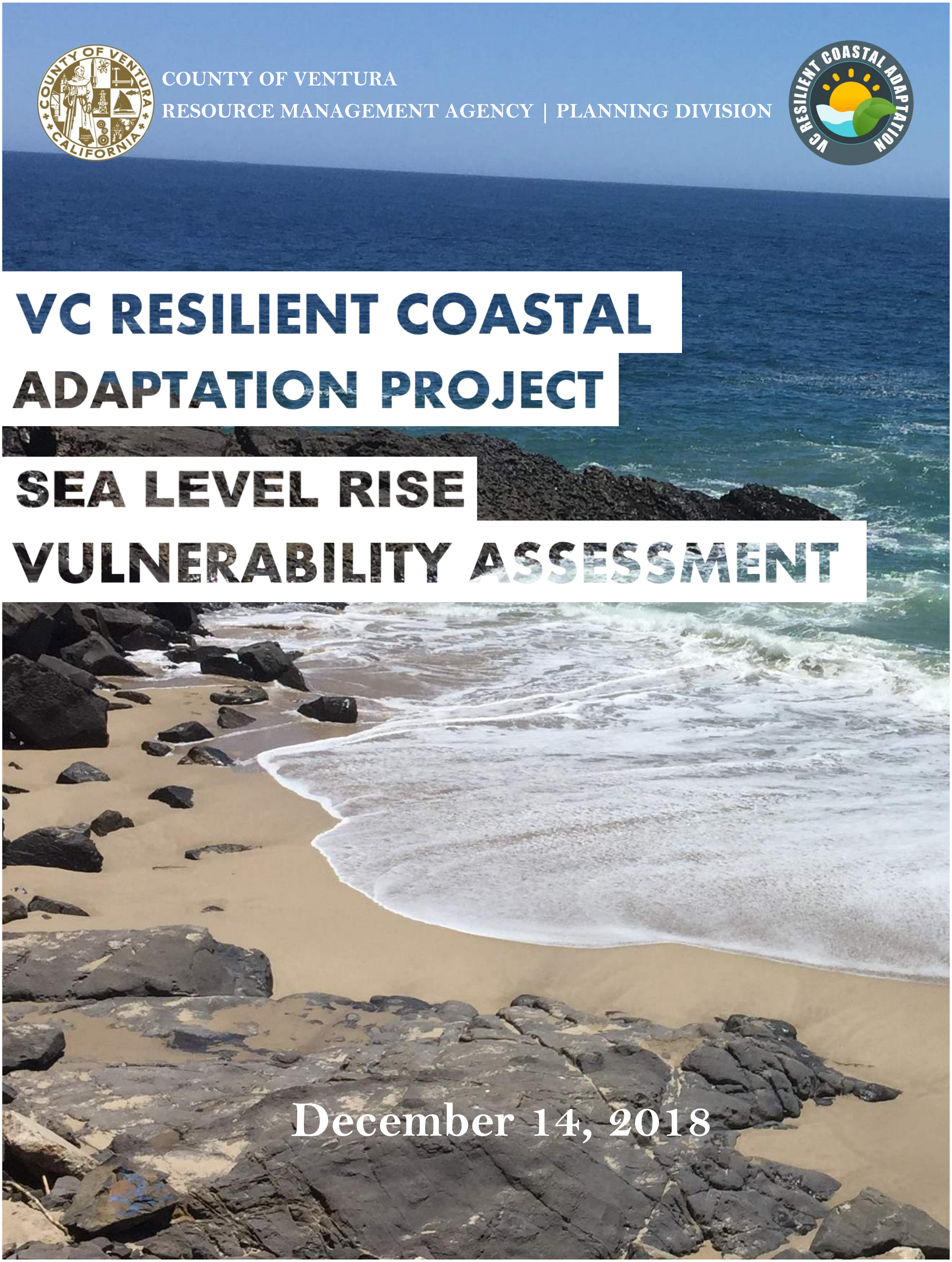
COUNTY OF VENTURA
RESOURCE MANAGEMENT AGENCY | PLANNING DIVISION

VC RESILIENT COASTAL ADAPTATION PROJECT

SEA LEVEL RISE VULNERABILITY ASSESSMENT



December 14, 2018

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

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ACKNOWLEDGEMENTS

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

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

- United States Geological Survey
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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

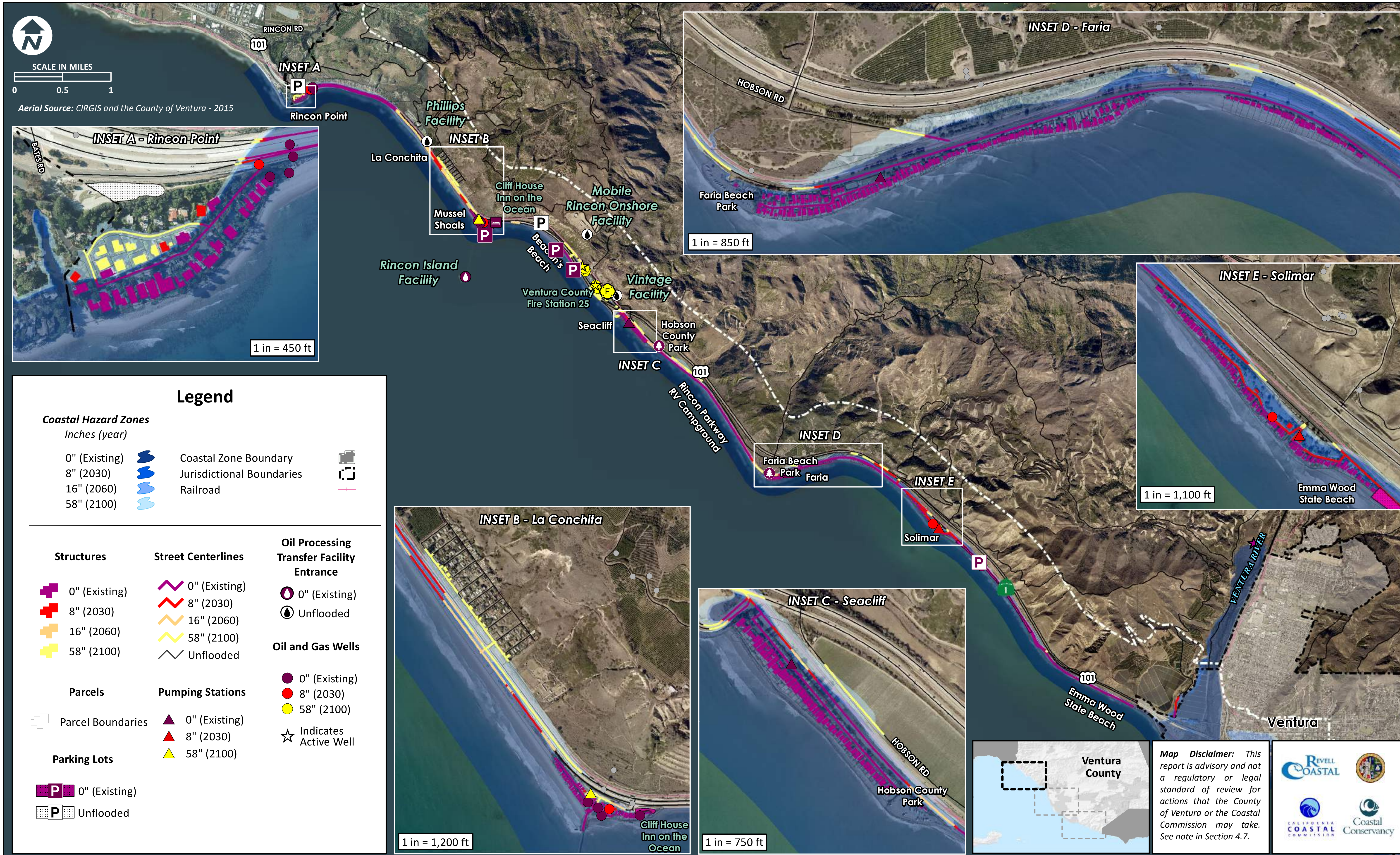


Figure ES-2 - Executive Summary: Central Coast

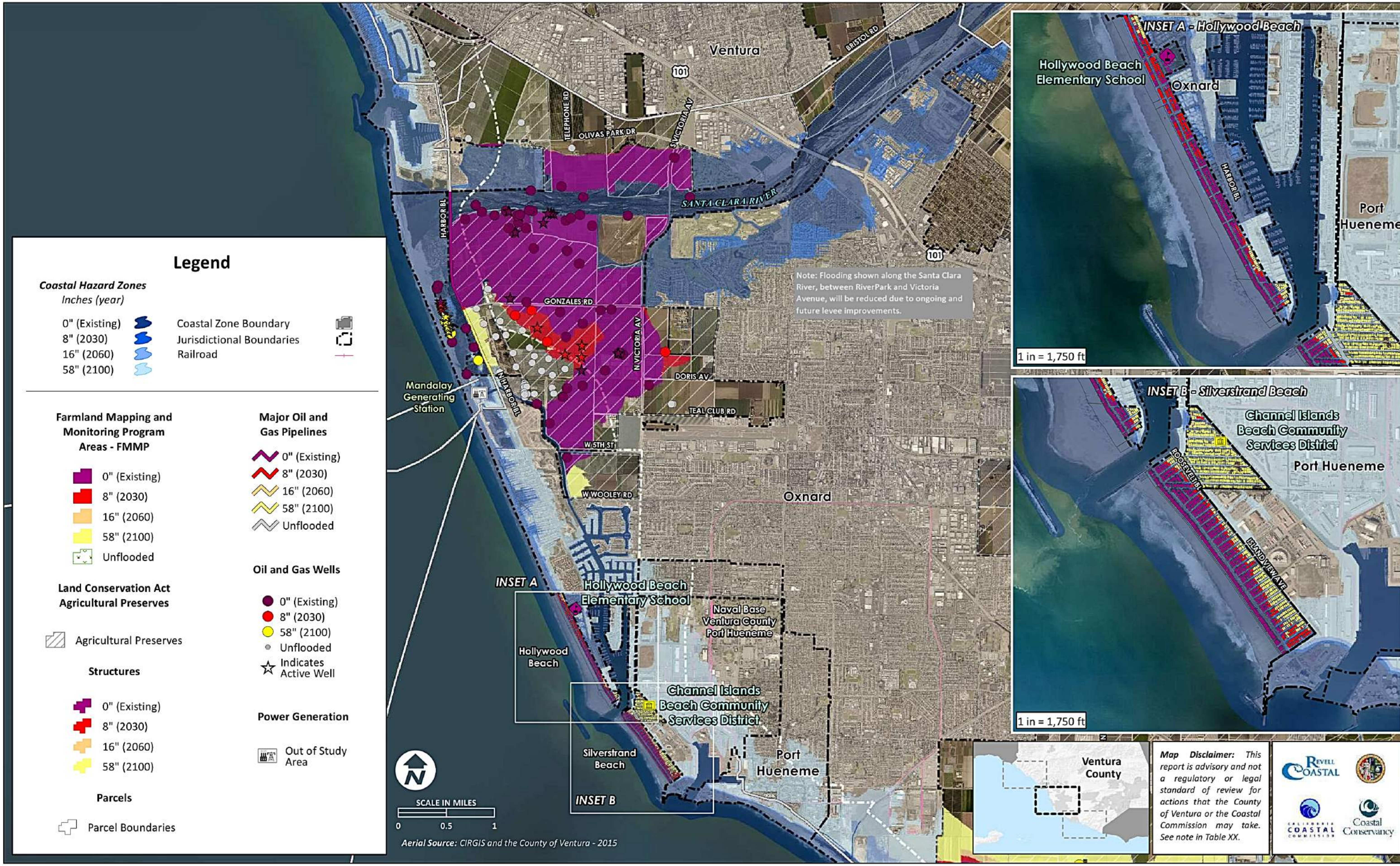
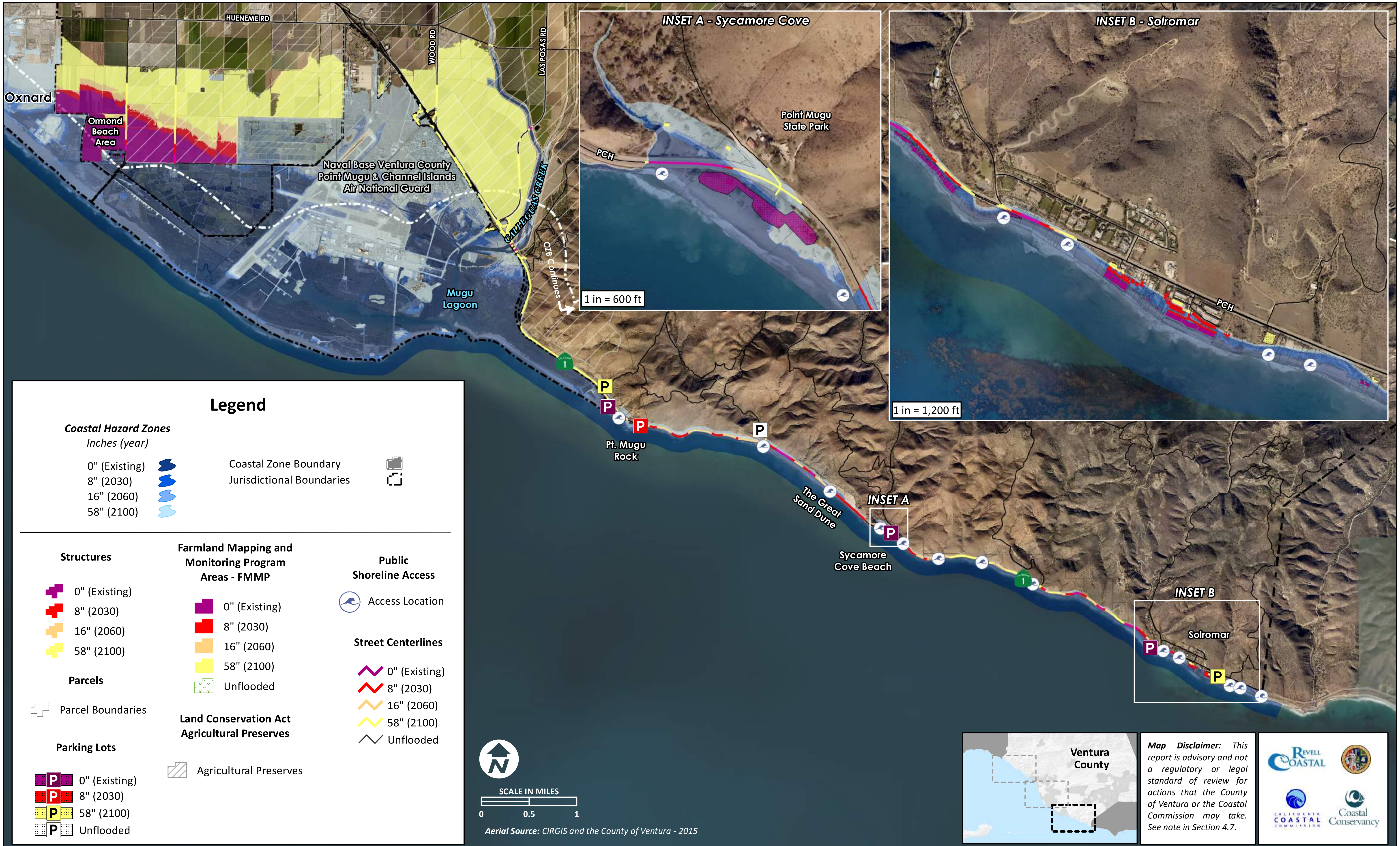


Figure ES-3 - Executive Summary: South Coast



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.

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[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.

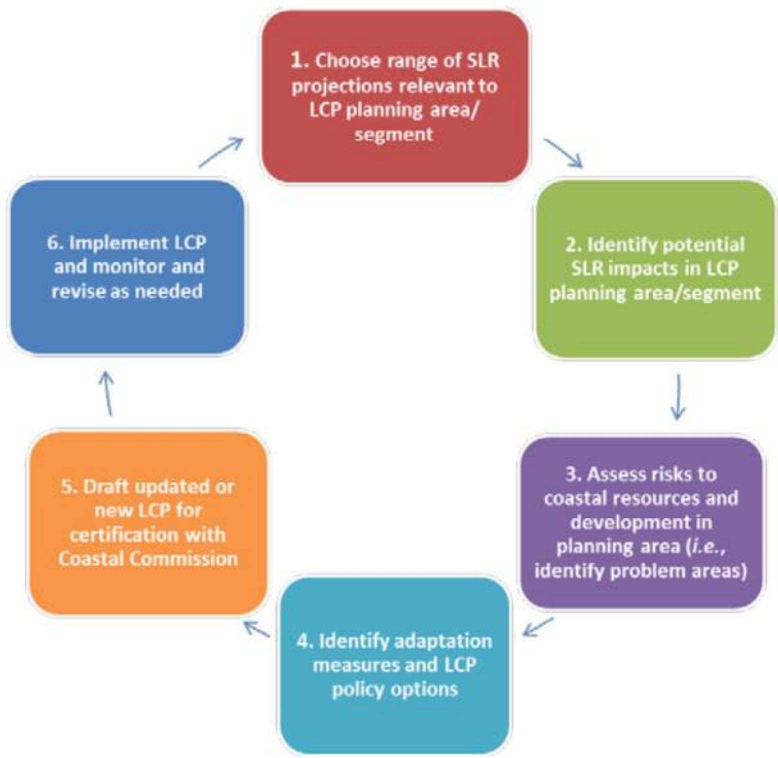

Figure 1-2. California Coastal Commission guidance for including sea level rise into Local Coastal Programs.

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.

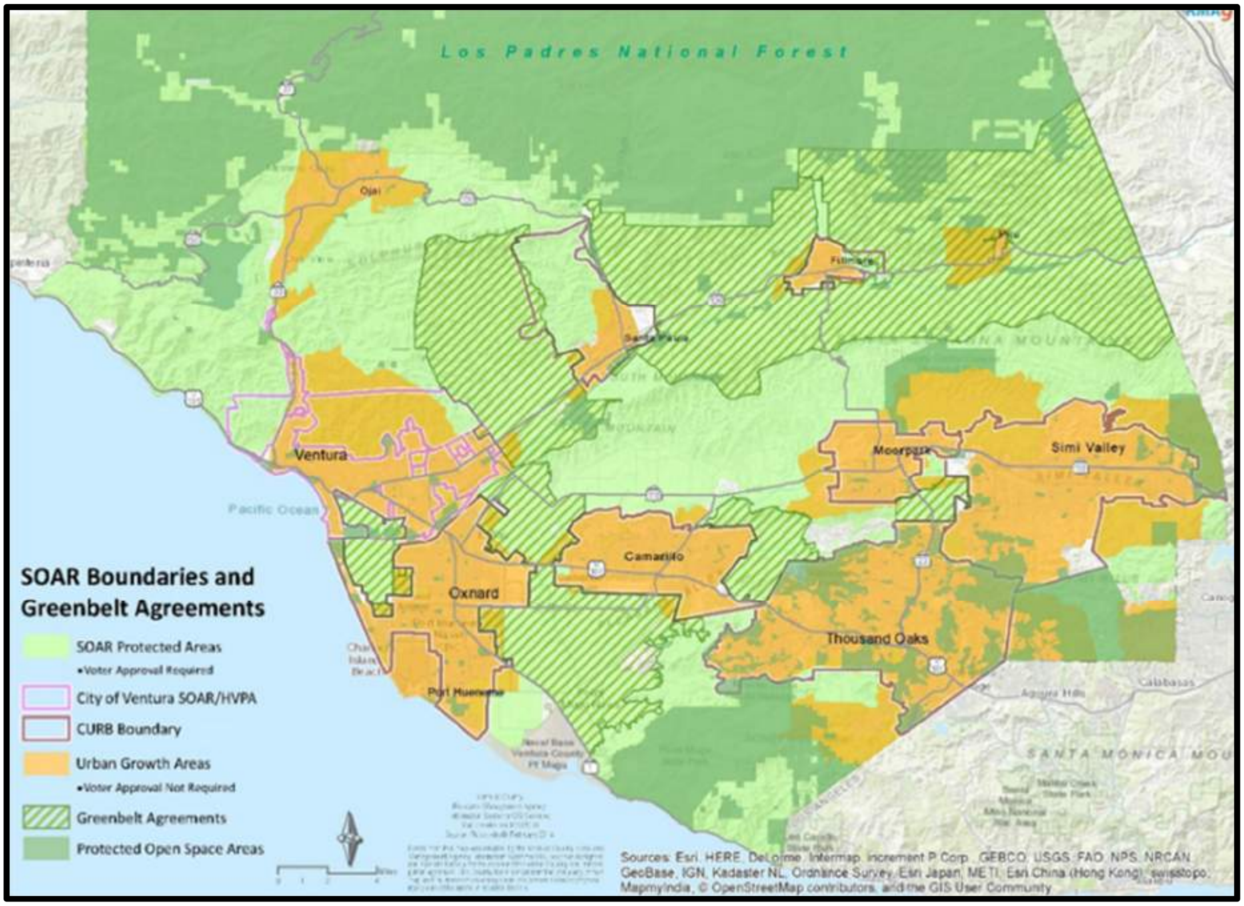

Figure 1-3. Greenbelt Agreements

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.

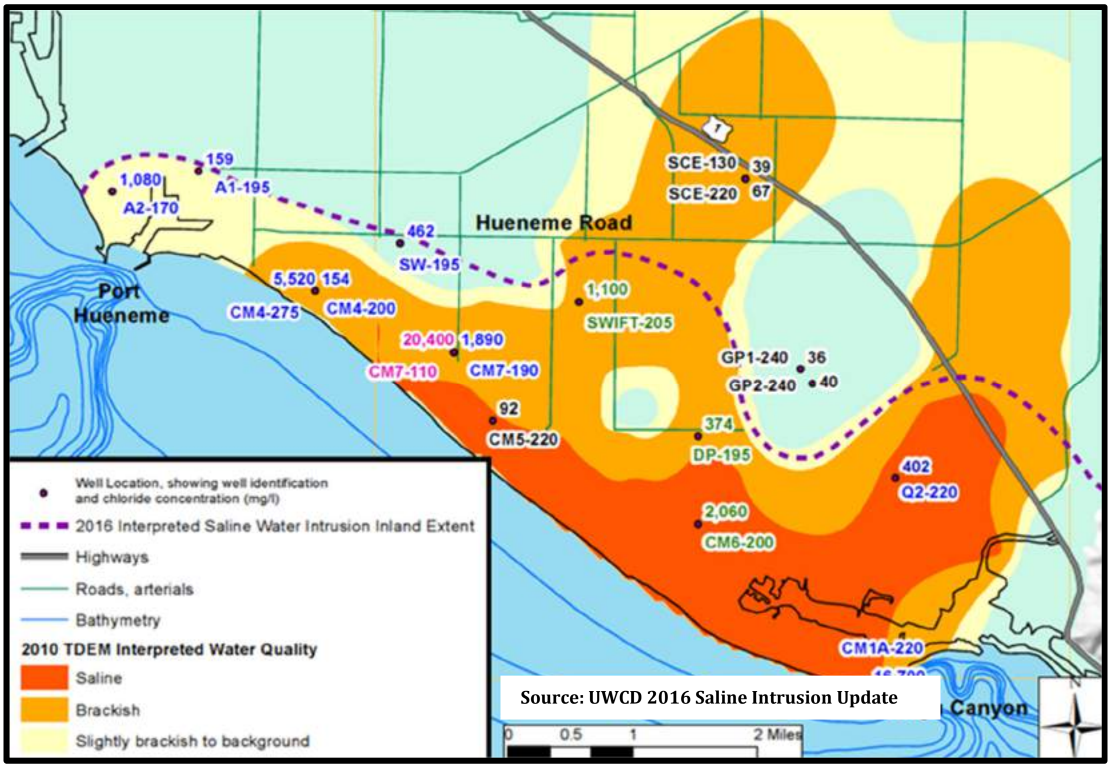

Figure 1-4. Map illustrating the saline intrusion and monitoring well locations in the Southern Oxnard Plain (the red and orange colors represent the extent of seawater intrusion).

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.

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[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).

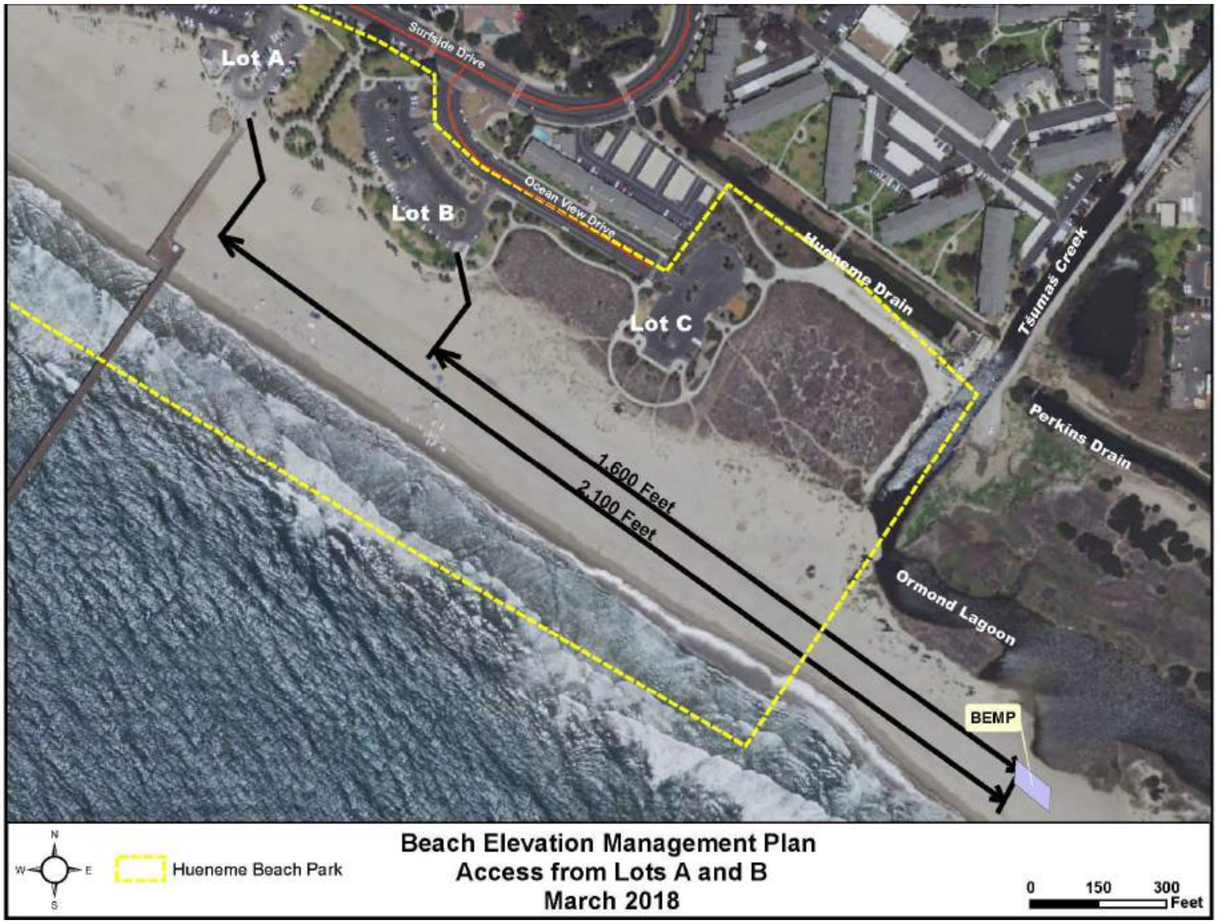

Figure 1-5. Beach Elevation Management Plan Access Route and Grooming Area

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.

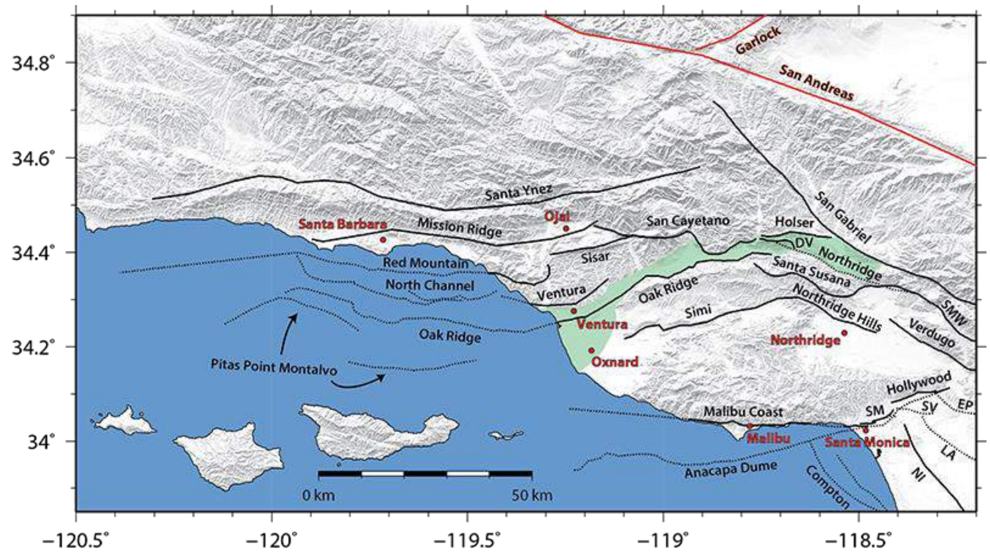

Figure 2-1. Geological Overview Map of Major Faults in Ventura County (source USGS)

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.

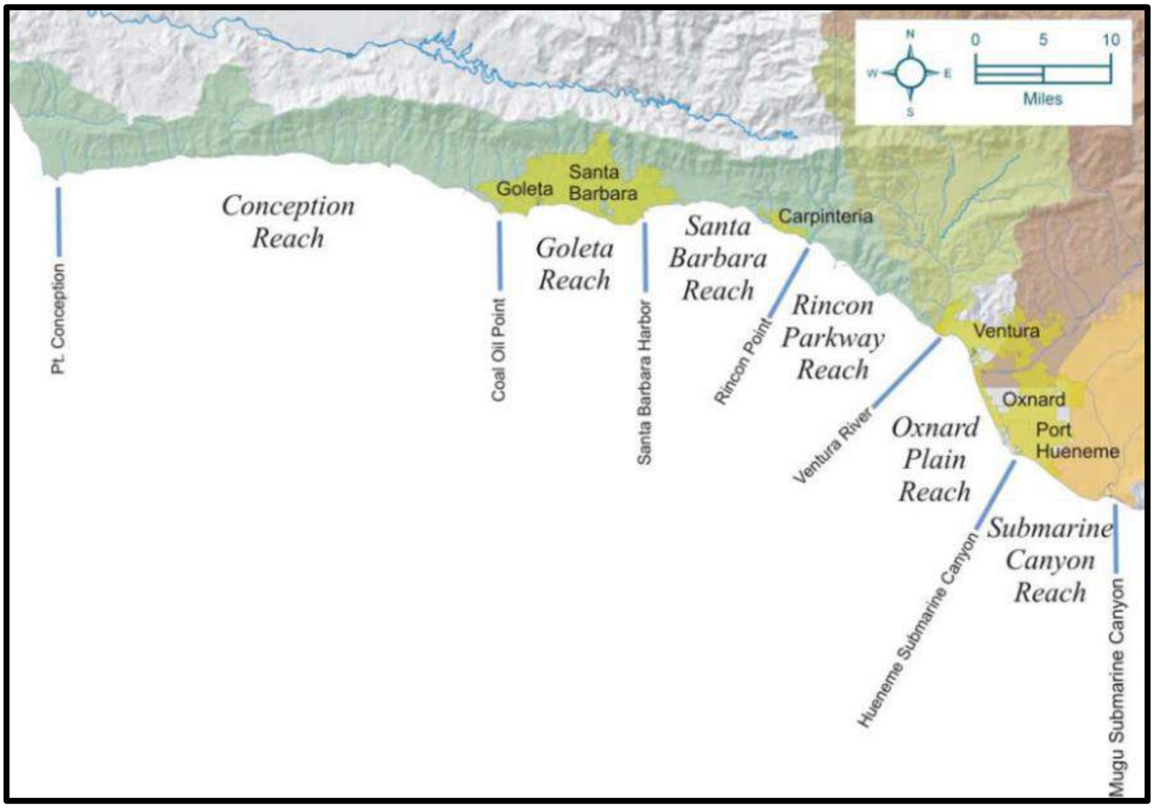

Figure 2-2. The Santa Barbara Littoral Cell (source: BEACON 2009)

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

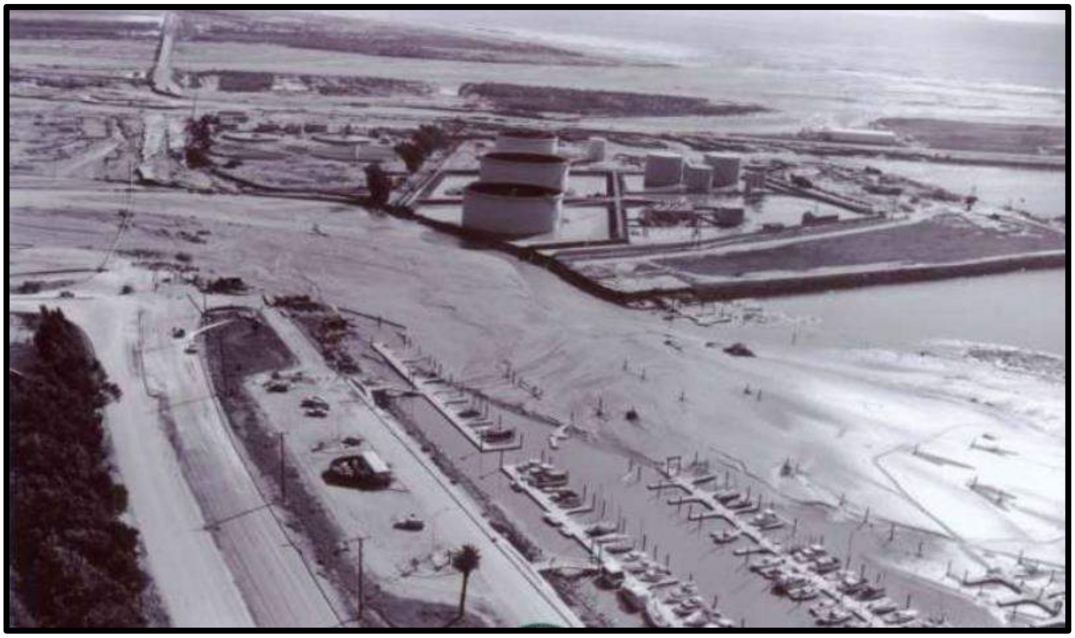

Photo 2-2. Flooding on the Santa Clara River during a storm of record in 1969.

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).


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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.

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[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*

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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).

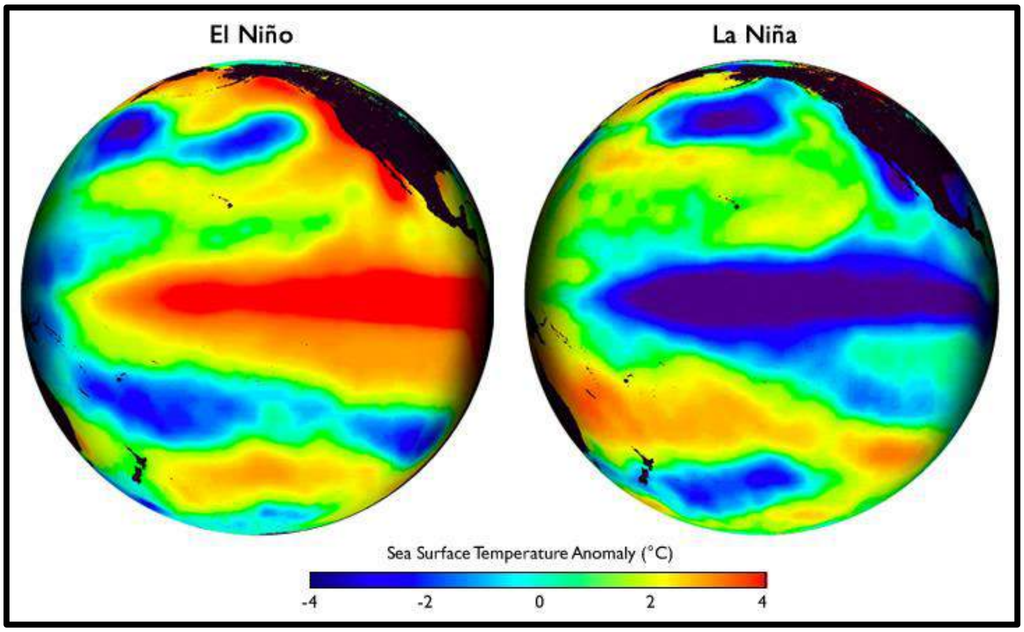


Figure 3-1. Sea surface temperature differences from average conditions during El Niño and La Niña (source: NOAA).

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).

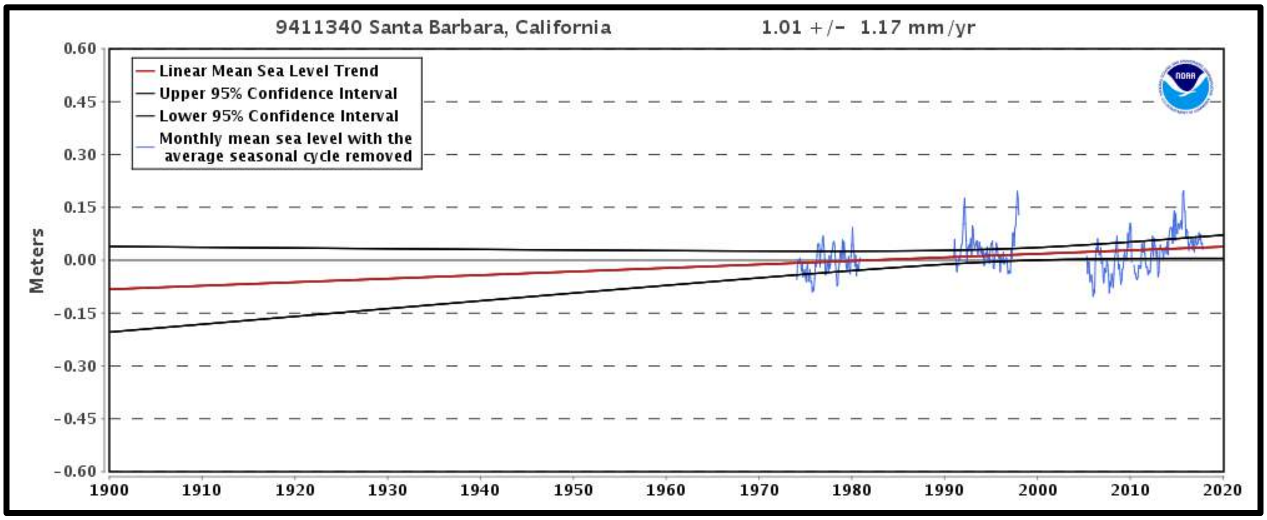


Figure 3-2. Plot showing Sea level rise trend from the Santa Barbara Tide Gauge.

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).

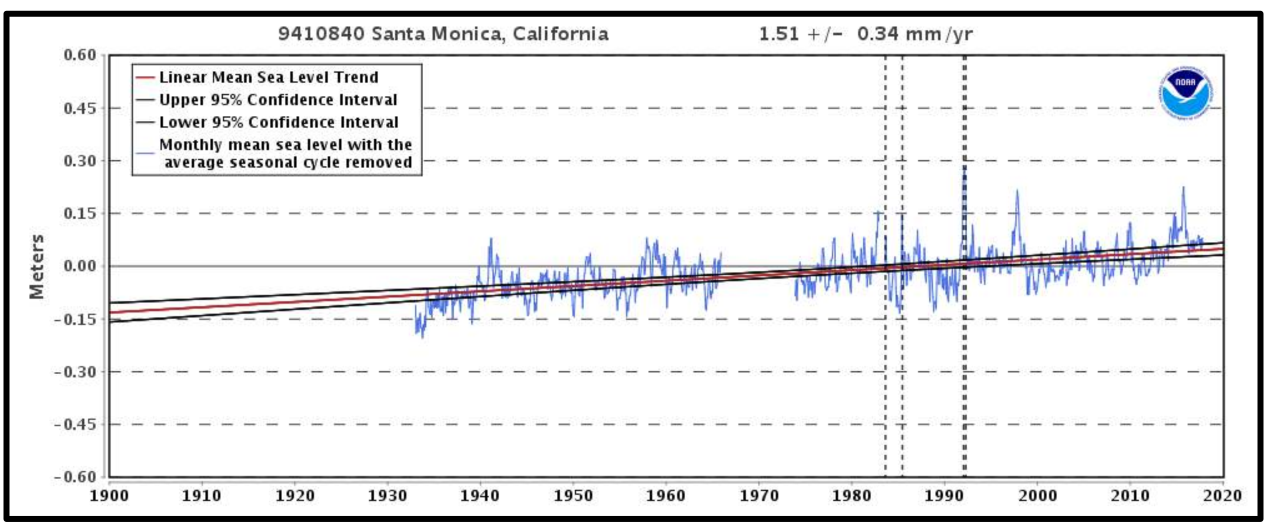


Figure 3-3. Plot showing sea level rise trend from Santa Monica Tide Gauge.

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).

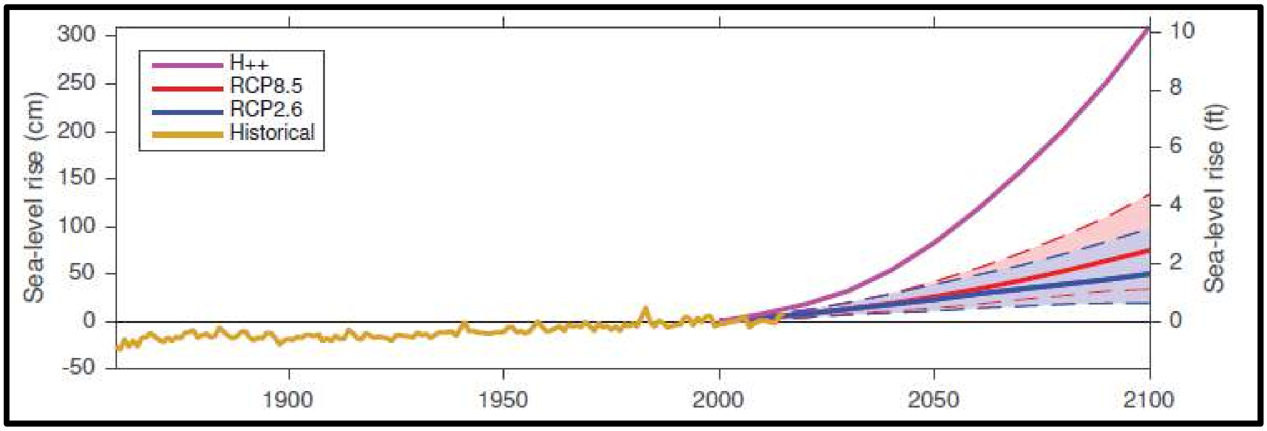


Figure 3-4. Relative sea level rise for San Francisco, California (source: Griggs et al. 2017).

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

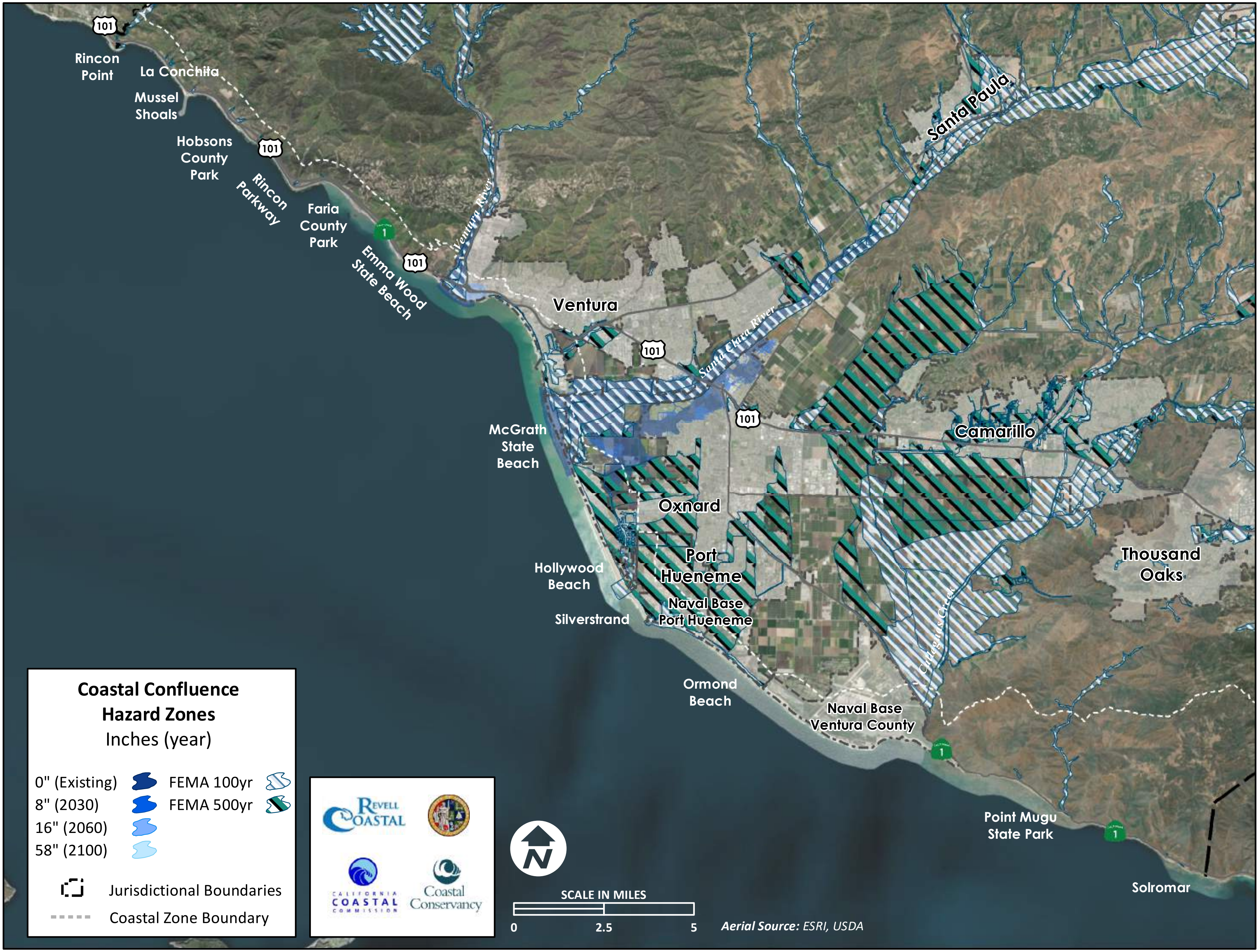
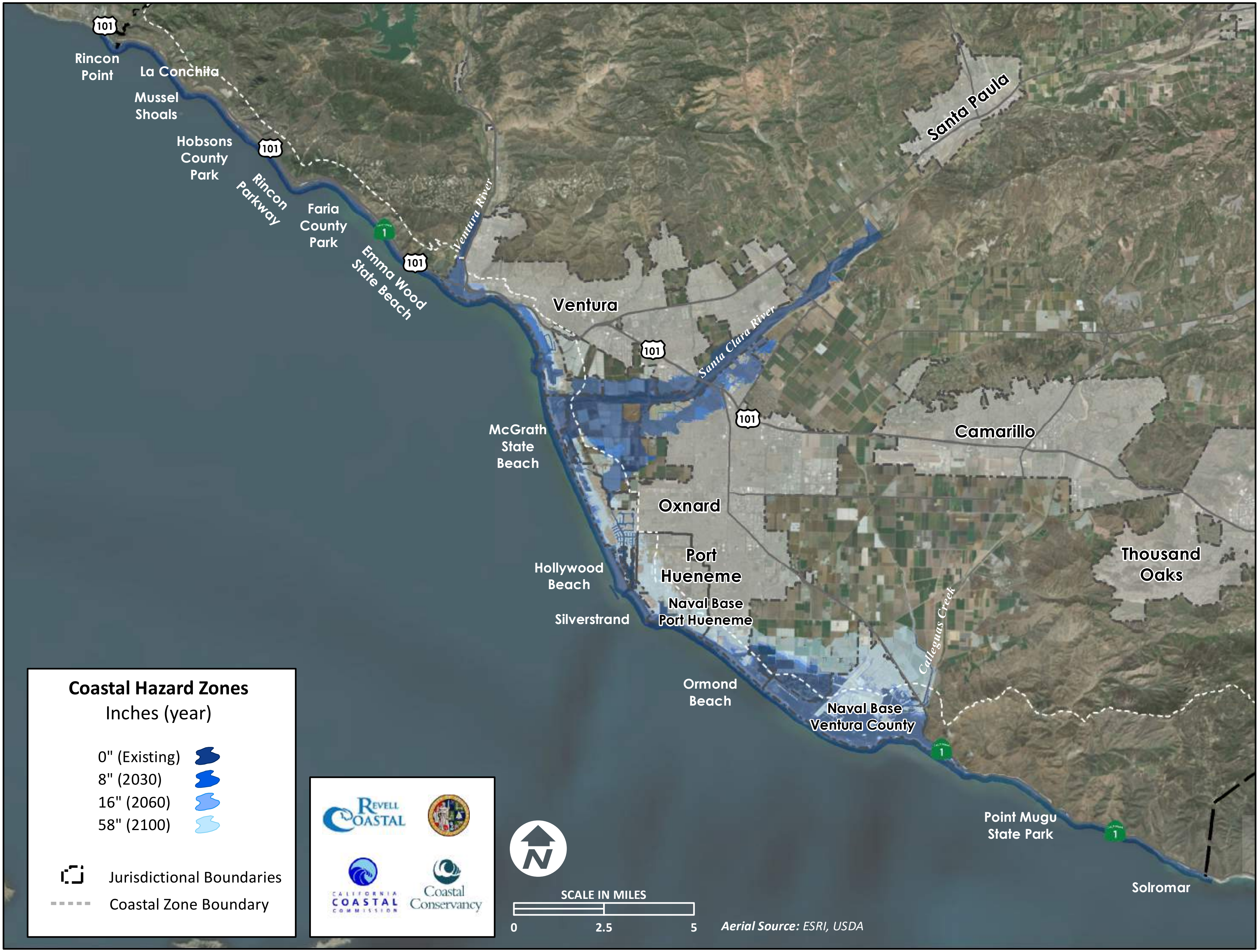


Figure 4-5. All Coastal and Existing Fluvial Hazards Map



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

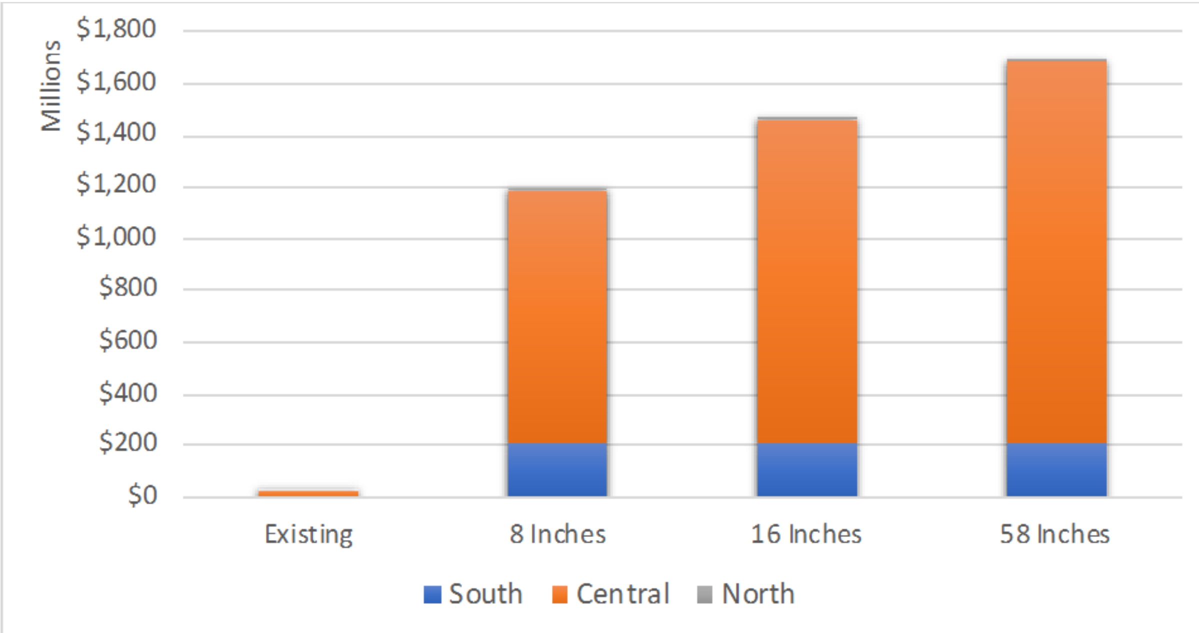
This section presents the results of the study's parcel data analysis of property at risk to coastal erosion, coastal flooding, and tidal inundation. The land use analysis used the same data set and further examined the following:

- 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.

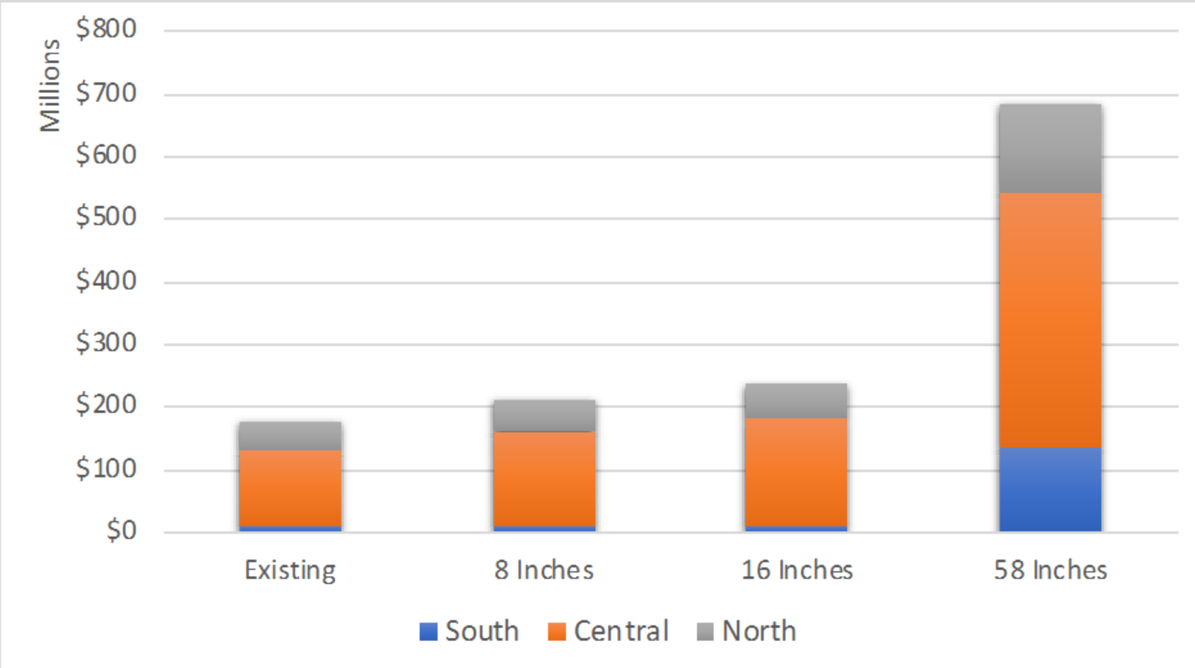


Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
North	$0	$1,100,000	$1,200,000	$1,200,000
Central	$26,600,000	$981,100,000	$1,255,400,000	$1,480,100,000
South	$0	$208,300,000	$208,300,000	$208,500,000
Total	**$26,600,000**	**$1,190,500,000**	**$1,464,900,000**	**$1,689,800,000**

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.

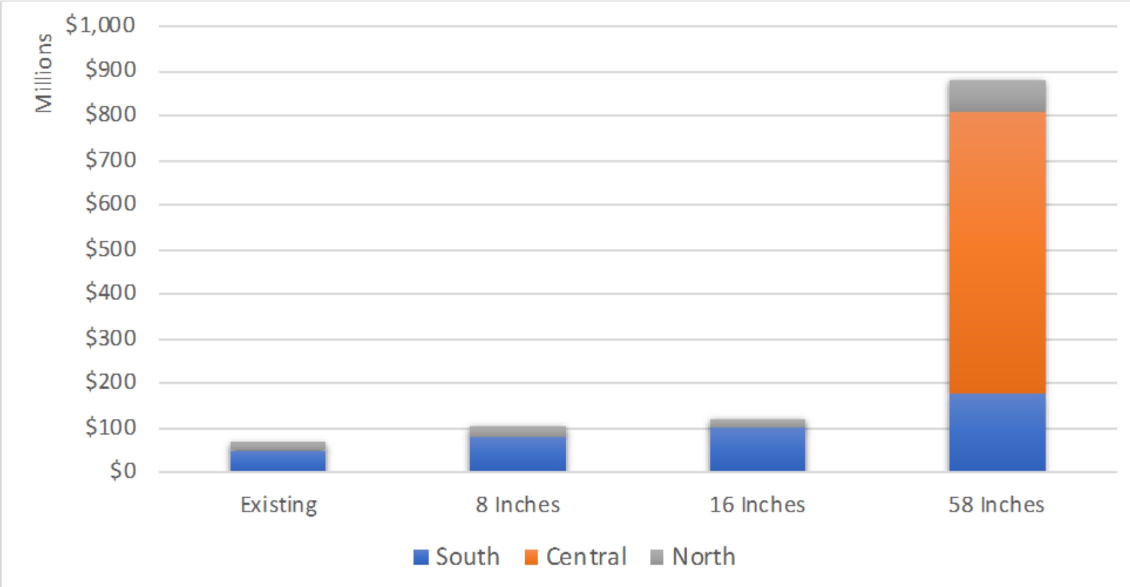
The South Coast will experience some small increases in erosion losses over time: $208.3 million with 8 and 16 inches of sea level rise and $208.5 million with about 5 feet of sea level rise, but this is limited as there is only a single row of parcels between Pacific Coast Highway and the ocean. The 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.

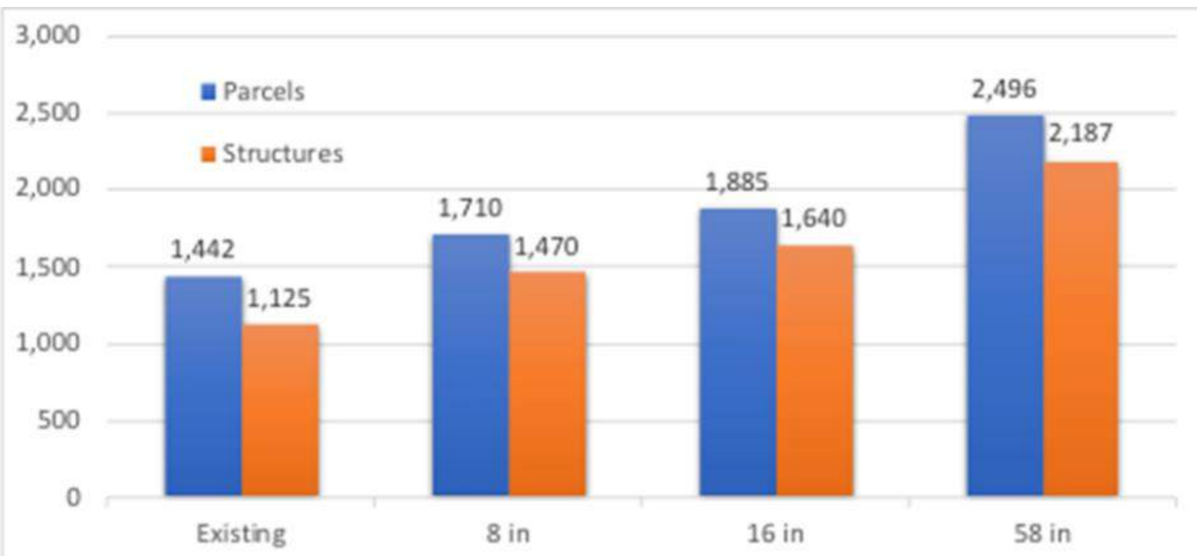
Storm Erosion	Existing	8 Inches	16 Inches	58 Inches
Agriculture	$0	$0	$0	$0
Comm. & Indust.	$100,000	$7,500,000	$11,300,000	$19,300,000
Open Space & Rec.	$0	$9,900,000	$12,400,000	$16,600,000
Other Residential	$500,000	$199,700,000	$226,800,000	$251,700,000
Single Fam. Res.	$26,000,000	$973,400,000	$1,214,300,000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

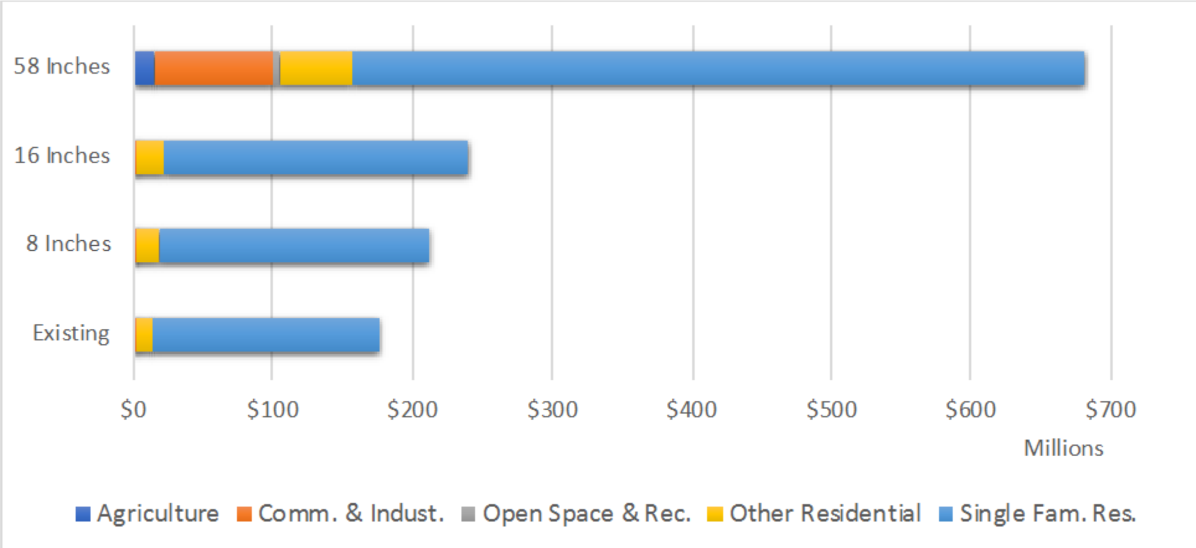
Figure 5-4. Cumulative number of parcels and structures, and estimated value of property losses due to erosion, by land use (2017 dollars). *Note: Only bluff erosion was modeled for the South Coast, and erosion was not modeled for the North Coast due to the existing shoreline armory.*

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.





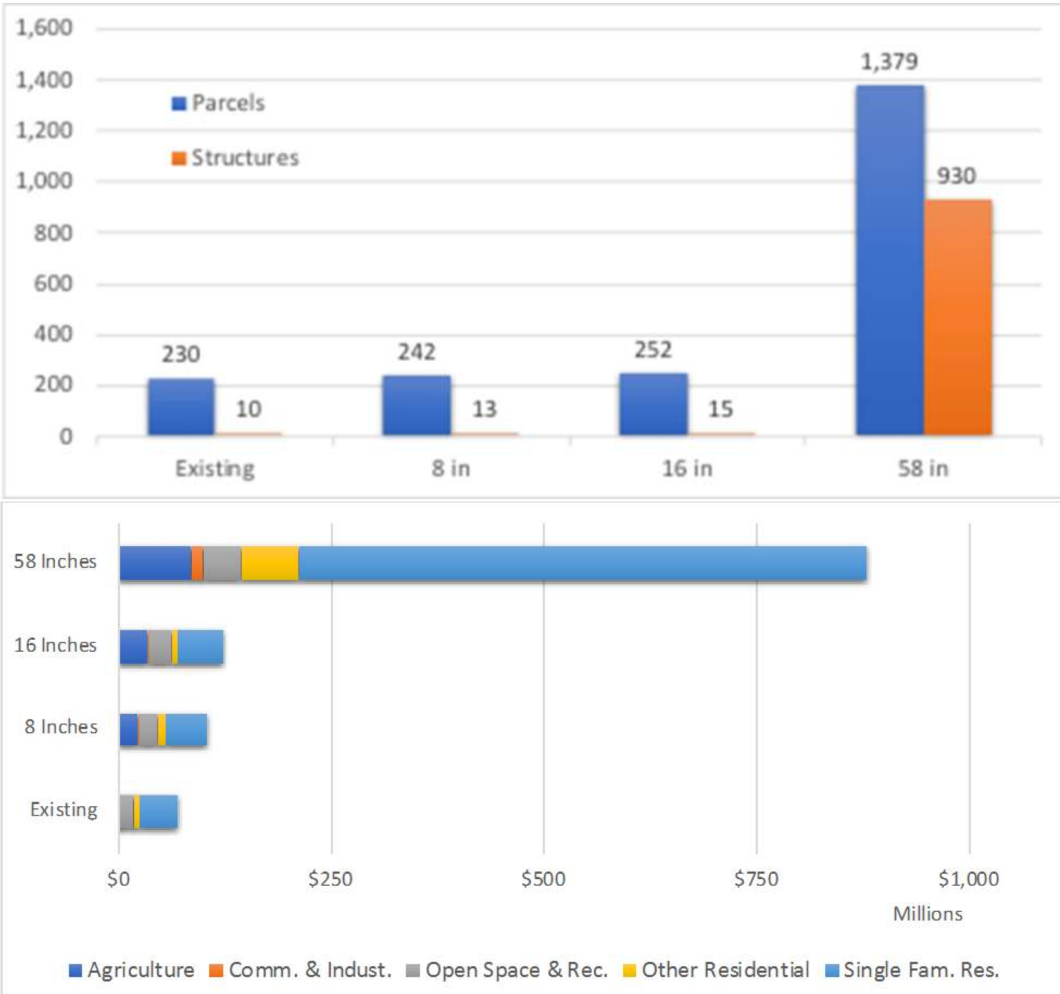
Coastal Flooding	Existing	8 Inches	16 Inches	58 Inches
Agriculture	$100,000	$100,000	$100,000	$15,100,000
Comm. & Indust.	$1,700,000	$2,700,000	$2,800,000	$84,100,000
Open Space & Rec.	$0	$100,000	$100,000	$6,400,000
Other Residential	$12,200,000	$16,000,000	$18,200,000	$50,800,000
Single Fam. Res.	$162,800,000	$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.

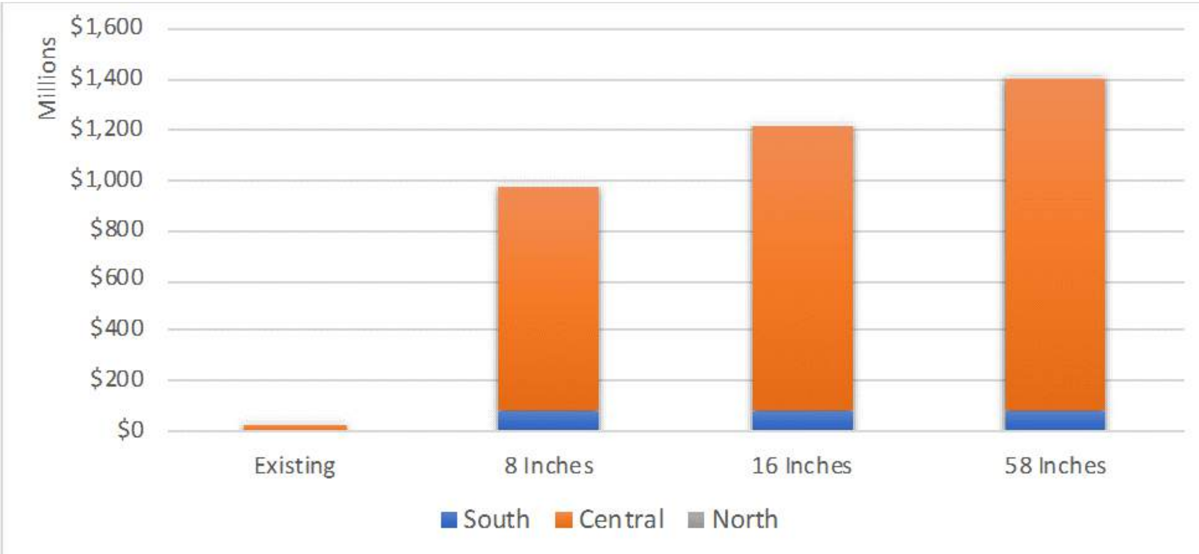
Tidal Inundation	Existing	8 Inches	16 Inches	58 Inches
Mixed Residential	$1,400,000	$1,500,000	$1,500,000	$1,900,000
Multi-Family	$5,700,000	$6,100,000	$6,500,000	$66,100,000
Single Family	$44,900,000	$49,500,000	$52,500,000	$667,800,000
Total	**$52,000,000**	**$57,100,000**	**$60,500,000**	**$735,800,000**

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

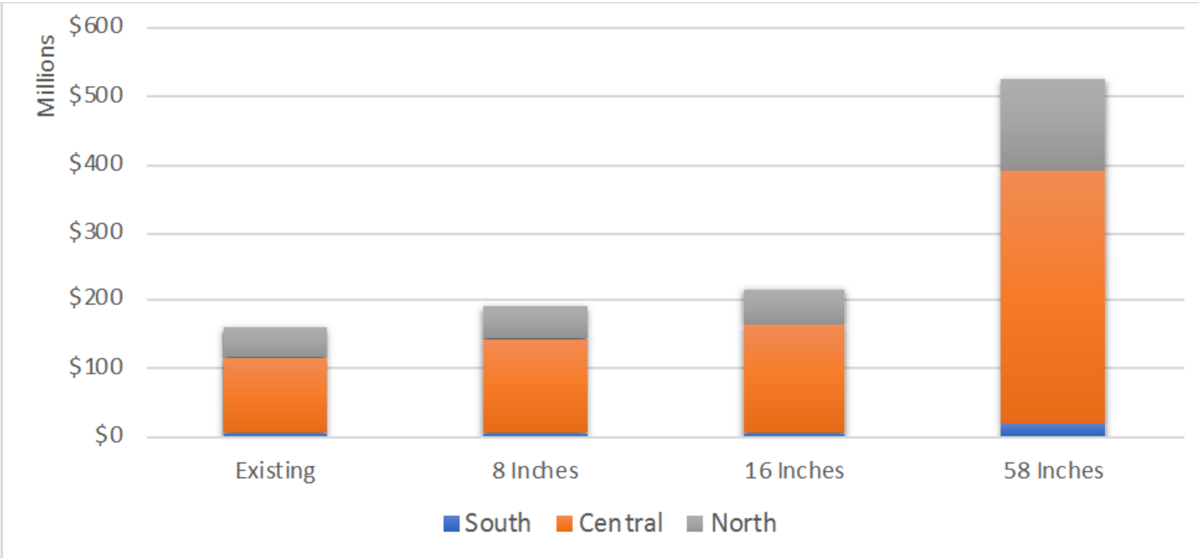
Figures 5-10 through 5-12 present this study's estimated losses of single-family dwellings due to sea level rise; these losses are broken down into the South, Central and North Coasts of Ventura County.



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.*

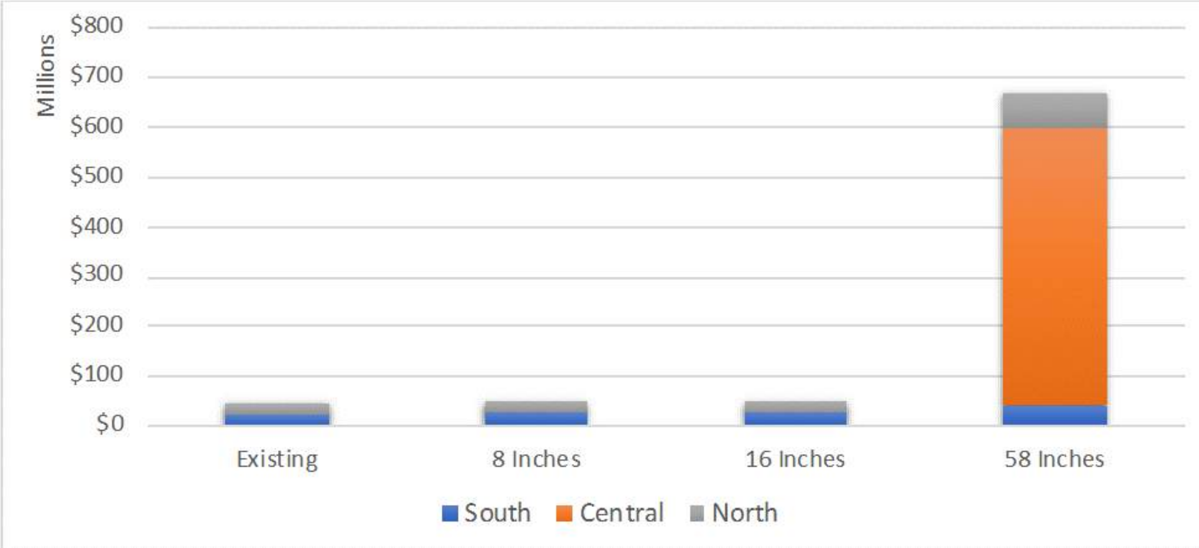
Figure 5-10 indicates that the Central Coast contains most of the single-family residential property at risk to losses from erosion during a 1% annual chance storm. Under existing conditions, $26 million in residential property is vulnerable within this area alone. This increases to $890.3 million with 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

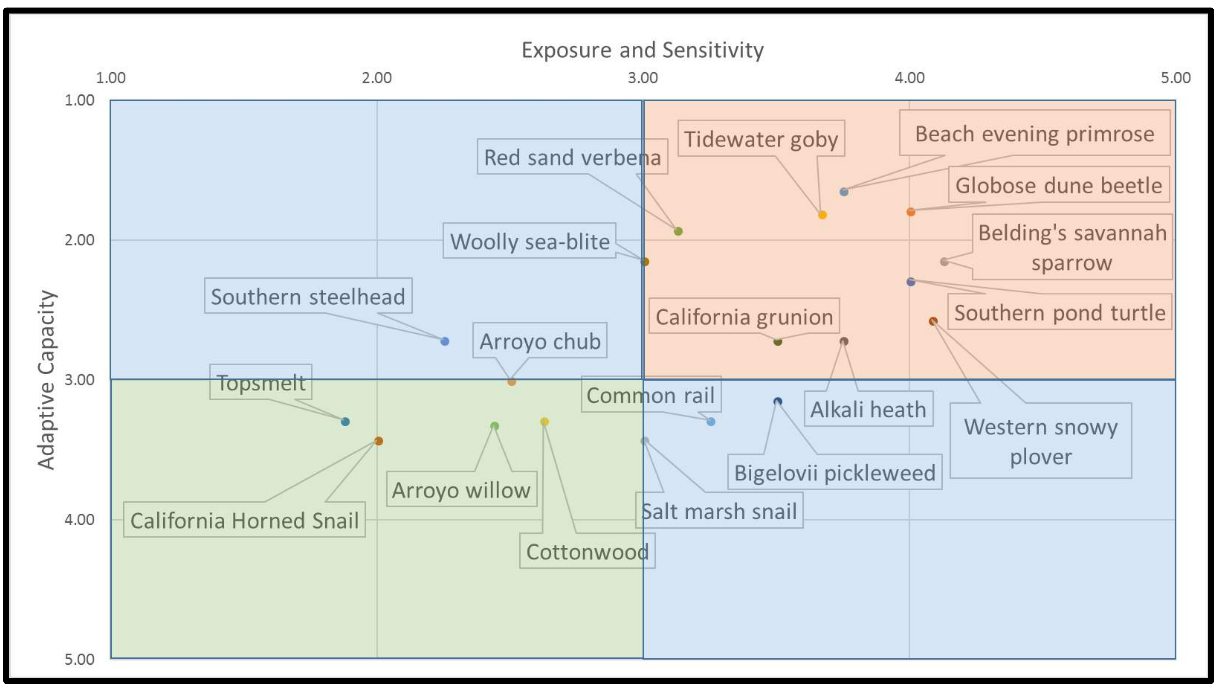


Figure 5-14. Top 20 focal species vulnerability assessment scores.

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

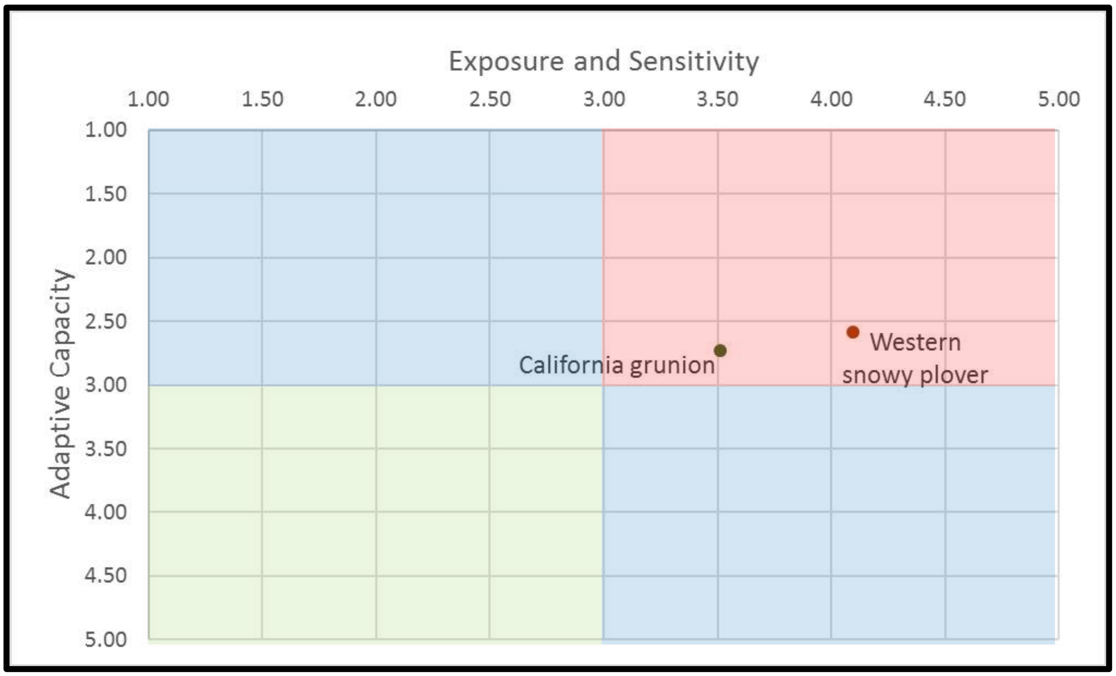


Figure 5-15. Beach Focal Species Vulnerability Scores.

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

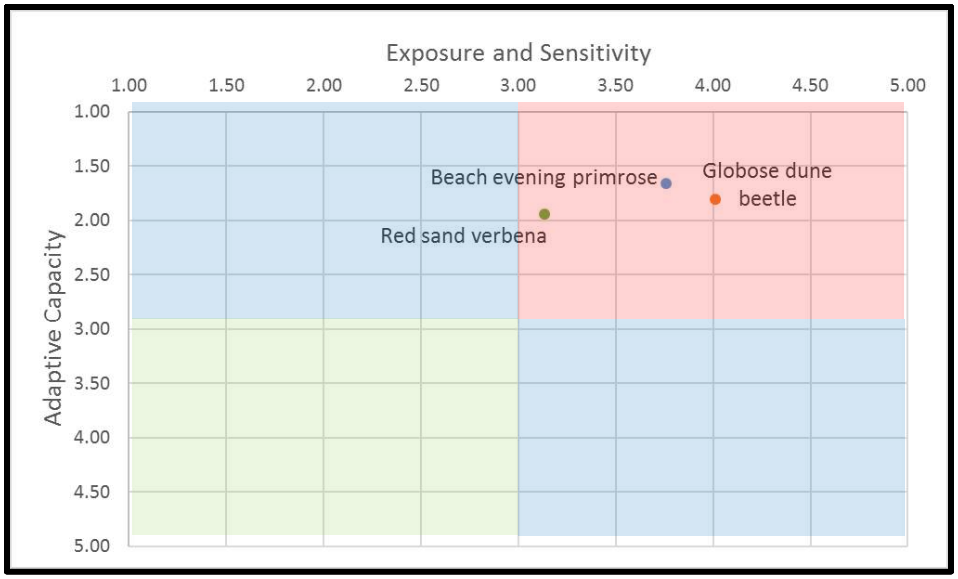


Figure 5-16. Dune Focal Species Vulnerability Scores.

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

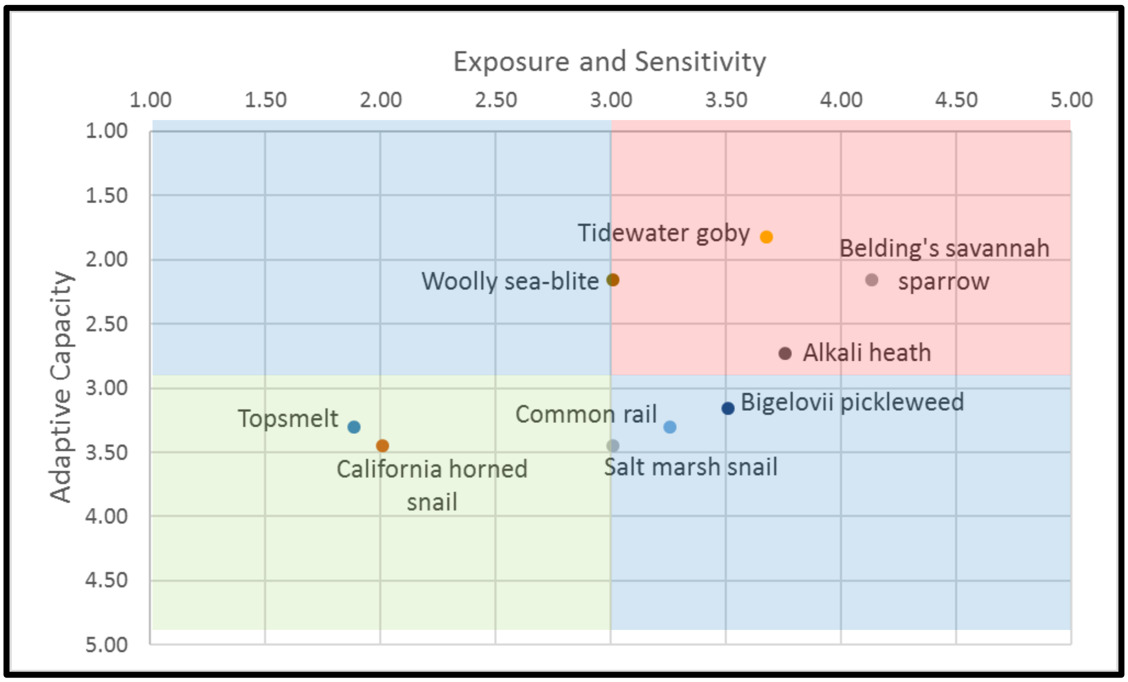


Figure 5-17. Estuarine Focal Species Vulnerability Scores

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

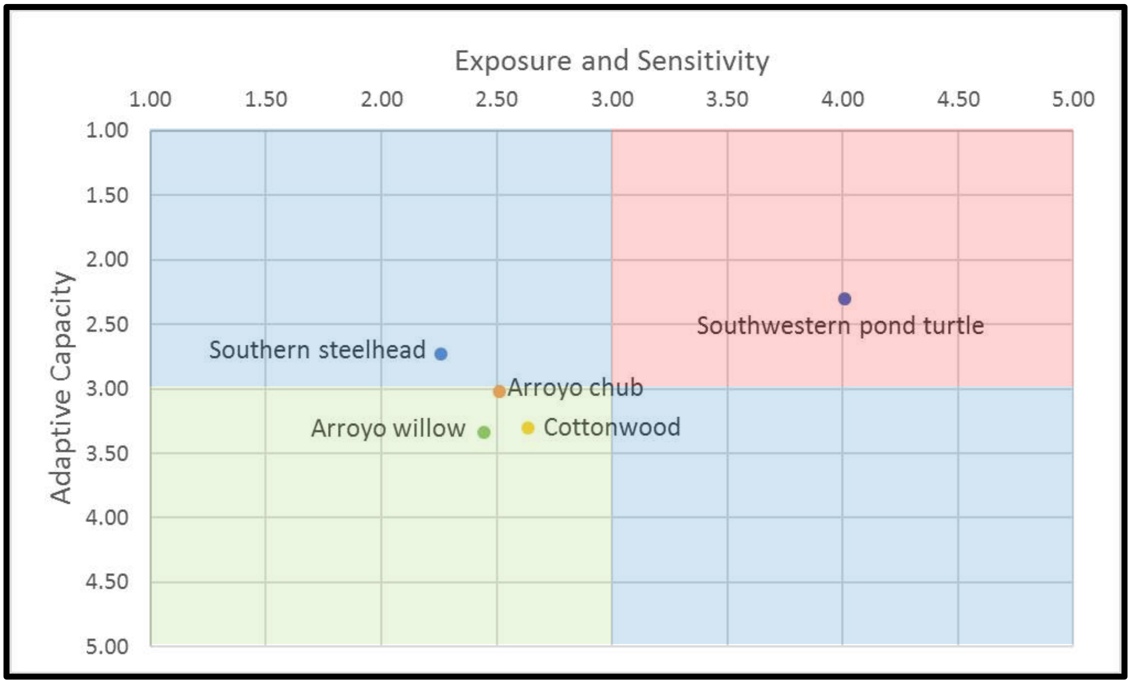


Figure 5-18. Freshwater Focal Species Vulnerability Scores

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.

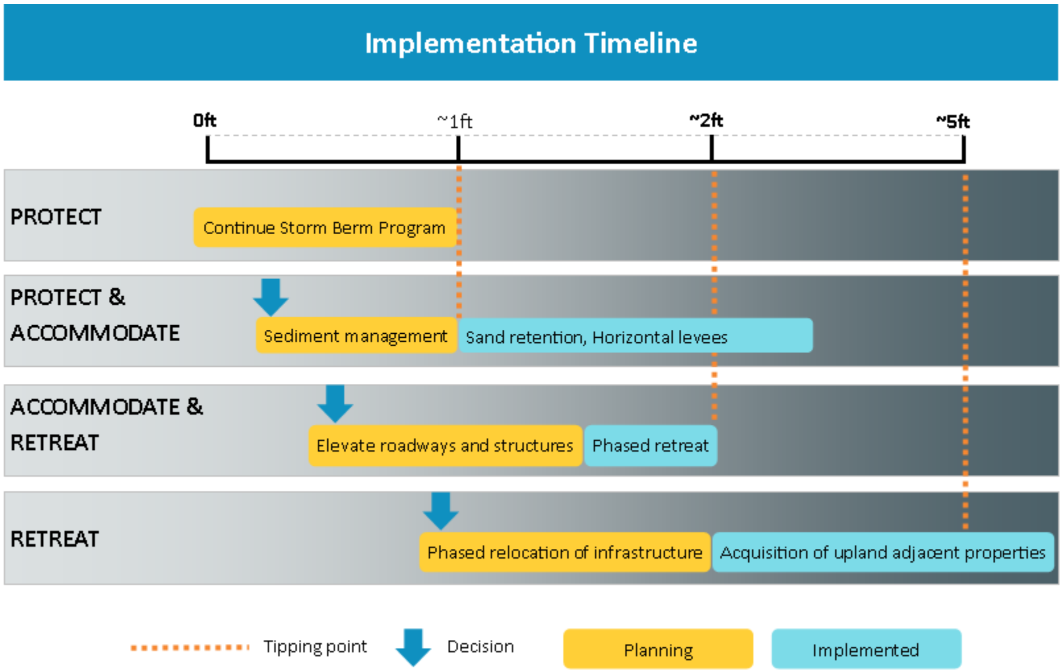


Figure 6-1. Example of an Implementation and Sea Level Rise Accommodation Timeline.

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.

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