habitat includes a range of water depths and provides a number of habitat benefits for both steelhead and tidewater goby.

For steelhead, the Restoration Area will result in an increase in available estuarine habitat and greater habitat heterogeneity and will support rearing and migration habitat identified as vital to the recovery of the species. Due to the north-south orientation of the fluvial channel, and the existing and enhanced riparian vegetation lining the feature, greater shading and reduced direct solar input will occur which is anticipated to help provide thermal refugia for smolts occupying the estuary. Wind-driven circulation will help reduce the potential for stagnation and associated water quality deterioration (e.g., low DO), and will promote aquatic habitat suitability for thermally sensitive steelhead. In addition to variable

depths and channel features, the access and rehabilitation of surrounding wetlands will help promote an invertebrate food source.

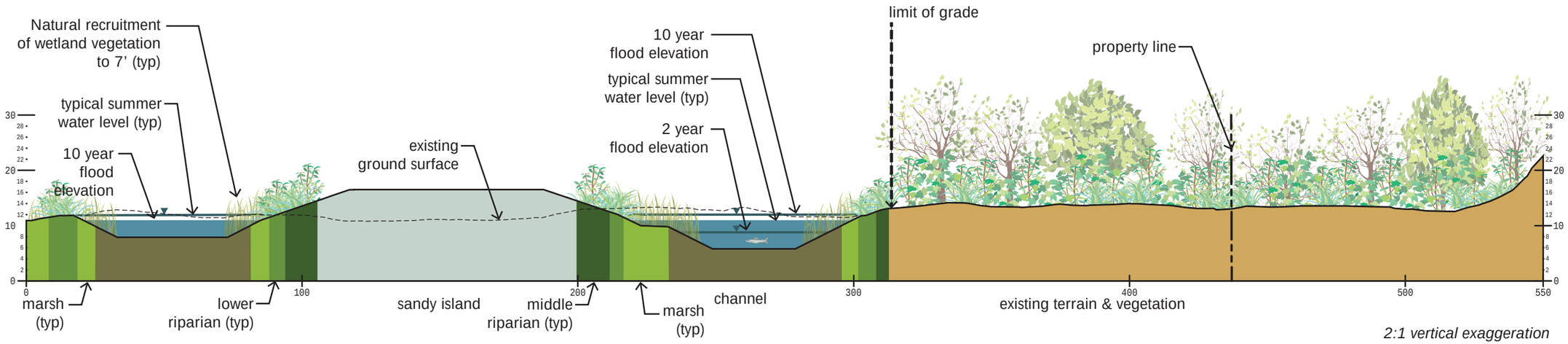
A critical component of estuarine habitat for steelhead is the capability to support the arthropod life-cycle as a food source during juvenile rearing and adult migration (NMFS, 2013). The increased habitat complexity is anticipated to foster a productive benthic and terrestrial invertebrate population. Abundant and diverse invertebrates can help improve juvenile salmonid growth and survival, even under elevated water temperatures that trigger a higher metabolic demand (Jeffres et al., 2008). The new and enhanced aquatic, wetland, and riparian features throughout the Restoration Area, will provide access to a greater range of habitat features, which can promote and improve steelhead rearing and facilitate migration through the system.

During breach events and river runoff events, the Restoration Area will provide additional velocity refugia for juvenile steelhead. Velocity tolerances of juvenile steelhead are generally around 1 fps (Moyle, 2002; USFWS, 1995), and premature ocean entry by juveniles involuntarily swept to sea can result in mortality. Although some low velocity habitat areas are already present within the SCRE under existing conditions, the expansion of such habitat is expected to increase relative survival of juvenile steelhead.

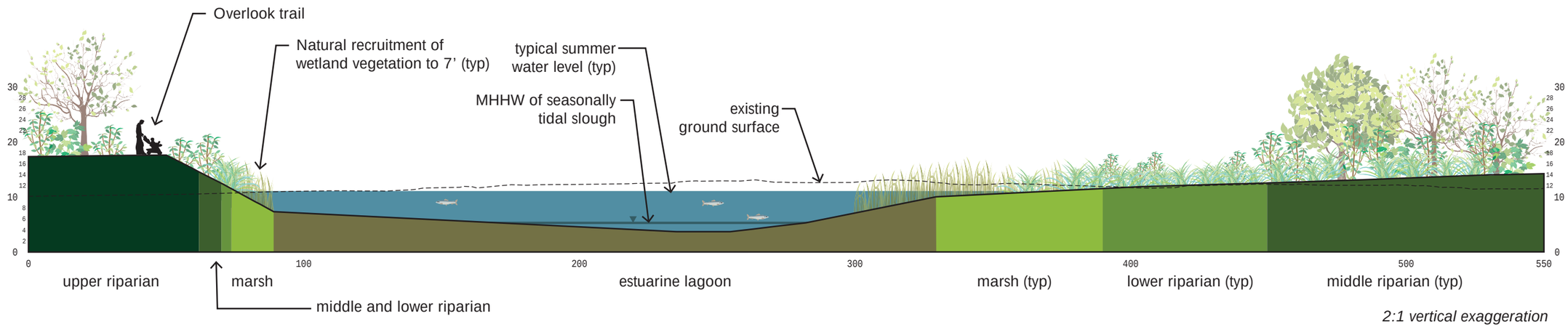
The expanse of open water habitat created within the Restoration Area during closed-berm conditions will also benefit tidewater goby. The replacement of the impervious campground infrastructure with natural estuarine substrate will provide increased spawning and rearing areas for tidewater goby. The increased aquatic habitat will result in an overall increase in habitat for the species, which unlike steelhead, is restricted to the estuary and lower reaches of the SCR. Improving and expanding available habitat in the SCRE is an important component of ensuring population resilience (USFWS, 2005).

During open-mouth conditions, when water levels within the SCRE are several feet lower and heavily influenced by the tide, a more limited amount of open water habitat will be available in the Restoration Area (Figure 16). Under these conditions, the intertidal slough channels will be alternately inundated by high tides and then partially drained at low tides[11]. The slough was designed with gentle slopes to drain from south to north into the main SCRE to reduce the potential for stranding in isolated areas. The introduction of more saline waters to the lagoon feature will create conditions more favorable for tidewater goby. The increased salinity may also exclude or reduce the habitat suitability for non-native and predatory species (such as common carp and centrarchids) currently found in the SCRE, which tend to have lower salinity tolerances. The lagoon and grading design will benefit tidewater goby breeding and refugia. In addition, there will also be an increase in rearing habitat with more suitable aquatic habitat conditions for tidewater goby following restoration compared to the existing flooded campground.

[11] Low sills currently exist at the breach opening and within the western edge of the SCRE lagoon and have been observed to prevent the complete dewatering of the SCRE even at very low tides. The slough channels of the Restoration Area are expected to provide aquatic habitat during open-mouth conditions, but it will be more limited and may be expected to change over time as the SCRE sediments are re-graded by flood events and tidal action. As sea level rise continues the amount of subtidal habitat within the Restoration Area may be anticipated to increase.



SECTION A-A'



SECTION C-C'

CUT LINES ARE SHOWN ON FIGURE 14 AND IN THE PLAN VIEW SHEETS OF THE 30% PLAN SET (APPENDIX F)

Figure 26. Schematic Cross Sections

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Ventura County, California

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6.1.2 MARSH

Surrounding the open water and intertidal habitats created by the slough channels, the Restoration Area includes a band of marsh habitats developed to mimic the existing, high-quality marsh conditions observed at some locations within the Project Area. The Restoration Area also features a large central marsh and riparian habitat island within the arms of the slough channels. The central and periphery marsh habitats were developed to include a range of marsh elevations to provide a depth of inundation or period of saturation sufficient to support emergent vegetation and to encourage the development of a range of microhabitats within the larger marsh complex. The restored marsh habitat will increase primary production and provide habitat and food for a wide range of aquatic species at multiple trophic levels.

The restoration approach focuses on creating a range of marsh elevations with shallow transition zones to allow for the development of diverse marsh vegetation and to allow upward migration of marsh habitat with sea level rise or downward migration of marsh habitat with VWRF discharge reduction or other changes to the hydrologic regime of the estuary. It is expected that the exact composition and distribution of marsh vegetation will change over time in-line with the natural variation inherent in this type of dynamic system.

The restored marsh habitats are anticipated to increase the water quality functions of the estuary by providing an increased wetland area for filtering of potential stormwater runoff entering the estuary from Harbor Blvd, from the relocated campground, and from other upstream sources.

6.1.3 RIPARIAN

The Preferred Restoration Concept was developed to preserve and enhance existing established riparian habitats while also creating a variety of new riparian habitats. Within the Restoration Area, riparian habitat is proposed for the southern and eastern periphery of the marsh, the higher elevations of the central marsh island, and lining the sides of the fluvial side channels.

Riparian habitat provides important nesting and foraging habitat for many of the avian species utilizing the SCRE. Native and migratory species of birds rely on the SCRE for key components of their life cycle, including the imperiled southwestern willow flycatcher and least bell's vireo which have the potential to occur in the Project Area. The Preferred Restoration Concept will increase the quality and acreage of riparian habitats in the SCRE and provide heterogeneous habitat areas that integrate wetland, riparian, and open water areas. Additionally, riparian vegetation can form an important link between the aquatic and terrestrial ecosystem by providing coarse organic material that supports invertebrate production. As previously noted, an abundant invertebrate food source is essential to the growth and survival of juvenile steelhead occurring in the estuary, especially during times of elevated water temperatures.

By encircling the open water habitats and marsh habitats with a thick band of riparian vegetation, the Preferred Restoration Concept provides an important physical and visual buffer between the Mixed Use Area and the Restoration Area, improving the quality of the habitat for waterfowl and other birds.

6.2 RESTORATION PLANTING PLAN AND APPROACH

This section describes the planting plan developed for the Restoration Area of the Preferred Restoration Concept (see Figure 27 and the 30% planting plan design plans included in Appendix F). This section also includes a description of the various design considerations that influenced the design of the Restoration Area including design elevations, culturally important and native vegetation species, habitat creation, visual screening, invasive plant species management, horticultural soil suitability, and species water needs/irrigation requirements.

6.2.1 PLANTING APPROACH

In addition to the historically mapped habitat types as shown in Figure 4 (Beller et al., 2011) which offer some clues about the vegetation that may have existed historically, the approach to developing the planting plan for the Preferred Restoration Concept was also informed by a number of general considerations based on lessons from similar restoration projects, the present day hydrologic regime of the estuary, and the distribution of desirable biological communities observed in the SCRE. These considerations are discussed in more detail below to provide additional support and rationale for the planting plans. As concepts are advanced beyond the 30% level, additional refinement of the planting plan is expected.

As the ecological functioning of estuary systems like the SCRE comes largely from the dominant species (as opposed to the handful of rare or otherwise unique species), the restoration approach used for the Project focused on creating the base vegetation (i.e., dominants). While additional species will colonize the site over time to slowly create a more floristically diverse site, the first goal of the planting plan is to quickly (i.e., as soon as possible after site grading is completed) establish a robust marsh and riparian woodland complex with adequate ecological functions.

A handful of rare or otherwise unique and protected species (e.g., Ventura marsh milk vetch and a variety of *Atriplex* species) may have occurred at the site historically and could, eventually, be considered for re-establishment in the marsh and dunes, but including them in the planting plan at this preliminary stage is potentially problematic for a number of reasons:

- Once these species become established they will be subject to regulatory projection which could put restrictions on the types of adaptive management activities that could be undertaken at the site.
- Additional scientific collection/research permits would be required to collect the propagules needed for establishing these plants at the site. While this may be desirable at a later phase of the project, it would bring additional permitting and monitoring requirements. Considering the objective of the grant, this could be viewed as a limiting factor at this stage of the process. It is entirely possible to conduct additional rare plant restoration work at a later time, preferably after the initial large scale restoration effort is complete.

The restoration approach was also based on an understanding of the current ecological drivers at the site, while also anticipating potential changes in these drivers due to climate change and other factors. While at first glance it may seem reasonable to attempt to recreate an historically accurate mix of plant communities, the underlying ecological and hydrological drivers that maintained historical vegetation conditions are no longer present and current hydrological conditions are not necessarily anticipated to support the full range of the historically mapped vegetation communities. Historical vegetation patterns also suggest the SCRE was a dynamic, changing landscape with successions of different vegetative communities based on evolving flood and inundation patterns.

6.2.2 FIELD SURVEYS

The wetland planting plan developed for the Restoration Area of the Preferred Restoration Concept is supported by two, targeted field surveys which were completed for the Project including a plant elevation survey and a suite of soil sample analyses for horticultural suitability. This section describes the primary considerations for the Preferred Restoration Concept that resulted from these field efforts. Detailed soil testing results are provided in Appendix G.

Plant Elevation Survey

Wetland plant species will generally colonize a marsh based on the long-term average water levels. Similarly, the development of estuarine riparian vegetation is often driven largely by proximity to the surface water feature and/or the depth to the groundwater. To support the development of a planting plan for the Preferred Restoration Concept, the Project included a plant elevation survey to determine the elevations at which target plants (both native and invasive) are currently growing within the SCRE (Figure 28 and Table 3). This information was useful in the design of the site grading (Section 4) and directly influenced the elevation ranges and species proposed for the re-vegetation of the Restoration Area.

Though plants were observed within the SCRE at elevations as low as 7.5 ft, the planting plan focused on elevations near the recently observed water levels within the estuary because newly planted container plants can drown when flooded to depths greater than 6 to 12 inches.

Horticultural Soil Sampling

In addition to the plant elevation survey, soil samples from the top 18 inches of existing soil from five locations across the site (Figure 29) were evaluated for the potential to support newly planted vegetation.

Transitional marsh species are salt tolerant. Some salinity in the topsoil is desirable to inhibit potential for weed invasion; however, high salinity will inhibit all vegetation. Organic content provides nutrient availability and water holding capacity. The texture of a soil is another indicator of water holding capacity and nutrient content, with finer soils having more potential nutrients and water holding capacity. Soils with the following characteristics are most desirable for salvage and placement in the transitional marsh areas:

- Salinity level below 20 dS/m
- Organic content between 1.5% and 10%
- Loamy sand to silt loam texture

Table 3 — Observed and proposed planting elevations

Target Species	Common Name	Mean Observed Range	Proposed Planting
Marsh Plants			
Anemopsis californica	Yerba mansa	n/a	10.5 – 11.0
Bolboschoenus maritimus	Alkali bulrush	7.5 – 10.8	10.0 – 11.0
Distichlis spicata	Salt grass	10.9 – 12.5	11.0 – 12.5
Schoenoplectus acutus	Common tule	7.5 – 11.5	10.0 – 11.0
Transitional Marsh			
Frankenia salina	Alkali heath	11.3 – 12.6	11.5 - 12.5
Distichlis spicata	Salt grass	10.9 – 12.5	11.0 – 12.5
Jaumea carnosa	Jaumea	11.2 – 11.9	11.0 – 12.0
Salicornia pacifica	Pickleweed	11.2 – 12.2	11.0 – 12.0
Riparian			
Artemisia douglasiana	Mugwort	n/a	11.5 – 16.0
Atriplex lentiformis	Big Saltbush	n/a	Above 14.0
*Baccharis glutinosa**	Marsh baccharis	11.9 – 12.5	11.5 – 16.0
Salix lasiolepis	Arroyo Willow	10.4 – 13.4	11.5 – 14.0
*Baccharis salicifolia**	Mulefat	n/a – 17.0	13.0 – 19.0
Species to Discourage			
Arundo donax	Giant Reed	7.5 – 11.0	-
Typha sp.	Cattail	10.7 – 12.1	-

Notes: Elevations provided in ft (NAVD88) *limited data.
Proposed planting ranges are limited to elevations above 10 ft to reduce the potential for plant drowning (see Section 6.2.2).

The results of the soil analysis show that sample site 2 had no significant chemistry or texture concerns. Top soil from a depth of up to 18 inches in this area should be prioritized for salvage. Topsoil from sample site 4 could also be used. While salinity is somewhat higher than sample site 2 at 6.3 dS/m, this is not expected to inhibit growth in the proposed salt tolerant transitional marsh species.

In other soil sampling areas, two primary constituents were evident that could inhibit plant establishment: salinity and boron. Soil samples taken at sites 1, 3 and 5, in particular (Figure 29) show elevated levels of salinity, sodium, and boron. Topsoil salvage from these areas should be avoided because it is likely to inhibit plant growth.

Site 5, in particular, has elevated salinity above 30 dS/m. While this is the highest observed salinity value found on-site, this level does not exceed salinity levels found in natural tidal marsh and transitional marsh zones along the California coast (Moffett, 2010). However, young transitional marsh plants are more sensitive to high salinity conditions. Natural establishment of new marsh vegetation likely occurs during an influx of freshwater during the rainy season. Therefore, high salinity soils over 20 dS/m should be avoided, and lower salinity soils should be prioritized for salvage.

Other areas designated for planting will not require topsoil placement; however, it is recommended that the soil be amended with compost to enhance fertility and water holding capacity of the exposed sub soils. Existing soils are expected to have very low organic content. Therefore, except for the marsh areas in which plants can grow in sand with very little organic content, compost amendment is recommended to be applied in the riparian and transitional marsh areas per the soil lab's recommended rates.

6.2.3 MARSH PLANTS

The plant elevation survey found that most marsh plants within the Project Area tend to colonize the areas between approximately 7.5 ft and 12.5 ft with the invasive giant reed observed as low as 7.5 ft.

Newly planted marsh vegetation generally requires an establishment period of at least three months before it can survive inundation in water deeper than 12 inches. To reduce the potential for plant drowning during the first year, the restoration planting plan for the Restoration Area is limited to areas above a finished elevation of 10 ft (corresponding to a water depth of approximately 1 ft with water levels at those recently observed during extended closed-berm conditions). Once established, marsh plants are expected to begin to colonizing down slope into deeper waters.

The planting plans for the marsh areas within the Restoration Area were developed using the species composition observed in existing marsh habitat at similar elevations in the Project Area. The marsh will feature broad vegetation zones, with species such as hardstem bulrush (*Schoenoplectus acutus*) and alkali bulrush (*Bolboschoenus maritimus*) forming an inner band of vegetation in the lower marsh and low-growing, salt-tolerant species, such as salt grass, dominating the mid- and upper marsh. It is not anticipated that these species will require any special soil treatment or over-excavation.

6.2.4 TRANSITIONAL MARSH PLANTS

Transitional marsh species included in the Preferred Restoration Concept include alkali heath (*Frankenia salina*), saltgrass (*Distichlis spicata*), jaumea (*Jaumea carnosa*), and pickleweed (*Salicornia pacifica).* Within the Project Area, these species were observed to grow at elevations from approximately 11 ft to 12.5 ft in relatively open areas without riparian trees. These species and elevations are recommended for transitional marsh areas along the southern periphery of the Restoration Area (see Table 3). These species are more salt tolerant but do require finer textured soils. As the soil at the design grade may not provide suitable soil conditions, over-excavation and the salvaging and placement of conditioned topsoil is recommended in the transitional marsh areas (see the 30% design plans in Appendix F).

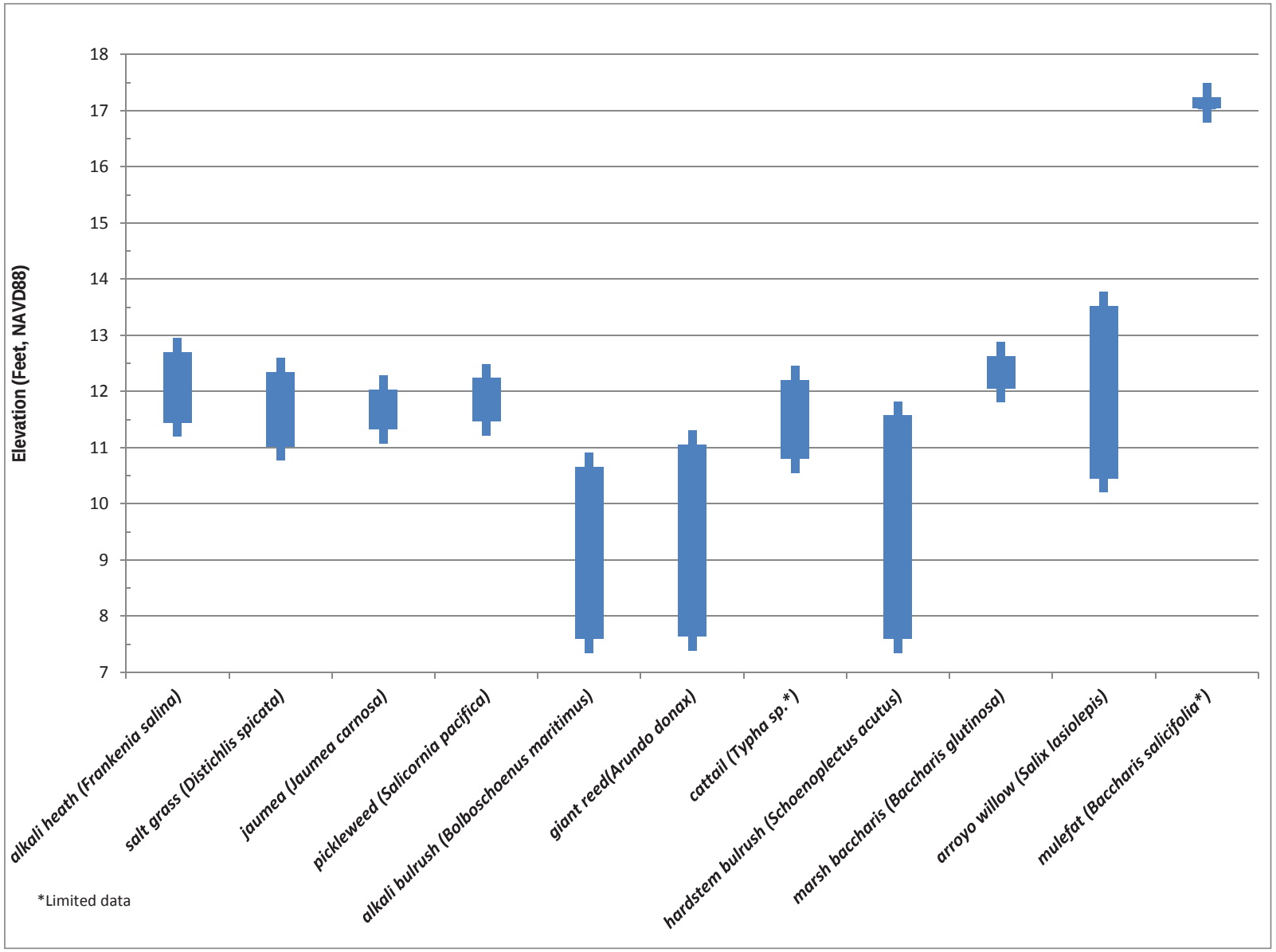

Figure 28. Plant Elevation Survey

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Ventura County, California

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Date: May 2015
Source: MS, TH

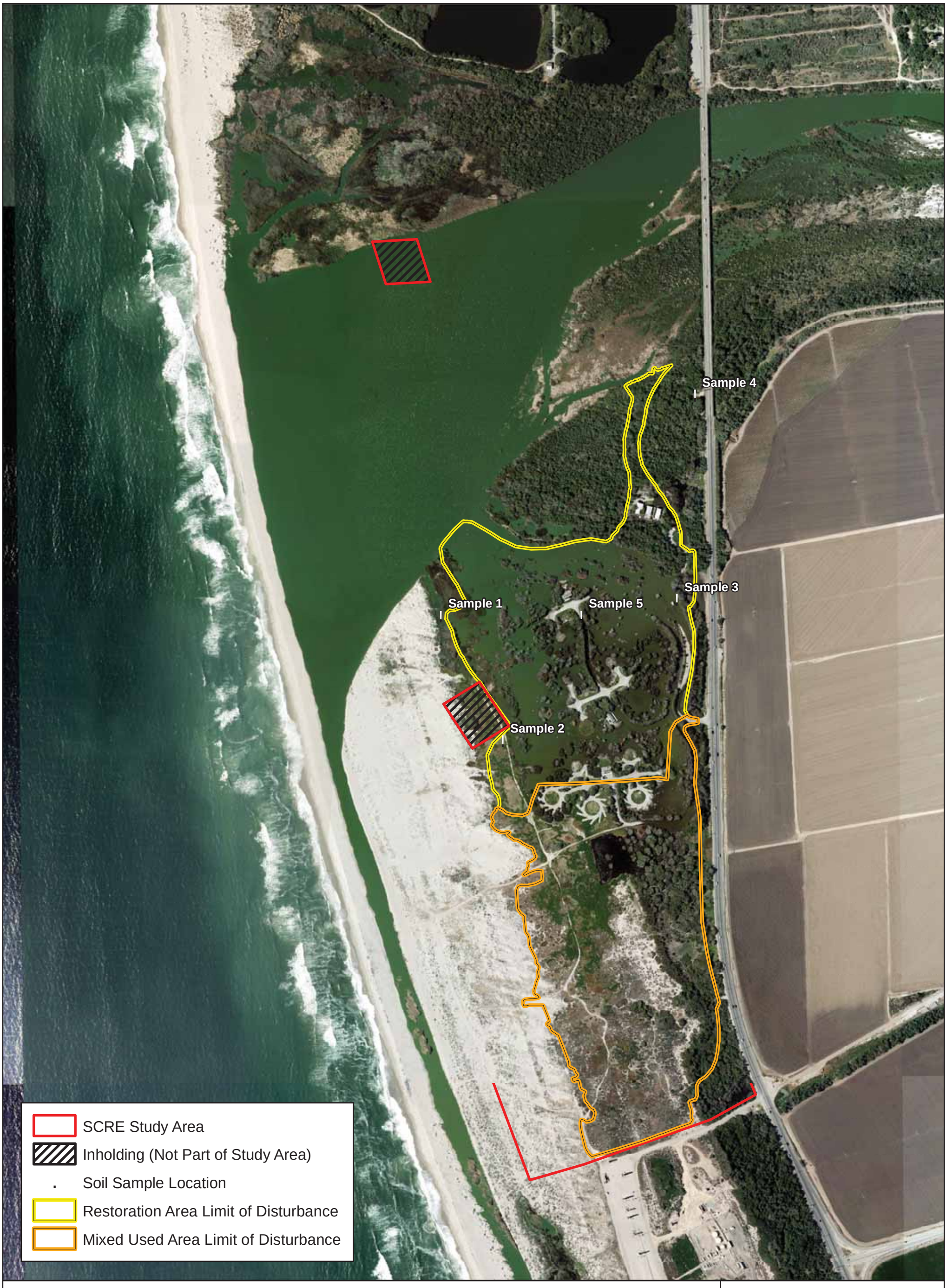

Figure 29. Soil Sample Locations

Santa Clara River Estuary
Ventura County, California

0 250 500 1,000 Feet
1 Inch = 500 Feet

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Map By: SG
Date: May 2015
Base Source: USGS April 2013

Path: L:\Acad 2000 Files\18000\18106-2\GIS\ArcMap\FigX_SoilSample.mxd

6.2.5 RIPARIAN PLANTS

As with the marsh planting, restored riparian habitat zones within the Restoration Area were designed with a range of suitable elevations to promote the development of diverse and appropriate riparian vegetation (see Table 3). The planting palette for the riparian areas of the Restoration Area features three riparian zones: upper, mid, and lower and will be dominated by a mix of woody and herbaceous native species, which follow the composition observed in existing quality riparian habitats in the SCRE. Species include arroyo willow, mule fat (*Baccharis salicifolia*), marsh baccharis (*B. glutinosa*), mugwort (*Artemisia douglasiana*), big saltbush (*Atriplex lentiformis*), and black cottonwood (*Populus trichocarpa*).

Areas slated for riparian trees and shrubs include the higher elevations of the central marsh island, the elevated areas along the southern periphery of the Restoration Area, and along the eastern border. Trees and shrubs will be planted more densely along the edge of the entrance road to provide separation between the marsh and development and to block headlights from penetrating into the marsh.

To ensure establishment and survival, newly planted shrubs and trees will need to have access to groundwater or they will need to be irrigated. Though groundwater levels fluctuate seasonally with changes in the water levels of the SCRE, water levels during extended closed-berm conditions have been around 11 ft. Willows and shrubs planted above an elevation of 13 ft are unlikely to be planted deeply enough to allow the roots access to groundwater. Riparian areas within the Restoration Area (including the central island) above an elevation of 13 ft will most likely need to be irrigated.

6.2.6 IRRIGATION

Irrigation will not be necessary to establish marsh plants, however, timing of installation will be an important consideration. Marsh plants will need to be installed when the marsh is dry to allow for access. Temporary hand watering may be necessary prior to breaching the marsh and letting water return to the Restoration Area. If the water level at the time of installation is lower than approximately 10.5 ft, supplemental watering of marsh plants may need to continue until the water level returns to its expected normal summer elevation of 11 ft.

As mentioned above, trees and shrubs that are installed above elevation 13 ft will most likely require supplemental irrigation for at least one year and up to three years if significant plant replacement is required. Options for supplemental irrigation include hand watering from a water truck, installing biodegradable gel packs, and a hard pipe irrigation system. A hard pipe irrigation system is the most cost-effective solution because it provides the best establishment success for plants for the lowest price. The irrigation plans (Appendix F) show the layout of the irrigation mainline to the riparian planting zone, including the elevated areas of the central island complex.

6.2.7 INVASIVE SPECIES

The planting plans for the Preferred Restoration Concept reflect a number of measures aimed at reducing the potential for giant reed colonization within the Restoration Area. Within the surveyed elevation range where giant reed colonies have been observed, the planting plans call for densely planted marsh plants bordered with dense riparian tree plantings to shade out giant reed. Benches along the fluvial channels were designed so that they could be densely planted immediately with native plants including tules (*Schoenoplectus acutus*), and alkali bulrush (*Bolboschoenus maritimus).*

During construction, control of new or established stands of giant reed should be accomplished through mechanical removal of all plant parts, including roots and culms, and/or through careful application of a suitable herbicide. After construction, giant reed management should be a primary component of an adaptive management program (see also Section 6.5). The management period is expected to be at least 10 to 15 years before elimination is possible. If nearby and upstream sources of new giant reed are not also controlled, the management period could extend indefinitely.

6.3 PROJECT IMPACTS

While the Preferred Restoration Concept was specifically developed to improve and expand habitat for steelhead and other native species and biological communities, construction of the project has the potential to result in temporary and/or permanent impacts to protected sensitive wetland and upland communities as well as to rare plants and special-status animals. These potential impacts are discussed in the following sections.

6.3.1 WETLANDS, WATERS, AND RIPARIAN AREAS

The Preferred Restoration Concept proposes to remove the existing pavement and structures from the Restoration Area and to replace the disturbed, low-quality, fragmented wetlands of the graded and frequently disturbed campground area with contiguous natural high-quality wetlands. However, the Preferred Restoration Concept will have temporary and permanent impacts to existing wetland and riparian habitats. Although the restoration will result in an overall increase in wetland and riparian habitat, there will be a redistribution of these habitats, with the conversion of wetland types (e.g., from seasonal wetland to freshwater marsh) and conversion of wetland areas to riparian habitat and vice versa. Wetland and riparian habitats are regulated by multiple natural resource agencies. To inform the feasibility of the Preferred Restoration Concept, a detailed accounting of temporary and permanent impacts, including changes in acreage between wetland types and riparian habitat is included below. Potential impacts to sensitive upland habitats are discussed in Section 6.3.2

At present, the Project Area is estimated to contain approximately 166 acres of wetland and non-wetland waters features (Figure 30) regulated by one or more resource agency including the Corps,

LARWQCB, and CCC. Following construction of the Preferred Restoration Concept, the Project Area[12] is expected to contain approximately 173 acres of wetland and non-wetland waters features (Figure 31), which is an increase of approximately 7 acres. Table 4 provides a summary of pre- and post-construction acreages of areas subject to jurisdiction by the Corps under Section 404 of the Clean Water Act, by the LARWQCB under Section 401 of the Clean Water Act and the Porter-Cologne Act, and by the CCC under the California Coastal Act. At present, the Project Area contains approximately 35 acres of riparian habitat regulated by the CDFW (as well as by the LARWQCB and the CCC; Figure 32). Post-construction, the Project Area is expected to contain approximately 41 acres of riparian habitat, which is a net increase of approximately 6 acres (Figure 33). Table 5 provides a summary of pre- and post-construction acreages of riparian habitat subject to CDFW jurisdiction under the California Fish and Game Code, as well as jurisdiction by the CCC and LARWQCB. In addition to an increase in the overall acreage of wetland and riparian habitats, the restoration will enhance existing areas of wetland and riparian habitat to be retained. Enhancement activities may include removal of invasive weeds such as giant reed and/or planting of native riparian species.

Table 4 — Pre- and post-construction acreages of Corps Section 404, LARWQCB Section 401, and CCC jurisdictional features

	Feature Type	Pre-Construction Area (Acres)	Post-Construction Area (Acres)	Change in Area (Acres)
Section 404/401 and CCC Jurisdiction	Non-Wetland Waters	69.46	85.13	+15.67
	Freshwater Marsh	37.60	46.56	+8.96
	Scrub-Shrub Wetland	37.04	31.14	-5.9
	Seasonal Wetland	1.19	0.08	-1.11
	Disturbed Wetland	19.29	0.00	-19.29
Additional CCC Jurisdiction	Scrub-Shrub Wetland	0.00	10.05	+10.05
	Seasonal Wetland	0.35	0.02	-0.33
	Disturbed Wetland	0.99	0.00	-0.99
	Total	165.92	172.98	+7.06

Table 5 — Pre- and post-construction acreages of riparian habitat

Feature Type	Pre-Construction Area (Acres)	Post-Construction Area (Acres)	Change in Area (Acres)
Riparian Scrub	34.70	40.68	+5.98
Total	34.70	40.68	+5.98

[12] Additional wetland and riparian habitat may be created by the Mixed Use Area as the plans are developed further. The acreage calculations include the impacts of the entire Preferred Restoration Concept but benefit calculations are limited to just the Restoration Area.

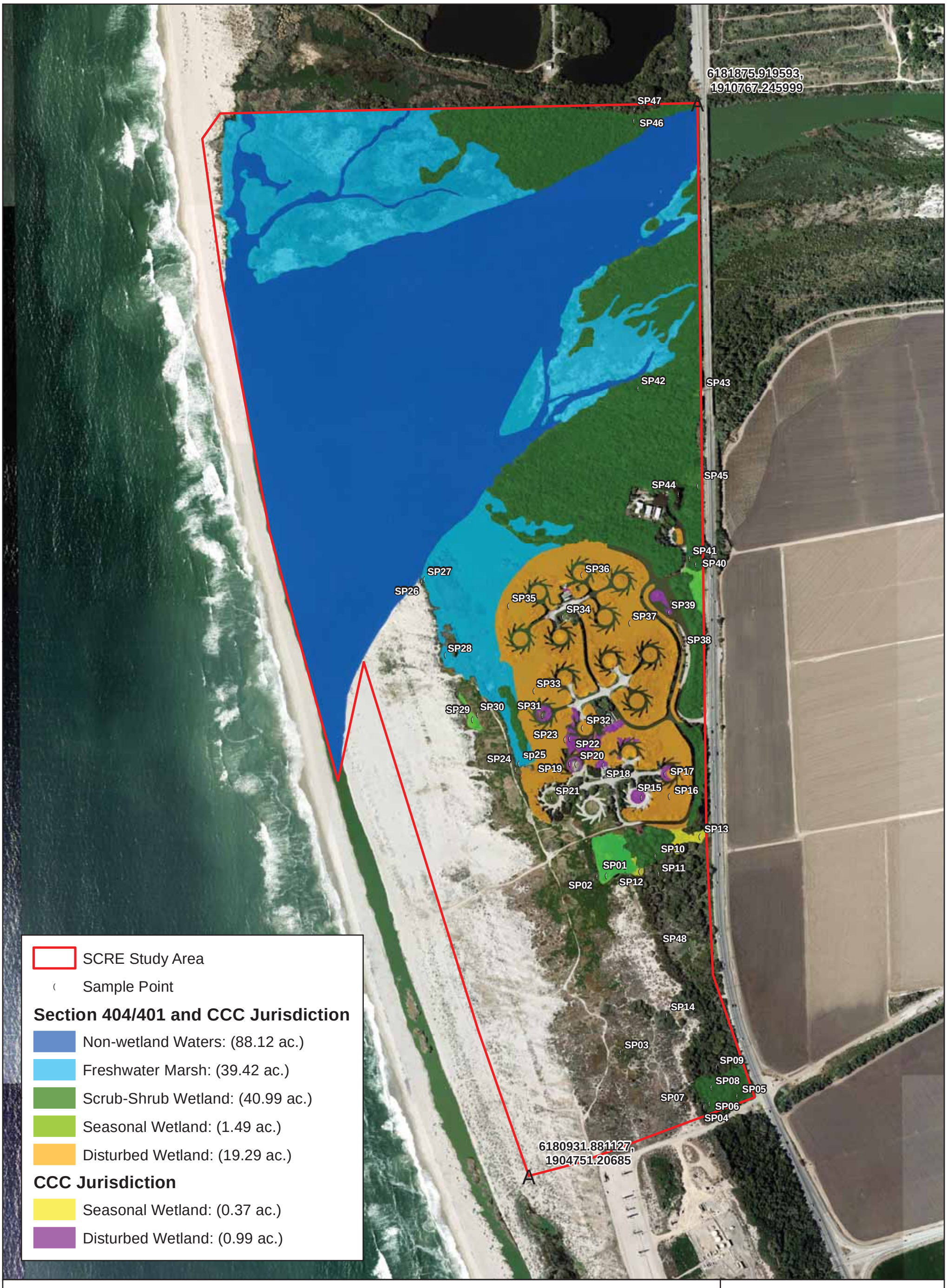

Figure 30. Corps (404), RWQCB (401), and CCC Jurisdictional Features within the Study Area

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Santa Clara River Estuary
Ventura County, California

0 250 500 1,000 Feet
1 Inch = 500 Feet

Map By: SG
Date: Novemebr 2014
Base Source: USGS April 2013

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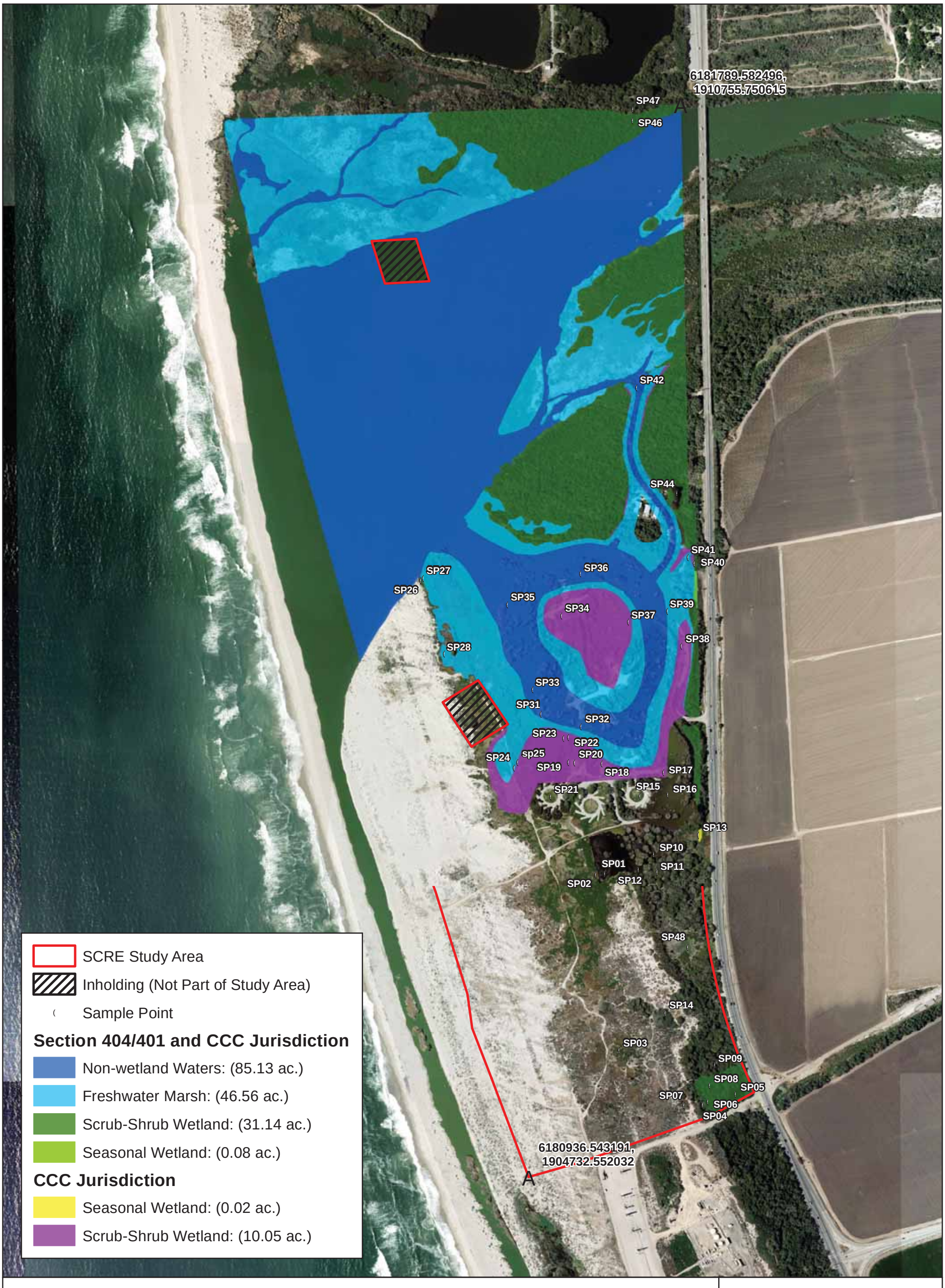

Figure 31. Post-Construction Corps (404), RWQCB (401), and CCC Jurisdictional Features within the Study Area

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Santa Clara River Estuary
Ventura County, California

0 250 500 1,000 Feet
1 Inch = 500 Feet

Map By: SG
Date: May 2015
Base Source: USGS April 2013

Path: L:\Acad 2000 Files\18000\18106-2\GIS\ArcMap\FigX_PostCon_CorpsCCCDelin_20150511.mxd

Figure 32. CDFW Jurisdictional Features within the Study Area

Santa Clara River Estuary
Ventura County, California

0 250 500 1,000
Feet
1 Inch = 500 Feet

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Map By: SG
Date: Novemebr 2014
Base Source: USGS April 2013

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6181789.582496,
1910755.750615

A

6180936.543191,
1904732.552032

A

SCRE Study Area

Inholding (Not Part of Study Area)

Non-wetland Waters: (85.13 ac.)

Freshwater Marsh: (46.56 ac.)

Willow Riparian Scrub: (40.68 ac.)

Figure 33. Post-construction CDFW Jurisdictional Features within the Study Area

Santa Clara River Estuary
Ventura County, California

0 250 500 1,000 Feet

1 Inch = 500 Feet

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ENVIRONMENTAL CONSULTANTS

Map By: SG
Date: Novemebr 2014
Base Source: USGS April 2013

Path: L:\Acad 2000 Files\18000\18106-2\GIS\ArcMap\FigX_PostCon_CDFWDelin_20150511.mxd

6.3.2 SENSITIVE TERRESTRIAL COMMUNITIES

The majority of the terrestrial communities (i.e., non-wetland/waters, non-riparian) in the Project Area occur to the west of the existing campground in the foredunes or to the south of the campground, in the Mixed Use Area. The foredunes running along the western edge of the Project Area are of relatively high quality and dominated by native dune plants. Habitat within the Mixed Use Area was historically disturbed for oil exploration and continues to reflect this disturbance today. Terrestrial communities in the Mixed Use Area contain minimal topography and are predominantly characterized by invasive plant species.

Two sensitive terrestrial communities—dune mat and black cottonwood forest—occur in the Project Area. Dune mat vegetation occurs along the intact foredunes along the western edge of the Project Area. This habitat has high potential to support rare plant and wildlife species and provides high function and value. As such, the project will protect and preserve all intact foredune habitat on the site.

A small stand of black cottonwood forest is present in the eastern side of the Mixed Use Area footprint. Black cottonwood forest is usually associated with riparian habitats; however, this stand occurs on a sandy berm, disassociated from any apparent surface water sources. The black cottonwood forest vegetation alliance has a ranking of S3, which is defined as "vulnerable" (Sawyer et al., 2009), presumably in association with the loss of riparian habitat statewide. However, due to its small size (0.49 acre) and disassociation with riparian habitat, this stand provides little function and value and it is assumed that any impacts to this stand will be compensated through the increased acreage of riparian habitat expected to develop post-restoration. For these reasons, impacts to this low-quality stand should not be considered significant. Table 6 provides a summary of pre- and post-construction acreages of sensitive terrestrial communities in the Project area.

Table 6 — Pre- and post-construction acreages of sensitive terrestrial communities

Feature Type	Pre-Construction Area (Acres)	Post-Construction Area (Acres)	Change in Area (Acres)
Dune Mat	32.76	32.76	0
Black Cottonwood Forest	0.49	0	-0.49

6.3.3 SPECIAL-STATUS PLANT SPECIES

Through the fieldwork conducted for the Project, it was determined that 19 special-status plant species have moderate to high potential to occur within the Project Area (see detailed list in the ECTR). Four of these species (red sand verbena, coast dudleya, sand dune sedge, and fragrant flatsedge), all rated as Locally Important in Ventura County, were observed during late-season surveys within the Project Area. Red sand verbena occurred in the foredune habitat to the west. Given that the foredunes will be protected and preserved, it is assumed that the restoration will not adversely impact this species. The other three species occur within the proposed Restoration Area and Mixed Use Area footprints. Fragrant flatsedge was observed in disturbed wetland habitat in the Restoration Area footprint and coast dudleya

and sand dune sedge were observed in disturbed upland habitat within the Mixed Use Area footprint. Although these species are not necessarily rare, they may be important at a local level and are therefore subject to special consideration under the CEQA. Appropriate mitigation plans will need to be developed for impacts to these species, which may include the collection of seed or other propagules to be replanted in suitable habitat post-restoration.

The remaining 15 special-status plant species determined to have potential to occur within the Project Area are primarily associated with sandy dune habitat or marsh habitat and are therefore expected to occur primarily in the foredunes along the western portion of the site or in the marsh habitat at the northern end of the campground and along the margins of the SCR. Early and mid-season rare plant surveys are recommended for the additional 15 species determined to have potential to occur within the project footprint. If additional special-status plant species are found, suitable propagation and/or relocation plans will need to be developed on a species-by-species basis.

6.3.4 SPECIAL-STATUS ANIMALS

As identified in the ECTR, over 50 different special-status animals have been observed in or have the potential to occur within the SCRE. The restoration is anticipated to result in an increase in habitat for special-status animals in the SCRE; however, there will be temporary impacts associated with construction activities including anticipated dewatering, excavation, and fill placement. The Restoration Area will result in an increase in higher quality habitat for aquatic species, including steelhead and tidewater goby, and increased foraging areas for avian species, such as California least tern. Additionally, marsh and riparian vegetation enhancement will add habitat complexity for the SCRE, thereby providing a diverse range of avian nesting substrates and foraging areas.

The timing and duration of construction activities required for the restoration will determine the extent and magnitude of impacts to special-status animals, including sensitive life stages of breeding and juvenile rearing. Careful analysis of impacts to each special-status animal occurring in the SCRE will be required when the final restoration footprint, project description, and construction approach are determined.

While impacts are anticipated for many of the habitat types present, foredune habitat will be avoided during restoration activities. There is no expected loss or impact anticipated to species relying on this rare habitat feature, which provides nesting for western snowy plover and represents all habitat needs for silver legless lizard and globose dune beetle. The placement of fill will occur within the Mixed Use Area which is primarily degraded non-native vegetation communities, and is not anticipated to result in a loss of habitat features to special-status animals.

6.4 CLIMATE CHANGE, RESTORATION RESILIENCE, AND UNCERTAINTY

The potential local effects of global climate change are uncertain. Guidance for addressing climate change in habitat and vegetation restoration planning typically focuses on restoration resilience and adaptive capacity, or the ability of the system to change in response to changing climatic conditions. As

a result, most planning is focused on the effects of rising sea levels (OPC, 2013; CDFW, 2011; State Coastal Conservancy, 2011; CCC, 2011). The Restoration Area of the Preferred Restoration Concept incorporates several physical elements that are anticipated to help the vegetation evolve in response to variable estuary water levels including sea level rise. Vegetation and habitat planning within the Restoration Area of the Preferred Restoration Concept were designed with the current hydrology in mind.

Fundamental to the restoration design is the concept of a gradual transition between wetland and upland areas, with the intent that broad transitional slopes will allow tidal marsh and transitional habitats to persist, even as sea level rises, by shifting landward to higher elevations. Marsh vegetation reproduces and spreads relatively rapidly, and will therefore likely be able to move up-slope with a gradual rise in sea level. Salinity may also change with sea level rise and could result in changes to the vegetation community. While the overall extent of habitats may decrease, or change in configuration, the broad transitional zones are anticipated to continue to provide space for a variety of habitats (and the wildlife that rely on them).

Additional considerations for the design included potential changes in the VWRF discharge rates which would bring about a more rapid change in estuary water levels during closed-berm conditions. A sudden and prolonged lowering of the marsh water level could leave large areas of the marsh in a drought condition. Vegetation would likely shift downward in this condition. While native recolonization is expected under this scenario, there is potential for colonization by invasive species such as giant reed in new areas of the marsh. If new colonies of giant reed began to invade, management activities would need to be initiated to reduce giant reed dominance in the Restoration Area. Long-term, vegetation will adapt on its own to these changes in hydrology.

Development of an adaptive management plan will be essential for ensuring the successful achievement of restoration goals and objectives for the SCRE. Performance criteria will need to be developed to evaluate monitoring data and to provide triggers for adaptive management actions that ensure the long-term success of the restoration.

6.5 MEASURING AND MANAGING SUCCESS

The SCRE is a naturally dynamic system that adjusts to changing conditions from season to season and year to year. Seasonal variations in vegetation occur with the ebb and flow of floodwaters. Annual variations occur in response to major storm events that redistribute sediment and plant propagules within the estuary, often resulting in drastic changes. The inherent dynamism of the SCRE system poses challenges to designing and implementing a successful restoration and requires some level of comfort with uncertainties in the progress of the restoration. Whereas many restoration efforts focus on creating specific acreages of specific communities, the Preferred Restoration Concept aims to restore the ecological drivers of a natural estuarine system with the overall goal of creating a diverse wetland-riparian mosaic with increased functions and values relative to the existing degraded habitat within the campground footprint.

To allow for uncertainties in the development of the restoration, a robust adaptive management program should be implemented. Adaptive management is an iterative process whereby restoration practices are guided by best available technologies and hypothesis testing followed by implementation and monitoring to evaluate results. This approach allows for restoration and management under changing conditions and with uncertainties in the course of habitat development. Adaptive management involves six primary steps: (1) research and planning, (2) design, (3) implementation, (4) monitoring, (5) evaluation, and (6) modification or adaptation. Most importantly, adaptive management is a reflective process in which management actions are continuously monitored and evaluated and necessary changes in management are planned and implemented, followed by continued monitoring and evaluation.

As part of the adaptive management program, it will be critical to develop measurable and attainable goals but to also understand that static goals may not be compatible with the dynamic nature of the SCRE. The progress of the restoration should be measured based on indicators of habitat development, species composition, and ecosystem function. The restoration should be considered successful if an overall increase in wetland and riparian habitats is achieved and these habitats demonstrate improved functions and values over those provided by the existing disturbed wetlands within the campground footprint. This objective is compatible with the recovery of steelhead because healthy wetland and riparian habitat is essential for a productive estuarine system. Physical elements to be evaluated include erosion and sedimentation rates, tidal prism, soil salinity, etc. Biological elements to be evaluated include vegetative cover development in wetland areas, habitat distribution and changes in open water and mudflat areas, habitat use by fish and birds, and presence of invasive weeds that may affect wetland function. A detailed monitoring and adaptive management plan should be developed to guide management decisions and to evaluate the success of the restoration. The adaptive management plan should identify thresholds for triggering management actions and should provide guidance for determining the success of such actions.

7 OPINION OF PROBABLE COST

This section presents the opinion of probable cost at the 30% concept feasibility level for the physical construction of the Preferred Restoration Concept described in this Feasibility Study. This opinion of probable cost is only for the construction of the Restoration Area and general grading and loose placement of the excavated material within the Mixed Use Area. It does not include costs associated with the contoured grading and construction of a new campground (which may require imported gravel subgrades, more arduous compaction specifications, and/or the need to follow specific building foundation soil placement recommendations) or demolition of the existing campground infrastructure (pavement removal, utility relocation, building demolition, etc.). Environmental review and permitting costs are also not included as permit application timelines and the level of effort required vary considerably with permit agency schedules and directives. There is a significant level of uncertainty in determining construction cost information at the feasibility or conceptual level of a project. As the project moves forward towards final design and construction schedules are taking shape, it will be necessary to revise and refine the cost information and assumptions used in the preparation of this opinion of probable cost.

The opinion of probable cost was developed using bid information and experience with similar projects, specialty excavation equipment costs, published cost information, and other sources. An allowance of 20 percent was included for contingencies and potential change orders during construction. A separate line item was included for the internal administrative costs for State Parks which were estimated at 3.5% based on previous similar restoration projects with State Parks. The opinion of probable cost, shown in Table 7, is organized into seven sections: General, Site Preparation, Water Management, Excavation and Grading, Planting, and Irrigation. More detail on the approach and methods used to prepare the opinion of probable cost is provided below.

Table 7 — Opinion of probable cost for the restoration component of the Project at the 30% concept feasibility level

Description	Quantity	*Units*	Unit Cost	Total
GENERAL				**$ 346,000**
Mobilization and Demobilization	1	*LS*	$ 40,000	$ 40,000
Contractor Insurance and Bonding	1	*LS*	$ 60,000	$ 60,000
Construction Surveying	1	*LS*	$ 22,000	$ 22,000
Implement Stormwater Pollution Prevention Plan (SWPPP)	1	*LS*	$ 50,000	$ 50,000
Engineering Services During Construction	1	*LS*	$ 18,000	$ 18,000
Biological Monitoring	5	*month*	$ 24,000	$ 120,000
Cultural and Historical Monitoring	3	*month*	$ 12,000	$ 36,000
SITE PREPARATION				**$ 340,000**
Remove/Relocate Existing Underground Utilities	*not included*			$ -
Remove Existing Pavement	*not included*			$ -
Remove Existing Buildings	*not included*			$ -
Clearing and Grubbing (Mixed Use Area & Restoration Area)	85	*AC*	$ 4,000	$ 340,000
WATER MANAGEMENT				**$ 145,000**
Coffer Dam	2300	*SF*	$ 50	$ 115,000
Nuisance Water Management & Dewatering	1	*LS*	$ 30,000	$ 30,000
EXCAVATION AND GRADING				**$ 3,783,400**
Excavation	249,000	*CY*	$ 10	$ 2,490,000
Over-excavation (Transitional Wetlands)	1,800	*CY*	$ 10	$ 18,000
Transport of Excavated Material to Mixed Use Area	170,000	*CY*	$ 2	$ 391,000
Fill Placement & Final Grading				
Restoration Area (Excavated Material & Salvaged Topsoil)	72,000	*CY*	$ 5	$ 360,000
Transitional Wetlands (Salvaged Wetland Topsoil)	1,800	*CY*	$ 8	$ 14,400
Mixed Use Area (Excavated Material & Salvaged Topsoil)	170,000	*CY*	$ 3	$ 510,000
PLANTING				**$ 1,212,800**
Marsh Plants - containers	11,200	*each*	$ 18	$ 201,600
Marsh Plants - plugs	44,500	*each*	$ 6	$ 267,000
Transitional Marsh Plants - plugs	8,000	*each*	$ 6	$ 48,000
Riparian Shrubs - containers	14,000	*each*	$ 18	$ 252,000
Riparian trees - containers	11,500	*each*	$ 30	$ 345,000
Riparian trees - cuttings	6,200	*each*	$ 16	$ 99,200
IRRIGATION				**$ 223,600**
Hard-Piped, Spray System (Mid-Upper Riparian & Transitional Marsh)	11	*AC*	$ 20,000	$ 223,600
MAINTENANCE AND MONITORING				**$ 810,600**
Irrigation Maintenance	12	*months*	$ 2,500	$ 30,000
Plant Replacement - Year 1	*7% of base planting cost*			$ 84,900
Plant Replacement - Year 3	*5 % of base planting cost*			$ 60,700
Weed Removal - Year 1	40	*AC*	$ 2,500	$ 100,000
Weed Removal - Year 2	40	*AC*	$ 2,000	$ 80,000
Weed Removal - Year 3	40	*AC*	$ 1,000	$ 40,000
Weed Removal - Year 4	40	*AC*	$ 1,000	$ 40,000
Weed Removal - Year 5	40	*AC*	$ 500	$ 20,000
Post-Construction Monitoring - Year 1	1	*LS*	$ 75,000	$ 75,000
Post-Construction Monitoring - Year 2-5	4	*LS*	$ 70,000	$ 280,000
		SUBTOTAL CONSTRUCTION COST		$ 6,861,400
			Contingency (~20%)	$ 1,373,000
		TOTAL CONSTRUCTION COST		$ 8,234,400
			State Parks Internal Administrative Costs (3.5%)	$ 289,000
		TOTAL PROJECT COST		$ 8,523,400

General

A number of general project costs are anticipated for the construction of the Preferred Restoration Concept including contractor mobilization and demobilization (excavation equipment hauling, specialty item purchasing, or leasing, etc.), contractor insurance and bonding expenses, construction surveying (staking, as-built conditions, etc.), implementation of the SWPPP, engineering services during construction, biological monitoring, and cultural, archeological, and paleontological monitoring. These general project costs were either estimated as a percentage of the overall project construction cost, adapted and revised from previous projects, or projected based on a summer construction season and the level of engineering, ecological, and cultural oversight potentially merited. It was generally assumed that the project would be constructed in tandem with the construction of the new campground, but considerations for the design and construction schedule for the campground were not included in this effort.

Site Preparation

Prior to the bulk of the excavation and grading work, and after the removal of the existing hard infrastructure of the campground (not included), the main site preparation activity will be clearing vegetation within the grading limits and removal ('grubbing') of the top several inches of soil material. This material is often generally unsuitable for structural fill and is typically handled separately from other, deeper excavated soil materials. It was anticipated that this material would be stockpiled on site until the majority of the mass site grading is nearly complete, and would then be used to achieve final grades within the transitional wetland areas of the Restoration Area and the vegetated areas of the Mixed Use Area. Clearing and grubbing was included for the footprints of the Restoration Area and the Mixed Use Area (this will most likely be a requirement for the geotechnical preparation of the site for the infrastructure of the new campground) and was determined on an overall acreage basis given the typical vegetation conditions of the site.

Water Management

Management of water on the site will pose additional challenges during construction of the project and will likely increase the overall construction costs beyond those at a site where water levels are easier to predict or control. Estimating water management costs at this feasibility concept level is problematic as SCRE water levels (and groundwater levels) vary significantly due to seasonal fluctuations, VWRF discharge rates, groundwater flows, and weather conditions. After a breach event, or with open-mouth / tidal conditions, water levels may be low enough to allow much of the construction to be done with a dry site. Alternatively, closed-berm conditions and elevated water levels may flood the majority of the excavation area. This would likely require more involved and more expensive construction methods, increased material handling costs, additional water pumping and dredging activities, and could significantly increase the need for biological monitoring and construction oversight. Without a well-defined construction schedule, final designs, and an understanding of what the various construction and environmental permits may require or allow for site water management and species monitoring, there will continue to be substantial uncertainty in estimating the costs for this part of the project.

The opinion of probable cost for this Feasibility Study was prepared with the assumption that construction would occur during the summer months and with elevated water levels such that a sizable coffer dam (or other substantial efforts) and a nuisance water management plan would be required in addition to any typical unit costs for excavation and grading. Other construction methods may be appropriate and costs may be substantially higher or lower than the opinion provided.

Excavation and Grading

Excavation and grading costs for the Preferred Restoration Concept were estimated on a unit cost basis. Unit earthwork quantities were calculated by comparing the existing and design surfaces for excavation, over-excavation, transport, and final grading. Final designs and an additional site topographic survey will provide refined quantity estimates. Unit costs were developed from previous unit costs for similar projects, discussion with an experienced general contractor, and the level of construction effort potentially required to reach final grades and design conditions for each area. Higher costs were assumed for placement and grading of wetland topsoil in over-excavated areas than for general placement of excavated sandy materials. Unit costs for fill placement in the Mixed Use Area do not include any special conditions for construction of a campground and only reflect general grading and placement.

The overall grading for the Restoration Area and the Mixed Use Area was developed to provide a roughly balanced site (within 3.5%), but shrink and swell information was not available and not included in the quantity calculations. Similarly, this opinion of probable cost was developed with the assumption of a balanced site. No import or export costs were included except where specifically indicated. On-site truck transport costs were estimated using a general purpose swell factor of 1.2 and an approximate average hauling distance (from the Restoration Area to the Mixed Use Area), but otherwise it was assumed that the excavated material would return to the original in situ volume. No other swell or shrink analysis was performed. As the design is completed and the grading refined, a more extensive geotechnical analysis will allow for reduced uncertainty in cost and quantity estimates.

Planting and Irrigation

Planting and irrigation costs for the Preferred Restoration Concept were developed based on a unit cost basis. Planting quantities were estimated for each type of planting (containerized marsh plants, marsh plugs, riparian shrubs, riparian trees, and cuttings) based on the acreage of each habitat type and the planting density (see specifically sheet L-1.1 within Appendix F). Irrigation costs were estimated based on the amount of acreage anticipated to require hard-piped, spray irrigation (areas above 11 ft). Unit costs were based on recent bids for large-scale restoration projects in California.

This approach was based on a number of recommendations and assumptions.

- It was assumed that a dense planting of containerized plants was preferable to reduce the potential for the invasion of giant reed and other invasive species. Though this assumption increases the capital costs required for construction it will likely reduce long-term maintenance costs.

- The cost estimate (and the planting plans) does not include any considerations for planting vegetation in areas below an elevation of 10 ft as it was assumed that young plants installed below this level would drown as the estuary water levels returned to recently observed levels near 11 ft. Areas below 10 ft will naturally colonize over time.
- It was assumed it would be necessary to plant larger container sizes of marsh plants in the deepest areas of the marsh to avoid drowning in the first period of elevated summer water levels.
- All other marsh plants were assumed to be plugs.
- It was assumed that marsh plants, riparian trees, and shrubs (except lower riparian cuttings) placed at elevations above the recently observed, typical summer water surface elevation would require irrigation for 1 year. It was assumed this irrigation would need to be a hard-piped, spray system to minimize rodent damage and maintenance.
- Maintenance costs for irrigation maintenance, plant replacement, and weed removal were included for 5 years. The weed abatement program could be required beyond 5 years.
- Biological maintenance costs were included for 5 years to fulfill the typical requirements of environmental permits.

8 RECOMMENDATIONS AND NEXT STEPS

This section provides a list of recommendations and next steps to guide future efforts aimed at moving the Preferred Restoration Concept beyond the 30% level. It includes management practices, permitting considerations, recommendations for additional focused technical studies, specific design considerations, and other next steps. These recommendations are mostly focused on habitat considerations and the restoration of the estuary, but because relocation of the campground facilities enables the restoration, several considerations are also included for the campground design. This is not an exhaustive list of permit considerations and is only intended to highlight the key permits that will be required and may affect the feasibility of the project. As an early step in future project efforts, it is recommended that funds be allocated to allow for a comprehensive permit planning report which would include potential timelines for permit application and review periods based on consultation and coordination with permitting agency staff.

8.1 MANAGEMENT PRACTICES

A recently published guidance document, "Best Practices for Southern California Coastal Wetland Restoration and Management in the Face of Climate Change" (Fejtek, 2014), which was a collaboration of UCLA's Institute of the Environment and Sustainability and numerous wetland professionals (many of whom participated in the design charrette and served as independent technical advisers for the Project), developed a comprehensive set of best management practices (BMPs) for each restoration phase including Planning, Construction/Restoration Implementation, and Post-Restoration Management. Though this guidance document was published after the Project had been scoped, many of the BMP recommendations were used by the Project team. As the restoration of the site moves forward into permitting and design, the BMP's developed should be reviewed, and expressly built into future planning efforts to facilitate stakeholder involvement, to improve the prospects of a successful and sustainable design, and to expedite the actual construction of the restoration.

8.2 PERMITTING

Coastal Development Permit

The California Coastal Act of 1976 established the California Coastal Commission (CCC) in order to plan and regulate the use of land and water in the coastal zone in partnership with local cities and counties. As the Project is located within a sensitive habitat area of the designated coastal zone for the City of Oxnard, California, which has developed and maintained a certified Local Coastal Program (LCP), the Project will require a Coastal Development Permit (CDP) from the City of Oxnard Planning and Environmental Services Department. Given the scale and location of the Preferred Restoration Concept, the Project may also need permit review at the CCC level. The Preferred Restoration Concept was developed to be consistent with the principles and priorities of the Coastal Act, which prioritized the preservation of sensitive habitat areas and coastal access followed by public recreational uses, and the LCP set forth by the City of Oxnard.

As the project moves forward, it will be critical to work with the City of Oxnard and the CCC to ensure the restoration (and campground) designs continue to balance and incorporate both local and regional coastal resource priorities and the specific requirements of the LCP.

California Environmental Quality Act

To demonstrate compliance under the California Environmental Quality Act (CEQA), an Initial Study will need to be prepared to determine the level of impacts associated with the Project and whether a Mitigated Negative Declaration or an EIR will be required. Additional planning documents may need to be prepared, including a final project description and analysis of impacts, an adaptive management and monitoring plan, and an operations and management plan. State Parks should be the lead agency for the project and will need to comply with the CEQA process and procedures.

Environmental Permitting

Because the Project will occur within habitats that are potentially under the jurisdiction of the Corps, LARWQCB, CDFW, or CCC, the following permits will be required:

- Clean Water Act Section 404 Nationwide or Individual Permit
- Clean Water Act Section 401 Water Quality Certification
- California Fish and Game Code Section 1602 Lake and Streambed Alteration Agreement

A verified jurisdictional determination from the Corps is necessary to identify the exact acreage of wetland habitat subject to federal jurisdiction within the project footprint. This information is critical for planning purposes as it will be necessary to ensure that the project does not result in a net loss of federally regulated wetlands. Similarly, it will be important to verify the extent of CCC, CDFW, and LARWQCB jurisdiction within the project footprint.

Prior to issuance of any federal permits, it may be necessary to conduct formal consultation with the USFWS and/or the NMFS under Section 7 of the Endangered Species Act to ensure that the project will not jeopardize the continued existence of threatened or endangered species, or adversely modify or destroy their designated critical habitat. Depending on the construction schedule and the final project footprint, additional permitting through CDFW may be necessary to comply with the California Endangered Species Act. Therefore, it is possible that a CDFW 2081 Incidental Take Permit (ITP) may also be required.

The need for additional consultation for cultural and historical resources will have to be evaluated in accordance with Section 106 of the National Historic Preservation Act. Due to the size of the restoration and the involvement of multiple natural resource agencies, including State Parks, a multi-agency pre-planning meeting is recommended prior to the initiation of major planning efforts or applications for project approval.

Floodplain Development Permit

The Ventura County Watershed Protection District (VCWPD) participates in the National Flood Insurance Program (NFIP) of the Federal Emergency Management Agency (FEMA). As the Project site is located within the Special Flood Hazard Area of the local Flood Insurance Rate Map (FIRM) (last updated in 2010 and included in Appendix D), it is likely the Project will require a floodplain development permit from Ventura County. Though the majority of the site is not located in the currently mapped regulatory floodway, a small sliver of the property at the southeast end of the proposed campground site may be within a 'breakout' floodway of the SCR which passes to the south. As currently proposed, the Mixed Use Area aims to avoid any grading or other development within this area. However, as the design of the Mixed Use Area is developed and refined, it will likely be crucial to work with the VCWPD to address this corner of the site and how the Project may impact flood routing and anticipated flood elevations. A more intensive flood modeling study may be required. A separate watercourse permit may also be required. Further development of the Preferred Restoration Concept should include close coordination with the VCWPD to ensure the Project is in step with the VCWPD's mission to protect life, property, watercourses, and public infrastructure from the dangers and damages associated with flood and stormwater.

County Permits

In conjunction with the more extensive environmental and development permit review processes described above, the project team will also need to work with Ventura County staff to incorporate any specific considerations as required to apply for a Grading Permit and a Building Permit.

This may include confirming project setbacks, plan set review, fire department requirements, etc.. It will also likely require coordination with the Ventura County Transportation Department to ensure the Preferred Restoration Concept is developed to be compatible with planned bridge/road widening and intersection-widening projects planned for Harbor Blvd.

8.3 ADDITIONAL STUDIES

The SCRE has been studied at length, but a few additional focused technical studies are appropriate to support further restoration design development. These include:

- A detailed subsurface and geotechnical assessment to inform soil preparation requirements, agronomic suitability, fill placement considerations, the final design of the planting pallete, and specific foundation recommendations as necessary for the Mixed Use area and relocated campground infrastructure. This subsurface and geotechnical study should include subsurface coring below the elevation of the groundwater (high groundwater levels limited sample depths for the initial sampling already performed by hand augering methods) in both the restoration area (to characterize the fill material) and within the footprint of the Mixed Use area. This assessment should also include review of the subsurface site data recently acquired by Oakridge Geotechnical Inc. (OGI, 2015), Topanga Anthropological Consultants (2015), the Soil and Plant Laboratory, Inc. (2015), and Stillwater Sciences (2011).

- Review and independent analysis of the City of Ventura's Phase 3 Special Studies (due in draft form in September 2017), which will include an expanded water budget analysis, a Nutrient and Toxicity Special Study, and a Groundwater Special Study (LARWQCB, 2013; City of Ventura, 2014). In the face of climate change and the potential reduction of VWRF discharge into the estuary, the temperature, quantity, and seasonality of groundwater inflows to the SCRE may have important design considerations that should be incorporated into the final design of the Preferred Restoration Concept.

8.4 DESIGN CONSIDERATIONS

Additional future design considerations are included below:

- The 30% plans and designs developed for the Preferred Restoration Concept for the Project were based on the best available data including LIDAR, bathymetric surveys, and recent, but limited topographic field surveys of the mouth berm and outfall channels. Moving beyond the 30% conceptual design level, a Professional Licensed Surveyor (PLS) should be tasked with providing the final design team with surveyed easements, property lines, building corners, inverts and sizing information for existing site drainage systems, culverts, and utilities.

- A small study should be done to evaluate the existing agricultural drainage and runoff system that runs underneath Harbor Blvd just to the south and east of the current maintenance area. This existing feature does not appear to pose any feasibility constraints, but should be evaluated further as part of final design work.

- Prior to final design and construction vegetation planting, a revised set of predicted estuary water levels should be generated from field observations and hydrologic modeling. Though efforts were made to anticipate uncertain future management changes (by providing flexible and gradual grading designs within the Restoration Area), proposed planting elevations may need to be adjusted downwards when future water level ranges can be predicted with more certainty because this is likely to affect the elevations at which various marsh and riparian plants will survive.

- Final designs should be accompanied by a basis of design report and supported by a more detailed hydrodynamic and sediment transport modeling effort to include coastal sediment transport, larger flood events, and additional circulation and water quality simulations.

- The final design of the Preferred Restoration Concept should consider including design details for additional habitat complexity, including large woody material and/or engineered wood structures. Some potential locations are indicated in Figure 14.

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