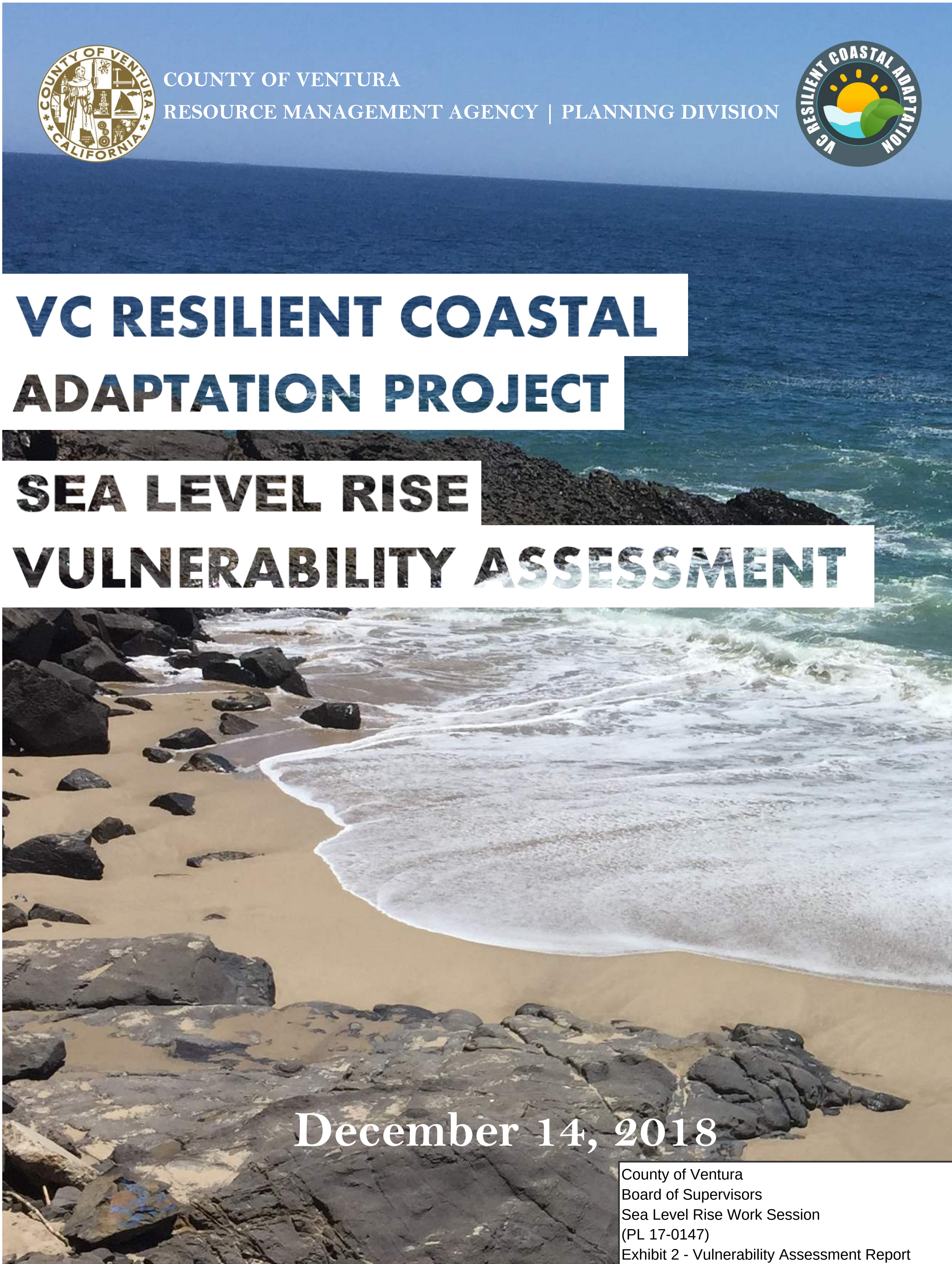
COUNTY OF VENTURA

RESOURCE MANAGEMENT AGENCY | PLANNING DIVISION

VC RESILIENT COASTAL ADAPTATION PROJECT

SEA LEVEL RISE VULNERABILITY ASSESSMENT



December 14, 2018

County of Ventura
Board of Supervisors
Sea Level Rise Work Session
(PL 17-0147)
Exhibit 2 - Vulnerability Assessment Report

County of Ventura
Resource Management Agency - Planning Division
800 South Victoria Ave
Ventura, CA 93009

CALIFORNIA COASTAL COMMISSION

REVELL COASTAL
Surf. Sand. Sustainability.

Coastal Conservancy

ACKNOWLEDGEMENTS

This report was prepared by the following individuals:

County of Ventura

- Tricia Maier, Long-Range Planning Manager
- Aaron Engstrom, Senior Planner
- Abigail Convey, Planning Biologist
- Angela Kim, CivicSpark Climate Fellow

Revell Coastal, LLC

- David L. Revell, PhD, Project Director
- Matt Jamieson, MFA, GIS and Coastal Scientist
- Phil King, PhD, Lead Economist
- Jeffrey Giliam, Economist

The sea level rise models used to compile this report were developed by the following organizations:

2012 Coastal Resilience Ventura Model:

- The Nature Conservancy, California Chapter
- County of Ventura
- Environmental Science Associates (ESA)

2017 Coastal Storm Modeling System (CoSMoS v3.0):

- United States Geological Survey
- California Coastal Conservancy

This page was intentionally left blank.

CONTENTS

FIGURES

TABLES

PHOTOGRAPHS

ACRONYMS/ ABBREVIATIONS

BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BFE	Base Flood Elevation
CoSMoS	Coastal Storm Modeling System of the USGS
County	County of Ventura
EFGS	Ecological Functions Goods and Services
EMHW	Extreme Monthly High Water
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FIRMs	Flood Insurance Rate Maps
GHG	Greenhouse gases
GIS	Geographic Information System
GSW	General Steel Works
MHMP	Multi-Hazard Mitigation Plan
IPCC	Intergovernmental Panel on Climate Change
JPA	Joint Powers Agency
LCP	Local Coastal Program
LIDAR	Light Detection and Ranging
LUP	Land Use Plan
NAVD	North American Vertical Datum 1988
NOAA	National Oceanic and Atmospheric Administration
OPC	Ocean Protection Council
PDO	Pacific Decadal Oscillation

RCP	Relative Concentration Pathways
Report	2018 VC Resilient Coastal Adaptation Project Vulnerability Assessment Report
SCE	Southern California Edison
SLR	Sea Level Rise
TOT	Transient Occupancy Tax
USACE	United States Army Corps of Engineers
USGS	U.S. Geological Survey

REPORT, MAP, AND DATA DISCLAIMER

The maps and associated analyses in this Report are intended as planning tools to illustrate the potential for inundation and coastal flooding under a variety of future sea level rise and storm surge scenarios. The maps depict possible future inundation if nothing is done to adapt or prepare for sea level rise. This Report is advisory and not a regulatory or legal standard of review for actions that the County of Ventura or the California Coastal Commission may take.

This Report is part of an ongoing process to understand and prepare for coastal hazards. The maps are based on model outputs and do not account for all of the complex and dynamic Pacific Ocean processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades. There are inherent uncertainties associated with modeling and projecting future hazards and their potential impacts.

Although every effort was made to review all resource sector and infrastructure data received from other sources, neither the Planning Division nor its consultant, Revell Coastal, LLC can verify the location or completeness of all spatial data. For this reason, we do not accept responsibility for any errors, omissions, or for any positional inaccuracies. Users of the data displayed in the maps that are included with this report are strongly cautioned to verify all information.

DEFINITIONS

The following terms are defined for the purpose of use in this Report:

1% Annual Chance Storm: often called a 100-year storm event, it is an exceptionally large storm with a 1% chance of occurring in any given year. It is the basis for the FEMA regulatory flood maps. In rivers it is based on streamflow, and on the open coast it is based on wave run up.

Adaptation: anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the vulnerabilities.

Adaptation Pathway: an adaptation pathway is a planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures and allows analysis/exploration of the robustness and flexibility of various options across those multiple futures.

Adaptive Management: a process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.

Adaptive Capacity: the ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, and to cope with the consequences.

Base Flood Elevation: reflects the height (in feet) above sea level that flood water is predicted to rise during a 1% annual chance storm. Base Flood Elevations are shown on FEMA Flood Insurance Rate maps. The relationship between the BFE and a structure's actual elevation above sea level determines flood insurance premiums.

Coastal Armoring: structures developed for shoreline protection constructed from durable materials such as rock and reinforced concrete. In Ventura County, most shoreline protective devices consist of seawalls and rock revetments.

Coastal Erosion: loss of land in the dunes or cliffs along the coast caused by wave attack.

Coastal Flooding: pooling of seawater on land as a result of any wave uprush with momentum that causes damage. A 1% annual chance storm would cause coastal flooding, but common storm events may also cause coastal flooding.

Coastal Zone: a regulatory zone established by State Legislature and shown on maps prepared by the California Coastal Commission for which the California Coastal Act establishes policies and regulations.

Climate Change: a shift in climate and weather patterns over time, due to natural causes or as a result of human activity.

Economic Benefits: can be measured in two ways – market and non-market benefits. Market benefits are measured using market values. For example, to value a private residence one would use the market price of the home. Many of the benefits in this study are non-market benefits. Economists have developed a number of techniques to measure benefits when the price is set at zero. For example, beaches are free in California, but numerous studies indicate that visitors are willing to pay to go to the beach. This willingness to pay is a non-market value.

Economic Costs: in this Report, costs are measured as replacement or repair costs. or as the market value of lost land. For example, this study measured the costs of roads at replacement cost.

Economic Impacts: measure the spending and economic activity resulting from a policy change.

Emissions Scenarios: scenarios representing alternative rates of global greenhouse gas emissions growth, which are dependent on rates of economic growth, the success of emission reduction strategies, and rates of clean technology development and diffusion, among other factors.

Feedback Mechanisms: when the result of an activity or improvement triggers changes in a second process that in turn influences the initial one. Ocean warming is an example of a feedback mechanism. As the ocean warms, it releases carbon dioxide into the atmosphere, further warming the ocean.

Fiscal Impacts: measure not only tax revenue impacts, but also changes in costs to a county/city from a policy change. For example, if increased beach recreation requires increased public safety/lifeguards, a fiscal impact analysis would also incorporate these changes.

Global Climate Models: a numerical representation of the climate system that is based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and that accounts for all or some of its known properties.

Maladaptation: inadvertently increases the vulnerability to sea level rise hazards and can be a result of badly planned adaptation actions or decisions that place greater emphasis on short-term outcomes than longer-term threats.

Mean High Tide Line: the average of the higher high water height of each tidal day, as observed over a 19-year period by the National Ocean Service.

Net Benefits: estimate of economic benefits minus economic costs. Typically, these net benefits are discounted over time.

Planning Horizon: the planning horizon is the future time identified with forecasts of climate impacts and the time that an organization will look into the future when preparing a strategic plan. This Report focuses on the amount of sea level rise rather than the forecast planning horizon.

Property at Risk: the total fair market value of the land and structure on a parcel (2017 dollars).

Risk: commonly considered to be the combination of the likelihood of an event and its consequences – i.e., risk equals the probability of climate hazard occurring multiplied by the consequences a given system may experience.

Sector: a category of natural or built resources, such as building structures, wastewater infrastructure, beach access, and sensitive biological resources.

Sector Profile: a summary or description of existing sector resources to be impacted by future sea level rise and coastal hazards.

Special Status Species: A term used in the scientific community for species that are considered sufficiently rare that they require special consideration and/or protection. Groups categorized as special status species are recognized by federal, state, and local natural resources agencies as threatened, endangered, rare, candidate species/species of special concern, California fully protected species, or are species listed as of "greatest conservation concern" due to the decline of the species.

Tax Revenue Impact: measures the changes in taxes as a result of a policy change. This Report estimates changes in sales taxes and transient occupancy taxes resulting from changes in beach tourism/recreation.

Tidal Inundation: flooding caused during predictable high tides that occur with some regularity.

Vulnerability Assessment: the process of identifying, quantifying, and prioritizing the potential exposure of resources or infrastructure in an area or a system.

EXECUTIVE SUMMARY

This Vulnerability Assessment reveals that Ventura County will face considerable challenges adapting to sea level rise. Analyses focused on the potential impacts of coastal erosion, coastal flooding and future high tides with 8 inches, 16 inches and nearly 5 feet of sea level rise.

Residential properties, critical transportation and infrastructure corridors, as well as high-value coastal recreation top the list of coastal resources that are vulnerable to sea level rise. Agriculture located near the coast, while only preliminarily assessed here, is also vulnerable. Beach, foredune, and estuarine systems are the most vulnerable sensitive coastal ecosystems and may experience significant changes. The Point Mugu Naval Air Weapons Station is also a vulnerable facility that is located on low-lying coastline within the unincorporated area. While the Navy Base and many coastal communities face similar challenges, the County is fortunate in that there are no critical facilities such as sewage or water treatment plants, energy plants, airports, or hospitals within the County's jurisdiction that are projected to be impacted through the end of the century.

Ventura County is no stranger to addressing coastal hazards. With over 18 miles of coastal armoring in the unincorporated areas, without any adaptation measures or actions, over $1 billion dollars in oceanfront residential properties are potentially vulnerable to storm erosion and temporary coastal flooding with less than one foot of sea level rise. Small, narrow beaches in the North and South Coasts that support a vibrant $156 million per year coastal recreation economy may be lost within the next few decades. Future adaptation strategies will be needed to reduce hazards and expensive emergency cleanup costs, and to conserve vulnerable beaches.

There are many opportunities and choices ahead and future funding sources will need to be identified. Coastal recreation demand is growing, and there is too much sand in some places, such as on the broad beaches along the central County coastline, and not enough on the northern and southern county coastlines. Efforts to manage sediment and restore coastal ecosystems to bolster natural defenses are underway here and in other areas of the state. These adaptation strategies, among others, hold great promise to reduce some of the vulnerabilities of today while preserving coastal resources for tomorrow.

Introduction

The 2018 VC Resilient Coastal Adaptation Vulnerability Assessment (Report) provides Ventura County (County) with a science-based vulnerability assessment that evaluates a variety of resources and infrastructure in the unincorporated coastal areas of the county and the risk of future damage associated with coastal hazards (high tides, erosion, and storm flooding) and sea level rise. This Report will be used to support community discussions on existing and future hazards, identify potential adaptation strategies that can reduce the risk of future damage, and guide land use goals, policies and programs.

The California Coastal Act requires local governments in the state's coastal zone to create and implement Local Coastal Programs (LCPs). Each LCP consists of a Coastal Land Use Plan (Ventura County's is called the "Coastal Area Plan") and an Implementation Plan (Ventura County's is called the "Coastal Zoning Ordinance"). The County of Ventura's Coastal Land Use Plan is one of the County's nine Area Plans. These Area Plans are extensions of the County's General Plan and are used to achieve the community's vision for future growth and ensure the provision of adequate services. LCPs must be certified by the California Coastal Commission once they are determined to be consistent with the California Coastal Act. After certification, local governments manage coastal development, prioritize coastal-dependent uses, and protect coastal resources, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion.

In 2015, the Coastal Commission adopted the Sea Level Rise Policy Guidance document to aid jurisdictions in incorporating sea level rise into LCPs, Coastal Development Permits, and regional strategies. The document outlines specific issues that policymakers and developers may face as a result of sea level rise, such as extreme flood events, challenges to public access, vulnerability and environmental justice issues, and consistency with the California Coastal Act. The policy guidance document also lays out the recommended steps to incorporate sea level rise hazards into the legal context and planning strategies to reduce vulnerabilities and inform adaptation planning.

Funding for this project has been provided by the County and a grant received from the Coastal Commission and the California State Coastal Conservancy. The project is being led by the County of Ventura Resource Management Agency Planning Division with support from Revell Coastal consultants.

Background

Climate science is constantly evolving as the scientific understanding grows of the natural climate cycles, human impacts, and feedback mechanisms within earth systems. In the County, sea levels are rising as a result of three factors – warming of the ocean, ice melt, and vertical tectonic land motion. As a result of differences in vertical uplift associated with the Red Mountain, Pitas Point and Sycamore Canyon faults, there are areas in the North Coast and South Coast of the Ventura County unincorporated area (North Coast and South Coast, respectively) which are rising and so the effects of local sea level rise are diminished. In the Central Coast of the Ventura County unincorporated area (Central Coast), there is some land subsidence occurring due to several factors— tectonic movement, groundwater extraction, oil and gas extraction—making the effects of local sea level rise greater.

Rising sea levels alone will not be the primary cause of damage to County resources and infrastructure. These impacts will be caused by coastal process hazards, particularly coastal erosion and coastal flooding, that occur during large wave events. Over time with sea level rise, the episodic storm event impacts will become more routine and predictable as high tides inundate county lands with more depth and frequency. This Report examines the impact of coastal erosion, coastal flooding and high tides on County resources and infrastructure and how these will change over time with sea level rise. Because of the different shoreline orientations in the County, it is highly unlikely that a single storm wave event would affect all shorelines simultaneously during a high tide in order to cause the types of damage shown on all of the hazard maps in Appendix A.

For purposes of this Report, the team evaluated a range of available coastal hazard models and sea level rise projections. The hazard modeling selected was largely based on Coastal Resilience modeling partially funded by Ventura County and completed in 2013. These modeling results are also being used by the neighboring jurisdictions of Santa Barbara and Los Angeles Counties, and the Cities of Oxnard and Carpinteria. The Coastal Resilience modeling assumed the following sea level rise projections and time periods. They are consistent with State guidance to use the "best available science" (Table ES-1).

Table ES-1. Sea level rise Projections used in this Vulnerability Assessment Report[1]

Approximate Year	Height of Sea Level Rise
2030	8 inches
2060	16 inches
2100	58 inches

[1] Year 2010 is the baseline for the Coastal Resilience Modeling used in these projections.

It should be noted that since the Coastal Resilience modeling was completed, more recent scientific projections modeled in preparation for the California 4th Climate Assessment have been integrated into the Rising Seas in California (Griggs et al. 2017), and as part of the State of California Sea-Level Rise Guidance, 2018 Update. While most of the sea level rise estimates in the 2030 to 2060 time-frames are similar to earlier projections, some of the projections for sea level rise at the end of century have increased. As such, this Report should not be considered a worst-case scenario. In fact, recent State guidance suggests considering 10 or more feet of sea level rise by the year 2100 for some types of land uses. For more detailed discussion of the State guidance as it relates to sea level rise and the scenarios considered, please see Section 1.3.

The amount of sea level rise shown in the projections above will occur in the future and pose considerable planning and operational challenges. Other climate variables such as temperature, precipitation, wildfires, and changes to the earth's polar ice sheets were not evaluated in this report, but will contribute to sea level rise hazards as the climate system changes. These variables may alter the amounts of projected sea level rise that are currently set to planning horizon years of 2030, 2060, and 2100, and sea level rise may occur sooner or later than those years.

The important point is that sea level rise will occur within most of our lifetimes and it will only intensify for future generations. This Report and subsequent adaptation strategies will rely on thresholds set to the amounts of sea level rise that are empirically predicted to occur, rather than use the less-certain planning horizon years.

County Resources

This Report provides a science-based vulnerability assessment based on the best available data that included extensive geospatial data gathering and compilation of existing data and information. Some of the coastal hazards extend inland, beyond the coastal zone, and while the geographic extent of these areas generally corresponds to the North, Central, and South Coast designations in the Coastal Area Plan, this Report generally refers to the hazardous sea level rise areas in the unincorporated areas as North Coast, Central Coast, and South Coast. Potential impacts on multiple resource sectors and infrastructure categories are reported based on the spatial intersection with the three coastal process hazards: shoreline erosion, storm flooding, and rising tides.

Based on the unique characteristics of the County's coastline and watersheds, the eleven sectors listed below were chosen specifically for their importance to the County and Coastal Act requirements to ensure protection of coastal resources and support policy development:

- Land Use Parcels and Structures
- Agriculture
- Wastewater
- Stormwater
- Water Supply
- Public Access, Recreation, and Trails
- Roads and Parking
- Public Transportation
- Oil and Gas Infrastructure
- Hazardous Materials
- Critical Services
- Natural Resources
- Vulnerable Populations

For most of the sectors and types of infrastructure, the evaluation also included an economic component to provide an initial estimate of fiscal impacts to the vulnerable resources. The economic analysis estimated the value of damage to property, key infrastructure, and the potential losses of spending and tax revenue due to impacts to the County's beaches and beach parks. This type of economic analysis is just one factor evaluated for the overall adaptation planning effort, but there are many other considerations such as property rights, ecosystem services (e.g., habitat for fish to spawn), and the inherent value of scenic beauty along the County's shorelines. Section 4.5 describes in more detail the assumptions that were used for the economic analysis of sea level rise impacts on the County's shoreline. The economic analysis presented in this Report will be followed by preparation of a subsequent economic evaluation of various adaptation strategies.

Key sector vulnerabilities are summarized in the following maps by North, Central and South Coasts (Figures ES-1, ES-2, and ES-3). More specific map summaries for each individual sector are presented in Appendices A, C, and D. Flooding along the Santa Clara River shown on Figure ES-2, between River Park and Victoria Avenue, will be reduced due to ongoing and future levee improvements.

Figure ES-1 - Executive Summary: North Coast

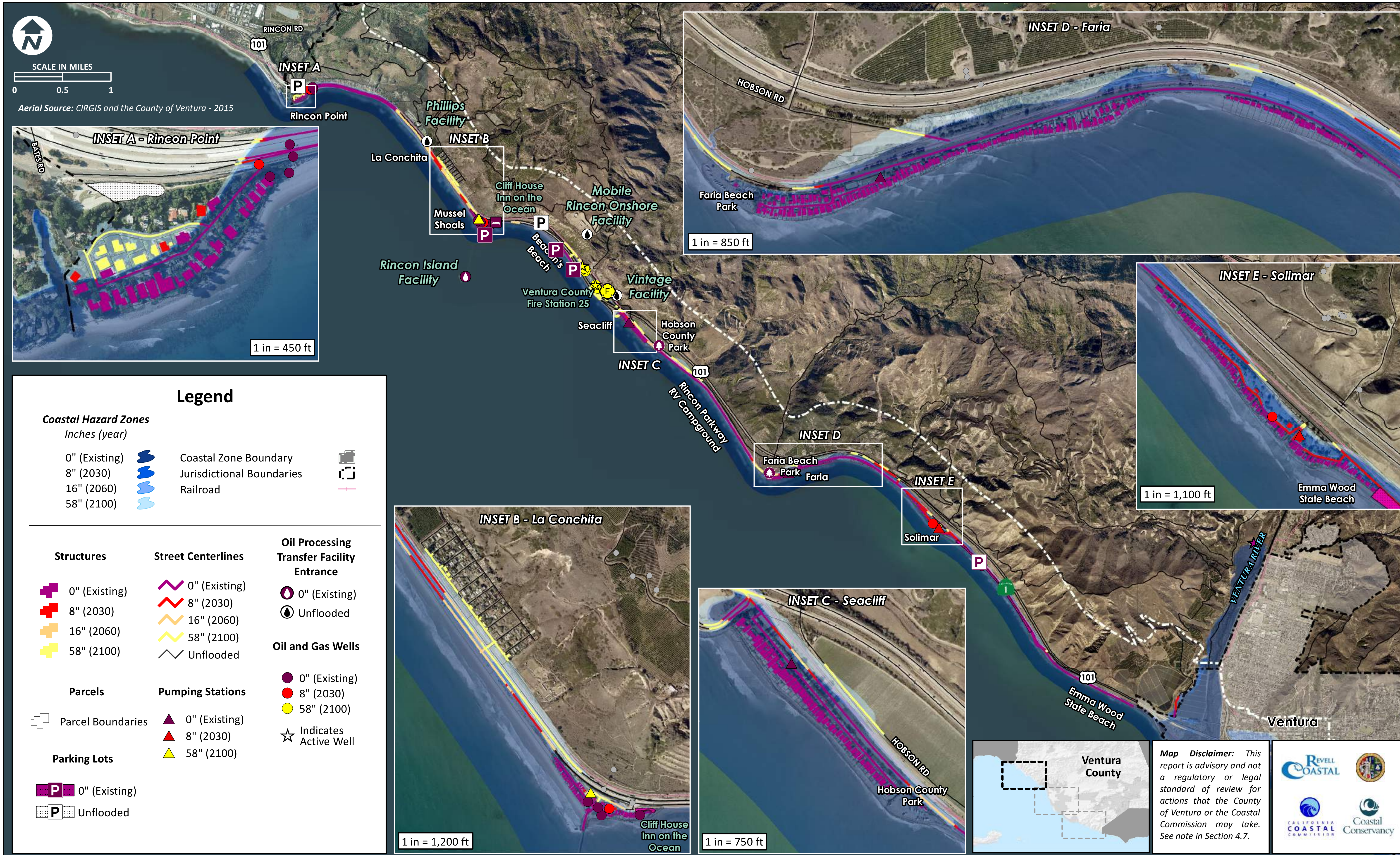


Figure ES-2 - Executive Summary: Central Coast

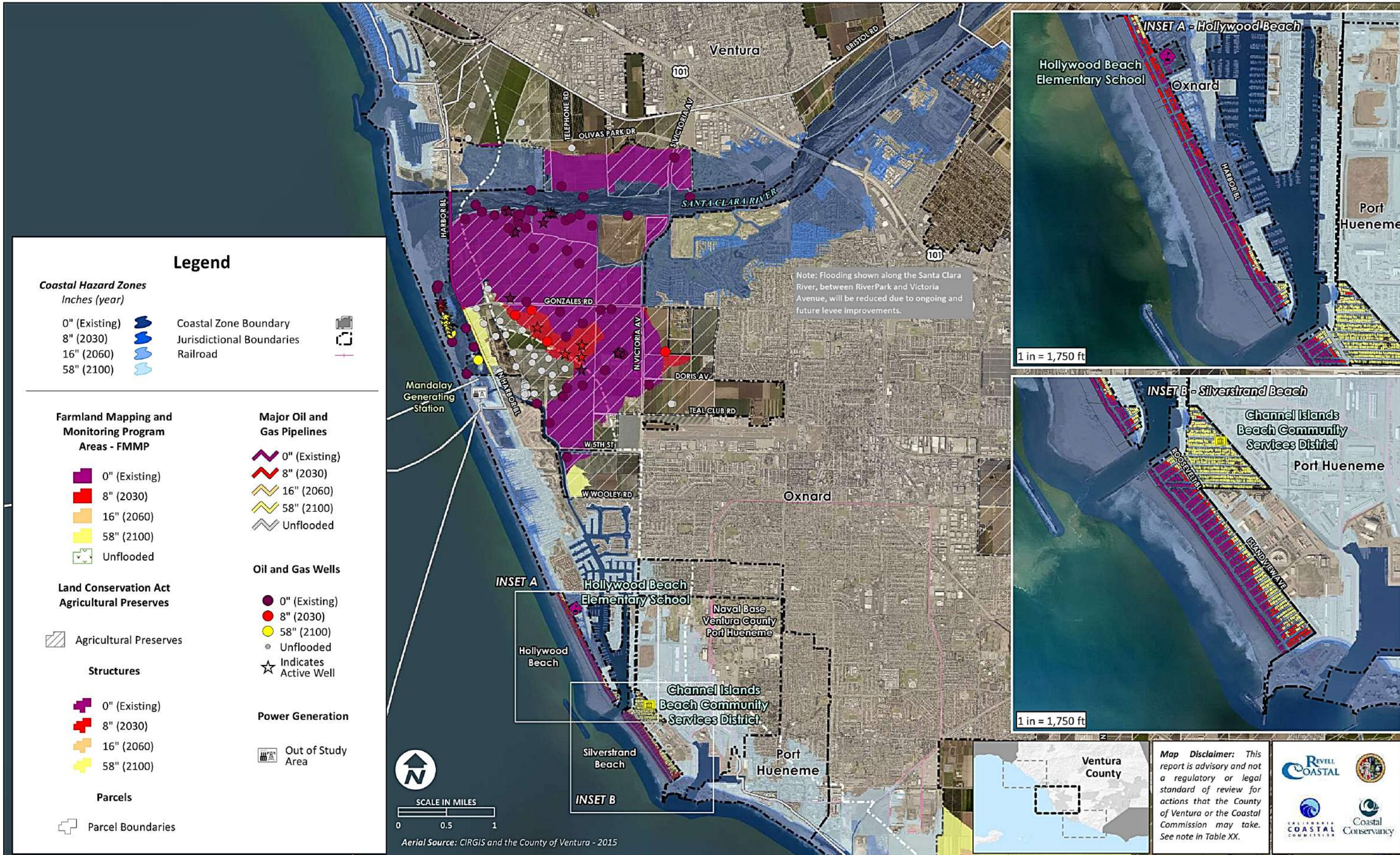
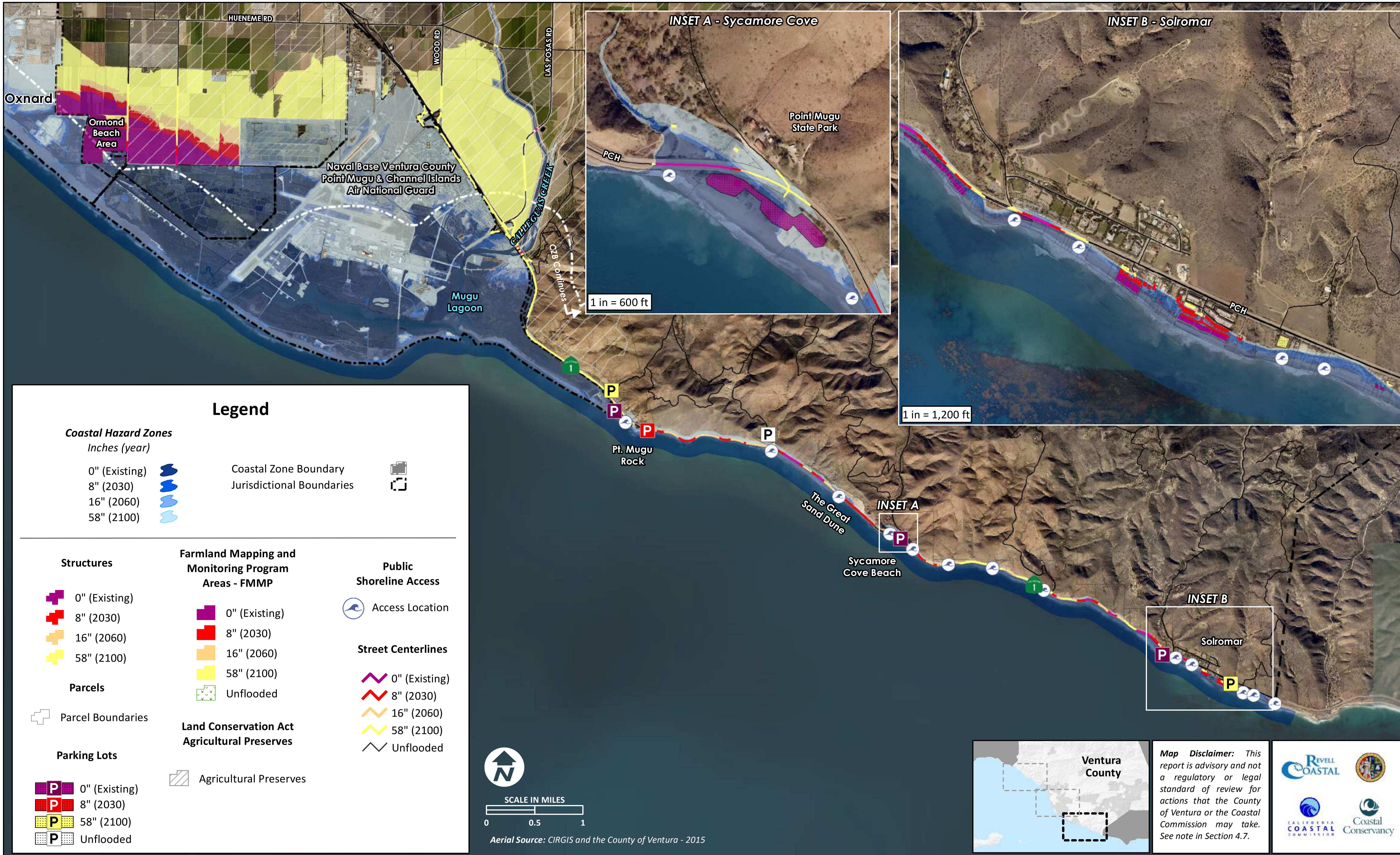


Figure ES-3 - Executive Summary: South Coast



Key Findings

Coastal armoring, primarily rock revetments and seawalls, extend over 18 miles of County shoreline, primarily along the North and South Coasts, where it protects crucial County transportation, recreation, wastewater infrastructure, and private residences. Much of this armoring is of variable materials and unknown condition, which complicates future projections of vulnerabilities to coastal hazards and sea level rise. Most of it is already exposed to monthly high tides. Replacing this existing armoring would cost an estimated $500 million to $1 billion dollars without considering any new armoring or future maintenance costs.

Residential properties are the most vulnerable land use. While all coastal residential areas are vulnerable to storm hazards and sea level rise, the densely-populated areas of Hollywood Beach and Silverstrand neighborhoods comprise over 95% of all parcels with structures at risk now and in the future with rising sea levels. Without adaptation and with about 5 feet of sea level rise, 2,500 parcels across the County could be vulnerable to coastal flood damage during a single 1% annual chance storm causing nearly $400 million in residential damage in just Hollywood Beach and Silverstrand. Over 1,700 parcels and an estimated $1.7 billion dollars in property could be exposed to coastal erosion along the Central and South Coasts. Monthly high tides could routinely affect $880 million in property on nearly 1,400 parcels across the unincorporated County with five feet of sea level rise.

Annually, County beaches draw over three million visitor days per year, generating an estimated $112 million in spending. These beaches provide ~$156 million in economic benefits, $2.3 million in Transient Occupancy Taxes and around $1 million in sales taxes to the County and local public agencies. Under existing conditions, all the coastal access points are vulnerable to coastal erosion and coastal flooding, with more than half of the beaches unusable at high tide due to the historically narrow gap between the ocean and developed areas. With about 5 feet of sea level rise, Faria and Hobson County Parks and several State Parks may be routinely flooded by waves, requiring seasonal closures. Significant portions of the California Coastal Trail would be at risk to coastal erosion (~30%), tidal inundation (~20%), and coastal flooding (~60%) with about 5 feet of sea level rise.

The majority of coastal ecosystems (beaches, dunes, marshes) and all federally designated critical habitats in coastal areas are currently at risk to erosion, tidal inundation, and coastal flooding. Many of the vulnerabilities exist today. For instance, sandy beach habitats on the Central Coast, as well as federally designated critical habitat for the Western snowy plover at Hollywood Beach are vulnerable to potential erosion associated with a large coastal storm event. Large areas of freshwater habitats and sand dune environments that are intermixed with existing agricultural fields may also be exposed to coastal storms and flooding from the Santa Clara River. In addition, four Western monarch butterfly overwintering aggregation sites that are located near the coastline may be vulnerable to sea level rise and combined flood hazards.

In the future, coastal ecosystems and the species that live within them could be increasingly vulnerable due to the effects of sea level rise (e.g., erosion, increased tidal inundation, intermittent flooding). For example, over half of the marshes may be exposed to increasing tidal inundation and salt water. Potential changes may affect the distribution and abundance of sensitive species such as the Belding's savannah sparrow and the tidewater goby.

Depending upon how each species responds to these effects, the function of the ecosystem has the potential to be altered. In order to provide an understanding of how and to what degree focal species within a particular ecosystem may be affected by sea level rise, focal species assessments have been completed. The results of the focal species assessments indicate that the Southwestern pond turtle, Western snowy plover, beach evening primrose, red sand verbena, globose dune beetle, Belding's savannah sparrow, and California grunion are potentially the most vulnerable species to sea level rise. Five out of the seven most vulnerable species are found in beach and dune habitats. These results indicate that beach and dune ecosystems as a whole are most vulnerable to sea level rise changes.

A coastal oil spill could have devastating environmental and economic impacts to Ventura County. Substantial oil and gas infrastructure, including the McGrath Beach slant well facility, the decommissioning Rincon Island terminal, and numerous pipelines and wells (both active and inactive) are exposed to existing and future coastal hazards. Impacts to oil and gas infrastructure in neighboring jurisdictions could also be detrimental to unincorporated County areas, as oil spills will not be confined to jurisdictional boundaries.

Agriculture, a $2 billion dollar a year industry in Ventura County, faces many challenges from climate change and requires more analysis to fully understand the magnitude of potential impact. With a projected ~5 feet of sea level rise, 2,600 acres of high-quality farmland soils[1] will be susceptible to coastal flooding that will salt the soil and force farmers to grow lower value crops which are less sensitive to saline environments. Tidal inundation is likely to impact 1,200 acres of high-quality farmland soils, likely removing these lands from agricultural production without adaptation.

These projected vulnerabilities to sea level rise and future coastal hazards will greatly affect the County economy. Adaptation choices exist, but some of these decisions require tradeoffs that will be difficult. The information presented here should be viewed as a starting point to open community discussion and begin to shape a shared vision for the future.

Summary of Sector Results

Key vulnerability results for twelve resource sectors are summarized here. More detailed results are provided in Sections 4 and 5, as well as in the appendices.

Land Use Parcels and Structures

Losses to residential land uses represent over 95% of all land use vulnerabilities in the County and are concentrated in a few neighborhoods of mostly single-family residences. Existing North Coast oceanfront neighborhoods of Seacliff, Solimar, and Faria Beach Colony currently have approximately $10 million of residential property at risk to coastal storm flooding. Cliff House Inn, the only visitor serving hotel in the unincorporated coastal zone, is currently at risk to coastal flooding. Future maintenance of the armoring structures will determine future erosion vulnerabilities. Currently, $120.1 million of Central Coast property may be damaged during a 1% annual chance storm, assuming this 100-year storm hits the entire coast with the same force at the same time, which could also cause $26.6 million in losses due to coastal erosion. Along the South Coast, short to near term potential cliff erosion with up to 8 inches of sea level rise could impact over $208 million worth of property, although most of the cliff hazards exist today and there is little escalation of damage even with about 5 feet of sea level rise.

[1] High-quality farmland soils include farmland designated as Prime, Statewide Importance, Unique or Local Importance, and Grazing through the State Department of Conservation Farmland Mapping and Monitoring Program.

With about 5 feet of sea level rise, coastal flooding may cause $138.2 million in property damage along the North Coast, including in the La Conchita community. Along the County's Central Coast, about 5 feet of sea level rise could cause an estimated $407.3 million in property flood damage and $1.5 billion in losses due to coastal erosion during a 1% annual chance storm. Coastal flooding on the South Coast, with between 16 inches and about 5 feet of sea level rise could cause another $136.6 million in storm damage.

Agriculture

Agriculture in the County is a $2-billion-dollar-a-year economic driver. Nearly all of the agriculture in the coastal zone occurs on the Central Coast, across the Oxnard Plain. During a 1% annual chance storm, flooding along the Santa Clara River may cause temporary damage and disruption to about 2,400 acres of high-value farmland that includes strawberries and nursery crops. Coastal storm flooding with high tides and large waves could temporarily disrupt agricultural operations, escalating from about 430 acres today to about 2,600 acres with 58 inches of sea level rise. Increasing high tides are likely to have the most permanent impacts on agriculture as saltwater inundates and degrades the soils, possibly requiring a shift to lower value crops. With about 5 feet of sea level rise, over 1,440 acres of farmland become vulnerable to routine high tides.

Wastewater

The County Water and Sanitation Department oversees the wastewater collection system of 17 wastewater districts located throughout the County. Currently, most of the wastewater from the coastal zone is processed at regional wastewater treatment plants, the Ventura Wastewater Treatment Facility (in the City of Ventura), and the Oxnard Wastewater Treatment Plant (in the City of Oxnard). While these facilities are outside the unincorporated study area, impacts to these treatment facilities could be detrimental to unincorporated residents.

Across the unincorporated County, 14.5 miles of pipeline is vulnerable to coastal flooding with about 5 feet of sea level rise. If existing coastal armoring fails, much of this pipeline could also be exposed to coastal erosion damage. Along the North Coast, wastewater infrastructure is largely protected from erosion by 12 miles of coastal armoring in various conditions. Along the Central Coast, with just 8 inches of sea level rise, coastal erosion may damage up to 1.5 miles of wastewater pipes in the Hollywood Beach and Silverstrand neighborhoods. By about 5 feet of sea level rise, 3.3 miles of pipe may be damaged from erosion. With about 5 feet of sea level rise, 39 manholes could be exposed during coastal storms and 26 manholes could be routinely exposed during high tides.

Along the South Coast, septic systems may be damaged by erosion and tidal inundation. With about 5 feet of sea level rise the private wastewater treatment facility in Solromar is not projected to be impacted by the coastal hazards evaluated, but the restroom facility at Sycamore Cove State Beach could be exposed to tidal inundation.

Stormwater

The County stormwater system is based on gravity discharging runoff to the nearest body of water. As tides and sea levels rise, the efficiency of this gravity flow may decrease as outfall pipes may be completely submerged during more of the tide cycle. Specific elevations of key outfalls were not available to evaluate this change in detail. In some cases, stormwater pipes may also serve as a flow path for ocean water to enter neighborhoods. Already, 3.2 miles of stormwater pipe are affected during monthly high tides, particularly in the Hollywood Beach and Silverstrand neighborhoods. As sea levels continue to rise, the North Coast La Conchita community and the areas inland of Harbor

Boulevard which drain into McGrath Lake may be impacted as key culverts become exposed to tidal inundation and coastal flooding.

Water Supply

The County's coastal water supply system is managed by three water districts. Casitas Municipal District supplies water in the North Coast, while the United Water Conservation District supplies the Central Coast, and Calleguas Municipal District supplies the South Coast. Most of the water supply is groundwater, but it also includes surface water diverted from the Santa Clara and Ventura Rivers, imported State water, and recycled water. Coastal hazards could affect the coastal water supply.

Along the North Coast, some 2.9 miles of pipeline are currently exposed to a 1% annual chance storm, primarily along the Rincon Parkway neighborhoods of Rincon, Mussel Shoals, and the Faria Beach Colony, which may affect residential service. The Central Coast neighborhoods of Hollywood Beach and Silverstrand are especially vulnerable, and a large storm with substantial wave swell today could potentially flood two pump stations. With about 5 feet of sea level rise both pump stations would likely be at risk of inundation during routine monthly high tides. Along the South Coast, groundwater wells in the Ormond Beach and Calleguas Creek areas will become increasingly exposed to coastal flooding during large wave events. Residential service along the South Coast could also be affected as some 1,600 feet of water distribution pipe could become damaged by coastal cliff erosion with 8 inches of sea level rise. With about 5 feet of sea level rise, a total of about 3,800 feet of pipe could potentially be eroded.

Public Access, Recreation, and Trails

Coastal access and recreation in the County includes a wide variety of activities such as beach recreation, surfing, camping, birdwatching, and surf fishing. County beaches draw over three million visitor days per year with estimated visitor spending of $112 million annually on beach recreation. Along the North Coast, already armored campgrounds at Hobson and Faria County Parks, as well as camping spaces along the Rincon Parkway and at Emma Wood State Beach, are vulnerable to coastal flooding. In the Central Coast, the campground at McGrath State Beach is already frequently closed due to fluvial and estuary flooding and is being considered for relocation further south (away from the river). There are an estimated 31 beach access points, in addition to non-designated street ends through Silverstrand and Hollywood Beach. Currently, all beach access points and about 15 miles of the California Coastal Trail are vulnerable to erosion and coastal flood hazards that occur during a 1% annual chance storm. Coastal erosion with about 5 feet of sea level rise may affect 9.7 miles (about 30% of the trail) including portions of the planned alignment along Pacific Coast Highway in the South Coast. Beaches at Point Mugu, Sycamore Cove, Yerba Buena Beach, and Leo Carrillo Beach will be increasingly eroded and may disappear or require seasonal closures.

Natural Resources

The natural resources assessment evaluated potential sea level rise exposure of sensitive coastal ecosystems (including federally designated habitats and Western monarch overwintering roosts). It did not consider the transition or migration of habitat types due to sea level changes.

Coastal sand dunes (countywide), beaches, estuarine ecosystems, and associated federally designated critical habitats were the most vulnerable to sea level rise. With 58 inches of sea level rise, all of the beach (100%) and estuarine (100%) habitats could be exposed to combined coastal hazards (high tides, erosion, and storm flooding). Most of the freshwater (86%) habitats, as well as half the dune habitats (49%) may also be exposed to combined coastal hazards. The 49% of dunes that may be exposed are generally foredunes located close to beaches. The largest area of vulnerable habitat is freshwater, with over 2,680 acres that could be damaged by increased salinity. The majority of plant and animal species that are dependent upon these habitats were also found to be among the most vulnerable. Beach and coastal sand dune environments may be eroded, inundated, and flooded, resulting in altered ecosystem function. Foredunes are vulnerable to erosion today. Existing beach conditions on the North and South Coasts are likely to change over time to beaches that are narrower, steeper, and occur in smaller isolated pockets. In addition, sea level rise may contribute to changes in the relative proportions of the different ecological zones within beach habitats, exposing all levels of the food web, degrading habitat quality, and preventing the formation of coastal dunes. Where development or other barriers block upland migration of these systems, existing beaches and dunes are likely to be reduced in size, fragmented, lost, or degraded.

Roads and Parking

Approximately 183 miles of road lie within coastal hazard areas. The responsibility for maintaining these roads is shared between Caltrans and the County Transportation Department. Overall, the most vulnerable road on the North and South Coasts is Pacific Coast Highway, which is owned by Caltrans although the Rincon Parkway segment is maintained by the County. Fifteen parking lots that provide the public with coastal access are maintained by the County, Caltrans, or State Parks. Most of the roads and parking lots subject to coastal hazards are already armored, particularly in the North Coast along Highway 101 and the Rincon Parkway, and in the South Coast along Pacific Coast Highway. Today, 19 miles of road and 9 parking lots across the County are vulnerable to coastal flooding during a 1% annual chance storm. With about 5 feet of sea level rise this amount increases to 45 total miles of road and 11 parking lots exposed to coastal flooding. While flooded, 14 miles of road could also be damaged by coastal erosion, and 12 miles of roads could be routinely inundated during monthly high tides. The most notable impacts to County-maintained roads occur along Harbor Boulevard, and to residential streets in the Hollywood Beach and Silverstrand neighborhoods. It is also important to note that any future failures of the coastal armoring along the North and South Coasts may substantially increase the amount of erosion to roads and parking lots.

Public Transportation and Bike Routes

Ventura County has approximately five miles of Class 1 bike trails including the recently completed Ralph Fertig Memorial Trail connecting the Beacon's Beach area to Rincon Point along Highway 101. The Union Pacific Railroad alignment hugs the North Coast shoreline and provides some public use through AMTRAK. The Coastal Express Bus, operated by VISTA, extends from the City of Ventura to Isla Vista in Santa Barbara County along Highway 101, but there are no stops in the unincorporated area. Bike lanes are planned to generally follow the Pacific Coast Highway along the South Coast.

Along the North Coast, coastal armoring currently protects the bike, bus and rail lines from coastal erosion. Coastal flooding from a 1% annual chance storm today may temporarily impact portions of the Coastal Express Bus route along Highway 101, the Ralph Fertig Memorial Bike Trail, and Class 2 bike lanes along the Rincon Parkway. Along the Central Coast, there is some exposure of Class 2 bike lanes to coastal flooding in Hollywood Beach and Silverstrand, and as sea level rises, potential damage from coastal erosion and routine closures from high tides may occur. Along the South Coast, some existing exposure of Pacific Coast Highway to coastal flooding and erosion may affect bike routes, and this exposure is expected to increase with sea level rise.

Oil and Gas

Interruptions in oil and gas supply and oil spills will continue to pose a risk to Ventura County with potential fiscal impacts estimated in the hundreds of millions of dollars range. There are 105 active wells and approximately 363 inactive and capped wells within the unincorporated coastal zone. Minor pipelines connect wells to local storage facilities which in turn connect with major pipelines to refineries in Los Angeles. Major oil and gas pipelines are generally located along the railroad and Highway 101 in the North Coast. There are also distribution and transmission pipelines that transport and distribute oil and natural gas across the region and to homes and businesses.

Most of the infrastructure on the North Coast is protected from erosion by 12 miles of coastal armoring, but nine inactive wells and four miles of pipeline may be exposed to coastal flooding from large waves. With about 5 feet of sea level rise, two active wells north of Rincon Parkway become exposed to coastal flooding. Additionally, about 0.7 miles of gas pipeline is exposed to potential coastal flooding in the Faria community. Along the Central Coast, 15 active and 58 inactive wells, including the active slant drilling operation at McGrath Beach, are exposed to existing fluvial flood hazards along the Santa Clara and Ventura Rivers. As sea level rises by about 5 feet, coastal flooding may expose 17 active and 32 inactive wells, mainly around the McGrath Beach facility. About 0.5 miles of gas transmission pipeline may be exposed to coastal flooding in Ormond Beach. Coastal erosion at McGrath and Ormond Beach may exacerbate flooding and allow storm waves to reach oil and gas facilities if the fronting protective dunes erode.

Hazardous Materials

An initial assessment of hazardous materials was conducted to evaluate businesses that store hazardous materials, entities operating with a waste discharge permit, or any identified contaminated sites in the unincorporated areas. The EPA Superfund Halaco site in the City of Oxnard near Ormond Beach has been emphasized by the City of Oxnard as a particular vulnerability. The spread of contamination from the Superfund site would likely affect unincorporated County lands. Thirteen businesses storing hazardous materials were also identified, most of which are associated with the aging oil and gas infrastructure on the North Coast and the Agromin Organics Recycling facility near Ormond Beach. With 16 inches of sea level rise, the Agromin Organics Recycling facility could be exposed to tidal inundation, which may cause wider contamination that affects agriculture and sensitive habitat.

Critical Services

Critical facilities assessed include those that support emergency operations and disaster response such as medical, fire, and sheriff facilities. The North Coast Fire Station #25 near Seacliff could be exposed to coastal flooding with about 5 feet of sea level rise. Fire Station #56 on the South Coast is not exposed to coastal hazards even with about 5 feet of sea level rise.

Secondary facilities including schools, government facilities, and communication towers as well as tsunami evacuation routes were also evaluated. Hollywood Beach Elementary School could be exposed to coastal flooding under existing conditions. As sea level rises to 16 inches, the foundation of the school could become exposed to coastal erosion. With about 5 feet of sea level rise, a Channel Islands Community Service District building in Silverstrand may become vulnerable to coastal storm flooding.

Evacuation routes along Highway 101 on the North Coast, at Silverstrand on the Central Coast, and Pacific Coast Highway on the South Coast are currently exposed to coastal flooding and erosion. With about 5 feet of sea level rise, evacuation routes will be increasingly exposed to coastal flooding

(4.7 miles), coastal erosion (0.4 miles), and routine tidal inundation (2.2 miles) across the County. As evacuation routes cross jurisdictional boundaries, emergency responses to and from unincorporated areas could be affected.

A critical facility that is in the unincorporated area, but is not regulated by the County's Local Coastal Program, is Naval Base Ventura County. The base is the largest employer in Ventura County with more than 17,320 personnel and it provides almost $2 billion in economic benefit to the local and regional economy. Given its locations at Point Mugu and Port Hueneme, Naval Base Ventura remains vulnerable to sea level rise. As such, a separate federally funded vulnerability assessment is underway to fully evaluate all vulnerabilities and potential adaptation measures.

Positive Findings

There are increasing funding opportunities for sea level rise adaptation planning efforts, and many neighboring jurisdictions are already conducting sea level rise studies. Thus, there is potential for collabo rative planning to address risks early. The following summarizes positive findings from this report. Generally, some of the County's residents and coastal resources may not be vulnerable until 5 feet or more of sea level rise occurs (approximately year 2100 or later).

- There are no airports, wastewater treatment facilities, or power plants in the County's jurisdiction that are vulnerable with up to 5 feet of sea level rise. Though it should be noted that Point Mugu Naval Air Weapons station, under federal jurisdiction, is susceptible to sea level rise impacts.
- There are no critical facilities such as Fire stations or Sheriff stations at risk with up to 5 feet of sea level rise.
- No oil and gas infrastructure is exposed to coastal erosion along the Central or South Coasts.
- The inland sand dune (backdunes) and freshwater habitats are not particularly vulnerable to sea level rise and there is still time to design and implement adaptation strategies for other inland sensitive habitats.
- While residential structures may be vulnerable to erosion and coastal flooding, there is time to plan for the effects of tidal inundation, which are projected to occur with 5 feet of sea level rise. No densely populated disadvantaged communities are directly exposed to coastal hazards with up to 5 feet of sea level rise.

1. PLANNING BACKGROUND

1.1 Introduction

In order to address sea level rise and associated hazards in the County's VC Resilient Coastal Adaptation Project, the County of Ventura (County) and its consultant team prepared this 2018 Vulnerability Assessment (Report). The purpose of this Report is to provide technical analysis using climatic modeling and geospatial analyses to support the County's effort to incorporate a range of coastal and sea level rise hazards into the County's planning and regulatory processes. Through a better understanding of coastal hazards and vulnerabilities, we can begin to prepare for a future when sea level rise impacts are more severe. Key jurisdictional boundaries and subareas in the County are shown in Figure 1-1.

The California Coastal Act requires local governments in the state's coastal zone to create and implement Local Coastal Programs (LCPs). Each LCP consists of a Coastal Land Use Plan and an Implementation Plan. Using the California Coastal Act, the California Coastal Commission (Coastal Commission) and local governments manage coastal development and protection of coastal resources, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion. Sea level rise and a changing climate present new management challenges with the potential to significantly threaten many coastal resources, including both natural resources and public access. One of the CCC's priority goals is to coordinate with local governments, such as the County of Ventura, to amend the LCP to address sea level rise.

The goal of this project is to complete a vulnerability assessment for the County that will support adaptation planning, ultimately leading to enhanced community resilience and certification of an LCP consistent with new State and Federal laws. A high priority of the LCP is to conserve coastal dependent uses for County residents and visitors into the future.

Figure 1.1 - North, Central, and South Coast Planning Subareas in the Local Coastal Program

1.2 Ventura County Local Coastal Program

Ventura County's Coastal Area Plan and the Coastal Zoning Ordinance together constitute the "Local Coastal Program" (LCP) for the unincorporated portions of Ventura County's coastal zone. The primary goal of the LCP is to ensure that the local government's land use plans, zoning ordinances, zoning maps, and implemented actions meet the requirements of, and implement the provisions and polices of the Coastal Act at the local level. In addition to being an element of Ventura County's LCP, the Coastal Area Plan is also an Area Plan for the unincorporated coastal portions of Ventura County and, as such, is part of the County's General Plan.

The Coastal Area Plan addresses topics such as shoreline access and public trails; development in scenic areas, coastal hazards, and coastal bluffs; environmentally sensitive habitat areas; cultural resources; transportation; public services; and more. The LCP specifically applies to development undertaken in the unincorporated portions of the coastal zone of Ventura County.

In 2017, the County of Ventura was awarded an LCP Local Assistance Grant from the Coastal Commission and the California State Coastal Conservancy to develop a balanced and forward-thinking response to sea-level rise. Based on the technical information presented in this Report, the County will draft LCP policies and potential adaptation strategies to be considered by decision makers to address future sea level rise.

The Ventura County Planning Division is responsible for administration of the County's General Plan and LCP. Since the LCP was certified by the Coastal Commission, the County serves as the lead agency for review and approval of development projects in the coastal zone. Currently, Planning Division staff, in collaboration with staff from the Public Works Watershed Protection District and Public Works Land Development Services Department, reviews new coastal projects for potential hazards associated with sea level rise and storm events. However, there are few specific County policies or regulations pertaining to sea level rise. It is anticipated that the draft policies resulting from this study will result in future LCP amendments to proactively address sea level rise. They may also provide a higher level of certainty for County staff, the Coastal Commission, landowners and businesses when processing discretionary coastal development permits.

1.3 Recent State Sea Level Rise Guidance

There are two recent State sea level rise guidance documents that are meant to guide local jurisdictions in sea level rise planning throughout California. These are the State of California Sea-Level Rise Guidance Year 2018 Update, adopted by the Ocean Protection Council (OPC) in 2018, and the Sea Level Rise Policy Guidance, certified by the Coastal Commission in 2015.

The 2018 OPC update to the State of California Sea-Level Rise Guidance reflects advances in sea level rise science and addresses the needs of state agencies and local governments as they incorporate sea level rise into their planning, permitting, and investment decisions. The updated Guidance provides: 1) a synthesis of the best available science on sea level rise projections and rates for California based on foundational modeling work completed as part of the 4th California Climate Assessment; 2) a stepwise approach for state agencies and local governments to evaluate those projections and related hazard information in decision-making; and, 3) preferred coastal adaptation approaches. The first recommendation for sea level rise planning and adaptation in the OPC guidance is that adaptation planning and strategies should prioritize social equity, environmental justice and the needs of vulnerable communities. To incorporate this new guidance on equitable adaptation strategies, the County conducted a social vulnerability analysis that can be found in Appendix C. In August 2015, the Coastal Commission adopted the Sea Level Rise Policy

Guidance to aid jurisdictions in addressing sea level rise in LCPs, coastal development permits, and regional strategies. The document outlines specific issues that policymakers and developers may face as a result of sea level rise, such as extreme weather events, challenges to public access, vulnerability, and maintaining consistency with the California Coastal Act. The policy guidance document also lays out six recommended planning steps to incorporate sea level rise into the legal context that lead to development of strategies to reduce identified vulnerabilities and inform further adaptation planning (Figure 1-2). This Report completes Steps 1 through 3 and provides initial input on Step 4, as shown below.

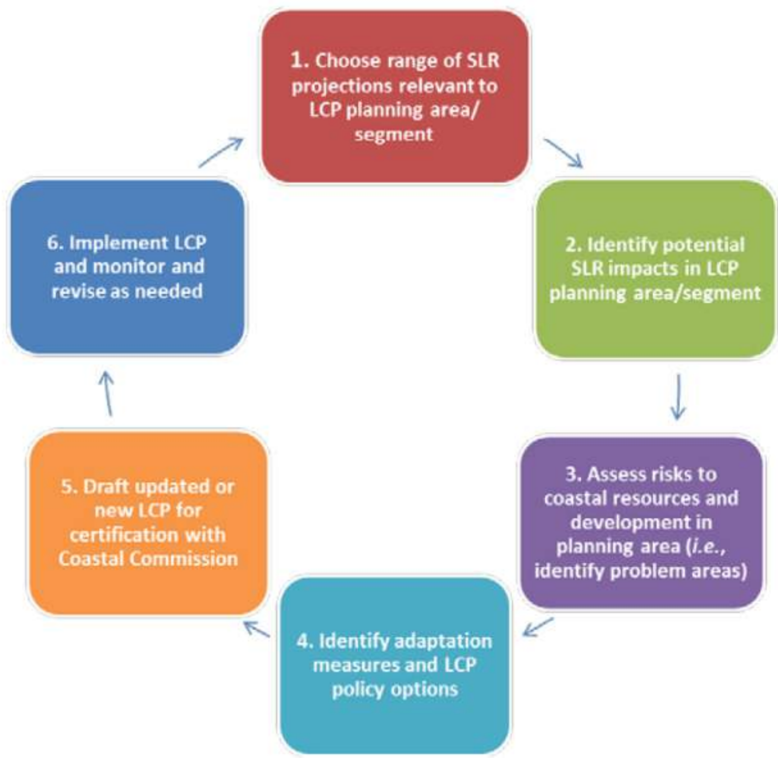


Figure 1-2. California Coastal Commission guidance for including sea level rise into Local Coastal Programs.

The policy guidance places strong emphasis on combining existing coastal hazards (storm surge and high tides) with sea level rise into LCP planning, and using adaptation strategies known as "soft" or "green" strategies because they mimic or enhance natural processes and defenses, rather than "gr ay" or "hard" strategies they rely on engineered methods , such as seawalls and riprap, that increase the rate of beach erosion. This Report and the VC Resilient Coastal Adaptation Project follows the specific steps outlined in the Coastal Commission 2015 guidance document, as described below:

Step 1. Establish the Projected Sea Level Rise Ranges

When the Coastal Resilience modeling was completed in 2013, it included "low", "medium", and "high" SLR projections that are measured in inches for each of the years 2030, 2060, and 2100. New sea level rise projections were published in the State of California Sea-Level Rise Guidance 2018 Update that are widely recognized as the best available science. Table 1-1 compares the Coastal Resilience sea level rise projections with the recent State guidance, and includes a "H++ scenario".

Recent State guidance included a "H++ scenario" that considers that there could be over 8.5 feet of sea level rise by 2100 due to significant reductions in polar ice sheets.

Table1-1. Sea Level Rise (SLR) projections in inches, comparison between the State of California Sea Level Rise Guidance 2018 Update (High Emissions) and Coastal Resilience Ventura 2012.

	State of California Sea Level Rise Guidance 2018 Update			Coastal Resilience Ventura			H++ Scenario
Year	Low (50% probability SLR meets/exceeds)	Medium (5% probability SLR meets/exceeds)	High (1 in 200 chance SLR meets/exceeds)	Low SLR	Medium SLR	High SLR*	Single Scenario
2030	0.8" (total for years 2010-2030)	0.8" (total for years 2010-2030)	0.8" (total for years 2010-2030)	2.3"	5.2"	8.0"	0.8" (historical rate)
2060	7.7"	13.7"	20.9"	7.4"	16.1"	25.3"	29.0"
2100	20.3"	43.7"	71.9"	17.1"	36.5"	58.1"	104.6"

**Adapted from 2018 SLR Guidance Update and ESA PWA 2012*
***Orange shading indicates the sea level rise elevations used in the analysis.*

The County selected the years 2010, 2030, 2060, and 2100 as the most relevant planning horizons to support the County's coastal management, planning, and LCP updates, because these time horizons align with the Coastal Resilience modeling that was completed in 2012 The year 2010 represents the most recently flown LIDAR topography for the Ventura coastline and therefore provides the baseline of existing conditions for this analysis. The legends in each of the maps provided in this Report refer to the year 2010 modeling work as "existing".

Consistent with the Coastal Commission policy guidance, the County evaluated a high sea level rise scenario, which is 58.1 inches by year 2100 used in the Coastal Resilience modeling. The year 2100 time horizon is the most distant time horizon included in this Report, although recent sea level rise projections extend to year 2150. The year 2100 time horizon is widely accepted as appropriate for sea level rise adaptation planning, because it roughly mirrors the life expectancy for new structures and large infrastructure projects, such as bridges. The more distant the time horizon, the less reliable the projections tend to be due to the unpredictable nature of future sea level rise. Thus, it is expected that projections identified as most appropriate today will be revisited and revised over time as science and information evolves.

The H++ scenario has no probability attributed to it since the mechanisms driving polar ice melt today may change and become more severe (See Section 3.4 to learn more about the H++ scenario). The H++ scenario was included in State guidance after the modeling was completed for this Report. Therefore, while the modeling of 58.1 inches by year 2100 scenario is considered high, it is not an extreme scenario and should not be interpreted as the worst-case scenario for the County.

The Coastal Resilience mapping tool was used to help evaluate the most useful "low," "medium," and "high" scenarios highlighted in Table 1-1, above. This analysis determined that the 2030 "high" projection for 8 inches is a useful scenario because it provides a context to address current and near-term flooding issues.

For the year 2060, the "medium" sea level rise scenario was selected, which modeled 16 inches of sea level rise. Other options for the year 2060 sea level rise scenario included 25 inches and 37 inches. Although there are some additional sea level rise impacts for the 25- and 37-inch scenarios, this Report focuses on 16 because it still captures a majority of impacts from the intermediate scenarios and also provides additional certainty of impacts for policy development due to the higher probabilities of occurrence. Comparison of the mapped modeling results indicated that few additional unincorporated coastal areas were vulnerable at 25 inches and 37 inches of sea level rise when compared to the 16 inch modeling results. The areas that are more vulnerable at 25 inches and 37 inches of sea level rise compared to 16 inches are generally located outside of the County's jurisdiction, in the cities of Oxnard, Port Hueneme, and on Naval Base Ventura County.

The year 2060 "medium" sea level rise scenario of 16 inches is also associated with a substantially higher statistical probability of occurrence. Based on the recent work in the State guidance, which assigned probabilities to future sea level rise elevations based on the current rate of global greenhouse gas emissions, the 16-inch sea level rise scenario has close to 66% probability of occurrence by 2060, compared to greater than 5% for the 25-inch scenario, and less than 0.5% for the 37-inch scenario. A comparison of the local areas vulnerable to sea level rise according to different Coastal Resilience mapping tool sea level rise scenarios are described in more detail below. These findings were discussed with Coastal Commission staff before the 8-inch, 16-inch, and 58-inch scenarios were selected for this Report.

1. A 1% annual chance storm combined with 8 inches of sea level rise could affect many coastal areas within the year 2040 Planning Horizon of the County's General Plan Update.
2. The North and South Coasts of the County have steeper topography and shoreline armory, so there are only minor differences in areas exposed between the sea level rise scenarios of 16 inches, 25 inches, and 37 inches.
3. In the unincorporated area located inland of McGrath State Beach on the Central Coast, the 16-inch, 25-inch, and 37-inch sea level rise exposure generally extends to, and ends at, Harbor Boulevard, so there is no noticeable difference between the scenarios for the McGrath Beach area.
4. The unincorporated area of Hollywood Beach would incur incremental additional flooding at the sand trap near the north entrance of the Channel Islands Harbor with 16 inches, 25 inches, and 37 inches of sea level rise, but the results are all generally very similar.
5. In the unincorporated residential community of Silverstrand, the sea level rise scenarios for 16 inches, 25 inches, and 37 inches result in similar impacts and do not depict as much flooding as the formidable 58-inch year 2100 scenario.
6. Agricultural land inland of Ormond Beach would be exposed to a larger extent of flooding at 25 inches and 37 inches of sea level rise, compared to the 16-inch scenario. However, with sparse development in this area, it is likely that subsequent adaptation strategies will be similar even though a larger extent of flooding is projected.

Step 2. Identify Potential Impacts from Sea Level Rise

The potential hazards for the County associated with sea level rise include dune erosion, beach loss, cliff erosion, coastal flooding from waves, coastal confluence flooding (river flooding altered by sea level rise), and tidal inundation. In addition, saltwater intrusion into the groundwater aquifers could pose substantial risk to water supply and agriculture, although additional work is needed to address this issue in the County. Long term impacts to beaches may also occur, and the Coastal Resilience mapping tool estimates that the effects of erosion will increase.

The County has been attempting to understand these potential hazards by contributing funding and participating in development of the Nature Conservancy-led Coastal Resilience Ventura mapping tool. In addition, Planning Division staff have engaged in regional discussions with the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) and the City of Oxnard regarding their Sea Level Rise LCP Update. This Report represents the most current effort toward quantifying these impacts and moving toward adaptation planning. The County is also working toward better understanding potential impacts of climate change, saltwater intrusion, and water supply impacts through its participation in the Regional Energy Alliance, preparation of the General Plan Update, and the Integrated Regional Water Management Plan update (Section 1.4).

Step 3. Assess the Risks and Vulnerabilities to Coastal Resources and Development

The following "sectors" were determined to experience some form of existing or future vulnerability and risk due to sea level rise (e.g., dune erosion and/or coastal flooding):

- Land Use Parcels and Structures
- Agriculture
- Wastewater
- Stormwater
- Water Supply
- Public Access, Recreation, and Trails
- Roads and Parking
- Public Transportation
- Oil and Gas Infrastructure
- Hazardous Materials
- Critical Services
- Natural Resources
- Vulnerable Populations

In addition, as a first step toward incorporating environmental justice into sea level rise planning for Ventura County, a social vulnerability assessment was completed. Show in Appendix C, the social vulnerability assessment identifies the demographics of the residents in the unincorporated coastal zone, evaluates identified vulnerable populations (seniors, renters, and Hispanics), and provides adaptation strategy recommendations to address these vulnerable populations.

Staff also contacted Native American tribes and determined that there are some vulnerable areas with a high likelihood of containing archeological sites. While the precise location of vulnerable archaeological sites is not listed in this report, the areas with a high likelihood of containing sites include Rincon Point, Seacliff, Mussel Shoals, McGrath State Beach, and throughout the South Coast. More detailed assessments are needed to assess the vulnerability of these locations.

Step 4. Identify Adaptation Measures

The County will be conducting additional work on adaptation strategies later in the adaptation planning and implementation process. The Vulnerability Assessment is a starting point for a common understanding of the risks, but it does not provide solutions. There are few easy solutions and most require additional input from the public and from private landowners, resource agencies, and others affected by sea level rise. This first step is a comprehensive look at what happens and when it might happen. The next step is to begin planning for adaptation.

Adaptation measures such as beach nourishment, armoring, new groins, dune restoration, and inland relocation will be considered. The 8-, 16-, and 58-inch sea level rise thresholds discussed above will be used when evaluating imminent risk and the effectiveness of various adaptation measures. The secondary impacts of each adaptation measure, the relative cost, and the potential for maladaptation will also be evaluated.

Step 5. Update the LCP

Over the last few years, the County completed a comprehensive update to many sections of its LCP. Pending future funding, information from this Report and the resulting Adaptation Report will be used in conjunction with public input and direction from the Board of Supervisors to prepare future LCP amendments to address sea level rise. It is expected this will include integration of adaptation strategies that are assigned a high priority by the County.

Step 6. Monitor Implementation

Ongoing monitoring is critical to adaptation planning. It highlights the actions that are most effective and feasible, any unintended consequences, and new data that may inspire new strategies. Ultimately, the adopted plan will identify responsible parties and prioritize adaptation strategies for sea level rise. It will also monitor progress through tracking timeframes and thresholds, and define reporting requirements. Larger scale interventions may be phased in over longer timeframes as funding and the necessary partnerships become available.

1.4 Related County Planning and Project Initiatives

Generally, adaptation can be addressed in two ways: 1) through changes to planning and policy documents; and, 2) through the implementation of specific projects. This Report is focused on informing the planning and policy efforts in the County. The County has been addressing coastal hazards and sediment supply issues for many decades and the shoreline throughout the County (including incorporated areas) includes many examples of different adaptation approaches that have been implemented with varying levels of success. These projects are discussed in more detail below.

Presently, there are numerous County planning initiatives that are focused on various aspects of addressing climate change impacts, as well as improving planning and adaptation. Typically, local coastal hazards are managed in three ways: accommodate, protect, or retreat. The implementation of land use regulations that limit development in flood-prone areas is one example of accommodation. Elevating homes above tidal elevations is another example of accommodation. Coastal armoring and beach nourishment are methods used to protect existing development. An example of retreat could include the efforts to restore Ormond Beach, which would likely incorporate planning for habitat migration of the salt marshes.

Planning documents and initiatives involving one or more County agencies to implement adaptation strategies that protect, accommodate, or retreat from coastal hazards in Ventura County are listed and then described in more detail below.

- Comprehensive Land Use Regulations
- Open Space and Growth Control Measures
- Ventura County General Plan and Local Coastal Program
- Ventura County General Plan Update
- Ventura County Climate Action Plan
- 2009 BEACON Regional Sediment Management Plan
- Ventura County Multi-Jurisdiction Hazard Mitigation Plan
- Integrated Water Resource Management Plan Update
- Groundwater Initiatives
- Ormond Beach Restoration

Comprehensive Land Use Regulations

While there are some dense pockets of development, most of the unincorporated coastline serves open space and recreational uses. In the unincorporated area, 95% of the coastline is zoned for open space and recreation. Growth control measures and land-use regulations make it unlikely that coastal land will be opened to significant new development. Instead, there is a longstanding desire to direct growth— both new population and new development— to existing communities within the County.

The policies that limit the development of new land are implemented through the County's LCP which must be consistent with the California Coastal Act, which discourages new development that is not dependent on coastal resources and ensures protection of coastal resources. Policies and programs in the LCP are organized based on the geography of the coast.

Open Space and Growth Control Measures

Land use planning and development in the County is guided by interjurisdictional agreements and a voter initiative that generally guide development away from open space and into the cities. These measures also help site new development away from flood-prone areas. Save Open Space & Agricultural Resources (SOAR), the Guidelines for Orderly Development, and the greenbelt agreements are described in more detail below and illustrated in Figure 1-3.

- SOAR is a series of land use ballot initiatives that, in the unincorporated area, require voter approval on any proposal to redesignate rural land, farmland, or open space to more intensive land uses. In the cities, voter approval is required to annex areas that are located outside of identified Urban Restriction Boundaries. The first initiative was enacted in the City of Ventura in 1995 and the County's initiative followed in 1998. The cities of Camarillo, Thousand Oaks, Fillmore, Santa Paula, Simi Valley, Moorpark and Oxnard also have approved SOAR initiatives. In 2017, all of the County's SOAR initiatives were renewed through the year 2050. While other jurisdictions in the State have adopted similar measures, the County of Ventura is unique in the coordinated application of these measures by virtually all jurisdictions.
- The Guidelines for Orderly Development were initially adopted in 1969 by the Ventura Local Agency Formation Commission (LAFCo) and Ventura County to address growth and the delivery of urban services. They were revisited in 1976, 1983, and 1995. Later revisions were adopted by all cities in the County. Ultimately, the Guidelines limited the number of cities and mandated orderly annexations within the Spheres of Influence created around each city. As currently adopted, the Guidelines maintain the consistent theme that urban development should be located within incorporated cities whenever or wherever practical. In exchange for forgoing urban development, the County receives a percentage of the sales tax revenue earned by the cities. The Guidelines promote efficient and effective delivery of community services for existing and future residents as the countywide population increases.
- Beginning in 1967 and continuing to the 1980s, greenbelt agreements were originally adopted by cities and the County to protect rural, open space, and agricultural lands from being converted to incompatible uses. They were implemented through resolutions that were adopted by the Board of Supervisors and the local city councils. The cities agreed to not annex greenbelt land or to extend municipal services into the greenbelts and the County agreed to only permit land uses that were consistent with open space and agriculture. More recently, two of the greenbelt agreements were adopted as ordinances that enhance their legal authority. In the coastal zone, only the unincorporated agricultural lands inland of McGrath State Beach and Mandalay Beach are located within the Ventura-Oxnard Greenbelt, which was adopted by ordinance in 2015.

Ventura County General Plan and Local Coastal Program

The Ventura County General Plan provides goals, polices, and programs that are used to achieve a vision for future growth and to provide adequate services for existing development. One of the General Plan directives is to site development away from hazardous areas. The County's LCP incorporates both a Coastal Area Plan and a Coastal Zoning Ordinance. The Coastal Area Plan and Coastal Zoning Ordinance provide more detailed implementation measures for the General Plan that are consistent with the California Coastal Act. The Land Use chapter of the Coastal Area Plan states that one purpose of the Open Space land use designation is to "protect public safety through the management of hazardous areas such as flood plains, fire prone areas, or landslide prone areas." Cumulatively, The County's General Plan and LCP, the Coastal Act, and overarching countywide growth control measures make it unlikely that open space or agricultural areas along the coast will be converted to more intensive land uses.

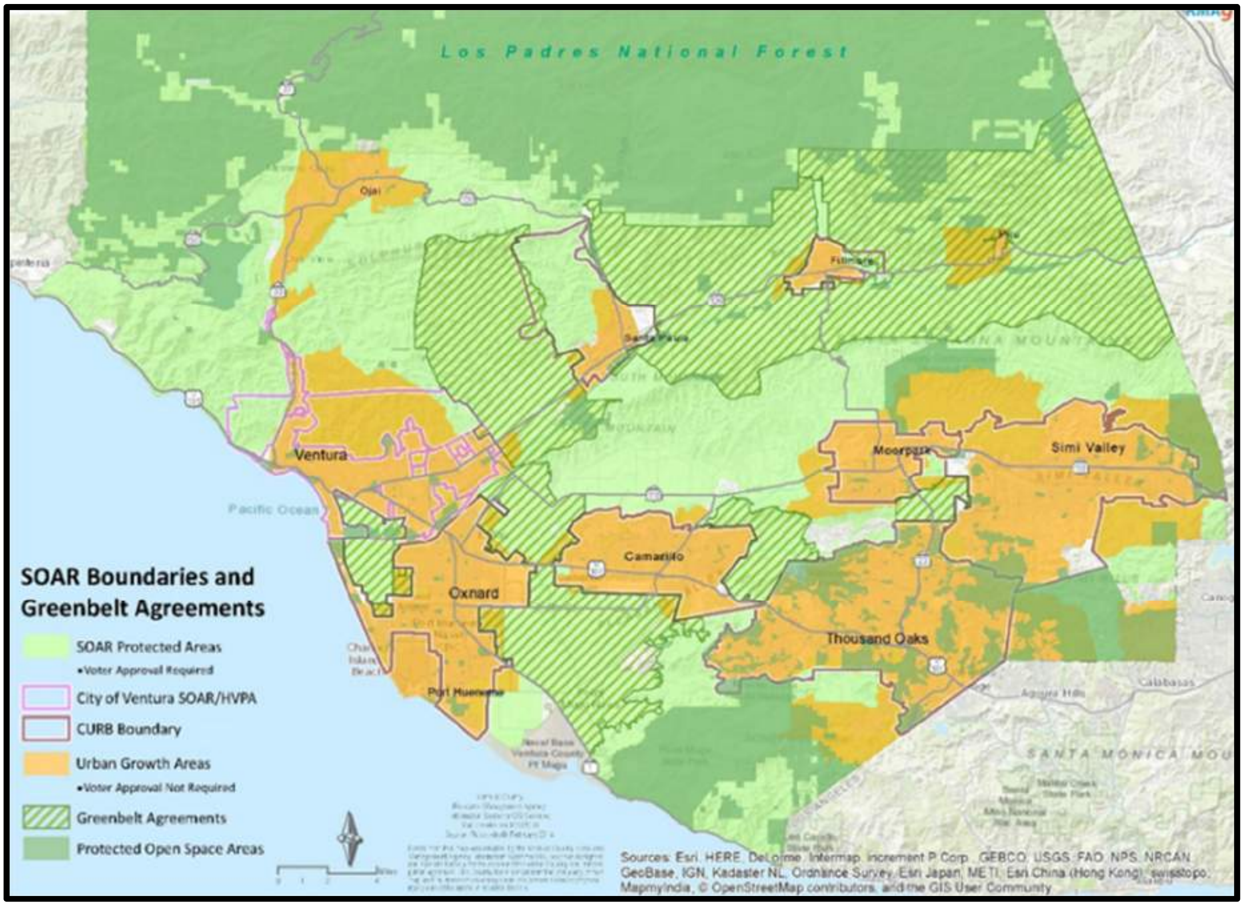


Figure 1-3. Greenbelt Agreements

Ventura County General Plan Update

The County is working on an update to its General Plan. The current General Plan expires in 2020 and it has not been comprehensively updated since 1988. Since that time, there have been many important changes to state law that dictate what issues must be included in a general plan. For example, state law now requires that general plans address climate change and street design to better accommodate pedestrians and bicycles.

Most general plans are organized by topics or "elements." State law requires that every General Plan contain seven elements: Land Use, Circulation, Housing, Conservation, Open Space, Noise, and Safety. State law allows every jurisdiction to decide how to organize its general plan as long as the required elements are included. The current Ventura County General Plan combines the seven required elements into four broad topic areas:

- Resources (Conservation, Open Space)
- Hazards (Noise, Safety)
- Land Use (Land Use, Housing)
- Public Facilities and Services (Circulation)

In addition to the four topic areas, the County's existing General Plan includes a document called the "Ventura County Goals, Policies, and Programs." As the name implies, it includes the goals, policies, and programs for all topic areas.

As a part of the General Plan Update[2], the existing elements may be reorganized and the County will develop three additional elements to address issues related to agriculture, economic development, and water. The topics of health and climate change will also be addressed. This important project will help shape the next 20 years of Ventura County's land use management.

Climate Action Planning

Climate action planning for local governments typically begins with efforts to reduce "operational" greenhouse emissions that result from government-owned buildings, land uses, and activities such as use of the vehicle fleet. The Ventura County Regional Energy Alliance (VCREA) is working with the County, as well as various cities, to evaluate energy use in selected municipal buildings, set reduction goals, and propose potential energy-efficient projects to meet those goals.

The Ventura County Planning Division is currently responsible for ensuring that discretionary development does not exceed greenhouse gas emissions thresholds that are adopted and periodically updated by the Ventura County Air Pollution Control District. Individual discretionary projects are reviewed in conjunction with the Air Pollution Control District on a case-by-case basis.

The General Plan Update will include a Climate Action Plan that addresses community-wide, activity-based greenhouse gas (GHG) emissions in the unincorporated area associated with land use, transportation, energy use, water use, wastewater treatment, solid waste, industry, and agriculture. Through this process, a greenhouse gas emissions reduction goal for the unincorporated area will be identified that is consistent with the State's requirements, along with policies and programs to achieve the goal. The Climate Action Plan will also address climate change vulnerability and adaptation, per the requirements of Senate Bill 379. The Board of Supervisors may elect to formally adopt a GHG reduction target, associated GHG reduction measures, and climate adaptation measures.

Ventura County Multi-Hazard Mitigation Plan

The purpose of the Multi-Hazard Mitigation Plan (MHMP) is to identify policies and actions that can be implemented in Ventura County over the long term to reduce risk and future losses. In 2005 and 2010, Ventura County's Board of Supervisors adopted the first and second Ventura County MHMP, which focused on threats posed by sea level rise, earthquakes, floods, geologic hazards, wildfires, tsunamis, and other hazards. The 2015 Ventura County MHMP update was a multi-lateral effort and included coordination with 40 other communities and special districts within the Ventura County Operational Area. The County's 2015 MHMP serves to enhance public awareness and understanding, provide a decision tool for management, strengthen local priorities for hazard mitigation capabilities, provide inter-jurisdictional coordination of mitigation-related programming and achieve regulatory compliance. The 2015 draft document includes a climate change section that addresses rising tides and coastal storms. Additionally, the MHMP complies with the requirements of Assembly Bill 2140 (2007) and all other state and federal requirements. Assembly Bill 2140

[2] To learn more about the Ventura County General Plan Update, visit the project website (vc2040.org).

requires that the County's emergency plans are coordinated with the County's General Plan Hazards Appendix. The MHMP enables approved agencies to apply for disaster assistance and mitigation funds in the event they become available.

Groundwater Initiatives

Decades of local reliance on groundwater has reduced the water table in many aquifers to below sea level and seawater has seeped into the groundwater basins of the Oxnard Plain. As sea level increases, saline waters will likely continue to intrude on water tables. In 1991, a network of coastal monitoring wells was installed to improve local understanding of the location and severity of saline water intrusion. Figure 1-4 below, illustrates that saline water tends to be drawn landward through the deep-water sea canyons near Port Hueneme and Point Mugu. As these plumes of seawater disperse, it will become more difficult to flush the saline water back to the sea.

The groundwater management system in Ventura County is complex. There are 122 water purveyors that mostly rely on extraction from groundwater sources. Seawater intrusion has been a recognized concern since the 1940s, and in response to local and State agency concerns about groundwater overdraft and seawater intrusion, the County supported establishment of the Fox Canyon Groundwater Management Agency (FCGMA), which was created by the California Legislature in 1982. The FCGMA was tasked with development of a groundwater management plan and managing the groundwater resources. The FCGMA's efforts combined with projects constructed and operated by others such as United Water Conservation District's Vern Freeman Diversion have benefited the Oxnard Subbasin that is impacted by seawater intrusion. Despite these efforts, population growth, changes of crop types, and drought have contributed to the continued overdraft and expansion of the saline plumes.

In September of 2014, the California Legislature enacted the Sustainable Groundwater Management Act. The legislation provides a comprehensive framework for sustainable management of groundwater supplies by local authorities, with a limited role for State intervention when necessary to protect the resource. Through the Sustainable Groundwater Management Act, the legislature directed the California Department of Water Resources to identify groundwater basins and subbasins in conditions of critical overdraft. Conditions of critical overdraft result from undesirable impacts that can include seawater intrusion, land subsidence, groundwater depletion, and/or chronic lowering of groundwater levels. One or more undesirable impacts within a basin places the basin in a critical overdraft category. There are three basins in Ventura County in a condition of "critical overdraft" and the Oxnard Subbasin is the only basin in the coastal area that is identified as critically overdrafted.

Groundwater basins ranked by the state as critically overdrafted must form groundwater sustainability agencies (GSAs) and prepare groundwater sustainability plans. Once plans are in place, local agencies have 20 years to fully implement them and achieve the sustainability goal. The draft sustainability plan for the Oxnard Subbasin is currently available for public review.

In addition to groundwater planning efforts, a number of other management strategies and projects have been implemented to address overdraft and saline intrusion. The FCGMA allocates and regulates groundwater pumping within four groundwater basins including Oxnard and Pleasant Valley. The Pumping Trough, Oxnard-Hueneme, and Pleasant Valley pipelines have been constructed and operated by the United Water Conservation District and Pleasant Valley County Water District, respectively, to move pumping away from coastal areas and reduce pumping in the overdrafted lower aquifer system. While these management strategies and projects have significantly reduced the impacts of seawater intrusion and groundwater overdraft, they have not been sufficient to completely mitigate impacts, especially in light of sea level rise.

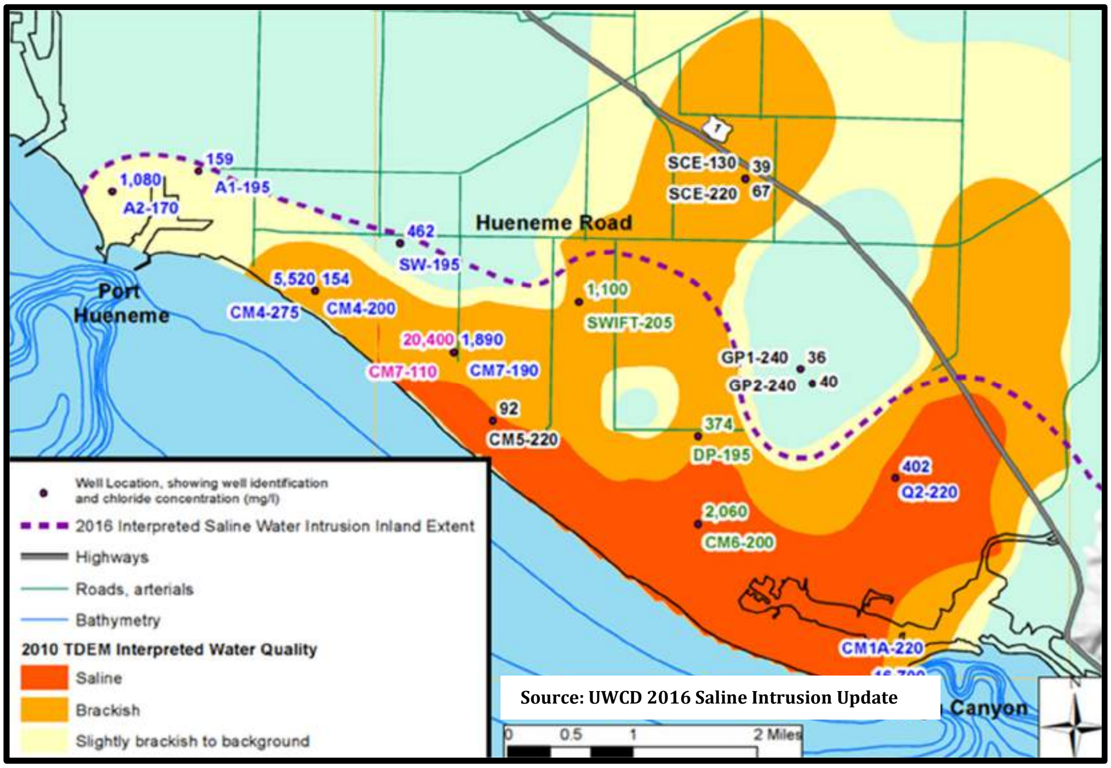


Figure 1-4. Map illustrating the saline intrusion and monitoring well locations in the Southern Oxnard Plain (the red and orange colors represent the extent of seawater intrusion).

Proposed management strategies being considered include desalters to remove salts from extracted groundwater in the coastal area; seawater desalination plants to convert seawater to drinking water; additional pipeline projects to move pumping away from coastal areas; pipelines to increase availability of recycled water; and further reduction in pumping allocations. Desalters constructed away from the coast could be connected to the Regional Salinity Management Pipeline developed by the Calleguas Municipal Water District. This “brine line” system transports chloride impacted water to the ocean at Port Hueneme. This proposed project as well as others being considered could be used in conjunction with groundwater recharge efforts, and other initiatives to reverse the historical trend of seawater intrusion.

Integrated Regional Water Management

In 2002, 2006, and again in 2014 California voters approved water management funding initiatives (water bonds) that have provided grant funds for Integrated Regional Water Management (IRWM) planning and implementation. The Watersheds Coalition of Ventura County, which serves as the Regional Water Management Group for the purposes of IRWM planning and governance, updates and implements the IRWM plan and determines which projects are needed to meet the plan’s goals. The plan also addresses climate change resilience efforts on a regional level, including enhancing water supply, water quality, flood management, ecosystem health, and recreation.

The state’s IRWM grant program provided key funding for the Natural Floodplain Protection Program that is described below. An update to the IRWM Plan is currently underway which will explore additional opportunities to develop “green” infrastructure and other solutions that will enhance the region’s resilience to climate change impacts.

Ormond Beach Restoration

The Ormond Beach wetlands historically spanned approximately 1,500 acres, and today it consists of some remaining wetlands, agriculture, and industrial land uses. It is one of the few ecosystems in Southern California with contiguous sand dunes and marsh land, and where the sparse amount of existing development may provide space for habitat to retreat from sea level rise. The Coastal Conservancy and Nature Conservancy are pursuing acquisition of approximately 900 acres of agriculture and open space at Ormond Beach, which straddles both the unincorporated area and the City of Oxnard.[3] In 2002, the Coastal Conservancy acquired 265 acres, and in 2005 the Nature Conservancy acquired 276 acres. Since these achievements, additional land transactions have stalled, but the Coastal Conservancy is in negotiations for an additional 340 acres of agricultural land located in the County. A restoration and access plan is expected to be completed in 2018, but the study area is limited to the land located within the City of Oxnard.

South Oxnard Flood Protection and Community Enhancement Project

This project will balance the development of green and grey flood protection infrastructure to reduce 1% annual chance storm flooding in developed areas of south Oxnard and Port Hueneme that are located inland of the beach. The South Oxnard Flood Protection and Community Enhancement Project has approximately $4 million in funding from Proposition 84. It's estimated that the project will be completed by 2020. Project partners include the Watershed Protection District, the City of Oxnard, the Watershed Coalition of Ventura County, and the City of Port Hueneme.

Beach Elevation Management Plan at Ormond Beach

The Ventura County Watershed Protection District administers the Beach Elevation Management Plan (BEMP) for Ormond Beach that provides an example of a threshold-based program for beach sand management that has been used every year since 2010. The plan was formally authorized through a coastal development permit that was issued by the Coastal Commission in 2013. Prior to a storm event, thresholds are evaluated against a sand elevation gauge on the beach to determine whether to allow grooming of the sand berm at *tšumaš* Creek and Ormond Beach Lagoon that prevents inland flooding. The plan specifies a maximum safe beach height and provides a method to groom the sand berm at a pre-specified location.

A combination of rainfall, storm event intensity, and water surface elevation data are gathered from monitoring systems such as the Ventura County Automated Local Evaluation in Real Time (ALERT) system and the Watershed Protection District water level gauge in *tšumaš* Creek. These data are evaluated for a combination of the following threshold conditions necessary to breach the sand berm: (1) the lagoon is fully enclosed by the sand berm; (2) the sand berm elevation adjacent to the lagoon is observed to be above 6.5 feet National Geodetic Vertical Datum; and, (3) there is a storm event predicted within 72-hours that will affect the watershed.

[3] Approximately 55 undeveloped acres of the Ormond Beach are located in the County's unincorporated coastal zone.

Once the Beach Elevation Management Plan thresholds have been met, the sand berm is groomed with heavy machinery to the maximum safe beach elevation that also allows the berm to breach when lagoon water levels rise to a certain point (Figure 1-6).

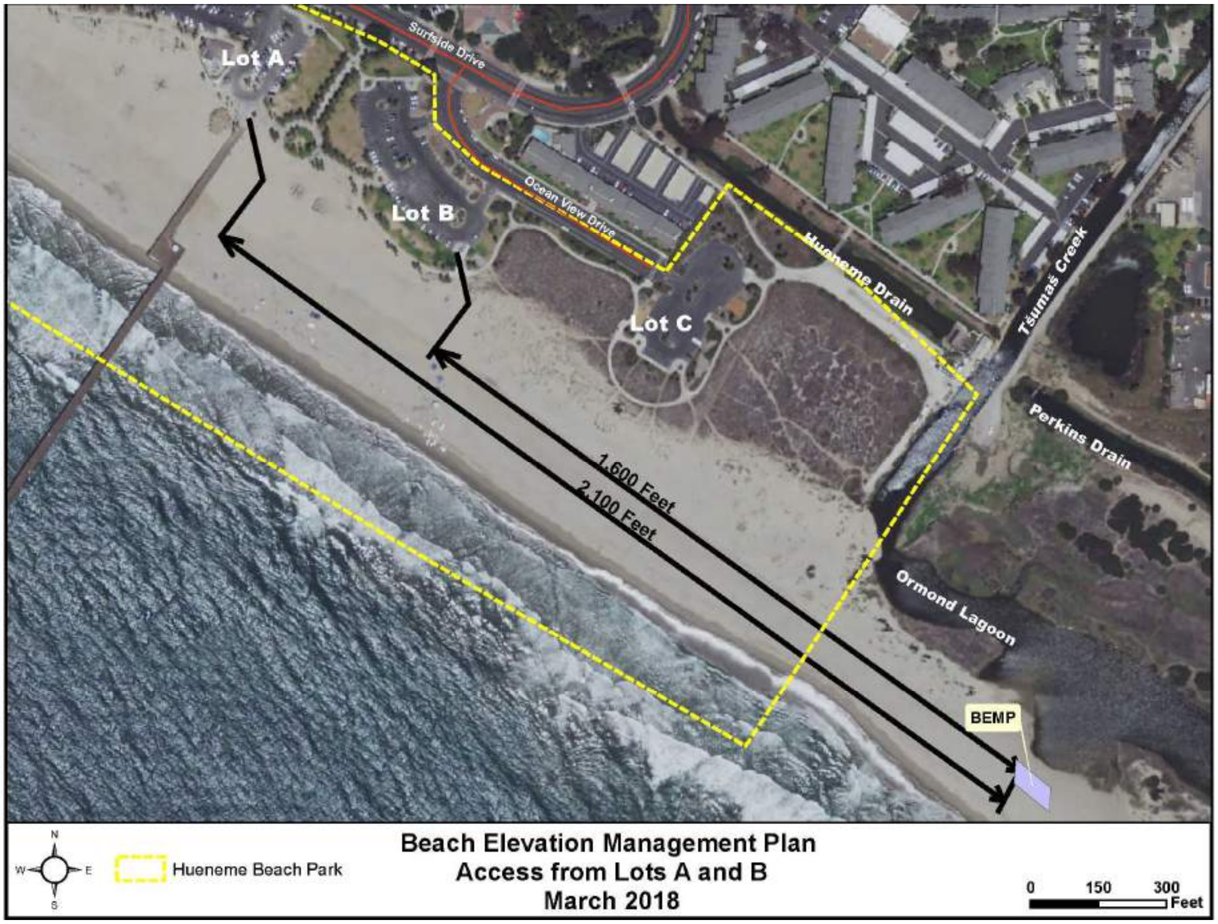


Figure 1-5. Beach Elevation Management Plan Access Route and Grooming Area

Sediment Supply, including the Calleguas Creek at Upland Road

The Ventura County Watershed Protection District conducts routine watercourse maintenance in the County's watersheds and is gaining more experience in providing sediment for coastal resource management. Such efforts, however, have proven costly due to the need to evaluate, clear, excavate, screen, load and transport the sediment. In 2017 the Board of Supervisors authorized approximately $2.8 million to excavate 197,000 cubic yards of sediment from a segment of the Calleguas Creek near the City of Camarillo. The cost of the sediment removal was to be paid by residents of Broad Beach (located in the City of Malibu), who wanted to use it for beach nourishment. However, the agreement was not executed and the sediment is still available for excavation.

Natural Floodplain Protection Program

In 2011, the Nature Conservancy led a consortium of organizations that included the Ventura County Watershed Protection District to successfully obtain $4.5 million in grant funding to institute a Natural Floodplain Protection Program in Ventura County. The goal of the program was to secure conservation easements on 225 acres of agricultural lands that are located within the 500-year floodplain of the Santa Clara River. This goal was vastly exceeded, and easements were obtained on 480 acres, with additional transactions pending. The acquisition of easements at strategic locations is also expected to reduce the likelihood of development in other areas of the floodplain.

The easements enable landowners to sell limited property rights to a third party (the Nature Conservancy) and are based on voluntary, market-based agreements. These property rights run with the title to the land and are used to ensure that hazardous flood areas are protected from urban development. When the easements are granted, farming or other open space uses may continue on the site, but stormwater infrastructure such as berms and levees are prohibited in order to allow non-structural flood control that, in conjunction with fee title property acquisitions, will reduce potential flood waters by as much as four feet[4]. Unlike land use regulations that are enacted to conserve open space (e.g. SOAR), and can be altered or expire, conservation easements run with the land in perpetuity.

While the 84-mile Santa Clara watershed is mostly located outside of the coastal zone, some coastal zone areas inland of McGrath State Beach and the Ventura Harbor are included. The program is administered by the Nature Conservancy with input from the Ventura County Floodplain Conservation Working Group, which includes the Ventura County Watershed Protection District, the Ventura County Farm Bureau, the Ventura County Resource Conservation District, and the Natural Resources Conservation Service (US Department of Agriculture).

The Nature Conservancy also operates a sister program, called the Santa Clara River Parkway Program. Over the course of 17 years, 3,475 acres along the river have been purchased and will be restored. The Nature Conservancy estimates that over $1 billion in flood damage will be avoided by protecting the river's floodplain.

1.5 Other Regional Resilience Initiatives and Projects

Given the interconnectedness of the natural shoreline processes, it is important to understand regional initiatives from nearby jurisdictions, since no one jurisdiction will be able to adapt their respective community in isolation. The regional studies discussed below provide a short summary of ongoing initiatives that may support planning and adaptation efforts within the County of Ventura. Regional initiatives include:

- BEACON Regional Sediment Management Plan - 2009
- City of Goleta Vulnerability and Fiscal Impact Report - 2015
- Coastal Resilience Santa Barbara County - 2016
- City of Oxnard LCP Update - ongoing
- City of Santa Barbara Vulnerability Assessment and LCP Update - ongoing
- City of Carpinteria LCP and General Plan Update – ongoing

[4] Final Plan to Minimize Impacts to Adjacent Landowners, The Nature Conservancy – Santa Clara River Flood Protection Project

BEACON Regional Sediment Management Plan - 2009

One unique component to the regional coastal governance is the presence of a Joint Powers Authority known as the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON). BEACON was established in 1986 to address coastal erosion, beach nourishment and clean oceans within the Central California Coast from Point Conception to Point Mugu. The member agencies of BEACON include the Counties of Santa Barbara and Ventura as well as the coastal cities of Santa Barbara, Goleta, Carpinteria, Ventura, Oxnard and Port Hueneme. The BEACON Board is made up of two Supervisors from each county and one Councilmember from each city. Although the agency does not exercise land use authority, BEACON's management activities extend to all coastal jurisdictions in Ventura and Santa Barbara counties. Thus, the BEACON board provides important education and information to elected officials as well as providing a forum for discussion of coastal and beach issues. BEACON should be a key partner in the development of future regional sea level rise adaptation strategies.

In 2009, BEACON completed an update of its Coastal Regional Sediment Management Plan, which identified what is known about sand supplies to the coastline between Point Conception and Point Mugu, including a better understanding of erosion hot spots and shoreline armoring (See Section 2 for more detail). This plan did not include an analysis of sea level rise effects or evaluate the short section of coastline south of Point Mugu; however, recommendations from this plan include new ways to manage coastal sediments in the region, including development of an opportunistic beach nourishment program, sand rights policies, and changes in regional governance structure. The Sediment Management Plan is thus useful for sea level rise adaptation planning because it summarizes the opportunities and challenges relating to regional sediment management.

The Sediment Management Plan breaks the Santa Barbara Littoral Cell into several reaches. Ventura County falls within the southern end of the cell and includes the Rincon Parkway Reach between Rincon Point and the Ventura River, the Oxnard Plain Reach between the Ventura River and Hueneme Submarine Canyon, and the Submarine Canyon Reach between Hueneme Submarine Canyon and Mugu Submarine Canyon. The Rincon Parkway Reach is the most fortified section of the Santa Barbara Littoral Cell and is characterized by narrow beaches and widespread development that has altered the natural shoreline. Within the Oxnard Plain Reach, the Ventura and Channel Islands harbors require regular sand bypass dredging to maintain navigability. Sand bypassing also serves to preserve the supply of sand to downcoast beaches such as McGrath State Beach and Port Hueneme Beach. South of the Submarine Canyon Reach lies the most southern stretch of the County's coastline. This reach lies within the Zuma Littoral Cell and was not addressed in the Sediment Management Plan for the Santa Barbara Littoral Cell.

The Sediment Management Plan provides the following recommendations specifically for the County of Ventura:

- Pursue alternative and innovative sand retention pilot projects along the Rincon Parkway and Oxnard Plain Reaches including development of a sand stockpile and processing center to assist with a periodic beach nourishment program.
- Implement an offshore reef project near Mobil Pier Road.
- Import beach-compatible sediment from debris basins and other excavations.
- Support removal of the Matilija Dam to release sediment that would travel down the Ventura River.
- Coordinate with watershed protection districts to maintain and enhance sediment delivery from the Ventura and Santa Clara Rivers.
- Implement wind-blown sand management projects in developed areas.

City of Goleta Vulnerability and Fiscal Impact Report - 2015

The City of Goleta, with funding from the California Coastal Commission and the City, completed a Vulnerability Assessment and Fiscal Impact report to support development of new LCP policies and zoning. The City utilized Santa Barbara County Coastal Resilience modeling to evaluate the potential impacts of Coastal Hazards on the community. Key impacts identified related to potential oil and gas spills, wastewater infrastructure, and some low lying residential properties. Draft Land Use Plan (LUP) policies were submitted to the Coastal Commission and will be processed for LCP certification after the City's zoning ordinance is revised.

Santa Barbara County Coastal Resiliency Project - 2016

Santa Barbara County, in a multi-phased project with funding from the California State Coastal Conservancy, developed projections of coastal hazards that were mapped using the same modeling used in Ventura County. With projections of future coastal hazards, the County conducted a vulnerability assessment evaluating the projected changes in hazard extents to multiple resource and infrastructure sectors. Key findings highlighted potential impacts from oil and gas vulnerabilities, transportation disruptions and residential property impacts. The County is continuing to evaluate updates to the LCP, including consideration of restricting development in high risk areas, conditioning development on improved coastal construction standards, adjusting erosion setback calculations, identifying areas appropriate for managed retreat as implemented through rolling easements, protection, restoration and enhancement of coastal resources, and maintaining public access to beaches and the coastline, including coastal trails. The adaptation strategy work is ongoing and Santa Barbara County has identified the need to work with adjacent jurisdictions.

City of Oxnard LCP Update - ongoing

The City of Oxnard is in the process of preparing a Coastal Hazards Vulnerability Assessment and Fiscal Impact Report to address sea level rise and associated hazards in the City of Oxnard coastal zone. The fiscal impact analysis will inform the LCP update process and future City adaptation planning efforts. Key vulnerabilities identified include the power plants, residential neighborhoods in and around Oxnard Shores, and the regional wastewater treatment plant. As part of the adaptation planning process, some economic tradeoffs of various types of adaptation strategies were evaluated including coastal armoring, beach nourishment, dune restoration, and managed retreat. The economic analysis showed the benefits of these strategies at different points in time. Results of this analysis may support adaptation planning in the County's Central Coast. In addition, there have been several public and regional stakeholder engagement efforts to obtain technical feedback and educate the public and elected officials.

City of Santa Barbara Vulnerability Assessment and LCP Update - ongoing

The City of Santa Barbara received funding from the Coastal Commission in 2013 to update their LCP. This update was intended to incorporate sea level rise adaptation actions. However, as the City began work, they realized that to codify the last 25 years of parcel by parcel amendments it was going to require a complete rewrite of the LCP. With an additional grant from the Coastal Commission, some vulnerability assessment work by several graduate student groups done at UC Santa Cruz and UC Santa Barbara (Bren 2009, Russell and Griggs 2012, and Bren 2015), as well as some of the new Santa Barbara County Coastal Resilience Modeling, the City embarked on a longer-term adaptation planning process. In the interim, the City proposed policies to support maintenance of existing coastal armoring structures along the City waterfront and continuation of the Santa Barbara harbor dredging.

City of Carpinteria Vulnerability Assessment and LCP/General Plan Update - ongoing

The City of Carpinteria, with funding from the Coastal Commission, is working on a vulnerability assessment that will guide an update to their key planning documents. The City is currently developing a focused update of the General Plan and LCP that builds upon the City's success in maintaining a small beach town community character, with an emphasis on addressing sea level rise, incorporating a Healthy Communities Element, and focused amendments to key planning areas. The City of Carpinteria intends to update its General Plan/LCP in a manner that defines its unique qualities and characteristics, reflects local preferences and objectives, and aligns with and implements the City's long-term vision and values through the planning horizon year of 2040.

2. EXISTING CONDITIONS & PHYSICAL SETTING

2.1 Planning Subareas

The coastal zone in Ventura County covers 42 miles of coastline that includes three cities and two military installations. Land uses along the County's coastline include 7.5 linear miles of public beach, State and County park facilities, critical infrastructure such as bridges, State highways and coastal access routes, residential communities, agricultural fields, and world class surfing spots.

There are approximately 4,700 residents within the County unincorporated coastal zone[5]. These residents live in geographically disparate areas in the North Coast, Central Coast, and South Coast subareas, as described below[6].

- The North Coast subarea is defined by the close proximity of Highway 101 and the Union Pacific rail line to the ocean. Intermittent strips of land lie between Highway 101 and the coastline, but that land is occupied by existing residential development, small County beach parks, and the Rincon Parkway. Steep cliffs abut the narrow strip of coastline that are highly susceptible to landslides. The North Coast is home to about 750 residents of which 25% are seniors (65 and over), 35% are renters, and 10% are Hispanic.
- The Central Coast subarea is generally occupied by the cities of Ventura, Oxnard, and Port Hueneme. Unincorporated areas within the Central Coast subarea primarily consist of wide sandy beaches and active agricultural fields located inland from the coastline. Adjacent to the shoreline lies a portion of McGrath State Beach, the West Montalvo Oil Field, and two residential neighborhoods. The Central Coast has about 3,200 residents of which 14% are seniors (65 and over), 48% are renters, and 14% are Hispanic.
- The South Coast subarea includes Naval Base Ventura County, agricultural land, and mountainous terrain in the Santa Monica Mountains National Recreation Area. Point Mugu and Leo Carrillo State Parks provide day use and camping. A narrow strip of land lies between the Santa Monica Mountains and the ocean, and is primarily occupied by the Pacific Coast Highway, but also includes small beaches and shoreline residential development at the Solromar community. The South Coast is home to about 750 residents of which 18% are seniors (65 and over), 41% are renters, and 17% are Hispanic.

[5] The population estimate includes Census blocks located along the unincorporated area coastline that are within 500 feet of the coastal zone. In some cases, the blocks that are included extend further inland. For more on the methodology, see Appendix C (Vulnerable Populations).

[6] These subareas were shown in Figure 1-1.

- Located entirely in the City of Oxnard, the Channel Islands Harbor is not regulated by the County's LCP, but it is owned and operated by the County. Land uses in the harbor are regulated by the Harbor Department's Channel Islands Harbor Public Works Plan and the City of Oxnard's LCP. The Harbor Department and City of Oxnard are coordinating to amend the LCP to account for sea level rise hazards. The Harbor is not considered in this vulnerability assessment because it is included in the vulnerability assessment being conducted by the City of Oxnard.

2.2 Climate

Episodic winter storms, cool foggy summers, and warm "Indian Summer" fall seasons characterize the Mediterranean climate of this region. Precipitation is variable, and averages between 16.12 and 21.33 inches across the County, depending on which rain gauge is considered. Rainfall primarily occurs in the winter months, with actual rainfall amounts varying widely depending on tropical moisture in the subtropical Pacific. El Niño conditions can increase this subtropical moisture; many of the wettest years on record occurred during El Niño years. See Section 3.1 to learn more about climate cycles.

2.3 Geology

Ventura County is a seismically active region in Southern California, located on the Western Transverse Mountain Ranges, which are related to a bend in the San Andreas Fault. Within the County, there are multiple geologic faults which shape the topography of the County, dividing it roughly into three subareas (Figure 2-1). Along the North Coast, the Ventura/Pitas Point fault and the Red Mountain faults have uplifted marine terraces with high landslide-prone bluffs that extend from Rincon in the north to the Ventura River Valley where the Red Mountain Fault separates the North Coast from the rest of the County. The marine terrace deposits along the North Coast have shown geologic evidence of large earthquakes (7.7 to 8.1 magnitude) along the Ventura/Pitas Point fault system where uplift from a single event could cause 16 to 32 feet of offset (Hubbard et al. 2014) and potentially trigger tsunamis.

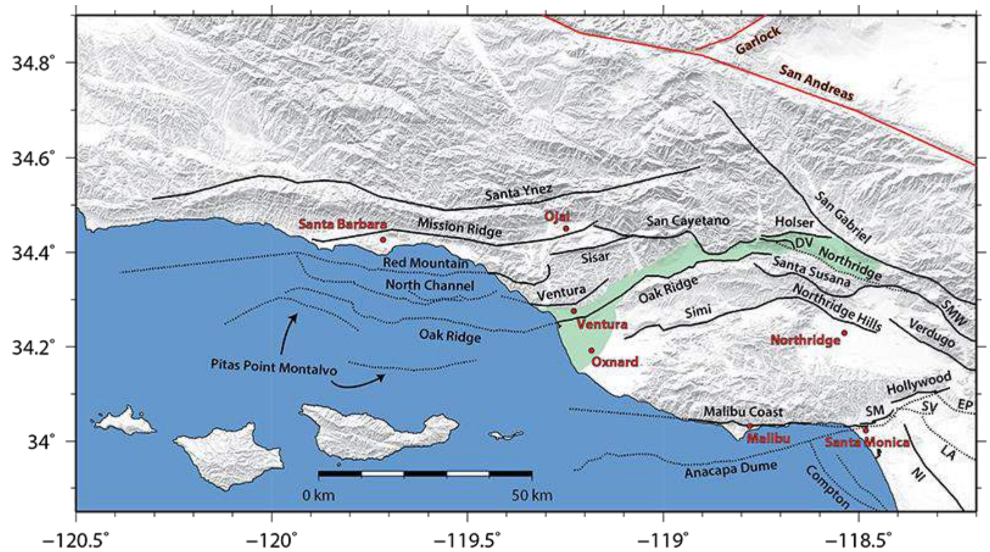


Figure 2-1. Geological Overview Map of Major Faults in Ventura County (source USGS)

The Central Coast of the County is known as the Oxnard Plain and is largely a depositional basin formed by the geologically migrating pattern of the Santa Clara River. One of the largest rivers in Southern California, the Santa Clara has migrated geologically over the Oxnard Plain and its previous alignments are responsible for the wetland formation of places such as the Mugu Wetlands, Ormond Beach Wetlands, and the now present-day locations of the Channel Islands Harbor and the Ventura Harbor. The Santa Clara was also responsible for the formation of the Hueneme and Mugu Submarine Canyons, where the river scoured channels across the continental shelf (Beller et al. 2011).

The South Coast of Ventura begins just east of the Mugu wetlands where the Sycamore Canyon fault isolates the Santa Monica Mountains from the Oxnard Plain and Central Coast. The Santa Monica Mountains are considered to be an eastern extension of the Channel Islands which have largely been created by volcanic activity and complex uplift and submergence along the Raymond Fault (National Park Service 2015).

2.4 Coastal Processes

The coastal processes of tides, waves, longshore currents, and winds move sediment and shape the coastline of Ventura County. These processes vary seasonally. Coastal erosion is a natural process that occurs from a combination of sea level rise and coastal storms. These natural processes, allowed to occur unimpaired by human activities, move sediment and have shaped the landscape (morphology), and created habitats over geologic time periods. Beaches form as a result of erosion of the backshore during storm events and the daily tidal and wave action that reworks the sands to form these important recreational areas and habitats.

Coastal erosion and shoreline changes are dependent on sediment supply, coastal processes such as large storms, and human activities. If sediment supply exceeds sediment removal, the coast will accrete seaward; if there is more sediment removed than supplied, the coast will erode. These processes occur over a range of time and spatial scales. There are long-term changes caused by sediment supply and sea level rise, and short-term or event-based changes caused by large storms.

Ventura County beaches experience seasonal cycles during which winter storms may remove significant amounts of sand, creating steep, narrow beaches. In the summer, gentle waves return the sand, widening beaches, and creating gentle slopes. As a result of seasonal cycles, the beaches are the widest in midfall and narrowest in early spring. Because there are so many factors involved in coastal erosion, including human activity, sea level rise, seasonal fluctuations, and climate change, sand movement will not be consistent year after year in the same location.

Sediment is a natural adaptation resource. As human development has occurred, the landscape has become less resilient to moving sediment and to accommodating large storm changes. Adaptation planning could be used to manage and restore these natural processes.

Tides

The tides in Ventura are mixed, predominantly semi-diurnal and are composed of two low and two high water levels of unequal heights per 24.8-hour tidal cycle. Typically, the largest tide ranges in a year occur in late December to early January when the moon and sun are in alignment and closest in their orbits to the earth. These are known as “king tides” (Photo 2-1).

Maximum tide elevations occur due to astronomical tide, wind surge, wave set-up, density anomalies, long waves (including tsunamis), El Niño, and Pacific Decadal Oscillation events. On longer time scales, the tides will reach higher elevations as sea level rise increases.

Photo 2-1. Photo showing a king tide, taken on December 3, 2017 at Channel Islands Harbor.

Waves

The waves that approach the Ventura coast are characterized by three dominant types, broken down by their wave source and direction. The northern hemisphere waves typically are generated by cyclones in the North Pacific during the winter and bring the largest waves (up to 25 feet). The southern hemisphere waves are generated in the Southern Ocean during summer months and produce smaller waves with longer wave periods (greater than 20 seconds). Local wind waves are generated throughout the year either as a result of storms coming ashore during the winter, or strong sea breezes in the spring and summer. The varying orientations of the shoreline in Ventura are affected differently by the angles of wave approach. Some wave swells are also blocked or refracted through the Channel Islands. Given these various shoreline orientations, wave directions, and the effects of the islands, it is unlikely that any single large wave event would simultaneously cause extensive damage along the entire coast.

Longshore Currents

The focus of waves into the Santa Barbara Channel drive an almost unidirectional longshore sediment transport from west to east in which beaches narrow during the winter and spring (November to April) and widen during the summer and fall (May to October). The sand found on the beaches of Ventura move along the coast of southern Santa Barbara and Ventura Counties to the Point Mugu submarine canyon in the south.

Winds

Winds vary seasonally and play an important role in sand dune formation, particularly along the Central Coast. In the spring and summer, westerly sea breezes blow sand onshore into dunes. In the fall and winter, winds come from the north and tend to be lighter, while easterly winds (also known as Santa Ana conditions) can occur in this same seasonal period when inland Southern California deserts gets extremely warm and the winds blow from the high inland temperatures to the cool ocean across Southern California.

Tsunamis

Tsunamis have occurred throughout the geologic past and can affect the Ventura County Coast. There are two sources of tsunamis, those that come from distant sources (farfield) and those that come from local faults or submarine landslides (nearfield). Recent farfield events, such as those generated from the 2011 Japanese or 2010 Chilean tsunamis, have caused millions of dollars of damage to the Ventura Harbor. Nearfield sources identified by researchers have included submarine landslides in nearby Goleta (CGS 2014), and potential earthquakes along the Pitas Point and Lower Red Mountain Faults. These nearby faults have the potential to generate tsunamis in the range of 13 to 23 feet (Ryan et al. 2015).

2.5 Littoral Cell and Sediment Budget

A littoral cell is an area of coastline that contains the complete cycle of sedimentation, including sources, transport pathways, and sinks. The presence of sand on any beach depends on the transport of sand within the littoral cell. Most of the Ventura County shoreline lies within the Santa Barbara Littoral Cell, which extends from the Santa Maria River in San Luis Obispo County to Point Mugu, a distance of 145 miles. Point Conception is an important feature within the cell, marking the point where the north-south–trending coastline becomes west-east forming the start of the Southern California Bight (Figure 2-2). Two other important features are the Hueneme and Point Mugu Submarine Canyons, with the latter being the point where the littoral cell sand is transported offshore into the deep ocean waters (BEACON 2009).

The most southern section of the Ventura County coastline lies within the Zuma Littoral Cell which extends some 16 miles from Mugu Submarine Canyon to Dume Submarine Canyon. This section of coastline is characterized by narrow beaches and rocky headlands due to the limited supply of coastal sediments.

The County shoreline is oriented in several directions due to its geologic faults and tectonic processes. Along the Rincon Parkway Reach, the coastline is oriented relatively east to west as a result of the Western Transverse Ranges. Because of the large wave angle and limited sediment supply in this region, beaches tend to be narrow and backed by cliffs and bluffs. The Oxnard Plain Reach is oriented more north to south and supplied by a large amount of sand from the Ventura and Santa Clara Rivers. Due to the combination of reduced wave angle and increased sediment supply, this section of coastline is backed by sand dunes and remnant wetlands.

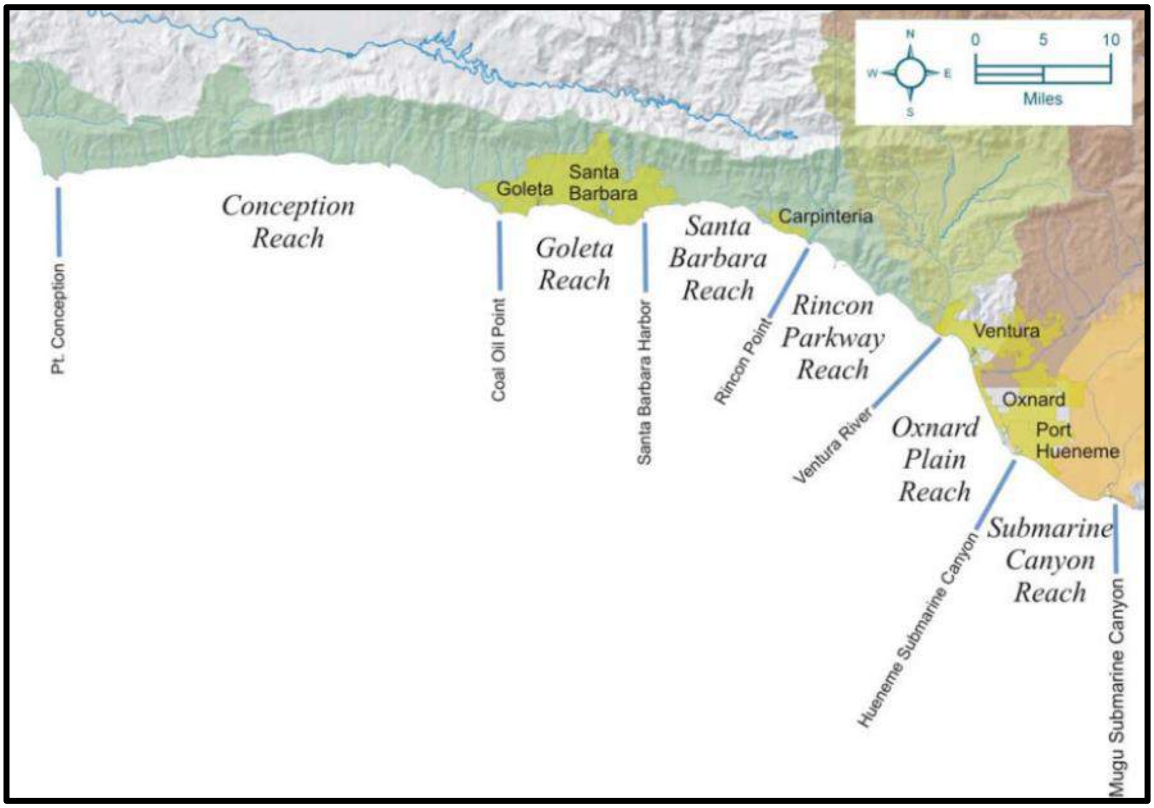


Figure 2-2. The Santa Barbara Littoral Cell (source: BEACON 2009)

The Rincon Parkway Reach has generally been steadily eroding through time. Cobbles and bedrock are sometimes exposed during winter storm events in this area. Historical erosion rates along this reach are hard to quantify given the extensive armoring which has taken place over recent decades.

The beaches and shoreline position along the Oxnard Plain and submarine canyon reaches have oscillated through time. This difference is largely caused by the reduced wave angle, increases in sediment supply and trapping of sand by the Ventura and Channel Islands Harbors.

Point Conception to the northwest and the Channel Islands to the south create a narrow window for swell approaching from the west and south. As a result, the Ventura County coastline is generally sheltered from extreme wave events and the transport of sediment along the coast is nearly unidirectional from west to east. Within the Santa Barbara Littoral Cell, the Santa Barbara, Ventura, and Channel Islands harbors are littoral sand traps that require annual sand bypass dredging to maintain safe navigational depths. While Port Hueneme Harbor requires maintenance dredging, it does not need biennial by-bypass dredging because sand is pumped around it from Channel Islands Harbor. The dredged sand provides sustenance for downcoast beaches. Though dredging schedules vary, the annual average volume of sand that is dredged from each harbor indicates the increasing gradient of sand supply and movement along the Santa Barbara Littoral Cell from west to east:

- Santa Barbara Harbor – 315,000 cubic yards per year
- Ventura Harbor – 597,000 cubic yards per year
- Channel Islands Harbor – 1,010,000 cubic yards per year

Sediment supplied to the harbors and beaches largely comes from watershed sources which discharge a full range of sediment grain sizes. Fine grained sediments (e.g, clays and silts) typically are sorted by waves and transported offshore, while coarser sand and cobbles remain on the beaches, dunes and on the nearshore. Some sediment is derived from cliff erosion, but coastal development hinders much of that supply source.

Sediment supply also tends to be episodic, typically delivered during large river flood or coastal erosion storm events. The combination of wildfire and intense precipitation can also cause sediment debris flows, which resulted in tragic consequences in the community of Montecito during the aftermath of the Thomas Fire. This debris flow event occurred overnight ion January 9, 2018, and released about 2 million cubic yards of sediment from the foothills that was estimated to consist of about 80% sand, along with rocks, logs, and mud. The USGS and California State University Channel Islands are monitoring the natural movement and blending of the sand to better understand this form of sediment delivery to the coast.

2.6 Existing Coastal and Fluvial Hazards

FEMA delineates coastal and river flood hazards as part of the National Flood Insurance Program. Flood Insurance Rate Maps (FIRMs) map the existing 1% annual chance storm (i.e. 100-year event) and are the regulatory tool administered under the local flood plain ordinances used to determine flood insurance premiums, base flood elevation (BFEs), and coastal construction standards. While often called a 100-year storm, this is misleading since the storm could occur more frequently than once every 100 years. Statistically it could occur with a 1% probability any given year. In rivers, the flooding is based on streamflow, and on the coast, it is based on wave run up and overtopping of shoreline features (FEMA 2010).

This FEMA mapping program requires very specific technical analysis and hydraulic modeling of watershed characteristics, topography, channel morphology, and hydrology, to map the extent of existing watershed–related, and wave run-up related flood hazards. Figure 2-3 illustrates the existing FEMA 100-year and 500-year (1% annual chance storm and 0.2% annual chance storm) flood hazards across the County. Note that FEMA flood maps are based on historical conditions and do not account for climate change (e.g., changes in precipitation or sea level rise) shoreline erosion, or the interaction of fluvial and coastal processes.

Historically, fluvial flooding has occurred throughout the County (Photo 2-2). FEMA flood maps and BFEs for the major watersheds at the downstream end are shown in Table 2-1 and Figure 2-3.

Table 2-1. FEMA fluvial flood elevations for major watersheds in Ventura County.

Watershed	Base Flood Elevation (NAVD88)
Rincon Creek	16 feet
Ventura River	11 feet
Santa Clara River	8 feet
Calleguas Creek	23 feet

Figure 2-3 - FEMA Flood Map

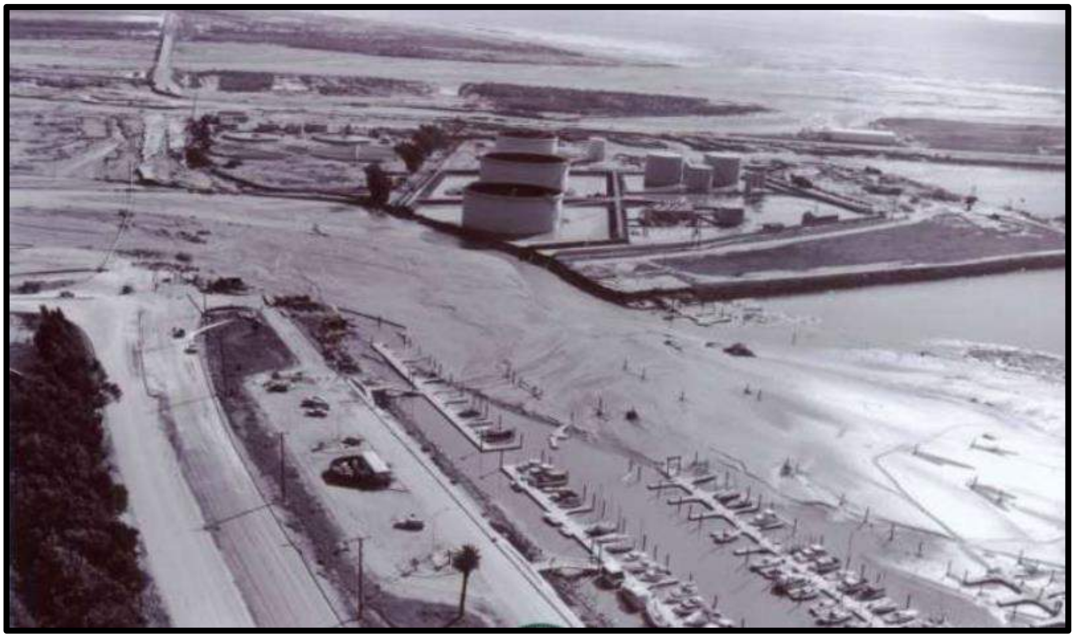


Photo 2-2. Flooding on the Santa Clara River during a storm of record in 1969.

Coastal flooding FIRM map extents are largely based on historical data from large storm waves coupled with high tides. The existing maps were initially developed in the mid-1980s and are based on a now outdated understanding of coastal processes. FEMA is currently remapping the Pacific Coast flood maps with final results expected in 2018.

The FEMA California Coastal Analysis and Mapping Project is an effort to conduct updates to the coastal flood hazard mapping along the entire coast of California with the most reliable science, coastal engineering, and regional understanding. These mapping revisions include revised hazard zones for categories VE (wave velocity), AE (wave height between 1.5 and three feet), AO (shallow and slow-moving water) and X (minimal flooding). Since FEMA bases their mapping on historical flooding, the new maps do not account for future sea level rise. The Preliminary draft revised FIRM maps were released in Fall 2016 and showed some major changes from the old FIRMs including some BFE changes greater than 22 feet (FEMA 2017). These larger FIRM changes were primarily along the North Coast and are a result of the calculation of elevation of wave splash. The changes would have been less if they calculated wave run up rather than wave splash (Photo 2-3). As a result of the dramatic changes summarized in Table 2-2 below, the County of Ventura, led by the Watershed Protection District, in collaboration with local communities, hired a consulting team to technically evaluate the maps and support the County in understanding the new maps.

The main findings by the consultants identified several shortcomings in the revised FIRMs that may require additional work by FEMA. Some of these findings are listed below:

- Storm-induced erosion should be included;
- Existing coastal armoring structures should be evaluated;
- The “Most Likely Winter Profile” should be considered; and,
- The sediment characteristics such as cobbles should be considered.

Photo 2-3. Wave splashing over a seawall that is located at the Faria Beach Colony.

The concluding technical report was submitted to FEMA in Fall of 2017 and made available to affected homeowners. At least one homeowners' association on the North Coast has filed an appeal to FEMA. At the time of this Report there has been no response from FEMA to the County regarding appeals and comments. FEMA is planning to issue a Letter of Final Determination for the Open Pacific Coast Flood Insurance Rate Maps in May 2019. The estimated effective date will be in November 2019.

Table 2-2. FEMA Base Flood Elevations for coastal areas in Ventura County.

	Base Flood Elevation Range (NAVD88)
Effective FIRMs	11-18 feet
Preliminary FIRMs	9- 37 feet

In some cases, if the preliminary maps become the new effective maps, the base flood elevation requirements would increase by as much as 24 feet above the existing effective FIRM maps (Table 2-2). If the Preliminary FIRM maps are adopted, there will be some new requirements for development that could impact the character of local neighborhoods and affect future sea level rise adaptation strategies.

Historic Storm Impacts

Coastal and creek flood hazards have historically occurred across most of the Ventura County coastline. Significant wave events in 1943, 1958, 1982–83, 1997–98, 2002, 2007, and 2015 have demonstrated that the coast is a dynamic and hazardous environment (Photo 2-4). Many of these storm events are associated with El Niño events. The largest fluvial flood event occurred on the Santa Clara River in 1969 during which the Santa Clara overtopped its banks and partially exited out the recently constructed Ventura Harbor (Photo 2-2).

Photo 2-4. Coastal flooding at the Pierpont Neighborhood in the City of Ventura on December 11, 2015 (source: Brian Brennan).

FEMA repetitive loss data shows that there have been 58 properties with multiple claims submitted to the National Flood Insurance Program since the program began in 1968, but there have been less than ten properties with multiple claims within the unincorporated area. The location of these properties is on file with the Ventura County Watershed Protection District. However, neither the spatial information, nor the source of the flood for these repetitive loss properties, is readily available.

Coastal Armoring

Coastal armoring is extensive along the County of Ventura coastline. Of the 29 miles of coastline in the unincorporated county, some 18 miles are presently armored (Figure 2-4). This most common type of management response to coastal erosion and flooding is to “hold the line” and construct coastal armoring – primarily shore-parallel seawalls and revetments, and shore-perpendicular sand retention structures. Like many engineering solutions, there are unforeseen and often significant effects on the environment.

With the exception of the Central Coast, unincorporated coastal Ventura County consists of mountainous terrain within the Santa Ynez Mountains on the North Coast and the Santa Monica Mountains on the South Coast. Narrow strips of land lie between the mountains and the ocean that are occupied by State highways, a rail line, public parks, and private structures that were mostly developed prior to the California Coastal Act. These confined land use conditions, along with exposure to the high energy conditions of the Pacific Ocean, have resulted in construction of 18 miles of coastal armoring. The coastal armoring here consists of three miles of concrete seawalls

Figure 2-4. Coastal Armoring Along Ventura County

and 15 miles of rock revetments. Overall, it's estimated that 75% of the coastal armoring in the county is located in the unincorporated area. The secondary impacts of coastal armoring are discussed in more detail in Section 6 and are summarized briefly here. Seawalls and revetments tend to have two main impacts: placement loss and passive erosion. *Placement loss* is the area of the beach that the footprint of the structure occupies. Seawalls, as shown in Photo 2-5 below, are typically thin and result in less placement or beach loss, because the structures have a small cross-shore width. Revetments are more permeable than seawalls, but their slope can serve as a launch ramp for incoming waves, and they occupy much more of the narrow North Coast and South Coast beaches.

In natural settings with erodible shorelines, beaches can migrate inland, but where there are roads and other forms of existing development, coastal armoring obstructs the natural migration pathway and beaches cannot retreat. Although there are some exceptions, in unincorporated Ventura County, concrete seawalls have been used to protect residential land uses while revetments have been used along roadways. *Passive erosion* squeezes or drowns the beach between rising seas and a non-erodible coast. Both placement loss and active erosion tend to narrow the beach and affect beach access. Shore-perpendicular structures, such as groins and harbor jetties tend to trap or impound sand, but can also cause downcoast erosion impacts or create nuisance sand issues.

The Coastal Commission recently released its Draft Residential Adaptation Policy Guidance which discusses the use of coastal armoring (Coastal Commission 2017). It highlights many of the secondary impacts of armoring on recreation, ecology and aesthetics. While the Coastal Act allows for protection of existing development, the new guidance document strongly discourages coastal armoring for new development, except in rare cases. Instead, the draft policies focus on avoidance and not perpetuating redevelopment in hazardous areas behind existing armoring. The Draft Policy Guidance suggests that property owners will face rebuilding restrictions over time to phase out high risk and high impact development.

Photo 2-5. This seawall is a form of coastal armoring that is located along the Rincon Parkway. Photo taken during a large wave event (source: D. Revell).

2.7 Historical Shoreline Management Responses

The Ventura County coast (including cities with the county) have a long history of erosion, shoreline changes and different approaches to balancing coastal hazards and development. These human alterations have changed the natural functioning of the coastal and sediment delivery watershed systems. As a result of this long history, there are many lessons, both positive and negative, that can serve to inform adaptation strategies into the future.

This section will generally move from north to south along the County's coastline, describing some of the key issues and adaptation strategies that have been implemented to address the various hazards.

North Coast

Highway 101 and Rincon Parkway

Highway 101 is the major transportation corridor in the County. In the North Coast, particularly from the County line to the Rincon Parkway, the highway fronts the coast where it is heavily armored with revetments. In the 1950s, a new highway interchange was constructed to connect the new Highway 101 to the old coastal scenic highway, “El Camino Real” or the Rincon Parkway. The highway and interchange construction buried much of the beach in this area, destroying a surf spot known as “Stanley’s”, and caused downcoast erosion to the Seacliff neighborhood. Almost the entire length of the Rincon Parkway is also armored, including the two County parks at Hobson and Faria. While these sites provide some roadside camping behind the coastal armoring, beach access is extremely limited and the beach is virtually non-existent at high tide. Winter waves frequently overtop the existing protective structures and cause closures of the parks and roadway (Photo 2-6).

Photo 2-6. Coastal flooding impacts recreational uses along the Rincon Parkway (source: Associated Press).

La Conchita

La Conchita on the North Coast has suffered several catastrophic landslides which have impacted the small community (Photo 2-7). These landslides have largely been attributed to the geology of the area as well as rain events. The sediment pulse caused by these landslides could provide an important source of sediment to the downcoast beaches, however most of this material has historically been hauled to various landfills.

Photo 2-7. Landslide at La Conchita that covered Highway 101.

Oil Piers

Part of the legacy oil and gas infrastructure in Ventura was a series of short piers that were used to support offshore oil and gas infrastructure and oil drilling (Photo 2-8). These short, dense pier pilings served similarly to a cross shore sand retention structure. The sand trapping caused by the pilings created more beach areas upcoast toward Mussel Shoals as well as surfing opportunities adjacent to the derelict pier structures prior to their removal.

In response to the removal of these oil piers and a narrowing of the beach, the Army Corps of Engineers were considering an artificial surf reef sand retention structure as part of their Section 227 Innovative Shore Protection Structure program. Although several rounds of engineering design were completed, funding for the project never materialized.

Photo 2-8. Historical photo of "Oil Piers" circa 1979 (source: California Coastal Records Project).

Emma Wood State Beach

Emma Wood State Beach suffers from erosion in multiple locations. The narrow primary access road and entrance kiosk is protected by failing seawalls (Photo 2-9). Maintenance and replacement of these structures is presently beyond the State Parks' financial resources. Retreat or reconfiguration options at the State Beach are complicated by the location of the railroad and the on-ramp from Rincon Parkway back onto Highway 101.

Photo 2-9. Damaged seawall at Emma Wood State Beach Park.

Matilija Dam on the Ventura River

Built in 1947 for water storage and flood control, the Matilija Dam was used until 1964. Today, the shuttered facility impounds sediment which would otherwise naturally reach the coast through the Ventura River and has resulted in a reduction of coarse sediment delivered to the beach, dunes, and river delta (Photo 2-10). In the past, the river migrated across the lower flood plain supplying coarse grained sand and cobbles to Emma Wood State Park and Surfer's Point in the City of Ventura. The reduction of this sediment supply by the dam has caused the river delta to shrink with resultant erosion on the edges of the contracting delta at upcoast Emma Wood State Beach and downcoast at Surfer's Point and the City of Ventura Promenade.

Efforts are underway to free 8 million cubic yards of sediment (all sediment sizes) that is trapped in Matilija Canyon near Ojai. The current plan (2016) to remove the dam estimated it would cost between $111 and $148 million. To date, only about $3.5 million of the removal cost is funded.[7] A number of projects and property acquisitions must be completed before the removal of the dam can move forward.

Photo 2-10. Matilija Dam

Surfer's Point

The City of Ventura has had ongoing erosion at Surfer's Point just downcoast of the Ventura River. It is an extremely popular surfing spot, with an important regional bike path along the shoreline and an adjacent County fairground parking lot. These sites experienced frequent damage from erosion and coastal flooding in the 1990s. Instead of building a seawall or other coastal armor, which would have destroyed the beach and surf break, stakeholders came together and approved a plan to move the parking lot, pedestrian path, and bike path away from the ocean. This has become

[7] The project has received $3.3 million from the California Department of Fish and Wildlife and $175,000 from the William and Flora Hewlett Foundation's Open Rivers Fund.

one of the best examples of a managed retreat project in the United States. In the recent 2015-2016 El Niño storms, this site was unharmed by the waves, while immediately downcoast, the City of Ventura Promenade and portions of the bike path continue to be threatened by erosion (Photo 2-11).

.

Photo 2-11. The Surfers Point Managed Retreat project (left) after a major winter storm. Downcoast of the managed retreat project (right) storms continue to flood and erode the bike path and parking lot (source: Paul Jenkins).

Pierpont Groins

Within the City of Ventura, erosion along Pierpont Bay Neighborhood started in the 1940s as a result of erosion caused by construction of the Santa Barbara Harbor and the trapping or impoundment of sand. As erosion increased, a series of seven cross shore groins were constructed to trap sand. These structures have been extremely effective and have served to widen the beach and accumulate sand dunes. However, this has also created a nuisance sand problem for the neighborhood street ends and ocean front homes adjacent to the dunes. The outcome of a lawsuit filed against the City by the residents now requires the City of Ventura to remove the sand within a recorded easement area in front of the residential properties.

Central Coast

The Central Coast is different from the North Coast and South Coast shorelines. This area on the Oxnard Plain is characterized by wide beaches and sand dunes. Dune deposits are highly susceptible to coastal erosion from waves and tidal events. Erosion potential varies along the length of the coast. Variability in erosion rates are caused by several factors including sea level, wave patterns influenced by the form of the ocean floor, storm patterns, and the structure and character of dunes in localized areas.

McGrath State Beach

McGrath State Beach, located on the south bank of the Santa Clara River, routinely floods during large river flood events in the winter and during the summer when the beach berm closes the estuary (Photo 2-12). The campground is frequently closed during floods and efforts are being made to relocate it further south.

Photo 2-12. Flooding in McGrath State Park (source: Citizens Journal).

Channel Islands Harbor Sand Trap and Dredging

Historical erosion has occurred downcoast of the Ventura Harbor and Channel Islands Harbor during periods when federal funding was not allocated for harbor dredging. These periods without dredging can cause substantial downcoast impacts as seen during the 1982-83 El Niño at Oxnard Shores (Photo 2-13) and in 2014 at Hueneme Beach downcoast of Channel Islands Harbor and the Port of Hueneme (Photo 2-14). Erosion along the coast of Naval Base Ventura County continues to threaten military structures including the building that houses the aviation electronics for the runways.

Photo 2-13. Erosion at Oxnard Shores following the storms of January 1983.

Photo 2-14. Erosion at the City of Port Hueneme in 2014 (source: VC Star).

Since 1959 the Army Corps of Engineers has periodically dredged the Channel Islands Harbor and supplied the sediment to down shore beaches. This maintenance is necessary because the natural littoral process of the coastal sand supply was interrupted after the construction of the Port of Hueneme in 1939. Channel Islands Harbor was designed with revetments that cause sand accumulation on the northern mouth of the harbor (Hollywood Beach, Figure 2-5, Photo 2-15). The sand trap area at Hollywood Beach hosts the largest foredune coastal sand dune system in the unincorporated area, and the sand is managed to offset erosion on Silverstrand, beaches in the City of Port Hueneme, and along Ormond Beach in Oxnard. The United States Army Corps of Engineers (USACE) dredges the sand trap and the mouth of the Harbor approximately every two years, after

Figure 2-5. Location of the "sand trap" at Channel Islands Harbor.

Photo 2-15. Sand dunes at Hollywood Beach.

authorization through a Consistency Determination from the Coastal Commission, and deposits the dredged sediment onto Hueneme Beach in the City of Port Hueneme.

South Coast

Erosion issues along the South Coast have resulted in substantial armoring along Pacific Coast Highway, which is the main transportation corridor in this area. In addition, Thornhill Broome State Park routinely faces winter storm damage from high waves (Photo 2-16).

Photo 2-16. Winter storm damage at Thornhill Broome State Park (source: CA State Parks).

The small oceanfront community in Solromar already contends with coastal erosion and large waves. Some homes are currently built on piles directly out over the beach. Many of these parcels are routinely exposed to tidal inundation, however, the buildings are elevated and the homes are still habitable (Photo 2-17).

Photo 2-17. Solromar homes on piles over the beach (source: D. Revell).

2.8 Habitats

This section describes existing conditions for the four types of important coastal habitats and the associated focal species that were selected for the vulnerability assessment. The following four types of coastal ecosystems are particularly vulnerable to sea level rise: 1) beaches; 2) dunes; 3) transitional marine and terrestrial salt water environments known as estuarine ecosystems, (e.g., estuaries, lagoons, salt marshes, salt pannes/flats); and 4) freshwater habitats (e.g., rivers, streams, wetlands, and lakes). While there are other vulnerable habitats in the County, the four selected vulnerable habitats cover a majority of the vulnerable ecosystems with readily available spatial data. This section describes the current characteristics and setting for the four selected ecosystems located in the unincorporated County.

Beach Ecosystems

Sandy beach areas are important ecosystems that form an ecological bridge between terrestrial and aquatic environments, and they provide several services not supplied by other coastal ecosystems (McLachlan, A. & Defeo, O. 2017). Beach ecosystems provide not only fishing, recreational, and tourism services, but also numerous ecosystem services such as: (1) water filtration (McLachlan and Brown 2006); (2) sand accumulation and storage that dissipates waves and buffers nearshore areas from coastal storm events; (3) the processing of organic matter and recycling of nutrients within the beach and nearby ecosystems (McLachland 1989; Dugan et al. 2011); (4) invertebrate infaunal and kelp wrack community that provides food for fish and birds; (5) critical spawning habitat for the California grunion and other beach spawning species; (6) haul-out and rookery areas for seals and sea lions; and, (7) nesting, roosting, and foraging habitat for sea and shorebirds.

Photo 2-18. Black bellied plovers forage on beach wrack (kelp). Wrack-dwelling invertebrates are an important prey resource for short-billed shorebirds that visually search for prey.

The physical and biological characteristics of beaches are largely determined by physical attributes such as exposure, orientation, wave energy, substrate type, as well as large-scale ecosystem processes such as currents, littoral cells, and tides. These factors shape the grain size (e.g., sand, gravel, cobble, or boulders) and the material types on a beach (e.g., sand moved from littoral cells).

The grain size of a beach substrate is fundamental in controlling the physical shape of a beach, as well as the existing biological communities on the beach. Grain size directly affects the percolation of water into the sand. When water percolates quickly through the surface of the swash zone, the backwash movements of the waves move less of the beach sand into the sea. Coarse sand beaches have greater slopes or steeper faces because more water is percolated into the beach substrate and less sand is moved in the backwash to equalize the slope. In addition, the color, angularity (roundness), and the range of grain sizes are also key factors that shape the biological character of beaches. For example, the color of the beach material influences the temperature of the substrate, which dictates the camouflage and thermal adaptation capacity of beach organisms. The degree of abrasion or sharpness of the material grains impact the types of organisms that can survive in the sand (e.g., soft bodied versus hard shelled organisms), and the range of grain sizes determines the voids or niches available for specific types of species of invertebrates.

Grain size has been correlated to burrowing speed of intertidal macroinvertebrates, which can directly affect the distribution and abundance of these species in different habitats by either directly excluding them from the beach, or by reducing their growth, reproduction, or lifespan. Research indicates that beaches with coarse grain sizes support much lower biodiversity than beaches with fine to medium grain sizes. In addition, beaches with a wide range of grain sizes have been shown to support much lower numbers of species of intertidal invertebrates than beaches with more uniform grain sizes. Beaches along the Ventura County coast have a wide range of characteristics that include finer, more uniform grain sizes associated with most of the beaches along the Oxnard Plain, with more variable, coarser, grainsized beaches interspersed along the South and North Coasts.

Intertidal beach widths, slopes, and sand/sediment grain size are not the only important components that affect the composition of beach ecosystems along the Pacific Coast (Engel 2014). The richness and abundance of intertidal species (e.g., clams, crabs, amphipods, isopods, and polychaetes) are especially important sources of food for higher organisms within the beach food web such as birds, fishes, and humans. An increasing body of scientific research illustrates the importance of beach wrack (e.g., kelp, surfgrass, brown, red and green macroalgae, other organic material that washes ashore) as a valuable resource subsidy to beach and dune ecosystems (Dugan et al. 2003; Hubbard and Dugan, 2003; Mooney and Zavaleta, 2016). Wrack directly affects the entire food web structure on beaches by increasing the diversity, biomass, and abundance of invertebrate prey, which has been associated with the presence of higher numbers of different shorebird species. The enhanced biomass also positively affects adjacent shoreline habitats (i.e., dunes and upland coastal strand habitats). Wrack also functions as a fertilizer to plants and promotes dune formation by catching blowing sand and seeds (Spiller et al., 2010; Piovia-Scott et al., 2013). The beaches in Ventura and Santa Barbara Counties have much more abundant and diverse invertebrate communities than beaches further south (Dugan et. al., 2018).

The beaches on the Oxnard Plain, in combination with the adjacent estuarine and riverine habitats, create important staging and stopover habitat for birds migrating along the Pacific Flyway during the spring and fall. In addition, the Central Coast ecosystems support a sizeable number and diversity of year-round resident birds, which qualifies these habitats to be designated as Globally Important Bird Areas[8]. Twenty-nine of the 42 miles of coastline in the county are located within the unincorporated area. Compared to the Central Coast cities, the unincorporated area also has the greatest area of sandy beach[9] above the mean high tide line (approximately 138 acres, or 34%) (Appendix D, Figures D-1, D-3, D-5 and D-6). Hollywood Beach supports breeding populations of the federally listed Western snowy plover and the California least tern. In addition, spawning California grunion have historically and recently been documented on both Hollywood and Silverstrand beaches (K. Martin, Grunion Greeter Program, personal communication, April 12, 2018) (See Figures D-9 and D-10 in Appendix D).

Photo 2-19. Solimar Beach at low tide. Compared to the Central Coast, there are only small pockets of sandy beach areas above the mean high tide line on the North and South Coasts.

[8] Important Bird Areas are sites that provide essential habitat for one or more of the following: (a) rare, threatened or endangered birds or at least 10 special status species birds; or (b) 1% or more of the global, or 10% or more of the California population, of one or more special status species birds (i.e., breeding or wintering or exceptionally large congregations of shorebirds, where 10,000 or more shorebirds were observed in one day); or (c) exceptionally large congregations of waterfowl (i.e., 5,000 or more waterfowl were observed in one day). The IBA program is administered through The American Bird Conservatory and the National Audubon Society.

[9] Note: Foredunes were not included in beach habitat acreage totals.

In contrast to the Central Coast, the North and South Coasts are heavily armored with seawalls and rock revetments. While sand levels can vary quite a bit from season to season and beach to beach in these areas, in most cases, the mean high tide line encroaches upon the toe of shoreline protection structures. Depending on the time of year, these beaches provide limited resources for sandy beach species, when access is available during periods of low-to-medium tides, and when beach substrates that change dramatically at different times of the year provide suitable habitat (e.g., pure cobble at one time of year, then sandy substrate at another). Wrack-associated invertebrates and their predators (e.g., shorebirds, surf fish) are negatively affected by beaches with mean high tides at seawalls due to the limited dispersal abilities of invertebrate species that rely on wrack, specifically the limited space for wrack above the mean high tide line, and the inability to migrate inland during large wave events has negative effects on the habitat. In addition, these "low-tide" beaches and beaches whose substrate changes dramatically throughout the year (e.g., Thornhill Broome State Beach, Solimar Beach, La Conchita) provide limited spawning habitat for California grunion and limited feeding and roosting opportunities for shorebirds.

Dune Ecosystems

Dune ecosystems are a rare habitat type in California that support an array of plants and animals uniquely adapted to this transition zone between land and sea (Lortie and Engel 2008). Coastal dunes are a type of dynamic habitat that becomes more stabilized as distinct vegetation communities transition landward from the shore. Dune systems are highly dependent upon wind and wave action. Dunes are formed parallel to the prevailing winds and perpendicular to the coastline (Lortie and Engel 2008). Dunes form above the high tide line with the help of materials (e.g., wrack, driftwood) that trap windblown sand and seeds. This results in sand accumulation and the formation of dunes. Closest to the sea, sparsely vegetated foredune habitat, also called "coastal strand", is a type of dune that is most exposed to onshore winds and salt spray. Low growing perennial herbs pioneer this harsh, low-nutrient environment. Coastal strand plant communities occur in areas where there is high sodium sand and silt, and onshore wind with salt spray. Plants characteristic of coastal strand include sand verbena (*Abronia* spp.) beach bur (Ambrosia chamissonis), and Saltbushes (Atriplex spp.). Foredunes occur between coastal strand and back dune areas and are subject to seasonal erosion (typically in the winter) and accretion (typically in the summer), and in some cases they may be completely destroyed by coastal storm events. In established dune ecosystems, deflation plains may occur behind foredunes. Deflation plains are characterized by patches of herbaceous plants similar to those found in foredunes that are often interspersed with dune swales and wetlands. Back dune habitat occurs behind deflation plains and is characterized by back dune scrub vegetation communities (Manual of California Vegetation. Vol. 2. 2009). Coastal sage scrub communities can include coyotebrush (*Baccharis spp.*), Western ragweed (*Ambrosia psilostachya*), manzanita (*Arctostaphylos spp.*), and California sagebrush (*Artemisia californica*).

Photo 2-20. The Hollywood Beach community circa 1929. This photo was taken facing north to the City of Ventura, and the expanse of coastal sand dunes is clearly visible (source: Dick Whittington).

Aside from providing habitat for plants and wildlife, the most notable ecosystem services that dunes provide for humans is that they can become a barrier against storm wave flooding, and a reservoir of sand for replenishment to the beach during erosion events (Nordstrom and Psuty 1983). The extent to which dunes provide protection to inland areas depends on their width and crest height (Lortie and Engel 2008). In addition, the dunes and their associated plant communities are capable of rebuilding washed-out areas and can migrate shoreward as sea level rises. Any significant changes in dune ecosystems can affect sand stability, dune mobility, groundwater levels, and stormwater flow patterns.

Photo 2-21. Remnant back dune habitat located south of Santa Clara River, near Harbor Boulevard.

In the 1800s, Ventura County had an expansive barrier beach-dune system that spanned from the Santa Clara River Mouth to the Mugu Lagoon, and it was between a half-mile to three-quarters of a mile wide. Since then, undisturbed coastal dunes are becoming a rarity in the County's landscape. There are about 402 acres of dune habitat that remain today, with the City of Oxnard having the greatest proportion (65%) (primarily foredune habitat) within its jurisdiction, spanning areas between the Santa Clara River estuary south to Oxnard Shores, as well as along Ormond Beach. As shown in Table 2-3 below, the unincorporated area contains a significantly lower proportion of the remaining dune habitat (17% or ~188 acres), mostly consisting of remnants of back dune habitat interspersed between agricultural fields and oil facilities just south of the Santa Clara River estuary (about 140 acres), two small areas of foredune habitat located on Hollywood Beach, and on a few unincorporated parcels near McGrath State Beach (about 28 acres). A large sand dune on the South Coast, inland from Thornhill-Broome Beach (about 20 acres) is a popular attraction to climb for recreationalists and tourists. The Point Mugu Naval Air Weapons Station has a large unbroken expanse of dune habitat that lies adjacent to Ormond Beach and runs south to the Santa Monica Mountains, equaling 12% of the dune habitat in the county. The Cities of Ventura (less than 5%) and Port Hueneme (less than 1%) also contain portions of the remaining dune systems.

Table 2-3. Acreage and percent of dune habitat types located within the unincorporated County.

Dune Type	Total Acres	Percent
Foredune	28	14.9%
Backdune	140	74.5%
Climbing Sand Dune	20	10.6%
Total	188	100%

Estuarine Ecosystems

The estuarine environment is characterized by a constantly changing mixture of seawater and fresh water. Estuarine habitats are transitional marine and terrestrial salt water environments. This category includes all estuaries, lagoons, and salt marsh environments. Various estuarine systems can differ significantly based upon the geomorphology, nutrient supply, seawater input, and freshwater input from surface water and groundwater. The estuarine environment provides numerous ecosystem services including nutrient and carbon cycling, filtration of pollutants, and protection from tidal inundation and flooding. These habitats also provide important foraging and nursery habitat for a diverse range of fish, invertebrates, and birds.

Photo 2-22. Facing north, photo of sand berm that closes the mouth of the Santa Clara River which creates a lagoon of brackish water. With the exception of the Lagoon at Point Mugu, all estuarine environments in the County are closed by sand berms.

Within the estuarine environment, salinity concentration affects sediment characteristics and species populations. As freshwater enters the system and begins to mix with seawater, fine sediment particles begin to stick together to eventually form pieces of larger sediment that fall out of the water column. Many types of contaminants, particularly metals such as arsenic, mercury, copper, lead and zinc, are also affected by salinity changes and bind to fine sediment particles in much the same way. Therefore, the spatial and temporal distribution of contaminants is also tied to changes of salinity within the system (Mooney, H., and Zavaleta, E. 2016).

Biological communities within estuaries are structured by the salinity gradient from fresh to seawater. Freshwater species become less abundant with increasing salinity and are gradually replaced by marine species, with estuarine species found at intermediate salinities. Estuarine salinity is dynamic and can be significantly influenced by specific events such as intrusions of upwelled ocean water, seasonal variations (e.g., river inflow), annual weather anomalies, and ecosystem disturbances such as the introduction of a new species.

Because the salinity of the water is constantly changing in an estuary, organisms in such environments must be able to handle osmotic changes. Osmosis is the tendency of water to have the same concentration on both sides of a material that allows liquid to pass (like a cell membrane, the structure surrounding a cell). Water flows to higher concentrations of a solute until equilibrium is reached. Organisms having blood with lower salt concentrations than the surrounding water are well-suited for high salinity levels (e.g., marine fish). The organism survives against the effects of osmosis by drinking large amounts of water and excreting the salt ions. When such organisms are exposed to fresher water, where their cells are adapted for a specific salinity range, the cells will take in water, expand and even burst.

Organisms can cope with salinity variation in two ways. The first way is the organism's tissues adjust their amino acid concentrations to the concentration of the water in the estuary. In the first case amino acids are preferred in osmoregulation because are commonly present in high concentration inside cells and are less likely to influence metabolic enzymes. The second way is to keep their osmotic pressure unchanged despite variations in the water's salinity. This can be done by behavior or biological adaptations. For example, oysters and bivalves close their shells and stop feeding when they are exposed to lower salinity water during low tides. Biological adaptations include waterproof coverings, kidneys, gills, salt glands, etc.

In general, biological communities within estuarine ecosystems have lower species diversity compared to freshwater or seawater environments. Invertebrates are particularly sensitive to variations in salinity compared to fishes and birds. Sandoval and Lafferty (1995) found that the invertebrate community of estuaries with regular tidal influence is dominated by relatively marine-dwelling species such as crabs, shrimp, polychaete worms, clams, mussels, and horn snails. In estuaries with variable salinity (like the usually-closed berm systems of the Santa Clara and Ventura Rivers), these species are usually absent. Instead, aquatic insects, amphipods, isopods, crayfish, small snails, and oligichaete worms can be abundant. There are three types of coastal estuarine systems: (1) freshwater-brackish water bodies that are seasonally or intermittently closed to the sea (e.g., Ventura, Santa Clara, Rincon, and Big Sycamore Canyon river and creek mouths); (2) dune-dammed, non-tidal lakes, lagoons, or wetland hummocks (e.g., McGrath Lake in Oxnard), and (3) tidally connected estuarine systems (e.g., Mugu Lagoon and Calleguas Creek) (Beller et al. 2011). Mugu Lagoon is managed by the U.S. Navy and totals approximately 1,892 acres, of which only 3% falls within the jurisdiction of the County at the mouth of Calleguas Creek (Figure D-3 and Table 2-4). The lagoon and the adjacent Ormond Beach estuarine wetland complexes (approximately 41 acres) are the largest estuarine environment in the County, supporting over two hundred species and over 30 special status species (Josselyn and Degraff, 2007; Tetra Tech, 2012).

The second largest estuarine environment in the County (approximately 156 acres) occurs at the mouth of the Santa Clara River (Figure D-4) and approximately 10% of it is located within the unincorporated area (Table 2-4). Some areas on the east side of the Santa Clara River are owned by the State of California, particularly McGrath State Park and portions of Mandalay Beach. The Santa Clara is the only river in Southern California that extends from the desert to the coast, linking several major ecoregions such as the Coastal Plain, Coast Ranges, Transverse Ranges, and the Mojave Desert. Both the Santa Clara River and the Ventura River are also important regional habitat connectivity corridors (Beier, P. et al. 2006).

Approximately 25 acres of estuarine environment at the mouth of the Ventura River falls under the City of Ventura's jurisdiction (Figure D-4 and Table 2-4). It is semi-isolated from the larger Oxnard Plain and it is smaller than the Santa Clara River estuary, constricted by the Red-Rincon Mountain range and the City of Ventura/Ventura Hills. Live oaks and sycamores are common tree types within the river corridor as well as a broad range of other riparian species. In contrast, the Santa Clara River's vegetation community is characterized by discrete patches of riparian forest interspersed with drier-habitat alluvial vegetation, with live oaks and sycamores occurring on the river's high outer banks (Beller, E.E et al. 2011).

Both the Ventura and Santa Clara Rivers historically supported self-sustaining populations of Southern steelhead (*Oncorhynchus mykiss*), arroyo chub (*Gila orcutti*), Pacific lamprey (*Entosphenus tridentatus*), and tidewater goby (*Eucyclogobius newberryi*), before the degradation of the habitat due to water diversions, invasive species, pollution, and the construction of infrastructure that blocked natural habitat migration up the watershed (Stoecker, M. and Kelley, E. 2005; Kentosh, J. 2008). All three watersheds on the Oxnard Plain (i.e., Ventura, Santa Clara, Calleguas-Mugu Lagoon) have been the focus of restoration efforts in recent years.

In addition, there are several small pockets of estuarine environments along the coast at the mouths of Rincon Creek, San Jon, and Sycamore Canyon Creeks; as well as on the wide beach in front of McGrath Lake (Table 2-4, Figures D-2, D-6, D-12).

Table 2-4. Total acreage and percentage of estuarine ecosystems within the unincorporated County.

Estuarine System	Total Acreage	Unincorporated County Acreage	Percent Estuarine habitat within the unincorporated County
Rincon Creek	0.9	0.9	100%
Ventura River	24.7	0	0%
San Jon Creek	2.1	0	0%
Santa Clara River	156.4	51.0	9.6%
McGrath Beach	4.9	0	0.5%
Ormond Lagoon	41.7	0.3	0.6%
Mugu Lagoon	1892.2	58.0	3.1%
Sycamore Creek	0.5	0.5	100%
Other (breakwaters)	4.4	2.3	0.5%
Total	2127.7	113.1	5.3% of All Estuarine Habitat Countywide

Freshwater Ecosystems

There are over 2,700 acres of freshwater habitat within the unincorporated County with the potential to be exposed to sea level rise (Table 2-5). The majority of freshwater habitats (72% or 2,775 acres) are within the unincorporated County, primarily consisting of coastal creeks and the Ventura and Santa Clara Rivers (See Table 2-5, and Appendix D, Figures D-1 through D-8). The remaining freshwater habitats are equally distributed among the City of Oxnard (13%), City of Ventura (7%), and the Naval Base (9%). The City of Port Hueneme has approximately 3 acres of freshwater habitat (0.1%) (Table 2-5). The largest freshwater bodies along the coast are outside the estuaries in the Ventura and Santa Clara Rivers as well as at McGrath Lake (located in the City of Oxnard), which is a rare freshwater lake created by coastal dunes, groundwater, and active surface flows from the Santa Clara River and nearby agricultural fields (See Figure D-4 and Table 2-5).

Table 2-5. Total acreage and percentage of freshwater habitats in each county jurisdiction.

Jurisdiction	Total Acreage	Percent
Unincorporated County	2,703	72.1%
Naval Base	337	8.8%
Oxnard	483	12.6%
Port Hueneme	3	0.1%
City of Ventura	249	6.5%
Grand Total	3,847	100.0%

USFWS Designated Critical Habitat

The United States Fish and Wildlife Service (USFWS) Critical Habitat designation occurs when a species is listed under the Endangered Species Act (ESA). The USFWS critical habitat designation requires a federal permit or license for any activities that are likely to impact critical habitat. The ESA requires USFWS to identify geographic areas that contain physical or biological features that are essential to conserve the species and requires special management or protection. Four species have designated critical habitat that may be exposed to sea level rise hazards in Ventura County (Table 2-6).

Photo 2-23. Western snowy plover protecting newly hatched chick.

- The Western snowy plover (*Charadrius alexandrinus nivosus*) designated habitat (639 acres) includes sandy beach and dune habitats along the Oxnard Plain;
- The Ventura marsh milk-vetch (*Astragalus pycnostachyus var. lanosissimus*) designated habitat (220 acres) is located east of McGrath Lake in wetland swales in back dune habitats;
- The tidewater goby (*Eucyclogobius newberryi*) designated habitat (442 acres) is in the Santa Clara and Ventura River mouths, Ormond lagoon, and at the mouth of Sycamore Canyon Creek; and
- The Southwestern willow flycatcher (*Empidonax traillii extimus*) designated habitat (2,337 acres) is located along the Santa Clara and Ventura Rivers, where there is the presence of willows and other riparian vegetation.



Photos 2-24. USFWS critical habitat along the County's coastline is designated for the following species: (left to right) Ventura marsh milk-vetch, tidewater goby, and Southwestern willow flycatcher.

The unincorporated County contains the majority of designated critical habitat for the Southwestern willow flycatcher, primarily consisting of the 2,000 acres along the Ventura and Santa Clara Rivers (approximately 86%). The City of Oxnard contains the highest percentage of designated critical habitat for the remaining three species discussed above.

Table 2-6. Acres and percent of USFWS designated critical habitat within each jurisdiction along the county's coast.

Jurisdiction	Western snowy plover		Ventura marsh milk-vetch		Tidewater goby		Southwestern willow flycatcher		Total	
County	156	24.7%	43	35.2%	117	26.5%	2,000	85.6%	2,316	65.5%
Oxnard	417	65.0%	177	67.4%	258	58.3%	167	7.2%	917	26%
Port Hueneme	21	3.4%	0	0%	0	0.1%	0	0%	21	0.6%
City of Ventura	46	7.0%	0	0%	67	15.1%	169	7.3%	280	7.9%
Total	639	100%	220	100%	442	100%	2,337	100%	3,531	100%

2.9 Focal Species

The County is home to 49 special status species that have the potential to be vulnerable to sea level rise exposure (CNDDB Data, 2018). Using the California Department of Fish and Wildlife's California's Natural Diversity Database, local biological studies and reports, as well as suggestions from the County's Natural Resources Working Group (Working Group), focal species representing each of the selected ecosystems were chosen to understand where, how, and why they may be exposed to predicted sea level rise hazards. The final list of focal species evaluated can be found in Table 2-7 below and the analysis is in Section 5.3. A total of 19 species were chosen as focal species, representing both plant and animals that are endemic to the four selected vulnerable habitat types.

Table 2-7. Plant and animal species that were used for the Focal Species analysis in Section 5.3.

Ecosystem	Species Common Name	Species Latin Name
Beach	California grunion	*Leuresthes tenuis*
	Western snowy plover	*Charadrius alexandrinus nivosus*
Dune	Beach evening primrose	*Camissoniopsis cheiranthifolia*
	Globose dune beetle	*Coelus globosus*
	Red sand verbena	*Abronia maritima*
Estuarine	Belding's savannah sparrow	*Passerculus sandwichensis beldingi*
	Tidewater goby	*Eucyclogobius newberryi*
	Alkali heath	*Frankenia salina*
	Woolly sea-blite	*Suaeda taxifolia*
	Bigelovii pickleweed	*Salicornia bigelovii*
	Virginia rail	*Rallus limicola*
	Topsmelt	*Atherinops affinis*
	Salt marsh snail	*Melampus olivaceus*
	California horned snail	*Cerithidea californica*
Freshwater	Cottonwood	*Populus* spp.
	Southern steelhead	*Oncorhynchus mykiss*
	Arroyo willow	*Salix lasiolepis*
	Southwestern pond turtle	*Actinemys pallida*
	Arroyo chub	*Gila orcutti*

This page was intentionally left blank.

3. SEA LEVEL RISE SCIENCE

3.1 Climate Cycles

Climate change is not to be confused with climate cycles, which operate independently of human-induced climate change. Some of these climate cycles occur at long time periods and are related to the orbit of the earth around the sun, the tilt of the earth on its axis, and precession (subtle shift) of the earth's orbit. These "Milankovitch Cycles" occur at approximately 41,000, 120,000, and 400,000 -year periods and are responsible for the Ice Ages observed in the geologic record.

Some of these climate cycles are shorter; the most commonly known cycle is the El Niño/La Niña cycle, which is related to changes in equatorial trade winds and shifts in ocean temperatures across the Pacific Ocean (Figure 3-1). An El Niño brings warmer water to the Eastern Pacific, and this shift in ocean temperatures elevates sea level rise by about a foot above predicted tides in Southern California. These warmer ocean temperatures can increase evaporation, resulting in more atmospheric moisture and often substantially more precipitation associated with atmospheric rivers. La Niña is the opposite of the El Niño and occurs when cooler water extends across the Pacific reducing evaporation and precipitation. This tends to shift the location of wave generating storms farther north. The usual effect from La Niña conditions in Southern California includes drought and decreased wave energy. The 1982–1983, 1997–1998, 2015-2017 El Niño events have caused both river and coastal flood damage across Ventura County (Photo 2-4).

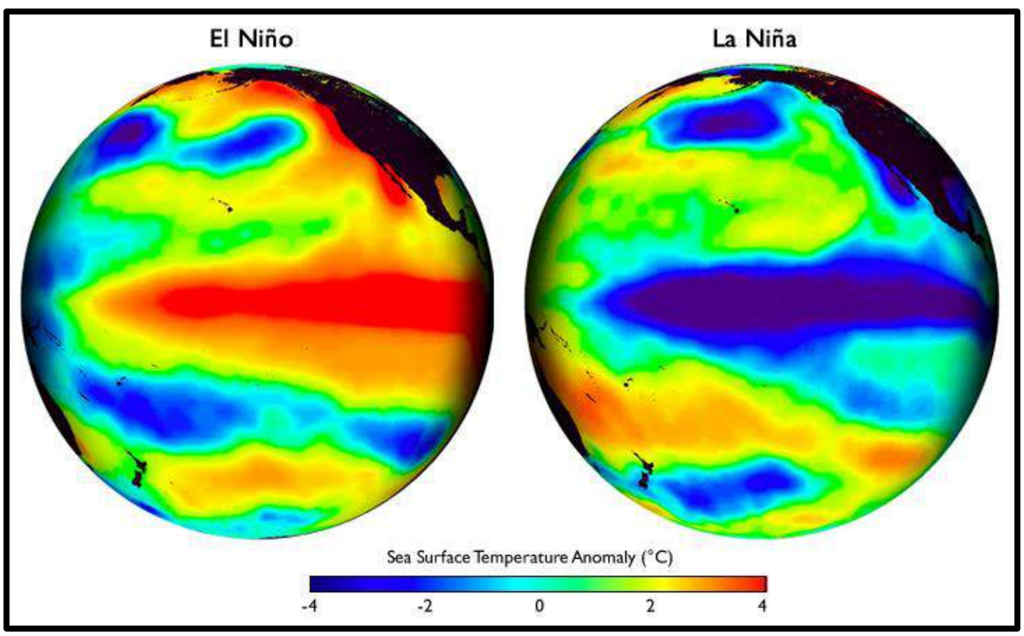


Figure 3-1. Sea surface temperature differences from average conditions during El Niño and La Niña (source: NOAA).

One other climate cycle that impacts the Ventura area, particularly in terms of the rates of precipitation, is the Pacific Decadal Oscillation (PDO). Between 2010 and 2013, the index was in the "cool phase", which tends to lead to less precipitation in Ventura. Then, between 2014 and 2017, the index entered the "warm phase", indicating that a shift may have occurred, however the most recent data shows that the PDO index remains in a neutral pattern. One of the main implications of the cool phase of the PDO is that the rate of sea level rise is reduced in the Eastern Pacific (off the U.S. West Coast). Recent PDO research indicates that a shift to the PDO warm phase would likely result in much more rapid rise in sea levels off the U.S. West Coast than has been seen in the last three decades (Bromirski et al. 2011).

3.2 Climate Change

Human-induced climate change is a consequence of increased greenhouse gas emissions from the burning of fossil fuels that accumulate in the atmosphere, insulate the earth (like a blanket), and prevent heat from dissipating into space. As this atmospheric emissions blanket gets thicker, more heat is trapped in the earth's atmosphere, warming the earth and triggering a series of climatic changes related to different feedback mechanisms. Sixteen of the 17 warmest years in the 136-year period of global temperature measurements have occurred since 2001 (NASA 2017). Once set in motion, many of the climate change feedback mechanisms take centuries to millennia to stabilize. For example, as the ocean temperatures warm, less sea ice forms. As the reflective ice disappears, the darker ocean absorbs more heat, accelerating the warming of the ocean.

3.3 Sea Level Rise

Globally, sea levels are rising as a result of two main factors related to climate change: thermal expansion and melting glaciers. The first factor is the thermal expansion of the oceans. As ocean temperatures warm, the water in the ocean expands and occupies more volume, resulting in sea level rise. The second factor contributing to (global) sea level rise is the additional volume of water added to the oceans from the melting of mountain glaciers and ice sheets. It is predicted that if all of the ice were to melt on earth, sea levels would rise by approximately 220 feet above present-day levels.

Sea level rise can increase flood risks in low-lying coastal areas and areas bordering rivers. A 5-foot increase in water levels caused by sea level rise, storms, and tides is estimated to affect 499,822 people, 644,143 acres, 209,737 homes, and $105.2 billion of property value in coastal areas across the United States (Climate Central 2014).

The time scales for sea level rise are related to complex interactions between the atmosphere and the oceans, and the lag times associated with the stabilization of greenhouse gases in the atmosphere combined with the dissolution of those gases into the ocean.

The projected rates of sea level rise depend on levels of greenhouse gases emitted into the atmosphere in the coming years, and therefore there are various possible scenarios. Sea level rise scenarios used in this analysis were selected to be consistent with the Coastal Commission's 2015 Sea Level Rise Policy Guidance (Coastal Commission 2015) for areas south of Cape Mendocino (where the faulting and vertical land motion change).

Relative Sea Level Rise

Sea level rise is not the same everywhere around the world. Because of local differences in tectonic uplift; subsidence caused by oil, gas, and groundwater extraction; and saltwater intrusion, the land itself is moving vertically. In Ventura County, the Ventura/Pitas Point, Red Mountain, and Sycamore Canyon faults contribute vertical uplift to the region (Figure 2-1), while groundwater and oil and gas extraction in the Oxnard Plain accelerate subsidence (Figure 1-4). The difference between the local land motion and the global rise of sea level gives the relative sea level rise that will determine the magnitude of local sea level rise impacts. Local sea level rise can be measured using data collected by tide gauges. Ventura County is situated between the Santa Barbara and the Santa Monica tide gauges. The nearest is the Santa Barbara tide gauge, which reports the local sea level rise rate of approximately 1.01 (+/-1.17) millimeters per year, with a sporadic historical record (Figure 3-2).

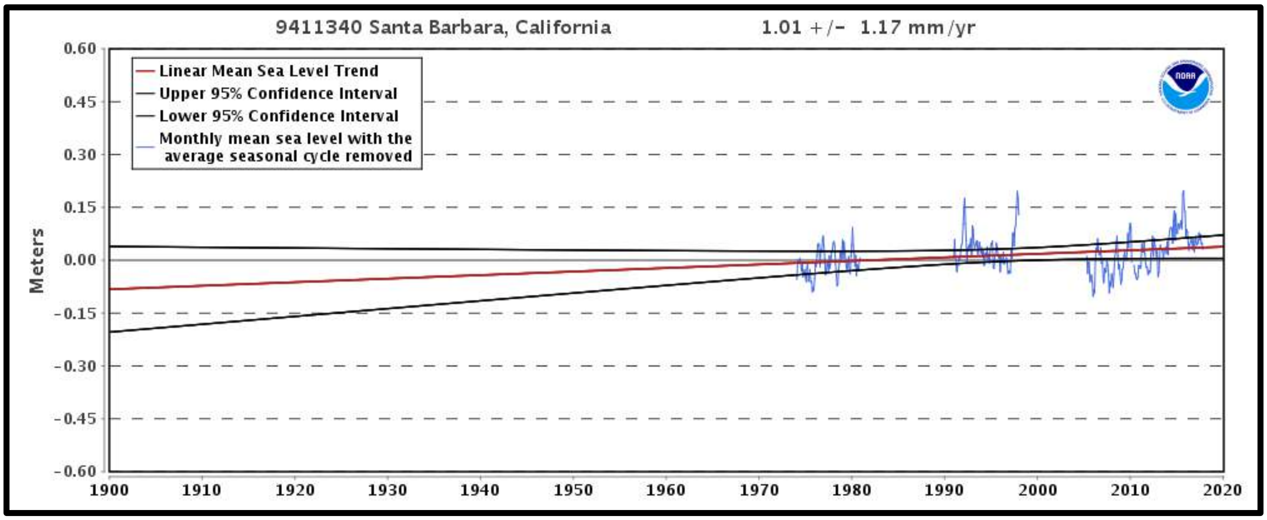


Figure 3-2. Plot showing Sea level rise trend from the Santa Barbara Tide Gauge.

Since the tide gauge was installed in the mid-1970s, nearly every major El Niño has broken the gauge and consequently left 7- to 10-year data gaps, rendering the relative sea level rise calculations from this tide gauge suspect. The Santa Monica gauge, in comparison, shows a higher rate of sea level rise of 1.51 +/- 0.34 mm per year with a longer, more consistent record that averages about a half an inch per decade (Figure 3-3).

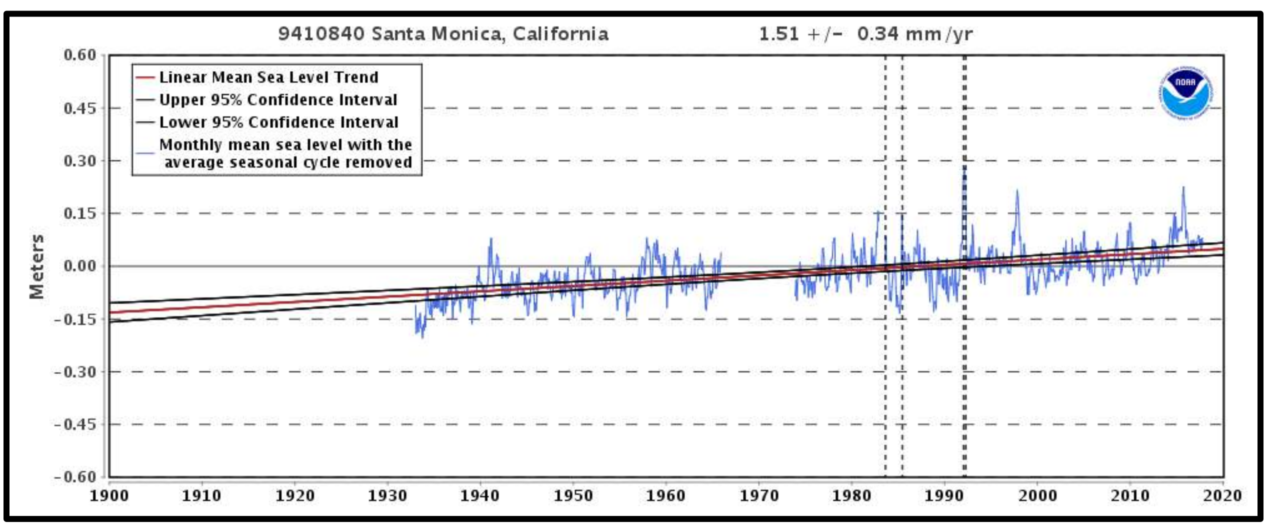


Figure 3-3. Plot showing sea level rise trend from Santa Monica Tide Gauge.

Based on this tidal reference data, historical rates of sea level rise are estimated to be about half an inch every decade, or approximately half of the global average. Given the existing GHG emissions and the long-term time scales and feedback mechanisms, this historic linear trend of sea level rise will not remain but rather the rates will accelerate in the future logarithmically, resulting in an increasingly upward curve (see Figure 3-4 below). For example, current trends of global sea level rise are around 3.2mm/ year which could escalate to 20+ mm/year by the end of the century. Recent improvements to the scientific projections of future sea level rise are discussed in the next section.

3.4 State of the Science in California

Substantial research in California is currently underway to effectively downscale global climate change model projections to more regional California projections that include a range of climate variables. Several of the key climate change impacts are likely to include increased temperature, uncertain precipitation changes, wildfire, and accelerating sea level rise. The following are key scientific studies, starting with the most recent, which form the basis of recent scientific understanding of sea level rise and coastal hazards in Ventura County. It is expected that both projections and modeling of sea level rise will be revisited and revised over time as science and information evolves.

2016-2018 California 4th Climate Modeling

Biennially the California Energy Commission funds climate assessments to better understand the impacts of climate on various natural resource and urban settings. As an initial integral part of the Fourth Assessment, Scripps Institution of Oceanography (University of California, San Diego) was commissioned to develop a new suite of sea level rise projections that reflect the latest scientific publications and global level emission reduction pledges made at the 2015 United Nations Framework Convention on Climate Change Conference in Paris France. The scientific modeling results projecting changes in sea level rise are summarized in OPC's 2017 Rising Seas in California report, which was written to be more approachable for policy making (Griggs et al. 2017), and integrated into the recent OPC State of California Sea-Level Rise Guidance (2018). These same modeling results (discussed below) form the basis for the current climate change impact assessments funded as part of the 4th California Climate Change Assessment, which is nearing completion and should be available later in 2018.

Much of the scientific advancement in recent years has been in understanding the contribution and rate of ice melt to global sea levels. The rate at which ocean levels rise will largely depend on the rate of melting of the ice. The uncertainties associated with the rate at which ice melts is largely responsible for the wide range in sea level rise projections in the latter half of the century. Recent science has found that the rate of ice melt has been accelerating. One recently discovered cause for this acceleration results from the melting of the sea ice surrounding the continents. Sea ice has historically buttressed the land ice from rapid melting. As the sea ice disappears, the rate of melting on the continents has been accelerating. Discovery of this new ice melt mechanism, particularly in Antarctica, has identified the potential for an extreme sea level rise scenario (H++ Scenario) that projects more than 10 feet of sea level rise by 2100 (DeConto and Pollard 2016).

Using several scenarios of future GHG emissions (known as Relative Concentration Pathways), projections of future sea level rise in California ranges from 1.0 foot to 6.9 feet by 2100 (Griggs et al. 2017) (Figure 3-4).

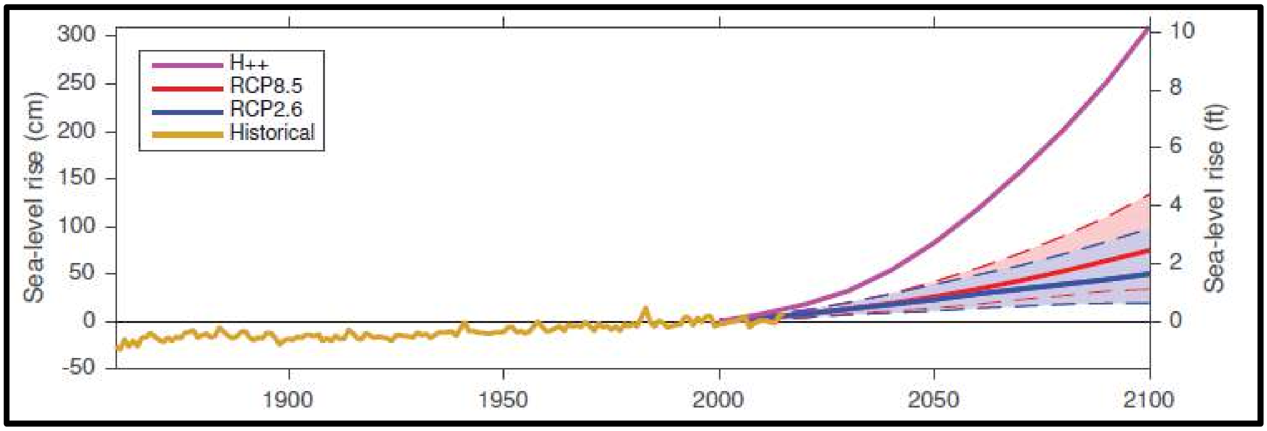


Figure 3-4. Relative sea level rise for San Francisco, California (source: Griggs et al. 2017).

The 4th Assessment modeling takes a new approach to the research. It carefully quantifies each contributing factor to global sea level rise and assigns a probability of occurrence based on the scientific uncertainties associated with each factor. The new resulting sea level rise projections for California thus amount to one of the first quasi-probabilistic approaches to identifying future levels of sea level rise at a particular time in the future (Cayan et al. 2016). Table 3-1 compares the scenarios used in the vulnerability assessment (Coastal Resilience 2012) with the latest scientific numbers (Griggs et al. 2017) and shows the probability of occurrence based on the latest science.

Table 3-1. Probabilities of sea level rise scenarios used in this Report. The orange-colored cells represent the amount of sea level rise, in inches, that were modeled and used in this report, while the percentages under the "Probabilities" column provide the closest corresponding likelihood of occurrence of these sea level rise amounts in a given timeframe.

Year/ Model	2012 Resilience – Mid (inches)	2012 Resilience – High (inches)	2018 Guidance – Low (inches)	2018 Guidance – High (inches)	Probabilities
2030	5"	8"	5"	9"	0.5% probability SLR exceeds 8 inches by 2030
2060	16"	25"	15"	35"	50% probability SLR exceeds 11 inches by 2060
2100	37"	58"	26"	74"	5% probability SLR exceeds 49.2 inches by 2100

[1] *Probabilities based on Santa Barbara tide gauge (OPC Guidance 2018).*

[2] *Numbers shaded in orange are the sea level rise elevations used in this Report.*

2017 CoSMoS 3.0

The Coastal Storm Modeling System of the USGS (CoSMoS 3.0) provides projections of coastal flood hazards and cliff erosion for the area between Point Conception in Santa Barbara County and the U.S.–Mexico border. The intent is to provide region-specific, consistent information on coastal storm and sea level rise scenarios. The model uses downscaled global climate models and considers factors such as long-term coastal shoreline change, stream inputs, winds, and varying sea level rise scenarios to produce hazard projections for every 9.8 inches (0.25 meters) of sea level rise. Results map a dynamic wave run up extent (differing from FEMA and Coastal Resilience maximum wave run up) and account for various sea level rise, storm frequencies and uncertainties. An interactive web mapping portal shows the results of the hazard data.

CoSMoS 3.0 is intended to support policy and planning through usage in vulnerability assessments, hazard mitigation plans, and LCPs, and by providing data for other shoreline change or hazard models within the region. This model was evaluated for use in this Report and the cliff erosion data was incorporated for the South Coast, as discussed in Section 5.3.

2012 Coastal Resilience Ventura

The Coastal Resilience Ventura Project was a pilot project in California funded by The Nature Conservancy and the County of Ventura. The climate change modeling effort was built on Pacific Institute work done in the 2nd California Climate Assessment (Revell et al. 2011). It projects the impacts of sea level rise and storm-caused coastal erosion on the Central Coast, and coastal flooding and tidal inundation in the entire County. Additional work was completed to evaluate potential habitat impacts. The coastal hazard modeling considered different scenarios of sea level rise, wave climate, and sand supply. This model provides much of the hazard identification used in this Report. Since this model was selected to best represent the extent of observed coastal hazards, additional detail on the modeling methods and assumptions is provided in Section 4.3.

The Coastal Resilience pilot project that started in Ventura County has been expanded to include various geographies around the world. The web mapping application provides an interactive visualization tool.[10] This tool allows users to explore the risks of different scenarios of coastal hazards—such as sea level rise, storm surges, and inland flooding—at a variety of spatial scales.

[10] Source: www.maps.coastalresilience.org/California

4. VULNERABILITY METHODOLOGY

4.1 Introduction

This chapter provides an overview of the methods used to assess existing and projected vulnerabilities from coastal hazards. This Report relied on several primary data sources:

- Coastal hazards modeling analysis results (ESA PWA 2012).
- FEMA effective and preliminary flood maps (FEMA 2012, FEMA 2017).
- Revised cliff erosion distances from CoSMoS 3.0 (USGS 2017).
- Spatial and locational resource sector and infrastructure data available from the County of Ventura, State of California, Environmental Systems Research Institute (ESRI), and The Nature Conservancy.
- Economic and attendance data from the County of Ventura and California State Parks.

Projections of future coastal hazards and sea level rise were modeled as part of a separate project called the Coastal Resilience Ventura Project (The Nature Conservancy, County of Ventura and ESA PWA 2012). Coastal Resilience Ventura was the primary source for sea level rise projections used in this Report. The methods used for the Social Vulnerability Assessment in Appendix C, and the natural resources assessment in Section 4.6 and Appendix D, were analyzed separately from the other County sectors.

4.2 Geospatial Data Collection

With input from the County, the project team identified preferred sectors to be used in the analysis as well as the measure of impact for each sector (Table 4-1). Data collection efforts began with available County data and expanded to include the State of California, the City of Oxnard, and available public data libraries. For specific infrastructure data and special districts, direct data requests were sent to California State Parks, water purveyors, and the Coastal Commission. In some cases, older data which only existed on paper maps, such as wastewater infrastructure and public parking lots , were digitized into electronic format on recently-available aerial photographs. GIS data that were somewhat dated, like bike trails, were updated to account for recent changes. All data were checked for topological completeness and spatial accuracy and were reviewed by both the County and Revell Coastal.

The project team utilized GIS to combine the various sea level rise and flood hazard models listed in Section 4.1 above, and to develop a quantitative measure of impact to the resource sectors listed in Table 4-1 below. Electrical utility line data were not included in the vulnerability analysis because these data were not publicly available. For each sector, metrics were identified to help describe how much of the assets critical to those sectors were vulnerable during a severe winter storm under current and future conditions.

Table 4-1. Resource Sectors and Measures of Impacts

	Sector	Measures of Impacts
Land Use	Land Use	Number of parcels, acreage, structures
	Commercial	Number of parcels, acreage, structures
	Industrial	Number of parcels, acreage, structures
	Residential	Number of parcels, acreage, structures
	Parks and open space	Number of parcels, acreage, structures
	Visitor serving accommodations	Number of parcels, acreage, structures
Agriculture	Crop Types grown in 2017	Acreage
Agriculture	Important Farmland Inventory[11]	Acreage
Wastewater	Wastewater	Number of shutoff valves, length of pipe, Number of lift stations, Number of manholes
Stormwater	Stormwater	Number control valves, manholes, and outfalls
Water Supply	Water Supply	Pipe length, Number of pump stations and groundwater wells
Trails and Access	Coastal Trails and Access	By type and length
Roads	Roads	Length
Parking	Parking	Number of lots
Public Transportation	Public Transportation	Length of bike routes, bus routes, railroad, bus stops
Habitat	Sandy Beaches	Acreage
	Sand Dunes	Acreage
	National Wetland Inventory Maps (2017)	Acreage
	CA Natural Diversity Database	Species Locational Data
	USFWS Critical Habitat	Acreage
Oil and Gas	Oil and Gas	Number of wells, miles of pipeline, other facilities
Coastal Armoring	Coastal Armoring	Number of structures, length
Hazardous Materials	Hazardous Business Materials storage (CUPA)	Number of businesses
	Hazardous Materials	Number of active clean up sites
	Hazardous Materials Leaking Underground Fuel Tanks(LUFTs)	Number of Storage Tanks
Critical services	Critical services	Number of police, fire, schools, medical, communication towers, length of evacuation routes

[11] This dataset was provided by the California Department of Conservation for the Farmland Mapping and Monitoring Program. For more information, see: www.conservation.ca.gov/dlrp/fmmp.

4.3 Coastal Hazards Projections

The Vulnerability Assessment includes evaluation of the following coastal process hazards:

- **Coastal Erosion:** Coastal erosion based on a 1% annual chance storm wave event, sea level rise and historic long term trends of beach, dune, and South Coast bluff erosion (e.g., as a proxy for sediment supply considerations).
- **Coastal Flooding:** Flooding caused by waves overtopping and filling low-lying areas.
- **Tidal Inundation:** Tidal inundation based on an expected monthly recurrence.
- **Fluvial Flooding and Coastal Confluence:** Flood extents based on a 1% annual chance river flow affected by climate changes related to precipitation changes and sea level rise. *Note that this analysis was only included in the evaluation of potential impacts to agriculture and natural resources.*

Hazard Model Selection

The project evaluated the two available models of coastal hazards: 1) the Coastal Resilience Ventura Hazard Models (2016), and 2) the USGS CoSMoS 3.0 model (2017). These models are summarized in Section 3.4. Both models were evaluated for data availability for each hazard in a GIS format suitable for analysis (closed polygon shapefiles). While both models have their strengths and weaknesses, in general, it was found that the Coastal Resilience model was available in a suitable GIS format and more accurately represented historic storm impacts when flood potential under existing conditions was compared with observations of previous storm flooding in the County. Results of this comparison resulted in the selection of the Coastal Resilience components of both models for use in this Report. Below is a summary of selection criteria for each coastal hazard model selection.

- **Coastal Wave Flooding** – Coastal Resilience modeling results closely matched observed coastal flooding at multiple locations in the County and incorporated jurisdictions. The model results were available in closed polygon format. The CoSMoS model does not realistically flood the beach during a 1% annual chance storm under existing conditions. The maximum run-up points mapped by CoSMoS were not in a format conducive for the preparation of this Report, which was point format data instead of polygon format data.
- **Coastal Erosion** – Coastal Resilience modeled the extents of dune erosion in the Central Coast. The CoSMoS model does not explicitly map any low lying dune erosion in the model. Coastal Resilience did not model cliff erosion, but the CoSMoS model does provide some cliff erosion hazard zones along the South Coast. CoSMoS cliff erosion hazard zones were not in a suitable GIS format for analysis (line versus polygon), so interpretation, and in some cases interpolation, were required to create a suitable GIS format and fill data gaps. However, there is no existing cliff erosion hazard zone. This remains a data gap. Also, no cliff erosion or shoreline erosion data was available for the North Coast. Erosion zones used in the sector profile maps and analysis represent the best available erosion modeling results, which are a combination of the Coastal Resilience dune erosion and the adjusted CoSMoS cliff erosion hazards.
- **Tidal Inundation** – The Coastal Resilience model explicitly maps an extreme monthly tide condition in an appropriate format for the prepration of this Report (closed polygons). The CoSMoS model does not explicitly map tidal inundation and thus is not applicable to the analysis of tidal inundation.

- **Coastal Confluence and Fluvial Flooding** – The CoSMoS model uses an average streamflow associated with a large coastal wave event to drive the creek flood component of the model. From the CoSMoS analysis, the stream flow is typically on the order of a 5-10 year fluvial (creek) flood event. The CoSMoS model outputs from the coastal confluence analyses are not explicitly mapped, and are combined into the coastal flooding, making it impossible to specifically assess the impacts of this type of flood hazard. The use of a 5-10 year creek flow event is inconsistent with the FEMA 1% annual chance storm. The Coastal Resilience modeling assesses potential precipitation changes with 1% annual chance storm stream flows and sea level rise in its coastal confluence modeling based on precipitation projections from the 2nd California Climate Assessment, which are explicitly mapped in a suitable GIS polygon format for the Ventura and Santa Clara Rivers.

There are also relevant Coastal Resilience and CoSMoS 3.0 modeling methods reports available online.[12]

Coastal Hazard Modeling Methods

Both coastal hazard modeling methodologies rely on a detailed parcel-level backshore characterization that includes backshore type, and local geomorphology such as elevations and beach slopes. The backshore characterization was analyzed at approximate 100-yard spacing. Offshore wave conditions were transformed from deep water conditions in the Pacific Ocean into the Santa Barbara Channel and along the coast of Ventura County at 33 feet of water depth. From that nearshore water depth, calculations of wave run-up and tides were combined into a total water level elevation, which then drove coastal erosion and shoreline response models (Heberger et al. 2009, 2017).

Projected impacts from the Coastal Resilience model were evaluated at four planning horizons: existing (2010), 2030, 2060, and 2100. CoSMoS 3.0 modeled impacts at 9.8-inch increments, so the nearest sea level rise elevation was selected for consistency with the Coastal Resilience modeling. All hazards were mapped on the California Coastal LIDAR Digital Elevation model at a two-meter (6.6 feet) horizontal spatial resolution (available from the NOAA Digital Coast website). Vertical accuracies for the LIDAR topography are reported to be on the order of 4.5 inches. Existing hazards were considered to be in 2010, which represents the topographic data that the modeling used for physical geomorphic parameters and mapping.

Coastal Erosion

Erosion was modeled for the respective backshore—dune-backed shorelines on the Central Coast, as well as the cliffs on the South Coast (Figure 4-1).

[12] Readers interested in more modeling details are referred to the Technical Methods report produced as part of the Coastal Resilience modeling at www.maps.coastalresilience.org/california. The relevant modeling methods for CoSMoS 3.0 are summarized here: https://walrus.wr.usgs.gov/coastal_processes/cosmos/socal3.0/index.html.

- **Dune Erosion:** The coastal dune erosion hazard modeling considered a short-term response based on the erosion from a 1% annual chance storm. Dune erosion included three components – potential 1% annual chance storm erosion impact, erosion from sea level rise, and erosion caused by historical trends in shoreline change (as a proxy for sediment supply). In modeling dune erosion, inland extents were projected using a geometric model of dune erosion originally proposed by Komar et al. (1999). The mapped extents of dune erosion depict the future location of the dune crest.
- **Cliff Erosion:** Cliff erosion from the CoSMoS 3.0 model was based on the work by Limber et al. (2014). The cliff modeling was an ensemble of four different cliff erosion models that have been published over the years in scientific literature. These models are described in more detail in the Limber et al. (2014) paper and referenced literature. Three of the models (Trenhaile, SCAPE equilibrium, non-equilibrium SCAPE) consider the physical processes, rock strength, cliff profile and geomorphology (i.e. height, shape), the rate of sea level rise, and require some form of wave energy to cause the erosion. Some adjustments within these three models account for shorter time scales more applicable to coastal management . The fourth model is based on an equilibrium profile transgression that results in the cliff profile moving up and is based on the amount of sea level rise balanced with the volume of sediment eroded from the cliff. The average of these four models was compared to a linear extrapolation that revealed that the acceleration of erosion from sea level rise into the future exceeds the historical trends.

  The mapped hazard lines represent future cliff edges based on different sea level rise elevations (Figure 4-1). There are no projections of existing cliff erosion hazard data available in the CoSMoS model. Note that since the CoSMoS modeling uses 9.8 inches of sea level rise, the team assumed that 9.8 inches occurred by 2030, 19 inches by 2060, and 59 inches by 2100, to closely align with the Coastal Resilience modeling results.

Coastal Flooding

The Coastal Resilience coastal wave flood modeling was consistent with FEMA's Pacific Coastal Flood Guidelines (FEMA 2005). The high tide coastal storm flood modeling was integrated with the coastal erosion hazard zones. Every 10 years, erosion projections were calculated, and the coastal storm flood model considered areas that were eroded during this time period, and thus exposed to wave flooding through enhanced hydraulic connectivity. For the coastal storm flooding along the North and Central Coasts, one of the storms of record was used—a large historic storm event from January of 1983 with wave characteristics of 24 feet at 22 seconds from a westerly 279 degrees, while the storm of record for the South Coast was 10 feet at 25 seconds from due south 180 degrees (ESA PWA 2012) (Figure 4-2).

Wave induced coastal flood modeling assessed the inland extent of wave velocity and inland extents of flooding using the method of Hunt (1959). This method calculated the dynamic water surface profile, the nearshore depth limited wave, the wave run-up elevation, and inland extent at the end of each representative profile. This hazard represents a future FEMA velocity wave impact zone (also known as V-Zone). The mapped extents are the inland limit of coastal flooding from wave run-up.

Tidal Inundation

Tidal inundation modeling represents the Extreme Monthly High Water level (EMHW = 6.55 feet NAVD88) and then it was applied to each of the sea level rise scenarios (Figure 4-3).

Coastal Confluence

Coastal confluence modeling represents the influence of climate change on fluvial flood hazards. As sea level rises, the fluvial flooding is backwatered during high tides which can cause additional flooding to previously unflooded areas. In addition, climate influences on precipitation are also expected to vary in the future. This modeling used the downscaled climate modeling developed during the 2008-9 2nd California Climate Assessment to derive these precipitation and flood flow changes. The streamflow projections showed a significant increase (11%) in 1% annual chance river flows by 2100 on the Santa Clara and Ventura Rivers (ESA PWA 2012). For areas not mapped with this Coastal Confluence method, the FEMA fluvial flood maps were included (Figure 4-4).

Combined Hazards

For each planning horizon, all of the projected hazards were combined into a single hazard layer that represents the maximum extent for all of the hazard zones in the County (Figure 4-5). This combined hazard layer is displayed on the resource sector profiles found in Appendix A.

Figure 4-1. Coastal Erosion Hazards Map

Figure 4-2. Coastal Wave Hazards Map

Figure 4-3. Tidal Hazards Map

Figure 4-4 - Coastal Confluence Hazards Map

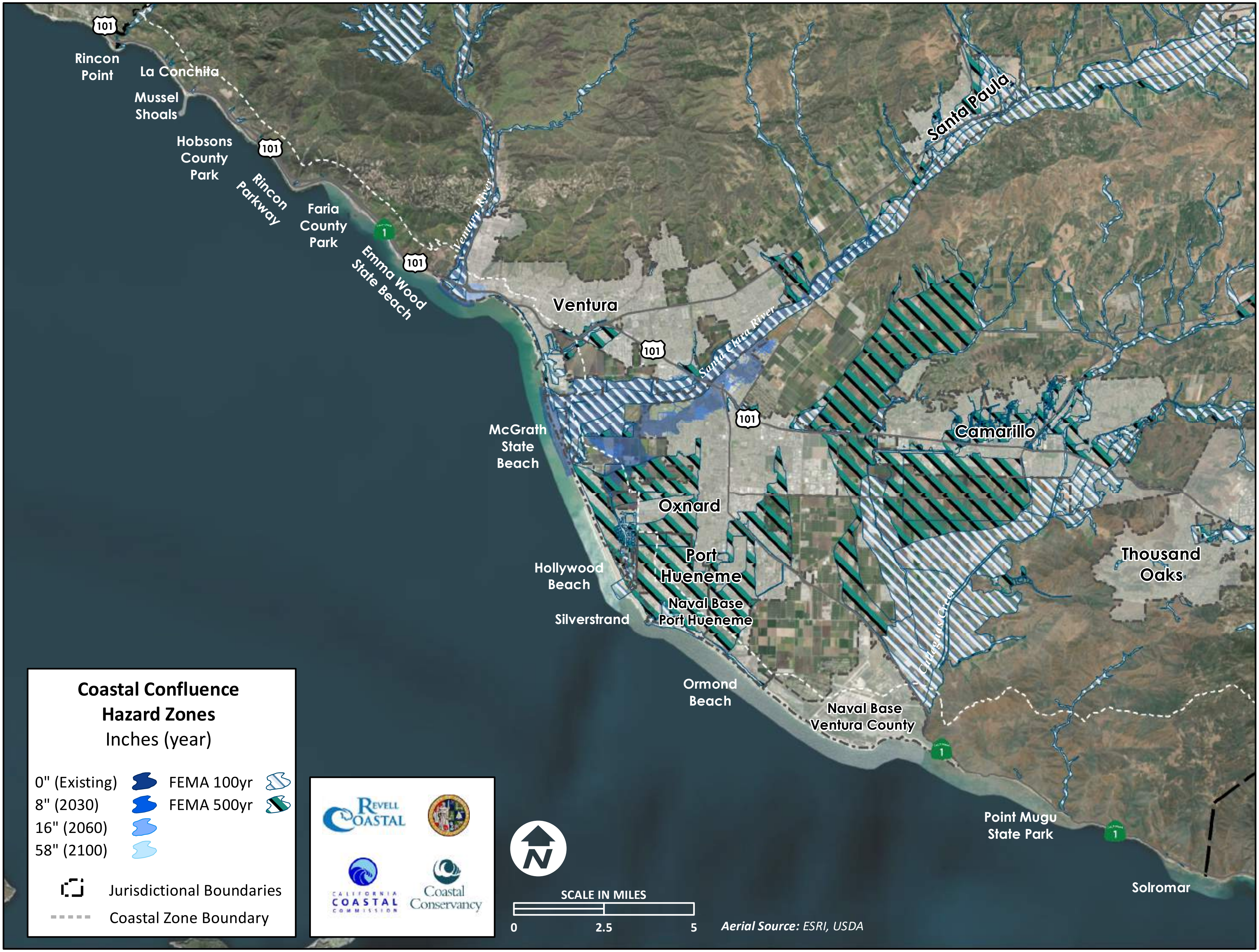
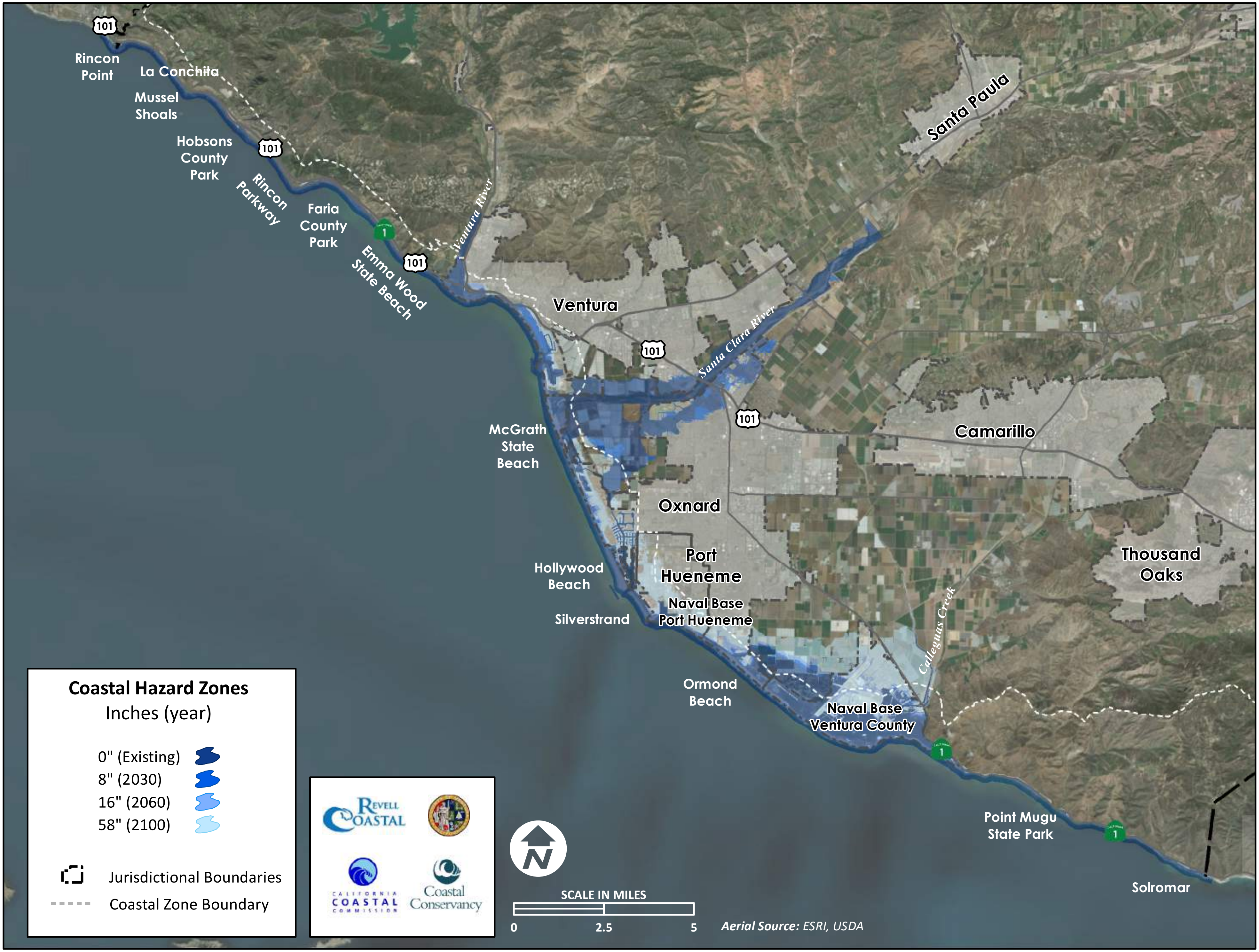


Figure 4-5. All Coastal and Existing Fluvial Hazards Map



Depth of Flooding Determination

The Coastal Resilience modeling did not include depth of flooding estimates, except for future tidal inundation. For coastal flooding, depths are needed to determine structural and content losses during events in the economic analysis. Flood depths were determined using the following assumptions and were associated with specific vulnerable structures to support the economic analysis. This was the same method used in the City of Oxnard, City of Imperial Beach, and City of Carpinteria vulnerability assessments.

- For any parcels inside the coastal erosion zone, a depth of three feet was assumed based on the cut-off depth of wave velocity flooding in the FEMA guidelines for identifying high velocity wave hazard zones. In areas where actual depth of flooding is deeper than 3 feet, this method would underestimate flood depths. (Note that presently the depth damage curves used in the economic analysis do not make a distinction between standing water and water with momentum, thus these economic damage estimates may be conservative.)
- For parcels outside the wave velocity hazard zone but inside the coastal flood hazard zone, the depth of flooding was assigned as 1 foot.
- For each time horizon, the appropriate sea level rise was added to the depth of flooding.
    - For the time period between existing and 2030, one foot was added.
    - For the time period between 2030 and 2060, another one foot was added (two feet total if in existing hazard zone).
    - For the time period between 2060 and 2100, an additional three feet was added (five feet total if in existing hazard zone).
- If at any time the coastal hazard went from tidal or coastal flooding to wave driven or erosion, then three feet was added to the flood depth for that time horizon.

Modeling Assumptions and Implications on Hazard Extents

As with all modeling, assumptions had to be made to complete the work. Below are some of the more important modeling assumptions made in the Coastal Resilience modeling (ESA PWA 2012).

Coastal Erosion and Flood Hazard Projections Do Not Consider Existing Coastal Armoring and Development

The coastal hazard projections did not consider the influence of existing development and coastal armoring on changes to coastal erosion and coastal flood hazard projections. Instead, erosion on the Central Coast was assumed to occur on a natural dune system without human alterations. This may overstate some of the erosion potential, as erosion through a sand dune would differ from erosion of asphalt roads and concrete structures.

Modeling results for cliff erosion was included for the South Coast, but as stated above, there are no existing geospatial cliff hazard data layers, and therefore the results understate the existing erosion potential, and potentially overstate the 8 inches of sea level rise erosion. Without a full understanding of existing hazards which would presumably be exacerbated by sea level rise, it would seem likely that future cliff erosion hazards may underpredict cliff erosion potential. There was no erosion modeling on the North Coast. The North Coast is nearly entirely armored and so the only erosion likely to occur would be to narrow beaches that lie seaward of the shoreline armoring; therefore, the results of beach narrowing on the North Coast may be understated.

Projections of Potential Erosion Do Not Account for Uncertainties in the Duration of a Future Storm

The erosion projections assume that the coast would respond to the combination of high tides and large waves that induce wave run-up. Instead of predicting future storm-specific characteristics (waves, tides, and duration), the potential erosion projection assumes that the coast would erode under a maximum high tide and storm wave event with undefined duration. This assumption may overstate the potential dune erosion from a single storm event and should be considered a maximum potential erosion distance.

Mapping of Coastal Flood Hazards Used Geomorphology from 2010 Topography

At the time of the modeling, the most recent comprehensive topographic data available was the State-funded 2009-2011 LIDAR data. This data was a single snapshot in time and represented the best available elevation data. This data was used to map existing and future hazards, so any changes from human activities or natural episodic events (e.g., debris/mud flows) that occurred since this topographic data was collected, are not included. The implication of this assumption is likely varied; however, the 2010 topography was collected during a relatively calm time of the year when beaches would have been near their maximum width. Thus, the 2010 topography may not be an accurate representation of the topography today or in the future and the hazards may be partly understated.

Fluvial hazards for Santa Monica Mountains Does Not Consider Future Changes to Precipitation and Runoff from the Watersheds with the Joint Occurrence of River and Coastal Flooding

Coastal confluence flood modeling has not been completed for the entire Ventura County (aside from the Santa Clara and Ventura Rivers), so the influence of changes in precipitation and higher water levels from sea level rise in the various creek mouths and sloughs, with the resultant effects of expanding the overall extent of flooding, has not been analyzed.

To represent the remaining fluvial hazards on other watershed drainages, the existing FEMA 1% annual chance storm (i.e. 100-year flood) was used to characterize existing hazards. The 0.2% annual chance storm (i.e. 500-year flood) was used to characterize future fluvial hazards. This likely underestimates the future potential flood extents along these drainages. It is important to note that the mapped extents of the 500-year event could occur any time between now and 2100. The assumption inherent in using the FEMA data is that there is no effect of climate change, and this likely underpredicts the combined coastal and creek flood extents. For most sectors, the analysis does not discuss the findings although they are shown in Appendix B. The key sectors for which it was discussed were agriculture and oil and gas.

Sediment Supply Remains Constant

Mapping of the coastal hazards assumes that sediment supply to the beaches remains constant and thus the beach elevations and beach widths would have similar capacity to rise in elevation with sea level rise, close off the barrier beach creek mouths, and buffer wave run-up. Additionally, it is assumed that the sand being bypassed from the Santa Barbara, Ventura, and Channel Islands harbors would continue with similar sand volumes and timing. Given the documented trapping of sand behind dams such as Matilija (Willis and Griggs 2003, Patsch and Griggs 2007), as well as the debris basins throughout the small coastal drainages, this assumption may be flawed. History also attests to the downcoast erosion caused when sand was not bypassed from Santa Barbara Harbor (Revell et al. 2008). The impact of this steady sediment assumption is that the mapped projections of coastal hazards may underpredict the erosion and coastal flood hazard extents.

4.4 Vulnerability Assessment Methodology

The County and Revell Coastal conducted spatial analysis on a wide variety of data. Efforts were made to obtain data directly from Coastal Commission staff and then to identify the appropriate resource sectors and measures of impact. All geospatial analysis was conducted in the ArcGIS software environment. For each resource sector and measure of impact, the respective data sets were queried and summary statistics were calculated by sea level rise elevation and by each type of coastal hazard.

Vulnerability was determined by the spatial intersection of the various coastal hazard types (see below) with the various resource sectors and infrastructure assets. Results were collated into a master vulnerability table and were interpreted into the sector vulnerability profiles found in Appendix A. The quantitative results are summarized in table format in Appendix B. As with all regional analyses, there are limitations to the application of the results. These limitations are discussed in Section 4.7.

The social vulnerability assessment in Appendix C was conducted using the 2010 US Census block data for the unincorporated County coastal zone. The potentially impacted population was identified by spatial intersection of the Census blocks with the 8-inch sea level rise coastal storm hazard layer. More information on the methodology of the social vulnerability assessment can be found in Appendix C.

4.5 Economic Analysis Methodology

The economic analysis estimated the value of damage to property, key infrastructure, and the potential losses of spending and tax revenue due to impacts to the County's beaches and beach parks. This type of economic analysis is just one factor evaluated for the overall adaptation planning effort. There are many other considerations such as property rights, ecosystem services (e.g., habitat for fish to spawn), and the inherent value of scenic beauty along the County's shorelines. This section describes in more detail the assumptions that were used in this economic analysis of sea level rise impacts on the County's shoreline.

The economic analysis for this project estimated the value of all property tax parcels using county parcel data. Assessed property values were adjusted to current market values and replacement cost. Small parcels (less than 1 acre) were assumed lost when eroded; losses to larger parcels (more than 1 acre) were weighted by the percentage loss of the parcel. Flooding damage was estimated based on the structure type, and depth of flooding using USACE depth damage curves. These are standard methods which have been applied in many jurisdictions in California. It is more difficult to estimate economic damage due to tidal inundation because there is no standard method to determine when a property becomes damaged or uninhabitable. This study reports the value of the property at risk to tidal inundation based on the loss of structure value and the percent of the land inundated.

However, as with all community economic damage assessments, site-specific characteristics such as small topographic features, flood elevations, and construction standards will factor into the amount of actual damage. For example, this study estimated substantial damage to the community of Solromar on the South Coast from tidal inundation because in many cases the oceanfront parcel boundary moves with the mean high tide line, and thus older parcel maps may not accurately represent the location of the existing mean high tide line. In addition, some of these homes are built on pile foundations over the beach, where high tides routinely cover most of the parcel. Clearly the ocean poses substantial risk to these properties, but the actual impact depends on unique site and engineering conditions, and that level of detailed study is beyond the scale of this County-wide vulnerability assessment.

To measure the economic value of beach recreation in Ventura County, this study relied on several sources. For attendance data, estimates from the State and County were used where available. In other cases, this study updated data from BEACON. Information on visitor spending and demographics was based on numerous recent studies.

The economic analysis evaluated the impacts of three mapped coastal hazards: 1) Monthly High Tide Inundation Zone, 2) Coastal Erosion Hazard Zone, and 3) Coastal Storm Flood Hazard Zone and identified existing land, buildings, infrastructure (roads, trails, water/sewer lines, etc.) within the erosion and flood zones for 8 inches, 16 inches, and approximately 5 feet of sea level rise. The analysis included both private and public property. Each hazard was analyzed separately, so there was no double counting of damage within each hazard type; however, if one were to add the same parcels reported in both erosion and flooding hazard categories, then the damage would be counted twice.

All economic results are reported cumulatively, so the results for 16 inches of sea level rise include economic impacts from existing conditions and 8 inches of sea level rise summed together.

Land Use

The land-use types evaluated in this analysis are:

- Residential Property (single-family and multiple-family)
- Commercial/Industrial property
- Open Space and Recreation
- Agriculture

Where feasible, the market value of land and replacement-cost value for structures was used, although some data gaps exist concerning identification of public structures. This Report was written in early 2018, and 2017 dollars was used as the metric since 2018 inflation data (e.g., consumer price index data) were not yet available. No discount rate was used in the analysis.

For land and structures subject to property tax, this Report used the Ventura County Assessor parcel data, which contains detailed information on the size of the parcel as well as the size of the structure. In California, any increase in the assessed value of the land/structure is capped at 2% a year by Proposition 13 until the parcel is resold. Since the rate of housing inflation in Ventura County has exceeded 2% for many years, the original sales price of the parcel was adjusted to reflect current market conditions using a housing price index created from local housing sales data. The replacement cost of the structure was estimated per square foot using FEMA's Hazard guidance files (2006).

Flood damage to structures were estimated by applying USACE depth damage curves, which estimate damags as a percent of the total value of the structure and contents. Thus the USACE method also allows one to estimate the average damage to the contents of the structure (e.g., furniture, appliances, etc.).

One limitation of using parcel data is that some parcels, such as those under ownership of local, State or Federal agencies, are not subject to property tax. For these properties, this study used data provided by the County on recent acquisitions of land by government and non-government agencies. Since some of these transactions may be below market value, it is possible that the estimates provided for the value of land loss were too low and should thus be considered as lower bounds. Additionally, these unassessed parcels typically do not have as much, if any, information about the structures on them. Therefore, it was difficult to estimate the value of structural damage on such parcels.

Another limitation 4-16or estimating the value of oceanfront parcels is that the shoreline parcel boundary is transitory, and shifts with the mean high tide line, which has likely moved inland over time. Many of the Assessor parcel boundaries extend well out onto the beach.

The analysis of open space and recreational lands did not include all of the beach areas in the County, but rather only those that are assigned an Assessor's parcel number, which excludes County beaches and beaches within roadway rights-of-way. The natural resources assessment, as described in Section 4-6 below, included an analysis of all beach areas.

Infrastructure

This Report estimated the replacement cost of certain infrastructure such as water and sewer pipes, and water pumps. The costs of infrastructure replacement for pipes, roads, and other sectors were estimated using publicly available data from Ventura County's Capital Projects Five Year Plan (2017) as well as other data provided by Ventura County. Where this information was not available, reasonable metrics were employed (e.g., replacing sewer lines) that were obtained from reputable sources, generally in Southern California (Table 4-2). Some public infrastructure was not valued, in particular this study had no data on buildings and structures in State and local parks and hence these were not valued.

However, this Report did estimate the cost of mitigating one source of wastewater. The underground storage tank associated with the Sycamore Cove restroom in Point Mugu State Park was valued at $125,000. If the tank is ruptured and contamination spreads, remediation estimates are $1.5 million.

Roads

This study identified portions of existing roads in Ventura County that would be subject to erosion and flooding. Where erosion due to a 1% annual chance storm occurs, this analysis assumed that these roads would be lost, and the value of the loss was estimated based on replacement costs used in engineering studies. However, the cost of land acquisition for roads was not estimated, which could be quite high in Ventura County, nor was the cost of relocating or elevating roads, which may be a solution in some places. Further, this analysis did not estimate the economic loss due to impaired traffic on roads subject to flooding. Since coastal flooding may impair Highway 101, the damage may be quite extensive e.

Recreation and Trails

This Report relied on numerous sources to estimate the value of beach recreation in Ventura County, including a previous study done for BEACON (2009) as well as official estimates of attendance at the local beaches from the State and the County's parks. This study also obtained detailed information on the location and length of coastal trails and bikeways, which are subject to erosion and coastal flooding. Where erosion cuts into existing trails, the study used estimates of the construction cost of creating new trails from the Ellwood Coastal Trails Restoration Project

Conceptual Funding Plan (Santa Barbara Trails Council 2015) to estimate the cost of trail replacement per linear foot. Some of these trails are along rather urbanized transportation corridors and some are mere footpaths, so this estimate in some places may be too high or too low, but overall it is a reasonable estimate. The estimated cost of the trail replacement is $170 per linear foot (Table 4-1). However, no data was obtained on the different types of materials that would be used, which could further refine this replacement cost. Flooding may also cause a loss in usage and thus recreational economic value, but specific loss of use numbers are not currently available.

Coastal recreation also generates a great deal of economic activity and taxes for the County and its residents. This analysis estimated spending on beach recreation based on estimates from the 2009 BEACON study as well as other studies (e.g., King and Symes 2004) that show a fairly consistent spending pattern for beach recreation. This study also used attendance estimates from California State Parks as well as Ventura County's parks, when available. The analysis also estimates the percentage of surfers at each beach. Economists consider surfing a higher value activity (not in terms of spending but in terms of willingness to pay). All spending estimates were updated for inflation and population growth. Differences in spending at different beaches depend primarily on whether visitors are overnight visitors (generally from out of town) or day-trippers from nearby.

The economic data and estimates presented in this Report only examine current conditions. As beach widths narrow and/or access disappears, one must account for the loss of recreational value. A smaller beach has a lower "carrying capacity" and may have lower recreational value if the size of the beach cannot accommodate current or projected future attendance. The USACE generally assumes that 100 sq. ft. of beach is necessary per person. For instance, if a beach is 10,000 sq. ft., it can carry 100 people at a given time. By examining the distribution of visitors over time, one can estimate the loss in attendance as carrying capacity is diminished. For example, demand for beach recreation is highest on July 4th and on weekends in July and early August, and narrowing beach width or loss of access would impact total attendance on those days first. As beach size is reduced farther, more peak usage days will be impacted.

If coastal erosion reduces parking or other coastal access, this loss must also be accounted for. For surfers and scuba divers the constraints differ since they spend little time on the beach, but sea level rise may constrain these activities in other ways. This study assumes that a day at the beach is worth $40, based on Coastal Commission guidance. A flat $40-a-day use value was used to evaluate impacts to the loss of recreational value due to decreasing beach size. Economic benefits and economic impacts were evaluated as two distinct categories. Economic benefits were assessed based on studies showing how much individuals are willing to pay for a day at the beach, based on standard economic methods. The economic literature also indicates that surfing is on average a higher value activity. As such, this study sets surfing apart as a separate activity, and assumes surfing to be worth $65 per day. In terms of benefits and costs, a reduction in beach width or access will factor into a benefit/cost analysis as a reduction in recreational benefits for a beach. For example, these estimates may be used to evaluate how armoring a beach may reduce its width and diminish recreational capacity.

Hazardous Materials

This study identified several hazardous materials sites. However, it did not attempt to quantify all of the costs involved due to lack of data available on the state of the hazardous material (solid, liquid or gas), or of the pollutant dispersal mechanism. However, the mitigation of hazardous materials can be very costly and such costs are likely to increase after exposure to coastal flooding or tidal inundation.

Flood Clean-Up

This study identified and estimated the flood costs to structures- residential structures in particular- and applied estimates of flood clean-up costs from the USACE depth damage curves. However, flooding entails numerous other costs that this study was not able to quantify, including the costs of debris clean-up and the costs of road closures (e.g., in terms of lost time and the inability of people to get to work on time). Recent debris clean-up costs from the Thomas Fire, and other recent debris flows could be used to improve these estimates. However, these costs were not available at the time of this analysis. For example, the City of Goleta identified their respective flood clean-up costs for the 2005 and 1998 floods as $500,000 and $4-$5 million (in 2017 dollars), respectively. The City of Oxnard also provided a cost estimate for annual sand clean-up, which was considered in this analysis.

Oil Spills

Numerous oil wells exist just onshore and offshore of the County. While some of these wells no longer operate, they still represent a danger should coastal erosion or flooding damage the wells. The County of Santa Barbara is currently facing similar issues and trying to resolve slow leakage in old wells near Summerland. Given the uncertainty involved in identification of the number of leaking non-operational wells, this Report identified a range of costs for possible abatement and damage. The recent Refugio oil spill in Santa Barbara County cost $257 million to mitigate. This was for a rupture on an abandoned minor pipeline, by no means a worst-case scenario. The estimated costs of capping legacy oil wells were estimated at $100,000 for wells on land and $800,000 for wells offshore, based on estimates of clean-up of similar wells at Summerland. This Report identified numerous vulnerable active and inactive wells located on and offshore.

Agriculture

This study estimated losses based on a reduction in agricultural land productivity from exposure to coastal flooding and tidal inundation. The analysis examines the percentage of total agricultural land by crop type subject to these two coastal hazards and assumes a loss in agricultural productivity due to increased salinity in the soils. For coastal flooding, the reduction in the values of exposed types of crops that are farmed in coastal areas today were assumed to be between 15% and 25%. It was presumed that tidal inundation has more impact on soil salinity since land is flooded with saltwater more frequently, so a reduction of 35% to 75% was assumed for this. The rationale for the percent reduction of agricultural productivity was to provide a range of estimates for potential damage over time.

Economic and Tax Revenue Impacts

Data from prior studies of beach visitors in Ventura County and elsewhere were used to estimate the spending and tax revenues of coastal tourism. Based on beach visitation, local sales tax and transient occupancy tax revenue were estimated based on this spending. The key determinant in estimating spending and taxes is whether the visitors are staying overnight. However, camping does not generate transient occupancy taxes.

Ecological Functions Goods and Services

The economic or dollar value of ecological services were estimated for recreation and storm buffering. Beaches and other coastal ecosystems provide many other ecological services (e.g., see Barbier 2011, and Dugan et. al. 2008), but the State of California has not approved any metrics for measuring or estimating the value of these services. Consequently, this Report describes the different types of coastal habitat in detail, but these ecosystems were not valued beyond their ability to support recreation and buffer storms. The fact that no value is presented does not mean there is no economic value. Communities should always consider the potential loss in ecological services when evaluating different adaptation measures.

Economic Cost Estimates

Table 4-2 summarizes the costs and sources of the estimates used to value the various losses identified in this Report. As discussed above, this study obtained these values in three main ways:

- The County Parcel Data was updated to reflect the market value of the parcel/structures and the replacement value of structures in the County.
- Cost estimates were obtained from State and County officials, and from adjacent jurisdictions.
- Standard engineering cost metrics from reliable sources were used to estimate other costs (e.g., cost of replacing sewer lines).

Table 4-2. Cost Estimates and Data Sources

Item	Cost/Value	Cost Basis	Source
LUSTs – not exposed	$125,000	Per tank	EPA
LUSTs – exposed	$1,500,000	Per tank	EPA
2005 Goleta flood costs	$500,000	Goleta	City of Goleta
1998 Goleta flood costs in 2015 dollars	$4-5,000,000	1998 flood adjusted	City of Goleta
Capping Oil well-on land	$100,000	Per well	City of Goleta
Capping Oil Well – in water	$800,000	Per well	City of Goleta
Oil spill costs	$257,000,000	Total cost	LA Times
Trails	$170	Per linear foot	Ellwood Trails Project
Road Replacement	$280	Per linear foot	Nichols Consulting Engineers
Manhole Cover Retrofits	$150	Per manhole	GSW
Wastewater Lift Station	$150,000	Per lift	GSW
Property Tax Parcel	Updated using HPI	Sale Price	County Assessor
Buildings/ Structures	Size of building	$/sq. ft.	FEMA
Flood Damage to Buildings	Current Market Value	Depth damage curve	USACE
Above Ground Power Lines	$10	Per linear foot	SCE
Below Ground Power Lines	$30	Per linear foot	SCE

4.6 Natural Resources Methodology

This assessment identifies which coastal natural resources are likely to be most affected, determines why they are or are not vulnerable, and describes how their vulnerabilities may vary throughout the coastline of the unincorporated County. Based on previous studies and data availability (see Appendix D for detailed methodology), the assessment includes four coastal habitats: 1) beaches, 2) dunes, 3) estuarine habitats (e.g., estuaries, lagoons, salt marshes, salt pannes/flats), and 4) freshwater habitats (e.g., rivers, streams, lakes, wetlands, riparian). Beaches, dunes, and estuaries are among the most vulnerable coastal habitats (Hutto et al. 2015). Analysis of potential exposure of freshwater habitats is also important because these habitats support vital ecosystem services and serve as critical dispersal corridors for plants and animals. While coastal bluffs are an additional important habitat in Ventura County, the lack of data on coastal bluffs was the limiting factor on the inclusion of that habitat type in this assessment. Using the sea level rise scenarios and coastal hazards models described in Section 4.3, each of the four habitats, as well as United States Fish and Wildlife (USFWS)-designated critical habitat areas and California Natural Diversity Database (CNDDB) data, were spatially analyzed to identify the potential loss of habitat (erosion was only evaluated for the Central and South Coasts), increased exposure to sea water inundation (tidal flooding), and increased exposure to coastal hazards due to wave and fluvial flooding associated with a 1% annual chance storm event.

The potential creation or replacement of habitats was not modeled in this study (e.g., the accretion of sand or changes from freshwater to estuarine habitat types). However, a model showing the extent of future habitat in the Ormond Beach and Mugu Lagoon area is viewable in the Coastal Resilience online mapping tool. In addition, the City of Ventura conducted studies for the wastewater treatment plant that predicts potential habitat changes for the Santa Clara River estuary.[13] These resources could be used for adaptation planning.

According to each sea level rise hazard model (erosion, tidal inundation, coastal storm flooding, fluvial flooding), percentages of habitat areas (based upon total existing habitat in the unincorporated County) that may be exposed to coastal hazards and sea level rise were calculated for each of the four selected habitat types. To understand when the greatest amount of habitat may be exposed due to rising seas, the percent of affected habitat for each sea level rise scenario (i.e., current conditions, 8 inches, 16 inches, and 58 inches) was calculated for each of the four sea level rise hazards. Scale-dependent effects of sea level rise were also accounted for within the analysis. For example, while the quantitative results (acres of habitat exposed) may suggest that a relatively small area of a habitat may be vulnerable to sea level rise, upon a further detailed analysis, those smaller areas may support a known special status species or provide critical spatial links in the chain of ecosystem services.

In addition to the geospatial analysis of habitat exposure to sea level rise, a Natural Resources Working Group (Working Group) was created and tasked with selecting and assessing the vulnerability of a group of plants and animals within each habitat type. The Working Group consisted of 35 federal, state, and local biologists, botanists, and ecologists who are subject-matter experts on the County's flora and fauna. The Working Group selected "focal species" that were both potentially vulnerable to sea level rise and have life history characteristics that could provide the

[13] See www.maps.coastalresilience.org/california/#(Ormond Beach) and www.cityofventura.ca.gov/1081/Library-of-Reports (Santa Clara River Estuary).

most guidance to help inform and implement adaptation strategies for the natural resources evaluated.

Vulnerability was measured through an evaluation of each species' exposure and sensitivity to changes in the environment, in relation to its capacity to adapt to environmental changes (i.e., adaptive capacity). A species with greater adaptive capacity can change its behavior to colonize more favorable habitats (e.g., expand its historic range and distribution), change observable characteristics in its lifespan (e.g., a particular species of aphid can grow wings when a plant becomes overpopulated), or evolve over multiple generations (e.g., mice have large ears to hear predators better because they do not have night vision and are nocturnal). By evaluating species vulnerabilities using these three criteria (sensitivity, exposure, adaptive capacity) an overall vulnerability score was generated and plotted to identify which species are most vulnerable to sea level rise hazards. Participants also recorded a confidence score for each answer to quantify the accuracy of their assessment. See Section 5.3 for the results and focal species assessments.

4.7 Limitations of the Vulnerability Assessment

This Report revealed potential hazards in Ventura County from sea level rise and associated erosion and flooding. Substantial efforts were made to apply the best available hazard projections and include the best available resource and infrastructure location data.

There are uncertainties inherent in the modeling, the elevation and rate of sea level rise, and the spatial location of the resources and infrastructure. No existing cliff erosion hazards were mapped on the South Coast, and no erosion projections exist for the North Coast. However, the results of this County-wide assessment still provide the County with enough information to identify critical future vulnerabilities and to draft preliminary policies in support of proactive and thoughtful adaptation planning and the associated capital expenditures that would be needed. Additional specific analyses of each sector will be required to improve spatial resolution and precision.

The exposure of each of these sectors was based on projections of future hazards that have inherent uncertainties. Professional judgement and assumptions which are described in Section 4.3 may over or underpredict the hazard extents. Coastal management and individual property decisions may alter or influence the hazard extents.

Using publicly available data, including County assessor parcel property data, estimates of beach attendance, and replacement cost estimates, this study was able to evaluate, with reasonable accuracy for the regional nature of the analysis, estimates of property at risk, current recreational uses, and replacement cost for some infrastructure. Each site and property have unique characteristics which were beyond the scope and budget of this County-wide analysis. There remain significant data gaps in this Report, and the analysis should be read with these data gaps in mind. This study used the best available data for each sector as provided by the County or acquired through various publicly available sources. In all cases, the County and consulting team attempted to review the spatial accuracy of the data using various aerial photographs, public maps and records, and local knowledge of the County. In many cases, the data was not complete for the entire County. Accuracy of parcel attribute data was much more difficult to evaluate, but standard quality control measures were followed prior to use of the data.

The economic property analysis is based on assessor's parcel data, adjusted to fair market value. However, the oceanside parcel boundaries obtained from the County are by law at the mean high tide line boundary. The ocean side of the existing parcel boundaries have not been adjusted to the present day (2010 topography in this study) mean high tide line, therefore the timing of potential impacts to these oceanfront parcels may be off. However, the economic analysis points to a potentially huge issue in the County. Although the estimates of private property loss based on parcel data are reasonably accurate given current market values, this study cannot predict the future market values or replacement costs of this property. Further, the flood damage curves created by the USACE are for standing water, and do not incorporate the force of waves in a coastal storm. Consequently, the extent of damage reported may underestimate actual damage. For tidal inundation, the study was only able to report the value of property at-risk, for the portion of the parcel that would be inundated. There are no standard metrics to determine when tidal inundation will result in a property condemnation.

In the analysis of agriculture no other climate impacts such as temperature and precipitation were included. Of the hazards examined, the most significant risk to Ventura County agriculture is likely due to increases in soil salinity from coastal flooding and tidal inundation. Soil contamination from this flooding is also a concern since flooding can spread pathogens and toxic materials. Changes in crop type from high value to lower value was not considered. This issue is recommended for further study.

The analysis of roads, pipes and other linear infrastructure did not account for the cost of acquiring property or access rights, nor did it account for costs of protecting existing pipes. Roads may need to be elevated or rerouted, or pipes may need protection, and these costs were not incorporated into the analysis.

The valuations of open-space and recreational land uses rely on an analysis of recent purchases by governmental and non-governmental organizations in the County and nearby jurisdictions. While the analysis considered beach recreation and surfing, there are a host of additional uses that are not quantified, including bike and trail usage, fishing, kiteboarding and other coastal-dependent recreational uses.

The analysis here also does not include the value of ecological functions, nor goods and services for coastal ecosystems other than the recreational value of beaches. Given the large variety of sensitive upland, riparian and wetland habitats, it is likely that these natural benefits are quite high in value, even if they are difficult to estimate. All of them contribute to the quality of life in Ventura County.

5. SECTOR VULNERABILITIES

5.1 Sector Profile Results

The North, Central and South Coast vulnerability assessment results are summarized in this section. Table 5-1 below lists the vulnerability results according to “sector” and is organized based on elevations of sea level rise. Economic analysis of potential impacts is provided in Section 5.2, and Section 5.3 presents results for natural resources, including a discussion of vulnerable habitats and focal species. Over 30 vulnerability maps and more detailed analyses are located in Appendices A and B. The results in Table 5-1 follow the order of the sectors listed below:

- Use Parcels and Structures
- Agriculture
- Wastewater
- Stormwater
- Water Supply
- Public Access, Recreation, and Trails
- Roads and Parking
- Public Transportation
- Oil and Gas Infrastructure
- Hazardous Materials
- Critical Services
- Natural Resources
- Vulnerable Populations

Table 5-1. Sector Vulnerability Results

Existing Vulnerabilities (Approx. Year 2010)

Land Use Parcels and Structures

- 1,125 (mostly residential) structures are at risk of coastal flooding throughout the County.
- Ten oceanfront residential structures are at risk of tidal inundation in the South Coast.

Agriculture

- More than 2,000 acres of agricultural land are at risk of fluvial flooding along the Santa Clara and Ventura Rivers and about 200 acres are at risk of coastal flooding.

Wastewater

- Two pump stations, 28 manholes, and 9.5 miles of wastewater pipelines are at risk of coastal flooding.
- About 20 septic systems under raised residential structures in Solromar are vulnerable to flooding.

Stormwater

- 600 feet of pipe are at risk from coastal erosion in Hollywood Beach and Silverstrand.
- Two pump stations in Silverstrand and one in Solimar are at risk of coastal flooding.
- Eight detention basins in Mussel Shoals and Faria are at risk of coastal flooding.

Water Supply

- Two pump stations in Hollywood Beach and five water supply wells in the Ventura River Valley and Ormond Beach are at risk of coastal flooding.

Public Access, Recreation, and Trails

- All vertical access points are at risk of coastal erosion and flooding.
- Hobson and Faria County Parks, Rincon Parkway, Emma Wood State Beach, McGrath State Beach, Point Mugu State Park, Sycamore Cove, Thornhill Broome Beach and Leo Carrillo State Park are at risk of coastal flooding and erosion.
- 4.7 miles of trail are at risk of coastal erosion while 15.3 miles of trail are at risk of coastal flooding.

Roads and Parking

- 19 road miles are at risk of coastal flooding along Rincon Parkway in the North Coast and Pacific Coast Highway in the South Coast.
- Eight South Coast parking lots are at risk of coastal erosion and three North Coast parking lots are at risk of coastal flooding.

Public Transportation

- Northern portions of the Ralph Fertig Memorial Bike Trail (Highway 101) are at risk of coastal flooding.

Oil and Gas Infrastructure

- 12 inactive wells in the North Coast are at risk of coastal flooding.

Hazardous Materials

- Four hazardous material (CUPA) sites are at risk of coastal flooding, including oil and gas sites and the Agromin Organics Recycling Site.

Critical Services

- No critical facilities are at risk of tidal inundation or erosion.
- Hollywood Beach Elementary School is at risk of coastal flooding during a 1% annual chance storm.

Natural Resources

- The majority of coastal habitats (beaches, dunes, marshes) and all federally designated critical habitats are currently at risk of exposure to tidal inundation and/or coastal flooding during storms.
- All beach habitat (i.e., Hollywood, Silverstrand, and Point Mugu State Beach) and the majority of designated USFWS critical habitat for the western snowy plover at beaches (i.e., Hollywood Beach) are currently at risk to increased erosion during a 1% annual chance storm event.
- Fortunately, the current risk of erosion to dune habitats is low (most dune habitats are back dunes located away from the immediate shoreline). Potentially over half of existing foredune habitat is currently vulnerable to a potential increase in erosion during a 1% annual chance storm event.

Vulnerabilities Between 0 and 8 Inches of Sea Level Rise (Approx. 2010-2030)

Land Use Parcels and Structures

- 1,470 structures are at risk of coastal flooding and 821 structures are at risk of coastal erosion (mainly in the Central Coast).

Agriculture

- Almost 200 acres of agricultural are at risk of tidal inundation.

Wastewater

- 21 manholes are at risk of coastal erosion.
- One pump station and five additional manholes are at risk of coastal flooding.

Stormwater

- 42 inlets and two pumps are at risk of coastal erosion in Hollywood Beach and Silverstrand.
- 11 storm drains are at risk of coastal flooding in Hollywood Beach and Silverstrand.

Water Supply

- 1,600 feet of water supply pipe are at risk of coastal erosion in Solromar.
- One well in Ormond Beach is at risk of coastal flooding.

Public Access, Recreation, and Trails

- 1.5 miles of lateral beach access are at risk of cliff erosion in the South Coast.
- All parks and trails in the North and Central Coasts are at risk of coastal flooding and erosion.
- 8.9 miles of trail are at risk of coastal erosion and 16.9 miles of trail are at risk of coastal flooding.

Roads and Parking

- 4.6 miles of road are at risk of coastal flooding along Rincon Parkway and Pacific Coast Highway.
- 3.2 miles of road are at risk of dune erosion in Silverstrand and Hollywood Beach.

Public Transportation

- The bike lane and sidewalks along Ocean Drive at Silverstrand are at risk of coastal erosion.
- 2.6 miles of the North Coast rail alignment are at risk of coastal flooding.

Oil and Gas Infrastructure

- Nine active wells along the Santa Clara River are at risk of fluvial flooding.
- 1.9 miles of major pipelines in the North Coast are at risk of coastal flooding.

Hazardous Materials

- Four hazardous material (CUPA) sites are at risk of coastal flooding, including SCG infrastructure and a Venoco facility near McGrath State Beach.

Critical Services

- 1.2 miles of evacuation routes are at risk of coastal flooding.

Natural Resources

- Hollywood and Silverstrand beaches may be exposed to increased erosion events, while estuarine, freshwater and back dune habitats may experience increased exposure to coastal storm flooding and monthly tidal inundation.
- All of the USFWS Western snowy plover critical habitat on Hollywood Beach could experience increased monthly tidal inundation, as well as continued storm flooding and erosion associated with a 1% annual storm event.

Vulnerable Populations

- About 2,000 residents of the unincorporated coastal zone could be impacted by coastal storms. Of those, 21% are seniors (65 and over), 41% are renters, and 10% are Hispanic.
- The evacuation route on Victoria Avenue could be flooded during a 1% annual chance storm, inhibiting evacuation from the Silverstrand community.

Vulnerabilities between 8 and 16 Inches of Sea Level Rise (Approx. 2030-2060)

Land Use Parcels and Structures

- 1,640 structures are at risk of coastal flooding and 1,513 structures are at risk of coastal erosion.
- 904 residential structures and 17 commercial buildings are at risk of tidal inundation.

Agriculture

- About 100 acres of Farmland Monitoring and Mapping lands are at risk of coastal flooding.

Wastewater

- Six manholes are at risk of coastal erosion.
- Two manholes and 0.9 miles of pipe are at risk of coastal flooding.

Stormwater

- 21 inlets in Hollywood Beach and Silverstrand are at risk of coastal erosion.
- One detention basin at McGrath State Beach is at risk of coastal flooding.

Water Supply

- Five wells in Ormond Beach are at risk of tidal inundation.
- Three additional wells in Ormond Beach are at risk of coastal flooding.

Public Access, Recreation, and Trails

- 1.5 miles of lateral beach access at risk of cliff erosion in the South Coast.
- 16.9 miles of trail are at risk of coastal flooding.

Roads and Parking

- 2.6 miles of road in the South Coast are at risk of cliff erosion.
- Roads near the Ventura County Game Preserve and sod farms are at risk of tidal inundation.

Public Transportation

- 1.6 miles of the rail line on the North Coast are at risk of coastal flooding.

Oil and Gas Infrastructure

- 1.5 miles of major pipelines are at risk of coastal flooding in the North Coast.

Hazardous Materials

- The Agromin Organics Recycling Site is at risk of tidal inundation.

Critical Services

- Hollywood Beach Elementary School is at risk of coastal dune erosion.
- 1.1 miles of evacuation routes along Highway 101 are at risk of coastal flooding.

Natural Resources

- Approximately half of the existing estuarine ecosystems may be exposed to increasing monthly tidal inundation and combined flood hazards. Streams/creeks, lagoons, and pocket estuaries located in the North and South Coasts may also be subject to increased exposure to combined flood hazards.

Vulnerabilities Between 16 and 58 Inches of Sea Level Rise (Approx. 2060-2100)

Land Use Parcels and Structures

- 2,187 structures are at risk of coastal flooding, 1,513 structures are at risk of coastal erosion, and 930 structures are at risk of tidal inundation.

Agriculture

- Over 800 acres of Farmland Monitoring and Mapping lands are at risk of tidal inundation.
- Over 1,500 acres of agricultural lands are at risk of coastal flooding.

Wastewater

- 26 manholes are at risk of tidal inundation.
- 14 manholes are at risk of coastal erosion and 19 manholes are at risk of coastal flooding.
- An active waste discharge site at Sycamore Cove Beach is at risk of tidal inundation.

Stormwater

- Three detention basins near Naval Base Ventura County are at risk of tidal inundation.
- Nine culverts in La Conchita and near McGrath Lake are at risk of coastal flooding.

Water Supply

- Two pump stations in Hollywood Beach are at risk of tidal inundation.
- 23 groundwater supply wells are at risk of coastal flooding throughout the county.

Public Access, Recreation, and Trails

- All vertical access points are at risk of coastal erosion and flooding.
- 17.6 miles of trail are at risk of coastal flooding.

Roads and Parking

- 16.5 miles of road are at risk of coastal flooding throughout the county.
- 8.28 miles of road are at risk of tidal inundation throughout the County.

Public Transportation

- 3.3 miles of the Ralph Fertig Memorial Bike Trail (Highway 101) are at risk of coastal flooding.
- 3.4 miles of rail line on the North Coast are at risk of coastal flooding.

Oil and Gas Infrastructure

- 17 active wells are at risk of coastal flooding near Seacliff and McGrath Beach.

Hazardous Materials

- Four hazardous waste (CUPA) sites are at risk of coastal flooding, including two sites associated with Southland Sod Farms.

Critical Services

- A Channel Islands Community Service District building is at risk of tidal inundation.
- 2.2 miles of evacuation routes are at risk of erosion along Highway 101 and Pacific Coast Highway.
- Six communication towers are at risk of coastal flooding.

Natural Resources

- The largest area of existing estuarine habitat may be exposed to increased erosion events.
- Hollywood and Silverstrand beaches may be exposed to additional coastal storm flooding and monthly tidal inundation events.
- Increased exposure to monthly tidal inundation has the potential to occur in the greatest area of existing back dune habitats and USFWS Western snowy plover habitat. Coastal storms may expose the most area of USFWS species habitats to more temporary flooding events.
- Combined coastal flood hazards may affect the habitat suitability for four Western monarch butterfly overwintering roosts (Rincon Point, Ventura River, La Jolla and Sycamore Canyon).

Summary of Sector Results

The following sections expand upon the summary table provided above and describe the sector results in more detail.

Land Use Parcels and Structures

Losses to residential land uses represent over 95% of all land use vulnerabilities in the County and are concentrated in a few neighborhoods of mostly single-family residences. Over time, properties that are flooded infrequently by large wave events and potentially damaged by coastal erosion, become subject to more routine monthly high tide inundation. Economic analyses focused on the variety of land uses vulnerable from each of the coastal hazards for each sea level rise scenario. Key vulnerability results are highlighted here with specific methods and detailed results discussed in Sections 4 and 5.

Existing North Coast oceanfront neighborhoods of Seacliff, Solimar, and Faria Beach Colony currently face approximately $10 million of residential property at risk to coastal storm flooding. These properties are currently protected from erosion by a variety of coastal armoring structures that are in a wide range of conditions. Future maintenance of these armoring structures will determine future erosion vulnerabilities. With about 5 feet of sea level rise, coastal flooding may cause $138.2 million in property damage, including portions of the La Conchita community. Tidal inundation with about 5 feet of sea level rise could routinely impact up to $70.2 million of property including both land and structures. Cliff House Inn, the only hotel in the unincorporated coastal zone, is currently at risk to coastal flooding. Recreation and open space land uses are also affected along the Rincon Parkway, including impacts to both Hobson and Faria County Parks, and Emma Wood State Beach, which are discussed more in the Public Access, Recreation, and Trails results below.

Along the sandy Central Coast, erosion and coastal flooding expose the Hollywood Beach and Silverstrand neighborhoods. Currently, $120.1 million of property may be damaged during a 1% annual chance storm, assuming this 100-year storm hits the entire coast with the same force at the same time, which could also cause $26.6 million coastal erosion damage. With 8 inches of sea level rise, vulnerabilities skyrocket to $981 million as potential storm erosion could impact all of the oceanfront properties. With about 5 feet of sea level rise, an estimated $407.3 million in property could be vulnerable to coastal flooding and $1.5 billion to potential coastal erosion damage during a 1% annual chance storm. Tidal inundation with about 5 feet of sea level rise would routinely affect $633 million worth of property and buildings. Additional impacts to commercial small businesses, agriculture, and open space land uses are also projected to occur.

Along the South Coast, most damage occurs to oceanfront residential properties situated between the ocean and Pacific Coast Highway, mainly in the Solromar neighborhood. Short to near term potential cliff erosion with up to 8 inches of sea level rise could impact over $208 million in property, with little additional escalation of damage even with about 5 feet of sea level rise. Most of these parcels are already exposed to high tides but the exact impact of this inundation is unclear given the variety of construction methods and existing coastal armoring. Between 16 inches and about 5 feet of sea level rise, coastal flooding vulnerabilities are estimated to cause $136.6 million in storm damage.

Detailed vulnerability maps for the land use sector can be seen in Figures A1a, A1b, and A1c in Appendix A.

Agriculture

Agriculture in the County is a $2-billion-dollar-a-year economic driver. The analysis focused on impacts to different crop types as identified in the County's 2016 Crop and Livestock Report, and farmland mapped by the State that is required for consideration under the California Environmental Quality Act. Except for a 40-acre site near the Seacliff community on the North Coast, nearly all of the agriculture in the coastal zone occurs on the Oxnard Plain.

Only the vulnerabilities to coastal hazards and sea level rise have been examined here. Coastal erosion has minimal impacts to agricultural lands, although it does potentially increase vulnerabilities by opening new flow paths through the dunes during large coastal wave events. The full effect of climate change on agriculture, including changes to temperature, precipitation, and water supply availability have not been studied fully.

Coastal confluence and fluvial flooding are likely to cause temporary damage and disruption to about 2,400 acres of mapped farmland, most of which occurs in already established floodplains along the Santa Clara River. These river flood processes may improve the quality of the soil by replenishing it with new sediment and reinvigorating some of the soils, although soil contamination is also a potential concern.

Coastal storm flooding impacts may cause temporary disruption to agricultural operations, escalating from about 430 acres today to about 2,600 acres with about 5 feet of sea level rise. Most of the vulnerable farmland (66%) is currently used for higher-value fruit and nursery crops. Once soil is exposed to saltwater, a shift in crop types grown, away from the highest value crops to lower value ones, may be required (e.g., strawberries to celery or grazing land).

Increasing high tides are likely to have the most permanent impacts on agriculture, as saltwater inundates and degrades the soils. Tidal impacts with just 8 inches of sea level rise may affect 280 acres, whereas with about 5 feet of sea level rise, over 1,440 acres of farmland become vulnerable to routine high tides.

Detailed vulnerability maps for the agriculture sector can be seen in Figures A2a, A2b, and A2c in Appendix A.

Wastewater

The County Water and Sanitation Department oversees the wastewater collection system of 17 wastewater districts located throughout the County. Currently, most of the wastewater from the coastal zone is processed at regional wastewater treatment plants, the Ventura Wastewater Treatment Facility (in the City of Ventura), and the Oxnard Wastewater Treatment Plant (in the City of Oxnard). While two wastewater treatment facilities are within incorporated cities, both could be exposed to coastal storms with 5 feet of sea level rise and disruption to their services would likely impact unincorporated areas as well. For example, the Hollywood Beach and Silverstrand communities are serviced by the City of Oxnard Wastewater Treatment Plant. Across the unincorporated County, 14.5 miles of pipeline is vulnerable to coastal flooding with about 5 feet of sea level rise. If existing coastal armoring fails, much of this pipeline could also be exposed to coastal erosion damag.

Community Service Area 29 provides service to most of the North Coast, with infrastructure that extends from Mussel Shoals to the City of Ventura. The North Coast La Conchita Community as well as the South Coast generally rely on septic systems, aside from a small private wastewater treatment facility associated with the Malibu Bay Club in Solromar. Currently, there is no uniform spatial dataset available to evaluate impacts to specific septic systems, however, coastal erosion may damage septic systems and tidal inundation may reduce the filtering capabilities, causing leeching of sewage into the surrounding County lands and the ocean.

Along the North Coast, wastewater infrastructure is largely protected from erosion by 12 miles of coastal armoring in various conditions. Presently, two pump stations at Seacliff and Faria are at risk of coastal flooding. As sea level rises by 8 inches, another pump station at Solimar becomes exposed, and with about 5 feet of sea level rise, an additional pump station at Mussel Shoals is exposed.

Along the Central Coast, with just 8 inches of sea level rise, coastal erosion may damage up to 1.5 miles of wastewater pipes in the Hollywood Beach and Silverstrand neighborhoods. By about 5 feet of sea level rise, 3.3 miles of pipe may be damaged from erosion. Replacement costs for the pipe are estimated to be around $4 million. Coastal flooding and tidal inundation could also add salt water into the sewage system through manholes. This could cause complications to the treatment process and potentially introduce a volume of sewage too great for the regional plants to accommodate. With about 5 feet of sea level rise, 39 manholes could be exposed during coastal storms and 26 manholes could be routinely exposed during high tides.

Along the South Coast, septic systems may be damaged by erosion and tidal inundation, but the lack of data makes this risk hard to assess fully. About twenty houses in Solromar are supported by caissons and most have septic systems in the sand underneath the houses. The poor drainage capacity of the sediment between the houses and the Pacific Coast Highway prevents the installation of septic systems in front of the houses. Most of the tanks and drain fields in the sand are protected by seawalls underneath the house. The buried tanks and associated drain fields under the sand could be flooded by strong waves today, potentially leaking wastewater into the ocean.[14]

The private wastewater treatment facility in Solromar is not projected to be impacted by the coastal hazards evaluated even with about 5 feet of sea level rise. One active waste discharge permit is held by California State Parks for the restroom facility at Sycamore Cove State Beach. This facility is presently exposed to coastal flood hazards. With about 5 feet of sea level rise, the restroom could be exposed to tidal inundation.

Detailed vulnerability maps for the wastewater sector can be seen in Figures A3a, A3b, and A3c in Appendix A.

Stormwater

The County stormwater system is based on gravity discharge of runoff to the nearest body of water. As tides and sea levels rise, the efficiency of this gravity flow may decrease as outfall pipes may be completely submerged during more of the tide cycle. Specific elevations of key outfalls were not available to evaluate this change in detail. In some cases, stormwater pipes may also serve as a flow path for ocean water to enter neighborhoods. Already, 3.2 miles of stormwater pipe are affected during monthly high tides, particularly in the Hollywood Beach and Silverstrand neighborhoods. As sea levels continue to rise, the North Coast La Conchita community and the areas inland of Harbor Boulevard, which drain into McGrath Lake, may be impacted as key culverts become exposed to tidal inundation and coastal flooding.

[14] This information is based on interviews that were conducted in June, 2018 with a local coastal engineer and operators of local septic tank installation companies.

Detailed vulnerability maps for the stormwater sector can be seen in Figures A4a, A4b, and A4c in Appendix A.

Water Supply

The County's coastal water supply system is managed by three water districts: Casitas Municipal District supplies water in the North Coast, United Water Conservation District in the Central Coast, and Calleguas Municipal District in the South Coast. Most County water comes from groundwater pumping, but also from surface water primarily diverted from the Santa Clara and Ventura Rivers, imported state water, and recycled water. Coastal hazards do pose some issues to water supply across the County, although because of multiple water districts, a single spatially uniform data set was not available for the analysis.

Along the North Coast, some 2.9 miles of pipeline are currently exposed to 1% annual chance storms, primarily along the Rincon Parkway neighborhoods of Rincon, Mussel Shoals, and Faria Beach Colony, which may affect residential service. If the coastal armoring should fail along the North Coast, then erosion impacts could further damage some of this water supply pipeline.

The Central Coast neighborhoods of Hollywood Beach and Silverstrand are especially vulnerable, and a large wave storm today could potentially flood two pump stations. As sea level rises just 8 inches, one of these pump stations could be eroded and the second one exposed to erosion with 16 inches of sea level rise. With about 5 feet of sea level rise both pump stations would likely be at risk to inundation during routine monthly high tides.

Along the South Coast, groundwater wells in the Ormond Beach and Calleguas Creek areas get increasingly exposed to coastal flooding during large wave events. While only one well is exposed currently, with 16 inches of sea level rise, three wells are exposed, and with about 5 feet of sea level rise, 23 wells become exposed. Residential service along the South Coast could also be affected as some 1,600 feet of water distribution pipe could become damaged by coastal cliff erosion with 8 inches of sea level rise. With about 5 feet of sea level rise, a total of about 3,800 feet of pipe could potentially be eroded and the Solromar neighborhood affected with replacement costs estimated at approximately $860,000.

Climate impacts associated with changes in precipitation, saltwater intrusion into the groundwater aquifers, and the influence of temperature and snowpack on imported water supplies was not assessed. However, there are many water supply initiatives and local groundwater sustainability agencies being coordinated through the Integrated Regional Watershed Management Plan and the Sustainable Groundwater Management Act. These initiatives are summarized in Section 1.

Detailed vulnerability maps for the water supply sector can be seen in Figures A5a, A5b, and A5c in Appendix A.

Public Access, Recreation, and Trails

Coastal access and recreation in the County includes a wide variety of activities such as beach recreation, surfing, camping, birdwatching, and surf fishing. County beaches draw over three million visitor days per year with estimated visitor spending of $112 million on beach recreation annually. Beach recreation provides $156 million in economic benefits and generates $2.3 million in transient occupancy taxes and just under $1 million in sales taxes for the County and other public agencies within the County. Beaches are squeezed in the North and South Coasts by 18 miles of coastal armoring, rising high tides, and storm waves, and are trapped between a literal "rock and a hard place". Beaches need either a consistent source of sand or inland space to retreat to in order to survive. If beaches disappear then so too may the substantial annual recreation revenues.

Along the North Coast, already armored campgrounds at Hobson and Faria County parks, as well as State Park camping along the Rincon Parkway and at Emma Wood State Park, are vulnerable to coastal flooding. Depending on maintenance of the coastal armoring, these could be subject to future erosion damage. In the Central Coast, the campground at McGrath State Beach is already frequently closed due to fluvial and estuary flooding and is being considered for relocation further south (away from the Santa Clara River). On the South Coast, beaches at Point Mugu, Sycamore Cove, Yerba Buena Beach, and Leo Carrillo Beach will be increasingly eroded. These beaches may disappear or require seasonal closures. Thornhill-Broome Beach already suffers frequent damage during large storm waves.

The California Coastal Trail transverses approximately 30 miles of sandy beaches, existing and planned trail segments across the County. There are an estimated 31 beach access points, in addition to non-designated street ends through Silverstrand and Hollywood Beach. Currently, all beach access points and about 15 miles of the California Coastal Trail are vulnerable to erosion and coastal flood hazards that occur during a 1% annual chance storm. Monthly high tides today inundate about 50% of lateral accesses along the narrower beaches in the North and South Coasts. The vulnerabilities increase with sea level rise and eventually nearly 19 miles (over 60%) of the California Coastal Trail will be subject to storm flooding and over six miles (20%) will be subject to routine high tides. Coastal erosion with about 5 feet of sea level rise may affect 9.7 miles (about 30%) including portions of the planned alignment along Pacific Coast Highway in the South Coast.

Detailed vulnerability maps for the public access, recreation, and trails sectors can be seen in Figures A6a, A6b, and A6c in Appendix A.

Natural Resources

The natural resources assessment evaluated potential sea level rise exposure of sensitive coastal ecosystems, including federally designated habitats and Western monarch overwintering roosts. It did not consider the transition or migration of habitat types due to sea level rise. The assessment determined that coastal sand dunes, beaches, estuarine ecosystems, and associated federally designated critical habitats are the most vulnerable to sea level rise. The focal species dependent upon these habitats were also found to be among the most vulnerable to sea level rise.

Beach and coastal sand dune environments may be eroded, inundated, and flooded, resulting in altered ecosystem function. Foredunes (sand dunes on the beach) are vulnerable to erosion during a 1% annual chance storm that could occur today.

Existing beach conditions on the North and South Coasts are likely to change over time to beaches that are narrower, steeper, and occur in smaller isolated pockets. In addition, sea level rise may contribute to changes in the relative proportions of the different ecological zones within beach habitats, exposing all levels of the food web, degrading habitat quality, and preventing the formation of coastal dunes. Where development or other barriers block upland migration of these systems, existing beaches and dunes are likely to be reduced in size, and remaining beaches could be fragmented, lost, and/or degraded.

Beaches and dunes provide valuable ecosystem services such as: (1) filtration of seawater through wave action on sands; (2) the physical protection of existing development from coastal flooding and inundation; (3) emotional and physical benefits associated with recreation and other use; and (4) nutrient cycling services and the filtration of pollutants that in turn support fish nurseries within estuaries and seagrass beds. While it is difficult to economically assess the value of these benefits, ecosystem services contribute to the natural, social, and economic well-being of Ventura County.

Detailed vulnerability maps for the natural resources sector can be seen in Appendix D.

Roads and Parking

Approximately 183 miles of road lie within the County's coastal zone and coastal hazard boundaries. The responsibility for maintaining these roads is shared between Caltrans, primarily for Pacific Coast Highway and Highway 101, and the County Transportation Department. Overall, the most vulnerable road on the North and South Coasts is Pacific Coast Highway, which is owned by Caltrans although the Rincon Parkway segment is maintained by the County. Fifteen parking lots that provide coastal access are maintained by the County or State Parks. Most of the roads and parking lots subject to coastal hazards are already armored, particularly in the North Coast along Highway 101 and the Rincon Parkway, and along the South Coast along Pacific Coast Highway and Point Mugu State Park. It is important to note that any future failures of the coastal armoring along the North and South Coasts may substantially impact the amount of erosion to roads and parking lots. Today, 19 miles of road and 9 parking lots across the County are vulnerable to coastal flooding during a 1% annual chance storm. With about 5 feet of sea level rise, this increases to 45 total miles and 11 parking lots exposed to coastal flooding. With about 5 feet of sea level rise, 14 miles of road could be damaged by coastal erosion, and 12 miles of roads could be routinely inundated during monthly high tides. The most notable impacts to County roads occur along Harbor Boulevard, and to residential streets in the Hollywood Beach and Silverstrand neighborhoods. These roads and parking lots become increasingly vulnerable to routine tidal inundation with about 5 feet of sea level rise.

Some roads are crucial for the safe movement of critical goods and services throughout the County, and an overall summary of the vulnerabilities may not highlight these important routes. For example, the Central Coast road system is also crucial to military operations at Naval Base Ventura County. In addition to disruption of commuter routes, flooding in the Central Coast can impede the mobilization of military equipment to and from the military base. Some roads are also key routes during emergency evacuations, like Highway 101 in the North Coast, Victoria Avenue in the Central Coast, and Pacific Coast Highway in the South Coast. Flooding to these roads may have more impacts for emergency operations than non-critical routes. See the Critical Services sector for more details on the vulnerability of evacuation routes.

Detailed vulnerability maps for the roads and parking sector can be seen in Figures A7a, A7b, and A7c in Appendix A.

Public Transportation and Bike Routes

Ventura County has approximately five miles of Class 1 bike trails including the recently completed Ralph Fertig Memorial Trail connecting the Beacon's Beach Area to Rincon Point along Highway 101. Union Pacific Railroad (UPRR) railroad alignment hugs the North Coast shoreline and provides some public use through AMTRAK. The Coastal Express Bus, operated by VISTA, extends from the City of Ventura to Isla Vista in Santa Barbara County along Highway 101, although there are no stops in the unincorporated area. Bike lanes are planned to generally follow the Pacific Coast Highway along the South Coast.

Along the North Coast, coastal armoring currently protects the bike, bus and rail lines from coastal erosion. Coastal flooding from a 1% annual chance storm today may temporarily impact portions of the Coastal Express Bus route along Highway 101, the Ralph Fertig Memorial Bike Trail, and Class 2 bike lanes along the Rincon Parkway. The railroad is also subject to coastal flooding along the North Coast alignment and continues to be subject to coastal erosion south of Emma Wood State Beach. These vulnerabilities increase with rising sea levels.

Along the Central Coast, there are no bus or rail lines exposed, but there is some exposure of Class 2 bike lanes to coastal flooding in Hollywood Beach and Silverstrand, and as sea level rises, potential damage from coastal erosion and routine closures from high tides may occur.

Along the South Coast, there are no bus lines or rail lines. Some existing exposure of Pacific Coast Highway to coastal flooding and erosion may affect bike routes, and this exposure is expected to increase with sea level rise.

Detailed vulnerability maps for the public transportation and bike routes sector can be seen in Figures A8a, A8b, and A8c in Appendix A.

Oil and Gas

Interruptions in oil and gas supply and oil spills will continue to pose a risk to Ventura County with potential fiscal impacts to the County estimated in the hundreds of millions of dollars range. Additionally, the spills do not have to originate in Ventura County in order to impact the County's coast. Nearby oil spills in 1969 (Santa Barbara) and 2015 (minor pipeline rupture near Refugio) have impacted Ventura County beaches. In nearby Summerland, unmarked inactive legacy wells have been leaking for years and have yet to be resolved. Potential impacts to the natural gas distribution lines could impact County residents and businesses who rely on it for heat generation.

Oil and gas development in Santa Barbara and Ventura County began in the late 1860s, and now over 12,000 wells have been drilled into the Ventura Basin. According to the California Division of Oils, Gas and Geothermal Resources, there are 105 active wells, and approximately 363 inactive and capped wells within the unincorporated coastal zone. Little is known about how the wells were capped. An active slant well drilling oil facility is located in the West Montalvo Oil Field near McGrath Beach.

Minor pipelines connect wells to local storage facilities and major pipelines that transport oil and gas to refineries in Los Angeles. There are also gas distribution and transmission pipelines that transport gas across the region to homes and businesses. Although there are some differences, these oil and gas major pipelines generally run under the same roads and easements. Major pipelines near the North Coast are generally located along the railroad and Highway 101. While hazards to oil and gas pipelines are summarized as the number of miles of pipeline exposed, there could be more than one distribution and transmission line included in the number.

Along the North Coast, aging oil and gas infrastructure is currently exposed to coastal flooding, which includes nine inactive wells and four miles of pipelines. SCG's pipelines are generally located in the same locations as other major oil and gas pipelines in the North Coast. One inactive well near Rincon is currently exposed to tidal inundation. The Rincon Island facility, which is being decommissioned, is currently exposed to potential coastal flooding. Additionally, about 0.7 miles of SCG distribution pipeline is exposed to potential coastal flooding in the Faria community. Over time, additional lengths of pipeline and inactive wells become exposed to coastal flooding and tidal inundation. With about 5 feet of sea level rise, two active wells north of Rincon Parkway become exposed to coastal flooding.

Along the Central and South Coasts, 15 active and 58 inactive wells including the active slant drilling operation at McGrath Beach are exposed to existing fluvial flood hazards along the Santa Clara and Ventura Rivers. Coastal flooding today may only expose one inactive well in Ormond Beach. As sea level rises by about 5 feet, coastal flooding may expose 17 active and 32 inactive wells, mainly around the McGrath Beach facility, where coastal erosion may potentially erode the fronting protective dunes and allow storm waves to reach the facility. Additionally, about half a mile of gas pipeline may be exposed to coastal flooding in Ormond Beach with 5 feet of sea level rise.

Fortunately, coastal erosion and tidal inundation do not directly affect any active wells and affect only three inactive wells in the Central Coast near Ormond Beach.

Under existing conditions and without adaptation, coastal and fluvial flooding is projected to affect up to 41 currently active oil wells by year 2100. When intermittent flooding occurs, pumping operations and the supply are likely to be interrupted as cleanup, maintenance, and needed replacements occur. Compared to temporary interruptions in supply, the danger of leaks from both active and inactive facilities are likely to promulgate the highest economic costs to the County and the public if no actions are taken.

No electricity generation or distribution infrastructure was analyzed in this Report. Southern California Edison is the largest energy provider in the County. While electricity is an important sector, detailed geospatial information on electricity infrastructure is not generally released in public reports.

Detailed vulnerability maps for the oil and gas sector can be seen in Figures A9a, A9b, and A9c in Appendix A.

Hazardous Materials

An initial assessment of hazardous materials was conducted to evaluate businesses that store hazardous materials, entities operating with a waste discharge permit, or any identified contaminated sites in the unincorporated areas. The Halaco site in Oxnard near Ormond Beach has been identified by the Environmental Protection Agency as a Superfund Site. It is included in the City of Oxnard's vulnerability assessment. The potential spread of contamination is likely to affect unincorporated County lands.

Fortunately, there were no identified hazardous material vulnerabilities from coastal erosion in the Central or South Coasts with up to about 5 feet of sea level rise. Thirteen businesses storing hazardous materials were identified, most of which are associated with the aging oil and gas infrastructure on the North Coast and the Agromin Organics Recycling facility near Ormond Beach. With 16 inches of sea level rise, Agromin Organics Recycling facility could be exposed to tidal inundation which may cause contamination issues.

Detailed vulnerability maps for the hazardous materials sector can be seen in Figures A10a, A10b, and A10c in Appendix A.

Critical Services

Critical facilities assessed include those that support emergency operations and disaster response such as medical, fire, and sheriff facilities. Secondary facilities including schools, government facilities, and communication towers as well as tsunami evacuation routes were also included.

Fortunately, no fire, medical, or sheriff stations are currently exposed, and only the North Coast Fire Station #25 off Seacliff could be exposed to coastal flooding with about 5 feet of sea level rise. Fire Station #56 on the South Coast is not exposed to coastal hazards even with about 5 feet of sea level riseHollywood Beach Elementary School is exposed to coastal flooding under existing conditions. As sea level rises to 16 inches, the school could become exposed to coastal erosion. With about 5 feet of sea level rise, a Channel Islands Community Service District building in Silverstrand may become vulnerable to coastal storm flooding.

Evacuation routes along Highway 101 in the North Coast, inland from Silverstrand on the Central Coast, and along Pacific Coast Highway in the South Coast are exposed to coastal flooding and erosion. With about 5 feet of sea level rise, evacuation routes will be exposed to coastal flooding

(4.7 miles), coastal erosion (0.4 miles), and routine tidal inundation (2.2 miles) across the County. Currently six communication towers may be subject to coastal flooding during a 1% annual chance storm.

A critical facility that is in the unincorporated area, but is not regulated by the County's Local Coastal Program, is Naval Base Ventura County. The base is the largest employer in Ventura County with more than 17,320 personnel and it provides almost $2 billion in economic benefit to the local and regional economy. The Base is vulnerable to sea level rise and is currently completing a vulnerability assessment.

Detailed vulnerability maps for the critical services sector can be seen in Figures A11a, A11b, and A11c in Appendix A.

5.2 Fiscal Impact Sector Results

This section reports additional details of the economic and fiscal impact analysis for each sector.

Land Use Parcels and Structures

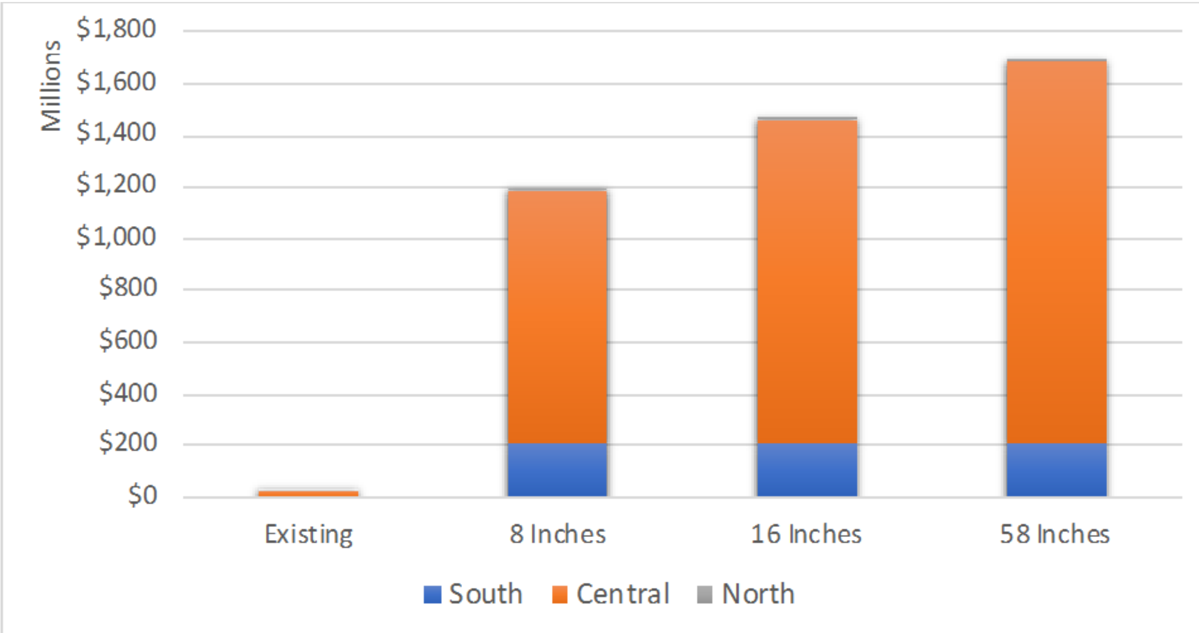
This section presents the results of the study's parcel data analysis of property at risk to coastal erosion, coastal flooding, and tidal inundation. The land use analysis used the same data set and further examined the following:

- Total Property Damage
- Property Damag by Land Use Type
- Impacts to Residential Sector
- Single-Family Dwellings

Total Property Damage

The following results will be organized in the following way: Each figure has four bars that represent the accumulated vulnerability within the four sea level rise scenarios (i.e., current conditions, 8 inches, 16 inches, and 58 inches). Figures present the property vulnerability to each of the three coastal hazards. Each bar within the figures is sub-divided either according to the three planning areas or according to the various land uses.

Figures 5-1 through 5-3 provide the aggregate vulnerability to each of the three threats (erosion, coastal flooding, and tidal inundation), sorted according to planning area. Figures 5-4 through 5-6 present these same aggregate vulnerabilities according to land use. Finally, Figures 5-7 through 5-9 depict the vulnerability of residential property alone, sorted according to planning area. All estimates of property loss are in 2017 dollars.

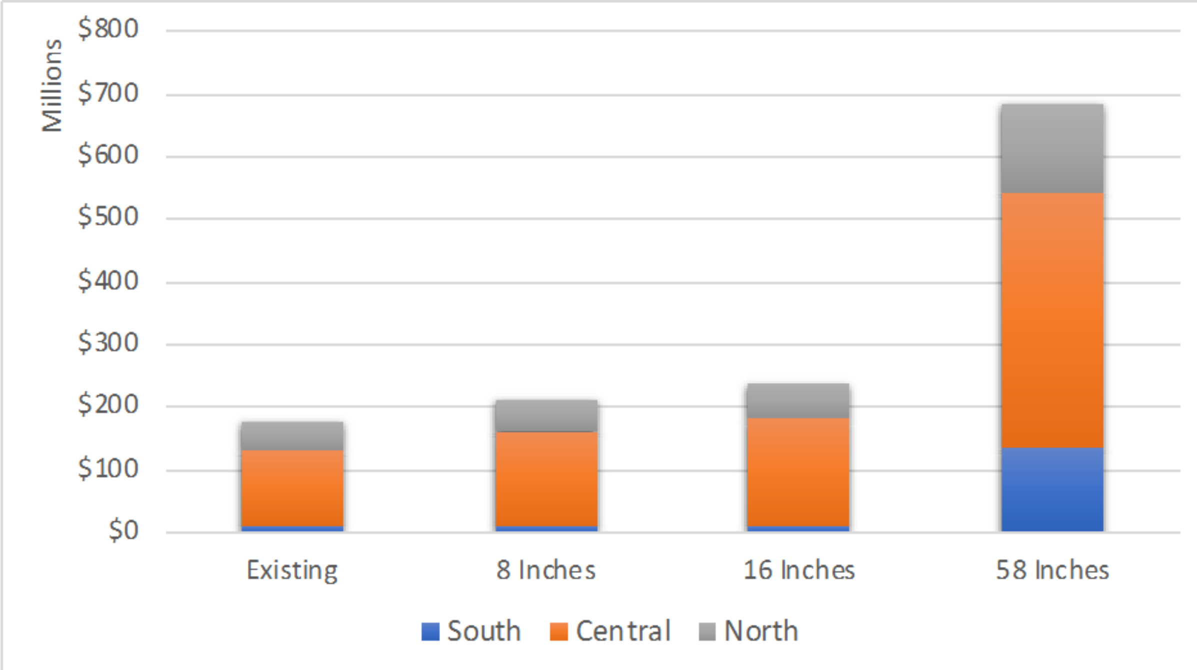


Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
North	$0	$1,100,000	$1,200,000	$1,200,000
Central	$26,600,000	$981,100,000	$1,255,400,000	$1,480,100,000
South	$0	$208,300,000	$208,300,000	$208,500,000
Total	**$26,600,000**	**$1,190,500,000**	**$1,464,900,000**	**$1,689,800,000**

Figure 5-1. Estimated cumulative value of property loss due to erosion by planning area with a 1% annual chance storm (2017 dollars). *Note: Only bluff erosion was modeled for the South Coast, and erosion was not modeled for the North Coast due to the existing shoreline armory.*

Figure 5-1 shows that the Central Coast is most exposed to erosion losses from a 1% annual chance storm. This is primarily because Hollywood Beach and Silverstrand in the Central Coast have more relatively highdensity residential neighborhoods, and the North Coast and South Coast are protected from erosion due to coastal armoring. It is also important to point out that there is no cliff erosion data on the South Coast for existing conditions, thus all property impacts are shown to occur with 8 inches of sea level rise, which impacts nearly all of the oceanfront parcels.

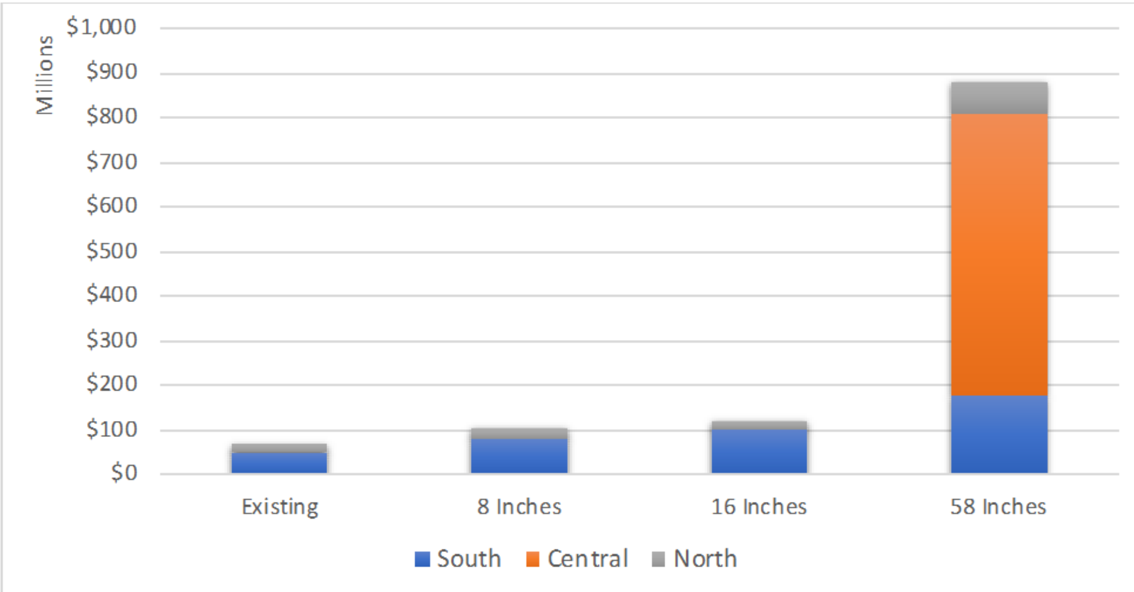
The South Coast will experience some small increases in erosion losses over time: $208.3 million with 8 and 16 inches of sea level rise and $208.5 million with about 5 feet of sea level rise, but this is limited as there is only a single row of parcels between Pacific Coast Highway and the ocean. The Central Coast of Ventura County is already subject to $26.6 million in potential erosion losses (if a 1% annual chance storm hits) and these losses may increase to $981.1 million with only 8 inches of sea level rise, $1.25 billion with 16 inches of sea level rise, and $1.48 billion with about 5 feet of sea level rise. The North Coast, with its existing armoring, has relatively little exposure to coastal erosion (unless the existing armoring fails) so presently it shows no current damage. The damage on the North Coast were estimated for structures at Emma Wood State Beach, which increase to $1.1 million with 8 inches of sea level rise, and $1.2 million with 16 inches and about 5 feet of sea level rise.



Coastal Flooding	Existing	8 Inches	16 Inches	58 Inches
North	$46,800,000	$51,600,000	$55,000,000	$138,200,000
Central	$120,100,000	$150,700,000	$173,300,000	$407,300,000
South	$10,000,000	$10,800,000	$11,000,000	$136,600,000
Total	**$176,900,000**	**$213,100,000**	**$239,300,000**	**$682,100,000**

Figure 5-2. Estimated cumulative value of property damage by planning area due to coastal flooding and a 1% annual chance storm (2017 dollars).

Figure 5-2 presents estimates of property damage due to coastal flooding during a 1% annual chance storm. As in Figure 5-1, most of the estimated damage is in the Central Coast neighborhoods of Hollywood Beach and Silverstrand. The Central Coast is already subject to $120.1 million in coastal flooding damage (if a 1% annual chance storm hits) and these losses may increase to $150.7 million with 8 inches of sea level rise, $173.3 million with 16 inches of sea level rise, and $407.3 million with about 5 feet of sea level rise. The South Coast may experience some increase in flood damage over time: $10 million under existing conditions, $10.8 million with 8 inches of sea level rise, $11 million with 16 inches of sea level rise, and losses increase significantly to $136.6 million with about 5 feet of sea level rise. The North Coast has some exposure to coastal flooding with $46.8 million in property currently at risk. This estimate increases to $51.6 million with 8 inches of sea level rise, $55 million with 16 inches of sea level rise, and $138.2 million with about 5 feet of sea level rise.



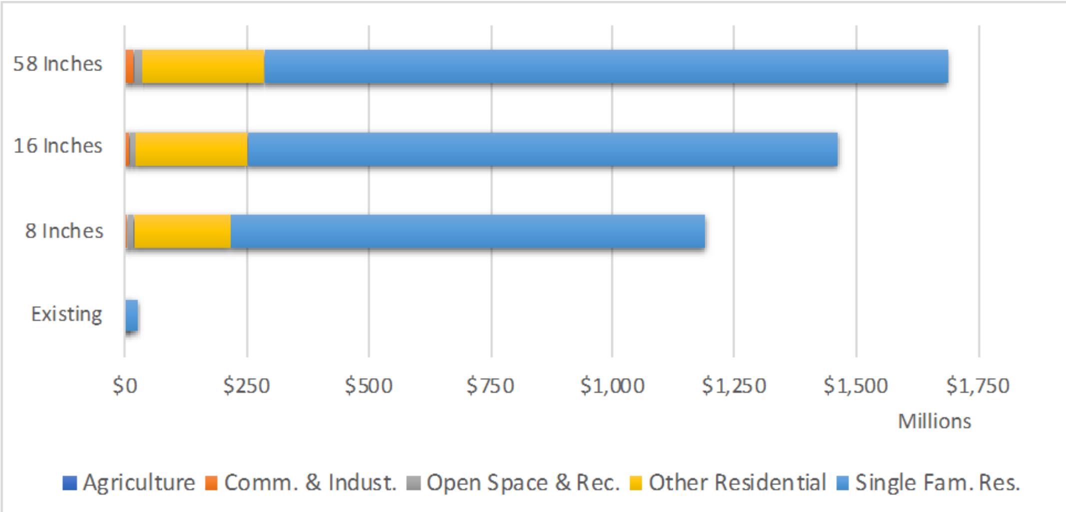
Tidal Inundation	Existing	8 Inches	16 Inches	58 Inches
North	$22,200,000	$23,500,000	$24,900,000	$70,200,000
Central	$0	$0	$0	$633,300,000
South	$48,500,000	$81,100,000	$98,000,000	$177,700,000
Total	**$70,700,000**	**$104,600,000**	**$122,900,000**	**$881,200,000**

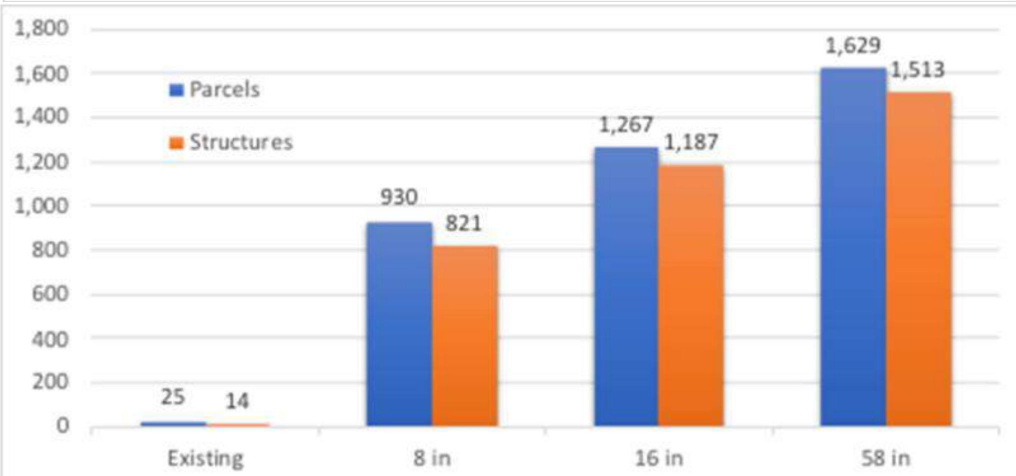
Figure 5-3. Estimated cumulative value of property exposed to monthly tidal inundation by planning area (2017 dollars).

Figure 5-3 presents estimates of the value of property that will be exposed to monthly tidal inundation. Unlike coastal erosion and flooding, the South Coast is more subject to tidal inundation because oceanfront parcel boundaries extend into the ocean south of Pacific Coast Highway. In the South Coast, $48.5 million in property is currently subject to tidal inundation, although, as noted, this parcel-based analysis does not consider that the properties are built on piles. This tidal exposure may increase to $81.1 million with 8 inches of sea level rise, $98 million with 16 inches of sea level rise, and $177.7 million with about 5 feet of sea level rise. The Central Coast is not exposed to significant tidal inundation until sea level rise increases to about 5 feet, at which point the estimated value of property at-risk to tidal inundation is potentially $633 million. This exposure lies primarily in the Silverstrand and Hollywood Beach neighborhoods, with some additional agriculture and open space lands exposed inland of Ormond Beach. Along the North Coast, $22.2 million in property may currently be subject to tidal inundation based on parcel boundaries. This exposure may increase to $23.5 million with 8 inches of sea level rise, $24.9 million with 16 inches of sea level rise, and $70.2 million with about 5 feet of sea level rise.

Property Damage by Land Use Type

Figure 5-4, Figure 5-5, and Figure 5-6 present the same property/parcel analysis as above but is now shown according to land-use rather than planning area. This analysis also includes the number of land parcels and structures vulnerable to storm erosion, coastal flooding and monthly tidal inundation.





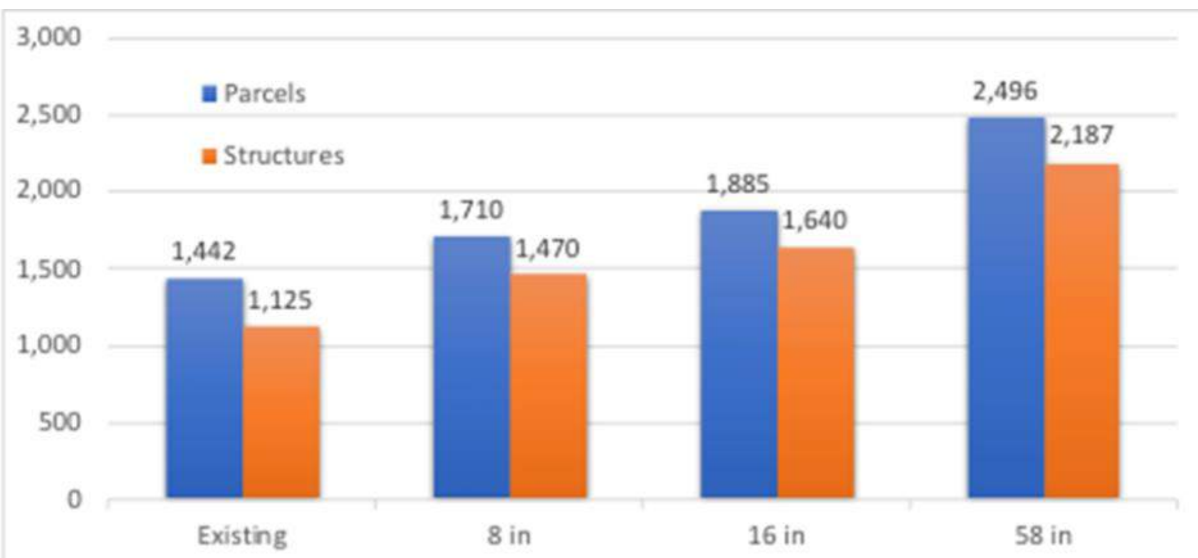
Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
Agriculture	$0	$0	$0	$0
Comm. & Indust.	$100,000	$7,500,000	$11,300,000	$19,300,000
Open Space & Rec.	$0	$9,900,000	$12,400,000	$16,600,000
Other Residential	$500,000	$199,700,000	$226,800,000	$251,700,000
Single Fam. Res.	$26,000,000	$973,400,000	$1,214,300,000	$1,402,100,000
Total	**$26,600,000**	**$1,190,500,000**	**$1,464,800,000**	**$1,689,700,000**

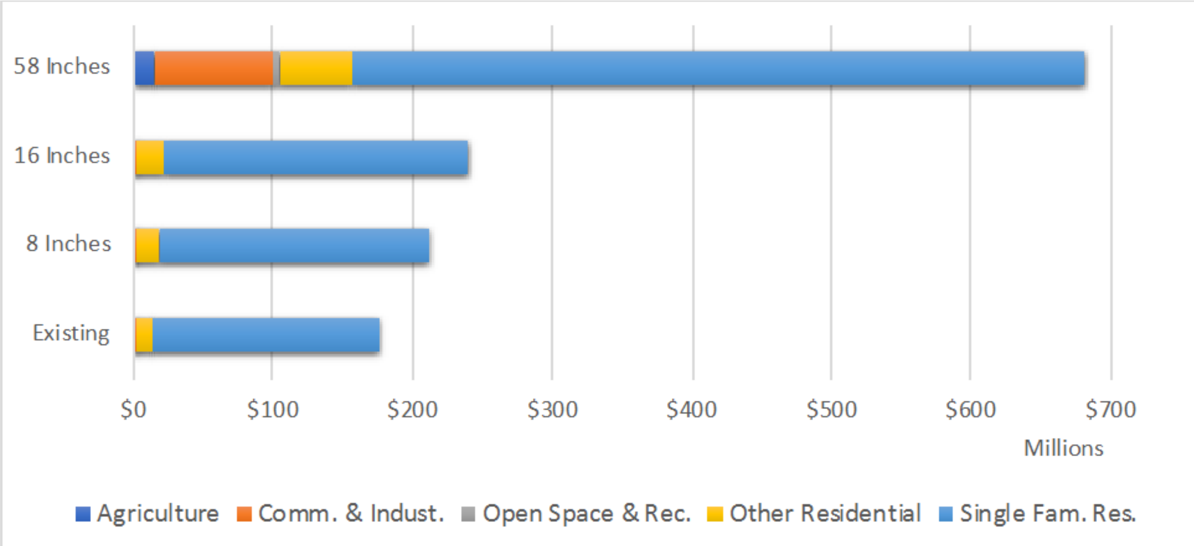
Figure 5-4. Cumulative number of parcels and structures, and estimated value of property losses due to erosion, by land use (2017 dollars). *Note: Only bluff erosion was modeled for the South Coast, and erosion was not modeled for the North Coast due to the existing shoreline armory.*

The bar chart in Figure 5-4 shows that while the county is not highly exposed to storm erosion under existing conditions (25 parcels and 14 structures), its exposure increases significantly with sea level rise. The analysis reveals that 930 parcels and 821 structures become vulnerable to storm erosion with 8 inches of sea level rise, 1,267 parcels and 1,187 structures with 16 inches of sea level rise, and 1,629 parcels and 1,513 structures with about 5 feet of sea level rise.

The most extensive vulnerability to storm erosion, by property value, is single-family residences. Currently, $26.6 million of property value may be exposed to potential coastal erosion associated with a 1% annual chance storm. This estimate increases to $973.4 million with 8 inches of sea level rise, $1.21 billion with 16 inches of sea level rise, and $1.4 billion with about 5 feet of sea level rise. The second largest category is "other residential", which is comprised of multifamily dwellings and mixed residential properties. Currently, $500,000 of "other residential" is exposed to erosion losses from a 1% annual chance storm. This exposure increases significantly with sea level rise; $199.7 million is at risk with 8 inches of sea level rise, increasing to $226.8 million with 16 inches of sea level rise, and $251.7 million with about 5 feet of sea level rise. The estimates indicate that no agricultural land is subject to erosion losses from a 1% annual chance storm between now and year 2100.

For open space and recreational uses, the analysis indicates that there are no potential losses from a 1% annual chance storm under existing conditions. These losses increase to $9.9 million with 8 inches of sea level rise, $12.4 million with 16 inches of sea level rise, and $16.6 million with about 5 feet of sea level rise. Note that the metrics used to value this property are somewhat different from residential property: this Report bases the market value for this land on government and non-governmental agencies' actual land-purchase-transaction prices. However, these prices are significantly lower than if the land had been zoned for residential development. The analysis of recreational facilities was similarly limited since only partial information on structures at State and local parks was available. The analysis does, however, value the recreational activities at these sites, and future adaptation analyses will thus value potential losses in coastal recreation. The analysis indicates that under existing conditions, $100,000 in property related to commercial and industrial uses is at risk to erosion from a 1% annual chance storm. This estimate increases to $7.5 million with 8 inches of sea level rise, $11.3 million with 16 inches of sea level rise, and $19.6 million with about 5 feet of sea level rise.





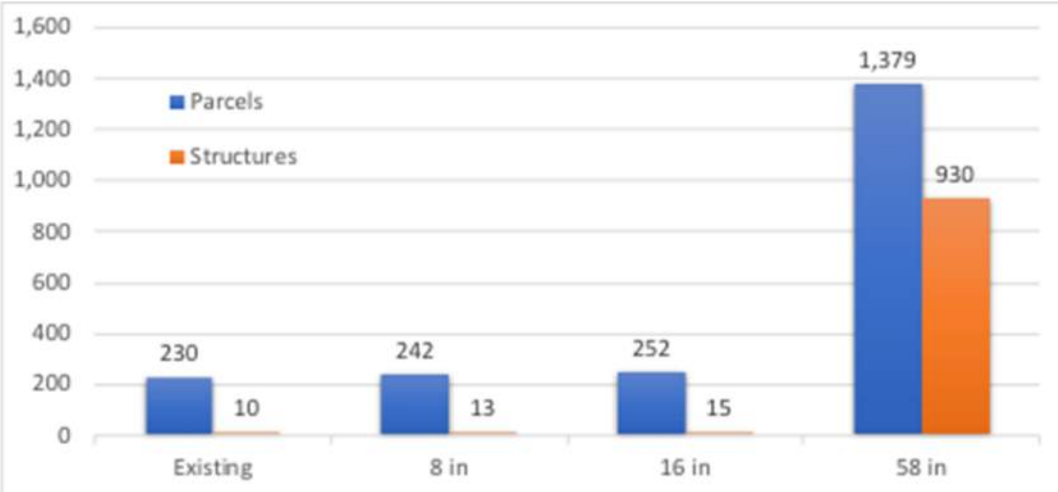
Coastal Flooding	Existing	8 Inches	16 Inches	58 Inches
Agriculture	$100,000	$100,000	$100,000	$15,100,000
Comm. & Indust.	$1,700,000	$2,700,000	$2,800,000	$84,100,000
Open Space & Rec.	$0	$100,000	$100,000	$6,400,000
Other Residential	$12,200,000	$16,000,000	$18,200,000	$50,800,000
Single Fam. Res.	$162,800,000	$194,200,000	$218,100,000	$525,700,000
Total	**$176,800,000**	**$213,000,000**	**$239,300,000**	**$682,100,000**

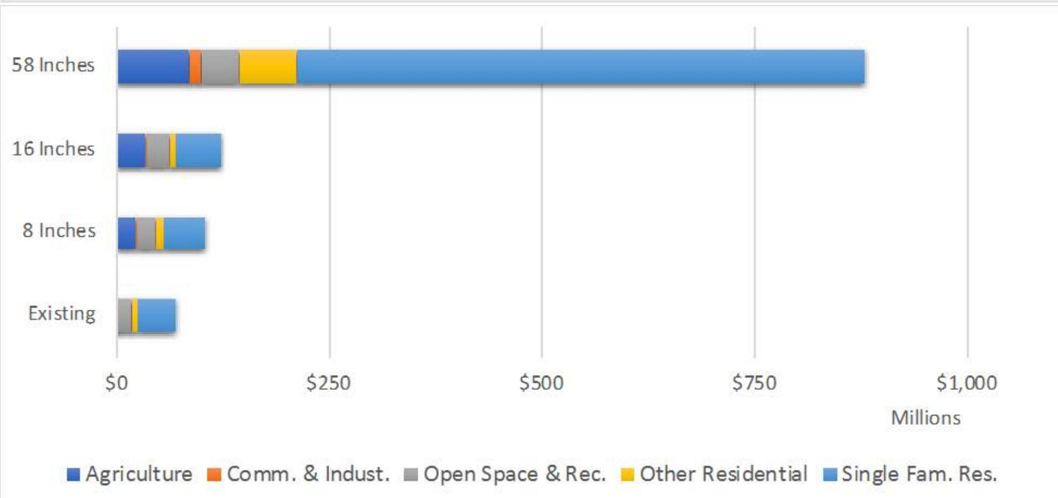
Figure 5-5. Cumulative number of parcels and structures, and estimated value of property damage by land use due to coastal flooding with a 1% annual chance storm (2017 dollars).

Figure 5-5 presents estimates for losses due to coastal flooding (once again due to a 1% annual chance storm), by land-use type, in addition to the number of land parcels and structures exposed to such coastal flooding. Under existing conditions, 1,442 parcels and 1,125 structures would be exposed to coastal flooding during a 1% annual chance storm. This vulnerability increases to 1,710 parcels and 1,470 structures with 8 inches of sea level rise, 1,885 parcels and 1,640 structures with 16 inches of sea level rise, and 2,496 parcels and 2,187 structures with about 5 feet of sea level rise.

Again, the largest exposure, by property value, is single-family residences. Currently, $162.8 million of property is exposed to potential flood damage. This estimate increases to $194.2 million with 8 inches of sea level rise, $218 million with 16 inches of sea level rise, and $525.7 million with about 5 feet of sea level rise. The second largest category is "other residential", comprised of multifamily dwellings and mixed residential properties. Currently, $12.2 million worth of property is at risk to damage from a 1% annual chance storm. This exposure increases to $16 million with 8 inches of sea level rise, $18.2 million with 16 inches of sea level rise, and $50.8 million with about 5 feet of sea level rise. The estimates indicate that only $100,000 in agricultural land is subject to storm damage from a 1% annual chance storm until year 2100, at which point the land becomes subject to $15.1 million in property damage.

For open space and recreational uses, the analysis indicates no existing potential for significant damage from a 1% annual chance storm. These losses increase to $100,000 with 8 and 16 inches of sea level rise, and $6.4 million with about 5 feet of sea level rise. Finally, the analysis indicates that currently $1.7 million in property related to commercial and industrial uses is at risk to coastal flooding from a 1% annual chance storm. This estimate increases to $2.7 million with 8 inches of sea level rise, $2.8 million with 16 inches of sea level rise, and $84.1 million with about 5 feet of sea level rise.





Tidal Inundation	Existing	8 Inches	16 Inches	58 Inches
Agriculture	$300,000	$24,200,000	$34,800,000	$87,000,000
Comm. & Indust.	$0	$100,000	$1,700,000	$12,400,000
Open Space & Rec.	$18,400,000	$23,200,000	$25,900,000	$45,900,000
Other Residential	$7,100,000	$7,500,000	$8,000,000	$68,100,000
Single Fam. Res.	$44,900,000	$49,500,000	$52,500,000	$667,800,000
Total	**$70,700,000**	**$104,500,000**	**$122,900,000**	**$881,100,000**

Figure 5-6. Cumulative number of parcels and structures, and estimated value of property by land use exposed to tidal inundation (2017 dollars).

Figure 5-6 presents estimates of property exposed to tidal inundation, sorted according to land use, in addition to illustrating the number of land parcels and structures exposed to such inundation. The county is moderately exposed to tidal inundation under existing conditions (230 parcels and 10 structures), 8 inches of sea level rise exposes 242 parcels and 13 structures, and 16 inches of sea level rise exposes 252 parcels and 15 structures. With about 5 feet of sea level rise, this exposure to monthly tidal inundation increases dramatically to 1,379 parcels and 930 structures.

Again, the largest exposure, by property value, is single-family residences. Currently, $44.9 million in property value may be exposed to tidal inundation around the Channel Islands Harbor. This estimate increases moderately to $49.5 million with 8 inches of sea level rise, $52.5 million with 16 inches of sea level rise, and jumps to $667.8 million with about 5 feet of sea level rise. The second largest category is agricultural lands. Under existing conditions, $300,000 in agricultural property is subject to tidal inundation connected through the Mugu wetlands. Since this flooding can increase the salinity of the soil, it is quite possible that a substantial amount of this value could be lost, although estimating losses due to soil quality is beyond the scope of this project. The value of agricultural property exposed to tidal inundation increases to $24.2 million with 8 inches of sea level rise, $34.8 million with 16 inches of sea level rise, and $87 million with about 5 feet of sea level rise.

A significant amount of open space and recreational land is also subject to tidal inundation. Under existing conditions, $18.4 million may be exposed to tidal inundation; this estimate increases to $23.2 million with 8 inches of sea level rise, $25.9 million with 16 inches of sea level rise, and $45.9 million with about 5 feet of sea level rise. Finally, no property in commercial/industrial land is exposed to tidal inundation under existing conditions; however, this increases to $100,000 with 8 inches of sea level rise, $1.7 million with 16 inches of sea level rise, and $12.4 million with about 5 feet of sea level rise.

Impacts to Residential Sector

The analysis above indicates that residential property is the largest land-use type (measured by market value) subject to losses. Figures 5-7 through 5-9 present losses to housing (single family, multi-family, and multiple use).

Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
Mixed Residential	$0	$105,800,000	$105,800,000	$105,800,000
Multi-Family	$500,000	$94,000,000	$121,000,000	$145,900,000
Single Family	$26,000,000	$973,400,000	$1,214,300,000	$1,402,100,000
Total	**$26,500,000**	**$1,173,100,000**	**$1,441,000,000**	**$1,653,800,000**

Figure 5-7. Cumulative loss of residential property due to erosion (2017 dollars). *Note: Only bluff erosion was modeled for the South Coast, and erosion was not modeled for the North Coast due to the existing shoreline armory.*

Figure 5-7 presents analysis of residential property at-risk due to erosion from a 1% annual chance storm. Under existing conditions, $26 million of single-family residential property, $500,000 of multi-family units, and no mixed residential property is at-risk. With 8 inches of sea level rise, $973.4 million of single-family residential property, $94 million of multi-family units, and $105.8 million in mixed residential property is at-risk. With 16 inches of sea level rise, $1.2 billion of single-family residential property, $121 million of multi-family units, and $105.8 million in mixed residential property is at-risk. With about 5 feet of sea level rise, $1.4 billion of single-family residential property, $145.9 million of multi-family units, and $105.8 million in mixed residential property may be at-risk.

Coastal Flooding	Existing	8 Inches	16 Inches	58 Inches
Mixed Residential	$5,800,000	$5,900,000	$6,000,000	$21,200,000
Multi-Family	$6,400,000	$10,100,000	$12,200,000	$29,500,000
Single Family	$162,800,000	$194,200,000	$218,100,000	$525,700,000
Total	**$175,000,000**	**$210,200,000**	**$236,300,000**	**$576,500,000**

Figure 5-8. Cumulative loss of residential property due to coastal flooding (2017 dollars).

Figure 5-8 presents analysis of residential property at-risk due to flooding from a 1% annual chance storm. Under existing conditions, $162.8 million of single-family residential property, $6.4 million of multi-family units, and $5.8 million of mixed residential property are at-risk. With 8 inches of sea level rise, $194.2 million of single-family residential property, $10.1 million of multi-family units, and $5.9 million in mixed residential property are at-risk. With 16 inches of sea level rise, $218.1 million of single-family residential property, $12.2 million of multi-family units, and $6 million in mixed residential property are at-risk. With about 5 feet of sea level rise, $525.7 million of single-family residential property, $29.5 million of multi-family units, and $21.2 million in mixed residential property are at-risk.

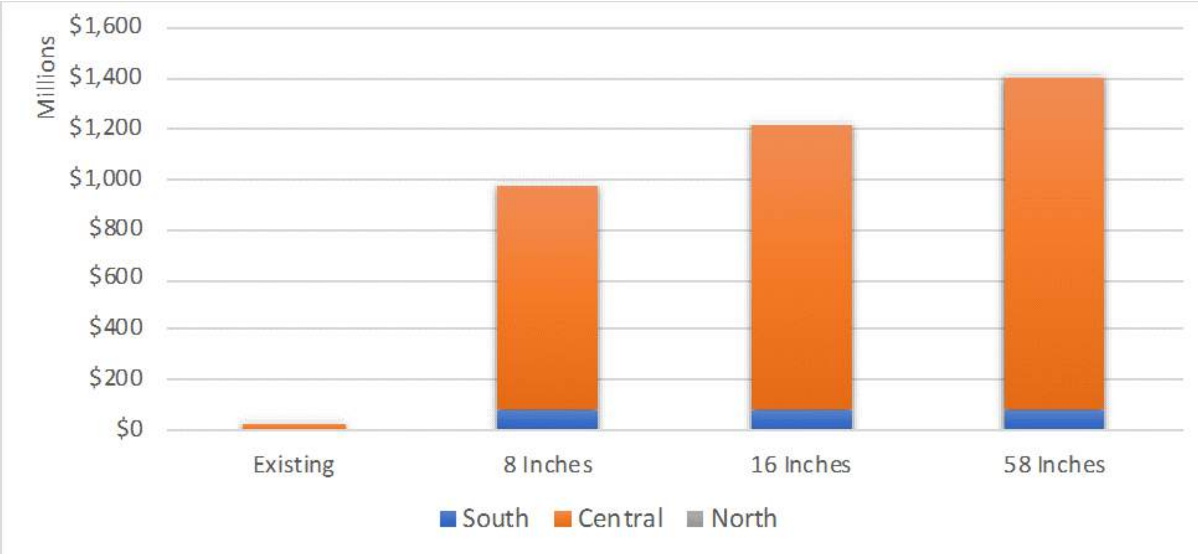
Tidal Inundation	Existing	8 Inches	16 Inches	58 Inches
Mixed Residential	$1,400,000	$1,500,000	$1,500,000	$1,900,000
Multi-Family	$5,700,000	$6,100,000	$6,500,000	$66,100,000
Single Family	$44,900,000	$49,500,000	$52,500,000	$667,800,000
Total	**$52,000,000**	**$57,100,000**	**$60,500,000**	**$735,800,000**

Figure 5-9. Cumulative loss of residential property due to tidal inundation (2017 dollars).

Figure 5-9 presents analysis of residential property at-risk due to tidal inundation. Under existing conditions, $44.9 million of single-family residential property, $5.7 million of multi-family units, and $1.4 million of mixed residential property are at-risk. With 8 inches of sea level rise, $49.5 million of single-family residential property, $6.1 million of multi-family units, and $1.5 million in mixed residential property are at-risk. With 16 inches of sea level rise, $52.5 million of single-family residential property, $6.5 million of multi-family units, and $1.5 million in mixed residential property are at-risk. With about 5 feet of sea level rise, $667.8 million of single-family residential property, $66.1 million of multi-family units, and $1.9 million in mixed residential property are at-risk.

Single-Family Dwellings

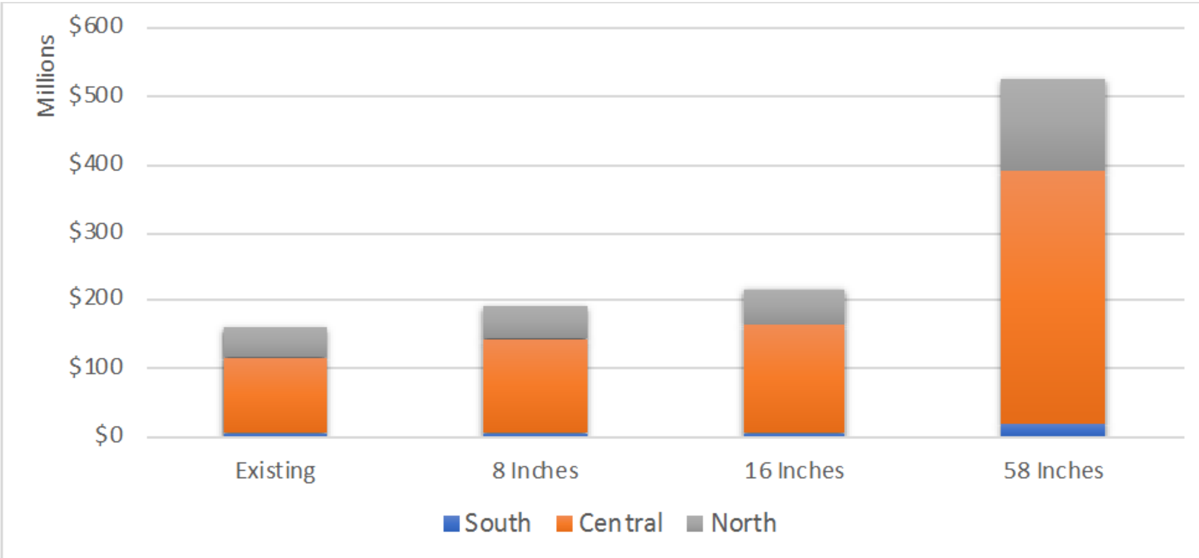
Figures 5-10 through 5-12 present this study's estimated losses of single-family dwellings due to sea level rise; these losses are broken down into the South, Central and North Coasts of Ventura County.



Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
South	$0	$83,100,000	$83,100,000	$83,100,000
Central	$26,000,000	$890,300,000	$1,131,200,000	$1,319,000,000
North	$0	$0	$0	$0
Total	**$26,000,000**	**$973,400,000**	**$1,214,300,000**	**$1,402,100,000**

Figure 5-10. Estimated cumulative value of single-family dwelling property losses by planning area due to coastal erosion (2017 dollars). *Note: No erosion was modeled for the existing South Coast and most of the North Coast.*

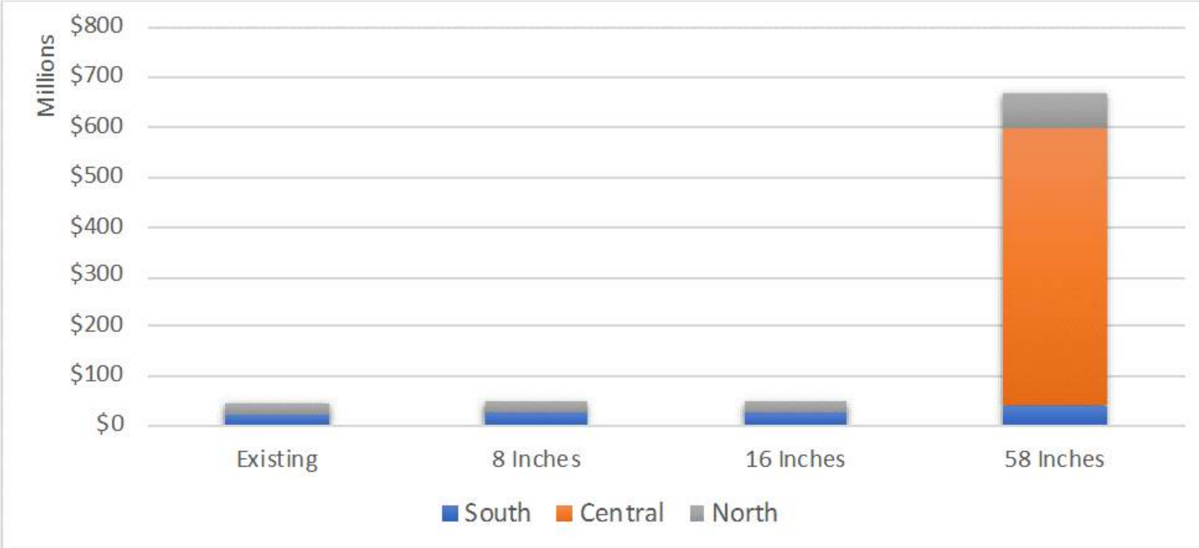
Figure 5-10 indicates that the Central Coast contains most of the single-family residential property at risk to losses from erosion during a 1% annual chance storm. Under existing conditions, $26 million in residential property is vulnerable within this area alone. This increases to $890.3 million with 8 inches of sea level rise, $1.11 billion with 16 inches of sea level rise, and $1.31 billion with about 5 feet of sea level rise. The South Coast has $83.1 million in residential property also at risk with 8 inches, 16 inches, and about 5 feet of sea level rise. The North Coast has no vulnerability according to this analysis, since no erosion was modeled for the North Coast due to the prevailing existing shoreline armory.



Coastal Flooding	Existing	8 Inches	16 Inches	58 Inches
South	$4,300,000	$4,300,000	$4,300,000	$19,100,000
Central	$112,500,000	$139,100,000	$159,700,000	$371,800,000
North	$46,100,000	$50,800,000	$54,200,000	$134,800,000
Total	**$162,900,000**	**$194,200,000**	**$218,200,000**	**$525,700,000**

Figure 5-11. Estimated cumulative value of single-family dwelling property losses by planning area due to coastal flooding (2017 dollars).

Figure 5-11 indicates that the Central Coast contains the most single-family dwelling properties at risk due to coastal flooding from a 1% annual chance storm. Under existing conditions, $112.5 million in property value is at risk near the Central Coast. This increases to $139.1 million with 8 inches of sea level rise, $159.7 million with 16 inches of sea level rise, and $371.8 million with about 5 feet of sea level rise. In the South Coast, under existing conditions, $4.3 million in property is at-risk now and with 8 and 16 inches of sea level rise; with about 5 feet of sea level rise, $19.1 million will be at risk. For the North Coast, under existing conditions, $46.1 million is currently at-risk, rising to $50.8 million with 8 inches of sea level rise, $54.2 million with 16 inches of sea level rise, and $134.8 million with about 5 feet of sea level rise.



Tidal Inundation	Existing	8 Inches	16 Inches	58 Inches
South	$23,000,000	$26,400,000	$28,000,000	$38,800,000
Central	$0	$0	$0	$559,300,000
North	$21,900,000	$23,200,000	$24,500,000	$69,600,000
Total	**$44,900,000**	**$49,600,000**	**$52,500,000**	**$667,700,000**

Figure 5-12. Estimated cumulative value of single-family dwelling property by planning area exposed to monthly tidal inundation (2017 dollars).

Figure 5-12 presents the estimates for single-family dwelling property exposed to tidal inundation. For the Central Coast, the analysis indicates that under existing conditions no properties are at risk and this remains the case until about 5 feet of sea level rise, when $559.3 million in property becomes at-risk. In the South Coast, $23 million in property is at-risk under existing conditions, $26.4 with 8 inches of sea level rise, $28 million with 16 inches of sea level rise and $38.8 with about 5 feet of sea level rise. In the North Coast, $21.9 million in property is at-risk under existing conditions, $23.2 million with 8 inches of sea level rise, $24.5 million with 16 inches of sea level rise and $69.6 with about 5 feet of sea level rise.

Agriculture

Agriculture is an essential component of Ventura County's economy. According to the County's 2016 Crop and Livestock Report, Ventura County produced $2.1 billion in crops and livestock in 2016. The results in Section 5.1 demonstrated that Ventura County has a significant portion of agricultural land exposed to tidal inundation. Unfortunately, there are no readily available data that can be used to evaluate the impact of tidal inundation on agriculture. As a proxy for more specific information about the effects of sea level rise on crop land, Tables 5-2 and 5-3 provide some loss estimates. Table 5-2 reveals that if the increased salinity decreased Ventura County's agricultural production by just fifteen percent (in the dollar value of crops), this would lead to a decrease of $316 million in the County's annual economy, plus additional damage from any resulting job losses. A 25% decrease (Table 5-2) in production would result in at least $527 million in direct losses.

According to Ventura County's Crop and Livestock Report, strawberries represent the County's most significant crop, generating $655 million in revenue per year, which is about one-third of the total agricultural production in Ventura County. Strawberries are particularly sensitive to salinity. It is likely that with increases in soil salinity, some agricultural production would need to be switched from high-value crops like strawberries to lower value crops, such as celery. Consequently, even if the amount of land in Ventura County dedicated to agriculture does not change, the impacts of sea level rise may reduce the economic value of total crop production.

Table 5-2. Value of Ventura County's crops in year 2016 (source: Ventura County Crop Report).

Crop	2016 Value (thousands)	Value of 15% Crop Loss (thousands)	Value of 25% Crop Loss (thousands)
Fruits and Nuts	$1,287,000	$193,050	$321,750
Vegetable Crops	$557,000	$83,550	$139,250
Nursery Stock	$207,000	$31,050	$51,750
Cut Flowers	$48,000	$7,200	$12,000
Livestock/Poultry	$6,000	$900	$1,500
Apiary Products	$3,000	$450	$750
Sustainable Agriculture	$2,000	$300	$500
Field Crops/Grazing	$2,000	$300	$500
Total	$2,110,000	$316,500	$527,500

This Report did not include a full analysis of the potential losses in agriculture due to coastal and tidal flooding, and much more needs to be done on this sector to understand crop impacts and incorporate other climate variables. However, the analysis did reveal that some crop types are more likely to be impacted than others.

Table 5-3 presents estimates for potential losses in agricultural productivity due to coastal flooding and tidal inundation. Under existing conditions, between $2.3 million and $3.9 million in damage can be expected from a 1% annual chance storm. For tidal flooding, the losses are relatively small, between $255,000 and $547,000. However, the potential damage increases significantly over time and with 58 inches, coastal flooding damage will increase to between $11.7 million and $19.4 million, while for tidal inundation damage will be between $18 million and $38.5 million.

Table 5-3. Potential loss in crop value from coastal flooding and tidal inundation.

	Coastal Flooding		Tidal Inundation	
Condition	Estimated Loss at 15%	Estimated Loss at 25%	Estimated Loss at 35%	Estimated Loss at 75%
Existing	$2,347,304	$3,912,174	$255,450	$547,393
8 inches	$2,900,845	$4,834,742	$4,064,097	$8,708,780
16 inches	$3,580,873	$5,968,122	$5,785,912	$12,398,383
58 inches	$11,664,670	$19,441,116	$17,979,337	$38,527,150

The analysis of crop types revealed that, compared to the Countywide average, high-value crops would be disproportionately affected by sea level rise. If the current uses of farmland were to continue, tidal inundation would largely affect land used for strawberries and nursery crops (mostly sod), which tend to be higher-value crops. The rising tides would also affect farmland used for row crops (mostly vegetables). Coastal flooding impacts would likely cause less-severe impacts due to the lower concentration of salinity, but they would occur over a broader area, and other high-value fruit crops such as raspberries would be exposed. Table 5-4 shows the amount various crop types are exposed to potential losses with 58 inches of sea level rise.

Table 5-4. Potential Impacts by Hazard and Crop Type (58 inches)

Crop Type	Coastal Flooding (acres)	Coastal Flooding (value)	Tidal Inundation (acres)	Tidal Inundation (value)
Field Crops	62	$922	63	$768
Fruit and Nut	817	$26,503,640	336	$11,615,075
Nursery	393	$39,816,662	376	$35,288,035
Vegetable	637	$11,443,240	211	$4,465,655
Total	1,909	$77,764,463	986	$51,369,533

Infrastructure Losses

Table 5-5 presents estimates for the value or length of key types of infrastructure that may affect stormwater, wastewater, water supply and others that are vulnerable to sea level rise. For coastal erosion, where roads, pipes and trails would be lost, this Report presents the replacement value of vulnerable assets using the metrics discussed in Section 4. These replacement cost estimates are only meant to give a preliminary estimate of the cost. Under existing conditions, a 1% annual chance storm may result in a loss of $50,000 in roads, and just under 25,000 linear feet of coastal trails. The analysis valued this loss at $4.2 million, based on an estimate of the cost for the City of Santa Barbara to acquire, permit and construct a new trail. The actual cost will vary significantly depending upon land acquisition costs, permitting costs, and engineering and construction costs.

By 2030, these erosion losses increase to $1.8 million losses in roads, $370,000 in water pipes, and $7.9 million in coastal trails. The estimates indicate that a 1% annual chance storm in 2060 would result in the loss of $2.7 million in roads, $490,000 in water pipes, and $8.2 million in trails. By 2100 the estimates indicate these erosion replacement costs will rise to $4 million in lost roads, $860,000 in water pipes, and $8.6 million in trails.

Table 5-5 also presents the analysis results for roads, sewer pipes, water pipes and trails that will be damaged by coastal flooding during a 1% storm or exposed to monthly tidal inundation. Sewer and water pipes may be unaffected by such flooding, but roads and trails will likely close during heavy flood periods. In the case of Highway 101, the economic losses caused by constrained traffic could be substantial.

Table 5-5. Estimated Losses for Key Infrastructure

	Erosion (in linear feet)	Losses to Erosion (2017$)	Coastal Flooding (in linear feet)	Tidal Flooding (in linear feet)
		Roads		
Existing conditions	200	$50,000	100,000	13,000
8 inches (2030)	26,000	$7,270,000	124,000	17,000
16 inches (2060)	50,000	$14,010,000	149,000	18,000
58 inches (2100)	76,000	$21,390,000	236,000	62,000
		Sewer Pipes		
Existing conditions	0	$0	50,000	0
8 inches (2030)	8,000	$1,830,000	60,000	0
16 inches (2060)	12,000	$2,780,000	64,000	0
58 inches (2100)	17,000	$3,980,000	76,000	9,000
		Water Pipes		
Existing conditions	0	$0	15,000	0
8 inches (2030)	2,000	$370,000	20,000	0
16 inches (2060)	3,000	$490,000	22,000	0
58 inches (2100)	4,000	$860,000	31,000	1,000
		Trails		
Existing conditions	25,000	$4,230,000	81,000	8,000
8 inches (2030)	47,000	$7,930,000	89,000	9,000
16 inches (2060)	48,000	$8,180,000	93,000	10,000
58 inches (2100)	50,000	$8,590,000	99,000	33,000

Coastal Access

Table 5-6 presents the data/estimates for beach attendance and recreational value. Ventura County has over three million beach day visits per year based on estimates from State and County Parks and updated numbers from BEACON. The total economic value of this activity is $156 million per year, with over half of that value generated by surfing (about $89 million).

Table 5-6. Annual Attendance and Estimated Value of Beach Recreation

Site	Yearly Attendance	Source	% surfers	Value of Surfing	Total Recreational Value
North Coast	1,170,000		38%	$46,352,800	$64,628,000
Rincon	350,000	BEACON	75%	$17,062,500	$20,562,500
La Conchita	40,000	BEACON	25%	$650,000	$1,850,000
Mussel Shoals	10,000	BEACON	90%	$585,000	$625,000
Hobson	90,000	Interviews	76%	$4,446,000	$5,310,000
Rincon Parkway North	100,000	BEACON	30%	$1,937,000	$4,745,000
Faria County	100,000	Interviews	46%	$3,003,000	$5,155,000
Rincon Parkway South	30,000	BEACON	55%	$1,072,500	$1,612,500
Mondos	210,000	BEACON	80%	$10,920,000	$12,600,000
Emma Wood	240,000	CA State Parks	43%	$6,676,800	$12,168,000
Central Coast	1,410,000		46%	$36,510,500	$70,442,500
C Street	400,000	BEACON	97%	$25,116,000	$25,660,000
San Buenaventura	500,000	CA State Parks	4%	$1,300,000	$20,500,000
Oxnard Shores	50,000	BEACON	15%	$487,500	$2,187,500
Silverstrand	410,000	BEACON	33%	$8,794,500	$19,782,500
Port Hueneme	50,000	BEACON	25%	$812,500	$2,312,500
South Coast	470,000		16%	$6,110,000	$21,150,000
Point Mugu	470,000	CA State Parks	20%	$6,110,000	$21,150,000
County Total	3,050,000		100%	$88,973,300	$156,220,500

Table 5-7 presents data on economic and tax revenue impacts from spending associated with beach recreation. The total estimated spending on beach recreation is just below $113 million annually, generating $916,800 in sales taxes for County and City governments and agencies,[15] and $2.3 million in transient occupancy taxes.

[15] These estimates include the City and County shares for sales taxes but not the State share. This share is 1.25% for all jurisdictions except Port Hueneme and Ventura, which are 1.75%

Table 5-7. Spending and Tax Revenue Generated by Beach Recreation

Site	Yearly Attendance	Estimated Spending Ventura County	Estimated Sales Taxes Generated	Estimated Transient Occupancy Taxes
Rincon	350,000	$10,224,973.95	$82,250	$140,000
La Conchita	40,000	$1,168,568.45	$9,400	$16,000
Mussel Shoals	10,000	$249,585.98	$2,175	$2,000
Hobson	90,000	$3,012,284.23	$22,725	$54,000
Rincon Parkway North	100,000	$5,474,789.20	$34,000	$160,000
Faria County	100,000	$4,198,105.16	$28,750	$100,000
Rincon Parkway South	30,000	$1,642,436.76	$10,200	$48,000
Mondos	210,000	$7,028,663.19	$53,025	$126,000
Emma Wood	240,000	$12,628,820.46	$79,500	$360,000
C Street	400,000	$12,536,807.20	$136,500	$200,000
San Buenaventura	500,000	$18,862,719.09	$189,000	$400,000
Oxnard Shores	50,000	$1,247,929.89	$15,225	$10,000
Silverstrand	410,000	$15,467,429.65	$110,700	$328,000
Port Hueneme	50,000	$1,460,710.56	$16,450	$20,000
Point Mugu	470,000	$17,730,955.95	$126,900	$376,000
Total	3,050,000	$112,934,779.73	$916,800	$2,340,000

5.3 Natural Resources Sector Results

Four habitat types were evaluated: beaches, dunes, estuarine systems, and freshwater systems. Geospatial habitat data for these four habitat types were evaluated using the five modeled sea level rise hazards: 1) erosion (habitat loss), 2) tidal flooding (inundation of sea water), 3) coastal storm flooding, 4) fluvial flooding associated with a 1% annual chance storm event (river and stream overtopping), and (5) a combination of all flood hazards for that area. There will be habitats and species that benefit from sea level rise changes, while others will not. In general, species that are reliant on habitats that are in immediate threat of erosion such as beaches and dunes, will likely experience the severest impacts from sea level rise. In contrast, other species may benefit from increases in freshwater flooding (terrestrial species) or salinity shifts (marine organisms). However, there are several other secondary effects that may affect whether sea level rise is directly beneficial to a species or habitat (e.g., pollution, nearby development constraining migration) which is discussed in further detail in the results of this section.

This evaluation is followed by a vulnerability assessment of focal species that were selected by the Natural Resources Working Group (Working Group). Please see section 4.3 for more detail about coastal hazard models, Section 4.6 for discussion about the methods used to obtain the following results, and Appendix D for comprehensive maps of vulnerable habitats throughout the county.

Habitats

While this report presents a quantitative analysis of habitat areas that may be exposed to sea level rise, these results should be interpreted as a very generalized picture of what may occur. The models used to derive the acreage of affected habitat do not incorporate other important conditions and physical processes such as sediment transport, soil types, impervious surfaces, storm direction, seasonal accretion, etc. that would affect the ultimate loss or gain of habitat acreage. In addition, the results do not account for or predict how sea level rise hazards may affect specific habitat niches within respective habitat ecotones such as shallow sub-tidal estuarine areas and mud flats, or the location where a freshwater habitat begins which abuts an estuary, or the erosion of a dune if it migrates inland. The analysis of niches and ecotones are beyond the level of detail that can be included in this initial assessment.

As mentioned throughout this Report, it is highly unlikely that a single storm event will have the combined quantitative impacts that are summarized for all of the County's coastal areas (see maps in Appendix D). Furthermore, similar habitats that are located in different areas of the coast may not all be vulnerable to sea level rise hazards at the same time, due to the direction of storms, different geology, elevations, etc. Estuarine habitat on the Central Coast may be currently exposed to tidal inundation, while estuaries located on the South Coast may not be exposed to those hazards until 58 inches of sea level rise occurs.

The quantitative habitat analysis presented in this section was conducted to provide a framework for considering what areas and types of habitats may be exposed to various sea level rise hazards (erosion, inundation, intermittent flooding). While these results may only be used as a rough measure of potential exposure to sea level rise hazards, the information presented is still valuable to land managers and planners to help quantify existing natural resources and to gain a broad understanding of potential environmental changes and vulnerabilities due to rising seas. The quantitative measures summarized here, according to different sea level rise scenarios, may also be helpful in prioritizing conservation and adaptation efforts for the habitats that will be exposed first.

Combined Flood Hazards and Fluvial Flooding Models

The combined flood hazard results provide an indication of the maximum extent for all habitat that may be vulnerable to predicted increases in rates of erosion, tidal inundation, and coastal storm events (see Sec. 4.3 under "Coastal Confluence Flooding" for more detail). As mentioned earlier, the combined flood hazard model is built with different data dependent on geographic location on the coast. The differences are as follows:

- The North Coast combined hazards model represents the effects of tidal inundation and coastal storm flooding.
- The Central Coast combined hazards model represents the effects of erosion, tidal inundation, and coastal storm flooding across the Oxnard Plain. Fluvial factors are also incorporated in the combined hazard model for areas adjacent to the Ventura and Santa Clara Rivers.
- The South Coast combined hazards model represents the effects of cliff erosion, tidal inundation, and coastal storm flooding.

Therefore, for the Central Coast, results of the combined hazard model are presented within this report rather than the fluvial and coastal storm models because the combined model more closely represents the hydrologic conditions and overall exposure that may occur adjacent to these rivers (i.e., erosion, coastal storm flooding, tidal inundation, and fluvial flooding interactions).

With up to 58 inches of sea level rise, the nearly all of beach (100%), estuarine (100%), and freshwater (86%) habitats, as well as half the dune habitats (49%) may be exposed to combined coastal hazards. The 49% of dunes that may be exposed are generally foredunes located close to beaches, with minor impacts to remnant dunes set back from the coastline behind agricultural fields and oil facilities (Figure D-20).

The orange-colored rows in Table 5-8 show that, cumulatively, 85% of all of the habitats evaluated could be exposed to combined flood hazards with up to 58 inches of sea level rise, and that 74% of this habitat, or 2,320 acres, is currently vulnerable to a 1% annual chance storm event (Figures D-19 through D-20). In between the 58 inches of sea level rise and the current vulnerabilities, the cumulative totals reveal that 50 additional acres of habitat are vulnerable with 8 inches of sea level rise, another 35 acres are vulnerable with 16 inches of sea level rise, and 275 additional acres are vulnerable with 58 inches. The vast majority of the vulnerable habitat is freshwater.

Table 5-8. Sensitive Habitats - Combined Flood Hazards: Percent and acres of flooding of existing unincorporated sensitive habitats in both the coastal and non-coastal zones that may occur with a 1% annual chance storm event.

Habitat	Existing Habitat Acreage	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Total %/Acreage of Existing Habitat Affected
Beaches	145.8	99.7% (145.4)	Less than 1% (0.2)	Less than 1% (0.1)	Less than 1% (0.1)	100% (145.8)
Dunes	173.1	34% (58.5)	5% (9.3)	1% (2.5)	9% (15.2)	49% (85.5)
Estuarine	113.1	98% (110.3)	1% (1.6)	Less than 1% (0.5)	Less than 1% (0.7)	99.9% (113.0)
Freshwater	2701.7	74% (2005.8)	1% (38.8)	1% (32.5)	10% (258.9)	86.4% (2336.0)
Scenarios (Column) TOTALS	3133.6	74.0% (2320.0)	1.6% (49.9)	1.1% (35.6)	8.7% (274.9)	85.5% (2680.3)
Cumulative TOTALS	3133.6	74.0% (2320.0)	75.6% (2369.9)	76.8% (2405.5)	85.5% (2680.4)	“

The combined flood model shows all USFWS-Designated Critical Habitats may have increased exposure to combined flood hazards. More than 90% of the habitats for the tidewater goby, Ventura marsh milk-vetch, and Western snowy plover are vulnerable to combined flood hazards with up to 58 inches of sea level rise (Table 5-9 and Figures D-19 though D-21). In addition, over 2,000 acres of these critical habitats may currently be vulnerable to such combined flood hazards (Cumulative Scenario Totals, Table 5-9).

Table 5-9. USFWS Designated Critical Habitats - Combined Flood Hazards: Percent and acres of flooding of unincorporated USFWS habitat in both the coastal and non-coastal zones that may occur due to a 1% annual chance storm event.

Species	Existing Habitat Acreage in Hazardous Sea Level Rise Areas	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Total %/Acreage of Existing Habitat Affected
Southwestern willow flycatcher	9103.5	22% (1976.3)	Less than 1% (23.4)	0% (0)	0% (0)	22% (1999.6)
Tidewater goby	117.3	99.8% (117.1)	Less than 1% (0.1)	Less than 1% (0.1)	Less than 1% (0.1)	100% (117.3)
Ventura marsh milk-vetch	42.8	77% (32.8)	4% (1.9)	4% (1.6)	8% (3.6)	93% (39.8)
Western snowy plover	155.6	99.7% (155.2)	Less than 1% (0.4)	0% (0)	0% (0)	100% (155.6)
Cumulative Scenario TOTALS	9419.2	24.2% (2281)	Less than 1% (25.8)	Less than 1% (1.7)	Less than 1% (3.7)	24.5% (2312.3)

Designated Ventura marsh milk-vetch critical habitat occurs within the back dunes near McGrath Lake and along wetland transition zones (Figure D-4). Ventura marsh milk-vetch can tolerate some salinity changes as suggested by its presence within transitional brackish wetland environments. However, the species is unable to live in areas with direct tidal inundation (Jensen, 2007; Mayta, S. and Meyer, M. 2009). While research indicates that ideal conditions for the plant would be dependent upon the extent and frequency of increased monthly tidal inundation and other freshwater hydrological factors in the area (Jensen, 2007; Mayta, S. and Meyer, M. 2009), drought, invasive species, and a lack of knowledge regarding the plant's habitats requirements make it difficult to identify ideal conditions for the plant. Because of this, plant recovery efforts are focused on learning more about the plant's ecology through experimental plantings rather than restoring areas within the designated critical habitat.

With what is currently known about the plant's habitat requirements, the increased frequency of coastal flood disturbance events associated with a 1% annual chance storm could have a positive effect for milk-vetch populations, due to the fact that areas may experience increased flooding of fresh or brackish water as sea levels rise. If this occurs, the vegetative cover is likely to be reduced, and a shift in pressure from herbivores may occur. However, adverse impacts may also occur during large storm flooding events due to potential herbicide runoff from agricultural fields that abut the critical habitat (Figure D-20).

The combined hazard model indicates that designated tidewater goby habitat (100%, 117 acres) and Southwestern willow flycatcher (22%, 2,000 acres) areas may be more exposed to coastal storm hazards. However, it is extremely difficult to predict how combined hydrological influences such as tidal, storm, and fluvial flooding, with erosion, may affect environmental conditions within these systems.

The extent of any adverse impacts due to the combined hydrological processes upon any of the designated critical habitats may depend on the magnitude, velocity, timing, and duration of flood events. For example, during a catastrophic flood event, flycatcher habitat itself may be damaged for a time, although it may have long-term positive effects for freshwater fish upstream due to the potential creation of better habitat structure from large debris washed downstream. Additionally, the timing and duration of the flood event may also determine whether the effects may adversely alter the ecosystem function of the habitat and be inhospitable or more hospitable to dependent plant and wildlife species. Predicting the changes in salinity, timing of flooding during spawning/breeding seasons, extent of contaminant and sediment runoff, all of which may occur in a flood event that has been magnified by rising seas, is not possible within this study.

The combined flood hazard model indicates that four Western monarch overwintering sites may be exposed to sea level rise. These environmentally sensitive habitat areas are located at Rincon Point, Sycamore Canyon, La Jolla Canyon, and along the Ventura River (Figures D-19 and D-21) (CNDDB data, 2018). Two of the sites at the Ventura River and Rincon Point may be currently vulnerable to tidal inundation and storm flooding, while the Sycamore and La Jolla Canyon sites appear to be vulnerable at 58 inches of sea level rise (Figure D-21). It should be noted that the accuracy of the locational data associated with the Rincon Point overwintering roost is not known and there is the potential that the roost site falls on the Santa Barbara side of the County line. Nonetheless, the roost site is reported in the assessment results. While the condition of the trees utilized as an overwintering roost is important because they provide various degrees of shading which supports temperature regulation, the habitat surrounding the roost site is fundamental in determining whether a site is suitable for overwintering monarchs that need to be buffered from the wind and have suitable distance to water and nectar sources (Xerces Society, 2017). For example, while a roost tree may appear to be outside the combined hazard exposure area (La Jolla Canyon- Figure D-21), changes to the habitat within 1,000 feet of the roost tree may affect the suitability of the tree as an overwintering site if it is no longer buffered from prevailing wind (Xerces Society, 2017). Sea level rise and coastal hazards can adversely impact overwintering sites in a variety of ways that make roost sites unsuitable for overwintering monarchs. Tidal inundation events or coastal storm flood events can: (1) increase mortality rates of roost or shelter trees that buffer winds; (2) change understory vegetation patterns by altering the flowering regimes of needed nectar plants, among other potential damage; (3) create pooling water under roost trees where monarchs may drown in a torpor state if blown off the tree during heavy winds; or (4), increase saline conditions in nearby freshwater sources.

Further examination is needed for critical habitats that may have significant areas exposed to combined sea level rise effects. While one effect such as increased coastal storm flooding on one portion of a critical habitat area may have limited adverse effects, when combined with additional sea level rise hazards such as tidal inundation or erosion it may create conditions across the entire area that are less than suitable to support listed species such as Western snowy plover and tidewater goby. To understand which of the hazards (i.e., erosion, tidal inundation, and coastal storm flooding) may impact these ecosystems, each potential hazard was analyzed in further detail in the following sections.

Projected Erosion During a 1% Annual Chance Storm Event

The projected erosion results are based upon the occurrence of a 1% annual chance storm event. The largest existing sandy beaches within the unincorporated County are Hollywood and Silverstrand beaches, and these Central Coast beaches are vulnerable to erosion today (99.4 %), with another half-acre of sandy beach becoming vulnerable to erosion within the first 8 inches of sea level rise (Tables 5-10 and 5-11). The existing sandy beach areas on the North and South Coasts, which are largely backed by shoreline armoring, were not modeled for erosion, but it is highly probable that those already-exposed beaches may experience extensive erosion in the near-term.

Table 5-10. Sensitive Habitats - Erosion: Percent and acres of erosion of existing unincorporated sensitive habitats that may occur with a 1% annual chance storm event.

Habitat	Existing Habitat Acre in Unincorporated County %/Acres	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Total %/Acreage of Existing Habitat in Unincorporated County Affected
Central Coast Beaches	95.1	99.4% (94.5)	1% (0.6)	0% (0)	0% (0)	100% (95.1)
Dunes	173.1	4.3% (7.4)	2.4% (4.1)	Less than 1% (1.0)	1.5% (2.6)	8.7% (15.1)
Estuarine	113.1	Less than 1% (1.1)	Less than 1% (0.1)	2.7% (3.1)	21.9% (24.7)	25.7% (29.0)
Freshwater	2701.7	0% (0)	Less than 1% (2.8)	Less than 1% (0.2)	0% (0)	Less than 1% (3.0)

Table 5-11. Central Coast Sandy Beach Habitats - Erosion: Percent and acres of erosion on Central Coast sandy beach habitats due to a 1% annual chance storm event.

Beach	Existing Habitat Acreage in Unincorporated County	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Total %/Acres
Hollywood	70.12	99% (69.6)	1% (0.6)	0% (0)	0% (0)	100% (70.1)
Silverstrand	24.98	100% (25.0)	0% (0)	0% (0)	0% (0)	100% (25.0)
Total	95.6	99% (95.0)	1% (0.6)	0% (0)	0% (0)	100% (95.6)

The majority of existing dune habitat in the unincorporated County is located away from the shoreline, intermixed with agricultural fields on the Oxnard Plain (Figure D-4). The erosion model predicts that 15.1 acres (approximately 9%) of existing dune habitats within the unincorporated County could be cumulatively eroded with up to 58 inches of sea level rise (Table 5-10).

About 7.4 acres of dune habitat in the unincorporated County are currently vulnerable to erosion with a 1% annual chance storm . That is almost half of the total 15.1 acres that are projected to be eroded by the end of the century. The erosion potential rate by 8 inches of sea level rise increases to 11.5 acres (7.4 acres + 4.1 acres), somewhat stabilizes by 16 inches (12.5 acres = 11.5 + 1.0) and increases again by 58 inches of sea level rise (15.1 acres = 12.5 + 2.6) (Table 5-10). Figure D-12 illustrates this pattern within unincorporated dune habitats, where the band associated with 16 inches of sea level rise on the map is much smaller in width in comparison to the band that represents 58 inches.

While only approximately 9% of dune area habitats may be vulnerable to erosion by 58 inches of sea level rise (Table 5-10), foredune habitats on Hollywood Beach and near the McGrath Lake area are vulnerable to erosion with only 8 inches of sea level rise (Figure D-12). The loss of existing sand dune habitats in combination with narrowing of sandy beaches could diminish the protection from coastal hazards that is currently provided to existing development such as the Hollywood Beach community and oil infrastructure. Erosion of dunes may directly affect Western snowy plover critical habitat and the California least tern, which are both species in danger of extinction/extirpation (Table 5-12 and Figure D-12).

A quarter of the estuarine habitats (29 acres of 113 acres, or approximately 26%) are exposed to erosion at 58 inches of sea level rise (Table 5-10). Overall, estuarine habitats show very little erosion throughout the scenarios, until 58 inches of sea level rise, where most of the habitat may become vulnerable to erosion and other associated changes that cascade through the habitat. It is also possible that these habitats may expand due to increased exposure to coastal flooding, erosion, and tidal inundation (see Tidal Inundation section below).

There was also minimal erosion projected to freshwater habitats (less than 1%) within the unincorporated area (Table 5-10), with no erosion projected to USFWS critical habitat for the tidewater goby, Ventura marsh milk-vetch, or the Southwestern willow flycatcher (Table 5-12, Figures D-11 and D-12). Since most of the unincorporated County's freshwater environments are set back from the coastline, critical habitats for species associated with this ecosystem are unlikely to be affected by coastal erosion (Figures D-11 and D-12).

Table 5-12. USFWS Critical Habitats - Erosion: Percent and acres of erosion of existing unincorporated USFWS habitat that may occur with a 1% annual chance storm event.

Species	Existing Habitat Acreage in Unincorporated County	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Total %/Acreage of Existing Habitat in Unincorporated County Affected
Ventura marsh milk-vetch	42.8	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Southwestern willow flycatcher	9103.5	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Tidewater goby	117.3	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Western snowy plover	155.6	12.68% (19.7)	6.63% (10.3)	Less than 1% (0.2)	Less than 1% (1.3)	20.26% (31.5)

The USFWS designated critical habitat for the Western snowy plover includes beach, dune, and Santa Clara River estuarine habitats. The beach and dune habitats provide critical breeding habitat for the plover, while the Santa Clara River estuary provides pockets of nesting area along gravel bars. All of these habitat types provide resources for foraging activity and overwintering sites (Patrick, A.M. and Colwell, M.A. 2014) (Figures D-4 and D-5). Critical habitat for the plover may be the most vulnerable to erosion in comparison to other species' critical habitats, as there is the potential to lose a total of about 20% of the existing habitat with 58 inches of sea level rise (Table 5-12), unless there is also sand accrual quickly following a large erosion event. The designated plover habitat is primarily located on Hollywood Beach, with some small areas on a property with an active slant oil drilling operation at McGrath Beach (Figure D-4). In addition, the data also suggests that the Hollywood Beach area may experience the majority of erosion exposure between now and 8 inches of sea level rise (100%) during a 1% annual chance storm event (Table 5-11 and Figure D-12).

In summary, the results indicate that sandy beach areas are the most vulnerable habitat to erosion today (99%) compared to dune, estuarine and freshwater habitats (Tables 5-10 and 5-11), although the model may overestimate the potential impacts because other factors such as seasonal changes in sediment transport dynamics and storm direction are not accounted for. While these results do not address the potential habitat evolution that may occur, overall it does not paint a promising picture for species such as the California grunion, Western snowy plover, or the California least tern, who are reliant on sandy beaches and foredune habitats to reproduce, feed, or rest. These habitats may be unable to migrate or retreat inland due to roads and existing development and agricultural operations. Pressure from increasing human recreation could also affect these species, especially during a critical life stage such as breeding, nesting, or migration. (McCrary, M.D. and Pierson, M.O., 2000; McLachlan, A. et al. 2013; Barringer, D. 2013, 2014, 2015; CA State Parks 2002-2009).

Consistent Flooding of Habitats (Tidal Inundation)

The tides are composed of two low and two high water levels of unequal heights per 24.8-hour cycle. Typically, the largest tide annual ranges occur in late December to early January. Maximum tide elevations are due to the relative position of the moon, wind surge, wave direction, density anomalies, long waves, and climate cycles. Sea level rise will increase the tidal elevations, causing the sea to reach farther inland, submerging more transitional and dry habitats.

Table 5-13. Sensitive Habitats – Tidal Inundation: Percent and acres of potential tidal inundation to sensitive habitat within the unincorporated County that could occur with a 1% annual chance storm event.

Habitat	Existing Habitat Acreage in Unincorporated County	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Cumulative Total %/Acreage of Existing Habitat in Unincorporated County Affected
Beaches	145.8	14% (20.4)	2% (2.3)	2% (2.6)	18% (25.8)	35% (51.2)
Dunes	173.1	Less than 1% (0.8)	Less than 1% (0.2)	Less than 1% (0.3)	5% (9.5)	6% (10.8)
Estuarine	113.1	42% (47.4)	6% (6.6)	4% (5.0)	2% (2.5)	54% (61.4)
Freshwater	2701.7	15% (404.4)	4% (100.0)	2% (50.4)	7% (200.8)	28% (755.4)

With sea level rise, tidal inundation will expose the habitats of concern, depending on their elevation, to more frequent inundation by sea water and thus to more saline conditions. Dune habitats are the least likely habitat to be affected by tidal inundation (10.8 acres or 6%), even with 58 inches of sea level rise (Table 5-13). As mentioned earlier, this is due to their spatial location on the landscape, where the unincorporated County's back dunes are set back from the coastline within a fragmented matrix of agricultural fields and oil facilities (Figure D-14). This also explains how the majority of dune habitat area (9.5 of 10.8 acres, or 88% of total exposed area) may be affected by tides at 58 inches of sea level rise, but very little area (1.3 acres) is projected to be affected at 8 and 16 inches of sea level rise (Table 5-13).

While 54% (approximately 61 acres) of the existing estuarine environment may be exposed to greater amounts of tidal inundation based upon the extreme monthly high-water levels with 58 inches of sea level rise (Table 5-13), predicting how those changes may affect the different estuarine types of sub-habitat (e.g., shallow sub-tidal, mud flats, salt marsh, tidal creeks, upland transition zone) within those areas is beyond the scope of this project.

The effects of tidal inundation on lagoons, such as the mouths of the Santa Clara or Ventura Rivers, that are usually isolated from the sea with sand berms, are more difficult to predict. For example, the sea could still continue to supply sand and maintain the intermittent connection to the ocean, or eventually the river mouths may be opened year-round to tidal influences. Estuaries such as Mugu Lagoon and the estuarine habitat at the mouth of Calleguas Creek that are tidally connected to the sea, may grow in size, transition to deeper water habitats, and have more inundated mud flats. Under any circumstances, increases in the salinity of estuaries and lagoons may be expected. In addition, while this analysis does not take into account habitat that is created, it is clear that estuarine habitats may be expanding into existing connected freshwater areas.

Overall, these results suggest that tidal inundation may occur sooner within the estuarine environments associated with Rincon Creek and Sycamore Canyon Creek than in the unincorporated portions of the Santa Clara and Ventura River estuaries because of how far inland the jurisdictional boundary for unincorporated portions of those environments fall from the shoreline (Figures D-13 through D-15).

The unincorporated County's freshwater habitats that are vulnerable to tidal inundation are the most exposed habitat type by acreage. A little over a quarter of the unincorporated area's freshwater habitats that were evaluated (755 out of 2,701 acres or 28%) are vulnerable to tidal inundation with 58 inches of sea level rise (Table 5-13). Of the 755 acres of freshwater habitat that are projected to be inundated at 58 inches of sea level rise, half (404 acres) are currently at risk of inundation during an extreme monthly high tide (Table 5-13). The 755 acres of freshwater habitat that may be exposed are more than 12 times the area of the second-most exposed habitat type, which is 61.4 acres of estuarine habitat. The tidal inundation of freshwater habitats suggests that existing freshwater habitat may be converted into an estuarine environment with 58 inches of sea level rise.[16]

The potential acreages and percentages that may be exposed to sea level rise, and are summarized in Table 5-13, were derived from existing beach (35%), freshwater (28%) and the dune (6%) habitat analyses. These estimates were unable to capture the significant variation of a habitat's vulnerability to tidal inundation in a specific geographic location because of the spatial configuration of habitat types on the landscape and their proximity to the shoreline. For example, the differences in potential exposure are most apparent with the estimates associated with coastal dunes, where the majority of back dune habitat near McGrath Lake may be unaffected by tidal inundation, while the foredune ecosystem located on Hollywood Beach may experience major tidal inundation by 58 inches of sea level rise (Figure D-14).

This vulnerability assessment focuses on habitats within the unincorporated County that may be exposed to sea level rise. It should be noted that this assessment includes a large area of existing freshwater habitat (755 acres) that may be exposed monthly to high tides, but the total amount of stream and river area within the County is not fully accounted for in the tabular percentage estimates, as many of these areas are located long distances inland from the coastline (Table 5-13).

[16] Note: The overall potential increase only includes mapped beach, dune, and freshwater habitats and does not include other types of habitats that may be affected such as agriculture, upland coastal sage scrub, etc.

Table 5-14. USFWS Designated Critical Habitats – Tidal Inundation: Percent and acres of tidal inundation of unincorporated USFWS Habitat that could occur due to a 1% annual chance storm event.

Species	Existing Habitat Acreage in Unincorporated County	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Cumulative Total %/Acreage of Existing Habitat in Unincorporated County Affected
Ventura marsh milk-vetch	42.8	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Southwestern willow flycatcher	9103.5	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Tidewater goby	117.3	0% (0)	0% (0)	0% (0)	Less than 1% (0.0)	Less than 1% (0.0)
Western snowy plover	155.6	0% (0))	Less than 1% (0)	Less than 1% (0.1)	3.73% (5.8)	4% (6.0)

Exposure of USFWS designated critical habitats to tidal inundation may be minimal, with the largest exposure totaling 4%, or 6 acres, of designated Western snowy plover habitat. Most of the potential tidal inundation is projected to occur with 58 inches of sea level rise on Hollywood and Silverstrand Beaches and within unincorporated areas along the Santa Clara River (Table 5-14 and Figure D-14).

Designated USFWS Western snowy plover critical habitat within the unincorporated County is located on Hollywood Beach (Figure D-5) and along the Santa Clara River, from the Harbor Boulevard bridge inland about one mile (Figure D-4). Hollywood Beach serves as critical breeding and overwintering habitat for the plover, while the Santa Clara River area serves as a foraging habitat. The majority of nesting and overwintering habitat on Hollywood Beach may be subject to erosion now through 8 inches of sea level rise, and a portion of the area may be completely inundated by the ocean at 58 inches of sea level rise (Figures D-12 and D-14).

The results also suggest that 42% (approximately 47 acres) of the affected estuarine environments may experience increased monthly tidal inundation now (Table 5-13). Tidewater goby critical habitat located in the Sycamore Canyon creek estuary appears to be the only critical habitat for this species within the unincorporated County that may be affected by increased monthly tidal inundation by 58 inches of sea level rise (Table 5-14 and Figure D-15).

Coastal Storm Flooding

Overall, 76% of beach, estuarine, and dune habitats may be exposed to flooding during a 1% annual chance storm event. This is equal to 329 out of 432 existing acres of habitat (Table 5-15). Today, 235 acres are vulnerable, which includes virtually all of the sandy beach habitats, 18% of dune habitats, and 52% of estuarine habitats. Additionally, 557 acres, or 21%, of freshwater habitat is currently vulnerable to coastal storm flooding if a 1% annual chance storm event occurs. Relatively minor increases in the areas affected by flooding are projected for all habitats until 58 inches of sea level rise, when half of the sand dunes, 86% of estuarine habitats, and 33% of freshwater habitats within the unincorporated County may be exposed to major storm flooding (Table 5-15 and Figures D-16 through D-18).

Table 5-15. Sensitive Habitats – Coastal Storm Flooding: Percent and acres of coastal storm flooding of existing unincorporated sensitive habitats that may occur with a 1% annual chance storm event.

Habitat	Existing Habitat Acreage in Unincorporated County	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Cumulative Total %/Acreage of Existing Habitat in Unincorporated County Affected
Beaches	145.8	99.9% (145.4)	Less than 1% (0.2)	Less than 1% (0.1)	Less than 1% (0.6)	100% (146.3)
Dunes	173.1	18 % (30.4)	5 % (8.9)	3 % (5.7)	24% (39.9)	50% (84.9)
Estuarine	113.1	52% (59.3)	1% (1.6)	5% (5.8)	27% (31.0)	86% (97.7)
Freshwater	2701.7	21% (557.0)	Less than 1% (26.5)	1% (36.6)	10% (280.6)	33% (900.7)

Coastal storm flood events that are amplified by sea level rise may include a variety of factors that cannot be predicted with the information analyzed in this report. For example, wrack deposits may increase on beaches, since waves and wind dislodge kelp, which can help maintain the foundation to the food web associated with beach ecosystems. Conversely, depending on the timing of a large storm event, breeding birds, including ground nesting birds like the Western snowy plover, could be disturbed by flooding. In addition, small mammal activity and mortality due to the temporary flooding of burrows may increase in estuarine and freshwater habitats. Vegetation communities in wetlands pocketed within sand dunes may be found to benefit from increased storm flood events (e.g., Ormond Beach and Santa Clara River/McGrath Lake areas) due to a temporary reduction of herbivores and the redistribution of nutrients. Due to the proximity to surrounding agricultural and urban areas, non-point source pollutants may also inhibit plant growth and temporarily affect the food web through adverse chemical effects to associated invertebrates (Mooney and Zavaleta, 2016). To understand which potential effects would occur and where would require a more detailed study in the future.

Table 5-16. USFWS Designated Critical Habitats - Coastal Storm Flooding: Percent and acres of coastal storm flooding of unincorporated USFWS habitat that may occur due to a 1% annual chance storm event.

Species	Existing Habitat Acreage in Unincorporated County	Current Potential %/Acres	8 inches %/Acres	16 inches %/Acres	58 inches %/Acres	Total %/Acreage of Existing Habitat in Unincorporated County Affected
Ventura marsh milk-vetch	42.84	32% (13.9)	11% (4.6)	12% (5.0)	38% (16.4)	93% (39.8)
Southwestern willow flycatcher	9103.48	0% (0)	0% (0)	0% (5.4)	0% (40.7)	Less than 1% (46.0)
Tidewater goby	117.34	Less than 1% (0.5)	Less than 1% (0.1)	5% (5.4)	Less than 34% (39.6)	39% (45.5)
Western snowy plover	155.62	21% (32.9))	Less than 1% (0.4)	3% (5.0)	24% (38.1)	49% (76.4)

Coastal storm flooding could adversely expose 49% of unincorporated Western snowy plover critical habitat with 58 inches of sea level rise (Table 5-16). If the flooding occurred during the nesting season, a variety of ground nesting shorebirds, including the federally endangered California least tern, would experience decreased productivity due to washed-out nests. The acreages of Western snowy plover critical habitat that could be exposed to flooding as a result of large coastal storm events are similar to the exposure of dune habitat acreage (Figure D-17), where similar proportions of the existing habitat are vulnerable today (Dune-18%, USFWS- 21%) and the vulnerability increases to half of the habitat at 58 inches of sea level rise (Dune-50%, USFWS- 49%), as shown in Tables 5-15 and 5-16. This pattern makes sense because the beach portion of the plover critical habitat may currently be subject to flooding along with the foredunes on Hollywood Beach, and the portion of designated critical habitat that occurs along the Santa Clara River with the nearby back dunes may be exposed later at 58 inches of sea level rise (Figure D-17). Positive impacts to the habitat may include increases in deposited wrack (Dugan et al. 2003; Hardy, M. A. and Colwell, M.A. 2012) and the potential flattening of taller dunes by coastal storms if tides do not erode them. Flattening of coastal sand dunes is beneficial for the Western snowy plover because it can see predators approaching (Patrick, A.M. and Colwell, M.A. 2014).

Ventura marsh milk-vetch USFWS critical habitat (93%) is projected to be flooded during a 1% annual chance storm event and 58 inches of sea level rise (Table 5-16). As explained above in the combined hazard flooding section of this Report, critical habitat supporting the Ventura marsh milk-vetch population may benefit because of the disturbance associated with the intermittent coastal storm flooding. Because the milk-vetch habitat occurs within the back dunes near McGrath Lake and wetland transition zones, the potential area of this habitat exposed to flooding is very similar to the area of back dunes projected to be flooded (Figure D-17). Infrequent fresh water flooding in itself would likely have a positive effect for the milk-vetch in the back dune and wetland hummocks. Coastal flooding events associated with a 1% annual chance storm event and other sea level rise effects that have the potential to reduce vegetative cover may be beneficial for these populations which appear to need transitional disturbed areas with low and reduced pressure from herbivores. While there is a potential of herbicide runoff from agricultural fields, the location of this species' critical habitat appears to be buffered from agricultural lands by a dune field to the east, as well as buffered from the beach and sea by dune fields on the coast (Figure D-17)

About 39%, or approximately 46 acres, of the critical habitat for the tidewater goby may be increasingly exposed to 1% annual chance storm events (Table 5-16). The tidewater goby critical habitat that falls within the unincorporated County is located in the upper estuary on the Santa Clara River within the fresh-saltwater interface (Figure D-17). To reproduce, gobies generally select salinity levels that range between a short distance upstream in relatively fresh water, and downstream into water of up to about 75% sea water (e.g., a concentration of 28 parts per thousand) (USFWS, 2007; Worcester and Lea 1996). Therefore, while both the Ventura and Santa Clara River estuary mouths are within the jurisdictions of the City of Ventura and Oxnard, the transitional brackish water habitats that the goby are found within may potentially move within the unincorporated area with sea level changes (Figures D-16 and D-17).

It is very difficult to predict the effects of infrequent freshwater flooding when combined with other hydrological impacts such as drought, water diversion, groundwater over drafting, channelization, sandbar breaching, increased sedimentation, and pollution discharges. Recent storm events that occurred between January and April of 2018 provided an indication of how quickly the conditions can dramatically change in estuarine habitats. High-flow coastal storm events can deliver considerable sediment that dramatically affects the bottom profile and substrate composition of a lagoon or estuary, particularly after widespread wildfires like the Thomas Fire. These conditions can cause an increase in the elevation of an estuary and a decrease in the overall water depth within the habitat. When this occurs, the reduced water storage capacity can then cause the same amount or less water to breach the sandbar enclosing the estuary more frequently, which can further channelize and scour the bottom of any remaining goby habitat. These types of environmental conditions can cause the following effects: (1) a reduction of suitable goby habitat for breeding, foraging, and cover; (2) air exposure to goby nest burrows (depending on the timing of the storm event); and (3), flushing of adults and juveniles out to sea (Swift et al. 1989). Therefore, coastal storm flooding events associated with sea level rise may ultimately adversely affect tidewater goby abundance, survival, and productivity (USFWS, 2005; USFWS, 2007).

Coastal storm flooding may expose two Western monarch overwintering roosts at Rincon Point and Sycamore Canyon (CNDDB data, 2018). Flooding and wind events associated with the 1% annual chance storm event have the potential to critically alter microclimate conditions in the overwintering groves making them unsuitable for Monarch roost sites, if trees are extripated during such storm events. As mentioned previously, it has been shown that it is important for a monarch roosting tree to be buffered from the wind. Without it, the roost is unusable for the overwintering monarchs (Xerces Society, 2017).

Focal Species

The following species-specific vulnerability assessments provide a foundation for understanding how and to what degree sea level rise may affect the function of the four selected ecosystems and how those changes may affect the fitness of the organisms within them. By understanding how each of the sea level rise factors (inundation, flooding, erosion) may affect each focal species, more effective adaptation strategies and management actions can be developed to reduce the vulnerability of the species and its habitats.

Vulnerability was measured through an evaluation of each species' exposure and sensitivity to changes in the environment, in relation to its capacity to adapt to environmental changes (i.e., adaptive capacity). A species with greater adaptive capacity can change its behavior to colonize more favorable habitats (e.g., expand its historic range and distribution), change observable characteristics in its lifespan (e.g., a particular species of aphid can grow wings when a plant becomes overpopulated), or evolve over multiple generations (e.g., mice have large ears to hear predators better because they do not have night vision and are nocturnal). By evaluating species' vulnerabilities using these three criteria (sensitivity, exposure, adaptive capacity) an overall vulnerability score was generated and plotted to identify which species are most vulnerable to sea level rise hazards. Natural Resources Working Group (Working Group) participants also recorded a confidence score for each answer to quantify the accuracy of their assessment.

The graphic in Figure 5-13 below, illustrates how to interpret the species vulnerability assessment results. The species' final score for sensitivity and exposure is plotted on the X-axis and the species' final score for adaptive capacity is plotted on the Y-axis. Then the graph is split into quadrants to clarify how the combination of adaptive capacity, exposure, and sensitivity may or may not categorize a species as being particularly vulnerable to the effects of sea level rise and coastal hazards.

Low Adaptive Capacity Low Exposure/Sensitivity	**HIGH VULNERABILITY** High Exposure/Sensitivity Low Adaptive Capacity
High Adaptive Capacity Low Exposure/Sensitivity **LOW VULNERABILITY**	High Exposure/Sensitivity High Adaptive Capacity

Figure 5-13. Key to Interpreting Vulnerability Assessment Scores

Table 5-17 and Figure 5-14 show that out of the 19 species evaluated for the vulnerability assessment, 9 of the focal species plotted on the graphs fall completely within the high vulnerability quadrant (red colored rows), four fall within the low vulnerability quadrant (green colored rows), and the remaining species have moderate overall vulnerability (gray-blue colored rows). The overall vulnerability score provides a strong indication of a species' vulnerability. By using the quadrant approach shown in Figure 5-14, management actions may be focused on those species that are most at risk.

Table 5-17. Summary of final vulnerability scores for all focal species.

Species Nam	Exposure and Sensitivity Score	Adaptive Capacity	Vulnerability Score
Beach evening primrose	3.75	1.64	3.35
Globose dune beetle	4.00	1.79	3.29
Belding's savannah sparrow	4.13	2.14	2.98
Tidewater goby	3.67	1.81	2.95
Southwestern pond turtle	4.00	2.29	2.73
Red sand verbena	3.13	1.93	2.27
Western snowy plover	4.08	2.57	2.24
Alkali heath	3.75	2.71	2.12
Woolly sea-blite	3.00	2.14	2.10
Bigelovii pickleweed	3.50	3.14	1.83
California grunion	3.50	2.71	1.80
Virginia rail	3.25	3.29	1.45
Arroyo chub	2.50	3.00	1.33
Salt marsh snail	3.00	3.43	1.31
Cottonwood	2.63	3.29	1.22
Southern steelhead	2.25	2.71	1.15
Arroyo willow	2.44	3.32	1.07
Topsmelt	1.88	3.29	0.76
California horned snail	2.00	3.43	0.73

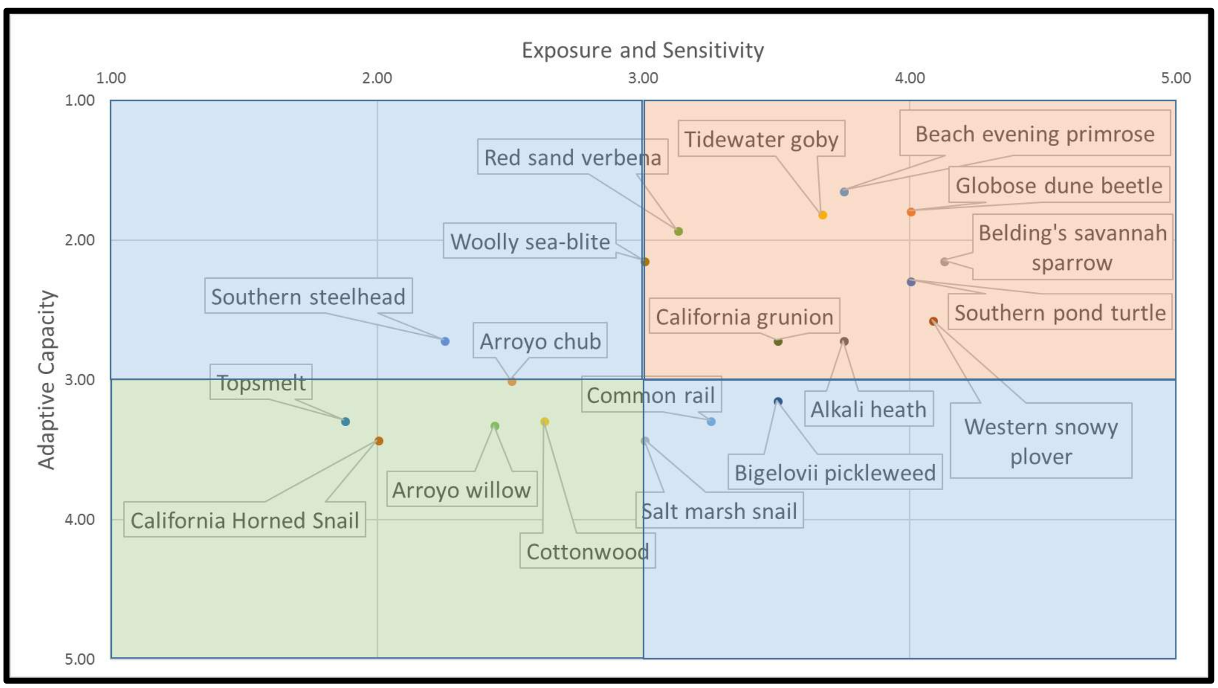


Figure 5-14. Top 20 focal species vulnerability assessment scores.

In the high vulnerability quadrant, four species associated with estuarine habitats and three dune habitat species were identified, followed by two beach species, and one freshwater species. For the species' Latin names, see Table 2-8. Highly vulnerable focal species are discussed in more detail below by habitat type.

Beach Focal Species Results

Table 5-18. Sandy beach focal species vulnerability and confidence scores.

Beach Focal Species	Exposure Score	Exposure Confidence Score	Sensitivity Score	Sensitivity Confidence Score	Adaptive Capacity Score	Adaptive Capacity Confidence Score	Vulnerability Score
California grunion	3.5	2.50	2.75	2.13	2.71	2.38	1.80
Western snowy plover	4.6	3.0	3.3	2.25	2.57	2.79	2.24

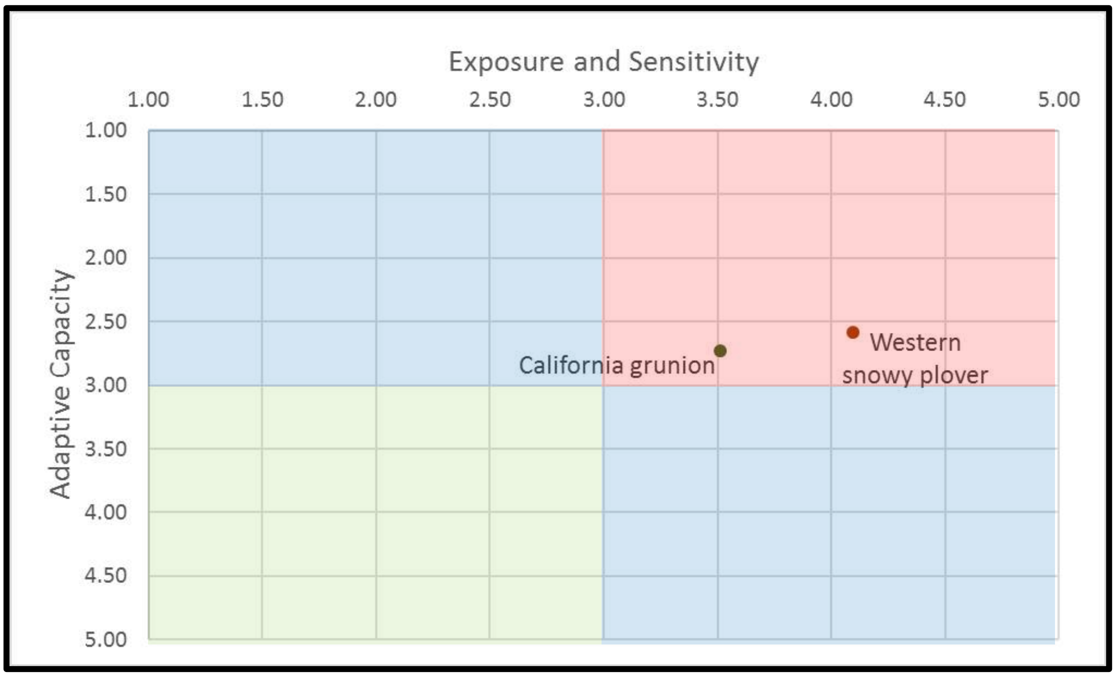


Figure 5-15. Beach Focal Species Vulnerability Scores.

California Grunion

The California grunion was ranked highly-vulnerable to sea level rise, with "high" exposure and sensitivity scores, and "moderate" adaptive capacity scores (Table 5-17 and Figure 5-15). Current and historical data show that the grunion will spawn on beaches with enough sand above the highest monthly high tide line (~March-August) (K. Martin, Grunion Greeter Program, personal communication, April 12, 2018). Exposure and Sensitivity scores were high for the grunion (the average score was 3.5) due to the limited spawning habitat along the armored North and South Coasts, and the potential exposure from beach erosion, tidal inundation, and flooding. Although Hollywood and Silverstrand beaches along the Central Coast have the greatest potential to support grunion as sea level rises due to their substantial beach widths, significant erosion and inundation of these beaches are also projected as sea levels rise. Other physical threats identified for the grunion that influenced the exposure score included: beach grooming activities, sand replenishment projects, fishing/handling, sand compaction due to vehicle traffic/recreation, noise, lighting, vibrations, coastal armoring structures, rising ocean temperatures, pollution, predation, and harmful algal blooms. The sensitivity of grunion to sea level rise was ranked on the cusp between “moderate” and “high”, with the sensitivity score slightly tempered because grunion have a broad latitudinal range and spawn on a variety of beaches as long as there is sandy substrate above the mean high tide line (K. Martin, Grunion Greeter Program, personal communication, April 12, 2018).

While sensitivity and exposure scores are “high”, grunion were ranked with a “moderate” adaptive capacity score due to the species’ extent and connectivity among metapopulations. The species overall population was considered diminished, but generally stable. Grunion have a short life expectancy, and its beach-spawning reproductive strategy makes the species vulnerable to sea level rise effects if there is loss of beach habitat area. There is the possibility that grunion can become locally extirpated. In general, Working Group participants felt that there was a moderate likelihood for managing or alleviating the sea level rise exposure to this species, although adaptive capacity scores had wide-ranging variability ranging from “low” to “moderate-high”. On the lower end of the spectrum, participants thought that interventions to prevent beach erosion such as beach nourishment can be ineffective or detrimental to the grunion. While the loss of sandy beach substrates is critical to grunion survival, respondents also felt that simple changes to beach grooming protocols and maintenance activities that require vehicles on the beach could easily be addressed by avoiding spawning areas during certain times. All participants ranked the grunion “moderate-high” with a high confidence score that the grunion has societal value and there is a willingness to support this species.

Western Snowy Plover

The Western snowy plover ranked highly-vulnerable to sea level rise (Table 5-18 and Figure 5-15). Compared to the California grunion, plover had a higher average exposure score of 4.6, higher sensitivity score of 3.3, and a slightly lower “moderate” adaptive capacity score of 2.6. As with the grunion, the physical threats that affect the snowy plover from sea level rise include projected erosion resulting in fewer wide sandy beaches for breeding and overwintering, which would also result in greater conflicts with human recreational activities. Participants identified this bird as extremely vulnerable to predation and disturbance by humans particularly during the nesting period. Nests may also be lost to exposure due to coastal storms and increasing tidal inundation. Unlike the grunion who rely on the sandy beach habitat seasonally for spawning, the snowy plover relies on wide beaches of the County’s Central Coast to breed and overwinter because these beaches support abundant wrack deposits and invertebrate communities year-round. Unlike the Central Coast, the North and South Coast beach habitats are unsuitable for shorebirds during the nesting season due to low sandy beach widths. In addition, foraging opportunities are considered limited for shorebirds on these armored coasts due to high tides that often reach the toe of shoreline armoring, which impacts the food web and availability of prey items for shorebirds (Mooney and Zavaleta, 2016).

The Western snowy plover “high” sensitivity score was also based upon the plovers’ specific type of breeding and overwintering habitat required and its limited diet consisting of wrack invertebrates and other beach insects. Plovers require wide open sandy flat areas to see the approach of predators, in combination with adequate cover provided by low native plant colonizers or beach wrack for nests and chicks. Most of the low-growing native plants in these areas are being outcompeted by invasive plants, which increase dune heights and decrease the visibility of predators to the plover. In addition, critical cover provided by beach wrack for nests and chicks is often removed through beach grooming operations.

The Working Group ranked the Western snowy plover more susceptible to non-sea level rise exposure stressors, including the following: 1) chicks are frequently lost to predators; 2) nests are abandoned or impacted by human activity associated with dogs, ATVs/golf carts, low-flying aircraft/drones, sand removal, and special events; 3) feeding sources such as beach wrack are removed through beach grooming; and 4) habitat degradation associated with invasive plant species, which create higher dunes and less suitable habitat for plover breeding. These frequent disturbances and reduction of food sources cause the birds to expend comparatively more energy to avoid human disturbance, and this activity decreases their ability to build up critical fat reserves that are needed for the overwintering and breeding seasons.

The adaptive capacity of the Western snowy plover was ranked at 2.8, slightly higher than the grunion at 2.4 (Table 5-18). These scores are close to "moderate". The Western snowy plover breeds on coastal beaches and dunes in California, Oregon, and Washington and is considered to have a "moderate-high" distribution in terms of regional range. The metapopulations are considered to be almost continuous, although the bird has low genetic variability due to low population numbers, which may limit its ability to physically adapt to changing environmental factors. Working Group participants rated the reproductive strategy as susceptible to sea level rise because of the specialized nature of its food source (wrack invertebrates) and breeding habitats, although there is some evidence that the bird could adapt its behavioral responses so that it is not completely reliant on beach and dune habitats for breeding. For example, the Navy has observed these birds nesting on salt pannes and on airplane runways at the Point Mugu Naval Air Weapons Station.

Working Group participants felt that the Western snowy plover faces significant challenges to survival as sea level rises, noting that the purchase of replacement habitats adjacent to the ocean to allow for beach and dune migration may be costly and scarce. Others felt optimistic that there are potential opportunities for dunes and beaches to migrate in certain areas along the coast. The societal value of the Western snowy plover was ranked "moderate-high" because it is viewed as "very cute" and well-liked by the public. The local Audubon Society has a growing outreach program to educate local residents and visitors on how to limit the disturbances that affect the plover. Limitations on beach activities such as grooming, sand removal, access for dogs and vehicles were recommended. Currently, beach grooming occurs year-round on some beaches in the unincorporated County (Figures D-9 and D-10), although the County takes special measures to avoid nesting Western snowy plovers and maintenance staff are aware of the spawning grunion seasons.

Dune Focal Species Results

All three dune focal species were ranked in the "high" vulnerability quadrant (Figure 5-16). Table 5-19 shows they have "moderate" exposure and sensitivity scores and "low" adaptive capacity scores. Beach evening primrose and Globose dune beetle were ranked the most vulnerable focal dune species, respectively, followed by red sand verbena. These species are described in more detail below.

Table 5-19. Dune focal species vulnerability and confidence scores.

Dune Focal Species	Exposure Score	Exposure Confidence Score	Sensitivity Score	Sensitivity Confidence Score	Adaptive Capacity Score	Adaptive Capacity Confidence Score	Vulnerability Score
Beach evening primrose	4	3	3.5	3	1.65	3	4.56
Globose dune beetle	4.25	3	3.75	3	1.79	2.67	4.48
Red sand verbena	3.75	2.75	2.5	2.5	1.93	2.39	3.25

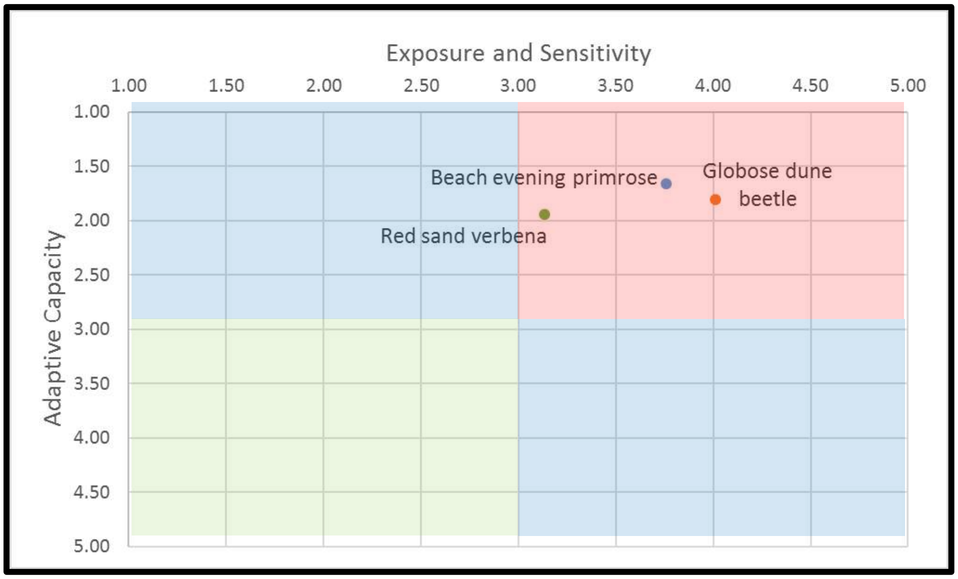


Figure 5-16. Dune Focal Species Vulnerability Scores.

Beach Evening Primrose

Beach evening primrose was ranked as the most vulnerable due to the threat of erosion and tidal inundation of the dune habitat. It grows in a very narrow zone, at low elevations on sandy foredune and back dune habitats, and it has "low-moderate" dispersal ability. Its population is diminished but generally stable. Additional non-sea level rise stressors to the plant include beach grooming, trampling, and coastal development. It received "low" to "low-moderate" scores for adaptive capacity primarily because the plant has limited population connectivity and dispersal ability. The plant is not well known to the general public. The ability of the primrose to migrate with dunes further inland will be important to monitor, as the migration paths may be obstructed by urban development and agricultural.

Globose Dune Beetle

The globose dune beetle was considered to have "high" exposure to disturbance from sea level rise due to potential loss of dunes from erosion, tidal inundation, and storm flooding, and this exposure would be amplified by other non-sea level rise stressors associated with beach grooming, trampling of habitat, invasive species, and coastal development. The beetle is listed by the State as critically imperiled at the global and state level, with isolated and fragmented connectivity among metapopulations. The insect has "low-moderate" dispersal abilities due to its sessile and flightless nature. Like the primrose, the beetle resides in a limited area and is only found in foredunes, sand hummocks and sometimes back dunes that are within approximately 100 feet of the high tide line. The beetle was ranked "moderate-high" in terms of sensitivity (Table 5-19). The Working Group felt hopeful about the likelihood of alleviating impacts to the beetle through restoration, conservation, and protection of the beach and dune habitat where it forages and shelters. In addition, refraining from the practice of beach grooming was thought to be a huge step toward conservation and restoration of this species. Additional management suggestions included planning for refuge areas and buffers in beach replenishment projects, avoidance of burying and bulldozing beach strand and dune habitats, as well as setting up buffers for recreational activities and public access to beaches and dunes. The societal value of the species is very low, as most people do not even know it exists.

Red-Sand Verbena

Red-sand verbena is a plant native to California that functions as a major foredune stabilizer (Tillett, S.S. 1967). Like the other dune focal species in this category, participants ranked this species as vulnerable to sea level rise exposure as well as to the human activities cited above for the beetle and primrose (the average score was 3.75, as shown in Table 5-19). The succulent tissues of the plant have adapted to isolate and store salt, because it survives on saline water which it receives mostly in the form of sea spray, so its sensitivity to sea level rise exposure that occurs adjacent to the beach is a little lower than the other dune species (the average score was 2.5). The plant also needs pollinators, and seed dispersal takes place by wind and during extreme high tides. As a perennial plant, the seeds are produced over prolonged periods of time, which may result in lower amounts of overall seed production than other foredune plants (Wilson, R.C. 1972).

The adaptive capacity of sand verbena was ranked "low-moderate" at 1.9 (Table 5-19) because the population size of the plant is diminished, but is generally stable with "somewhat isolated and/or fragmented" connectivity among metapopulations. In addition, the plant had a slightly higher adaptive capacity score than other dune species due to its ability to spread readily on sand dunes and beaches. As with other dune species, the adaptive capacity to alleviate sea level rise impacts is tied to the overall conservation and management of the species. While the plant is attractive when it flowers, there is generally not a high societal value associated with it, although that may change with its ability to hold sand dunes in place and therefore protect development and land uses that lie inland from beaches with dunes.

Estuarine Focal Species Results

Three of the nine focal species assessed within the estuarine ecosystem were ranked in the "high" vulnerability quadrant (Figure 5-17). These species are the Belding's savannah sparrow, tidewater goby, and alkali heath. These three species also had the highest average vulnerability score out of all estuarine species (Table 5-20).

Belding's Savannah Sparrow

The Belding's Savannah Sparrow was considered to have "high" exposure to disturbance from sea level rise due to a factors such as the potential decrease in salt marsh if the habitat is unable to migrate, pollution, reduced sediment supplies, increased fragmentation, invasive species, loss of pollinators, and coastal development. As shown in Table 5-20 below, the average exposure score was 3.75.

The bird was ranked with a "high" sensitivity score of 4.5 (Table 5-20), primarily due to its dependence on large expanses of undisturbed pickleweed to breed. In addition, the sparrow relies completely on the presence of invertebrates and small vertebrates for forage and feeding young. which can be impacted by secondary impacts of sea level rise described earlier. The impacts to species that rely on niche habitats like the sparrow are very difficult to project without a detailed study that analyses potential alterations in elevation from inundation, flooding, sediment supply, as well as other factors that support the bird's habitat needs. The adaptive capacity of the Belding's savannah sparrow was ranked "low-moderate" at 2.14 (Table 5-20) because of the restricted extent of the species, low population numbers, low connectivity to sub-populations, dependence on specific forage, and habitat requirements.

Tidewater Goby

The tidewater goby was considered to have "high" exposure to sea level rise impacts and the average exposure score was 4 (Table 5-20) due to projected tidal inundation, flooding, and potential habitat loss from rising seas. In addition, habitat for this species is frequently altered by humans, which directly affects its survival. Such alterations include artificial breaches in estuary sand berms, water management activity with surface and groundwater extractions, and substances that are introduced into the habitat for vector control. The goby's sensitivity score was 3.3, which is "moderate" (Table 5-20). It can tolerate a wide range of salinity conditions, but requires warm and calm waters for spawning. The goby is somewhat dependent upon humans for conservation and management of suitable habitat, but human activities in estuaries frequently adversely affect the species. As mentioned above, artificial breaching of sand berms at the outlets of rivers and streams restrict populations to areas upstream of tidal action, and these areas generally have lower salinity and higher dissolved oxygen. The goby is also highly susceptible to mortality by non-native fish populations which damage breeding areas, compete for food resources, and predate directly on the goby.

The adaptive capacity score of the goby was 1.8, which is "low" (Table 5-20), but responses from the Working Group varied. In general, it was suggested that the persistence of tidewater goby populations is related to habitat size, configuration, location, and proximity to human development. Some of the more stable populations occur in lagoons and estuaries that are more than 2.5 acres in size and that have remained relatively unaffected by human activities. It was also noted that while sea level rise may increase available habitat for the species, it may be especially challenging to restore or create suitable habitat conditions within the County.

Alkali Heath

Alkali heath exposure score to sea level rise impacts was 4, which is as high as the tidewater goby (Table 5-20). The high exposure is due to projected tidal inundation, flooding, and potential habitat loss from rising seas. Loss of habitat due to development was also cited as an additional concern. Alkali heath was also ranked "high" in terms of sensitivity (the average score was 4) to sea level rise effects due to its dependence upon pollinators and niche habitat with consistent soil moisture levels that help the plant maintain osmosis. The "low" adaptive capacity score of the plant of 2.7 (Table 5-20) was directly tied to its dependence on niches in salt marsh habitat.

Table 5-20. Summary of estuarine focal species vulnerability and confidence scores.

Estuarine Focal Species	Exposure Score	Exposure Confidence Score	Sensitivity Score	Sensitivity Confidence Score	Adaptive Capacity Score	Adaptive Capacity Confidence Score	Vulnerability Score
Belding's savannah sparrow	3.75	3	4.5	2.75	2.14	2.86	2.98
Tidewater goby	4	2.67	3.33	2.67	1.81	2.57	2.95
Alkali Heath	4	3	3.75	3	2.71	3	2.12
Woolly sea-blite	3	3.5	4	3	2.14	3	2.10
Bigelovii pickleweed	2.5	3	4.5	4	3.14	3.75	1.83
Common rail	3.5	2	3.25	2.5	3.29	2.57	1.45
Salt marsh snail	3	3	3	3.5	3.43	4	1.31
Topsmelt	2.5	2	1.25	3	3.29	2.64	0.76
California horned snail	3	3	1	3.5	3.43	3	0.73

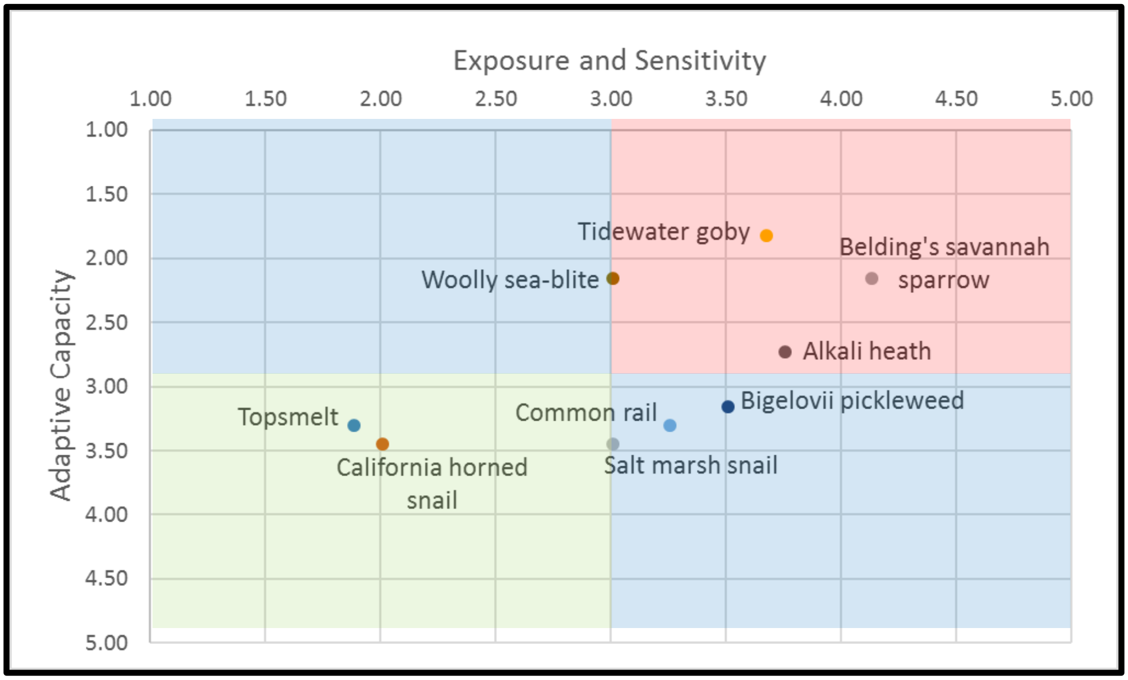


Figure 5-17. Estuarine Focal Species Vulnerability Scores

Of the remaining six focal species, California horned snail and topsmelt were considered to have low sensitivity and relatively low exposure scores to sea level rise effects, with a “moderate” to “moderate-high” capacity to adapt to the environmental changes, and therefore, were the least vulnerable focal species within the estuarine habitat (Figure 5-17).

The remaining four estuarine species are woolly sea-blite, Bigelovii pickleweed, common rail, and salt marsh snail. These species generally had higher sensitivity and exposure scores, although they also had higher scores associated with the ability to adapt to sea level rise (Table 5-20 and Figure 5-17). The vulnerability of wooly sea-blite fell on the cusp of the highly vulnerable quadrant. It is a perennial plant that occurs on the edges of salt marshes, on bluffs above beaches, and in other saline coastal environments. It is included in the California Native Plant Society List 4.2, meaning it has a limited distribution and that it is moderately threatened (CNPS 2017), although it is not listed by the federal or State governments.

Freshwater Ecosystem Focal Species Results

As discussed in the habitats section, tidal inundation could affect 28% (approximately 750 acres) of unincorporated freshwater habitats (Table 5-13). It is generally expected that freshwater systems will experience more frequent flash flood events due to brief and intense storms (EcoAdapt, 2017). The county's steep local topography on the North and South Coast is likely to exacerbate flash flood events. An overall decline in stream and river flows is also predicted (EcoAdapt, 2017). Along with the sea level rise impacts, predicted changes in precipitation may cause additional stressors to focal species such as cottonwoods and arroyo willows, which are heavily reliant on water availability in riparian areas.

The habitat analysis also showed that the greatest acreage of freshwater ecosystems in the unincorporated County that may be exposed to sea level rise is located on the Central Coast (Figures D-16 and D-17). Unincorporated portions of Calleguas Creek, the Santa Clara River, and the Ventura River combine to account for 92% of freshwater habitats that may be affected by combined flood hazards with 58 inches of sea rise and a 1% annual chance storm event. While flooding is important to maintain water flow and provide restoration to aquatic biota by scouring accumulated sediment and moving it to other areas along the channel, large wildfires such as the recent Thomas Fire may cause significant changes in water quality, sedimentation, light levels, riparian cover, leaf litter input, invertebrate populations, and algal community structure (Cooper et al. 2014; Morrison and Kolden 2015). These changes can be an additional exposure stressor in conjunction with sea level rise on focal species like the tidewater goby, arroyo chub, Southern steelhead, and Southwestern pond turtle.

Table 5-21. Summary of freshwater focal species vulnerability and confidence scores.

Freshwater Focal Species	Exposure Score	Exposure Confidence Score	Sensitivity Score	Sensitivity Confidence Score	Adaptive Capacity Score	Adaptive Capacity Confidence Score	Vulnerability Score
Southwestern pond turtle	3.5	3	4.5	3	2.29	3	2.73
Arroyo chub	2.0	3	3	3	3.00	3	1.33
Cottonwood	2.5	3.5	2.75	3	3.29	3	1.22
Southern steelhead	2.75	3	1.75	2	2.71	2.57	1.15
Arroyo willow	2.63	3	2.25	3	3.32	2.86	1.07

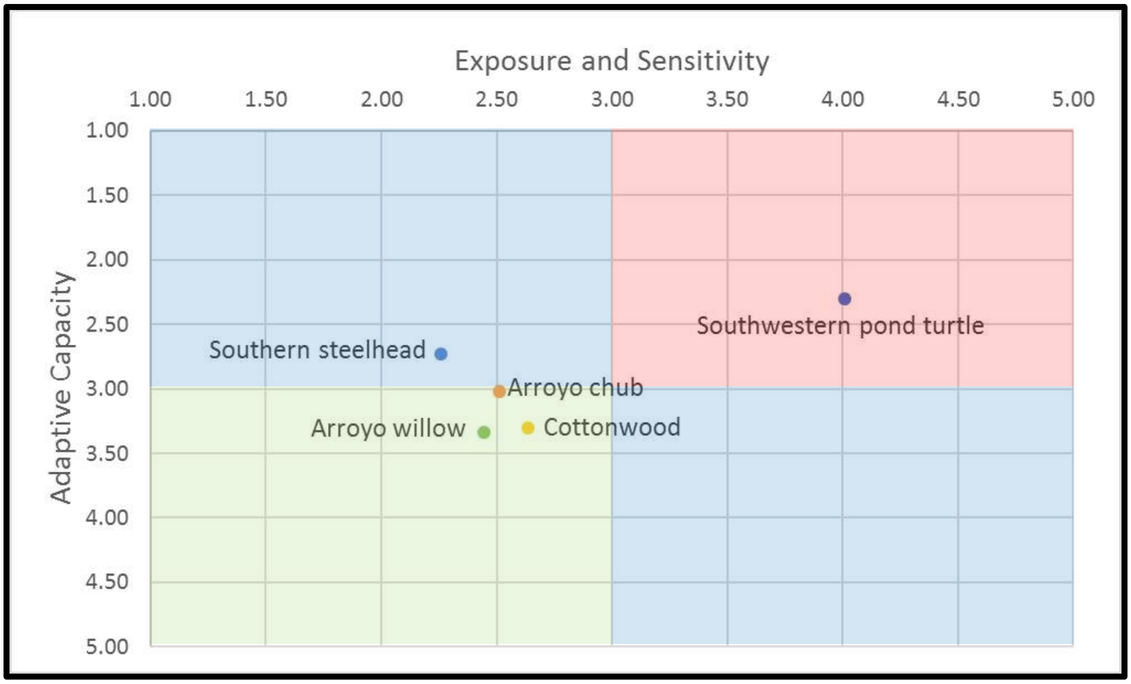


Figure 5-18. Freshwater Focal Species Vulnerability Scores

Southwestern Pond Turtle

The Southwestern pond turtle is within the highly vulnerable quadrant due to "moderate-high" sensitivity (the average score was 4.5) and exposure rankings (the average score was 3.5) and a "low-moderate" adaptive capacity score of about 2.3 (Table 5-21). Sensitivity and exposure scores were high because of the turtle's slow extirpation from its range due to drought and fires, its need for ponded slow-moving waters, access to quality adjacent upland habitat needed to complete the reproductive process, and its susceptibility to poor water quality, temperature fluctuations, and pollution. The species is also sensitive to habitat fragmentation associated with adjacent upland habitats.

The Southwestern pond turtle relies upon available freshwater and estuarine invertebrates, small fishes, and vegetation. It is a key species in the nutrient and mineral cycling associated with these ecosystems. The turtle has narrow physiological thresholds and is very sensitive to exposure to high salinity. The salinity affects its ability to function physiologically, including its ability to drink and eat (Agha et al. 2018). It is extremely vulnerable to tidal inundation and salinity changes. The Working Group felt that, while the species had a "low-moderate" adaptive capacity score, if appropriate freshwater estuarine habitats were conserved in order to provide a buffer and area to retreat from the increasing tidal inundation, the turtle's chances of persisting through the projected sea level rise changes to its environment would improve. Adjacent upland habitat would also still be needed.

Southern Steelhead Trout

The Southern steelhead Trout had lower sensitivity (the average score was 1.75) and exposure scores (the average score was 2.75) than the Southwestern pond turtle, because of its adaptive ability to water temperature changes and salinity. Steelhead utilize both the estuarine and freshwater environments, and non-sea level rise stressors make the population vulnerable. Juveniles are vulnerable to predators, and adult survival is often impacted by physical constraints such as dams, low water flow rates, and changes in water quality due to wildfire. The trout was rated to have a "low-moderate" adaptive capacity score of about 2.7, primarily due to the physical factors unrelated to sea level rise. Th Working Group recommended prioritization of management activities such as removal of barriers, restoration of habitat, and management of sediment discharge that would also improve resilience to sea level rise.

Cottonwood and Arroyo Willow

Cottonwoods and the arroyo willow were both ranked with "low-moderate" exposure scores and "low-moderate" sensitivity scores (Table 5-21 and Figure 5-18) because they are somewhat tolerant to saline conditions associated with sea level rise, although they require riparian ecosystems that function based upon freshwater availability and are unlikely to be able to adapt to daily tidal inundation.

Cottonwoods are mostly dependent upon abiotic factors (e.g., moist alluvium soils and flood related disturbance) rather than interactions with other species (Mahoney, J.M. and Rood, S.B. 1998; Stromberg, J. 1993). Working Group participants felt that if habitat was provided beyond the extent of the areas projected to be exposed to sea level rise, the species would persist due to its high dispersal ability (suckers, seeds, and roots distributed through flooding events/wind).

Arroyo willows were assessed with similar characteristics as the cottonwood. This willow is a tough pioneer species that can withstand moderate salinity provided that freshwater is available in adequate quantities. The arroyo willow was not seen as having increased exposure to sea level rise as long as riparian areas remain intact upstream. It may be able to propagate sites downstream with root runners and cuttings. The Working Group thought the tree could be successfully managed because of its ability to easily disperse seeds, as long as appropriate freshwater sources are available. Respondents also felt that cottonwoods have societal value based upon their perceived beauty, and they provide shade and habitat for other nesting and roosting species.

6. ADAPTATION

6.1 Introduction

Adaptation to sea level rise hazards involves a range of small and large adjustments in natural or human systems that occur in response to already experienced or expected coastal hazards. Adaptation planning involves a wide range of policy, project-level, and programmatic measures that can be undertaken in advance of the potential impacts, or reactively, depending on the degree of preparedness and the willingness to tolerate risk. Good adaptation planning should improve community resilience to coastal hazards and specifically address the identified vulnerabilities.

Maladaptation, in contrast to adaptation, is a result of adjustments in natural or human systems that are or become more harmful than helpful. An example of maladaptation is the levee system for the City of New Orleans. While the levees provided short-term adaptation and allowed communities to remain in areas that lie below sea level, they actually increased the long-term vulnerability to flooding—both by providing a false sense of security and by being under-engineered or insufficiently maintained to account for the impact that large storm events could cause.

Given the range of impacts that could occur as a result of sea level rise, and the uncertainties associated with sea level rise projections, the County will need to use adaptation strategies to effectively address coastal hazard risks and protect coastal resources over time. Good adaptation stems from a solid understanding of the County's specific risks, the projected timing of impacts, and the physical processes responsible for causing the risks, now and in the future.

6.2 Adaptation Planning

Sea level rise adaptation planning requires considering each vulnerable sector and taking effective and timely action to alleviate the range of consequences. One adaptation measure may reduce the risk to one sector, but cause issues in another sector or lead to unintended secondary consequences. One of the most important secondary consequences that the County must consider is the impact of the various strategies on the long-term health of the beaches. The County's desirable beaches provide substantive economic revenue and, in some cases, define the community's identity. Ventura County beaches are highly valued by both residents and visitors alike. Allowing the loss of these beaches would contribute to a diminished quality of life.

Good adaptation planning considers these secondary impacts and how different adaptation measures could be used to alleviate vulnerability in one sector, and interact with the other measures for other sectors. An interwoven tapestry of adaptation measures is needed to develop a sustainable community adaptation plan. In considering secondary impacts, it is also important to ensure that adaptation strategies are socially equitable and do not benefit one population to the detriment of another, or reinforce existing environmental and societal inequities. This approach is consistent with the recent State of California Sea-Level Rise Guidance, 2018 Update and the Coastal Commission Sea Level Rise Policy Guidance (2015). Some adaptation recommendations for vulnerable populations can be found in Appendix C.

Good adaptation planning is also "collaborative" through the consideration of interconnected ecological, social, political, and economic systems. A local example of collaboration between Ventura County and other jurisdictions is represented by BEACON. This organization facilitates a planning process for regional sediment management that leverages local resources and helps to avoid unintended secondary consequences to neighboring jurisdictions.

Sea level rise risks can be addressed by reducing vulnerability or exposure through the development of forward-thinking policies or implementation of specific projects. Inaction will likely result in costly damage and emergency repairs. Failure to take forward-thinking approaches to adaptation will result in increasing clean-up and maintenance costs. The County has a long history of combatting coastal hazards with varied success. Innovative retreat projects have shown promise in Surfer's Point in the City of Ventura. Sand retention has proven to be successful in some areas, but at the expense of increased erosion downcoast in other areas.

The County must choose what level of risk it is willing to tolerate. Increasing infrastructure resilience, transferring the risk from the public sector to the private sector, negating the risk through technological changes such as improved construction materials, retreat, or new monitoring programs can be used to help manage risk. Real estate disclosures of coastal and climate change hazards could help to shift liabilities from the County to individual property owners.

As not all issues can or should be addressed at once, it is important that the responses to risks be prioritized and phased to maximize the use of the County's resources while avoiding a costly emergency response. Specific early investments, particularly in long-lasting infrastructure, can avoid costly maintenance or repairs in the future. For example, an economic analysis conducted for Imperial Beach shows that by purchasing properties and leasing them back to owners, the City could realize its return on investment within a normal 30-year mortgage.

It is quite probable that an overarching adaptation plan will use a variety of approaches over time, as shown in the example of an implementation timeline, below (Figure 6-1). Hybrid approaches through time will likely cycle from protect, to accommodate, and then to retreat, as the sea level rise impacts exceed individual strategies' ability to reduce vulnerabilities from higher, more frequent exposure. For example, maintaining the existing armoring on the North Coast may be combined with some sediment retention and beach nourishment to increase recreation opportunities and provide more storm protection. Policies could be implemented that require redevelopment to raise foundations or change foundation types so that buildings are modified over time.

Many of these adaptation strategies take substantial time to implement. For example, the Surfer's Point took 16 years to conceive, design, permit, finance and construct. Advanced planning and fundraising is key. Also needed is the identification of important thresholds that will trigger planning processes and implementation efforts. Sea level rise policies in the LCP can be triggered by specific thresholds that prompt specific actions in the future. Factors to consider when prioritizing projects include: imminent risk, public health and safety, available funding sources, legal mandates, planning consistency, capacity and level of service, cost-benefit relationship, environmental impacts, and public support. Risks that present the most serious consequences and are projected to occur first should raise a project's level of priority.

This Report should increase understanding of the vulnerabilities associated with coastal hazards and encourage decision-makers to consider these potential impacts without creating further vulnerabilities or liabilities. As this is the beginning of the County's process of developing its adaptation response, early initiatives may be exploratory in nature and aim to identify potential changes or actions that respond to the vulnerabilities identified to be of most immediate concern.

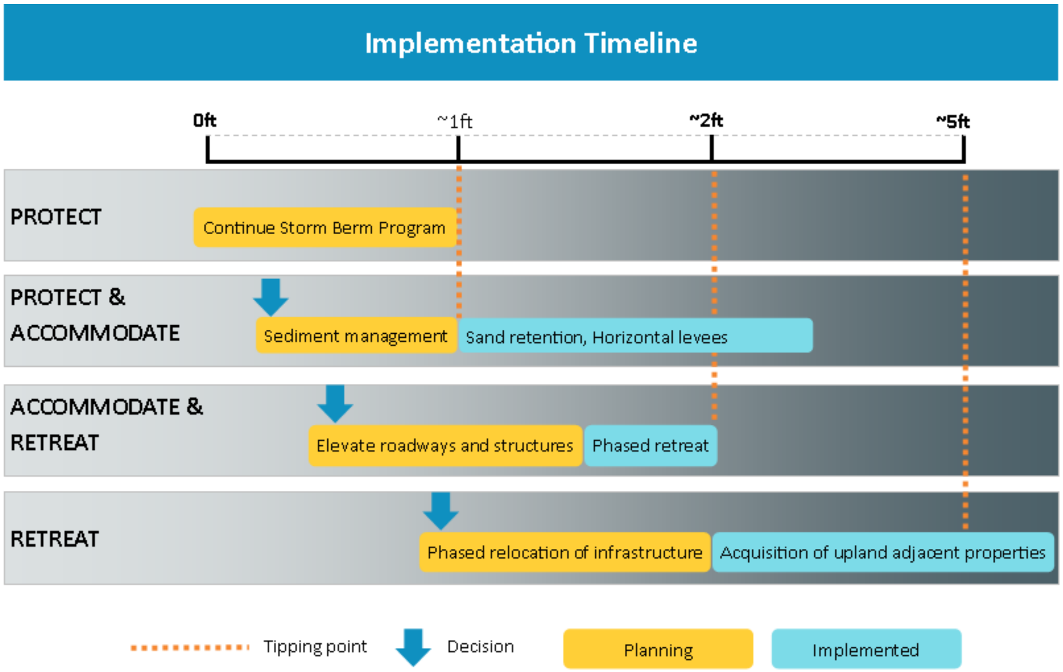


Figure 6-1. Example of an Implementation and Sea Level Rise Accommodation Timeline.

Reviewing current County programs and policies associated with risk reduction is the first step to identify potential short-term adjustments to alleviate or eliminate risks. Where adjustments to current practices will not sufficiently address the risks, more substantial actions should be identified and implemented.

Of utmost importance to the successful implementation of an adaptation strategy is communicating the issues and proposed response strategies to the community. Studies repeatedly show that knowledgeable and prepared communities with educated decision-makers that understand how to respond to extreme events will be far more resilient. An informed community is also more likely to implement programs and make decisions that reflect its knowledge of the projected changes. All of these factors enable community members to contribute to developing a prosperous, livable, and affordable lifestyle in the face of sea level rise.

6.3 Maladaptation

According to the Intergovernmental Panel on Climate Change, maladaptation inadvertently increases the vulnerability to sea level rise hazards and can be a result of badly planned adaptation actions or decisions that place greater emphasis on short-term outcomes ahead of longer-term threats.

One of the most significant concerns with maladaptation is that it reduces incentives to adapt for the future by establishing a false sense of security in the near term that places the community, its assets, and residents at risk. Maladaptation occurs when efforts intended to “protect” communities and resources result in increased vulnerability, often realized indirectly or too late after a direction has been set. Often these maladapted strategies are costly and time consuming and misplace financial resources that often result in more expensive future disasters. For instance, previously unaffected areas can become more prone to sea level rise-induced hazards if the system that is being altered is not sufficiently understood. Likewise, if too much focus is placed on one time period—either the future or the present—effects on the other can be ignored, resulting in an increased likelihood of impacts from climate-induced hazards.

Key characteristics of maladaptation include:

- Creates a more rigid system with a false sense of security and severe consequences;
- Increases greenhouse gas emissions; and
- Reduces incentives to adapt.

Avoiding maladaptation is critical to a successful sea level rise resilience strategy. To do so, the County must first be able to make informed decisions based on an accurate vulnerability assessment, and determine its own level of tolerance. Flexibility and a precautionary approach are critical to avoiding maladaptation in the adaptation planning process.

6.4 Challenges

Adaptation planning comes with challenges. A single jurisdiction like the County of Ventura cannot likely adapt to sea level rise on its own. A successful process requires regional dialog and partnerships to identify, fund, and implement solutions. Challenges range from acquiring the necessary funding for adaptation strategies, communicating the need for adaptation to elected officials and local departments, and gaining commitment and support from federal and state government agencies to address the realities of local adaptation challenges. Lack of resources and limited coordination between local, state, and federal agencies can add to the challenges for local governments to make significant gains in adaptation. Regional partnerships and dialogs between the County of Ventura, local jurisdictions, and regional entities such as BEACON, will be paramount in developing and implementing sound regional strategies.

When identifying appropriate adaptation responses, the County should consider taking a precautionary approach by using the following principles (adapted from Barnett and O'neill 2010):

1. The strategy should support the protective role of ecosystems and sustain their physical processes.
2. The strategy should avoid disproportionately burdening the most vulnerable citizens.
3. The strategy should avoid high-costs, unless holistic economic work (including ecosystem services, recreation, and damage) demonstrates a strong net benefit over time.
4. The strategy should incentivize adaptation (e.g., reward early actors).
5. The strategy should increase flexibility and not lock the community into a single long-term solution.
6. The strategy should reduce decision-making time horizons to better incorporate the evolving science of sea level rise.
7. The strategy should not increase long-term greenhouse gas emissions.
8. The strategy should reduce long-term maintenance costs over time.

6.5 Protect, Accommodate, and Retreat

Coastal adaptation generally falls into three main categories: protect, accommodate, or retreat. There are also the options of doing nothing or hybridizing the strategies over time.

The Protection Approach

Protection strategies employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself.

Protection strategies can be divided into "grey" and "green" defensive measures, and then further divided into "hard" and "soft" measures. A "grey", "hard" approach is usually an engineered structure that can be positioned either alongshore (such as a seawall, revetment, or offshore breakwater) or cross-shore (such as a groin or harbor jetty). Cross-shore structures tend to trap sand and widen the beach upcoast of the structure. A "soft" protection approach may be to nourish beaches, while a "green", "soft" approach may be to restore sand dunes.

Although the California Coastal Act clearly allows protective devices for "existing development," it also directs that new development be sited and designed to not require future protection that may alter a natural shoreline. It is important to note that most protective devices are costly to construct, require increasing maintenance costs, and have secondary consequences to recreation, habitat, and natural defenses such as beaches and wetlands. Many of these consequences are forms of maladaptation, especially if the protective device was intended to be a long-term solution.

The Accommodation Approach

Accommodation strategies employ methods that modify existing development or design new development standards to decrease hazard risks and therefore increase resilience to the impacts of sea level rise. On an individual project scale, these accommodation strategies include actions such as elevating structures, performing retrofits, using materials to increase the strength of development to handle additional wave impacts, building structures that can easily be moved and relocated, or using additional setback distances to account for acceleration of erosion. On a community-scale, accommodation strategies include many of the land use designations, zoning ordinances, or other measures that require the above types of actions, as well as strategies such as clustering development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas.

The Retreat Approach

Retreat strategies relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include creating land use designations and zoning ordinances that encourage building in less hazardous areas or gradually removing and relocating existing development. Acquisition and buy-out programs, transfer of development rights programs, and removal of structures where the right to protection is waived (e.g., via a permit condition) are examples of strategies designed to encourage retreat.

The Do-Nothing Approach

Choosing to "do nothing" or following a policy of "non-intervention" may be considered a form of adaptation. This approach tends to result in substantial damage and potentially costly repairs. As natural disasters have occurred around the country in recent years and the slogan of "We will rebuild!" continues to echo in affected areas, the huge expense of taking this approach is increasingly apparent. However, in most cases, the strategies for addressing sea level rise hazards will require proactive planning to balance protection of coastal resources with development.

The Hybrid Approach

For purposes of implementing the California Coastal Act, no single category or even specific strategy should be considered the "best" option as a rule. Different types of strategies will be appropriate in different locations and for different hazard management and resource protection goals. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies chosen may need to change over time. Nonetheless, it is useful to think about the general categories of adaptation strategies to help frame the discussion around adaptation and to consider the land use planning and regulatory options that are available to the County.

6.6 Secondary Impacts

Almost all adaptation strategies have secondary impacts associated with them. Some of these impacts are associated with construction or escalating maintenance costs. Other impacts can degrade ecosystems or limit recreational opportunities. Still others can affect community aesthetics or property views. Often one of the most controversial issues is associated with adaptation strategies for the long-term preservation of a beach, which pits private versus public interests with strong overtures to property rights, social justice, and community inequality.

Some of the secondary impacts are minor issues, such as short-term impacts to habitat due to the removal of infrastructure, the undergrounding of overhead power lines, or other construction activity. Others can be quite substantial and expensive, such as the burial of beaches under rocks following construction of revetments, or a retrofit to a critical infrastructure component, such as installing pumps to prevent saltwater intrusion into the wastewater system. Another example of secondary impacts is the potential impact to visual resources associated with accommodation strategies that elevate buildings or coastal armoring through increased height limits to protect against elevated levels of flooding.

Many communities have relied on setbacks in an effort to reduce hazard risk, and some, such as Goleta and Monterey, are currently experimenting with establishing setback lines that are based on modeled accelerated erosion rates and additional factors of safety. Setbacks alone could be considered potentially maladaptive because they eventually lead to structures being at risk. Therefore, it is important to have elements of retreat, such as movable foundations. Further, triggers for action, such as relocation through voluntary public acquisition, should take the place or work in conjunction with regulatory setback policies. However, any form of public acquisition, whether through bonds or other means, can be very costly to public taxpayers.

Coastal Armoring

Coastal armoring can adversely affect a wide range of coastal resources and uses that the California Coastal Act protects. For example, coastal armoring often impedes or degrades public access and recreation along the shoreline by occupying beach area or tidelands and by reducing shoreline sand supply through active and passive erosion. The County has many examples of adverse impacts from shoreline protective devices, particularly along the Rincon Parkway (Figure 2-5) and Pacific Coast Highway in the South Coast.

Protecting the back of the beach ultimately leads to active erosion and the loss of the beach on adjacent unarmored sections. Shoreline protection structures therefore raise serious concerns regarding consistency with the public access and recreation policies of the California Coastal Act. Such structures can also be placed in coastal waters or tidelands and harm marine resources and biological productivity, which is in conflict with California Coastal Act Sections 30230, 30231, and 30233. They often degrade the scenic qualities of coastal areas and alter natural landforms, which is in conflict with Section 30251. Finally, by disrupting landscape connectivity, structures can prevent the inland migration of intertidal and beach species during large wave events. This disruption may prevent intertidal habitats, saltmarshes, beaches, and other low-lying habitats from advancing landward as sea level rises over the long-term.

It is important to note that shoreline protection devices such as seawalls and revetments have several inevitable secondary impacts, including the following:

Placement Loss

Wherever a hard structure is built, there is a footprint of the structure. The footprint of this structure results in a loss of coastal area known as placement loss. This inevitable impact can bury the beach beneath the structure and reduce the usable beach for recreation or habitat purposes. For example, a 20-foot high revetment may cover up to 40 horizontal feet of dry sand beach. A vertical seawall or sheet pile groin typically has a smaller placement loss than a revetment or rubble mound groin.

Active Erosion

Active erosion refers to interactions between coastal armoring and the physical processes that increase erosive forces. Some of these processes can include wave reflection, positive wave interference which causes waves to get bigger before breaking, increased beach scouring, and "end effects". In some cases, the armoring may increase longshore currents, which increases the rate of beach loss in front of the structure, and in turn escalates the erosion effects at the “ends” of adjacent, unarmored sections of the coast. Active erosion is typically site-specific and dependent on the length of structure, sand supply, wave direction, specific design characteristics, and other local factors. There is some debate in the scientific literature, particularly in areas where sediment transport direction can reverse, but there are clear indications in the Santa Barbara littoral cell of active erosion causing increases in longshore currents and resulting in seasonal coarsening of grain sizes and erosion hotspots (Revell et al. 2008).

Passive Erosion

Wherever a hard structure is built along a shoreline undergoing long-term net erosion, the shoreline will eventually migrate landward to (and potentially beyond) the structure. The effect of this migration will be the gradual loss of beach in front of the seawall or revetment as the water deepens and the shore face moves landward while the backshore cannot erode. While private structures may be temporarily saved, the public beach is lost. This process of passive erosion is a generally agreed-upon result of fixing the position of the shoreline on an otherwise eroding stretch of coast and is independent of the type of seawall constructed. Passive erosion will eventually destroy the recreational and habitat beach area unless the shoreline is continually replenished. Excessive passive erosion may impact the beach profile such that shallow areas required to create breaking waves for surfing are lost.

Limits on Beach Access

Depending on the type of structure, impacts to beach access vary. Typically, vertical beach access (ability to get to the beach) can be impacted unless there are special features integrated into the engineering design of the individual structure such as stairs or contoured trails; however, as passive erosion occurs, lateral (along) beach access is usually impacted.

Downcoast Erosion

Some structures such as groins and breakwaters that are oriented cross-shore are effective at trapping sand as it moves along the coast. These sediment retention structures can cause downcoast impacts. Ventura County has already experienced this type of erosion as a result of the construction of the Santa Barbara Harbor in 1928 which caused an erosion wave, or moving erosion hotspot, that traveled downcoast. This caused major erosion to the dunes of Sandyland in Carpinteria. The Pierpont groins were constructed in response to this erosion wave to retain sand in front of that neighborhood. Recent erosion at the City of Port Hueneme is also from downcoast erosion caused by a lack of dredging that bypasses sand around the Channel Islands Harbor and Port Hueneme navigational channels.

Economic Issues

The potential use of local, state, or federal subsidies to build or protect private property, or obtain subsidized insurance coverage, can create environmental justice issues. For example, when a private armoring structure covers a public beach it results in a loss of public resources. Shoreline protective devices for private property should be confined to private property, but as sea level rises, and the tideline moves in, then the footprint of the structure becomes public property. The public that used the beach is typically not directly compensated for this loss of valuable property, but the State Lands Commission may request lease revenues from the owner of the protective device.

The potential economic impacts of a seawall, which should be considered in the assessment or potential adaptation strategies include:

- Changes to property values;
- Capital costs from seawall construction and recurrent costs associated with seawall maintenance and managing any off-site erosion impacts;
- Erosion impacts on adjacent properties; and
- Visual amenity and beach access impacts.

Ecological Impacts

Scientific studies have documented a loss of ecosystem services such as narrowing and/or loss of specific beach ecological habitat zones, and reduction in biodiversity when seawall-impacted beaches were compared to natural beaches. This has shown to reduce kelp deposition on the beach, and result in the loss of sand crabs, shorebirds and grunion (Dugan et al. 2008).

Sediment Management

Sediment management is another option to combat erosion by building wider beaches and higher sand dunes, or through increasing wetland accretion. However, sediment management can be costly, and ongoing sand supplies for large projects can be difficult to source. Secondary impacts from sediment management vary depending on the volume, frequency and method of placement, but typically include substantially degrading sandy beach ecosystems, temporary changes to flooding, changes to surfing resources, and limiting recreational use.

Longshore sediment movement rates are largely determined by the relationship of wave direction to shoreline orientation. On the North and South Coasts, waves approach the shoreline at an angle which causes rapid sediment transport. On the Central Coast, the waves approach the shoreline more directly, resulting in slower sediment transport rates. Along the North and South Coast, sediment retention could be effective through the use of artificial reefs or groins, however these also have risks of secondary impacts which could cause downcoast erosion.

7. REFERENCES

Agha, M., Ennen, J. R., Bower, D. S., Nowakowski, A. J., Sweat, S. C. and Todd, B. D. (2018). Salinity tolerances and use of saline environments by freshwater turtles: implications of sea level rise. Biol Rev.

Barbier, E. B., S. D. Hacker, C. Kennedy, E. W. Koch, A. C. Stier, and B. R. Silliman (2011). The value of estuarine and coastal ecosystem services. Ecological Monographs 81: 169-193.

Barnard, P.L., Revell, D.L., Hoover, D., Warrick, J., Brocatus, J., Draut, A.E., Dartnell, P., Elias, E., Mustain, N., Hart, P.E. and Ryan, H.F., (2009). Coastal processes study of Santa Barbara and Ventura County, California: U.S. Geological Survey Open-File Report 2009-1029, 926 pp., http://pubs.usgs.gov/of/2009/1029/

Beier, P., Penrod, K., Luke, C. L. A. U. D. I. A., Spencer, W., & Cabañero, C. (2006). South Coast Missing Linkages: restoring connectivity to wildlands in the largest metropolitan area in the United States. Connectivity conservation. Cambridge University Press, Cambridge, United Kingdom, 555-586.Piovia-Scott et al., 2013

Beller, E. E.; Grossinger, R. M.; Salomon, M.; Dark, S.; Stein, E.; Orr, B. K.; Downs, P. W.; Longcore, T.; Coffman, G.; Whipple, A.; et al. (2011). Historical Ecology of the lower Santa Clara River, Ventura River, and Oxnard Plain: an analysis of terrestrial, riverine, and coastal habitats. SFEI Contribution No. 641. SFEI: Oakland.

Bromirski, P. D., A. J. Miller, R. E. Flick, and G. Auad (2011). Dynamical suppression of sea level rise along the Pacific coast of North America: Indications for imminent acceleration, J. Geophys. Res., 116, C07005, doi:10.1029/2010JC006759.

Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) (2009). Coastal Regional Sediment Management Plan Central Coast from Pt. Conception to Pt. Mugu. Available online: http://www.dbw.ca.gov/csmw/pdf/CRSMP_Report_FINAL_30Mar2011.pdf

California Coastal Commission (CCC) (2013). Local Coastal Program Update Guide. Available online: https://documents.coastal.ca.gov/assets/lcp/LUPUpdate/LCPGuidePartI_Full_July2013.pdf

California Coastal Commission (CCC) (2015). Sea Level Rise Policy Guidance. Available online: http://documents.coastal.ca.gov/assets/slr/guidance/August2015/0_Full_Adopted_Sea_Level_Rise_Policy_Guidance.pdf.

California State Coastal Conservancy (2016). Ormond Beach Wetlands Restoration Plan. Staff Recommendation May 26, 2016. Available online: http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2016/1605/20160526Board20_Ormond_Beach_Wetlands.pdf

California State Coastal Conservancy (2017). Ormond Beach Wetlands Restoration Project [website]. Available online: http://scc.ca.gov/2010/01/07/ormond-beach-wetlands-restoration-project/

California Department of Finance (2016). E-1 Population Estimates for Cities, Counties, and the State — January 1, 2015 and 2016. Available online: http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-1/

California Department of Parks and Recreation (2002). California State Parks Western Snowy Plover Management 2002 Systemwide Annual Report Overview. Available online: https://www.fws.gov/arcata/es/birds/WSP/documents/siteReports/California/CAStateParks/2002_CA_State_Park_Annual_Report.pdf

California Department of Parks and Recreation (2003). California State Parks Western Snowy Plover Management 2003 Systemwide Annual Report Overview. Available online: https://www.fws.gov/arcata/es/birds/WSP/documents/siteReports/California/CAStateParks/2003_CA_State_Park_Annual_Report.pdf

California Department of Parks and Recreation (2007). California State Parks Western Snowy Plover Management 2007Systemwide Annual Report Overview. Available online: https://www.fws.gov/arcata/es/birds/WSP/documents/siteReports/California/CAStateParks/2007_CA_State_Park_Annual_Report.pdf

California Department of Parks and Recreation (2009). California State Parks Western Snowy Plover Management 2009 Systemwide Annual Report Overview. Available online: https://www.fws.gov/arcata/es/birds/WSP/documents/siteReports/California/CAStateParks/2009_CA_State_Park_Annual_Report.pdf

California Department of Parks and Recreation (2017). Attendance Estimates for Selected Beaches.

California Native Plant Society (2017). California Native Plant Society Rare Plant Rankings Available online: https://www.cnps.org/rare-plants/cnps-rare-plant-ranks

California Department of Fish and Wildlife (2018). California Natural Diversity Database. Available online: https://www.wildlife.ca.gov/Data/CNDDB/Maps-and-Data California State Board of Equalization (CABOE). 1978. California Constitution: Article 13A [Tax Limitation]. http://www.leginfo.ca.gov/.const/.article_13A.

National Oceanic Atmospheric Administration (NOAA) (2018). Tide gauges for Santa Barbara and Santa Monica. www.tidesandcurrents.noaa.gov

National Oceanic Atmospheric Administration (NOAA) (2014). “California Tsunami Evacuation.”

Cayan, D, Tyree, M, Dettinger, M, Hidalgo, H. Das, T., Maurer, E, Bromisrksi, P Graham, N, Flick, R. (2009). Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment. CEC-500-2009-014-F. Available: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2009-014-F

Climate Central (2014). Surging Seas Available: http://sealevel.climatecentral.org/ssrf/california

Dugan, J. E., Hubbard, D. M., McCrary, M. D., & Pierson, M. O. (2003). The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of Southern California. Estuarine, Coastal and Shelf Science, 58, 25-40.

Dugan, J.E., Hubbard, D.M., Rodil, I., Revell, D.L., & Schroeter, S. (2008). Ecological effects of coastal armoring on sandy beaches. Marine Ecology, 29, 160–170.

Dugan, J. E., Hubbard, D. M., Page, H. M., & Schimel, J. P. (2011). Marine macrophyte wrack inputs and dissolved nutrients in beach sands. Estuaries and Coasts, 34(4), 839-850.

EcoAdapt (2017). Climate Change Vulnerability Assessment for the Southern California Climate Adaptation Project. Southern California River and Stream Habitats. Available online: http://www.ecoadapt.org/programs/adaptation-consultations/socal

Engel, J.D. (2008). Southern Foredune Community at 30732 Pacific Coast Highway. California Coastal Commission.

Engel, J.D. (2014). Potential Impacts of the Broad Beach Geologic Hazard Abatement District Proposed Project on Terrestrial and Marine Resources in and Adjacent to the Project Footprint, Broad Beach, Malibu, California. California Coastal Commission.

ESA PWA (2012). Coastal Resilience Ventura – Technical Report for Coastal Hazards Mapping. Prepared for the Nature Conservancy, 7/31/2013, 59 pgs. Available at: http://maps.coastalresilience.org/ventura/methods/CRV_Hazards_Mapping_Technical_Report.pdf

Federal Emergency Management Authority (FEMA) (2005). Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States. Oakland, CA. Prepared for the U.S. Department of Homeland Security. Available: http://www.fema.gov/media-library-data/840f98e4cb236997e2bc6771f04c9dcb/Final+Draft+Guidelines+for+Coastal+Flood+Hazard+Analysis+and+Mapping+for+the+Pacific+Coast+of+the+United+States.pdf .

Federal Emergency Management Authority (FEMA) (2006). “Hazards U.S. Multi-Hazard (HAZUSMH).” In Computer Application and Digital Data Files on 2 CD-ROMs. Washington, D.C.: Jessup. http://www.fema.gov/plan/prevent/hazus/.

Federal Emergency Management Authority (FEMA) (2005). Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States. Oakland, CA. Prepared for the U.S. Department of Homeland Security. Available: http://www.fema.gov/media-library-data/840f98e4cb236997e2bc6771f04c9dcb/Final+Draft+Guidelines+for+Coastal+Flood+Hazard+Analysis+and+Mapping+for+the+Pacific+Coast+of+the+United+States.pdf .

Federal Emergency Management Authority (FEMA) (2006). “Hazards U.S. Multi-Hazard (HAZUSMH).” In Computer Application and Digital Data Files on 2 CD-ROMs. Washington, D.C.: Jessup. http://www.fema.gov/plan/prevent/hazus/.

Federal Emergency Management Authority (FEMA) (2010). FEMA Effective Flood Insurance Rate Maps and Flood Insurance Study for the County of Ventura.

Federal Emergency Management Authority (FEMA) (2017). FEMA Preliminary Flood Insurance Rate Maps and Flood Insurance Study for the County of Ventura.

Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group) (2017). Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust.

Gulf Engineers and Consultants (GEC) (2006). Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. Prepared for the U.S. Army Corps of Engineers New Orleans District.

Hapke, C., D. Reid, D. Richmond, P. Ruggiero, and J. List (2006). National Assessment of Shoreline Change, Part 3: Historical Shoreline Change and Associated Land Loss Along Sandy Shorelines of the California Coast. Santa Cruz, California: U.S. Geological Survey Open-file Report 2006-1219, 79p.

Hapke, C. and D. Reid (2007). National Assessment of Shoreline Change, Part 4: Historical Coastal Cliff Retreat along the California Coast. Santa Cruz, California: U.S. Geological Survey Open-file Report 2007-1133, 57p.

Hardy, M. A., & Colwell, M. A. (2012). Factors influencing Snowy Plover nest survival on ocean-fronting beaches in coastal northern California. Waterbirds, 35(4), 503-656.

Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore (2009). The Impacts of Sea-Level Rise on the California Coast. California Climate Change Center. Available: http://pacinst.org/wp-content/uploads/sites/21/2014/04/sea-level-rise.pdf.

Hubbard, J., et al. (2014). Structure and seismic hazard of the Ventura Avenue Anticline and Ventura Fault, California: Prospect for large, multisegment ruptures in the Western Transverse Ranges, Bull. Seismol. Soc. Am., 104, 1070–1087.

Hunt, I. (1959). Design of Seawalls and Breakwaters. Journal of Waterways and Harbors Division, Proceedings of the American Society of Civil Engineers. Vol 85, No. WW3, Part 1, September 1959, pp. 123-152.

Hutto, S.V. and K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg (2015). Climate Change Vulnerability Assessment for the North-central California Coast and Ocean. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473pp.

Jensen, N. J., Magney, D. L., & Chapter, C. I. (2007). The Habitat of Astragalus pycnostachyus var. lanosissimus (Ventura marsh milk-vetch) and an Assessment of Potential Future Planting Sites. Submitted to Channel Islands Chapter, California Native Plant Society. Kentosh, J. 2008

Josselyn, M. and DeGraff, T. (2007). Final Biological Assessment, Ormond Beach, Oxnard, Ventura County California. Prepared for Aspen Environmental Group. Agoura Hills, CA. 146 pp.

Komar, P.D., W.G. McDougal, J.J. Marra, and P. Ruggiero (1999). The rational analysis of setback distances: applications to the Oregon Coast. Shore and Beach 67(1):41-49.

King, Philip., and Symes, D. (2004). "Potential Loss in GNP and GSP from a Failure to Maintain California's Beaches", Shore and Beach, Fall 2004.

King, P., A. McGregor and J. Whittet (2015). Can California Coastal Managers Plan for Sea-Level Rise in a Cost-Effective Way. Journal of Environmental Planning and Management.

Limber, P. P. Barnard, C. Hapke. (2014). Towards Projecting the Retreat of California's Coastal Cliffs During the 21st Century. Proceedings of Coastal Sediments 2014.

Lortie, A. and Engel, J.D. (2008). Pierpont Beach Sand Management Plan. Prepared for the City of Ventura.

Martin, K. Grunion Greeter Program, personal communication (April 12, 2018)

Mahoney, J.M. & Rood, S.B. Wetlands (1998) 18: 634.

Mayta, S. and Meyer, M. (2009). Ventura Marsh Milkvetch—A Rare Re-Discovery. Available online: http://www.sbbg.org/sites/default/files/images/ecesis09fall.pdf

McCrary, M. D., & Pierson, M. O. (2000). Influence of human activity on shorebird beach use in Ventura County, California. In Proceedings of the Fifth California Islands Symposium (pp. 424-427).

McLachlan, A. (1989). Water Filtration by Dissipative Beaches. Limnology and Oceanography, 34(4), 774-780.

McLachlan, A.; Defeo, O.; Jaramillo, E; Short, A. D. (2013). Sandy Beach Conservation and Recreation: Guidelines for optimizing management strategies for multi-purpose use, Ocean & Coastal Management, Vol. 71, , (pp. 256-268).

McLachlan, A., & Defeo, O. (2017). The Ecology of Sandy Shores. Academic Press.

Mooney, H., & Zavaleta, E. (2016). Ecosystems of California. Univ of California Press.

Morrison, K. D., & Kolden, C. A. (2015). Modeling the impacts of wildfire on runoff and pollutant transport from coastal watersheds to the nearshore environment. Journal of environmental management, 151, 113-123.

NASA (2017). NASA, NOAA Data Show 2016 Warmest Year on Record Globally. https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally

National Park Service (2015). Geology of the Santa Moncia Mountains. https://www.nps.gov/samo/learn/nature/geologicformations.htm

National Research Council (NRC) (2012). Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Prepublication. National Academy Press: Washington, D.C.

Nichols Consulting Engineers (2011). California Statewide Local Streets and Roads Assessment. Prepared for California League of Cities.

OPC (California Ocean Protection Council) (2017). State of California DRAFT Sea Level Rise Guidance Document, 2017 Update. Accessible at: http://www.opc.ca.gov

Patsch and Griggs (2006). Littoral Cells, Sand Budgets, and Beaches: Understanding California S Shoreline. Available online: http://www.dbw.ca.gov/csmw/PDF/LittoralDrift.pdf

Pacific Institute (2009). The Impacts of Sea-Level Rise on the California Coast. A paper from the California Climate Change Center, May 2009

Patrick, A. M., Colwell, M. A., & Patrick, A. (2014). Snowy Plovers Select Wide Beaches for Nesting. Wader Study Group Bulletin, 12(2), 17-20.

PWA (2009). "California Coastal Erosion Response to Sea Level Rise - Analysis and Mapping." Prepared for the Pacific Institute.

Santa Barbara Trails Council (2015). Ellwood Coastal Trails Restoration Project Conceptual Funding Plan (Memo)

Southern California Edison (2014). Unit Cost Guide.

Revell, D.L. (2007). Long Term and Storm Event Changes in the Santa Barbara Sandshed. PhD Dissertation. Earth Science Department, University of California, Santa Cruz. March 148 pp.

Revell, D.L., Barnard, P. and Mustain, N. (2008). Influence of Harbor Construction on Downcoast Morphological Evolution: Santa Barbara, California. Published in Coastal Disasters ’08 Conference, April 2008 North Shore, HI.

Revell, D.L., R.Battalio, B. Spear, P. Ruggiero, and J. Vandever (2011). A Methodology for Predicting Future Coastal Hazards due to Sea-Level Rise on the California Coast. Climatic Change 109:S251-S276. DOI 10.1007/s10584-011-0315-2.

Ryan, K. J., E. L. Geist, M. Barall, and D. D. Oglesby (2015). Dynamic Models of an Earthquake and Tsunami Offshore Ventura, California, American Geophysical Union, Geophysical Research Letters, 42, doi:10.1002/2015GL064507

Spiller, D. A., Piovia-Scott, J., Wright, A. N., Yang, L. H., Takimoto, G., Schoener, T. W., & Iwata, T. (2010). Marine subsidies have multiple effects on coastal food webs. Ecology, 91(5), 1424-1434.

Schlacher, T. A., Dugan, J., Schoeman, D. S., Lastra, M., Jones, A., Scapini, F., & Defeo, O. (2007). Sandy beaches at the brink. Diversity and Distributions, 13(5), 556-560

Stromberg, J. C. (1993). Fremont cottonwood-Goodding willow riparian forests: a review of their ecology, threats, and recovery potential. Journal of the Arizona-Nevada Academy of Science, 97-110.

Stoecker, M., & Kelley, E. (2005). Santa Clara River steelhead trout: Assessment and recovery opportunities. Santa Clara River Trustee Council.

Tetra Tech (2012). Integrated Natural Resource Management Plan for Naval Base Ventura County Port Hueneme. Port Hueneme, California. March. 557 pp.

Tillett, S. S. (1967). The Maritime Species of Abronia (Nyctaginaceae). Brittonia, 19(4), 299-327.

U.S. Army Corps of Engineers (USACE) (1984). Shore Protection Manual, Volume 2. pp 7-35 to 7-43.

U.S. Army Corps of Engineers (USACE) (2003). Economic Guidance Memorandum (EGM) 04-01, Generic Depth-Damage Relationships. http://www.usace.army.mil/CECW/PlanningCOP/Documents/egms/egm04-01.pdf

U.S. Fish and Wildlife Service (2005). Recovery Plan for the Tidewater Goby (Eucyclogobius newberryi). U.S. Fish and Wildlife Service, Portland, Oregon. vi + 199 pp.

U.S. Fish and Wildlife Service (2007). Tidewater Goby (Eucyclogobius newberryi) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Ventura. California. 50 pp.

U.S. Fish and Wildlife Service (2013). FINAL 2013 Breeding Season Monitoring Report for Western Snowy Plover and California Least Tern Hollywood Beach, Oxnard, California. Available online: https://www.fws.gov/arcata/es/birds/wsp/documents/siteReports/California/2013_hollywood_beach_Final_Report_to_USFWS.pdf

U.S. Fish and Wildlife Service (2014). FINAL 2014 Breeding Season Monitoring Report for Western Snowy Plover and California Least Tern Hollywood Beach, Oxnard, California. Available online: https://www.fws.gov/arcata/es/birds/WSP/documents/siteReports/California/2014_Ormond_Beach_Final_Report.pdf

U.S. Fish and Wildlife Service (2015). FINAL 2015 Breeding Season Monitoring Report for Western Snowy Plover and California Least Tern Hollywood Beach, Oxnard, California. Available online: https://www.fws.gov/arcata/es/birds/wsp/documents/siteReports/California/2015%20Hollywood%20Beach%20Report_FINAL.pdf

Ventura, City of (2014). Santa Clara River Estuary: Flood Management Options for McGrath State Beach. http://www.cityofventura.net/files/file/public-works/water/McGrath%20Flood%20Management%20Plan%20Report%2020140828%20Item%2016%20LARWQCB%20Mtg.pdf

Ventura, County of (2017). Capital Projects Five Year Plan. http://vcpublicworks.org/engineering-services-department/capital-projects-five-year-plan.

Ventura, County of (2017). Attendance Estimates for Selected Beaches.

Ventura, County of (2017). Crop and Livestock Report. Annual Report

Weigel, R. L. (2002). Seawalls, Seacliffs, Beachrock: What Beach Effects? Part 2. Shore and Beach, v. 70, no. 2, p. 13-22.

Willis, C. M. and G. B. Griggs (2003). Reductions in fluvial sediment discharge by coastal dams in California and implications for beach sustainability. Journal of Geology 111: 167-182.

Wilson, R. C. (1972). Abronia: I. Distribution, Ecology and Habitat of Nine Species of Abronia found in California. Aliso: A Journal of Systematic and Evolutionary Botany, 7(4), 421-437.

Worcester, K. R., & Lea, R. N. (1996). Observations on tidewater goby habitat utilization and laboratory maintenance during the California drought. In Unpublished abstract from Symposium on tidewater goby, Southern California Academy of Sciences Annual Meeting at Loyola Marymount University May (pp. 3-4).

COUNTY OF VENTURA
RESOURCE MANAGEMENT AGENCY | PLANNING DIVISION

VC RESILIENT COASTAL ADAPTATION PROJECT

SEA LEVEL RISE VULNERABILITY ASSESSMENT

APPENDIX A-1. MAP ATLAS AND SECTOR PROFILE RESULTS

This page was intentionally left blank.

APPENDIX A-1. MAP ATLAS & SECTOR PROFILE RESULTS

This Appendix summarizes the effects of 8 inches, 16 inches and 58 inches (about 5 feet) of sea level rise (SLR) on routine monthly high tide inundation and from the potential erosion and flooding impacts caused by a large coastal wave storm (1% annual chance storm). These storms could happen in any given year, however the extent of the damage would not likely occur everywhere across the entire County shoreline from a single event given the different shoreline orientations and wave directions.

Each Sector profile shows the findings and recommendations that can be used to identify vulnerabilities and consider possible solutions and policy directions. Each sector profile, has a set of 3 vulnerability maps (North, Central and South Coast) color coded to the sea level elevation of impacts and a 2-page summary of findings for each of the following resources:

Sectors in Appendix A-1

- Land Use Parcels and Structures
- Agriculture
- Wastewater
- Stormwater
- Water Supply

Sectors in Appendix A-2

- Parks, Trails and Coastal Access
- Roads and Parking
- Public Transportation and Bike Routes
- Oil and Gas
- Hazardous Materials
- Critical Services

These sector profiles are intended to summarize the impacts to the key measures of impact for each sector as identified in Section 5. The overview section provides a short summary of the resource sector and any specifics about the analysis as well as identifies the individual measures of impact. The existing conditions and future vulnerabilities sections highlights components of the sector that are potentially at risk today and projected to be at risk in the future sea level rise and tidal inundation, coastal erosion, coastal flooding, and fluvial flood hazards (Section 4.3). Future vulnerabilities and potential impacts are discussed for each sea level rise scenario based on what else becomes vulnerable with that additional amount of sea level rise. The ~5 feet by 2100 sea level rise scenario identifies what else potentially becomes vulnerable, but the text summarizes everything at risk by coastal hazards and ~5 feet of sea level rise. The adaptation section is a relatively simple summary of potential ranges of options of strategies. This adaptation section will evolve as additional workshops and dialogs are held with the City and key stakeholders. Finally, the summary section, identifies key findings, thresholds of significant impacts, and data gaps. Potential next steps suggests future policy directions, and monitoring needs.

This page was intentionally left blank.

Land Use and Structures

Overview

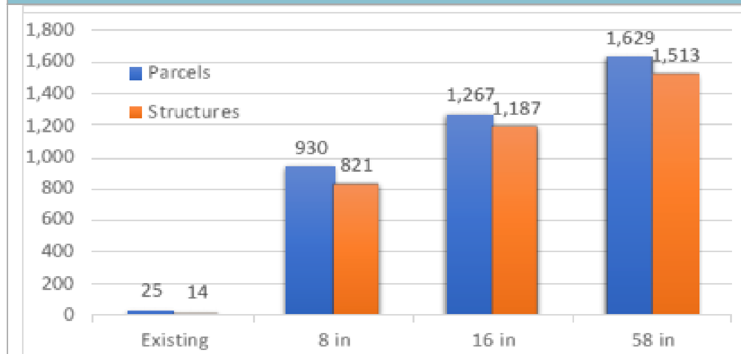
There are 12 land use categories within Ventura County, which were categorized into four distinct land use types for evaluation. Land uses were categorized into (1) residential, (2) commercial, (3) industrial, and (4) visitor serving accommodations. More detail on the methods and results can be found in Sections 4 and 5 of the Report.

Cliff and dune erosion results in a loss of land and structures and coastal flooding causes temporary damages from a large 1% annual chance storm. Monthly high tides inundate at-risk properties (land and structures). Narrow ocean front parcels on the North and South Coast have a Mean High Water boundary, so portions of the parcels are already affected by routine high tides.

The following measures of impacts quantify the impact of coastal hazards and sea level rise (SLR) on land uses and structures:

- **Parcels by land use type**
- **Number of structures**

Coastal Erosion



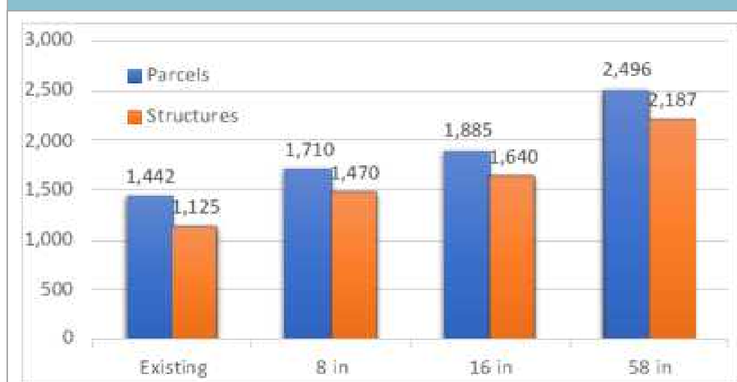
Cliff erosion along the South Coast causes vulnerabilities to residential parcels with 8" of SLR (131 parcels), although some of these could occur today. Beach and dune erosion on the Central Coast shows existing condition impacts to 14 parcels, rising to 619 parcels with 8" of SLR. Erosion affects mainly residential parcels located in Silverstrand and Hollywood Beach. Commercial impacts include businesses along Los Altos St. in Hollywood Beach, along Ocean Dr. in Silverstrand.

Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
North	$0	$1,100,000	$1,200,000	$1,200,000
Central	$26,600,000	$981,100,000	$1,255,400,000	$1,480,100,000
South	$0	$208,300,000	$208,300,000	$208,500,000
Total	**$26,600,000**	**$1,190,500,000**	**$1,464,900,000**	**$1,689,800,000**

ECONOMICS: South Coast cliff erosion was not calculated for existing conditions, but potential impacts of over $208 million ($M) with only 8" of SLR. The Central Coast is already subject to $26.6M in dune erosion losses (1% annual chance storm) and losses may increase to $981.1M with 8", $1.25 billion with 16", and $1.48 billion with ~5 feet of SLR. The North Coast lacks future erosion projections, potential damages are understated as $1.2M for structures in Emma Wood State Beach. Failure of existing armoring would cause substantially more property damages.

Note: North Coast erosion modeling was not conducted and erosion may cause vulnerabilities in this area. The model used for South Coast cliff erosion may have underestimated existing cliff erosion hazards.

Coastal Flooding



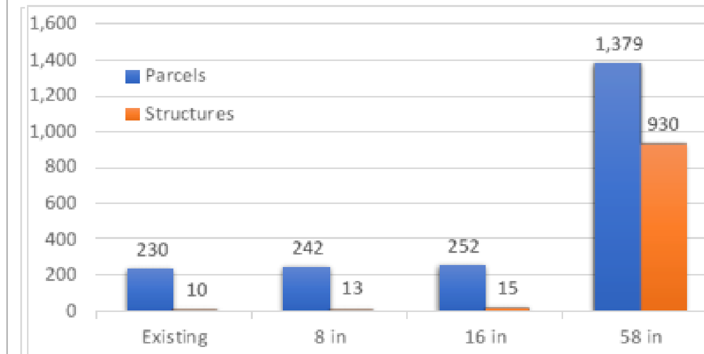
Residential buildings are >95% of vulnerable structures. Half of all parcels exposed to flooding with ~5 feet of SLR are in the Silverstrand and Hollywood Beach neighborhoods. Ten commercial buildings are vulnerable today and 31 may be exposed with ~5 feet of SLR.

ECONOMICS: South Coast experiences increasing flood damages over time: $10M presently, about $11M with 8" and 16" of SLR and losses increase significantly to $136.6M with ~5 feet of SLR. The Central Coast is already subject $120.1M in coastal flooding losses (during a 1% annual chance storm) and losses increase to $150.7M with 8", $173.3M with 16", and $407.3M with ~5 feet of SLR. North Coast coastal flooding currently exposes $46.8M in property. This estimate increases to $51.6M with 8", $55.0M with 16", and 138.2M with ~5 feet of SLR.

Coastal Flooding	Existing	8 Inches	16 Inches	58 Inches
North	$46,800,000	$51,600,000	$55,000,000	$138,200,000
Central	$120,100,000	$150,700,000	$173,300,000	$407,300,000
South	$10,000,000	$10,800,000	$11,000,000	$136,600,000
Total	**$176,900,000**	**$213,100,000**	**$239,300,000**	**$682,100,000**

Tidal Inundation

Currently, 230 oceanfront parcels are at risk of tidal inundation. Between 16" and ~5 feet, impacts escalate by 904 residential structures and 11 commercial buildings.



$48.5M in property is currently vulnerable. Tidal exposure increases to $81.1M with 8", $98M with 16", and $177.7M with ~5 feet of SLR. The Central Coast is not at risk until ~5 feet of SLR, when $633.3M in property is exposed. The North Coast has $22.2M in property exposed currently, increasing to $23.5M with 8", $24.9M with 16", and $70.2M with ~5 feet of SLR.

Tidal Inundation	Existing	8 Inches	16 Inches	58 Inches
North	$22,200,000	$23,500,000	$24,900,000	$70,200,000
Central	$0	$0	$0	$633,300,000
South	$48,500,000	$81,100,000	$98,000,000	$177,700,000
Total	**$70,700,000**	**$104,600,000**	**$122,900,000**	**$881,200,000**

Potential Adaptation Strategies

Range of Strategies: Includes "No Action" and cleanup, as well as retreat, accommodate and protection strategies.

Accommodate - Includes elevating structures and increasing setbacks. Elevating is expensive if completed as a retrofit, however building code changes would enable elevation to occur overtime with the bulk of the cost placed on developers and private property owners when redeveloping their properties.

Protect – Constructing levees and coastal armoring to reduce vulnerabilities is the "gray" protection approach, which has already been implemented in the North Coast. A "green" protection approach likely cost effective in the Central Coast would be to augment sand dunes to protect against future coastal hazards.

Retreat - Includes policy and/or regulatory options (e.g. transfer of development, repetitive loss, and rolling easements) as well as voluntary purchase of the vulnerable properties potentially with a lease back option.

Secondary Impacts: Retreat strategies have secondary impacts due to the loss of structures, property, and subsequent resulting impacts on the tax base revenues to the County. Gray protection options have been traditionally used with some success in the past, but continued use would result in a loss of beaches over time. Green protection strategies may benefit beaches and homes by maintaining recreational uses, but may not be suitable for high-energy shorelines that erode.

Findings

Summary

- Residential parcels make up ~95% of exposed property.
- Coastal erosion poses the highest economic risk to land uses, primarily in Hollywood Beach and Silverstrand.
- Currently $26.6M in property is at-risk to erosion and $176.9M is at-risk to flooding from a 1% storm.
- With 8 inches $1.2 billion in property is at-risk to erosion and $213M is at-risk to flooding from a 1% storm.
- With ~5 feet of SLR, $1.7 billion in property is at-risk to erosion and $682M exposed to coastal flooding.

Thresholds:

- Coastal erosion impacts substantially more residential property with 8" of SLR ($26M to $1.2 billion).
- Tidal inundation impacts escalate between 16" & ~5 feet of SLR, particularly in the Central Coast.

Strategy Options

Policy:

- Consider codifying an increase to base flood elevation or movable foundation standards for new development.
- Develop real estate disclosure requirements to inform homebuyers of the risk of living adjacent to the coast.

Projects:

- Develop a phased long-term managed retreat plan.
- Potentially require any abandonment or retreat to remove derelict or threatened structures.
- Develop dune and shoreline management plans.

Monitoring:

- Monitor frequency, duration and depth of impacts.

Figure A1a - Land Use Parcels and Structures: North Coast

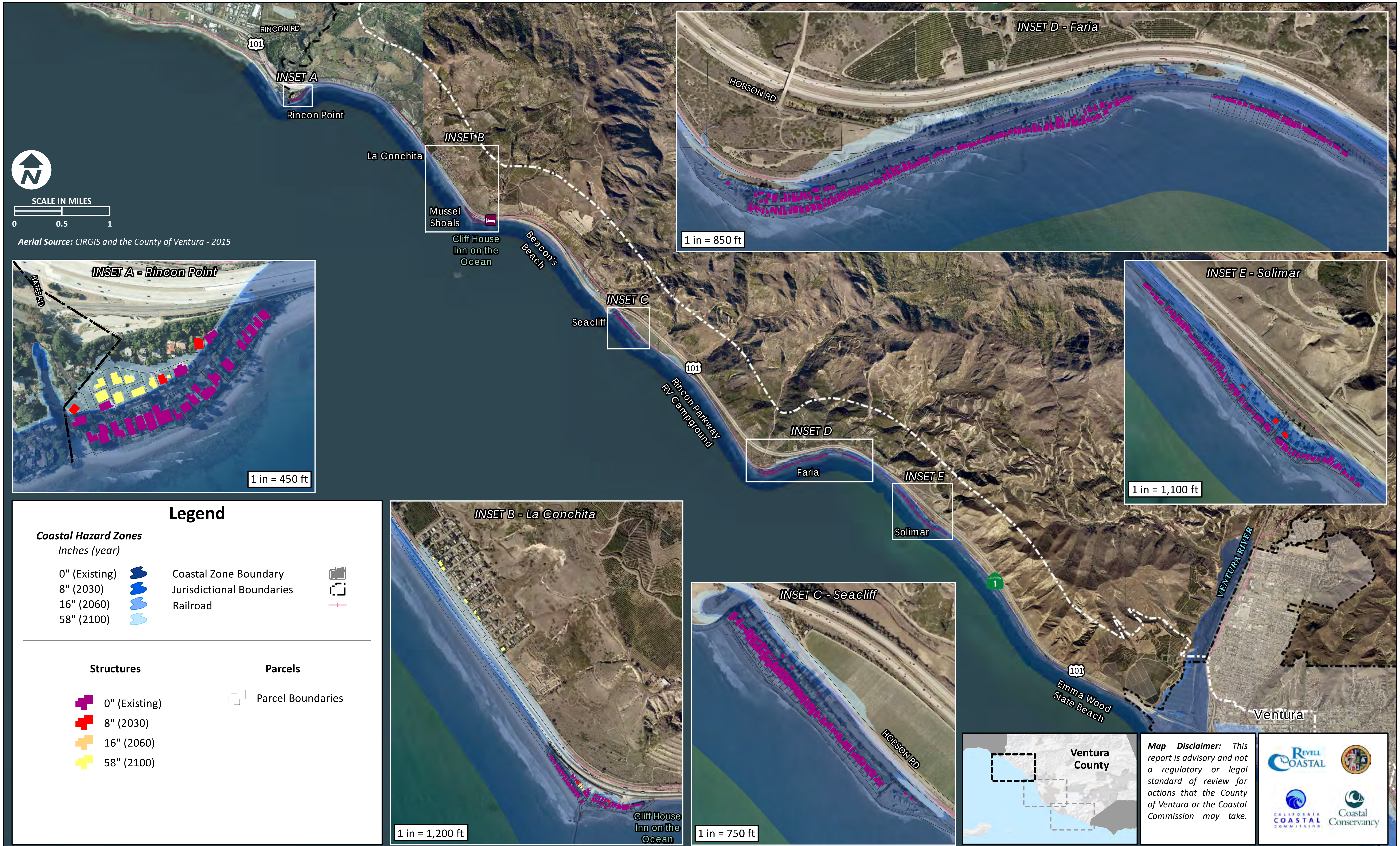


Figure A1b - Land Use Parcels and Structures: Central Coast

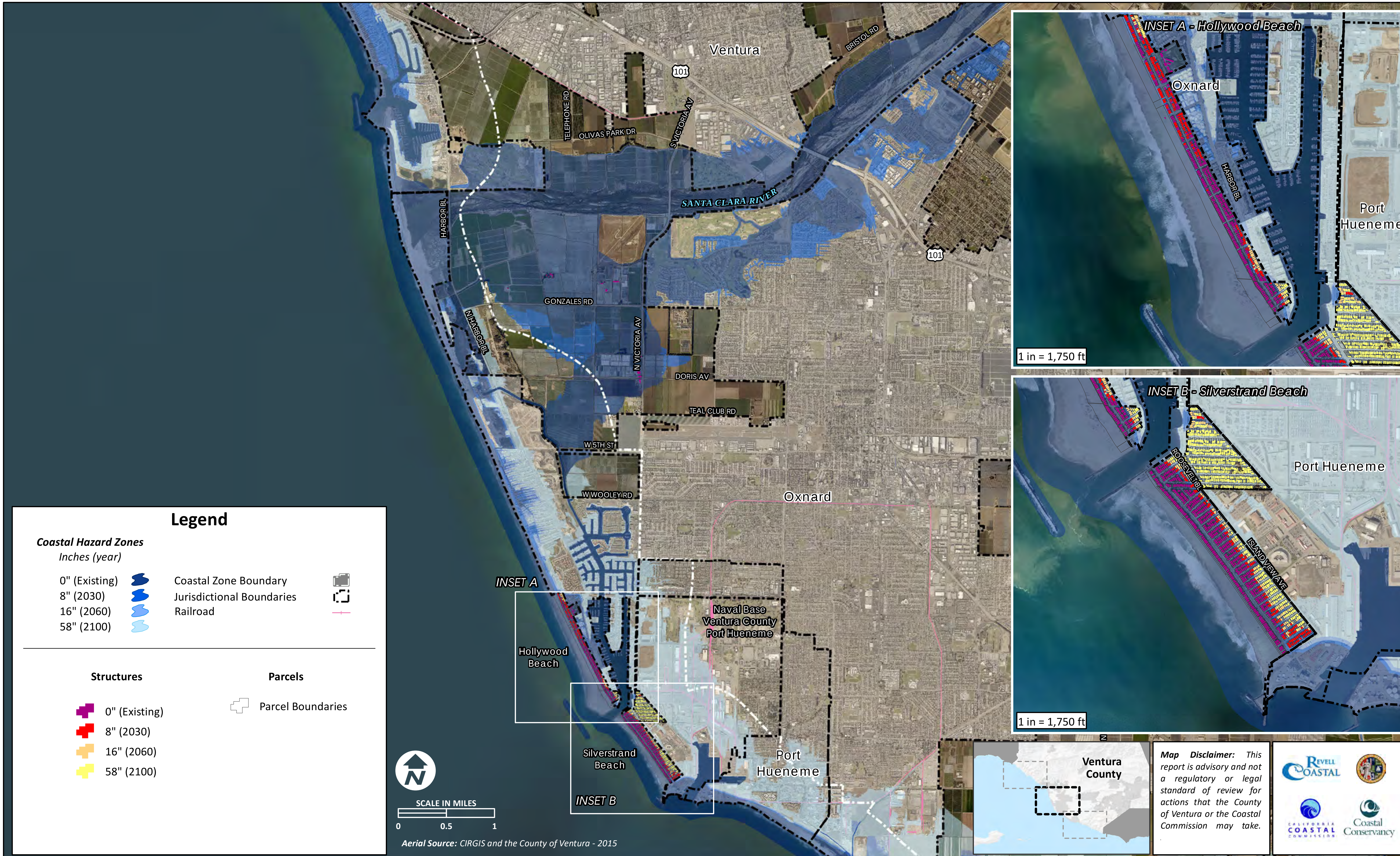
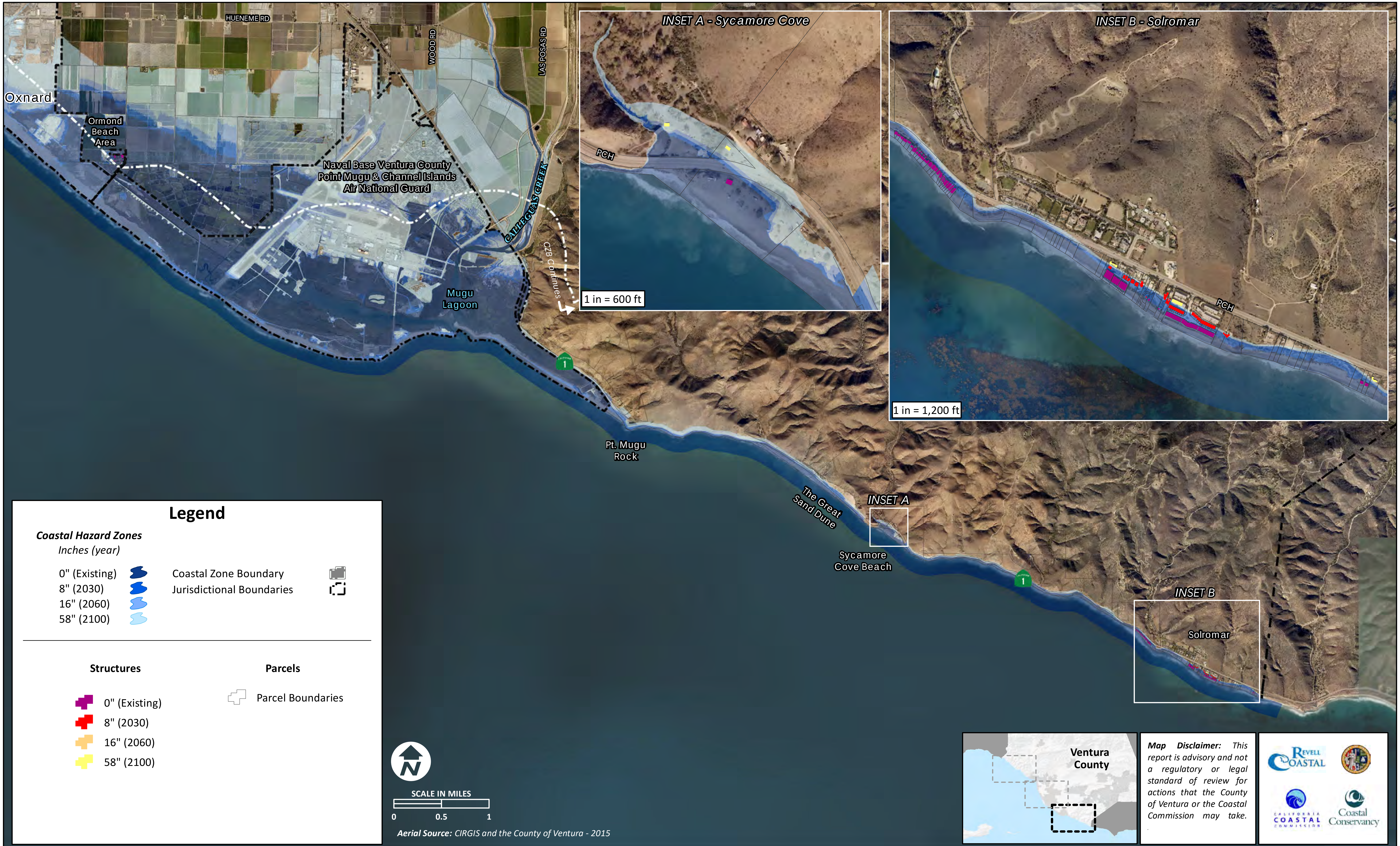
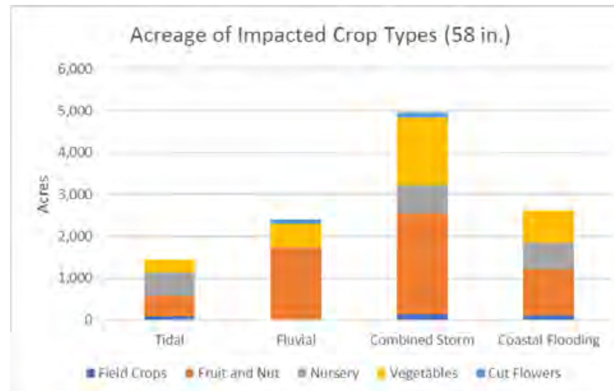


Figure A1c - Land Use Parcels and Structures: South Coast



Overview

Ventura County has approximately 96,000 acres of irrigated farmland and a total acreage in agricultural zoning of nearly 295,000 acres. Some of the top crops grown near the coast in recent years are strawberries, sod, celery and other row crops. The Farmland Monitoring and Mapping Program (FMMP) lands are high-value agricultural soils identified for environmental review purposes under CEQA, with the Farmland categories from highest value downward of Prime, Statewide Importance, Unique, Local Importance, and Grazing Land constituting "agricultural lands." The estimated value of agricultural land was based on the 2017 Crop & Livestock Report and GIS spatial crop types data. The County has substantial agricultural facilities that may be impacted. For example, Dole has a facility off West Gonzalez Rd. near N. Harbor Blvd., and there are a number of flower nurseries with greenhouses. Impacts to coastal hazards and sea level rise (SLR) on agriculture in coastal areas were quantified by:



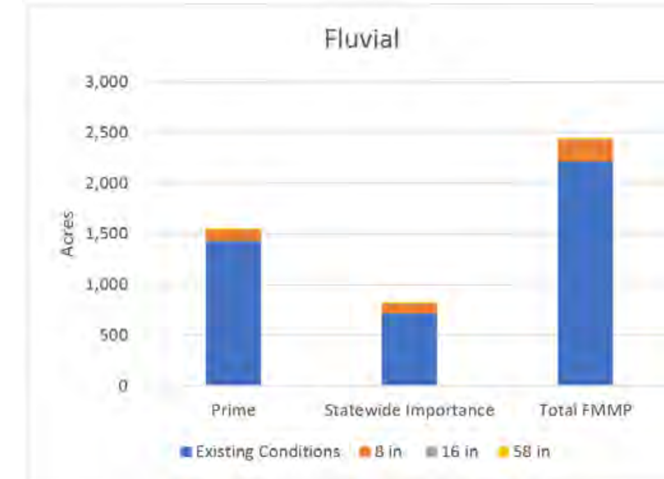
- **Acres of Farmland Monitoring and Mapping Program land (FMMP)**
- **Loss of agricultural productivity from changes in soil salinity based on crop types - $ Millions ($M)**

Coastal Confluence and Fluvial Flooding

Coastal confluence and fluvial flooding are likely to cause temporary damages and disruption to agriculture, but may serve to improve the quality of the soil by replenishing it with new sediment and reinvigorating some of the soils.

Most fluvial impacts to agriculture occur in the existing floodplains and hazard zones. The SLR influence on fluvial flooding is around 2,430 acres on the Santa Clara River, most of which occurs between existing conditions and 8" of SLR.

ECONOMICS: Fluvial flooding economic impacts were not estimated in this report. One significant risk of flooding is potential contamination of farmland.

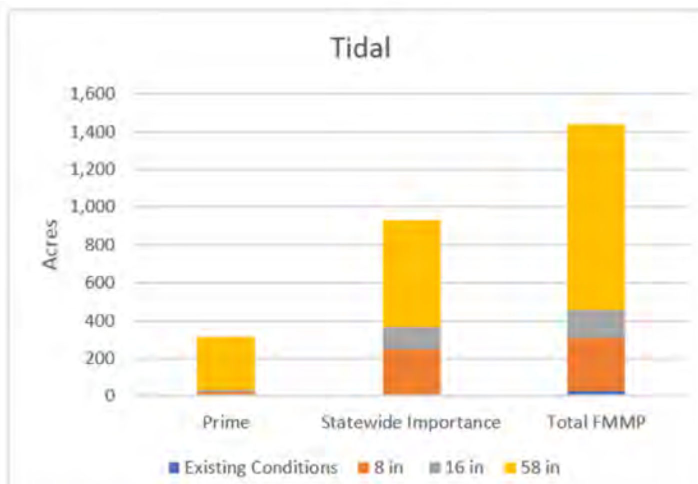


Coastal Erosion and Tidal Inundation

Coastal erosion and tidal inundation are likely to have permanent impacts to agriculture as either a result of the loss of land, or saltwater saturation degrading the soil.

Coastal erosion has minimal impact, and up to seven acres may be exposed to dune erosion with ~5 feet of SLR. Tidal inundation may presently affect 26 acres of FMMP land, 308 acres with 8", 455 acres with 16", and 1,440 acres may be impacted with ~5 feet of SLR.

ECONOMICS: Losses from erosion now are small (<$100K), but with ~5 feet of SLR it may affect 7 acres of farmland (<$500k). However, tidal inundation may impact $12M of farmland with 8", $17M with 16", and $51M with ~5 feet of SLR. Assuming a 35% to 75% loss in productivity from tidal inundation compromising soil salinity, crop yields could be reduced by $4.1M to $8.7M with 8", $5.8M to $12.4M with 16", and $18M to $38.5M with ~5feet of SLR.



Potential Adaptation Strategies

__Range of Strategies__: Includes "No Action" and cleanup, as well as retreat, accommodate and protection strategies.

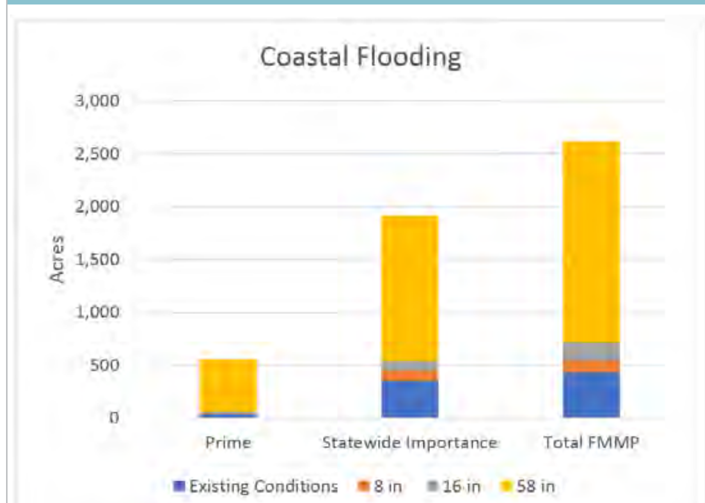
Accommodate - Includes elevating farmhouses and barns. Choose salinity-tolerant crops and explore aquaculture in areas impacted by rising tides. Flood plain easements can compensate farmers for allowing fluvial processes to occur.

Protect – Constructing levees and coastal armoring to reduce vulnerabilities is the "gray" protection approach, which has traditionally been implemented along the shoreline and rivers. A "green" protection approach in the Central Coast would be to augment sand dunes or contour horizontal levees to protect against future coastal and fluvial hazards.

Retreat - Includes policy and/or regulatory options (e.g. transfer of development and rolling easements) as well as purchase of the vulnerable properties. Retreat options are limited by the absence of large tracts of vacant suitable land.

__**Secondary Impacts:**__ Retreat strategies have secondary impacts due to the loss of agricultural properties and subsequent decline in soil quality. Gray protection options would result in a loss of beaches and soil quality over time. Green protection strategies may benefit agriculture by managing some freshwater flooding that improves soil quality while protecting from seawater intrusion and tidal inundation.

Coastal Flooding



Coastal storm flooding impacts cause temporary disruption to agricultural operations, but once soil is exposed to saltwater, a shift of crop types away from the highest value crops to lower value ones may be required (e.g. strawberries to celery or grazing). Most impacts from coastal flooding increase between 16" and 58" of SLR with the largest impacts to the FMMP Statewide Importance lands.

ECONOMICS: Coastal flooding could-damage $15.6M in farmland today, rising to $19.3M with 8 inches, $23.8M with 16 inches, and $77.7M with ~5 feet of SLR. Assuming a 15% to 25% loss in productivity losses from coastal floods, crop yields could be reduced by $11.7M to $19.4M with ~5feet of SLR and impacts for a 1% annual chance storm.

Findings

Summary

•Under existing conditions, fluvial hazards could impact over 2,400 acres of high value farmland along the Santa Clara and Ventura Rivers which may add nutrients and top soil, but also pollutants.

•Tidal inundation and erosion may permanently affect >1,400 acres of agricultural lands with ~5 feet of SLR.

•Agriculture faces added challenges from temperature changes and salt water intrusion not analyzed here.

•High value crops like strawberries are sensitive to soil salinity, which will increase with exposure to coastal hazards and SLR, requiring a shift to lower value crops.

__**Threshold:**__

•Between 16" and 58", coastal flooding and tidal inundation vulnerabilities escalate substantially.

Strategy Options

__**Policy**__

•Expand the floodplain easement program.

•Update the Land Conservation Act Program with a focus on areas projected to be tidally inundated.

__**Projects and Monitoring**__

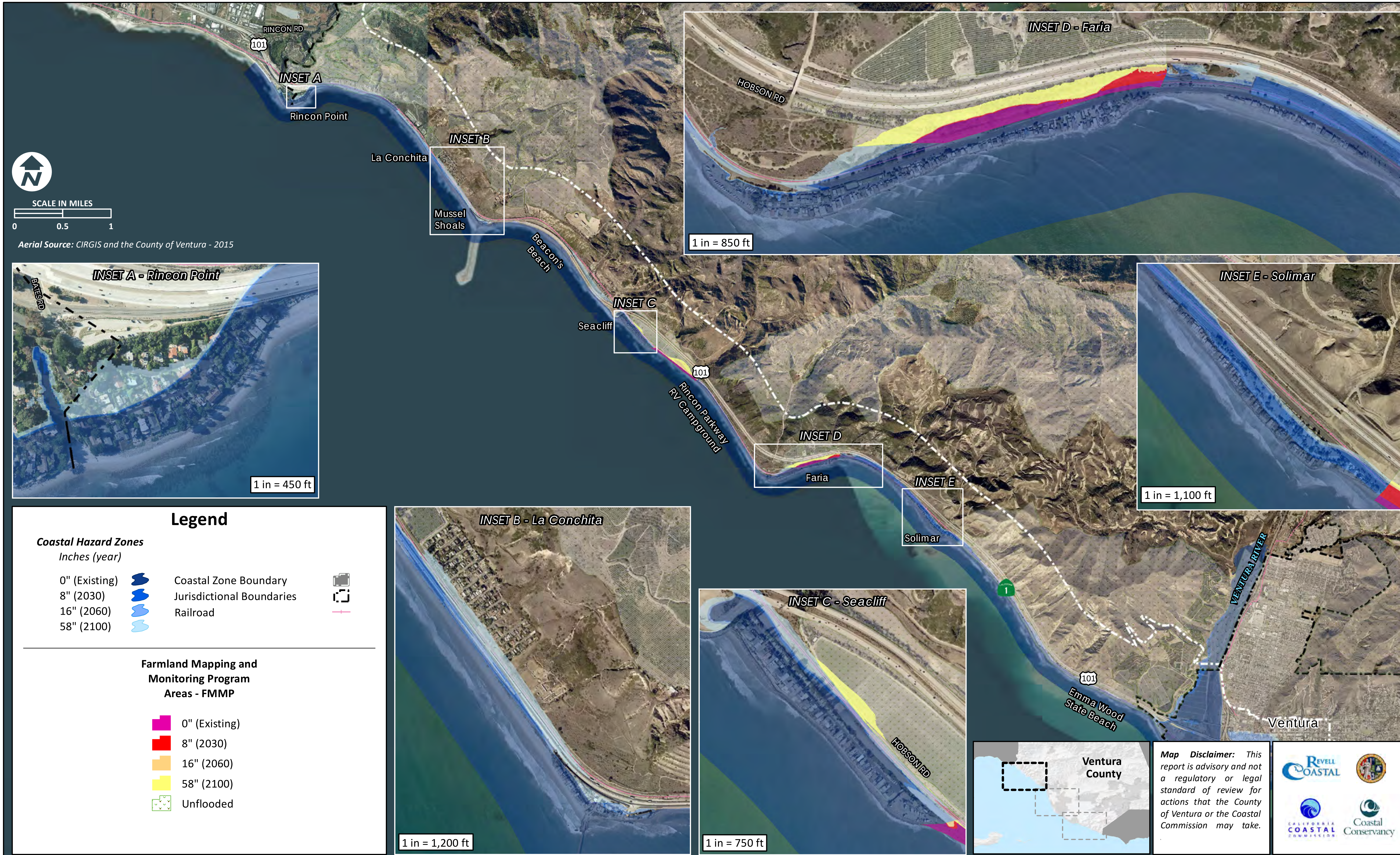
•Conduct detailed analysis of climate change on specific crops and agricultural lands.

•Potentially require any abandonment or retreat strategies to remove derelict or threatened structures.

•Evaluate the effect of saltwater intrusion into groundwater basins and rising salinity in the irrigation water supply.

•Monitor frequency, duration and depth of flooding and soil salinity at low lying areas around the County.

Figure A2a - Agriculture: North Coast



Legend

Coastal Hazard Zones
Inches (year)

- 0" (Existing)
- 8" (2030)
- 16" (2060)
- 58" (2100)

- Coastal Zone Boundary
- Jurisdictional Boundaries
- Railroad

Farmland Mapping and Monitoring Program Areas - FMMP

- 0" (Existing)
- 8" (2030)
- 16" (2060)
- 58" (2100)
- Unflooded

Map Disclaimer: *This report is advisory and not a regulatory or legal standard of review for actions that the County of Ventura or the Coastal Commission may take.*

Figure A2b - Agriculture: Central Coast

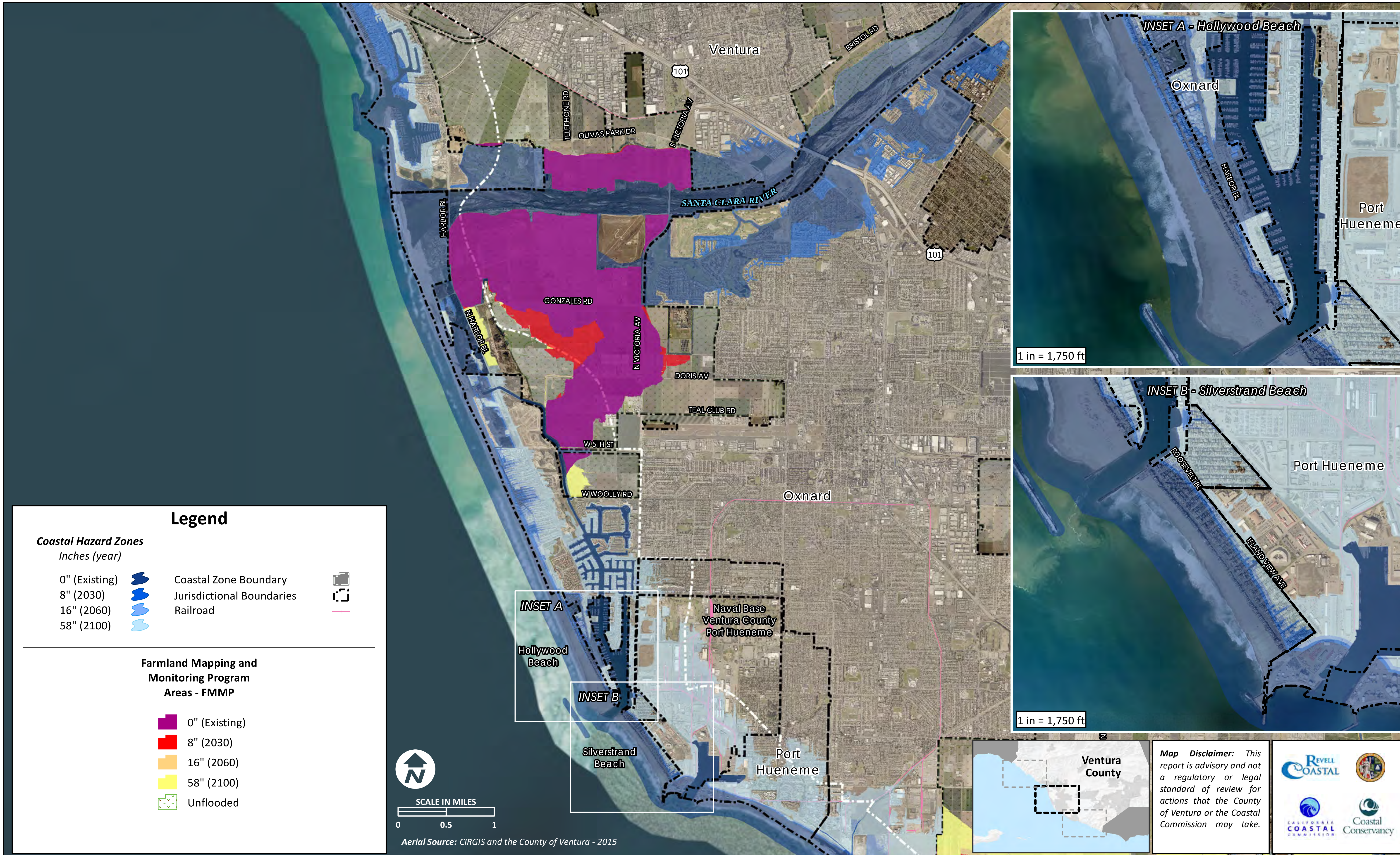
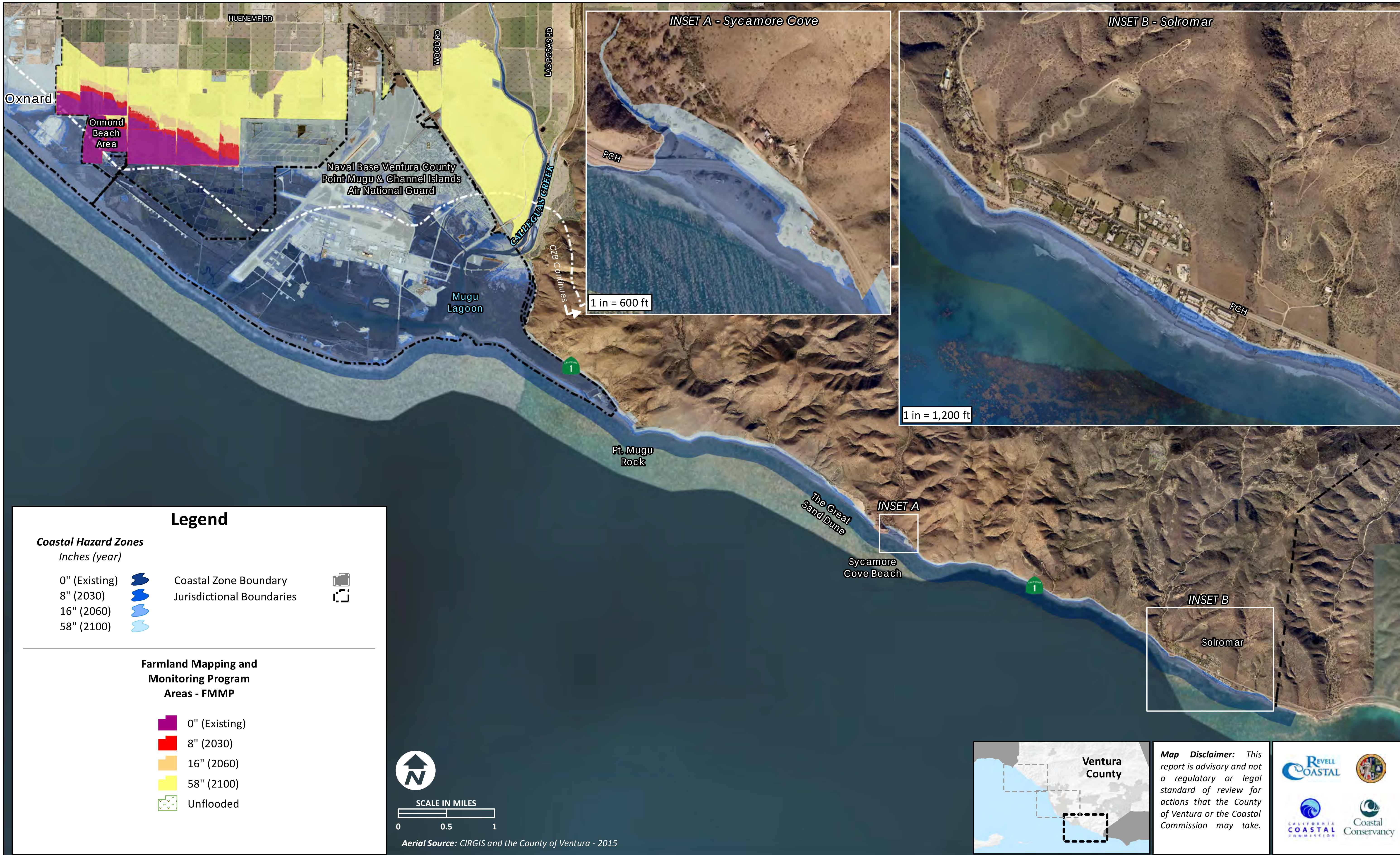


Figure A2c - Agriculture: South Coast



Wastewater

Overview

The wastewater system is comprised of 17 wastewater districts located throughout the County. The County Water and Sanitation Department oversees the wastewater collection system. Currently, most of the wastewater from the coastal zone is processed at regional wastewater treatment plants, the Ventura Wastewater Treatment Facility (in the City of Ventura), and the Oxnard Wastewater Treatment Plant (in the City of Oxnard). Community Service Area 29 provides service to most of the North Coast, with infrastructure that extends from Mussel Shoals south to the City of Ventura. The North Coast community of La Conchita, as well as buildings in the South Coast, use septic systems, but there is no uniform spatial dataset available to evaluate impacts to septic systems. There is however a public bathroom on septic in Sycamore Cove State Park and a small private wastewater treatment facility associated with the Malibu Bay Club in Solromar (not impacted).

Impacts of coastal hazards and sea level rise (SLR) were quantified using the following measures of impacts:

- **Number of pump stations**
- **Number of shut off valves**
- **Number of manholes**
- **Length of pipe (miles)**
- **Treatment plants**

Note: Erosion modeling was not conducted on the North Coast, yet erosion may cause vulnerabilities in this area. Replacement cost of pipes from erosion was estimated to be $230 per foot.

Existing Vulnerabilities

Coastal Flooding • 2 pump stations / 1 valve • 28 manholes • 9.5 miles of pipe	Under existing conditions, there are no impacts from erosion or tidal inundation to the wastewater system, although if existing coastal armoring on the North Coast were to fail, then additional impacts should be expected. Coastal flooding may temporarily impact the pump stations at Seacliff and Faria during large wave events ((1% chance annual storm) as well as an emergency shut off valve just south of Faria. Impediments to accessing the shut off valve caused by a large wave event increase the potential for a sewage spill. Nine and a half miles of pipe are susceptible to coastal flood hazards along the Rincon Parkway and at Hollywood Beach.

Projected Vulnerabilities

8 inches by ~2030

Coastal Erosion • 1.5 miles of pipe • 21 manholes **Coastal Flooding** • 1 pump station • 5 manholes • 1.8 miles of pipe	Coastal dune erosion could impact 1.5 miles of wastewater pipe in the Central Coast and 21 manholes in the Hollywood Beach neighborhood. Replacement cost of these pipes is estimated on the order of $1.8 million. Coastal flooding is projected to impact an additional pump station in Solimar, and an additional 1.8 miles of pipe along the Rincon Parkway and at Hollywood Beach.

16 inches by ~2060

Coastal Erosion • 0.8 miles of pipe • 6 manholes **Coastal Flooding** • 0.9 miles of pipe • 2 manholes	Coastal dune erosion could impact an additional 0.8 miles of wastewater pipe in the Hollywood Beach neighborhood. Replacement cost of these pipes is estimated on the order of $1.0 million. Coastal flooding is projected to impact an additional 0.9 miles of pipe and two manholes along the Rincon Parkway, at Silverstrand, and at Hollywood Beach.

58 inches by ~2100

Tidal Inundation • 1.7 miles of pipe • 26 manholes	Tidal inundation with ~5 feet of SLR may affect a total of 1.7 miles of pipe and limit routine accessibility to the pipe. Twenty six manholes exposed with ~5 feet of SLR may result in substantial salt water inundating and corroding the wastewater system.
Coastal Erosion • 1.0 miles of pipe • 14 manholes **Coastal Flooding** • 1 pump station • 19 manholes • 2.3 miles of pipe	The restroom site at Sycamore Cover Beach may also be inundated. Dune erosion with ~5 feet of SLR may affect a combined total of 3.3 miles of wastewater pipe in the Central Coast and 41 manholes in Hollywood Beach and Silverstrand. Replacement cost of these pipes is estimated to be ~$4 million. Coastal flooding with ~5 feet of SLR may affect a combined total of 14.5 miles of pipe along Rincon Parkway, at Silverstrand, and at Hollywood Beach neighborhoods, as well as potentially impact four pump stations and the bathroom at Sycamore Cove State Park.

Potential Adaptation Strategies

Range of Strategies: A range of strategies include retreat, elevating key vulnerable infrastructure, increasing conveyance and pumping capacity, and completing flood proofing retrofits to protect existing system components.

Accommodate: Elevating vulnerable components of pump stations and shut off valves may accommodate some SLR. State Parks could elevate the restroom storage tank or further flood proof the facility at Sycamore Cove.

Protect: Complete flood-proofing retrofits to the vulnerable pump stations in order to protect electrical and pump system operations. This may provide a short-term relatively low-cost option to accommodate several feet of SLR. Sealing manholes can reduce the potential for coastal flood waters from overwhelming the sewage system. Coastal armoring (gray), or enhanced sand dunes (green) would provide protection from coastal erosion and flooding.

Retreat: Phased relocation of the wastewater infrastructure must be tied to a community wide managed retreat strategy and coordinated with the regional wastewater treatment plants located in neighboring jurisdictions. Erosion and tidal inundation could necessitate retreat strategies, particularly for septic systems and the restroom at Sycamore Cove.

Secondary Impacts: Vary based on approach and integration of adaptation measures to community adaptation planning. Failure in the system could cause pollution to spill into the ocean or the Santa Clara River and Ormond Beach estuaries. If the wastewater treatment plants in the cities of Ventura and Oxnard are exposed to hazards, the unincorporated areas that are serviced by these plants will be impacted.

Findings

Summary

- No pump stations, shut off valves or treatment plants are susceptible to coastal erosion or tidal inundation even with ~5 feet of SLR, although impacts may occur if coastal armoring along the North Coast fails.
- Two pump stations are currently exposed to flooding, and four pump stations are vulnerable with ~5 feet of SLR.
- Nearly 9.5 miles of wastewater pipe are currently exposed to existing flooding hazards, this vulnerability increases with ~5 feet of SLR to 14.5 miles.
- Both the wastewater treatment plants in Ventura and Oxnard become exposed to tidal and coastal flooding by ~5 feet of SLR.

Thresholds:

- With 8” of SLR, erosion hazards potentially erode 1.5 miles of wastewater pipe. Three pump stations would be vulnerable to coastal flooding.
- With ~5 feet of SLR, tidal inundation affects 26 manholes.

Strategy Options

Policy:

- Encourage regional dialog about the future location of the sewer network or upgrades to existing treatment plants.
- Add policy language to require relocation or avoidance of wastewater hazards to the extent possible.

Projects:

- Relocate pipe segments susceptible to coastal erosion. Prioritize sections by timing of impact.
- Conduct advanced maintenance to keep lines clear.
- Recommend flood proofing the pump stations.
- Retrofit manholes to reduce flooding into sewer system.
- Work with State Parks to flood-proof the restroom facility at Sycamore Cove.

Monitoring:

- Continue to monitor the groundwater levels and salinity levels to understand the impact of both on sewer capacity.

Data Gaps:

- Missing data on pipes, connections with treatment plants, and septic systems in South Coast at Solromar, and at La Conchita.

Figure A3a - Waste Water: North Coast

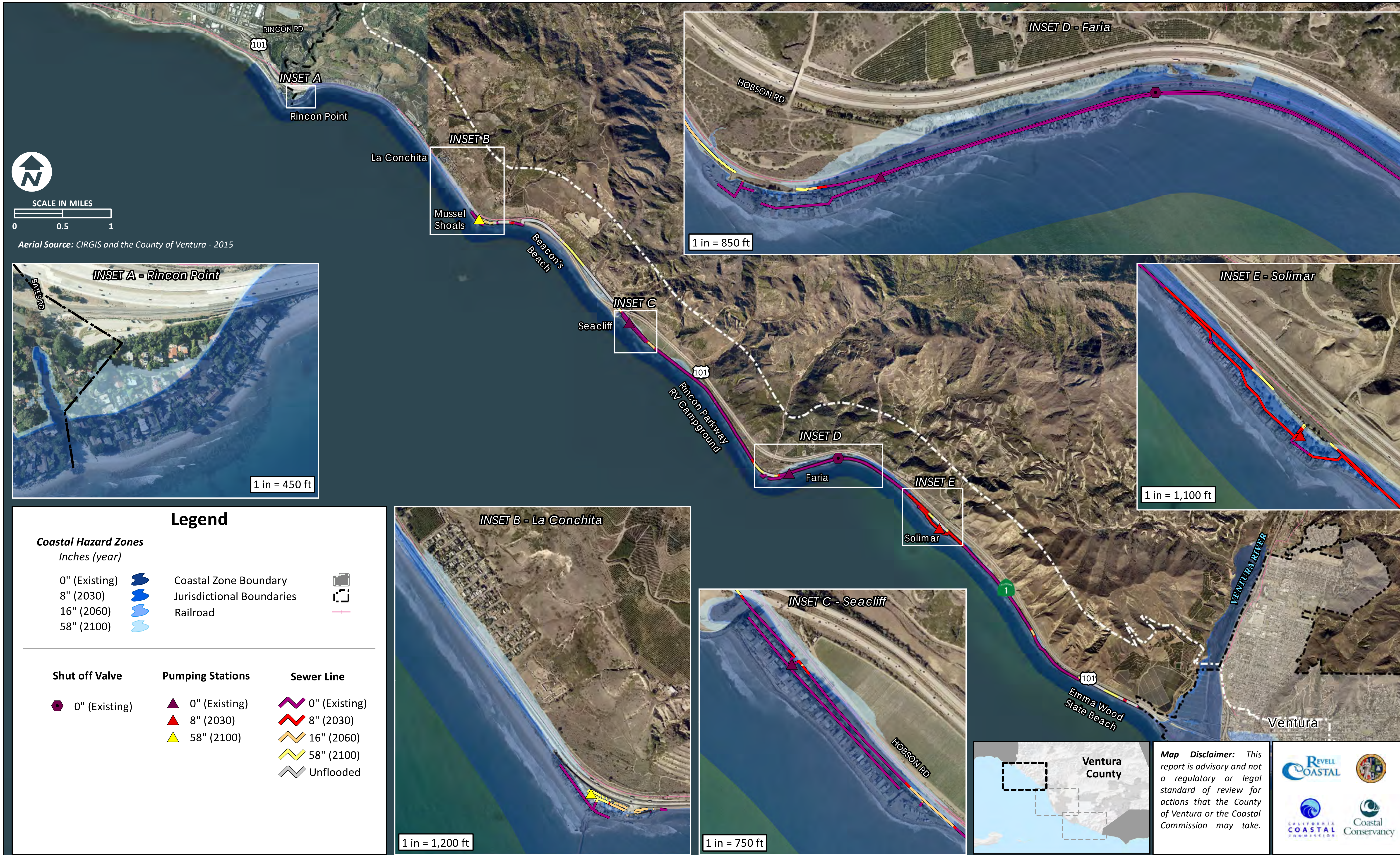
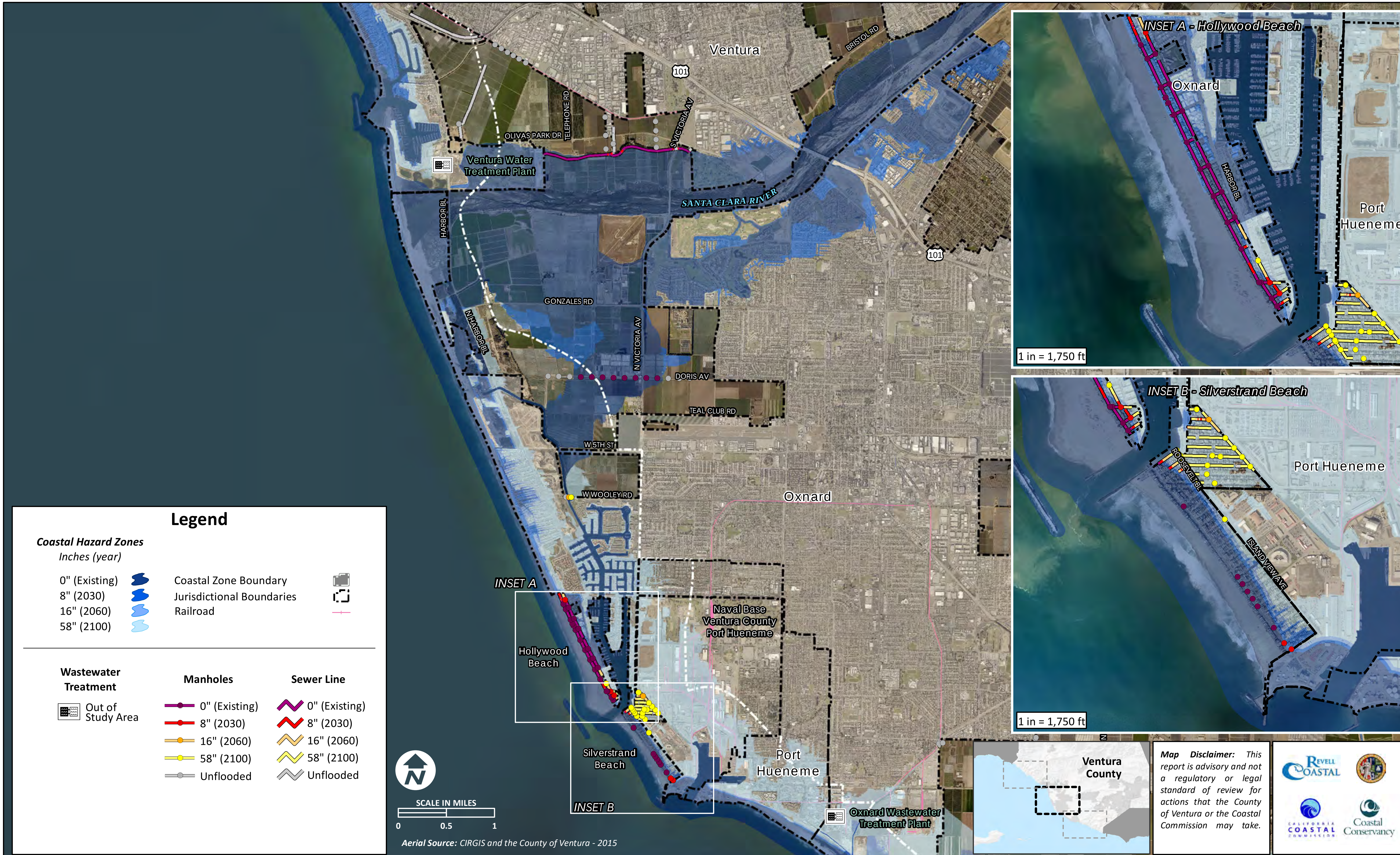


Figure A3b - Waste Water: Central Coast



Legend

Coastal Hazard Zones
Inches (year)

- 0" (Existing)
- 8" (2030)
- 16" (2060)
- 58" (2100)

- Coastal Zone Boundary
- Jurisdictional Boundaries
- Railroad

Wastewater Treatment
- Out of Study Area

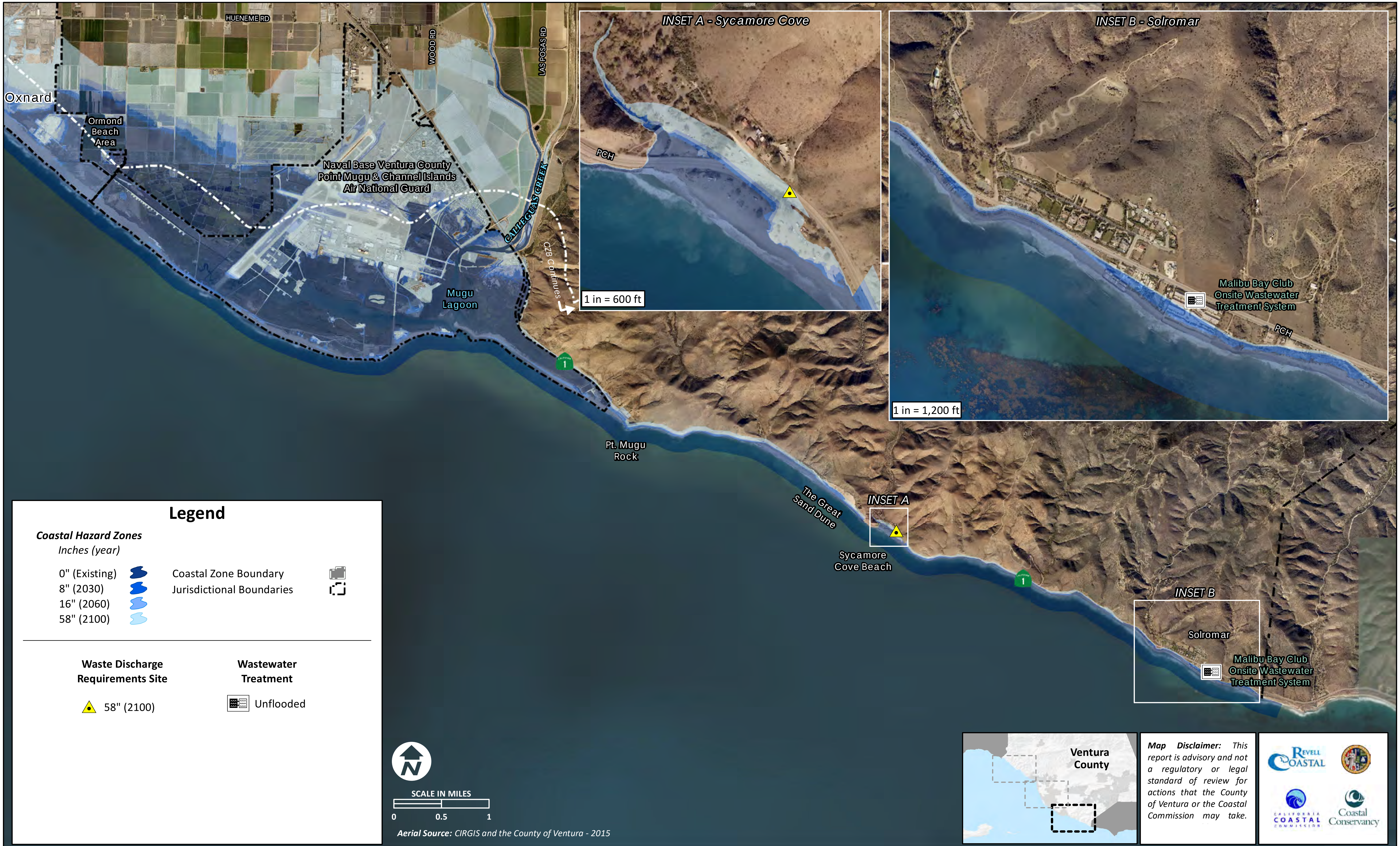
Manholes
- 0" (Existing)
- 8" (2030)
- 16" (2060)
- 58" (2100)
- Unflooded

Sewer Line
- 0" (Existing)
- 8" (2030)
- 16" (2060)
- 58" (2100)
- Unflooded

Aerial Source: *CIRGIS and the County of Ventura - 2015*

Map Disclaimer: *This report is advisory and not a regulatory or legal standard of review for actions that the County of Ventura or the Coastal Commission may take.*

Figure A3c - Waste Water: South Coast



Stormwater

Overview

Ventura County's stormwater system is managed by the Ventura County Watershed Protection District, responsible for stormwater management, flood control, and floodplain management. The stormwater system consists of a series of flood control channels, storm drain inlets and culverts that discharge to the nearest body of water using gravity flow. A substantial storm drain system is near current sea level in the neighborhoods of Silverstrand and Hollywood Beach. Storm drains have historically backed up at several locations in these neighborhoods. Presently, one pump station at Silverstrand diverts stormwater to a wastewater treatment plant for treatment. As sea level rises, portions of the system may not drain during high tides and during more of the tide cycle, which in turn increases flood depths and frequency. Culverts and pipes may also cause ocean water to flow into these neighborhoods.

Impacts of coastal hazards and sea level rise (SLR) on stormwater infrastructure, were quantified by:

- **Number of pumps**
- **Number of storm drain inlets**
- **Number of detention basins**
- **Number of culverts**
- **Length of pipe** *(replacement cost from erosion estimated using $230 per foot)*

Existing Vulnerabilities

Tidal Inundation • 2 basins • 3.2 miles of pipe	Tidal inundation may presently impact 3.2 miles of storm drains, and two detention basins located in Faria.
Coastal Erosion • 600 feet of pipe	Coastal erosion during a 1% annual chance storm may impact 600 feet of pipe in the Hollywood Beach and Silverstrand neighborhoods. Replacement cost of these pipes is estimated at $140,000.
Coastal Flooding • 58 inlets • 8 basins/ 3 pumps • 5.7 miles of pipe	Coastal flooding from a 1% annual chance storm may presently impact 58 storm drain inlets and 5.7 miles of pipes. Two pump stations in Silverstrand and one in Solimar may also be affected during large wave events. Eight detention basins are also potentially impacted at Mussel Shoals and Faria.

Projected Vulnerabilities

8 inches by ~2030

Tidal Inundation • 0.4 miles of pipe	Tidal inundation may impact an additional 0.4 miles of storm drains in Hollywood Beach and Silverstrand.
Coastal Erosion • 42 inlets / 2 pumps • 2 basins • 1.2 miles of pipe	Coastal erosion is projected to potentially damage 42 inlets, 2 pumps and 1.2 miles of pipe in the southern portions Hollywood Beach and Silverstrand neighborhoods. In addition to 2 detention basins in Hollywood Beach, one on Sunset Ln. near Las Palmas St., and one on Ocean Dr. near Los Robles St. Replacement cost of these pipes is estimated at $1.5 million.
Coastal Flooding • 11 inlets / 1 basin • 0.8 miles of pipe	Coastal flooding from a 1% annual chance storm may impact an additional 11 storm drain inlets and 0.8 miles of pipes in the Hollywood Beach and Silverstrand neighborhoods. One detention basin on Sunset Ln. near Las Palmas St. in Hollywood Beach may be impacted.

16 inches by ~2060

Tidal Inundation • 1 basin • 0.9 miles of pipe	Tidal inundation may impact an additional 0.4 miles of storm drains, and 1 detention basin located at the end of Casper Rd. near the Ventura County Game Preserve.
Coastal Erosion • 21 inlets / 2 basins • 0.4 miles of pipe	Coastal erosion may damage 21 inlets, 2 basins and additional 0.4 miles of pipe in the Hollywood Beach and Silverstrand neighborhoods. Replacement cost of these pipes is estimated at $485,000.
Coastal Flooding • 9 inlets / 1 basins • 1.4 miles of pipe	Coastal flooding from a 1% annual chance storm may impact an additional 9 storm drain inlets and 1.4 miles of pipes in the southern Hollywood Beach and Silverstrand neighborhoods. In addition, one detention basin may also be impacted at McGrath State Beach near the N. Harbor Blvd. Bridge.

58 inches by ~2100

Tidal Inundation • 53 inlets / 2 pumps • 3 basins • 5.4 miles of pipe	Tidal inundation may impact a combined total of 10 miles of storm drains, 2 pumps, and 3 detention basins located near Naval Base Ventura County at the Pt. Mugu Duck Club, the Casper Rd. Ditches north of the Ventura County Game Preserve, and the Mugu Drain adjacent to the Point Mugu Naval Air Weapons Station . This infrastructure was previously impacted by other hazards with less sea level rise.
Coastal Erosion • 20 inlets • 0.7 miles of pipe	Coastal erosion is projected to potentially damage a combined 83 inlets, 3 basins and 2 pumps and 2.0 miles of pipe across the County. Total replacement cost of these pipes is estimated at $2.4 million.
Coastal Flooding • 12 inlets /9 culverts • 8 basins • 3.6 miles of pipe	Coastal flooding from a 1% annual chance storm may impact a combined total of 90 storm drain inlets, 18 basins, 3 pumps, and 12 miles of pipes across the County. Nine culverts which drain La Conchita and around McGrath Lake are projected to be vulnerable with ~5 feet of SLR.

Potential Adaptation Strategies

Range of Strategies: A range of strategies include retreat, elevating key vulnerable infrastructure, and increasing conveyance and pumping capacity, or flood proofing retrofits to protect existing system components.

Accommodate: Increasing the pump capacity, creating detention basins and expanding the size of the conveyance are mid-term solutions, which may accommodate several feet of sea level rise. Floodplain easements can reduce fluvial flooding. In the Central Coast, accommodation efforts must be coordinated with the Harbor Department.

Protect: Flood proof retrofits to the vulnerable pump stations to protect electrical and system operations may provide a short term relatively low-cost option to accommodate sea level rise. Consider other infrastructure improvements to divert storm water away from low-lying neighborhoods.

Retreat: Phased relocation of the stormwater infrastructure must be tied to a community wide managed retreat strategy.

Secondary Impacts: Vary based on approach and integration of adaptation measures to community adaptation planning. Debris accumulation before and during storm events can exacerbate coastal flooding impacts. Additional detention basins could help recharge groundwater aquifers. Stormwater carries hazardous materials and pollutants.

Findings

Summary

- Increasing tidal inundation poses the largest threat over time due to reduced stormwater conveyance.
- Silverstrand & Hollywood Beach are already vulnerable to coastal flooding with a 1% annual chance storm and high tides.
- With ~5 feet of SLR, much of the Central Coast gravity-fed system will likely be impacted during routine high tides and may not function effectively on a regular basis.
- With ~5 feet of SLR, nine culverts at La Conchita and McGrath Lake may be impacted by coastal flooding.
- Erosion threatens 2 miles of pipe with ~5 feet of SLR.

Thresholds:

- With 8" of sea level rise, erosion may impact many storm drains in Hollywood Beach and Silverstrand.
- With ~5' of SLR, stormwater conveyance from La Conchita and near McGrath Lake may also be impacted.

Data gaps:

- No pipes are shown connecting the stormwater pump stations suggesting that data may be missing.

Strategy Options

Policy:

- Increase base flood elevation of new development to reduce potential storm water flood impacts.
- Revise stormwater policies in the Local Coastal Program, Capital Improvement Plan, and General Plan addressing sea level rise and future decline in conveyance.
- Develop a Stormwater Master Plan for Hollywood Beach and Silverstrand.

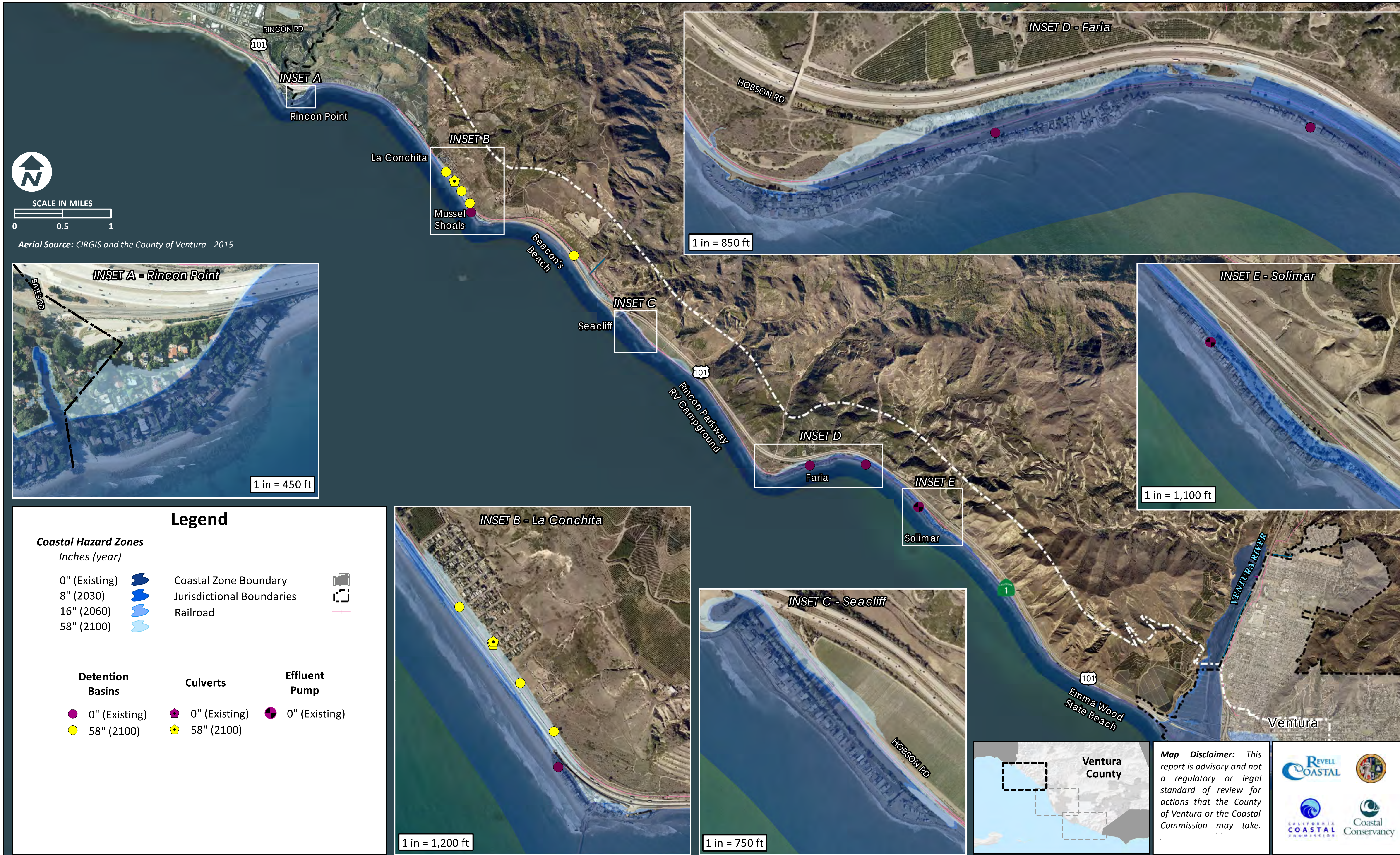
Projects:

- Conduct a stormwater system analysis that examines alternative pump locations, capacity, and expanded conveyance.
- Consider adding flap gates after expanding capacity.
- Develop stormwater retention basins that allow for reuse or release once tides drop to efficient levels.

Monitoring and Maintenance:

- Monitor frequency, duration and depth of stormwater at low lying areas around the County.
- Remove debris from inlets and culverts before storms.

Figure A4a - Stormwater: North Coast



Map Disclaimer: This report is advisory and not a regulatory or legal standard of review for actions that the County of Ventura or the Coastal Commission may take.

Figure A4b - Stormwater: Central Coast

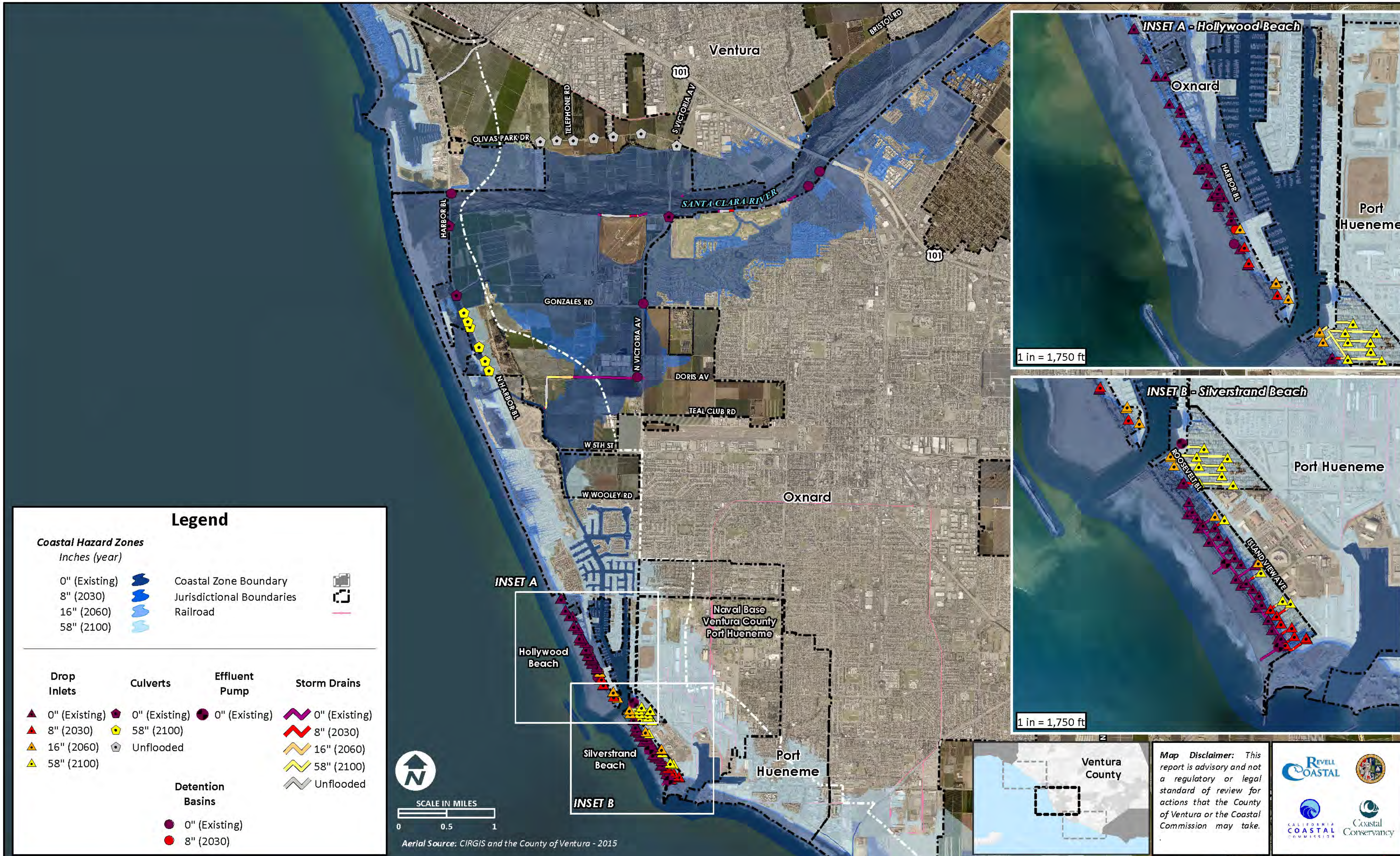
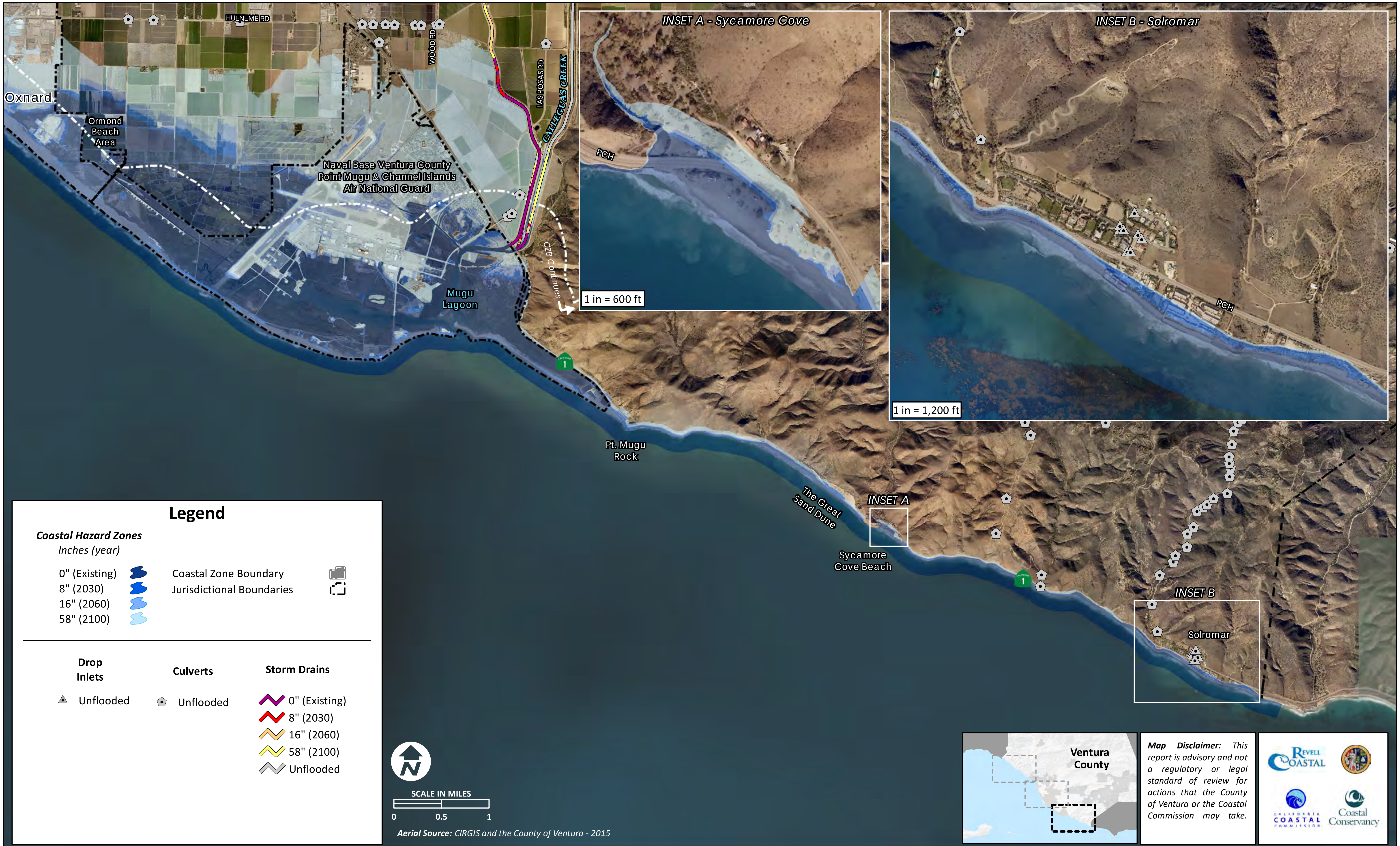


Figure A4c - Stormwater: South Coast



Water Supply

Overview

The County's coastal water supply system is managed by three water districts: Casitas Municipal District supplies water to the North Coast, United Water Conservation District supplies water to the Central Coast, and Calleguas Municipal District supplies water to the South Coast. Total annual water demand for cities and farms within Ventura County is about 445,000 acre feet with about 56% being used for agriculture. Most of the water supply comes from groundwater basins, but also from surface water primarily diverted from the Santa Clara and Ventura Rivers, imported state water, and recycled water. There are many water supply initiatives and local groundwater sustainability agencies that are coordinated through the Integrated Regional Watershed Management Plan and the Sustainable Groundwater Management Act. Higher average temperatures could increase evapotranspiration causing an increase in water use and crop irrigation. The focus of this water supply analysis is solely on supply infrastructure exposure to existing and future coastal hazards. Impacts of coastal hazards and sea level rise (SLR) on water supply infrastructure, were quantified by:

- **Length of pipes (feet)**
- **Number of wells**
- **Number of lift stations**

While the coastal flooding analysis shows that some pipes are vulnerable, if they are buried or elevated, periodic flooding may not be a problem unless there is a need to access the pipes for maintenance or system management. Replacement costs of pipes from erosion was estimated using $230 per foot.

Note: Erosion modeling was not conducted on the North Coast and erosion may cause vulnerabilities in this area.

Existing Vulnerabilities

Coastal Flooding • 2 pump stations • 5 wells • 2.9 miles of pipe	There are no vulnerabilities to water supply infrastructure from either tides or coastal erosion under existing conditions during a 1% annual chance storm. Coastal flooding impacts two pump stations located in the Hollywood Beach area. In addition, four water supply wells are impacted in the Ventura River Valley (located outside of the map extant), and one well is vulnerable in the Ormond Beach area. Some 2.9 miles of water distribution pipe are also vulnerable along the North Coast around Rincon, Mussel Shoals, Seacliff and the Faria Beach Colony. Small exposure to coastal flooding occurs around Solromar in the South County.

Projected Vulnerabilities

8 inches by ~2030

Coastal Erosion • 1 pump station • 1621 feet of pipe **Coastal Flooding** • 1 well • 0.9 miles of pipe	Coastal erosion may threaten over 1,600 feet of water supply pipe which may cause disruptions along the Solromar community. One pump station in the Hollywood Beach neighborhood becomes susceptible to erosion. Replacement costs of the pipe was estimated at $375,000. Coastal flooding may impact an additional groundwater well in the Ormond Beach area and an additional 0.9 miles of pipeline in the North Coast Faria Beach Colony and Solimar neighborhoods and some additional sections in the South Coast Solromar neighborhood.

16 inches by ~2060

Tidal Inundation • 5 wells **Coastal Erosion** • 1 pump station • 500 feet of pipe **Coastal Flooding** • 3 wells • 0.4 miles of pipe	Tidal inundation may routinely affect five wells located in the Ormond Beach area. Coastal erosion may impact one of the pump stations in the Hollywood Beach neighborhood and an additional ~500 feet of pipeline in the Solromar neighborhood. Replacement costs of the pipe was estimated at $115,000. Coastal flooding is projected to impact three additional groundwater supply wells located in the Ormond Beach Area and an additional 0.4 miles of water supply pipeline in the communities of Faria Beach Colony, Mussel Shoals, and Seacliff.

58 inches by ~2100

Tidal Inundation • 2 pump stations • 750 feet of pipe **Coastal Erosion** • 1 pump station • 1611 feet of pipe **Coastal Flooding** • 2 pump stations • 1.7 miles of pipe • 23 wells	Tidal inundation may routinely affect two pump stations in Hollywood Beach and 750 feet of pipe. Coastal erosion may impact another pump station in the Silverstrand and an additional ~1600 feet of pipeline in Solromar. Total replacement costs of pipes is estimated at $860,000. Coastal flooding is projected to impact two additional pump stations, one in Silverstrand and the other near Wooley Road and Harbor Boulevard as well as an additional 1.7 miles of water supply pipeline in the communities of Rincon, La Conchita, Seacliff, Mussel Shoals, and Faria Beach Colony. An additional 23 groundwater supply wells may be impacted by coastal flooding located primarily in the Ormond Beach and Calleguas creek area, but also supply wells at Oil Piers, Rincon Parkway, Silverstrand, and inland of North Harbor Blvd. near McGrath State Beach.

Potential Adaptation Strategies

Range of Strategies: Adaptation strategies that are implemented over the coming decades could include infrastructure changes to improve water supply reliability and storage capability, as well as increased conservation efforts and availability of recycled water. Regional supply should be coordinated with other jurisdictions.

Accommodate – Elevate or seal pump stations, add emergency control valves at strategic locations.

Protect – Constructing levees and coastal armoring to reduce vulnerabilities is the "gray" protection approach, which has already been implemented on the North and South Coasts of the county. A "green" protection approach likely more cost effective in the Central Coast would be to augment sand dunes or contour horizontal levees to protect against future coastal hazards.

Retreat – Relocate distribution pipelines away from erosion hazard areas; and consider future locations of pump stations and wells to avoid coastal hazards.

Secondary Impacts:

Retreat strategies have secondary impacts due to the loss of structures and property and subsequent resulting impacts on the tax base revenues to the County. Gray protection options would result in a loss of beaches over time. Green protection strategies may benefit beaches and homes by maintaining recreational uses.

Findings

Summary

- With ~5 feet of SLR, coastal hazards could impact at least 32 wells and four pump stations.
- While many of the metered connection pipelines near on the North Coast and South Coast are vulnerable, the main water supply pipeline is not vulnerable because they are inland with gravity flow down to the coast.
- Supply wells in the Ormond Beach Area are especially vulnerable to future coastal flood and tidal hazards. Several of these well locations are also in current areas of seawater intrusion.

Thresholds:

- Significant increases in vulnerabilities at ~5 feet of SLR.

Data gap:

- More detailed pipe locations from the United Water Conservation District and Calleguas Municipal District.
- Fire hydrants and control valve data were not available.

Strategy Options

Policy:

- Improve policies to promote water conservation and increase reclaimed water use and availability.
- Coordinate with local water districts and relevant County departments to adapt the system to future demands and include climate change policies in the Integrated Regional Watershed Management Plan.
- Ensure adequate long-term water supplies for the lifetime and intended use of development.
- Restrict development of new wells in vulnerable areas.

Projects:

- New projects and maintenance on water supply infrastructure should include features for SLR adaptation.

Monitoring:

- Continue to monitor groundwater wells and aquifers for seawater intrusion.

Figure A5a - Water Supply: North Coast

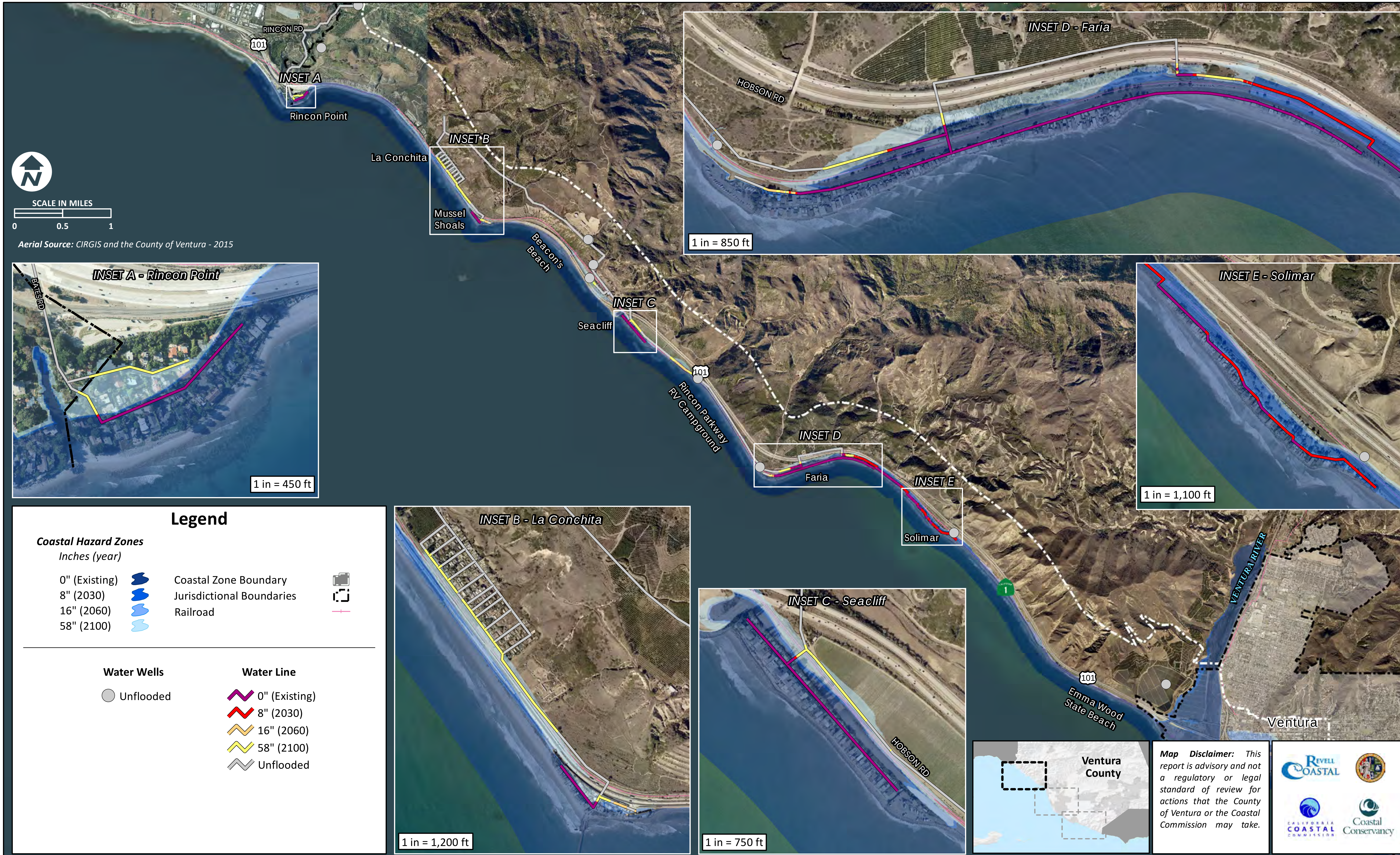


Figure A5b - Water Supply: Central Coast

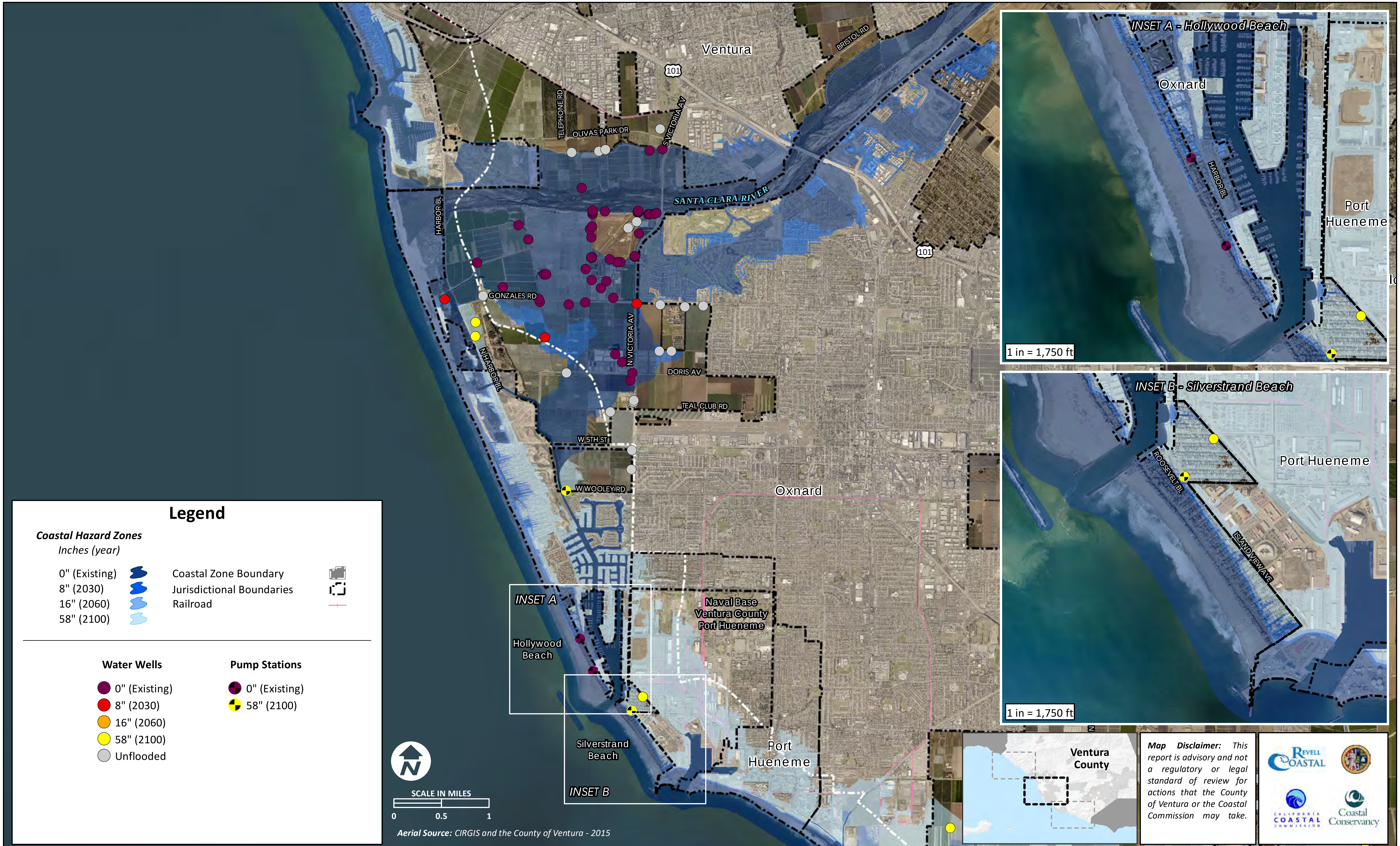
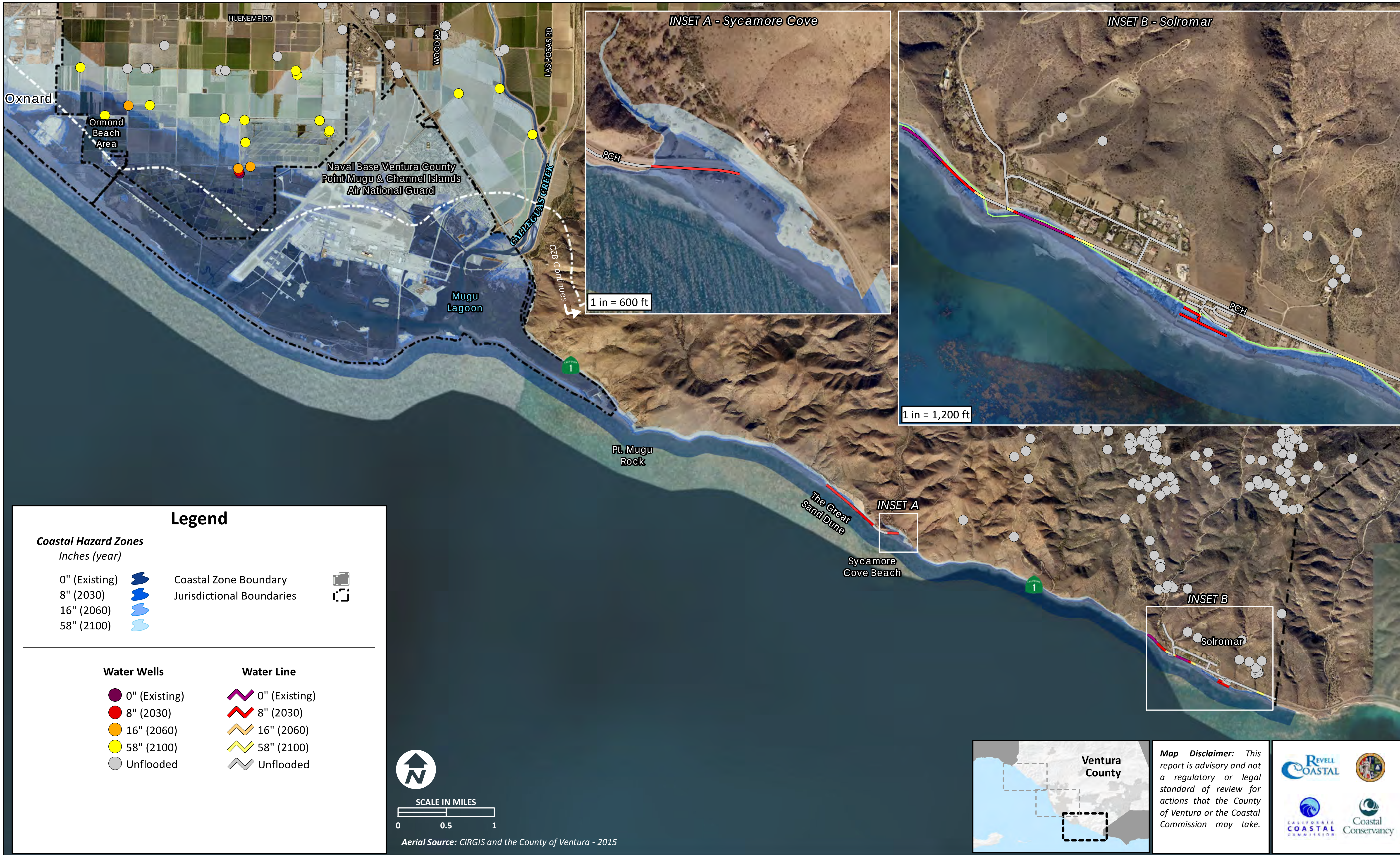


Figure A5c - Water Supply: South Coast



COUNTY OF VENTURA
RESOURCE MANAGEMENT AGENCY | PLANNING DIVISION

VC RESILIENT COASTAL ADAPTATION PROJECT

SEA LEVEL RISE VULNERABILITY ASSESSMENT

APPENDIX A-2. MAP ATLAS AND SECTOR PROFILE RESULTS

This page was intentionally left blank.

APPENDIX A-2. MAP ATLAS & SECTOR PROFILE RESULTS

This Appendix summarizes the effects of 8 inches, 16 inches and 58 inches (about 5 feet) of sea level rise (SLR) on routine monthly high tide inundation and from the potential erosion and flooding impacts caused by a large coastal wave storm (1% annual chance storm). These storms could happen in any given year, however the extent of the damage would not likely occur everywhere across the entire County shoreline from a single event given the different shoreline orientations and wave directions.

Each Sector profile shows the findings and recommendations that can be used to identify vulnerabilities and consider possible solutions and policy directions. Each sector profile, has a set of 3 vulnerability maps (North, Central and South Coast) color coded to the sea level elevation of impacts and a 2-page summary of findings for each of the following resources:

Sectors in Appendix A-1

- Land Use Parcels and Structures
- Agriculture
- Wastewater
- Stormwater
- Water Supply

Sectors in Appendix A-2

- Parks, Trails and Coastal Access
- Roads and Parking
- Public Transportation and Bike Routes
- Oil and Gas
- Hazardous Materials
- Critical Services

These sector profiles are intended to summarize the impacts to the key measures of impact for each sector as identified in Section 5. The overview section provides a short summary of the resource sector and any specifics about the analysis as well as identifies the individual measures of impact. The existing conditions and future vulnerabilities sections highlights components of the sector that are potentially at risk today and projected to be at risk in the future sea level rise and tidal inundation, coastal erosion, coastal flooding, and fluvial flood hazards (Section 4.3). Future vulnerabilities and potential impacts are discussed for each sea level rise scenario based on what else becomes vulnerable with that additional amount of sea level rise. The ~5 feet by 2100 sea level rise scenario identifies what else potentially becomes vulnerable, but the text summarizes everything at risk by coastal hazards and ~5 feet of sea level rise. The adaptation section is a relatively simple summary of potential ranges of options of strategies. This adaptation section will evolve as additional workshops and dialogs are held with the City and key stakeholders. Finally, the summary section, identifies key findings, thresholds of significant impacts, and data gaps. Potential next steps suggests future policy directions, and monitoring needs.

This page was intentionally left blank.

Public Access, Recreation, and Trails

Overview

Coastal access and recreation in the County of Ventura includes a wide variety of activities such as hiking, beach recreation, surfing, camping, kite surfing, birdwatching, and surf fishing. The County recently amended its Local Coastal Program to include the California Coastal Trail, which consists of existing and planned trail segments that transverse the unincorporated coastline and covers approximately 30 miles. Overall in the unincorporated area, there are 31 beach access points with several miles of vertical access trails, in addition to non-designated street end accessways through much of Silverstrand and Hollywood Beach. The County has two beach parks at Hobson and Faria in the North Coast, and State Parks operates five parks in the unincorporated coastal areas.

Impacts of coastal hazards and sea level rise (SLR) were quantified using the following measures of impacts:

- **Number of vertical coastal accessways**
- **Length of lateral beach trails**
- **Length of California Coastal Trail**
- **Number of Parks**

Replacement costs from erosion to the Coastal Trail were estimated at $170 per foot.

Existing Vulnerabilities

Access: All vertical access points are potentially impacted by erosion and coastal flood hazards that could occur during a 1% annual chance storm. Also, 25% of the lateral access along beaches are susceptible to dune erosion. Tidal inundation affects about 50% of the vertical access trails in the County.

Parks: Under existing conditions, Hobson and Faria County parks, the Rincon Parkway RV campground, Emma Wood State Beach, McGrath State Beach, Point Mugu State Park, Sycamore Cove, Thornhill Broome Beach and Leo Carrillo State Park are all day use and camping recreational facilities that are potentially vulnerable to coastal flooding and erosion. McGrath State Beach has already closed its campground and Thornhill Broome, which routinely faces coastal erosion and flood damages, is being considered for seasonal winter closures.

Coastal Trail: Currently just under 4.7 miles of trail are vulnerable to erosion from a 1% annual chance storm. The estimated cost of replacement is $4.2 million. 15.3 miles of trail are vulnerable to coastal flooding and 1.5 miles to tidal inundation.

Winter damage to Thornhill-Broom Campsite in Point Mugu State Park

Photo courtesy California State Parks

Projected Vulnerabilities

8 inches by ~2030

Access: All vertical access points may continue to be impacted by erosion and coastal flood hazards during a 1% annual chance storm. 1.5 miles of lateral beach access is susceptible to coastal cliff erosion on the South Coast.

Parks: With additional sea level rise, more of each of the parks is impacted. On the North and Central Coasts, all parks and trails are impacted by storm flooding and erosion. On the South Coast, Point Mugu Rock, Sycamore Cove, Yerba Buena Beach, and Leo Carrillo Beach will be increasingly eroded and except for Sycamore Cove, these beaches may drown.

Coastal Trail: With 8" of SLR, 8.9 miles of trail on the Central and South Coasts are vulnerable to erosion from a 1% annual chance storm. The estimated cost of replacement is $7.9 million. Also, 16.9 miles of trail are vulnerable to coastal flooding and 1.7 miles are vulnerable to tidal inundation.

16 inches by ~2060

Access: All vertical access points may continue to be impacted by erosion and coastal flood hazards.

Parks: With additional sea level rise, more of each of the parks is impacted.

Coastal Trail: In 2060, 9.1 miles of trail are vulnerable to erosion loss from a 1% annual chance storm. The estimated cost of replacement is $8.1 million. Over 17 miles of trail are vulnerable to coastal flooding and 1.9 miles to tidal inundation.

58 inches by ~2100

Access: All vertical access points may continue to be impacted by erosion and coastal flood hazards and all of the vertical and lateral access would be impacted with routine tidal inundation.

Parks: With additional sea level rise, all of the remaining parks are either lost or impacted. Nearly all of the day-use faciltiies at Sycamore Cove are impacted by coastal flooding hazards.

Coastal Trail: In 2100, 9.7 miles of trail are vulnerable to cliff erosion loss, much of this length consists of planned Coastal Trail improvements along PCH on the South Coast. The estimated cost of replacement is $8.6 million. Nearly 19 miles of trail are also vulnerable to coastal flooding and 6.3 miles to tidal flooding.

Potential Adaptation Strategies

Range of Strategies:

Accommodate – It is possible to elevate parks, trails and campgrounds to accommodate higher flood water levels, and this is currently being considered for McGrath State Beach facilities. Vertical access points can de designed with removable or telescoping elements or constructed in to seawalls and revetments.

Protect – Most of the parks and trails along the North and South Coasts are already armored which include Hobson and Faria County Parks, as well as Rincon Parkway RV campground, and Emma Wood State Beach. The revetments used to protect the parks are up to 70 feet in width, occupying considerable beach area. A "green" protection approach in the North Coast would involve retaining sediment to widen beaches and protect against future coastal and fluvial hazards.

Retreat – Relocate or remove parks from hazardous areas. Coastal access is strongly protected under the California Coastal Act and it will be difficult to find new land for shoreline beach parks without relocating other infrastructure.

Secondary Impacts:

Elevating Coastal Trail segments that are located on roadways would need to be included in a broader adaptation strategy coordinated with transportation authorities.

Findings

Summary

- Annually beaches draw > 3 million visitor days per year and generate an estimated spending of $112 million.
- Beaches provide ~$156 million in economic benefits, $2.3 million in hotel taxes and ~$1 million in sales taxes.
- Under existing conditions, all the coastal access points and over 50% of the Coastal Trail are vulnerable to coastal erosion and coastal flooding and more than half of the lateral accesses along beaches are already affected by tidal inundation.
- With ~5 feet of SLR, all coastal accesses and all lateral Coastal Trail beaches are vulnerable to coastal erosion, coastal flooding, and tidal inundation.
- Faria and Hobson County Parks may be routinely flooded by large waves requiring seasonal closures.
- Significant portions of the Coastal Trail are at risk to coastal erosion (~30%), tidal inundation (~20%), and coastal flooding (~60%) with ~5 feet of SLR.

Strategy Options

Policy

- Work with State Parks to identify future beach access constraints and seasonal closures for parks.
- Develop a long-range coordinated plan for the Coastal Trail with agencies such as State Parks and Caltrans.

Monitoring

- Monitor depth, extent and frequency of park flooding along frequently impacted areas. Track clean-up and maintenance costs for flooding.

Data gaps

- State park campgrounds, parking lots and trail alignments.

Thresholds:

- A major erosion or coastal flood could temporarily impact vertical and lateral access to coastal Ventura County today.

Figure A6a - Parks, Trails, and Coastal Access: North Coast

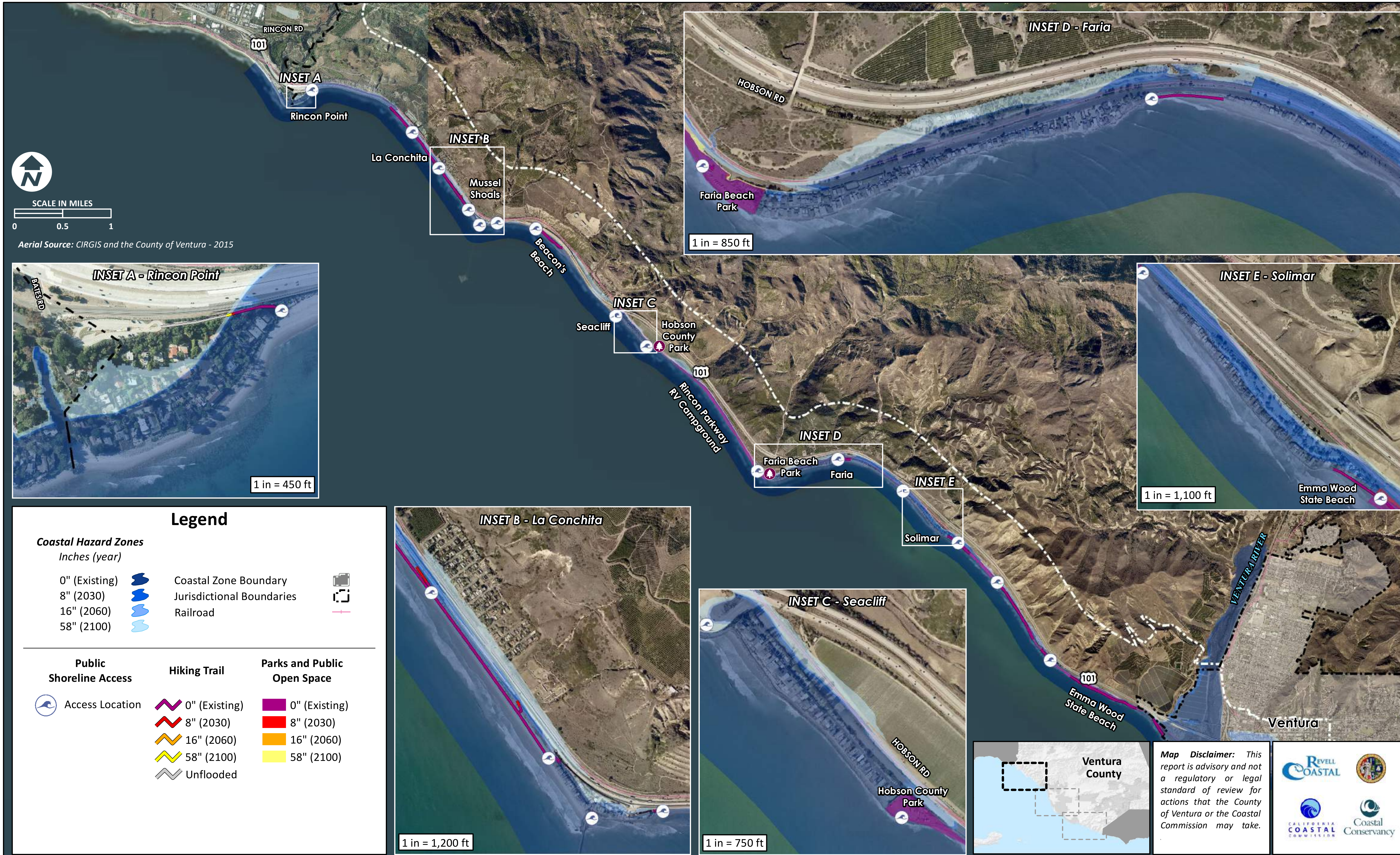


Figure A6b - Parks, Trails, and Coastal Access: Central Coast

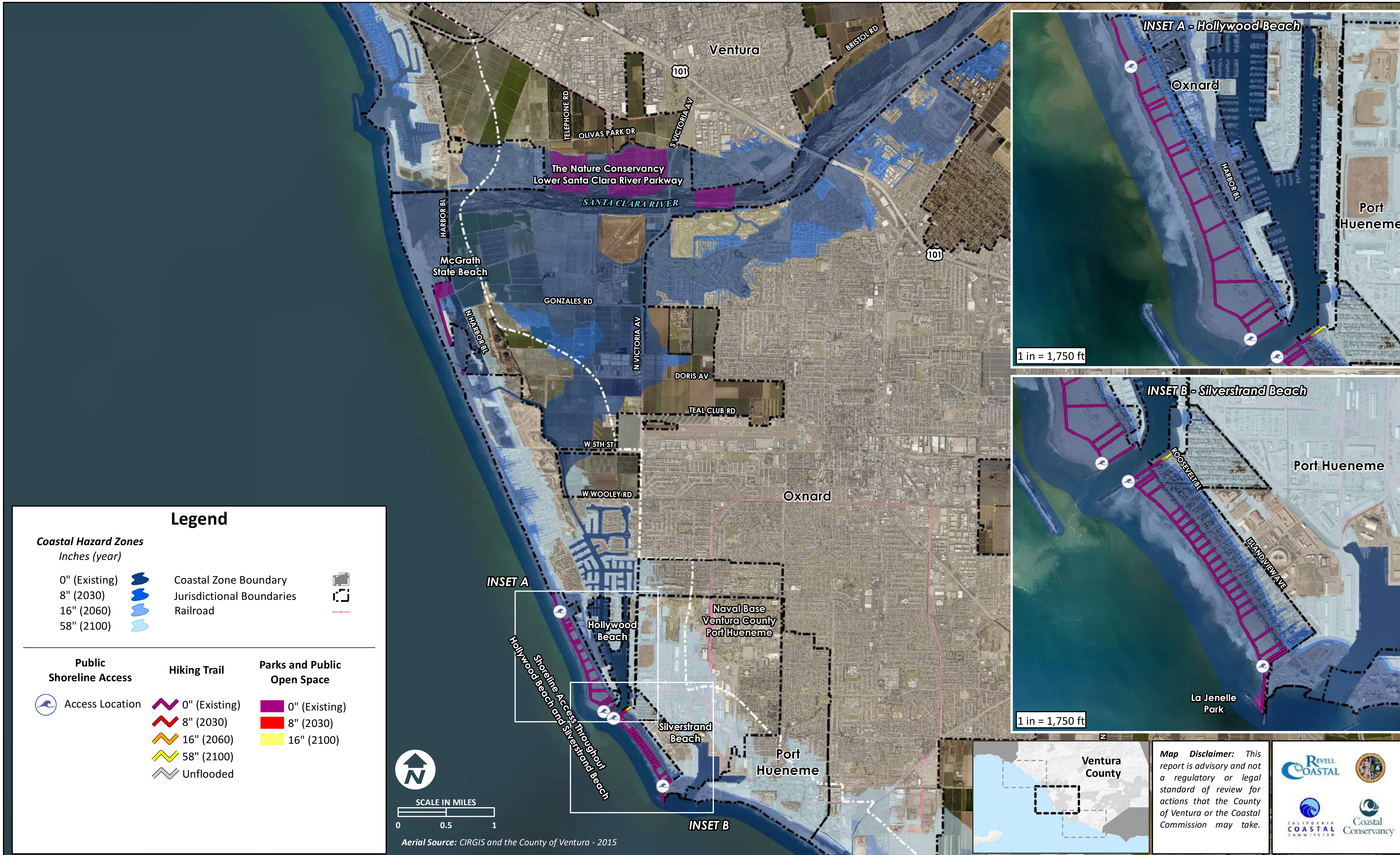
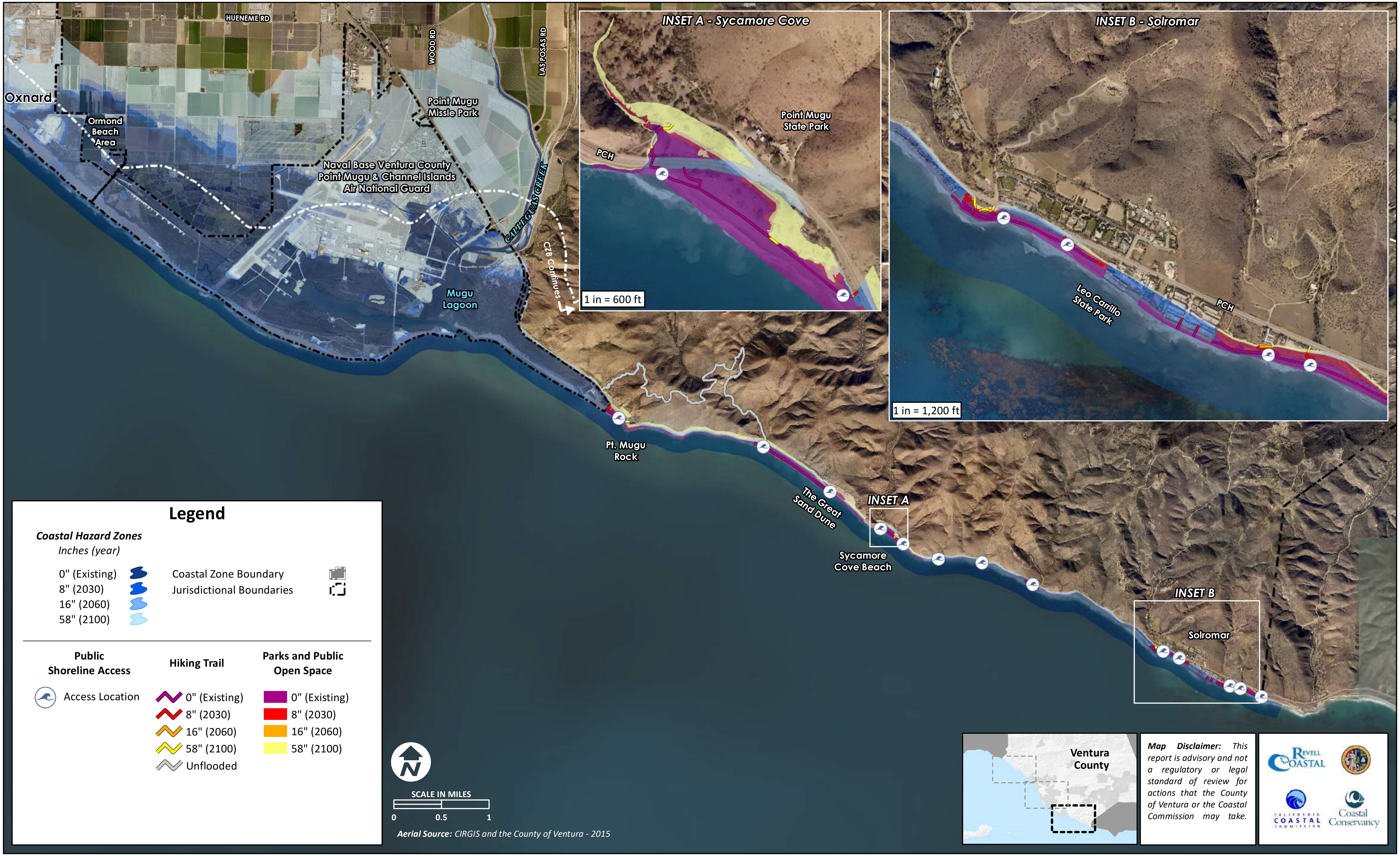


Figure A6c - Parks, Trails, and Coastal Access: South Coast



Roads and Parking

Overview

The County of Ventura Transportation Department is responsible for the planning, designing, funding, building, operating and maintaining the County road system, with approximately 544 miles of roadway, bridges, drainage and related transportation facilities. Approximately 183 miles of road lie within the County coastal zone and coastal hazard boundary. The responsibility for maintaining these roads lie between Caltrans, primarily for Highway 101 and Pacific Coast Highway (PCH), and the County Transportation Department. Fifteen (15) parking lots are maintained by the County or State Parks that provide coastal access. A failure of the coastal armoring along the North Coast may substantially increase the amount of erosion impacts to roads and parking lots.

To quantify the impact of coastal hazards and sea level rise (SLR) on roads and public transportation, the following measures of impact have been identified:

- **Length of roads (miles),** *replacement costs from erosion estimated at $280 per road foot*
- **Number of Parking lots (data not available for all State Parks parking lots)**

Note: Erosion modeling was not conducted on the North Coast and erosion may cause vulnerabilities in this area.

Existing Vulnerabilities

Tidal Inundation • 2.5 miles **Coastal Erosion** • 1.8 miles **Coastal Flooding** • 19.0 miles	*Roads*: Under current conditions, with a 1% annual chance storm, 19 miles of road are vulnerable to coastal flooding. Much of this is along the Rincon Parkway in the North Coast and along PCH in the South Coast. Tidal inundation may affect portions of roads around the Ventura County Game Preserve during extreme high king tides. Replacement costs for the erosion damages estimated at $2.7 million. *Parking:* Six parking lots are subject to erosion under existing conditions at Point Mugu, Solromar, and Yerba Buena Beach located in the South Coast and two parking lots on the north side of Channel Islands Harbor at Hollywood Beach. Coastal flooding may impact an additional three parking lots at Faria and Hobson County parks and along the Rincon Parkway.

Projected Vulnerabilities

8 inches by ~2030

Tidal Inundation • 0.7 miles **Coastal Erosion** • 4.9 miles **Coastal Flooding** • 4.6 miles	*Roads*: With a 1% annual chance storm and 8" of SLR, an additional 4.6 miles of road are vulnerable to coastal flooding. Much of this is along the Rincon Parkway in the North Coast and along PCH in the South Coast. Dune erosion could impact 3.2 miles in Silverstrand and Hollywood Beach, and cliff erosion along the South Coast could damage 1.8 miles of PCH. Tidal inundation may affect additional road portions near the Ventura County Game Preserve during high monthly tides. Replacement costs for the erosion damages estimated at $7.2 million. *Parking:* No additional parking lots are exposed.

16 inches by ~2060

Tidal Inundation • 0.3 miles **Coastal Erosion** • 4.6 miles **Coastal Flooding** • 4.6 miles	*Roads*: With a 1% annual chance storm, an additional 4.6 miles of road are vulnerable to coastal flooding. Additional portions of the Rincon Parkway, PCH in the South Coast, and streets at Silverstrand and Hollywood Beach also become more vulnerable. Dune erosion could impact 1.9 miles in Silverstrand and Hollywood Beach and cliff erosion along the South Coast could damage another 2.6 miles of PCH. Tidal inundation may affect additional road portions around the Ventura County Game Preserve and the sod farms during high monthly tides. Replacement costs for the erosion damages were estimated to be $6.8 million. *Parking:* No additional parking lots are exposed.

58 inches by ~2100

Tidal Inundation • 8.28 miles **Coastal Erosion** • 5.0 miles **Coastal Flooding** • 16.5 miles	*Roads*: With a 1% annual chance storm, a combined total of 45 miles of road are vulnerable to coastal flooding across coastal Ventura County including almost all of Rincon Parkway and portions of PCH and Highway 101. Dune erosion could impact 8 total miles in Silverstrand and Hollywood Beach and cliff erosion along the South Coast could damage 6 total miles. Tidal inundation impacts increase substantially and periodically affect 12 miles of road across the county, the biggest changes occur at Rincon and Silverstrand. *Parking:* One additional lot near Point Mugu which provides parking for the Chumash trailhead becomes exposed to coastal flooding. A total of 12 County and State Parks parking lots may be vulnerable with ~5 feet of SLR.

Potential Adaptation Strategies

Range of Strategies:

Accommodate – It is possible to elevate roads to accommodate higher flood water levels. This could be accomplished by elevating segments of road on causeways, or by incrementally elevating the road surface during routine repaving by adding an additional 2-3 inches of asphalt.

Protect – (Green) Contour additional elevation into dunes along the Central Coast, nourish the North Coast Rincon Parkway area with additional cobble. (Gray) Construct and maintain coastal armoring and/or install pumps to flood proof the most vulnerable road segments, such as Harbor Boulevard.

Retreat – Relocate or remove roads from the hazardous areas.

Secondary Impacts:

Retreat strategies may negatively impact traffic and other resources of the County, depending on the realignment. Accommodation strategies may create additional storm water drainage issues. Protection strategies (green) could provide some room for habitat transgression for roads adjacent to wetlands. Gray protection strategies could negatively impact beach and dune habitat transgression as well as escalate maintenance costs.

Findings

Summary

- PCH on the South Coast and Rincon Parkway and Highway 101 in North Coast are currently vulnerable.
- Erosion could damage 14 miles of roads with ~5 feet of SLR and an estimated replacement cost of $20.7 million.
- Coastal flooding may affect 19 miles of roads now and 45 miles with ~5 feet of SLR including all of Rincon Parkway and portions of Highway 101 and PCH.
- 11 County parking lots providing beach access are presently vulnerable to coastal hazards. A total of 12 lots may be affected by coastal flood hazards with ~5 feet of SLR, and six lots may be eroded.

Thresholds:

- Transportation could be substantially impacted today by erosion (1.8 miles) or coastal flooding (19 miles).
- With ~5 feet of SLR, tidal inundation affects an additional 8.3 miles of road.

Data Gaps:

- Parking lot data used for State Parks' properties was manually created and may not be precise or complete.

Strategy Options

Policy:

- Work with Caltrans on PCH to ensure that regional connections remain intact.
- Work with State Parks to identify future beach access parking so that there is no net loss of coastal access.
- Update the transportation planning documents such as the Strategic Master Plan to identify preferred adaptation strategies to reduce impacts to roads and parking lots.

Projects:

- Elevate or relocate critical roads including Harbor Boulevard and the Rincon Parkway.
- Consider amending the County's Capital Improvement Plan to add additional inches of street resurfacing to gain elevation at the pace of sea level rise or greater.
- Consider multi-modal transportation such as bike lanes and pedestrian facilities while planning for adaptation.

Monitoring:

- Monitor depth, extent and frequency of road flooding along frequently impacted areas.

Figure A7a - Roads and Parking: North Coast

Figure A7b - Roads and Parking: Central Coast

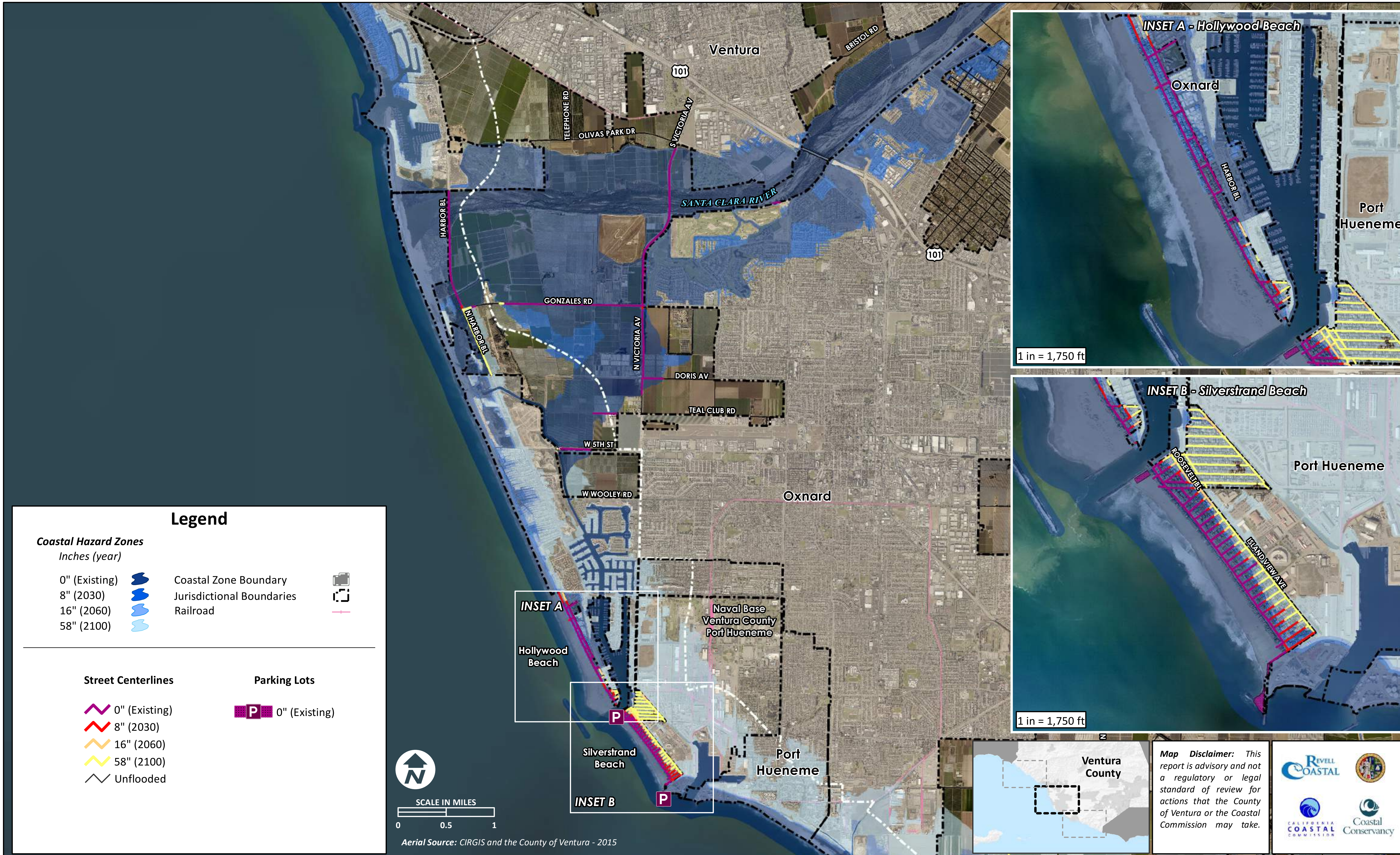
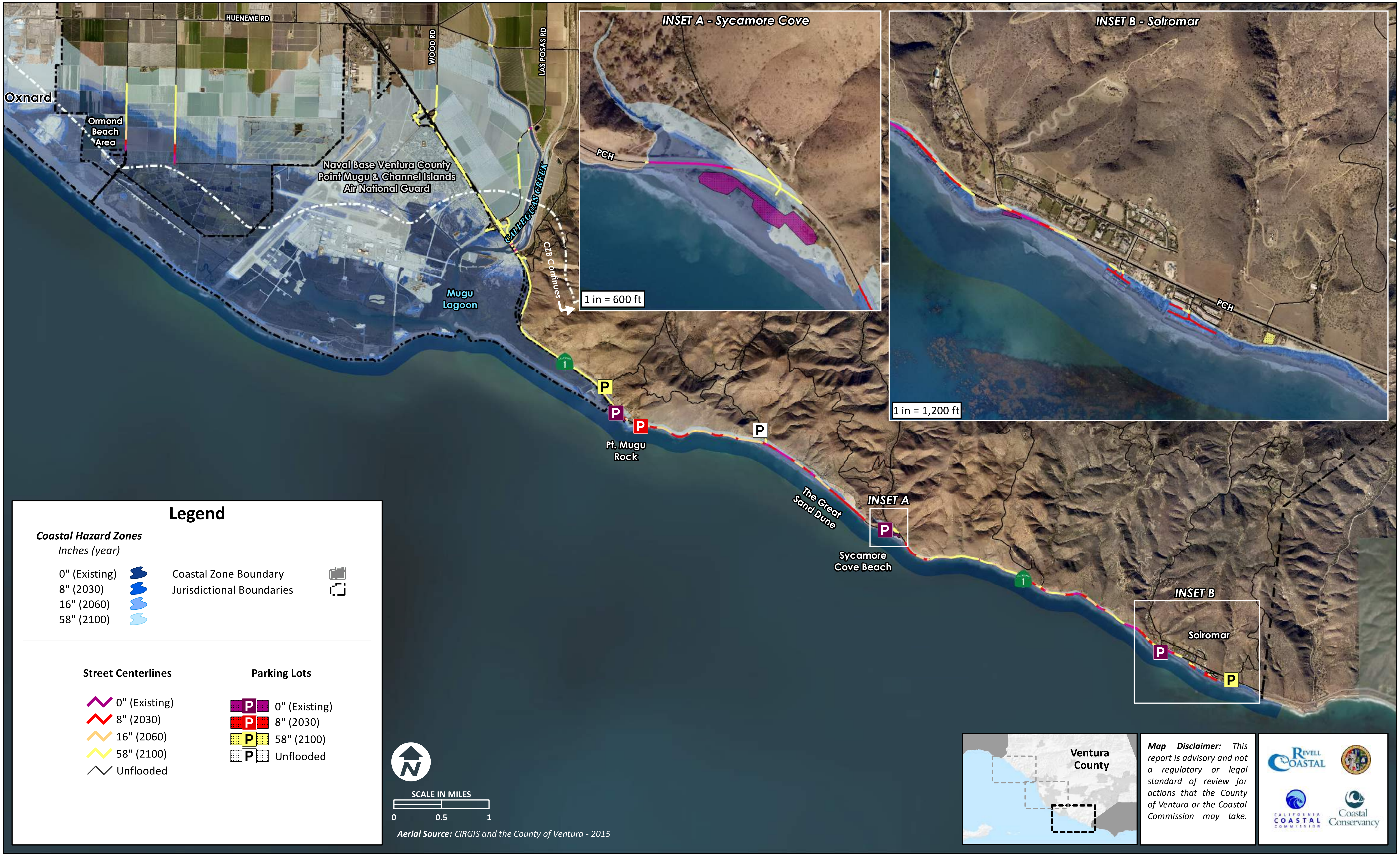


Figure A7c - Roads and Parking: South Coast



Overview & Measures of Impact

Ventura County has approximately five miles of Class 1 bike trails including the recently completed Ralph Fertig Memorial Trail connecting the Beacon's Beach Area to Rincon Point along Highway 101. Union Pacific Railroad (UPRR) owns and operates the railroad through Ventura County and provides some public use through AMTRAK. The railroad alignment hugs the North Coast coastline and has existed since before the Coastal Act. Episodic erosion has threatened the railroad, which has built emergency revetments for protection. The Coastal Express Bus, operated by VISTA, extends from the City of Ventura to Isla Vista in Santa Barbara County. There are no stops on the North Coast, but the bus route traverses Highway 101. The local bus system, operated by Gold Coast Transit provides no bus routes in the unincorporated coastal zone.

To quantify the impact of coastal hazards and sea level rise (SLR) on roads and public transportation, the following measures of impacts were identified:

- **Number of bus stops; bus routes (miles)**
- **Biking trails (miles)**
- **Railroad (miles)**

Note: Erosion modeling was not conducted in the North Coast and erosion may cause vulnerabilities in this area.

Existing Vulnerabilities

Coastal Erosion

- 0.9 miles (bike)
- 0.1 miles (rail)

Coastal Flooding

- 5.7 miles (bike)
- 3.0 miles (rail)

Bike: The most northern portions of the Ralph Fertig Memorial Trail and Sycamore Cove are exposed to coastal flooding.

Rail: While no erosion impacts were modeled, the extensive coastal armoring in the area indicates that coastal erosion has already affected much of the North Coast.

Ralph Fertig Memorial Bike Trail

(Photo courtesy of SB Bike Coalition)

Projected Vulnerabilities

8 inches by ~2030

Coastal Erosion

- 0.9 miles (bike)
- 0.1 miles (rail)

Coastal Flooding

- 0.6 miles (bike)
- 2.6 miles (rail)

Bike: Additional portions of the Ralph Fertig Memorial Trail and Sycamore Cove are exposed to coastal flooding. Coastal erosion could potentially affect the bike lane and sidewalks along Ocean Dr. at Silverstrand Beach.

Rail: Coastal flooding from a 1% annual chance storm could impact another 2.6 miles of the North Coast rail alignment, bringing the total to 5.6 miles of rail line at risk of storm flooding. Erosion is likely to be an ongoing vulnerability.

16 inches by ~2060

Coastal Erosion

- 0.2 miles (rail)

Coastal Flooding

- 0.2 miles (bike)
- 1.6 miles (rail)

Bike: Additional portions of the Ralph Fertig Memorial Trail and Sycamore Cove are exposed to coastal flooding. Coastal erosion could potentially affect the bike lane and sidewalks along Ocean Dr. at Silverstrand Beach.

Rail: Coastal flooding from a 1% annual chance storm could impact the North Coast rail alignment, bringing the total to 7.2 miles of rail line at risk of storm flooding. Erosion is likely to be an ongoing vulnerability.

58 inches by ~2100

Tidal Inundation

- 0.9 miles (bike)

Coastal Erosion

- 0.2 miles (rail)

Coastal Flooding

- 3.3 miles (bike)
- 3.4 miles (rail)

Bike: Additional portions of the Ralph Fertig Memorial Trail and Sycamore Cove routes are exposed to coastal flooding. Erosion could affect the trail along Silverstrand. With ~5 feet of SLR, 9.9 total miles of bike lanes could be affected by coastal flooding. Tidal inundation begins to affect Silverstrand and lower Oxnard plain near Pt. Mugu.

Rail: Coastal flooding from a 1% annual chance storm could impact another 3.4 miles of the North Coast rail alignment, bringing the total to 10.6 miles of rail line at risk of storm flooding. Erosion is likely to be an ongoing vulnerability.

Potential Adaptation Strategies

Range of Strategies:

Accommodate – Elevate roads and bike paths to accommodate higher flood water levels, consider developing additional causeways. Another option would be to add an additional 2-3 inches of asphalt during routine repaving of the roads or bike paths.

Protect – Constructing levees and coastal armoring to reduce vulnerabilities is the "gray" protection approach, which has already been implemented in the North Coast. A "green" protection approach in the Central Coast would be to augment sand dunes to protect against future coastal hazards.

Retreat – relocate or reroute bike trails and rail lines outside of the vulnerable areas.

Secondary Impacts:

Since most of the existing and planned Class 2 bike lanes are located on Pacific Coast Highway, retreat strategies for bike lanes would need to accompany a broader adaptation strategy for Caltrans roads. Accommodation strategies may create additional demand for stormwater drainage capacity. Dune protection strategies (green) could provide some habitat particularly along the Central Coast. Gray protection strategies could negatively impact beaches, coastal dependent recreation, as well as escalate maintenance costs.

Findings

Summary

- No bus routes or bus stops are susceptible to coastal hazards with ~5 feet of SLR.
- At least 11 miles of rail and 9.9 miles of bike trails may be subject to coastal flooding with ~5 feet of SLR.
- Coastal erosion may substantially damage rail and bike routes along portions of the North Coast particularly if the existing coastal armoring fails.
- Tidal inundation will routinely close about a 0.9 miles of bike path during high tides with ~5 feet of SLR.

Thresholds:

- Significant increases in vulnerability with ~5 feet of SLR as episodic storm impacts become periodic tidal inundation.

Data gaps:

- Erosion to the railroad has already occurred but was not modeled into the future, because the railroad is located inland of major roadways that are armored.

Strategy Options

Policy:

- Develop alternative bike routes, further inland.
- Review the status of the coastal armoring emergency permits in the County.
- Coordinate with UPRR and Caltrans on future plans and adaptation strategies.

Projects:

- Amend the County's Capital Improvement Plan for the bike lanes on Harbor Boulevard, and Caltrans' Transportation Concept Reports and District System Management Plans to add additional inches to the lift in street resurfacing to gain elevation at the pace of sea level rise or greater than the pace of sea level rise.

Monitoring:

Monitor depth, extent and frequency of road flooding and erosion along existing alignments. Track clean-up costs.

Figure A8a - Public Transportation and Bike Routes: North

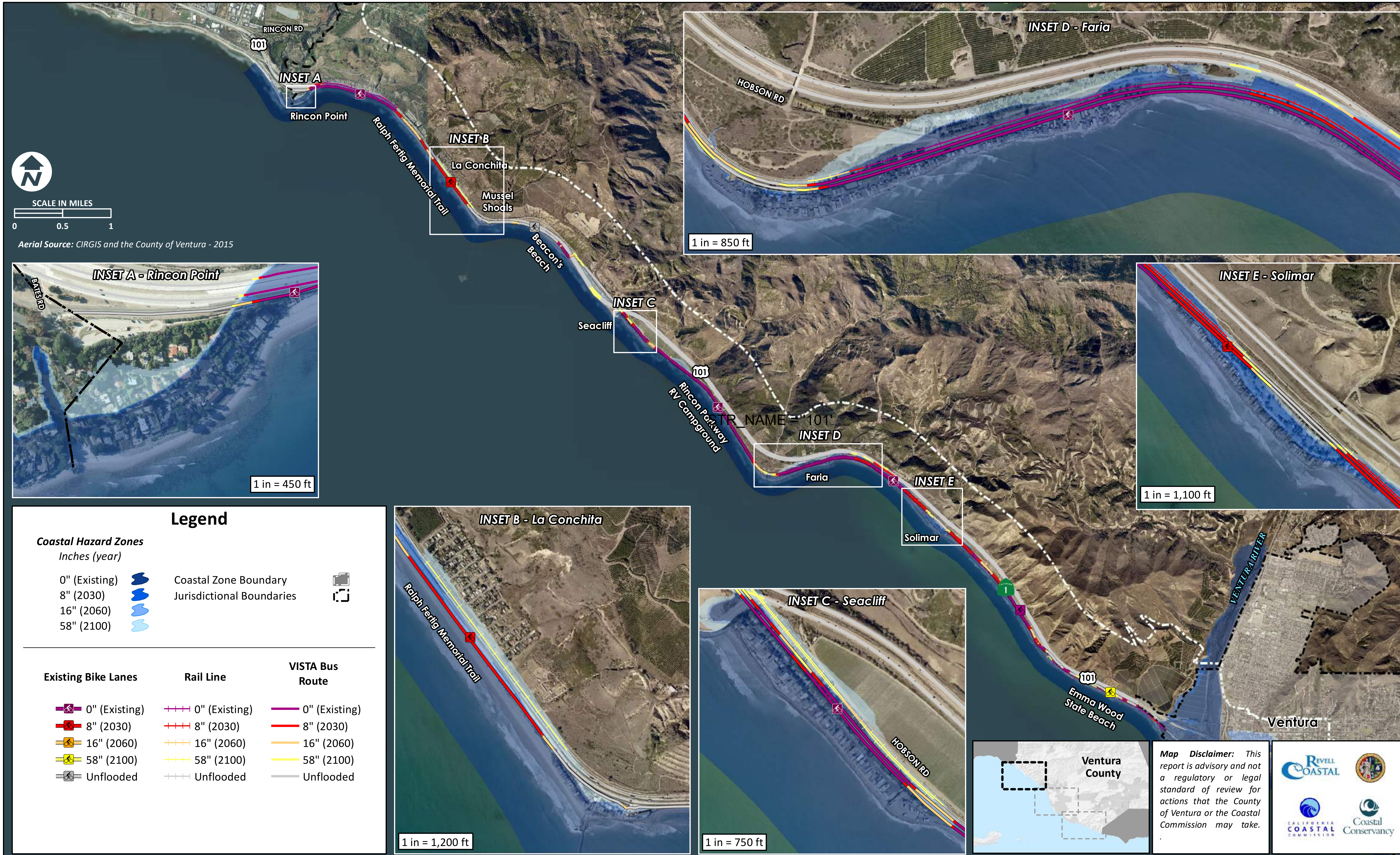


Figure A8b - Public Transportation and Bike Routes: Central

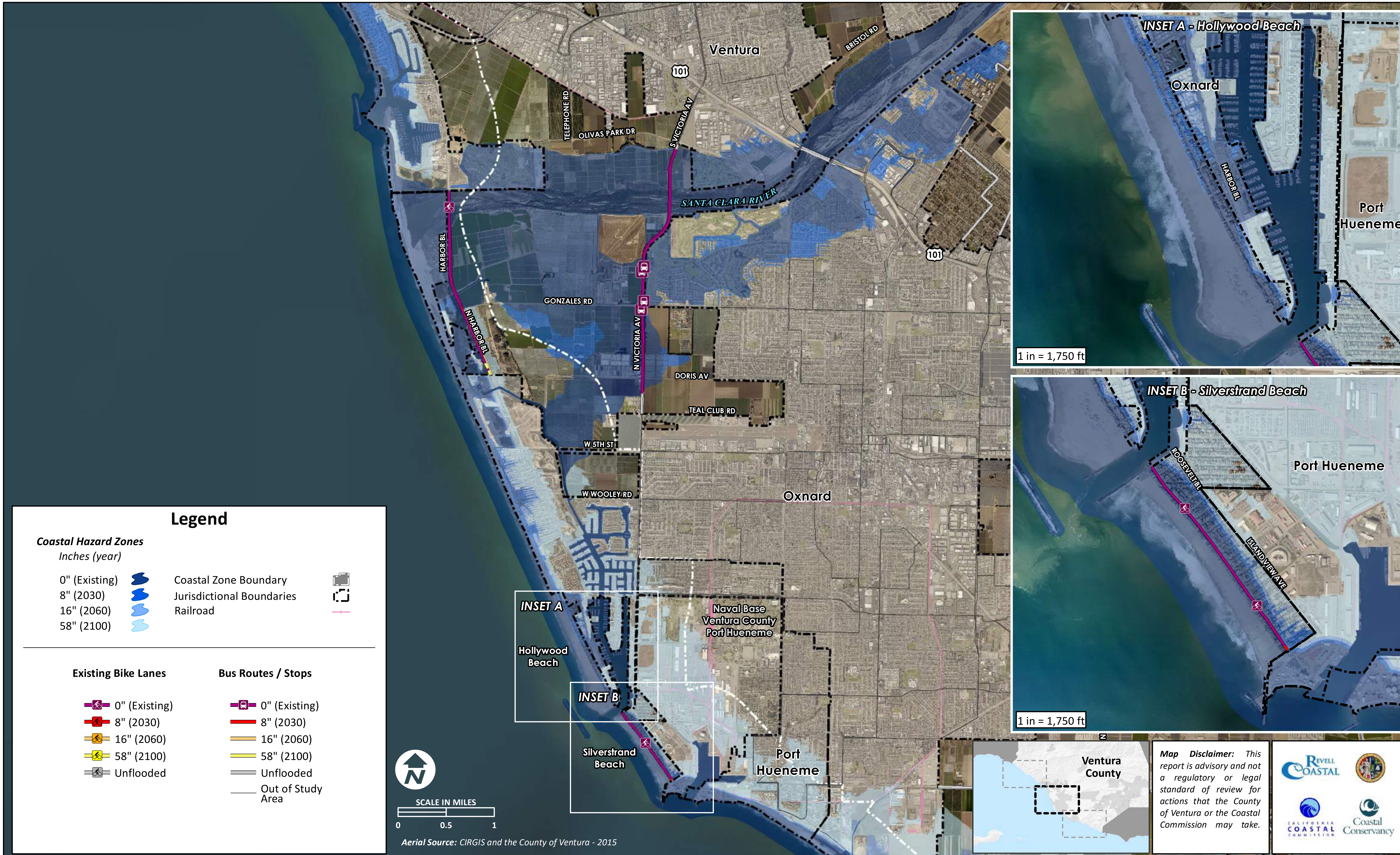
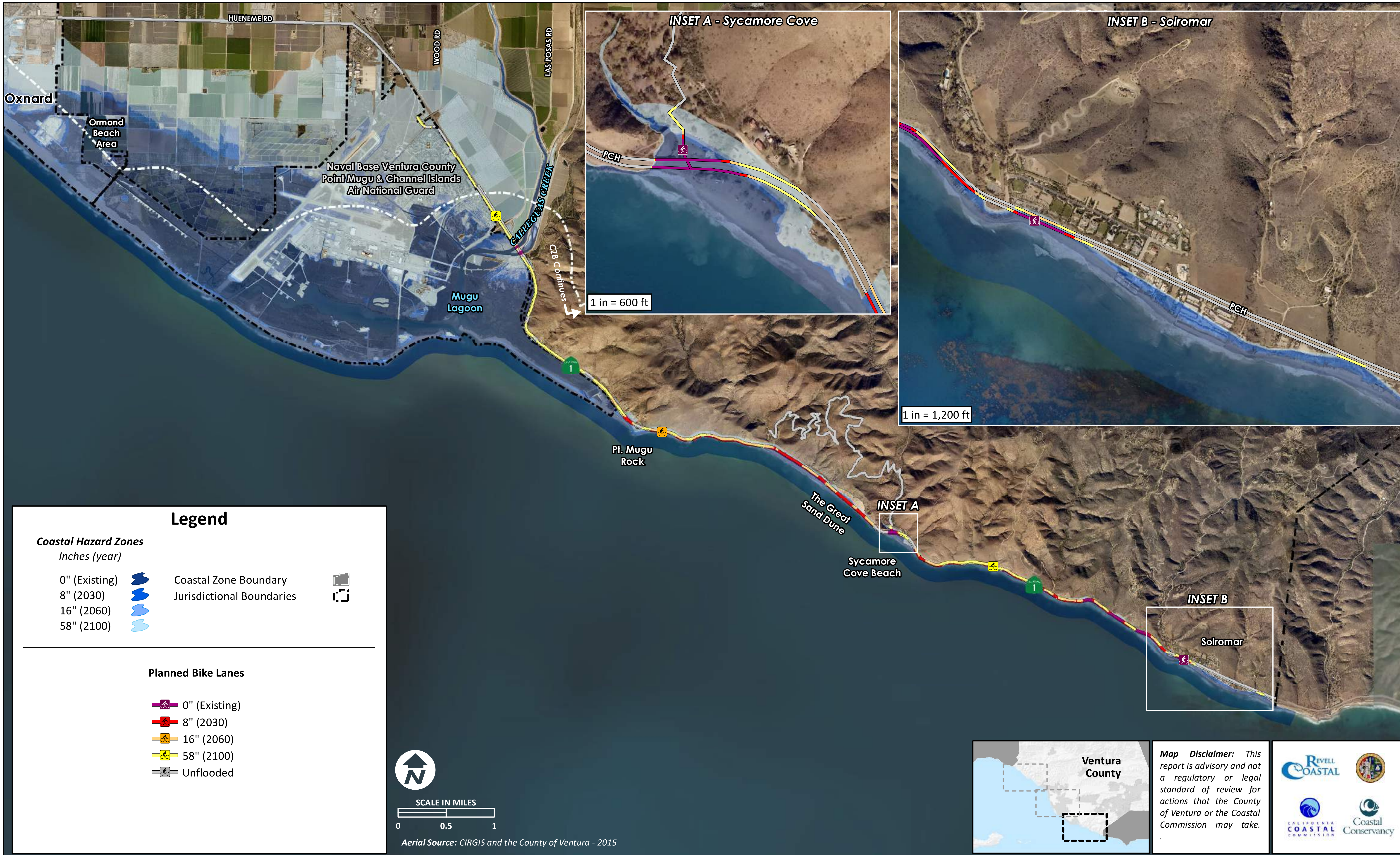


Figure A8c - Public Transportation and Bike Routes: South Coast



Oil and Gas Infrastructure

Overview

Oil and gas development in the Santa Barbara and Ventura Counties began in the late 1860s. Over 12,000 wells have been drilled into the Ventura Basin. Presently there are ~3,800 active wells in Ventura County. Some of these are operating under permits dating back to the late 1940s, when local oil provided fuel for the Pacific Fleet during World War II. According to the California Division of Oils, Gas and Geothermal Resources, there are 105 active wells within the unincorporated coastal zone, and approximately 363 inactive and capped wells. Little is known about how wells were capped.

Rincon Island, once a major oil and gas processing facility located on the North Coast, is being decommissioned. An additional slant drilling oil facility is located in the West Montalvo Oil Field near McGrath Beach. Minor pipelines connect wells to local storage facilities and connect with major pipelines to transport oil and gas to refineries in Los Angeles. Major pipelines are generally located along the railroad and Highway 101. Nearby oil spills in 1969 (Santa Barbara) and 2015 (minor pipeline rupture near Refugio) have impacted Ventura County beaches. In nearby Summerland, unmarked inactive legacy wells have been leaking for years and have yet to be resolved. Potential fiscal impacts to the County may be in the hundreds of millions of dollars should an oil spill occur.

Impacts of coastal hazards and sea level rise on oil and gas are quantified using the following measures of impact:

- **Number of wells (active vs inactive)**
- **Miles of major pipelines**
- **Miles of minor pipelines**
- **Number of facilities**

Note: Erosion modeling was not conducted in the North Coast and erosion may cause vulnerabilities in this area.

Existing Vulnerabilities

Tidal Inundation • 2 inactive wells **Coastal Flooding** • 12 inactive wells • 1.9 miles major pipelines • 2.1 miles minor pipelines • 1 Facility **Fluvial Flooding** • 58 inactive wells • 15 active wells	The two wells exposed to tidal inundation are both inactive, one near Rincon Point, and one near Ormond Beach in the Ventura County Game Preserve. Inactive wells and minor pipelines are exposed to coastal flooding along the North Coast. Coastal flooding also affects major pipelines along Highway 101 and the railroad in the North Coast. Fluvial hazards affect 73 wells (14 active) on the Santa Clara River and one active well on the Ventura River (not shown on the North Coast map extent). For all the historic above-ground infrastructure there remains unknown amounts of below-ground infrastructure along the Santa Barbara and Ventura County coasts. Impacts to oil and gas infrastructure could occur within the county or adjacent jurisdictions with oil spills drifting downcoast and contaminating County beaches. **Economics**: The biggest potential economic loss is an oil spill, e.g., the recent Refugio oil spill from a minor pipeline cost $257 million to remediate and could easily happen in Ventura. Twelve wells are already subject to coastal or tidal flooding and an additional 73 are vulnerable to fluvial flooding.

Projected Vulnerabilities

8 inches by ~2030

Coastal Flooding • 3 inactive wells • 1.9 miles major pipelines • 1.5 miles minor pipelines **Fluvial Flooding** • 9 active / 7 inactive wells	Wells and pipelines exposed to additional coastal flooding are found along the North Coast and near McGrath Beach. Coastal flooding also affects major and minor pipelines along Highway 101 and the railroad on the North Coast. Fluvial flooding along the Santa Clara River may expose additional wells along McGrath State Beach and inland of Harbor Blvd.

16 inches by ~2060

Coastal Flooding • 1.5 miles major pipelines • 0.9 miles minor pipelines	Coastal flooding continues to potentially impact additional segments of the major and minor pipelines along Highway 101 and the railroad on the North Coast, as well as near the Mandalay Generating Station on the Central Coast.

58" by ~2100

Tidal Inundation • 3 inactive wells **Coastal Flooding** • 17 active / 32 inactive wells • 4.1 miles major pipelines • 1.6 miles minor pipelines	Tidal inundations are projected to impact 3 inactive wells in and around the Mugu Wetlands and the agricultural fields surrounding Point Mugu Naval Air Weapons Station. Coastal flooding potentially impacts several wells (active and inactive) near the Seacliff Highway 101 offramp to the Rincon Parkway and additionally near McGrath Beach. Coastal flooding from a 1% annual chance storm potentially impacts segments of the major and minor pipelines along the North Coast Highway 101, railroad, and near McGrath Beach on the Central Coast. Seventeen of the 105 currently active wells could be impacted by coastal flooding hazards and 24 active wells by fluvial flooding hazards.

Potential Adaptation Strategies

Range of Strategies: Oil and gas infrastructure could be relocated, elevated, or protected in place. Regulatory requirements for oil and gas facility adaptation will be contentious and may include State and federal jurisdictions. Generally, oil and gas facilities that are exposed to erosion may need to employ protection or retreat strategies, while facilities that are periodically inundated by tides and flooding could be retrofitted or protected.

Accommodate – For some facilities, it may possible to elevate the equipment and install pumps.

Protect –While coastal erosion has not been projected to directly impact any oil and gas facilities, by ~2100 McGrath State Beach is projected to erode to the edge of the facility near the Mandalay Generating Station and dune erosion facilitates enough coastal flooding to reach many facilities. Maintaining or constructing coastal armoring would be one means to protect these oil and gas resources. A green protection option would be to construct or augment sand dunes to protect the oil and gas infrastructure in the Central Coast.

Retreat – Involves a phased removal to cap, abandon, decommission, and restore facilities. Well casings and onshore support infrastructure may be re-exposed as erosion continues. Permit conditions of approval to require removal would be beneficial.

Secondary Impacts: Delays in any response could result in oil spills and nuisance hazards. Environmental assessments and permitting require substantial lead time and high costs. Elevating may extend the exposure to wave impacts and have escalating maintenance costs. All options could have short-term impacts on sensitive habitats.

Findings

Summary	Strategy Options
• Substantial vulnerabilities exist due to current hazards. • No oil and gas infrastructure is exposed to coastal erosion along the Central or South Coasts. • Fluvial hazards create vulnerabilities today and with minor sea level rise (8"). • There is the potential for oil spills from active and inactive wells as well as major and minor pipelines. The costs of remediating a spill could be enormous, and the County could be liable. **Thresholds:** • There is a substantial increase in vulnerabilities after 16" of sea level rise. **Data gap:** • Minor pipeline alignments and details on well caps for inactive wells are not well documented.	**Policy:** • Coordinate oil and gas responses and share lessons learned with neighboring cities, counties, the CA Fish and Wildlife Office of Spill Prevention and Response, State Lands Commission, and Coast Guard. • Explore the use of bonds or other forms of financial assurance for rapid response to remove damaged wells. • Clarify and streamline the permitting process for remediation of legacy wells. **Projects:** • Upon decommissioning of active sites, ensure the removal of all shore protection, access roads, pipes and other infrastructure. **Monitoring:** • Monitor the State's clean up and removal of Rincon Island facilities for potential impacts to the North Coast.

Figure A9a - Oil and Gas: North Coast

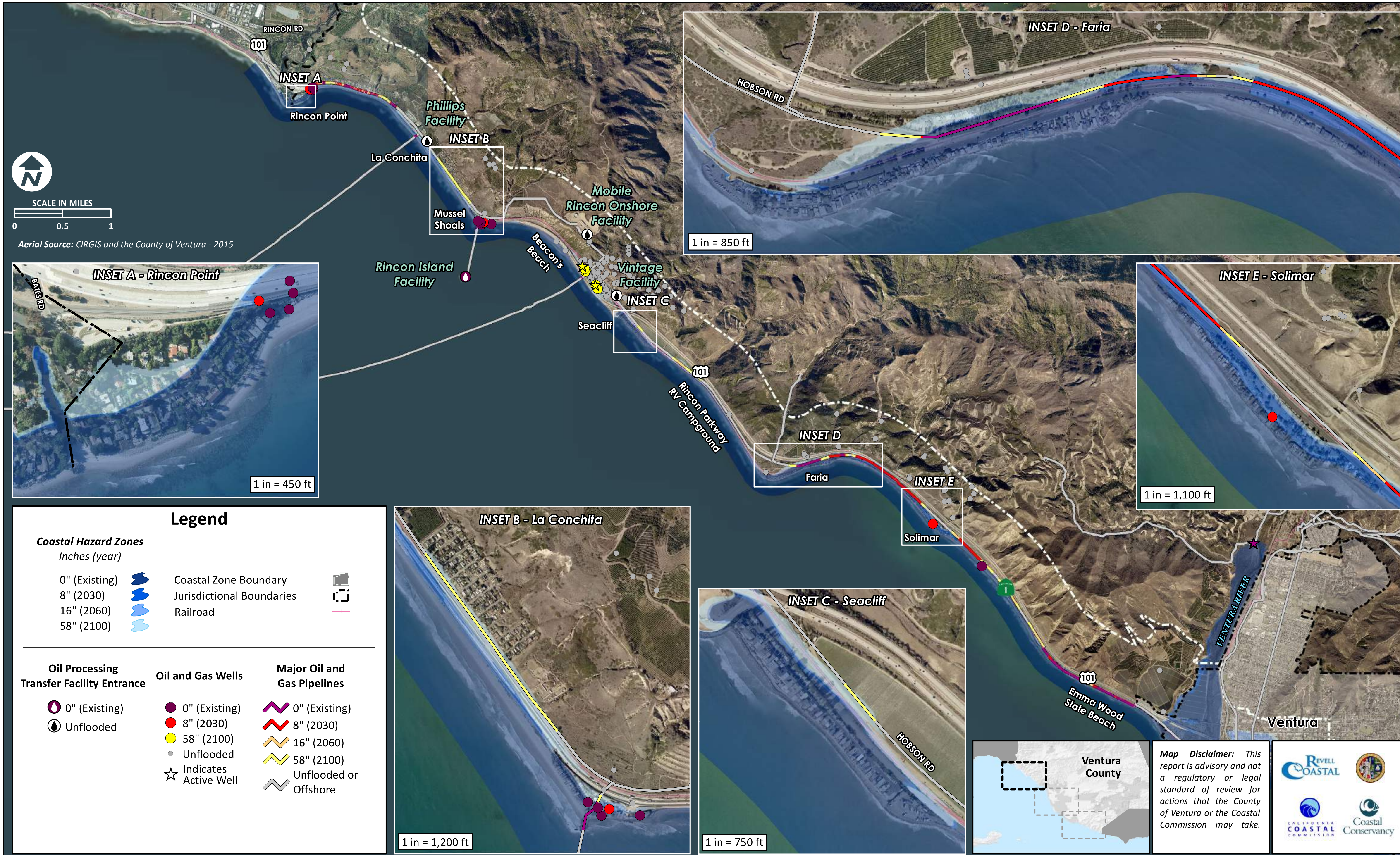


Figure A9b - Oil and Gas: Central Coast

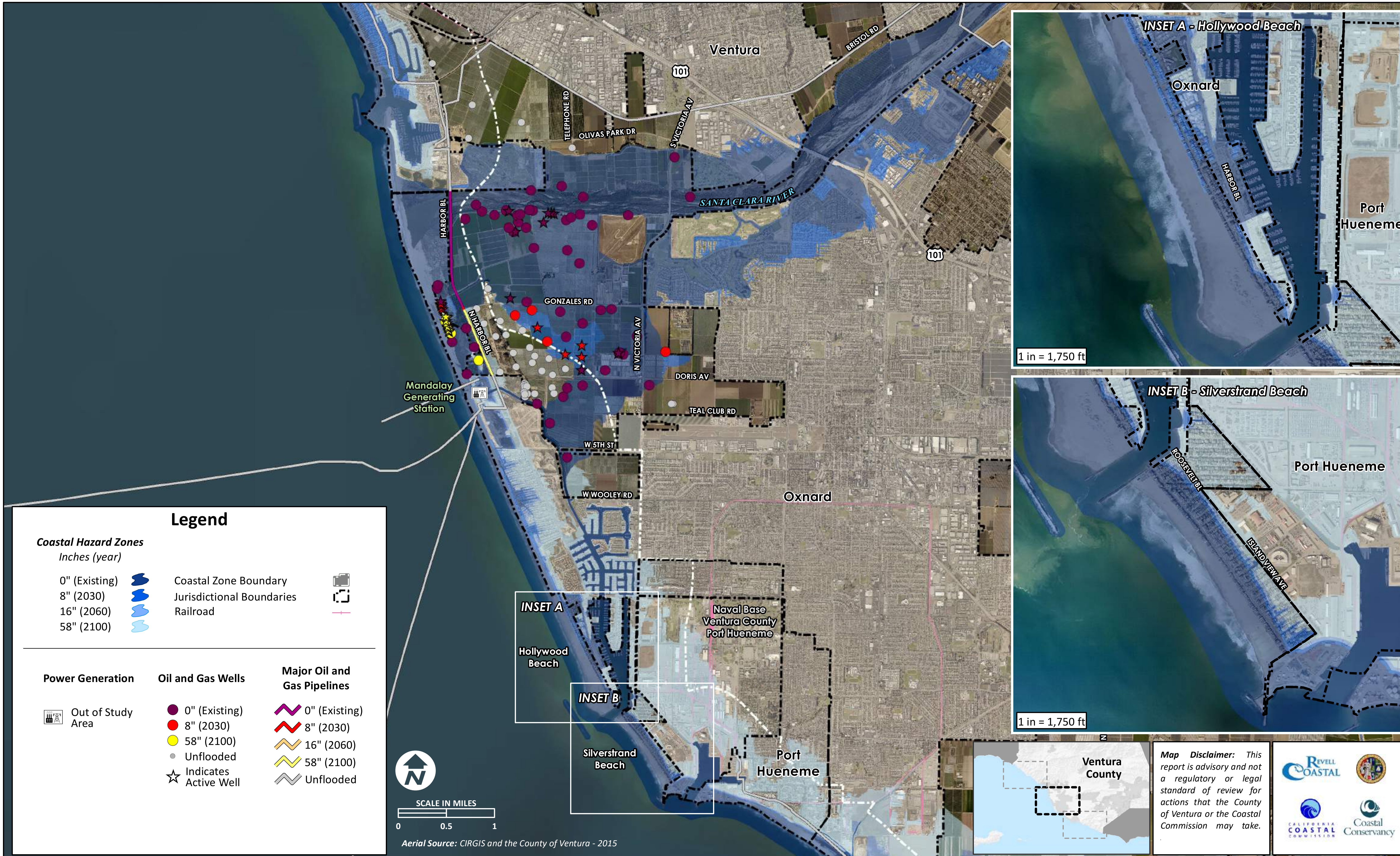
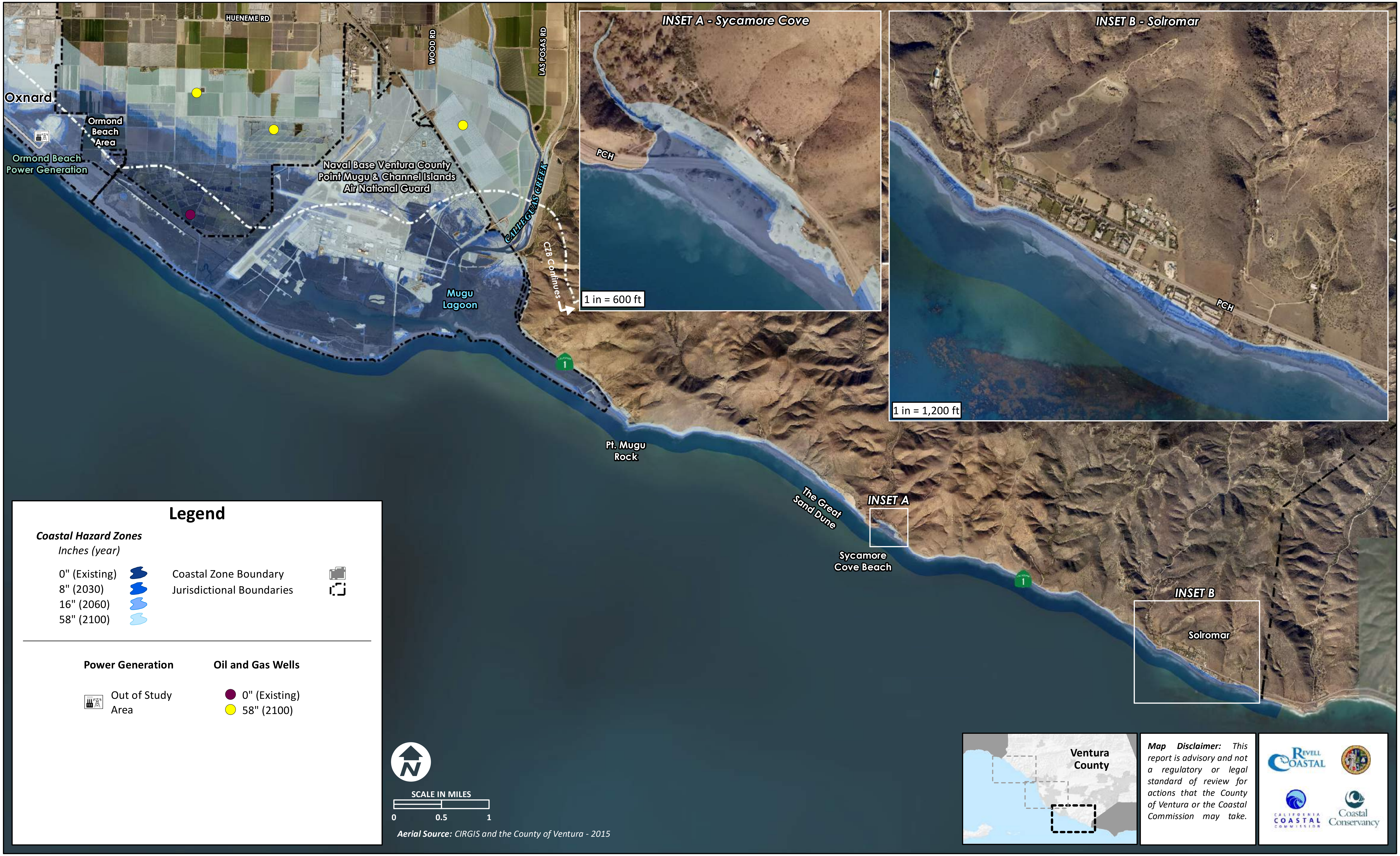


Figure A9c - Oil and Gas: South Coast



Hazardous Materials

Overview

There are two types of hazardous materials evaluated in this Report: businesses that store hazardous materials and sites that have been identified for cleanup remediation.

The Ventura County Environmental Health Division Certified Unified Program Agency (CUPA) provides regulatory oversight for the following six statewide environmental programs: Hazardous Materials Business Plan, Hazardous Waste program, Onsite Hazardous Waste Treatment Permitting, Underground Storage Tank program, Aboveground Petroleum Storage Tank program, and the California Accidental Release Prevention Plan. The implementation of CUPA includes State and Federal laws, as well as County ordinances and policies. CUPA activities also cover hazardous materials emergency response, investigation of illegal disposal of hazardous waste, and public complaints. Compliance is achieved through inspections, educational guidance, and enforcement actions.

A number of state agencies which include the California Environmental Protection Agency, the Office of Emergency Services, Cal Fire, the State Water Board, and the Department of Toxic Substances Control also provide regulatory oversight for hazardous materials and hazardous waste facilities, and, are involved with emergency response and management activities.

The California State Water Resources Control Board monitors waste discharge and leaking underground storage tanks (LUSTs) through their Geotracker web portal which provides a tool to evaluate the potential for contamination to threaten drinking water. The State Water Board actively investigates hazardous spills and works with the owner to clean them (remediate them). The type of chemical and the state (solid, liquid or gas) determines the relative risk of dispersal.

To quantify the impact of coastal hazards and sea level rise (SLR) on hazardous materials, the following measures of impacts have been identified:

Number of active Geotracker sites • **Number of LUSTs** • **Number of CUPA companies**

Existing Vulnerabilities

Coastal Flooding • 4 CUPA businesses • 1 Active site **Fluvial Flooding** • 5 CUPA sites	There are four CUPA businesses potentially exposed to a current 1% annual chance storm. These are an oil and gas related site near Seacliff owned by Pacific Offshore, part of the SoCal natural gas infrastructure just south of Seacliff, and Agromin Organics Recycling Site in Ormond Beach (part in Oxnard, part in County). Five additional CUPA businesses are subject to fluvial flooding in the Santa Clara floodplain.

Projected Vulnerabilities

8 inches by ~2030

Coastal Flooding • 4 CUPA sites	Coastal flooding may affect four additional CUPA sites including: a Verizon site in La Conchita, some additional SoCal gas infrastructure, some oil and gas infrastructure south of Faria owned by Vintage Production, and a Venoco facility near McGrath State Beach.

Agromin compost and mulch processing site

16 inches by ~2060

Tidal Inundation • 1 CUPA site	Tidal inundation may affect the CUPA site at the Agromin Organics Recycling Site near Ormond Beach.

58" by ~2100

Tidal Inundation • 1 active cleanup site **Coastal Flooding** • 4 CUPA sites	Coastal flooding may affect 13 total CUPA business sites including four additional sites: additional SoCal gas infrastructure, two sites associated with the Southland Sod Farms.

Potential Adaptation Strategies

Range of Strategies: The majority of impacts to hazardous material storing businesses are potentially avoidable due to a variety of viable adaptation strategies. However, storage tanks must be protected or removed as contaminated soils can be costly to remediate. The adaptation costs are primarily incurred by private businesses or permit holders. However, when contained on a single parcel, the County should incentivize cleanup so that Geotracker sites are remediated before they become a County liability if leaking occurs beyond the parcel boundaries.

Accommodate – For businesses, there are relatively low-cost options to store materials in a more flood-proof manner by elevating, or floodproofing the facilities or components.

Protect – Adaptation strategies that reduce the exposure of the contaminants would include coastal armoring or potentially some kind of cobble berm. A horizontal levee around the CUPA sites in the Ormond Beach area integrated into the potential restoration design may provide protection.

Retreat – Businesses could avoid leakage by relocating away from the coastline.

Secondary Impacts: Failure of any strategy could result in substantial cleanup impacts if spills occur. Typical cleanup/remediation costs for storage tanks range from $125,000 (no groundwater leakage) to $1.5 million or more (groundwater leakage). The type of chemical and the state (solid, liquid or gas) determines the type of approach that may be preferable.

Findings

Summary

- There are no hazardous material vulnerabilities from coastal erosion in the Central or South Coasts with up to ~5 feet of SLR.
- Thirteen total CUPA businesses could be impacted by coastal flooding.
- **Thresholds:**
- With ~5 feet of SLR the active cleanup site near Seacliff could be exposed to tidal inundation spreading the contaminants much farther.
- With 16" of SLR the Agromin Organics Site will be consistently impacted by tidal inundation.

Data gaps:

- The CUPA data and LUST data does not have good spatial reference information and needs to be improved.

Strategy Options

Policy:

- Improve the storage of hazardous materials.
- Work with utility and telecommunications companies to develop standards for floodproofing, podiums, or require alternatives analysis to relocate key infrastructure and avoid future hazards.

Projects:

- Improve the geospatial accuracy of CUPA and LUST data.

Monitoring:

- Continue to monitor CUPA businesses for compliance with hazardous material storage standards.

Figure A10a - Hazardous Materials: North Coast

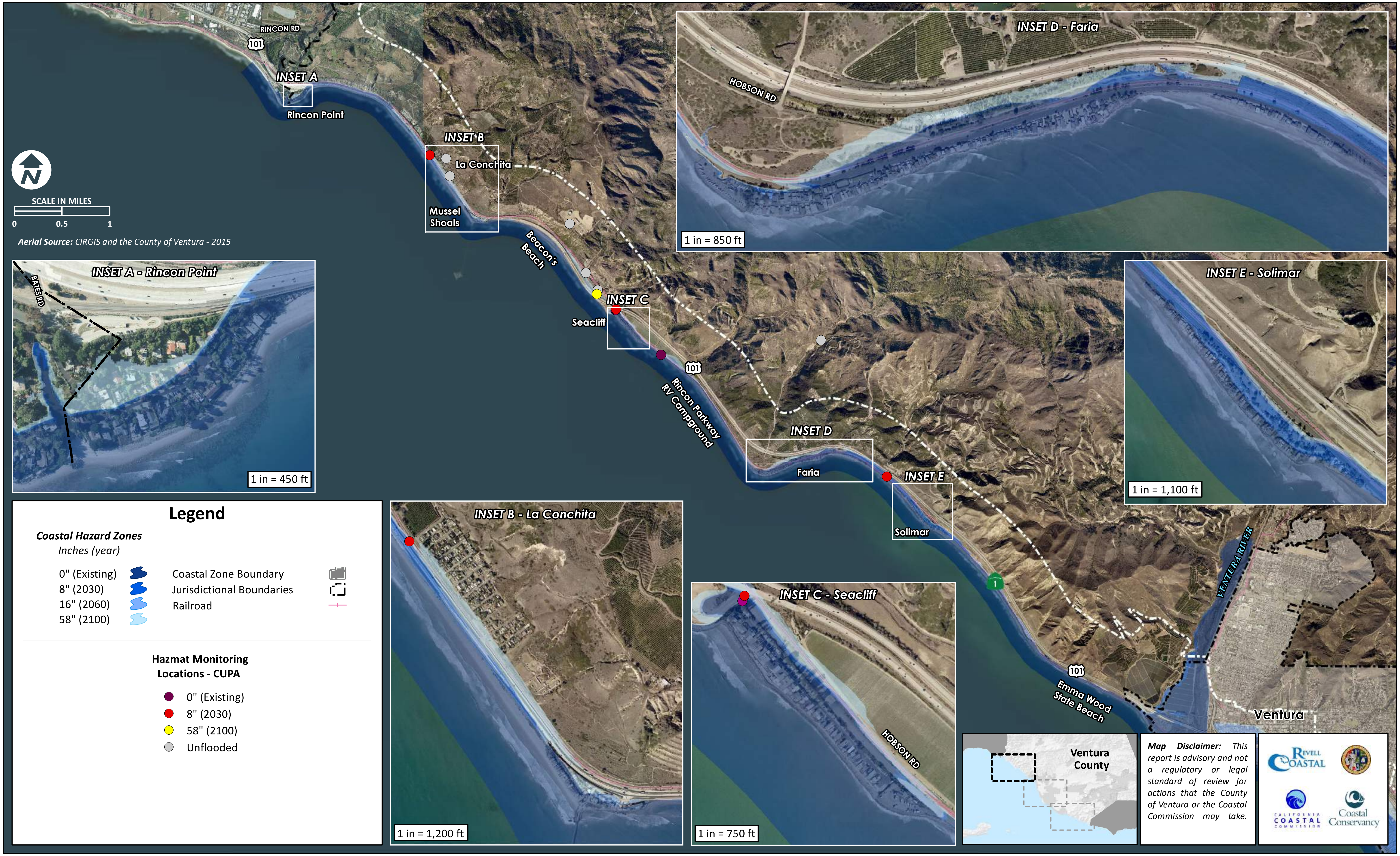


Figure A10b - Hazardous Materials: Central Coast

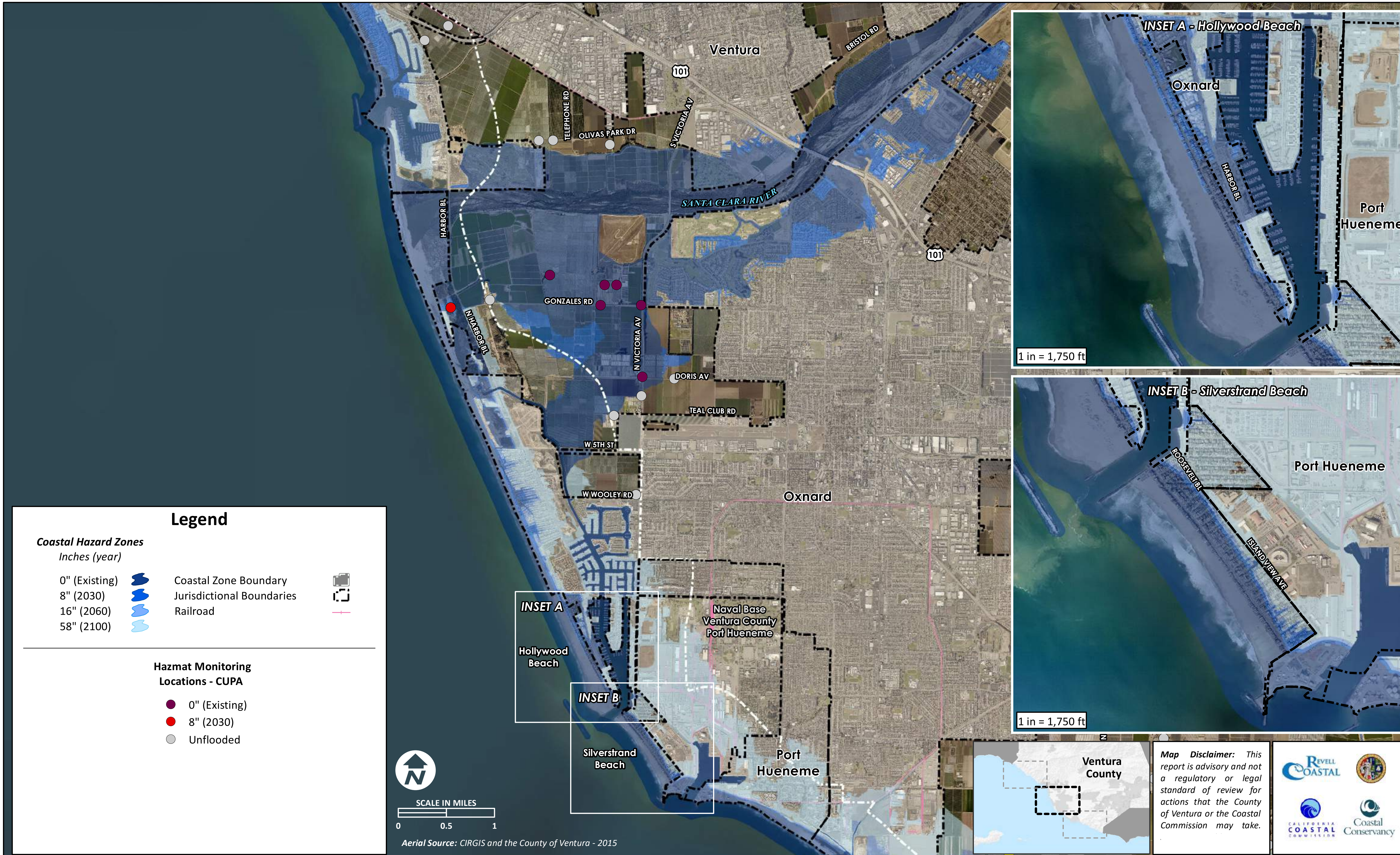
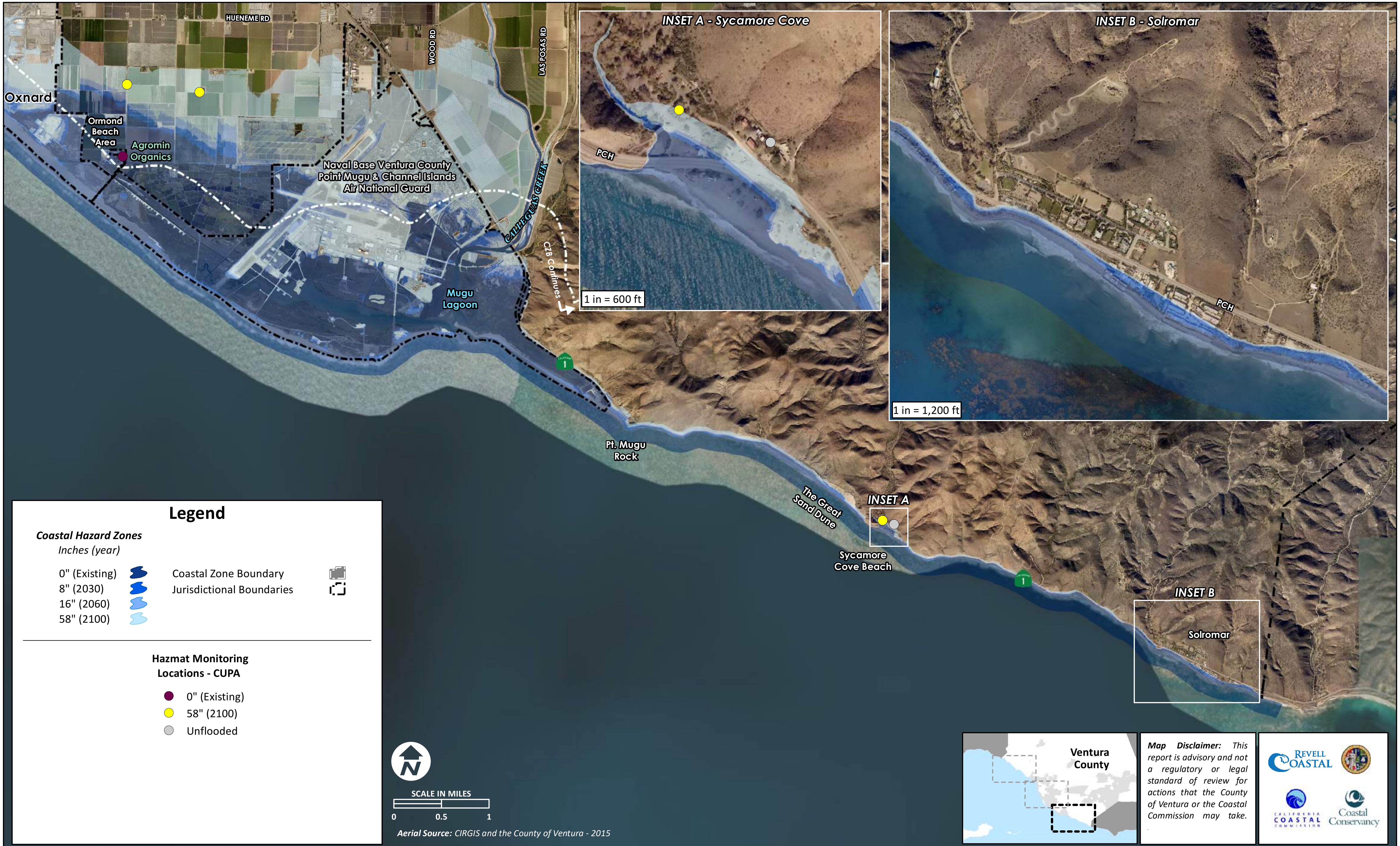


Figure A10c - Hazardous Materials: South Coast



Critical Facilities

Overview

Critical facilities include those that support emergency operations and disaster response. This analysis includes emergency responders such as fire and sheriff facilities. Tsunami evacuation routes are included. Additionally, secondary facilities have been assessed that would serve to support operations or as evacuation centers. These facilities include medical facilities, schools, government facilities, and communication towers. Communication towers may function when exposed to coastal flooding depending on electrical components but have been identified as a potentially vulnerable resource. To quantify the impact of coastal hazards and sea level rise (SLR) on critical facilities, the following measures of impacts have been identified:

- **Number of fire and police stations**
- **Number of medical facilities**
- **Miles of evacuation routes**
- **Number of government facilities**
- **Number of communication towers**
- **Number of schools**

Note: Erosion modeling was not conducted on the North Coast and erosion may cause vulnerabilities in this area.

Existing Vulnerabilities

Coastal Flooding • 1 school / 6 towers • 2.1 miles of evac. routes	No critical facilities are exposed to tidal inundation or erosion under existing hazards. Coastal flooding during a 1% annual chance storm could impact Hollywood Beach Elementary School. Up to 2.1 miles of evacuation routes on Highway 101 near Rincon Point on the North Coast and Pacific Coast Highway (PCH) along the South Coast. Six total communication towers may be subject to coastal flooding: four towers along the Rincon Parkway south of Faria, one in Hollywood by the Sea, and one near Point Mugu.

Projected Vulnerabilities

8 inches by ~2030

Coastal Erosion • 1 tower • 0.9 miles of evac. routes **Coastal Flooding** • 1 tower • 1.2 miles of evac. routes	Coastal cliff erosion could impact 0.9 miles of evacuation route along Highway 101 near La Conchita on the North Coast, and PCH in the South Coast. A communications tower at Point Mugu is also projected to be vulnerable. Coastal flooding is projected to impact an additional 1.2 miles of evacuation routes, and an additional communication tower near Emma Wood State Beach Park.

16 inches by ~2060

Coastal Erosion • 1 school • 1.7 miles of evac. routes **Coastal Flooding** • 1 tower • 1.1 miles of evac. routes	Coastal dune erosion could begin to impact Hollywood Beach Elementary School. Coastal cliff erosion could impact an additional 1.7 miles of along PCH in the South Coast. Coastal flooding affects an additional tower at Point Mugu and an additional 1.1 miles of evacuation routes along Highway 101 near La Conchita and Mussel Shoals.

58 inches by ~2100

Tidal Inundation • 1 fire station / 1 govt. facility • 0.4 miles of evac. routes **Coastal Erosion** • 3 towers • 2.2 miles of evac. routes **Coastal Flooding** • 1 fire station / 1 govt. facility • 6 towers • 4.7 miles of evac. routes	Tidal inundation may affect a total of 0.4 miles of evacuation routes, two towers and a Channel Islands Community Service District building during routinely high tides. Dune and cliff erosion accelerated by ~5 feet of SLR may impact a total of 4.7 miles of evacuation routes along Highway 101 and PCH as well as in Silverstrand. Coastal flooding is projected to affect a combined total of 9.1 miles of evacuation routes along Highway 101, PCH, and in Silverstrand. Six additional communication towers near Mussel Shoals, Mugu Lagoon, and Solromar are impacted for a combined total of 14 towers with ~5 feet of SLR. Finally, Ventura County Fire Station #25 near Seacliff and the Channel Islands Community Service District building in Silverstrand are projected to be exposed to coastal flooding.

Potential Adaptation Strategies

Range of Strategies:

Accommodate – It is possible to elevate buildings and communication towers to accommodate higher flood water levels or examine additional setbacks for new buildings and supporting infrastructure. Poles and anchors supporting towers could be required to use more salt tolerant metals or anchors.

Protect – Coastal armoring (gray), or enhanced sand dunes (green) would provide protection from coastal erosion and flooding.

Retreat – relocate or remove critical facilities and communication towers from the hazardous areas. If feasible, reroute the evacuation routes susceptible to existing and future coastal hazards.

Secondary Impacts:

Retreat strategies may negatively impact Hollywood Elementary School and displace residents and children attending the school. Accommodation strategies that involve elevating structures could be extremely costly depending on the types of structural foundation needed. Elevating communications facilities that are located in scenic areas would increase aesthetic impacts. Green protection strategies could provide some room for dune habitat transgression for roads adjacent to wetlands. Gray protection strategies could negatively impact beach and recreational opportunities as well as have escalating maintenance costs.

Findings

Summary

- No medical facilities or sheriff stations are impacted by coastal hazards with up to ~5 feet of SLR. Ventura County Fire station #56 at Solromar would also not be affected.
- Hollywood Elementary School, Ventura County Fire Station #25, and a Channel Islands Community Service District building are vulnerable to coastal hazards with ~5 feet of SLR. The fire station is estimated to cost $6.5 million to replace.
- 9.1 miles of evacuation routes could be impacted during coastal flood events and 4.7 miles may be eroded with ~5 feet of SLR.

Thresholds:

- Hollywood Beach Elementary School is vulnerable to coastal flooding now, and with 8" of SLR may become exposed to coastal erosion damages.
- There are significant increases in vulnerability to the Fire station #25 on the North Coast and the Channel Islands Community Service District building in Silverstrand becomes exposed to tidal inundation and coastal flooding with ~5 feet of SLR.


Hollywood Beach Elementary

Strategy Options

Policy:

- Evaluate alternative facility locations, especially those facilities affected by tidal inundation or erosion.
- Include language in policy updates to consider sea level rise and flood hazards in the renewal of any future communication tower leases.

Projects:

- Continue to work on alternative evacuation routes for geographically isolated communities such Silverstrand and Solromar.
- Evaluate population demographics exposed.
- Update sea level rise hazards in the Multi-Hazard Mitigation Plan.

Monitoring:

- Monitor extents, depths and frequency of inundation at the school.


Ventura Fire Station #25

Figure A11a - Critical Services: North Coast

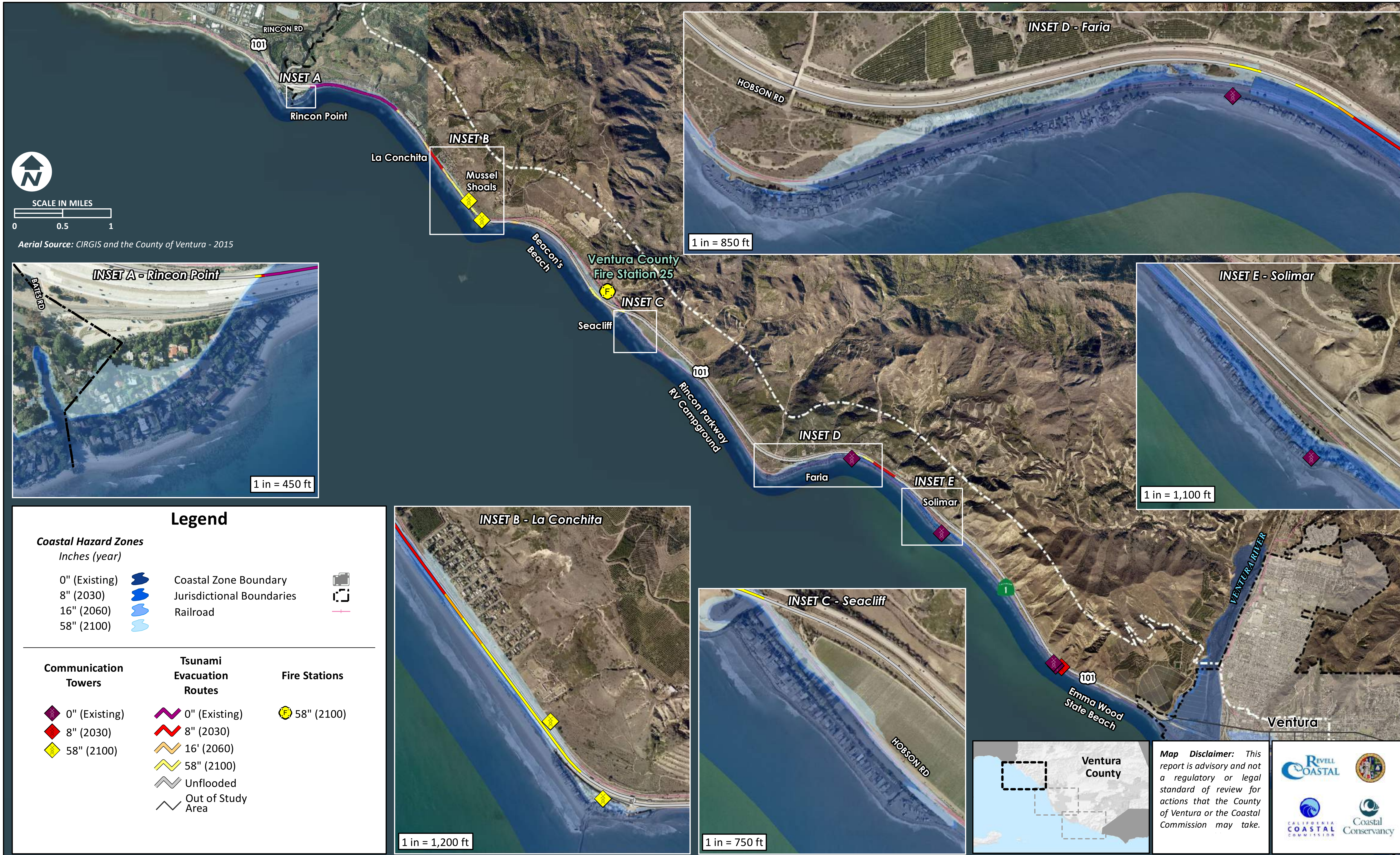


Figure A11b - Critical Services: Central Coast

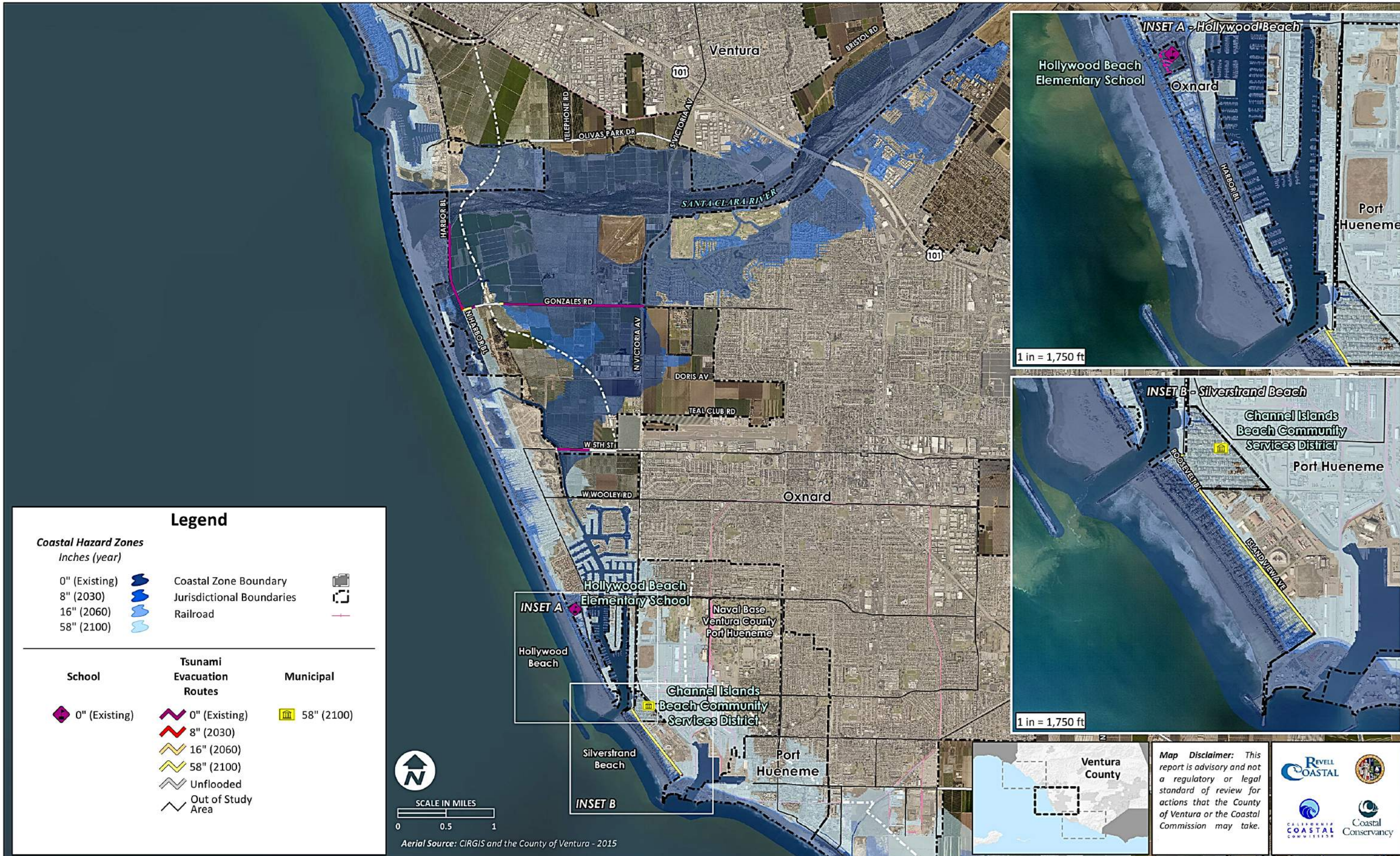
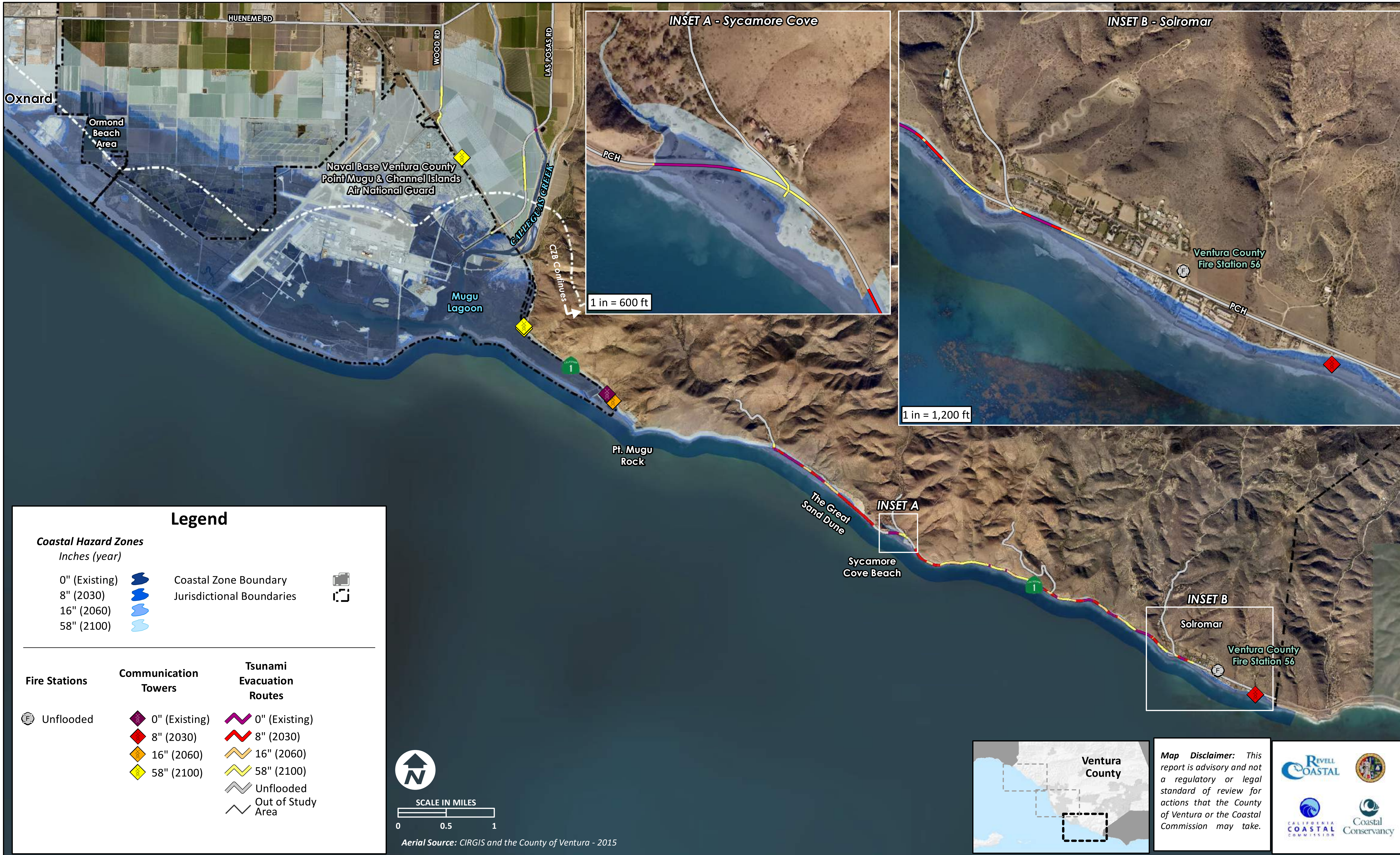


Figure A11c - Critical Services: South Coast



APPENDIX B. VULNERABILITY TABLE

This section is a data table which shows the results of the geospatial analysis. This analysis is described in Section 4 of this Report. The data interpretation is found in Section 5 and Appendix A of this Report. This table provides numerical results for each resource sector, showing the exposure for each hazard type at 8”, 16”, and 58” of sea level rise.

Sector													
METRIC	# of parcels												
TYPE	Residential												
	Mixed Res.l	Multi-Fam. Res.	Single Fam. Res.	Commercial	Agriculture	Extraction	Facilities	Hotels and Motels	Industrial	Transportation, Communication, Utilities	Open Space	Vacant	Total
UNITS	count	count	count	count	count	count	count	count	count	count	count	count	count

Non-Cumulative

	Mixed Res.l	Multi-Fam. Res.	Single Fam. Res.	Commercial	Agriculture	Extraction	Facilities	Hotels and Motels	Industrial	Transportation, Communication, Utilities	Open Space	Vacant	Total
Coastal erosion (Central)													
Existing conditions	0	1	15	0	0	0	8	0	0	0	1	0	25
8 in	2	73	619	9	1	0	2	0	0	3	1	21	731
16 in	0	30	296	0	0	0	1	0	0	1	1	8	337
58 in	0	37	256	13	2	0	2	0	0	0	1	28	339
Total	2	141	1,186	22	3	0	13	0	0	4	4	57	1,432
Coastal erosion - Cliff (South)													
9.8 in	53	49	29	0	0	0	1	0	0	1	31	10	174
19.6 in	0	0	0	0	0	0	0	0	0	0	0	0	0
59 in	3	16	0	0	0	0	0	0	0	2	1	1	23
Total	56	65	29	0	0	0	1	0	0	3	32	11	197
Tidal inundation													
Existing conditions	5	6	135	0	10	0	5	1	1	15	36	16	230
8 in	0	0	5	0	4	0	0	0	1	0	0	2	12
16 in	0	0	7	0	2	0	0	0	0	1	0	0	10
58 in	0	102	915	17	13	0	11	0	0	8	6	55	1,127
Total	5	108	1,062	17	29	0	16	1	2	24	42	73	1,379
Fluvial													
Existing conditions	0	2	0	0	82	0	0	0	4	61	3	21	173
8 in	0	0	0	7	8	0	0	0	34	12	0	26	87
16 in	0	0	0	0	0	0	13	0	0	1	0	0	14
58 in	0	0	0	0	0	0	4	0	0	0	0	0	4
Total	0	2	0	7	90	0	17	0	38	74	3	47	278
Coastal storm flooding													
Existing conditions	54	95	1,127	8	19	0	18	1	2	33	40	45	1,442
8 in	0	28	217	1	2	0	3	0	0	3	2	12	268
16 in	1	15	134	6	0	1	1	0	0	3	3	11	175
58 in	0	54	432	9	43	1	10	0	0	16	2	44	611
Total	55	192	1,910	24	64	2	32	1	2	55	47	112	2,496
Combined - All													
Existing conditions	54	97	1,127	8	99	0	30	1	6	90	41	65	1,618
8 in	0	28	217	8	8	0	7	0	34	15	2	38	357
16 in	1	15	134	6	1	1	1	0	0	4	3	11	177
58 in	0	54	432	9	36	1	10	0	0	14	2	44	602
Total	55	194	1,910	31	144	2	48	1	40	123	48	158	2,754

METRIC	# of Buildings																				
TYPE	Residential				Commercial		Agriculture	Ag. Garage or Out Building	Extraction	Facilities	Fac. Garage or Out Building	Hotels and Motels	Industrial	Ind. Garage or Out Building	Transportation, Communication, Utilities, and Channels	TCU Garage or Out Building	Open Space	Open Space Out Building	Vacant (miscode or derelict)	Vac. Garage or Out Building	Total
	Mixed Res.	Multi-Fam Res.	Single Fam. Res.	R. Garage or Out Building	Commercial or Services	C. Garage or Out Building															
UNITS	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count	count
Coastal erosion (Central)																					
Existing conditions	0	1	11	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	14
8 in	2	72	595	10	9	0	0	0	0	0	0	0	0	0	0	1	0	0	4	0	693
16 in	0	29	311	24	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	366
58 in	0	36	255	11	12	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	317
Total	2	138	1,172	46	21	1	0	0	0	1	1	0	0	0	0	1	0	0	7	0	1,390
Coastal erosion - Cliff (South)																					
9.8 in	52	29	24	5	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	114
19.6 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59 in	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	9
Total	55	34	24	5	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	123
Tidal inundation																					
Existing conditions	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
8 in	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3
16 in	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2
58 in	0	89	779	23	16	1	0	1	0	0	0	0	0	0	1	2	0	0	2	1	915
Total	0	90	791	23	16	1	0	1	0	0	0	0	0	2	1	2	0	0	2	1	930
Fluvial																					
Existing conditions	0	0	0	0	0	0	7	5	0	0	1	0	0	0	0	0	0	0	0	0	13
8 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
16 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	7	5	0	0	1	0	0	0	0	0	0	0	0	1	14
Coastal storm flooding																					
Existing conditions	52	84	962	4	8	0	0	0	0	2	2	1	0	0	0	2	3	0	4	1	1,125
8 in	2	32	302	6	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	345
16 in	0	13	138	10	5	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	170
58 in	0	57	457	12	7	1	0	3	0	1	1	0	0	0	1	2	0	2	2	1	547
Total	54	186	1,859	32	21	1	0	3	0	3	4	1	0	2	2	4	3	2	8	2	2,187
Combined - All																					
Existing conditions	52	84	962	36	8	0	7	5	0	2	3	1	0	2	0	2	3	0	4	1	1,172
8 in	2	32	302	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	344
16 in	0	13	138	10	5	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	168
58 in	0	57	457	12	7	1	0	2	0	1	1	0	0	0	1	2	0	2	2	1	546
Total	54	186	1,859	64	21	1	7	7	0	3	4	1	0	2	2	4	3	2	8	2	2,230

METRIC	sq ft of Buildings																				
TYPE	Residential				Commercial																
	Mixed Residential	Multi-Fam Residential	Single Fam Residential	R. Garage or Out Building	Commercial or Services	C. Garage or Out Building	Agriculture	Ag. Garage or Out Building	Extraction	Facilities	Fac. Garage or Out Building	Hotels and Motels	Industrial	Ind. Garage or Out Building	Transportation, Communication, Utilities, and Channels	TCU Garage or Out Building	Open Space	Open Space Out Building	Vacant (miscode or derelict)	Vac. Garage or Out Building	Building Area Total (Affected / Grand)	
UNITS	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	sq ft	affected sq ft	total sq ft
Coastal erosion (Central)																						
Existing conditions	0	2,084	6,775	78	0	0	0	0	0	0	696	0	0	0	0	0	0	0	0	0	9,633	19,864
8 in	2,109	105,878	794,091	3,433	13,386	0	0	0	0	0	0	0	0	0	0	148	0	0	5,131	0	924,175	1,004,545
16 in	0	52,545	447,005	5,306	2,022	0	0	0	0	12,636	0	0	0	0	0	0	0	0	1,455	0	520,969	697,834
58 in	0	70,120	366,621	4,065	18,313	0	0	0	0	12,652	0	0	0	0	0	0	0	0	3,685	0	475,456	551,806
Total	2,109	230,626	1,614,491	12,882	33,721	0	0	0	0	25,288	696	0	0	0	0	148	0	0	10,271	0	1,930,233	2,274,048
Coastal erosion - Cliff (South)																						
9.8 in	73,018	34,820	44,061	1,927	0	0	0	0	0	0	0	0	0	0	1,666	0	4,710	0	0	0	160,201	177,290
19.6 in	0	2,775	779	0	0	0	0	0	0	0	0	0	0	0	0	0	673	0	0	0	4,226	33,336
59 in	311	7,066	2,356	0	0	0	0	0	0	0	0	0	0	0	0	0	1,260	0	0	0	10,993	41,560
Total	73,328	44,660	47,195	1,927	0	0	0	0	0	0	0	0	0	0	1,666	0	6,642	0	0	0	175,419	252,185
Tidal inundation																						
Existing conditions	0	149.38	2,786.58	0.00	0.00	0.00	0	0.00	0	0	0	0	0	0.00	0.00	0.00	0	0	0.00	0.00	2,936	18,983
8 in	0	167.33	1,119.08	0.00	0.00	0.00	0	0.00	0	0	0	0	0	371.78	0.00	0.00	0	0	0.00	0.00	1,658	23,883
16 in	0	119.97	1,328.36	0.00	0.00	0.00	0	0.00	0	0	0	0	0	35,655.65	0.00	0.00	0	0	0.00	0.00	37,104	63,547
58 in	0	124,961.99	918,738.37	8,788.19	21,754.37	305.09	0	2,995.32	0	0	0	0	0	1,120.16	3,133.97	179.21	0	0	6,267.94	63.53	1,088,308	1,308,852
Total	0	125,399	923,972	8,788	21,754	305	0	2,995	0	0	0	0	0	37,148	3,134	179	0	0	6,268	64	1,130,006	1,415,265
Fluvial																						
Existing conditions	0	0	0	0	0	0	93,931	29,067	0	0	590	0	0	0	0	0	0	0	0	0	123,588	123,588
8 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,519	1,519	1,519
16 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58 in	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	93,931	29,067	0	0	590	0	0	0	0	0	0	0	0	1,519	125,107	125,107
Coastal storm flooding																						
Existing conditions	44,477	119,786	1,460,030	22,465	4,749	0	0	0	0	26,227	2,186	3,482	0	36,017	0	0	4,987	0	3,895	1,519	1,729,822	1,965,863
8 in	10,287	57,911	488,508	1,850	10,659	0	0	0	0	0		0	0	1,130	0	0	0	0	2,847	0	573,192	910,131
16 in	994	30,218	195,099	3,685	4,519	0	0	0	0	0	423	0	0	0	227	0	0	0	2,365	0	237,530	478,890
58 in	19,369	97,094	618,942	5,405	13,794	305	0	5,690	0	976	2,968	0	0	0	4,574	0	0	1,607	1,508	100	772,331	902,366
Total	75,127	305,009	2,762,580	33,406	33,721	305	0	5,690	0	27,204	5,578	3,482	0	37,148	4,800	0	4,987	1,607	10,614	1,618	3,312,875	4,257,250
Combined - All																						
Existing conditions	44,477	119,786	1,460,030	22,465	4,749	0	93,931	29,067	0	26,227	2,777	3,482	0	36,017	0	0	4,987	0	3,895	1,519	1,853,410	2,089,451
8 in	10,287	57,911	488,508	1,850	10,659	0	0	0	0	0	0	0	0	1,130	0	0	0	0	2,847	0	573,192	910,131
16 in	994	30,218	195,099	3,685	4,519	0	0	0	0	0	0	0	0	0	227	0	0	0	2,365	0	237,107	478,467
58 in	19,369	97,094	618,942	5,405	13,794	305	0	4,821	0	976	2,801	0	0	0	4,574	0	0	1,607	1,508	100	771,294	901,329
Total	75,127	305,009	2,762,580	33,406	33,721	305	93,931	33,887	0	27,204	5,578	3,482	0	37,148	4,800	0	4,987	1,607	10,614	1,618	3,435,004	4,379,378

		Agriculture								Roads					Public Transportation					Sewer					Water Supply			
	Parkland and Open Space (non-parcel based) (Totals are for Entire Un. County)	Agriculture (parcel based)	Cropland (non-parcel based)	FMMP Farmland Catagories (Totals for Entire Un. County) Grazing	Local Importance	Prime	Statewide Importance	Unique	Total FMMP	length of roads (Totals for Entire Un. County)		Parking			# of bus stops	length of routes by type bike	bus	rail	rail	# of lift/pump stations	length of pipe	# of manholes	# of manholes (Totals Entire Un. County)	# of shutoff valves	length of pipe		# of lift/pump stations	# of wells (active)
UNITS	acres	acres	acres	acres	acres	acres	acres	acres	acres	ft	miles	count	sq ft	acres	count	miles	miles	ft	miles	count	miles	count	count	count	ft	miles	count	count
Coastal erosion (Central)																												
Existing conditions	0.58	0.00	0.00	0.03	0.67	0.00	0.00	0.00	0.70	195	0.04	2	81,969	1.88	0	0.00	0.00	0	0.00	0	0.00	0	0	0	0	0.00	0	0
8 in	0.38	1.06	0.00	0.24	4.63	0.00	0.00	0.00	4.87	16,620	3.15	0	62,927	1.44	0	0.87	0.00	764	0.14	0	1.51	13	21	0	0	0.00	1	0
16 in	0.17	0.04	0.00	0.00	0.63	0.00	0.00	0.00	0.63	10,221	1.94	0	14,767	0.34	0	0.00	0.00	327	0.06	0	0.78	5	6	0	0	0.00	1	0
58 in	0.85	2.22	0.00	0.14	0.16	0.00	0.00	0.00	0.31	17,719	3.36	0	6,197	0.14	0	0.00	0.00	56	0.01	0	0.99	13	14	0	0	0.00	1	0
Total	1.99	3	0.00	0	6	0	0	0	7	44,755	8	2	165,860	3.81	0	0.87	0	1,147	0	0	3.28	31	41	0	0	0	3	0
Coastal erosion - Cliff (South)																												
9.8 in	6.92	0	0	0	0	0	0	0	0	9,146	1.73	3	33,430	0.77	0	0	0	0	0	0	0	0	0	0	1,621	0.31	0	0
19.6 in	0.25	0	0	0	0	0	0	0	0	13,863	2.63	0	20,585	0.47	0	0	0	0	0	0	0	0	0	0	499	0.09	0	0
59 in	4.06	0	0	0	0	0	0	0	0	8,634	1.64	1	12,242	0.28	0	0	0	0	0	0	0	0	0	0	1,611	0.31	0	0
Total	11.23	0	0.00	0	0	0	0	0	0	31,642	6	4	66,258	1.52	0	0.00	0	0	0	0	0.00	0	0	0	3,731	0.71	0	0
Tidal inundation																												
Existing conditions	3.53	21.77	322.00	5.52	0.77	0.00	0.43	1.02	26.19	13,279	2.51	2	39,026	0.90	0	0.00	0.00	0	0	0	0.00	0	0	0	0	0.00	0	0
8 in	0.40	268.81	348.01	1.07	0.11	20.53	249.13	0.13	282.19	3,718	0.70	0	19,911	0.46	0	0.00	0.00	0	0	0	0.00	0	0	0	0	0.00	0	0
16 in	0.40	139.35	168.75	1.11	0.10	10.02	121.73	0.12	146.87	1,474	0.28	0	26,002	0.60	0	0.00	0.00	0	0	0	0.00	0	0	0	0	0.00	0	5
58 in	1.98	880.27	987.75	6.42	0.97	281.16	561.02	0.49	985.86	43,715	8.28	1	207,947	4.77	0	0.93	0.00	0	0	0	1.67	15	26	0	750	0.14	2	13
Total	6.32	1,310	1,826.51	14	2	312	932	2	1,441	62,186	12	3	292,886	6.72	0	0.93	0	0	0	0	1.67	15	26	0	750	0	2	18
Fluvial																												
Existing conditions	60.55	3,169.33	2,162.19	136.03	10.66	1,430.97	713.13	250.82	2,210.83	45,541	8.63	0	0	0.00	4	0.85	8.35	604	0.11	0	1.49	0	9	0	0	0.00	0	67
8 in	0.45	252.42	210.19	5.98	14.84	110.16	95.43	18.81	214.88	7,321	1.39	0	0	0.00	0	0.01	0.46	0	0.00	0	0.09	0	7	0	0	0.00	1	4
16 in	0.00	3.51	3.28	0.00	0.09	0.08	4.29	0.00	3.55	22	0.00	0	0	0.00	0	0.00	0.00	18	0.00	0	0.00	0	0	0	0	0.00	0	0
58 in	0.00	2.88	2.74	0.00	0.61	1.69	1.60	0.00	2.65	187	0.04	0	0	0.00	0	0.00	0.00	274	0.05	0	0.00	0	0	0	0	0.00	0	0
Total	61.00	3,428	2,378.40	142	26	1,543	814	270	2,432	53,072	10	0	0	0.00	4	0.86	9	896	0	0	1.58	0	16	0	0	0	1	71
Coastal storm flooding																												
Existing conditions	12.73	399.43	806.70	55.46	7.02	28.49	344.17	10.16	430.11	100,138	18.97	8	663,335	15.23	0	5.69	0.00	15,658	2.97	2	9.52	21	28	1	15,459	2.93	2	5
8 in	0.84	112.87	111.22	8.66	1.23	10.24	97.67	0.42	113.07	24,221	4.59	0	84,215	1.93	0	0.64	0.00	13,818	2.62	1	1.75	3	5	0	4,872	0.92	0	1
16 in	0.63	129.49	128.96	11.11	0.06	23.25	95.27	2.35	164.82	24,354	4.61	0	21,188	0.49	0	0.21	0.00	8,342	1.58	0	0.88	1	2	0	1,911	0.36	0	3
58 in	3.72	1,953.59	2,075.26	12.48	1.82	495.06	1,377.47	10.33	1,908.77	86,933	16.46	1	10,861	0.25	0	3.31	0.00	18,031	3.41	1	2.31	14	19	0	8,761	1.66	2	23
Total	17.92	2,595	3,122.14	88	10	557	1,915	23	2,617	235,646	45	9	779,599	17.90	0	9.85	0	55,849	11	4	14.47	39	54	1	31,003	6	4	32
Combined - All																												
Existing conditions	73.02	3,567.73	2,968.93	191.47	14.69	1,459.46	1,057.34	260.98	2,640.77	145,679	27.59	8	663,335	15.23	4	8.14	8.35	16,262	3.08	2	11.01	21	37	1	15,459	2.93	2	72
8 in	1.27	370.04	323.31	14.64	14.95	121.26	193.91	19.23	339.03	31,690	6.00	0	84,215	1.93	1	0.67	0.48	13,214	2.50	1	1.84	3	12	0	4,872	0.92	1	5
16 in	0.54	125.86	129.06	11.11	0.00	23.33	96.38	2.35	164.82	24,097	4.56	0	21,188	0.49	0	0.21	0.00	8,342	1.58	0	0.88	1	2	0	1,911	0.36	0	3
58 in	2.26	1,854.32	2,018.28	12.48	0.00	480.79	1,330.01	8.14	1,908.77	82,322	15.59	1	10,861	0.25	0	1.50	0.00	18,031	3.41	1	2.31	14	19	0	8,761	1.66	2	22
Total	77.09	5,918	5,439.57	230	30	2,085	2,678	291	5,053	283,789	54	9	779,599	17.90	5	10.52	9	55,849	11	4	16.05	39	70	1	31,003	6	5	102

Sector	Stormwater						Public Access							Armoring				Hazardous Materials			
METRIC	length of storm drains (Entire Unincorp. County)		# of effluent pump stations	# of inlets or catch basins	# culverts	# detention basins	length of trail							length of coastal armor		length of riverine levee		# of sites by type			
TYPE							VERTICAL		LATERAL		ALL OTHER DEDICATED		Total Trail					Certified Unified Program Agencies (County Edit) (Entire Unicorp County)	Toxic Release inventory Facilities (EPA TRI)	Geotracker (Active Cleanup)	Geotracker ESI Reporting Sites
UNITS	ft	miles	count	count	count	count	ft	miles	ft	miles	ft	miles	miles	ft	miles	ft	miles	count	count	count	count
Coastal erosion (Central)																					
Existing conditions	596	0.11	0	0	0	0	11471	2.17	13,394	2.54	0	0.00	4.71	7,689	1.46	0	0.00	0	0	0	0
8 in	6053	1.15	2	42	0	2	6813	1.29	1,039	0.20	222	0.04	1.53	0	0.00	0	0.00	0	0	0	0
16 in	2326	0.44	0	21	0	1	640	0.12	210	0.04	0	0.00	0.16	0	0.00	0	0.00	0	0	0	0
58 in	3860	0.73	0	20	0	0	341	0.06	1,212	0.23	1	0.00	0.29	0	0.00	0	0.00	0	0	0	0
Total	12,835	2	2	83	0	3	19,265	3.65	15,855	3.00	223	0.04	6.69	7,689	1.46	0	0	0	0	0	0
Coastal erosion - Cliff (South)																					
9.8 in	0	0	0	0	0	0	2,564	0.49	10,722	2.03	406	0.08	2.59	25,148	4.76	0	0.00	0	0	0	0
19.6 in	0	0	0	0	0	0	286	0.05	0	0.00	376	0.07	0.13	0	0.00	0	0.00	0	0	0	0
59 in	0	0	0	0	0	0	151	0.03	0	0.00	660	0.12	0.15	0	0.00	0	0.00	0	0	0	0
Total	0	0	0	0	0	0	3,001	0.57	10,722	2.03	1,441	0.27	2.87	25,148	4.76	0	0	0	0	0	0
Tidal inundation																					
Existing conditions	16,672	3.16	0	0	0	2	435	0.08	7,692	1.46	0	0.00	1.54	33,803	6.40	0	0.00	0	0	0	0
8 in	2,036	0.39	0	0	0	0	58	0.01	969	0.18	0	0.00	0.19	1,643	0.31	0	0.00	0	0	0	0
16 in	4,581	0.87	0	0	0	1	67	0.01	937	0.18	0	0.00	0.19	2,334	0.44	0	0.00	1	0	1	0
58 in	28,729	5.44	2	53	0	3	4,236	0.80	18,646	3.53	0	0.00	4.33	14,359	2.72	0	0.00	0	0	0	5
Total	52,018	10	2	53	0	6	4,796	0.91	28,244	5.35	0	0.00	6.26	52,139	9.87	0	0.00	1	0	1	5
Fluvial																					
Existing conditions	13,541	2.56	0	0	3	7	0	0.00	68	0.01	750	0.14	0.16	0	0.00	27,301	5.17	6	0	0	2
8 in	619	0.12	0	7	0	1	0	0.00	57	0.01	0	0.00	0.01	0	0.00	1,274	0.24	8	0	0	1
16 in	802	0.15	0	0	0	0	0	0.00	0	0.00	0	0.00	0.00	0	0.00	0	0.00	0	0	0	0
58 in	0	0.00	0	0	0	0	0	0.00	34	0.01	0	0.00	0.01	0	0.00	0	0.00	0	0	0	0
Total	14,962	3	0	7	3	8	0	0.00	159	0.03	750	0.14	0.17	0	0.00	28,575	5.41	14	0	0	3
Coastal storm flooding																					
Existing conditions	29,990	5.68	3	58	0	8	22,375	4.24	51,840	9.82	7,243	1.37	15.43	95,534	18.09	0	0.00	4	0	1	0
8 in	4,120	0.78	0	11	0	1	1,979	0.37	220	0.04	5,037	0.95	1.37	343	0.06	0	0.00	4	0	0	0
16 in	7,563	1.43	0	9	0	1	247	0.05	19	0.00	3,953	0.75	0.80	212	0.04	0	0.00	0	0	0	0
58 in	19,117	3.62	0	12	9	8	1,159	0.22	629	0.12	3,861	0.73	1.07	1,897	0.36	0	0.00	4	0	0	5
Total	60,790	12	3	90	9	18	25,761	4.88	52,708	9.98	20,094	3.81	18.67	97,986	18.56	0	0	12	0	1	5
Combined - All																					
Existing conditions	43,531	8.24	3	58	3	15	22,459	4.25	52,382	9.92	9,697	1.84	16.01	95,534	18.09	27,301	5.17	10	0	1	2
8 in	4,921	0.93	0	18	0	2	1,979	0.37	220	0.04	5,037	0.95	1.37	343	0.06	1,274	0.24	11	0	0	1
16 in	8,365	1.58	0	9	0	0	247	0.05	19	0.00	3,598	0.68	0.73	212	0.04	0	0.00	0	0	0	0
58 in	19,063	3.61	0	12	8	8	1,151	0.22	87	0.02	2,120	0.40	0.64	1,897	0.36	0	0.00	4	0	0	5
Total	75,881	14	3	97	11	25	25,837	4.89	52,708	9.98	20,453	3.87	18.75	97,986	18.56	28,575	5.41	25	0	1	8

Sector	Critical Facilities and Emergency Services										Sensitive Biological Resources							Energy Infrastructure						Cultural Resources (attractions, landmarks)
METRIC	# of entire (grouped) of facilities by type								Length of evacuation routes (ft)		Environmentally Sensitive Habitat Area (ESHA)		USFWS Critical Habitat		California Natural Diversity Database (CNDDB, Extant Only, Layers are Stacked)			# of facilities		length of Pipe		length of Pipe		# by Type
TYPE	Govt Facility	Health Care	Fire	Police	Ambulance	Schools	Communications Towers (active)	Other (Utility Building, Power, Water Treatment, Airport)										Oil Wells (all)	Oil Wells (Active)	Major Pipelines (En Un County)		Minor Pipelines (En Un County)		
UNITS	count	count	count	count	count	count	count	count	ft	miles	acres	count	acres	count	sq ft	acres	count	count	count	ft	miles	ft	miles	count
Coastal erosion (Central)																								
Existing conditions	0	0	0	0	0	0	0	0	0	0.00	0.00	0	53.91	1	3,480,218	79.90	3	0	0	0	0.00	0	0.00	0
8 in	0	0	0	0	0	0	0	1	0	0.00	0.00	0	10.64	1	992,181	22.78	3	0	0	0	0.00	0	0.00	1
16 in	0	0	0	0	0	1	0	0	0	0.00	0.00	0	0.18	0	43,156	0.99	0	0	0	0	0.00	0	0.00	1
58 in	0	0	0	0	0	0	3	0	4,656	0.88	0.13	1	1.32	0	689,742	15.83	4	0	0	0	0.00	0	0.00	0
Total	0	0	0	0	0	1	3	1	4,656	0.88	0.13	1	66.05	2	5,205,297	119.50	10	0	0	0	0.00	0	0	2
Coastal erosion - Cliff (South)																								
9.8 in	0	0	0	0	0	0	1	0	4,557	0.86	11.52	1	0	0	663,139	15.22	3	0	0	0	0.00	0	0.00	1
19.6 in	0	0	0	0	0	0	0	0	9,099	1.72	8.57	0	0	0	76,157	1.75	1	0	0	0	0.00	0	0.00	1
59 in	0	0	0	0	0	0	0	0	6,636	1.26	34.48	0	0	0	367,768	8.44	0	0	0	0	0.00	0	0.00	0
Total	0	0	0	0	0	0	1	0	20,293	3.84	54.57	1	0.00	0	1,107,065	25.41	4	0	0	0	0.00	0	0	2
Tidal inundation																								
Existing conditions	0	0	0	0	0	0	0	0	283	0.05	0.64	1	0.48	2	4,050,112	92.98	40	2	0	30	0.01	0	0.00	5
8 in	0	0	0	0	0	0	0	0	9	0.00	0.12	0	0.25	0	666,290	15.30	0	0	0	7	0.00	0	0.00	1
16 in	0	0	0	0	0	0	0	0	10	0.00	0.13	0	0.38	0	639,176	14.67	0	0	0	6	0.00	0	0.00	0
58 in	1	0	1	0	0	0	2	1	1,968	0.37	0.54	0	11.85	0	2,971,943	68.23	6	3	0	79	0.01	0	0.00	2
Total	1	0	1	0	0	0	2	1	2,270	0.43	1.43	1	12.96	2	8,327,522	191.17	46	5	0	122	0.02	0	0	8
Fluvial																								
Existing conditions	0	0	0	0	0	0	8	0	14,357	2.72	11.10	3	2,269.83	13	164,688,921	3,780.76	38	73	15	11,939	2.26	494	0.09	0
8 in	0	0	0	0	0	0	0	0	134	0.03	1.78	0	21.88	0	6,158,857	141.39	0	16	9	1,379	0.26	231	0.04	0
16 in	0	0	0	0	0	0	0	0	22	0.00	0.00	0	0.00	0	18	0.00	0	0	0	4	0.00	0	0.00	0
58 in	0	0	0	0	0	0	0	0	187	0.04	0.00	0	0.01	0	5,463	0.13	0	0	0	0	0.00	0	0.00	0
Total	0	0	0	0	0	0	8	0	14,701	2.78	12.88	3	2,291.72	13	170,853,259	3,922.28	38	89	24	13,322	2.52	725	0	0
Coastal storm flooding																								
Existing conditions	0	0	0	0	0	1	6	1	10,879	2.06	14.02	4	81.68	6	12,877,041	295.62	53	12	0	9,825	1.86	10,830	2.05	8
8 in	0	0	0	0	0	0	1	0	6,367	1.21	13.50	0	5.18	0	1,805,186	41.44	3	3	0	9,879	1.87	8,132	1.54	2
16 in	0	0	0	0	0	0	1	0	5,987	1.13	6.64	0	20.76	3	2,548,689	58.51	6	1	0	7,691	1.46	4,549	0.86	0
58 in	1	0	1	0	0	0	6	0	24,720	4.68	18.43	0	135.36	1	12,591,698	289.07	6	32	17	21,551	4.08	8,655	1.64	2
Total	1	0	1	0	0	1	14	1	47,953	9.08	52.59	4	242.98	10	29,822,613	684.64	68	48	17	48,945	9.27	32,165	6	12
Combined - All																								
Existing conditions	0	0	0	0	0	1	14	1	25,236	4.78	20.48	4	2,344.31	15	176,090,411	4,042.51	78	85	15	21,764	4.12	11,323	2.14	8
8 in	0	0	0	0	0	0	1	0	6,502	1.23	11.24	0	26.00	0	6,883,685	158.03	3	19	9	11,258	2.13	8,363	1.58	2
16 in	0	0	0	0	0	0	1	0	6,009	1.14	5.52	0	1.65	0	1,060,896	24.35	3	0	0	7,459	1.41	4,549	0.86	0
58 in	1	0	1	0	0	0	6	0	21,772	4.12	16.04	0	3.65	0	3,187,589	73.18	2	22	11	17,066	3.23	8,655	1.64	2
Total	1	0	1	0	0	1	22	1	59,519	11.27	53.27	4	2,375.61	15	187,222,581	4,298.07	86	126	35	57,547	10.90	32,890	6	12

APPENDIX C.
SOCIAL VULNERABILITY

This social vulnerability analysis supplements the Vulnerability Assessment Report. Sea level rise impacts will not be evenly distributed among population groups and it is important to identify the most vulnerable populations so that adaptation strategies can be developed in an equitable manner. This work is also consistent with new State Ocean Protection Council guidance on addressing environmental justice while planning for sea level rise.

Contents

1. Executive Summary

Since 2015, the California Coastal Commission and the Ocean Protection Council have provided formal guidance to local jurisdictions that are planning for sea level rise adaptation regarding how to address social equity and environmental justice for vulnerable populations[1]. As a first step toward incorporating environmental justice in sea level rise planning for Ventura County, this report identifies the demographics of the population in the unincorporated coastal zone, evaluates some vulnerable populations, and provides social adaptation strategy recommendations[2]. By State definition[3], the only disadvantaged communities in the unincorporated coastal zone of Ventura County are located in the Ormond Beach area and along the Santa Clara River. These are very small populations in low-density agricultural areas and therefore a more detailed social vulnerability analysis of the residential areas in the unincorporated coastal zone was conducted.

To further assess the social vulnerabilities to sea level rise in the unincorporated coastal zone, the following three vulnerable populations were selected: seniors, renters, and Hispanic residents. These populations were chosen based on data availability and previous studies that indicate that these populations have higher vulnerability to sea level rise hazards[4]. The analysis identified that there is a higher than average percentage of seniors and renters that could be exposed to sea level rise hazards and that there is lower than average percentage of Hispanic residents throughout the unincorporated coastal zone. Overall, there are about 4,700 residents in the unincorporated coastal zone, of which about 2,000 live in areas that could be exposed to coastal storms today[5] and with the projected amount of sea level rise by 2030 (see Section 3.2). Other vulnerable groups (e.g. disabled, coastal visitors, homeless) were not quantitatively analyzed but should be considered in future studies. Four key recommendations are listed below:

- Develop a sea level rise retreat strategy with habitat restoration and public access in Ormond Beach that could reduce current environmental pollution and increase coastal recreational opportunities for the most vulnerable populations in the unincorporated County coastal zone.
- Initiate an "adopt a neighbor" campaign to help senior residents that are most vulnerable during a coastal emergency evacuation, particularly in the communities of the North and South Coasts.
- Provide education materials (including information on renter's insurance) to residents of the coastal zone. These should also be made available in Spanish (especially in the Central Coast).
- Incorporate a coordinated population vulnerability analysis for all coastal jurisdictions in the county, possibly in the Ventura County Multi-Hazard Mitigation Plan.

---

[1] See the 2015 "California Coastal Commission Sea Level Rise Policy Guidance" and the "State of California Sea-Level Rise Guidance: 2018 Update."

[2] Historical exposure to pollutants in marginalized is also an important component of environmental justice. Exposure to pollutants is addressed in Section. 2.1.

[3] By "State definition," this analysis refers to Senate Bill 535, which defines disadvantaged communities as the top 25% scoring areas from CalEnviroScreen along with other areas with high amounts of pollution and low populations. See www.oehha.ca.gov/calenviroscreen/sb535 for more information on SB535.

[4] While there are other populations that may be vulnerable to sea level rise hazards (e.g., income, race, disability), lack of data availability at a high spatial scale was a limiting factor for the analysis. Information for these other population groups is provided at a regional scale in section 2.2.

[5] 1% annual chance coastal storms at current sea levels.

1.1 Background

Social vulnerability is the susceptibility of a population to harm from exposure to a hazard and includes the ability to prepare for, respond to, and recover from that hazard[i]. Social vulnerability to sea level rise involves the study of populations exposed to sea level rise hazards by using demographic data to identify groups that may be at higher risk. Building resilient communities "requires increasing the capacity of communities and people to be able to withstand and recover from climate-related disruptions, and to be able to learn and adapt in the face of this change"[ii]. To do so, proactive planning and investments can be made to prepare the most vulnerable communities before sea level rise impacts occur, and response actions should be available when and where populations are most vulnerable. The first step in a social vulnerability analysis is to understand the demographics of the population exposed to sea level rise hazards. Given that this project is funded by the California Coastal Commission ("Coastal Commission") and the State Coastal Conservancy for a Local Coastal Program update for the County of Ventura, the focus is on the residents of the unincorporated coastal zone in Ventura County. This assessment was designed to answer the question "*What are some of the groups that are most vulnerable to sea level rise hazards in the coastal zone?*" [6]

2. Identifying Vulnerable Populations: From the State to the Local Scale

There has been increasing State guidance directing local governments to consider social vulnerability and environmental justice issues in sea level rise planning. The 2015 Coastal Commission "Sea Level Rise Policy Guidance", the 2017 Coastal Commission draft environmental justice policy, and the Ocean Protection Council's "State of California Sea-Level Rise Guidance: 2018 Update" all have components that address environmental justice in coastal planning[7]. These guidance documents are primarily concerned with loss of affordable coastal access and recreation, unequitable impacts of adaptation strategies, and public engagement of marginalized communities. While local governments are to consider impacts on vulnerable populations regarding those issues, the State allows flexibility in how this guidance is to be implemented locally. There have been multiple methodologies developed to aid local governments in identifying vulnerable populations. Two State and one federal study are summarized below.

2.1 Social Vulnerability Summarized by State and Federal Agencies According to U.S. Census Tracts and Block Groups

Recent State sea level rise policy guidance recommends the prioritization of vulnerable populations when developing adaptation strategies to sea level rise. While there are State and federal definitions of vulnerable populations, it is important to evaluate these within a local context. In 2012, the California Energy Commission (CEC) conducted a statewide assessment of social vulnerability to various climate change-related hazards[iii]. The study assessed the potential number of people affected by coastal flooding according to Census tract[8] demographic information. Compared to other coastal

---

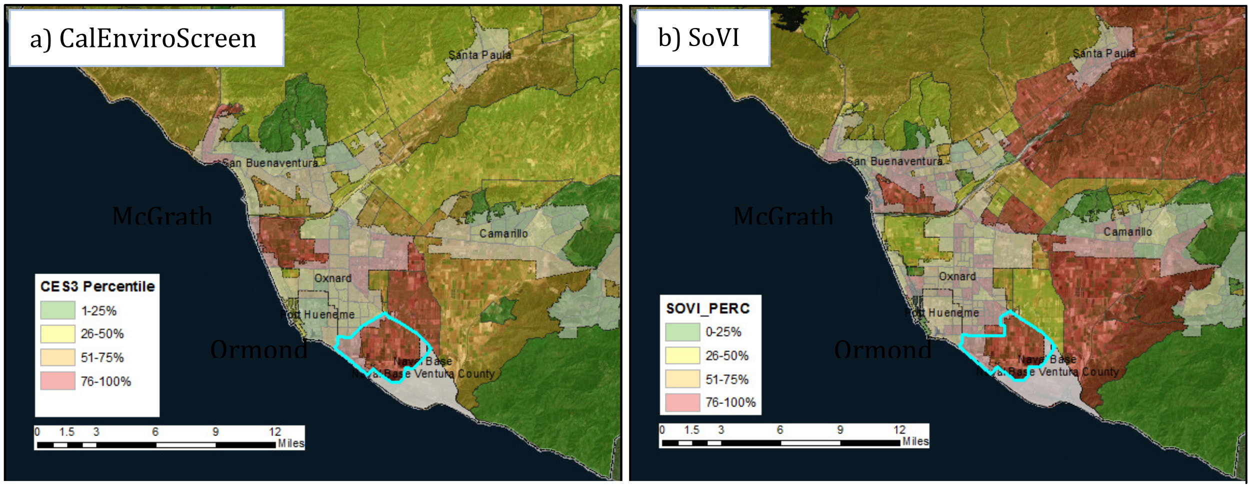
[6] There are other climate change-induced hazards that will also affect the vulnerability of these populations and other vulnerable populations in surrounding jurisdictions. Other environmental hazards are discussed in the main body of the report (ES-16) and in Appendix A.

[7] In addition to these sea level rise guidance documents, the 2018 Statewide climate change adaptation report *Safeguarding California* includes an entire chapter on environmental justice.

[8] Census tracts are small geographic areas that usually have a population between 2,500 to 8,000 persons.

counties in Southern California, the CEC study found that Ventura County (including the cities within the County) has higher than average social vulnerability to coastal flooding. More than half of those potentially impacted live in Census tracts with high social vulnerability. The State analysis offers an effective big-picture image that allows for the comparison between California counties and may allow for prioritization of State-funded projects. However, for the purposes of local planning, a higher spatial analysis is needed.

Figure C-1. State and Federally-Defined Vulnerable Populations*



* Although the CalEnviroScreen (a) and SoVI (b) use different indicators and methods to identify vulnerable populations, the same color scheme is used for both for consistency. Red in both maps shows the vulnerable populations as defined by each metric.

Two online screening tools are often used to identify vulnerable populations at the regional level in California: CalEnviroScreen and the Social Vulnerability Index (SoVI). In April 2017, the State of California defined disadvantaged communities in order to target these areas for investment from the State's cap-and-trade program (Senate Bill 535). According to SB535, disadvantaged communities are ranked within the top 25% of Census tracts from CalEnviroScreen, a screening tool that identifies communities disproportionately burdened by multiple sources of pollution and other variables that make them susceptible to harm and decrease their capacity to adapt.

In terms of sea level rise hazards, CalEnviroScreen can be a proxy to estimate social vulnerability. According to CalEnviroScreen, the disadvantaged communities in Ventura County are shown in red in Figure C-1a above, and there are two disadvantaged communities located in the unincorporated coastal zone (highlighted in bright blue). The low-density agricultural lands in Ormond Beach, and areas along the southern bank of the Santa Clara River both score high according to some of CalEnviroScreen's 20 pollution indicators. The two areas have especially high exposure to pesticides (100% percentile), hazardous materials cleanup sites (greater than 90% percentile), and pollution (greater than 90% percentile). In addition, the screening tool shows that persons living near the southern bank of the Santa Clara River experience high rates of asthma, cardiovascular disease, and low birth rates. Whereas, the area around Ormond Beach has very low quality drinking water, poor educational attainment, and high exposure to solid waste.

Another readily available social vulnerability assessment tool is the SoVI developed by the National Agency of Toxic Substances and Disease Registry (Figure C-1b). Although the SoVI was developed to identify communities most vulnerable to human health stresses, it has often been used as a general assessment of population vulnerability[9]. The vulnerable populations identified by the SoVI are shown in red in Figure C-1b above. The Ormond Beach area is the only place in unincorporated Ventura County that is identified as vulnerable by both CalEnviroScreen and the SoVI (Figure C-1, blue highlight). This area has the highest scores for the Minority Status/Language Theme and the Housing/Transportation Theme of the SoVI[10]. Ormond Beach generally consists of existing agricultural land uses and is sparsely populated (about 120 residents). There are wetland restoration and coastal access projects underway that could provide flood control and recreational opportunities for vulnerable resident populations. As Ormond Beach is designated as a disadvantaged community by the State, there may be opportunities to incorporate sea level rise adaptation strategies that benefit the local population in conjunction with other projects. This, however, will require interjurisdictional coordination with the City of Oxnard and the City of Port Hueneme.

While CalEnviroScreen and SoVI provide a regional analysis, they may not identify all vulnerable populations to specific hazards, such as sea level rise. The existing communities in the unincorporated coastal zone are not identified as vulnerable by State standards[11], but may have specific social vulnerabilities. Thus, a more detailed analysis was conducted to identify locally vulnerable populations that might not be obvious in all the data layers used for CalEnviroScreen or by the analysis at the lower spatial resolution.

2.2 Defining Vulnerable Populations to Sea Level Rise in Unincorporated Coastal Ventura County by Census Blocks

To assess the groups within unincorporated Ventura County that are more vulnerable to sea level rise hazards, it is necessary to use population data at a higher spatial resolution. One solution to remedy the challenge of spatial coarseness identified in the CalEnviroScreen and SoVI assessments is to use Census block demographic data[12]. The Census data summarized at the block level is the most detailed demographic unit available, and therefore lends itself well to evaluating sparsely populated coastal communities for vulnerability to sea level rise hazards. The drawback of higher spatial resolution is that there is less information available at the block level. For example, there is no income or disability data at the block level, as these are deemed to be sensitive information at this scale and are not available from the Census Bureau. This assessment focuses on some populations (out of the demographic information available at the block unit from the 2010 Census) that may have higher vulnerability to sea level rise hazards.

According to the 2017 California Department of Public Health "Climate Change and Health Profile Report: Ventura County"[iv], the types of populations in flood-prone areas most affected by flood hazards are the elderly, children, and low-income populations. A 2015 study[v] identified the following additional demographic characteristics that increase a population's vulnerability to floods: age, race, ethnicity, immigration status, language ability, employment, land tenure, and health, among other

[9] This SoVI was used in the social vulnerability analysis done by the County of Santa Barbara and the cities of Hermosa Beach and Los Angeles.

[10] The SoVI ranks each Census track on 14 social factors and groups them into four related themes: socioeconomic status, household composition, minority status/language, and housing/transportation. The minority status/language theme uses the variables "minority" and "speaks English less than well." The housing/transportation theme uses the variables "multi-unit structures", "mobile homes", "crowding", "no vehicle", and "group quarters."

[11] According to SB535.

[12] While there are only eight Census block groups and tracts in the unincorporated coastal zone, there are over 300 Census blocks that better follow jurisdictional and neighborhood boundaries.

factors. Of the demographic information available at the block level[13], the following three were chosen as vulnerable populations for their demonstrated vulnerability to sea level rise hazards: seniors age 65 and over (Seniors), number of people who are living in rental housing units (Renters), and Hispanic residents (Table C-1). Each of these three populations is most vulnerable at a specific stage of a hazard[14]. Seniors may be most vulnerable during the response stage due to limited mobility, decreased access to information, and possible hearing limitations that may hinder them from receiving emergency warnings. Renters may be most vulnerable during the preparation and recovery stages due to limited control over their home infrastructures and potential lack of renters' flood insurance. Hispanics may be most vulnerable during the recovery stage due to potential language barriers that may limit easy access to recovery resources.

Table C-1. Populations Vulnerable to Sea Level Rise Hazards

Indicator	Description
Seniors	Total population (male and female) age 65 and over
Renters	Total population in rented accommodations
Hispanics	Total Hispanic population regardless of race

Seniors (65 and Over). Age is the leading demographic driver of social vulnerability to floods[vi]. The elderly have decreased mobility and are more exposed to hazards during emergency evacuations. Emergency warning systems (especially digital media like Twitter and text alerts) may also not be effective in reaching this population. Many seniors also live on fixed incomes and may lack resources to recover from hazards if they suffer loss of property or belongings.

Renters. Land tenure is a vulnerability factor most common in developed areas prone to fluvial and coastal floods. Renters are most vulnerable during the mitigation and recovery stages of hazards. Renters' lack of autonomy over their residence generally decreases their ability to prepare the house for flooding, decreasing their ability to mitigate the hazard before it occurs. Renters are also less likely to have flood insurance coverage for their belongings compared to homeowners and may lack adequate resources to recover from a flood event[vii].

Hispanics. Race, class, ethnicity, and immigration status may present cultural and language barriers that impede access to disaster recovery resources. While these factors are highly interactive, the Hispanic population was included because it is the largest ethnic minority population in Ventura County[viii] and they experience a disproportionate amount of poverty and have lower incomes compared to White/non-Hispanics. Countywide, Hispanic residents had an average per capita annual income of $23,159 compared to $41,974 for white non-Hispanic residents in 2016[15] (Table C-2).

Although the vulnerable populations chosen for this detailed spatial analysis do not cover all social vulnerabilities to sea level rise hazards, they highlight some of the specific vulnerabilities of residents in the unincorporated coastal zone. Many other persons who live and work inland also visit beaches and use the coastline. Future studies should consider how other potentially vulnerable populations that use the coastline, such as the disabled, homeless, and low-income, could be affected. For now, some general countywide analysis is provided for these populations below:

---

[13] Other demographic information available at the block level includes gender, race, family type, number of children, and urban/rural designation.

[14] There are three hazard stages: preparation, response, and recovery.

[15] Estimates based on 2016 American Community Survey 5-Year Estimate.

- According to the American Community Survey 5-Year Estimate of 2012-2016, about 6.7% of the population countywide have a disability[16]. If that proportion were uniformly distributed throughout the County, there would be over 250 residents with a disability in the unincorporated coastal zone.
- Every year, the Ventura County Continuum of Care Alliance conducts a homeless count. The 2018 Ventura County Homeless Count Report estimated that there are about 1,299 homeless persons in the entire county (cities and unincorporated areas) with about 77 in the unincorporated areas. Some of the homeless persons camp in streambeds near the coastal zone and may be exposed to sea level rise hazards.
- Table C-2 below summarizes the County's average per capita income (including incorporated cities) roughly separated by location in terms of the coastal zone and ethnicity[17]. While white residents make on average 4% more in the coastal zone compared to the non-coastal zone, Hispanic residents make 20% less in the coastal zone compared to the non-coastal zone. There are some low-income, predominantly Hispanic communities found within the coastal zones in the cities of Oxnard and Port Hueneme. Residents with a lower annual income could have more difficulty recovering from a disaster. Countywide, Hispanic residents ($23,159) make 45% less annually per capita than white, non-Hispanic residents ($41,974).

Table C-2. Countywide 2016 Income Estimates by Coastal Zone and Ethnicity (2010 Census)

	Hispanic	White alone, Not Hispanic[18]
Coastal zone	$19,868	$43,520
Non-coastal zone	$23,434	$41,845
Countywide	$23,159	$41,974

The remainder of this report focuses on the vulnerable populations for which there is data at the Census block level. While disability, homelessness, and income are important demographic factors, they cannot be carefully analyzed due to lack of data at the Census block level. Therefore, only the specific vulnerability of the populations identified above (seniors, renters, and Hispanic) will be analyzed in the following section.

3. Vulnerable Populations of the Unincorporated Coastal Zone and Potential Exposure with Eight Inches of Sea Level Rise

Sea level rise hazards can impact populations in direct and indirect ways over time. Some residents will be exposed to flooding, erosion, and debris damage to their homes while others will be indirectly impacted by damage to a school or the closure of roads. Storms and rising seas could also exacerbate environmental pollution burdens and hazards. The focus of this analysis is on location-based

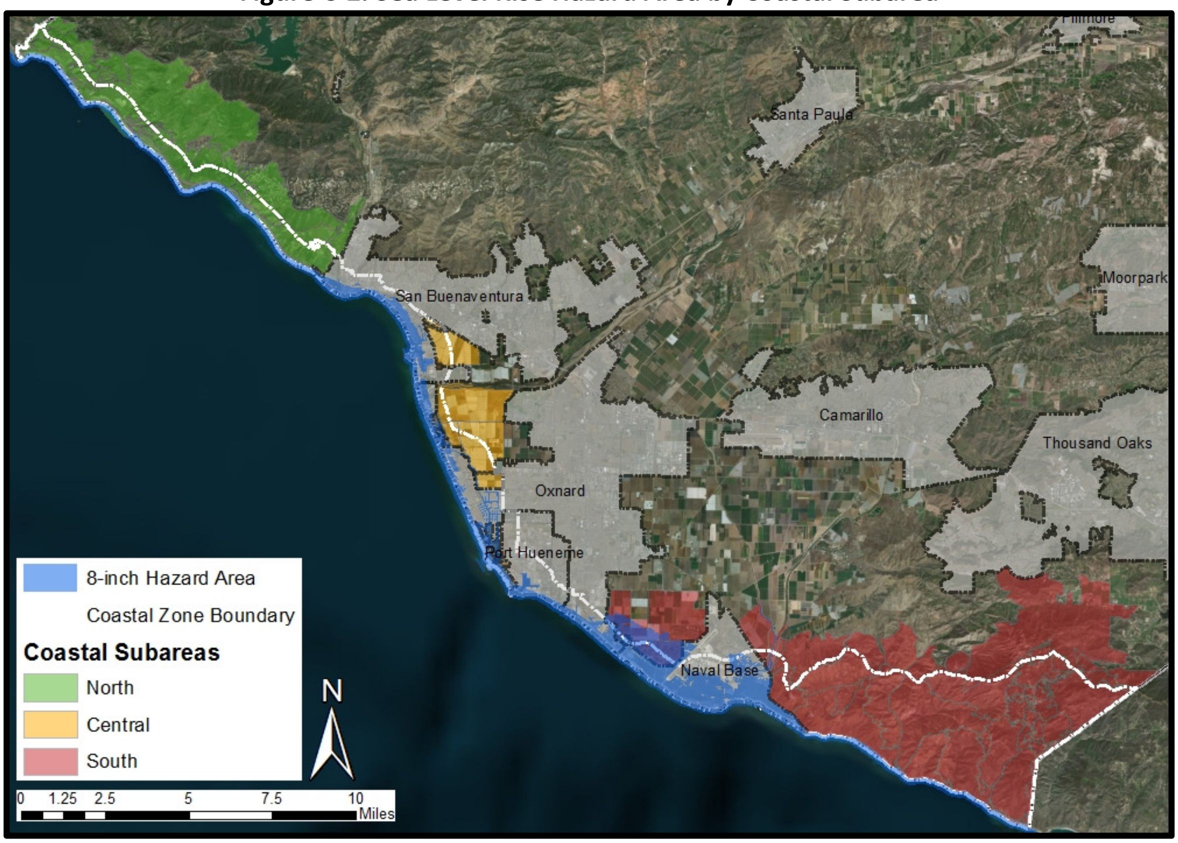
[16] The American Community Survey defines disability as having serious difficulty with hearing, vision, cognition, or ambulation for persons under the age of 65.
[17] The data was taken at the block group level from the 2016 American Community Survey. Block groups do not follow jurisdictional boundaries. The separation between the coastal zone and non-coastal zone are therefore low-resolution estimates.
[18] In the Census, people who respond to the question on race by indicating only one race are referred to as *race alone* population. White alone are respondents who marked only the "White" category. Hispanic origin is a separate Census question. Therefore, "White alone, Not Hispanic" are all those who marked only the "White" category in the race question and the "Not Hispanic" category in the ethnicity question.

vulnerability of populations that will be exposed to sea level rise hazards[19]. To this end, this section starts with the definitions of the sea level rise hazard area (SLR Hazard Area) and the Exposure Area (Sections 3.1 and 3.2), followed by a quantitative analysis of the impacted population (Section 3.3). This section concludes with a qualitative narrative on the potential vulnerabilities of these populations and how local governments could intervene to alleviate identified risks (Section 3.4).

3.1 Defining the Sea Level Rise Hazard Area

The SLR Hazard Area consists of the 329 Census blocks in unincorporated Ventura County located within 500 feet of the coastal zone[20] (Figure C-2). The SLR Hazard Area is separated into three coastal subareas: North Coast (green), Central Coast (orange), and South Coast (red). The subarea divisions are derived from the planning regions in the County's Coastal Area Plan, but also extend beyond the coastal zone and include a 500-foot buffer to capture most of the coastal hazards associated with sea level rise. In some areas, the SLR hazard area extends farther inland due to the large size of the Census blocks.

Figure C-2. Sea Level Rise Hazard Area by Coastal Subarea



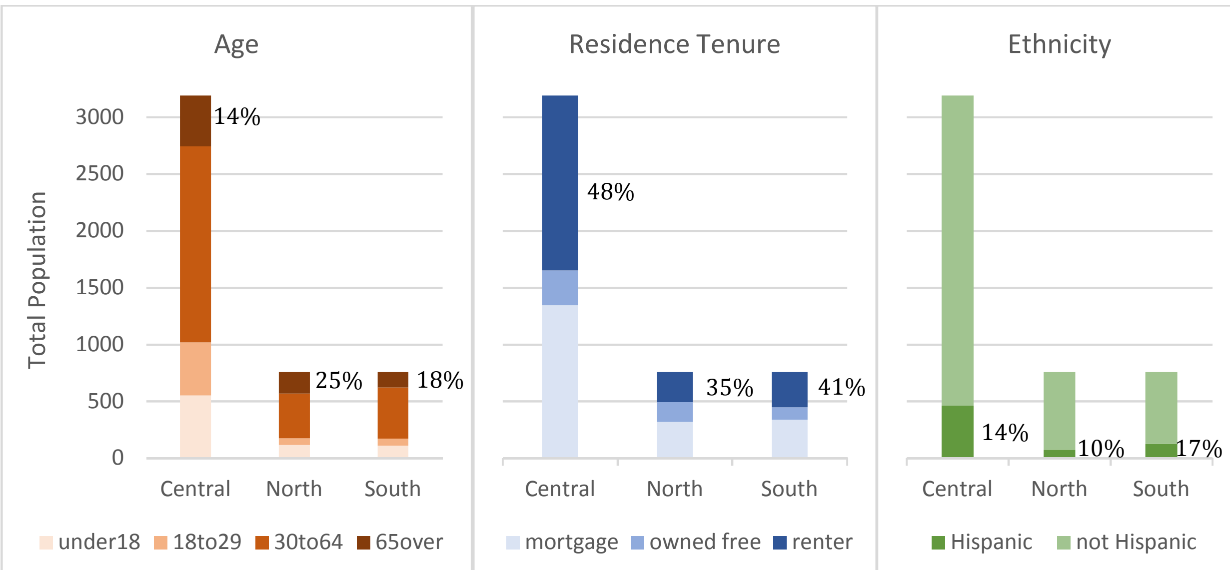
There are 4,703 residents and 2,895 housing units in the SLR Hazard Area. More than 65% of the population in the SLR Hazard Area lives in the Central Coast (3,190 of the 4,703 people). The North and South Coasts have about the same number of residents (~750 in each subarea). The demographic breakdown of the SLR Hazard Area is summarized according to the vulnerable populations in Figure

[19] Location-based analysis relies on the population that resides in the area of study and does not include people who visit or work in the area.

[20] As defined by the Coastal Commission and mapped in the Ventura County Coastal Area Plan.

C-3 below. The left axis shows the total population in each subarea. For example, the Central Coast has more than 3,000 residents while the North and South Coasts have about 750 residents each. The colors in each bar graph show the demographic breakdown according to each vulnerable population metric. Age is shown in red (with the darkest red showing the proportion of seniors), residence tenure is shown in blue (with the darkest blue showing the proportion of renters), and ethnicity is shown in green (with the darkest green showing the proportion of Hispanics). The percentages in each chart show the percentage of the population in the subarea that falls into one of the categories of vulnerable populations (i.e., seniors, renters, Hispanic). For example, 14% of residents in the Central Coast are seniors, 41% of residents in the South Coast are renters, and 14% of residents in the North Coast are Hispanic. For comparison across demographics, the entire composition of the vulnerable population categories are shown. Age is shown in the brackets "under 18", "18 to 29", 30 to 64", and "65 and over" (seniors). Residence tenure is shown as "mortgage", "owned free"[21], and "renter". And ethnicity is shown in the binary "Hispanic" or "not Hispanic".

Figure C-3. Demographic Breakdown of the Residents of the SLR Hazard Area



The Central Coast consists of the residents who live at Silverstrand, Hollywood Beach, and along the Santa Clara River. The Central Coast, being the most populated subarea, has the highest number of vulnerable residents with 446 seniors (14%), 1538 renters (48%), and 462 Hispanic residents (14%) living in the SLR Hazard Area. The North and South Coasts consist of interspersed communities and have similar demographics and total population when compared to one another. The age distribution in the two subareas are similar, with the North Coast having a slightly higher percentage of senior residents (25% compared to 18%). The South Coast, on the other hand, has a higher percentage of the other two vulnerable populations with 41% of South Coast residents being renters (compared to 35% in the North Coast) and 17% being Hispanic (compared to 10% in the North Coast). This demographic information could be useful in other coastal management plans in the County.

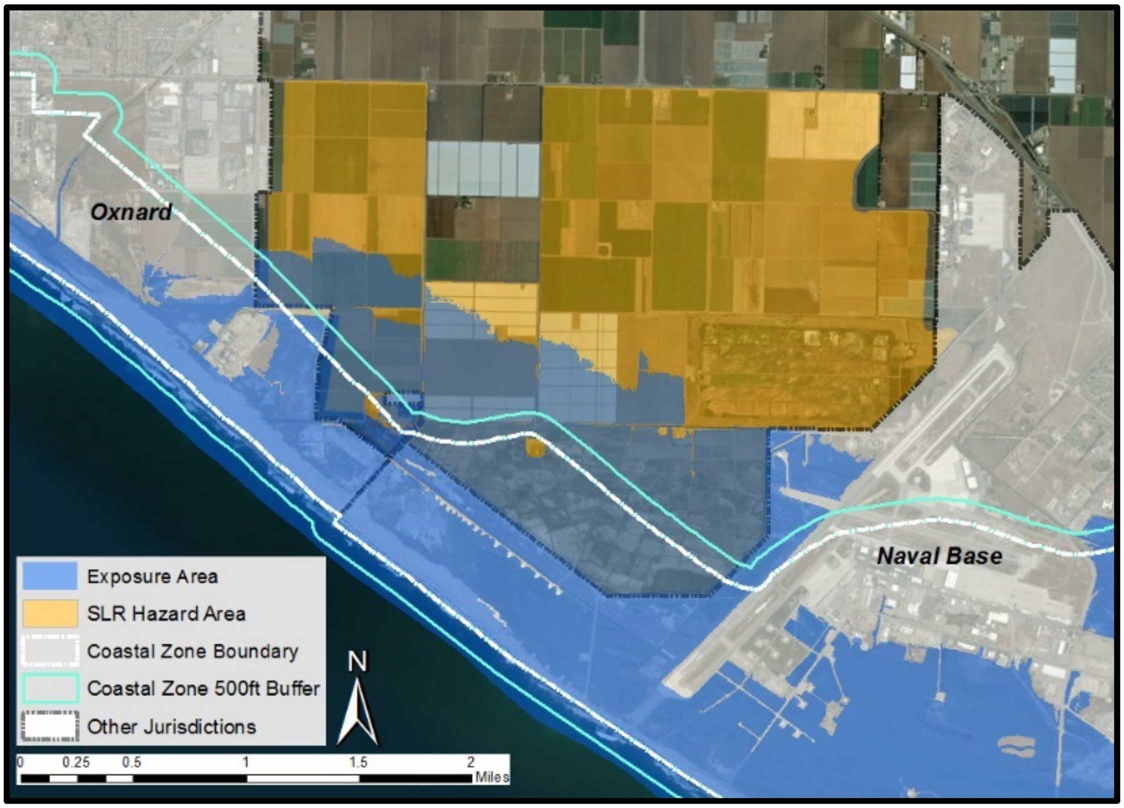
3.2 Exposure Area Calculation and Population Demographics

The Exposure Area is the part of the Census block that, according to the sea level rise models, could be exposed to eight inches of sea level rise and a large coastal storm (Figure C-4). To calculate the population in the Exposure Area, the population in each block was multiplied by the fraction of that

[21] In real estate, owned free and clear means that there is no lien or mortgage.

block that is inundated with up to eight inches of sea level rise. For example, if 50% of the area of a 100-person block is inundated, the population in the Exposure Area is estimated to be 50 people. Eight inches of sea level rise was used for the population analysis because it is projected to occur by 2030, which is within the year 2040 planning horizon of the County's General Plan Update.

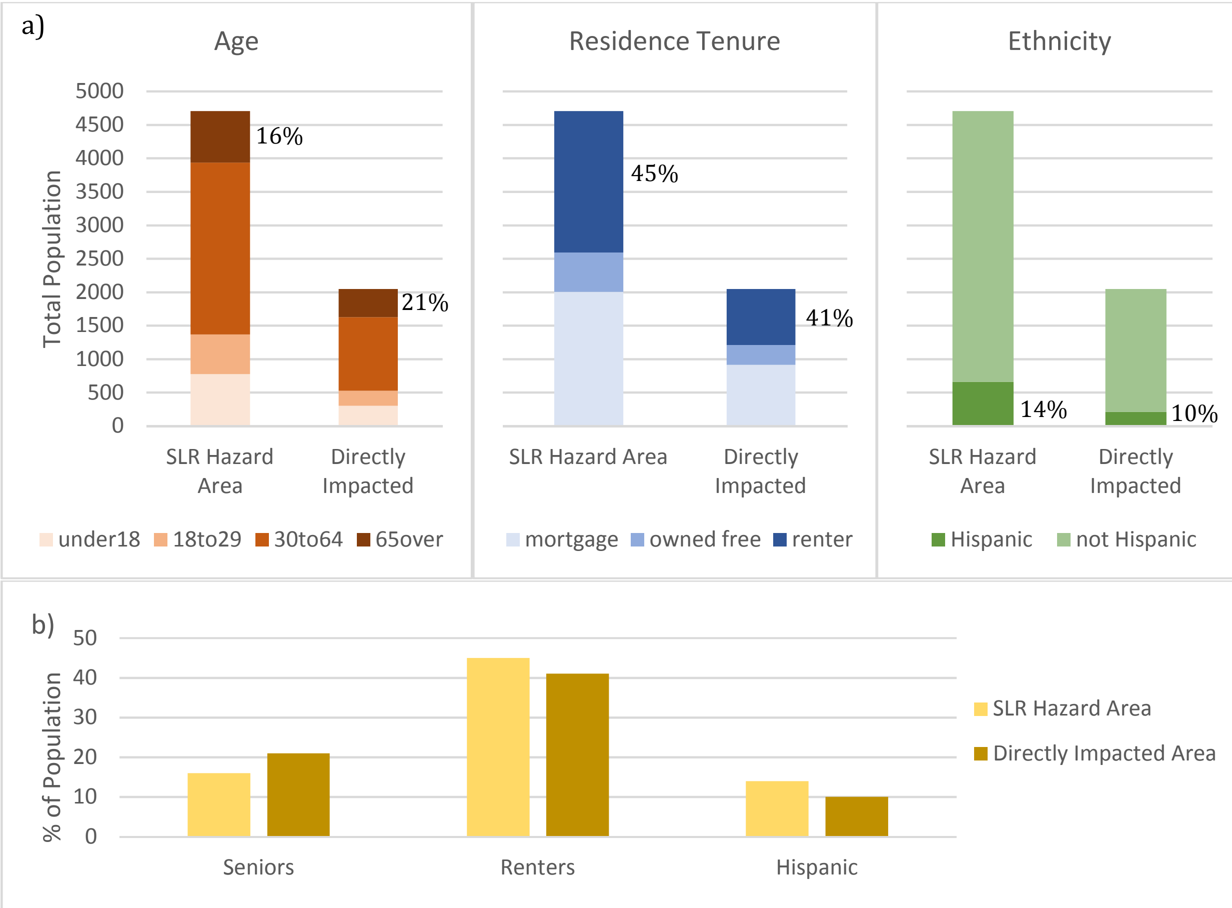
Figure C-4. Sea Level Rise Hazard Area and Exposure Area Illustration*



*The SLR Hazard Area (Census blocks) is shown in orange and the Exposure Area is shown in blue.

The demographics of the population in the Exposure Area (flooded with up to eight inches of sea level rise) are summarized in Figure C-5a. A total of 2,048 residents (or 44% of the population in the SLR Hazard Area) live in the Exposure Area. Comparing the population in the SLR Hazard Area to the population in the Exposure Area highlights that there is a higher proportion of seniors exposed to sea level rise hazards Figure C-5b compares the proportional representation of each vulnerable population in the SLR Hazard Area and the Exposure Area. The light yellow shows the proportion of the population in the SLR Hazard Area who are from a vulnerable population and the dark yellow shows the proportion of the population in the Exposure Area who are from a vulnerable population.

Figure C-5. Vulnerable Population in SLR Hazard Area versus Exposure Area



While only 16% of the population in the SLR Hazard Area are seniors, 21% of the population in the Exposure Area fit that demographic. This indicates that within the SLR Hazard Area, a higher proportion of seniors live closer to the coast or closer to low-lying areas. The Hispanic population, on the other hand, is not disproportionately affected by sea level rise hazards. While 14% of the population in the SLR Hazard Area is Hispanic, only 10% of the population in the Exposure Area is Hispanic[22]. The proportional distribution of renters in the SLR Hazard Area and the Exposure Area are similar (45% in the SLR Hazard Area compared to 41% in the Exposure Area). Overall, the population in the Exposure Area has a higher proportion of seniors, lower proportion of Hispanics, and similar proportion of renters as the population in the SLR Hazard Area.

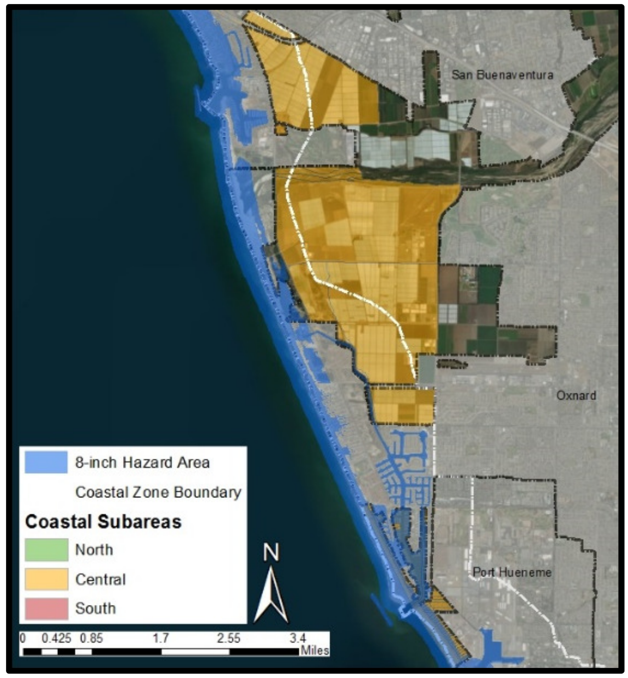
3.3 Population Demographics in the Hazard Area versus the Exposure Area

In the following subsections, the demographics of the SLR Hazard Area and the Exposure Area are discussed in more detail by subarea. The Central Coast is addressed first, as it has the highest population. The North and South Coasts are addressed together since they have similar demographic distributions and topography.

[22] While this indicates low disproportionate burden of direct impacts, it may shed light on other social vulnerability factors in that living closer to the coast in California generally requires more financial stability.

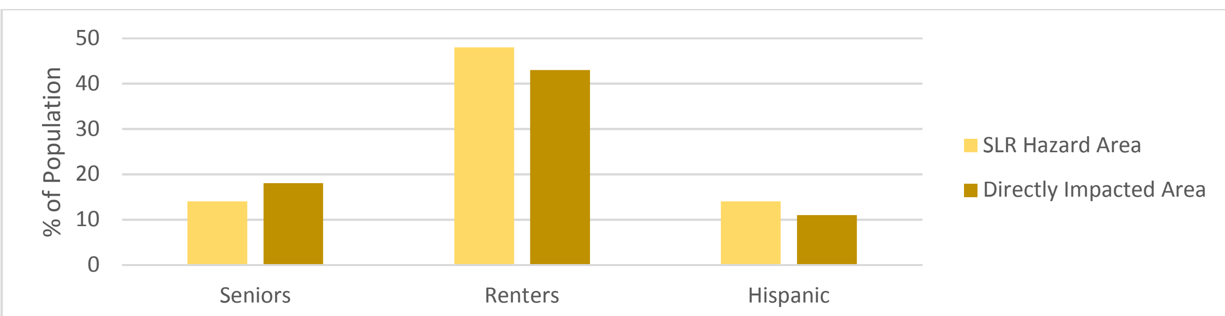
3.3.1 Central Coast

Figure C-6. Central Coast SLR Hazard Area



Overall, the Central Coast accounts for 68% of the population in the SLR Hazard Area and 75% of the population in the Exposure Area. The Central Coast consists of the Silverstrand and Hollywood Beach communities, and the few Census blocks at the mouth of the Santa Clara River (Figure C-6). The population in the hazard area at the mouth of the Santa Clara River is about 30 residents and none are in the Exposure Area. Although the population along the Santa Clara River is not within the Exposure Area, it should be considered in more detail since it was one of the areas identified by CalEnviroScreen and SoVI. A third of the population in that area is Hispanic, half are renters, and a majority are between the ages of 30 and 64. CalEnviroScreen shows that this area has high indices of pesticides, water pollution, asthma, and cardiovascular disease. The area is composed of agricultural land that, although not vulnerable to coastal flooding, may be vulnerable to fluvial (river) flooding. Flooding of polluted sites could be a hazard to the residents who live in this area. Flood protection projects could address the special vulnerabilities of the residents in this area.

Figure C-7. Central Coast Vulnerable Population Representation in SLR Hazard Area versus Exposure Area



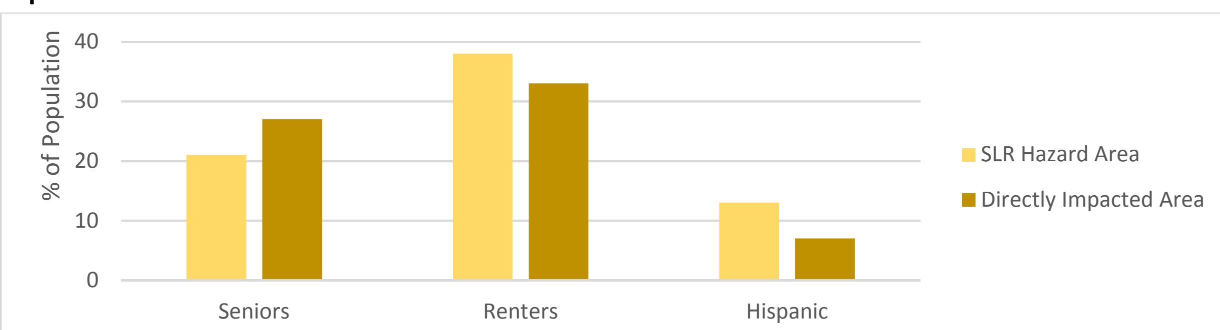
The more populated communities at Silverstrand and Hollywood Beach have about 1,545 residents in the Exposure Area (of the 3,190 in the hazard area). Of those in the Exposure Area, 18% are seniors, 43% are renters, and 11% are Hispanic (Figure C-7). The proportional distributions of the vulnerable populations are similar between those in the Exposure Area and those within the hazard area. In other words, at the scale of this analysis there are no vulnerable populations that would be disproportionately affected by sea level rise hazard on the Central Coast. By sheer number, renters are the most vulnerable in the Central Coast. More than 650 renters are within the Exposure Area with up to eight inches of sea level rise. The senior population includes more than 280 residents living in the Exposure Area. Lastly, while the Hispanic population has the lowest number, the 170 Hispanic residents in the Exposure Area may be more vulnerable to indirect impacts than the other vulnerable groups.[23]

3.3.2 North and South Coast

The North and South Coasts each have their unique communities and specific vulnerabilities, but they have very similar topographies, total populations, and demographic distributions. The population in the Exposure Area is therefore summarized in one figure for the North and South Coasts. An area of special consideration in the South Coast is the population near Ormond Beach. This is the only populated area within the SLR Hazard Area that coincides with both CalEnviroScreen and SoVI's definitions of vulnerable communities. As with the few Census blocks at the mouth of the Santa Clara River, Ormond Beach is primarily composed of agricultural land. According to CalEnviroScreen, this area has very high indices of pollution burden but low indices of population vulnerability. The pesticides and solid waste indices both scored in the top 90% percentile. Flooding could expose the residents of this area to pesticides and solid waste. The area inland of the Ormond Lagoon will be severely flooded with sea level rise. The population in these three blocks is composed almost entirely of Hispanics and renters. Although the total population in this area is roughly 120 people, engagement with this community should be targeted to the Hispanic majority. Flood hazard awareness should be incorporated into community safety and awareness programs for this area.

Of the 1,513 residents in the North and South Coasts in the SLR Hazard Area, about 500 are in the Exposure Area (about 33%). Of the population in the Exposure Area, 27% are seniors, 33% are renters, and 7% are Hispanic residents (Figure C-8 below). The senior population is disproportionately represented in the Exposure Area. There are more than 130 senior residents in the Exposure Area, with a majority in the North Coast. The North and South Coasts also have more than 160 renters and 35 Hispanic residents in the Exposure Area. Given the steep topography of these coastal subareas and the interspersed communities, emergency warning alerts may not effectively reach all vulnerable residents. In an age where most up-to-date information is shared through digital means and social media, some seniors may lack access to important communication tools.

Figure C-8: North and South Coasts Vulnerable Population Representation in SLR Hazard Area versus Exposure Area



This quantitative analysis describes how the vulnerabilities of these populations are manifested and where equitable adaptation strategies may best be implemented. The vulnerable populations addressed here are most susceptible to limited mobility during evacuation, limited resources for recovery, and limited resources for flood hazard preparation. The following narrative discussions are centered around these themes.

---

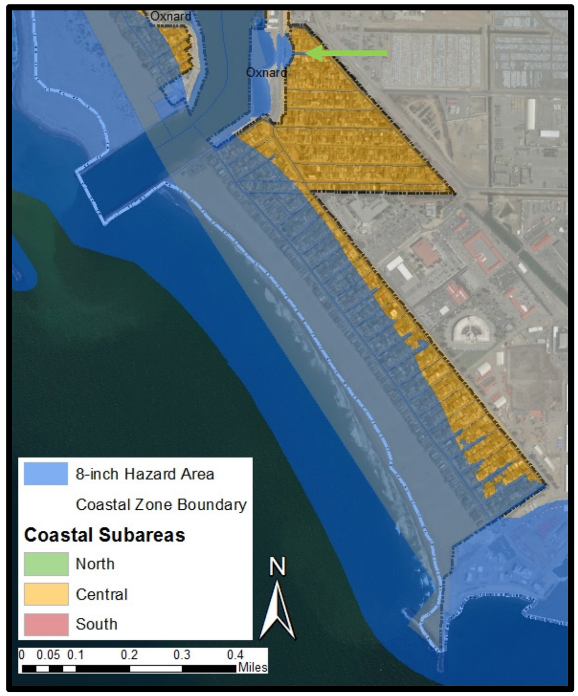
[23] Potential non-location-based (indirect) impacts are discussed in Section 4.

3.4 Vulnerability Narratives and Social Adaptation Strategy Options

While the charts above show the total number of residents that may be impacted with up to eight inches of sea level rise, it is important to discuss their vulnerability in terms of narratives to help develop potential social adaptation strategies. The three themes discussed below closely match the vulnerable populations chosen. The emergency evacuation narratives address the vulnerabilities of the senior population, while the flood recovery and flood hazard preparation narratives address the vulnerabilities of the renter and Hispanic populations.

Emergency Evacuation. Of critical concern in the Central Coast is the flooding of crucial evacuation routes and choke points that could constrain the evacuation process. Main evacuation routes out of both Hollywood Beach and Silverstrand are at risk of flooding with up to eight inches of sea level rise. Victoria Avenue (the only outlet from Silverstrand) already has nuisance flooding at high tides (Figure C-9, green arrow). It is highly likely that an adaptation strategy will have to be implemented at this location in the near term. There are more than 400 senior residents in the Hollywood Beach and Silverstrand communities that should be considered in evacuation planning. In case of an emergency, this population will likely need more time and resources to be evacuated. Evacuation of the Central Coast communities will also be affected by the evacuation of neighboring cities. Continued coordination between jurisdictions is crucial to address emergency operations[24].

Figure C-9. Silverstrand Evacuation Hazard



The North Coast consists of various small communities interspersed between Highway 101 and the ocean. Highway 101 may be flooded at various points in the North Coast with eight inches of sea level rise. Flooding at these points may isolate the communities and trap the residents during an evacuation. For example, the community at Rincon Point may be isolated from the rest of the County if Highway 101 is flooded. With the existing seawalls along Highway 101 in the North Coast, it is unlikely that the freeway will be flooded to an extent that prevents evacuation in an emergency. In the South Coast, most of the population is located in the Solromar community. As with the North Coast, it is unlikely that the Pacific Coast Highway will be flooded to an extent that prevents evacuation. More worrisome than the impacts on evacuation routes in the North and South Coasts is the direct impact to the residential units in the region. More than 280 people may have their homes flooded with up to eight inches of sea level rise in the North and South Coasts. Populations with decreased mobility (e.g. seniors) may have difficulty evacuating their homes even if the evacuation routes are unimpeded. Emergency plans should take these populations into account.

The Ventura County Multi-Hazard Mitigation Plan (MHMP) is the main set of policies governing emergency planning in the County of Ventura. While the 2015 Draft MHMP includes a section on climate change and briefly mentions sea level rise, it does not consider vulnerable populations. Future updates to the MHMP would benefit from conducting a population vulnerability analysis for

[24] The 10 cities of the County participate in the County's Hazard Mitigation Plan (2010).

the entire county. As the MHMP is coordinated between the County and its cities, it would be a good place to insert a comprehensive population vulnerability analysis.

Flood Recovery. While the National Flood Insurance Program (NFIP) requires homeowners to purchase flood insurance in areas of high flood risk, federal law does not cover all the populations in the SLR Hazard Area. There are two main reasons why the NFIP does not address all those at risk of flooding with sea level rise: (1) The Federal Emergency Management Agency (the agency that manages the NFIP) does not take climate change and sea level rise into account when creating the digital flood insurance rate maps; and (2) renters are not required to purchase flood insurance. During the recovery stage, renters are highly vulnerable because they may not have their belongings insured. In the North and South Coasts, 33% of the population in the Exposure Area are renters; and in the Central Coast, 43% of the population are renters. Local assistance efforts after a flood will have to take into account that many of these people may not have flood insurance. Renters are the most vulnerable during the recovery stage. The County should provide information on renter's flood insurance to residents of the hazard area and emphasize its importance. In the Central Coast, information on flood recovery should also be provided in Spanish to accommodate the more than 450 Hispanic residents. The same may not be necessary in the North and South Coasts.

Flood Hazard Preparation. The first stage of disaster is the preparation before a hazard. The impacts of a disaster can be mitigated if the population is prepared even before the impacts occur. Flood hazard preparation can help mitigate the impacts of floods by encouraging homeowners to prepare their properties for floods and prepare at-home emergency protocols. Community involvement in government projects is one way to increase flood hazard awareness. Materials prepared for community members should be targeted towards the vulnerable populations. For example, in the North and South Coasts, education efforts should be targeted towards the elderly and renter population. This can be done through infographics about best practices during evacuation (targeted for the elderly) or information on renters' insurance. In the Central Coast, it is important that these materials be also available in Spanish to accommodate for the larger Hispanic population, perhaps in collaboration with a Spanish radio broadcasting station.

4. Coastal Zone Workers and Visitors

A location-based social vulnerability analysis does not consider the populations that work or visit the coastal zone. For example, there are a few commercial parcels and many agricultural parcels within the SLR Hazard Area that may function as work sites for residents from other parts of the County. Workers in the service industries may be directly vulnerable to flooding during work hours. Indirect impacts could increase the vulnerability of workers to financial impacts if access to a work site is disrupted for a period of time. Even more significant, if a business suffers losses or damage from sea level rise hazards, employees may be let go to cover costs or because the business cannot operate. The worker population also includes the farm workers in the SLR Hazard Area. Agriculture parcels are primarily located near Ormond Beach and McGrath Park in the Central Coast. Impacts to farm workers may be significant and more work can be done to address sea level rise hazards with farm workers and employers[25]. It would also be helpful for State guidance documents to address in more detail how workers in the coastal zone may be affected by sea level rise.

A second vulnerable population not addressed through a location-based analysis includes the visitors to the SLR Hazard Area. The SLR Hazard Area contains several recreation areas including public beaches, County parks (Faria and Hobson), a hotel (Cliff House Inn), and temporary housing

[25] Agricultural workers may also be socially vulnerable due to their immigration status. While there are no estimates for the coastal zone, Ventura County as a whole is home to about 182,987 immigrants (about 22% of population) and an estimated 14,000 undocumented farmworkers (CAUSE 2011).

accommodations (e.g. Airbnb). The Coastal Commission is especially invested in equitably protecting public access and recreation to California's coastal resources through sea level rise policies. State guidance is currently focused on how to address environmental justice in development of sea level rise adaptation projects and through community engagement but provides no clear guidance on how local governments should assess the vulnerabilities of populations that live outside of the coastal zone (and therefore outside the jurisdiction of Local Coastal Programs). While the vulnerability of populations outside the coastal zone was not evaluated, the County's Local Coastal Program has regulations in place that protect coastal public recreation and access[ix]. The vulnerability of public access and recreation to sea level rise were also evaluated in the main body of this report . Unincorporated County beaches draw over two million visitor days per year. In the North and South Coasts, existing beaches are largely protected by 18 miles of coastal armoring and will be narrowed by rising high tides (ES-13). Coastal access points and various sections of the California Coastal Trail are vulnerable to coastal erosion and flooding under existing conditions (Appendix A). Public access and recreation vulnerabilities can be addressed during the adaptation strategies and policies phase of sea level rise planning. Adaptation strategies adopted at the planning level should consider existing social vulnerabilities and inequities and protect public coastal access for all.

5. Recommendations to Address Identified Social Vulnerabilities

Addressing environmental justice issues in sea level rise planning is a challenging task. The work done in this social vulnerability assessment has allowed for a better understanding of the population demographics of the coastal zone and how specific populations could be impacted by sea level rise. It is important that environmental justice and social vulnerability be addressed at every stage of sea level rise planning (following State guidance). A few conclusions and recommendations can be drawn from the work done above:

- Ormond Beach and the Santa Clara River are the two vulnerable communities in the unincorporated coastal zone, according to state and federal definitions (Section 2.1). The recommendations for this area include:
    - Coordinate climate action and disadvantaged communities funding opportunities towards restoration of Ormond Beach to provide the most disadvantaged population with coastal recreational opportunities.
    - Further study the impacts of sea level rise hazards on hazardous sites and oil wells in this area to protect the potentially exposed population.
    - Funding may be available to pilot resilience projects in these disadvantaged communities.
- There is a high proportion of seniors living in the coastal zone who may have limited mobility during evacuation warnings (Section 3). The recommendations from this conclusion include:
    - Analyze evacuation routes and accessibility for seniors and residents with limited mobility.
    - Initiate an "adopt a neighbor" campaign in the scattered communities in the North and South coasts to connect senior residents with their neighbors.
    - Implement early warning systems that are cognizant of seniors' limited mobility and potential lack of connection to modern means of communication (e.g. social media).
- Almost half of all residents of the coastal zone live in rented accommodations (Section 3). They may have less control over preparing their homes for flooding and less resources to recover from loss of belongings. The recommendations from this conclusion include:
    - Provide renter's flood insurance flyers and educate renter residents in the coastal zone on sea level rise hazards.

- Encourage landlords to consider how to prepare their properties for sea level rise hazards.

- The Hispanic population may face institutional and structural barriers to access resources to prepare for, respond to, and recover from sea level rise hazards. About 14% of residents in the hazard area in the unincorporated Central Coast are Hispanic (Section 3.2). The recommendations for this population include:
  - Outreach materials should be made available in Spanish (especially in the Central Coast).
  - The County should coordinate with community groups that have relationships with the Hispanic community during recovery from a hazard event to bridge the gap between local government and potentially marginalized communities.
- It is important for local governments to assess population vulnerabilities that are relevant to the region of study and the specific hazard being addressed. Vulnerabilities to one hazard and within a specific jurisdiction may overlap. The recommendations from this conclusion include:
  - Coordinate with other County agencies to conduct population vulnerability analysis for other specific hazards and existing environmental pollution burdens.
  - Utilize the MHMP as a platform to initiate a population vulnerability assessment of all coastal jurisdictions in the county.
- Though the vulnerability of visitors to the coastal zone was not addressed, coastal access and recreation are very important issues in equitable sea level rise planning. The recommendations from this conclusion include:
  - Revise coastal access and recreation regulations to consider the potential impacts of sea level rise hazard on visitors from vulnerable communities.
  - Develop adaptation strategies that consider the disproportionate impacts on coastal access and recreation resources.
- Future studies should consider other vulnerable populations like the disabled, homeless, institutionalized, and low-income. Local governments in coordination with neighboring jurisdictions. would benefit from a statewide study that establishes methodology and guidance on assessing the vulnerabilities of these populations relevant to small coastal communities.
- Ventura County (incorporated and unincorporated areas) has high social vulnerability to coastal flooding compared to other coastal counties in California (Section 2.1). State funding to address social vulnerability to sea level rise should be targeted towards the most vulnerable counties.
- Sea level rise hazards will impact communities across jurisdiction boundaries. It is important that strategies for vulnerable communities are coordinated across neighboring jurisdictions.

6. References

[i] Cutter, S.L. and C.T. Emrich, J.J. Webb, D. Morath (2009). Social Vulnerability to Climate Variability Hazards: A Review of Literature.
[ii] *Safeguarding California Plan: 2018 Update*. California Natural Resources Agency.
[iii] Cooley, H. and E. Moore M. Heberger, L. Allen (Pacific Institute) (2012). Social Vulnerability to Climate Change in California. California Energy Commission.
[iv] Maizlish, N. and D. English, J. Chan, K. Dervin, P. English (2017). "Climate Change and Health Profile Report: Ventura County." Sacramento, CA. Office of Health Equity, California Department of Public Health (CDPH).
[v] Rufat, S. and E. Tate, C. G. Burton, A. S. Maroof (2015). "Social Vulnerability to floods: Review of case studies and implications for measurement." International Journal of Disaster Risk Reduction 14: 470-486.
[vi] Rufat, S. and E. Tate, C. G. Burton, A. S. Maroof (2015). "Social Vulnerability to floods: Review of case studies and implications for measurement." International Journal of Disaster Risk Reduction 14: 470-486.
[vii] Casazza, C. (2017). "Why Renters Should Consider Getting Flood Insurance." Forbes. <https://www.forbes.com /sites/ccasazza/2017/06/15/why-renters-should-consider-getting-flood-insurance/#13b92cad7ec8>
[viii] Heberger, M. and H. Cooley, P. Herrera, P.H. Gleick, E. Moore (2009). "The Impacts of Sea-Level Rise on the California Coast." California Climate Change Center.
[ix] Ventura County Coastal Area Plan.

APPENDIX D. NATURAL RESOURCES MAPS AND METHODS

To plan for the effects of sea level rise on coastal natural resources, vulnerable habitats, plant and animal species were identified and evaluated. Section 1 of this Appendix contains detailed information on the methodology used to complete the natural resources component of the Vulnerability Assessment. Section 2 contains the natural resources maps that are referenced in Sections 2.7 and 5.3 of the main body of the Report. The four habitat types evaluated were beaches, dunes, estuarine, and freshwater environments that could be exposed according to projections in sea level rise models. These habitats are mapped in Section 2. The two sections are organized as follows:

Section 1: Sea Level Rise Planning Process for Natural Resources

- 1.1: Species Vulnerability Assessment Overview
- 1.2: Methods and Process
- 1.3: Methods for Ecosystem Selection and GIS Data Analysis
- 1.4: Focal Species Selection Methods
- 1.5: Vulnerability Assessment Methods

Section 2: Natural Resource Maps for the Unincorporated County

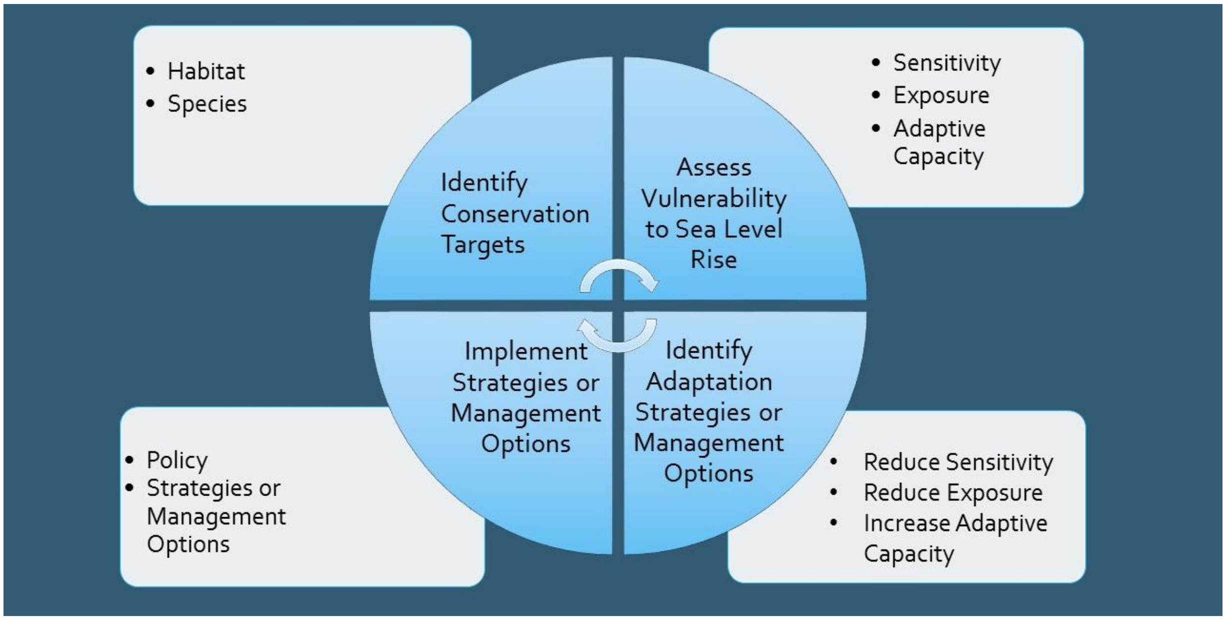
Section D-1: Sea Level Rise Planning Process for Natural Resources

The vulnerability of coastal natural resources to sea level rise is measured by an analysis of the extent to which a species, habitat, or ecosystem is susceptible to sea level rise impacts. The results of such an assessment may be used in the planning process for land managers, localities, and agencies to develop adaptation strategies that will increase the capacity of the County's natural resources to adapt to climate change. Understanding how and why these resources may be impacted is the first step in developing any adaptation strategy and it relies on assessing the sensitivity, exposure, and adaptive capacity of the resources to sea level rise. There are many types of vulnerability assessments (e.g., quantitative/qualitative) that can be conducted at various scales, so no two are alike.

The goal of the natural resource component of the project was to "coordinate and plan for the effects of sea level rise on existing coastal resources to ensure their resilience and conservation for future generations". To meet this goal, the vulnerability assessment was designed to focus on specific ecosystems that are vulnerable to sea level rise. This translated into an evaluation of a subset of coastal habitats (beaches and dunes, estuaries and salt marsh, freshwater wetlands, rivers, streams and lakes) and selection of a suite of focal species that would provide the most guidance to implement adaptation strategies by land managers, agencies, and local governments as sea level rise occurs locally. The intent is to use focal species for a vulnerability assessment that will inform the development of adaptation strategies and be used to update the policies and ordinances of the Local Coastal Program[17] (See Figure D-1).

[17] Funding for this project was provided by the California Coastal Commission and the State Coastal Conservancy.

Figure D-1. Sea Level Rise Planning Process for Natural Resources



1.1 Species Vulnerability Assessment Overview

To develop effective adaptation strategies for sea level rise it is useful to identify which species are likely to be most affected, why they are vulnerable, and to gain an understanding of how those vulnerabilities to sea level rise may vary throughout the coastline. The following three components define the vulnerability of a species to a stressor: (1) its sensitivity to changes in its environment, (2) its anticipated exposure to those environmental changes, and (3) its capacity to adapt to those changes. By evaluating species vulnerabilities using these three criteria (sensitivity, exposure, adaptive capacity) along with recording how much confidence a scientist had in his/her assessment, an overall vulnerability and confidence score can be used to evaluate which species are potentially the most vulnerable to sea level hazards. Vulnerability assessments identify how and why a selected focal species may be vulnerable to sea level rise using the following definitions and guidance:

Sensitivity

How much is the species affected by a given the amount of change?

Example Considerations:

- Does the species have narrow environmental tolerances or thresholds to live? Direct (e.g., physiological) or indirect impacts from sea level rise such as rapid changes in salinity, sediment transport, the intensity/frequency of a disturbance regime such as wind, flooding, diseases, or storms, etc. can directly impact the long-term viability of a species. A species that has a high physiological sensitivity to such disturbances will be more vulnerable to sea level rise.
- Species that utilize multiple habitats or have multiple food sources are less likely to be sensitive to sea level rise. Conversely, species with very narrow habitat needs, or reliant on a single food source likely have greater sensitivity to sea level rise. In addition, species that may depend on a specific habitat type or environmental condition for part of a critical life stage (e.g., nesting, overwintering) may also be vulnerable to sea level rise changes.

Exposure

How much change will occur in the environment that would impact the species?

Example Considerations:

- How exposed is the species to changes in sea levels and major storms (e.g., inundation, physical damage/death from storm surge, erosion)? This includes secondary impacts such as rapid changes in salinity, sediment transport, reduced productivity with increasing inundation regimes, etc.
- Are there other physical threats unrelated to sea level rise? Species that must endure multiple stressors may be more sensitive to sea level rise. Other stressors may include: development, fragmentation, pollution, invasives, etc.

Adaptive Capacity

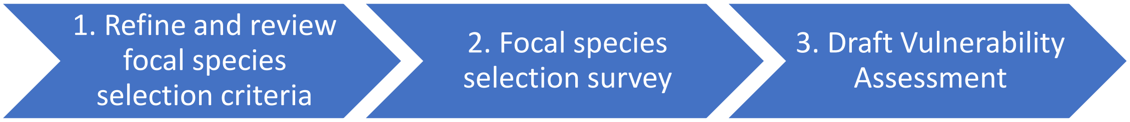
A species ability to adapt or respond to change.

Example Considerations:

- Species that demonstrate a diversity of life history strategies (e.g., variations in age at maturity, reproductive or nursery habitat use, or resource use) are likely to have greater adaptive capacity. Similarly, species able to express different and varying traits (e.g., phenology, behavior, physiology) in response to environmental variation have greater adaptive capacity than those that cannot modify their physiology or vary behavior to better cope with sea level rise changes and its associated effects.
- Some species and/or populations will be better able to adapt evolutionarily to sea level rise. For example, species may have greater adaptive capacity if they exhibit characteristics such as faster generation times, or geographic connectivity to allow for gene flow among sub-populations.
- Species that are currently widespread in their geographic extent, with a robust population status, high connectivity, and a high ability to disperse may be better able to withstand and persist into the future despite sea level rise and other non-related stressors. Species that are endemic, endangered, or with isolated or fragmented populations and/or limited ability to disperse will likely have lower adaptive capacity.
- A species response to management techniques will allow adaptive management strategies to be effective.

1.2 Methods and Process

The County formed a Natural Resources Working Group with 35 participants to help evaluate and assess the vulnerability of selected coastal species and habitats. This group consisted of federal, state, and local biologists, botanists, and ecologists familiar with the County's flora and fauna and who are subject-matter experts in the natural ecosystems of Ventura County. Participants were directly involved with the following tasks: (1) Refinement of criteria used to select focal species and assess species vulnerability; (2) Selection of focal species; and (3) Species Vulnerability Assessment. This work was conducted through three online surveys: (1) Survey for Focal Species Criteria for those working group members that missed or phoned in to the meeting on October 18, 2017; (2) Focal Species Selection Survey; (3) Species Vulnerability Assessment Survey. And three workshops: (1) Project Overview and Criteria Refinement; (2) Focal Species Selection Survey Results and Refinement of Final Focal Species Group; (3) Results of Vulnerability Assessment Survey and Selection of Eight Species for further analysis.



1.3 Methods for Ecosystem Selection and GIS Data Analysis

Four ecosystems were selected for evaluation based on Geographic Information Systems (GIS) data availability, types of ecosystem services, and potential ecosystem changes associated with sea level rise scenarios[18] The ecosystems assessed were beach, dune, estuarine (e.g., estuaries, lagoons, salt marsh, etc.), and freshwater habitats (e.g., rivers, streams, lakes, wetlands, riparian, etc.).

GIS habitat metadata is presented in Table D-1 below. Using ArcMap 10.4 and the clip overlay function, acreages of each habitat type were extracted from the GIS layers listed in Table D-1 when they spatially overlapped with polygons in each of the five sea level rise models (see Report Section 4.3 Coastal Hazards Projections).

Table D-1. GIS Layer Metadata Excerpts

Habitat Layer	Base Data	Features Used
Beach	Digitized sandy beach areas above high tide line using 2017 aerial photos at 0.75-foot resolution at 1:400 scale.	Beach areas above high tide line.
Dune	Digitized dune areas above high tide line using 2017 aerial photos at 0.75-foot resolution at 1:400 scale.	Foredune, mid-dune and vegetated back dune features.
Estuarine	National Wetland Inventory Maps downloaded from website https://www.fws.gov/wetlands/Data/Data-Download.html November 2017.	Wetland Types in Analysis Layer: 1) Estuarine and Marine Wetland; 2) Estuarine and Marine Deepwater located in drainage features (e.g., Santa Clara River, Ventura River, Mugu Lagoon, Big Sycamore Canyon, etc.).
Freshwater	National Wetland Inventory Maps downloaded from website https://www.fws.gov/wetlands/Data/Data-Download.html November 2017.	Wetland Types in Analysis Layer: 1) Riverine; 2) Freshwater Pond; 3) Freshwater Emergent Wetland; and 4) Freshwater Forested/Shrub Wetland.
USFWS Critical Habitat	Downloaded from ECOS- Environmental Conservation Online System, USFWS. https://ecos.fws.gov/ecp/report/table/critical-habitat.html	Clipped layer to extract features in sea level rise projection zone. Features extracted were: Western Snowy Plover, Ventura marsh milk vetch, Tidewater Goby, and Southwestern Willow Flycatcher.

1.4 Focal Species Selection Methods

Refinement of Criteria and Questions for Focal Species Selection

The County is home to 49 *special status species* that may be vulnerable to sea level rise hazards[19]. Due to the limited project scope, between three and five species were selected within each ecosystem (i.e.,

[18] The ecosystem selection process also took into account results of a climate change vulnerability assessment done for the central coast of California. (Climate Change Vulnerability Assessment for the North-central California Coast and Ocean, Marine Sanctuaries Conservation Series ONMS-15-02, Office of National Marine Sanctuaries and Department of Commerce, May 2015). In addition, projected sea level rise changes for the County were also taken into consideration based upon a visual assessment of which ecosystems may be affected.

[19] This number was calculated by overlaying the extent of the projected sea level rise models to California Natural Diversity Database spatial information.

beaches, dunes, estuarine and freshwater habitats) that may be used to guide the development of land use adaptation policies for the vulnerable habitats in the County. The final focal species would also provide the natural resource community with the most guidance to conserve and manage these ecosystems with respect to the projected exposure to sea level rise.

The first workshop began with an overview of the entire project and how the natural resource component fits in with the County's overall vulnerability assessment. County staff presented a set of base criteria for focal species selection (Table D-2) as well as a vulnerability assessment survey (Table D-7). The working group proceeded to review and refine the base criteria for focal species selection and the vulnerability assessment. To ensure that species selected for the assessment would be able to provide guidance within each of the different ecosystems, and to weight desired species characteristics higher than others, the working group ranked the importance of each of the base criteria from 0 (no importance) to 3 (high importance). The seven criteria were weighted by taking the averages of all the responses (Table D-2). Workshop participants who attended via conference call submitted the survey responses online. Table D-2 shows the weight of each selection criteria to be used when selecting focal species. Criteria 1, with a weighted value of 3.00 is the most important criteria. During the species selection stage, species that are considered "keystone, foundation, umbrella species" are ranked as more important than species that have "societal value" (criterion 6).

Table D-2. Weighted Values of Criteria Used to Select Focal Species

No.	Criteria	Weighted Value
1	The species is considered a keystone, foundation, umbrella species, or an indicator species of sea level rise changes.	3.00
2	The species has legal protections or is recognized as a species of concern for conservation (federal, state, local).	2.47
3	Level of knowledge of species' life history requirements and the understanding of the role of that species within the ecosystem (ecological niche).	2.18
4	Species response to management techniques.	1.76
5	Stakeholder ability and resources to monitor the species over time.	2.18
6	Level of societal value of the species and/or the ecosystem services that the species provides.	1.56
7	Species dependence on habitats affected by sea level rise.	2.76

The seven selection criteria listed above were used to evaluate and select focal species from a list of 182 animal species and 209 plant species. The resources used to form the initial list of 391 species to be evaluated can be found in Table D-3. The species were selected to represent an ecosystem they are dependent upon: (1) Beaches and Dunes, (2) River, Riparian-Alluvial Vegetation Communities, and Freshwater Wetlands, and (3) Estuarine/Salt March ecosystems. Species that utilized more than one of the four ecosystems were placed in the ecosystem that the working group felt was most critical for the species. Survey responders answered "yes" or "no" for each criterion for each species survey (Table D-2)[20]. In addition, working group members had the opportunity to submit species that were not on the original list (Table D-4). Staff presented the additional suggested species to other working group

[20] Criteria 2 was not included in the working group survey and was instead determined by the County staff biologist. County staff scored bird species as protected, if the species was listed as threatened or endangered by the state or federal government, or listed as a species of concern by either of these entities.

members during a follow-up workshop where the final focal species list was reviewed and finalized. The top-ranked species were not automatically chosen without the review of the working group due to additional species that were proposed during the survey. In addition, other unforeseen factors or assumptions that were not accounted for within the original criteria selection were discussed at this time.

Table D-3. Resources Used to Create Species List for Focal Species Selection

No.	Resource
1	California Natural Diversity Database
2	US Fish and Wildlife Services BIOS Information
3	California Native Plant Society Manual of California Vegetation
4	Calflora Plant Search
5	Santa Clara River Estuary Habitat Restoration and Enhancement Feasibility Study
6	Santa Clara River Parkway, California Conceptual Enhancement Plan and Staff Recommendation
7	Santa Clara River Enhancement and Management Plan
8	Prioritizing Sites Along the Santa Clara River for Conservation of Threatened and Endangered Species
9	Botanical Resources at Emma Wood State Beach and Ventura River Estuary
10	Integrated Natural Resources Management Plan for Naval Base Ventura County
11	The Ecology of Riparian Habitats of the Southern California Coastal Region: A Community Profile
12	Conservation Plan for the Lower Santa Clara River Watershed and Surrounding Areas

Table D-4. Additional Focal Species Suggested for Consideration by Working Group Members

Ecosystem	Common Name	Scientific Name
Beach and Dune	Coyote tobacco	*Nicotiana attenduata*
Beach and Dune	Red racer	*Coluber flagellum piceus*
Beach and Dune	Sand wasp	*Bembix spp.*
Beach and Dune	Pismo clams	*Tivela stultorum*
Beach and Dune	American black oystercatcher	*Haematopus bachmani*
Estuarine	Douglas' baccharis/ Salt marsh baccharis	*Baccharis douglasiana*
Estuarine	Common eelgrass	*Zostura marina*
Estuarine	Pacific eel grass	*Zostura pacifica*
Estuarine	Salt marsh snail	*Melampus olivaceus*
Estuarine	California horned snail	*Cerithideopsis californica*
Freshwater	Cottonwood (Fremont and Black)	*Populus spp.*
Freshwater	Rabbitsfoot grass	*Polypogon monspeliensis*
Freshwater	Virginia rail	*Rallus limicola*
Freshwater	Topsmelt	*Atherinops affinis*
Freshwater	Broad leaf cattail	*Typha latifolia*

A total of 17 participants submitted responses in person and online. The species were scored by averaging (weighted) the “YES” answers to the criteria in Table D-2. County staff calculated final scores by using the following equation:

$$Final\ Species\ Score = \sum\left(\frac{number\ of\ "yes"\ answers\ for\ that\ criterion}{number\ of\ responses\ for\ that\ criterion} \times criterion\ weight\right)$$

Species selection criteria scoring results were presented to the working group at a meeting on November 21, 2017 and are shown in Table D-5 below. Before and during the workshop, species were removed from consideration for the following reasons: (1) the species did not occur in the unincorporated County’s jurisdiction for the Local Coastal Program (e.g., eelgrasses, Pismo clams, light-footed clapper rail); (2) there was not a large enough population within the unincorporated County to provide guidance for the adaptation strategies (e.g., red racer, lamprey, tricolored blackbird); (3) the species was found in numerous focal habitats (e.g., freshwater and estuarine ecosystems) and did not capture the characteristics of an important ecosystem niche for sea level rise hazards (e.g., American avocet, willet, coyote); (4) species captured similar niches within the ecosystem and one was selected over another (i.e., Bigelow's pickleweed and Belding's savannah sparrow); (5) the species would be too difficult to monitor or other factors associated with its life history (e.g., silvery legless lizard, Southern California legless lizard, senile tiger beetle); (6) highly unlikely that the species would be monitored by someone in the future (e.g., California beach flea, all species of crabs, wandering saltmarsh skipper); (7) a focal species survey was not filled out by any of the working group members due to limited experience or knowledge of a specific species[21].

[21] Scientific names are listed in Table D-5.

Table D-5. Focal Species Survey Results[22].

Ecosystem	Taxa	Common Name	Species Name	Score
Beach and Dune	Plant Species	Red sand-verbena	*Abronia maritima*	15.18
Beach and Dune	Plant Species	South coast saltscale/saltbush	*Atriplex pacifica*	13.73
Beach and Dune	Plant Species	Silver dune lupine	*Lupinus chamissonis*	12.69
Beach and Dune	Plant Species	Ventura marsh milk vetch	*Astragalus pycnostachyus var. lanosissimus*	12.64
Beach and Dune	Plant Species	Sea scale, White-leaf saltbush	*Atriplex leucophylla*	12.35
Beach and Dune	Plant Species	Beach evening primrose	*Camissoniopsis cheiranthifolia*	12.32
Beach and Dune	Plant Species	Aphanisma	*Aphanisma blitoides*	11.97
Beach and Dune	Plant Species	Beach sand-verbena	*Abronia umbellata*	11.6
Beach and Dune	Plant Species	Beach morning-glory	*Calystegia soldanella*	11.6
Beach and Dune	Plant Species	Beach bur	*Ambrosia chamissonis*	11.545
Beach and Dune	Plant Species	Sea rocket	*Cakile maritima*	11.31
Beach and Dune	Animal Species	Western snowy plover*	*Charadrius alexandrinus nivosus*	15.69
Beach and Dune	Animal Species	California least tern*	*Sternula antillarum browni*	15.4
Beach and Dune	Animal Species	Elegant tern*	*Sterna elegans*	14.35
Beach and Dune	Animal Species	Marbled godwit*	*Limosa fedoa*	13.7
Beach and Dune	Animal Species	California brown pelican*	*Pelecanus occidentalis californicus*	13.58
Beach and Dune	Animal Species	American avocet*	*Recurvirostra americana*	13.34
Beach and Dune	Animal Species	Willet*	*Catoptrophorus semipalmatus*	12.66
Beach and Dune	Animal Species	Globose dune beetle	*Coelus globosus*	12.43
Beach and Dune	Animal Species	California grunion	*Leuresthes tenuis*	12.39
Beach and Dune	Animal Species	Southern California legless lizard*	*Anniella stebbinsi*	12.14
Beach and Dune	Animal Species	Silvery legless lizard*	*Anneilla pulchra*	11.89
Beach and Dune	Animal Species	Sand crabs, Mole crabs	*Emerita analoga*	11.82
Beach and Dune	Animal Species	Long-billed curlew*	*Numenius americanus*	11.78
Beach and Dune	Animal Species	Sandy beach tiger beetle	*Cicindela hirticollis gravida*	11.57
Beach and Dune	Animal Species	California beach flea	*Megalorchestia californiana*	11.26
Freshwater	Plant Species	Woolly seablite*	*Suaeda taxifolia*	12.91
Freshwater	Plant Species	Estuary seablite*	*Suaeda esteroa*	11.82
Freshwater	Plant Species	Southwestern spiny rush*	*Juncus acutus ssp. leopoldii*	11.15
Freshwater	Plant Species	Salt marsh bird's-beak*	*Chloropyron maritimum ssp. maritimum*	10.06
Freshwater	Plant Species	Coulter's goldfields*	*Lasthenia glabrata ssp. coulteri*	10.06
Freshwater	Animal Species	Southern steelhead*	*Oncorhynchus mykiss*	15.91
Freshwater	Animal Species	Great blue heron*	*Ardea herodias*	12.57
Freshwater	Animal Species	Belted kingfisher*	*Megaceryle alcyon*	12.47
Freshwater	Animal Species	Pacific lamprey*	*Entosphenus tridentata*	12.05
Freshwater	Animal Species	Tricolored blackbird	*Agelaius tricolor*	11.96
Freshwater	Animal Species	Great egret*	*Ardea alba*	11.4
Freshwater	Animal Species	Silvery legless lizard*	*Anneilla pulchra*	11.29
Freshwater	Animal Species	Least Bells vireo	*Vireo bellii pusillus*	11.28
Freshwater	Animal Species	Southwestern pond turtle	*Actinemys pallida*	11.22
Freshwater	Animal Species	White-faced ibis*	*Plegadis chihi*	11.05

[22] Yellow highlighted rows in Table D-5 represent the plant and animal species ranked the highest within the ecosystem type.

Ecosystem	Taxa	Common Name	Species Name	Score
Freshwater	Animal Species	Western yellow-billed cuckoo	*Coccyzus americanus*	10.72
Freshwater	Animal Species	Two striped garter snake	*Thamnophis hammondii*	10.53
Freshwater	Animal Species	Arroyo toad	*Bufo californicus*	10.51
Freshwater	Animal Species	California red-legged frog	*Rana draytonii*	10.51
Freshwater	Animal Species	Western least bittern*	*Ixobrychius exilis*	10.46
Freshwater	Animal Species	Arroyo chub	*Gila orcutti*	10.15
Freshwater	Animal Species	Loggerhead shrike*	*Lanius ludovicianus*	10.1
Estuarine	Plant Species	Woolly sea-blite*	*Suaeda taxifolia*	15.91
Estuarine	Plant Species	Estuary seablite*	*Suaeda esteroa*	13.82
Estuarine	Plant Species	Glasswort, Pickleweed	*Salicornia pacifica*	13.44
Estuarine	Plant Species	Salt marsh bird's-beak	*Chloropyron maritimum ssp. maritimum*	13.43
Estuarine	Plant Species	California cordgrass	*Spartina foliosa*	12.56
Estuarine	Plant Species	Alkali heath, Alkali sea heath	*Frankenia salina*	12.35
Estuarine	Plant Species	Coulter's goldfields*	*Lasthenia glabrata ssp. coulteri*	12.06
Estuarine	Plant Species	Ventura marsh milk vetch*	*Astragalus pycnostachyus var. lanosissimus*	11.97
Estuarine	Plant Species	Pappose tarweed	*Centromadia parryi*	11.97
Estuarine	Plant Species	California sea-blite*	*Suaeda californica*	11.97
Estuarine	Plant Species	Inland saltgrass, Salt grass	*Distichlis spicata*	11.26
Estuarine	Plant Species	Bigelow's pickleweed, Dwarf saltwort	*Salicornia bigelovii*	10.18
Estuarine	Plant Species	Virginia glasswort	*Salicornia depressa*	10.18
Estuarine	Animal Species	Light-footed clapper rail	*Rallus longirostris levipes*	15.29
Estuarine	Animal Species	Western snowy plover*	*Charadrius alexandrinus nivosus*	14.69
Estuarine	Animal Species	Southern steelhead*	*Oncorhynchus mykiss*	14.56
Estuarine	Animal Species	Tidewater goby	*Eucyclogobius newberryi*	14.23
Estuarine	Animal Species	Pacific lamprey*	*Entosphenus tridentata*	14.14
Estuarine	Animal Species	California least tern*	*Sternula antillarum browni*	14.05
Estuarine	Animal Species	Belding's savannah sparrow	*Passerculus sandwichenis beldingi*	13.98
Estuarine	Animal Species	Arroyo chub*	*Gila orcutti*	13.39
Estuarine	Animal Species	Southern California saltmarsh shrew	*Sorex ornatus salicornicus*	12.77
Estuarine	Animal Species	California brown pelican*	*Pelecanus occidentalis californicus*	12.69
Estuarine	Animal Species	Elegant tern*	*Sterna elegans*	12.6
Estuarine	Animal Species	Wandering (saltmarsh) skipper	*Panoquina errans*	12.53
Estuarine	Animal Species	Western least bittern*	*Ixobrychius exilis*	12.24
Estuarine	Animal Species	Shiner surfperch	*Cymatogaster aggregate*	11.57
Estuarine	Animal Species	Marbled godwit*	*Limosa fedoa*	11.49
Estuarine	Animal Species	Long-billed curlew*	*Numenius americanus*	11.37
Estuarine	Animal Species	American avocet*	*Recurvirostra americana*	11.19
Estuarine	Animal Species	American white pelican*	*Pelecanus erythrorhynchos*	11.15
Estuarine	Animal Species	Santa Ana sucker	*Catostomus santaanae*	11.15
Estuarine	Animal Species	Yellow shore crab	*Hemigrapsus oregonensis*	11.12
Estuarine	Animal Species	Lined shore crab	*Pachygrapsus crassipes*	11.12
Estuarine	Animal Species	Southwestern pond turtle*	*Actinemys pallida*	11.11
Estuarine	Animal Species	Great egret*	*Ardea alba*	11.06
Estuarine	Animal Species	Osprey*	*Pandion haliaetus*	10.98
Estuarine	Animal Species	Senile tiger beetle	*Cicindeis sentilis frosti*	10.95
Estuarine	Animal Species	Prickly sculpin	*Cottus asper subspecies*	10.95
Estuarine	Animal Species	White-faced ibis*	*Plegadis chihi*	10.84
Estuarine	Animal Species	Double-crested cormorant*	*Phalacrocorax auritus*	10.77

Ecosystem	Taxa	Common Name	Species Name	Score
Estuarine	Animal Species	Belted kingfisher*	*Megaceryle alcyon*	10.74
Estuarine	Animal Species	Gabb's tiger beetle	*Cicindela gabbi*	10.49
Estuarine	Animal Species	Polychaete worm	*Polychaete*	10.48
Estuarine	Animal Species	California brackish water snail	*Tryonia imitator*	10.22
Estuarine	Animal Species	Great blue heron*	*Ardea herodias*	10.14
Estuarine	Animal Species	Willet*	*Catoptrophorus semipalmatus*	10.14

Note: * Species occurs in more than one of the focal ecosystems.

The selection scores were used to guide discussion on which species should be chosen as focal species. Although some of the focal species selected for the vulnerability assessment did not have the highest selection scores, they were chosen as the best species to guide future adaptation strategies planning. At the end of the workshop, the working group selected 21 focal species listed in Table D-6 for inclusion in the next task which was the vulnerability assessment.

Table D-6. Final Focal Species Selected for Vulnerability Assessment

Common Name	Species Name
Beach Habitats	
California grunion	*Leuresthes tenuis*
Western snowy plover	*Charadrius alexandrinus nivosus*
Dune Habitats	
Sand verbena	*Abronia maritima/umbellata*
Beach evening primrose	*Camissoniopsis cheiranthifolia*
Globose dune beetle	*Coelus globosus*
Riverine/Palustrine Habitats	
Arroyo willow	*Salix lasiolepis*
Rabbitsfoot grass	*Polypogon monspeliensis*
Cottonwood	*Populus spp.*
Broad leaf cattail	*Typha latifolia*
Southern steelhead	*Oncohynchus mykiss*
Southern pond turtle	*Actinemys pallida*
Arroyo chub	*Gila orcuttii*
Estuarine Habitats	
Woolly sea-blite	*Suaeda taxifolia*
Alkali heath, Alkali sea heath	*Frankenia salina*
Bigelow's pickleweed, Dwarf saltwort	*Salicornia bigelovii*
Salt marsh snail	*Melampus olivaceus*
Virginia rail	*Rallus limicola*
Tidewater goby	*Eucylogobius newberryi*
Topsmelt	*Atherinops affinis*
Belding's savannah sparrow	*Passerculus sandwichensis beldingi*
California horned snail	*Cerithideopsis californica*

2.5 Vulnerability Assessment Methods

The vulnerability assessment was conducted through an online survey. The survey questions shown in Table D-7 below captured species characteristics associated with each vulnerability component (exposure, sensitivity, adaptive capacity), and was reviewed and revised by the working group during the two previous meetings. Work on the revisions in a group setting was intended to standardize as much as possible the interpretation of questions among all participants. Before experts evaluated the vulnerability of each focal species, background information on the predicted environmental changes expected for Southern California was provided, as well as a synthesis of the vulnerability of riverine freshwater habitats to climate change[23]. Participants were instructed to complete online surveys for only species with which they were familiar.

Table D-7. Vulnerability Assessment Survey Questions

Question #	Category	Question
1	Species Exposure	**Within the species ecosystem, how exposed to sea level rise and major storms is the species niche habitat?"** *Evaluated by County staff based upon results of the GIS-based sea level rise analysis of the ecosystems and was not included as a question in the assessment taken by the working group.*
2	Species Exposure	**To what degree is the species fitness affected by other physical threats unrelated to sea level rise?** **Scale. 1= Low, 2=Low-Moderate, 3=Moderate, 4=Moderate-High, to 5= High.** *Guidance. Assess the degree of exposure to other physical threats that affect the fitness of the species. In the comment box, please list what physical stressors affect the species fitness. Evaluate your confidence in the answer given.*
3	Species Sensitivity	**How dependent is the species on specific interactions with other species for survival?** **Scale. 1= Low, 2=Low-Moderate, 3=Moderate, 4=Moderate-High, to 5= High**. *Guidance. Assess the degree to which the species relies upon other species or conditions within its ecosystem for survival such as dependence on sensitive habitat types, specific prey or forage species for food, other dependencies (e.g., pollinators, dispersal mechanisms, tidal heights), generalist/specialist or a mixture of the two in certain life stages, etc., and evaluate your confidence in the answer given. Provide a short summary of the dependent interaction in the comment box.*
4	Species Sensitivity	**Does the species have narrow environmental tolerances or thresholds to live?** **Scale. 1= Low, 2=Low-Moderate, 3=Moderate, 4=Moderate-High, to 5= High**. *Guidance. Assess the degree of physiological sensitivity the species may have in response to direct sea-level rise changes. How sensitive is the species to the environmental stressors introduced by sea level rise? Evaluate your confidence in the answer given. Provide a short description of which stressors affect the species in the comment box.*
5	Adaptive Capacity	**What is the species geographic extent?** **Scale. 1= Low (Small geographic region within a single state), 2= Low-Moderate (Moderate to large geographic region within a single state), 3= Moderate (Distribution within single state to two states), 4 = Moderate-High (Distribution within a region), 5= High (Transcontinental)** *Guidance. Assess the species range and distribution and evaluate your confidence in the answer given.*
6	Adaptive Capacity	**What is the connectivity among the species metapopulation?** **Scale. 1= Low (isolated and/or fragmented), 2= Low-Moderate (Somewhat isolated and/or fragmented), 3 = Moderate (patchy across an area with some connectivity among patches), 4= Almost continuous; 5=Continuous.** *Guidance. Assess the degree of connectivity among the species within the metapopulation and evaluate your confidence in the answer given.*
7	Adaptive Capacity	**What is the population status of the species?** **Scale. 1= Endangered, 2= Threatened, 3= Diminished, but generally stable, 4 = Stable population at abundant levels, 5=Healthy and/or expanding** *Guidance. Is there evidence to suggest that the species is experiencing low genetic variability in our region through studies, watch lists, etc. In the comment box, provide any additional details. Evaluate your confidence in the response given.*

[23] Vulnerability assessments for alluvial scrub habitats and river and stream habitats were developed by EcoAdapt.

8	**Adaptive Capacity**	**Does the evolutionary strategy (r or k) make the species susceptible to sea level rise effects? (size of organism, energy for reproduction, number of offspring, maturity rate, life expectancy, survivorship pattern). How?** **Scale. Yes or No.** *Guidance. Determine whether the impacts of sea level rise (physical damage/death from storm surge, erosion, rapid changes in salinity, sediment transport, intensity, and frequency of disturbance regime, etc.) favors the species' evolutionary strategies. In the comment box provided, describe how the strategy does or does not make the species susceptible to sea level rise effects. Evaluate your confidence in the response.*
9	**Adaptive Capacity**	**What is the species' dispersal ability?** **Scale. 1= Low, 2=Low-Moderate, 3=Moderate, 4=Moderate-High, to 5= High.** *Guidance. Assess a species' dispersal ability. In the comment box provide the species maximum annual dispersal distance.*
10	**Adaptive Capacity**	**What is the likelihood of managing or alleviating the impacts of sea level rise?** **Scale. 1= Low, 2=Low-Moderate, 3=Moderate, 4=Moderate-High, to 5= High.** *Guidance. Assess whether management activities have a high likelihood of alleviating the negative impacts of sea level rise on the species. If the species is currently managed, incorporate the success of the management actions into your answer. Use the comment box to further explain your response. Evaluate your confidence in the response given.*
11	**Adaptive Capacity**	**Societal value - Is the species highly valued?** **Scale. 1= Low, 2=Low-Moderate, 3=Moderate, 4=Moderate-High, to 5= High.** *Guidance. Assess whether the species is valued by all residents, a portion of residents, or none. Evaluate your confidence in the response given. Use the comment box to further explain your response.*

County staff assessed vulnerability using the protocol used in the climate change vulnerability assessment for central coast natural resources[24]. Each question in the assessment was answered using one of five scores (High-5, Moderate-High-4, Moderate-3, Moderate-Low-2, or Low-1). In addition, staff asked experts to assign one of three levels (High-3, Moderate-2, or Low-1) that indicated their confidence in the answers given for each question, along with the request to provide further details for answers given in a text box associated with the question. These additional explanations in combination with the vulnerability scoring provided guidance to why a species is vulnerable and what management actions may reduce vulnerabilities given possible tradeoffs when interpreting the assessment results.

The scores for exposure, sensitivity, and adaptative capacity were calculated from the survey responses. The exposure score is the average of all responses to questions 1 and 2, the sensitivity score is the average of all responses to questions 3 and 4, and the adaptive capacity score is the average of all responses to questions 5 through 11 (Table D-7). The overall vulnerability score for each species was then calculated using the following equation:

$$Vulnerability = \frac{(Exposure * 0.5 + Sensitivity)}{Adaptive\ Capacity}$$

Vulnerability increases with increasing exposure and sensitivity, and decreases with increasing adaptive capacity. In other words, higher exposure increases vulnerability, higher sensitivity increases vulnerability, and higher adaptive capacity decreases vulnerability. Due to the uncertainty associated

[24] Climate Change Vulnerability Assessment for the North-central California Coast and Ocean, Marine Sanctuaries Conservation Series ONMS-15-02, Office of National Marine Sanctuaries and Department of Commerce, May 2015.

with the magnitude and rate of sea level rise, the equation weights “Exposure” (0.5) less than sensitivity and adaptive capacity. As each question was scored on a scale of one through five, the maximum vulnerability score for each of the focal species also ranges between one through five. Draft results were presented to the natural resource working group at a workshop held on February 6, 2018 and are included in Table 5-19 of Report Section 5.3.

Section D-2 Natural Resource Maps for the Unincorporated County

The following pages contain natural resource maps that are cited in the main body of the Report.

Figure D-1. North Coast Map Key

Figure D-2. North Coast Ecosystems Vulnerable to Sea Level Rise (Study Areas 1 and 2)

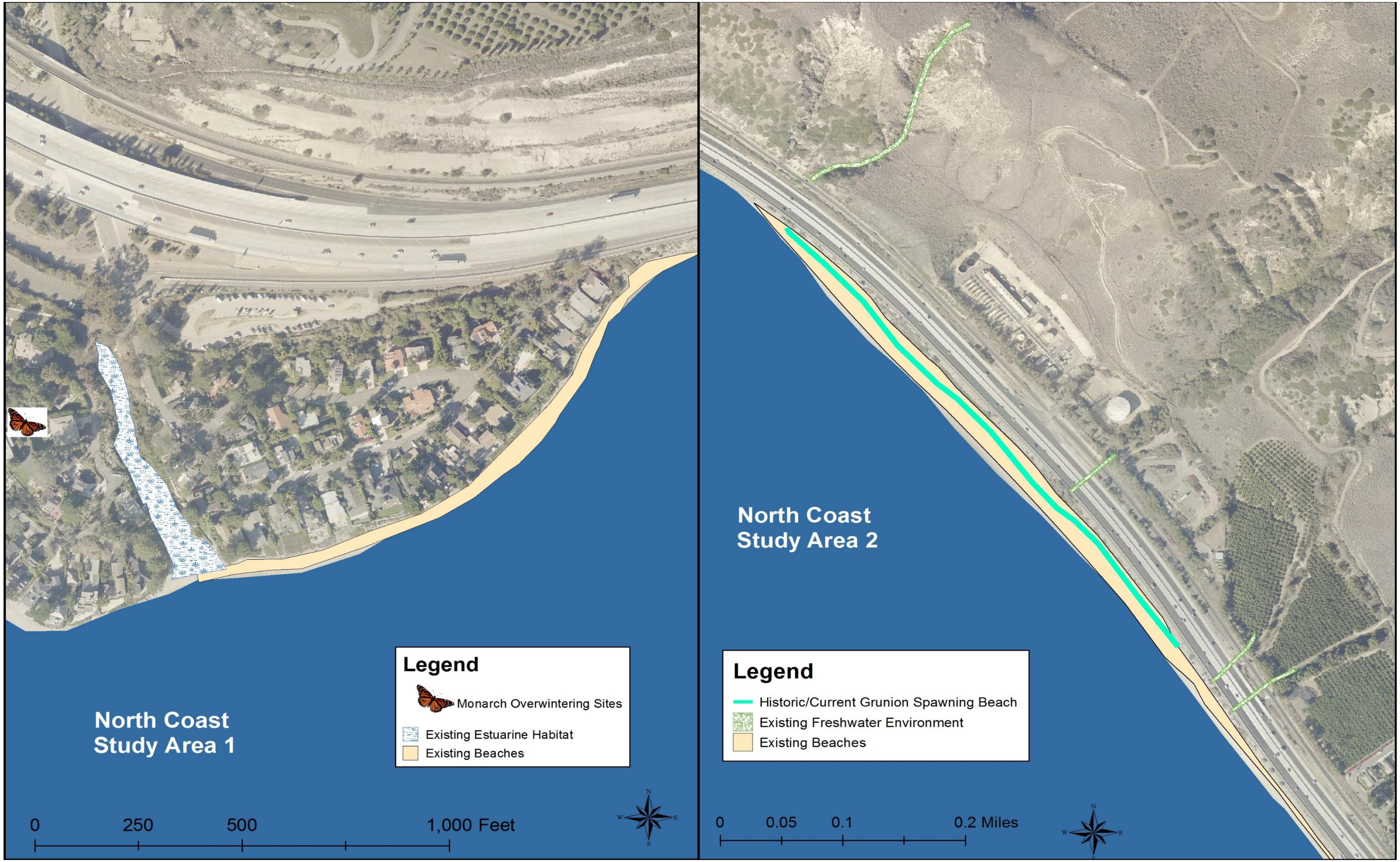


Figure D-3. Central Coast Map Key

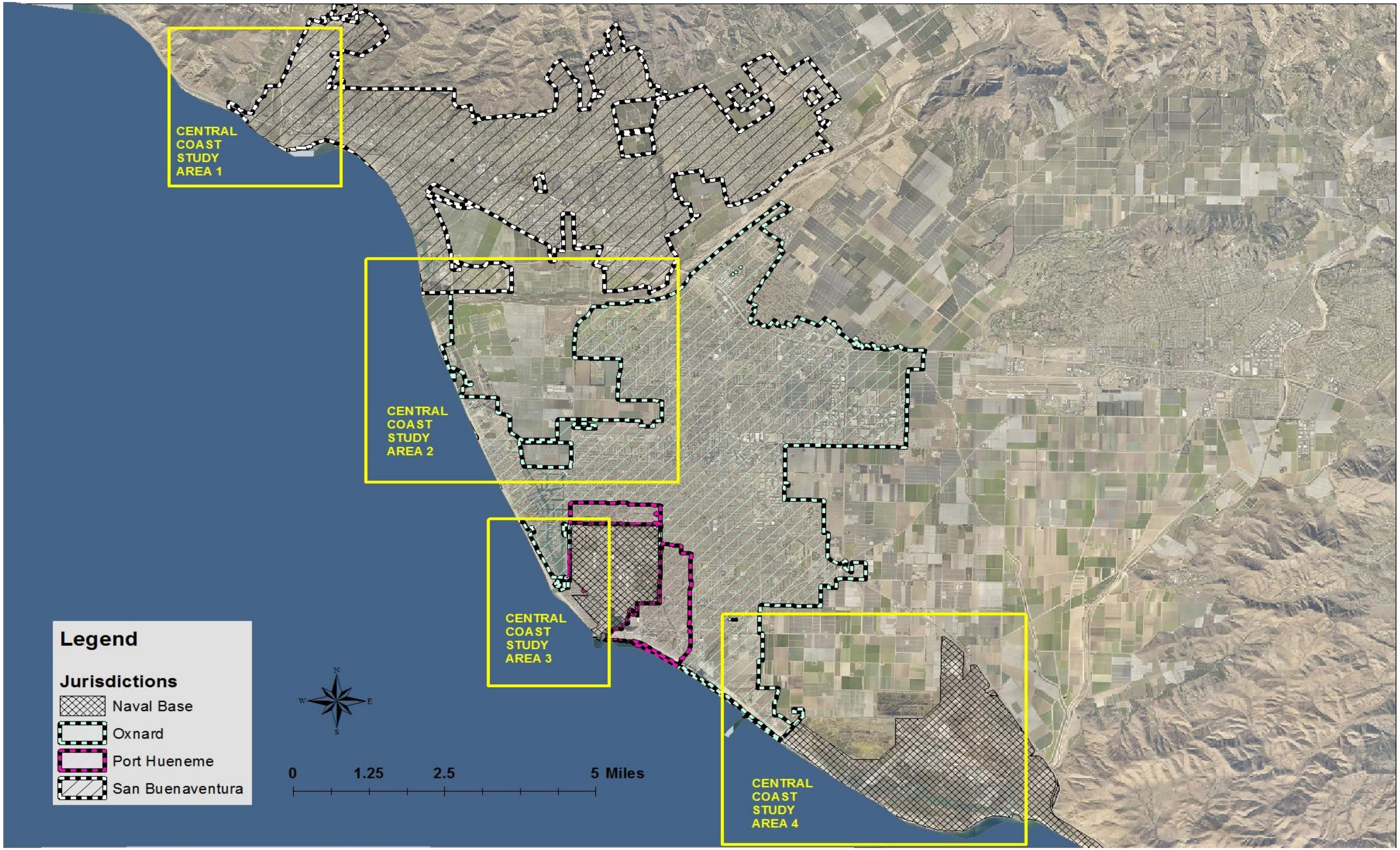


Figure D-4. Central Coast Ecosystems Vulnerable to Sea Level Rise (Study Area 1 and 2)

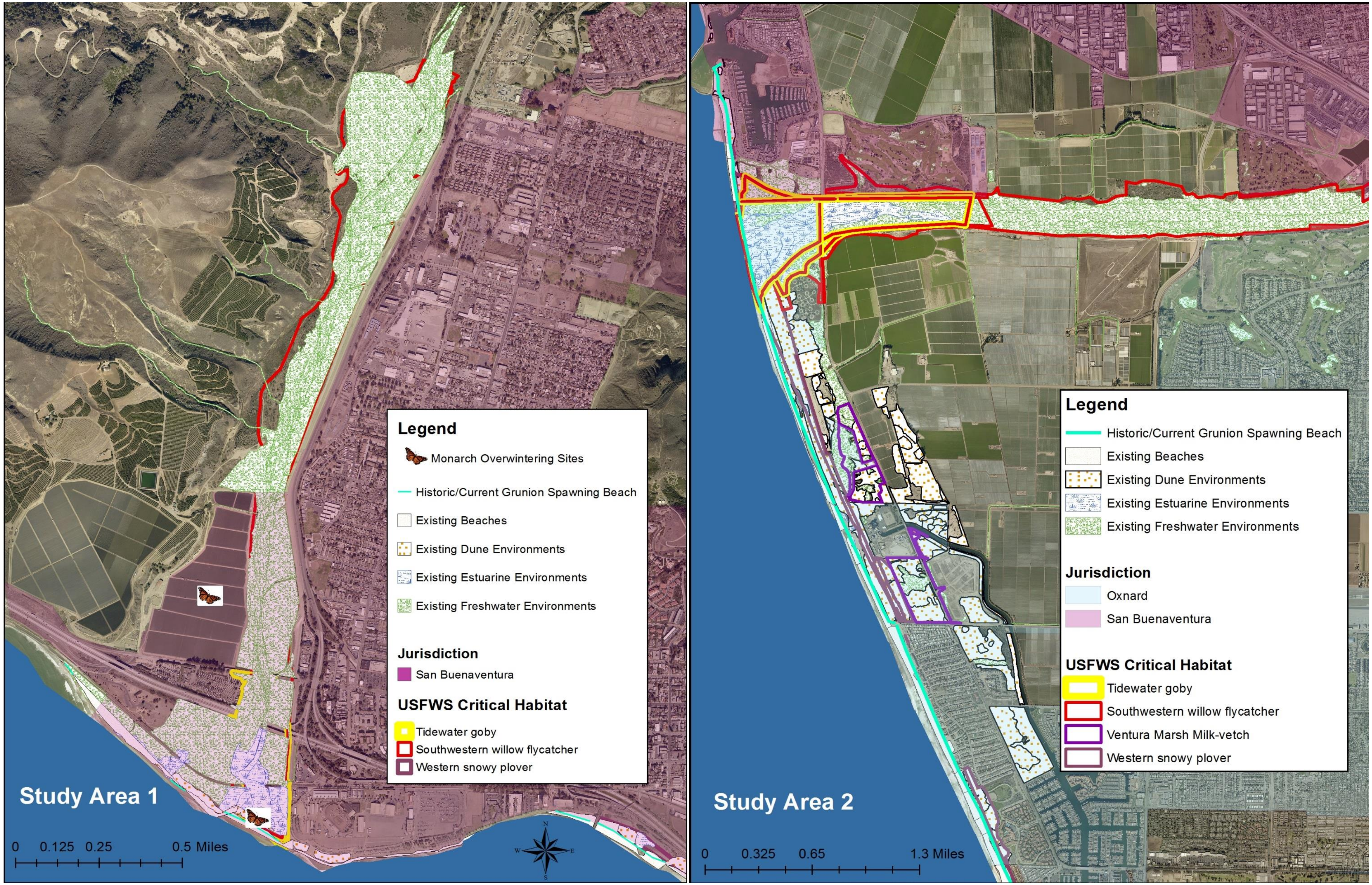


Figure D-5. Central Coast Ecosystems Vulnerable to Sea Level Rise (Study Areas 3 and 4)

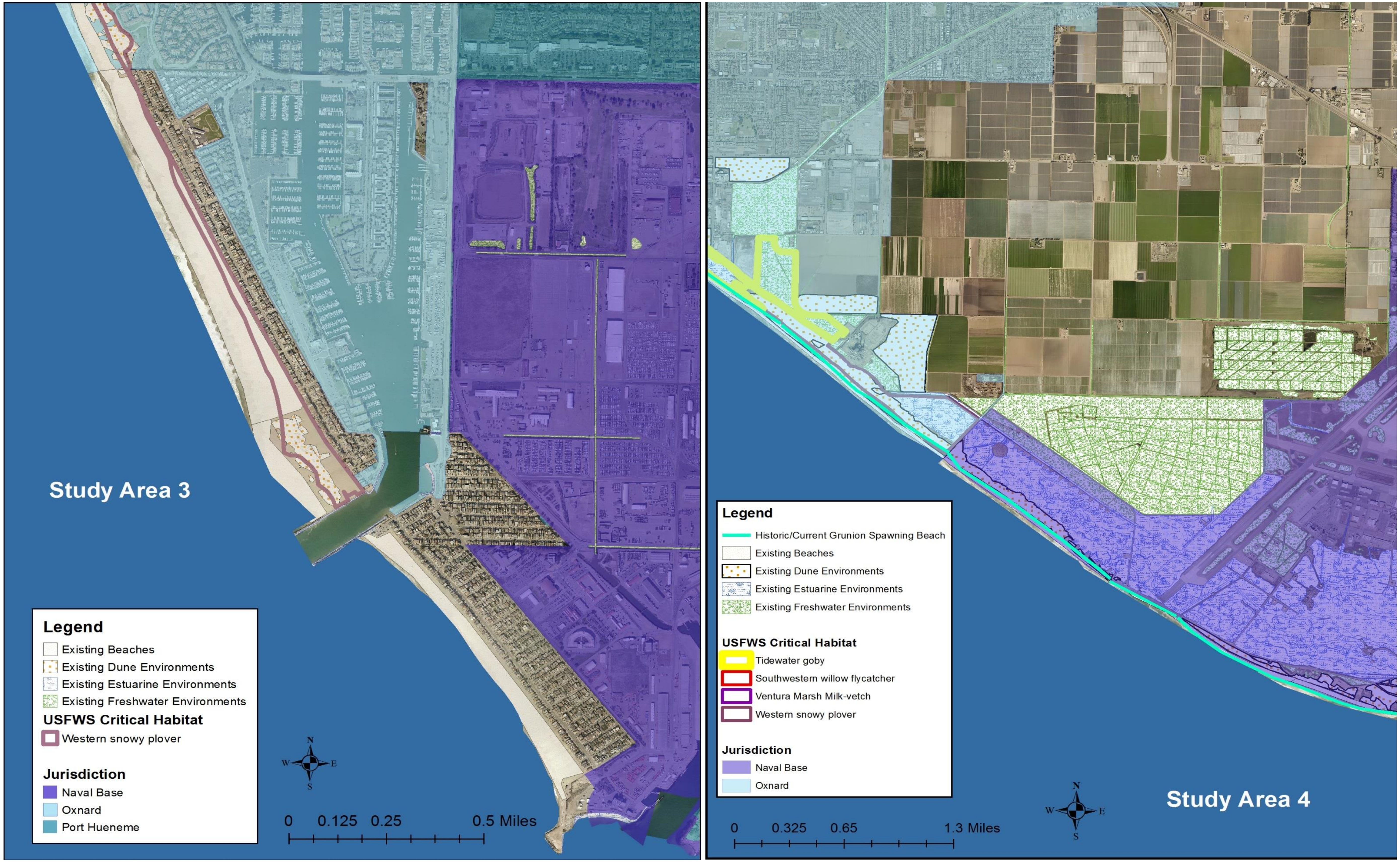


Figure D-6. South Coast Map Key

Figure D-7. South Coast Ecosytems Vulnerable to Sea Level Rise (Study Areas 1 and 2)

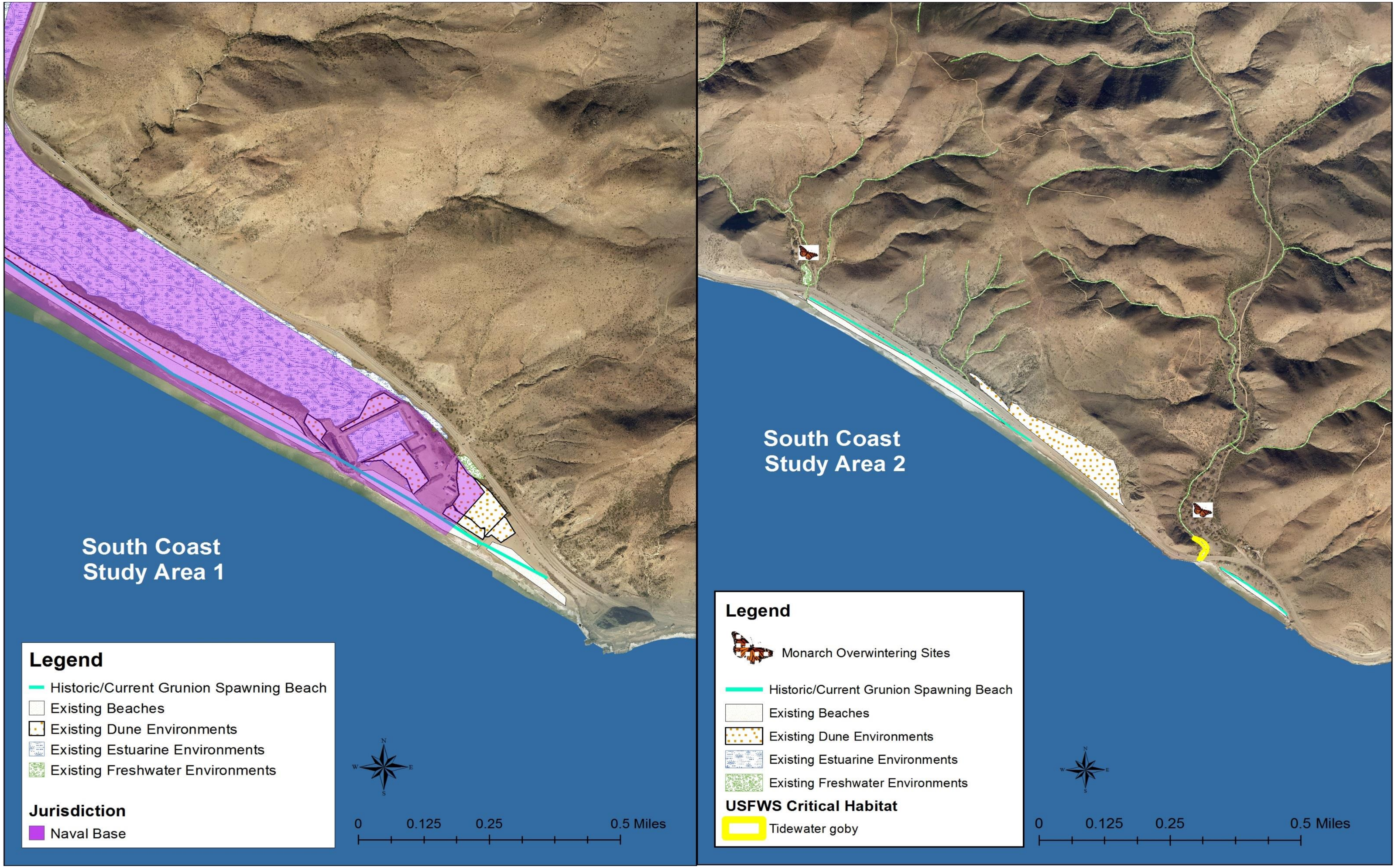


Figure D-8. South Coast Ecosytems Vulnerable to Sea Level Rise (Study Area 3)

Figure D-9. Beach Management Practices Occuring on USFWS Snowy Plover Critical Habitat

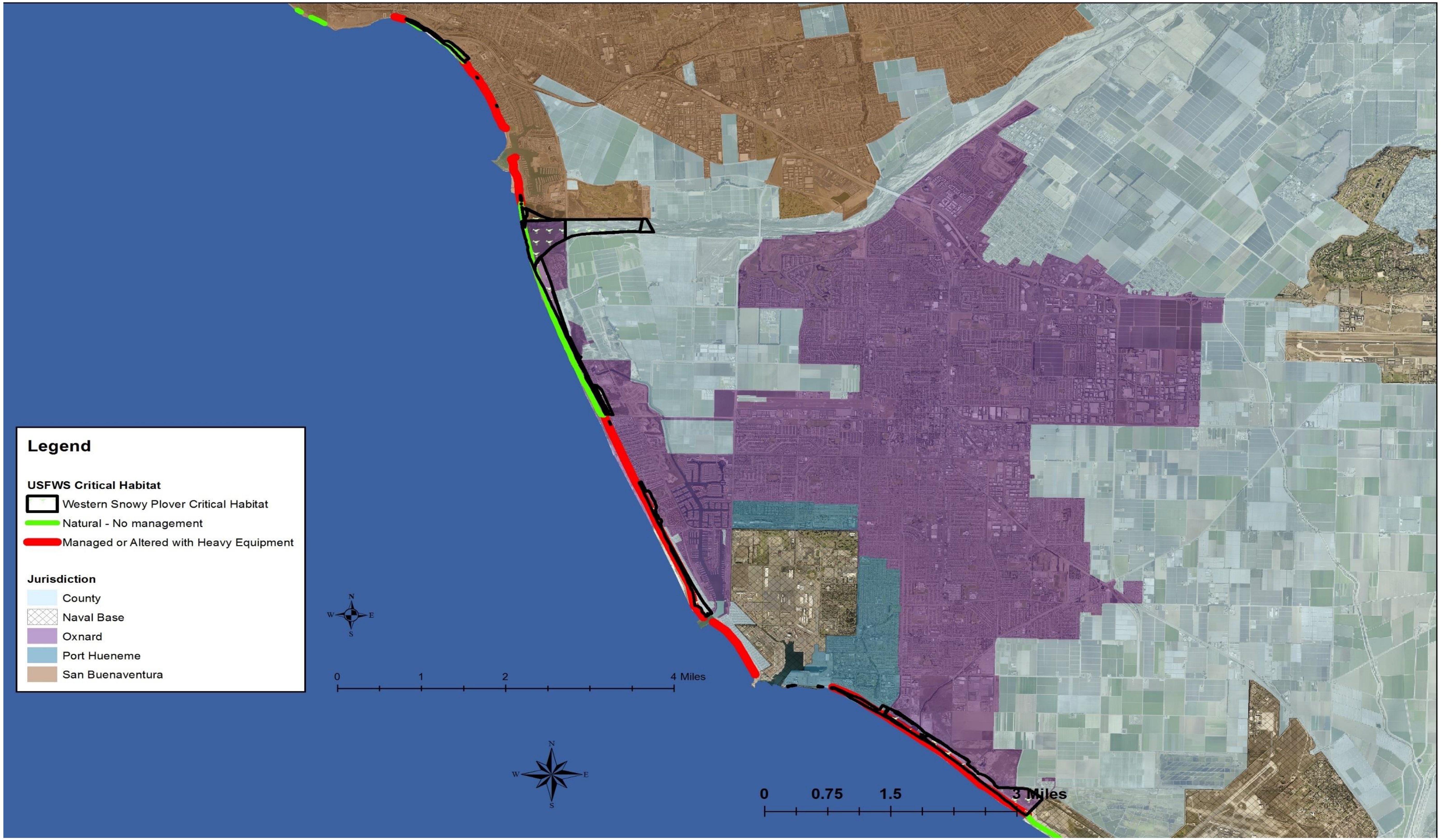


Figure D-10. Beach Management Practices Occuring on California Grunion Spawning Areas

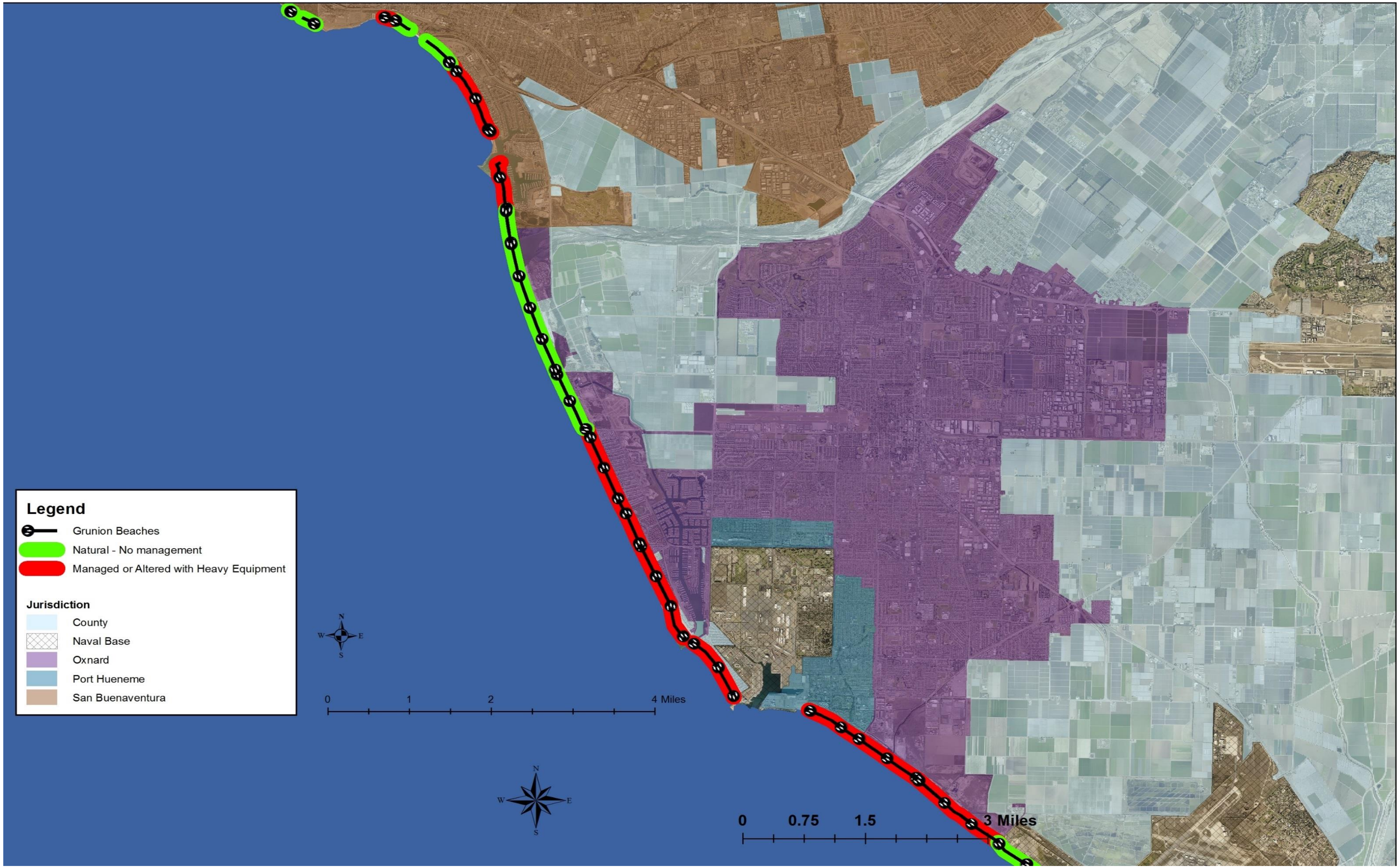


Figure D-11. Central Coast Projected Habitat Erosion Due to Sea Level Rise (Study Area 1)

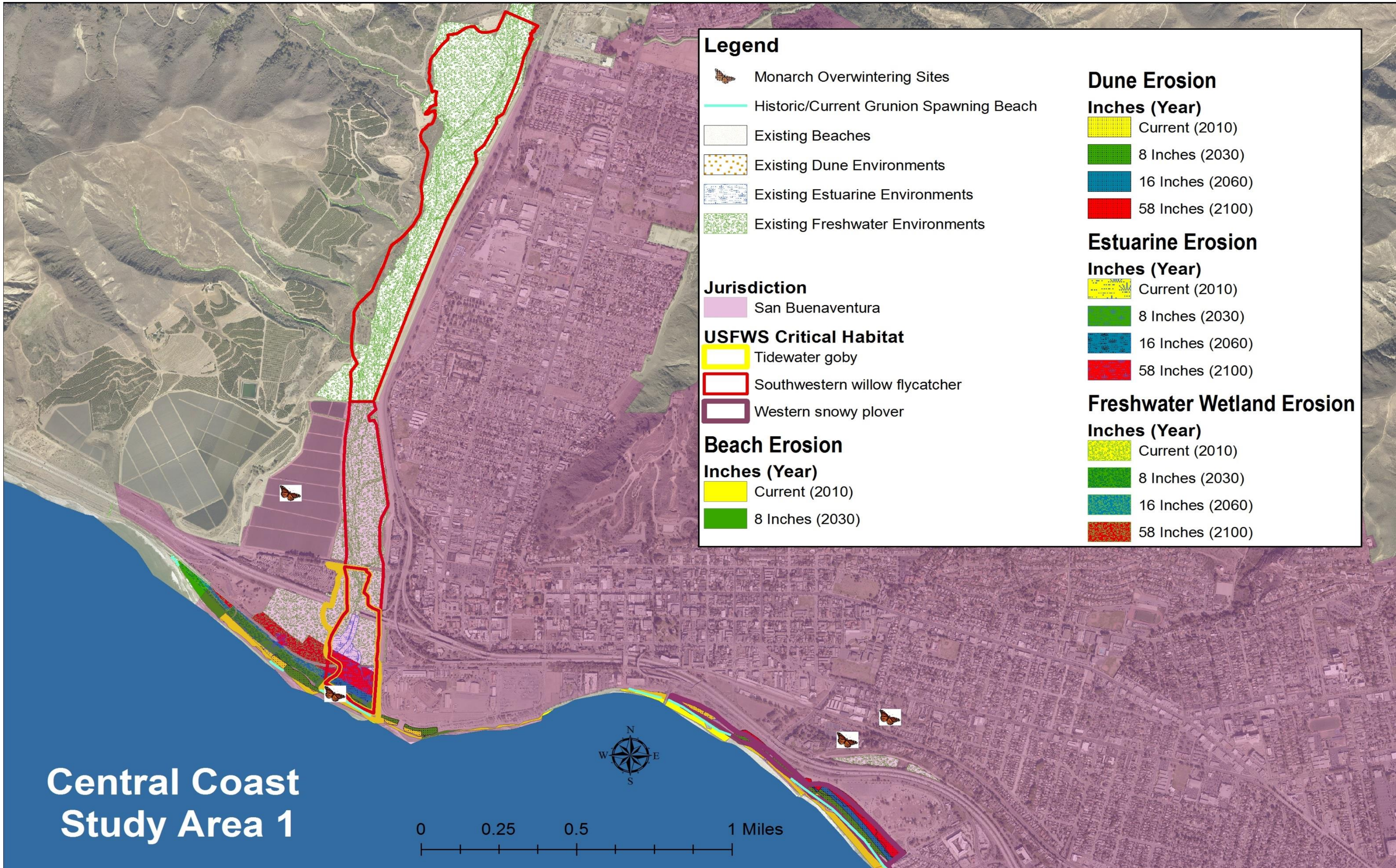


Figure D-12. Central Coast Projected Habitat Erosion Due to Sea Level Rise (Study Areas 2 and 3)

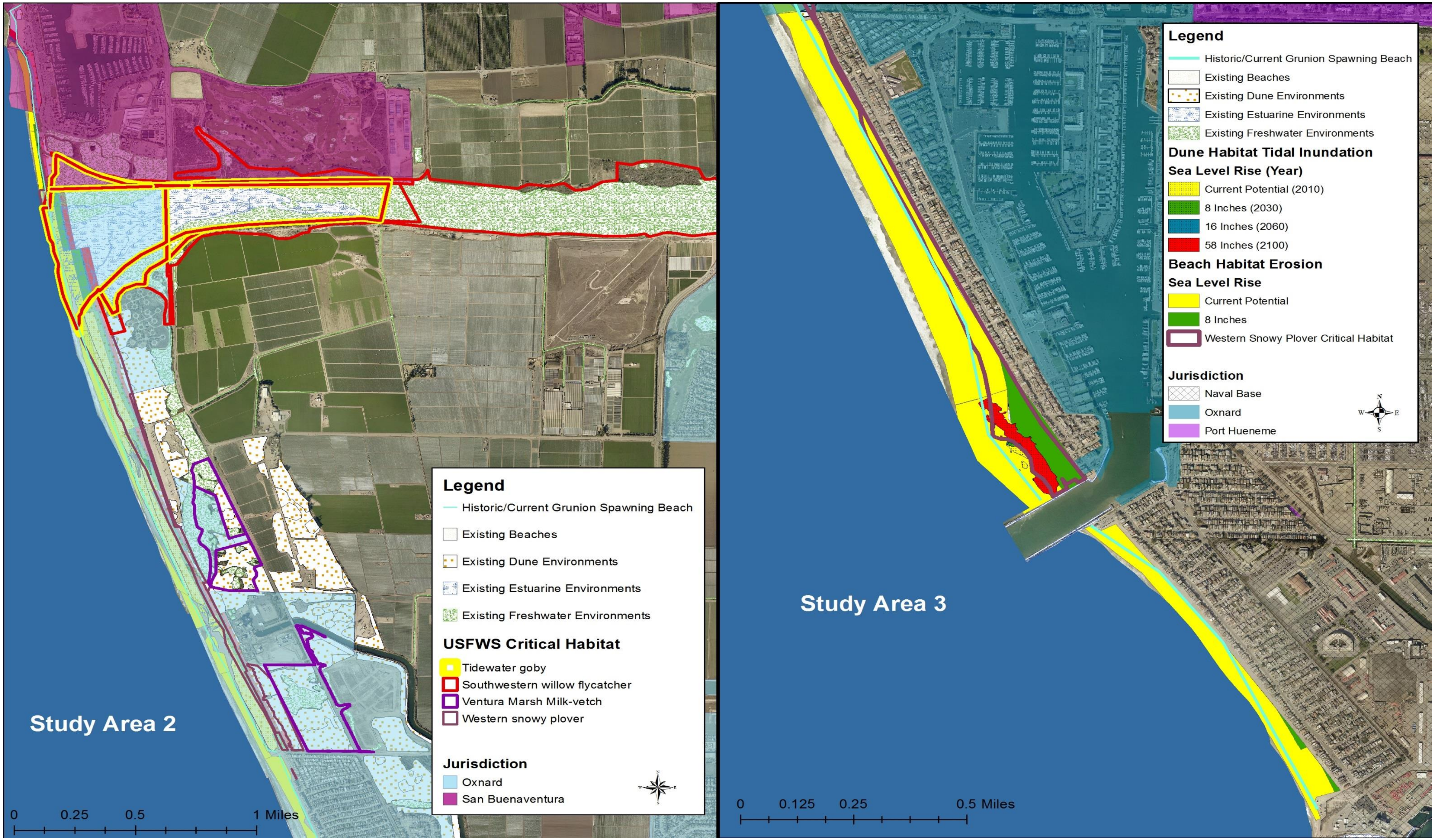


Figure D-13. Central Coast Projected Tidal Inundation Due to Sea Level Rise (Study Area 1)

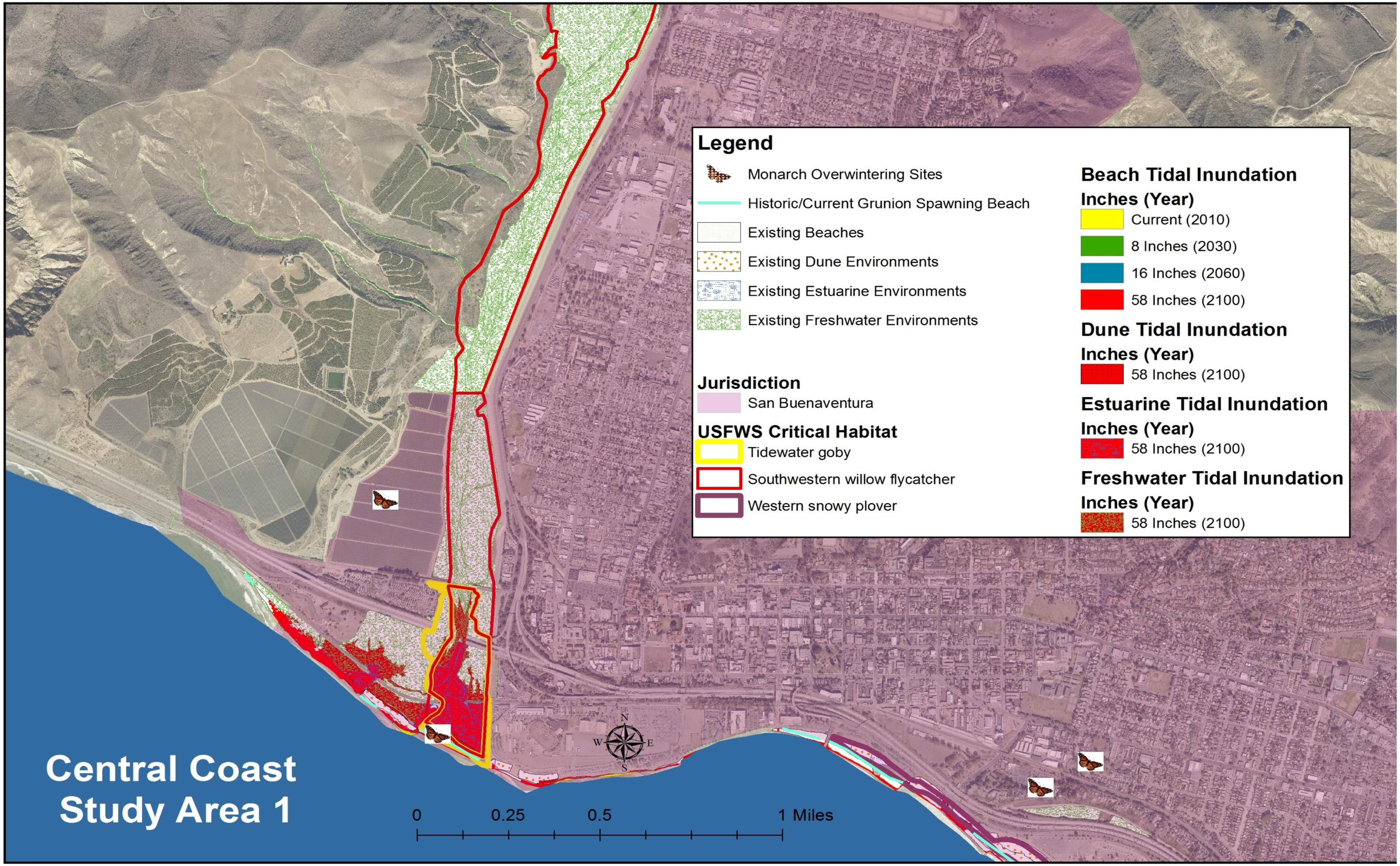


Figure D-14. Central Coast Projected Tidal Inundation Due to Sea Level Rise (Study Areas 2 and 3)

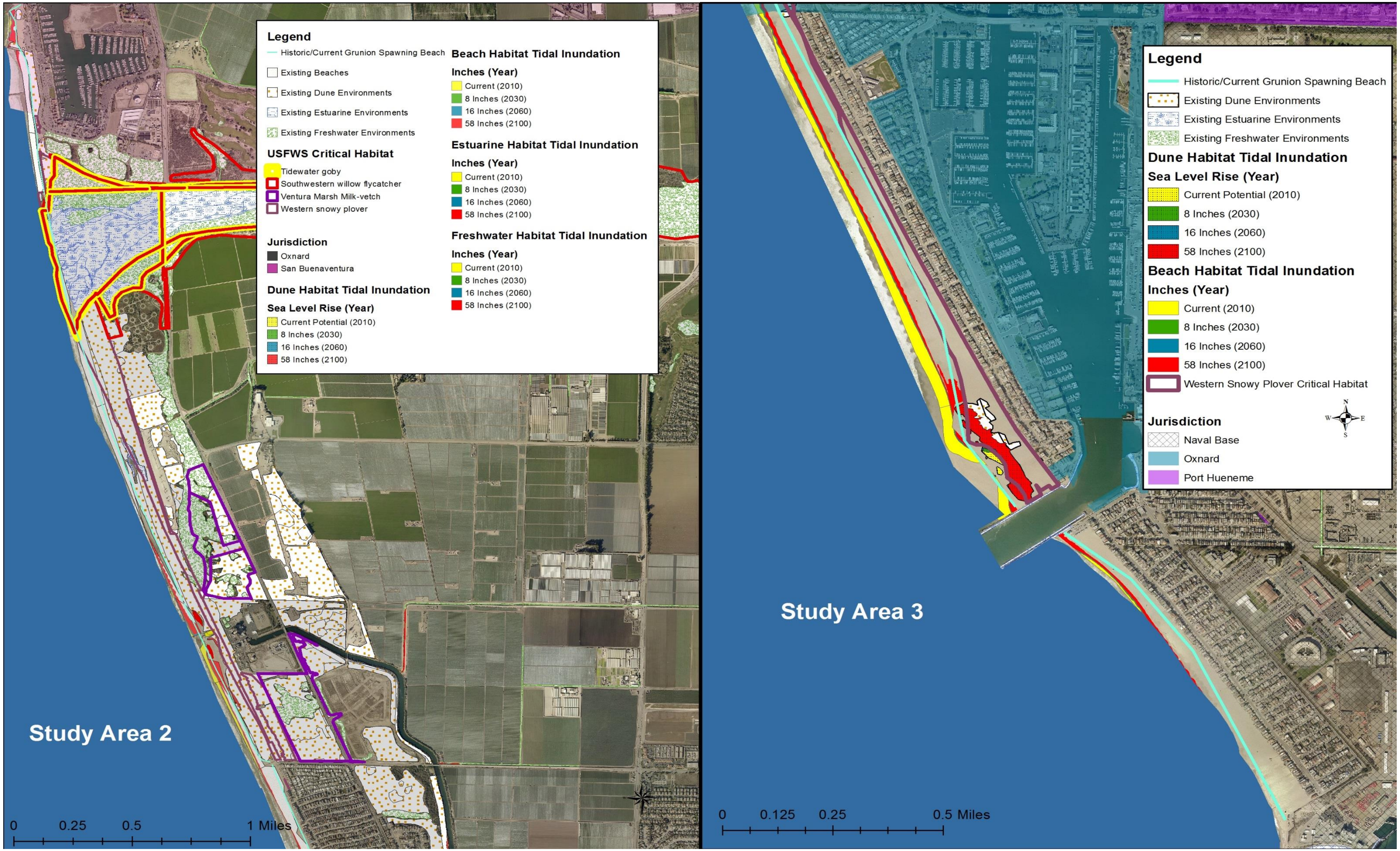


Figure D-15. North Coast Projected Tidal Inundation Due to Sea Level Rise (Study Areas 1 and 2)

Figure D-16. Central Coast Projected Coastal Storm Flooding Due to Sea Level Rise (Study Area 1)

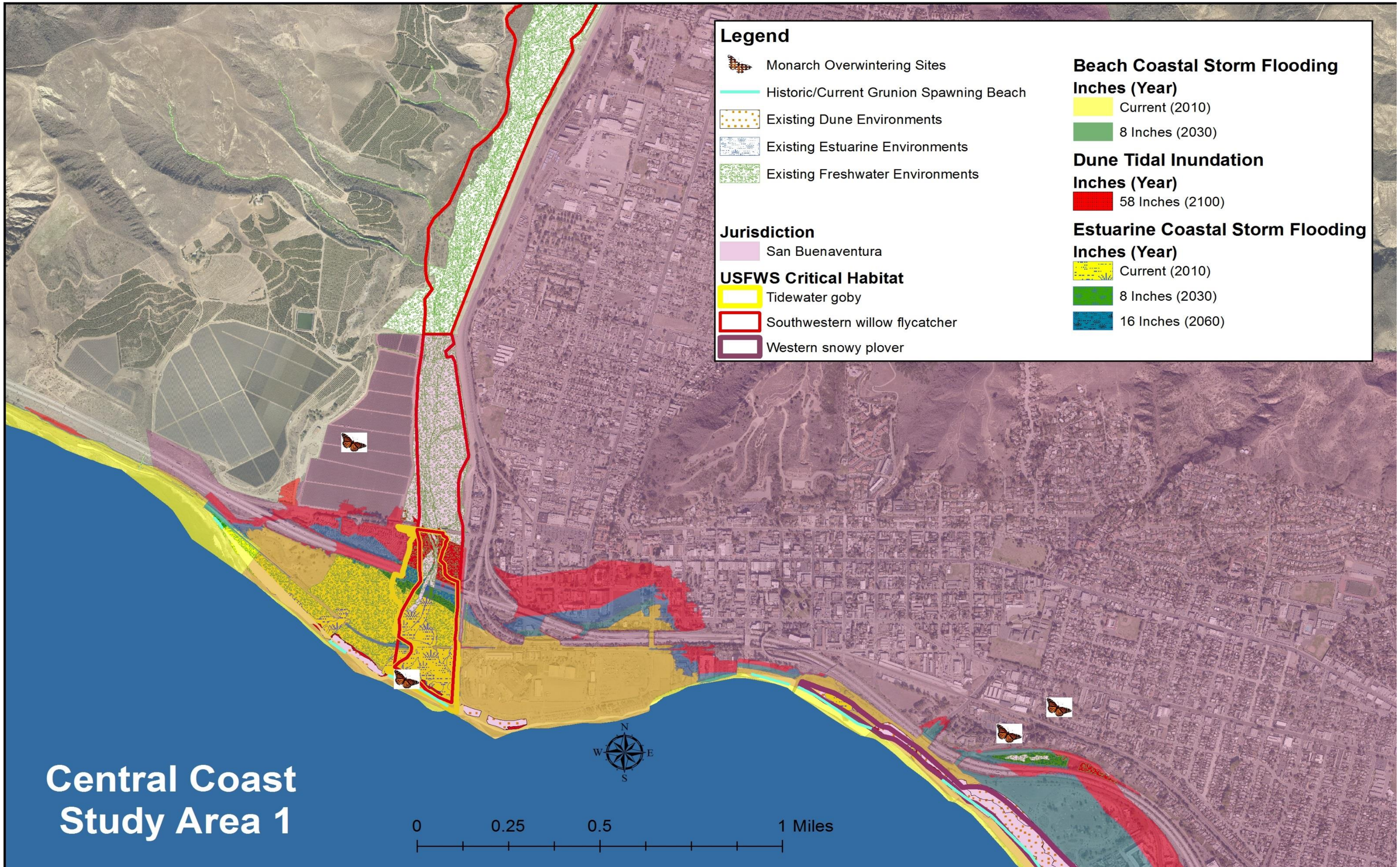


Figure D-17. Central Coast Projected Coastal Storm Flooding Due to Sea Level Rise (Study Areas 2 and 3)

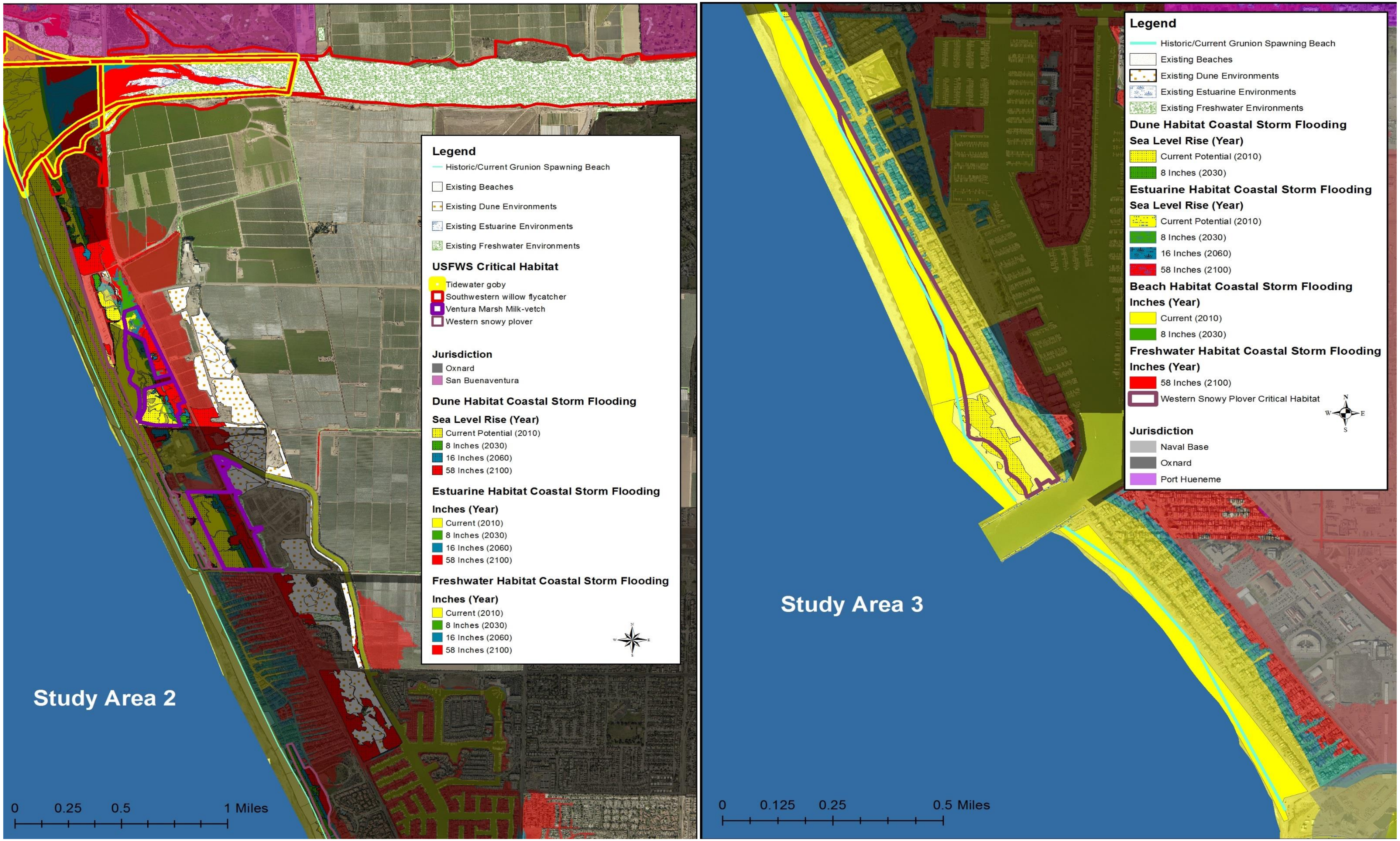


Figure D-18. North Coast Projected Coastal Storm Flooding Due to Sea Level Rise (Study Areas 1 and 2)

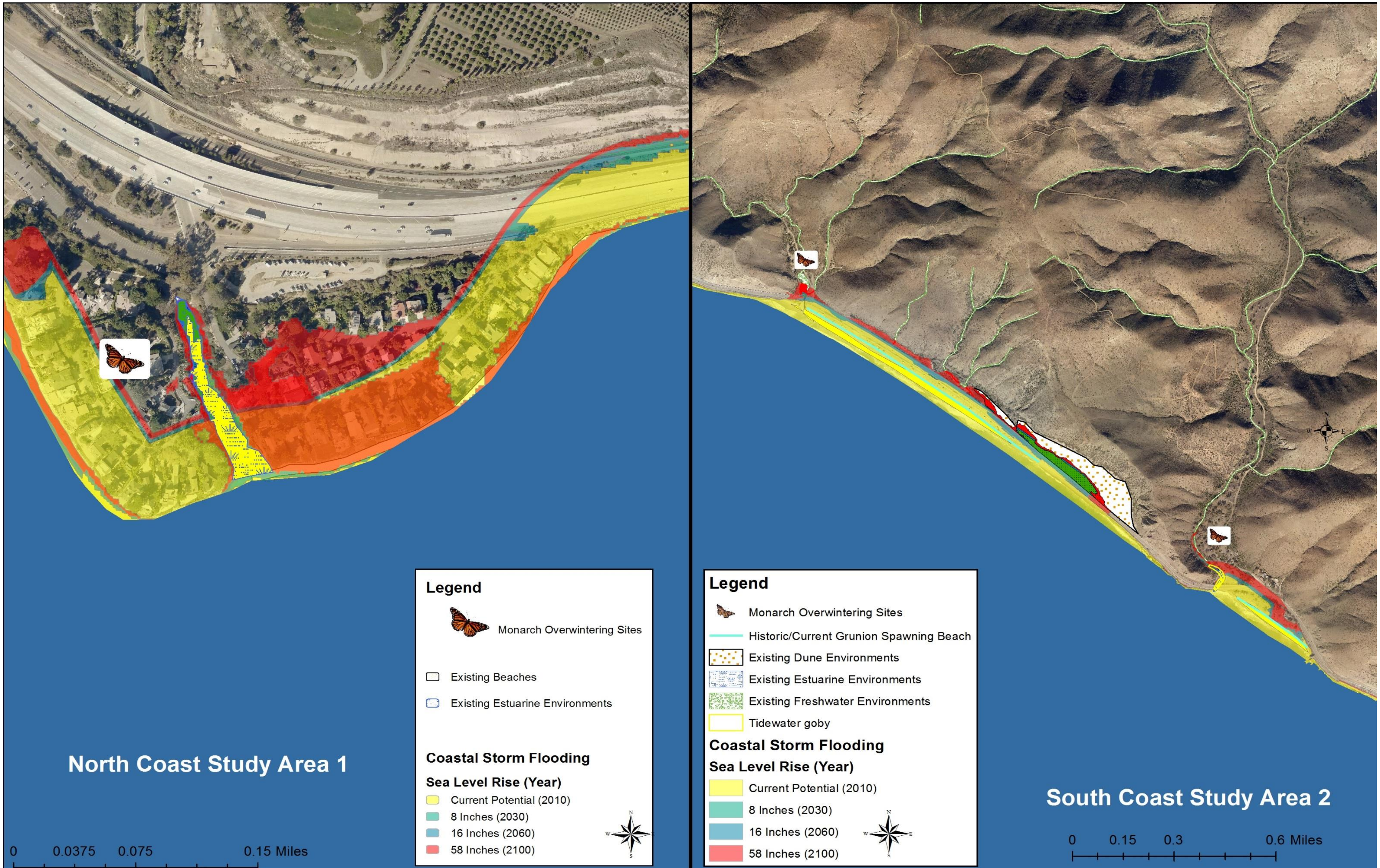


Figure D-19. Central Coast Projected Combined Flooding Due to Sea Level Rise (Study Area 1)

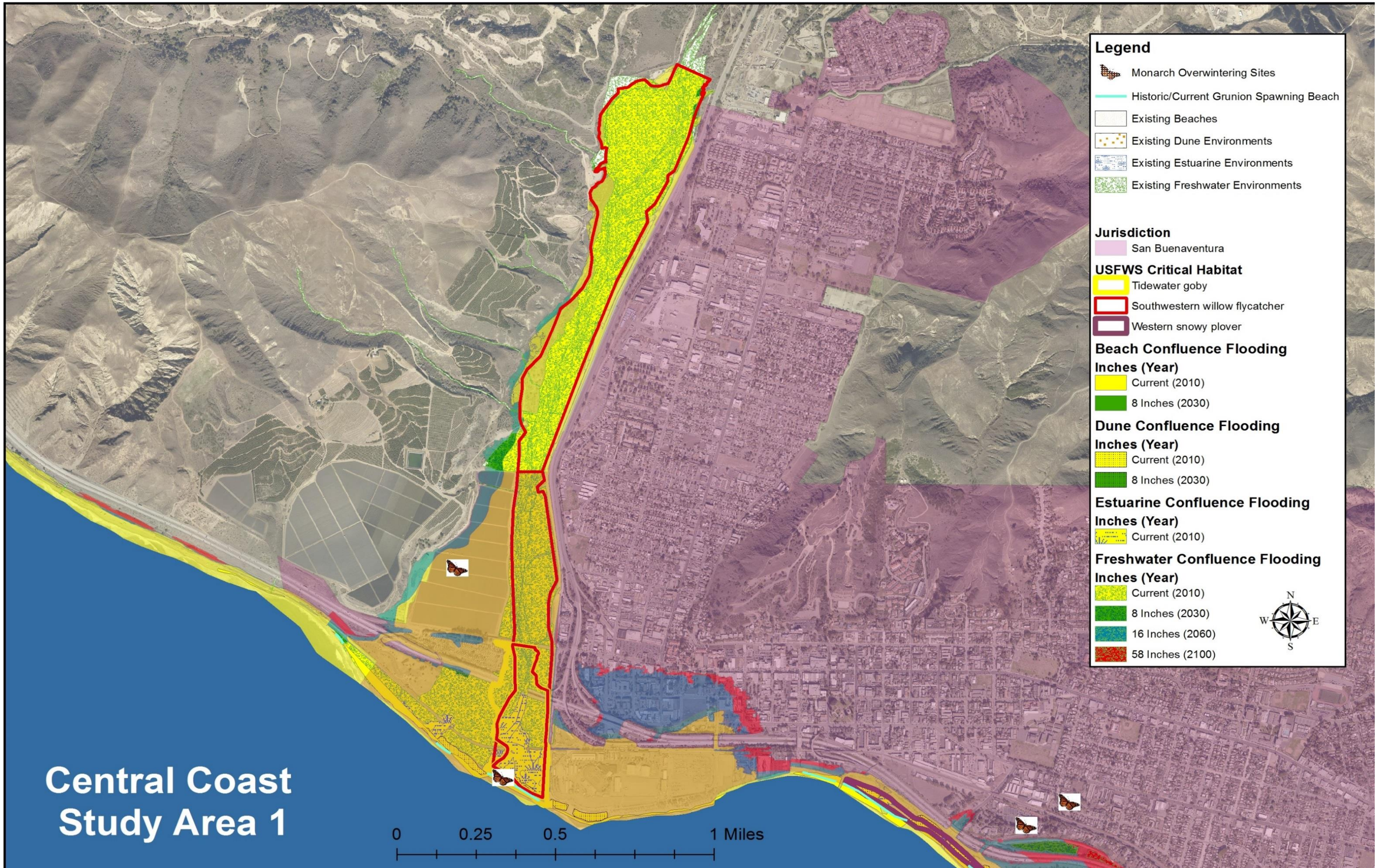


Figure D-20. Central Coast Projected Combined Flooding Due to Sea Level Rise (Study Areas 2 and 3)

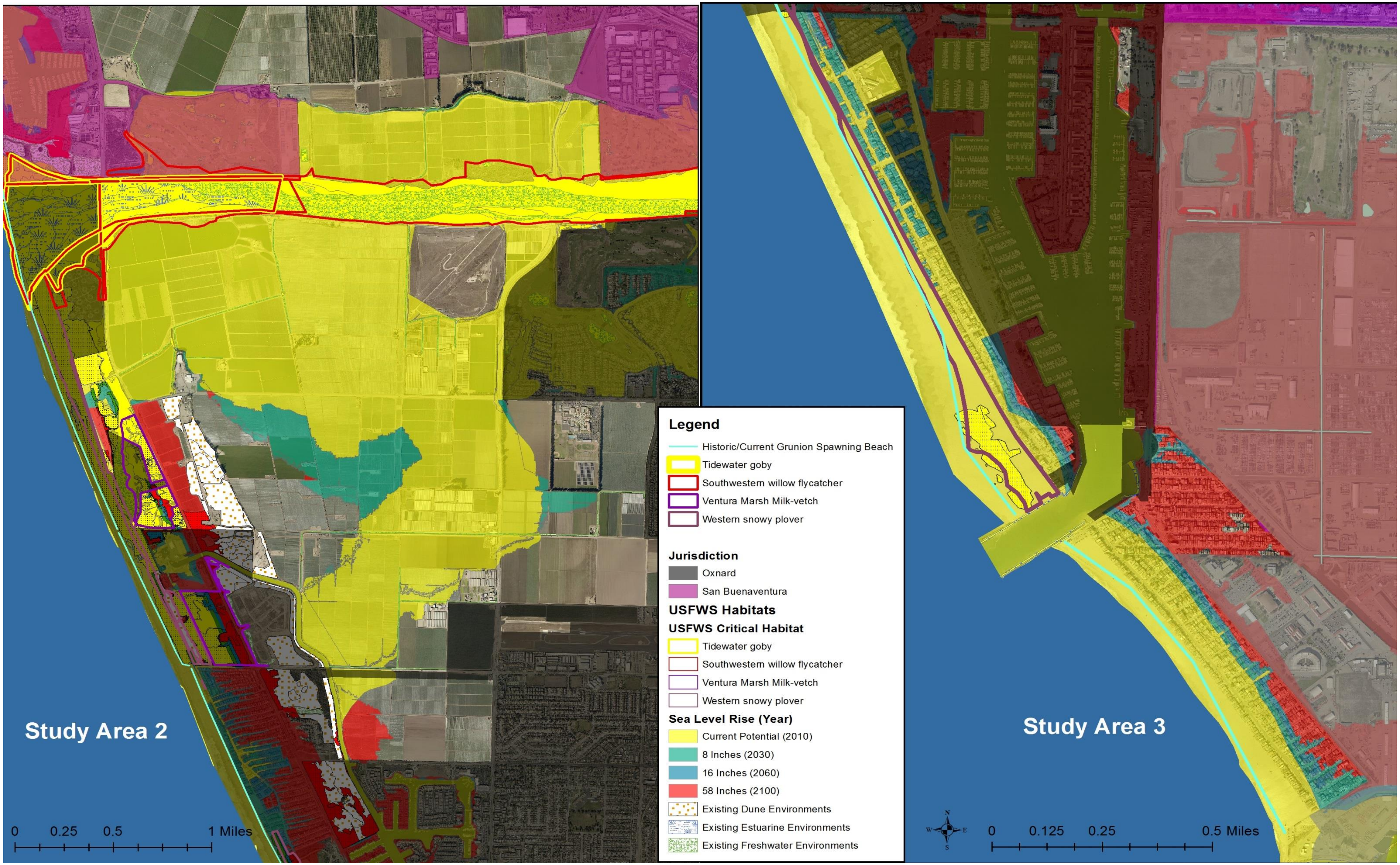


Figure D-21. North Coast Projected Combined Flooding Due to Sea Level Rise (Study Areas 1 and 2)