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City of Carpinteria

Sea Level Rise Vulnerability Assessment and Adaptation Project

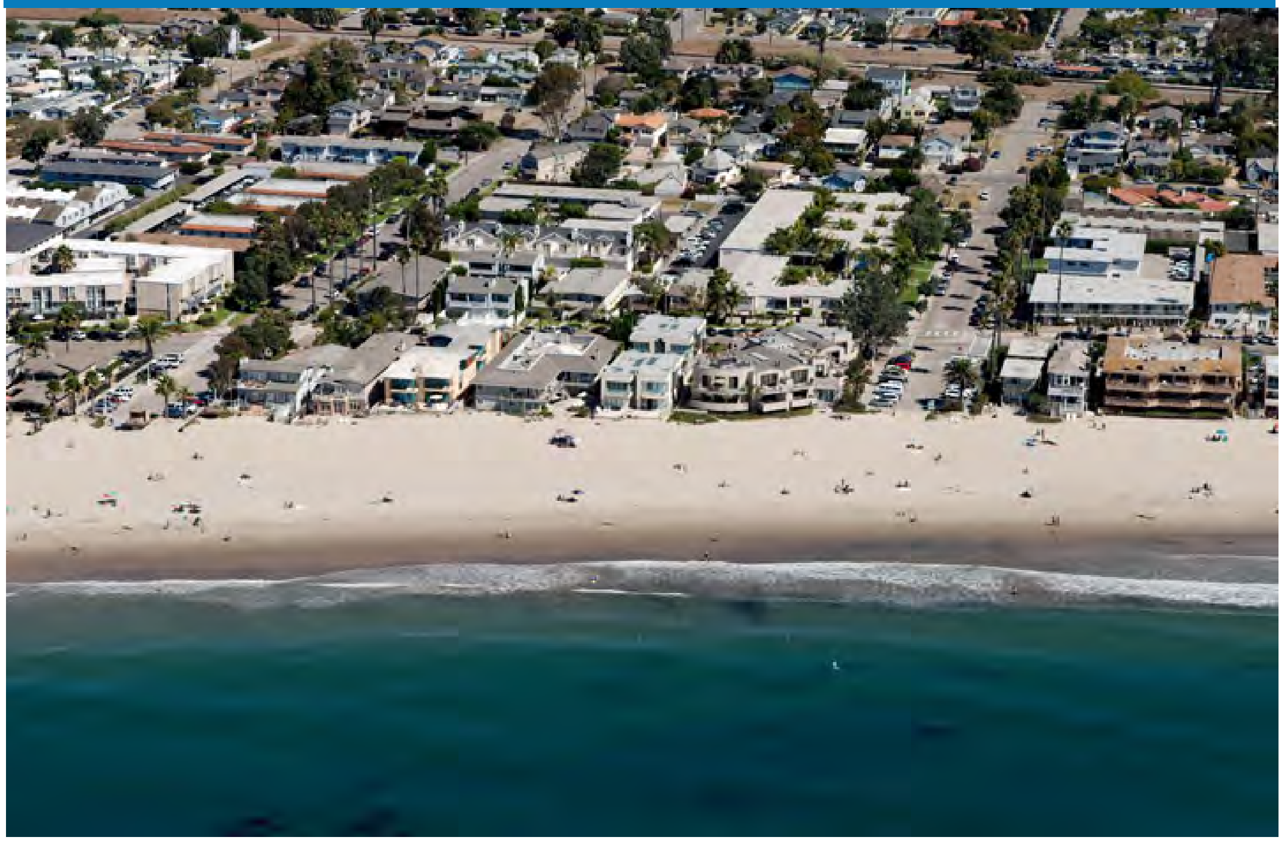

Photo courtesy of California Coastal Records

City of Carpinteria
5775 Carpinteria Avenue
Carpinteria, CA 93013

March 2019

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Definitions, Acronyms, & Abbreviations

Definitions

Definitions below are based upon the California Coastal Act and California Coastal Commission (CCC) *Sea Level Rise Policy Guidance* document; however, where appropriate, definitions have been refined to more accurately reflect the methodologies used in this investigation and related modeling (e.g., "Coastal Erosion" as defined below does not include wind and current attributes as project modeling did not have these factors).

1 percent Annual Chance Storm: A single storm wave event with a 1 percent annual chance of occurring in any given year based on extreme value analysis of historic storms (also referred to as a 100-Year storm event). A storm event of this magnitude on one day does not change the probability of another 1 percent annual chance event occurring in the same year.

100-Year/500-Year FEMA Flood Event: A fluvial flooding event based on extreme value analysis of historic storms with a 1 percent (100-Year)/0.2 percent (500-Year) chance of occurring in a given year; or a 1 in 100/1 in 500 chance of occurring in a given year. A storm event of this magnitude on one day does not change the probability of another 1 percent annual chance event occurring in the same year.

Active Cleanup Program Sites: State program that includes all non-federally owned sites currently undergoing active cleanup from an unauthorized release of toxic material.

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.

Coastal Confluence: The combination of fluvial flooding and high tides elevated by sea level that expands creek flooding extents.

Coastal Erosion: Loss of sand, sediment, vegetation, or soil in the beaches, dunes, bluffs, or cliffs along the coast caused by wave attack and bluff retreat.

Coastal Flooding: Flooding caused by wave run-up that occurs during high tide during a large 1 percent annual chance storm. The wave run-up typically has a velocity that can cause damage. While smaller magnitude storms could also cause damages, these were not considered in this report.

Coastal Zone: A regulatory zone established by State Legislature and shown on maps prepared by the California Coastal Commission, and for which the California Coastal Act establishes policies and regulations. The entire extent of the City of Carpinteria is within the Coastal Zone.

Climate Change: A shift from the normal climate weather patterns associated with a place, whether due to natural causes or as a result of human activity, such as the burning of fossil fuels and the release of greenhouse gases (GHGs).

Dwelling: Any residential structure or an apartment or condominium unit within a structure that is used for habitation and contains a kitchen. This does not include hotel/motel rooms or long-term communal or transitory type accommodation. This includes vacation rental units within defined residential zoning districts. There can be more than one dwelling within a building; these include multi-family, apartment, or condominium residential land uses.

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 Report are non-market benefits. Economists have developed several 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 non-market value. This Report incorporates the literature on non-market valuation to measure these changes. In addition to these direct economic impacts, beach recreation also has several indirect impacts on local spending, sales and transient occupancy tax revenues, etc. There are, however, no reliable means by which these indirect costs and benefits could be quantified without additional substantive work.

Economic Costs: Costs are measured similarly to economic benefits and can be measured as either market or non-market costs. In many cases in this Report, market costs are measured as replacement or repair costs. For example, this Report measured the costs of roads at replacement cost.

Economic Impacts: Measure of spending and economic activity resulting from a physical change to the landscape or a policy change.

Electronic Submittal of Information (ESI) Sites: Hazardous waste sites that are required to report regularly to the State Water Resources Control Board (SWRCB) for soil, vapor, underground storage, or land disposal activities.

Environmentally Sensitive Habitat Areas (ESHA): Any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.

Estuarine: Habitats where fresh water from creeks mixes with salty ocean water.

Extreme Monthly High Water: Highest tide elevation based on the average elevation of the highest monthly high tide for a 19-year tidal epoch period. This level would be expected to be inundated once a month.

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

Fluvial Flooding: Fluvial, or creek flooding, occurs when excessive rainfall over an extended period of time causes a river/stream/creek to exceed its channel capacity. The fluvial flood is usually described by the volume of streamflow. Actual flood extents can also be influenced by sedimentation, material obstruction of a water corridor (e.g., debris blocking culverts), and extreme high tides, but these are not typically included in the fluvial flood mapping.

King Tide: A non-scientific term for an extreme high spring tide that occurs when the Moon is the closest to Earth in its elliptical orbit. These typically occur three to four times per year.

Large Quantity Generators: EPA-administered program for sites that generate 1,000 kilograms per month or more of hazardous waste, or more than one kilogram per month of acutely hazardous waste. Examples may include larger industries, pharmacies, and large service stations.

Leaking Underground Storage Tanks: Includes underground storage tanks or underground piping connected to a tank that have had an unauthorized release (leak or spill) of a hazardous substance. Examples of these incidents include leaks at underground fuel tanks associated with gas stations or large fleet operators such as government facilities.

Maladaptation: An adaptation strategy which may protect a single sector but reduces the incentive to implementing additional adaptation measures while diminishing the long-term capacity to adapt in the future.

Net Benefits: Estimates the economic benefits minus the economic costs. Typically, these net benefits are discounted over time, making later generations less important than the current generation. However, in the economic analyses within this Report, discount rates were not used and everything is reported in 2017 dollars.

Open Space: A land use designation within the City of Carpinteria General Plan.

Planning Horizon: Within this Report, the span of time outward to the future when sea level rise or other climate-based impacts are projected to occur. This plan cycle is often defined by an agency to analyze and prepare for potential vulnerabilities, define a planning framework with policies focused on physical development of the land, and to manage community services and resources.

Sandshed: A system of sand supply and transport pathways that contain both watershed delivery and transport along the coastal littoral cell.

Sea Level Rise: Relative average rise in mean sea level. Global sea level rise, driven by the expansion of ocean waters as they warm, the addition of freshwater to the ocean from melting land-based ice sheets and glaciers, and extractions from groundwater. However regional and local factors such as techtonics and ocean and atmospheric circulation patterns result in relative sea level rise rates that may be higher or lower than the global average.

Sector: A category of natural or built resources, such as building structures, wastewater infrastructure, beach access, and ESHA.

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

Small Quantity Generators: EPA-administered program for sites that generate more than 100 kilograms per month, but less than 1,000 kilograms of hazardous waste per month. Examples may include: small service stations, dry cleaners, medical facilities, or a small wastewater treatment facility.

Tax Revenue Impact: Measures the changes in taxes as a result of a physical or policy change. This Report estimates changes in sales taxes and transient occupancy taxes (TOTs) resulting from changes in beach tourism/recreation caused by potential vulnerabilities to coastal hazards and sea level rise. In addition, the loss in property taxes from coastal erosion for 2018 and 2030 are estimated.

Tidal Inundation: Flooding caused during predictable monthly high tides that occur at least once a month.

Toxics Release Inventory: EPA-administered program that monitors industries that work with certain toxic chemicals that may pose a risk to human health and the environment. These facilities are typically larger industries that are involved in manufacturing, mining, power generation, or waste treatment.

Trigger: A measureable indicator that catalysts or "triggers" the start of a planning, permitting, and/or implementation process.

Vulnerability Assessment: Within this Report, the process of identifying, quantifying, and prioritizing (or ranking) potential exposures, threats, and values (intrinsic and economic) of resources and infrastructure in an area or a system.

Acronyms and Abbreviations

°F	Fahrenheit
ADT	average daily trips
BAU	Business as Usual
BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BFE	Base Floor Elevation
Cal OES	California Governor's Office of Emergency Services
Caltrans	California Department of Transportation
CCAMP	California Coastal Analysis and Mapping Project
CCC	California Coastal Commission
CCT	California Coastal Trail
CDP	Coastal Development Permits
CEC	California Energy Commission
CEVA	Coastal Ecosystem Vulnerability Assessment
CHAD	Coastal Hazard Abatement Districts
CIRGIS	Channel Islands Regional Geographic Information System
City	City of Carpinteria
CoSMoS	Coastal Storm Modeling System
County	County of Santa Barbara
CP	Coastal Plan
CRSMP	Coastal Regional Sediment Master Plan
CSBAT	California Sediment Benefits Analysis Tool
CSD	Carpinteria Sanitary District
CSLC	California State Lands Commission
CUPA	Certified Unified Program Agency
CVWD	Carpinteria Valley Water District
DOGGR	California Division of Oil, Gas, and Geothermal Resources
DTSC	Department of Toxic Substances Control
EFGS	Ecological Functions Goods and Services
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EMHW	Extreme Monthly High Water
EPA	U.S. Environmental Protection Agency
ESA	Environmental Science Associates
ESH	Environmentally Sensitive Habitat
ESHA	Environmentally Sensitive Habitat Areas
ESI	Electronic Submittal of Information
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GCM	Global Climate Model
GHAD	Geologic Hazard and Abatement District
GHG	Greenhouse Gas
GIS	Geographic Information System
GP	General Plan

GSW	General Steel Works
HMBP	Hazardous Materials Business Plan
HMP	Hazard Mitigation Plan
HPI	Housing Price Index
IPCC	Intergovernmental Panel on Climate Change
JPA	Joint Powers Agency
LCP	Local Coastal Plan
LHMP	Local Hazard Mitigation Plan
LiDAR	Light Detection and Ranging
LPT	Local Planning Team
LQG	Large Quantity Generators
LUP	Land Use Plan
LUST	Leaking Underground Storage Tank
MHW	Mean High Water
MJHMP	Multi-Jurisdictional Hazard Mitigation Plan
MLLW	Mean Lower Low Water
mm/year	millimeters per year (mm/year
MSL	Mean Sea Level
MTD	Metropolitan Transit District
NAVD	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OPC	Ocean Protection Council
OSPR	Office of Spill Prevention and Response
PDO	Pacific Decadal Oscillation
RCP	Relative Concentration Pathways
Report	2018 Coastal Resiliency, Vulnerability Assessment, and Adaptation Project
SBA	Santa Barbara Area
SCC	California State Coastal Conservancy
SCE	Southern California Edison
SLR	Sea Level Rise
SMR	Salt Marsh Reserve
SQG	Small Quantity Generator
State Parks	California Department of Parks and Recreation
SWRCB	California State Water Resources Control Board
TOT	Transient Occupancy Tax
TRI	Toxics Release Inventory
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WWTP	Wastewater Treatment Plant

Report, Map, & Data Disclaimer

This research is intended to help individuals and communities appreciate the vulnerabilities of the City of Carpinteria's resources to sea level rise based on the current available science. This Report is advisory and does not describe regulatory or legal actions that the City of Carpinteria or the California Coastal Commission may take to address sea level rise. This Report is part of an ongoing process to understand and prepare for future coastal hazards as a result of climate change. Substantial uncertainties exist with modeling and projecting future hazards and their potential impacts to the City of Carpinteria.

The data utilized for purposes of this Report were collected from various sources and are not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory or other legal uses. Users of the information displayed in maps are strongly cautioned to verify all information. Although the authors strive to review all resource sector and infrastructure data received, we cannot verify the completeness or accuracy of all spatial data. For this reason, Revell Coastal LLC, Wood PLC, and the City of Carpinteria are not responsible for any errors, omissions, or positional inaccuracy contained in this Report.

Neither the authors nor the City of Carpinteria are responsible or liable for financial or reputational implications or damages to homeowners, insurers, investors, mortgage holders or any other entities. The authors and City of Carpinteria do not warrant this Report. The content of this Report should not be relied upon to make business, real estate or other real-world decisions without independent consultation with professional experts with relevant experience.


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Executive Summary

ES.1 Purpose

This study examines coastal hazard vulnerabilities with approximately 5 feet of sea level rise by 2100. However, sea level rise projections for 2100 range from a low of 2 to 10 feet, with recent science identifying this higher level as the worst-case scenario.

Sea level rise rates in Carpinteria will be dependent on three factors – warming of the ocean, ice melt, and vertical land motion. Local oceanic and atmospheric circulation patterns and groundwater extractions do not have a significant direct influence upon sea level rise rates in the City of Carpinteria (City). Existing coastal hazards from severe storms cause erosion and wave flooding. Routine tidal inundation already affects community resources; sea level rise could exacerbate already difficult and often competing management challenges. Many of the affected areas were once historic wetlands before the development of Carpinteria. As the habitats have been altered and land uses expanded into flat low-lying areas, infrastructure, roads, and neighborhoods have been built in these areas. These habitats, land uses, and built infrastructure will need to adapt to rising sea levels. The process of examining existing and future vulnerabilities is the first step for a community to take in understanding the extent of the potential challenges and to begin discussing and formulating effective adaptation strategies over time to maintain the quality of life in Carpinteria.

This **2019 Sea Level Rise Vulnerability Assessment and Adaptation Project (Report)** provides the City, public service providers, interested members of the public, and community organizations with a comprehensive, science-based assessment of the vulnerabilities of City resources, structures, and infrastructure, as well as the potential for future damages to the City associated with various coastal hazards, including sea level rise. This Report will be used by the City to inform community discussions on the impacts from existing and future coastal hazards, identify a full range of potential future adaptation strategies that can be employed to reduce the risk of future damages, and identify thresholds of impacts that can guide long-term land use and planning goals, policies, and programs, including capital improvements and implementation measures related to citywide physical development. This Report's identified vulnerabilities will support adaptation planning to inform the update of the City's Coastal Land Use Plan and General Plan and (CLUP/General Plan), which will ultimately lead to enhanced community resilience.

Funding for this Report has been provided by the Local Coastal Program Planning Grant received from the California Coastal Commission (CCC) and the California Department of

Transportation (Caltrans) Adaptation Planning Grant (FY 2017-2018). The Report is prepared for the City of Carpinteria Community Development Department, with assistance from Wood Environment & Infrastructure Solutions, Inc. and Revell Coastal consultants.

ES.2 Report Overview

Chapter 1, *Sector Profiles*, summarizes the existing and future vulnerabilities of 11 key resource and infrastructure sectors to coastal hazards and sea level rise.

Chapter 2, *Background*, describes the planning process that was conducted as part of the preparation of the Report. This Report follows the steps outlined in the *Sea-Level Rise Policy Guidance* (CCC 2015) and the *State of California Sea-Level Rise Guidance* (California Ocean Protection Council [OPC] 2018) guidance for preparing local communities for sea level rise and an uncertain future. An overview of the efforts of other local jurisdictions to address coastal hazards, climate change, and sea level rise is also included in this section.

Chapter 3, *Existing Conditions & Physical Setting*, characterizes developed areas, natural resources, creeks, coastal and shoreline areas, and topography. Further details are provided in subsections that elaborate on the unique climate, geological, ecological, and coastal processes and hazards of the Carpinteria shoreline.

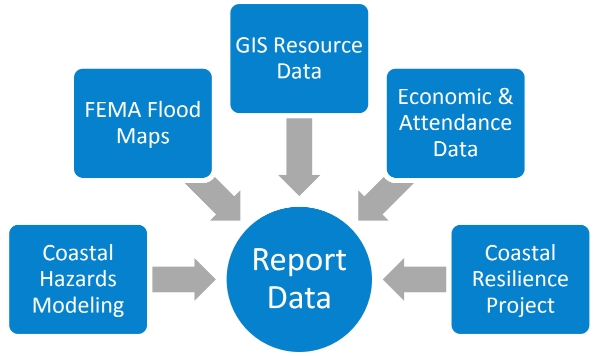
Chapter 4, *Climate & Sea Level Rise Science*, describes the current science on the topics of climate change and sea level rise. The scientific understanding of the natural climate cycles, human impacts, and feedback mechanisms within the earth systems continues to grow and evolve. A summary of the current state of the science in California is provided. In addition to the sea level rise projections used in the Report, a summary of the extreme worst-case scenario of up to 10 feet of sea level rise by 2100 (H++ scenario) is provided in Section 4.3 *Sea Level Rise*, of this Report. Table ES-1 shows the estimated elevations of sea level rise under the high emissions scenario and their associated probabilities by projected time in the future used in the Report. However, under the H++ worst-case scenario, the projected 5 feet of sea level rise could occur as early as 2070.

Table ES-1. Sea Level Rise Projections Used in the Carpinteria Vulnerability Assessment, with Associated Probabilities of Occurring in the Projected Year

Projected Horizon Year / Time	Sea Level Rise (inches/feet)	Probability of Occurring in Projected Year[1]
2030	10.2 in/~ 1 ft	<0.5%
2060	27.2 in/~ 2 ft	~2%
2100	60.2 in/~5 ft	~2%

Source: Revell Coastal and ESA 2016 and OPC 2018.
[1]The range of probabilities relate to scenarios in future greenhouse gas (GHG) emissions as well as sea level rise uncertainties largely associated with the rate of global ice sheet melt. The H++ scenario does not have a specific probability assigned and is presently considered the worst-case scenario.

Chapter 5, *Vulnerability Methodology*, provides an overview of methodologies used in assessing existing and projected vulnerabilities from coastal hazards. The City Community Development Department and consultant team evaluated a range of available coastal hazard models and sea level rise projections, with input from the CLUP/General Plan Update Committee and public. Input was also considered for key decisions including resource and service sectors to be included in the vulnerability assessment, during a public meeting in July 2017 (Appendix A). Based on comparative analysis and needs of the City, the hazard model selected is the County of Santa Barbara Coastal Resilience Project (Coastal Resilience), funded by the California State Coastal Conservancy (SCC) and the County of Santa Barbara (County) (Revell Coastal and Environmental Science Associates [ESA] 2016). Coastal Resilience modeling results are also used by the neighboring jurisdictions of Santa Barbara and Ventura Counties, and the Cities of Oxnard and Goleta.



Vulnerable assets, facilities, and infrastructure are identified by using Geographic Information System (GIS) data to determine the change between the existing (baseline) and each future hazard and sea level rise scenario. The results identify the potential effects of coastal hazards under a variety of future scenarios. The model does not consider the influence of existing development and/or future adaptation decisions.

Fiscal Land Use Impacts were assessed by:

1. Escalate County Assessors database to Fair Market Value (2017 $)
2. Estimate losses due to sea level rise/storms/ coastal erosion (2017 $)
   - Erosion impacts based on percent land and structure damage
   - Coastal flooding impacts based on depth of flooding and replacement
   - Tidal inundation based on "property (land and structure) at risk"

Economic analysis was conducted using County assessor data for land uses to fair market value to evaluate impacts to property, for both land and structures at risk. This included an evaluation of multi-unit structures such as apartments and condominiums as well as single parcels with multiple structures on them for each hazard type and sea level rise scenario. Recreation and camping data obtained from the California Department of Parks and Recreation (State Parks) and other local sources were used to estimate revenues associated with recreation. Additionally, replacement costs for key infrastructure was estimated based on readily available cost estimates from similar studies and City documents.

Chapter 6, *Sector Results*, provides an overview of potential risks to 11 resource sectors for three (3) sea level rise elevations (1 foot, 2 feet, and 5 feet of sea level rise) for the medium-high sea level rise scenario. Coastal hazards are presented and include the following:

- **Coastal Flooding:** Flooding caused by wave run-up and overtopping from a 1 percent annual chance storm.
- **Coastal Erosion:** Coastal erosion based on sea level rise and a 1 percent annual chance storm.
- **Tidal Inundation:** Tidal inundation based on a predicted monthly high tide.

For most of the resource sectors, the vulnerability assessment also includes an economic component to provide an initial estimate of fiscal impacts to the vulnerable resources. Further, information on potential vulnerabilities related to fluvial flooding and coastal confluence is included within Appendix C.

Chapter 7, *Adaptation Overview*, provides an overview of the process to identify potential adaptation strategies, followed by a discussion of possible strategies that may address Carpinteria-specific hazards and vulnerable assets. Tradeoffs of different adaptation strategies are presented to provide further context in the decision-making process. The focus is on the areas of protection, accommodation, and managed retreat, consistent with CCC policy guidance.

Chapter 8, *Adaptation and Resiliency Building Strategies,* identifies focused regional coordination needs, policy enhancements and specific sea level rise adaptation strategies that warrant additional analysis for the Carpinteria region as well as within three distinct areas in the City.

- Area 1: Beach Neighborhood
- Area 2: Carpinteria Salt Marsh
- Area 3: Carpinteria Bluffs

The adaptation strategies included within this Chapter are based on modeling of coastal hazards using the Coastal Resilience model, technical analysis within Chapter 6, *Sector Results*, and are intended to address impacts to known vulnerabilities within the City. In accordance with *Update to the Sea-Level Rise Policy Guidance* (CCC 2018), the adaptation strategies are based on best available science, known adaptation practices implemented in other regions, input from stakeholders, special districts, the CLUP/General Plan Update Committee, and the public. The below adaptation strategies were developed specifically with the intent of minimizing damage to the known vulnerabilities within Carpinteria and prioritizing the protection of assets valued most by the community.

ES.3 Key Findings of this Report

The future elevation and rates of sea level rise affect the extent of potential hazards and are projected estimates based on the best available science and modeling results. Rising sea levels alone are not anticipated to be the primary cause of vulnerabilities and potential damages to City resources and public infrastructure. Rather, impacts may be caused by existing severe storm coastal process-related hazards increasing in frequency and duration as a result of sea level rise. Initially, if sea level rise proceeds at the higher-level projections, episodic coastal erosion and coastal flooding impacts that already occur during large storm wave events could become more frequent as predictable high tides regularly inundate public beaches and City neighborhoods.

Figure ES-1. *Historic coastal erosion along Carpinteria City Beach, near Ash Avenue (Winter 1983).*

Coastal Hazards Expansion

Coastal hazards and sea level rise escalate potential damages from coastal flooding exposure, coastal erosion, and tidal inundation. Storm waves associated with a 1 percent annual chance storm have historically caused coastal flooding and coastal erosion in the Beach Neighborhood, Carpinteria State Beach, and along the Carpinteria Bluffs. Coastal confluence flooding, (creek flooding exacerbated by sea level rise), are also a future risk, however additional study is needed on this topic. Further information on coastal confluence and fluvial hazards is provided within Appendix C.

> Vulnerable residential dwellings exposed to coastal wave flooding within Carpinteria could increase from 86 today, to 237 by 2030, and up to 1,090 by 2100.

With approximately **1 foot of sea level rise**, coastal beach and dune erosion could increase the landward extent of coastal flooding, which in turn could raise the vulnerabilities of oceanfront dwellings and increase the likelihood of infrastructure damages in the Beach Neighborhood and Carpinteria State Beach. Salt Marsh Park could also be affected during storm events. Cliff erosion along Carpinteria Bluffs may affect the Union Pacific Railroad (UPRR) and recreational trails.

With approximately **2 feet of sea level rise**, more extensive coastal flooding and coastal beach erosion during storms could affect structures, land uses, and infrastructure between Ash and Linden Avenues north of UPRR, as well as in the Carpinteria State Beach campgrounds. Coastal bluff erosion could continue to impact UPRR, recreational trails, and habitats along the Carpinteria Bluffs. Coastal flooding may also begin to encroach the Carpinteria Salt Marsh and into the Beach Neighborhood. Routine high tides would largely be confined to existing creek channels and the Carpinteria Salt Marsh, but during rain events, the increased tide elevations would likely back up stormwater drains and could cause extensive stormwater flooding in low-lying neighborhoods.

With approximately **5 feet of sea level rise**, coastal beach erosion could extend through the first row of parcels to inland of Sandyland Road, and begin to affect dwellings and infrastructure in the Concha Loma Neighborhood. Coastal flooding during a large storm wave event could expand in depths and extend inland into the Downtown core along Linden Avenue, affecting portions inland of UPRR, Carpinteria Salt Marsh and areas along Franklin Creek. Coastal bluff erosion could continue to impact UPRR, recreational trails, and habitats along the Carpinteria Bluffs and potentially impact one commercial structure. Routine monthly high tides could inundate much of the Beach Neighborhood and Carpinteria State Beach inland to the Tomol Interpretative Park, even in areas not directly connected to the ocean due to daylighting (surfacing) of groundwater due to tidal inundations. While this Report used sea level rise scenarios and modeling data for approximately 5 feet of sea level rise occurring in 2100, under the worst-case H++ scenario, this could occur as early as 2070.

Key Vulnerabilities

The following is a summary of key community vulnerabilities, without adaptation in place. Please also refer to Chapter 1, *Sector Profiles,* and Chapter 6, *Sector Results*, for summaries of community resources and infrastructure vulnerabilities by time horizon, sea level rise elevation, and hazard type.

- **Residential Land Uses:** Residential dwellings are the most vulnerable land use exposed to coastal hazards and comprise over 90 percent of all parcels and structures at risk in the City today and in the future. Most of these impacts occur in the Beach Neighborhood. Multi-family units (apartments and condominiums) represent over 80 percent of these vulnerabilities, under both existing hazard conditions and in the future with increasing sea level rise. Many of these units are short-term (less than 30 days) rental properties; their loss may also impact transient occupancy tax (TOT) and sales tax revenues for the City.
- **Beaches and Dunes:** With approximately 5 feet of sea level rise by 2100, beaches and dunes would be severely eroded and frequently inundated. This would impact coastal recreation, Environmentally Sensitive Habitat Areas (ESHA), and expose landward development to coastal hazards and flooding. Transition of dry sandy beach and dunes over time to more frequently inundated intertidal or subtidal beach could impact City tax revenues and residents' quality of life if beaches narrow significantly or become largely intertidal/subtidal.
- **Coastal Access:** Today, during a 1 percent annual chance storm, all public coastal access points (vertical and lateral) are vulnerable to erosion and coastal flood hazards, especially when severe storms occur during high tides. Such a storm would affect beach visitation and recreational uses, and intertidal, dune, and reef habitats.
- **State Park Campground:** The Carpinteria State Beach and campground areas are vulnerable to coastal hazards with approximately 5 feet of sea level rise (2100). By 2100, 34 percent of the campground area may be damaged by coastal erosion; 31 percent may be vulnerable to tidal inundation; and 67 percent of the campground area may be flooded during large coastal storm events. Loss of the Carpinteria State Beach campground would result in the loss of low-cost overnight accommodations in the Coastal Zone, as well as a loss of open space and recreational opportunities.
- **State/City Beach Economic Revenues:** The total estimated spending for beach visitation is $48 million annually, generating $445,000 in sales taxes for the City, and just under $1.9 million in TOT for the City from overnight visitors who do not camp. Loss of the State and City Beaches could result in an economic impact associated with loss of beach visitation and associated spending. In addition to economic impacts, the State and City beaches are strongly associated with the community's identity and serve as important open space and recreation opportunities.

- **Structural Damage and Property Loss:** Overall, a total of 914 parcels and 627 structures (including many that are multi-unit residential) overlying 223.6 acres may be exposed to the combined threats of erosion loss, inundation exposure or flood damages with approximately 5 feet of sea level rise. While most of these properties are exposed to tidal inundation or coastal flooding, this vulnerability represents an estimated $439.9 million in total land use property *lost* to coastal erosion, $219.1 million in total flood *damages* to property from a single severe wave storm, and $651.1 million in potential property *exposure* to routine monthly high tides.
- **Railroad:** The UPRR corridor alignment along the Carpinteria Bluffs is highly vulnerable to coastal erosion; with approximately 5 feet of sea level rise, up to 1.4 miles of railroad could be damaged. This vulnerability may lead to pressure to repair existing seawalls or armor a significant portion of the City's shoreline, which could further impact coastal access, beach habitats, and sand supply. Coastal flooding could also impact UPRR in other parts of the City north of Carpinteria Salt Marsh and in the Downtown core. Disruption of UPRR could have substantial economic impacts to the region.
- **U.S. Highway 101:** U.S. Highway 101 (U.S. 101) would not be affected by any coastal hazard until ~5 feet of sea level rise. With ~5 feet of sea level rise, a nearly 1,500-foot section north of the Carpinteria Salt Marsh could be flooded during a large coastal storm event. This model does not take into account creek runoff, and the combined extent of flooding from a 1 percent annual chance storm and impacts could be greater when combined with increased rainfall and creek runoff from Santa Monica, Franklin, and Carpinteria Creeks. As noted above, under the H++ scenario, damage could occur earlier than 2100 and may be more frequent and severe.
- **Environmentally Sensitive Habitat Areas:** Coastal hazards and sea level rise could result in erosion or inundation of beaches and dunes, transition of high marsh ESHA to mudflat or subtidal habitats, transition of riparian habitat along Carpinteria Creek to estuarine wetlands, and substantial erosion of coastal bluff scrub and other terrestrial ESHAs along the Carpinteria Bluffs. With approximately 5 feet of sea level rise, more than 340 acres of ESHA may be impacted by dune or bluff erosion, tidal inundation or coastal flooding, with some ESHAs dependent upon landward migration to remain viable.
- **Bluffs:** With approximately 5 feet of sea level rise by 2100, Tar Pits Park and Carpinteria Bluffs are projected to erode 360-460 feet landward, damaging parks and trails, ESHA, and exposing the Concha Loma Neighborhood, commercial industrial development, and UPRR to severe erosion hazards. Armoring the shoreline would limit erosion damage but may in turn cause inundation and loss of beaches and intertidal habitats in these areas.
- **Affordable Housing:** Currently, no affordable units nor mobile home units are vulnerable to modeled coastal hazards (coastal erosion, coastal flooding, or tidal inundation). However, up to 41 of affordable housing units would vulnerable to coastal flooding and regular monthly tidal inundation with 5 feet of sea level rise.

Positive Findings

- No major emergency first response facilities (e.g., police, fire, or medical) would be exposed to coastal hazards with up to approximately 5 feet of sea level rise. However, three lifeguard towers are currently vulnerable to coastal flooding and coastal beach erosion on Carpinteria City Beach, and the Carpinteria State Beach Rangers Office/Visitors Center is vulnerable to coastal storm flooding with approximately 5 feet of sea level rise.
- No transit facilities (i.e., bus stops) would be subject to damage from erosion under any sea level rise scenario. Bus routes could be rerouted to avoid eroded or flooded roadways, though significant flooding associated with a coastal storm or tidal inundation combined with 5 feet of sea level rise could temporarily inhibit transit services.
- No hotels or motels would be vulnerable to coastal hazards with up to approximately 5 feet of sea level rise. However, many short-term rentals in the Beach Neighborhood could be exposed to the range of coastal hazards.
- Coastal erosion hazards associated with up to approximately 5 feet of sea level rise only affect three commercial parcels and one commercial structure within Carpinteria Bluffs.
- No municipal groundwater wells would be exposed to coastal hazards with up to approximately 5 feet of sea level rise.
- The City has minimal shoreline protection structures across its 2.5 miles of shoreline, largely as a result of its active seasonal winter storm berm program.[1] This creates an opportunity to plan for nature-based adaptation measures.
- Development within Bluff 0 would not be affected by coastal hazards with up to approximately 5 feet of sea level rise and represents an opportunity for future redevelopment when the site is remediated (refer to Figure 2-1).

Recommended Future Studies

This Report provides a comprehensive and programmatic analysis of potential hazards to the City associated with sea level rise. However, limitations and data gaps to the analysis have been identified. The following issues warrant further investigation. Additional studies are described within Section 8.6, *Recommendations and Next Steps*.

- **Coastal Confluence and Fluvial Hazard Modeling:** This Report provides partial analysis of potential fluvial and coastal confluence hazards in Appendix C. However, at the time of this analysis modeling data was limited. Improved modeling of coastal confluences and analysis of updated Federal Emergency Management Agency (FEMA)

[1] The City's seasonal winter storm berm program is not incorporated under modeling projections of future coastal hazards.

flood maps is recommended for a more comprehensive understanding of the extent of impacts.

- **Sediment Management:** Sediment debris basins in the Carpinteria Valley have had the negative effect of starving Carpinteria beaches of coarse grained materials which provide storm buffering capabilities. Further examination of sediment fluxes and the range of conditions that contribute sediment to the coast is warranted.
- **Future Redevelopment of Bluffs 0:** Bluffs 0 is located in a highly desirable area on the coast which could potentially be redeveloped following remediation of soil and groundwater resources with land uses that are subject to coastal hazards in other areas of the City.
- **Environmentally Sensitive Habitat Area (ESHA):** Additional study could be conducted to evaluate the potential impacts of the full suite of climate change variables (e.g. temperature, precipitation, drought, sea level rise, etc.) to provide a better understanding of the potential future impacts to ESHA.

ES.4 Adaptation Planning and Next Steps

A variety of cost and benefit tradeoffs between adaptation strategies exist and are essential to understand to help decision-makers determine the most effective policies and project-level adaptation strategies to implement. Adaptation planning is introduced in Chapter 7, *Adaptation Planning,* of this Report, with more specific adaptation strategies identified as a result of this analysis in Chapter 8, *Adaptation and Resiliency Building Strategies*. Adaptation planning requires considering each vulnerable sector and taking effective and timely actions to reduce the anticipated consequences.

Sea level rise adaptation generally falls into five main categories, consistent with CCC policy guidance:

- **Do nothing** or a policy of non-intervention is also considered an adaptation strategy, and often results in emergency response at the highest cost without consideration of the full range of tradeoffs and secondary impacts.
- **Protection strategies** employ engineered structures or other measures to protect existing development (or other resources) in its current location without changes to the development itself. Protection strategies can range from “grey” or “hard” engineered seawalls to “green” or “soft” natural dune defenses.
- **Accommodation strategies** employ methods that modify existing or design new developments or infrastructure to decrease hazard risks. On a community-scale, these strategies include changes in land use designations, zoning ordinances, or clustering development in less vulnerable areas. On an individual project scale, these accommodation strategies include actions such as elevating structures.

- **Managed retreat strategies** gradually realign infrastructure and development away from hazard areas and limit new construction in those same areas. These strategies can include a range of policies and programs that incentivize relocation such as repetitive loss programs, acquisition and buy-out programs, and transfer of development rights programs. The key to effectiveness is determining which, if any, of these policies fit the local community's goals and adaptation strategies, and then managing their implementation in a proactive, phased, and orderly manner to avoid expensive emergency responses.
- **Hybrid strategies** blend a variety of strategies to achieve different hazard reduction and resource protection goals across a range of time horizons. The effectiveness of different adaptation strategies varies across time and space. There is no single adaptation strategy that will effectively adapt to climate impacts; a hybrid approach that uses strategies from multiple categories will be necessary, and the suite of strategies will change over time.

Recommended Adaptation Strategies

The City has identified a range of adaptation strategies with consideration to the community's values and priorities, including maintaining the City's small beach town character and high quality of life, protection of public access to the beach and coastal recreational opportunities, and protecting or adapting vulnerable neighborhoods within the City's fiscal capabilities. A list of key adaptation strategies is provided in Table ES-2.

Table ES-2. Summary of Adaption Strategies for Carpinteria

Adaptation Strategy	Description & Approach
Winter Storm Berm Program	• Continue the existing winter storm beach berm program to protect the Beach Neighborhood from high energy wave events
Army Corps of Engineers Storm Damage and Shoreline Protection Feasibility Study	• USACE has an existing agreement with the City to conduct a coastal erosion feasibility study and fund a mitigation strategy as a result of construction of the Santa Barbara Harbor • Opportunity to identify project to address the coastal erosion issues, such as nourishment, cobbles, sediment management pier, using USACE funding
BEACON Projects	• BEACON projects and programs represent a valuable opportunity for the City to begin early coordination and/or collaboration with BEACON to optimize protection of City resources from coastal hazards

Table ES-2. Summary of Adaption Strategies for Carpinteria (Continued)

Adaptation Strategy	Description & Approach
Living Shoreline/ Dune Restoration	• Create a cobble and vegetative dune system along the City beach that would serve as the first line of defense during a large storm event, protecting landward development within the Beach Neighborhood
Sediment & Beach Nourishment	• Work with BEACON to develop a program that augments existing sand supply along the beaches and bluffs to provide additional natural defenses against wave attack by dissipating wave energy and buffering the bluffs and backshore from erosion • Opportunistic beach nourishment activities in coordination with Santa Barbara County Flood Control and BEACON
Sand Retention Structures	• Cross shore sand retention structures are designed to trap sand and are often used to widen beaches which provide more natural defenses to coastal wave hazards. Sand retention structures can take many forms, the most common is called a groin. Other examples include a recreational pier • Offshore structures dissipate high energy waves and result in less erosion and flooding. These can be designed as a nature-based solution such as a multi-purpose reef, a natural rock outcrop feature
Stormwater Infrastructure Improvements	• Beach Neighborhood: Rainfall events and high tides can create areas of ponded flood waters within the Beach Neighborhood. Modifications such as channel improvements along Franklin Creek, pumps, an floodgates could reduce flooding • Carpinteria Bluffs: Capital improvement to drainage outlets along the bluffs, which may accelerate the rate of bluff erosion
Coastal Adaptation Overlay	• Establish policy and program framework for adaptation such as a development standards for accommodation of sea level rise • Place a special zone district over properties within defined coastal hazard areas with provision of additional adaptation options to avoid the need for developers to seek costly variances for projects that are designed to avoid or accommodate sea level rise hazards but may not be consistent with existing zoning
Repetitive Loss Program	• In the long-term, relocate development subject to repetitive damage and highly vulnerable utility infrastructure
Union Pacific Railroad/LOSSAN Rail Corridor	• Downtown: Elevate the railroad to serve as flood protection for the Downtown area north of the tracks • Carpinteria Salt Marsh: Raise the railroad on a causeway to provide opening for tidal inundation to extend beyond the tracks and encourage wetland transgression • Carpinteria Bluffs: Armoring to slow erosion of the bluffs

Next Steps

The next steps include developing the long-term vision for the coast of Carpinteria, discussing with the community and decision-makers the potential pros and cons of each adaptation strategy, and accepting a certain level of risk to guide the selection of future adaptation strategies. This work will be evolving and the City's adaptation strategy will be refined as the science continues to provide updated and more accurate data, continued dialog with the community, and coordination with local and state agencies. Additional analysis of the potential site-specific could better inform decision-making and adaptation planning.

- **Financing Strategy:** the City would identify, evaluate, and pursue all feasible potential sources of revenue for funding within Section 8.5, *Funding Mechanisms*. The costs of priority adaptation strategies would be allocated and shared in proportion to the benefits realized by the affected parties, including the public, the City, and the beachfront and bluff property owners, respectively.
- **Future Technical Study:** Given the significant vulnerabilities identified in this Report, the City may consider a more detailed analysis of certain hazards or site-specific study to inform implementation of an adaptation strategy. Therefore, this Report recommends additional study to support City adaptation planning efforts prior to implementation of any of adaptation measure.
- **Public Outreach:** The City will continue to solicit input, comments and feedback from the public, agencies, and interested parties on these proposed adaptation strategies. Successful implementation of any adaptation strategy requires communication of vulnerabilities, potential adaptation tradeoffs, costs, and alternatives.
- **Multi-Agency Coordination:** The City will need to address coastal hazards by establishing collaborative regional solutions and partnerships with adjacent and affected jurisdictions and entities.
- **Monitoring Sea Level Rise and Triggers:** The City will monitor sea level rise elevation data, storm frequency, and storm damages to determine when to implement adaptation measures, with sufficient time for coordination, planning, permitting, engineering, and financing.

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1. Sector Profiles

In order to address sea level rise and associated coastal hazards, the City of Carpinteria (City) and its consultant team prepared the 2019 Sea Level Rise Vulnerability Assessment and Adaptation Project (Report). The purpose of this Report is to provide technical analysis using climatic modeling and geospatial analyses to support the City's efforts to incorporate policy responses to a range of coastal and climate change hazards into the City's planning and regulatory processes in the Coastal Zone. This information will assist the City in making decisions regarding land use policies and development standards from a long-range planning level to the individual project level. These sector profiles summarize the findings of the vulnerability analyses to support decision-making. Each of the following sectors contain a vulnerability map and summary of findings:

- Land Use Parcels and Structures
- Roads and Parking
- Public Transportation
- Camping and Visitor Accommodations
- Coastal Trails and Access
- Hazardous Materials Sites, and Oil and Gas Wells
- Stormwater Infrastructure
- Wastewater Infrastructure
- Water Supply Infrastructure
- Community Facilities and Critical Services
- Environmentally Sensitive Habitat Area

Within each sector profile, an overview provides a summary of the key findings for each sector. Existing and future vulnerabilities highlight potential risks from tidal inundation, coastal erosion, and coastal flooding. For each projected sea level rise elevations, results are summarized based on what becomes vulnerable. If nothing is reported with additional sea level rise over that timeframe, no additional vulnerabilities are identified.

The approximately 5 feet of sea level rise by 2100 scenario identifies both what becomes vulnerable between approximately 2 and approximately 5 feet of sea level rise, as well as the cumulative totals for all planning horizons. Please note that under the worst-case H++, approximately 5 feet of sea level rise could occur as early as 2070.

A range of potential adaptation strategies to address potential vulnerabilities are identified within the sector.

Potential next steps include examples of policy direction, monitoring needs, and potential adaptation projects. Section 7, *Adaptation Overview,* and Section 8, *Specific Adaptation and Resiliency Strategies* further identify and recommend potential adaptation strategies based on vulnerable assets, community priorities, and stakeholder input, within the framework of the California Coastal Act, California Coastal Commission (CCC) 2018 *Sea Level Rise Policy Guidance – Final Science Update*.

LAND USE PARCELS AND STRUCTURES

Overview

Land uses are categorized by: (1) residential, (2) commercial and mixed use, (3) industrial, and (4) open space and recreation. To identify land uses vulnerable to SLR and coastal hazards, this study evaluated the following:

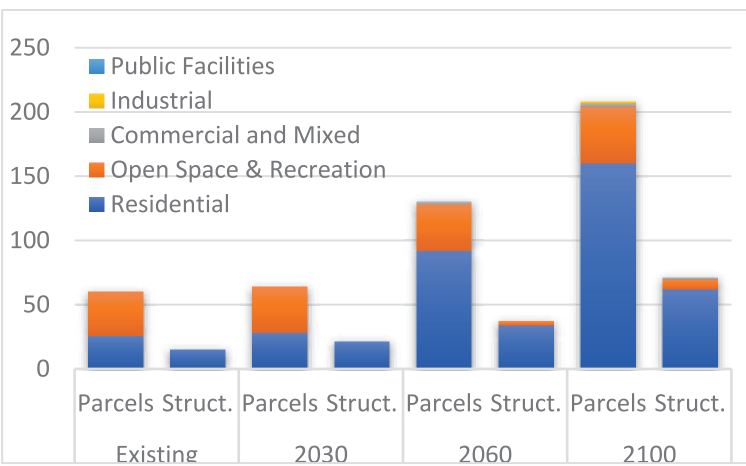
Number of Parcels/Acreages/Number of Structures at Risk with 5' of SLR

Residential	Commercial & Mixed Use	Industrial	Open Space & Recreational
769/44.8 acres/579	20/5.85 acres/16	10/5.02 acres/11	59/105.82 acres/11

- **Property damage from coastal flooding and erosion**
- **Property values exposed to tidal flooding**

Currently, residential parcels comprise approximately 90% of all parcels vulnerable to coastal hazards. Most of these vulnerable parcels are in the Beach Neighborhood. **With 1' of SLR**, coastal flooding extends further inland into the Beach Neighborhood. **With 2' of SLR**, beach/dune erosion could damage parcels/homes in the Beach Neighborhood south of Sandyland Road due to flooding and minor periodic tidal inundation. **With 5' of SLR**, the Concha Loma Neighborhood and Carpinteria Bluffs would see substantial erosion; much of the Beach Neighborhood could be damaged/inundated by high monthly tides. Although not the focus of this study, fluvial (creek) flooding creates substantial existing and future vulnerabilities to many land uses (see Appendix C).

Coastal Erosion

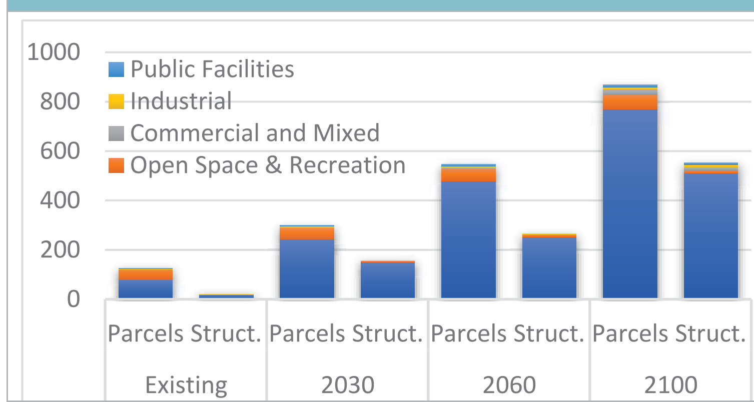


Currently, beach/dune erosion could damage 15 residential structures and State and City lifeguard towers are at risk. With 5' of SLR, 132 residential parcels may be eroded, with homes damaged/ destroyed and restrooms on Ash Ave. and State Beach become vulnerable. No commercial or industrial structures are at risk.

Cliff erosion currently exposes 18 open space parcels (39.2 acres) along the Carpinteria Bluffs to damage. With 5' of SLR, erosion accelerates and 44 open space parcels may be at risk, including Bluff 0, and 28 residential parcels and the UPRR and 21 structures with in the Concha Loma Neighborhood and up to 3 structures in bluffs industrial area.

ECONOMICS: Without adaptation, coastal erosion damage to all land uses escalate from an existing $3.7 million to $35.9 million with 1' of SLR, $114.8 million with 2' of SLR, and $285.5 million with 5' of SLR; damage primarily impacts Beach Neighborhood residential multi-unit properties in the, Concha Loma homes, Bluff industrial buildings Carpinteria Bluffs open space and UPRR.

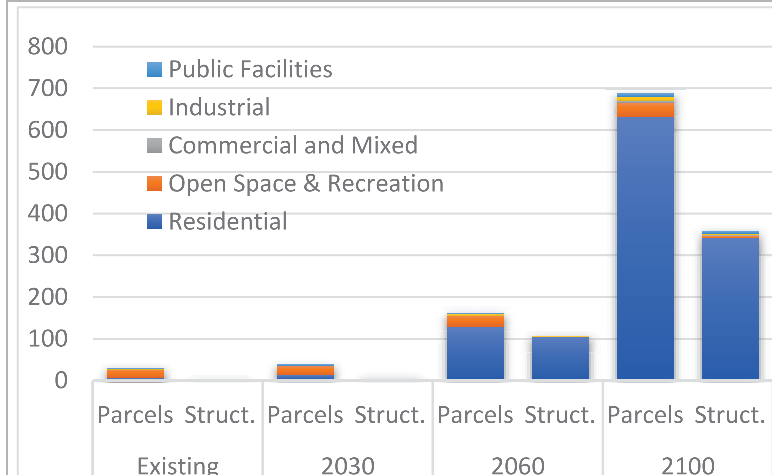
Coastal Flooding



Currently, 20 structures (19 residential and 1 industrial) are vulnerable. This increases to 156 structures with 1' of SLR, mainly in the Beach Neighborhood. With 2' of SLR, 265 total structures become vulnerable extending north of the railroad and inland of the Salt Marsh. With 5' of SLR, 553 total structures could be exposed to flooding; homes north of the State Park and the Salt Marsh may be at risk. 11 additional commercial buildings and 9 industrial structures become vulnerable in a large wave event with 5' of SLR, particularly along Carpinteria Avenue.

ECONOMICS: Currently $8.5 million of property is vulnerable to coastal flooding from a 1% wave event, rising to $28.0 million with 1' of SLR, $53.8 million with 2' of SLR, and $128.8 million with 5' of SLR, the majority of which is multi-unit residences in the Beach Neighborhood, with flooding extending inland to and beyond the UPRR.

Tidal Inundation



Currently, monthly tidal inundation does not impact structures. By 2' of SLR, risk increases to 105 residential structures. With 5' of SLR, monthly tidal inundation is projected to affect 510 residential, 13 commercial, and 11 industrial structures; monthly high tides inundate Beach Neighborhood to UPRR.

ECONOMICS: Estimates for tidal inundation impacts are for property value at risk. Actual damages will likely be smaller (e.g., frequent clean up and repair)**.** Currently, $800,000 (mainly open space) is exposed, though exposure rises quickly to $42.1 million in 2030, $111.5 million with 2' of SLR, and $496.7 million with 5' of SLR.

Adaptation Strategies

Range of Strategies:

Protect – Develop a regular beach nourishment program with both sand and cobbles. Transition the winter storm berm program to a permenant "living shoreline" dune system to protect against coastal erosion. Examine potential of offshore structures and sand retention structures to dissipate wave energy and/or widen the natural beaches.

Accommodate – Amend City building code and zoning ordinance to improve foundation requirements or to enable elevation and/or relocation to occur over time. Update setback requirements to account for acceleration of erosion.

Manage – Develop a repetitive loss program to allow for public acquisition of properties. Establish a coastal adaptation overlay zone that would encourage the siting of new development or redevelopment away from coastal hazards.

Trade-offs: Managed retreat strategies may result in loss of development and subsequent impacts to City's tax base/ revenues. Hard armoring may protect some structures, but could also threaten the beach, coastal recreation and access, natural processes and habitats over time. Green protection strategies (e.g., sediment nourishment, dunes) may benefit beach recreation and protect homes but require routine maintenance, regular secure funding, and may be less effective with 5' of SLR without other actions.

Potential Next Steps

Policy:

- Allow increases to base floor elevation or movable foundation standards for new development.
- Develop real estate disclosure requirements to inform homebuyers of the risk of living adjacent to the coast.
- Potentially require abandonment or relocation of derelict or threatened structures.
- Establish an assessment district or seek regular state/ federal funding for shoreline management (e.g., beach nourishment).

Projects:

- Support regional beach nourishment and develop a long-term dune and shoreline management plan.

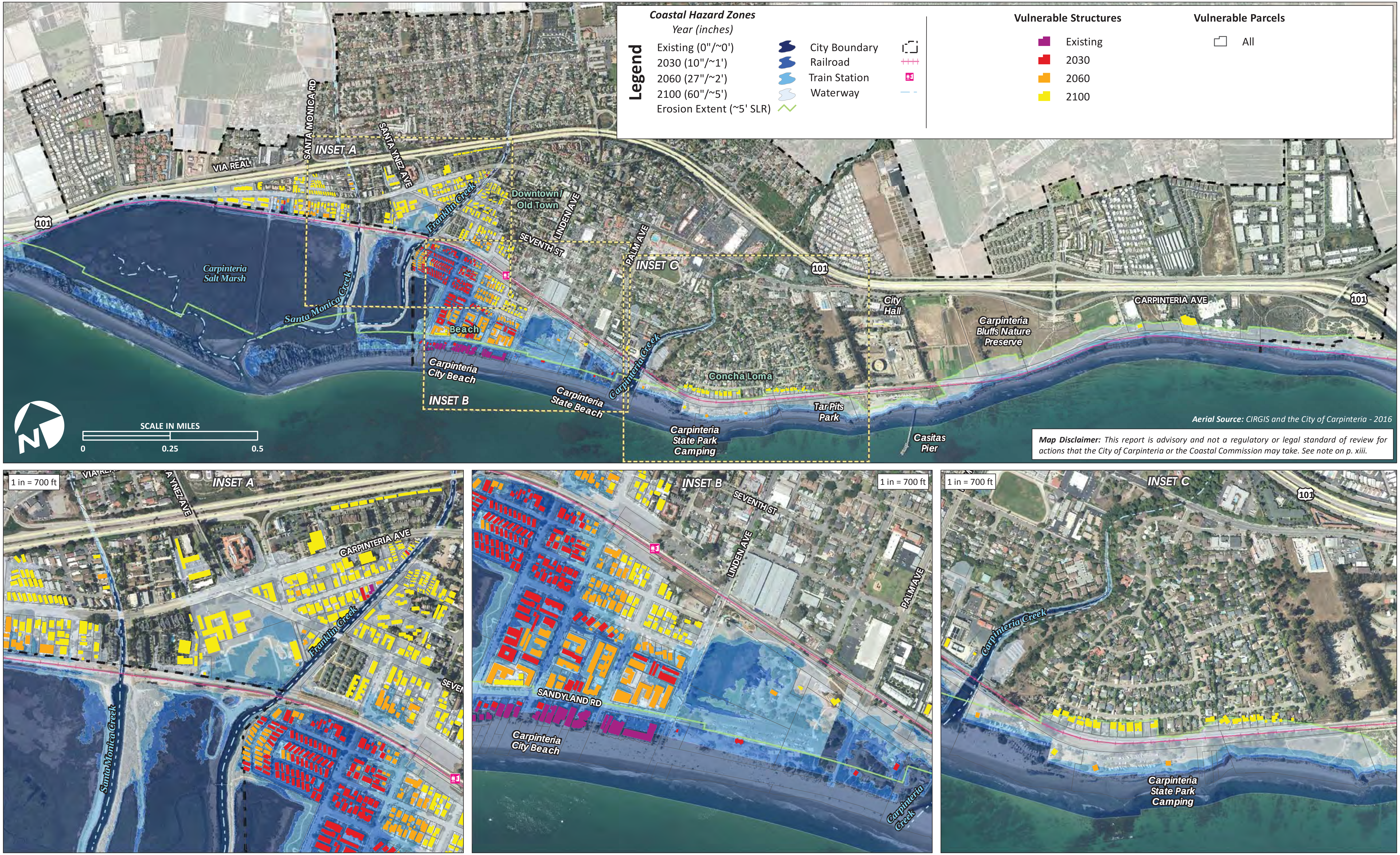
Monitoring:

- Monitor frequency, duration, and depth of flood impacts.

Tipping Point:

- With 2' of SLR, substantial damages are projected.

Figure 1-1. Land Use Parcels and Structures



ROADS AND PARKING

Overview

To identify roads and parking facilities potentially vulnerable to climate change and SLR hazards, this study evaluated:

- **50.3 Miles of Roads**
- **16 Parking Areas**

Currently, coastal erosion and tidal inundation do not substantially impact roads or parking. Street end parking in the Beach Neighborhood and State Park lots are currently exposed to coastal flooding. **With 1' of SLR,** additional roads and street end parking in the Beach Neighborhood and Carpinteria State Beach becomes at risk from coastal flooding, which may include damage or loss of roadways. **With 2' of SLR,** coastal flooding impacts escalate and affect an additional 2.0 miles of roads and coastal erosion may impact 7 parking lots. **With 5' of SLR,** road impacts from all coastal hazards increase substantially. Coastal flooding could pose a risk to a total 4.8 miles of roads and 11 parking lots in the Beach Neighborhood, Carpinteria State Beach and Downtown north (inland) of the railroad, including the train station parking lot (City Parking Lot #3). A total of 8 parking areas could become routinely inundated during monthly high tides, and 9 lots could be exposed to erosion in the Beach Neighborhood and Carpinteria State Beach.

U.S. 101 in Carpinteria could be affected by coastal flooding with 5' of SLR.

Tipping Point: With 2' of SLR, tidal inundation impacts to roads and erosion impacts to parking lots escalate.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
• Roads – <0.1-mile • Parking Lots – 0	• Roads – <0.1-mile • Parking Lots – 0	• Roads – 0.1-mile • Parking Lots – 7

Roads: Roadways in the immediate vicinity of the City Beach and State Beach are the most vulnerable to coastal hazards.

Parking: Public coastal access parking lots at the ends of Ash, Holly, Elm, and Linden Avenues in the Beach Neighborhood, and Carpinteria State Beach parking lots are currently at risk from coastal flooding during a 1% annual chance storm.

ECONOMICS: Damage to parking facilities may affect beach visitation and consumer spending.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Roads – <0.1-mile • Parking Lots – 0	• Roads – <0.1-mile • Parking Lots – 1	• Roads – 1.1 miles • Parking Lots – 8

Roads: 1.1 miles of roads become vulnerable to hazards along lower Linden and Elm Avenues.

Parking: 1 additional parking lot at the end of Linden Avenue in the Beach Neighborhood becomes at risk to coastal erosion, and 1 additional parking lot at Carpinteria State Beach becomes vulnerable to coastal flooding.

ECONOMICS: Damage to parking facilities may affect beach visitation, consumer spending and require recurring expensive clean up and repair.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Roads – 0.8-mile • Parking Lots – 1	• Roads – 0.1-mile • Parking Lots – 7	• Roads – 2.0 miles • Parking Lots – 8

Roads: Coastal hazards expand to impact Ash, Holly, Elm, and Linden Avenues further into the Beach Neighborhood.

Parking: Additional parking facilities that were previously exposed to only coastal flooding become exposed to coastal erosion and tidal inundation.

ECONOMICS: Potential road damage from coastal erosion (325 feet) is estimated at $90,000; recurring impacts to roads and parking areas would require expensive clean up and repair costs that could impact City and State Park budgets.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Roads – 3.0 miles • Parking Lots – 8	• Roads – 0.7-mile • Parking Lots – 9	• Roads – 4.8 miles • Parking Lots – 11

Roads: Impacts from all coastal hazards increase substantially, affecting additional roadways including all of the Beach Neighborhood, Carpinteria State Beach, north of the railroad, U.S. Highway 101, and inland of the Salt Marsh along portions of Carpinteria Ave and 7th Street near Franklin Creek.

Parking: Coastal hazard impacts could extend to onstreet parking in the Beach Neighborhood, facilities in Carpinteria State Beach, the train station parking lot (City Parking Lot #3), and curbside parking along Holly Avenue.

ECONOMICS: Potential road replacement costs are estimated at $1,050,000 (3,733 feet) from coastal erosion. Disruption to U.S. Highway 101 could have significant economic consequences. Damage to parking may affect beach visitation and spending; recurring impacts to roads and parking areas expensive clean up and repair could impact City and State Park budgets.

Adaptation Strategies

Range of Strategies:

Protect – Implement regular beach nourishment program with both cobbles and sand. Expand the winter storm berm program to create a "living shoreline" dune system to protect against coastal erosion. Consider a combination of dune system with sand retention where needed to maintain a sandy beach buffer that protects essential roads or parking.

Accommodate – Elevate roads and parking lots above future projected coastal flood levels through construction of raised causeways, or by incrementally elevating road and parking area surfaces by 2-3 inches during routine repaving. Install storm drain pumps to dewater the most vulnerable road segments and parking areas.

Manage – Relocate or remove roads and parking lots from the hazardous areas along the shoreline.

Trade-offs:

Management strategies may impact traffic and coastal access, depending on the location of realigned roads. Increasing road and parking elevation may flood adjacent properties or exacerbate storm water flooding. Green protection measures such as beach or dune nourishment require recurring maintenance expenses, with more frequent maintenance requirements for higher levels of SLR. Gray techniques using revetments would provide protection, but could impact beach and dune habitats, natural processes and coastal access.

Potential Next Steps

Policy:

- Coordinate with Caltrans to ensure that regional connections such as U.S. Highway 101 remain intact.
- Coordinate with State Parks on shoreline management, beach nourishment, and coastal access parking.
- Coordinate with the County, coastal cities, BEACON, and local state legislators to create a sustainable funding mechanism for beach nourishment.

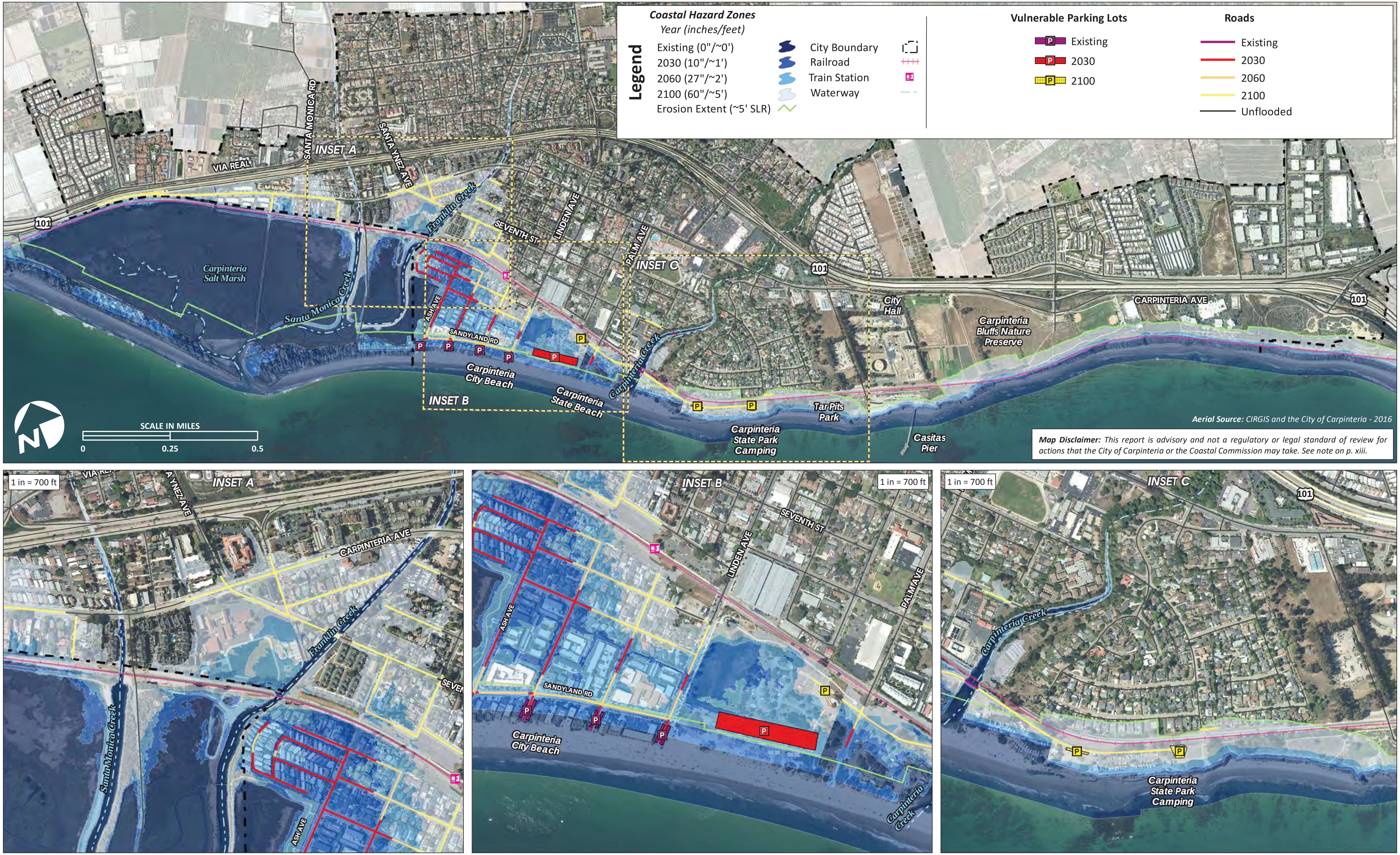
Projects:

- Redesign, realign, or relocate critical roads and parking.
- Amend the City's Capital Improvement Plan to require roadway elevation during street resurfacing.
- Perform regular beach nourishment and dune restoration.

Monitoring:

- Update the Local Hazard Mitigation Plan (LHMP) to identify preferred adaptation strategies to reduce impacts to roads and parking facilities.
- Monitor depth, extent, and frequency of road and parking facility flooding along areas with identified vulnerability.

Figure 1-2. Roads and Parking



PUBLIC TRANSPORTATION

Overview

To identify public transportation facilities potentially vulnerable to climate change and SLR hazards, this study evaluated the following:

- **13.4 Miles of Class I, II, and III Bikeways**
- **21.8 Miles of Bus Routes; 50 Bus Stops**
- **2.54 Miles of Railroad; 1 Train Station**

Union Pacific Railroad (UPRR) along Carpinteria Bluffs, with Casitas Pier in the background. (Photo: M. MacDougall)

Currently, episodic coastal bluff erosion damage to railroad segments has led to construction of emergency revetments. **With 1' to 2' of SLR,** additional public transportation facilities, such as bus and bike routes within the Beach Neighborhood, Downtown, and along the Bluffs, become vulnerable to coastal hazards, such as bike routes on Sandyland Road and the Seaside Shuttle bus route Linden Avenue. **With 5' of SLR,** cliff erosion may damage 1.5 miles or roughly ½ of the rail alignment through the City. An estimated 1.5 mile of railroad, 2.0 miles of bus routes, and 1.2 miles of bike routes may be subject to coastal flooding. Tidal inundation will routinely close about <0.1-mile of railroad, 1.0 mile of bus routes, and 0.7-mile of bike routes during high tides. Disruption of the rail line could seriously disrupt freight, commuter, and other visitor traffic in Carpinteria and throughout the region.

Tipping Point: With ~1' of SLR, the railroad faces an expanded risk of cliff erosion. With ~2' of SLR, damage becomes widespread to rail. With ~5' of SLR as tidal inundation forces routine closures, overlapping bike and bus route vulnerabilities escalate.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
Bike – 0 miles	Bike – 0 miles	Bike – <0.1-mile
Bus – 0 miles	Bus – 0 miles	Bus – 0 miles
Rail – <0.1-mile	Rail – 0.1-mile	Rail – 0.1-mile

Bike: A small portion of the Class II lane along Linden Avenue is currently at risk from coastal flooding.
Bus: Currently, coastal hazards do not pose any risk to bus facilities.
Rail: Portions of the railroad near Carpinteria Creek and along the Bluffs are currently at risk from all coastal hazards.
***ECONOMICS**:* Potential railroad damages from coastal erosion (388 feet) are estimated at $130,000. Damage costs only consider construction costs of a new rail segment. Any disruption to the railroad, bus, and/or bike facilities would have costs due to loss of alternative transportation, coastal access, and recreation; however, these costs are not quantified.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
Bike – 0 miles	Bike – 0 miles	Bike – <0.1-mile
Bus – <0.1-mile	Bus – 0 miles	Bus – 0.3-mile
Rail – <0.1-mile	Rail – 0.4-mile	Rail – 0.4-mile

Bike: Coastal flooding could expand along an additional 209 feet (265 feet total) of Class III routes along Sandyland Road and Ash and Linden Avenues.
Bus: Portions of Seaside Shuttle bus route along Linden Avenue become vulnerable to tidal inundation and coastal flooding.
Rail: Coastal erosion impacts to the railroad could expand an additional 0.3-mile (0.4-mile total) along the Bluffs, and coastal flooding impacts to the railroad could expand an additional 0.3-mile (0.4-mile total) near Carpinteria Creek.
***ECONOMICS**:* Potential railroad replacement costs increase to $760,000 (2,223 feet total) from coastal erosion.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
Bike – 0 miles	Bike – <0.1-mile	Bike – <0.1-mile
Bus – 0.2-mile	Bus – 0 miles	Bus – 0.7-mile
Rail – <0.1-mile	Rail – -0.8-mile	Rail – 0.9-mile

Bike: Coastal flooding may affect an additional 408 feet (673 feet total) of Class III routes in the Beach Neighborhood. A small portion of the Class II lanes along Linden Avenue becomes vulnerable to coastal erosion.
Bus: Tidal inundation and coastal flooding may affect an additional 0.4-mile (0.7-mile total) and 0.4-mile (0.6-mile feet total) respectively of the Seaside Shuttle bus route along Linden Avenue.
Rail: Coastal erosion and flooding may damage an additional 0.4-mile of railroad segments along the Bluffs.
***ECONOMICS**:* Potential railroad replacement costs increase to $1,510,000 (4,394 feet total) from coastal erosion; costs of substantial flood damage to bus and bike facilities is unknown.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
Bike – 0.7-mile	Bike – <0.1-mile	Bike – 1.2 miles
Bus – 0.8-mile	Bus – 0.3-mile	Bus – 2.0 miles / 2 stops
Rail – <0.1-mile	Rail – 1.4 miles	Rail – 1.5 miles

Bike: Bike routes become vulnerable to tidal inundation, an additional 132 feet (194 feet total) become at risk of coastal erosion, and an additional 1.1 miles (1.2 miles total) become at risk of coastal flooding. All coastal hazards could impact portions of Class III routes in the Beach Neighborhood along Sandyland Road and Ash Avenue. Coastal flooding may impact the Carpinteria Avenue Class II lane east of the Salt Marsh and the Carpinteria Avenue and 7th Street Class III route around Franklin Creek.

Bus: Tidal inundation and coastal flooding may inundate an additional 0.6-mile (0.8-mile total) and 0.6-mile (1.5 miles total) respectively of the Seaside Shuttle bus route in the Downtown. Two bus stops may become impacted by coastal flooding on Linden and Carpinteria Avenues. Coastal erosion may damage a 0.3-mile total of the Seaside Shuttle bus route in the Beach Neighborhood.

Rail: Coastal erosion and coastal flooding impacts may expand to a total of 1.4 miles (55%) and 1.5 miles (59%) of railroad, respectively, along the Bluffs, State Park, and near the Train Station.

***ECONOMICS**:* Potential railroad replacement costs increase to $2,550,000 (7,432 feet total) from coastal erosion, costs of substantial flood damages to bus and bike facilities is unknown.

Adaptation Strategies

Range of Strategies:

Protect – Work with UPRR to coordinate railroad track elevations that protect the railroad as well as important resources in the Salt Marsh and Downtown. Control bluff face drainage and restore coastal bluff scrub vegetation to minimize bluff erosion. Build or augment cobble and sand dunes and/or other shoreline protective devices.

Accommodate – Elevate roads and bikeways to accommodate higher flood water levels. Add an additional 2-3 inches of asphalt during routine repaving of roads and bikeways. Coordinate with LOSSAN to elevate portion of the railroad Downtown.

Manage – Relocate or reroute bikeways and bus routes from the hazardous areas along shoreline. Install stormwater pumps to dewater the most vulnerable road segments.

Trade-offs: Accommodation through increased road elevation may create additional stormwater drainage issues. Green protection measures such as beach and dune nourishment may require frequent maintenance, particularly with higher levels of SLR. Gray protection strategies would likely be effective in protecting public transportation facilities, but could have negative impacts for beach and dune habitats, natural processes, and coastal access.

Potential Next Steps

Policy:

- Develop alternative bikeways and bus routes further inland.
- Identify the status of various coastal armoring strategies in the County.
- Coordinate with UPRR on use of green and gray protection measures, and identify the opportunity for collaboration on future plans and adaptation strategies.

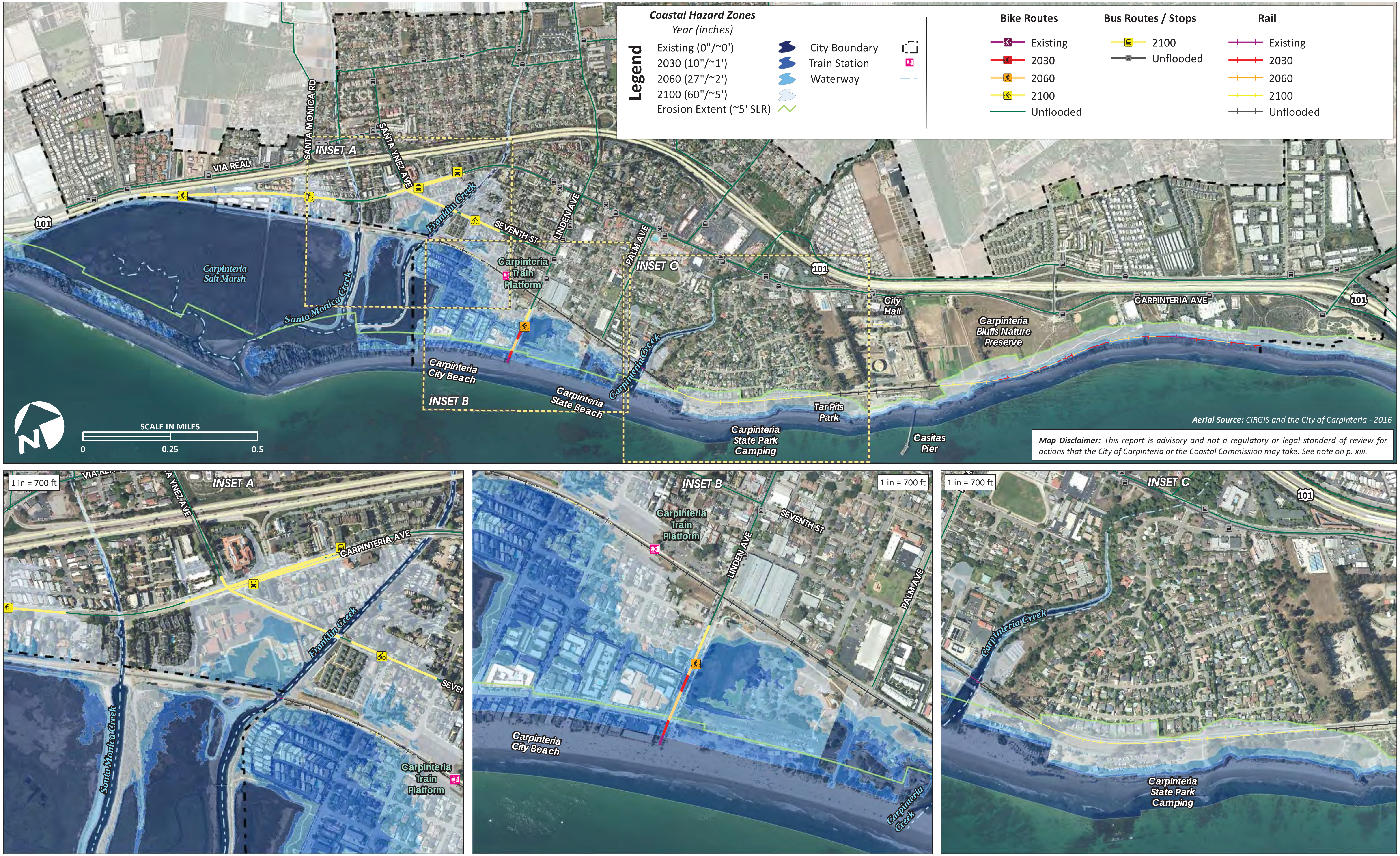
Projects:

- Amend the City's Capital Improvement Plan to add additional inches to roadways during routine street resurfacing efforts in order to gain elevation at or greater than the pace of SLR.
- Coordinate with BEACON to identify and develop strategic beach nourishment projects.

Monitoring:

- Monitor the depth, extent, and frequency of road and railroad flooding and erosion along existing alignments.

Figure 1-3. Public Transportation



CAMPING AND VISITOR SERVING LAND USES / ACCOMMODATIONS

Overview

To identify camping and visitor serving accommodations potentially vulnerable to SLR hazards, this study evaluated the following:

- **4 Campgrounds in Carpinteria State Beach - 18.6 Acres of Camping Area**
- **231 State Park Campsites – Santa Cruz (47 sites), Santa Rosa (80 sites), Anacapa (30 sites), San Miguel (56 sites)**
- **5 Hotels/Motels**
- **218 Short Term Rental (STR) Unit Permitted Licenses (189 existing rentals)**

Currently, 2 State Beach campgrounds are vulnerable to coastal erosion and coastal flooding. **With 1' and 2' of SLR,** all 4 campgrounds become vulnerable to all coastal hazards. **With 5' of SLR,** potential impacts to all 4 campgrounds increase for all coastal hazards; coastal erosion could affect one-third of current State Beach camping visitation. No hotels/motels are at risk from any coastal hazard currently or in the future, but the majority of STR units located in the Beach Neighborhood are vulnerable to all coastal hazards with 5' of SLR. The estimated 189 existing STR units (e.g., AirBnB) of the 219 permitted under City ordinance, primarily located in the Beach Neighborhood generate an estimated $400,000 in annual transient occupancy taxes (ToT) for the City. Carpinteria State Beach averages over 420,000 overnight campers annually, the City and State Beaches average over 1.5 million visitors annually, and beach visitors currently generate $445,000 in sales tax revenue and hotel guest and STR renters generate $2.3 million in ToT revenue for the City annually.

__Tipping Point:__ With 2' of SLR, coastal erosion and flooding could impact camp visits by damaging/destroying a substantial number of campsites and associated acreage.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
• Campgrounds – 0 / 0 acres	• Campgrounds – 2 / 1.1 acres	• Campgrounds – 2 / 3.0 acres

Camping: 2 campgrounds, Santa Cruz and Santa Rosa, are potentially vulnerable to coastal (dune) erosion and coastal flooding during a large wave event. Dune erosion from a 1% annual chance wave event may lead to a loss of 36,954 campers annually.

Hotels/Motels: Currently, there are no hotels/motels at risk from any coastal hazards.

STR: All 55 allowable STR units within Area A located seaward of Sandyland Road in the Beach Neighborhood are potentially vulnerable to coastal flooding, particularly first floor units. The majority of allowable STR units in Areas Band C (up to 145 units) inland of Sandyland Road are also potentially vulnerable to coastal flooding, particulary ground floor damage.

ECONOMICS: Carpinteria's City and State beaches generate ~1.5 million visits per year, generating $445,000 in sales tax and hotels/ modtels $1.9 million in ToTannual revenues for the City. STRs generated ~$400,000 in transient occupany tax (TOT) revenues for the City annually. As potential vulnerabilities increase, damages may affect visitation and in turn, State and City revenues. Coastal fooding that affects beach parking may also diminish attendance and spending.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Campgrounds – 0 / 0 acres	• Campgrounds – 2 / 1.6 acres	• Campgrounds – 2 / 5.5 acres

Camping: 2 additional campgrounds (4 total), Anacapa and San Miguel, become vulnerable to 0.5-acre (1.6 acres total) of potential coastal (beach/ dune) erosion, and 2.5 acres (5.5 acres total) of camping area become at risk from coastal flooding during a large wave event.

STR: Potential coastal flooding with 1' of SLR exposes STR units in Areas B inland of Sandyland Road, and a few in Area C further inland in the Beach Neighborhood become vulnerable to coastal flooding, particularly ground floor areas. Potential STR units in Area A become vulnerable to damage from beach/ dune erosion, including ground floor and parking.

ECONOMICS: The State Beach could lose ~53,000 camping days due to coastal (beach/ dune) erosion with a 1% annual chance wave event, with the City potentially loosing ToT revenue during cleanup/ repair of flooded STR units. Coastal (cliff) erosion could impact a small area of State Beach campground potentially losing approximately 400 annual visitors.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Campgrounds – 1 / 0.3-acre	• Campgrounds – 0 / 2.3 acres	• Campgrounds – 4 / 9.7 acres

Camping: Portions of the Anacapa campground become vulnerable to tidal inundation. An additional 1.4 acres (2.9 acres total) of area in Anacapa and San Miguel campgrounds becomes at risk to coastal (dune and cliff) erosion. An additional 4.2 acres (9.7 acres total) of area in all 4 campgrounds could be impacted by coastal flooding during a large wave event.

STR: 55 allowable STR units in Area A of the Beach Neighborhood become vulnerable to more frequent and severe damage due to beach/ dune erosion and coastal flooding; extent and severity of coastal expands in Areas B, C, and D to inland of 4th Street, with more frequent and severe damage to up to 163 STR units, particular to ground floors.

ECONOMICS: The State Beach could lose ~79,000 camping days (19% of total) due to coastal (beach/ dune) erosion from a 100-year storm, and ~20,000 camping days due to coastal (cliff) erosion, or almost 5% of total camping days, impacting City sales tax and State Beach revenues. Damage to and required cleanup/ repair of STR units would reduce City ToT revenue.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Campgrounds – 5.8 acres	• Campgrounds – 4.1 acres	• Campgrounds - 12.4 acres

Camping: Tidal inundation may affect an additional 5.5 acres (5.8 acres total; 31%) of campgrounds. Coastal erosion could impact an additional 1.8 acres (4.1 acres total; 34%) of campgrounds. Coastal flooding may impact an additional 2.7 acres of camping areas (12.4 acres total; 67% of camping areas) during large wave events.

Hotels/Motels: No hotels/motels become at risk from any coastal hazards.

STR: The majority of the 218 allowable STR units in the Beach Neighborhood become vulnerable to tidal inundation and coastal flooding, with more frequent and severe damage. The 55 allowable STR units in Zone A seaward of Sandyland Road becone exposed to frequent wave attack and severe recurring damage, reducingng continued viability of these units.

ECONOMICS: State Beach camping days could be reduced by ~140,000 camping days annually (33%) of total) due to beach/ dune erosion; ~76,000 annual camping days (18% of total) vulnerable due to cliff erosion. Tidal inundation could reduce camping days by ~40,000 (~10% of total). impacting City sales tax and State Beach revenues. Damage to and required cleanup/ repair of STR units would reduce City ToT revenue that was $400,00 in 2017.

Adaptation Strategies

__Range of Strategies:__

Protect – Consider implementing gray shoreline protective measures such as sand retention and offshore breakwaters. Consider green strategies such as development of a "living shoreline" dune system and regular beach nourishment with sand and/or cobbles.

Accommodate – Elevate the grade of campgrounds and STR units to reduce imapcts of coastal flooding/tidal inundation. Encourage flood proofing and reinforcement of first floors in STRs. Upgrade storm drainage in Beach Neighborhood by installing pumps, lift stations, and other improvements.

Manage – Coordinate with State Parks to redesign or relocate campsites and facilities to less vulnerable areas of the State Beach. Adjust Short Term Rental program as needed to shift allowable units to less vulnerable areas.

__Trade-offs:__ STR upgrades and location shifting may be contentious among property owners. Green adaptation measures require regular maintenance and associated costs, particularly with higher SLR. Coastal armoring strategies would protect capgrounds and STRs but would impact beach/dune habitats, natural processes and coastal access.

Potential Next Steps

__Policy:__

- Coordinate with State Parks to identify a long-range plan for future beach access and seasonal closures for the State Park campgrounds considering SLR and coastal hazards.
- Coordinate with the County, coastal cities, BEACON and local legislators to create sustainable funding mechanism for beach nourishment.

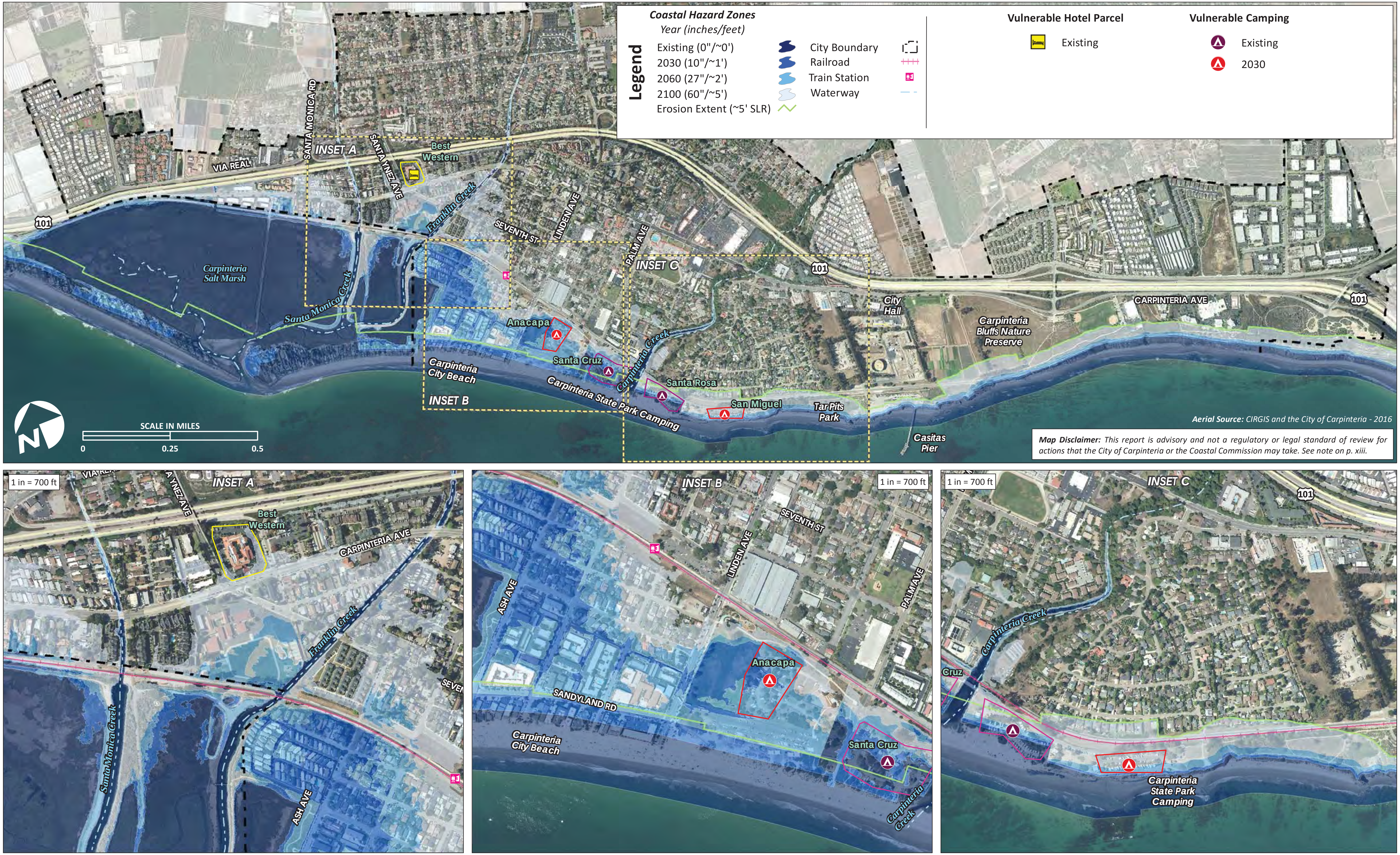
__Monitoring:__

- Monitor depth, extent, and frequency of flooding within the State Park.

__Data Gaps:__

- Precise campground/ amenity footprints.

Figure 1-4. Camping and Visitor Accommodation



COASTAL ACCESS AND TRAILS

Overview

To identify coastal access ways and trails potentially vulnerable to climate change and SLR hazards, this study evaluated the following:

- **13 Vertical Coastal Access Points**
- **2.5 Miles of Lateral Coastal Access**
- **5.2 Miles of Trails (Salt Marsh & Bluffs)**

Vertical Coastal Access and bluff top trail near seal haulout *(Photo: California Coastal Records*

Ash Avenue Vertical Coastal Access and Carpinteria Salt Marsh Trail *(Photo: California Coastal Records Project)*.

Currently, all the vertical coastal access points and all lateral coastal trails are vulnerable to coastal erosion and coastal flooding, and more than half of them are vulnerable to tidal inundation. **With 5' of SLR,** all vertical access trails, lateral coastal access along beach and all bluff top coastal trails and those within Carpinteria Salt Marsh Park are vulnerable to coastal erosion, coastal flooding, and tidal inundation.

<u>Tipping Point:</u> With 2' of SLR, coastal erosion and flooding regularly impacts beaches, and dunes and cliff erosion impact lateral and vertical access trails.

Existing Vulnerabilities

<u>Tidal Inundation</u>
- Vertical Coastal Access Points – >6
- Lateral Coastal Access – 2.5 miles
- Trails – <0.1-mile

<u>Coastal Erosion</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 1.2 miles

<u>Coastal Flooding</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 1.3 miles

Vertical Coastal Access: At least half of the vertical access points west of Carpineria Creek are susceptible to tidal inundation during monthly extreme tides or large coastal storm waves, and all access points are currently at risk from coastal erosion and and coastal flooding; vertical access points east of Carpinteria Creek (e.g., Tar Pits Park, Carpinteria Bluffs) are vulnerable to cliff erosion.

Lateral Coastal Access: All 2.5 miles (100%) of lateral access along City beaches are vulnerable to coastal flooding and erosion from a 100-year wave event, but generally recover post-storm.

Trails: 0.4-mile (100%) of the Carpinteria Salt Marsh Trail is susceptible to coastal flooding.

ECONOMICS: Carpinteria's beaches generate 1.5 million beach-day visits per year, with 600,000 going to the City Beach and 910,000 attending the State Beach. Beach visitors spend $48 million per year, generating $445,000 in sales tax revenue for the City and $2.3 million in ToT revenue from hotels and short term rentals. This study did not estimate costs associated with loss in recreational value or replacement of trails.

Future Vulnerabilities

10.2 inches (~1 foot) by 2030

<u>Tidal Inundation (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – <0.1-mile

<u>Coastal Erosion (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 1.9 miles

<u>Coastal Flooding (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 2.2 miles

Vertical Coastal Access: All vertical access points are susceptible to tidal inundation and continue to be vulnerable to coastal erosion and coastal flooding.

Lateral Coastal Access: Lateral beach access along all 2.5 miles of City beaches becomes more vulnerable to to tidal inundation, coastal erosion, and coastal flooding.

Trails: Coastal erosion may impact an additional 0.7-mile (15%) of the bluff top trail through the Carpinteria Bluffs.

27.2 inches (~2 feet) by 2060

<u>Tidal Inundation (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 0.1-mile

<u>Coastal Erosion (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 2.7 miles

<u>Coastal Flooding (total)</u>
- Vertical Coastal Access Points – 13 additional
- Lateral Coastal Access – 2.5 miles
- Trails – 3.4 miles

Vertical Coastal Access: All vertical access points continue to be vulnerable to coastal/cliff erosion and/or coastal flooding. At the State Beach, coastal hazards could extend further inland from the vertical access points.

Lateral Coastal Access: All lateral access is susceptible to tidal inundation, coastal erosion, and coastal flooding.

Trails: Coastal cliff erosion may impact an additional 0.8-mile (17%) of the bluff top trail that transverses the Carpinteria Bluffs, Carpinteria State Beach, Tar Pits Park, and Carpinteria Salt Marsh Park.

60.2 inches (~5 feet) by 2100

<u>Tidal Inundation (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 1.4 miles

<u>Coastal Erosion (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 4.6 miles

<u>Coastal Flooding (total)</u>
- Vertical Coastal Access Points – 13
- Lateral Coastal Access – 2.5 miles
- Trails – 5.4 miles

Vertical Coastal Access: All vertical access points continue to be vulnerable to coastal erosion and coastal flooding. At the State Beach, coastal hazards could extend further inland from the vertical access points.

Lateral Coastal Access: Depending on degree of shoreline retreat, beach may transition to intertidal and subtitidal, severely limiting lateral beach access.

Trails: Coastal erosion may impact an additional 1.9 miles or 40% a total of 4.6 miles of the bluff top trail and interweaving trails of the various parks along the City's almost 3.0-mile long shoreline extent.

Adaptation Strategies

<u>Range of Strategies:</u>

Protect – Consider green protection measures such as augmentation of sand dunes and cobble beach nourishment. Consider gray protection devices such as sand retention structures or offshore breakwaters.

Accommodate – Elevate the grade of trails to accommodate future coastal flood levels.

Manage – Remove or relocate trails and coastal access ways away from areas vulnerable to coastal hazards.

<u>Trade-offs:</u> Green protection measures may benefit lateral access by maintaining sandy and intertidal beaches for recreational uses, but require regular maintenance, particularly with higher levels of SLR. Gray protection measures would effectively protect coastal access and trails but could lead to loss of beaches and public access over time. Measures such as sand retention or offshore breakwaters may better maintain access and beaches over time as compared to revetments.

Potential Next Steps

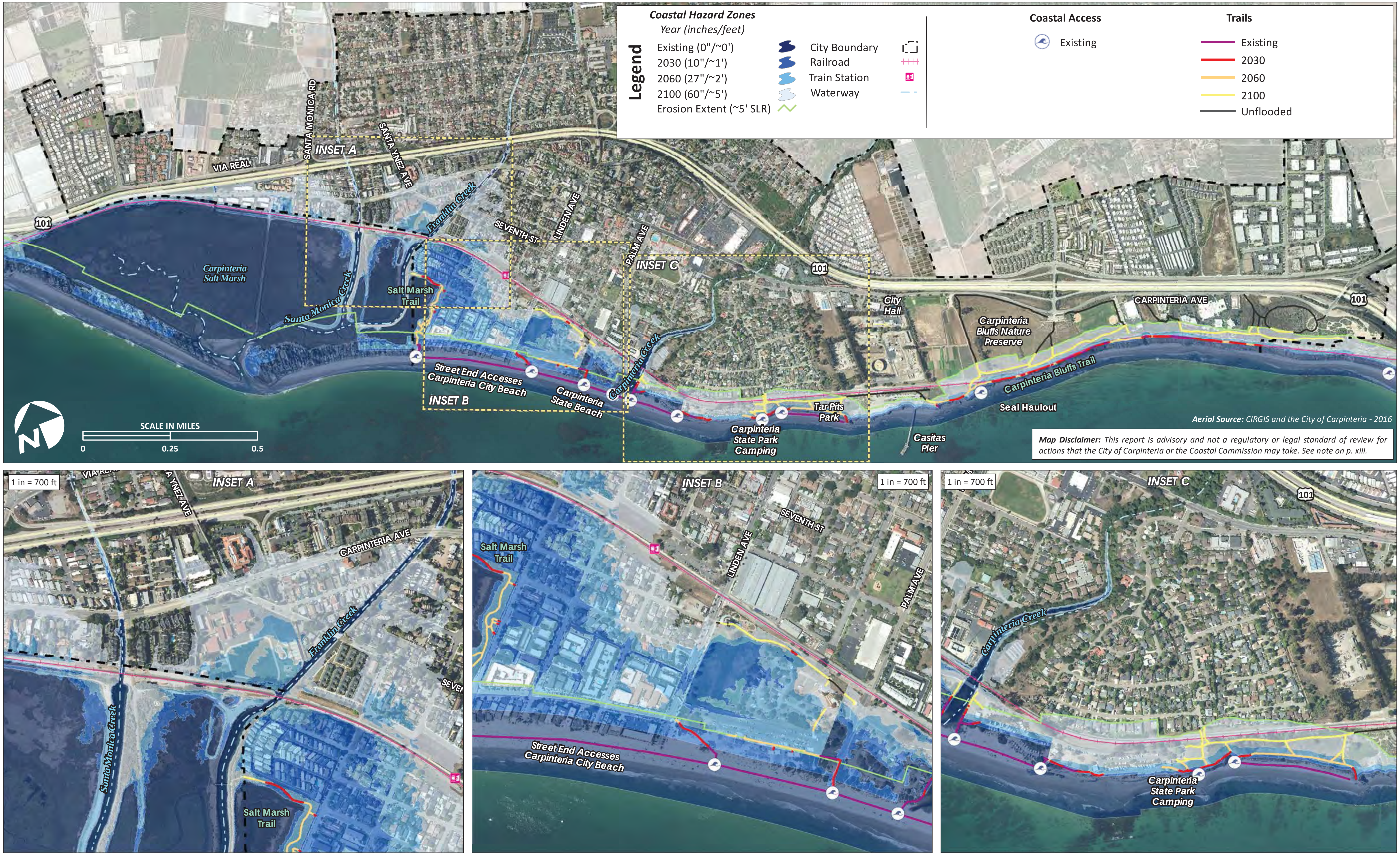
<u>Policy:</u>
- Coordinate with State Parks and regional partners on shoreline management to maintain beach access.
- Coordinate with the County, other coastal cities (e.g., BEACON), and local legislators to create sustainable funding mechanism for beach nourishment and other measures.
- Develop a long-range plan for the California Coastal Trail.

<u>Projects:</u>
- Relocate portions of trails exposed to erosion.
- Perform regular beach nourishment/ dune restoration.

<u>Monitoring:</u>
- Monitor depth, extent, and frequency of flooding within the State Beach.

<u>Data Needs:</u>
- Designated alignment of the California Coastal Trail.
- Complete trail network in the City.

Figure 1-5. Coastal Trails and Access



HAZARDOUS MATERIALS SITES, AND OIL AND GAS WELLS

Overview

Hazardous Materials Sites: The California State Water Resources Control Board (SWRCB) monitors hazardous materials storage and contamination. Sites that are exposed to flooding, erosion, or tidal inundation could potentially result in a release of hazardous materials into the environment, affecting soils and water quality.

Legacy Oil and Gas Wells: The Carpinteria area has a long history of oil development. The City provides regulatory oversight and permit compliance for existing oil and gas facilities, whereas nearshore wells within 3 miles are governed by the California State Lands and Coastal Commission (CSLC). There are at least 53 known inactive legacy wells within the City or just offshore. It is unclear how these wells were capped, but older abandoned wells were sometimes capped with a short concrete plug (e.g., 20 feet) or even phone poles with some concrete, but often do not meet modern standards for a 50-foot concrete plug. Nearby Summerland continues to deal with leaking nearshore wells. Large storm events and tidal inundation could erode, expose, and damage existing well infrastructure, and result in leaks and spills. To identify potentially vulnerable hazardous materials sites, and oil and gas wells, this study considered the following known, existing sites:

Year	Number of Wells
Existing Nearshore	16
Existing Onshore	37
2030	0
2060	2 Onshore
2100	3 Onshore
Unaffected Onshore	32

Category	Program	Total in City	Total Affected
Hazardous Waste Storage	EPA Toxics Release Inventory (TRI)	6	0
	EPA Small Quantity Generators (SQG)	35	4
	EPA Large Quantity Generators (LQG)	7	0
	State Geotracker Electronic Submittal of Information Sites (ESI)	10	3
Cleanup Programs	Leaking Underground Storage Tanks - Active Cleanup (LUST)	0	0
	State Active Cleanup Program Sites	4	1

Currently, coastal hazards may expose 22 legacy oil wells; 5 more wells may be at risk **with 5' of SLR.** With 5' of SLR, coastal hazards may expose an additional 2 ESIs and 1 business. This study did not estimate remediation costs, though these costs can be large; for example, the recent Refugio oil spill on a minor pipeline cost $257 million to mitigate.

Tipping Point: With 2' of SLR, one of the active cleanup sites related to oil and gas becomes exposed to coastal erosion and coastal flooding.

Existing Vulnerabilities

Tidal Inundation
- 0 active cleanup sites
- 0 ESIs
- 0 businesses
- 22 wells

Coastal Erosion
- 0 active cleanup sites
- 1 ESI
- 0 businesses
- 0 wells

Coastal Flooding
- 0 active cleanup sites
- 1 ESI
- 0 businesses
- 22 wells

Hazardous Materials: One ESI, an underground storage tank associated with the Venoco operations is just east of Casitas Pier is at risk from erosion and coastal flooding hazards. No active cleanup sites are exposed to any hazards.

Oil and Gas: There are 16 legacy oil wells offshore of Carpinteria beaches that are currently inundated. An overlapping number of these wells, totaling 8 onshore legacy wells located within Carpinteria's beaches, are currently also exposed to coastal dune and bluff erosion.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

There are no additional hazardous material sites or legacy oil wells at risk.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)
- 0 active cleanup sites
- 0 ESIs
- 0 businesses
- 22 wells

Coastal Erosion (total)
- 1 active cleanup site
- 1 ESIs
- 0 businesses
- 2 wells

Coastal Flooding (total)
- 1 active cleanup site
- 1 ESIs
- 0 businesses
- 24 wells

Hazardous Materials: One active cleanup site with potential soil contamination from crude oil and hydrocarbons and is potentially vulnerable to erosion and coastal flooding along the Carpinteria Bluffs.

Oil and Gas: There are 2 additional legacy wells exposed to erosion and related coastal flooding located in the State Park and off Elm Avenue in the Beach Neighborhood.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)
- 0 active cleanup sites
- 1 ESI
- 0 businesses
- 26 wells

Coastal Erosion (total)
- 1 active cleanup sites
- 1 ESIs
- 0 businesses
- 5 wells

Coastal Flooding (total)
- 1 active cleanup sites
- 3 ESIs
- 1 business
- 27 wells

Hazardous Materials: The previously exposed ESI site is vulnerable to tidal inundation. One light industrial building north of the Carpinteria Salt Marsh is exposed to coastal flooding.

Oil and Gas: There are 3 more legacy wells exposed to erosion and coastal flooding with 5' of SLR, including two wells within the State Park and one within Carpinteria Bluffs I. It is unknown how these wells were abandoned.

Adaptation Strategies

The majority of the hazardous material and impacts identified in the vulnerability assessment are avoidable if the City updates storage requirements and expedites clean-up measures.

Range of Strategies: The City should update storage requirements for businesses storing hazardous materials that would either elevate or floodproof the storage to accommodate potential levels of flooding without exposing the hazardous materials to the environment. Another policy approach would be to rezone so that businesses with a Hazardous Materials Business Plan (HMBP) are excluded from the Coastal Hazard Overlay Zone.

Active cleanup sites should remediate or adjust the timing to reduce exposure of contaminants to prolonged and more frequent coastal hazards. Adaptation strategies that reduce the exposure of the contaminants would include coastal armoring, flood proofing containment, and remediation.

Oil and gas wells could be protected in place. Well casings and onshore support infrastructure may be re-exposed as erosion continues. Maintaining or constructing coastal armoring would be one means to protect these legacy oil and gas wells. A green protection option would be to construct or augment sand dunes in the Beach Neighborhood and cobbles below the Carpinteria Bluffs to minimize exposure of oil and gas wells to erosion.

Secondary Impacts: The "do nothing" approach could have substantial cleanup impacts if spills or leaks occur. Delays in any response could result in oil spills and release of contaminants. Environmental remediation and permitting require substantial time and are high in cost.

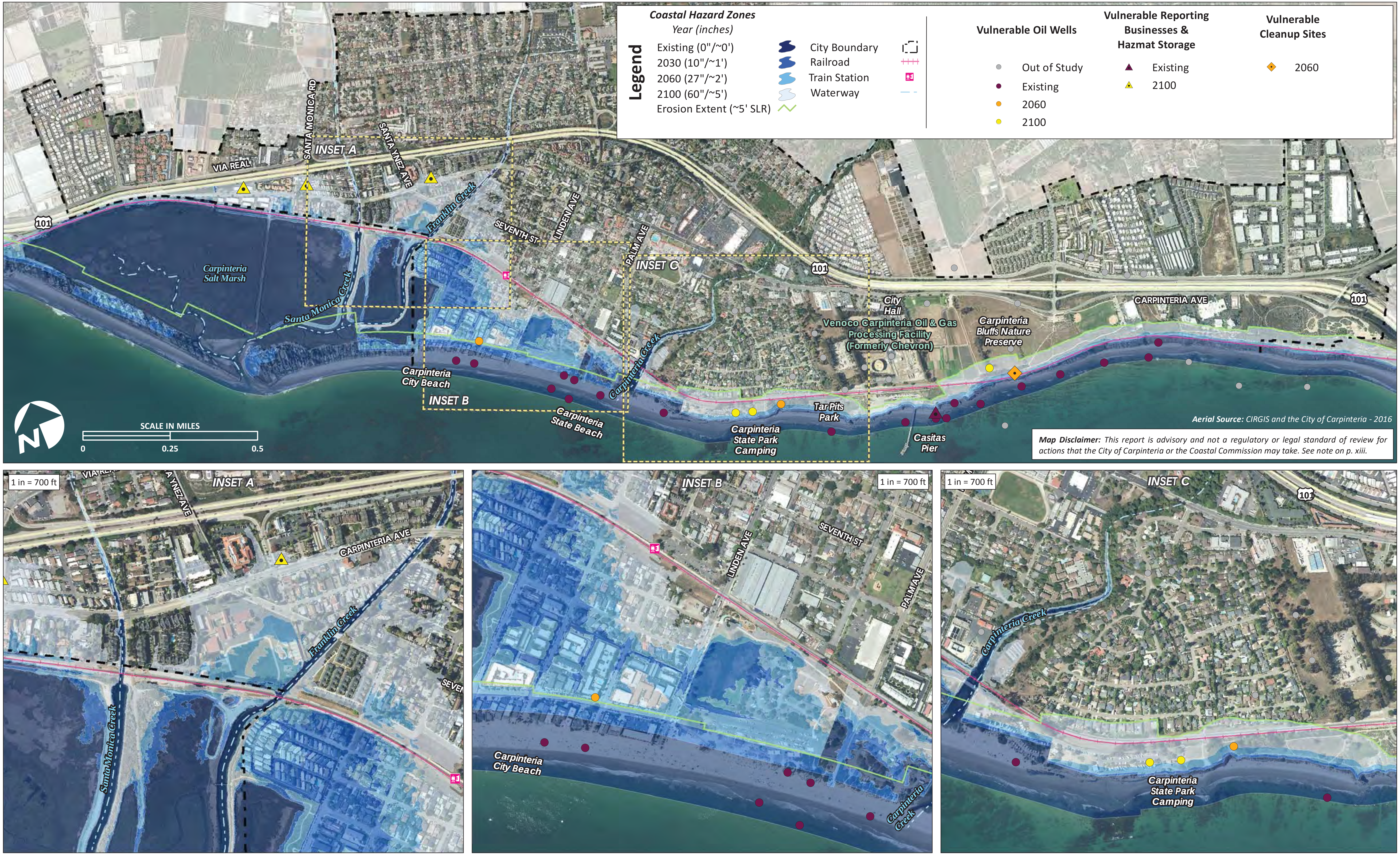
Potential Next Steps

Policy:
- Coordinate with California Department of Toxic Substances and Control (DTSC) to improve hazardous materials storage, management, and remediation in the risk zones.
- Formalize and participate in a regional Joint Powers Authority (JPA) with Office of Spill Prevention and Response (OSPR), CSLC, Coast Guard, and the County. A JPA would form a round table for oil and gas responses and lessons learned.
- Develop a regional environmental and permit streamlining process for rapid remediation of legacy wells.

Projects:
- Generate rapid response funds to remove damaged wells.
- Decommissioning of active sites such as Venoco should require permit holders to remove all shore protection, access roads, pipes and other oil and gas infrastructure.

Monitoring:
- Continue monitoring of remediation actions.

Figure 1-6. Hazardous Materials, and Oil and Gas Infrastructure



STORMWATER INFRASTRUCTURE

Overview

To identify stormwater infrastructure potentially vulnerable to climate change and SLR hazards, this study evaluated the following:

- **342 Storm Drain Inlets**
- **316 Storm Drain Outfalls**
- **24.5 Miles of Storm Drain Pipe**

The City's stormwater system consists of concrete flood control channels along Santa Monica and Franklin Creeks, the natural channel of Carpinteria Creek, and storm drain inlets that gather water from City streets and outfalls that discharge to these creeks or other water bodies via gravity flow. Much of the City's storm drain system is near mean sea level elevation in the Beach Neighborhood and inland of the Salt Marsh, increasing difficulty of rapid drainage during high tides. **Currently,** 36 outfalls are affected by high tides, which increases risk of storm drain backup and flooding, especially in low lying areas such as the Beach Neighborhood and floodplains in the Downtown. Storm drains can back up at several locations in these neighborhoods during high tides. **With 1' of SLR,** portions of the system may not drain during high tides, which in turn may increase stormwater flood depths and frequency. Culverts and pipes may also create flows of ocean water into the neighborhoods. Outfalls along Franklin and Santa Monica Creeks become at risk from high tides, and additional infrastructure around the Beach Neighborhood, State Park open space, and Tomol Interpretive playground become at risk from coastal flooding. **With 2' of SLR,** additional stormwater infrastructure becomes vulnerable to tidal inundation along the railroad corridor in the Downtown, to coastal erosion along the Bluffs, and to coastal flooding in the Beach Neighborhood. **With 5' of SLR,** tides could impair drainage 100% of the tide cycle and may be a source of flooding into neighborhoods, and 1/3 of all outfalls in the City would be covered, reducing stormwater conveyance during high tide. Half of all outfalls become at risk from coastal flooding, and may channel ocean waters into various parts of the City. Coastal erosion threatens 1.0-mile of storm drains/outfalls.

__Tipping Point:__ With 2' of SLR, pipe, inlets, and outfalls become substantially vulnerable to coastal hazards, resulting in loss or damage.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
• Inlets – 3	• Inlets – 0	• Inlets – 2
• Outfalls – 36	• Outfalls – 1	• Outfalls – 60
• Pipe – 0.5-mile	• Pipe – <0.1-mile	• Pipe – 0.7-mile

Tidal inundation may reduce stormwater conveyance by potentially inundating a number of inlets and outfalls and 0.5-mile of storm drains, particularly in the Beach Neighborhood. **Coastal erosion** may impact 2 outfalls and 277 feet of storm drains along the Carpinteria Bluffs. **Coastal flooding** from a 100-year wave event may impact stormwater infrastructure along the shoreline, which may be a source of flood waters into the City.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Inlets – 10	• Inlets – 0	• Inlets – 43
• Outfalls – 49	• Outfalls – 1	• Outfalls – 69
• Pipe – 0.6-mile	• Pipe – 0.1-mile	• Pipe – 1.4 miles

Tidal inundation potentially backs up an additional 7 inlets (10 total), 13 outfalls (49 total), and 662 feet (0.6 miles total) of storm drain along Franklin and Santa Monica Creeks. **Coastal erosion** may potentially damage an additional 276 feet (553 feet total) of storm drain pipes near the Casitas Pier. **Coastal flooding** from a 100-year wave event may impact an additional 41 storm drain inlets (43 total), 9 outfalls (69 total), and an additional 0.7-mile (1.4 miles total) of storm drains around the Beach Neighborhood, State Park open space, and Tomol Interpretative playground.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Inlets – 34	• Inlets – 2	• Inlets – 62
• Outfalls – 61	• Outfalls – 1	• Outfalls – 85
• Pipe – 1.1 mile	• Pipe – 0.5-mile	• Pipe – 2.3 miles

Tidal inundation could impact an additional 24 inlets (34 total), 12 outfalls (61 total), and 0.5-mile (1.1 miles total) of storm drains along the railroad corridor inland of the Salt Marsh and Beach Neighborhood. 2 storm drain inlets become vulnerable to **coastal erosion**, which also could damage an additional 0.4-mile (0.5-mile total) of pipe along the Bluffs. **Coastal flooding** from a 100-year wave event may impact an additional 19 inlets (62 total), 16 outfalls (85 total), and an additional 0.9-mile (2.3 miles total) of pipe in the Beach Neighborhood and along the Bluffs.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Inlets – 82	• Inlets – 6	• Inlets – 95
• Outfalls – 99	• Outfalls – 3	• Outfalls – 116
• Pipe – 2.5 miles	• Pipe – 1.0-mile	• Pipe – 4.2 miles

Tidal inundation potentially impacts an additional 48 inlets (82 total), 38 outfalls (99 total), and 1.4 miles (2.5 miles total) of storm drains in Franklin, Carpinteria, and Santa Monica Creeks, and the Upper Beach Neighborhood off Ash Ave. **Coastal erosion** may damage an additional 4 inlets (6 total), 2 outfalls (3 total), and 0.5-mile (1.0-mile total) of storm drain pipe across the City. **Coastal flooding** from a 100-year wave event may impact an additional 33 storm drain inlets (95 total), 31 outfalls (116 total), and 2.0 miles (4.2 miles total) of pipes across the City. Drainage and stormwater conveyance is inhibited and impacted in large areas of the City, throughout the Beach Neighborhood, in portions of Downtown and in areas along the western end of Carpinteria Avenue north of the Marsh.

Adaptation Strategies

__Range of Strategies:__ A range of strategies include relocation and elevation of key vulnerable infrastructure, increasing conveyance and pumping capacity, or flood proofing retrofits to protect existing system components.

Protect – Flood proof pump stations to protect electrical and system operations. Sediment nourishment and dune construction may help reduce loss of storm drains resulting from erosion damage.

Accommodate – Expand pumping capacity in low lying areas in the Beach Neighborhood and landward of the Salt Marsh. Install tide/ flap gates on outfalls into creeks. Acquire land to expand floodplain setbacks. Consider expanding the size of conveyance pipes. Develop a drainage plan for the Carpinteria Bluffs to reduce bluff erosion.

Manage – Develop a repetitive loss program to allow phased relocation of stormwater infrastructure as development is relocated over time. Add longer term considerations of sea level rise and expanded hazards into the Capital Improvement Plan.

__Trade-offs:__ Pump station floodproofing may provide a short-term, relatively low-cost option to accommodate SLR. Potential elevation of railroad and roadways may require additional stormwater drainage planning.

Potential Next Steps

__Policy:__

- Increase base flood elevation requirements for new development to reduce storm water flood vulnerability.
- Update CLUP/General Plan drainage policies and Capital Improvements Plan to address SLR and future decline in conveyance.
- Coordinate with County Flood Control on regional drainage.
- Develop a Stormwater Master Plan for low-lying areas in the City, such as the Beach Neighborhood.

__Data Gaps:__

- Elevation information for the outfalls would allow more robust analysis of each drain and subdrainage basin.

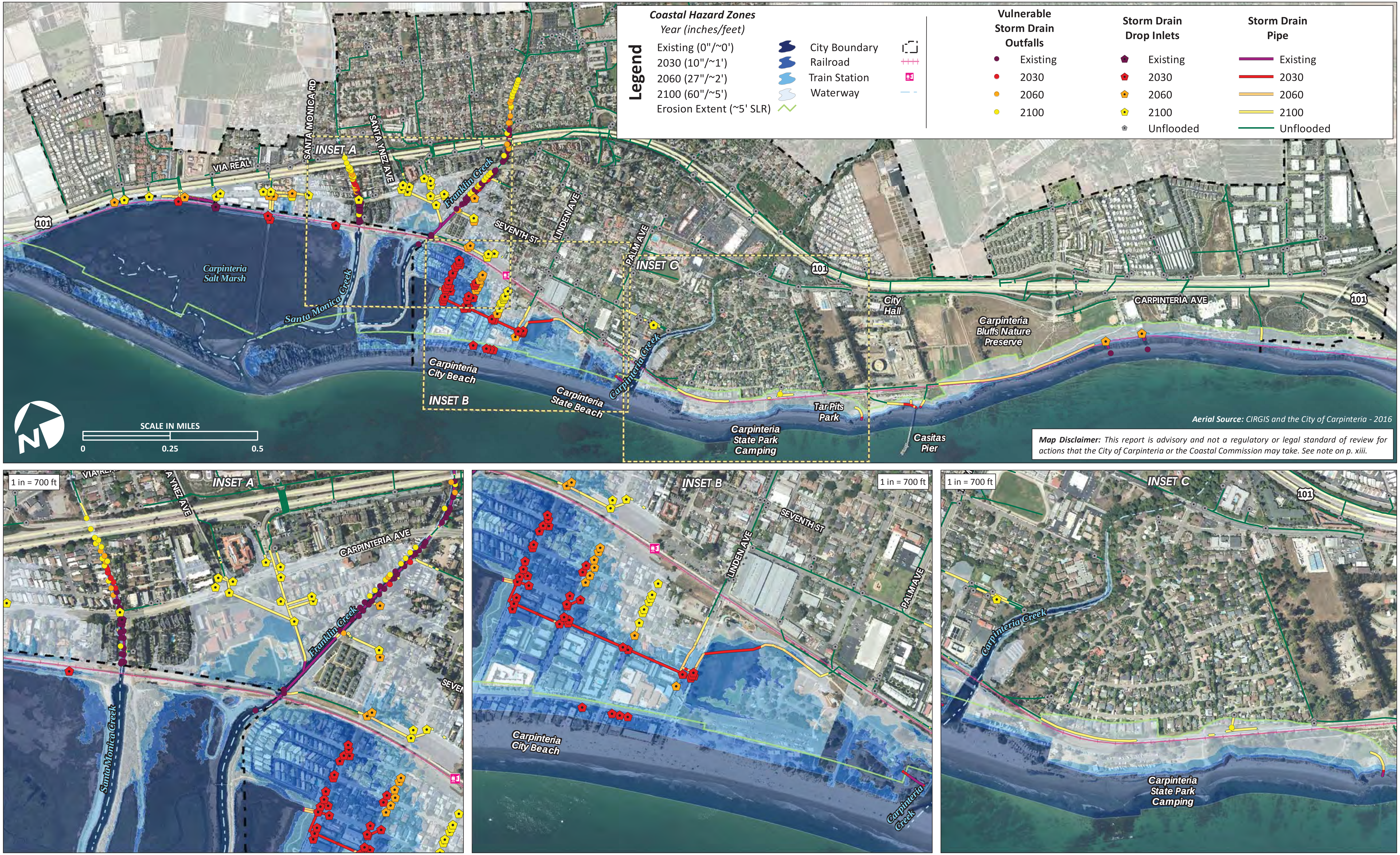
__Projects:__

- Conduct a stormwater system analysis that examines potential pump locations.
- Add tide/flap gates/coffer dams, to reduce inflow from high tides and storm waves into neighborhoods.
- Develop culvert replacements and stormwater retention basins that allow for reuse or release once tides drop to sufficiently low levels.

__Monitoring:__

- Monitor frequency, duration, and depths of floods in low-lying areas around the City (e.g., Beach neighborhood).

Figure 1-7. Stormwater



WASTEWATER INFRASTRUCTURE

Overview

To identify wastewater infrastructure potentially vulnerable to climate change and SLR hazards, this study evaluated the following:

- **39.7 miles of Sewer Pipe**
- **762 Manholes**
- **6 Lift Stations**
- **Wastewater Treatment Plant (WWTP)**

Currently, portions of the sewer pipe network are vulnerable to all coastal hazards. Coastal hazards could further increase the volume of flows to the WWTP through infiltration into manholes and add additional complications from increased salinity. **With 1' and 2' of SLR,** increasing segments of sewer pipes and manholes in the Beach Neighborhood become at risk from all coastal hazards, with vulnerability of all wastewater infrastructure substantially increasing **with 5' of SLR,** including the WWTP.

Tipping Point: With ~5 feet of SLR, there is a substantial escalation of coastal flooding, tidal inundation and erosion risk to pipes, manholes and lift stations.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
• Pipe – <0.1-mile	• Pipe – <0.1-mile	• Pipe – 0.2-mile
• Manholes – 0	• Manholes – 0	• Manholes – 0
• Lift Stations – 0	• Lift Stations – 0	• Lift Stations – 0

Coastal erosion may damage pipes in the Beach Neighborhood, while **coastal flooding** may temporarily affect maintenance and repair access to pipes north of the Salt Marsh during storm events. A sewage lift station just outside the City boundary west of the Carpinteria Salt Marsh is subject to coastal flooding and its disruption could affect the wastewater system.

ECONOMICS: The estimated cost of replacing eroded sewer pipes from coastal erosion is estimated at $60,000 (261 feet). If the sewer pipes have to be rerouted or protected, the cost could be considerably higher; this analysis only estimates the cost of pipeline infrastructure replacement, without factoring in additional manhole vaults or costs of land acquisition or rerouting.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Pipe – <0.1-mile	• Pipe – 0.1-mile	• Pipe – 0.9-mile
• Manholes – 0	• Manholes – 0	• Manholes – 20
• Lift Stations – 0	• Lift Stations – 0	• Lift Stations – 0

Additional lengths of sewer pipe in the Beach Neighborhood become at risk to **all coastal hazards**, **coastal erosion** may impact an additional 30 feet (291 feet total) of pipe. **Coastal flooding** may affect an additional 0.8-mile (0.9-mile total) of pipe, and 20 manholes in the Beach Neighborhood.

ECONOMICS: Potential replacement costs of sewer pipes damaged by erosion are estimated at $10,000 more than the existing vulnerabilities, for a cumulative total of $70,000 (291 feet); higher if pipes need to be rerouted or protected. Potential economic effects of any damage to the wastewater treatment plant from increased salt water infiltration through manholes from coastal flooding are unknown and have not been calculated.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Pipe – 0.6-mile	• Pipe – 0.1-mile	• Pipe – 2.0 miles
• Manholes – 13	• Manholes – 0	• Manholes – 32
• Lift Stations – 0	• Lift Stations – 0	• Lift Stations – 1

In the Beach Neighborhood, **tidal inundation** could affect 0.6-mile of pipe and 13 manholes, **coastal erosion** could impact an additional 46 feet (337 feet total) of pipe. **Coastal flooding** from a 100-year storm event may affect an additional 1.1 miles (2.0 miles total) of pipe, an additional 12 manholes (32 total), and 1 lift station to the northwest of the City limits, disruption of which could affect the wastewater system.

ECONOMICS: Potential replacement costs of sewer pipes are estimated at a cumulative total of $80,000 (337 feet) from coastal erosion (increasing $10,000 from 2030); these costs could become higher if pipes need to be rerouted or protected. Coastal flooding could damage 1 pump station west of the Marsh, which would cost $1 million to replace. Potential economic effects of any damage to the wastewater treatment plant from increased salt water infiltration through manholes from coastal flooding and tidal inundation are unknown and have not been calculated.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• Pipe – 3.1 miles	• Pipe – 0.5-mile	• Pipe – 4.7 mile
• Manholes – 56	• Manholes – 12	• Manholes – 95
• Lift Stations – 2	• Lift Stations – 1	• Lift Stations – 3
		• WWTP

Tidal inundation may affect 2 lift stations in the Beach Neighborhood; an additional 43 manholes (56 total), resulting in substantial saltwater infiltration to the wastewater system; and an additional 2.5 miles (3.1 miles total) of pipe, limiting maintenance and repair access to the sewer pipe network. **Coastal erosion** may affect 1 lift station, 12 manholes, and an additional 0.4-mile (0.5-mile total) of pipe within the Beach Neighborhood. **Coastal flooding** may affect 2 additional lift stations (3 total) and an additional 2.7 miles (4.7 miles total) of pipe inland of the Salt Marsh up to Carpinteria Avenue and in the Beach Neighborhood. Also see Appendix C.

ECONOMICS: Potential cumulative replacement costs of sewer pipes are estimated at $610,000 (0.5-mile) from coastal erosion; higher if manhole vaults need to be replaced, or if pipes need to be rerouted or protected. Tidal inundation, coastal erosion, and/or coastal flooding from a 100-year wave event could risk damaging 2 lift additional stations, which may cost $2 million to replace ($1 million each). Potential economic effects of any damage to the wastewater treatment plant from substantially increased salt water infiltration through manholes from coastal flooding and tidal inundation, as well as damage to wastewater treatment plant buildings are unknown and have not been calculated.

Adaptation Strategies

Range of Strategies: A range of strategies include managed retreat, elevating key vulnerable infrastructure, increasing conveyance and pumping capacity, or flood-proofing retrofits that protect existing system components.

Protect – Raise flood walls on Carpinteria Creek to protect against a 500 year FEMA fluvial event. Flood-proof vulnerable lift stations to protect electrical and pump system operations. Seal manholes to prevent coastal flooding and tidal inundation from overwhelming the sewage system. Fund regular sustained beach nourishment and restore sand dunes and integrate with sand retention or offshore breakwater devices to protect from coastal erosion and flooding.

Accommodate – Elevate lift stations, shut off valves, and vulnerable components above future coastal flood levels. Require any metal parts to be of an alloy more resistant to salt corrosion. Install tide gates/flaps at key drainage outfalls and coffer dams across Carpinteria creek channels.

Manage – Phased relocation of the wastewater infrastructure, tied to a community-wide shoreline management strategy and regional coordination with neighboring jurisdictions. Add longer term considerations of sea level rise and expanded hazards into the Infrastructure Improvement and Maintenance Plan.

Trade-offs: Retrofits may provide a short-term, relatively low-cost option to protect from flood hazards. Green protection such as beach and dune nourishment may require frequent maintenance and associated ongoing costs with higher levels of SLR. Gray protection strategies could negatively impact beach and dune habitats, natural processes, and public coastal access, but could effectively protect wastewater infrastructure.

Potential Next Steps

Policy:

- Update the 2005 Wastewater Master Plan to incorporate future climate change and sea level rise vulnerabilities.
- Develop wastewater management policies to require accommodation or avoidance of coastal hazard areas to the extent possible.
- Coordinate with BEACON and state legislators to fund and perform regular beach and dune nourishment.

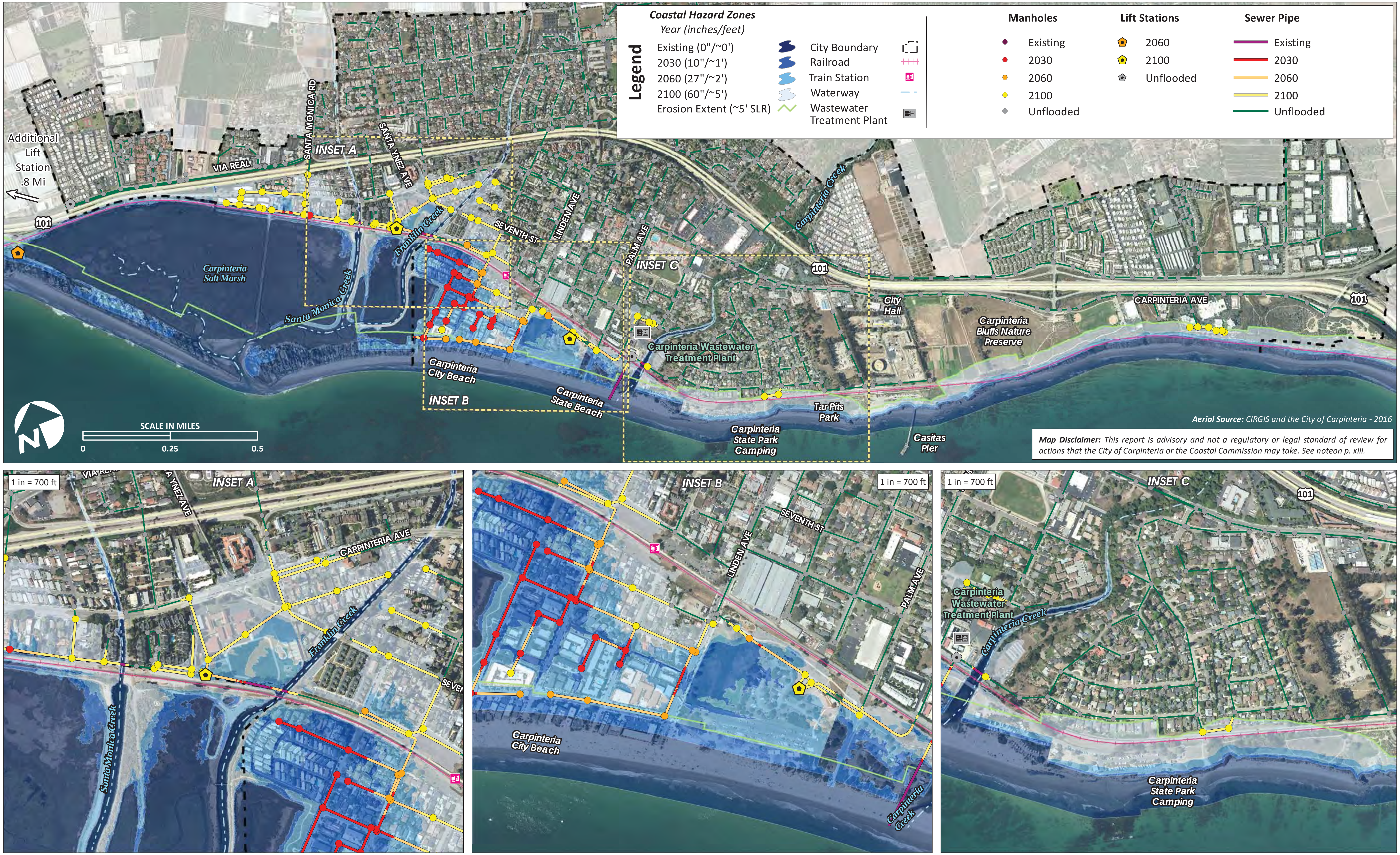
Projects:

- Relocate sewer pipe segments susceptible to coastal erosion. Segments should be prioritized based on the timing of potential impacts.
- Flood proof lift stations and WWTP.
- Install tide gates/flaps at outfalls and coffer dams across creeks.
- Retrofit manholes to reduce flood water intrusion into the sewage system.
- Upgrades should consider additional elevation or setbacks, correspondent with expected sea levels.

Monitoring:

- Monitor the volume and salinity levels of water during storm events to understand the impacts on sewer capacity.

Figure 1-8. Wastewater



WATER SUPPLY INFRASTRUCTURE

Overview

To identify water supply infrastructure potentially vulnerable to climate change and SLR hazards, this study evaluated the following:

- **46 Miles of Water Supply Pipes**
- **290 Hydrants**
- **1550 Control Valves**
- **4 Pressure Regulators**
- **3516 Customer Water Meters *(not mapped)***
- **4 Groundwater Wells *(not mapped)***

The City's water supply system is managed by the Carpinteria Valley Water District (CVWD) and maintained by pressure regulators, hydrants, and control valves that distribute water through pipes to connect to customer water meters. The Beach Neighborhood and neighborhood north of the Salt Marsh have the most vulnerable water supply infrastructure to future coastal hazards. Saltwater intrusion into the groundwater aquifers is not currently a major problem, but could pose substantial risk to groundwater supplies, a key source of City water; additional analysis is needed to understand this issue. **Currently,** small portions of the water supply pipe network are at risk from coastal hazards. **With 1' and 2' of SLR,** coastal flooding and tidal inundation impacts escalate, primarily in the Beach Neighborhood. **With 5' of SLR,** coastal erosion impacts occur, and other coastal hazard impacts escalate, expanding north of the Salt Marsh. While not the focus of this study, fluvial (creek) flooding creates substantial existing and future water infrastructure vulnerabilities (see Appendix C).

Tipping Point: With 2' of SLR, pipes, hydrants and valves, pressure regulators, meters and wells for water supply become substantially vulnerable to coastal hazards, resulting in loss or damage.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
Pipe – <0.1-mile	Pipe – <0.1-mile	Pipe – <0.1-mile
Hydrants – 0/Valves – 0	Hydrants – 0/Valves – 0	Hydrants – 0/Valves – 0
Pressure Regulators – 0	Pressure Regulators – 0	Pressure Regulators – 0
Meters – 0/Wells – 0	Meters – 0/Wells – 0	Meters – 0/Wells – 0

Portions of the water supply pipe network are vulnerable to **coastal flooding** in the Beach Neighborhood.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
Pipe – 0.1-mile	Pipe – <0.1-mile	Pipe – 1.0-mile
Hydrants – 0/Valves – 3	Hydrants – 0/Valves – 0	Hydrants – 4/Valves – 38
Pressure Regulators – 0	Pressure Regulators – 0	Pressure Regulators – 0
Meters – 3/Wells – 0	Meters – 0/Wells – 0	Meters – 136/Wells – 0

Tidal inundation may affect a number of control valves, some water meter connections, and 0.1-mile of supply pipe, which may hinder access periodically in the Beach Neighborhood. **Coastal flooding** may impact a number of hydrants, control valves, water meter connections, and 1.0-mile of pipe during a large wave event; impacts would primarily occur in the Beach Neighborhood along lower Linden and Elm Avenues. No impacts to groundwater resources are anticipated with this level of SLR, but additional study is required.

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
Pipe – 0.8-mile	Pipe – <0.1-mile	Pipe – 1.8 miles
Hydrants – 2/Valves – 35	Hydrants – 0/Valves – 0	Hydrants – 9/Valves – 67
Pressure Regulators – 0	Pressure Regulators – 0	Pressure Regulators – 0
Meters – 79/Wells – 0	Meters – 0/Wells – 0	Meters – 194/Wells – 0

Tidal inundation may routinely impact hydrants, as well as 0.8-mile of pipe, 32 control valves (35 total), and 76 meter connections (79 total), primarily in the Beach Neighborhood. During a large wave event, **coastal flooding** may impact an additional 0.8-mile of pipe (1.8 miles total), 5 hydrants (9 total), 29 control valves (67 total), and 58 water meter connections (194 total), with impacts expanding in the Beach Neighborhood along Sandyland Road, and lower Linden and Elm Avenues. No impacts to groundwater resources are anticipated with this level of SLR, but additional study is required.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
Pipe – 2.9 miles	Pipe – 0.5-mile	Pipe – 4.5 miles
Hydrants – 18/Valves – 128	Hydrants – 1/Valves – 15	Hydrants – 27/Valves – 182
Pressure Regulators – 0	Pressure Regulators – 0	Pressure Regulators – 1
Meters – 302/Wells – 0	Meters – 47/Wells – 0	Meters – 444/Wells – 0

Tidal inundation may routinely inundate 2.9 miles of pipe, 16 hydrants (18 total), 93 control valves (128 total), and 223 water meter connections (302 total), with hazards increasing primarily in the Beach Neighborhood, above 3rd Street toward the railroad tracks. Water supply pipe (0.5-mile total), a hydrant, and 15 total control valves and 47 total water meter connections become vulnerable to **coastal erosion** on the oceanfront parcels in the Beach Neighborhood and along the Carpinteria Bluffs. **Coastal flooding** may affect 4.5 miles of pipe, 18 hydrants (27 total), 115 control valves (182 total), and 250 water meter connections (444 total), with impacts expanding in the Beach Neighborhood inland of the railroad and on the north side of the Salt Marsh, also exposing a pressure regulator. While it is unknown of this level of SLR would affect groundwater resources through potential for saltwater intrusion, additional study is required to ascertain at what level SLR may begin to affect groundwater resources.

ECONOMICS: The replacement cost of water pipes due to coastal erosion is estimated at $560,000 (0.5-mile). This analysis only factors cost of replacement for eroded water supply pipes and does not consider additional costs to replace or repair hydrants, valves or pressure regulators. Cost is not estimated for previous planning horizons as water supply pipes would not be impacted by coastal erosion with less than 5' of SLR.

Adaptation Strategies

Range of Strategies: Adaptation strategies over the coming decades could include infrastructure changes to improve water supply reliability and storage capability, as well as increased conservation efforts and availability of recycled water.

Protect – Construct additional flood control channels or shoreline protective devices. Augment, nourish, and/or construct sand dunes to protect against future coastal hazards.

Accommodate – Elevate key system maintenance components or replace with remotely operated valves. Require any metal parts to be of an alloy more resistant to salt corrosion.

Manage – Relocate distribution pipelines away from erosion hazard areas. Identify future locations for pump stations and wells such to avoid potential coastal hazards. Add longer term considerations of sea level rise and expanded hazards into the Infrastructure Improvement and Maintenance Plan.

Trade-offs: Green protection measures such as beach and dune nourishment may require frequent and expensive maintenance, particularly with higher levels of SLR. Gray protection strategies could effectively protect water supply infrastructure, but could also have negative impacts on beach and dune habitats, natural processes, and public coastal access.

Potential Next Steps

Policy:

- Develop CVWD-wide policies that promote water conservation and increase reclaimed water use and availability.
- Coordinate regionally with local water districts and relevant County departments to adapt the water supply system to future demands and include climate change into the Integrated Water Resource Management and Sustainable Groundwater Management Act plans.
- Ensure adequate long-term water supplies for the lifetime and intended use of development prior to permitting.
- Restrict development of new wells in hazardous areas.

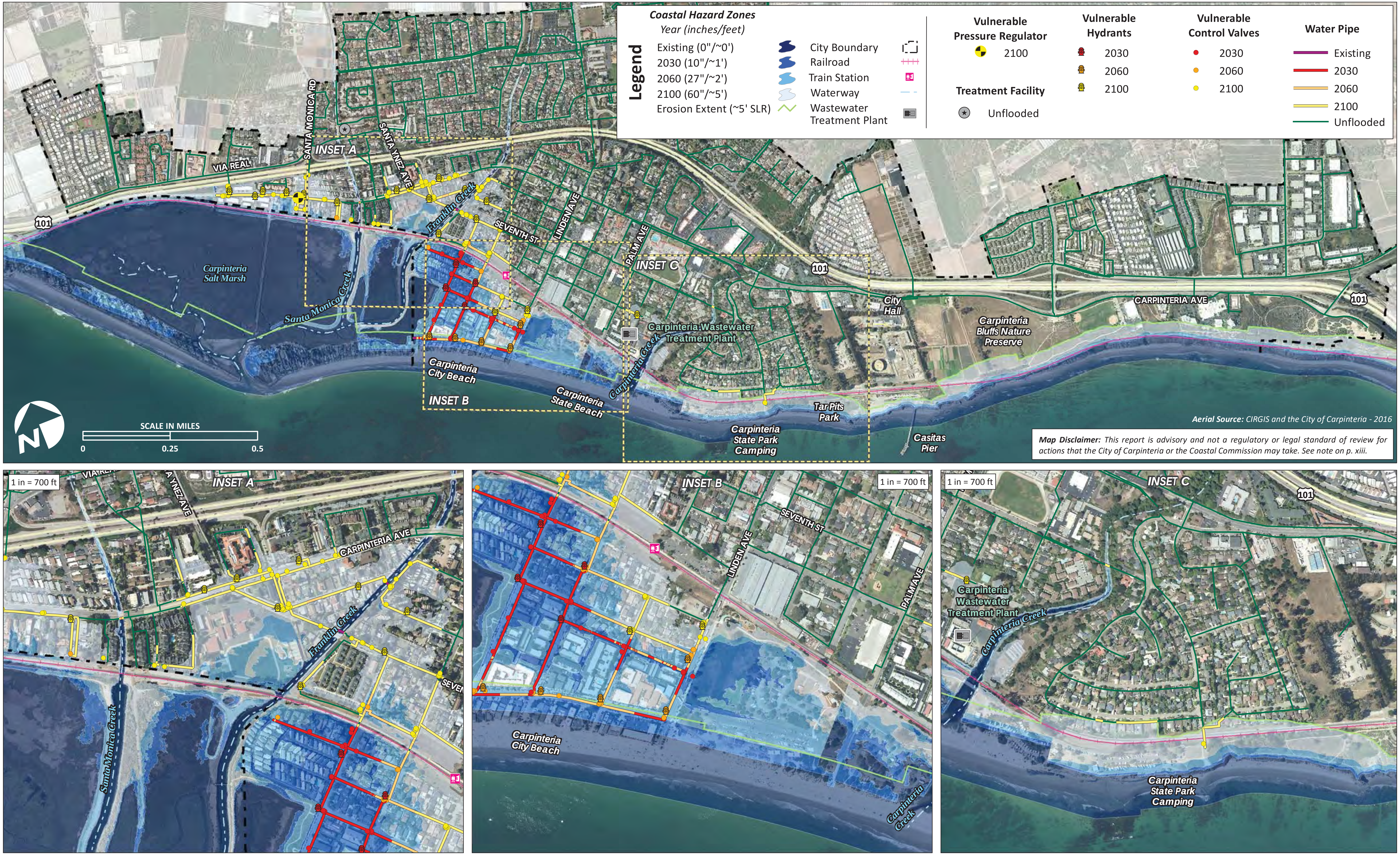
Projects:

- Specific projects should be identified in other water supply planning documents such as updates to the Carpinteria Valley Recycled Water Facilities Plan or Groundwater Basin Master Plan.

Monitoring:

- Support CVWD efforts to develop a monitoring well to evaluate salinity intrusion into the aquifer.

Figure 1-9. Water Supply



COMMUNITY FACILITIES AND CRITICAL SERVICES

Overview

To identify community facilities and critical services potentially vulnerable to climate change and SLR hazards, this study evaluated the following:

- **# Community Facilities**
  - **6 School Campuses / 34 School Buildings**
  - **3 Churches**
  - **6 Other Community Facilities (Post Office, Wastewater Treatment Plant [WWTP])**
- **# Critical Services**
  - **1 Fire Station/1 Admin Office**
  - **1 Police Station**
  - **1 Medical Facility**

The City's Wastewater treatment plant is located along Carpinteria Creek inland of the State Beach and railroad. (Photo: California Coastal Records Project)

Currently and with 1' of SLR, coastal hazards do not threaten any community facilities or critical services. **With 5' of SLR,** up to nine buildings at Aliso Elementary School building are vulnerable to coastal flooding and tidal inundation hazards and seawater infiltration into sewer lines has an unknown increase in potential for additional complications and damage to the WWTP. No emergency response facilities are exposed to coastal hazards with up to 5' of SLR.

<u>**Tipping Point:**</u> With 5' of SLR, tidal inundation may regularly affect Aliso Elementary School, and coastal flooding may impact the WWTP, State Beach Service Yard, and Sanitary District offices.

Existing Vulnerabilities

Tidal Inundation	Coastal Erosion	Coastal Flooding
• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0

No community facilities or critical services are exposed to existing coastal hazards.

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0

No community facilities or critical services are exposed to coastal hazards. Nevertheless, seawater infiltration into sewer lines via manhole covers has an unknown increase in potential for complications and/or damage to the WWTP (see Wastewater Infrastructure Sector for more detail).

27.2 inches (~2 feet) by ~2060

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• School Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• School Buildings – 1 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0

During a 100-year wave event, one building at the Aliso Elementary School may be susceptible to temporary flood damages from **coastal flooding**. No critical services are at risk from coastal hazards. An increased amount of seawater into sewer lines has an unknown increased potential for complications and/or damage to the WWTP.

60.2 inches (~5 feet) by ~2100

Tidal Inundation (total)	Coastal Erosion (total)	Coastal Flooding (total)
• School Buildings – 8 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• Schools Buildings – 0 • Churches – 0 • Other Community Facilities – 0 • Critical Services – 0	• Schools Buildings – 9 • Churches – 0 • Other Community Facilities – 4 • Critical Services – 0

Tidal inundation and **coastal flooding** may impact an additional 8 buildings (9 total) at Aliso Elementary School during routine high tides. Coastal flooding could also impact the WWTP. A potentially large increase of seawater infiltration into sewer lines has an unknown potential for complications and/or damage to the WWTP (see Wastewater Infrastructure Sector for more detail). Finally, the properties of the State Beach Service Yard and the Sanitary District offices could be affected.

Adaptation Strategies

<u>**Range of Strategies:**</u>

Protect – Transition the winter storm berm program to a permanent "living shoreline" persistent dune system. Consider additional opportunities for beach nourishment with cobble and sand. Work with UPRR to elevate tracks on berms that could protect Aliso Elementary School from tidal inundation and coastal flooding. Install independent berms at perimeters of WWTP and Aliso Elementary School.

Accommodate – Require retrofitting buildings during major remodels to increase elevation or setbacks. Amend City building code and zoning ordinance to enable elevation to occur over time. Install tide gates/ flaps at key drainage outfalls and coffer dams across creek channels.

Manage – Develop evacuation routes that avoid roadways that are vulnerable to existing and future coastal hazards.

<u>**Trade-offs:**</u> Elevation of structures could be costly, depending on the types of structural foundation improvements needed, although the extended time until potential impacts allows for appropriate planning. Building elevation may also result in negative aesthetic impacts on the community. Green protection strategies may benefit beaches by maintaining recreational uses but would require frequent maintenance with higher levels of SLR and may offer limited protection. Coffer dams and tide gates/ flaps require initial capital outlays as well as operations and maintenance funding.

Potential Next Steps

<u>**Policy:**</u>

- Work with School District to evaluate site options (e.g., tide gates/ flaps/ berms, building elevation, school relocation).
- Coordinate with UPRR of increasing track elevations.
- Coordinate with BEACON and local state legislators to create a sustainable funding program for beach nourishment efforts.
- Include policy language (e.g., renewal of school leases, health care, etc.) that considers SLR and flood hazards.

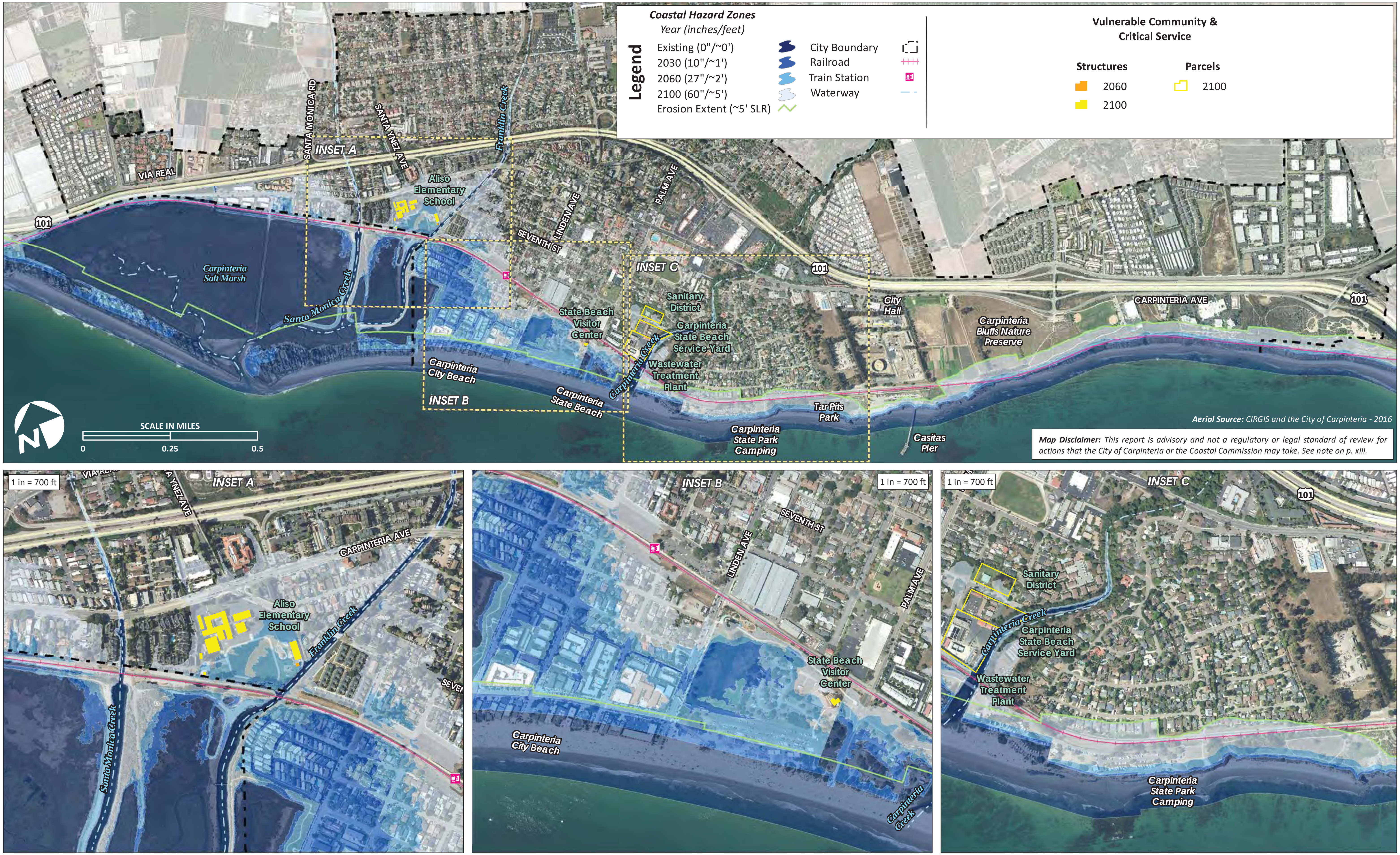
<u>**Monitoring:**</u>

- Monitor extents, depths, and frequency of tidal inundation at Aliso Elementary School.

<u>**Data Gap:**</u>

- No evacuation route information was determined.

Figure 1-10. Community Facilities and Critical Services



Environmentally Sensitive Habitat Area (ESHA)

Overview

Within the City, ESHA includes native habitats on the Carpinteria Bluffs (e.g., coastal bluff scrub), wetlands of the Carpinteria Salt marsh and Carpinteria Creek, beaches, dunes, reefs, a harbor seal rokery and monarch butterfly roosts. Coastal hazards and SLR could directly impact substantial acreage of existing ESHA in the City. Coastal flooding and cliff erosion could impact the greatest acreage of ESHA; SLR may cause transitions in wetland habitats. Impacts of climate change extend beyond sea level rise and would affect temperature, precipitation, droughts, and wildfire risk; for more information see Section 6.8, *Environmentally Sensitive Habitat Area*.

ESHA Directly Influenced by Coastal Hazards and Sea Level Rise

Hazard	Dune Erosion	Cliff Erosion	Tidal Inundation	Coastal Flooding
	Combined Acreage of ESHA Habitats			
Existing Vulnerabities	19.3	15.6	10.1	46.5
2030	1.9	3.8	1.6	7.3
2060	2.3	9.1	3.1	12.9
2100	3.0	27.1	14.6	30.2
Cumulative Total	**26.5**	**55.6**	**29.4**	**96.9**

Note: The variability in the onshore acreages relates to where the different coastal hazard zones (arbitrarily drawn offshore) and the ESHA mapping overlap; boundaries of offshore ESHA (e.g., kelp beds, subtidal reefs are not well defined).

Reporting acreages of vulnerable ESHA may misrepresent habitat vulnerability. Quantitatively predicting future habitats is challenging as there is a complex interplay of variables. As coastal hazards and SLR progress, habitats may disappear from current location (e.g., dune erosion) if strategies are implemented to protect landward resources or migrate landward if there is adapatation (e.g., managed retreat). Likely impacts to the seven types of ESHA in the City due to SLR and coastal hazards are qualitatively analyzed and summarized below.

Carpinteria Bluffs

The Carpinteria Bluffs and adjacent shoreline host many sensitive animal species, including the white-tailed kite and the harbor seal. ESHA may include the Central Coast riparian scrub, coastal sage scrub, and coastal bluff scrub. Nearshore ESHA below the Carpinteria Bluffs, consisting of rocky intertidal habitat interspersed with sandy beach, may be more frequently submerged by SLR, with accelerated bluff erosion and increased depth and duration of coastal flooding. Coastal bluff scrub habiats and bluff face wetland seeps would be directly impacted by accelerated bluff erosion associated with SLR, although such habitats may re-establish after bluff failures and retreat with eroding bluffs, depending on available space to do so. Bluff top habitats including coastal sage scrub, nonnative grassland, eucalyptus groves, Central Coast riparian scrub in Carpinteria Bluffs II, and ephermal wetlands and associated endangered vernal pool fairy shrimp in Carpinteria Bluffs III would all be threatened, with up to 360-460 feet of bluff erosion with 5' of SLR by 2100, potentially eliminating large areas of these habitats.

Wetlands within Carpinteria Salt Marsh

High salt marsh and transitional ESHA are most vulnerable to SLR. With 1' of SLR, vegetated high marsh habitat would begin to be more frequently inundated, converting to mudflat habitat with 5' of SLR by 2100. This could lead to conversion of most low, mid, and high marsh vegetated habitats to subtidal habitats. Because the marsh is confined by the railroad, U.S. Highway 101, and urban development, potential for landward retreat of these habitats is limited. Sediment input from Franklin and Santa Monica Creeks at the east end of the marsh and from beaches at the marsh mouth could increase marsh surface elevations and permit some habitat adaptation in these areas. A transition of this vegetated high marsh ESHA to mudflat or subtital habitat could affect 14 of the 16 plant species of special concern found in the salt marsh as well as species such as the endangered Belding's savannah sparrow and others which are dependent upon vegetated marsh ESHA.

Beaches, Dunes, Tidelands, and Subtidal Reefs

Carpinteria beaches, some of which may be considered ESHA, are projected to narrow as SLR increases, even in places where sand dunes (e.g. at the State Beach) back the beach. With between 1' and 2' of SLR, dune erosion would accelerate and about 60% of the dry sand beaches could erode or become more frequently submerged, transitioning to intertidal or subtidal beach. With 5' of SLR by 2100, beaches and dunes would be severely eroded and frequently inundated impacting ESHA, unless the shoreline retreats substantially landward; such retreat would require relocation of State Park campgrounds and parking lots. Loss of beach upper intertidal zone would reduce the connectivity required by species to migrate inland to survive high waves and storm conditions. Depending on shoreline landward retreat, rocky intertidal habitats may become increasingly subtidal, potentially transition to subtidal reefs.

Harbor Seal Rookery and Haulouts

The harbor seal rookery and haulout area could be more frequently inundated by tides and wave action. If coastal bluff erosion is allowed to continue unabated, the seal haulout may migrate landward with the beach; however, if the rate of SLR exceeds the rate of bluff erosion, then the beach and the haulout will be inundated for more of the tide cycle, potentially reducing or eliminating beach used for haul out.

Creek and Riparian Habitats

Carpinteria Creek is the most significant creek ESHA in the City as it is a perennial stream, supports a major rirparian woodland serves as designated Critical Habitat for southern steelhead trout, and its lagoon is a sensitive wetland that harbors an endangered fish species, the tidewater goby. Assuming adequate sediment supply from upcoast Santa Barbara Harbor continues, and maintains a beach in front, then the seasonal lagoon opening and closing should be maintained, if the beach is allowed to migrates landward. The Creeks' riparian habitats including tall canopy, midstory, and understory -- that serve a wide variety of wildlife including birds may transition to estuarine habitats with increased seawater intrusion under SlR. With 5' of SLR, riparian habitats south of 8th Street would be impacted by regular tidal inundation up Carpinteria Creek, which would reduce riparian vegetation. The extent of riparian habitat transition to estuarian and associated adjacent upland scrub habitat would likely correspond with extents of tidal inundation, which increases with SLR.

Native Plant Communities

Native plant communities that may be considered ESHA include: coastal sage scrub, oaks, chaparral, native oak woodland, riparian vegetation, and rare plant species. Coastal hazards and SLR would impact these communities in different ways, depending on their location. For example, plant communities such as coastal sage scrub and chaparral that exist on the Carpinteria Bluffs would be increasingly vulnerable to cliff erosion as SLR increases. The vulnerability of riparian vegetation would increase as coastal flooding and tidal inundation extends further into the reaches of creeks, altering suitability of riparian habitat as SLR increases, which could result in additional estuarine or marsh habitat in these areas.

Monarch Butterfly Habitat

The Monarch butterfly roosts within the riparian corridor of Carpinteria Creek are the most susceptible to coastal flooding hazards, and a large flood event could uproot trees and disturb habitat. The Monarch butterfly roosts in the Venoco buffer parcels along the Carpinteria Bluffs may eventually become vulnerable to coastal cliff erosion as SLR increases.

Adaptation Strategies

Range of Strategies:

Protect – Expand flood plains, augment sand dunes, and perform regular beach nourishment with sand and/or cobbles to sustain beach and dune systems, maintain seal haul out area, and reduce erosion and loss of terrestial habitats. Consider fixing the landward ocean boundary through the use of shoreline protective devices and/or increased floodwalls.

Accommodate – Use excess sediment to elevate vulnerable portions of Carpinteria Salt Marsh and protect Carpinteria Lagoon.

Manage – Coordinate with State Parks to allow beach, dune, and bluff ecosystems to migrate landward where possible or when unavoidable. As the Carpinteria Salt Marsh is largely surrounded by the UPRR, flood control levees, and concrete lined channels, consider allowing salt marsh habitat to migrate landward toward the City's Salt Marsh Park and Aliso School. Additionally, floodplain setbacks along creek corridors could be expanded. Incorporate phased upgrading of existing walkways to raised boardwalks in order to support ESHA while maintaining use and public access.

Trade-offs: Green protection measures through floodplain setbacks, beach and dune nourishment may require frequent maintenance with higher levels of SLR, but may benefit habitats by maintaining floodplains and beach width. Gray protection using shoreline protection or floodwalls could reduce terrestrial blufftop and wetland habitat vulnerabilities but could negatively impact riparian, beach, and dune habitats and natural processes by resulting in a loss of beaches over time.

Potential Next Steps

Policy:

- For ESHA policy development affecting Carpinteria Creek, maintain hydrologic connectivity upstream and coordinate with the County, other agencies and landowners to enourage replacement/expansion of riparian woodlands in areas not impacted by SLR.
- Coordinate with the County, coastal cities, BEACON and local legislators to create sustainable funding mechanism for potential beach nourishment programs.

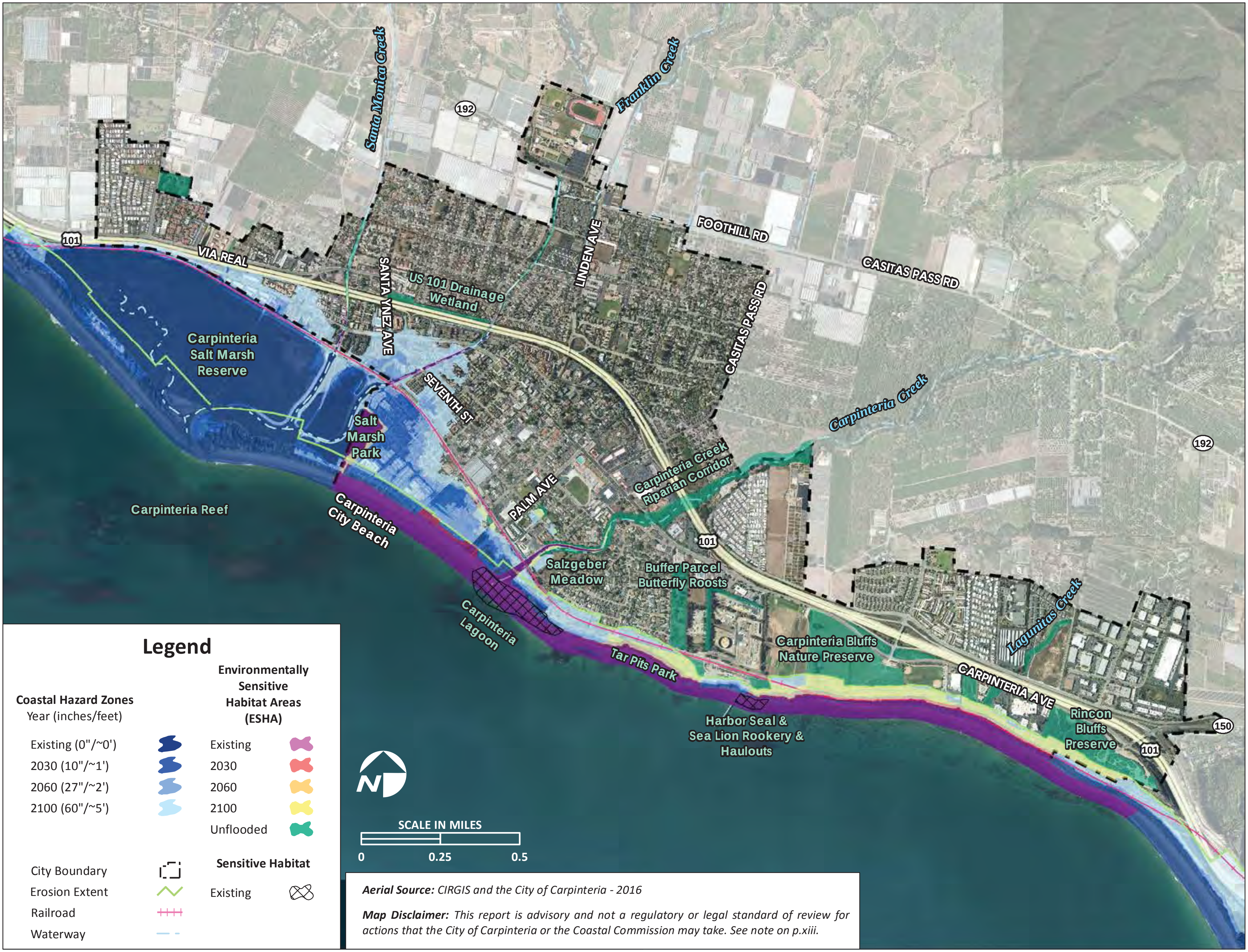
Projects:

- Improve habitat mapping in the City and vicinity.
- Restore and maintain terrestrial habits impacted by SLR (e.g., coastal bluff scrub).
- Allow more sediment from local watersheds to enter the Carpinteria Salt Marsh and littoral cell in order to provide additional material for evolutions of ecosystems.
- Support development and implementation of regional programs for beach nourishment and dune creation/ restoration.

Monitoring:

- Monitor indicators reflective of SLR (e.g., long-term trends in water levels, marsh accretion rates).
- Evaluate and identify meaningful tipping points to ensure appropriate timing and implementation of adaptation strategies.

Figure 1-11. Environmentally Sensitive Habitat Areas (ESHA)



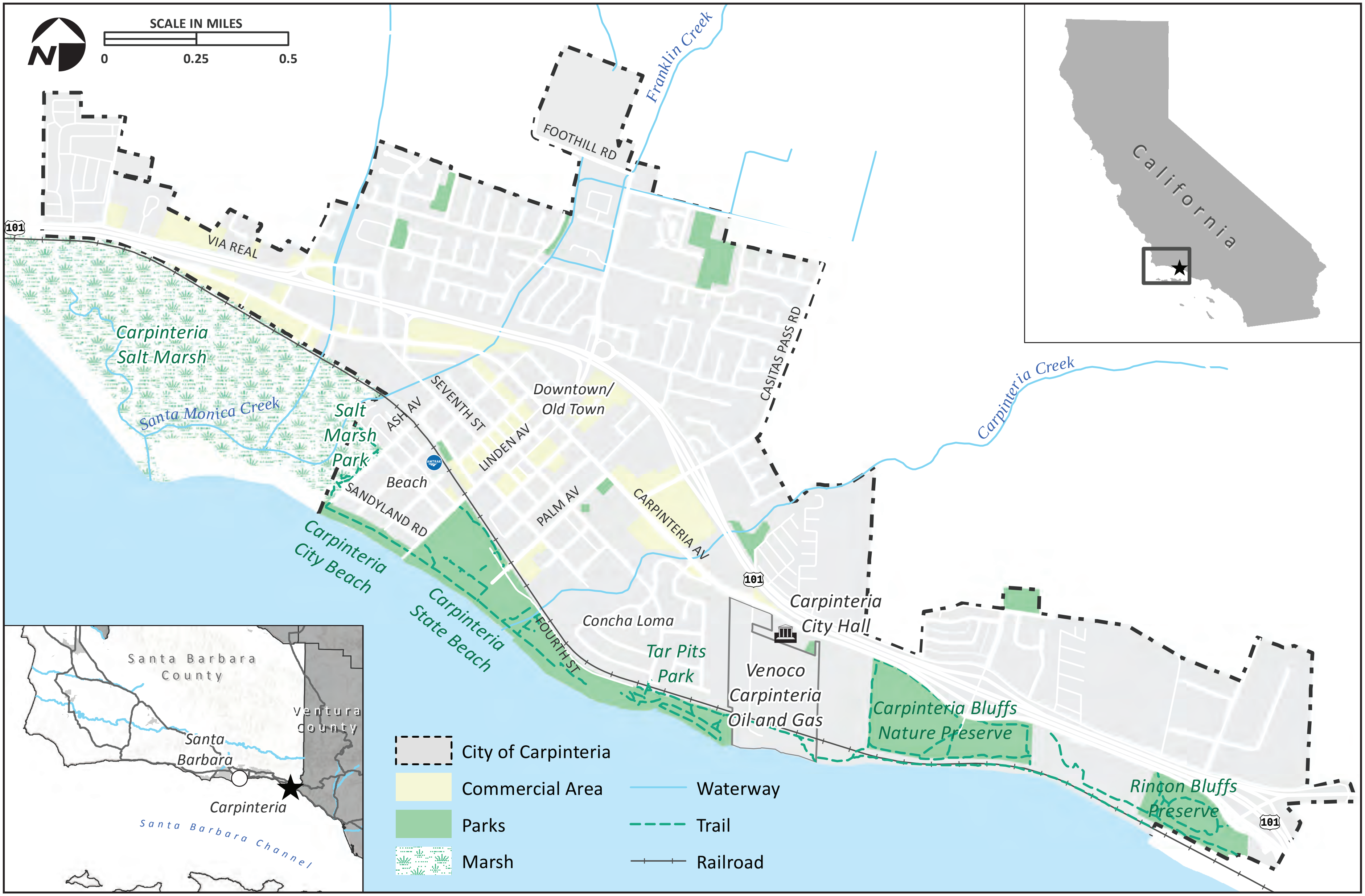
2. Background

2.1 Introduction

The California Coastal Act (1976) requires local governments in the state's Coastal Zone to create and implement Local Coastal Plans (LCPs). Each LCP consists of a Coastal Land Use Plan and an Implementation Plan. Using the California Coastal Act, the California Coastal Commission (CCC) and local governments manage coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion. One of the CCC's goals is to coordinate with local governments, such as the City, to complete a comprehensive LCP update in a manner that addresses sea level rise and coastal hazards associated with large storm events and climate change.

Sea level rise and the changing climate present new management challenges as well as opportunities to address long-term protection of coastal resources, including natural resources, public beach access, critical public infrastructure, and other development and structures.

The goal of the City for this project is to identify vulnerabilities in the City to inform planning for adaptation to future sea level rise conditions. The findings and recommendations of this Report will support policy development that ultimately leads to enhanced community resilience and certification of a LCP consistent with the California Coastal Act. A priority of the LCP is to conserve coastal-dependent uses into the future. Key jurisdictional boundaries and subareas in the City are shown in Figure 2-1.



Regional Overview of the City of Carpinteria

FIGURE 2-1

2.2 Carpinteria General Plan/ Local Coastal Plan History & Status

The City's General Plan/Local Coastal Plan (GP/LCP) is the primary long-term planning document for the City. The GP/LCP encompasses the City's vision for maintaining a high quality of life, preserving its small beach town character, and natural resource protection through the identification of opportunities and constraints, development of goals and objectives, and policy and regulatory implementation.

The GP was initially adopted in 1969 after the City's incorporation and comprehensive updates were completed in 1986 following implementation of California Coastal Act regulations. The Central Coast Regional Coastal Commission certified the City's LCP which included land use policies and regulations with suggested modifications on December 15, 1979. The State Commission found no substantial issue with the LCP as approved by the Regional Commission and certified the LCP with suggested modifications on January 22, 1980. In 2003, the City combined the GP and LCP into one consolidated document, which included significant amendments to land use policies that focused on the Carpinteria Bluffs, including the oil and gas processing facility at Bluff 0 and the remainder of the bluffs extending east along Carpinteria Avenue.

The GP/LCP contains seven elements, including the mandatory Land Use Element, Circulation Element, Open Space, Recreation, & Conservation Element, Safety Element, and Noise Element, as well as the optional Community Design Element and Public Facilities & Services Element. In addition, the City contains a standalone Housing Element adopted in 1995 and updated in 2011.

As required by state planning law (Government Code Section 65300.5) all City GP/LCP elements are designed to be integrated and internally consistent and are also consistent with the California Coastal Act. In 2017, the City began preparation of this current comprehensive update to the GP/LCP given receipt of an LCP planning grant received from the CCC.

2.3 The Planning Process

In August 2015, the CCC adopted the *Sea Level Rise Policy Guidance* to aid public agencies in preparing for sea level rise in LCPs and regional strategies, and to assist applicants preparing coastal development permit (CDP) applications. The 2015 CCC policy guidance 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, increased vulnerabilities, and compliance/consistency with the California Coastal Act. The policy guidance document also lays out the recommended planning steps for public agencies to follow in their efforts to incorporate sea level rise into their planning strategies and regulatory context, and to reduce vulnerabilities and inform sea level rise adaptation planning efforts (Figure 2-2). In April of 2018, as this Report was being completed, the California Ocean Protection Council (OPC) finalized an update to the guidance that follows the same methodology as this Report (OPC 2018).

The purpose of this vulnerability assessment is to complete Steps 1-3 shown below in Figure 2-2, and provide initial input on Step 4. The 2015 CCC policy guidance document places an emphasis on incorporating coastal hazards and sea level rise into LCP planning and using "soft" or "green" adaptation strategies, which mimic or enhance natural processes and defenses, rather than "gray" or "hard" engineering strategies, such as seawalls and riprap. The following are specific steps outlined in the 2015 CCC policy guidance document:

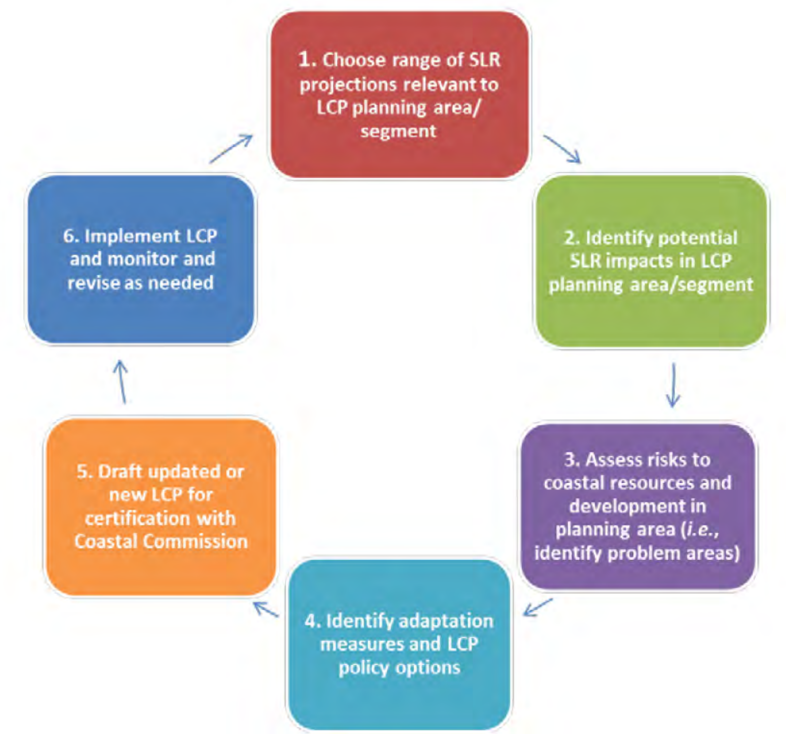


Figure 2-2. California Coastal Commission Policy Guidance for Incorporating Sea Level Rise into Local Coastal Programs

Step 1. Establish the Projected Sea Level Rise Ranges

Consistent with the CCC policy guidance, the City evaluated a range of scenarios, including a high sea level rise scenario with an estimated 60.2 inches by 2100 as based on available coastal hazard modeling which relied on the science from the National Research Council (NRC) *Report on Sea Level Rise* (NRC 2012). This sea level rise scenario is considered a high, though not worst-case scenario[1] and was used in the regional *County of Santa Barbara Coastal Resilience Project* (Coastal Resilience model) to map projections of existing and future coastal hazards. The City selected 2030, 2060, and 2100 as the planning horizons for this Report because they align with the best available modeling completed in 2016, prior to the updated OPC 2018 projections, to support coastal management, planning, and LCP updates in the County of Santa Barbara (County). Probabilities shown in Table 2-1 provide the probability of sea level rise elevations being reached by 2030, 2060 and 2100, that were used in the model.

2010 represents the "existing conditions", or topographic baseline used for the modeling and mapping of future coastal hazards. The 2100 timeframe is the furthermost (or most distant) planning horizon since this is the last year that the coastal hazard models are available and is close to the approximately 75-year economic life of a typical structure. However, under the H++ worst-case scenario, approximately 5 feet of sea level rise could occur by 2070 and up to 9.8 feet by 2100.

Table 2-1. Sea Level Rise Scenarios

Projected Horizon Year / Time	Sea Level Rise (inches/feet)	Probability of Occurring in Projected Year[2]
2030	10.2 in/~ 1 ft	< 0.5%
2060	27.2 in/~ 2 ft	~1%
2100	60.2 in/~5 ft	~2%

Source: Revell Coastal and ESA 2016, and OPC 2018

Step 2. Identify Potential Impacts from Sea Level Rise

The potential hazards for the City associated with sea level rise include beach and dune erosion, 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 also pose substantial risk to water supply and agriculture; although limited work has been done on this issue by the Carpinteria Valley Water District (CVWD), additional analysis is recommended.

1 Worst-case scenario is the H++ scenario which projects 9.8 feet by 2100 and is discussed further in Section 4, *Climate and Sea Level Rise Science.*

2 The range of probabilities relate to scenarios in future greenhouse gas emissions as well as sea level rise uncertainties largely associated with the rate of ice melt around the world.

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

The following sectors were determined to experience existing and/or future vulnerabilities and risk due to sea level rise (e.g., erosion, flooding, and/or tidal inundation):

- Land Use Parcels and Structures
- Roads and Parking
- Public Transportation
- Camping and Visitor Accommodations
- Coastal Trails and Access
- Hazardous Materials Sites, and Oil and Gas Wells
- Stormwater Infrastructure
- Wastewater Infrastructure
- Water Supply Infrastructure
- Community Facilities and Critical Services
- Environmentally Sensitive Habitat Areas

Step 4. Identify Adaptation Measures

The City anticipates conducting additional work on adaptation strategy development during future public education, outreach, and decision-maker engagement efforts. The process will consider the full range of potential adaptation measures including, but not limited to, beach nourishment, shoreline protection including living shorelines/beach sand dune restoration, groins, managed relocation, and shoreline management. The process will identify triggers and evaluation criteria to determine the most appropriate approach, measure success of the various strategies, and evaluate whether the strategies could be considered long-term maladaptation. A thorough cost benefit analysis of the various adaptation strategies is also recommended as an important decision-making tool.

Step 5. Update the GP/LCP

The City has been taking substantive steps toward updating the GP/LCP which is being prepared concurrent with this Report. The City is currently developing a focused update of the GP/LCP that builds upon the City's success in maintaining its 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 intends to update their GP/LCP in a manner that defines the City's 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.

Step 6. Implement and Monitor the GP/LCP

The City will implement and monitor the GP/LCP progress based on the final certified LCP.

2.4 Other Regional Sea Level Rise Planning Efforts

The City is one of multiple local jurisdictions addressing sea level rise. Currently, there are several regional planning and technical studies on the impacts of coastal hazards, climate change, and sea level rise. Many local jurisdictions are updating their LCPs with the intent of moving toward adaptation planning in the Santa Barbara and Ventura region. As part of the LCP update process, the City will integrate sea level rise hazards and adaptation planning into the update.

One unique component to the regional coastal governance along the South Central Coast region is the presence of a Joint Powers Authority (JPA) known as the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON). BEACON is a California JPA established in 1986 to address coastal erosion, beach nourishment, and clean oceans within the South 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 coastal city. The BEACON Board educates and provides important information to other elected officials, the public, and interested stakeholders, and provides a forum for the discussion of pressing coastal and beach issues.

Given the interconnectedness of regional sediment management in the Santa Barbara Sandshed (littoral cell and watershed), it is important to understand regional initiatives, as no single jurisdiction will be able to adapt their respective community in isolation. The regional studies discussed below provide a summary of current/ongoing initiatives that may support planning and adaptation efforts within the City. Relevant regional efforts and studies include:

- Carpinteria GP/LCP Update
- Carpinteria Hazard Mitigation Plan
- Carpinteria Recycled Water Facilities Plan
- Carpinteria Valley Water District Groundwater Initiatives
- County of Ventura Coastal Resiliency Vulnerability Assessment
- County of Santa Barbara Vulnerability Assessment and LCP Update
- City of Oxnard LCP Update
- City of Santa Barbara LCP Update
- City of Goleta Vulnerability Assessment and Fiscal Impact Report

Carpinteria GP/LCP Update - ongoing

The City is currently developing a focused update of the GP/LCP that builds upon the City's success in maintaining its small beach town character, with an emphasis on addressing sea level rise as part of the LCP update, consistent with California Coastal Act and CCC *Sea Level Rise Policy Guidance* document. The GP/LCP update will also include a new Healthy Community Element and focused amendments to key planning areas. The City intends to update their GP/LCP in a manner that defines the City's 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.

2017 City of Carpinteria Local Hazard Mitigation Plan

Hazard mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. It is most effective when implemented under a comprehensive, long-term mitigation plan. State, tribal, and local governments engage in hazard mitigation planning to identify risks and vulnerabilities associated with natural disasters and develop long-term strategies for protecting people and property from future hazard events. Mitigation plans are key to breaking the cycle of disaster damage, reconstruction, and repeated damage. The Federal Emergency Management Agency (FEMA) requires state, tribal, and local governments to develop and adopt hazard mitigation plans as a condition for receiving certain types of non-emergency disaster assistance, including funding for mitigation projects. Jurisdictions must update their hazard mitigation plans and re-submit them for FEMA approval every five years to maintain eligibility.

In July 2017, the City Local Planning Team (LPT) participated in updating its Local Hazard Mitigation Plan (LHMP) as an Annex to the Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan (MJHMP). The City's updated LHMP was adopted by the City Council on September 11, 2017 and approved by FEMA on September 26, 2017. The City Council also resolved to incorporate the updated LHMP by reference into the next update of the Safety Element of the GP/LCP.

2016 Carpinteria Recycled Water Facilities Plan

The City, CVWD, and Carpinteria Sanitary District (CSD) with funding from the State Water Resources Control Board (SWRCB), collaborated to investigate the feasibility and costs associated with developing a recycled water facility at the Carpinteria Wastewater Treatment Plant (WWTP). The 2016 Carpinteria Recycled Water Facilities Plan looked at a variety of options and projected costs to upgrade the WWTP and provide a range of recycled water options to offset CVWD's water supply portfolio. The existing portfolio currently relies heavily on imported supplies from Lake Cachuma and State Water projects, which face greater uncertainties in the face of future climate-related changes to temperature, precipitation, and snowpack. The Carpinteria Groundwater Basin presently supplies about one-fourth of the existing supply. The plan considered the use of recycled water for landscape irrigation, agricultural irrigation, and groundwater recharge. Groundwater recharge with full advanced water treatment was selected as the preferred use of recycled water. It is unclear what the next steps in the process may be, but the GP/LCP should develop policies to streamline such a project, which would benefit the City and its natural resources.

Carpinteria Valley Water District Groundwater – ongoing

CVWD has been evaluating the Carpinteria Groundwater Basin for decades as a critical water supply source. The Groundwater Basin Plan was initially adopted in 1999 and bi-annual monitoring has been ongoing. In 2007, with a substantial update in 2012, the CVWD funded a groundwater basin model to provide CVWD with an ongoing basin monitoring tool to evaluate the supply and to assess potential impacts to the basin from increases in groundwater pumping, extended drought, and to simulate alternative basin management strategies. Using available well data, the Report examined previous droughts and found that during the extended 6-year drought between 1987 and 1992, water levels in the basin were 40 feet below sea level, a condition conducive to salt water intrusion into the aquifer. Presently, while salt water intrusion has not been detected, the location of the fresh and saltwater interface is unknown. One key recommendation was to install a sentinel well near the coast to monitor for saltwater intrusion. Presently, CVWD has identified a location, but has not completed planning and permitting processes. Any update to the LCP should facilitate the installation of this monitoring well.

The Carpinteria Valley Groundwater Basin was designated from a low priority to a high priority basin as part of the California Department of Water Resources 2018 Re-Prioritization. Based on this designation, the basin is now subject to the Sustainable Groundwater Management Act requirements to develop a Groundwater Sustainability Plan. As this process unfolds, enhanced coordination between the City and CVWD that involves land use planning efforts shall be necessary to ensure future development activities are aligned with available water supplies.

2015 City of Goleta Vulnerability and Fiscal Impact Report

The City of Goleta, with funding from the CCC, completed a *Vulnerability Assessment and Fiscal Impact Report* to support development of new LCP policies and zoning regulations. The City of Goleta utilized the Coastal Resilience modeling to evaluate the potential impacts of coastal hazards on their community. Key impacts identified were related to potential oil and gas spills, wastewater infrastructure, and some low-lying residential properties. Draft LUP policies were submitted to the CCC and the City of Goleta and are on hold (as of 2018), extending LCP certification until their Zoning Ordinance is updated.

Ventura County Coastal Resiliency Adaptation Project - ongoing

Ventura County received funding from the CCC and is currently conducting a Coastal Resiliency Vulnerability Assessment of their coastal resources using the *County of Ventura Coastal Resilience Project* modeling. This effort supports the sea level rise update to the LCP. Ventura County is addressing 13 natural resource and infrastructure sectors in three (3) subareas. The North County Subarea is facing substantial vulnerabilities to transportation, recreation, oil and gas, and residential land uses. The Central County is expected to experience substantial impacts in the relatively near-term in the agriculture and residential sectors. The South County Subarea faces challenges to transportation, parks, and recreation. With a higher sea level, agriculture is also anticipated to be impacted. Ventura County will be starting public outreach in the spring of 2018 with completion of the Vulnerability and Adaptation Project planning reports by the end of 2018 and draft policies submitted to the CCC in summer 2019.

2016 Coastal Resilience Santa Barbara County - ongoing

In addition to the Coastal Resilience modeling described in more detail in Section 4, *Climate and Sea Level Rise Science*, Santa Barbara 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 their 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 the County identified the need to work with adjacent jurisdictions, including Carpinteria.

City of Oxnard LCP Update - ongoing

The City of Oxnard has been preparing a *Coastal Hazards Vulnerability Assessment and Fiscal Impact Report* to address sea level rise and associated hazards in the City of Oxnard's Coastal Zone, and to provide a fiscal impact analysis to inform the LCP update process and future adaptation planning and regulatory processes. Key vulnerabilities identified the power plants, residential neighborhood around Oxnard Shores, and the regional wastewater treatment plant as critical. As part of the adaptation planning process, some economic tradeoffs of various types of strategies were evaluated including shoreline protection (hard structures), beach nourishment, dune restoration, and managed retreat. The economic analysis showed the benefits of various strategies at different points in time. Results of their report may support adaptation planning in the Ventura County's Central Coast Subarea. In addition, there have been several public and regional stakeholder engagement efforts to obtain technical feedback and educate the public and elected officials. Submittal of LCP language to the CCC is expected in spring of 2018.

City of Santa Barbara Vulnerability Assessment and LCP Update - ongoing

The City of Santa Barbara received funding from the CCC in 2013 to update its LCP. These updates were intended to incorporate sea level rise adaptation actions. However, as the City of Santa Barbara 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 CCC, the City of Santa Barbara embarked on a longer-term adaptation planning process and expanded vulnerability assessment work by several graduate student groups at the University of California, Santa Cruz and University of California, Santa Barbara (Bren 2009, Russell and Griggs 2012, and Bren 2015), as well as some of the Coastal Resilience modeling. In the interim, the County proposed policies to support maintenance of existing shoreline protective structures along the City of Santa Barbara waterfront and continuation of the Santa Barbara harbor dredging.

2009 BEACON Coastal Regional Sediment Management Plan

In 2009, BEACON completed an update of the Coastal Regional Sediment Management Plan (CRSMP), which identified what is known about sand supplied to the Santa Barbara Littoral Cell between Point Conception and Point Mugu, including new understanding of erosion hot spots and shoreline protection. This plan did not include much sea level rise analysis; however, recommendations from this plan include new ways to manage sediment in the region, including development of an opportunistic sand placement program, sand rights policies, and changes in regional governance structure, which would support better use of coastal sediments. BEACON should also be a key partner in the development of regional adaptation strategies and education of elected officials.

City of Carpinteria and U.S. Army Corps of Engineers Shoreline Feasibility Study - ongoing

The City and the U.S. Army Corps of Engineers (USACE) have been working on a study of Carpinteria City Beach between Ash Avenue and Linden Avenue. The study reach is about 0.24-mile of shoreline. The Carpinteria State Beach borders the southern limit of the reach and the Carpinteria Salt Marsh borders the northern limit. There are existing structures within the reach that are directly affected by shoreline erosion and wave attacks. The structures behind the fronting properties may be affected by coastal flooding during severe storms.

The project was authorized by Section 208 of the Flood Control Act (1965). Current funding will be used toward development of an array of alternatives leading to the selection of a proposed project to address shoreline erosion along the City beaches. A joint Environmental Impact Report (EIR) and Environmental Impact Statement (EIS) will be prepared to evaluate potential environmental effects associated with the proposed project and alternatives, and is pending.

3. Existing Conditions & Physical Setting

3.1 Setting

The City is located in southern Santa Barbara County. The 2010 U.S. Census reports that the City had a population of 13,040 and a total area of 7.3 square miles. The City is located almost entirely on a coastal plain between the Santa Ynez Mountains and the Pacific Ocean. In general, the area's topography slopes from the foothills of the Santa Ynez Mountains in the north towards the Pacific Ocean to the south. Between the foothills and the populated area of the City is an agricultural zone. Transportation corridors running east-west, including U.S. Highway 101 (U.S. 101) and the Union Pacific Railroad (UPRR), bisect the City. The urban core of the City is located primarily along Carpinteria Avenue. The entire City is located within the designated California Coastal Zone.

The Carpinteria coastline faces south and is generally aligned in a northwest-southeast direction and transitions from sandy beaches in the northwest to uplifted cliffs in the southeast. The Channel Islands, located offshore and to the south, protect the coast from southerly waves.

The sandy public beaches are maintained by the City and the California Department of Parks and Recreation (State Parks) and are heavily used; State Parks estimates these beaches get over 1,000,000 visitors annually. To the northwest is Carpinteria City Beach, which extends 0.3 miles from the south end of Ash Avenue to Linden Avenue and is owned and maintained by the City. The neighborhood behind Carpinteria City Beach is largely residential and is known as the Beach Neighborhood. Moving southeastward, Carpinteria State Beach stretches 0.7 miles and is operated by State Parks. Combined with the Carpinteria City Beach, this 1-mile stretch of beach is known for its gentle sandy slope and relatively calm conditions, earning the acclaim as the "World's Safest Beach". Eastward, beyond Carpinteria State Beach, the land rises rapidly in the form of marine terraces known as the Carpinteria Bluffs, which host a variety of different industrial oil and gas facilities and infrastructure, commercial research facilities, and parks and open space. Beaches below the bluff are owned by the City and run another 1.5 miles to the City limits near Rincon County Beach Park.

Three main creeks transect the study area, including Carpinteria Creek, Santa Monica Creek, and Franklin Creek, along with other smaller drainages and tributaries. Santa Monica Creek and Franklin Creek within the City boundary are concrete-lined drainage channels that both terminate at the Carpinteria Salt Marsh, one of the area's prominent hydrologic features. Carpinteria Creek remains unlined and has been identified as a target for restoration to improve habitat for threatened and endangered southern steelhead trout and tidewater goby. The City's Wastewater Treatment Plant (WWTP) is located adjacent to the lower reach of Carpinteria Creek.

Several key habitat features are found in and adjacent to the City which influence the local ecology and coastal processes. Offshore, Carpinteria Reef provides wave dissipation and helps protect Carpinteria from large waves. The Carpinteria Salt Marsh, part of the University of California Natural Reserve System, is home to several threatened and endangered plant and animal species. Finally, the coastal bluffs and beach in the easternmost part of the City provide a harbor seal haul out area on the beach as well as sensitive upland habitats on the cliff tops.

3.2 Climate

The climate in the study area is Mediterranean, characterized by dry summers and moderately wet winters. Based on data from 1985 to 2016, the annual average precipitation in the Santa Barbara region is approximately 18 inches. However, it is not uncommon to see significant annual variation from this average, with especially wet years attributed to El Niño conditions. Most of the precipitation occurs between the months of November and March. Average monthly temperatures range from a low of approximately 63 degrees Fahrenheit (°F) in January to a high of approximately 75°F in August and September. During the fall, hot dry Santa Ana winds blow from east to west and can substantially raise the risk of wildfires.

This region has historically experienced substantial droughts with multiple consecutive low precipitation years. The most recent drought began in 2011 and to date a Stage II Drought Condition remains in effect in the area served by the Carpinteria Valley Water District. Significant storm events have occurred in the past two years, which could lift the current drought status. Two severe storm events occurred during this time, which triggered mudslides and debris flows at El Capitan Ranch in February 2017 and in Montecito and Carpinteria in January 2018. Both debris flow events resulted from a combination of large fires in the watershed followed by short, intense rains. Mudslides and debris flow in Montecito resulted in the loss of life and property.

3.3 Geology

Carpinteria 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. Offshore faults include the Red Mountain and Pitas Point/Ventura Faults that separate the Santa Barbara mainland from the Channel Islands. Within the City, the Carpinteria and Rincon Faults run east-west through the City and are largely responsible for the elevational differences across the City, including the formation of the Carpinteria Salt Marsh and Carpinteria Bluffs (Figure 3-1).

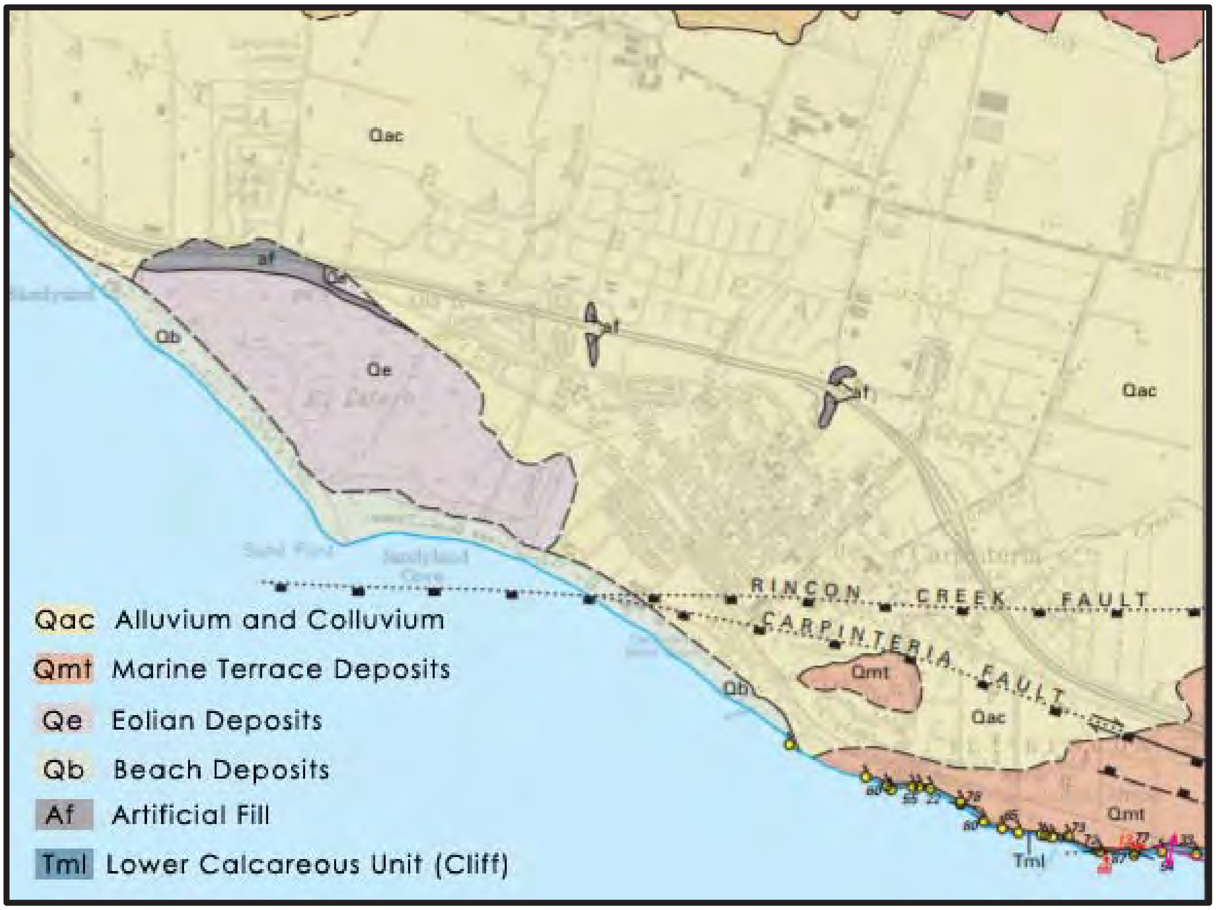


Figure 3-1. *Fault Map of Carpinteria. Source: USGS.*

Carpinteria Tar Pits Park plays a role in the shape of beaches in the City and is one of only five natural asphalt tar pits in the world. The tar pits are an area where oil deposits seep to the ground surface along various fault fractures. Deposits from this tar pit date back to the Pleistocene Age (2.6 million to 11,700 years ago). The tar has hardened portions of the shoreline provides geologic evidence of now extinct species including mastodons and saber tooth tigers. The tar also hardened surrounding marine terrace deposits near or above the delineated Carpinteria and Rincon Creek Faults. As a result, the tar created a small headland, which serves to trap sand that nourishes City beaches. According to State Parks, the area was at one point used as a local dump site (State Parks 2011).

3.4 Historic Ecology and Habitats

Based on historic mapping completed by the United States Coast and Geodetic Survey in the 1860s (T-1127), Carpinteria used to have a much more extensive wetland and dune system (Figure 3-2). Sand dunes used to extend from the mouth of Carpinteria Salt Marsh to the tar

Figure 3-2. *Historic Extent of Coastal-Dependent Habitat in Carpinteria c. 1869. Source Grossinger et al 2011.*

pits in Carpinteria State Beach. These dune systems allowed the formation of more extensive vegetated wetlands and intertidal sand and mud flats. Much of the low-lying neighborhoods and Carpinteria State Beach were once wetland. Based on recent sea level rise flood and inundation maps, many of these historic wetland areas are likely to be subject to future coastal flooding and tidal inundation as sea levels rise.

In the 1870s, a large dune field was present upcoast from the entrance to the Carpinteria Salt Marsh. As a result of this historic dune field, the neighborhood adjacent to Carpinteria was named Sandyland and the mouth to the salt marsh was named Sand Point. Discussion of shoreline change is provided below in Section 3.8, *Historic Shoreline Changes and Erosion*.

Although physical processes and human alterations have affected these historic habitats, they have evolved into the habitat areas of value that are currently proactively managed. Additionally, some of these habitats are now identified as Environmentally Sensitive Habitat Areas (ESHA).

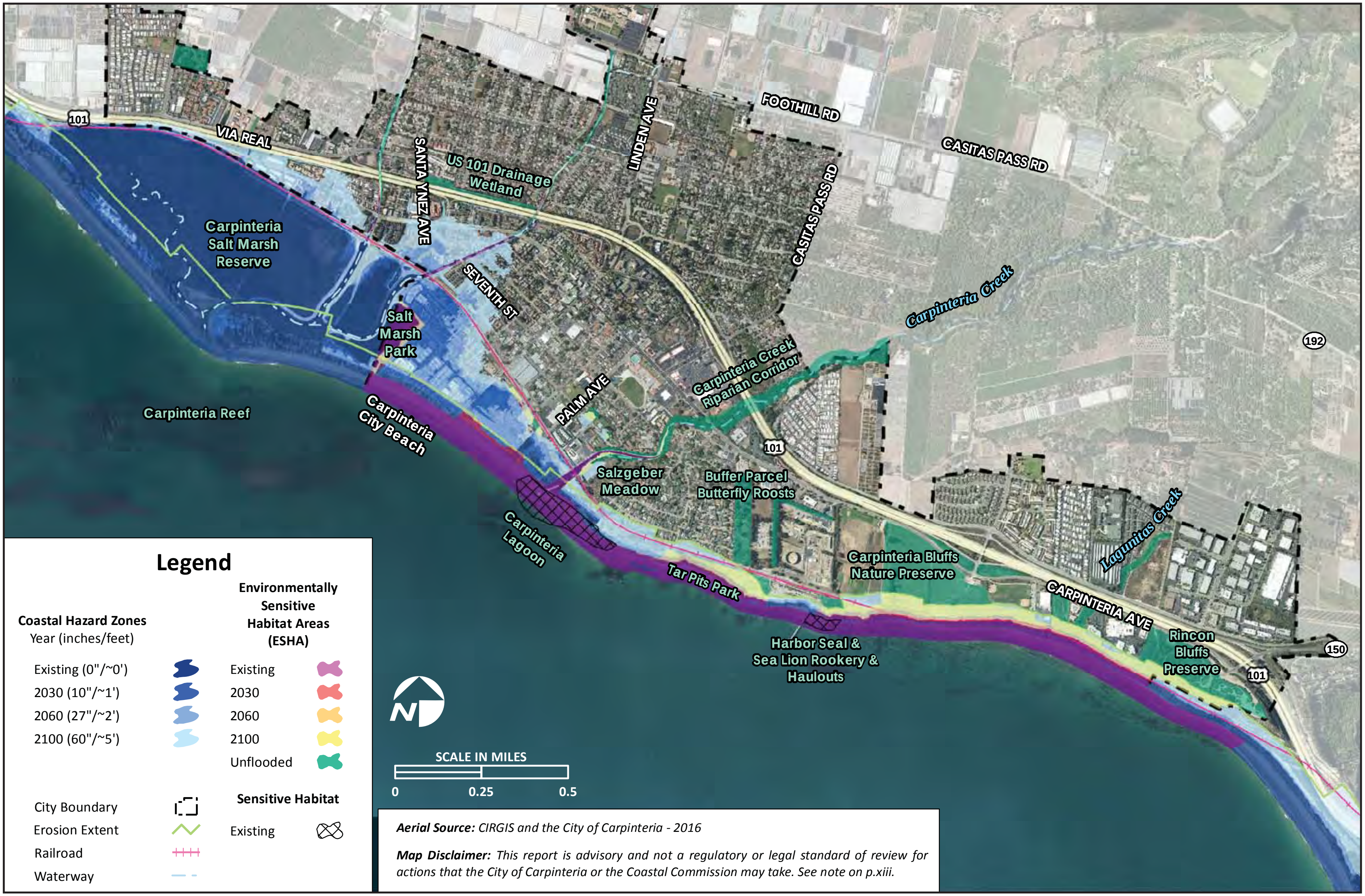
3.5 Environmentally Sensitive Habitat Area (ESHA)

Habitats evolve as a result of physical processes over time. In Carpinteria there are a wide range of habitats ranging from offshore reefs, an intertidal shoreline zone, and the upland areas. An Environmentally Sensitive Habitat Area (ESHA) is a type of habitat that has been specially designated by the City and the CCC to have special status (Table 3-1). ESHAs are presently found throughout the City. The ESHA overlay designation is depicted on the City's land use plan and resource habitat maps and is intended to be representative of general locations of known sensitive habitats. Although these ESHA overlay designations have not been updated since 1999, they meet the Local Coastal Program (LCP) and CCC definitions for ESHA and remain the standard of review for habitats in the City's existing CLUP/GP. As acknowledged in the CLUP/GP, all sensitive communities may not be known, or may migrate or otherwise change over time. Therefore, the maps are intended to identify the existence but not the full extent of sensitive habitat areas, and supplemental investigations may be required for land use activities.

The location of existing mapped ESHA are shown below (Figure 3-3), and potential future impacts to these habitats caused by climate change are described in Section 6.8, *Environmentally Sensitive Habitat Area*. Additionally, these habitats are required to be analyzed for impacts prior to any permit approval.

Table 3-1. Environmentally Sensitive Habitat Areas in Carpinteria

Habitat Type	Area
Wetlands	Carpinteria "El Estero" Salt Marsh, Lower Carpinteria Creek, Higgins Spring at Tar Pits Park, Ellinwood Parcel, U.S. Highway 101 Drainage between Santa Ynez Ave and Linden Ave
Butterfly Habitat	Salzgeber Meadow, Carpinteria Oil and Gas Plant buffer parcels, Carpinteria Bluffs
Marine Mammal Rookeries and Hauling Grounds	Carpinteria Harbor Seal Rookery, sandy pocket near Carpinteria Oil and Gas Plant pier near Carpinteria Bluffs
Rocky Points and Intertidal Areas	Carpinteria Bluffs
Subtidal Reef	Carpinteria Reef, reefs below Carpinteria Bluffs
Beaches and Dunes	Carpinteria City Beach, Carpinteria State Park
Kelp Beds	Carpinteria Reef, reefs below Carpinteria Bluffs
Creeks and Riparian Habitat	Santa Monica Creek, Franklin Creek, Carpinteria Creek, Lagunitas Creek
Significant Native Plant Communities such as: Coastal Sage Scrub, Riparian Scrub, Coastal Bluff Scrub, and Native Oak Woodlands	Carpinteria "El Estero" Salt Marsh, Carpinteria Bluffs, Carpinteria Creek, Tar Pits Park, Farmer Parcel
Significant Native Trees or Specimen Trees	Ellinwood Parcel, Portola Sycamore, Woodholme Torrey Pine
Sensitive, Rare, Threatened or Endangered Species Habitat	Carpinteria Bluffs, Carpinteria Creek, Carpinteria Salt Marsh



Environmentally Sensitive Habitat Areas in the Carpinteria Planning Area

FIGURE 3-3

3.6 Littoral Cell and Sediment Budget

The Carpinteria coast is located in the Santa Barbara Sandshed, a combination of the watershed and littoral cell, which contains a complete cycle of offshore sedimentation, including a sediment source, transport path, and area of deposition. This sandshed extends 145 miles from the Santa Maria River in the north and around Point Conception, where the north-south trending western U.S. coast abruptly changes to a west-east trending shoreline orientation in the Southern California Bight (Figure 3-4). The Santa Barbara Littoral Cell extends from the Santa Maria River in San Luis Obispo County to the north, through Santa Barbara and Ventura Counties to the Mugu Submarine Canyon to the south. The Mugu Submarine Canyon is the ultimate sediment sink for the littoral cell, where sand is transported offshore beyond the depth of closure (a beach profile where sediment transport becomes minimal or non-existent) into the deep Santa Barbara Basin (Figure 3-4; Beach Erosion Authority for Clean Oceans and Nourishment [BEACON] 2009).

Beach sediments primarily come from stream delivery of watershed-derived sediments and some cliff erosion. Numerous steep watersheds drain the sandstone dominant Western Transverse Ranges, which serve to nourish local beaches. The shoreline characteristics and natural supply of sediment within this region primarily result from sediment from upcoast beaches and contributions from small coastal watersheds. Cobbles and bedrock are often seasonally exposed in the wintertime, particularly at the base of the Carpinteria Bluffs or on local beaches after large storm events. In the summer beaches are naturally replenished with sand and sediments that are transported from upcoast sources.

Point Conception to the northwest and the Channel Islands to the south create a narrow swell window into the Santa Barbara Channel that shelters much of the Carpinteria's coast from extreme wave events and creates a nearly unidirectional sand transport from west to east. Within the littoral cell, four manmade harbors (Santa Barbara, Ventura, Channel Islands, and Port Hueneme Harbors) require annual sand bypassing to maintain safe navigational bathymetry/depths. However, these harbors are sand traps, and regular dredging is required to maintain sand supply to the downcoast beaches. The annual average volumes of sand dredged from each harbor indicate the increasing gradient of sand (sediment budget) movement along the littoral cell shoreline from west to east:

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

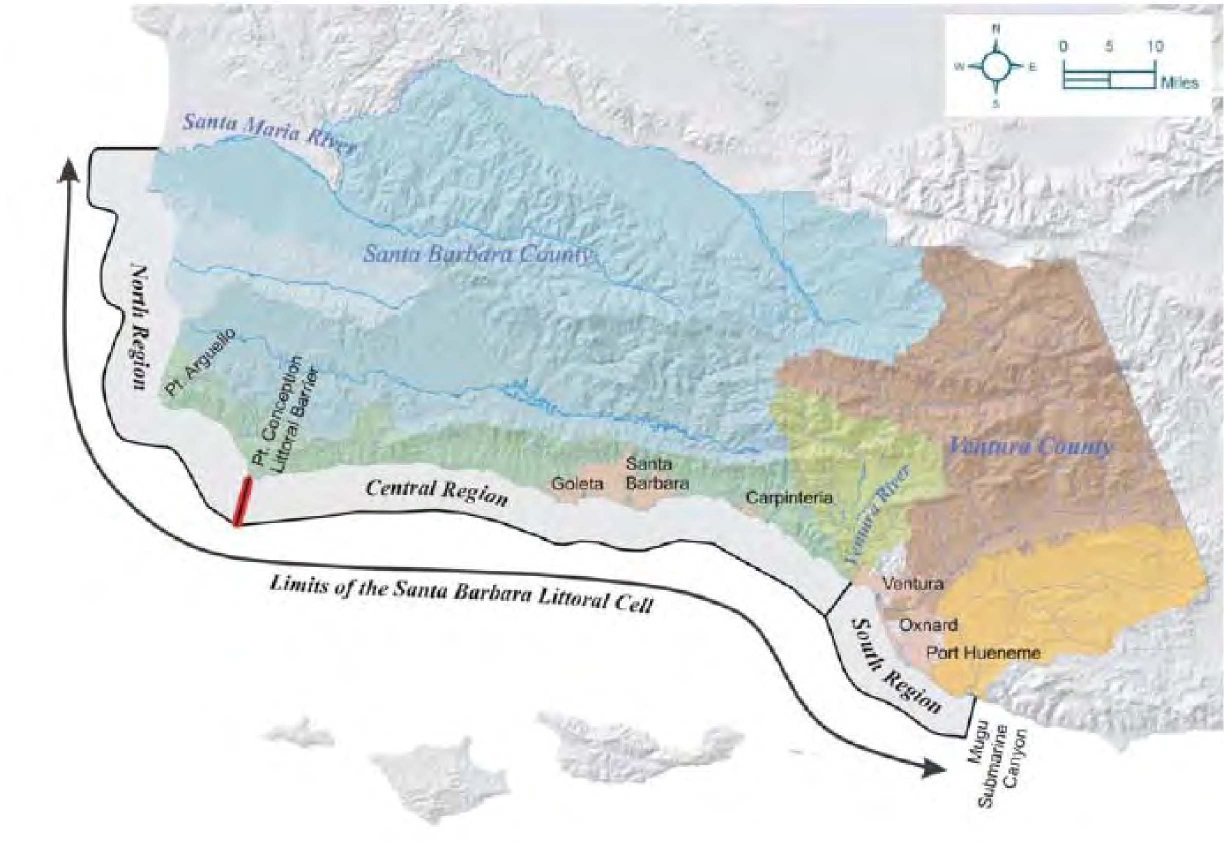


Figure 3-4. *The Santa Barbara Sandshed (Littoral Cell and Watersheds). BEACON 2009.*

3.7 Coastal Processes

The coastal processes of tides, waves, and longshore currents shape the coastline of Carpinteria. Winds and wave heights vary seasonally.

Tides

The tides in Carpinteria 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. Typical tide heights range from 5.4 feet during full and new moon spring tides and 3.6 feet during the neap (1/4 and 3/4 moon) tides. Maximum tide elevations are due to astronomical tides associated primarily with gravitational pull from the sun and the moon, wind surge, wave set-up, density anomalies, long waves (including tsunamis), climate-related El Niño events, and Pacific Decadal Oscillation events. The maximum tidal water level elevation recorded at the nearby Santa Barbara tide station was 10.79 feet above mean lower low water (MLLW) on December 13, 2012. On longer time scales, sea level rise becomes increasingly important, as extreme high tide elevations become more common.

The largest tide ranges in a year typically occur from late December to early January and are known as "king tides". In Carpinteria, king tides can reach up to 7.2 feet in elevation above MLLW. The tidal inundation projections used in this study assume Extreme Monthly High Water (EMHW) levels, calculated by averaging the maximum monthly water level for every month recorded at the Santa Barbara tide gauge. The elevation of this tide level is 6.5 feet above MLLW and can be expected to be the area that gets inundated once a month. This elevation was modeled and mapped as part of the County's 2016 Coastal Resilience efforts and approved by involved public agency stakeholders.

Waves

Two dominant types of waves approach Carpinteria's shoreline, characterized by wave source and direction. First, northern hemisphere waves are typically generated by cyclones in the north Pacific during the winter and bring the largest waves (up to 25 feet). Second, the southern hemisphere waves are generated in the Southern Ocean during summer months and produce smaller waves with longer wave periods (> 20 seconds). However, due to the presence of the offshore Channel Islands, these long period southern swells/waves are generally much smaller when they reach Carpinteria, supporting the City's claim as the "World's Safest Beach." Additionally, local wind waves are generated throughout the year either as a result of winter storms coming ashore, or strong sea breezes in the spring and summer.

There remains some uncertainty about the influence of climate change on wave heights, frequency of large events and intensity. Presently, work by the U.S. Geological Survey (USGS) indicates that there may be additional southern hemisphere wave energy (not likely to affect Carpinteria), a northerly shift in the average northern hemisphere wave direction (which may diminish the average winter wave heights), and more intense storms (Erikson et al 2015).

Longshore Currents and Sediment Transport

Currents in the Santa Barbara Channel drive a nearly unidirectional longshore sediment transport from west to east which cause beaches to narrow during the winter and spring (November to April) and widen during the summer and fall (May to October). The sand on the beaches of Carpinteria moves along the coast of southern Santa Barbara and Ventura Counties to the Point Mugu Submarine Canyon in the south.

3.8 Historic Shoreline Changes and Erosion

Shoreline changes (accretion and erosion) result from a change in sediment supply, coastal processes including large storms, and human activities. When sediment supply exceeds the gross longshore sediment transport rates then the coast will accrete seaward; when more sediment is removed than supplied, the coast will erode. Long-term changes in the shoreline are caused by sediment supply and sea level rise, whereas short-term or event-based erosion is caused by large storm events.

Carpinteria beaches experience seasonal cycles in which winter storms move significant amounts of sand offshore, creating steep, narrow beaches. In the summer, gentle waves return the sand onshore, widening beaches and creating gentle slopes. Sandy beach widths along Carpinteria City beach range between 65 and 200 feet, although width varies seasonally and along the coast. Because many factors influence coastal erosion, including human activity, sea level rise, seasonal fluctuations, and climate change, sand movement will generally be locally variable.

Coastal and creek flood hazards have historically occurred throughout Carpinteria. Significant wave events in 1938, 1943, 1958, 1982–83, 1988, 1997–1998, 2002, 2007, and 2015-2016 demonstrate the dynamic and hazardous coastal environment. While many of these storm events and creek flooding hazards are associated with El Niño, other causes can threaten the environment including storm events post-wildfire. In such situations, due to an absence of vegetation and resultant soil erosion, large fluxes of sediment can be rapidly transported to the coast (e.g., January 2018 mud and debris flows in Montecito and Carpinteria).

The Carpinteria and Sandyland shoreline has changed dramatically since the late 1800s when a large dune field was present (refer to Figure 3-2). These changes are mostly due to indirect or direct human impact or influences, including the downcoast erosion and loss of sediment supply as a result of construction of the Santa Barbara Harbor approximately 10 miles to the west, and loss of dune and wetland habitat due to development along the Carpinteria shoreline. The installation of the Santa Monica Creek debris basins in 1970 has interrupted the migration of natural course sediments that to the shoreline, reducing the amount of cobble transported to Carpinteria's beaches. Lack of cobble significantly reduces the shoreline's natural resilience to wave attack during high energy events. In localized spots adjacent to Carpinteria City Beach, shoreline protection in the form of coastal armoring structures also causes seasonal impacts to the sandy beach width, including a narrowing of the beach, an acceleration of sand transport, and a seasonal erosion hotspot at the end of Ash Avenue near the lifeguard tower (Revell et al 2008). Armoring of the coastline upcoast from Carpinteria significantly reduces sediment input to the shoreline. Armored shoreline structures do not allow sediment to migrate offshore during storm events and thereby prevent sand bars from forming. The Sandyland Revetment has had significant "end effects" of reducing the sandy beach width on Carpinteria City Beach, as well as the Santa Barbara Harbor, upcoast armored coastline structures and watershed debris basins, with the unintended consequence of starving the Carpinteria shoreline of natural sediments that are critical to provide shoreline resiliency.

Erosion wave en route to Carpinteria in 1936.
Photo source: Spence Collection – UCLA

Updrift erosion at Sandyland circa late 1930s.
Photo source: Santa Barbara Independent

Breakwater construction at the Santa Barbara Harbor began in 1927 and was completed by 1930, during which approximately 2.6 million cubic yards of sand were impounded updrift of the Santa Barbara Harbor at Ledbetter Beach. Sand impoundment led to a well-documented erosion wave[1] that migrated downcoast at a pace of approximately 1 mile per year. The arrival of the erosion wave to Sandyland and Carpinteria, combined with storm waves arriving from a hurricane that made landfall in Long Beach in 1938, resulted in the erosion of the historic dune field at Sandyland and the beach at Carpinteria in the late 1930s. (Bailard 1982; Komar 1998; Weigel et. al 2002). In addition, the natural underwater sand peninsula (tombolo) between the sand dunes and Carpinteria Reef was eroded.

The effect of this erosion changed the longshore currents in Carpinteria and likely allowed more swell energy to rotate Carpinteria beaches in a slightly clockwise direction. The long-term shoreline and beach responses to this erosion event were to erode the beach in front of Sandyland Cove and accrete the beach in front of Tar Pits Park, effectively rotating the beach slightly to the southeast. Photogrammetric analysis of 16 historic aerial photographs show long-term changes along the Carpinteria shoreline since the 1869 shoreline position was documented at Sandyland Cove Beach, Ash Avenue, Linden Avenue, and Tar Pits Park. Sandyland Cove Beach saw the largest changes, eroding by approximately 100 feet, and Ash Avenue narrowed by approximately 50 feet (Figure 3-5). Meanwhile, accretion occurred on the beach at Linden Avenue (approximately 30 feet) and Tar Pits Park (approximately 60 feet) (Revell et. al 2008).

1 Erosion wave is an area of sand deficit that travels along the coast.

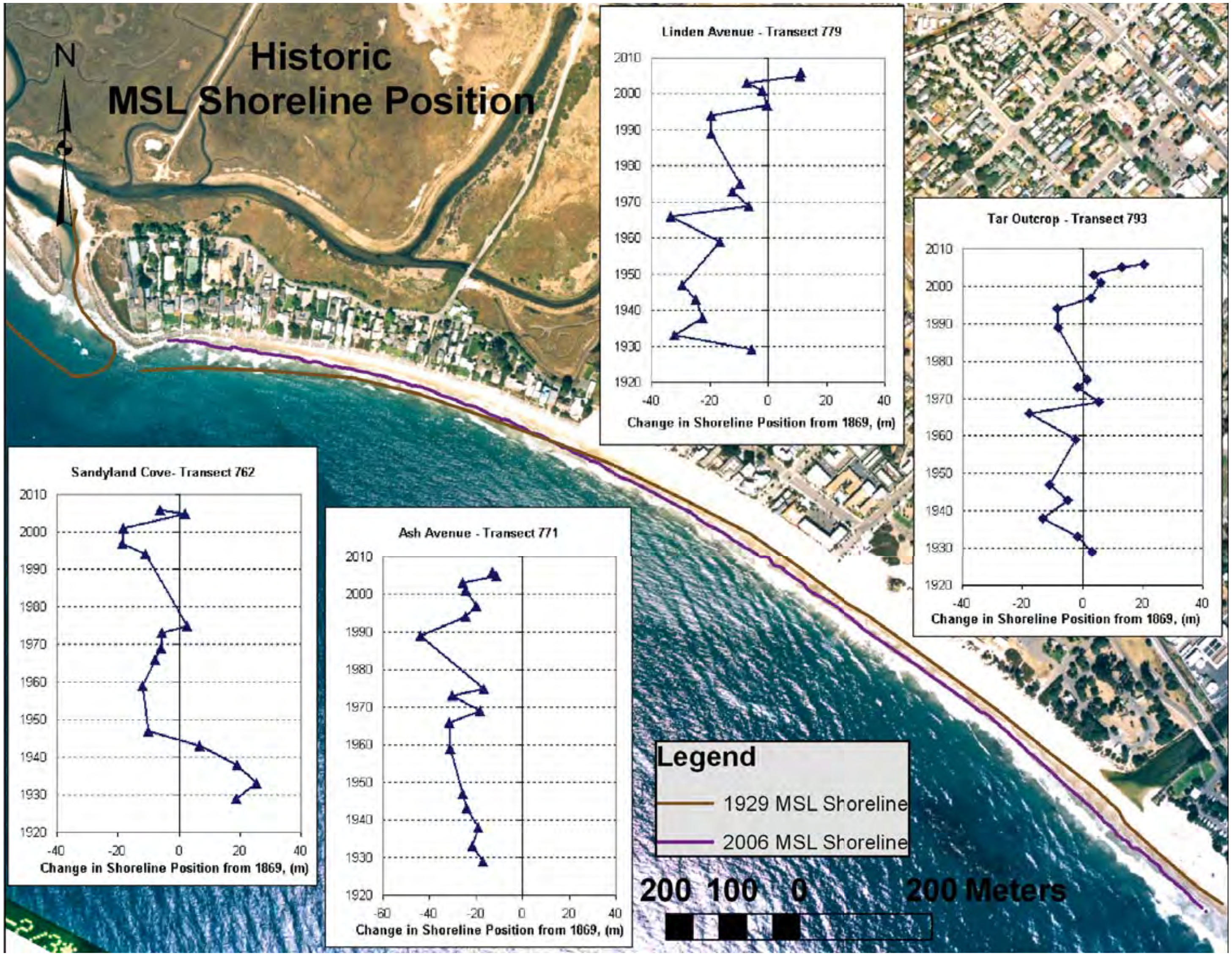


Figure 3-5. *Changes in Mean Sea Level (MSL) shoreline position relative to the 1869 shoreline at four locations. The 1929 and 2006 MSL shorelines also show updrift erosion and downdrift accretion*

As a result of these shoreline changes, Sandyland Cove residents built a revetment in the mid-1980s under an emergency permit issued by the County of Santa Barbara that partially encroached on the public beach seaward of the homes and resulted in burial of the beach due to the footprint of the structure. Additionally, active erosion caused by an increase in the longshore currents moves sand along the revetment and scours sand near the Ash Avenue access to the City Beach (Revell et al 2008).

Placement loss of the beach in front of Sandyland Cove has resulted in a narrowing of the beach width. Photo courtesy of California Coastal Records Project.

These active erosion processes create a seasonal erosion hotspot which is shown in seasonal beach changes and a coarsening of the sediment grain size (Revell et al 2008). This erosion hotspot resulted in damage to the City lifeguard facility at the terminus of Ash Avenue in 1987 (Figure 3-6).This storm also caused significant damage to the property located at the end of Ash Avenue; subsequent development was therefore raised on pier piles to make the structure more resilient to future storms.

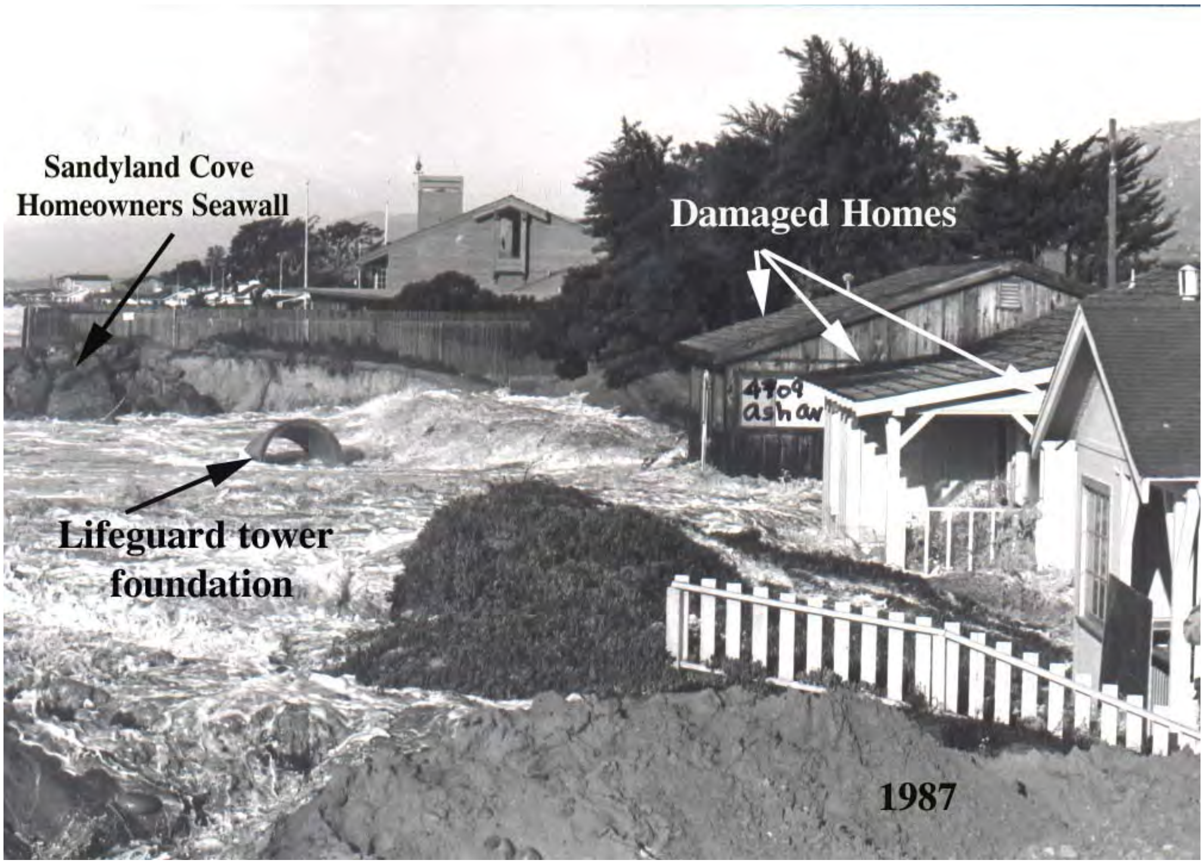


Figure 3-6. *Storm damages at Ash Avenue at the end of the Sandyland Cove Revetment in 1987.*

As discussed in Chapter 2.4, *Other Regional Sea Level Rise Planning Efforts*, and Chapter 8, *Adaptation and Resiliency Building Strategies*, the U.S. Army Corps of Engineers (USACE)is currently studying the Carpinteria shoreline and potential strategies for restoration. A reconnaissance study was partially completed by USGS and the University of California, Santa Cruz in order to evaluate the physical processes as well as the long-term and seasonal changes to the beach (Barnard et. al 2007). This information has been included in the ongoing USACE study.

Cobbles and Storm Berm Changes

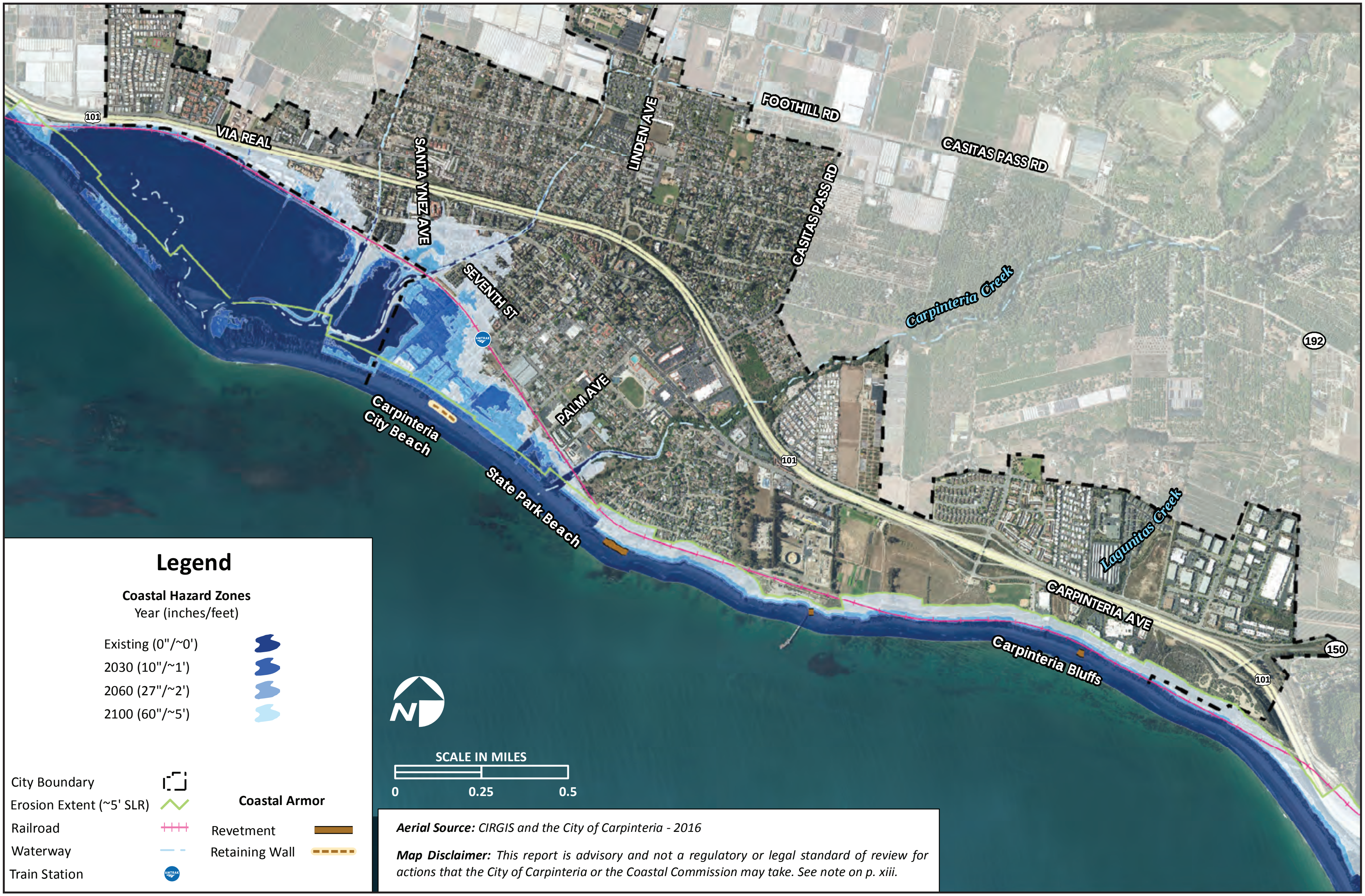
Cobbles were once plentiful under the Carpinteria beaches, and typically visible during the winter storm season. Cobbles enabled the beaches to dissipate large destructive wave energy. However, large El Niño storms in 1982-1983 and 1997-1998 removed most of the cobbles. While no definitive studies have identified the exact cause, it is possible that factors include a decline in the supply of cobbles due to changes in the watersheds, construction of sediment debris basins, and upcoast coastal armoring that protects cliffs from erosion.

Each year, the City installs an approximately 1,300-foot-long seasonal storm berm out of sand along Carpinteria City Beach in the fall and winter to buffer against large wave events. When the storm wave season passes in the spring, the City pushes the sand back onto the beach.

Existing Shoreline Protection

Winter Storm Berm along the City Beach. Photo Source: Matt Roberts

Existing shoreline protection in the City is relatively minimal (Figure 3-7). This Report does not include detailed cost estimates to maintain existing shoreline protection devices, although summary information may be found in Chapter 8, *Adaptation and Resiliency Building Strategies*. A sand retention wall originally constructed in 1977 is located along the Carpinteria Shores apartments, and small portions of revetment are located at the base of Casitas Pier and under the Carpinteria Bluffs. Tar Pits Park, Carpinteria State Beach, and a portion of San Miguel Campground also have a small amount of shoreline protection. The protective features at San Miguel Campground consist of materials used as part of the former burn dump site and were installed in fall 2013 under a Development Plan and Coastal Development Permits (CDP) issued by the City. Given the age of some of the other existing shoreline protection devices within the City and Carpinteria State Beach, current permitting status is unclear, and some structures may precede applicable permitting requirements.



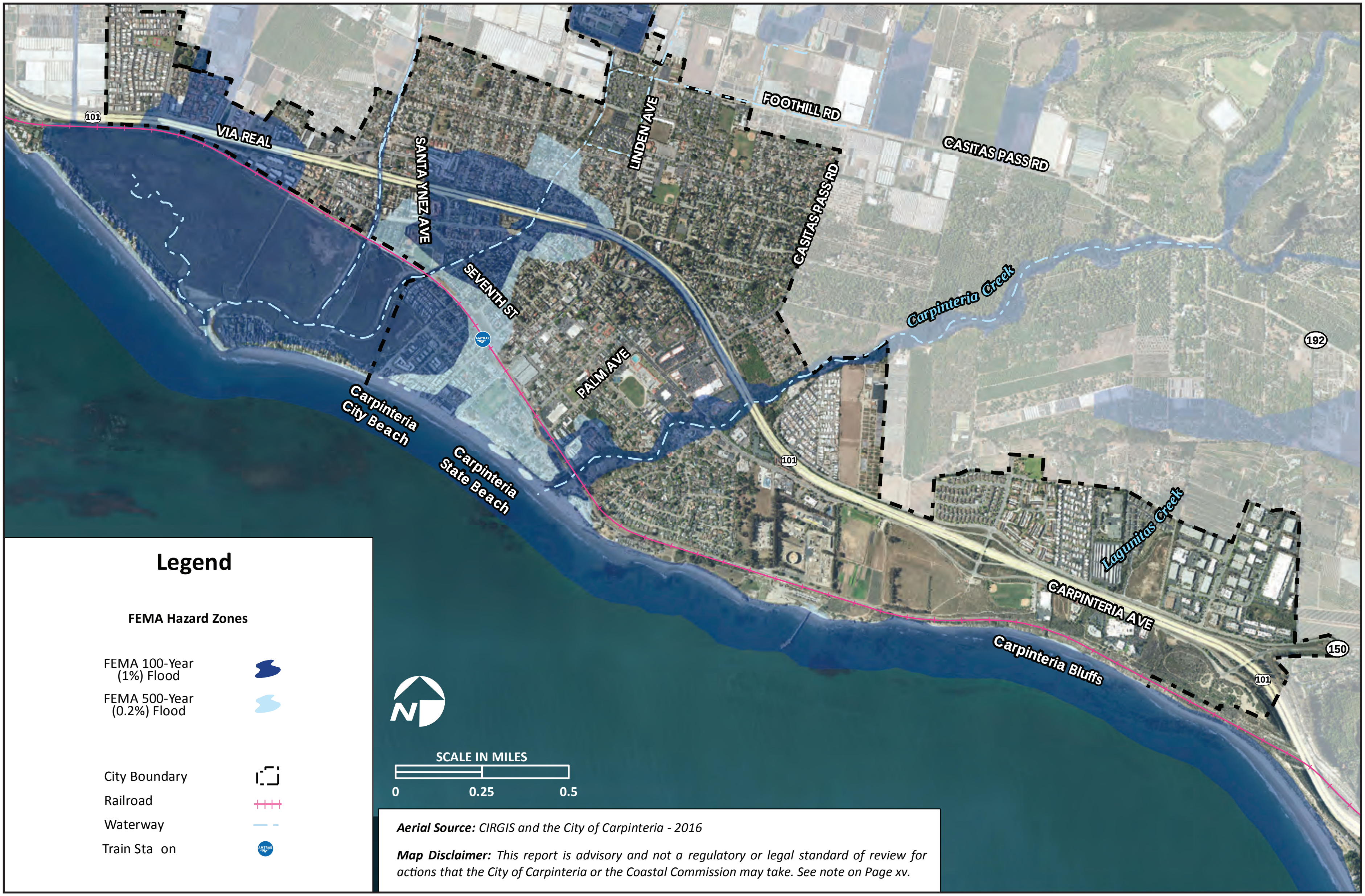
Extent of Shoreline Protection in the City of Carpinteria

FIGURE 3-7

3.9 Existing Coastal Hazards

FEMA Flood Insurance Rate Maps (FIRMs) delineate coastal flood hazards as part of the National Flood Insurance Program (NFIP). This program requires highly specific technical analysis of watershed characteristics, topography, channel morphology, hydrology, and hydraulic modeling to map the extent of existing wave run-up-related flood hazards. These maps represent the existing 100-year and 500-year FEMA flood events (1 percent and 0.2 percent annual chance of flooding, respectively) and determine the flood extents and flood elevations across the landscape. FEMA flood maps are based on existing flood hazards and do not account for coastal processes, sea level rise, or climate change.

Shoreline Protection at Tar Pits Park.



Aerial Source: *CIRGIS and the City of Carpinteria - 2016*

Map Disclaimer: *This report is advisory and not a regulatory or legal standard of review for actions that the City of Carpinteria or the Coastal Commission may take. See note on Page xv.*

Adopted FEMA Flood Insurance Rate Map

FIGURE 3-8

Coastal flooding extents are caused by large storm waves coupled with high tides. FEMA does not include coastal erosion or sea level rise in the mapping of coastal hazards. FEMA is currently remapping the Pacific Coast FIRMs with an emphasis on the high wave velocity (VE zone); the Santa Barbara County Preliminary FIRMs were released in December 2016; however, final regulatory maps are not yet adopted. The preliminary FEMA flood maps have not integrated storm erosion into the mapping of coastal hazards for existing conditions; however, the results of the preliminary analysis generally show an increase of 4 feet in the base flood elevation along Carpinteria City Beach between Ash Avenue and Linden Avenue and a 6-foot increase along the State Beach (Table 3-2). Carpinteria regulatory flood hazard zones are covered in FEMA Preliminary Panels No. 06083C1419H and 06083C1438H.

Table 3-2. Preliminary Proposed and Effective FEMA Coastal Base Flood Elevations (VE Zones) for Carpinteria Shoreline

FIRM Map Version	Base Flood Elevations (NAVD 88)
Effective FIRMs	11 feet
Preliminary FIRMs (2016)	15-17 feet

Repetitive Flooding Related Losses

FEMA repetitive loss data shows that there have been 18 properties in Carpinteria with multiple claims against the NFIP. Four (4) of these properties have had more than three (3) insurance claims, and one (1) of them has had a total of six (6) claims.

4. Climate & Sea Level Rise Science

4.1 Climate Cycles

Climate change as defined by general consensus among scientists is caused by the increase in human emitted greenhouse gases (GHGs), which differ from natural climate cycles observed in the Earth's geological record. Some of these climate cycles occur over 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 and referred to as "Milankovitch cycles". These Milankovitch cycles occur at approximately 41,000, 120,000, and 400,000 years respectively, and are responsible for the glacial and interglacial periods 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. An El Niño event brings warmer water to the Eastern Pacific, and this shift in ocean temperatures elevates sea levels by approximately 1.0 foot above predicted tides in the Santa Barbara Channel. These warmer ocean temperatures can increase evaporation, resulting in more atmospheric moisture and often substantially more precipitation. The 1982–1983, 1997–1998, and 2015-2017 El Niño events have caused flooding damages across the Carpinteria region. The January 1983 wave events are associated with one of the largest storms recorded in the Santa Barbara Channel.

Another climate cycle that regularly impacts the Carpinteria area is the Pacific Decadal Oscillation (PDO), which is an approximately 25–30-year cycle that changes the distribution of sea surface temperatures across the Pacific Ocean. Its effects were first noticed by fishery researchers in Washington (Mantua et al. 1997). The result of this ocean temperature shift is largely attributed to a shift in the jet stream. During the warm phase, the jet stream changes the storm track toward the south, affecting both the wave direction (resulting in an increase in wave energy into the Santa Barbara Channel) and precipitation. At present, the index has been on the cool side, which tends to lead to less precipitation in Carpinteria. One other implication of the PDO is that the rate of sea level rise is reduced in the Eastern Pacific Ocean (off the U.S. West Coast). Recent PDO research indicates that a shift in the PDO would likely result in a 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).

4.2 Climate Change

Human-induced climate change is a consequence of increased GHG emissions from the burning of fossil fuels, the result of which is an increase in heat trapping gases in the atmosphere that serve to insulate the earth (like a blanket) from outgoing long-wave radiation (heat). As this atmospheric emissions blanket gets thicker, more heat is trapped in the earth's atmosphere, warming the earth and triggering a series of climate changes related to different feedback mechanisms. Once set in motion, many of the climate change feedbacks take centuries to millennium to stabilize.

Worldwide, there are multiple Global Climate Models (GCMs) which attempt to project future climate conditions by modeling key variables of the earth, ocean, and atmospheric dynamics, and interactions based on assumptions of global future population growth and global levels of GHG emissions. The modeling assumptions of future geopolitical responses to addressing GHG emissions are called the relative concentration pathways (RCP). The two RCP scenarios included in the climate projections for the *Fourth Climate Assessment* are RCP 4.5, which assumes global emissions peak in 2040 and then begins to decline, and the RCP 8.5, which assumes emissions peak around 2100 and then begins to decline. The RCP 4.5 scenario is a mid-range scenario, while RCP 8.5 is a high-end scenario that is often referred to as a "business-as-usual" scenario. The RCP 8.5 scenario is consistent with a future where there are few global efforts to limit or reduce emissions, and GHG emissions worldwide continue to follow the current "business-as-usual" trajectory. This Report considers primarily the RCP 8.5 emission scenarios.

4.3 Sea Level Rise

Globally, sea levels are rising as a result of two factors caused by human-induced climate change. 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 a rise in sea levels. 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 on land. It is predicted that if all of the ice on earth were to melt, ocean levels would rise by approximately 225-265 feet above present-day levels. The rate at which sea levels will rise is largely dependent on the feedback loop between the melting of the ice, which changes the land cover from a reflective ice surface, and the open ocean water, which absorbs more of the sun's energy and increases the rate of ice melt. The uncertainties associated with the rate at which ice melt occurs is largely responsible for the wide variation in sea level rise projections in the latter half of this century (i.e., between 2050 and 2100) and can help to explain the H++ scenario which could cause the analyzed approximately 5 feet of sea level rise by 2100 to occur as early as 2070.

The time scales for sea level rise are related to complex interactions between the atmosphere and the oceans, the lag times associated with the stabilization of GHGs in the atmosphere, and the dissolution of those gases into the ocean. The Intergovernmental Panel on Climate Change (IPCC) has published scientific evidence that demonstrates that due to the GHGs that have already been released into the atmosphere, sea levels will be rising for the next several thousand years. Given this long-term perspective, it is not a question of if sea level rise will happen, but the rate at which seas will rise.

Much of the scientific advancement in recent years has been in understanding the contribution and rate of ice melt to global sea levels. It has also revealed the potential for extreme sea level rise resulting from rapid acceleration of ice melt as noted above under the RCP 8.5 and H++ scenarios. In general, the higher the GHG emissions, the higher the temperature, the more rapid the ice melt, and the higher the rate of sea level rise.

Relative (Local) Sea Level Rise

Due to local differences in tectonic uplift/subsidence, subsidence caused by oil, gas, and groundwater extraction, and saltwater intrusion, as well as other factors such as near shore bathymetry, sea levels are rising at different rates in different regions of the world. Due to local variation and applicable factors, it is important that local sea level rise monitoring be conducted and that a baseline be established to assess future changes to local sea levels.

In southern Santa Barbara County, the offshore Ventura/Pitas Point and Red Mountain faults contribute to a wide range of vertical uplift and subsidence, while local groundwater, and oil and gas extraction accelerate subsidence. Other factors including near shore bathymetry are not applicable to the local setting. The difference between the local land motion and the global rise of sea level yields the relative sea level rise that will determine the magnitude of local sea level rise impacts.

The nearest tide gauge (Santa Barbara Tide Gauge) reports the local sea level rise rate at approximately 1.01 (+/-1.17) millimeters per year (mm/year) but has a sporadic historical record (Figure 4-1). Globally the average annual rate of sea level rise is estimated to be 3.2mm/year (Griggs et al 2017). The longest tide gauge in operation is near the mouth of San Francisco Bay and shows a 100-year sea level rise of about 7 inches. Since the Santa Barbara tide gauge was installed in the mid-1970s, nearly every major El Niño event has broken the gauge and consequently left a 7- to 10-year data gap, rendering the relative sea level rise trend calculations from the tide gauge unreliable. However, the gauge continues to be operated and should be used for future monitoring of rates and elevations of sea level rise that may support the development of policy triggers for adaptation.

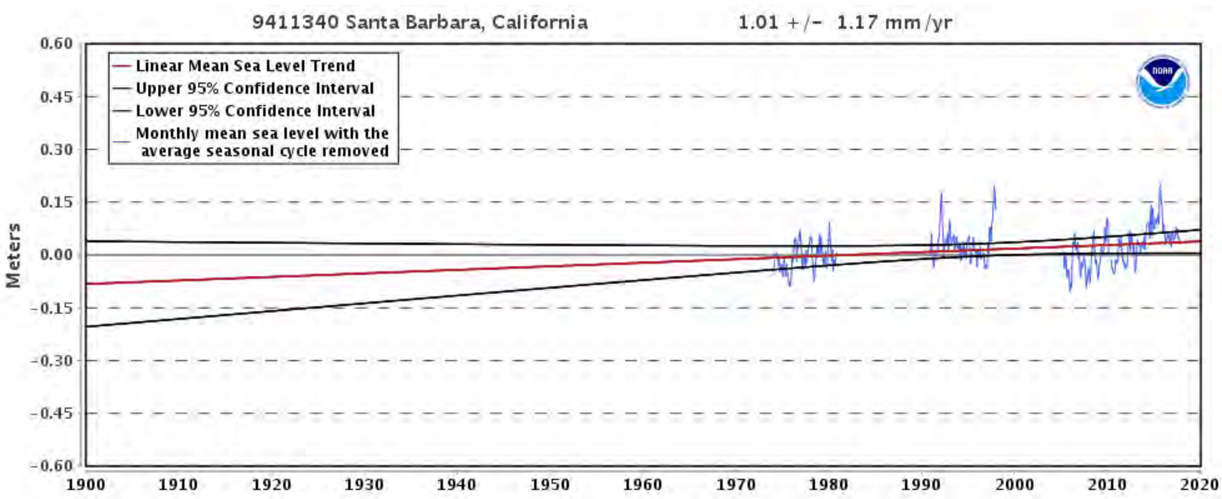


Figure 4-1. *Tide Record and Sea Level Rise Trend from Santa Barbara Tide Gauge (National Oceanic and Atmospheric Administration Station 9411340)*

4.4 State of Climate Science in California

Substantial research in California is currently underway to effectively downscale GCMs and to project various human-induced climate change impacts at a scale more relevant to California. Several of the key climate change impacts are likely to include increased temperature, uncertainty in precipitation changes, increased wildfire risk, and sea level rise. The following are recent scientific studies which form the basis of recent climate hazard understanding in Carpinteria.

2016-2018 California Fourth Climate Assessment

Biannually, the California Energy Commission (CEC) 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 Climate Assessment*, Scripps Institution of Oceanography at the University of California, San Diego was commissioned to develop a new suite of climate projections reflecting the latest scientific publications and global level GHG emission reduction pledges made at the 2015 IPCC Paris climate change convention.

The downscaled climate model projections include the entire suite of climate variables including temperature, wildfire risk, precipitation, and sea levels. The modeling included assumptions on population growth, and future global political responses to addressing GHGs called the RCP. The modeling included assumptions on population growth and future global political response to addressing GHGs and used RCP 4.5 and RCP 8.5 as described above. Future climate scenarios are compared to the historic period from 1961-1990. Four (4) GCMs were identified by the State for use in the *Fourth Climate Assessment* work.

- HADGEM2-ES (Warm/Dry)

- CNRM-CM5 (Cool/Wet)
- CanESM2 (Average)
- MIROC5 (Compliment)

Results for key climate variables for the Carpinteria area were extracted from the downscaled California models (Table 4-1). The results shown in Table 4-1 are the average of all four of the State-prioritized GCMs and assume the Business as Usual (BAU) emissions scenario (RCP 8.5) and a medium population growth. RCP 8.5 is considered an extreme scenario with a low probability (0.5 percent chance) of occurring by 2100 as shown in Table 4-2 below. A brief discussion of the implications to Carpinteria is included below.

Table 4-1. Results from the California Fourth Climate Assessment for Key Climate Variables

Category	Threshold	Units	Historical Record (1961-1990)	2030	2060	2100
Extreme Heat	>90.1°F	days	4.3	5	9	10
Temperature	Maximum	°F	71.2	73.7	76.3	79
Temperature	Minimum	°F	49	51.6	53.9	56.7
Precipitation	Annual Total	inches	19.9	24	24.1	24.3
Wildfire	Annual average	hectares	28.9	33.8	44.4	39.5

Temperature

Overall average maximum temperatures in Carpinteria are projected to rise by 7.8°F by 2100 as shown in Table 4-1. These projections differ depending on the time of year and the type of measurement (highs vs. lows), all of which have different potential effects on the state's ecosystem health, agricultural production, water use and availability, and energy demand. Extreme heat has been defined for the Carpinteria area as 90.1°F for the time of year between April and October. Extreme heat during this baseline period averaged 4.3 days per year. There are wide ranges between the available climate models, however in general, the extreme heat projections show not only an increase in the number of days expected to exceed the extreme heat threshold, but also their occurrence both earlier and later in the season.

Precipitation

In Carpinteria, the average of the models' precipitation projections show an increase in total annual precipitation. However, among the current models, precipitation projections are not consistent over the next 100 years. Some individual models show a decrease and others show an increase. Uncertainty around the future trend of precipitation is high. The Mediterranean seasonal precipitation pattern is expected to continue, with most precipitation falling during the winter season from North Pacific storms. However, even modest changes could have a significant impact because California ecosystems are conditioned to historical precipitation levels and water resources are nearly fully utilized.

Wildfire Risk

As the devastating Thomas Fire in December 2017 attests, wildfire is a serious hazard in California and in Carpinteria. Several studies have indicated that the risk of wildfire will increase with climate change. While the models differ, there is a general pattern for wildfires to start earlier in the season and continue later in the year.

Sea Level Rise

The *Fourth Climate Assessment* scenarios take a new approach and carefully quantify each contributing factor to global sea level rise and assign a probability of occurrence based on the scientific uncertainties associated with each factor. The new resulting sea level rise projections for California are the first to identify probabilities for future levels of sea level rise (Cayan et al 2016). The new sea level rise numbers are summarized in a scientific summary which was written to be more approachable for policy making (Griggs et al 2017). Overall, the future sea level rise projections from 2016 are lower than those projections from the National Research Council (NRC) 2012 report, except for the high emissions (RCP 8.5) 2100 scenario. In addition, recent scientific work has identified the potential for an extreme sea level rise scenario caused by runaway ice melt. This scenario is called the H++ scenario and projects 9.8 feet of sea level rise by 2100.

Ocean Protection Council (OPC) has used these scientific updates to develop revised sea level rise planning guidance and has included the associated probabilities of sea level rise for the Santa Barbara tide gauge. These are summarized in Table 4-2 below.

Table 4-2. Probabilistic Projections of Sea Level Rise for Santa Barbara (OPC 2018)

		Probabilistic Projections (ft/yr) (based on Kopp et al. 2014)				H++ Scenario (Sweet et at. 2017) *Single High-Emissions Scenario
		Median	Likely Range	1-in-20 Chance	1-in-200 Chance	
Scenario	Year	50% Probability Sea-level Rise Meets or Exceeds…	66% Probability Sea-level Rise is Between…	5% Probability Sea-level Rise Meets or Exceeds…	0.5% Probability Sea-level Rise Meets or Exceeds	
High Emissions	2030 – 2050	0.3 – 0.7	0.2 – 1.0	0.5 – 1.2	0.7 – 1.8	1.0 – 2.5
Low Emissions	2060 – 2080	0.7 – 1.0	0.4 – 1.5	1.4 – 2.0	2.2 – 3.6	3.6 – 6.3
High Emissions	2060 – 2080	0.9 – 1.4	0.6 – 2.1	1.6 – 2.7	2.5 – 4.3	
Low Emissions	2080 – 2100	1.0 – 1.2	0.5 – 2.0	2.0 – 2.9	3.6 – 5.3	6.3 – 9.8
High Emissions	2080 - 2100	1.4 – 2.1	0.9 – 3.1	2.7 – 4.1	4.3 – 6.6	

Note: The 'Low Emissions' scenario for the OPC 2018 guidance document represents the RCP 2.6 scenario and is not reflective of the RCP 4.0 scenario modeled throughout this report. The 'High Emissions' scenario provided above does reflect the RCP 8.5 scenario modeled throughout this report.

2017 CoSMoS 3.0

U.S. Geological Survey' (USGS') Coastal Storm Modeling System version 3.0 (CoSMoS 3.0) provides projections of coastal flood hazards and cliff erosion for the area between Point Conception 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 GCMs and considers factors such as long-term coastal shoreline change, stream inputs, dynamically downscaled 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 Federal Emergency Management Agency [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 (www.ourcoastourfuture.org). For a comparison of the model results please see Appendix B.

CoSMoS 3.0 also provides data for other shoreline change or hazard models within the region. This model was evaluated for the Carpinteria vulnerability study; however, the model was not selected due to the following reasons: inaccuracies in observed flood extents compared with existing 1 percent annual chance storm mapped hazard zones, lack of explicit mapping of coastal erosion hazards, and the unavailability of hazard data in a format (closed polygon) suitable for the geospatial analysis. For details on the selection of the model for the vulnerability assessment, please see Appendix A.

2017 Coastal Ecosystem Vulnerability Assessment

The 2017 Santa Barbara Area Coastal Ecosystem Vulnerability Assessment (CEVA) is a multidisciplinary research project that investigates future changes to southern Santa Barbara County climate, beaches, watersheds, wetland habitats and beach ecosystems. This assessment builds on the State's *Fourth Climate Assessment* with a focus on ecosystem changes.

The hydrological model results provide additional insights, beyond the small increase in average annual precipitation (Myers et al 2017):

- Change in annual precipitation averaged over coastal watersheds is small.
- The number and magnitude of larger rainfall events increases.
- Annual runoff and annual peak discharge increases.
- Changes in year-to-year variability and an increase in annual peak discharges alter watershed flood frequency distributions.
- Specific discharges (e.g., 1 percent annual chance storm) are projected to increase even more than high extreme annual peak discharges.

These increases in storm intensity may indicate that there could be larger fluxes of sediment supplied to the coast followed by wildfires and longer droughts, as exemplified by the January 2018 mudslides in Montecito and Carpinteria.

Ecosystem results for Carpinteria Salt Marsh show that high salt marsh and transitional habitats are the most vulnerable to sea level rise with a threshold of impact beginning to occur with approximately 1 foot of sea level rise. A decline in these wetland habitats could affect 14 of the 16 plant species of special concern found in the Carpinteria Salt Marsh (Myers et al 2017). In addition, beaches, which provide a valuable habitat as well as recreational resources, are projected to narrow even in places where sand dunes (like Carpinteria State Beach) back the beach. With approximately 20 inches of sea level rise, about 60 percent of the dry sand beaches could be gone without additional human intervention.

2016 FEMA Revised Flood Insurance Rate Maps

FEMA FIRMs map the existing 100-Year FEMA Flood Event (e.g. 1 percent annual chance storm) and are the regulatory tool administered under local flood plain ordinances, which are used to determine flood insurance premiums, base floor elevations (BFE), and coastal construction standards. The existing maps were initially developed in the mid-1980s, based on a now outdated understanding of coastal processes.

The FEMA California Coastal Analysis and Mapping Project (CCAMP) is conducting Countywide updates to the coastal flood hazard mapping along the entire coast of California with best improved science, coastal engineering, and regional understanding. These mapping revisions include revised VE (wave velocity), AE (ponded water), and X (minimal flooding) hazard zones. The FEMA methodology specifically maps flood extents associated with the existing 1 percent annual chance storm (e.g. 1 percent wave event). The new maps will not account for future sea level rise. The Preliminary Draft revised FIRM maps were released in December 2016 for Santa Barbara County and showed some increases in coastal high velocity zones that require changes in BFEs from 11 feet to between 15 and 17 feet for the City beach areas.

2016 County of Santa Barbara Coastal Resilience Project

The Coastal Resilience model was a multi-year effort to evaluate the impacts of sea level rise and other coastal hazards along the County's coastline. The project modeled coastal hazard projections for the entire County. The climate change modeling effort, building on initial Pacific Institute studies in the State's *Second Climate Assessment*, projects the impacts of coastal erosion and coastal flooding for the entirety of Santa Barbara County, extending from Jalama Beach County Park to Rincon Point (Revell et al 2011; PWA 2009). Unlike other models, the Coastal Resilience model includes coastal confluence modeling for Carpinteria Creek. A technical methods report presents technical documentation of the methods used to map erosion and coastal flood hazards under various future climate scenarios. The climate change-exacerbated coastal hazard modeling considered different scenarios of sea level rise, waves, and existing coastal shoreline protection. The study and model outputs provide most of the hazard identification used in support of the City's vulnerability assessment.

A web mapping application operated in collaboration with The Nature Conservancy provides an interactive visualization tool allowing users to view the projected risks of different scenarios of coastal hazards—such as coastal storm flooding, erosion, tidal inundation, and fluvial flooding—at a variety of spatial and temporal scales, including modeling results for the City (https://maps.coastalresilience.org/California).

Since the Coastal Resilience model was selected by the City to best represent the extent of observed coastal hazards, additional details on the modeling methods and assumptions are described further in Chapter 5, *Vulnerability Methodology*.

2017 Rising Seas in California: An Update on Sea-Level Rise Science

In 2017, OPC commissioned a scientific update on sea level rise to reflect advances in understanding of ice sheetloss and sea level rise projections. *Rising Seas in California: An Update on Sea-Level Rise Science* is a synthesis of the state of the science around sea level rise and identifies several key findings, with the intent of providing guidance in preparing for sea level rise:

- Scientific understanding of sea level rise is advancing at a rapid pace;
- Coastal California is already experiencing early signs of sea level rise, including more extensive flooding during coastal storms and high tides;
- The rate of ice loss from Greenland and Antarctic ice sheets is increasing, which is a primary contributor to sea level rise;
- New evidence has highlighted a potential for extreme sea level rise with up to 10 feet by 2100;
- Probabilities of sea level rise scenarios are identified, and can inform planning decisions;
- Current policy decisions are shaping the coastal future; and
- Adaptation planning should start immediately without waiting for scientific certainty.

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5. Vulnerability Methodology

5.1 Introduction

This chapter provides an overview of the methodologies used to assess existing and projected vulnerabilities from coastal hazards. Decisions on the sea level rise scenarios, sector selection, hazard models, and measures of impacts were made in concert with the City of Carpinteria (City) and consultant team with input from the City's Coastal Land Use Program/General Plan (CLUP/GP) Update Committee and are documented in Appendix A.

This Report relied on several primary data sources:

- Coastal hazards modeling analysis results (Revell Coastal and ESA 2016).
- FEMA effective and preliminary updated FIRMs (FEMA 2016).
- Spatial and locational data available from the City, Carpinteria Valley Water District (CVWD), Carpinteria Sanitary District (CSD), Santa Barbara County Planning and Development, Santa Barbara County Public Works, State Parks, California Coastal Commission (CCC), California Division of Oil, Gas, and Geothermal Resources (DOGGR), California State Water Resources Control Board (SWRCB), U.S. Environmental Protection Agency (EPA), and Environmental Systems Research Institute (ESRI) (Table 5-1).
- Economic and beach attendance data from Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) and State Parks.

Projections of future coastal hazards and sea level rise were modeled as part of a separate project: *Santa Barbara County Coastal Resilience Project* (Revell Coastal and ESA 2016, Revell Coastal 2015) and this data was extracted for use in this Report.

5.2 Geospatial Data Collection

With input from the City and the public, the consultant team identified preferred sectors to be used in the analysis as well as measures of impact for each sector (Table 5-1). Data collection efforts began with available City data and were expanded to include County data and available state and federal public data libraries. For specific infrastructure data and special districts, direct data requests were made to the City Community Development Department.

Table 5-1. Description of Geospatial Data: Resource Sector, Measures of Impacts, and Data Sources

Sector	Land Use Categories Sub-Sector	Measures of Impacts	Data Source
Land Use Parcels and Structures	Agriculture	# of parcels, acreage of parcels	Parcels – County Planning Structures – Revell Coastal with input from City Community Development Department
	Commercial	# of parcels, acreage of parcels, # of structures, square feet of structures	
	Facilities (Institutions and Government)	# of parcels, acreage of parcels, # of structures, square feet of structures	
	Industrial	# of parcels, acreage of parcels, # of structures, square feet of structures	
	Residential	# of parcels, acreage of parcels, # of structures, square feet of structures	
	Open Space and Recreation	# of parcels, acreage of parcels, # of structures, square feet of structures	
Roads and Parking	Roads	length of road	County Planning Department
	Parking Lots	# of lots, acreage of lots	Revell Coastal with Input from Open Street Map
Public Transportation	Public Transportation	Length of: bike routes, bus routes, railroad lines; # of bus stops, # of train platforms	County Planning and Public Works Departments
Camping and Visitor Accommodations	Hotels and Motels	# of parcels, # of structures	County Planning Department
	Campgrounds	# of sites, acreage of sites	Revell Coastal with input from State Parks
Coastal Access and Trails	Coastal Access and Trails	# of access points, length of trail by type	Revell Coastal with input from CCC and the City

Table 5-2. Description of Geospatial Data: Resource Sector, Measures of Impacts, and Data Sources (Continued)

Sector	Land Use Categories Sub-Sector	Measures of Impacts	Data Source
Hazardous Materials Sites and Oil and Gas Wells	Geotracker Electronic Submittal of Information (ESI) Reporting Sites (Hazardous Business Materials Storage)	# of sites	SWRCB
	EPA Small Quantity Generators (SQGs)	# of sites	EPA
	Cleanup Program Active Sites	# of sites	EPA
	Oil and Gas Wells	# of wells	DOGGR
Storm water Infrastructure	Storm water Infrastructure	# of drop inlets, # of outfalls, length of drains	County Public Works Department and City Public Works Department
Wastewater Infrastructure	Wastewater Infrastructure	# of lift stations, # of manholes, length of pipes	City Public Works Department and CSD
Community Facilities and Critical Services	Community Facilities	# of: government, religious, lodges, other cultural buildings	Revell Coastal with input from County Planning Department
	Critical Services	# of: police, fire, school, medical, communication, water treatment facilities	Revell Coastal with input from City and County Planning Department
Environmentally Sensitive Habitat Area	ESHA	Types of sensitive habitats	City GP/LCP

In some cases, older data such as structures were updated using standard digitizing techniques from the most recent available aerial photograph from the Channel Islands Regional Geographic Information System (CIRGIS) Collaborative (2016). All data was checked for topological fidelity (spatial relationship), spatial accuracy, and accuracy of tabular data (attributes).

5.3 Coastal Hazards Projections

Modeling for the 2016 *Santa Barbara County Coastal Resilience Project* includes assessment of the following coastal processes:

- **Coastal Flooding:** Flooding caused by wave run-up and overtopping from a 1 percent annual chance storm.
- **Coastal Erosion:** Coastal erosion based on sea level rise and a 1 percent annual chance storm.
- **Tidal Inundation:** Tidal inundation based on a predicted monthly high tide.

Modeling methods for the Santa Barbara County Coastal Resilience Project are summarized here. Additional modeling details are available in the Technical Methods report produced as part of the Coastal Resilience modeling (Revell Coastal and Environmental Science Associates [ESA] 2016; https://maps.coastalresilience.org/california).

Coastal Resilience Hazard Modeling

The Coastal Resilience modeling methodology relies on a detailed parcel-level backshore characterization that includes backshore type, geology, and local geomorphology (i.e., elevations, beach slopes). The backshore characterization spatially analyzed approximate 100-yard alongshore spacing and then statistically represented results at an approximate 500-yard alongshore distance. Calculations of wave run-up and tides are combined to identify a total water level elevation, which then drives coastal erosion and shoreline response models (Heberger et al. 2009, Revell et al. 2011). Climate change impacts—assessed using a series of sea level rise, wave climate, and precipitation scenarios—projected potential future coastal erosion and flooding hazards (Revell Coastal and ESA 2016, Revell Coastal 2015). Projected impacts are evaluated at four planning horizons: existing (2010), 2030, 2060, and 2100. All hazards were mapped on the California Coastal Light Detection and Ranging (LiDAR) Digital Elevation model at a 2-meter (6.5 feet) spatial resolution (available from the National Oceanic and Atmospheric Administration [NOAA] Digital Coast website). The year 2010 represents the existing coastal hazards baseline as the most recent LiDAR topographic data collection used for physical geomorphic parameters and mapping was conducted in 2010.

Coastal Erosion

Erosion models projected both low-lying dune-backed erosion and cliff-backed shoreline erosion hazards (Figure 5-1).

Aerial Source: *CIRGIS and the City of Carpinteria - 2016*

Map Disclaimer: *This report is advisory and not a regulatory or legal standard of review for actions that the City of Carpinteria or the Coastal Commission may take. See note on Page xv.*

Extent of Dune and Cliff Erosion

FIGURE 5-1

Dune Erosion: The coastal dune erosion hazard modeling considered a short-term response based on the erosion from a 1 percent annual chance storm. Dune erosion included three components – potential erosion impact from 1 percent annual chance storm, erosion from sea level rise, and erosion caused by historic trends in shoreline change (as a proxy for sediment supply). In modeling dune erosion, inland extents are projected using a geometric model of dune erosion originally proposed by Komar et al. (1999) for storm impact and applied with different slopes to make the model more applicable to sea level rise (Revell et al. 2011). This method is applied in the initial Pacific Institute work and is consistent with the FEMA Pacific Coast Flood Guidelines for storm-induced erosion (FEMA 2005). Erosion models were calibrated using historic photos documenting extents of past erosion from large wave events.

Cliff Erosion: Cliff erosion modeling considered the geology and geomorphic failure mechanism inherent in each geologic unit, and then accelerated historic erosion rates based on the increase in duration of wave attack at various elevations on the cliff. The accelerated historic erosion rates for each geologic unit are then multiplied by the number of years in the planning horizon. In addition, an erosion distance based on the observed extent of existing cliff failure width was included to evaluate the effects of a cliff failure occurring at the end of the future time horizon.

Coastal Storm Flooding

The coastal storm flood modeling is consistent with FEMA's Pacific Coastal Flood Guidelines (FEMA 2005). Every 10 years, erosion projections are calculated, the topography is updated to reflect actual erosion, and areas that were eroded during this time period and thus exposed to wave flooding through newly connected overland flow pathways are considered.

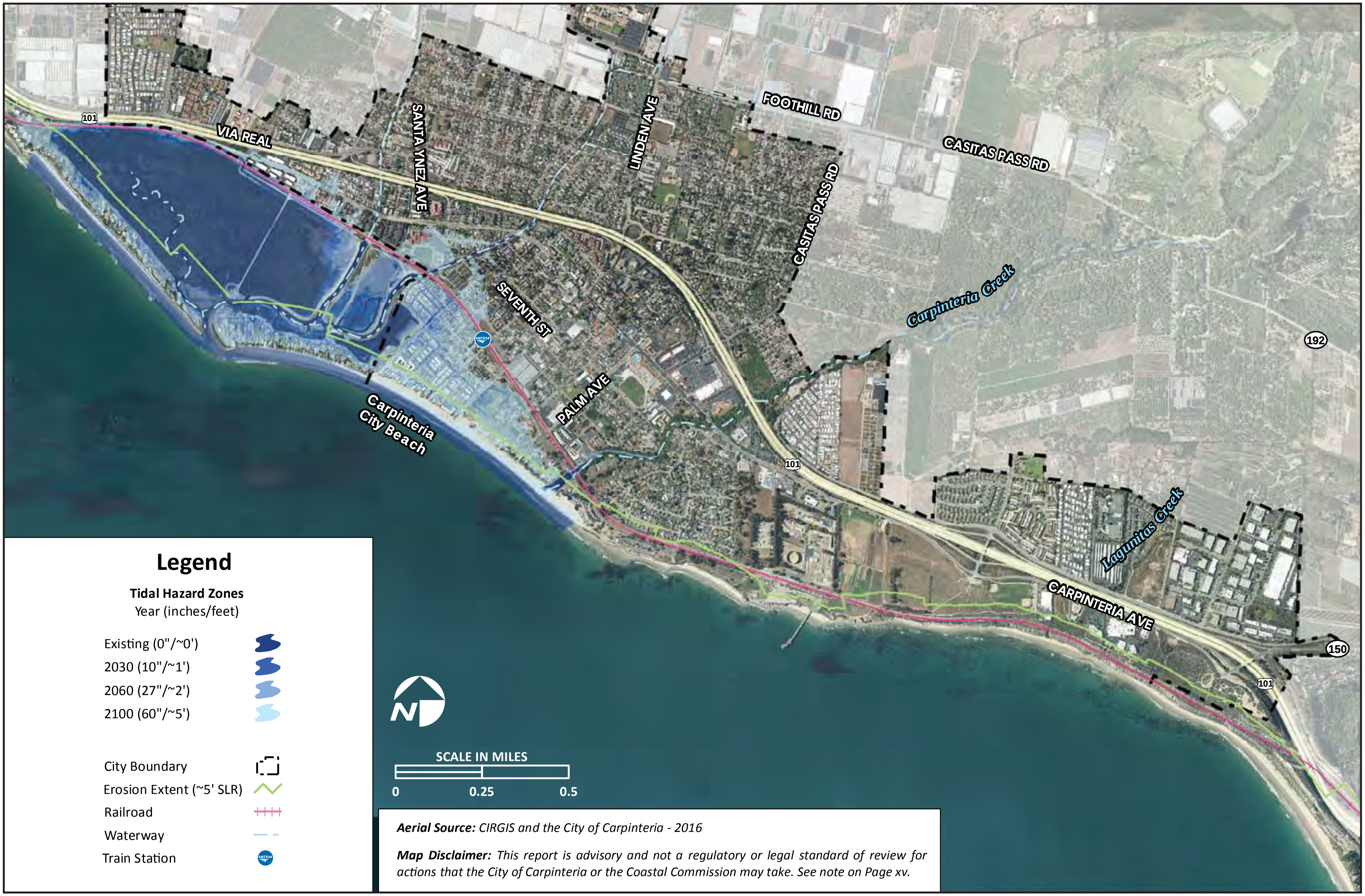
Wave-induced coastal flood modeling assessed the inland extents of flooding using the method of Hunt (1959), as supported in the Shore Protection Manual (U.S. Army Corps of Engineers [USACE] 1984). This method calculates a dynamic water surface profile, nearshore depth limited wave, wave run-up elevation, and inland extent of wave run-up at the end of each representative profile (Figure 5-2).

Tidal Inundation

Tidal inundation modeling represents the Extreme Monthly High Water (EMHW) level based on the tidal statistics from water levels at the Santa Barbara Tide Gauge (EMHW = 6.55 feet North American Vertical Datum of 1988 [NAVD88]). These hazard zones show the projected maximum extent of what could be tidally inundated once a month under a given sea level rise scenario (Figure 5-3).

Coastal Storm Wave Flooding from a 1% Annual Chance Storm

FIGURE 5-2



Tidal Inundation from an Extreme Monthly High Tide

FIGURE 5-3

Combined Hazards

For each planning horizon, all projected hazards (except fluvial) were combined into a single hazard layer that represents the maximum extent for all of the hazard zones in the City (Figure 5-4). This combined hazard layer is displayed on all of the resource sector profiles found in Chapter 1, *Sector Profiles.*

Depth of Flooding Assumptions

The Coastal Resilience modeling did not provide depth of flooding estimates, except for future tidal inundation, so a method was devised to fill this data gap. For coastal flooding, depths were needed in the economic analysis to determine structural and content losses during large storm events. The following assumptions were used to identify specific vulnerable structures and support the economic analysis, consistent with the methodology used in the City of Oxnard *Sea Level Rise Vulnerability Assessment and Fiscal Impact Document* and the *Ventura County Resilient Vulnerability Assessment*.

- For any parcels inside the coastal erosion zone, a depth of 3 feet is assumed based on the cut-off depth of flooding in the FEMA guidelines for high velocity wave zones which cause erosion. Because the depth damage curves do not distinguish between standing water and water with momentum, scour is not considered in this analysis and these estimates may be conservative.
- For parcels outside the coastal erosion/high wave velocity hazard zone but inside the coastal flood hazard zone, the depth of flooding is assigned a value of 1 foot.
- For each planning horizon, the corresponding amount of sea level rise increase is added to the baseline depth of flooding:
    - In 2030, 1 foot is added for a total flooding depth of 4 feet in coastal erosion/high velocity wave zones and 2 feet in coastal flood zones outside the high wave velocity hazard zone.
    - In 2060, 2 feet are added for a total flooding depth of 5 feet in coastal erosion/high velocity wave zones and 3 feet in coastal flood zones outside the high wave velocity hazard zone.
    - In 2100, 5 feet are added for a total flooding depth of 8 feet in coastal erosion/high velocity wave zones and 6 feet in coastal flood zones outside the high wave velocity hazard zone.
- If at any time the coastal hazard escalates from tidal or coastal flooding to erosion, then 3 feet is added to the flood depth for that horizon year.

Aerial Source: *CIRGIS and the City of Carpinteria - 2016*

Map Disclaimer: *This report is advisory and not a regulatory or legal standard of review for actions that the City of Carpinteria or the Coastal Commission may take. See note on page xiii.*

Combined Coastal Hazards Considered in the Vulnerability Assessment

FIGURE 5-4

Modeling Assumptions

As with all modeling, assumptions had to be made to complete the work. Presented below are the modeling assumptions used in the *Santa Barbara County Coastal Hazard Modeling and Vulnerability Assessment*, which were also used for analysis in this Report (Table 5-2; Revell Coastal and ESA 2016).

Table 5-2. Hazard Model Assumptions and Biases

Geospatial Data	Potential Bias	Type of Bias	Reason for Bias
Not accounting for existing structures	Too High	Spatial	Erosion rate of sand dunes would be higher than erosion rates of asphalt roads and concrete structures.
Storm duration	Too High	Spatial and Temporal	Duration of a single storm event may not be enough to reach the maximum potential erosion distance.
2010 morphology as existing conditions	Too Low or Too High	Spatial	Management activities (e.g. winter berms) or natural events (e.g. seasonal beach cycles, post-Thomas Fire January 2018 storm debris flows) may alter the topography and the results.
Sediment supply	Too Low	Attribute	Assumes sand supply and harbor bypassing remains constant, allowing for beaches to rise with sea level. If reductions in sand supply or bypassing occur, beaches may be lost and potential hazards could be greater.

Coastal Erosion and Flood Hazard Projections Do Not Consider Existing Shoreline Protection and Development

The coastal hazard projections do not consider the influence of existing development and shoreline protection on changes to coastal erosion and coastal flood hazard projections. Instead, erosion was assumed to occur on a natural dune or cliff system without human alterations regardless of the presence of existing shoreline protection. This may result in an overstatement of some of the erosion potential, as erosion extent of a sand dune would differ than erosion extent of asphalt roads and concrete structures.

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

Erosion projections assume that the coast would respond to the combination of high tides and large waves inducing 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 estimates should therefore be considered a maximum potential erosion distance.

Mapping of Coastal Flood Hazards Uses Geomorphology from 2010 Topography

At the time of the modeling, the most current comprehensive topographic data available was the state-funded 2009-2011 LiDAR data. Although this was the best available elevation data at the time, it only offers information on a single "snapshot" in time. This data was used to map existing and future hazards., and any changes resulting from human activities or natural episodic events (e.g. post-Thomas Fire January 2018 storm debris flows) that occurred since this topographic data was collected are not accounted for in the modeling.

Sediment Supply Remains Constant

Mapping of the coastal hazards assumes that sediment supply to the beaches remains constant. Therefore, the beach elevations and beach widths are assumed to 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 Santa Barbara Harbor would continue with similar volumes. Given the documented trapping of sand behind dams on the Santa Maria and Santa Ynez Rivers (Willis and Griggs 2003; Patsch and Griggs 2007), as well as the debris basins throughout the small coastal drainages, this assumption is likely inaccurate. History also attests to the downcoast erosion caused when sand was not bypassed from the Santa Barbara Harbor (Revell et al 2008). The impact of this assumption is that the mapped projections of coastal hazards may underestimate the erosion and coastal flood hazard extents.

5.4 Vulnerability Assessment Methodology

The vulnerability assessment involves spatial analysis on sector data from a wide variety of sources. The sector data, sea level rise, and model selection decisions were made with input from the public, the City, and the consultant team. These decisions are documented in Appendix A. In addition, some data was obtained directly from CCC staff in order to identify appropriate resource sectors and measures of impact. The coordination with CCC staff provided insight that while there was some spatial information on shoreline protection, spatially explicit permit data for the City and official mapping of beach accesses and the California Coastal Trail alignment are currently unavailable; this required additional effort to estimate and document. All spatial data was evaluated for accuracies (Table 5-1).

All geospatial analysis was conducted in ArcGIS. For each resource sector and measure of impact, the respective data set was queried, and summary statistics were calculated by planning horizon (or sea level rise elevation) and by each type of coastal hazard.

Table 5-3. Geospatial Bias and Error

Geospatial Data	Potential Bias	Type of Bias	Reason
Land Use Structures	Too High	Spatial	Some structures are spot checked and digitized based on rooflines visible from aerials. This may overestimate the structure footprint.
Residential Land Use Parcels	Too Low	Attribute	Commonly held residential parcels (condominium, apartment, and mobile home parking lots and landscaped areas) are excluded from analysis results. These parcels have no appraisal valuation and overlap with parcels included in the analysis.
All Land Use Parcels	Too High	Spatial	Parcels that contain or abut intermittent water channels (e.g. a drainage ditch) may appear to be vulnerable to coastal flooding. The actual vulnerability to the property can only be assessed on a case-by-case basis.
All Land Use Parcels	Too High	Spatial	Some parcels are remnants of legacy legal frameworks (e.g. Spanish Land Grants) and may contain land that is currently inundated. The actual vulnerability is likely known, and these cases can only be assessed on a case-by-case basis.
Residential Units	Too High or Too Low	Attribute	Unit counts for multi-family units and large apartments are estimates based on general details from parcel attribute tables and attributes that may under- or over-predict the total number of units. All information is post-processed to ensure accuracy. In addition, assessors' data will not include illegal accessory dwelling unit additions.
Roads	Too Low	Spatial	Features are represented as linear features rather than areas.
Roads/Bus Routes/ Bike Routes/ Pipes	Too High	Spatial	Bridges may be considered in the hazard zone when they intersect flooded water channels (pipes may be cantilevered under these bridges as well). Bridge elevation is not considered in this study.
Bus Routes	Too High	Spatial	Features are represented as linear features rather than areas. Bus routes include both incoming and outgoing buses that may cover the same section of road.
Bike Routes	Too Low	Spatial	Features are represented as linear features rather than areas. The street centerline is used for bike route location.
EPA SQGs, Cleanup Program Sites	Too Low	Spatial	Location is represented as a point rather than an area.

Table 5-3. Geospatial Bias and Error (Continued)

Geospatial Data	Potential Bias	Type of Bias	Reason
Electronic Submittal of Information (ESI) Reporting Sites	Too Low	Spatial	Points are matched to the centroid of the nearest business location and the location is represented as a point rather than an area.
Drop Inlets, Outfalls, Manholes	Too High or Too Low	Spatial/ Attribute	Height relative to ground is unknown.

Vulnerability points (e.g. oil wells) and line features (e.g. roads) are determined by the spatial intersection of the various coastal hazard horizons with the various resource/infrastructure assets. Vulnerability counts for smaller polygons with specific categories (e.g. structures) are determined by dissolving the entire polygon with attributes from the first (i.e. lowest) coastal hazard horizon intersection. Therefore, if a structure is flooded across multiple horizons, only the first instance is documented. Vulnerability for larger polygons (e.g. Environmentally Sensitive Habitat Areas [ESHA], where the area affected across horizons is a relevant statistic) is determined in the same manner as points and lines. Results are collated into a master vulnerability table and summarized in the sector profiles found in Chapter 1, *Sector Profiles*. The complete vulnerability table of results can be found in Appendix B.

5.5 Economic Analysis Methodology

The economic analysis prepared for this Report estimates the economic value of assets at risk from coastal hazards, which will be exacerbated by continuing sea level rise. Understanding current and projected vulnerabilities from coastal hazards is the first step a community must take to identify appropriate adaptation pathways including development of LCP policies and regulatory strategies.

The economic analysis estimates and evaluates the impacts of three coastal hazards: 1) tidal inundation, 2) coastal erosion, and 3) coastal wave flooding. Damage estimates are separated for each of the individual sectors. The sources of all spatial data analyzed are found in Table 5-1.

While not specifically assessed, any large flooding/storm event that damages resources or assets City would have a longer-term negative effect on tourism spending and associated tax revenue that would otherwise come to the City.

Land Use Parcels and Structures

For land and structures subject to property tax (i.e., land/structures not owned by a governmental entity or non-profit entity), this Report uses Santa Barbara County parcel data from 2017, 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 percent a year by Proposition 13 until the parcel is either resold or improved. Since the rate of housing inflation in Carpinteria has exceeded 2 percent for many years, the original sale price of the parcel (land and structures) was adjusted to estimate current market value of the property using a housing price index (HPI) from local housing sales data created specifically for this Report. Due to a lack of more reliable or adequately refined price indices, this Report also updated non-residential parcel values using the Consumer Price Index for real estate sales (Zillow 2018; U.S. Bureau of Labor Statistics 2018).

Fiscal Land Use Impacts were assessed by:

1. Escalating County Assessors database to Fair Market Value (2017 $)
2. Estimating losses due to sea level rise/storms/ coastal erosion (2017 $)
    - Erosion impacts based on percentage of land and structural damage
    - Flooding impacts based on depth of flooding and replacement

This Report assumes a complete loss for small residential parcels (< 0.25-acre) subject to coastal erosion, but assumes that larger open space parcels such as State and City Parks and land trusts diminish in value in proportion to the amount of land subject to erosion. This method may overstate existing damages since several of the City's oceanfront parcels have multiple condominiums, apartments, or other accessory structures on them.

For coastal flooding, this Report applies the USACE depth damage curves for losses to residential and other buildings based on projected flood depths from the coastal flood hazard modeling. Since these curves are calibrated for standing water, they may underestimate the damage caused by rapidly moving waves during a large coastal storm event (USACE 2003).

For tidal inundation, this Report identifies which parcels are subject to tidal inundation during various time horizons. However, it should be noted that many properties in Carpinteria and elsewhere are already subject to tidal inundation, particularly on the oceanfront where many parcels have a Mean High Water (MHW) tideline property boundary. There are currently no standards for evaluating tidal inundation or determining when a property may become red-tagged and deemed uninhabitable. Minor tidal inundation may be considered a nuisance, but it likely impacts (lowers) the value of the property. Precisely how much tidal inundation impacts property values is unknown. This Report presents data on total "property at risk" from tidal inundation.

Flood damages to structures are estimated by applying the USACE depth damage curves, which approximate flood damages as a percentage of the total value of the structure. The USACE method also estimates the average damage to the contents of the structure; e.g. furniture, appliances, and other contents (USACE 2003).

One limitation of using parcel data is that parcels such as those owned by local, state, or federal government agencies (e.g. schools, post offices, city hall, administration buildings, etc.) or non-profits are not subject to property tax. For these properties, this study estimated the value of land using data provided by the County for recent land acquisitions by government and non-government agencies. Because some of these government transactions may be below market value, the estimates for the loss of such potentially undervalued land should be considered a lower bound. Additionally, non-assessed parcels typically do not have information regarding onsite structures onsite, and thus it is likely that this Report's estimates do not include all structures on non-assessed parcels.

Roads and Parking

This Report identified portions of existing roads in the City that could be subject to erosion and flooding. Where erosion occurs, it assumes that these roads would be removed and replaced with the cost of road removal and replacement based on engineering construction costs. However, this Report does not estimate the cost of land acquisition for roads, which could be high, nor does it consider costs for elevating roads. Additional study is warranted to fully estimate costs to repair or relocate roadways that are vulnerable to coastal hazards, and will be further refined as part of the City's California Department of Transportation (Caltrans) Sea Level Rise Transportation Policy and Infrastructure Adaption Planning Grant. Further, this Report does not estimate economic losses from delays due to impaired traffic on roads subject to flooding, or if employees working in the City cannot commute from neighboring jurisdictions. Because U.S. Highway 101 is subject to flooding, there is a significant potential for non-estimated costs including lost work days and extra travel expenses.

Public Transportation

This Report did not estimate economic losses from public transportation disruptions; it only reports the distances of potentially vulnerable routes.

Camping and Visitor Accommodations

This Report relies on attendance data from State Parks (2017) to estimate camping and other attendance at Carpinteria State Beach. For Carpinteria City Beach, this Report relies on beach attendance data from BEACON (2009), adjusted for population growth in the County and California. Using these attendance estimates, in conjunction with survey data (King and Symes 2004; BEACON 2009), this Report provides estimates of current recreational value, local spending, and tax revenue to the City generated by beach-related spending. The Report also describes the potential for losses in camping and beach recreation due to coastal flooding, erosion, and tidal inundation.

This Report also identifies the key economic (spending) and tax impacts from loss of coastal recreation. Coastal recreation generates a great deal of economic activity, including sales and transient occupancy taxes (TOT) for the City and its residents (the current TOT for Carpinteria is 12 percent). This Report focuses on the economic value of beach visitation using the standard metric Day Use Value. This Report estimated spending on beach recreation based on estimates from BEACON (2009) as well as King and Symes (2004), which show consistent spending patterns for beach recreation. All spending estimates were updated using the U.S. Consumer Price Index to reflect 2017 prices (U.S. Bureau of Labor Statistics 2018). Differences in spending at different beaches depend primarily on whether visitors are overnight visitors that rent accommodations within the City (generally from outside the Carpinteria Valley) or day-use visitors from within the region. Since campground users do not generate TOT for the City, spending for these visitors was treated differently.

Presently, many of the oceanfront properties in the Beach Neighborhood are short-term vacation rentals and contribute a substantial amount to the City tax base from TOT. The specific properties which are short-term vacation rentals are not parcel specific but rather specified in certain areas in the Beach Neighborhood. A significant portion of visitors to Carpinteria City Beach stay overnight, so any diminishment in short-term vacation rentals could impact beach tourism and associated spending and tax revenues (BEACON 2009). Results of the first year of the Short-Term Rental program are summarized in Chapter 6.3, *Camping and Visitor Accommodations*.

Coastal Access and Trails

Data on coastal trail use is extremely limited. This Report uses the scarce available data to identify the length of coastal trails subject to flooding and erosion. However, estimating usage on the portions of coastal trails subject to erosion or flooding is beyond the scope of this Report. The economic losses associated with the loss of coastal trails can be estimated in several ways. First, the replacement cost of the trail could be estimated, assuming that the City would replace these trails. The City of Goleta's *Coastal Vulnerability and Fiscal Impact Assessment* (2015) estimated the replacement cost of trails per linear foot, based on a recent trail project. However, the cost of replacing a trail varies significantly based on alignment and materials needed, and thus using one standard unit cost is not always accurate. In addition, municipalities may decide not to replace or improve existing coastal trails. Given this uncertainty, this Report only reports length of trail lost (see Chapter 6.4, *Coastal Access and Trails*).

Hazardous Materials Sites, and Oil and Gas Wells

This Report identified various hazardous materials sites, including small business and light industrial sites, oil and gas wells, and active clean-up sites (Table 5-1). However, due to lack of data availability it did not attempt to quantify all of the costs involved, such as permitting, mitigation, and site restoration.

The City has a wide array of oil and gas infrastructure, much of it in the form of legacy inactive wells and associated infrastructure. For example, the former oil processing facility within Carpinteria Bluff 0 contains oil storage, processing and cleaning facilities used to support offshore oil production. While this Report does identify these sites and structures, the economic analysis only evaluates sites and structures to the extent to which data is available. In many cases little data about the cost of mitigation was available.

The City also contains other hazardous materials sites, including four sites designated by the EPA as "small quantity generators" (SQGs) of hazardous waste such as dry cleaners and gas stations. One issue with hazardous materials that cities should consider is their potential liability, especially if hazardous materials are released into the environment. This economic analysis identifies these sites as a potential liability for the City, should the responsible party go bankrupt or otherwise default. Typically, the costs of cleanup for these sites are much higher after a release occurs.

In addition to abandoned or previously capped legacy wells in the City, there are several other oil wells offshore of the City. These wells represent a danger given the combustible chemical nature of their historic use; should the cap on a well fail, an event which has happened previously in Summerland. This Report uses estimates of recent flood cleanup and mitigation efforts (e.g., 2015 Plains All American Pipeline Oil Spill at Refugio State Beach) to provide an estimate of the potential for possible remediation and damages, which should not be considered a worst-case scenario.

Although estimates for damages to hazardous materials sites and oil and gas wells are not identified due to lack of data, this is not an indication that these issues should be ignored. The potential for serious groundwater contamination, leakage of toxic material, and other damages could be considerable and should be studied further.

Storm water Infrastructure

Storm water infrastructure data (Table 5-1) was evaluated for each hazard type, using the GIS methods described in Chapter 5.4, *Vulnerability Assessment Methodology*. Critical City infrastructure including storm water pipes were valued at replacement cost. The cost of infrastructure replacement was estimated using publicly available data including the City's Capital Improvement Program (2017) as well as other available data described in Table 5-4. While the cost of storm water infrastructure replacement has been estimated, ongoing coordination with the City and County is being conducted to further refine the final cost estimates of replacement. Given this ongoing coordination effort, the economic costs of storm water infrastructure replacement are not presented in this Report.

This Report also identified and estimated the flood costs to structures – residential structures in particular – and applied estimates of flood cleanup costs from the USACE depth damage curves (USACE 2003a; USACE 2003b). However, flooding entails numerous other costs that this Report was not able to quantify, including the costs of debris cleanup and the costs of road closures (in terms of lost time and the inability of employees to get to work on time). Given these uncertainties, this Report provides no specific estimates for the costs of flood cleanup, though it does provide recent estimates of flood cost cleanup for other municipalities in the region. For example, debris cleanup costs from the 2017 Thomas Fire, and 2018 Montecito debris flows could be used to improve these estimates. Similarly, the City of Goleta identified flood cleanup costs for the 2005 and 1998 floods as $500,000 and $4 to $5 million (in 2017 dollars) respectively.

Wastewater Infrastructure

Wastewater infrastructure data (Table 5-1) was evaluated for each hazard type, using the GIS methods described in Chapter 5.4, *Vulnerability Assessment Methodology*. Critical City infrastructure including wastewater infrastructure was valued at replacement cost. The cost of infrastructure replacement was estimated using publicly available data including the City's Capital Improvement Program (2017) as well as other available data found in Table 5-4. The cost of replacing sewer pipes was estimated from an engineering cost study for the CSD's *Wastewater Master Plan* (Dudek and Associates 2005).

Water Supply Infrastructure

Water supply infrastructure data (Table 5-1) was evaluated for each hazard type, using the GIS methods described in Chapter 5.4, *Vulnerability Assessment Methodology*. Critical City infrastructure including water supply infrastructure was valued at replacement cost using the City's Capital Improvement Program (2017) as well as other available data found in Table 5-4. The cost of replacing water pipes was estimated from an engineering cost study for the CSD's *Wastewater Master Plan* (Dudek & Associates 2005).

Community Facilities and Critical Services

Community facilities and critical services data (Table 5-1) was evaluated for each hazard type, using the GIS methods described in Chapter 5.4, *Vulnerability Assessment Methodology*. The community facilities were extracted from the County Assessor's parcel data land use category.

Environmentally Sensitive Habitat Areas (ESHA)

Performing Geographic Information System (GIS) analysis of acreages on dated and generalized mapped habitats substantially lessens the accuracy of estimations for habitat vulnerability or complex ecological interactions, changing physical processes, and other climate variables. All habitats could be affected by climate change.

ESHAs were evaluated qualitatively by interpreting the range of potential climate variables and their cumulative impact on the various ESHA habitats. There was no habitat evolution modeling conducted, and a review of recent literature on wetland habitats (Largier et al 2010, Coastal Ecosystem Vulnerability Assessment [CEVA] 2017) as well as regional observations from the current extended drought were extrapolated to provide interpretation. Additional work including revised mapping is strongly recommended.

Additionally, beaches and other coastal ecosystems have many other benefits not incorporated in this Report, such as the ability to buffer storm waves, filter water, or provide shade and cooler temperatures for sensitive fish species. However, the inability of this Report to quantify the economic value does not indicate a lack of value. The City should consider the loss or degradation in sensitive biological resources when evaluating different adaptation options, although economic valuation may be difficult given the limited habitat and climate data available for this analysis. Ongoing planning analysis related to the CLUP/GP Update and the Caltrans Sea Level Rise Transportation Policy and Infrastructure Adaptation Planning Grant should refine the extent of sensitive resources, as well as the effects of sea level rise upon such resources.

5.6 Cost Estimates Used in the Economic Analysis

Table 5-4 summarizes the measures used to estimate the costs employed in this Report.

Table 5-4. Economic Cost Estimates Used in this Report

Item	Cost/Value	Cost Basis	Source
Road Replacement	$280	per linear foot	Environmental Science Associates (2016)
Railroad Replacement	$340	per linear foot	Compass International Inc. (2017)
Water Pipeline Replacement	$230	per linear foot	Dudek & Assoc. (2005)
Sewer Pipeline Replacement	$230	per linear foot	Dudek & Assoc. (2005)
Wastewater Lift Station	$1,000,000	per lift	Ventura County Public Works Agency (2016)
Property Tax Parcel	Updated with HPI	Sale Price	Zillow (2018), Federal Reserve Economic Data (2018)
Flood Damages to Buildings	Current Market Value	Depth Damage Curves	USACE (2003)
2005 Goleta Flood Clean Up Costs	$500,000	Goleta	City of Goleta (2015)
1998 Goleta Flood Clean Up Costs	$4-5,000,000	1998 flood adjusted	City of Goleta (2015)
Capping Oil well-on land	$100,000	per well	City of Goleta (2015)
Capping Oil Well-in water	$800,000	per well	City of Goleta (2015)
Refugio Oil spill costs	$257,000,000	total cost	Los Angeles Times

These values were obtained in the following three ways:

- The County Assessor Parcel Data was updated to accurately reflect the market value of the parcel/structures and the replacement value of the structures in the City.
- This Report includes data obtained from the City as well as state and County officials (Table 5-1).
- Finally, standard cost estimates were used to estimate other costs (e.g., cost of replacing sewer lines) as obtained from the sources indicated in Table 5-4.

5.7 Assumptions Used in the Economic Analysis

The economic analysis of the Land Use Parcels and Structures sector contained in this Report is based upon the best available economic data today. There remain, however, limitations in this analysis. First, the analysis depends crucially upon future projections of erosion and flooding, which are subject to uncertainty. Second, the damage curves used for flooding from the USACE may underestimate the actual damages caused by waves with a high velocity.

Furthermore, this Report's analysis of tidal inundation only examines combined property that is exposed or at risk (land and structure values) since there is no widely accepted method for estimating the damages and losses from tidal inundation.

This Report evaluated losses to the Roads and Parking sector solely in terms of replacement cost. A more detailed analysis of reductions in economic activity and other economic impacts was beyond the scope of this Report. Similarly, the Public Transportation sector was evaluated solely in terms of potential flooding and erosion to bus and bike routes along with losses to UPRR line along the Carpinteria Bluffs.

This Report's analysis of the Camping and Visitor Accommodations sector provides information on current beach recreation and projects future demand based on population growth. Beach erosion, or flooding and erosion losses to parking lots or access roads may, however, limit future beach recreation. As indicated, many residential structures in the Beach Neighborhood are short-term vacation rentals. Further study of the impacts of coastal erosion and flooding on beach recreation is warranted. While this Report does provide preliminary estimates of potential camping loss due to erosion and flooding, these results need additional refinement before substantive use by decision makers.

While the analysis of the Coastal Access and Trails sector examines the length of trails impacted by flooding and erosion, it does not estimate the loss in recreation or the cost of replacing these trails, as necessary data on levels of use, types of trails and specific costs was not available.

This Report's analysis of the Hazardous Materials Sites, and Oil and Gas Wells sector indicates that the City has several hazardous material sites including inactive legacy oil and gas wells and facilities, most notably the oil and gas processing facilities at Bluff 0. Although the liability for mitigating these sites does not lie with the City, the costs of mitigating these sites will likely be high and the City should be aware of potential negative consequences.

This Report estimated the cost of replacing certain storm water, wastewater, and water supply infrastructure components, most notably pipes damaged by erosion based on available data. However, the full costs of repairing valves, hydrants, pressure regulators, etc. or rerouting this infrastructure is not included in this Report.

Table 5-5 identifies the potential biases in the economic methods and estimates contained within this Report, and attempts to determine the direction of the bias. Some of this Report's estimates (e.g., property damages from tidal inundation) may overstate the actual impacts. Other estimates of damages to infrastructure and hazardous materials may not include all components or costs, and thus may be too low. A sensitivity analysis of the impact of changing these assumptions would help clarify the impact of these biases on the results, although this was beyond the scope of this Report.

Table 5-5. Economic Bias and Error

Sector Type and/or Coastal Hazard	Potential Bias	Reason
Property damage from Tidal Inundation	Too High	Many coastal structures already elevated. Assumes total exposure of all structures on parcel if any parcel is exposed. Damage and repair cost metrics unavailable.
All damage from Coastal Flooding 1% Annual Chance Storm	Too Low	Flooding damage curves do not account for wave velocity. 1% annual chance storms may become more frequent or severe. No actual City cleanup cost data available.
Multifamily Unit damage from Coastal Flooding 1% Annual Chance Storm	Too High	Only part of parcel may be flooded/eroded.
Property damage from Coastal Erosion 1% Annual Chance Storm	Too High	Assumes total loss of entire parcel and all structures for parcels less than 0.25-acre.
Damages to Infrastructure	Too Low	Rerouting pipes, roads, etc., not factored in completely. Cost of land acquisition not factored in. Cleanup costs to infrastructure unavailable for 1% annual chance storms.
Beach Recreation	Too High	Substitution to other beaches/sites not accounted for. Does not account for loss in recreation value due to narrowing of beach width which will largely depend on choice of future adaptation strategies.
Beach Recreation	Too Low or Too High	Demand for beach tourism may grow more or less than population/economy.
Hazardous Materials	Too Low	Mitigation may be more expensive, especially if hazards are not mitigated before a severe storm.

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6. Sector Results

> This Chapter describes the results of the vulnerability assessment and potential physical and fiscal impacts associated with inaction in the face of rising sea levels and coastal hazards in Carpinteria.

This Chapter provides detailed results of the potential risks to multiple sectors for the various sea level rise elevations and coastal hazards. This includes a geospatial analysis of each resource and infrastructure sector and an evaluation of the potential costs and economic losses assuming no action is taken to prevent or minimize erosion, flooding, or inundation. Please refer to Chapter 1, *Sector Profiles*, for information of additional resource and service elements vulnerable to coastal hazards.

Based on the unique characteristics of the City's coastline and watersheds, input from City staff, the Coastal Land Use Plan (CLUP)/General Plan Update Committee, and the public, the sectors listed below were chosen specifically to support policy development. The sectors analyzed include:

- Land Use and Structures;
- Roads, Parking, and Public Transportation;
- Camping and Visitor Accommodations;
- Coastal Access and Trails;
- Hazardous Materials Sites, and Oil and Gas Wells;
- Stormwater, Wastewater, and Water Supply Infrastructure;
- Community Facilities and Critical Services;
- Environmentally Sensitive Habitat Areas (ESHA);
- Social Vulnerabilities; and
- Housing.

The 2018 Ocean Protection Council (OPC) *State of California Sea-Level Rise Guidance* requires consideration of the H++ scenario for critical facilities. The identified sectors with vulnerable critical facilities include Section 6.2, *Roads, Parking, and Public Transportation,* and Section 6.6, *Infrastructure*. No modeling data is available for the H++ scenario, which provides another measure of uncertainty in that all vulnerable sectors with impacts occurring with 5 feet of sea level rise by 2100 could occur as early as 2070. It is also noted that coastal hazarding modeling indicates that existing fluvial flood hazards appear to be a larger threat to the City when compared to coastal hazards, even with approximately 5 feet of sea level rise. While analysis in this Report focuses upon coastal hazards, a discussion of fluvial flooding hazards is contained within Appendix C.

6.1 Land Use and Structures

Analysis of land uses is based on County Assessor parcel data including structures. Land use types are classified as either residential, commercial, industrial, open space, or public facilities. Parcels, land area, structures, and structure area at risk are quantified to the extent feasible. Since residential land uses are particularly vulnerable, this Report examines vulnerabilities to residential structures by type (e.g., condominiums, apartments, multi-family and single-family residences). The following assumptions support understanding and interpretation of the land use analysis.

- Parcels may contain multiple non-dwelling structures (e.g., garages and sheds). Some parcels may be vacant and contain no structures. Not all structures are affected by hazards; this comprises 9 percent of the total tally (i.e., the parcel is affected, and the structure is not). Parcels where less than 1 percent of the parcel area is in the hazard zone and where the structure(s) is unaffected by the hazard zone are not included in the structures count (typically parcels that abut stream channels). See Definitions for more information on dwellings.
- Large apartment complexes have multiple units per structure and can have multiple structures per parcel.
- Condominiums typically have multiple units, and therefore multiple parcels per structure. Commonly held condominium parcels (parking and landscaped areas) are not included in the tally.
- Multiple units may exist on one lot (e.g., mobile home parks).
- Multi-family complexes can contain either multiple lots per structure or multiple structures per lot.
- An additional 15 large residential apartments encompassed within 2 complexes are projected to become islands from combined coastal hazards and approximately 5 feet of sea level rise. These units would not be directly vulnerable to coastal hazards and are not included in the analyses.
- Economic analyses rely on County Assessor parcels located within the City limits and include all lots that intersect a coastal hazard flood zone (details on the types and extent of the hazard zones can be found in Figure 5-1, Figure 5-2, Figure 5-3, and Figure 5-4).

The total land area of parcels at risk to coastal hazards with up to 5 feet of sea level rise is 380 acres, encompasses approximately 23 percent of the land area in the City, and 23 percent of all parcels in the City. All structures within these parcels are included for study, and this includes 630 individual structures with a combined area of 28 acres or 1,222,608 square feet. The land use designation for these structures is as follows: 16 Commercial (5 percent), 13 Facilities (4 percent), 11 Industrial (6 percent), 1 Mixed Use (<1 percent), 11 Recreation (1 percent), and 579 Residential (83 percent). Of this total, 106 (17 percent) structures are coded as an outbuilding[1], which includes garages, car ports, or storage sheds (Table 6-1, Figure 6-1, and Figure 6-3). A total of 1,090 housing units were identified as potentially at risk with up to 5 feet of sea level rise, including up to 218 short-term vacation rentals located primarily in the Beach Neighborhood (City of Carpinteria [City] 2018).

Table 6-1. Vulnerable Land Uses and Structures[2]

Sea Level Rise	Residential	Commercial and Mixed Use	Industrial	Open Space & Recreational	Public Facilities
	(Parcel acres) / (# of Parcels) (Structure sq. ft) / (# of Structures)				
Existing	2.99/79 44,365/19	<0.1/1 0/0	0.15/1 3/1	39.18/42 0/0	0.36/3 0/0
~1 ft	7.00/164 171,147/146	<0.1/1 0/0	0.04/3 1,010/0	13.46/4 5,043/5	0.14/1 0/0
~2 ft	10.29/234 246,526/116	0.23/3 52/2	0.17/2 3,683/1	19.25/5 4,982/4	3.45/3 348/1
~5 ft	24.51/292 430,438/298	5.62/16 29,557/14	4.67/4 62,955/9	33.93/8 3,809/2	5.52/2 51,448/12
Total	**44.80/769 892,477/579**	**5.85/20 29,609/16**	**5.02/10 67,651/11**	**105.82/59 13,834/11**	**9.48/9 51,796/13**

Note: All counts and sums are non-cumulative across sea level rise elevations, and categories do not include land in the public right-of-way (e.g., roadways and rail corridors), commonly held residential parcel areas (e.g., trailer park drives, and apartment parking and landscaped areas), flood control channels, and vacant land. The one affected agricultural field is not included. The one affected mixed-use structure is attributed as a commercial land use.

Land Uses at Risk

Figure 6-1 illustrates the increased total exposure (to coastal erosion, coastal flooding and tidal inundation) to parcels and structures over time, according to land use. The majority of vulnerable parcels and structures are residential. Open space and recreational uses are the second most vulnerable land use.

[1] This is a conservative number as it only includes clear outbuildings. Many people rent out space in converted garages, so the actual number may be larger.

[2] 15 additional large residential apartments encompassed within 2 complexes are projected to become islands from combined coastal hazards and approximately 5 feet of sea level rise.

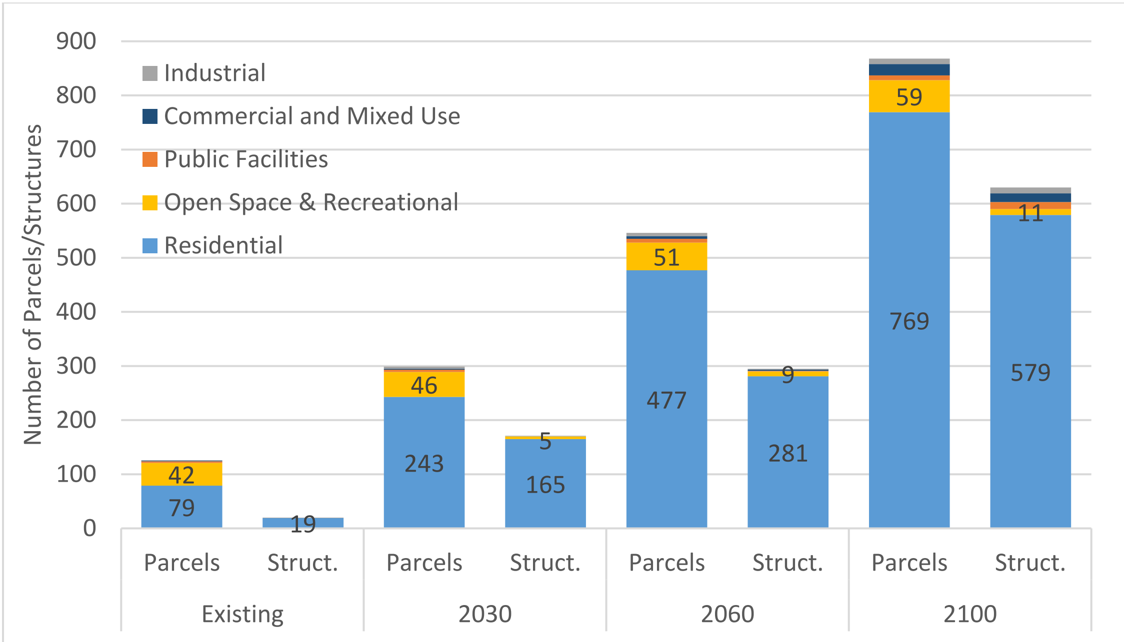


Figure 6-1. *Number of Vulnerable Land Use Parcels and Structures*

Figure 6-2 illustrates the increase in vulnerable land area (measured in acreage) over time, according to property land use. Open space and recreational land uses constitute the majority of the vulnerable land area, as measured by acreage. A significant amount of residential land area is also at risk of coastal hazards, especially with greater elevations of sea level rise.

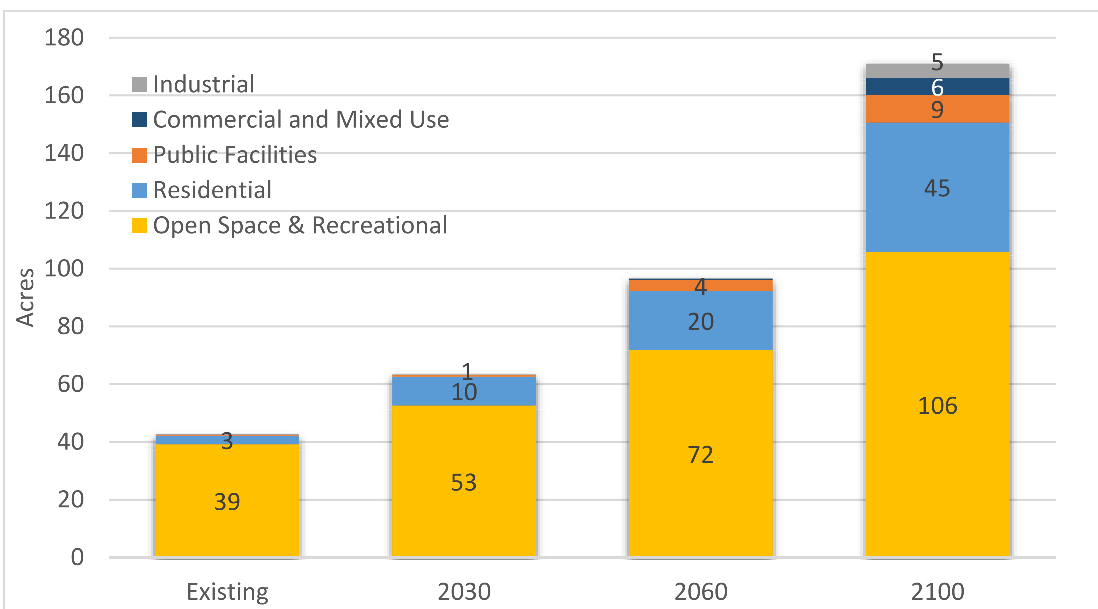
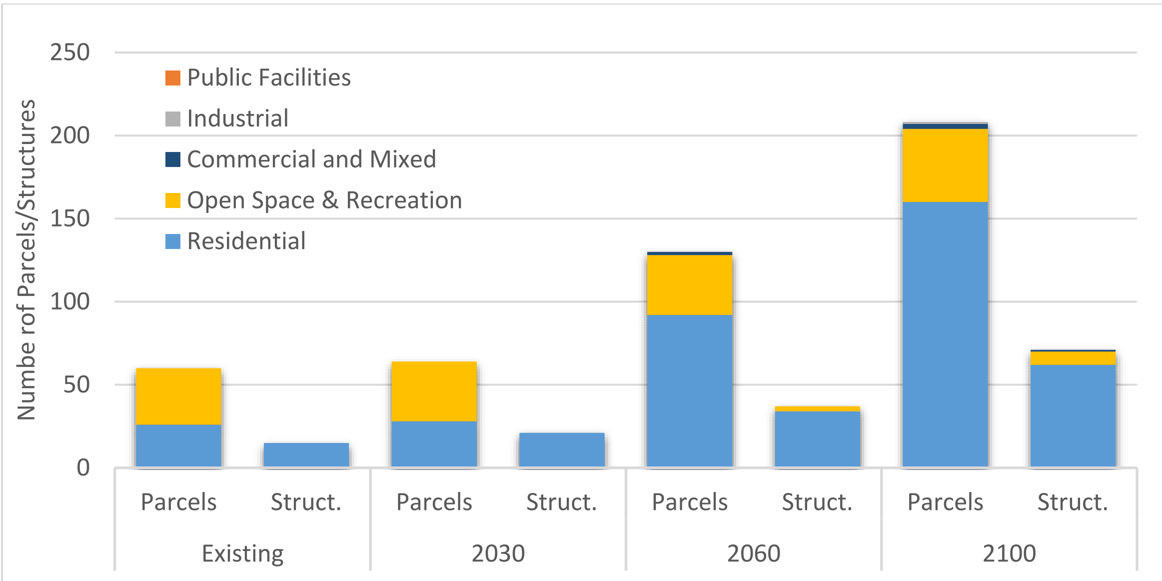


Figure 6-2. *Acres of Vulnerable Land Uses*

Coastal Erosion Impacts to Land Uses and Structures

Figure 6-3 illustrates the number of land use parcels and structures that become vulnerable to coastal erosion with sea level rise. Nearly all vulnerable parcels and structures are either residential, or open space and recreation. Under existing conditions, 60 parcels and 15 structures are at risk to coastal erosion, which escalates with up to 5 feet of sea level rise, to 208 parcels and 71 structures potentially vulnerable to coastal erosion.

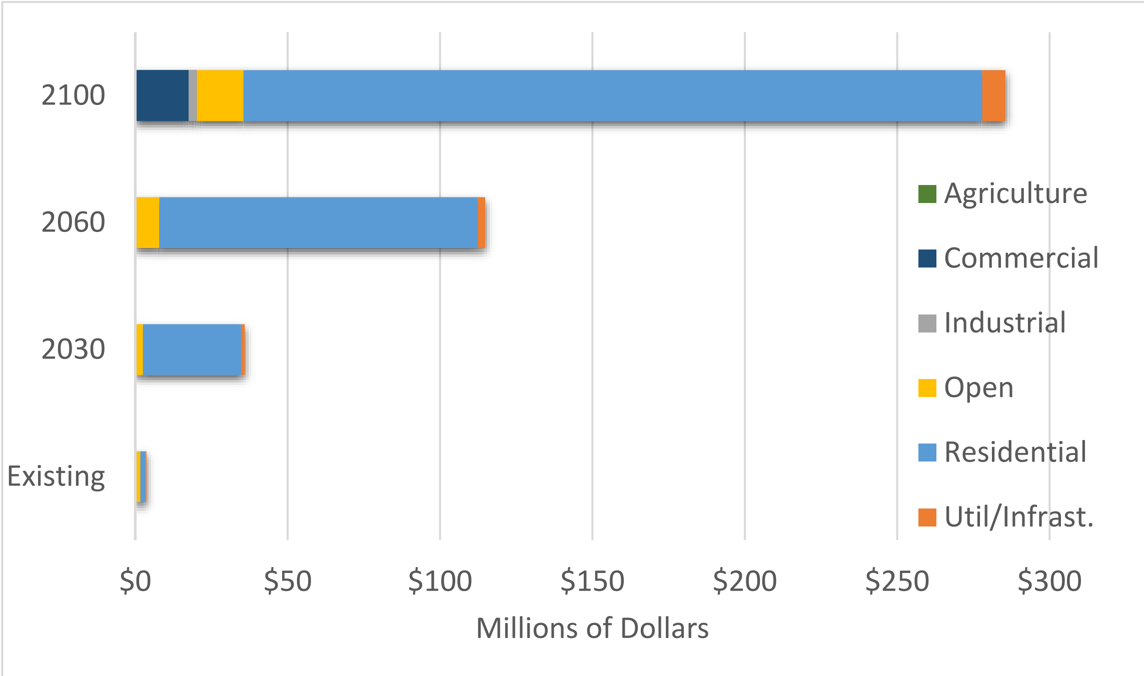


Sea Level Rise	Parcel/ Structure	Residential	Open Space & Recreation	Commercial & Mixed	Industrial	Public Facilities	Total
Existing	Parcels	26	34	0	0	0	**60**
	Structures	15	0	0	0	0	**15**
~1 ft	Parcels	28	36	0	0	0	**64**
	Structures	21	0	0	0	0	**21**
~2 ft	Parcels	92	36	2	0	0	**130**
	Structures	34	3	0	0	0	**37**
~5 ft	Parcels	160	44	3	1	0	**208**
	Structures	62	8	1	0	0	**71**

Note: The number of parcels and structures are cumulative across all time horizons.

Figure 6-3. *Number of Land Use Parcels and Structures Vulnerable to Coastal Erosion During a 1% Annual Chance Storm*

As shown in Figure 6-4, $3.7 million (in 2017 dollars) of property in the City is currently at risk to potential erosion losses should a 1 percent annual chance storm occur without any sea level rise or adaptation strategies implemented. This exposure significantly increases with sea level rise, to $35.9 million with 1 foot of sea level rise, $114.8 million with 2 feet of



sea level rise, and $285.5 million with 5 feet of sea level rise. Residential property most vulnerable to erosion includes beachfront residences, including condominiums and apartments. Approximately 55 short-term vacation rental units are located along the south side of Sandyland Road, and an additional 115 units are located along the north side of the street.

Erosion Losses	Existing	~ 1 ft	~2 ft	~5 ft
Agriculture	$0	$0	$0	$400,000
Commercial	$0	$0	$0	$17,100,000
Industrial	$0	$0	$0	$2,700,000
Open	$1,700,000	$2,500,000	$7,900,000	$15,300,000
Residential	$1,600,000	$32,200,000	$104,500,000	$242,400,000
Utility/ Infrastructure	$400,000	$1,200,000	$2,400,000	$7,600,000
Grand Total	**$3,700,000**	**$35,900,000**	**$114,800,000**	**$285,500,000**

Figure 6-4. *Estimated Value of Property Loss Due to Coastal Erosion from a 1% Annual Chance Storm (2017 dollars)*

Utilities and infrastructure are a category that includes losses and damages to parcels owned by railroad companies, oil, gas and electric companies, water pumps, water and sewer pipes, and roads. Open land, finally, includes open land that has not been developed. As such, these losses to erosion do not include losses to structural improvements. See also Section 6.6, *Infrastructure*.

Revenue Implications to the City

Currently, the City receives approximately $2.3 million in Transient Occupancy Tax (TOT), from hotels, motels, and short-term vacation rentals, with an estimated $400,000 of annual TOT from vacation rentals. Damages to other visitor serving land uses may also affect tourism spending and associated sales tax revenues in the City.

Structures within the Carpinteria Bluffs could become vulnerable to cliff erosion with approximately 5 feet of sea level rise.

This Report estimates the potential property tax loss due to land and structure losses from erosion in 2017 and in 2030 with 1 foot of sea level rise (Table 6-2). Currently, erosion hazards are not expected to result in a loss of property tax revenues; however, losses could be $231,000 (assuming 2017 property tax values). For potential flooding losses, this report assumes that property would be repaired, and property tax rates would not change. Property taxes were not estimated for 2060 and 2100 due to uncertainty about future housing prices and inflation.

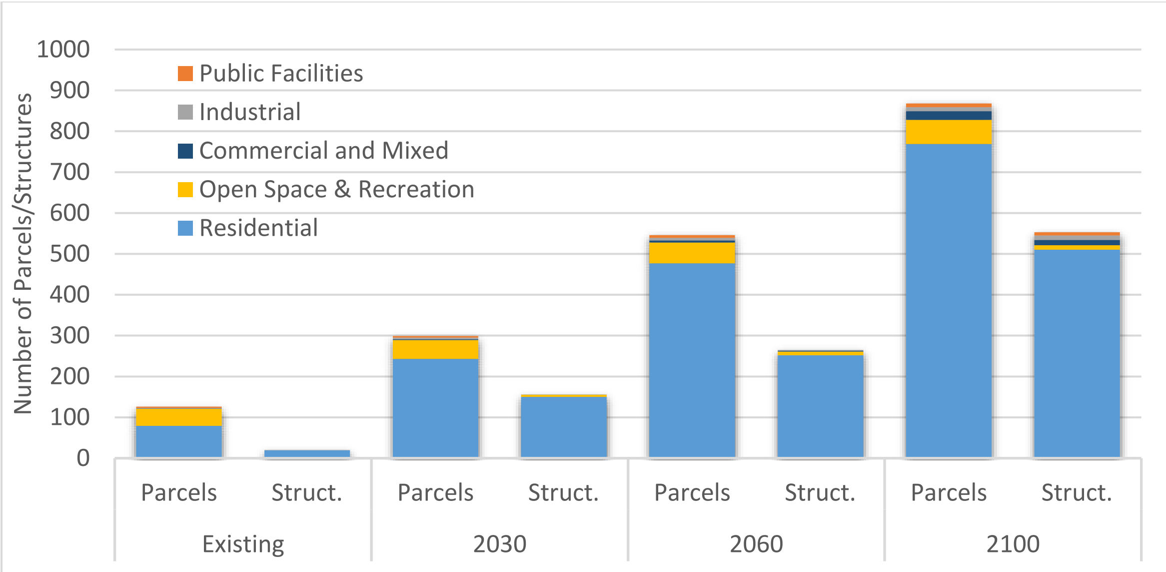
Table 6-2. Estimated Loss in Property Tax from Erosion

	2017	2030
2017 Property Tax Values	$0	$231,000

Coastal Flooding Impacts to Land Uses and Structures, and Infrastructure

Figure 6-5 depicts the number of parcels and structures vulnerable to coastal flooding during a 1 percent annual chance storm. Residential land uses comprise the strong majority, by number, of vulnerable structures and parcels. Open space and commercial and mixed-use uses are also vulnerable to coastal storm damage. The majority of land uses susceptible to coastal storm damage are within the Beach Neighborhood and Downtown.

Estimates of property loss from coastal flooding reflect the vulnerability of damaged property to severe coastal flooding without consideration of coastal erosion damages (Figure 6-6). Increased potential coastal flooding damages is expected with increased sea level rise due to an expanded flood zone and increased flood depths.

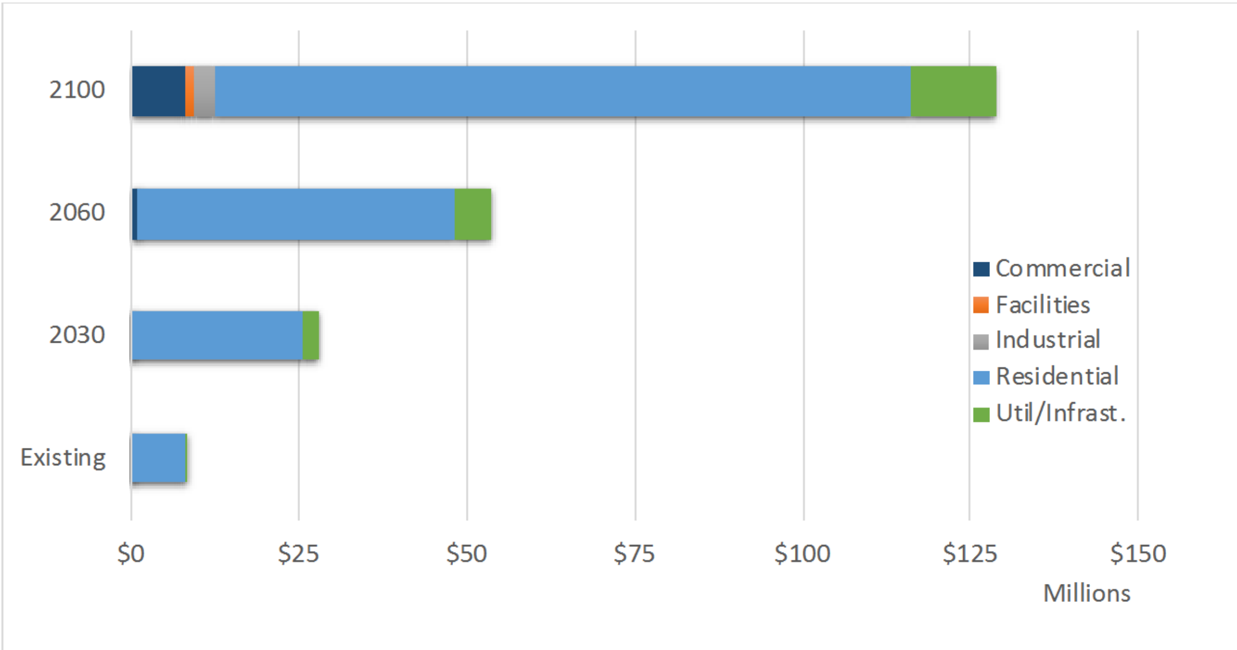


Sea Level Rise	Parcel/ Structure	Residential	Open Space & Recreation	Commercial & Mixed	Industrial	Public Facilities	Total
Existing	Parcels	79	42	1	1	3	**126**
	Struct.	19	0	0	1	0	**20**
~1 ft	Parcels	243	46	2	4	4	**299**
	Struct.	150	5	0	1	0	**156**
~2 ft	Parcels	477	51	5	6	7	**546**
	Struct.	252	9	2	2	0	**265**
~5 ft	Parcels	769	59	21	10	9	**868**
	Struct.	510	11	13	11	8	**553**

Note: Counts of parcels and structures are cumulative across all time horizons.

Figure 6-5. *Number of Land Use Parcels and Structures Vulnerable to Coastal Flooding During a 1% Annual Chance Storm*

Currently $8.5 million of property is at risk to coastal flooding, increasing to $28 million with 1 foot of sea level rise, $53.8 million with 2 feet of sea level rise, and $128.8 million with 5 feet of sea level rise. Residential land uses comprise the majority of property value estimates. Commercial assets that become vulnerable by 2100 with 5 feet of sea level rise include the multi-story office buildings within the Carpinteria Bluffs. With 5 feet of sea level rise, community and public facilities also become vulnerable to coastal flooding, including churches, medical facilities, fire and police stations, post offices, and schools.



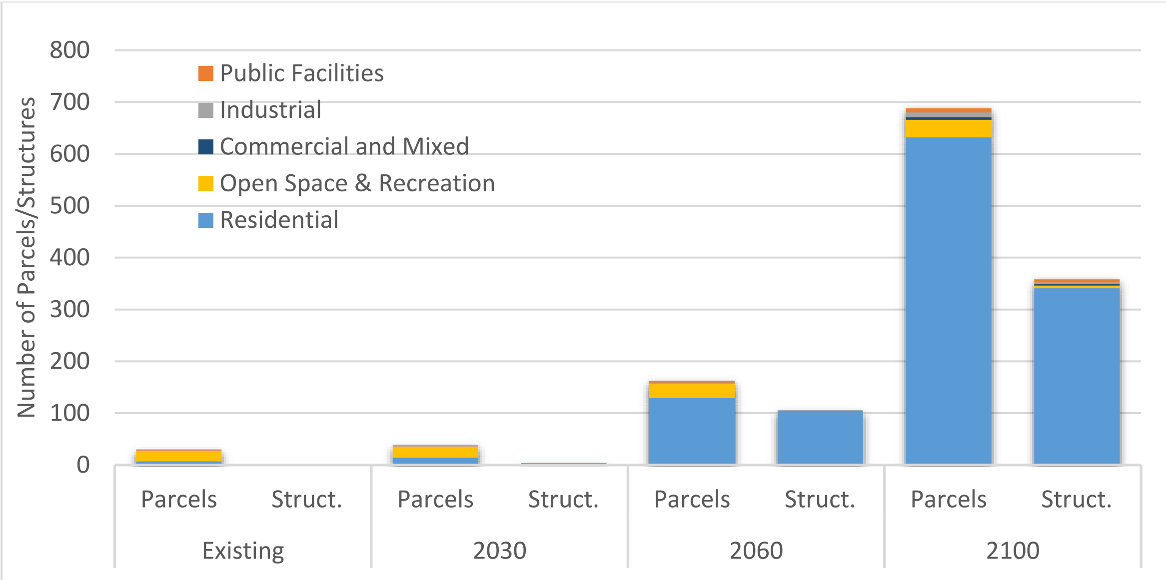
Coastal Damages	Existing	~1 ft	~2 ft	~5 ft
Commercial	$0	$0	$1,000,000	$8,000,000
Facilities	$0	$0	$0	$1,300,000
Industrial	$0	$0	$0	$3,200,000
Residential	$8,200,000	$25,500,000	$47,300,000	$103,600,000
Utility/ Infrastructure	$300,000	$2,500,000	$5,500,000	$12,700,000
Grand Total	**$8,500,000**	**$28,000,000**	**$53,800,000**	**$128,800,000**

Note: Estimates of losses are cumulative across all time horizons.

Figure 6-6. *Estimated Value of Property Loss to Coastal Flooding from a 1% Annual Chance Storm (2017 dollars)*

Tidal Inundation Impacts to Land Uses and Structures

Figure 6-7 depicts the number of parcels and structures according to land use at risk to tidal inundation. Mostly open space land uses would be affected by tidal inundation with up to 2 feet of sea level rise. With more than 2 feet of sea level rise, residential parcels and condominium/apartment structures, particularly in the Beach Neighborhood, start to become exposed to tidal inundation. The dramatic increase in property loss value between 2 feet and 5 feet of sea level rise is due to typically high value of shoreline property.

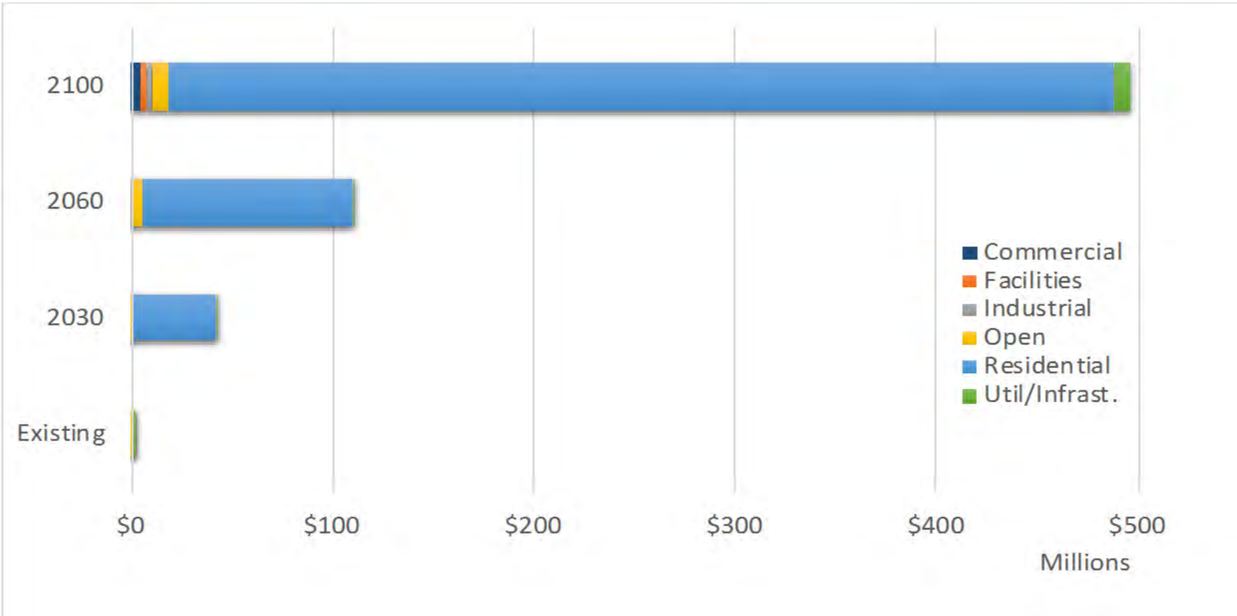


Sea Level Rise	Parcel/ Structure	Residential	Open Space & Recreation	Commercial & Mixed	Industrial	Public Facilities	Total
Existing	Parcels	7	20	0	1	2	**30**
	Struct.	0	0	0	0	0	**0**
~1 ft	Parcels	14	21	0	1	2	**38**
	Struct.	4	0	0	0	0	**4**
~2 ft	Parcels	129	27	0	3	3	**162**
	Struct.	105	0	0	1	0	**106**
~5 ft	Parcels	632	34	5	9	8	**688**
	Struct.	510	11	13	11	8	**553**

Note: Estimates of losses are cumulative across all time horizons.

Figure 6-7. *Number of Land Use Parcels and Structures Vulnerable to Monthly Tidal Inundation*

Figure 6-8 presents estimates of property at risk to tidal inundation. Since there are no current methods to evaluate the cost of potential damages associated with tidal inundation, estimates represent the total value of the property at risk rather than actual damages or losses due to tidal inundation.



Tidal Exposure	Existing	~1 ft	~2 ft	~5 ft
Commercial	$200,000	$0	$0	$4,100,000
Facilities	$0	$0	$0	$3,800,000
Industrial	$0	$300,000	$500,000	$2,600,000
Open	$300,000	$300,000	$5,300,000	$8,200,000
Residential	$200,000	$41,400,000	$103,900,000	$469,800,000
Utility/Infrastructure	$100,000	$100,000	$1,800,000	$8,200,000
Grand Total	**$800,000**	**$42,100,000**	**$111,500,000**	**$496,700,000**

Note: Estimates of losses are cumulative across all time horizons. These numbers only estimate property at risk to tidal flooding, not estimated damages.

Figure 6-8. *Estimated Value of Property Vulnerable to Tidal Inundation (2017 dollars)*

The Carpinteria Salt Marsh during a king tide in 2013. The Carpinteria Salt Marsh is hydraulically connected to the ocean and increases in tidal elevation may result in flooding of adjacent development. Photo credit: Bill Dewey for Heal the Ocean

Currently, only $800,000 in property value is at risk to tidal inundation. $200,000 of this is in commercial damages resulting from a drainage ditch that flows from Carpinteria Salt Marsh into a commercial area on the west side of town. Tidal exposure is projected to rise gradually to $42.1 million with 1 foot of sea level rise and then increase to $111.5 million with 5 feet of sea level rise. By 2100, however, sea levels may inundate a much greater number of structures, increasing the total exposure to $496.7 million in land, structures, and infrastructure, covering almost the entirety of the Beach Neighborhood. Significant, non-residential vulnerabilities include the multi-story office building on Carpinteria Avenue, the Carpinteria Business Park on Carpinteria Avenue, the Aliso Elementary School at Carpinteria Avenue and 7th Street, and the St. Joseph's Catholic Church building on 7th Street.

Residential Property Vulnerabilities

> Vulnerable residential dwellings exposed to coastal wave flooding within Carpinteria could increase from 86 today, to 237 with 1 foot of sea level rise, and up to 1,090 with 5 feet of sea level rise.

Residential properties represent approximately 90 percent of all structural vulnerabilities in the City. All vulnerable residential properties are in the Beach, Downtown/Old Town, and Concha Loma Neighborhoods. Residential land use parcels may contain multiple structures, and apartments/condominiums can overlay multiple parcels. Table 6-3 below highlights these differences and identifies the number of dwellings in each of the residential unit types.

Table 6-3. Residential Land Uses Affected by Coastal Hazards

Type	Large Apartments (5+ units)[1]	Condominiums and Mixed Use[2]	Mobile Homes[3]	Multi-family (2-4 units)[4]	Single-family	Total
Parcels	25	426	83	74	166	**774**
Structures	46	75	154	110	194	**579**
Dwelling Units	210	426	154	152	148	**1090**

Notes: All parcels can contain multiple non-dwelling structures (e.g., garages and sheds). Some parcels may be vacant and contain no structures. Not all structures are affected by hazards, this comprises 9% of the total tally (i.e., the parcel is affected, and the structure is not). Parcels where less than 1% of the parcel area in the hazard zone and where the structure(s) is unaffected by the hazard zone are not included in the structures count (typically parcels that abut stream channels). See definitions section for more information on dwellings.
[1]Large apartments have multiple units per structure and can have multiple structures per parcel.
[2]Condominiums have multiple parcels per structure. Commonly held condominium parcels (parking and landscaped areas) are not included in the tally.
[3]Multiple homes may exist on one lot (e.g., mobile home parks).
[4]Multi-family can contain either multiple lots per structure or multiple structures per lot.

To facilitate a better understanding of the impacts to residential land uses, the analysis identifies the residential dwelling units projected to be affected by varying levels of sea level rise (Table 6-4).

Table 6-4. Vulnerable Residential Dwelling by Categories[3]

Sea Level Rise	Large Apartments (5+ units)	Condominiums and Mixed Use	Mobile Homes	Multi-family (2-4 units)	Single-family	Total
	Number of dwellings					
Existing	0	73	0	11	2	86
~1 ft	49	63	63	32	30	237
~2 ft	64	217	21	28	33	363
~5 ft	97	73	70	81	83	404
Total	**210**	**426**	**154**	**152**	**148**	**1090**

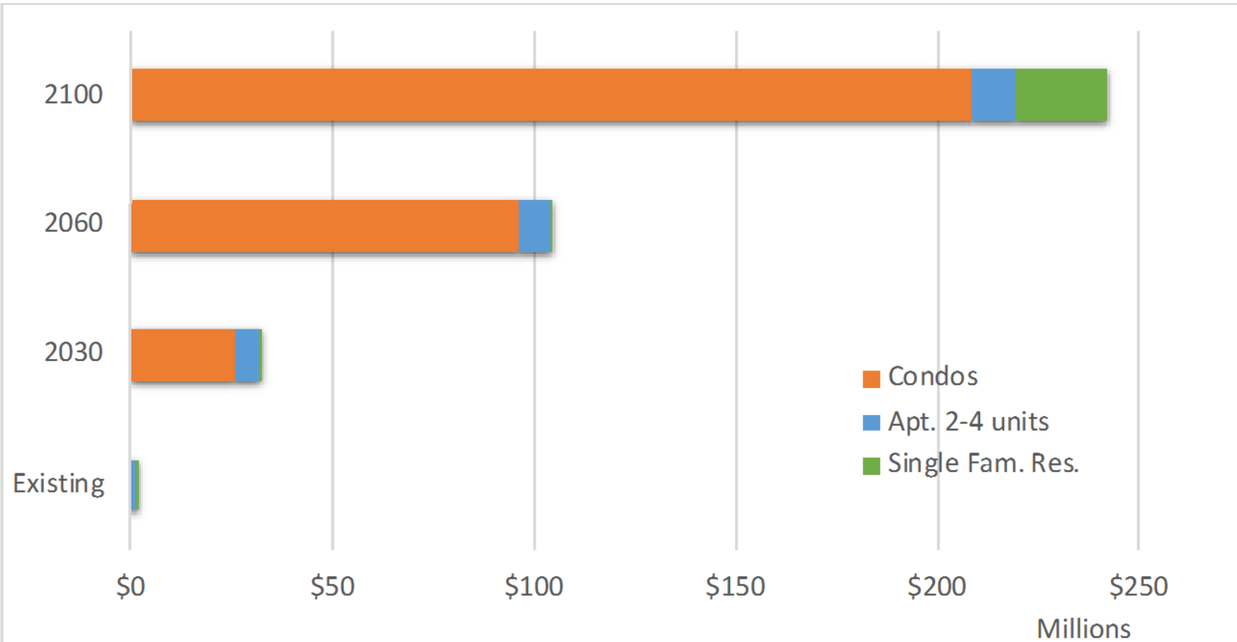
Note: All counts and sums are non-cumulative across time horizon years. Number of dwelling units assigned to each structure is an estimation based on assessor's data information.

Coastal Erosion Damages to Residential Parcels and Structures

Figure 6-9 presents the current market value of residential property subject to erosion from coastal storms. This analysis does not account for any future appreciation in residential property prices. Currently, $1.6 million (in 2017 dollars) in residential property is vulnerable to coastal erosion during a 1 percent annual chance storm. The estimated property values in Figure 6-10 increase substantially over time, topping out at $242 million

3 Please note that there are an additional 15 large residential apartments encompassed within 2 complexes which are projected to become islands from combined coastal hazards and approximately 5 feet of sea level rise.

in vulnerable residential property with 5 feet of sea level rise. The majority of this property value occurs in the Beach Neighborhood condominium and apartment buildings. Single-family residences in the Concha Loma Neighborhood also become exposed with 5 feet of sea level rise.



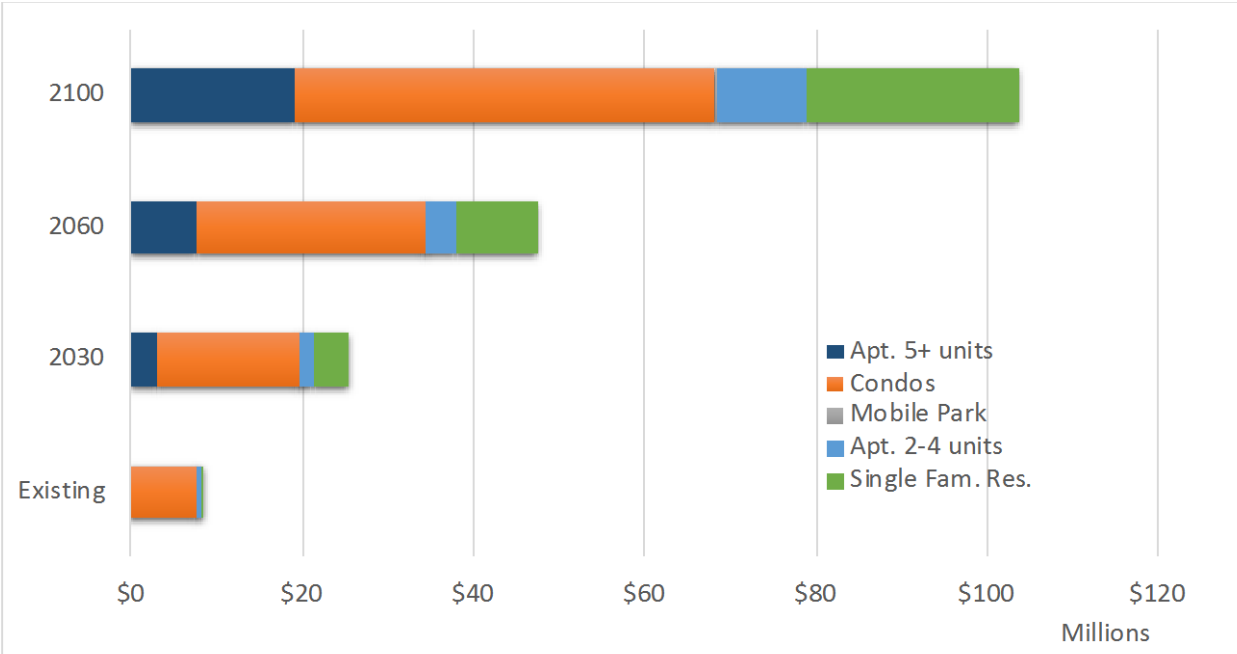
Erosion Losses	Existing	~1 ft	~2 ft	~5 ft
Condominiums	$200,000	$25,900,000	$96,100,000	$208,500,000
Apartments, 2-4 units	$1,000,000	$6,000,000	$7,700,000	$11,000,000
Single Family Residence	$300,000	$300,000	$600,000	$22,900,000
Grand Total	**$1,600,000**	**$32,200,000**	**$104,500,000**	**$242,400,000**

Note: Estimates of losses are cumulative across all time horizons.

Figure 6-9 *Estimated Value of Infrastructure Vulnerable to Coastal Erosion from a 1% Annual Chance Storm (2017 dollars)*

Coastal Flooding Damages to Residential Parcels and Structures

Figure 6-10 presents the current market value of residential property subject to coastal storm flooding. Unlike coastal erosion, coastal storm flooding can impact low-elevation parcels, even if they are not directly adjacent to the shoreline. Such flooding also does not impact second- or third-story residences.



Coastal Damages	Existing	~1 ft	~2 ft	~5 ft
Apartments, 5+ units	$0	$3,000,000	$7,700,000	$19,200,000
Condominiums	$7,700,000	$16,600,000	$26,600,000	$49,000,000
Mobile Park	$0	$0	$0	$300,000
Apartments, 2-4 units	$400,000	$1,700,000	$3,700,000	$10,500,000
Single Family Residence	$200,000	$4,200,000	$9,400,000	$24,700,000
Grand Total	**$8,200,000**	**$25,500,000**	**$47,300,000**	**$103,600,000**

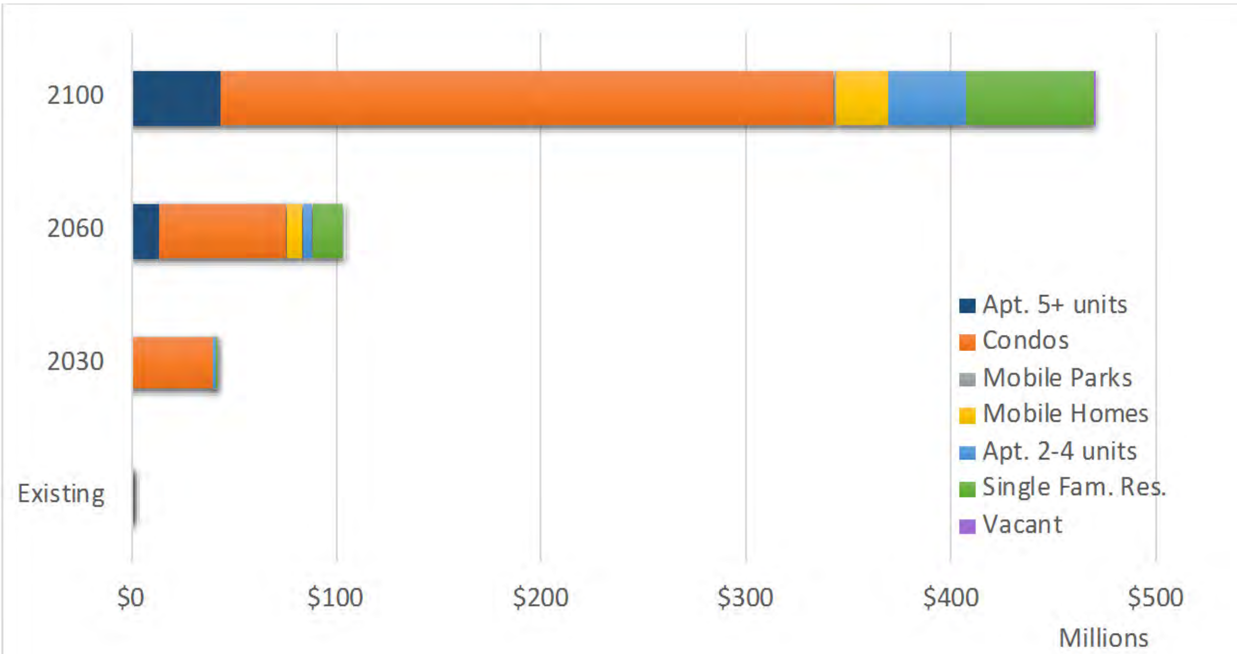
Note: Estimates of losses are cumulative across all time horizons.

Figure 6-10. *Estimated Value of Property Vulnerable to Coastal Flooding from a 1% Annual Chance Storm (2017 dollars)*

Under existing conditions, this Report estimates $8.2 million in potential damages and losses to residential property due to a 1 percent annual chance storm. This figure could increase dramatically with 5 feet of sea level rise to over $100 million. While ground floor residences in the Beach Neighborhood, including large condominium and apartment complexes, constitute the largest vulnerability by market value, large apartment buildings (5 units or more) on Holly, Ash, and Elm Avenues, along with single-family residences on Dorrance Way and 3rd Street are also impacted as early as 2030 or 2060.

Tidal Inundation Exposure to Residential Parcels and Structures

Figure 6-11 considers the value of property that is vulnerable to tidal inundation. This Report estimates the land and structural value exposed to tidal inundation with sea level rise and does not estimate the value of potential losses and damages due to insufficient data.



Tidal Exposure	Existing	~1 ft	~2 ft	~5 ft
Apartments, 5+ units	$0	$0	$13,100,000	$43,100,000
Condominiums	$0	$40,600,000	$62,700,000	$300,100,000
Mobile Parks	$0	$0	$200,000	$700,000
Mobile Homes	$0	$0	$7,300,000	$25,900,000
Apartments, 2-4 units	$100,000	$200,000	$5,300,000	$37,100,000
Single Family Residence	$100,000	$600,000	$15,200,000	$62,400,000
Vacant Residential	$0	$0	$0	$600,000
Grand Total	**$200,000**	**$41,400,000**	**$103,900,000**	**$469,800,000**

Note: Estimates of losses are cumulative across all time horizons.

Figure 6-11. *Estimated Value of Property Vulnerable to Tidal Inundation (2017 dollars)*

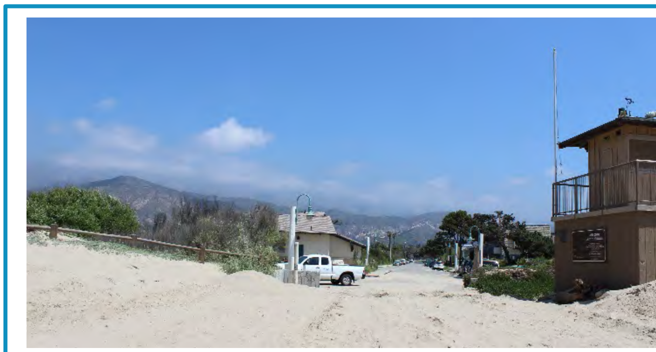
The condominiums and apartments along Sandyland Road, constitute the majority of residential property value exposed to tidal inundation, including up to 170 short-term vacation rentals. Unlike coastal flooding, tidal inundation does not only impact the ground floor. With 2 or more feet of sea level rise, however, single-family residences and large apartment buildings (5 units or more) along Holly, Ash, and Elm Avenues, 3rd Street, and Dorrance Way also become exposed to tidal inundation and mobile homes along Ash Avenue become increasingly inundated by tides.

6.2 Roads, Parking, and Public Transportation

Much of the western portion of the City, including the Union Pacific Railroad (UPRR) and Amtrak corridor, portions of U.S. Highway 101 (U.S. 101), local roads, and bikeways lie at low elevations behind a generally unarmored one-mile long coast and are vulnerable to flooding and damage associated with sea level rise; in contrast, the eastern two miles of City shoreline is fronted by steep coastal bluffs which are potentially vulnerable to accelerated cliff erosion from sea level rise. This coastal bluff area supports the UPRR and the Carpinteria Bluffs Trail, as well as local roads. To identify roads and parking areas potentially vulnerable to sea level rise hazards, 50.3 miles of roadways and 16 surface parking areas within the City are evaluated. To identify public transportation facilities potentially vulnerable to sea level rise hazards, 4.1 miles of bike routes, approximately 7.0 miles of bus routes, 50 bus stops, 3.6 miles of railroad line, and 1 train station within the City are evaluated. Impacts are described based on modeled results showing the extents of hazards under existing conditions (based on 2010) and with approximately 1 foot, approximately 2 feet, and approximately 5 feet of sea level rise. All modeled results estimate the extent of vulnerabilities assuming no adaptive measures are taken.

Coastal Erosion

Currently, no roadways, bikeways, or bus routes within the City are vulnerable to coastal erosion. However, if a large storm event were to occur, some small portions of Union Pacific Railroad (UPRR) along Bluffs II and III would be vulnerable to cliff failure and damage from storm-based erosion. With approximately 1 foot of sea level rise, UPRR would continue to be vulnerable to erosion from a large singular storm event. Modeling results show road ends at Ash, Holly, Elm, and Linden Avenues in the Beach Neighborhood become exposed to potential beach and dune erosion with approximately 2 feet of sea level rise (both long-term and storm-based erosion); such road ends would be exposed to wave uprush through gaps in the existing homes that would erode the beach and dunes fronting these road end, damaging



Sand from Carpinteria City Beach abuts Ash Avenue, which serves as a buffer from wave attack and runup damaging and eroding the roadway. With approximately 2 feet of sea level rise, erosion of this sand buffer could result in damage to this roadway, as well as at Linden, Holly, and Elm Avenues, which also terminate at the sandy beach.

or eroding road paving, sidewalks, bike lanes, and parking. The roadway network would potentially become significantly more vulnerable to erosion with approximately 5 feet of sea level rise, with the model showing a total of 0.7 mile of roadway at risk of damage from erosion. Seaward segments of Ash, Holly, Elm, and Linden Avenues in the Beach Neighborhood could erode landward approximately 220 feet to inland of Sandyland Road, as well as 1,331 linear feet of Sandyland Road. Approximately 382 linear feet of 4th Street within the State Park east of Carpinteria Creek would also be subject to erosion. However, as noted above, the model may at least initially over-project the extent of beach and dune erosion to these roadways as paved surfaces and development in this area would erode at a slower rate; damage these roads, particularly Sandyland Road, would be strongly linked to management and adaptation measures undertaken for beach front homes. Therefore, the accuracy of modeling damage to roads from beach and dune erosion is strongly dependent on actions to protect or adapt structures such as the beachfront homes that line Sandyland Road.

Further, infrastructure along the Carpinteria Bluffs could be extremely vulnerable to cliff erosion with potentially 1.4 miles of UPRR, with approximately 5 feet of sea level rise. The model shows that erosion of the bluffs in the eastern portion of the City would not expose any roadways to damage until approximately 5 feet of sea level rise, at which point, it could affect over 1,336 feet of 4th Street within the State Park if no adaptive actions are taken. It is noted however, that 700 feet of the rail line in the Carpinteria Bluffs area is protected by a 500-foot long seawall and a 200-foot long rock revetment which would substantially slow cliff erosion and retreat in these areas. Further, UPRR typically responds to cliff erosion and track failure with emergency coastal armoring, which if continued over time, would protect the tracks and trails within most of the Carpinteria Bluffs, which lie landward to the tracks. However, this response could lead to armoring of much of the shoreline of eastern Carpinteria, with secondary impacts to sand supply, coastal access and habitats.

Roads will not become significantly vulnerable to erosion until approximately 5 feet of sea level rise at which point 0.7-mile of roadway ($1 million) becomes vulnerable to erosion during a 1 percent annual chance storm. The increasing vulnerability of UPRR, however, is much more gradual in nature. By 2100, 1.4 miles of railroad ($2.5 million) may be exposed to coastal erosion along the Carpinteria Bluffs (Table 6-5).

Table 6-5. Length and Replacement Costs of Roads and Railroad due to Coastal Erosion during a 1% Annual Chance Storm

Erosion	Roads	Roads	Railroads	Railroads
Existing	< 0.1-mile	$0	0.1-mile	$130,000
~1 ft	< 0.1-mile	$0	0.4-mile	$760,000
~2 ft	0.1-mile	$90,000	0.8-mile	$1,510,000
~5 ft	0.7-mile	$1,050,000	1.4 miles	$2,550,000

Note: All linear totals and losses are cumulative across horizon years.

Coastal Storm Flooding

The area extent of flooding of the transportation network during a 1 percent annual chance storm increases with increased sea level rise elevation. Coastal storm flooding is episodic in nature, and roadways, and the railroad, could be flooded temporarily following a storm, leading to damage, closures, and circulation issues. The model shows that no significant amount of roadways, bikeways, or bus routes are currently at risk of flooding; although, coastal flooding could temporarily inundate the 7th Street and Carpinteria Avenue bridge crossings over Franklin Creek during a large storm event. With approximately 1 foot of sea level rise, storm flooding could inundate many roadways within the Beach Neighborhood, including Ash, Holly, Elm, Linden, 3rd Street, and 4th Street. The UPRR tracks, which are elevated in places up to four feet above adjacent roadways would act as a levee between Elm Avenue and Ash Avenue that would protect landward development within the Downtown with up to approximately 2 feet of sea level rise; although, flooding of lower lying areas along Linden and by Amtrak station inland of the railroad could occur. With approximately 2 feet of sea level rise, 2.0 miles of roadway, including segments of every roadway located within the Beach Neighborhood become subject to coastal flooding from wave run-up. In addition, some road segments immediately north of UPRR, including about 300 feet of 5th Street could be flooded.

With approximately 5 feet of sea level rise, 4.8 miles of roadway segments could be at risk of flooding, including 100 percent of roadways within the Beach Neighborhood, and some roadway segments north of the Carpinteria Salt Marsh (south of U.S. 101) including Carpinteria Avenue, 7th, 8th, and 9th Streets, Reynolds, Santa Ynez, and Holly Avenues. Some of the road lengths at risk include a 1,497-foot segment of U.S. 101 and the on-ramp to Carpinteria Avenue at exit 87B. Further, the actual area of flooding has the potential to be greater under all scenarios, as precipitation runoff down Santa Monica, Franklin, and Carpinteria Creeks could further exacerbate the extent and depth of flooding on roadways under all scenarios. With 5 feet of sea level rise, 4.8 miles of roads ($7.1 million) and 1.5 miles of railroad lines ($2.6 million) may be vulnerable to coastal flooding along the Carpinteria Bluffs and near the Carpinteria Salt Marsh (Table 6-6).

The UPRR tracks near Ash Avenue are raised about four feet above the roadway and could protect landward infrastructure from flooding with up to approximately 2 feet of sea level rise.

Table 6-6. Length and Replacement Costs of Roads and Railroad due to Coastal Flooding during a 1% Annual Chance Storm

Sea Level Rise	Roads	Roads	Railroads	Railroads
Existing	0.1-mile	$120,000	0.1-mile	$180,000
~1 ft	1.1 miles	$1,690,000	0.4-mile	$810,000
~2 ft	2.0 miles	$2,970,000	0.9-mile	$1,560,000
~5 ft	4.8 miles	$7,090,000	1.5 miles	$2,630,000

Note: All linear totals and losses are cumulative across horizon years.

Tidal Inundation

The Carpinteria Salt Marsh is an open tidal system where the creek watershed and tidal processes are directly connected. With approximately 5 feet of sea level rise, the Carpinteria Salt Marsh could be completely submerged by regular monthly tides and could result in the flooding of adjacent and nearby roadways.

Tidal inundation is projected monthly flooding due to rising tides under non-storm conditions and would extend further inland as sea levels rise. Tidal inundation is of concern as it would occur during monthly peak high tides with potential for frequently repeated damage and ongoing cleanup or maintenance costs. Tidal inundation could result in the flooding of roadways and infrastructure at low elevations, resulting in road closures and damage, leaving some areas periodically inaccessible. This type of hazard would occur along many of the same roadway segments that are also subject to coastal flooding under a large storm event, particularly in the Beach Neighborhood and north of the Carpinteria Salt Marsh; however, the area and depth of flooding is lesser under this non-storm scenario that would occur on a monthly basis. Currently, no transportation infrastructure is affected by tidal inundation due to regular monthly high tides or periodic Extreme Monthly High Water (EMHW) tides. With approximately 1 foot of sea level rise, a 600 foot segment of Ash Avenue south of the railroad may be periodically inundated due to the low elevation and configuration of storm drain infrastructure along this roadway segment. With approximately 2 feet of sea level rise, several roads within the Beach Neighborhood including a total of 2,485 linear feet along Ash, Holly, Elm, and Linden Avenues could become periodically inundated under EMHW tide conditions. With approximately 5 feet of sea level rise, the area exposed to tidal inundation increases significantly, where a total of 3.0 miles of roads could be inundated, including all roadways within the Beach Neighborhood, and roadways north of the Salt Marsh but south of U.S. Highway 101, including 4th, 5th. 7th, 8th, and 9th Streets, Carpinteria Avenue, Estero, Pear, and Plum Streets.

Tidal inundation is a chronic threat. As such, it is much more amenable to removal costs rather than total losses or replacement costs. The recurring nature of this threat makes the indirect losses to redirected traffic more significant. With 5 feet of sea level rise, 3.0 miles of roads ($4.5 million) may be exposed or at risk to tidal inundation, while less than 0.1-mile of railroad lines may be exposed, although these appear to be co-located with bridges, so damages may not be as severe (Table 6-7).

Table 6-7. Length and Replacement Costs of Roads and Railroad due to Monthly Tidal Inundation

Tidal	Roads	Roads	Railroads	Railroads
Existing	< 0.1-mile	$20,000	< 0.1-mile	$30,000
~1 ft	< 0.1-mile	$50,000	< 0.1-mile	$30,000
~2 ft	0.8-mile	$1,220,000	< 0.1-mile	$30,000
~5 ft	3.0 miles	$4,480,000	< 0.1-mile	$40,000

Note: All linear totals and losses are cumulative across horizon years.

H++ Scenario

Although no modeling data for the H++ scenario is currently available, it can be assumed that damage to the transportation network described above could be experienced even sooner than the planning horizon years used for this analysis (2030, 2060, and 2100) if the H++ scenario were to occur. Further, **approximately 10 feet of sea level rise by 2100** under the H++ scenario could impact a substantially greater portion of the transportation network if no adaptive measures are taken, as well as potentially causing more severe damage to the facilities already forecasted to be impacted. Coastal erosion could occur at an accelerated rate and retreat further inland; coastal flooding and tidal inundation hazards could also extend further inland, affecting a greater area north of the Carpinteria Salt Marsh and within the Downtown north of the railroad. Such impacts could also occur more frequently as with higher sea levels, less intense storm and non-peak monthly high tides could cause repeated more frequent damage. Under this scenario, impacts to the transportation network would increase in magnitude. In particular, it should be noted that flooding of U.S. 101 north of the Salt Marsh, flooding of UPRR within the Downtown, and erosion of UPRR along the Bluffs could be even more detrimental. U.S. 101 and UPRR are considered critical facilities serving the local and regional transportation network. These facilities have a limited potential for adaptation, are costly to repair, adapt or relocate, where repeated or substantial damage to or destruction of such facilities could result in significant and widespread economic and socioeconomic impacts. The need for adaptation planning to ensure the long-term protection of these facilities becomes even more important under this scenario.

Roadways

Currently, roadways are generally not exposed any coastal hazards, apart from storm-based flooding of a low-lying portion of Sandyland Road within the State Park, and potential flooding of bridge crossings over Carpinteria Creek and Franklin Creek (however, the model may be over-projecting these results as the elevations of the bridges are not taken into account). Storm-based flooding begins to significantly affect roadways within the Beach Neighborhood with approximately 1 foot or more of sea level rise. With approximately 2 or more feet of sea level rise, roadways in the Beach Neighborhood begin to be significantly impacted by periodic tidal inundation, and erosion of sand within the City Beach could start to expose north-south oriented roadways to damage from erosion. Approximately 4.8 miles of roadway, or 14.9 percent of the total road network within Carpinteria, would be affected by at least one type of coastal hazard with approximately 5 feet of sea level rise (Table 6-8); many roadway segments in the Beach Neighborhood would be affected by multiple hazards. Specific roadway segments impacted by coastal erosion, coastal flooding and tidal inundation are described below (Table 6-9).

Table 6-8. Cumulative Length of Total Potential Road Damage due to Coastal Hazards

SLR Elevation	Coastal Erosion		Coastal Flooding		Tidal Inundation	
	Length	**%**	**Length**	**%**	**%**	**%**
Existing	~0 mile	< 0.1%	<0.1 mile	< 0.1%	~0 mile	< 0.1%
~1 foot	< 0.1 mile	< 0.1%	1.1 miles	2.2%	< 0.1 mile	< 0.1%
~2 feet	0.1 mile	0.3%	2.0 miles	6.2%	0.8 mile	2.5%
~5 feet	0.7 mile	1.4%	4.8 miles	14.9%	3.0 miles	9.3%

Note: All linear totals and losses are cumulative across planning horizons. % indicates the percentage of the Carpinteria roadway network affected out of 50.3 miles of roadway within the City.

Table 6-9. Cumulative Length and Location of Potential Road Loss due to Coastal Hazards

Road	Existing				~1 foot by 2030				~2 feet by 2060				~5 feet by 2100			
	BDE	CE	CF	TI	BDE	CE	CF	TI	BDE	CE	CF	TI	BDE	CE	CF	TI
U.S. Highway 101	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,497 ft	--
Carpinteria Avenue	--	--	--	--	--	--	--	--	--	--	204 ft	--	--	--	4,314 ft	2,145 ft
Via Real	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Linden Avenue	--	--	--	--	--	--	105 ft	--	76 ft	--	735 ft	173 ft	206 ft	--	934 ft	778 ft
Ash Avenue	--	--	--	--	--	--	1,415 ft	419 ft	62 ft	--	1,601 ft	1,148 ft	243 ft	--	1,794 ft	1,810 ft
Holly Avenue	--	--	--	--	--	--	1,065 ft	--	47 ft	--	1,281 ft	924 ft	200 ft	--	1,714 ft	1,536 ft
Elm Avenue	--	--	--	--	--	--	460 ft	--	54 ft	--	702 ft	240 ft	195 ft	--	1,100 ft	934 ft
3rd Street	--	--	--	--	--	--	524 ft	--	--	--	870 ft	504 ft	--	--	1,270 ft	1,270 ft
4th Street	--	--	--	80 ft	--	--	658 ft	85 ft	148 ft	--	1,203 ft	820 ft	382 ft	1,336 ft	3,800 ft	1,105 ft
7th Street	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,572 ft	920 ft
Sandyland Road	--	--	128 ft	--	--	--	1,810 ft	--	--	--	2,369 ft	440 ft	1,331 ft	--	2,505 ft	2,505 ft

Note: All linear totals and losses are cumulative across planning horizons. Coastal hazards (e.g., coastal flooding and tidal inundation) may account for losses in the same area. Note that model does not account for existing structures such as homes along Sandyland Road or limited areas of seawalls and rock revetments which may reduce erosion or affect severity of coastal flooding and tidal inundation.
BDE = Beach & Dune Erosion
CE = Cliff Erosion
CF = Coastal Flooding
TI = Tidal Inundation

- **U.S. 101** would not be affected by any coastal hazard until approximately 5 feet of sea level rise. With approximately 5 feet of sea level rise, a nearly 1,500-foot section north of the Carpinteria Salt Marsh could be flooded during a large coastal storm event. This model does not take into account creek runoff, and the combined extent of flooding from a 1 percent annual chance storm and approximately 5 feet of sea level rise could be greater when combined with increased rainfall and creek runoff from Santa Monica, Franklin, and Carpinteria Creeks. As noted above, under the H++ scenario, damage would occur earlier than 2100 and may be more frequent and severe.

U.S. 101 and Exit 87B (pictured above) could be exposed to flooding during a storm when combined with approximately 5 feet of sea level rise or more.

- **Carpinteria Avenue** would be vulnerable to coastal hazards with approximately 2 or more feet of sea level rise. With approximately 2 feet of sea level rise, 204 linear feet of roadway in western Carpinteria north of the Carpinteria Salt Marsh and west of Plum Street could be flooded during a large storm. With approximately 5 feet of sea level rise, large sections of Carpinteria Avenue west of Santa Ynez Avenue/ 7th Street and north and northeast of the Carpinteria Salt Marsh become at risk to coastal flooding (4,314 linear feet) and tidal inundation (2,145 linear feet).
- **Linden Avenue** becomes exposed to damage from coastal flooding with approximately 1 foot of sea level rise (105 linear feet). With approximately 2 feet of sea level rise, the segment south of the railroad also becomes vulnerable to beach and dune erosion (76 linear feet), coastal flooding (735 linear feet), and tidal inundation (173 linear feet). With approximately 5 feet of sea level rise, the entire segment of Linden Avenue south of the railroad is exposed to tidal inundation and coastal flooding hazards.

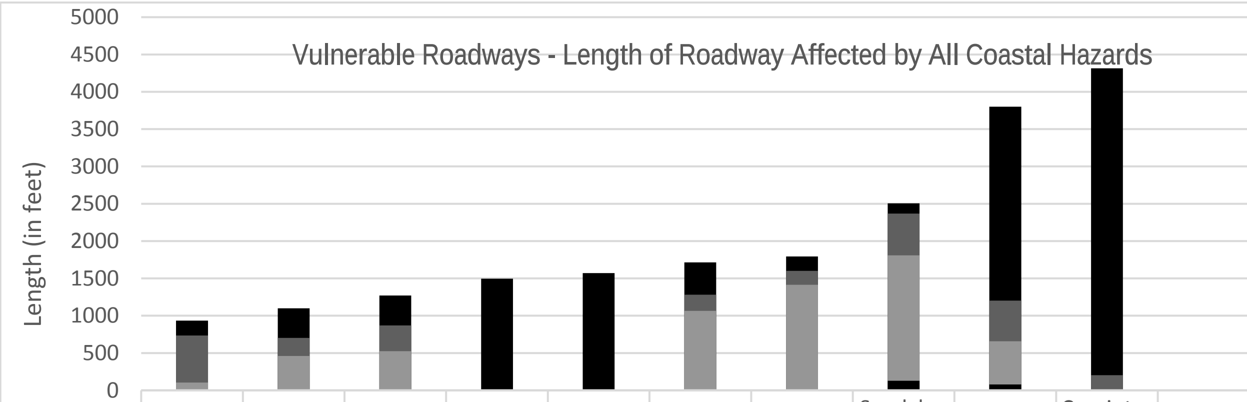
With 5 feet of sea level rise, Linden Avenue south of UPRR could be exposed to erosion, flooding from a coastal storm and extremely high tides.

- A large section of **Ash Avenue** becomes vulnerable to coastal flooding (1,415 linear feet) and tidal inundation (419 linear feet) with approximately 1 foot of sea level rise. With greater sea level rise, Ash Avenue becomes increasingly vulnerable to all coastal hazards. With approximately 5 feet of sea level rise, the entire segment of Ash Avenue becomes exposed to coastal flooding and tidal inundation, and the segment south of Sandyland Road could be damaged by erosion.

- A large section of **Holly Avenue** south of the railroad becomes vulnerable to coastal flooding with approximately 1 foot of sea level rise (1,065 linear feet). With approximately 2 or more feet of sea level rise, Holly Avenue also becomes increasingly vulnerable to dune erosion, coastal flooding, and tidal inundation. With approximately 5 feet of sea level rise, the entire segment of Holly Avenue south of the railroad is exposed to coastal flooding and tidal inundation hazards, and in addition, coastal flooding and tidal inundation impacts could extend approximately 400 feet north of the railroad.
- The section of **Elm Avenue** closest to the coast becomes vulnerable to coastal flooding with approximately 1 foot of sea level rise (460 linear feet). With approximately 2 feet or more of sea level rise, Elm Avenue could be exposed to erosion. With approximately 5 feet of sea level rise, the entire segment of Elm Avenue becomes exposed to coastal flooding and tidal inundation hazards.
- Sections of **3rd Street** become vulnerable to coastal flooding with approximately 1 foot or more of sea level rise (524 linear feet), increasing in length with approximately 2 and approximately 5 feet of sea level rise (870 linear feet and 1,270 linear feet, respectively). With approximately 2 and approximately 5 feet of sea level rise, 3rd Street also becomes exposed to tidal inundation (504 linear feet and 1,270 linear feet). With approximately 5 feet of sea level rise, the entire segment of 3rd Street becomes exposed to coastal flooding and tidal inundation.
- Currently, the model shows that the 80-foot segment of **4th Street** crossing Carpinteria Creek is exposed to tidal inundation with an EMHW tide and will continue to be exposed to periodic tidal inundation under all sea level rise scenarios. In addition to tidal inundation, 4th Street within the State Park becomes vulnerable to coastal flooding with approximately 1 foot of sea level rise (658 linear feet). With approximately 2 feet of sea level rise, a 148-foot segment of 4th Street north of Carpinteria State Beach could also be impacted by dune erosion, in addition to coastal flooding impacts (1,203 linear feet) and tidal inundation (802 linear feet). Coastal hazard impacts increase with approximately 5 feet of sea level rise. A 1,300-foot section of 4th Street within the State Park and leading to the Carpinteria Bluffs Trail becomes vulnerable to cliff erosion with approximately 5 feet of sea level rise. This section is also vulnerable to coastal flooding and tidal inundation with approximately 5 feet of sea level rise.
- **7th Street** isn't affected by coastal hazards until approximately 5 feet of sea level rise, at which point the entire segment between Santa Ynez Avenue and Holly Avenue could be vulnerable to coastal flooding (1,572 linear feet) and regular tidal inundation (920 linear feet).
- A 128-foot long segment of **Sandyland Road** within the State Park is currently exposed to coastal flooding if a large storm were to occur. With approximately 1 foot of sea level rise, the 1,810-foot segment of Sandyland Road within the Beach Neighborhood becomes vulnerable to coastal flooding. This amount nearly doubles with approximately 2 feet of

sea level rise, where the entire length of the road is subject to coastal flooding (2,369 linear feet), with added vulnerabilities to tidal inundation within the State Park (404 linear feet).

- **Via Real** is not vulnerable to coastal hazards with projected sea level rise; however, Via Real has flooded from rainfall runoff in past storm events and would continue to be subject to this type of flooding.



	Linden	Elm	3rd St	U.S. 101	7th St	Holly	Ash	Sandyland	4th St	Carpinteria	Via Real
~5 feet	934	1,100	1,270	1,497	1,572	1,714	1,794	2,505	3,800	4,314	0
~2 feet	735	702	870	0	0	1,281	1,601	2,369	1,203	204	0
~1 foot	105	460	524	0	0	1,065	1,415	1,810	658	0	0
Existing	0	0	0	0	0	0	0	128	80	0	0

Parking

The model indicates that paid parking facilities within the State Park, as well as public parking along Ash, Holly, Elm, and Linden Avenues often used to access the beach, are currently vulnerable to coastal flooding during a 1 percent annual chance storm and that flooding could become more extensive as sea levels rise. With approximately 5 feet of sea level rise, 12 parking lots or facilities, and roughly 75 percent of public and semi-public parking facilities south of U.S. 101 would become vulnerable to at least one coastal hazard when combined.

Table 6-10. Number of Parking Facilities Potentially Impacted due to Coastal Hazards

SLR Elevation	Coastal Erosion	Coastal Flooding	Tidal Inundation
Existing	0 lots	6 lots	0 lots
~1 foot	1 lot	8 lots	0 lots
~2 feet	7 lots	8 lots	1 lot
~5 feet	10 lots	12 lots	8 lots

Note: All totals and losses are cumulative along planning horizons. Note that model does not account for existing structures such as homes along Sandyland Road which may reduce erosion or affect severity of coastal flooding and tidal inundation at road end parking areas.

- **State Park Campground Parking Lots:** With approximately 1 foot of sea level rise, the majority of parking in the State Park becomes vulnerable to coastal flooding, with risk of impacts extending to the entire campground with approximately 5 feet of sea level rise. In addition, these parking lots become vulnerable to coastal erosion with approximately 2 feet of sea level rise. With approximately 5 feet of sea level rise, these lots could be completely eroded.
- **State Beach Parking Lot:** Currently, a small portion of this large parking lot in front of the State Beach east of Linden along Sandyland Road is vulnerable to coastal flooding if a large storm event were to occur. With approximately 2 feet of sea level rise, the entire lot would be subject to coastal flooding during the 1 percent change major coastal storm. With approximately 5 feet of sea level rise, the southern edge of this parking lot could become exposed to erosion. In addition, the entire lot could be regularly inundated during an extreme high tide when combined with approximately 5 feet of sea level rise.

Linden Avenue provides several public parking spaces for coastal access. With approximately 5 feet of sea level rise, parking along this road could be lost to erosion or damaged by both episodic and periodic flooding.

- **Road End Parking and Street Parking along Ash, Holly, Elm, and Linden Avenues:** Currently, these road end street parking areas and parking lot are vulnerable to coastal flooding during a large storm, with risk and extent of flooding increasing as sea levels rise. With approximately 1 foot of sea level rise, these parking areas become vulnerable to damage from dune erosion. With approximately 5 feet of sea level rise, these parking areas become vulnerable to tidal inundation in addition to erosion and coastal flooding hazards.
- **Carpinteria Train Station Parking Lot:** This lot would not be exposed to any coastal hazards with up to approximately 5 feet of sea level rise. However, it is possible that this lot could be subject to flooding from a coastal storm or tidal inundation under the H++ scenario with approximately 10 feet of sea level rise.
- **Aliso School:** The parking lot at Aliso School could be exposed to coastal flooding combined with approximately 2 feet or more of sea level rise. With approximately 5 feet of sea level rise, this lot could also be periodically inundated during EMHW tides.
- **Dump Road:** This privately-owned parking lot near Casitas Pier becomes at risk of damage from erosion when combined with approximately 1 foot or more of sea level rise.

Table 6-11. Potential Parking Facilities Affected by Coastal Hazards

Parking Facility	Existing				~1 foot by 2030				~2 feet by 2060				~5 feet by 2100			
	BDE	CE	CF	TI	BDE	CE	CF	TI	BDE	CE	CF	TI	BDE	CE	CF	TI
State Park Campground Lots	--	--	X	--	--	X	X	--	X	X	X	--	X	X	X	X
State Beach Lot	--	--	--	--	--	--	--	--	--	--	X	--	X	--	X	X
Linden Avenue Parking	--	--	X	--	--	--	X	--	X	--	X	--	X	--	X	X
Ash Avenue Parking	--	--	X	--	--	--	X	--	X	--	X	--	X	--	X	X
Holly Avenue Parking	--	--	X	--	--	--	X	--	X	--	X	--	X	--	X	X
Elm Avenue Parking	--	--	X	--	--	--	X	--	X	--	X	--	X	--	X	X
Aliso School	--	--	--	--	--	--	--	--	--	--	X	--	--	--	X	X
Dump Road	--	--	--	--	--	X	--	--	--	X	--	--	--	X	--	--
Bluff II	--	--	--	--	--	--	--	--	--	--	--	--	--	X	--	--
Carpinteria Avenue (north of Salt Marsh)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	X
Carpinteria Train Station	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Note: All totals and losses are cumulative across planning horizons. Coastal hazards (e.g., coastal flooding and tidal inundation) may account for losses in the same area. Note that model does not account for existing structures such as homes along Sandyland Road or limited areas of seawalls and rock revetments which may reduce erosion or affect severity of coastal flooding tidal inundation
DE =Beach & Dune Erosion
CE = Cliff Erosion
CF = Coastal Flooding
TI = Tidal Inundation

Bikeways

Currently, no bike routes are vulnerable to coastal hazards. Out of the existing and planned bicycle facilities within the City, only the Class II route along Linden Avenue south of the railroad would be affected by coastal hazards with approximately 1 foot of sea level rise. Impacts to the bicycle network become increasingly greater with approximately 5 feet of sea level rise, affecting a total of 1.2 miles of facilities, or 29.3 percent of the bicycle network within the City. No existing or planned Class I routes would be exposed to coastal hazards with up to approximately 5 feet of sea level rise.

Currently, existing bikeways are not at risk of coastal hazards. However, with approximately 5 feet of sea level rise, 1.2 miles of bikeways, or about 30 percent of the City's bikeway system, would be exposed to coastal flooding.

Table 6-12. Length of Bikeways Potentially Impacted due to Coastal Hazards

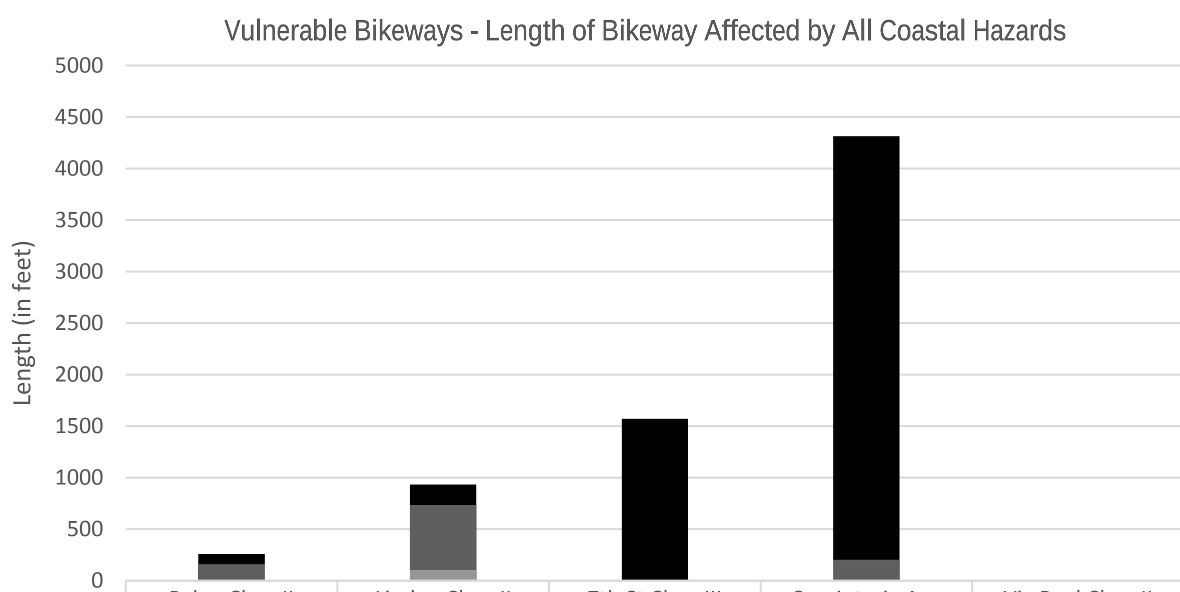
Planning Horizon		Coastal Erosion		Coastal Flooding		Tidal Inundation	
		Length	%	Length	%	Length	%
Existing		0 mile	0%	0	0%	0 mile	0%
~1 foot		0 mile	0%	<0.1 mile	<0.1%	0 mile	0%
~2 feet		< 0.1 mile	<0.1%	0.1 mile	2.4%	0 mile	0%
~5 feet		< 0.1 mile	<0.1%	1.2 mile	29.3%	0.7 mile	17.1%

Note: All linear totals and losses are cumulative along planning horizons. % indicates the percentage of the Carpinteria bikeway network affected out of 4.1 miles of dedicated Class I & II bikeway facilities within the City.

- **Carpinteria Avenue Class II Bike Lanes:** With approximately 2 feet of sea level rise, 204 linear feet of the Carpinteria Avenue Class II route may be subject to storm-based flooding north of the Carpinteria Salt Marsh and west of Plum Street. With approximately 5 feet of sea level rise, large sections of the Carpinteria Avenue Class II route west of Holly Avenue and north of the Carpinteria Salt Marsh become vulnerable to both coastal flooding and regular tidal inundation (4,314 linear feet and 2,145 linear feet, respectively).
- **Via Real Class II Bike Lanes:** The Class II bike route along Via Real is not vulnerable to coastal hazards across all planning horizons, however it is currently vulnerable to fluvial flooding from rainfall runoff and would continue to be subject to this type of flooding.
- **Linden Avenue Class II Bike Lanes:** Linden Avenue Class II route becomes exposed to damage from coastal flooding with approximately 1 foot of sea level rise (105 linear feet). With approximately 2 feet of sea level rise, the segment south of the railroad also

becomes vulnerable to dune erosion (76 linear feet), coastal flooding (735 linear feet), and tidal inundation (173 linear feet). With approximately 5 feet of sea level rise, the entire segment of Linden Avenue south of the railroad becomes exposed to coastal flooding and tidal inundation.

- **Palm Avenue Class II Bike Lanes:** A small section of the Class II bike route along Palm Avenue becomes vulnerable to coastal flooding when combined with approximately 2 feet of sea level rise (160 linear feet) or more. With approximately 5 feet of sea level rise, this route may also be subject to periodic tidal inundation.
- **7th Street Class III Onstreet Bike Route:** 7th Street Class III route is a shared roadway and would not be affected by coastal hazards until approximately 5 feet of sea level rise. In this scenario the entire road segment between Santa Ynez Avenue and Holly Avenue could be vulnerable to coastal flooding (1,572 linear feet) and tidal inundation (920 linear feet). However, as there are no bike facilities on this roadway, bicycles could be rerouted to other roadways if 7th Street is flooded.



	Palm Class II Lanes	Linden Class II Lanes	7th St Class III Onstreet Route	Carpinteria Ave Class II Lanes	Via Real Class II Lanes
~5 feet	260	934	1,572	4,314	0
~2 feet	160	735	0	204	0
~1 foot	0	105	0	0	0
Existing	0	0	0	0	0

Table 6-13. Length and Location of Potential Bike Route Loss due to Coastal Hazards

Bike Facility	Existing				~1 foot by 2030				~2 feet by 2060				~5 feet by 2100			
	BDE	CE	CF	TI	BDE	CE	CF	TI	BDE	CE	CF	TI	BDE	CE	CF	TI
Carpinteria Avenue Class II Bike Lanes	--	--	--	--	--	--	--	--	--	--	204 ft	--	--	--	4,314 ft	2,145 ft
Via Real Class II Bike Lanes	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Linden Avenue Class II Bike Lanes	--	--	--	--	--	--	105 ft	--	76 ft	--	735 ft	173 ft	206 ft	--	934 ft	778 ft
Palm Avenue Class II Bike Lanes	--	--	--	--	--	--	--	--	--	--	160 ft	--	--	--	260 ft	95 ft
7th Street Class III Onstreet Bike Route	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,572 ft	920 ft

Note: All linear totals and losses are cumulative across planning horizons. Coastal hazards (e.g., coastal flooding and tidal inundation) may account for losses in the same area. Note that model does not account for existing structures such as homes along Sandyland Road or limited areas of seawalls and rock revetments which may reduce erosion or affect severity of coastal flooding and tidal inundation.

BDE = Beach & Dune Erosion

CE = Cliff Erosion

CF = Coastal Flooding

TI = Tidal Inundation

Bus Routes & Facilities

Currently, coastal hazards do not pose any risks to existing bus routes or facilities. With approximately 1 and approximately 2 feet of sea level rise, Metropolitan Transit District (MTD) Bus Route 36 – Seaside Shuttle becomes at rise of coastal flooding and tidal inundation. With approximately 5 feet of sea level rise, MTD Bus Routes 20 and 21x become at risk. No transit facilities (i.e., bus stops) would be subject to damage from erosion under any sea level rise scenario, and a very small portion of the Seaside Shuttle route could be affected by erosion of the roadway. In any scenario, bus routes could be rerouted to avoid eroded or flooded roadways, though significant flooding associated with a coastal storm or an EMHW tide combined with approximately 5 feet of sea level rise would inhibit transit services within the Downtown.

Table 6-14. Length of Bus Routes/Number of Bus Stops Potentially Impacted due to Coastal Hazards

Planning Horizon	Coastal Erosion	Coastal Flooding	Tidal Inundation
Existing	0 miles / 0 stops	0 miles / 0 stops	0 miles / 0 stops
~1 foot	0 miles / 0 stops	0.3 mile / 0 stops	< 0.1 mile / 0 stops
~2 feet	0 miles / 0 stops	0.7 mile / 0 stops	0.2 mile / 0 stops
~5 feet	< 0.1 mile / 0 stops	1.8 mile / 2 stops	0.9 mile / 0 stops

Note: All linear totals and losses are cumulative across planning horizons.

- **MTD Bus Routes 20 and 21x:** Line 20 – Carpinteria, travels along Carpinteria Avenue and Via Real through Carpinteria, then travels along Via Real until Summerland, where it travels on U.S. Highway 101 until Montecito, and along local roads until the transit center in downtown Santa Barbara. Line 20 includes multiple local stops along the route. Line 21x – Carpinteria Express, travels along Carpinteria Avenue and Via Real through Carpinteria then travels west along Via Real until Padaro Lane with multiple stops; it then travels on U.S. Highway 101 with no stops until downtown Santa Barbara, where there are multiple stops, including the transit center. Within the City, Line 20 and Line 21x have the same routes and stops. These bus routes are not considerably vulnerable to coastal hazards until approximately 5 feet of

Portions of the electric Seaside Shuttle bus route within the Downtown could be affected by coastal flooding and periodic inundation along Carpinteria Avenue with approximately 5 feet of sea level rise. However, bus routes are adaptable and can be rerouted to avoid coastal hazards.

sea level rise, when the route along Carpinteria Avenue between Santa Ynez Avenue and Franklin Creek, including two bus stops become at risk of coastal flooding.

- **MTD Bus Route 36:** Line 36 – Seaside Shuttle, travels in a loop within the City, with stops at the train station and along Linden Avenue, Carpinteria Avenue, Casitas Pass Road, El Carro Lane, and Santa Ynez Road. Connections are available to MTD Line 20 or 21x. The portion of the shuttle route along Carpinteria Avenue between Santa Ynez Avenue and Franklin Creek as well as one shuttle stop become vulnerable to coastal flooding with approximately 5 feet of sea level rise.

Rail

The City contains 3.6 miles of railroad that runs through the City. Currently, approximately 0.1 mile of railroad line along the Carpinteria Bluffs is vulnerable to cliff erosion if a 1 percent annual chance storm were to occur. In addition, the segment over the Carpinteria Creek crossing is currently subject to coastal flooding and tidal inundation; although, this section appears to be co-located with bridges, thus damages may not be as severe. With approximately 1 foot of sea level rise, 0.4 mile of railroad line along the bluffs could be vulnerable to cliff erosion. With approximately 2 feet, a cumulative total of 0.8 mile of railroad line could be vulnerable to cliff erosion. With approximately 5 feet of sea level rise, 1.4 miles of railroad line, or most of its alignment along the Carpinteria Bluffs, could be exposed to coastal erosion, and 1.5 miles of railroad could be vulnerable to coastal flooding along the Carpinteria Bluffs and where the railroad runs adjacent to the Carpinteria Salt Marsh. Over 80 percent of the railroad within the city could be vulnerable to coastal hazards with approximately 5 feet of sea level rise; however, the model does not account for existing rock revetments or seawalls, which may reduce erosion or affect severity of coastal erosion of the railroad.

While the parking lot adjacent to the train station becomes vulnerable to coastal flooding with approximately 5 feet of sea level rise, the train station remains outside of any coastal hazard zone.

Table 6-15. Length of Potential Railroad Line Loss due to Coastal Hazards

Planning Horizon	Coastal Erosion		Coastal Flooding		Tidal Inundation	
Existing	0.1 mile	2.8%	0.1 mile	2.8%	< 0.1 mile	<0.1%
~1 foot	0.4 mile	11.1%	0.4 mile	11.1%	< 0.1 mile	<0.1%
~2 feet	0.8 mile	22.2%	0.9 mile	25.0%	< 0.1 mile	<0.1%
~5 feet	1.4 miles	38.9%	1.5 miles	42.6%	< 0.1 mile	<0.1%

Note: All linear totals and losses are cumulative across planning horizons. % indicates the percentage of UPRR affected out of 3.6 miles of railroad track within the City. Note that model does not account for existing rock revetments or seawalls which may reduce erosion or affect severity of coastal erosion of the railroad.

With approximately 5 feet of sea level rise, over 80% of UPRR could be at risk of damage or loss from coastal hazards. A significant portion of the railroad north of Carpinteria Salt Marsh could be subject to coastal flooding during a large storm event, while nearly the entire segment along the Carpinteria Bluffs could be at risk of both long-term erosion and cliff failure during a storm.

Even closing a small portion of U.S. Highway 101 near and along exit 87B (southbound U.S. Highway 101 Carpinteria Avenue exit) would have serious consequences on commuters, business owners, and other travelers access to their respective destinations given the number of average daily trips (ADT) on this major interstate highway. Similarly, any disruption to the railroad services in the City would have economic losses far exceeding the costs of replacing UPRR.

Please refer to Chapter 1, *Sector Profiles*, for additional information related to road, parking, and public transportation systems vulnerable to coastal hazards including bikeways, bus routes, bus stops, and parking lots. In summary, with approximately 1 foot of sea level rise, parking in the Beach Neighborhood and Carpinteria State Beach becomes at risk from coastal flooding, which may include damage or loss of roadways. With approximately 2 feet of sea level rise coastal flooding impacts escalate and may impact 7 parking lots. With approximately 5 feet of sea level rise, impacts from all coastal hazards increase substantially. Coastal flooding could pose a risk to 11 parking lots in the Beach Neighborhood, Carpinteria State Beach and Downtown north (inland) of UPRR, including the train station parking lot (City Parking Lot #3). A total of 8 parking areas could become routinely inundated during monthly high tides, and 9 lots could be exposed to erosion in the Beach Neighborhood and Carpinteria State Beach.

6.3 Camping and Visitor Accommodations

The City is a small beach community with an annual population of 13,040. During the summer however, the population of the City can more than double with an influx of tourists and out of town visitors. Many of the local businesses and residents depend on this influx of tourism and the City benefits from the sales tax revenues. Parking and campgrounds are at risk to damages from coastal storms. As this vulnerability increases over time, damages to the Carpinteria State Park will affect attendance, and thus State and City revenues.

Short-term vacation rental units (less than 30 days) are a growing business for the City. There are an estimated 218 short-term vacation rental units located in the Beach Neighborhood (City 2018). Given that up to 170 units are located along Sandyland Road, with approximately 55 located along the seaward side of the road, a large majority of short-term vacation rentals would be vulnerable to loss as described in Section 6.1, *Residential Property Vulnerabilities*, of this Report. In addition, these units, as well as hotels and motels are required to pay TOT, currently estimated at $2.5 million per year for all visitor accommodations, which would result in significant loss of City revenues (City 2018).

Given that no impacts are expected to hotels or motels from coastal hazards and sea level rise, the following analysis focuses on beach recreation and camping. Both the City and State beaches, and the Carpinteria State Park campgrounds are vulnerable to existing and future coastal hazards. This Report examines campgrounds that are vulnerable to coastal erosion and coastal flooding and provides preliminary estimates of loss in campsites and campground activity. This beach-centered recreational value is important to consider when selecting and evaluating future adaptation options.

Beach Recreation

The City has two main beaches, Carpinteria City Beach and Carpinteria State Beach, which are adjacent to one another but administered separately. This Report employs data on beach visitation and spending from several sources. For Carpinteria State Beach, this Report uses recent State Parks data for camping and other attendance. The Report also uses data from the Coastal Regional Sediment Master Plan (CRSMP) prepared for Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) (2009), updated for the growth within the population of Santa Barbara County as well as the State of California (numerous visitors come from beyond Santa Barbara County).

Table 6-16 presents the data/estimates for beach attendance and recreational value. This Report assumes that a day beach visit results in $40 of recreation spending per adult visitor, based on studies of non-market value for beaches in California and California Coastal Commission (CCC) guidance (CCC 2015). This Report bases economic benefits on studies of how much individuals are willing to pay for a day at the beach, based on numerous travel cost studies of beach attendance in southern California. Carpinteria experiences approximately 1.5 million beach day visits per year (Table 6-17). The total economic value of this activity is estimated at $60.4 million per year.

Table 6-16. Annual Attendance and Recreational Value of Carpinteria's Beaches

Site	Total Yearly Attendance	Yearly Camping	Source	Total Recreational Value
Carpinteria City Beach	600,000	-	BEACON	$24,000,000
Carpinteria State Beach	910,428	420,828	State Parks	$36,417,120
Total	**1,510,428**	**420,828**	**-**	**$60,417,120**

The total estimated consumer spending associated with beach recreation is just below $48 million annually, generating $445,000 in sales tax revenues for the City[4] and just under $1.9 million in TOT (Table 6-17).

Table 6-17. Annual Spending and Tax Revenue Generated by Beach Recreation Visitors

Site	Total Yearly Attendance	Estimated Spending in Carpinteria	Estimated Sales Tax	Estimated Transient Occupancy Taxes
Carpinteria City Beach	600,000	$21,900,000	$144,000	$1,440,000
Carpinteria State Beach	910,428	$26,068,708	$301,051	$437,005
Total	**1,510,428**	**$47,968,708**	**$445,051**	**$1,877,005**

Camping

Carpinteria State Beach has four campgrounds (Anacapa, Santa Cruz, Santa Rosa, and San Miguel), named after the Channel Islands, with an estimated 213 campsites (Table 6-18). These campgrounds draw an estimated 420,828 overnight visitors per year (Table 6-19). These campgrounds are vulnerable to to dune erosion, cliff erosion, and coastal storms (Table 6-18). This Report assumes that the potential reduction in camping attendance will be proportional to the loss in campground area due to coastal erosion or coastal flooding (i.e., camping population density remains constant per square foot area). The Report also assumes that tidal inundation will disrupt camping at least six days a month (20 percent of the time) based on the full moon-new moon spring tide cycle; given that the campground may also need to be closed and opened following flooding, this estimate may be low. Ultimately, coastal erosion may lead to a permanent loss of camping area at Carpinteria State Beach in the absence of any adaptation measures.

[4] These estimates only include the City share (1%) of sales tax revenues, not the County share.

Table 6-18. Percentage of Carpinteria State Campground subject to Coastal Hazards and Estimated Loss in Camping Visits per Year

Campground Name	# of Sites	Type	% of Area Loss to Coastal Erosion (by Time Horizon)	% of Area Flooded by Coastal Storm (by Time Horizon)
			(Existing / 2030 / 2060 / 2100)	
Anacapa	30	Tent Camping & RVs	0 / 0 / 0 / 0	0 / 23 / 99 / 100
Santa Cruz	47	Tent Camping & RVs	1 / 3 / 6 / 28	45 / 77 / 95 / 100
Santa Rosa	80	Mostly RVs	32 / 45 / 65 / 92	32 / 45 / 65 / 100
San Miguel	56	RVs only	0 / 2 / 30 / 100	0 / 1 / 30 / 100

Note that these categories may overlap. All percentages listed above are cumulative across time horizons. Campground sites are defined as single and group locations for tents, motorhomes, and trailers (camp host not included).

This Report does not estimate reduction of overnight camping attendancefrom wave run-up during 1 percent annual chance storms.[5] As indicated in Table 6-19, under existing conditions, 9 percent of all campground areas are vulnerable to dune or cliff erosion from a 1 percent annual chance storm. This loss increases over time to 33 percent with 5 feet of sea level rise, with those lost campground areas primarily reducing camping opportunities in the more southerly Santa Rosa and San Miguel campgrounds that have less dune protection. With 5 feet of sea level rise, nearly half (46 percent) of the entire campground areas may be subject to tidal inundation, and all campground areas (100 percent) could be subject to coastal flooding during a 1 percent annual chance storm.

Table 6-19. Projected Losses in Camping Days per Year

Timeline	% Loss of Campground Area (Dune Erosion)	# of Camp Visits Lost per Year	% Loss of Campground Area (Cliff Erosion)	# of Camp Visits Lost per Year	% Inundated Campground Area (Tidal Inundation)	# of Camp Visits Lost per Year
Existing	9	36,954	0	-	0	-
~1 ft	13	53,206	0	393	0	-
~2 ft	19	78,598	5	20,167	2	1,768
~5 ft	33	139,387	18	75,906	46	39,131

Note: Totals and losses are cumulative across horizon years.

5 The analysis assumes that camping attendance will remain the same. However, while camping is generally at or close to capacity (approximately 40,000 campers per month) during the summer months, visitation is below capacity most other months. Storm waves usually arrive in winter and seasonal closures of some of the sites may avoid these impacts.

Hotels, Motels and Short-term Vacation Rentals

Beach tourism generates a significant portion of the City's revenue. As indicated in Table 6-17, beach tourism generates $1.9 million in TOT and $445,000 in sales tax revenues annually, partially from camping visitors in the Carpinteria State Beach campgrounds. A significant portion of visitors to the City Beach stay overnight, and a reduction in the number short-term vacation rentals could impact beach tourism and associated spending and tax revenues (BEACON 2009).

Presently, many of the oceanfront properties in the Beach Neighborhood are short-term vacation rentals and contribute a substantial amount to the City tax base from TOT. City records show that 75 short-term (less than 30 days) vacation rental operators were registered to collect TOT on 104 units in the City in 2015. However, the actual number of short-term vacation rentals was likely much higher.

In November 2016, the City Short-Term Vacation Rental program was approved by the CCC (Local Coastal Plan [LCP] Amendment No. LCP-4-CPN-16-0024-1). This program approved the licensing of 218 short-term vacation rentals in four (4) areas in the City primarily in the Beach Neighborhood (Figure 6-12). In fiscal years 2016-2017 and 2017-2018, 189 short-term vacation rentals were licensed, generating about $400,000 annually in TOT revenues.

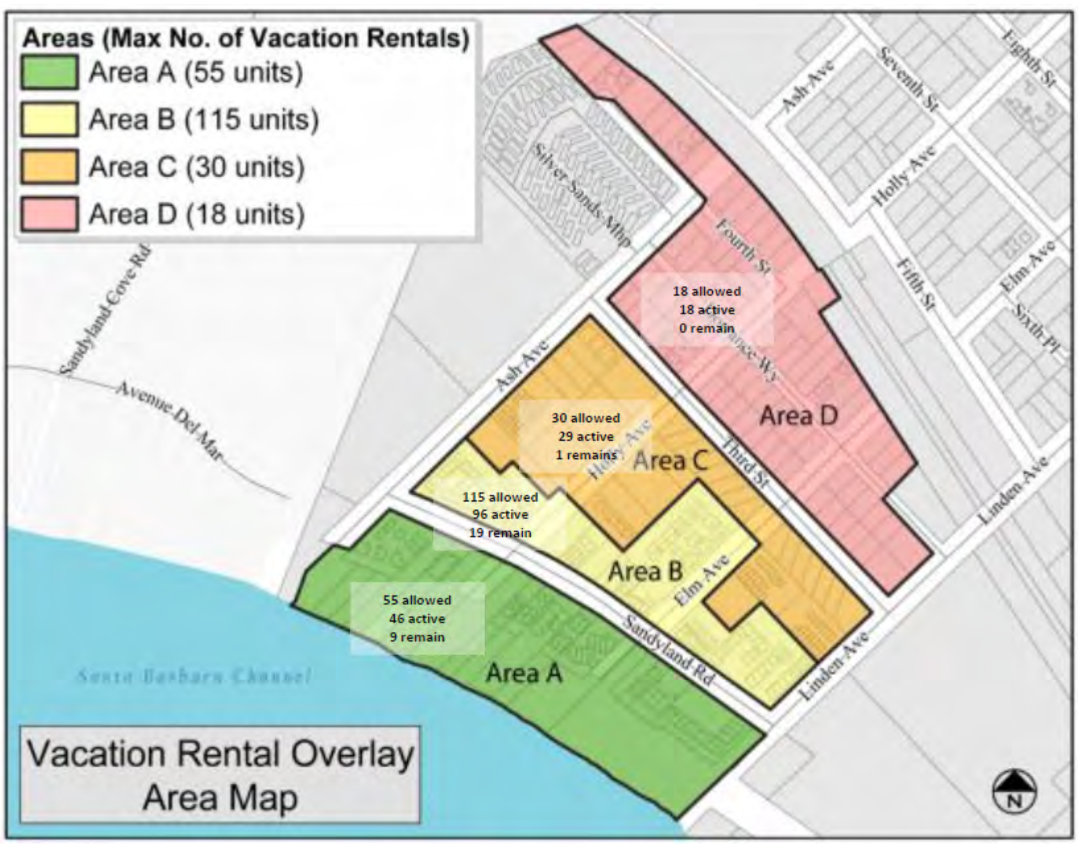


Figure 6-12. *Short Term Rental Overlay Map with Units permitted in 2017*

Analysis of vulnerable land uses in Section 6.1, indicate that many short-term vacation rental properties in the City are currently vulnerable to coastal hazards, particularly in Area A (Figure 6-12). With approximately 5 feet of sea level rise, nearly the entire short-term vacation rental overlay could be subject to episodic coastal flooding and periodic tidal inundation. However, coastal flooding, which typically occurs in the winter, may not significantly disrupt the short-term vacation rental market which peaks in the summer. Tidal inundation and coastal erosion are likely to have a larger impact on short-term vacation rentals and TOT revenues.

6.4 Coastal Access and Trails

Overall, in the City, there are an estimated 13 vertical beach access points, lateral beach access along the entire 2.5 miles of shoreline under most conditions, an additional estimated 0.4-mile of hiking trails within the Carpinteria Salt Marsh, and an additional estimated 6.7 miles of trails throughout the Carpinteria State Park and Carpinteria Bluffs. Each coastal access and trail has its own set of amenities (Table 6-20). The California Coastal Trail (CCT) also traverses the City but no designated alignment was available for analysis.

Under existing conditions, all of the vertical coastal access points and all lateral coastal trails are vulnerable to coastal erosion and coastal flooding, and more than half of the vertical coastal access points are potentially impacted by tidal inundation during monthly extreme tides or large coastal storm driven waves. By 2100 with 5 feet of sea level rise, all vertical coastal access points and all lateral coastal trails are vulnerable to coastal erosion, coastal flooding, and/or tidal inundation.

Table 6-20. Coastal Access Amenities and Coastal Trails

Park Name	Trail Name	Total Miles of Coastal Trail	Coastal Access Points	Facilities and Amenities
Salt Marsh Nature Park	Carpinteria Salt Marsh Trail	0.4	Access at terminus of Ash Ave	Parking, Restroom, Junior Guard Shed
Carpinteria City Beach	City Beach	0.3	Access throughout Downtown Beach Neighborhood from Ash Ave to Linden Ave	Parking, Lifeguard towers (3), Restroom
Linden Field	Beach boardwalk traversing sand dunes	<0.1	Access at Linden Ave, Palm Ave terminus and sand dunes	Parking
	Trail adjacent to Tomol Interpretive Play Area in State Park	<0.1	-	Playground and Street Parking

Table 6-20. Coastal Access Amenities and Coastal Trails (Continued)

Park Name	Trail Name	Total Miles of Coastal Trail	Coastal Access Points	Facilities and Amenities
Carpinteria State Beach	State Beach	0.6	Access throughout State Park from Linden Ave to San Miguel Campground	Day Use area, Parking, Camping
	Trail from Tomol Interpretive Play Area to 4th St	0.2	-	Parking, Playground, Restrooms
	Campground Trails	0.6	Access at Santa Cruz and Santa Rosa Campgrounds	Parking, Camping, Restroom, Lifeguard Tower
	Carpinteria Bluffs Trail	0.1	Access at stairs traversing the bluffs south of Calle Ocho	-
Tar Pits Park	Carpinteria Bluffs Trail	0.9	Access at western terminus of the park	Tar Pits
Carpinteria Bluffs Nature Preserve (Carpinteria Bluffs Area 1)	Carpinteria Bluffs Trail	2.2	Access from trail descending from Carpinteria Bluffs Trail to Seal Sanctuary	Seal Sanctuary, Parking, Restroom
Property between Carpinteria Bluffs Nature Preserve and Rincon Bluffs (Carpinteria Bluffs Area 2)	Carpinteria Bluffs Trail	0.7	-	-
Rincon Bluffs (Carpinteria Bluffs Area 3)	Carpinteria Bluffs Trail	0.9	-	-
Rincon Beach Park (Unincorporated County Adjacent to City)	-	-	Access at trail descending from Rincon Parking Lot to the beach at the eastern edge of the City	-

Table 6-21. Estimated Length of Public Trails Vulnerable to Storm Erosion, Storm Flooding and Chronic, Tidal Inundation

Trail Vulnerability	Coastal Erosion	Coastal Flooding	Tidal Inundation
	Miles		
Existing	1.2	1.3	<0 1
2030	1.9	2.2	<0.1
2060	2.7	3.4	0.1
2100	4.6	5.4	1.4

Note: All linear totals are cumulative miles across horizon years.

Trails

Currently, trails and UPRR tracks along the Carpinteria Bluffs are vulnerable to damage if a large coastal storm event (i.e., 1% annual chance storm) were to result in cliff failure.

To identify coastal access ways and trails potentially vulnerable to climate change and sea level rise hazards, this study evaluated 5.6 miles of trails, primarily within the Carpinteria Salt Marsh, Tar Pits Park, and Carpinteria Bluffs, as well as lateral coastal access that is proposed as the CCT alignment through the City. Table 6-22 presents projected public trail losses due to coastal erosion, coastal flooding, and tidal inundation. Under existing conditions, all coastal trails are vulnerable to coastal erosion and cliff failure during a 1 percent annual chance storm, and lateral beach access, the area seaward of the mean tide line, a dynamic boundary under sea level rise, would be affected by tidal inundation during high tides or large coastal storm driven waves. The portion of the Carpinteria Bluffs Trail along the entire extent of the Carpinteria Bluffs is may be particularly vulnerable to erosion, with potentially 0.1 mile at risk from coastal hazards currently, 0.6 mile at risk with approximately 1 foot of sea level rise, and 1.0 mile at risk with approximately 2 feet of sea level rise – encompassing most of the length of the trail along the bluffs. 1.2 miles of trails are currently vulnerable to coastal erosion from a 1 percent annual chance storm, and 1.3 miles of trail within the Carpinteria Salt Marsh are vulnerable to coastal flooding.

With approximately 5 feet of sea level rise, many trails adjacent to the Carpinteria Bluffs Trail are also vulnerable, putting 2.3 miles at risk to cliff erosion. It is anticipated that with approximately 5 feet of sea level rise, approximately 5.4 miles of Carpinteria's coastal trails will be eroded, flooded, or periodically inundated by tides (see Figure 4-1). With approximately 5 feet of sea level rise, all coastal trails become vulnerable to cliff erosion, coastal flooding, and tidal inundation (Table 6-22).

Table 6-22. Length of Potential Public Trail Damage due to Coastal Hazards

Planning Horizon	Coastal Erosion	Coastal Flooding	Tidal Inundation
Existing	1.2 miles	1.3 miles	< 0.1 mile
~1 foot	1.9 miles	2.2 miles	< 0.1 mile
~2 feet	2.7 miles	3.4 miles	0.1 mile
~5 feet	4.6 miles	5.4 miles	1.4 miles

Note: All linear totals and losses are cumulative across planning horizons.

- **Carpinteria Bluffs Trail:** From the eastern border of the Carpinteria Bluffs Nature Preserve, the Carpinteria Bluffs Trail runs west along the inland side of the railroad, crossing the railroad tracks near the seal haul out to run along the bluff edge until it ends at Tar Pits Park. The trail is currently vulnerable to cliff erosion, with potential impacts increasing with rising seas. With approximately 5 feet of sea level rise, the majority of the trail is at risk, with about one mile of the trail adjacent to the bluffs lost to erosion. However, it should be noted that several hundred feet of trail in the Carpinteria Bluffs industrial area is protected by an existing 200-foot long rock revetment which would substantially slow cliff erosion and retreat in this area. Further, more than 4,000 feet of the existing Bluffs Trail across the Carpinteria Bluffs and the industrial area lies landward of the UPRR. The UPRR typically responds to erosion and track failure with emergency coastal armoring, which if continued over time, would protect the tracks and the landward sections of coastal trail, but could lead to armoring of much of the shoreline of eastern Carpinteria, with secondary impacts to sand supply, coastal access and habitats.
- **California Coastal Trail (CCT):** The proposed CCT route follows the Carpinteria Bluffs Trail alignment along the bluffs for approximately two miles. While the CCT is not yet complete, and the alignment within the City is not yet approved, a route has been planned. From where the eastern City boundary meets the coast, the CCT would run west along the coast through Carpinteria State Beach until Linden Avenue, where it would turn inland from the coast and follow north along Linden Avenue; it would then turn west onto 7th Street and connect with Carpinteria Avenue, where it would then run along the northern boundary of the Carpinteria Salt Marsh and exit the western City boundary (Coastwalk 2005). Coastal erosion currently threatens the CCT; portions along the beach are vulnerable to dune erosion, and sections along the Carpinteria Bluffs are vulnerable to cliff erosion; these risks increase. Sections of the CCT along the beach and Carpinteria Salt Marsh are currently vulnerable to dune erosion, with this length increasing with rising sea levels and including sections of Linden Avenue and Carpinteria Avenue. With approximately 5 feet of sea level rise, the majority of the CCT within the City becomes vulnerable to coastal flooding, and tidal inundation also could periodically flood sections of the CCT along the beach, part of Linden Avenue, and near the Carpinteria Salt Marsh. Given sea level rise, the dynamic mean tide line, the boundary for lateral public access seaward of the line, will move landward; however, access could nonetheless become impassible along the beach given landward private properties and related protection structures.

- **Carpinteria Salt Marsh Trail:** The Carpinteria Salt Marsh Trail is a one-mile out and back trail that begins west of the intersection of Ash Avenue and Sandyland Road and runs along the eastern and northern edge of Salt Marsh Park, ending at Franklin Creek. Sections of the trail become vulnerable to coastal flooding approximately 1 foot or more of sea level rise. The trailhead becomes vulnerable to dune erosion with approximately 2 feet of sea level rise and the section of the trail closest to Franklin Creek could be regularly inundated by EMHW tides with approximately 2 or more feet of sea level rise. With approximately 5 feet of sea level rise, the entire trail could be subject to episodic coastal flooding and regular tidal inundation.

With as little as approximately 1 foot of sea level rise, the Carpinteria Marsh Trail would become at risk to coastal hazards (left). The Carpinteria Bluffs Trail is currently at risk of cliff erosion hazards if a large coastal storm event were to occur, and with approximately 5 feet of sea level rise, the entire trail could be eroded. However, it is noted that the railroad is located seaward of the trail for much of this alignment and could serve as coastal armoring that would help slow the rate of erosion along the Bluffs.

Other Potential Impediments to Coastal Recreation

The coastal hazard maps prepared for this Report indicate that paid parking access to the State Beach, as well as City-owned free parking often used to access the City Beach, are subject to flooding, which may also impede beach access and other tourism. This Report did not attempt to estimate these losses in beach-related spending, though they could be significant.

6.5 Hazardous Materials Sites, and Oil and Gas Wells

The City has 62 sites, consisting of legacy inactive oil wells and hazardous materials, with the potential to spill/leak hazardous materials. The economic costs of these leaks are not evaluated in the analysis above due to the difficulty and uncertainties inherent in this type of analysis and the fact that the costs would likely be borne by private parties other than the City. Therefore, any such costs would be in addition to the costs/losses discussed earlier.

The Carpinteria area has a long history of oil and gas development. The City provides regulatory oversight and permit compliance for existing oil and gas facilities (Table 6-23). The City has 53 legacy inactive oil wells, with 16 nearshore (up to 600 feet from mean high tide), and 37 onshore. Of the onshore wells, 8 are located on the beach, 5 are vulnerable to coastal erosion across later time horizons (2 in 2060, 3 in 2100), and 32 are unaffected by coastal erosion.

Table 6-23. Oil Wells in Carpinteria by Horizon/Location

Year	Number of Wells
Existing Nearshore	16
Existing Onshore	37
2030	0
2060	2 Onshore
2100	3 Onshore
Unaffected Onshore	32

Note: All totals are non-cumulative across horizon years.

The City has 43 distinct sites categorized by the State and U.S. Environmental Protection Agency (EPA) (Table 6-24).

Table 6-24. Hazardous Materials by Program

Category	Program	Total in City	Total Affected
Hazardous Waste Storage	EPA Toxics Release Inventory (TRI)	6	0
	EPA Small Quantity Generators (SQG)	35	4
	EPA Large Quantity Generators (LQG)	7	0
	State Geotracker Electronic Submittal of Information (ESI) Sites	10	3
Cleanup Programs	Leaking Underground Storage Tanks (LUST) - Active Cleanup	0	0
	State Active Cleanup Program Sites	4	1

See definitions section for a detailed description of Hazardous Material Monitoring Programs. Data was accessed from the State of California and the EPA in fall 2017).

Only one (1) hazardous material reporting site is vulnerable to coastal sea level rise hazards under existing conditions, which is a location at the terminus of Dump Road near the former oil and gas processing site at Bluff 0.

The State Electronic Submittal of Information (ESI) list has this site categorized as a former "Underground Storage Tank - Oil and Gas Plant". By 2030, these vulnerabilities remain the same. By 2060, one active cleanup site (the Conoco Phillips Kittie Ballard Well Site) may become vulnerable to both coastal erosion and flooding on the Carpinteria Bluffs in the Carpinteria Bluffs Nature Preserve. This site, an area of special biological significance (a harbor seal haul out and breeding ground), is located less than 600 feet to the south of Dump Road/Bluff 0. In addition, by 2100, another two hazardous material reporting sites become vulnerable to coastal flooding. These are light industrial business on Carpinteria Avenue in the west side of the City.

This Report did not attempt to estimate the costs of remediation for these sites, though these costs could be large. For example, the costs of remediating the recent Refugio Oil Spill are estimated at $257 million. The costs of mitigating a leaking underground storage tank are estimated (by the EPA) at $125,000 before leakage and $1.5 million after leakage. The cost of capping and remediating leaky oil wells have been estimated by the nearby town of Summerland which is currently facing this problem. Recapping costs from this effort range from $100,000 for wells onshore to $800,000 for wells offshore. These estimates are intended to provide an idea of the magnitude of the costs, and therefore, risks involved. Therefore, the City could incur anywhere from hundreds of thousands of dollars, to millions of dollars in costs mitigating these issues if the responsible party is negligent or given protections under bankruptcy.

Even though the legal liability of many of these wells and hazardous materials sites does not formally lie with the City, it is possible that the liable parties may fail to mitigate, mitigate inadequately, or go bankrupt and default on their liability. Consequently, the City may be compelled to ask state or federal authorities to cleanup. Given that the costs of mitigation are likely to be much higher after the fact, this Report strongly recommends that further study of the potential for oil and hazardous materials leaking into the environment be evaluated more thoroughly.

The City also regulates the 55-acre former oil and gas processing facility situated on the Carpinteria Bluffs at Bluff 0. This site contains oil storage, processing and cleaning facilities used to process offshore oil. A private oil corporation has re-acquired this site and is currently in discussion with the City about decommissioning and remediation. However, remediation could take several years. No impacts to any structures on the property would occur aside from those associated with Casitas Pier and associated access routes. Some erosion to the Casitas pier parking lot could occur as early as 2060 or with approximately 2 feet of sea level rise.

6.6 Infrastructure

This section contains this Report's results from several sectors involving City infrastructure for stormwater (drains and pipes), wastewater (sewer pumps and pipes), and water supply (water pipes). These sectors have been combined as they are likely of most interest to the City's Public Works Department. The tables for these categories have been combined in order to simplify the discussion and minimize the number of graphs/tables. As in previous sections, vulnerabilities to coastal erosion, coastal flooding, and tidal inundation are presented below. It is important to note that private sector utility providers (i.e. natural gas, fiber optic, electrical) data was not available for this analysis.

Stormwater Infrastructure

Carpinteria's stormwater system is managed by the City Public Works Department and Santa Barbara County Flood Control District These departments are responsible for stormwater management, flood control, and floodplain management. The stormwater system consists of a series of flood control channels along Franklin, Santa Monica, and Carpinteria Creeks, and 316 storm drain inlets and outfalls that discharge to the nearest body of water using gravity flow. A large portion of the City's storm drain system is near current sea level in the Beach Neighborhood and inland of the Carpinteria Salt Marsh. Storm drains have occasionally backed up at several locations in these neighborhoods during high tides or large storm events. Presently, none of the stormwater is diverted to the Wastewater Treatment Plant (WWTP) for treatment and there are no pumps to convey stormwater. As sea level rises, portions of the system may not drain during high tides and more of the tide cycle, which in turn may increase stormwater flood depths and frequency. Culverts and pipes may also create flows of ocean water into the neighborhoods.

Wastewater Infrastructure

The wastewater system in Carpinteria is managed by Carpinteria Sanitary District (CSD). CSD owns and operates 43 miles of pipeline, 8 lift stations and the 2.5 million gallons per day WWTP. Maintenance to the system is accessed through 960 manholes. CSD provides service to a 3.1-square mile service area within the City and portions of unincorporated County within the Carpinteria Valley. This includes service to about 4,423 residential parcels and 500 non-residential parcels. Most of the system is gravity fed to the WWTP located just inland of UPRR on Carpinteria Creek. The WWTP provides secondary treatment and chemical disinfection before discharging to the Pacific Ocean through an ocean outfall. The 2005 Master Plan identifies that flows are higher during rain events, indicating significant inflow and infiltration. Coastal hazards could further increase the volume of flows to the WWTP through manholes and add additional complications from increased salinity, when combined with fluvial flooding from Carpinteria Creek.

Water Supply Infrastructure

The City's water supply system is managed by the Carpinteria Valley Water District (CVWD). CVWD's service area is approximately 17.6 square miles, including areas outside of the City. Domestic water service is provided to about 15,619 people and approximately 3,253 acres of irrigated crops. Water is distributed through 46 miles of pipelines, and maintained by 4 pressure regulators, 290 hydrants, and 1,550 valves, to connect to 3,516 customer water meters within the City.

Currently the District relies on three sources of supply to meet water demand in its service area. These are the Cachuma Project, the State Water Project, and 4 local groundwater wells within the Carpinteria Valley. The CVWD, CSD, and the City have partnered to investigate development of a recycled water project to offset imported water and declines in Lake Cachuma supply. The recycled water project would likely be collocated at the WWTP. CVWD is attempting to install a sentinel well to monitor saltwater intrusion into the groundwater basin but is presently stalled in regulatory processes.

Combined Results

The City has several types of infrastructure close to the coast that are vulnerable to coastal erosion and tidal inundation, including of roads, railroads, pipelines, and infrastructure components that are vulnerable to coastal hazards (Table 6-25). Analysis below estimates replacement costs of such infrastructure to extent data is available. In some cases, there is insufficient data to estimate the replacement cost. In other cases (e.g., roads), the analysis considered replacement costs, but not the cost of additional land acquisition or right-of-way access, or potential costs of elevating roads to avoid flooding. Consequently, the estimates below may be too low in some cases. Further analysis of costs of acquiring the new land and right-of-way necessary for adaptation or the costs of elevating roads, railroad lines, and other infrastructure vulnerable to coastal hazards in the future is recommended.

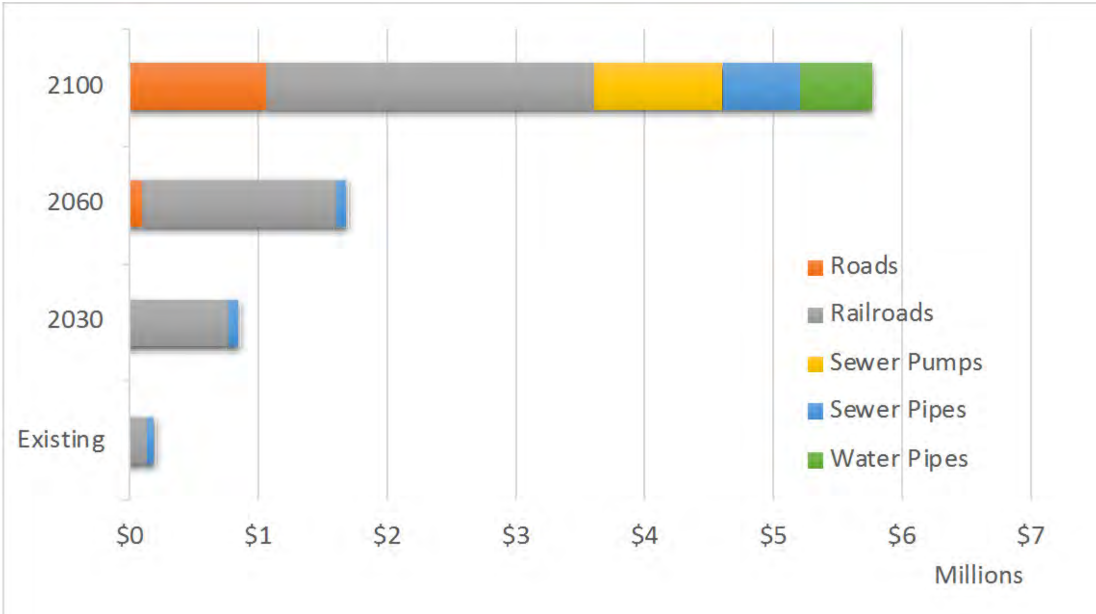
Table 6-25 presents estimates of the value of infrastructure vulnerable to coastal erosion, coastal flooding, and tidal inundation according to time horizon. While they also include the vulnerability to roads and railroads, the results for transportation-related infrastructure can be found above in Section 6.2, *Roads, Parking, and Public Transportation*, while impacts to recreational trails are described in Section 6.4, *Coastal Access and Trails.*

Table 6-25. Major Infrastructure in the City of Carpinteria

Category	# or Length in City	# or Length Affected by Coastal Flooding with ~5 ft of SLR
Roads	50.3 miles	4.8 miles
Railroad[1]	2.5 miles	1.5 miles
Hiking Trail	*Unknown*	5.4 miles
Sewer Pipe	36.5 miles	4.7 miles
Sewer Pump Stations	8 in District / 5 in City	3 in District / 2 in City
Water Pipe	45.6 miles	4.5 miles
Water Supply Pressure Regulators	4	1
Stormwater Drain	24.5 miles	4.2 miles
Stormwater Drain Inlets	342	95
Stormwater Drain Outlets	316	116

1. Railroad does not include the section from San Point Road to Franklin Creek adjacent to Carpinteria Salt Marsh, as it is outside of the City limits.

Water supply and wastewater pipelines and sewer pumps are not significantly exposed to coastal erosion with less than 5 feet of sea level rise.However, 0.5-mile of water pipelines ($560,000) and 0.5-mile of sewer pipelines ($610,000) primarily located under Sandyland Road and near the WWTP, and one sewer pump/lift station ($1 million) on Sand Point Road (inside the CVWD boundary, but outside of the City boundary), become vulnerable to coastal erosion. Altogether and including roads and railroads, a total of nearly $5.8 million in City infrastructure may be vulnerable with 5 or more feet of sea level rise. Similarly, stormwater infrastructure would not become substantially vulnerable to coastal erosion until 5 feet of sea level rise, at which point a total of 6 outlets, 3 outfalls, and 1.0-mile of storm drains may become vulnerable.



Erosion	Roads	Railroads	Sewer Pumps	Sewer Pipes	Water Pipes	Total
Existing	$0	$130,000	$0	$60,000	$0	$190,000
~1 ft	$0	$760,000	$0	$70,000	$0	$830,000
~2 ft	$90,000	$1,510,000	$0	$80,000	$0	$1,680,000
~5 ft	$1,050,000	$2,550,000	$1,000,000	$610,000	$560,000	$5,770,000

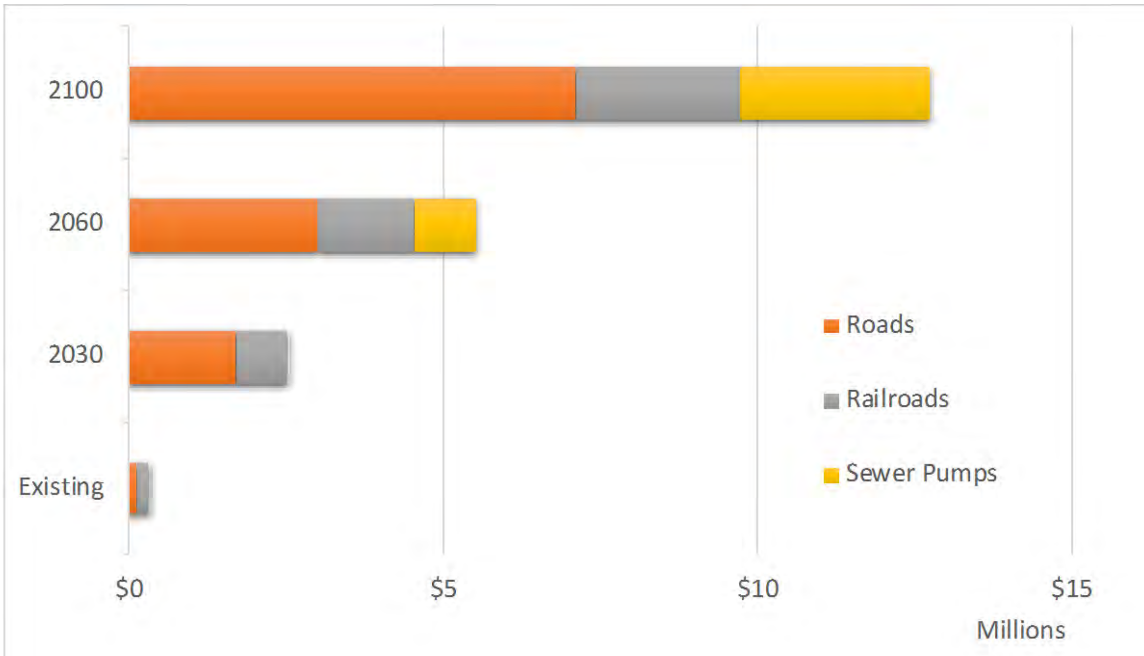
Erosion	Roads	Railroads	Sewer Pumps	Sewer Pipes	Water Pipes	Trails
Existing	< 0.1-mile	0.1-mile	0	< 0.1-mile	< 0.1-mile	1.2 miles
~1 ft	< 0.1-mile	0.4-mile	0	0.1-mile	< 0.1-mile	1.9 miles
~2 ft	0.1-mile	0.8-mile	0	0.1-mile	< 0.1-mile	2.7 miles
~5 ft	0.7-mile	1.4 miles	1	0.5-mile	0.5-mile	4.6 miles

Note: Totals are cumulative across horizon years.

Figure 6-13. *Estimated Value and Length (in miles) of Infrastructure Vulnerable to Coastal Erosion from a 1% Annual Chance Storm (2017 dollars)*

Figure 6-14 depicts the replacement costs of water and sewer pipelines and pumps due to coastal flooding. Cleanup estimates are unavailable for coastal flooding to underground pipelines and for this reason our estimation of replacement costs is limited to those of sewer pumps. Currently, the length of water and sewer pipelines vulnerable to coastal flooding is limited to 0.1-mile and 0.2-mile, respectively. These numbers gradually grow over time, peaking with 5 feet of sea level rise with 4.5 miles of water pipelines and 4.7 miles of sewer pipelines becoming vulnerable. More significantly, with 5 feet of sea level rise, 3 sewer pumps also become vulnerable to coastal flooding with a combined replacement cost of $3 million. Adding in the exposure of roads and railroad lines to coastal flooding, $12.7 million in City infrastructure may be vulnerable to coastal flooding with 5 feet of sea level rise. As previously mentioned above, drainage and stormwater conveyance is currently inhibited and impacted in large areas of the City, throughout the Beach Neighborhood, in portions of Downtown and in areas along the western end of Carpinteria Avenue north of the Marsh. However, coastal flooding would substantially increase impacts to stormwater infrastructure under even 1 foot of sea level rise. Under this condition, a total of 43 inlets, 69 outlets, and 1.4 miles of storm drains may be vulnerable. With further increases in sea level rise, impacts to stormwater infrastructure would similarly increase at a linear rate. For instance, with 5 feet of sea level rise, an additional 52 storm drain inlets (95 total), 47 outfalls (116 total), and 3.5 miles (4.2 miles total) of pipes across the City would be vulnerable to coastal flooding.

As in the case of coastal flooding of infrastructure, Figure 6-14 represents the replacement costs to infrastructure due to chronic tidal inundation according to time horizon. City pipelines and pumps are relatively safe from chronic tidal inundation with 2 feet of sea level rise. With 5 feet of sea level rise, approximately 2.9 miles of water pipelines, 3.1 miles of sewer pipelines, 128 hydrants and/or valves, and 2 sewer pumps ($2 million) become vulnerable to tidal inundation. Combined with the exposure to road and railroads, a total of $6.5 million in City infrastructure may be exposed to tidal inundation with 5 feet of sea level rise. City storm drains would be vulnerable to tidal inundation under existing conditions, with impacts being further exacerbated by sea level rise. With of 5 feet of sea level rise, approximately 82 inlets, 99 outlets, and 2.5 miles of storm drains become vulnerable to tidal inundation.

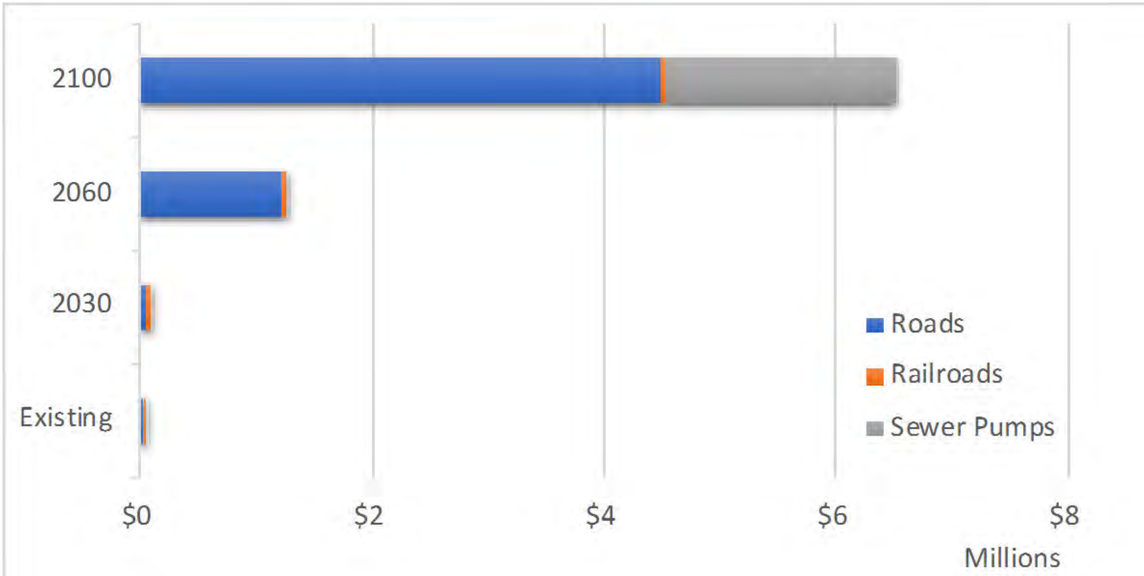


Coastal	Roads	Railroads	Sewer Pumps	Total
Existing	$120,000	$180,000	$0	$300,000
~1 ft	$1,690,000	$810,000	$0	$2,500,000
~2 ft	$2,970,000	$1,560,000	$1,000,000	$5,530,000
~5 ft	$7,090,000	$2,630,000	$3,000,000	$12,720,000

Coastal	Roads	Railroads	Sewer Pumps	Sewer Pipes	Water Pipes	Trails
Existing	0.1-mile	0.1-mile	0	0.2-mile	< 0.1-mile	1.3 miles
~1 ft	1.1 miles	0.4-mile	0	0.9-mile	1.0-mile	2.2 miles
~2 ft	2.0 miles	0.9-mile	1	2.0 miles	1.8 miles	3.4 miles
~5 ft	4.8 miles	1.5 miles	3	4.7 miles	4.5 miles	5.4 miles

Note: Totals are cumulative across horizon years.

Figure 6-14. *Estimated Value and Length (in miles) of Infrastructure Vulnerable to Coastal Flooding from a 1% Annual Chance Storm (2017 dollars)*



Tidal	Roads	Railroads	Sewer Pumps	Total
Existing	$20,000	$30,000	$0	$50,000
~1 ft	$50,000	$30,000	$0	$80,000
~2 ft	$1,220,000	$30,000	$0	$1,250,000
~5 ft	$4,480,000	$40,000	$2,000,000	$6,520,000

Tidal	Roads	Railroads	Sewer Pumps	Sewer Pipes	Water Pipes	Trails
Existing	< 0.1-mile	< 0.1-mile	0	< 0.1-mile	< 0.1-mile	< 0.1-mile
~1 ft	< 0.1-mile	< 0.1-mile	0	< 0.1-mile	0.1-mile	< 0.1-mile
~2 ft	0.8-mile	< 0.1-mile	0	0.6-mile	0.8-mile	0.1-mile
~5 ft	3.0 miles	< 0.1-mile	2	3.1 miles	2.9 miles	1.4 miles

Note: Totals are cumulative across horizon years.

Figure 6-15. *Estimated Value of Infrastructure Vulnerable to Tidal Inundation from a 1% Annual Chance Storm (2017 dollars)*

6.7 Community Facilities and Critical Services

With approximately 1 foot of sea level rise, coastal hazards are not anticipated to threaten any community facilities or critical services. With approximately 2 feet of sea level rise, one school building at Aliso Elementary School is potentially affected from flood damages due to coastal flooding. This Report found no emergency response facilities exposed to coastal hazards with up to approximately 5 feet of sea level rise. Up to eight buildings at Aliso Elementary School are vulnerable to tidal inundation hazards with approximately 5 feet of sea level rise and up to nine buildings at the school with a 1 percent annual chance storm and associated coastal flooding. At approximately 5 feet of sea level rise, one church (St. Joseph's Chapel), the WWTP, and the properties of the State Beach Service Yard and the

Sanitary District offices could also be impacted by a 1 percent annual chance storm. Finally, seawater infiltration into sewer lines throughout the years (from approximately 1 foot to approximately 5 feet of sea level rise) has an unknown increase in potential for additional complications and damage to the WWTP facility, due to the increase in salinity that may occur from seawater infiltration into inundated manholes.

6.8 Environmentally Sensitive Habitat Area

Climate change could affect all sensitive biological resources and Environmentally Sensitive Habitat Areas (ESHA) (see Figure 3-3). As with all habitats, there is a broad suite of physical and ecological processes responsible for creating and maintaining the habitats in their present location. Many of the impacts of climate change extend beyond sea level rise and will affect temperature, precipitation, drought, and wildfire risk (see Table 4-1). These climate effects, combined with the rising sea levels, will drive habitat changes. It is impossible to predict what will happen in the future with habitats as there is a complex interplay of variables for which future predictions remain uncertain (i.e. fog). However, coastal hazards and sea level rise may directly influence a substantial amount of acreage of existing designated ESHA within the City (Table 6-26). According to mapping acreages that consider the anticipated extent of coastal hazards, coastal flooding and cliff erosion affect the most amount of ESHA.

Table 6-26. ESHA Directly Influenced by Coastal Hazards and Sea Level Rise

Hazard	Dune Erosion	Cliff Erosion	Tidal Inundation	Coastal Flooding
	Acres			
Existing Onshore	19.3	15.6	10.1	46.5
~1 ft	1.9	3.8	1.6	7.3
~2 ft	2.3	9.1	3.1	12.9
~5 ft	3.0	27.1	14.6	30.2
Total	**26.5**	**55.6**	**29.4**	**96.9**

Note: The variability in the onshore acreages relates to where the different coastal hazard zones (arbitrarily drawn offshore) and the ESHA overlap. All totals are non-cumulative across horizon years.

Simply reporting acreages of ESHA severely misrepresents the vulnerability of sensitive habitat. If a wave overtops the Carpinteria Creek berm for example, that salt water volume is distributed across the entire estuary, not stopped by a line on the map. If the dunes at the State Park erode, then the sand is redistributed and the dune may migrate inland. If the wetland is inundated further, then it remains a wetland. If a freshwater wetland gets exposed to tides, then an estuarine wetland should gain area. Estuarine habitat by definition is habitat that is entirely exposed to coastal flooding and mostly exposed to existing tidal inundations, as is the case with the Carpinteria Salt Marsh which lies largely outside the City limits. In addition, changes in climate may support existing or new pest/exotic species, including potential shifts in the range of diseases, which may have ecological impacts beyond the physical changes projected into the future.

Carpinteria has identified seven types of ESHA in the CLUP/General Plan. These habitats are summarized in Table 3-1. Brief descriptions and likely impacts from a suite of climate change variables and a host of ecological interactions are described below. The ESHA habitats are as follows:

- Carpinteria Bluffs
- Wetlands
- Beaches, Tidelands, and Subtidal Reefs
- Carpinteria Harbor Seal Rookery and Haul outs
- Creekways and Riparian Habitats
- Native Plant Communities
- Butterfly Habitat

Conceptually, the combined influence of sea level rise and climate changes may result in three different species response patterns. First, species may shift inland and to higher elevations to stay away from coastal hazards and sea level rise. With this consideration, there may be development or other impediments to inland migration, which may result in the net loss of species, as discussed further in the below discussion of beach habitat. Second, temperature changes may shift species toward the coast resulting in more interaction with coastal processes for some species. Third, species may shift along the coast, to find temperature and precipitation thresholds more conducive to their individual species life history (Loarie et al 2008). The faster the climate changes, the more difficult it is for species to migrate, particularly for non-mobile plants and vegetation. Nevertheless, some of the more resilient species may adapt in place to climate change or be outcompeted by invasive species.

Carpinteria Bluffs

The shoreline along the Carpinteria Bluffs consists of rocky intertidal pools interspersed with sandy beach areas. The Carpinteria Bluffs and adjacent shoreline hosts many sensitive animal species, including the white-tailed kite and the harbor seal. Nearshore habitats seaward/below the Carpinteria Bluffs may face increasing sea levels, causing additional erosion of material from the cliffs and increased depth and duration of flooding.

Sensitive plant habitats within the Carpinteria Bluffs include the Central Coast riparian scrub, coastal sage scrub, and coastal bluff scrub. Upland scrub habitats, which are relatively adapted to the Mediterranean climate, will face increasing temperatures and potentially longer periods of extreme heat and drought. The projections of mild increases in precipitation may create more fuel for wildfires to spread during periods of drought.

Wetlands

Within the City, the Carpinteria Salt Marsh is the most studied and well-defined wetland. The Carpinteria Salt Marsh is a tidal salt marsh which is subject to a range of tides and receives freshwater flows from Franklin and Santa Monica Creeks. Other wetlands that have been historically identified, but not defined, include lower Carpinteria Creek and Higgins Spring at Tar Pits Park.

As the Carpinteria Salt Marsh is largely dependent on daily tidal inundation, it is anticipated that the increase in tidal elevations will be the largest stressor to the system unless the system is allowed to vertically expand or migrate landward and upslope. Recent ecosystem vulnerability assessment results for the Carpinteria Salt Marsh show that high salt marsh and transitional habitats are most vulnerable to sea level rise with a threshold of impact occurring with approximately 12 inches of sea level rise (Myers et al 2017). As the Carpinteria Salt Marsh is largely surrounded by flood control levees and concrete lined channels, one of the few places that salt marsh habitat could potentially transgress would be into the City's Salt Marsh Park. A decline in these wetland habitats could affect 14 of the 16 plant species of special concern found in the salt marsh (Myers et al 2017).

Beaches, Dunes, Tidelands, and Subtidal Reefs

The Carpinteria City Beach extends approximately 0.3-mile, from Ash Avenue to Linden Avenue. Carpinteria State Beach Park is located to the east of the City Beach and includes approximately 0.8-mile of beach and dune habitat from Linden Avenue to just east of Calle Ocho in the State Park.

Ecosystem results for the Carpinteria beaches, which form a valuable habitat and recreational resource, project beaches to narrow even in places where sand dunes (like Carpinteria State Beach) back the beach. With approximately 2 feet of sea level rise, approximately 60 percent of the dry sand beaches may be gone (Myers et al 2017). Dune erosion is anticipated to continue and depending on the chosen adaptation strategy may be able to migrate inland if the backshore is allowed to transgress. Nevertheless, species that shift inland and to higher elevations to stay away from coastal hazards and sea level rise may be hindered by development or other impediments to inland migration. This would reduce the overall area of habitat available to these species and may ultimately result in the net loss of species.

Tidelands and submerged lands within State waters extend 2 miles seaward from the mean high tide line between the City's east and west boundaries. The Carpinteria tide pools located offshore of Carpinteria State Beach have the most diverse intertidal habitat south of Point

Arguello. The Carpinteria Reef, located off of Sand Point, is a rocky reef adjacent to the Carpinteria Salt Marsh Reserve, which supports nearshore kelp bed communities off the Carpinteria coast.

For rocky intertidal habitats, species will migrate vertically within the active tidal range. For subtidal reefs, it is unclear what the climate impacts of increasing ocean temperature and ocean acidification will do to the viability of the rocky intertidal and subtidal reef communities found in Carpinteria.

Carpinteria Harbor Seal Rookery and Haul Out

The Carpinteria Harbor Seal Rookery is located in a sandy pocket beach that is connected by a sandspit to a shelf-like intertidal outcrop east of the Casitas Pier, below a portion of the Carpinteria Bluffs. Harbor seals seasonally use this area as a rookery to raise their young.

The seal haul out area could be exposed to more frequent inundation and wave action. If coastal erosion is allowed to continue unabated, the seal haul out may migrate inland; however, if the rate of sea level rise exceeds the rate of bluff erosion, then the beach and the haul out may be inundated for more of the tide cycle. If shoreline protection is paced to slow erosion, then the harbor seal haul out may cease to be viable in the nearer term as the habitat itself becomes inundated for more of the tide cycle.

Creekways and Riparian Habitats

Creeks in the study area include Santa Monica Creek, Franklin Creek, Carpinteria Creek, and Lagunitas Creek. The City's system of creeks provides habitat for a variety of sensitive plant and animal species. Carpinteria Creek is the most significant creek in terms of ESHA as it is one of only a few perennially flowing streams in the area. Its lagoon, extending above 6th Street, is a sensitive wetland that harbors a federally endangered fish species, the tidewater goby. Carpinteria Creek is also a designated Critical Habitat for southern steelhead trout. The creek's forested banks provide three riparian habitats including tall canopy, midstory, and understory, which serve a wide variety of wildlife including birds.

Provided that adequate sediment supply from upcoast Santa Barbara Harbor continues and the beach in front remains, then the seasonal lagoon opening and closing should be maintained as the beach migrates inland. However, changes in streamflow and increases in temperature may also create less desirable habitat and water quality conditions. Maintaining hydraulic connectivity upstream and into the tree-shaded riparian area should continue to be a management priority for ESHA policy development.

Native Plant Communities

As designated by the California Native Plant Society, native plant communities include: coastal sage scrub, oaks, chaparral, native oak woodland, riparian vegetation, and rare plant species. Oak trees also require special management, as certain subspecies are more susceptible to heat stress. Projected temperature increases and changes in precipitation are likely to stress native plant communities. Any restoration or native planting initiatives should consider native species that are more heat tolerant. Coastal hazards and Sea Level Rise (SLR) would impact these communities in different ways, depending on their location. For example, plant communities such as coastal sage scrub and chaparral that exist on the Carpinteria Bluffs would be increasingly vulnerable to cliff erosion as SLR increases. The vulnerability of riparian vegetation would increase as coastal flooding and tidal inundation extends further into the reaches of creeks, altering suitability of riparian habitat as SLR increases, which could result in additional estuarine or marsh habitat in these areas.

Monarch Butterfly Habitat

Monarch butterfly habitat exists in Salzgeber Meadow and the former oil and gas processing facility's vegetated buffer zone. During the fall and winter months, the trees within these areas are used by large numbers of migratory Monarchs as communal roosts.

Temperature changes, extreme heat, and longer droughts are likely to substantially impact the eucalyptus trees upon which the Monarchs depend. For example, after the recent seven-year drought, a catastrophic die off of the eucalyptus trees occurred in a eucalyptus grove along the Ellwood Mesa in the nearby City of Goleta, resulting in vastly reduced numbers of the large Monarch butterfly population which had historically inhabited the grove. For public safety reasons, the City of Goleta closed the grove to visitors in the winter of 2017/2018 due to the large die off of trees. In Carpinteria, the butterfly roosts within the riparian corridor of Carpinteria Creek are the most susceptible to coastal and fluvial flooding hazards, and a large flood event could uproot trees and disturb habitat. Ultimately, the monarch roosts in the oil and gas processing facility buffer parcels along the Carpinteria Bluffs may eventually become vulnerable to coastal cliff erosion.

6.9 Social Vulnerabilities

Areas containing the highest number of minority households and households below the poverty level in the City are the most at risk of being impacted from sea level rise. Additionally, bicycle and bus/transit routes that are utilized by low-income populations in the City as the primary means of transportation would be impacted. For instance, the 2017 Thomas Fire and related winter 2018 debris flows closed U.S. 101 for approximately three weeks, severely impacted services and associated jobs, increased childcare expenses, and destroyed homes. Affected populations included lower income populations and those with lost wages, resulting in a disproportionate effect on these vulnerable populations (805Undocufund 2018; SAMHSA 2017).

Income and Poverty

Lower incomes often correlate with challenging access to necessary resources to prepare for or evacuate in the case of a disaster or to proactively adapt to climate change (e.g., moving out of a flood plain, elevating living space above a given flood elevation, purchasing sump pumps, or acquiring flood insurance). Such residents are also often more transit dependent, and disruption of transit service to this neighborhood, particularly by future regular monthly tidal inundation and coastal flooding could disrupt access to jobs and services. The lowest income areas of the City are in the downtown and low-lying inland portions of the Beach Neighborhood. Although a number of short-term rentals (up to 218) and expensive beach front homes are located in the Beach Neighborhood area, between 152 and 252 households in this neighborhood are below the poverty level (distributed between census tract 16.04, blocks 3 and 4). Because these areas would experience the greatest impacts from coastal hazards (coastal erosion, coastal flooding, and tidal inundation), those within the Beach Neighborhood and downtown that are unable to afford remodeling or relocating would be at a disadvantage. Because there is a higher number of below poverty level households in this area compared to the rest of the City, these populations may be disproportionately affected by coastal hazards.

Age and Populations with Reduced Mobility

Age can play a role in coping and adaptive capacity as well, as it affects mobility and dependence on others. Infants, for example, are less able to protect themselves from or escape extreme conditions (e.g., in extreme heat or during flood events) and depend on others for special assistance in times of emergency. Similarly, the elderly are often more vulnerable than younger adults in emergency situations because of possible mobility challenges or other pre-existing health impairments. Moreover, they may be less connected to email, social media, or other typical public outreach tools that inform residents about preparing for disasters and taking emergency actions. For instance, while approximately 88 percent of 18 to 29 year-olds use at least one social media site, only approximately 37 percent of those 65 and up are estimated to use at least one social media site (Pew Research Center 2018).

The general location of senior member households of the Carpinteria community could not be determined by this report. The one established senior living center, GranVida Senior Living and Memory Care Center, is not vulnerable to the identified coastal hazards under any of the studied scenarios. Special attention and services are needed to meet the communication and mobility needs of older vulnerable residents, as well as of those with pre-existing health conditions, to ensure proper evacuation responses during emergency events. While this study examines vulnerable populations, Carpinteria also has an elder population that is active, healthy and mobile, and often volunteer in community affairs and services, and could provide very effective participation in the City's adaptation process.

The Mentally and Physically Impaired

Populations with physical and mental disabilities are of special concern for disaster planning and emergency response. The Sansum Clinic Family Medicine health center provides health services, including those with a disability, however as a clinic the facility does not provide beds for overnight stays and is located outside the identified coastal hazards under any scenario. People with physical and mental illnesses can have a greater sensitivity to high levels of stress during disasters and will require personalized attention during the crisis (American Medical Association 2012). Importantly, it is not necessarily the most disabled that are of greatest concern for the purposes of emergency response, as they are most likely to already receive ongoing assistance. By contrast, those among the impaired who – under normal circumstances – can handle life quite independently or with only minimal help, may require the most additional assistance when distress is high. It is important for emergency responders to know where these people reside, whether they live on their own or rely on a group living facility. Impaired populations may be dependent on the City and/or organizations which represent the interests of these populations to ensure that they are aware of where the disabled live, the nature of their disability, and what special needs they may have in an emergency (e.g., wheelchair accessibility). For long-term adaptive planning, the City and these organizations would need to take special care in addressing the special needs of these populations.

Minority Populations

Studies of public health and vulnerability to disasters indicate that minority populations tend to have less effective emergency disaster and climate change adaptation responses to natural hazards (California Energy Commission [CEC] 2012). This was illustrated in the City of Los Angeles during a major flood event in 2010, in which emergency response systems broke down in San Pedro and Wilmington when the American Red Cross opened a shelter in a local center for the elderly. Unfortunately, the flood victims that were of Hispanic/Latino descent, particularly those who did not speak English, did not know about the shelter. Many members of this population sought assistance at a local non-profit social services agency (the Toberman Settlement House/Neighborhood Center). This agency provides support services to Spanish-speaking and lower-income households but was not prepared to accommodate flood victims. Because the City of Carpinteria has a large proportion of Hispanic or Latino people, many of whom do not speak English, the City may need to provide relevant information and assistance in languages other than English, offering communication assistance during critical response efforts as well as adaptive planning efforts.

Minority populations of 60 percent or more are located on both sides of the freeway, near to the ocean, and further inland. The highest proportions of minority populations in Carpinteria are located within the downtown (particularly within the inland Beach Neighborhood), west of Linden Avenue north of the freeway, and in the eastern regions of the City (largely with populations north of the freeway). Save for the north-central census tract 16.01 block 3 of the City, which has a minority population of less than 50 percent, the minority population of Carpinteria is relatively dispersed. Therefore, while minority populations would not necessarily be disproportionately affected by coastal hazards due to the dispersed concentrations of minority populations, lack of access to non-English information during emergencies and the overall planning process would disproportionately affect the sizeable minority population throughout the City. Overall, the high proportion of minority populations located throughout the City, who largely identify as Hispanic or Latino and may not speak English, indicates that the City must provide coastal hazard information and conduct outreach in both English and Spanish languages to engage the entire City's population.

Homeless

Homeless individuals living in coastal areas could be directly exposed to flood events because of living in the streets or in a parked vehicle. Very little information is usually collected to document the location and living situation of this population, making it difficult for emergency response during a disaster to find and help this population. Public education, awareness campaigns and pre-disaster planning often do not reach this population, and the homeless often do not have adequate means to move to alternative locations. Nevertheless, data is provided within the Existing Conditions Report detailing the homeless population within the City, of which there have been between 10 to 18 homeless people identified within the City between 2011 and 2017.

There are no homeless shelters in Carpinteria. However, there are at least 11 shelters within 25 miles of Carpinteria, with six approximately 10 miles away in Santa Barbara and two approximately 13 miles away in Ventura, suggesting that there is a needy population to be concerned about in the region. As with all special-needs populations, especially when housed in group shelters, emergency planning considers the evacuation and recovery needs should the need arise. The City's current (2017) Hazard Mitigation Plan and Emergency Operations Plan includes consideration for special needs populations, including checklists provided by the Department of Social Services to assist those with disabilities and other special needs in an emergency.

6.10 Housing

Home Ownership vs. Renting

Housing ownership affects people's ability to prepare, respond to, and recover from flood or storm events as well as in their ability to engage in household-level adaptation activities. Home ownership versus renting points to possible income differences. However, with regard to adaptive capacity, it also indicates how much control individuals have over their housing, e.g., to make structural adjustments to their home for flood protection.

Along the southern coastal portion of the City, up to 70 percent of homes are renter-occupied, which is also the area that is most prone to flooding as sea level rises. The inland areas only have approximately 23 to 38 percent renter-occupied household units, indicating that there is a disproportionate impact that may occur due to coastal hazards, specifically on households that are currently occupied by renters that may not have control over what adaptive, protective measures can be made on their homes in the long term. In cases where landlords decide to retrofit or remodel their house property (e.g. raise above flood waters), these costs would likely result in raised rents for tenants to pay for the housing improvements. Displacement of renters could occur during major remodels or retrofits, or during post-flooding events.

Affordable Housing

Currently, no affordable units or mobile home units are vulnerable to modeled coastal hazards (coastal erosion, coastal flooding, or tidal inundation). Further, none of these units would experience these hazards with up to 1 foot of sea level rise, and only one mobile home park would experience flooding with 2 feet of sea level rise (Table 6-27). However, a number of affordable housing units are vulnerable to coastal flooding and regular monthly tidal inundation with 5 feet of sea level rise (up to 41 units). There are no affordable housing units that are subject to dune or cliff erosion in the City under any scenario.

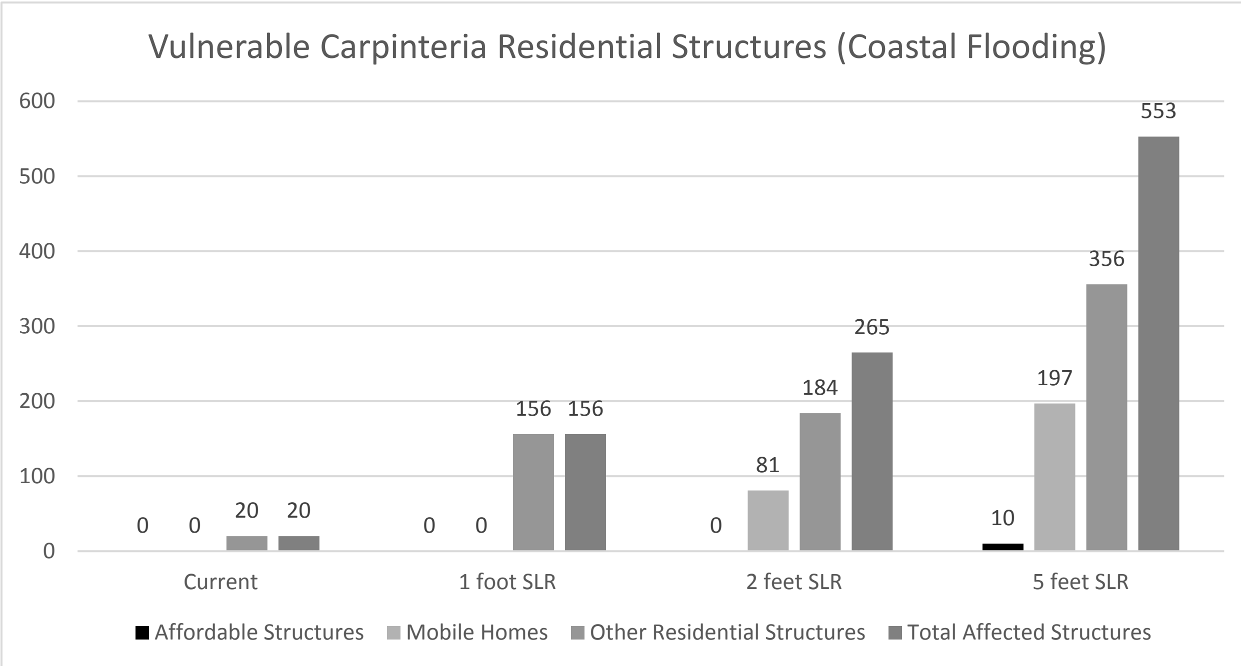
Coastal Flooding Impacts

Two of the six affordable low- to very-low-income housing projects in the City are vulnerable to potential future coastal flooding with 5 feet of sea level rise, representing approximately 22.7 percent of these units in the City. Of the three moderate- to above-moderate-income housing projects, only one unit is vulnerable with 5 feet of sea level rise, representing approximately 7 percent of these City units. Of the mobile home parks in the City, which are intended to be affordable by design according to the City's Housing Update, three of these parks are vulnerable, representing approximately 22.9 percent of mobile home park units in the City.

The City could experience up to total of 553 residential structures vulnerable to coastal flooding (579 to all coastal hazards including erosion and tidal inundation) (Revell Coastal 2018). It should be noted that the number of units quantified in this report do not correspond to the number of structures that may be affected. For instance, Chapel Court's 28 units are contained within 8 structures. Therefore, in total, there are approximately 10 affordable housing structures that are vulnerable to coastal hazards, in addition to approximately 197 mobile homes. Combined, this totals 207 affordable structures and mobile homes (238 units) vulnerable to coastal flooding, or approximately 37.4 percent of the 553 residential structures that may be affected by coastal flooding (see below chart).

Table 6-27. Affordable Housing Units in City of Carpinteria Vulnerable to Coastal Flooding

Affordable Housing Project	Number of Units	Number of Structures	1'	2'	5'
Affordable Low- to Very-Low-Income Housing Units in City of Carpinteria					
Casas de las Flores	43	7	No	No	No
Dahlia Court	54	10	No	No	No
Dahlia Court II	33		No	No	No
Chapel Court	28	8	No	No	Yes
Beach Court Accessible	6	2	No	No	No
Atrium Apartments	12	1	No	No	Yes
Total	*176*	*28*	*0*	*0*	*40 units (9 structures)*
Affordable Moderate- to Above-Moderate-Income Housing Units in City of Carpinteria					
Sparrow's Landing	1	1	No	No	Yes
Lagunitas Homes	11	11	No	No	No
Total	*12*	*12*	*0*	*0*	*1 unit (1 structure)*
Mobile Home Park Units in City of Carpinteria					
Sandpiper Mobile Village	281	281	No	No	No
Rancho Granada Mobile Home Park/Canbri Properties	116	116	No	No	No
San Roque Mobile Estates	142	142	No	No	No
Silver Sands Mobile Home Park	81	81	No	Yes	Yes
Seabreeze Mobile Home Park	71	71	No	No	Yes
Arbor Trailer Park	45	45	No	No	Yes
Vista De Santa Barbara Mobile Home Park	124	124	No	No	No
Total	*860*	*860*	*0*	*81*	*197 units (197 structures)*
Grand Total	1,048	900	0	81	238 units (207 structures)



Compared to the City as a whole, which contains 5,192 existing housing units, 1,048 units are affordable units or mobile homes. Of the 1,048 affordable units, 860 are mobile homes. If mobile home park housing is not included as affordable units, then there are only 188 affordable housing units within the City. Of these units, approximately 41 affordable units are vulnerable to coastal flooding with 5 feet of sea level rise, representing approximately 22 percent of the existing 188 affordable units.

Tidal Inundation Impacts

Many of the units that could be exposed to coastal flooding may also be at risk of tidal inundation with approximately 2 feet and 5 feet of sea level rise (Table 6-28). With 2 feet of sea level rise, the same units that would be affected by coastal flooding from a large storm would also be exposed to tidal inundation, with only the Silver Sands Mobile Home Park would be potentially affected. Fewer affordable housing units in the City are vulnerable to future monthly tidal inundation with 5 feet of sea level rise. With 5 feet of sea level rise, four affordable housing projects and mobile home parks would be affected by monthly tidal inundation (which is two less than the six that would be affected by coastal flooding). There would be 181 units (161 structures) of affordable housing projects and mobile home parks potentially affected by monthly tidal inundation with 5 feet of sea level rise. This number of structures is approximately 31.5 percent of the 510 total residential structures in the City that would be affected by tidal inundation. There are no affordable housing projects that are affected until 5 feet of sea level rise (only one mobile home park is affected, beginning at 2 feet of sea level rise). This indicates that affordable housing within the City is not significantly vulnerable to tidal inundation until after 2 feet of sea level rise. The inundation of the City's affordable and affordable by design housing stock would negatively affect renters, low and medium income populations, and minority populations which utilize this housing stock.

Table 6-28. Affordable Housing Units in City of Carpinteria Vulnerable to Tidal Inundation

Affordable Housing Project	Number of Units	Number of Structures	1'	2'	5'
Affordable Low- to Very-Low-Income Housing Units in City of Carpinteria					
Casas de las Flores	43	7	No	No	No
Dahlia Court	54	10	No	No	No
Dahlia Court II	33		No	No	No
Chapel Court	28	8	No	No	Yes
Beach Court Accessible	6	2	No	No	No
Atrium Apartments	12	1	No	No	No
Total	*176*	*28*	*0*	*0*	*28 units (8 structures)*
Affordable Moderate- to Above-Moderate-Income Housing Units in City of Carpinteria					
Sparrow's Landing	1	1	No	No	Yes
Lagunitas Homes	11	11	No	No	No
Total	*12*	*12*	*0*	*0*	*1 unit (1 structure)*
Mobile Home Park Units in City of Carpinteria					
Sandpiper Mobile Village	281	281	No	No	No
Rancho Granada Mobile Home Park/Canbri Properties	116	116	No	No	No
San Roque Mobile Estates	142	142	No	No	No
Silver Sands Mobile Home Park	81	81	No	Yes	Yes
Seabreeze Mobile Home Park	71	71	No	No	Yes
Arbor Trailer Park	45	45	No	No	No
Vista De Santa Barbara Mobile Home Park	124	124	No	No	No
Total	*860*	*860*	*0*	*81*	*152 units (152 structures)*
Grand Total	1,048	900	0	81	181 units (161 structures)

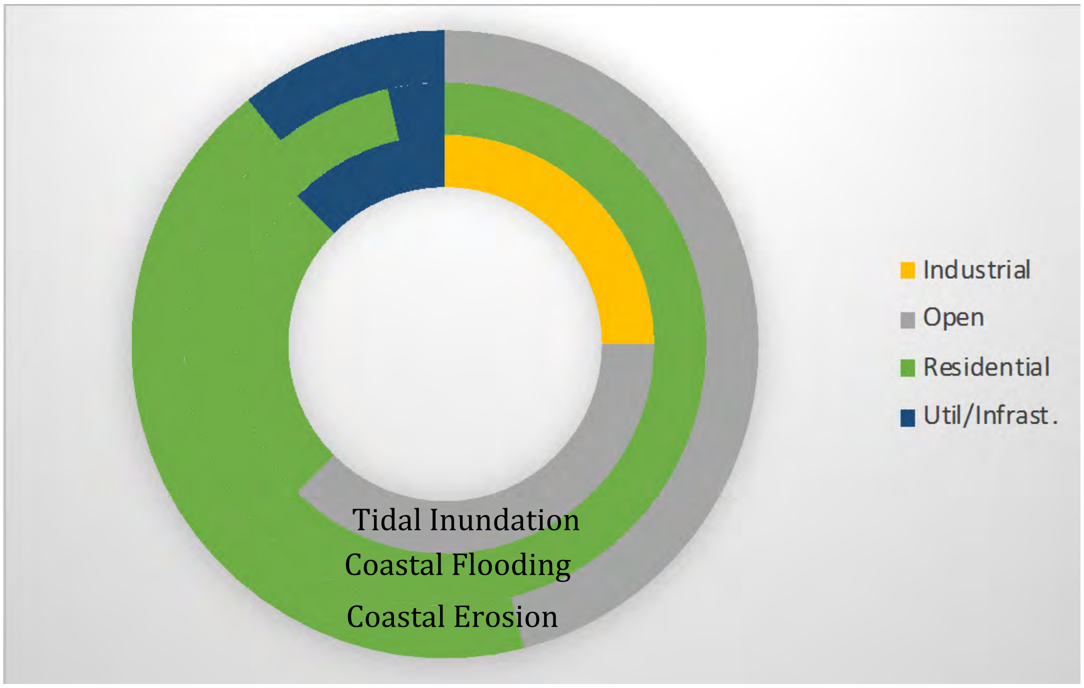
6.11 Conclusions

Coastal hazards and sea level rise escalate potential damages from coastal flooding exposure, coastal erosion, and tidal inundation. Storm waves associated with a 1 percent annual chance storm have historically caused coastal flooding and coastal erosion in the Beach Neighborhood, Carpinteria State Beach, and along the Carpinteria Bluffs. Coastal confluence flooding, (creek flooding exacerbated by sea level rise), are also a future risk; however, additional study is needed on this topic. Further information on coastal confluence and fluvial hazards is provided within Appendix C.

Existing Conditions

Under existing conditions, coastal flooding could result in severe economic damages to residential property. Existing vulnerabilities to tidal inundation are distributed among residential, commercial, open space, and industrial land uses. Vulnerable land uses to coastal erosion are largely residential and open space. Key findings for existing vulnerabilities are highlighted below:

- Carpinteria has approximately 1.5 million beach day visits per year. The estimated total recreational value of this activity is $60.4 million per year.
- The total estimated annual spending due to beach visitation is $48 million, generating $445,000 in sales taxes for the City and just under $1.9 million in TOT.
- 9 percent of the Carpinteria State Beach campground area is vulnerable to coastal erosion loss from a 1 percent annual chance storm.



Existing Conditions	Tidal	Coastal	Erosion
Totals	$800,000	$8,500,000	$3,700,000

Figure 6-16. *Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) under Existing Conditions*

- 1.2 miles of trails are currently vulnerable to coastal erosion from a 1 percent annual chance storm, and 1.3 miles are vulnerable to coastal flooding.
- $3.7 million in property and infrastructure is currently vulnerable to coastal erosion losses from a 1 percent annual chance storm. The City is vulnerable to an estimated $8.5 million in property and infrastructure damages from a 1 percent annual chance storm. $800,000 is currently exposed to tidal inundation.
- Less than 0.1 mile of railroad is currently vulnerable to coastal erosion with a 1 percent annual chance storm. This Report estimates the cost of replacement at $130,000 but this may underestimate costs. If UPRR is disrupted, the economic impacts to the region could be magnified.
- 0.1-mile of roadways are subject to coastal flooding.
- In terms of potential property loss weighted by market value, residential property is the largest land use at risk. Under existing conditions, $1.6 million in residential property is vulnerable to losses from coastal erosion, $8.2 million is vulnerable to losses from coastal flooding during a 1 percent annual chance storm, and $800,000 is exposed to tidal inundation.
- Residential dwellings are the most vulnerable land use exposed to coastal hazards and comprise over 90 percent of all parcels and structures at risk in the City. Most of these impacts occur in the Beach Neighborhood. Multi-family units (apartments and

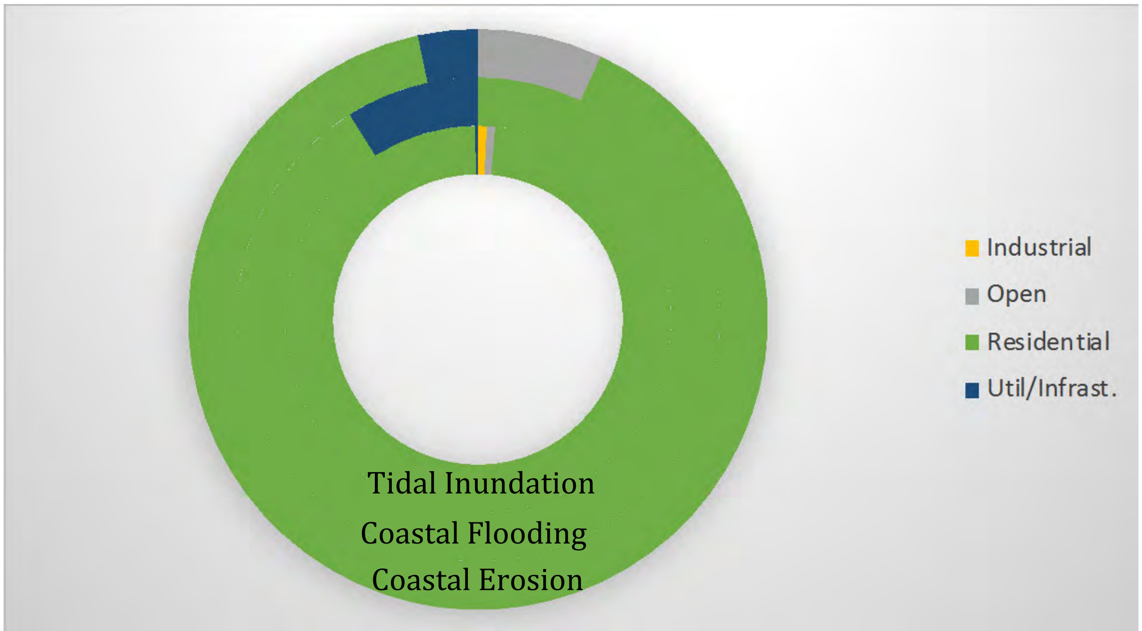
condominiums) represent over 80 percent of these losses both under current conditions and in the future and include short-term vacation rental properties; their loss would also impact transient occupancy and sales tax revenues for the City.

- Carpinteria has numerous sites with the potential to spill/leak hazardous waste including many inactive legacy oil wells and infrastructure associated with the oil and gas industry, which can be exacerbated by sea level rise. While the City may not be directly liable for the cleanup, bankrupt parties or impacts to tourism and habitats may result in a substantial economic impact to the City.
- Coastal hazards and sea level rise could result in erosion or inundation of beaches and dunes, transition of high marsh ESHA to mudflat or subtidal habitats, transition of riparian habitat along Carpinteria Creek to estuarine wetlands, and substantial erosion of coastal bluff scrub and other terrestrial ESHAs along the Carpinteria Bluffs. Refined ESHA mapping and site assessments are strongly recommended to identify effective adaptation strategies and develop sound preservation policies given sea level rise and coastal erosion will likely reduce the size and functioning of much of the ESHA in the City.

~1 Foot of Sea Level Rise

With approximately 1 foot of sea level rise, coastal beach and dune erosion could increase the landward extent of coastal flooding, which in turn could raise the vulnerabilities of oceanfront dwellings and increase the likelihood of infrastructure damages in the Beach Neighborhood and the Carpinteria State Beach without implementation of any additional adaptation strategies. Salt Marsh Park could also be affected during storm events. Cliff erosion along the Carpinteria Bluffs may affect UPRR and recreational trails.

Potential economic loss or damage associated with coastal erosion could increase substantially (ten-fold) and could be greater than that of coastal flooding (increased three-fold; Figure 6-17). This increased vulnerability is due to the prevalence of multi-story buildings (e.g. condominiums, apartments, etc.) that could be exposed to tidal inundataion and erosion. While coastal flooding could impact the ground floors of such buildings during a large storm event, entire structures may become unusuable if affected by routine tidal inundation and coastal erosion damages. It is for this same reason that the vulnerability of residential property (green) outweighs other types of land uses. That said, a non-trivial amount of utilities and infrastructure (blue) become vulnerable to erosion and flooding during a 1 percent probability storm (outer and middle rings, respectively).



~1 ft	Tidal	Coastal	Erosion
Totals	$42,100,000	$28,000,000	$35,900,000

Figure 6-17. *Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) with 1 foot of sea level rise*

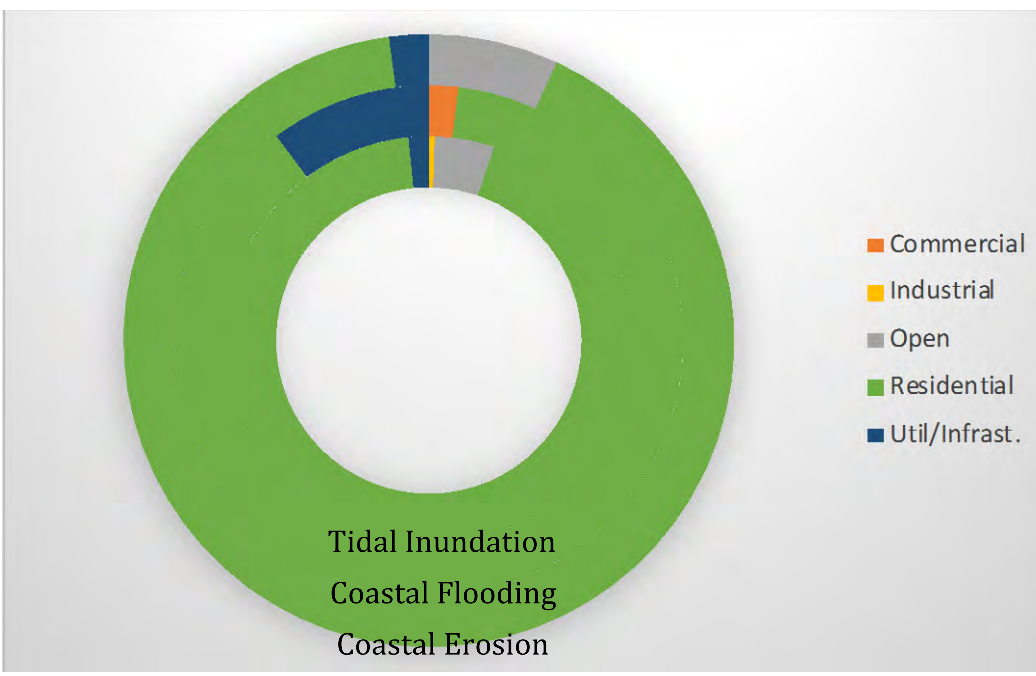
Key findings with 1 foot of sea level rise are highlighted below:

- 13 percent of the Carpinteria State Beach campground becomes vulnerable to coastal erosion loss from a 1 percent annual chance storm.
- 1.9 miles of trails become vulnerable to coastal erosion from a 1 percent annual chance storm, and 2.2 miles of trails become vulnerable to coastal flooding.
- $35.9 million in property and infrastructure become vulnerable to coastal erosion losses from a 1 percent annual chance storm. $28 million become vulnerable to coastal flooding losses from a 1 percent annual chance storm and $42.1 million become exposed to tidal inundation.
- 0.4-mile of railroad become vulnerable to coastal erosion with a 1 percent annual chance storm.
- Less than 0.1-mile of roads become subject to coastal erosion from a 1 percent annual chance storm. 1.1 miles of roads become subject to coastal flooding and less than 0.1-mile of roads become subject to tidal inundation.
- In terms of potential property loss weighted by market value, residential property represents the largest land use at risk. With 1 foot of sea level rise, $32.2 million in residential property becomes vulnerable to losses from coastal erosion, $25.5 million becomes vulnerable to losses from coastal flooding, and $41.4 million becomes vulnerable to tidal inundation.

~2 Feet of Sea Level Rise

With approximately 2 feet of sea level rise, more extensive coastal flooding and coastal beach erosion during storms could affect structures, land uses, and infrastructure between Ash and Linden Avenues north of UPRR, as well as the Carpinteria State Beach campgrounds, without additional adaptation strategies implemented. Coastal bluff erosion could continue to impact UPRR, recreational trails, and habitats along the Carpinteria Bluffs. Coastal flooding may also begin to encroach the Carpinteria Salt Marsh and extend further into the Beach Neighborhood. Routine monthly tidal inundation would largely be confined to the existing creek channels and the Carpinteria Salt Marsh, but during rain events increased tide elevations would likely back up stormwater drains and cause extensive flooding in low-lying neighborhoods.

While land uses vulnerable to coastal flooding will roughly double with 2 feet of sea level rise, land uses vulnerable to tidal inundation and coastal erosion will triple. Potential economic impacts associated with vulnerabilities to commercial parcels (orange) and infrastructure (dark blue) in the lower Downtown area along Linden Avenue will increase; and the vast majority of potential economic impacts would continue to be residential properties (green; Figure 6-18).



~2 ft	Tidal	Coastal	Erosion
Totals	$111,500,000	$53,800,000	$114,800,000

Figure 6-18. *Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) with 2 feet of sea level rise*

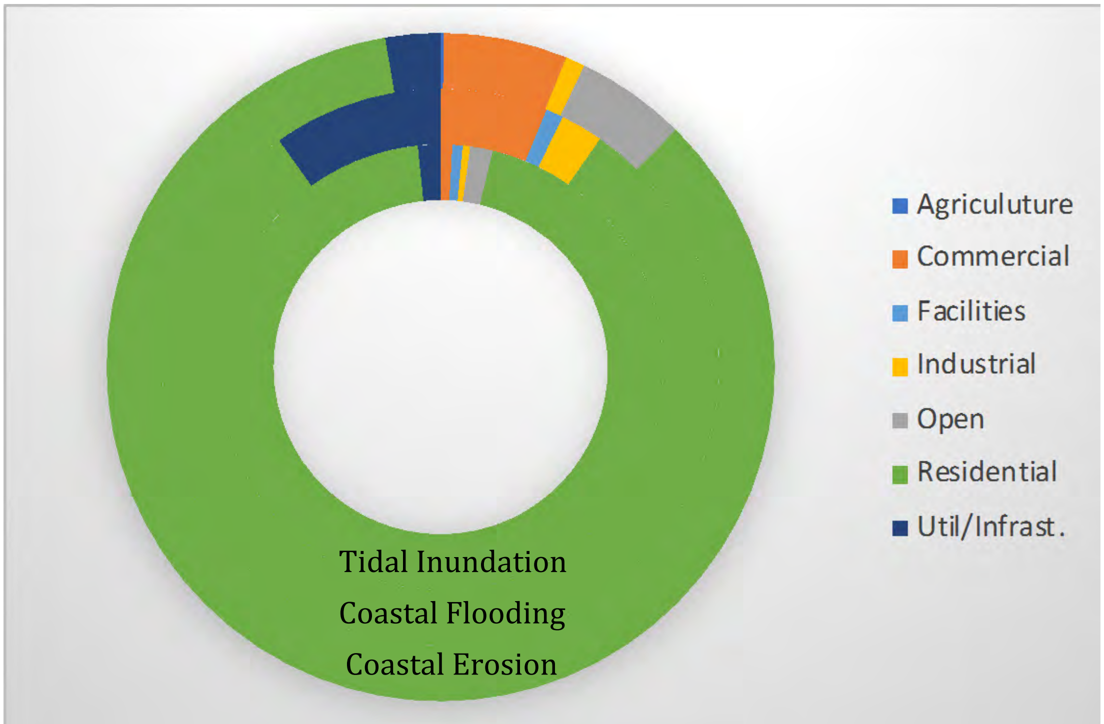
Key findings with 2 feet of sea level rise are highlighted below:

- 19 percent of Carpinteria State Beach campground becomes vulnerable to coastal erosion loss from a 1 percent annual chance storm.
- 2.7 miles of trails become vulnerable to coastal erosion from a 1 percent annual chance storm, and 3.4 miles of trails become vulnerable to coastal flooding.
- $114.8 million in property and infrastructure become vulnerable to coastal erosion losses from a 1 percent annual chance storm.
- $53.8 million in property and infrastructure become vulnerable to flooding losses from a 1 percent annual chance storm and $111.5 million is exposed to tidal inundation.
- 0.8-mile of railroad become vulnerable to coastal erosion with a 1 percent annual chance storm.
- Less than 0.1-mile of roadways become subject to coastal erosion from a 1 percent annual chance storm. 2.0 miles of roadways become subject to coastal flooding and 0.8-mile are subject to tidal inundation.
- In terms of property loss weighted by market value, residential property represents the largest land use at risk. With 2 feet of sea level rise, $104.5 million in residential property becomes vulnerable to losses from coastal storm erosion, $47.3 million becomes vulnerable to losses from a coastal storm, and $103.9 million in property becomes vulnerable to tidal inundation.

~5 Feet of Sea Level Rise

With approximately 5 feet of sea level rise, without implementation of any adaptation strategies, coastal erosion could extend through the first row of parcels to inland of Sandyland Road and begin to affect dwellings and infrastructure in the Concha Loma Neighborhood. Coastal flooding during a large storm wave event could expand in depths and inland extent into the Downtown core along Linden Avenue, affecting portions inland of UPRR, Carpinteria Salt Marsh, and areas along Franklin Creek. Coastal bluff erosion could continue to impact UPRR, recreational trails, and habitats along the Carpinteria Bluffs and potentially impact one commercial structure. Routine monthly high tides could inundate most of the Beach Neighborhood and Carpinteria State Beach inland to the Tomol Interpretative Park, even in areas not directly connected to the ocean due to daylighting of groundwater (surfacing). While this Report uses sea level rise scenarios and modeling data for approximately 5 feet of sea level rise occurring in 2100, under the worst-case H++ scenario, this could occur as early as 2070.

Figure 6-19 shows that land uses and property exposed to chronic tidal inundation could more than quadruple between 2 feet and 5 feet of sea level rise as all low-elevation structures within the City become exposed. Vulnerability to coastal flooding and coastal erosion could more than double during this same timeframe. While residential land uses (green) still accounts for the vast majority of vulnerable property values, commercial land uses (orange) continue to increase in vulnerability. Industrial parcels (yellow) and community facilities (light blue) also become exposed to coastal flooding and erosion (middle and outer rings, respectively).



2100	Tidal	Coastal	Erosion
Totals	$496,700,000	$128,800,000	$285,500,000

Figure 6-19. *Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) in 2100*

Key findings with 5 feet of sea level rise are highlighted below:

- One-third of the Carpinteria State Beach campground becomes subject to dune erosion and nearly half (46 percent) of the entire campground area becomes subject to tidal inundation.
- $285.5 million in property and infrastructure become vulnerable to coastal erosion losses from a 1 percent annual chance storm. $128.8 million become vulnerable to coastal flooding losses from a 1 percent annual chance storm and $496.7 million become exposed to tidal inundation.
- 4.6 miles of trails become vulnerable to coastal erosion from a 1 percent annual chance storm, and 5.4 miles of trails become vulnerable to coastal flooding.
- 1.4 miles of railroad become vulnerable to coastal erosion with a 1 percent annual chance storm.
- 0.7-mile of roadways become subject to coastal erosion from a 1 percent annual chance storm. 4.8 miles of roadways become subject to coastal flooding and 3.0 miles of

roadways become subject to tidal inundation. This includes a 1,500-foot-long segment of U.S. 101 and the southbound Carpinteria Avenue off-ramp at exit 87B.

- In terms of property loss weighted by market value, residential property represents the largest land use at risk. By 2100, $242.4 million in residential property become vulnerable to losses from coastal erosion, $103.6 million become vulnerable to coastal flooding losses from a coastal storm, and $469.8 million become vulnerable to tidal inundation.

7. Adaptation Overview

> Chapters 7 & 8 of the Sea Level Rise Vulnerability Assessment and Adaptation Project (2019) serve as the City's Adaptation Plan.

Adaptation is defined as a response to existing or anticipated climate-induced impacts, and can include policy, programmatic, and project-level measures. Good adaptation planning enhances community resilience to hazards and natural disasters and is based upon the understanding of the City's specific risks, projected timing of impacts, and existing and future coastal processes. As our understanding of climate science continues to evolve, it is important for the City to maintain flexibility and monitor sea level rise as part of adaptation planning and consider updated climate science, predictions, scenario probabilities, and diverse adaptation strategies. Adaptation planning provides the City with a toolbox of options to carry out its long-term vision for the community with consideration of sea level rise.

7.1 State of California Adaptation Guidance

The California Coastal Commission (CCC) and the Ocean Protection Council (OPC) have released sea level rise and adaptation planning guidance that can be used by local jurisdictions to update land use planning documents. The guiding principles and preferred adaption approaches are listed below. This information is useful for developing principles for the City's adaptation strategies.

CCC Sea Level Rise Policy Guidance (2018)

Sea Level Rise Policy Guidance (CCC 2018) outlines 20 guiding principles based on Coastal Act policies that address sea level rise in the coastal zone and fall under four categories:

- Use science to guide decisions (Coastal Act Sections 30006.5; 30335.5);
- Minimize coastal hazards through planning and development standards (Coastal Act Sections 30253, 30235; 30001, 30001.5);
- Maximize protection of public access, recreation, and sensitive coastal resources (Coastal Act Chapter 3 policies); and,
- Maximize agency coordination and public participation (Coastal Act Chapter 5 policies).

In November 2018, the CCC adopted the 2018 *Sea Level Rise Policy Guidance – Final Science Update* (CCC 2018b). The guidance update indicates that the *Report on Sea Level Rise* (National Research Council [NRC] 2012) guidance for assessing and modeling sea level rise is no longer the best available science. The CCC currently recommends use of the *State of California Sea-Level Rise Guidance: 2018 Update* (OPC 2018) for sea level rise modeling. Both the CCC 2018 and OPC 2018 guidance documents are complimentary and are utilized across the state for developing planning and adaptation strategies. These documents are available online at: https://www.coastal.ca.gov/climate/slrguidance.html.

OPC State of California Sea-Level Rise Guidance (2018)

In March 2018, the California Natural Resources Agency and OPC released an updated *State of California Sea-Level Rise Guidance* including eight (8) preferred sea level rise planning and adaptation approaches:

- Adaptation planning and strategies should prioritize social equity, environmental justice, and the needs of vulnerable communities[1];
- Adaptation strategies should prioritize protection of coastal habitats and public access;
- Adaptation strategies should consider the unique characteristics, constraints, and values of existing water-dependent infrastructure, ports, and Public Trust uses;
- Consider episodic increases in sea level rise caused by storms and other extreme events;
- Coordinate and collaborate with local, state, and federal agencies when selecting sea level rise projections; where feasible, use consistent sea level rise projections across multi-agency planning and regulatory decisions;
- Consider local conditions to inform decision making;
- Include adaptive capacity in design and planning; and
- Assessment of risk and adaptation planning should be conducted at community and regional levels, when possible.

Natural Resources Agency Safeguarding California Plan (2018)

The *Safeguarding California Plan: 2018 Update* (Natural Resources Agency [NRA] 2018) describes the State's climate change adaptation plan and actions state agencies are taking to adapt communities, infrastructure, services, and the natural environment to climate change. This Plan outlines several programmatic and policy responses as well as examples of adaptation projects. In addition, the Plan includes metrics for monitoring and evaluation. Seven overarching principles provide the framework for this plan:

[1] Vulnerable communities refer to communities of color and/or low-income communities that experience heightened risk and increased sensitivity to climate change, and have less adaptive capacity to cope with, adapt to, or recover from climate impacts. These disproportionate effects are caused by one or more physical (built and environmental), social, political, and economic factors, which are exacerbated by climate impacts.

- Consider climate change in all functions of government;
- Partner with California's most vulnerable populations to increase equity and resilience through investments, planning, research, and education;
- Support continued climate research and data tools;
- Identify significant and sustainable funding sources to reduce climate risks, harm to people, and disaster spending;
- Prioritize natural infrastructure solutions that build climate preparedness, reduce greenhouse gas emissions, and produce other multiple benefits;
- Promote collaborative adaptation processes with federal, local, tribal, and regional government partners; and
- Increase investment in climate change vulnerability assessments of critical built infrastructure systems.

7.2 Approaches to Adaptation

According to CCC *Sea-Level Rise Policy Guidance*, sea level rise adaptation generally falls into five main categories: do nothing, protect, accommodate, retreat, or a hybrid approach (Table 7-1; Figure 7-1). These approaches are described below. For the purposes of implementing the Coastal Act, no one category or specific strategy is considered the "best" option. Different types of strategies may be appropriate depending on location, backshore type, hazard management approach, resource protection goals, development intensity, and time horizons. Strategies for addressing sea level rise hazards require proactive planning to balance protection of coastal resources with physical development. The effectiveness of different adaptation strategies varies across spatial and temporal scales.

Table 7-1. Adaptation Strategies

Strategy	Description
Do Nothing	Following a policy of non-intervention
Protect	Engineered structures (soft or hard) or other measures to protect existing development (or certain coastal resources) in its current location
Accommodate	Modify existing areas or design new developments or infrastructure to decrease hazard risks and tolerate lower levels of flooding
Managed Retreat	Relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas
Hybrid	Employ strategies from multiple categories

The City is actively pursing adaptation strategies; therefore, the do nothing approach is dismissed from further evaluation. The following discussion introduces the three main approaches; however, the City is investigating hybrid approaches as they would provide the broadest array of adaptation measures and preserve the City's flexibility to implement strategies through time as science continues to advance and the physical settings change.

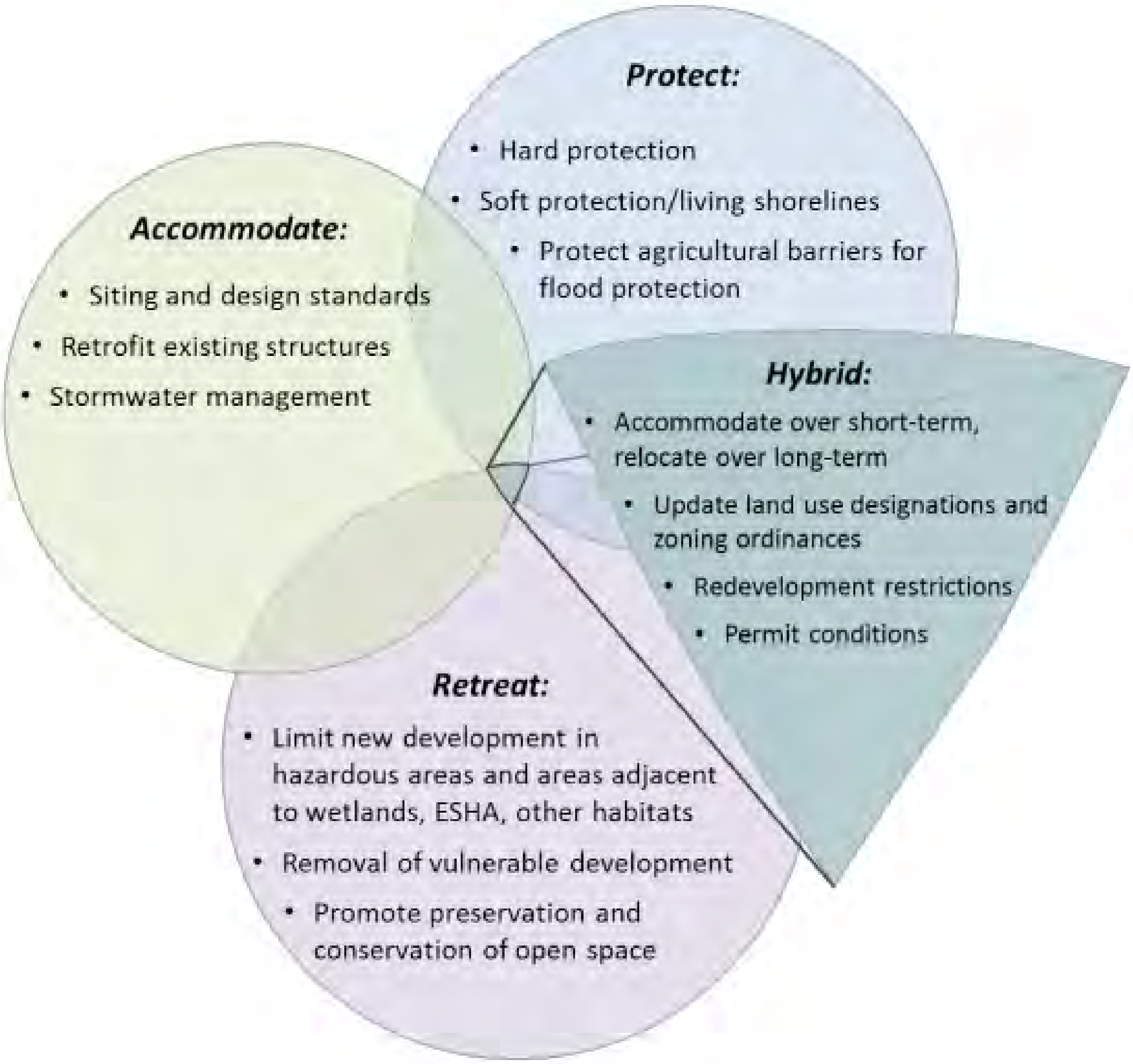


Figure 7-1. *Examples of General Adaptation Strategies. Source: CCC 2015.*

Protection

Protection strategies typically employ engineered structures or other measures to act as a barrier for existing development (or certain coastal resources) in its current location.

In accordance with the Coastal Act and *Safeguarding California Plan* (NRA 2018), priority should be given to options that protect, enhance, and maximize coastal resources and access. Protection strategies can range from “grey” to “green” and include either “hard” or “soft” defensive measures. A “soft” protection approach may be to nourish beaches with fine sand or natural sediments. A “green” soft approach may be to establish vegetated sand dunes, or to develop a “living shoreline”, which entails creation of a stabilized sand and cobble complex vegetated with local, native species. Dune systems are dynamic interfaces that act as a natural coastal defense by providing sand storage to buffer erosion and dissipate wave energy during extreme storm events. Successful implementation of such strategies may require some form of sand retention (e.g., enhanced headland or point to slow sand movement) to increase the longevity of such projects, as well as longer-term repeated nourishment of beaches or dunes. A “grey” and “hard” approach refers to an engineered structure and can be located either alongshore such as a seawall, revetment, or offshore breakwater, or cross-shore (i.e., shore-perpendicular) such as a groin, groin field, or jetty. Cross-shore structures are implemented to trap sand and widen the beach upcoast of the structure and must incorporate a downcoast pre-fill to prevent erosion. In most cases, “hard” structures must be accompanied by “soft” defensive measures such as beach nourishment and/or dune restoration to ensure efficacy in protecting the shoreline.

Although the Coastal Act provides for potential protection strategies when required to serve coastal dependent uses or for “existing development” in danger of erosion (i.e., California Coastal Act Section 30235), it also directs that new development be sited and designed to not require future protection that may alter a natural shoreline (California Coastal Act Section 30253). It is important to note that most protection strategies are costly to construct, require increasing maintenance costs, and may result in consequences to recreation, habitat, and natural defenses. The following options are considered protection strategies and are listed within the CCC *Sea Level Rise Policy Guidance*:

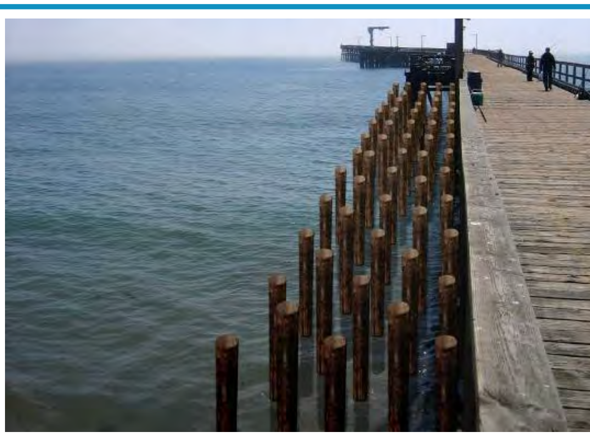
Example of hard shoreline protection. Portions of San Francisco’s Ocean Beach is partially armored by a concrete seawall and supplemented with regular beach nourishment.

- Beach nourishment to widen the beach.
- Living shorelines, or other soft, green solutions to protect development and resources.
- Restoration of natural dune processes to provide a buffer against erosion and flooding by trapping wind-blown sand, storing excess beach sand, and protecting inland areas.
- Regional sediment management programs that consider the entire watershed system and restore natural sediment supply.
- Beneficial reuse of sediment through dredging and placement on beaches.
- Use of hard protection such as seawalls or revetments under special considerations to preserve the function of critical facilities.

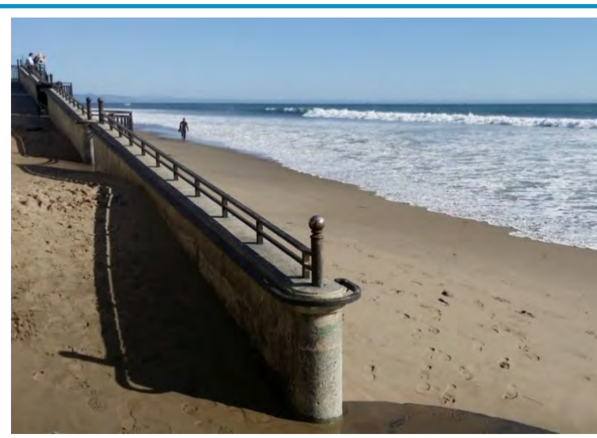
Other types of protection strategies include sand retention structures such as groins and recreational piers used for a cross-shore approach. Groins are thin and long structures perpendicular to the shoreline extending into the surf zone and slightly beyond the low water line. A recreational pier with a dense or impermeable set of support piles near the shoreline may be used to entrap sand while providing recreational benefits. Offshore artificial reefs are used to dissipate wave energy and consist of fill in the surf zone that reduces wave energy and anchors sand to the beach, slowing the rate of transport; kelp bed restoration may have similar effects. Many shoreline protective devices (e.g., flood control levees, revetments, etc.) can adversely affect a wide range of coastal resources and uses that the California Coastal Act protects. Placement of a "hard" shoreline protective device on the landward side of a beach ultimately leads to loss of the beach. Furthermore, hard shoreline protective devices often exacerbate erosion on adjacent unarmored beach areas. They often impede or degrade public access and recreation along the shoreline by occupying beach area or tidelines, by accelerating erosion, and reducing shoreline sand supply. Shoreline protective devices also raise serious concerns regarding marine resources and biological productivity and can degrade the scenic qualities of coastal areas and alter natural landforms.

Sand dunes act as a natural coastal defense by providing extra sand storage. Carpinteria State Beach currently has low-lying sand dunes that buffer the park.

Rock revetments are considered a "hard" coastal protection structure that fix the shoreline in place and buffer coastal resources from severe storm events.



Conceptual design for a permeable pier consisting of timber piles adjacent to a new or existing pier, which would trap sand from drifting downcoast.



Ramps connecting elevated walkways to the sand at Butterfly Beach in Montecito increase beach access and provide a safe path to traverse the seawall.

Accommodation

Accommodation strategies employ methods that modify existing areas or design new developments or infrastructure to decrease hazard risks and therefore increase the resiliency of development to the impacts of sea level rise.

On a community-scale, accommodation strategies include amendments to land use and zoning designations, or land use policy and zoning ordinance 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. On an individual project scale, these accommodation strategies include standards such as elevating structures, performing structural retrofits, or using materials to increase the durability of development from additional coastal process impacts, building structures that can easily be moved and relocated, or using additional setback distances to account for acceleration of erosion. The following options are considered accommodation strategies and are listed within the CCC *Sea-Level Rise Policy Guidance*:

- Consider sea level rise in site-specific development proposals.
- Update development siting, code, and design standards to avoid, minimize, or reduce risks from coastal hazards and extreme weather events. Limit basements and first floor habitable space.
- Elevate structures above base flood elevations using caissons.
- Design coastal dependent infrastructure to withstand coastal hazards.
- Increase the capacity of stormwater infrastructure.
- Retrofit outfalls and wastewater treatment systems that could damage water quality. Realign or retrofit transportation infrastructure to better withstand sea level rise impacts.

Example of accommodation approach. The Santa Barbara Yacht Club is elevated above the shoreline using caissons, water-tight pier structures. The parking lot and beach flooded during the 1983 El Niño event. Photo credit: Gary Griggs

Example of managed retreat approach. Surfer's Point Managed Shoreline Retreat Project in Ventura, CA relocated the parking lot away from the shoreline and restored the beach area with cobbles and sand. Photo source: Surfrider Foundation 2013.

Managed Retreat

> **Managed retreat** is considered a long-term adaptation measure that removes or relocates at-risk infrastructure to allow for natural retreat of the shoreline.

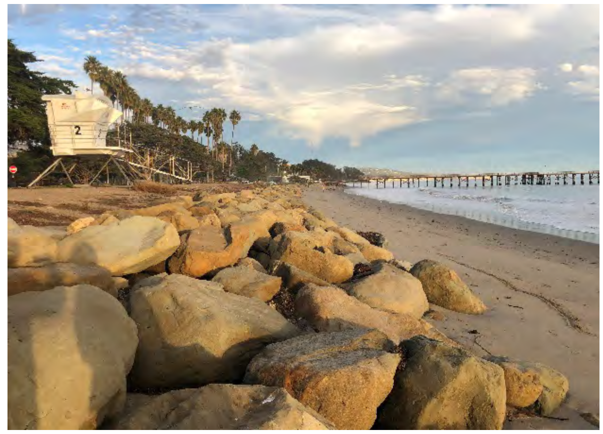
Managed retreat strategies prioritize proactive approaches to relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include amending land use designations and zoning ordinances to encourage siting and building in less hazardous areas, or gradually removing and relocating existing development outside of hazardous areas. Repetitive loss programs, development setbacks, and modification or removal of structures where the right to protection is waived (i.e., permit conditions) are examples of strategies designed to manage retreat from areas with existing and projected coastal hazards.

The following options are considered managed retreat strategies and are listed within the CCC *Sea-Level Rise Policy Guidance*:

- Establish mapped hazard zones or overlays that limit new development in current and future coastal hazard zones.
- Create shoreline management plans that address long-term shoreline changes due to sea level rise.
- Develop adequate setbacks for new development.
- Limit subdivisions in areas vulnerable to sea level rise.
- Develop a plan to remove or relocate structures that become threatened to coastal hazards.
- Plan to replace loss of land uses that could be lost to inundation or damage associated with sea level rise.
- Work with Caltrans and transportation agencies to identify alternative transportation routes.
- Coordinate planning and regulatory decisions with other appropriate local, state, and federal agencies.

Adaptation Trade-offs

Within each adaptation approach, adaptation measures have varying cost and benefit trade-offs. Consideration of trade-offs and impacts of different strategies and implementation mechanisms assists decision-makers and the public in determining the most effective policies and project-level adaptation strategies to advance. Factors to consider when prioritizing strategies include: public health and safety, economic, ecological, recreational, and visual resources, environmental justice[2], political will, and community support.



Rock revetments at Goleta Beach have become exposed following severe winter storms, impeding vertical beach access while protecting the Park.

A selected adaptation measure may reduce risks to one asset or resource but may affect another resource or lead to unintended consequences (Table 7-2). One of the most controversial trade-offs of adaptation is associated with the long-term preservation of a beach, which often pits private and public interests against each other with strong overtures to social justice and community inequality. Adaptation trade-offs could include significant alterations to the shoreline and costs, resulting in the loss of beach following construction of a revetment but protection of landward development. Such impacts can result in major alteration or loss of public resources, public facilities, and other infrastructure; the severity of impacts is also dependent upon adaptation planning variables, including selected actions, available funding resources, and implementation timeframes. Good adaptation planning considers these trade-offs and how adaptation measures implemented to alleviate vulnerability in one sector may affect other sectors.

Table 7-2. Examples of Adaptation Trade-offs

Strategy	Trade-off Examples
Protect – Rock Revetment	Loss of public beach following construction of the revetment; protects landward development and infrastructure.
Accommodate – Elevate Buildings	Change in visual character and public views; allows private development to adapt in place.
Managed Retreat – Limit New Development in Hazardous Area	Places additional restrictions or eliminates use on private development; leaves room for public beach to migrate inland, maintaining recreational and ecological benefits.

Maladaptation

Adaptation measures that reduce the ability of people and communities to address and respond to climate change over time are called maladaptation. Maladaptation has several

[2] Environmental Justice refers to the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (Government Code 65040.12[e]).

characteristics that help identify when it is occurring. One of the most significant concerns with maladaptation is that it reduces incentives to adapt while it simultaneously diminishes the capacity to adapt in the future. Maladaptation measures may:

- Result in sustained or increased hazardous conditions;
- Result in additional vulnerabilities, loss of property, and resources;
- Create a more rigid system with a false sense of security and severe consequences;
- Increase GHG emissions; and/or
- Reduce incentives to adapt.

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. For instance, previously unaffected areas can become more prone to climate-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. Avoiding maladaptation is critical to a successful climate adaptation strategy. To do so, the City must first be able to make informed decisions based on an accurate vulnerability assessment, and to determine its own level of tolerance to risk and vulnerability. Flexibility and a precautionary approach are key to avoiding maladaptation in the adaptation planning process.

7.3 Adaptive Capacity and Risk Tolerance

Adaptive capacity is the ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to address consequences. For purposes of this discussion adaptive capacity is categorized as:

- **High –** Strategy, asset, or resource can easily be adapted or has the ability and conditions to adapt naturally.
- **Moderate** - Strategy, asset, or resource can be adapted with minor additional cost or effort
- **Low** - Strategy, asset, or resource has limited ability to adapt without significant changes, cost, or additional engineering.

A guiding principle of adaptation planning is to limit the risk of coastal hazards to vulnerable assets. Risks to the City's vulnerabilities increase with sea level rise. The City must choose what level of risk it is willing to tolerate. Risks that present the most serious consequences and are projected to occur first should be elevated to top priorities for the City. Risks can be addressed by reducing vulnerability or exposure. Given limited resources, it is important that risks be prioritized and phased to maximize the use of community resources while avoiding a costly emergency response to the maximum extent feasible (Figure 7-2).

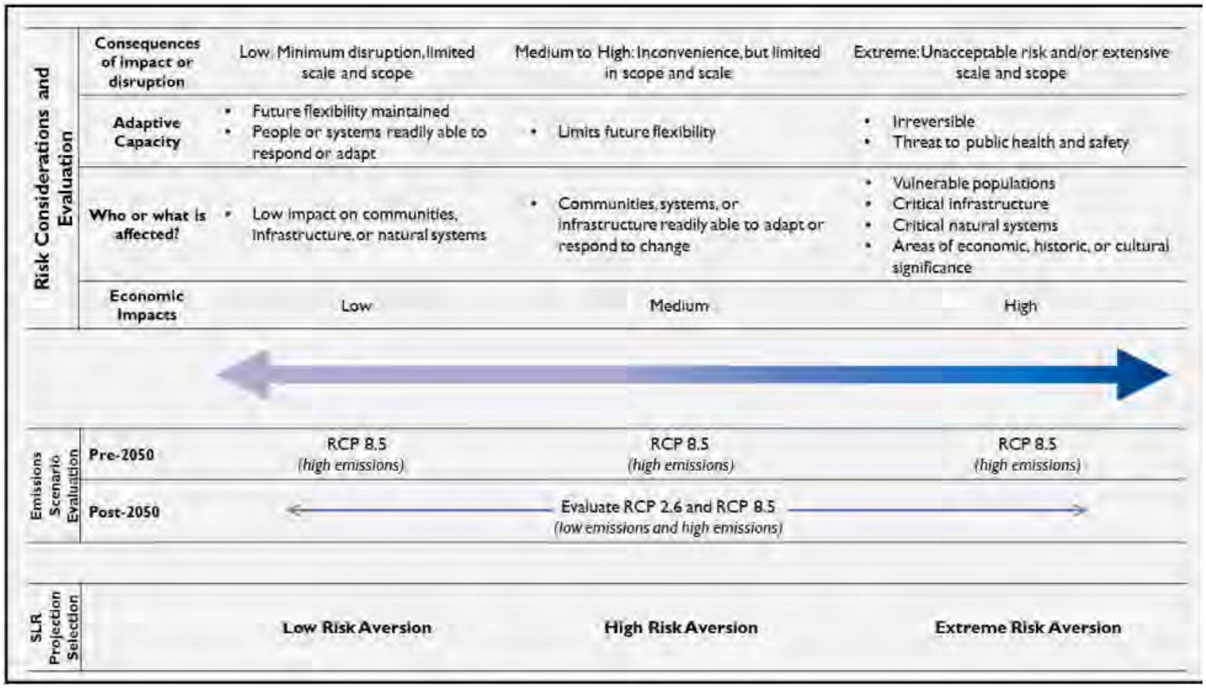


Figure 7-2. *Risk Tolerance Framework chart above includes factors to consider when prioritizing adaptation strategies. Source: OPC 2018.*

7.4 Triggers and Monitoring

Triggers represent a point in time when action must be taken to address coastal hazard-related vulnerabilities before impacts reach a critical mass. A trigger may be a shorter-term project such as a construction period associated with physical protection activities, or a longer-term program, such as a dynamic coastal adaptation overlay plan, which implements specific development regulations based on monitoring and assessment of need. Triggers are measurable indicators that serve as a catalyst or initiate planning, permitting, and/or the implementation process for adaptive measures. Triggers are useful in developing time-sensitive policies or actions and accommodate the required processes in advance of a needed adaptation measure. In cases where coastal hazards pose an existing threat, adaptation planning initiatives may be warranted regardless of future sea level rise, as adaptation can take several years to implement and any amount of sea level rise could exacerbate existing coastal threats. Each adaptation strategy has various lead times to plan, permit, finance, and implement. Updating the building code, for example, requires staff time to plan and develop followed by decision-maker approval—a process that may at a minimum require a year or two. Removing a dam or relocating a railroad would take much longer.

An appropriate trigger would provide enough notice to implement before vulnerabilities become severe. Adaptation planning sets triggers such that adaptation measures can be implemented to reduce risks before they become critical. Potential triggers need to be monitored and assessed to inform adaptation decisions, and triggers should be reevaluated and updated in the future to capture advances in sea level rise science and changing conditions.

For the purposes of this Report, the **tipping point** is when sea level rise critically affects vulnerable assets, resources, or infrastructure, as indicated from the sector results of sea level rise modeling in Chapter 6. Triggers should occur in advance of the projected tipping point for adaptation to be successfully implemented.

Triggers should be related to actions that can be monitored or measured rather than related to uncertain projections given the importance of timing when abating or reducing effects of coastal hazards. There are several types of monitoring mechanism with examples that are useful to consider, such as:

- **By sea level rise elevation (or rate of sea level rise)** – trigger planning stages, study requirements, or changes in setback calculations. The City will follow sea level rise reports from the State and Scripps Institute of Oceanography, and National Oceanic and Atmospheric Administration tide gages. The City is already vulnerable to hazards that may occur from an El Niño event or individual storms; however, sea level rise would increase the severity and impacts of these storms. Monitoring sea level, and the rate it is rising allows the City to implement further actions in advance of projected sea level rise impacts.
- **By physical beach width distances** – identify an observable or measurable distance or threshold, such as when the beach width at the end of summer is less than 100 feet. This could trigger actions such as the pursuit of beach nourishment or sediment placement.
- **By planning year** – specify that by a future planning year (e.g., 2025), a long-range study identifying appropriate strategies must be complete (e.g., wastewater upgrade or transportation planning). The drawback of monitoring mechanisms based on planning year is that modeled projections of coastal hazards could occur sooner or later than a given year.
- **By storm exposure and frequency** – monitor the frequency of exposure to wave action (e.g., at Sandyland Road). To monitor the frequency of flooding, the City should track and record coastal and fluvial flooding, including the date, location, type, and severity. This would assess if the rate and frequency of flooding is increasing. An

increase in the rate and severity of storm damage should trigger the implementation of adaptation. Monitoring of storm damage frequency and exposure could be a collaborative effort with the County.

- **By damages –** identify available structural improvement that may occur to damaged buildings and facilities (e.g., repair if under 30 percent, upgrade building standards if damaged by >50 percent, or relocated if the structure has multiple damage claims >50 percent).
- **By bluff top offset –** monitor the distance of bluff erosion as a trigger for bluff adaptation measures. When erosion of the bluff edge reaches a certain distance that poses a safety risk to an asset or infrastructure, a trigger to relocate the infrastructure or asset would occur.

Triggers and timeframes to implement strategies are considered to identify high priority adaptation strategies. Implementing adaptation measures will require coordination, planning, permitting, engineering, and financing. Each strategy should identify a certain lead time from initial concept to implementation that varies depending on the scale and type of strategy, and the amount of sea level rise that the strategy can accommodate. These lead times should then inform policy triggers that are monitored through measurable objectives to act as a catalyst for the planning process.

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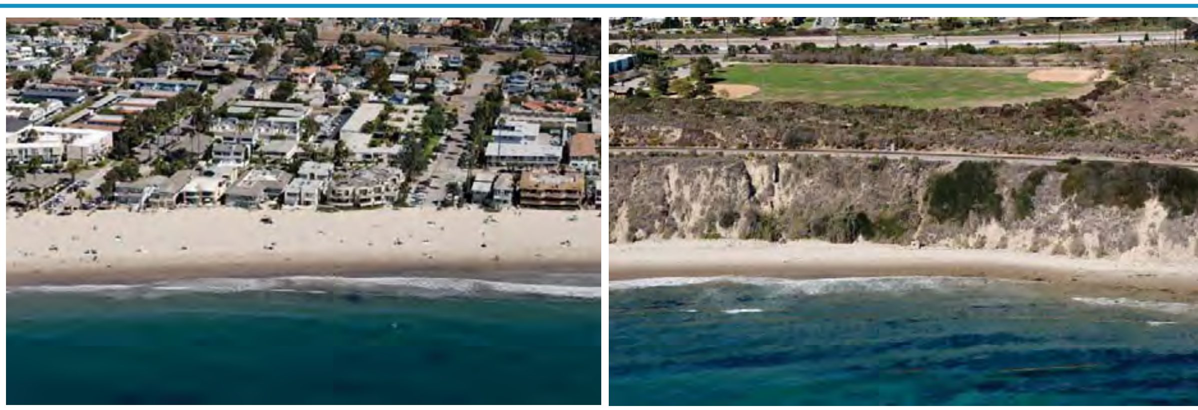
8. Adaptation and Resiliency Building Strategies

This Chapter of the *Sea Level Rise Vulnerability Assessment and Adaptation Project* provides a range of adaptation options the City may implement to address existing and future vulnerabilities. The adaptation strategies included within this section are developed specifically with the intent of minimizing damage to projected vulnerabilities identified within Section 6, *Sector Results*, with consideration of recommended strategies within California Coastal Commission (CCC) *Sea Level Rise Policy Guidance* (2018a) and input from stakeholders, special districts, the Coastal Land Use Plan (CLUP)/General Plan Update Committee, and the public. This section identifies both strategies that are programmatic that could be applied regionally and specific strategies that could be applied within targeted areas. Policy approaches to adaptation would be implemented through the certified CLUP/General Plan Update. Other strategies include approaches or projects that are based on regional coordination, planning, and implementation with other organizations. Several of City's adaptation strategies include regional assets outside of its jurisdiction that are of great importance to the City. Such strategies would benefit regional assets (Los Angeles–San Diego–San Luis Obispo Rail Corridor [LOSSAN Corridor] and Union Pacific Railroad [UPRR], U.S. Highway 101 [U.S. 101], Aliso Elementary School, etc.) and successful implementation relies on regional coordination and funding.



The Carpinteria shoreline is characterized by a stretch of sandy coastline transitioning to rugged bluffs that serves as a popular recreational space with a history of development and management. Photo Source: California Coastal Records Project.

A goal of this section is to increase the understanding of the vulnerabilities associated with coastal hazards and encourage consideration of these impacts without creating further vulnerabilities or liabilities. As this is the beginning of the City's process of developing its adaptation responses, many early initiatives are exploratory in nature and aim to identify potential changes or actions to respond to the impacts of concern. Recommendations and next steps are identified within Section 8.6, *Recommendations and Next Steps*, though adaptation measures are subject to change and further refinement over time. The City's adaptation approach outlined within this Chapter is based upon best available science and currently known adaptation practices. However, sea level rise science continues to evolve, and physical coastal conditions are constantly changing. While there remains some uncertainty in the rate and timing of sea level rise, an indeterminate amount of sea level rise is likely to occur. In the future, the City will reevaluate the feasibility and necessity of adaptation options as appropriate, continuing to use best available data, with reference to current state adaptation planning guidance. Additionally, the adaptation strategies identified within this Chapter may evolve or change over time as unknown variables become more certain.

8.1 Planning Principles

An objective of the City is to protect the community and natural resources that make Carpinteria a desirable location to live, work, recreate, and visit. The City's public beach and shoreline are a significant source of the community's quality of life and generate revenue from both community and visitor-recreational activities. Ensuring the City's beaches and shoreline are resilient to sea level rise over time is integral to the City's community character, healthful livability, and economic viability. Through the CLUP/General Plan Update and public outreach process, the City and its residents have identified several priorities to accomplish or balance when planning for adaptation to identified coastal vulnerabilities. Above all, the City and its residents choose to prioritize the following:

- Maintaining the City's small beach town character and high quality of life;
- Maintaining a wide sandy beach offering lateral beach access and a variety of recreational opportunities, such as surfing, paddle boarding, swimming, fishing, birdwatching, beachcombing, tide pooling, and other recreational activities for residents and visitors;
- Maintaining a healthy economy with opportunities for future economic viability;
- Protecting or adapting vulnerable neighborhoods, including the Beach Neighborhood and the Downtown;
- Identifying sustainable funding sources to allow the City to improve coastal resiliency; and,
- Improving regional collaboration and coordination with agencies to maintain, enhance, and protect key resources and critical infrastructure.

Many of the strategies provided in this section are focused on resiliency while balancing the City's priorities for adaptation with the long-term preservation of the public beach, visitor serving facilities, public infrastructure, and land uses. To achieve the appropriate balance, it is important to weigh considerations and achieve consistency with adopted policies and guidance. Guiding goals, principles, policies, and programs that have been considered in the development of policies for addressing rising seas within the City include those of the state's climate adaptation strategy – the *Safeguarding California Plan Update* (California Natural Resources Agency 2018), *Sea Level Rise Policy Guidance* (CCC 2018a), the City's CLUP/General Plan Update, and the California Coastal Act.

With applicable guidance and City priorities in mind, the City developed the following planning principles, with input from the public and other stakeholders. These principles are suggested for incorporation in the City's CLUP/General Plan Update and could be supported by additional policy and implementation guidance:

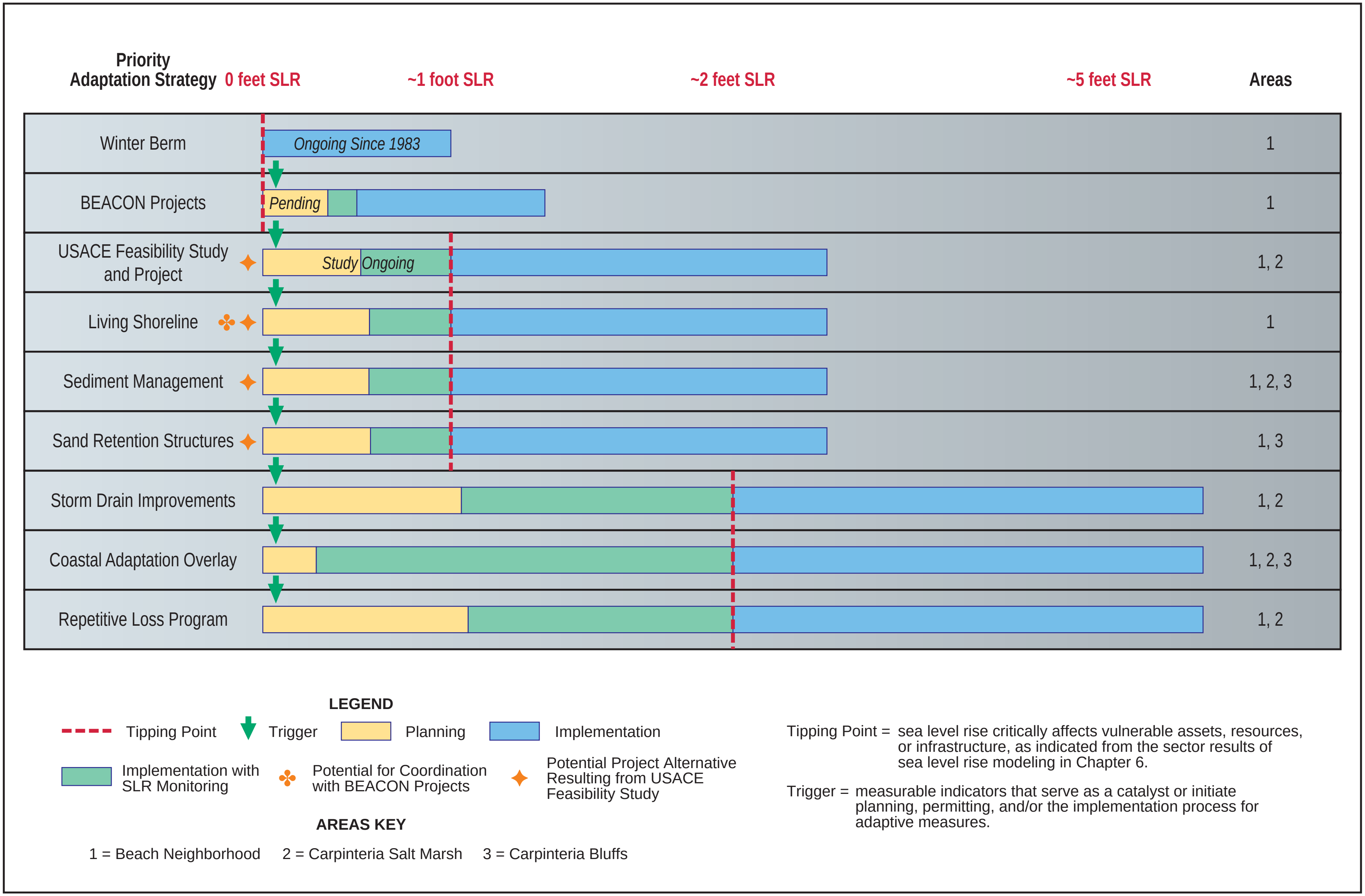
- Prioritize regional collaboration and coordination in planning for adaptation to sea level rise;
- Facilitate protection of, and assistance to populations vulnerable to coastal hazards;
- Reduce risk of extreme coastal hazards and damage upon vital infrastructure and structures in high-risk areas of the City;
- Maintain flexibility to meet changing conditions;
- Balance approaches to adaptation weighing benefits to costs, economic impacts, and appropriate use of public funds;
- Maintain natural defenses (e.g., sand dunes, marshes, native bluff vegetation) and physical processes (e.g., ecosystem services);
- Prioritize nature-based solutions designed to minimize extensive maintenance over time, avoiding "hard" or "gray" structures to the maximum extent feasible;
- Require new development to plan for coastal storm and sea level rise hazards;
- Develop adaptive measures that are consistent with the CLUP/General Plan and rely upon best available science; and,
- Conserve, maintain, and, when necessary, restore/enhance beaches for habitat value, recreation, and coastal access for the use of future generations.

8.2 Priority Measures for Resources and Assets

This section provides a road map for long-term adaptation planning, including identification of both programmatic measures and projects intended to reduce damage to the City from coastal hazards, triggers for implementation of such measures, areas of future study, financing options, and the next steps for the City to further its adaptation planning efforts. It also assists the City and decision-makers in making informed decisions regarding future land use and development. While the City has a long history of addressing coastal hazards, this is the first focused endeavor by the City to identify possible vulnerabilities to climate-related impacts.

Informed by state adaptation planning guidance and City priorities, the City has developed a hybrid approach to adaptation that is comprised of several complementary adaptation strategies. The City's preferred adaptation approach is to implement a combination of soft and nature-based protection measures, accommodation, and managed retreat concepts, based on potential sea level rise triggers and monitoring (Figure 8-1). This includes beach nourishment, sand dune restoration, sand retention/management, flood management projects, and proactive implementation programs for development and infrastructure in areas at risk to coastal hazards.

Priority adaptation strategies would ultimately be integrated into CLUP/General Plan policies, implementation plans, and/or actions. Managed retreat strategies which relocate existing development out of hazard areas will be considered if the City determines it is necessary and feasible, based on measured data and monitoring of physical conditions. A principle intent of the CLUP/General Plan is to implement policies that ensure permitted development is sustainable from coastal hazards and existing public improvements and development is managed to reduce exposure to coastal hazards. As part of this ongoing CLUP/General Plan Update process, policies will be further developed by stakeholders and public agencies, including further discussions at public workshops and hearings. Adaptation planning for these priority measures is anticipated to require significant regional or multi-jurisdictional coordination and funding. Many adaptation strategies take substantial time to implement. As a result, advanced planning and financing is vital. The City's adaptation approach allows flexibility to choose from an array of adaptation strategies over time as the identified triggers are reached. As indicated within Figure 8-1, the City recommends that planning for each priority adaption measure begin immediately. Next steps identified within this Report include additional study; public outreach; economic analysis; project funding; engineering; permitting, program adoption, and or/construction. These next steps are necessary to understand the feasibility and effectiveness of the identified adaptation measures in this Report, prior to implementation and/or adoption. The City would continue to monitor appropriate triggers such as an increase in sea level elevations, storm exposure and frequency, beach width distance, damages, and erosion distance, and evaluate the effectiveness of a strategy with consideration of social, economic, and environmental effects. Future trigger points will be evaluated and incorporated as more information on planning/modeling is gathered.



Carpinteria Priority Adaptation Strategies Matrix

FIGURE 8-1

Ongoing Programs

Ongoing programs are adaptation strategies that the City has already engaged in and continues to pursue. This includes the Winter Storm Berm Program and the U.S. Army Corps of Engineers (USACE) Storm Damage and Shoreline Protection Feasibility Study (Feasibility Study).

Winter Storm Berm Program

The winter storm berm is a protection device that buffers landward assets from coastal storm damage during the winter storm season. Since 1983, the City has implemented an annual Winter Storm Berm Program to protect beachfront properties along the Carpinteria City Beach from wave action and related flooding during the winter storm season. A sand berm is erected annually and is in place for approximately three months out of the year during the winter storm season, (typically late November until early March the following year), based on storm predictions and beach conditions. Funded by the City and an existing assessment district comprising potentially affected property owners, this ongoing measure reduces the probability of damage to development and infrastructure.

The City-installed seasonal sand berm along the shoreline is in place during the winter season to protect near-shore residences, infrastructure, and Carpinteria City Beach from coastal winter storms.

Historically, large waves generated by Pacific Ocean storms during the winter have caused damage to local beaches and coastal structures. Existing vulnerable buildings include 98 residential parcels in the Beach Neighborhood, as well as public parking and restroom facilities on Ash Avenue. To protect these structures and public infrastructure, every winter the City constructs a seasonal sand berm along the entire City Beach. The seasonal berm is approximately 1,400 feet long. Given an approximate width of 40 feet wide and a height of 12 feet (16 feet above sea level), the berm requires approximately 13,000 cubic yards (cu. yd.) of sand for installation. This material is bulldozed from the upper tidal zone during low tide and placed in the backshore area of the City Beach. The berm is constructed annually prior to the winter storm season and is removed by pushing sand back to the upper tidal zone by Memorial Day the following year (but is often restored at an earlier date). When in place, the berm reduces storm-based erosion of the sandy beach. This in turn maintains a wider sandy beach for recreation and associated economic benefits in the summer season, by minimizing the loss of sand during the storm season.

Table 8-1. Ongoing Adaptation Strategy - Winter Storm Berm Program

Adaptation Strategy	Winter Storm Berm Program		
Implementation Timeline	Permitting: ongoing	Berm Construction: 1 week annually	Beach Restoration (i.e., Berm Removal): 1 week annually
Trigger	On-going since 1983		
Tipping Point	Existing Coastal Flooding & Beach Erosion Hazards		
Potential Resource/Asset Benefits	• Protection of roadways and infrastructure in the Beach Neighborhood • Protection of up to 98 shoreline residential parcels between Ash Avenue and Linden Avenue from storm damage • Protection of recreation resources and public infrastructure from erosion (City Beach, public parking, bike facilities, and restrooms) between Ash Avenue and Linden Avenue • Retain the Citywide economic benefits of beach recreation for the period during which the berm program is effective • Can refortify in emergency storm situations		
Costs & Impacts	• Annual construction, maintenance, and restoration costs ($35,500) • Less effective over time with increasing rates of sea level rise, particularly over 2 feet, at which coastal storms may overtop the berm or result in severe beach erosion • Temporary displacement of available sandy beach during winter while the berm is in place • Impacts to beachside aesthetics while the berm is in place		
Permitting & Coordinating Agencies	CCC, USACE, California Reigional Water Quality Control Board		
Next Steps	• Continue to implement the Winter Storm Berm Program in the near-term until the berm is no longer effective (i.e., continual flooding and overtoping above the typical berm height), or another adaptation measure replaces the need to implement this program (e.g., living shoreline)		

The costs of installation, maintenance, and removal of the berm are borne by the City and beachfront property owners. Assessment District #5, formed by Resolution No. 3061 on December 14, 1992, levies fees on all shoreline properties immediately adjacent to the City beach frontage to help fund these annual costs. Property-specific assessments are based on fixed costs such as permit compliance and biological monitoring, as well as a variable cost based on the percent of City beach shoreline the respective property occupies.

Depending on environmental conditions, the approximate cost of annual berm construction, maintenance, and removal is $35,500. Total District #5 fees were set at $20,656.73 in

January 1997 by a mail ballot and cannot be raised without an affirmative vote of the affected property owners. Therefore, the remainder of the cost, approximately $14,843.27 annually, is contributed to the District by the City.

This berm is not intended to serve as a substitute for private storm protection improvements or flood insurance but can substantially reduce damage. Failure to erect the berm in 1995 led to private property damage exceeding $300,000. Additionally, with sufficient preparation, the City can rebuild and support the existing temporary berm after it experiences large storm events. However, storms can exceed the protection offered by the berm, and the berm is not impervious to being destroyed itself. Though beach front property damage by winter storms with installation of the berm has not been recorded along the City coastline in the past, the possibility remains present even with installation of the berm due to the variability of storms that can occur and potential flooding, wave-attack, and erosion that could occur over time when combined with sea level rise.

USACE Storm Damage and Shoreline Protection Feasibility Study

An independent study is currently being prepared by USACE that could result in a funding opportunity for an adaptation project. As a result of long-term erosion of City beaches (see Section 3.8, *Historic Shoreline Changes and Erosion*), USACE is working with the City to prepare a Storm Damage and Shoreline Protection Feasibility Study that will identify a range of possible measures to address coastal erosion. Analyzing an approximate 0.25-mile section of shoreline between Ash Avenue and Linden Avenue, this Feasibility Study investigates vulnerabilities to structures that may be directly affected by existing shoreline erosion and wave attack during severe storms. Additionally, the Feasibility Study aims to preserve and enhance the biological environment by restoring nesting, feeding, and resting areas for species dependent on sandy beaches.

A reconnaissance study was initially completed in 2007 by United Stated Geological Survey (USGS) to evaluate physical processes and long-term and seasonal changes to the stretch of City beach fronting Sandyland Road (Barnard et al. 2007). The study identified public beach resources and at least 14 residential structures that were under threat from shoreline erosion (City of Carpinteria 2010). The USACE then conducted coastline modeling; however, USACE did not include parameters for anticipated sea level rise. Without any protective measures (including the annual winter storm berm), USACE estimates total damages have a 2018 Net Present Value (NPV) of $21.5 million(USACE 2018). Following this analysis, the USACE narrowed down a final array of alternatives for economic modeling and environmental analysis under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA). Potential alternatives for analysis identified by USACE include:

- Continued implementation of the Winter Storm Berm Program to minimize risk of overtopping;

- Beach nourishment to widen the beach;
- Sand retention measures to increase resident time of sand on the beach;
- Cobbles and other sediment management activities;
- Recreational pier as a sand retention device; or
- Offshore submerged or partially submerged breakwater to dissipate wave energy.

Table 8-2. Ongoing Adaptation Strategy – USACE Feasibility Study

Adaptation Strategy	USACE Feasibility Study		
Implementation Timeline (2007 – est. 2020 for study completion)	Study Completion: additional 2 - 5 years	Permitting and Planning for Identified Project: 3-5 years	Construction/Installation of Identified Project: 1-2 years
Trigger	Construction of the Santa Barbara Harbor, due to the downcoast erosion and loss of sediment supply that occurred after its construction (See Section 3.8)		
Tipping Point	Existing Beach Erosion & Coastal Flooding Hazards		
Potential Resource/Asset Benefits	• Federally funded Feasibility Study that will provide additional information about coastal erosion and potential solutions • In-depth economic, environmental, and logistical analysis of potential erosion mitigation alternatives • Source of federal funding for 65 percent of identified project cost that could be used for an adaptation measure • Potential integration with existing and proposed adaptation measures (e.g., annual winter berm, living shoreline) • Provision of benefits to shoreline, assets, and infrastructure between Ash Avenue and Linden Avenue		
Costs & Impacts	• Requires local funding cost share for Feasibility Study project (approximately $2,700,000) • Requires local funding for 35 percent of identified project cost • Dependent on federal staffing, funding, and implementation schedules		
Permitting & Coordinating Agencies	USACE, USFWS, CCC, CLSC, CDFW, RWQCB, County of Santa Barbara		
Next Steps	• Work with USACE towards completion of the Feasibility Study, including facilitating data sharing and integration of Sea Level Rise Vulnerability Assessment and Adaptation Plan findings • Identify project alternative for implementation under this program in coordination with USACE, with consideration of options included in this Report • Identify funding sources for local cost share		

As noted, selection of the USACE alternatives did not initially consider sea level rise; however, the City has an opportunity to work with USACE and select a project alternative that could both address existing coastal erosion and future sea level rise hazards. This Study is ongoing but relies on available City and federal USACE funds. Federal funding is authorized by the federal Water Resources Development Act and budgeted under the annual USACE work plan budgets. The USACE is currently outlining necessary future steps and identifying anticipated federal funding opportunities. The total budget of the Feasibility Study is estimated to be $5.5 million, with an additional $ 3.1 remaining to be to paid. $1.6 million of this remainder will come from federal funding, and $1.5 million will be paid by local and state sponsors. The City committed $600,000 in December 2017 for this Study (USACE 2018). Following funding, the study would proceed with feasibility modeling and a cost-benefit analysis of potential strategies.

Once an eligible alternative is identified as the project, 65 percent of the cost of a potential adaptation project would be federally funded and the remaining 35 percent would require a local match of funds by the City, regional governmental agencies such as the County Flood Control District, the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON), and/or the State of California (City of Carpinteria 2010). Additionally, sea level rise adaptation planning efforts by the City may represent an in-kind contribution toward the local cost share, depending on the utility of the information within this Report to the Feasibility Study.

As a next step, the City intends to closely coordinate with USACE to integrate relevant findings of this Report into the Feasibility Study. Inclusion of this Report's sea level rise modeling data and City-identified adaptation priorities (e.g., a living shoreline project), would provide an up-to-date framework for continued USACE investigations and project implementation, and could significantly offset ultimate project costs.

Pending Projects

The following programs under BEACON are pending but have not yet been initiated. These projects and programs represent a valuable opportunity for the City to begin early coordination and/or collaboration with BEACON to optimize protection of City resources from coastal hazards. These projects are pending additional funding support through agencies and sources such as the Coastal Conservancy, Ocean Protection Council (OPC), or other grant opportunities.

BEACON - Coastal Regional Sediment Management Plan Update

The Coastal Regional Sediment Management Plan (CRSMP), adopted by BEACON in 2009, includes information on sand supplied to the Santa Barbara Littoral Cell between Point Conception and Point Mugu, including an understanding of erosion hot spots and shoreline protection (see also Section 2.4, *Other Regional Sea Level Rise Planning Efforts*). The CRSMP recommends sediment management strategies in the region, including development of an opportunistic sand placement program, sand rights policies, and changes in regional governance structure that would support better use of coastal sediments. Additionally, the

CRSMP outlines a blueprint for BEACON investments in studies, policies, and capital projects for the next 20 years.

Table 8-3. Pending Adaptation Strategies - BEACON Projects

Adaptation Strategy	BEACON Sediment Management Projects	
Implementation Timeline - Update Coastal Regional Sediment Management Plan (CRSMP)	Technical Study: 1-2 years	Plan Update: 1-2 years
Implementation Timeline - Regional Sediment Management Program	Program Development: 1-2 years	Adoption by Member Agencies: 1-2 years
Trigger	Near-term, based on beach width distance as determined through the CLUP/General PLan Update process	
Tipping Point	Existing Beach Erosion & Coastal Flooding (approximately 0 feet sea level rise)	
Potential Resource/Asset Benefits	• Provision of nourishment opportunities will result in wider beaches and recreational benefits • Provision of beach buffer from coastal storms and protection of shoreline development • Framework for enhanced regional coordination between jurisdictions	
Costs & Impacts	• Multi-agency determination of programs, intended outcomes, coordination, and permitting • Less effective over time with increasing rates of sea level rise	
Permitting & Coordinating Agencies	BEACON member agencies (Cities of Carpinteria, Goleta, Oxnard, Port Hueneme, Ventura, Santa Barbara; Counties of Santa Barbara and Ventura), CCC, USACE, USFWS, CLSC, CDFW, RWQCB	
Next Steps	• Share technical information from Sea Level Rise Vulnerability Assessment and Adaptation Plan with BEACON and member agencies • Work with BEACON to identify funding sources and permitting path • Support BEACON efforts to establish and implement regional programs	

BEACON plans to update the 2009 CRSMP to address several important issues. First, the CRSMP does not include substantive analysis of potential sea level rise and other impacts of climate change that would affect regional sediment distribution. Additionally, the CRSMP lacks specific implementation goals for development of a regional opportunistic sediment use program, as further described below. Finally, the CRSMP does not sufficiently assess the importance of cobbles and muds in regional sediment management. Sediment debris basins in Carpinteria area creeks cause large coarse-grained sediments to drop out before reaching local beaches. However, these materials provide substantial storm buffering capabilities. Opportunities to use debris basin clean outs to improve beach and dune resiliency needs further evaluation, including examination of sediment fluxes and other conditions that contribute sediment to the coast.

BEACON –Regional Sediment Management Program

As identified above, BEACON is working to develop a regional opportunistic sediment placement program as part of the intended update to the CRSMP. The program would focus on ensuring sediment reaches local beaches through the natural sediment transport process. This program would also establish a program of pre-permitted coastal locations (i.e., receiver sites) within the BEACON region where materials from sediment basins could be opportunistically deposited to augment existing sand supplies.

Proposed Adaptation Strategies

Proposed adaptation strategies are additional measures the City may choose to implement based on known vulnerabilities identified within this Report, dialogue with the community, and coordination with local and state agencies. These strategies are consistent with state guidelines on adaptation and the City's adaptation planning principles developed with input from the community (refer to Section 8.1, *Planning Principles*). Project-level planning, technical study, and coordination with approving agencies would be required for each strategy to further develop and implement the measure. In addition, some of the below strategies may be implemented through or assisted by the above USACE or BEACON planning efforts and programs. This Report also acknowledges that sea level rise science and adaptation practices are dynamic; the City will need to monitor the rate of rising seas and associated coastal hazards and reevaluate adaptation strategies and triggers in the future based on evolving science and technology.

Living Shoreline

A living shoreline is a shoreline management system designed to restore or protect natural shoreline ecosystems through the use of natural resource elements and, if appropriate, manmade elements (State Coastal Conservancy 2017). Improving shoreline resiliency to reduce hazards from coastal flooding and erosion from large storm events may include development of a stabilized (e.g., cobble-based) sand dune complex that would function as a "living shoreline", which would be historic to this region and vegetated with local, native coastal species. As described in Section 3.4, the City once supported a much more extensive wetland and dune system, with sand dunes extending from the mouth of Carpinteria Salt Marsh to the tar pits in the State Beach Park (Grossinger et. al. 2011). Historically, the City's western one mile of shoreline supported a large dune field which buffered low-lying areas from wave attack and flooding. The former dune system has been eroded over the last 90 years, largely due to human impacts (or influences), and the dune system has not recovered.

Table 8-4. Proposed Adaptation Strategy - Living Shoreline

Adaptation Strategy	Living Shoreline		
Implementation Timeline[1]	Planning: 1-2 years	Permitting: 2-3 years	Construction: 1 year
Trigger	Near-term, based on storm frequency and intensity, based on comparisons to historic trends		
Tipping Point	Beach Erosion & Coastal Flooding Hazards (approximately 1 foot sea level rise)		
Potential Resource/Asset Benefits	• Protection of roadways and infrastructure in the Beach Neighborhood • Protection of shoreline residences and short-term rentals between Ash Avenue and Linden Avenue • Protection of recreational resources (Carpinteria State Beach, Linden Field, trails) • Protection of public infrastructure including roadways, public parking, bike facilities, and public restrooms • Restoration of sensitive coastal habitat native to the area • Retention of economic benefits associated with beach recreation and State Beach		
Costs & Impacts	• Construction costs (>$2.2 million[1]) • Moderate ongoing maintenance costs required (roughly $100,000 per year, though costs increase with time) • Less effective over time with increasing rates of sea level rise, particularly as sea level rise nears 5 feet, which may result in more frequent overtopping of an installed dune system • Potential loss of private views		
Permitting & Coordinating Agencies	USACE, USFWS, CCC, Coastal State Lands Commission (CSLC), California State Parks, CDFW, RWQCB, Caltrans		
Next Steps	• Secure funding sources from grants • Modeling and additional study for concept design development • Coordinate with agencies to develop concept design and implementation plan • Public outreach and selection of alternatives		

[1] *Based on Cardiff Beach Living Shoreline in Encinitas, CA. Source: State Coastal Conservancy 2018.*

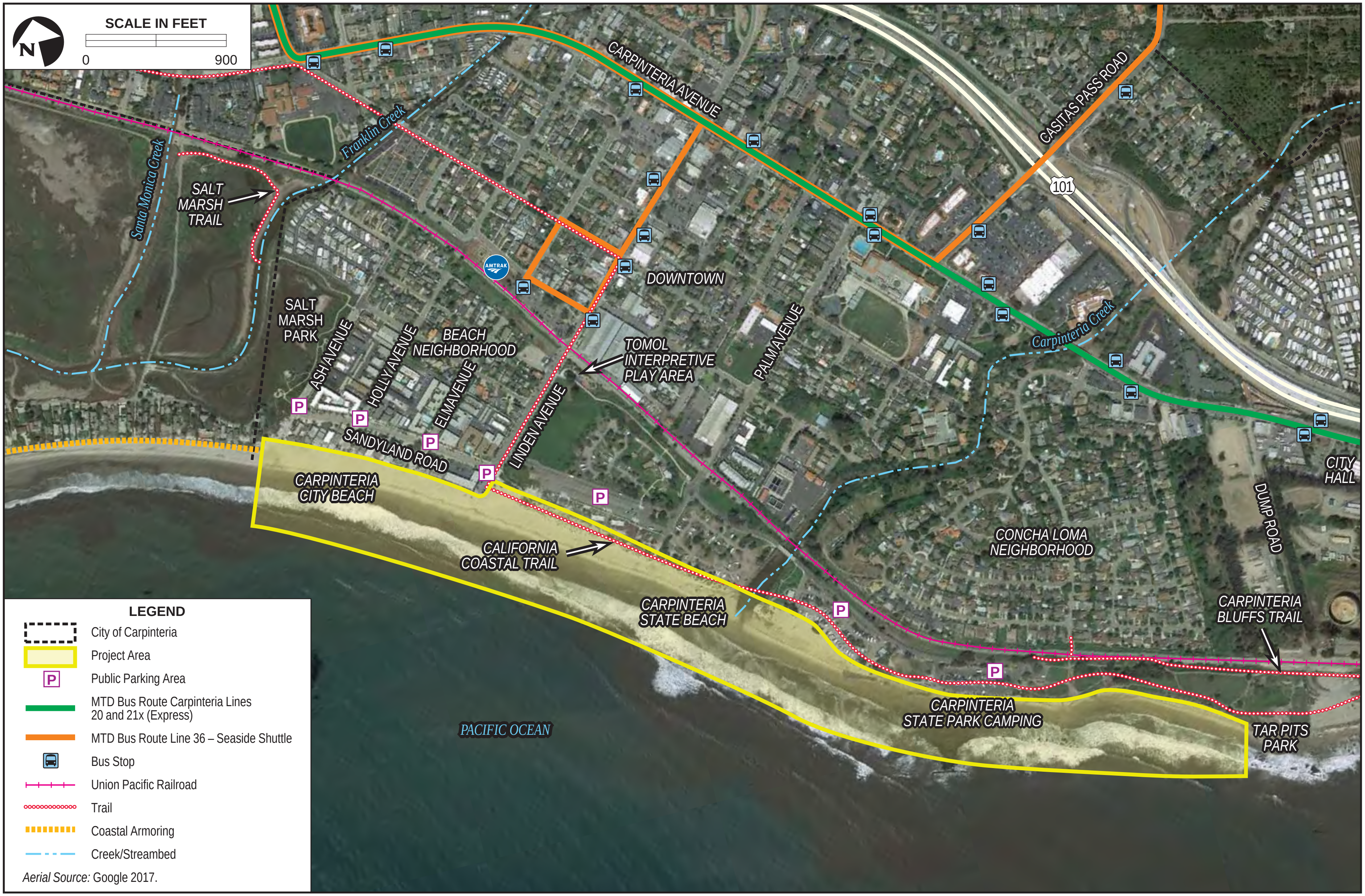
Carpinteria State Beach includes an existing dune system that is approximately five acres, developed by State Parks and integrated into the Park's 2009 Carpinteria State Beach Interpretation Master Plan. This complex was installed in response to dynamic sand movements during high wind events, which frequently resulted in costly maintenance for State Parks, to prevent future damages to the Park and parking lot. The success of this restoration project, along with the City's existing winter storm berm program, provide evidence of the efficacy of a dune system to protect land uses in the Beach Neighborhood and Carpinteria State Beach.

Reestablishment of the natural dune system is an effective sea level rise adaptation strategy that has been implemented in other jurisdictions facing similar coastal hazard threats within similar southern California community settings (e.g., at Cardiff Beach in the City of Encinitas and at Surfer's Point in the City of Ventura). Dune systems have been documented to reduce coastal storm damage, buffering the shoreline from wave attack during extreme storm events while also providing coastal habitat benefits.

A living shoreline would serve as a green protection strategy to address vulnerable infrastructure, resources, and assets within the Beach Neighborhood and Carpinteria State Beach, including residences, Linden Field, campgrounds, roadways, bikeways, pedestrian facilities, public parking, businesses within the Downtown, public trails, and utility infrastructure. The City contains a one-mile-long stretch of sandy beach between Ash Avenue and Tar Pits Park where a living shoreline could be established (Figure 8-2). This concept may include a cobble core persistent dune system or other engineering alternatives consistent with “living shoreline” principles (Figure 8-3). The City recommends engineering investigations that rely upon local sources of material to the maximum extent feasible (e.g., constructed with cobble acquired from Carpinteria area creeks and/or the County Flood Control District). This adaptation strategy would also require a robust monitoring program, including pre-project monitoring to inform the design and to serve as baseline for post-implementation monitoring. As demonstrated by erosion of dunes at Surfers Point in Ventura or the Devereux Slough in Goleta during major storm events (e.g., El Niño events), a living shoreline would require periodic maintenance. The need for maintenance and reconstruction would likely increase over time with sea level rise.

To implement a living shoreline, the City would need to coordinate with federal, state, and local agencies to acquire necessary permits, including State Parks for any action within or immediately adjacent to Carpinteria State Beach (refer to Table 8-4). Policies supporting this approach and incorporated into the CLUP/General Plan Update would allow the City to facilitate a living shoreline as an adaptation strategy.

Associated costs for a vegetated dune system can widely vary, depending on the existing setting of the system. For instance, new dune construction with imported sand and costs from the design process has been estimated at approximately $100,000 (2018) per acre, which would result in roughly $1 million for the 10 acres of Carpinteria shoreline (Natural Resources Agency 2018). The City of Encinitas, in partnership with California Department of Parks and Recreation, approved and has commenced construction of a 2,900-foot-long dune restoration project in Cardiff State Beach in October 2018, which will cover over 9 acres of beach. The project cost is approximately $2.2 million (roughly $200,000 per acre), or approximately double the cost estimated above (State Coastal Conservancy 2018). Carpinteria City Beach and State Beach would have space to accommodate a living shoreline of similar size (9 acres or more).



Potential Study Area for a Living Shoreline in Carpinteria

FIGURE 8-2

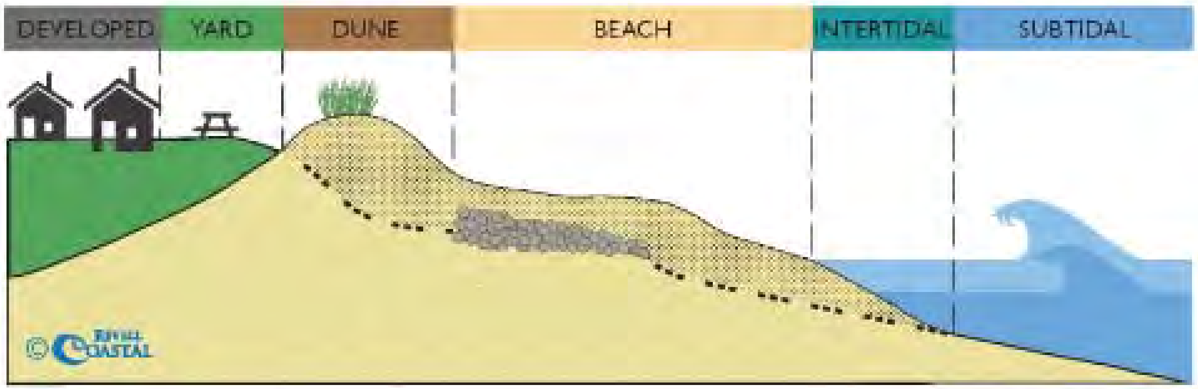


Figure 8-3. *Example of a dune restoration/living shoreline concept. A cobble-based, vegetated dune complex system is a green and soft shoreline protection approach that would serve as a barrier to coastal flooding and erosion.*

Annual maintenance costs of a dune system is approximately $10,000 (2018) per acre per year, not including the cost of labor for dune maintenance (Natural Resources Agency 2018). If Carpinteria were to implement a vegetated dune system covering 10 acres, this would result in a cost estimate of approximately $100,000 per year for maintenance of a living shoreline. As with other adaptation strategies, costs associated with the establishment and maintenance of these systems would likely increase and would be influenced by the rate of sea level rise.

Dune concept for the Cardiff State Beach living shoreline project, which would utilize dunes instead of rock revetments to ensure protection for the adjacent roadways. Photo Source: California Coastal Conservancy.

Regarding project implementation funding, living shoreline efforts would be eligible for USACE funds following the Feasibility Study. As such, construction of a dune system or similar living shoreline design is an eligible project under a USACE Project Partnership Agreement. In addition, the City has applied for grant funding under the 2019-2020 Caltrans Adaptation Planning grant to further the planning of this adaptation measure. Additional grant opportunities could be obtained for both planning and implementation efforts, including grants from the California Department of Boating and Waterways, the California Coastal Conservancy, and other entities.

Ultimately, the living shoreline adaptation strategy would partially address vulnerabilities to the 43 acres of land area within the City currently vulnerable to existing beach erosion and coastal flooding. This includes an initial 79 residential parcels and 19 structures currently at risk, in addition to 42 open space and recreational parcels such as the State

Beach and campgrounds, and 3 public facility parcels currently at risk. These properties could be subject to private property damages or loss equating to over $8.5 million in the City (2017 value) (refer to Section 6.1, *Land Use and Structures*). These damages are likely to escalate with sea level rise. As a next step, the living shoreline concept requires additional study; as is the nature of dune systems, this protection measure has the potential to be dynamic in the long term and may be adjusted to optimize effectiveness.

Sediment Management

Sediment is nature's adaptation resource and its delivery to the coastal beaches, dunes, and estuaries is instrumental in habitat maintenance and natural defenses. Regional sediment management can augment existing sand and cobble supply to widen beaches and supplement naturally occurring sediment inventories. Wide beaches provide natural defenses against wave attack by dissipating wave energy and buffering the bluffs, dunes, and land uses from erosion. The maintenance of a wide and sandy beach, which can result from management of sediment transport as has naturally occurred historically, has widespread economic and recreational benefits for nearby communities.

The Carpinteria City and State Beach once housed cobbles, which slowed erosion, particularly during the winter season's higher intensity storms and associated wave action.

In the early 1970s, USACE constructed debris basins in the Santa Monica Creek and Carpinteria Creek watersheds to prevent alluvial flooding of the Carpinteria community below and protect floodprone areas downstream (Santa Barbara County Flood Control and Water Conservation District 2017). However, this has created an unintended consequence of intercepting and exporting coastal sediment from the watershed instead of allowing it to flow its natural course to the ocean, thereby replenishing the shoreline. Fifty years after the debris basin installations in Carpinteria, the loss of natural beach cobble quantities is visible. A revised sediment management plan, in coordination with BEACON, to replenish the City's shoreline with currently exported sediment would help to re-nourish the beach and improve coastal resiliency. Adaptation strategies that export sediment from the watershed to sandy beaches to mimic historical natural processes would go a long way to improve coastline resiliency within existing funding levels.

Table 8-5. Proposed Adaptation Strategy - Sediment Management

Adaptation Strategy	Sediment Management		
Implementation Timeline	Planning: 1-2 years	Permitting: 1-2 years	Implementation: Ongoing - 20+ years
Trigger	Near-term, based on a beach width distance, based on comparisons to historic trends		
Tipping Point	Beach Erosion & Coastal Flooding Hazards (approximately 1 foot sea level rise)		
Potential Resource/Asset Benefits	• Provides a native source of beach nourishment • Increases and retains the quantity and quality of sand that is on the beach, potentially increasing the width of the beach • Complements other adaptation strategies including the Living Shoreline, by maintaining beach nourishment • Reduces the rate of sandy beach erosion • Enhances recreational value		
Costs & Impacts	• High ongoing costs (approximately $743,000 to $6 million annually) • Less effective over time with increasing rates of sea level rise, particularly as higher waves and larger storms have the potential to result in greater erosion rates • Sediment transport via truck trips may adversely affect City road networks and create short-term land use conflicts (e.g., noise, recreational access, commercial and residential activities) • Nourishment activities may have adverse impact on existing habitat with disruptive equipment and possible burial • Ecosystem recovery may be inhibited if fill material is too fine or coarse compared to native sand		
Permitting & Coordinating Agencies	USACE, USFWS, CCC, State Parks, CSLC, Caltrans, CDFW, County of Santa Barbara, BEACON member agencies		
Next Steps	• Secure funding sources from grants • Coordination with federal, state, and local agencies • Public outreach		

Development of a regional opportunistic sediment placement program for cobbles and sand with the designation of specific receiver sites (e.g., at Ash Avenue and upcoast at Santa Claus Lane) is a high priority for the City in coordination with other agencies, including the County and BEACON. Regional sediment management is currently described in the BEACON CRSMP and, as noted, updates to the CRSMP to address sea level rise are currently being pursued (refer to *Pending Projects* above). Partnerships with the County Flood Control District and BEACON would be required to ensure successful regional management, including the need for a consistent sustainable funding source and regulatory permit requirements. Changing the approach to local debris basin cleanout activities and the deposition of these materials within the watershed should be investigated, as well as transport to Carpinteria Beach or other adjacent coastlines, depending on the extent of sediment transport, sediment quality and quantity, and potential regional benefits. Consideration of mud placements in the Carpinteria Salt Marsh should also be investigated to increase sediment discharge from the Marsh that would ultimately elevate the marsh to keep pace with sea level rise and result in increased sediment transport along the coastline.

There are several components to a successful shoreline sediment management program that would benefit the City. This could include the following:

- Work with BEACON to update the CRSMP that includes sea level rise and addresses not only sand, but also cobbles and muds.
- Develop a flexible regional opportunistic sediment placement program that identifies and permits specific placement or receiver locations in and upcoast of the City for appropriate sediment sizes.
- Streamline regulatory approvals with extended permit duration (e.g., 20 years).
- Regulate existing practices that export debris basin sediments out of the watershed.
- Create sustainable local, state, and federal funding programs.

Mechanical sand nourishment, as opposed to natural sand nourishment transported via creek watersheds, is a coastline protection strategy; however, this approach can be costly. Sand-only nourishment projects can require millions of dollars in funding annually with a permit process and regulatory requirements sometimes constituting a substantial portion of project costs. Following the investment of time and resources, large wave events can strip beaches of all past nourishment and can require full replacement of beach nourishment. Additionally, the time at which a storm occurs over the studied span of sea level rise, directly influences the volume of sand needed for replenishment; a storm that occurs at approximately 1 foot of sea level rise would displace less sand and have a smaller re-nourishment cost than a storm event occurring at approximately 5 feet of rise. Finally, sediment nourishment becomes less effective with higher rates of sea level rise due to higher wave action and the potential for higher rates of erosion, particularly during the winter season.

Though sand retention and wave action are variable by beach location and orientation, an illustrative ongoing sediment management program is occurring at Goleta Beach County Park, a 0.74-mile-long beach approximately 20 miles west of the City. Goleta Beach has been subject to periodic nourishment as a permitted sediment receiver site and annual monitoring by the County since 2003. This program helps to maintain the beach's width, which ranged from 100 to 200 feet wide since monitoring commenced in 2003. This regular nourishment ceased in 2011 when regional drought conditions dramatically reduced the supply of sediment requiring disposal by County Flood Control District. Between 2003 and 2011, approximately 533,000 cubic yards of sand sourced from County Flood Control District was deposited on the beach by mechanical methods, with nourishment averaging nearly 55,000 cubic yards per year. This is approximately 14,100 cubic yards of sand required per 1,000 linear feet of beach. Applying these values to the approximate 1.0-mile length of Carpinteria's beaches, this suggests that maintenance of Carpinteria's beaches via sand nourishment would require approximately 74,300 cubic yards (or 56,806 cubic meters) of sand for annual beach nourishment. The cost of annual nourishment has been estimated at approximately $10 (2010) per cubic meter ($7.64 per cubic yard) for Carpinteria (Department of Boating and Waterways & San Francisco State University 2010), meaning that this strategy would cost approximately $568,000 per year under current conditions. When accounting for sea level rise, nourishment volumes required to keep pace with sea level rise intensely increase, and may require 2 to 8 times the volume of sand and sediment depending on the height of sea level rise (Flick & Ewing 2009). If Carpinteria's coastline required approximately 8 times the amount of sand coverage to ensure adequate nourishment under a high sea level rise scenario, this would necessitate approximately 594,600 cubic yards of sand annually, with an associated cost of nearly 6 million dollars per year for nourishment. This assumes that adequate sand would be available and associated costs do not increase.

Further, permit processes can take several years and the short duration of permits (e.g., 10 years) can require expensive repetitious permit processes for similar projects. Sustainable funding, longer-term permit durations (e.g., 20-year program-level permits), and increased regulatory flexibility should be explored if beach nourishment is to play a major role in sea level rise adaptation.

Similar to the living shoreline adaptation strategy, the sediment management adaptation strategy would reduce vulnerabilities to the 43 acres of land area within the City currently vulnerable to existing beach erosion and coastal flooding and may partially assist to protect portions of the 170 acres projected to be affected by approximately 5 feet of sea level rise. However, as noted, the effectiveness of sediment management will ultimately wane as sea levels rise.

Sand Retention Structures

Sand retention structures can take many forms. The most common is called a groin, a rigid structure built from an ocean shore that interrupts the movement of sediment downcoast. Locally, a groin is in place in neighboring Ventura along the Pierpont Neighborhood. Other types of sand retention structures can include a recreational pier with a dense or impermeable set of support piles near the shoreline. Another form of sand retention is known as headland control in which a headland (e.g., near Tar Pits Park) could be extended seaward to limit sand movement. Larger retention structures may need to have ramps or other public accessways to maintain lateral coastal access. These types of structures would also require potentially complex engineering, permitting, and discretionary review, particularly related to consistency with the Coastal Act and local coastal policies.

Additionally, other structures have sand retention value while reducing the physical disturbance/presence of the structure and associated costs. As described below, these options include a cross-shore structure or headway of rock or cobble that limits sand movement downcoast and an offshore breakwater or reef that retains sand in-place by reducing wave energy before it reaches the beach. Sand retention structures could reduce vulnerabilities to the 546 parcels within the City that would be vulnerable to existing beach erosion and coastal flooding with approximately 2 feet of sea level rise and 256 associated structures and may partially assist to protect portions of the 170 acres projected to be affected by approximately 5 feet of sea level rise. However, as noted, the effectiveness of such structures would ultimately decrease as sea level rises.

Table 8-6. Proposed Adaptation Strategy - Sand Retention Structures

<table>
<tr><th>Adaptation Strategy</th><th colspan="3">Sand Retention Structures</th></tr>
<tr><td>Implementation Timeline</td><td>Planning: 3-4 years</td><td>Permitting: 4-5 years</td><td>Construction: 3-8 years</td></tr>
<tr><td>Trigger</td><td colspan="3">Near- to Mid-term, based on sea level rise elevation and beach width distance, as indicated by a change from historic trends</td></tr>
<tr><td>Tipping Point</td><td colspan="3">• Beach Erosion & Coastal Flooding (approximately 2 feet sea level rise)</td></tr>
<tr><td>Potential Resource/Asset Benefits</td><td colspan="3">• Physically maintain existing land area with associated infrastructure
• Capture sand drift within retention structures
• Prevent loss of sand and associated habitats along shoreline
• Potentially increase effectiveness of winter berm or living shoreline improvements, depending on placement
• Potentially provide recreational opportunities along physical structures</td></tr>
<tr><td>Costs & Impacts</td><td colspan="3">• Construction costs
• High ongoing maintenance costs required
• Less effective over time with increasing rates of sea level rise, unless the installed structures are modified or heightened over time
• Potential loss or alteration of public views
• Disruption of natural sand drift along coastline
• Alteration to wave energy, potential associated loss of coastal access and recreational opportunities (e.g., surfing)</td></tr>
<tr><td>Permitting & Coordinating Agencies</td><td colspan="3">California State Parks, CCC, CSLC, County of Santa Barbara, USFWS, CDFW</td></tr>
<tr><td>Next Steps</td><td colspan="3">• Coordination with state and adjacent jurisdictions on project feasibility
• Modeling, engineering, and additional environmental investigations required
• Extensive public outreach
• Identify and secure funding sources from public agencies or grants</td></tr>
</table>

Cross-shore Sand Retention Structures/Headways

A cross-shore rock revetment has been implemented in Plum Island, Massachusetts, to retain sand and protect vulnerable neighborhoods from beach erosion. Photo Source: City of Newburyport.

Sediment transport along the Carpinteria shoreline is predominantly from west to east. In areas with dominant along coast sediment transport, cross-shore sand retention structures tend to trap sand upcoast of the retention structure in what is called a "fillet" and are often used to widen beaches and provide more natural defenses to coastal wave hazards. While a stone revetment may provide more suitable habitat for shorebirds and other coastline species, cobble can be utilized to provide a stable base for dune placement and maintain public access to the beach, as described above for *Living Shoreline* (Komar & Allan 2010). Both rock revetments and cobble are appropriate materials to dissipate wave energy, though cobble can be more effective at reducing sand placement loss (Komar & Allan 2010). Though these protection options may be challenging to design consistent with the Coastal Act and local coastal policies, they may be options to consider for sand and sediment retention along the City's shoreline.

Specific design considerations must be examined to avoid downcoast impacts resulting from the interruption of sand transport caused by the cross-shore structure. This typically involves beach nourishment both up and down drift of the retention structure to prevent loss of sand to downcoast beaches, emphasizing the need for regional coordination for such projects. As these types of projects result in potential regional changes to sediment, adjacent jurisdictions would need to be involved in the process; extensive outreach to these jurisdictions would be required along with a technical feasibility study to determine cost-benefits, structural design, funding, and processing requirements. The process would also involve agency permitting and environmental review.

Offshore Breakwater/Reefs

Erosion and coastal flooding are often caused by large waves running up the beach. If the wave energy can be reduced before it reaches the coast, then less beach erosion and flooding would occur. Carpinteria Reef already provides some natural defense in reducing wave energy by causing some waves to break farther offshore. However, as an adaptation strategy, engineered offshore structures could further dissipate wave energy. Offshore structures can reduce wave energy as it reaches the shore to reduce sand movement from the beach and, as a result, slow sand transport along the shoreline, acting as retention structures. The most common form of offshore structure is an offshore breakwater (e.g., Ventura or Channel

Islands Harbor), or a multi-purpose reef which may provide shoreline protection, recreational benefits and habitat benefits (e.g., Natural Shoreline Infrastructure oyster reef projects in San Francisco Bay) (The Nature Conservancy 2017). These structures can be designed to mimic nature-based solutions that are made of natural material (rock) and can replicate natural rocky structures offshore. Regarding offshore artificial reefs, both natural (e.g., recycled shell, gravel) and manmade (e.g., concrete, aggregates) materials can be used to construct artificial reef elements. Prior Natural Shoreline Infrastructure oyster reef projects in San Francisco Bay have used concrete "Reef Ball" installations, which cost approximately $500 to $550 (2018) per linear foot in a direct line, and between $700 to $1,000 (2018) per linear foot when arranged to accommodate a denser installation pattern (California Natural Resources Agency 2018). These options would similarly require initial outreach with adjacent jurisdictions, followed by an extensive feasibility study to determine the permit path and potential regional impacts.

Storm Drain Improvements

Formerly natural bottom Franklin Creek has been channelized within a concrete box channel to convey stormwater runoff to Carpinteria Salt Marsh. When combined with storm surges, Franklin Creek can contribute to localized flooding.

Within the City, the Franklin, Santa Monica, Carpinteria Creeks, and 316 storm drain inlets and outfalls that discharge to the nearest body of water all rely upon gravity flow for storm water drainage. A major infrastructure challenge associated with sea level rise is the need for efficient rapid drainage of storm water; however, the existing storm drain system lacks the elevation requirements necessary for a gravity flow system to accommodate current and projected storm events. Additionally, storm water is not diverted to the Carpinteria Waste Water Treatment Plant (WWTP) for treatment and no pumps exist to convey storm water. Within the Beach Neighborhood, some storm drains are located down-gradient from outfall locations, at a lower elevation than necessary for gravity flow, which is a problem that becomes exacerbated during high tide storm events when outfalls can be inundated. Presently, the existing infrastructure is not always able to accommodate all storm water flow, which can flood portions of the Beach Neighborhood and Downtown. As sea levels rise, greater portions of the system may not drain during high tides and during more of the tide cycle, which in turn may increase storm water flood depths and frequency. Culverts and pipes may also create back flows of ocean water into the neighborhoods.

Table 8-7. Proposed Adaptation Strategy - Storm Drain Improvements

Adaptation Strategy	Storm Drain Improvements		
Implementation Timeline	Planning: 3-4 years	Permitting: 4-5 years	Construction: 2-10 years
Trigger	Near- to Mid-term, based on sea level rise elevation		
Tipping Point	Coastal flooding & tidal inundation (approximately 2 feet sea level rise)		
Potential Resource/Asset Benefits	• Accommodate stormwater and inundation • Remove storm water from low-lying areas during rain events, and from future tidal inundation • Reduces the duration of flooding during storm water or tidal events • Can be relatively adaptable to higher volumes of water during pump replacements		
Costs & Impacts	• Construction/replacement costs (up to $4 million) • High ongoing maintenance costs required, and frequent maintenance checks to ensure operational reliability during storm or tidal inundation events • Requires reliable energy to operate during events		
Permitting & Coordinating Agencies	County Flood Control District, CCC, CSLC, Caltrans		
Next Steps	• Establish a Citywide Capital Improvement Program (CIP) to incorporate "Green Street" and storm water infrastructure in public right of way improvement projects to increase permeable surfaces and support improved drainage/storm water runoff/infiltration through the City • Evaluate the need to replace existing culverts that may contribute to coastal hazards • Investigate the use of pumps to move water out of areas affected by future tidal inundation areas • Public outreach • Secure construction and operational funding sources (e.g., assessment district, public agencies, etc.)		

The City recommends investigation of the use of storm water pumps and/or lift stations (pumps) to move water out of the Beach Neighborhood. Investigation should be focused along inland portions of Ash Avenue and Linden Field, which experience tidal inundation with areas of ponded flood waters from rainfall event storm water runoff. As tidal inundation increases with sea level rise, even without heavy rainfall or runoff events, the use of pumps to move water out of the lower-elevation areas could be investigated. The use of pumps is moderately adaptable, as the pumping capacity could be increased or improved over time when the pumps need to be replaced. As the necessary volume of water to be pumped increases, operational and maintenance costs would likely escalate over time. Additional challenges for the operation of storm water pump systems can include accommodating the large amounts of fibrous material and solids that often accompany storm water.

Accommodation for storm drain improvements could be integrated into the City's Capital Improvements Program (CIP). The action item would have the intent of improving storm water runoff, reducing tidal inundation, and accommodating larger volumes of storm or tidal water that have the potential to inundate vulnerable areas of the City. The range of options for consideration under the CIP action item should also include potential tide gates, mud flaps, and creek alterations that could be utilized as preventative measures before storm water or tidal effects can reach the storm drain systems (e.g., inlets, outfalls).

For the City, the storm water infrastructure that is vulnerable includes approximately 6 outlets, 3 outfalls, and 1.0-mile of storm drains, which would likely require a moderately sized storm water infrastructure installation. Examination of precedent storm water infrastructure projects that have included the installation or replacement of storm water pumps, lift stations, and associated maintenance results in a variety of associated costs. The installation of a comparative moderate size pump or lift station systems can range from $3 to $4 million, with replacement projects estimated at $100,000 to $3 million (California Division of Financial Assistance 2011; City of Huntington Beach 2018).

Coastal Adaptation Overlay

Overlay zoning is a regulatory tool that places a special zone district over an existing base zone with additional regulations and incentives. The overlay zone identifies special provisions in addition to or instead of the base zone given special circumstances to promote planning for orderly development and to provide protection of the public's health, safety, and general welfare.

Consistent with the Sea Level Rise Policy Guidance (CCC 2018), a Coastal Adaptation Overlay could provide a flexible ongoing and long-term strategy for the City to address land use and infrastructure vulnerabilities that could become at risk from coastal hazards affected by sea level rise in the future. Currently, other types of hazard overlay zones already exist within the City, such as FEMA floodplain management zones, which serve to reduce potential risks to development and infrastructure within the hazard zone. The Coastal Adaptation Overlay, in the near term, could increase awareness of potential hazards through real estate disclosures, provide for specific considerations of those hazards in land use and infrastructure planning processes. Based on the projected time of exposure, siting and construction standards may be applied including, but not limited to, increased setbacks, relaxed building heights, limitations on habitable first floors, and use of flexible construction methods (e.g. movable foundations) based upon site specific technical studies. Over time additional regulations could be implemented as the City determines appropriate responses to hazard avoidance. In the long term, the Coastal Adaptation Overlay could help inform future expectations for coastal development located in geographic areas at risk of coastal hazards and sea level rise.

Implementation of a Coastal Adaptation Overlay Zone could address potential risks to private property, reduce liability for the City, and accomplish multiple adaptation objectives. The purpose of the Coastal Adaptation Overlay Zone could be to minimize risks to life and property and manage and protect important resources and services from the adverse effects of sea level rise. For example, an overlay zone would define the nature, intensity, scale, uses, and location of suitable development within projected hazard areas. An important aspect of this overlay is that it may be able to provide more flexibility in design and/or use than is currently permitted by the base zone regulations. Standards for increased heights or mixed uses could also be incorporated into the overlay zone to respond to changing sea level rise conditions. As determined necessary and appropriate, the Coastal Adaptation Overlay Zone could also provide a framework to transition at-risk development away from coastal hazards and/or could implement the concepts of managed retreat over time, by including standards for gradual relocation of development away from the increasingly hazardous surf and coastal flooding areas.

Table 8-8. Proposed Adaptation Strategy - Coastal Adaptation Overlay Zone

Adaptation Strategy	Coastal Adaptation Overlay Zone		
Implementation Timeline	Planning: 1-2 years	Adoption: 2-3 years	Implementation: 30+ years
Trigger	Near-term, based on sea level rise elevation and lead time for adoption and implementation		
Tipping Point	Erosion & Coastal Flooding Hazards (approximately 2 feet sea level rise)		
Potential Resource/Asset Benefits	• Minimizes risks to life and property • Allow landowners` to redevelop residential properties in a way that minimizes damage from potential coastal hazards • Informs the community about projected hazards • Minimizes "coastal squeeze"1 and the loss of public beach		
Costs & Impacts	• Private costs of property damage and repairs • Over time, potential loss in property taxes and TOT • In the long term, potential loss of housing and short-term rentals in the Beach Neighborhood		
Permitting & Coordinating Agencies	CCC, State Parks, Special Districts (Carpinteria School District)		
Next Steps	• Monitor coastal flooding frequency and sea level rise elevation • Public workshops to distrubite information and provide input • Establish overlay zone based on projected coastal hazard mapping and best available science • Develop a Repetitive Loss Program consistent with CCC Residential Adaptation Policy Guidance (2018) • Adopt an ordinance including standards and procures that apply to the overlay • Consider integration with assessment district for reliant services wtihin the overlay zone • Integrate program framework into future cycles of Plan updates		

[1] *Coastal squeeze = loss of the beach due to the migration of the mean high tideline and fixed development that prevents the migration of the beach and intertidal area.*

The boundaries of a Coastal Adaptation Overlay Zone would correspond to best available science of projections of hazards. In addition, the boundaries of the Coastal Adaptation Overlay Zone should be reviewed periodically (e.g., every 5 to 10 years) to incorporate emerging scientific understanding of sea level rise and coastal hazards, as well as regional approaches to adaptation planning. Examples of adaptation strategies that may be explored in the future could include overwater or floating structures. Ultimately, the Coastal Adaptation Overlay Zone would address vulnerabilities to the 380 acres and 23 percent of land area within the City projected to be vulnerable to coastal hazards with approximately 5 feet of sea level rise. This includes 769 residential parcels, 20 commercial parcels, and 10 industrial parcels. These properties could be subject to private property damages or loss equating to over $346 million (refer to Section 6.1, *Land Use and Structures*).

The Coastal Adaptation Overlay Zone would define policy considerations and establish required processes triggered by actions. Such requirements may include:

- Provision of a Notice to Property Owner at the time of transfer of real property to future buyers within the Coastal Adaptation Overlay Zone of coastal hazard related development requirements. Such requirements could include, but are not limited to, building coverage, height, raised floors, or other adopted strategies. This disclosure would also inform interested buyers of potential hazards (e.g., erosion, flooding, inundation, possible intrusion onto public trust lands, etc.) as a result of climate-induced impacts, such as sea level rise.
- Submittal of site-specific Coastal Hazard and Sea Level Rise reports as part of a Coastal Development Permit application. The reports would evaluate specific risks for proposed structural development or for exterior expansions of habitable space in existing development, identify design requirements to ensure compliance with health and safety codes, and estimate the life expectancy of the development.
- Authority to implement necessary development requirements (e.g., increased base floor elevations, building heights, development setbacks, use of perimeter foundations, etc.) within the Coastal Overlay Zone would be based on findings of the Coastal Hazard and Sea Level Rise reports and/or compliance with planning and building codes for new structural development, including additions to habitable space.
- An indemnification agreement between the City and prospective applicants acknowledging coastal hazard risks and owner-assumption of damages resulting from development proposed in the Coastal Adaptation Overlay Zone.
- The City's CIP could include a provision to investigate and identify eligible roads within the Coastal Adaptation Overlay Zone that could be elevated or relocated. This study would also identify priority road segments, schedules, and methods (e.g., additional pavement improvements during established road resurfacing activates).
- The City and residents could consider creation or modification of an assessment district to address costs of special public services or improvements.

- Consistent with Coastal Commission guidance, the Coastal Adaptation Overlay may establish a prohibition of seawalls and hard armoring along the City and State Beaches.
- The planned/expected life of development and redevelopment could be standardized. The following table is provided as a recommended life of development based on state guidance and other jurisdictional policy approaches (Table 8-9). Coastal Development Permits may be required to include analysis of the effects of sea level rise and coastal hazards, identify and incorporate adaptation strategies into the project, and discuss the adaptive capacity of the development as part of the application process.

Table 8-9. Proposed Expected Life of Development and Redevelopment

Type of Development	Life Expectancy
New Development*	
Auxilary structures, coastal dependent amenties	5-25 years
Commercial or Industrial Development	75-100 years
Residential Development	75-100 years
Critical facilities – (water supply, wastewater, transportation corridors)	100-150 years
Major redevelopment (>50 percent)**	
Auxilary structures, coastal dependent amenties	10-20 years
Commercial or Industrial Development	25 years
Residential Development	50 years
Critical facilities – (water supply, wastewater, transportation corridors)	75 years
Minor redevelopment (<50 percent)**	
Auxilary structures, coastal dependent amenties	5-10 years
Commercial or Industrial Development	15 years
Residential Development	20 years
Critical facilities – (water supply, wastewater, transportation corridors)	25 – 50 years

Critical facilities should consider the extreme H++ scenario (9.8 feet by 2100) for sea level rise planning.
**These values are based on the Draft Residential Adaptation Planning Guidance, Model Policy A.2 approach to redevelopment and may be refined based on State guidance (CCC 2018).*
***This 50 percent threshold is based on existing General Plan Safety Element Objective S-4 Implementation Policy 14, which states, "All new construction or reconstruction, additions and remodels that have a valuation exceeding 50 percent of the valuation of the existing structure, shall be constructed to be protected from wave action."*

Benefits of the Coastal Adaptation Overlay Zone include the provision of additional adaptation options for properties within defined coastal hazard areas without negotiating on a case-by-case basis. Providing an overlay zone provides clarity and certainty and avoids the need for developers to seek costly and time-consuming variances for projects that are designed to avoid or accommodate sea level rise hazards but may not be consistent with existing zoning or development standards. An overlay also provides the City with a mechanism to implement comprehensive programs and policies associated with future land use and sea level rise hazards, as necessary, such as a repetitive loss program (see below).

Costs associated with this strategy assumed by the City would be largely administrative, including adoption of a zoning amendment and formal actions by the governing bodies. Adoption of a Coastal Adaptation Overlay Zone may present political challenges within the community that result in delays in adoption and implementation, including economic, social, and legal uncertainties. Implementation of a Coastal Adaptation Overlay Zone would require City planners to have detailed technical knowledge of sea level rise hazards and current projections, as well as local building and engineering requirements to address such hazards. Additional regulations for development and redevelopment within the overlay zone add a layer of requirements to the development review process and may increase time and expense for both developers and for agencies involved in the development approval process.

Repetitive Loss Program

The primary objective of a repetitive loss program is to reduce damage to private property, injury or loss of life, demand on emergency services, and disruption to public services caused by frequent flooding and associated damages. The Federal Emergency Management Agency (FEMA) operates a nationwide repetitive loss grant program authorized under the National Flood Insurance Act of 1968 with the intent of eliminating or reducing the long-term risk of flood damage. FEMA defines repetitive loss as any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. In addition, single family properties (consisting of one to four residences) that have incurred four or more separate flood-related damage claims totaling over $20,000 are considered “Severe Repetitive Loss” under FEMA. A repetitive loss property may or may not be insured by the NFIP. Currently, there are over 122,000 repetitive loss properties nationwide. FEMA may act on severe repetitive loss properties, including acquisition, demolition, or relocation of flood prone structures and deed restricting property for open space uses in perpetuity (FEMA 2018).

Under a repetitive loss program, a property that repeatedly experiences substantial damages from storms and coastal flooding within a given period may not be permitted to redevelop. It is important to note, however, that the City’s intent is to combine this adaptation strategy with other protection strategies, such as a living shoreline and beach nourishment, which could provide an additional buffer for private development from coastal hazards in the near-term. Nonetheless, in the mid to long term and with higher elevations of sea level rise, protection strategies may be less effective and could result in loss or damage to private property. In addition, in the long term, the City may experience a loss of housing units and short-term rentals, resulting in economic losses to the City in the form of tax revenue and transient occupancy tax (TOT) from hotels and short-term rentals. Prior to implementation of a repetitive loss program, the City would continue to monitor triggers such as storm frequency and sea level rise and evaluate the effectiveness of this measure with consideration to social, economic, and environmental effects.

As a mid-to-long term adaptation strategy, the City may choose to implement a repetitive loss program that allows properties subject to repetitive loss to be downsized, moved away from the shoreline, or in extreme cases with frequent and severe damages, may even grant the City, State, or other public agency the right of first refusal to purchase the property and restrict for open space uses. Any such program would be designed to be consistent with FEMA's repetitive loss program. In accordance with the CCC *Draft Residential Adaptation Guidelines* (2018), the City could choose to adopt a policy within the CLUP/General Plan Update that provides a mechanism for such a program to be developed when necessary and appropriate based on the increase of coastal hazards.

Table 8-10. Proposed Adaptation Strategy - Repetitive Loss Program

Adaptation Strategy	Repetitive Loss Program		
Implementation Timeline	Program Development: 1-2 years	Adoption: 1-2 years	Program Implementation: 30+ years
Trigger	Near to Mid-term, based on storm damage frequency and severity		
Tipping Point	Erosion, Coastal Flooding, and Inundation Hazards (approximately 2 feet sea level rise)		
Potential Resource/Asset Benefits	• Minimizes risks to life and property • Minimizes "coastal squeeze"[1] and the loss of public beach		
Costs & Impacts	• Private costs of property damage and repairs • Over time, potential loss in property taxes and TOT • In the long term, loss of housing and short-term rentals in the Beach Neighborhood		
Permitting & Coordinating Agencies	FEMA, Cal OES, CCC		
Next Steps	• Monitor coastal flooding frequency and sea level rise elevation • Develop a Repetitive Loss Program consistent with CCC *Residential Adaptation Policy Guidance* (2018) • Integrate program framework into future cycles of Plan updates		

[1] *Coastal squeeze = loss of the beach due to the migration of the mean high tideline and fixed development that prevents the migration of the beach and intertidal area.*

Currently, 79 residential structures are vulnerable to damage and flooding from coastal hazards; an additional 164 residential structures become vulnerable with approximately 1 foot of sea level rise, 234 additional residential structures become vulnerable with approximately 2 feet of sea level rise, and 264 additional residential structures become vulnerable with approximately 5 feet of sea level rise, for a total of 769 structures (refer to Table 6-1). This translates to over 45 acres of residential land uses. It is anticipated that over time, sea level rise would result in repetitive loss to at least a portion of these structures.

8.3 Regional Assets and Multi-Jurisdictional Coordination

Several of the critical facilities and assets within the City that are vulnerable to sea level rise are managed by other local, state, and federal agencies. These include UPRR, U.S. 101, Carpinteria State Beach, the WWTP, and Aliso Elementary School. Adaptation measures for these assets or facilities requires coordination, collaborative regional solutions, and partnerships with adjacent and affected jurisdictions and entities, including the County of Santa Barbara, University of California Natural Reserve System, California State Lands Commission (CSLC), CCC, BEACON (and member jurisdictions), State Parks, USACE, the California Governor's Office of Emergency Services (Cal OES), and FEMA; infrastructure and transportation providers, such as Caltrans (District 5), UPRR, Metropolitan Transit District (MTD), and LOSSAN; and special districts including the Carpinteria Unified School District (CUSD), Carpinteria Valley Water District (CVWD), and WWTP.

Good adaptation planning is collaborative, considering interconnected ecological, social, political, and economic systems. Partnerships and dialogue between the City and agencies would be essential in developing and implementing sound regional adaptation strategies. Through coordination with other jurisdictions and agencies, the adaptation planning process aims to improve coordination and leverage local resources to minimize vulnerabilities and impacts associated with sea level rise.

UPRR Corridor

The UPRR railroad corridor runs south of U.S. 101 and through the City, including all three Study Areas; Beach Neighborhood (Area 1), Carpinteria Salt Marsh (Area 2), and Carpinteria Bluffs (Area 3) (see also, Section 8.4, Neighborhood Area Specific Approaches). At its closest, the corridor is approximately 290 feet landward of the mean high water (MHW) tideline along the Carpinteria Bluffs.

Future railroad track improvements by the LOSSAN Rail Corridor Agency provide substantial opportunities for each of the Study Areas in the City. UPRR intends to construct an additional railroad track at the Carpinteria Station by 2023. A 0.4-mile segment of track will be elevated on a platform, and a pedestrian

UPRR plans to elevate 0.4 mile of track at the Carpinteria Station. These improvements provide an opportunity to address storm-based flooding vulnerabilities.

underpass will be constructed. Efforts to expand and raise the track are intended to increase pedestrian safety and expand train service provision in the region. Despite the inclusion of an underpass, this track elevation provides an opportunity to address storm-based flooding vulnerabilities. This project would impact 16 percent of existing railway within the City (LOSSAN Rail Corridor Agency 2018). LOSSAN has proposed a budget of $31.9 million for this project, the majority of which would be funded by the California Transit and Intercity Rail Capital Program ($30.3 million)(LOSSAN Rail Corridor Agency 2018). This program is intended to reduce state GHGs through improvements to public transportation systems. In addition to this project, there are several other opportunities for LOSSAN to protect rail infrastructure from the impacts of sea level rise and coastal storms.

Area 1: Beach Neighborhood

City and LOSSAN coordination of planned rail infrastructure improvements could provide significant opportunities to address storm-based flooding vulnerabilities to the railroad, which are projected to occur with approximately 5 feet sea-level rise by 2100 (refer to Figure 1-3). Elevation of the 0.4-mile segment of railroad within the Downtown provides an opportunity for integration of stormproof design elements that could enable segments of the railroad to function as a berm-like structure that could potentially protect the railroad and landward infrastructure from tidal inundation and coastal flooding, including structures and roadways in the Downtown.

Area 2: Carpinteria Salt Marsh

City and LOSSAN coordination could provide options to study and protect railroad tracks and nearby sensitive habitats in this Study Area. Strategic elevation of the track on causeways and bridges over creek inlets could allow upland wetland transgression into open spaces while protecting those portions of track from tidal inundation and high-water levels resulting from potentially simultaneous coastal and fluvial flooding associated with the Franklin Creek corridor. Alternatively, elevating the track on berms of cobble or other protective materials could potentially serve to protect the tracks while also providing protection to Aliso Elementary School and other developed uses adjacent to the railroad tracks. Additional modeling integrating coastal and fluvial flooding would inform agencies of preferred designs to address both coastal hazards and fluvial flooding associated with the creek corridor.

Area 3: Carpinteria Bluffs and Concha Loma Neighborhood

The rail tracks along the Carpinteria Bluffs are at risk of sea level rise and bluff erosion and may be realigned further inland in the future to protect the tracks and preserve marine ESHA.

The rail tracks along the Carpinteria Bluffs are the most seaward infrastructure at risk from sea level rise and coastal storms. Typical protective features of this portion of the railroad include cobble and hard armoring measures, which could protect the tracks as well as blufftop habitats, trails, and open space but would not allow potential landward migration of marine Environmentally Sensitive Habitat Areas (ESHA). Continuing to protect the tracks using this method would also reduce near- to mid-term bluff erosion, although loss of sandy beach due to scouring would be expected to occur. Protection measures may severely limit or eliminate public lateral beach access over time, submerge rocky intertidal and beach habitats, and result in degradation of the Seal Rookery and haulout area. Alternatively, the track could be realigned further inland to protect the tracks from cliff erosion and inundation while preserving marine ESHA. Financial and logistical challenges of negotiating private property easements along this section of the shoreline could be prohibitive.

In addition to strategy-specific challenges of implementation, coordination and financing of these adaptation measures would be a significant given the 351-mile LOSSAN Corridor travels through six counties, and is governed by the LOSSAN Rail Corridor Agency, an 11-member Board of Directors composed of elected officials representing rail owners, operators, and planning agencies along the rail corridor.

Despite such challenges, the City would pursue opportunities to coordinate with the LOSSAN Rail Corridor Agency and other regional jurisdictions to maintain and improve this important transportation corridor. The adaptation strategies chosen for these sections of railroad would play an important role in determining the rate and extent of bluff erosion, loss of public open space and trails, damage to existing development and/or impacts to beaches and ESHA. By establishing effective partnerships with these agencies, the City could ensure that a well-designed adaptation approach for the railroad synergistically protects important infrastructure such as recreational trails, downtown development, and residential neighborhoods.

U.S. 101

U.S. 101 and Carpinteria Avenue Southbound Exit 87B (pictured above) could be exposed to flooding during a storm when combined with approximately 5 feet of sea level rise or more. The City should continue to work with Caltrans to identify adaptation concepts.

The U.S. 101 corridor bisects the City, serves as the primary regional access route, and is under the jurisdiction of Caltrans. With approximately 5 feet of sea level rise, a nearly 1,500-foot section of the corridor, north of the Carpinteria Salt Marsh could be flooded during a large coastal storm event. The combined extent of flooding from a 1% annual chance storm and approximately 5 feet of sea level rise could be greater when combined with increased rainfall and creek runoff from Santa Monica, Franklin, and Carpinteria Creeks. Under the current worst case (H++) scenario, damage would occur earlier than 2100, and as soon as 2070, and may be more frequent and severe. Since U.S. 101 is subject to flooding with approximately 5 feet of sea level rise, significant economic cost to implement adaptive strategies and physical improvements are expected, as well as secondary socioeconomic costs to commuters, commerce, and travelers (e.g., delayed transport of goods and services, lost work days, alternative travel expenses, etc.). Significant coordination and collaboration between Caltrans and the City would be required to ensure protection from coastal hazards, particularly flooding. Caltrans has begun work statewide on sea level rise vulnerability assessments; however, District 5 is not scheduled to begin work for several more years.

The City has been awarded funding from Caltrans under the 2017-2018 Adaptation Planning Grant Program and has commenced investigations involving transportation policy and infrastructure adaptation planning (see Appendix E); initial data and concepts are incorporated into this Report. The scope of the Adaptation Planning Grant includes additional analysis of sea level rise impacts to transportation infrastructure with the City, impacts to vulnerable populations within the City, and the identification of adaptation strategies to build resiliency within the transportation network. In the long term, this may include capital improvements to improve drainage and conveyance beneath the U.S. 101 corridor, elevating the segment of U.S. 101 that is vulnerable to flooding impacts, or identifying alternative routes in case of closures. This grant award and the efforts of this Report serve as the first step towards planning for adaptation and/or protection of regional transportation services in coordination and collaboration with Caltrans. The City would need to continue to coordinate with Caltrans to efficiently facilitate such adaptation measures.

Carpinteria Sanitary District Wastewater Treatment Plant

The WWTP would be vulnerable to coastal flooding and inundation with approximately 5 feet of sea level rise. The City recommends coordination with CSD to identify potential capital improvements that will build resiliency.

The WWTP is located immediately north of Carpinteria State Beach and adjacent to Carpinteria Creek. The WWTP is an essential service that provides needed wastewater treatment services to the City and supplements or offsets heavily relied upon imported water supplies with recycled water capabilities. The WWTP would be subject to coastal flooding and inundation with approximately 5 feet of sea level rise. Further, seawater infiltration into sewer lines could result in potential complications or damages to the WWTP facility. The City recommends further coordination with Carpinteria Sanitary District (CSD) to identify and develop of mid- to long-term improvements to reduce coastal hazard risks, including installation of a fortified flood control wall along Carpinteria Creek, additional elevation and setbacks of any new facilities, and installation of back-flow protection devices. The City will continue to coordinate with the CSD regarding findings of this Report, as the CSD's current investigations to treat and distribute recycled water from the WWTP should consider future sea level rise hazards.

Aliso Elementary School

Aliso Elementary School serves approximately 400 students in the CUSD, ranging from kindergarten through fifth grade. The school is potentially subject to coastal flooding with approximately 2 feet or more of sea level rise, with potential flood damages increasing substantially with approximately 5 feet of sea level rise. Coastal hazards could be further exacerbated considering a higher H++ scenario (with ~5 feet of SLR occurring as soon as 2070), reducing the period to adapt Aliso Elementary School facilities from coastal hazards and rising sea levels. Further, Aliso Elementary School is already vulnerable to FEMA identified fluvial flood

Aliso Elementary School is near the Carpinteria Salt Marsh and could be subject to coastal hazards with approximately 2 feet or more of sea level rise.

hazards (see Appendix C); future coastal hazards exacerbated by sea level rise may increase these potential risks.

A variety of cost and benefit trade-offs between adaptation strategies exist and are essential to understand to help decision-makers determine the most effective policies and project-level adaptation strategies to implement. For Aliso Elementary School, such adaptation strategies may include both on- and offsite measures and regional approaches.

Protection

Protection strategies may include raising flood walls along Franklin Creek, increasing the elevation of the UPRR tracks, or installing floodgates at Franklin Creek, which would act as a dike to protect the school. Such actions would require CUSD coordination with other agencies such as the City, County Flood Control District, or UPRR. It should be noted that the LOSSAN project to double track the railroad east of Franklin Creek could potentially be designed to include raising the elevation of tracks; if this could be extended west of Franklin Creek, it may provide additional protection to Aliso Elementary School.

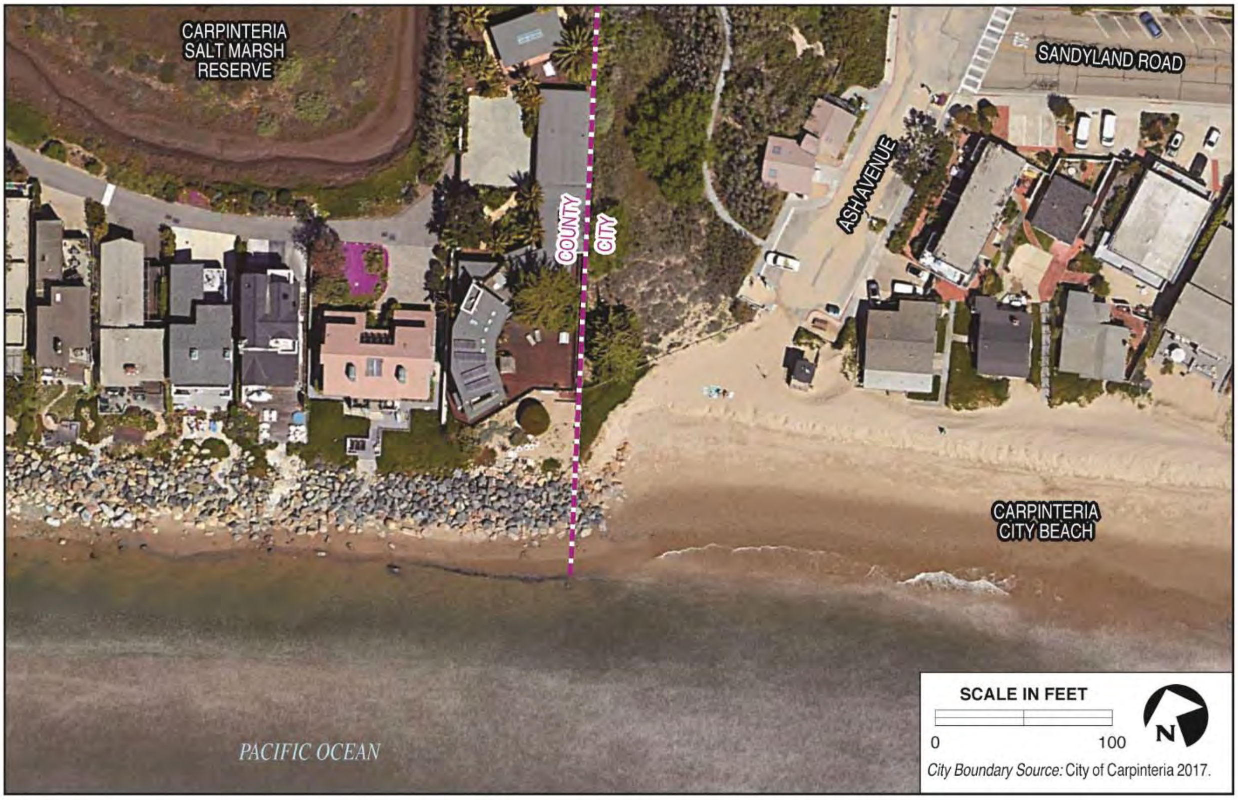
Accommodation

Potential adaptation options could include raising the finished floor elevations of existing or new structures above the elevation of projected flooding from the 1% annual chance storm event, as well as flooding associated with projected monthly tidal flooding at a greater frequency. Redevelopment of school structures onsite (e.g., elevating buildings, moving modular structures to higher elevations onsite, providing two-story clustered buildings, etc.) could be explored as the school considers renovations.

Next steps would include continued coordination between the City and CUSD to discuss the long-term approach for Aliso Elementary School. This would include continued discussions with the community and decision-makers about the potential pros and cons of each adaptation strategy for the School, and to reduce hazard risks and guide the selection of future adaptation strategies.

Sandyland Revetment

Presently there are minimal shoreline revetments within the City; however, the City experiences some impacts to Carpinteria City Beach at Ash Avenue as a result of the rock revetment fronting Sandyland Cove located within the County of Santa Barbara (refer to Figure 3-7; Figure 8-4). Coastal process research in Carpinteria has identified an erosion hotspot at Ash Avenue located at the end of the Sandyland revetment within the City



Approximate Sandyland Cove Revetment City – County Boundary

FIGURE 8-4

jurisdiction (Barnard et al 2010). Presently, approximately 10 to 15 feet of the approximately 2,800-foot-long rock revetment, or less than one percent, is placed on the City Beach within City jurisdiction. This small segment interacts with waves during most high tides in the winter. This wave and revetment interaction causes accelerating erosion and is increasing the alongshore current velocities and scour potential along the revetment on Carpinteria City Beach (see Section 3.8, Historic Shoreline Changes and Erosion) Alteration, relocation, or removal of the revetment could reduce this erosion hotspot that primarily affects a small portion of the City Beach and Beach Neighborhood. As Sandyland Cove is largely within Santa Barbara County, any alterations to the revetment would need to be processed by the County in coordination with the City, in addition to the CCC and Sandyland Cove Homeowners Association (HOA). However, alteration of the revetment may result in significant changes and cost and may expose homes to wave attack or damage or potentially increase flooding in areas adjacent to the Carpinteria Salt Marsh.

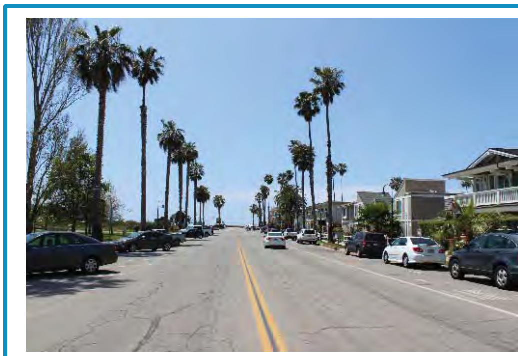
8.4 Area Specific Approaches

This section is organized using a spatial approach, which outlines regional strategies and adaptation measures focused within the following three Areas:

- **Area 1:** Beach Neighborhood (Ash Avenue to Carpinteria Creek)
- **Area 2:** Carpinteria Salt Marsh (includes Aliso Elementary School, Franklin Creek, and Carpinteria Avenue)
- **Area 3:** Carpinteria Bluffs and Concha Loma Neighborhood (Tar Pits Park, the Concha Loma neighborhood, and Carpinteria Bluff properties)

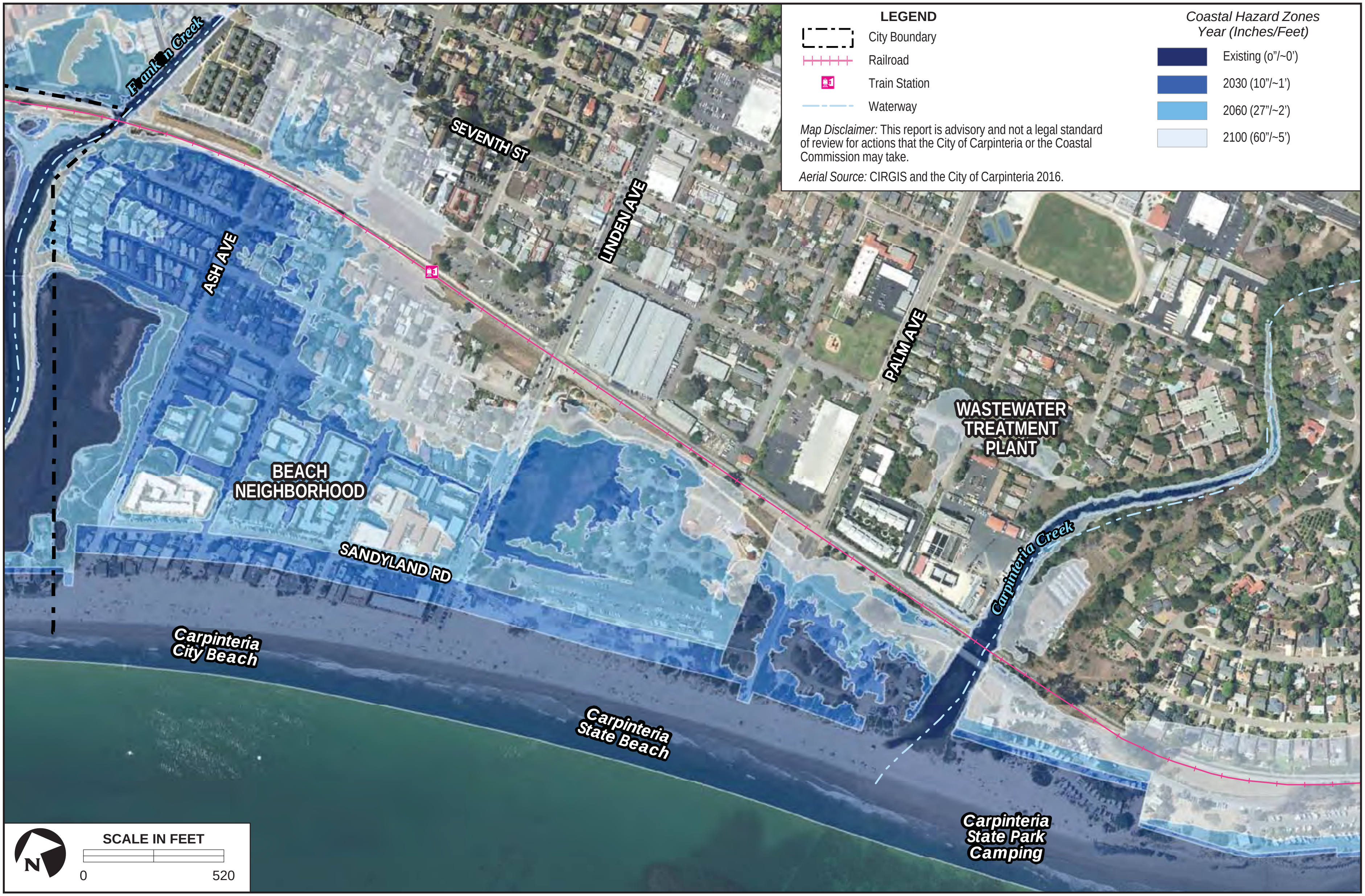
These three Areas are analyzed separately as the City's coastline contains three diverse coastal environments that provide separate planning challenges and key issues. These include urban beachfront backshore type (Area 1 – Beach Neighborhood; Figure 8-5), urban estuary backshore type (Area 2 – Carpinteria Salt Marsh; Figure 8-6), and urban bluff top backshore type (Area 3 – Carpinteria Bluffs and Concha Loma Neighborhood; Figure 8-7). Consideration towards the backshore landscapes and development intensity within each Area is an important factor in the success of an adaptation strategy. Adaptation strategies that the City could pursue to address vulnerabilities within each Study Area are presented below.

Area 1: Beach Neighborhood



Linden Avenue provides several public parking spaces for coastal access. With approximately 5 feet of sea level rise, the roadway and associated parking spaces could be lost to erosion or damaged by both episodic and periodic tidal flooding.

Area 1 is defined by the extent of potential hazards associated with the sandy beach and dune backshore environment, including beach erosion, coastal flooding, wave attack and runup, and tidal inundation. The Beach Neighborhood, Downtown, and Carpinteria State Beach and Campgrounds are landward of the one-mile length of sandy shoreline and are highly vulnerable to sea level rise and effects of coastal flooding and erosion (Figure 8-5). Important infrastructure and buildings in the Beach Neighborhood are exposed to coastal flooding, coastal erosion, and tidal inundation over time. Beach Neighborhood is seaward of the UPRR and includes the Linden Avenue Downtown corridor and the WWTP. Containing hundreds of residential units, including up to 218 short-term rental units, this Area is an important source of revenue to the City, garnering an approximate $1.9 million dollars in TOT revenues annually. Dozens of free public parking spaces on public streets and road ends and numerous



Area 1 – Beach Neighborhood

FIGURE 8-5

bicycle facilities are present along roads within the Beach Neighborhood. Carpinteria State Beach is located adjacent to the Neighborhood and provides 213 campsites and recreational open space. The natural sand beaches that line this section of coast provide substantial recreational opportunities; they are a resource that helps shape the community's identity. The beaches also draw 1,000,000 visitors annually (California State Parks 2017), thus providing significant revenue for the City. Linden Avenue serves as one of the City's primary routes to the coast, is a hub of commercial activity, and includes a popular bike route, pedestrian facilities, and parking for coastal access. In addition, the Beach Neighborhood provides 41 affordable housing units (approximately 22.7 percent of low- and very-low-income housing units in the City), and the 213 campsites within Carpinteria State Park provide the largest source of low-cost visitor accommodations near the coast within Santa Barbara County.

Resources within the Beach Neighborhood and Carpinteria State Beach are at varying risks to coastal threats, depending on location and sea level rise (Table 8-11).

Table 8-11. Summary of Vulnerabilities in Area 1

Sea Level Rise	Area 1 - Vulnerabilities
~0 feet	Residences located adjacent to the beach, bikeways, and public access and parking facilities are currently at risk from wave run-up, erosion and inundation from periodic coastal storms.
~1 foot	Storm flooding and tidal inundation could inundate most roadways within the Beach Neighborhood, including roads between Ash, Linden, and 4th Street. Residences within this area are vulnerable to severe damage from flooding and inundation. State Beach camping facilities would be vulnerable to erosion from a large singular storm event, as would nearby bikeway facilities.
~2 feet	Road ends and adjacent housing units on Ash, Holly, Elm, and Linden Avenues become exposed to potential damage resulting from beach and dune erosion. Additionally, the entire Beach Neighborhood and State Beach parking facilities would be subject to coastal flooding from wave run-up under large storm events. Periodic inundation under extreme monthly high tides could also occur 500-feet landward from the nearest residences.
~5 feet	Entirety of Beach Neighborhood would be at risk of inundation from Extreme Monthly High Water tides as well as flooding resulting from a large storm. Erosion of the seaward dunes and beach could also occur, which would result in increased vulnerability to these threats.

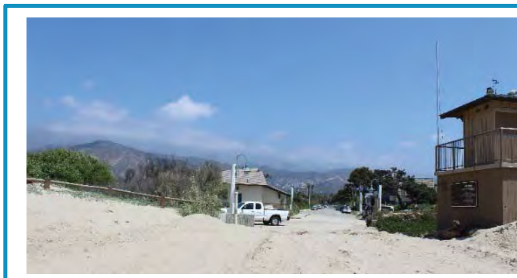
The City recommends pursuing the following strategies to help protect valuable resources within Beach Neighborhood and the State Beach:

Protection

- **Winter Storm Berm Program:** Continue to implement the annual winter storm berm program along the City Beach in the near term while monitoring rates of sea level rise and storm frequency**.**
- **Living Shoreline:** Design and construct a living shoreline to function as a permanent storm berm that will replace the annual winter berm and protect the Beach Neighborhood by the time approximately 1 foot of sea level rise has occurred. The efficacy of this project may decrease at sea level rise scenarios of approximately 2 feet and greater, particularly as sea level rise nears 5 feet, which may result in more frequent overtopping of an installed dune system.
- **USACE Feasibility Study:** Once an effective measure is identified, pursue funding opportunities to implement the program as soon as possible.

The berm protects residences and other important infrastructure and is funded by the City and an Assessment District of effected landowners.

- **BEACON Projects**: Once cost-effective sediment management strategies have been identified, work with regional partners to implement these programs as soon as possible.
- **Sediment Management Program:** In coordination with BEACON, establish a sediment management program in the near term and identify sediment sources for regular beach nourishment prior to approximately 1 foot of sea level rise.
- **Sand Retention Structures:** Assess the potential of sand retention structures to increase beach width, as well as the downcoast consequences that could result. These measures are more appropriate for utilization before approximately 2 feet of sea level rise has occurred and should be implemented by the time approximately 1 foot of sea level rise has occurred, unless the installed structures are modified or heightened over time. Further study is warranted prior to implementation.



Sand from Carpinteria City Beach abuts Ash Avenue and serves as a buffer from wave attack and run-up damaging and eroding the roadway. Adaptation strategies that increase beach sand can result in continued and enhanced protection of important resources in the Beach Neighborhood.

Accommodation

- **Coastal Adaptation Overlay Zone:** Prepare and adopt a coastal adaptation overlay zone within the Beach Neighborhood that contains measures such as coastal hazard related development requirements (e.g., raised floors, setbacks) and infrastructure investment priorities. Initial planning efforts for this strategy should occur in the near-term as part of the CLUP/General Plan Update, and this overlay should be adopted by the time approximately 1 foot of sea level rise has occurred.

- **Storm Drain Improvements:** Improve water pumps within storm water drains in the Beach Neighborhood to reduce the threat of flooding from storms and tidal inundation. This is an adaptive measure that could be monitored as necessary over time to address changing conditions. While not currently necessary, planning should begin with approximately 1 foot of sea level rise, and implementation should occur with approximately 2 feet of sea level rise.

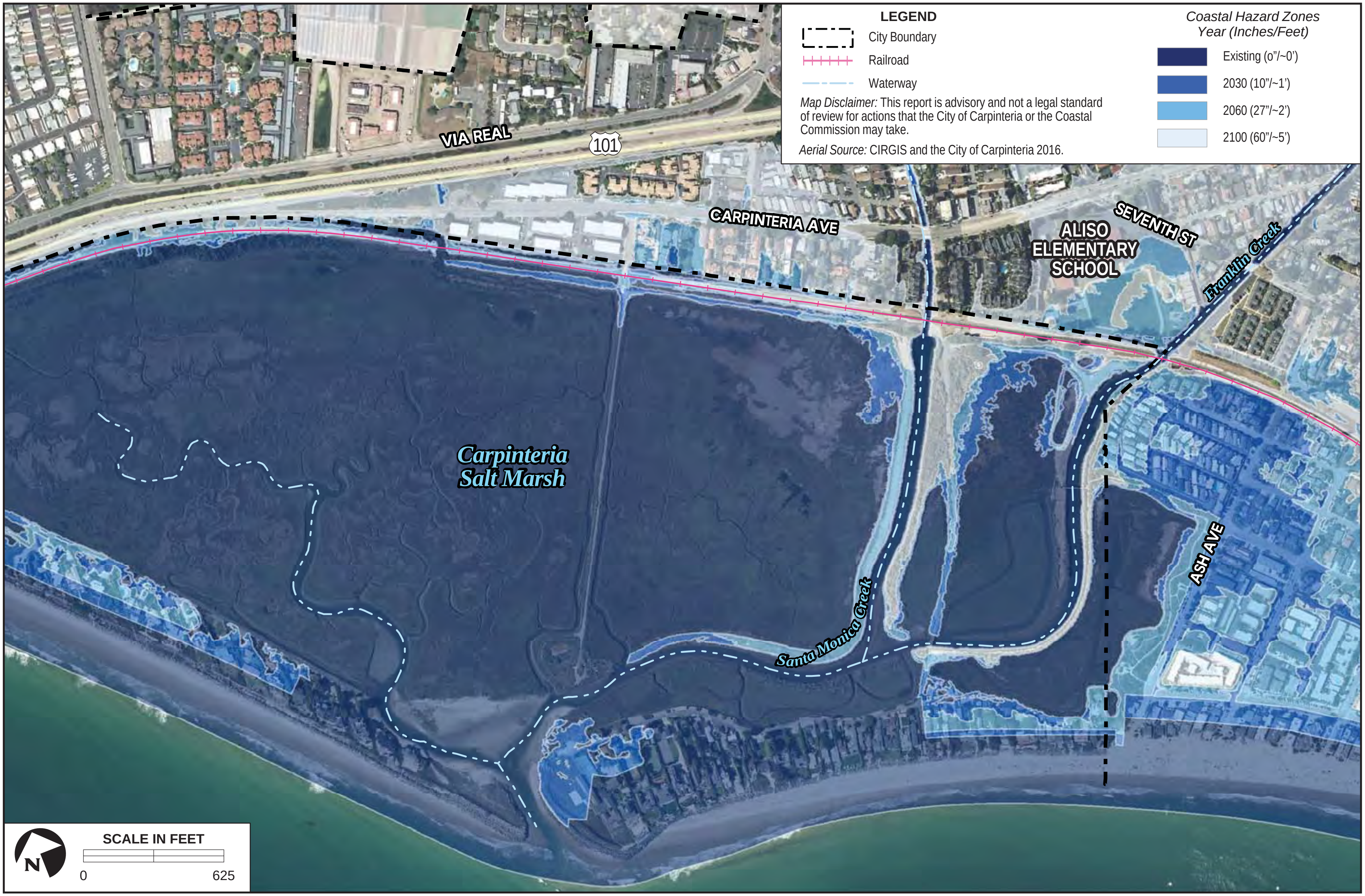
Managed Retreat

- **Coastal Adaptation Overlay Zone:** Prepare and adopt a coastal adaptation overlay zone within the Beach Neighborhood that includes provisions for key infrastructure and land uses to be relocated and may contain development measures such as requirements for a site specific coastal hazard analysis and sea level rise reports for new development, construction standards for removable foundations, an indemnification agreement acknowledging coastal hazards, etc.; this overlay should be adopted by the time approximately 1 foot of sea level rise has occurred.
- **Repetitive Loss Program:** Consider developing and adopting development requirements that correlate with a property's vulnerability to coastal threats.

Area 2: Carpinteria Salt Marsh

Carpinteria Salt Marsh, located within Santa Barbara County, is adjacent to residences, Aliso School, UPRR, and local roadways and infrastructure within the City.

Area 2 is defined by its vulnerability to hazards associated with the estuarine and riverine backshore environment. Area 2 is located to the north of the Carpinteria Salt Marsh and includes lands and assets which lie between U.S. 101, UPRR, and Holly Avenue (see Figure 8-6). This Area contains up to 70 acres of residential units, including mobile homes and affordable housing units. Additionally, the area contains Aliso Elementary School, U.S. 101 and UPRR, a segment of the Carpinteria Avenue commercial corridor, Salt Marsh Park, and the Salt Marsh Trail.



Area 2 – Carpinteria Salt Marsh

FIGURE 8-6

Table 8-12. Summary of Vulnerabilities in Area 2

Sea Level Rise	Area 2 - Vulnerabilities
~0 feet & ~1 foot	While fluvial flooding from nearby creeks is currently a threat to Area 2, existing threats from sea level rise and coastal storms are minimal. While storm drain inlets and outfalls are affected by high tide levels, this mostly impacts repair timelines and is unlikely to substantially increase the risk of storm drain backup and flooding.
~2 feet	The parking lot and recreational areas of Aliso Elementary School could be exposed to coastal flooding. Sections of UPRR would also be impacted, as well as several residences. Additional storm drain infrastructure would be subject to potential flooding, which would temporarily affect maintenance and repair access to pipes during storm events.
~5 feet	Aliso Elementary School could be exposed to coastal flooding during extreme monthly high tides and large storms. Over 100 residential buildings would be subject to tidal inundation and coastal wave flooding, as well as potentially simultaneous fluvial flooding. Vulnerable transportation infrastructure within this Area include a 1,500-foot segment of U.S. 101 and the on-ramp to Carpinteria Avenue at exit 87B, as well as roadway segments including 7th, 8th, and 9th Streets and Carpinteria, Ash, and Holly Avenues. Businesses along Carpinteria Avenue could be impacted by flooding and damages.

While threats to Area 2 from coastal sea level rise and storms were assessed, modeling and analysis of flood threats from Santa Monica and Franklin Creeks were outside of the scope of this Report. Given that runoff from these creeks could backup storm drain systems and result in a confluence of coastal and fluvial flooding, the actual area of flooding has the potential to be greater under all scenarios.

The City recommends pursuing the following strategies to address potential threats of sea level rise, coastal storms, and concurrent fluvial flooding on this Area:

Protection

- **Elevate UPRR:** Work with UPRR to identify opportunities that would elevate the track onto a berm of cobble or similar material to protect rail infrastructure and consider design elements that could effectively act as a levee to protect Aliso Elementary School and adjacent residences. Coordination between the City and UPRR is essential and can result in an optimum protection design with shared investigations, outreach, permitting, and financing. These agencies should begin planning before approximately 1 foot of sea level rise and complete construction before approximately 2 feet of sea level rise.

Accommodation

- **Coastal Adaptation Overlay Zone:** Prepare and adopt a coastal adaptation overlay zone within this Area that contains measures including coastal hazard related development requirements (e.g., raised floors, setbacks) and infrastructure investment priorities. This overlay should be adopted by the time approximately 1 foot of sea level rise has occurred.
- **Storm Drain Improvements:** Water pumps within storm water drains in the Area should be improved in coordination with the County Flood Control District to reduce the threat of water from storms and tidal inundation. This measure is adaptive and can be moderated as necessary to address given sea level conditions. While not immediately necessary, planning should begin by approximately 1 foot of sea level rise and improvements should occur by approximately 2 feet of sea level rise. The City should include these improvements in a Citywide CIP.
- **Channel Improvements:** Coordinate with the County Flood Control District to increase the flow capacity of Franklin and Santa Monica Creeks to reduce the possibility for confluence of coastal and fluvial flooding. Planning should begin by approximately 1 foot of sea level rise, and improvements should be completed by approximately 2 feet of sea level rise. The City should include these improvements in a Citywide CIP.

Managed Retreat

- **Repetitive Loss Program:** Consider developing and adopting development requirements that correlate with a property's vulnerability to coastal threats. As the City continues to experience sea level rise (approximately 2 feet and greater), this may be an important tool for encouraging more sustainable development adjacent to the Carpinteria Salt Marsh and in other areas especially vulnerable to coastal resources.

Area 3: Carpinteria Bluffs

Currently, trails and UPRR tracks along the Carpinteria Bluffs are vulnerable to damage if a large coastal storm event (i.e., 1% annual chance storm) were to result in cliff failure.

Area 3 extends eastward from the Carpinteria Creek along the coastline. Approximately 1.8 miles of railroad traverse the bluffs along Area 3. Development in Area 3 includes residences within the Concha Loma Neighborhood, as well as commercial research facilities and former oil and gas processing infrastructure within Bluffs 0 (Figure 8-7). Along the western coastline of this Area, Carpinteria State Beach has 136 campsites located along the beach with restroom and parking facilities. Area 3 also contains extensive swathes of open space, trails, and ESHA. Natural habitats include a rookery for harbor seals, as well as ecosystems that support species such as coastal sage scrub and white-tailed kites.

Area 3 is characterized by its vulnerability to coastal bluff erosion. Although the 700 feet of hard armoring protects landward infrastructure, these measures will not be sufficient in the long term and most of Area 3 remains unarmored.

Table 8-13. Summary of Vulnerabilities in Area 3

Sea Level Rise	Area 3 - Vulnerabilities
~0 feet	Significant portions of open space and trails are currently vulnerable to cliff erosion, including 15.6 acres of cliff and the harbor seal rookery. 80 camp sites within the Carpinteria State Beach are also vulnerable to erosion, as well as 0.1 mile of UPRR.
~1 foot	An additional 56 campgrounds would be vulnerable. Along the bluffs, 3.8 acres of cliffs as well as additional length of trails would be at risk. Additional UPRR tracks would also be threatened.
~2 feet	Additional segments of the Carpinteria Bluffs Trail, restrooms.
~5 feet	2.71 additional acres of this Area could be lost to cliff erosion. Infrastructure along the Carpinteria Bluffs could be extremely vulnerable to cliff erosion with potentially 1.4 miles of UPRR, and approximately 3.6 miles of trails within the State Park, Tar Pits Park and along the Bluffs at risk. Erosion of the bluffs in the eastern portion of the City could affect over 1,336 feet of 4th Street within the State Park if no adaptive actions are taken.

Area 3 – Carpinteria Bluffs and Concha Loma Neighborhood

FIGURE 8-7

The City recommends pursuing the following strategies to address the potential threats of sea level rise and cliff erosion in this Area:

Protection

- **Sediment Management Program:** As part of a sediment management program, consider placement of cobbles along the base of the bluffs to help dissipate wave energy and reduce coastal bluff erosion. Establish a sediment management program and identify sediment sources for regular beach nourishment prior to approximately 1 foot of sea level rise.
- **Sand Retention Structures:** Assess the potential of sand retention structures to increase beach width, which could slow the rate of erosion. These measures are more appropriate before approximately 2 feet of sea level rise has occurred and should be implemented by the time approximately 1 foot of sea level rise has occurred. Further study to determine feasibility of such structures is necessary, including investigation of a preliminary design or engineering concept, a cost-benefit analysis, and funding mechanisms. Environmental review and planning approvals requiring Coastal Act consistency would be necessary for project implementation.

Accommodation

- **ESHA Adaptation Plan:** Prioritize the long-term preservation of key ESHA sites such as the Carpinteria Harbor Seal Rookery through incorporation of policies in the CLUP/General Plan, and coordinate with other jurisdictions to identify ways to develop a long-term plan for the seal rookery with consideration to sea level rise. A plan should be in place by the time approximately 1 foot of sea level rise has occurred.

Managed Retreat

- **Coastal Adaptation Overlay Zone:** Prepare and adopt a coastal adaptation overlay zone within the Area that contains measures including increased bluff setback requirements. Bluff setback requirements may be established by updating the setback calculation methodology based on the expected sea level rise with consideration of the life of the structure and site specific hazards analysis (see Table 8-6). This overlay will be evaluated as part of the City's current CLUP/General Plan update and should be adopted before approximately 1 foot of sea level rise has occurred.

8.5 Funding Mechanisms

Adaptation planning is a challenging undertaking and the City cannot adapt to sea level rise on its own. A successful adaptation plan requires regional dialog and state and federal partnerships to identify, fund, and implement solutions. Challenges include acquiring the necessary funding for adaptation strategies, communicating the need for adaptation to elected officials and staff, and gaining commitment and support from federal and state government agencies to address the realities of local adaptation challenges. Lack of resources from state and federal agencies make it difficult for cities to make significant gains in adaptation on their own due primarily to lack of funding. Potential sources of funding that could be explored are described below.

Establishment of a Shoreline Account

The City may consider establishing a "Shoreline Account" which would serve as the primary account where all funds generated pursuant for future resiliency building programs would be held. The City should invest the Shoreline Account funds prudently and expend them for purposes outlined in the Adaptation Plan including, without limitation:

- Sand and cobble replenishment and retention studies and projects;
- Opportunistic beach nourishment programs and development of stockpile locations;
- Updating the mean high tide line survey;
- Preparation of other shoreline surveys and monitoring programs;
- Public recreation improvements;
- Repair and maintenance of shoreline protection systems (such as the winter storm berm or a living shoreline) subject to reimbursement by the affected and/or non-compliant property owners; and
- Repair and replacement of beach access infrastructure.

The City may use the funds in the Shoreline Account, subject to the restrictions of any terms of the funding sources, to pay for projects such as beach sand replenishment and retention structures, public recreation and public beach access improvement projects, feasibility and impact studies, operating expenses, and to pay to conduct surveys and monitoring programs. Some potential resiliency building programs and funding mechanisms that can be further explored are described below.

Expand Existing Assessment District and/or Establish New Coastal Hazard Assessment or Geologic Hazard Abatement District

Assessment districts are common funding mechanisms for utilities, such as water supply and utility providers. Coastal Hazard Assessment Districts (CHADs) and Geologic Hazard and Abatement Districts (GHADs) are also opportunities for beach and bluff front property owners to establish an assessing entity to implement one or more of the priority adaptation strategies described above. CHADs provide a potential means for future renovations or improvements to flood control structures, including future alterations that may be necessary because of sea level rise. By accumulating a funding reserve for future maintenance and rehabilitation, a CHAD can provide the financial resources necessary for potential future expansion, maintenance, or repairs of flood or erosion control structures. Further, because of the relative safety of CHAD revenues (CHADs are typically financed through the collection of supplemental tax assessments), CHADs can borrow from lenders or issue bonds with very attractive credit terms. A CHAD or GHAD should be established to better assess hazards and fund improvements for issues that affect a larger regional area, resulting in greater reserves of funding and often improved maintenance or repair services. Given the threat from coastal hazards extends well beyond the City, the possibility exists for establishment of a CHAD or GHAD that includes particularly at-risk areas of the City, as well as threatened adjacent unincorporated communities or neighborhoods.

Infrastructure Financing Districts

As of September 2014, California law allows cities and other entities to create enhanced infrastructure financing districts. This allows incremental property tax revenues to be devoted to a specified purpose such as a fund for cleanup, infrastructure, parks and open space, transportation, or other things that could be applied to a variety of adaptation approaches. With the passage of Assembly Bill 313 and Senate Bill 628, the requirements for establishing these districts have been streamlined. The intent of these bills was to fill the local funding void left by the dissolution of the redevelopment agencies. Basically, the City would establish an Economic Infrastructure Financing District, develop a business plan with priority projects (e.g., infrastructure, adaptation, etc.), and then draw funds from changes in local tax revenues occurring as part of a redevelopment or rezone or apply for grant funds.[1]

Dedicated Sales or Transient Occupancy Tax Increase

TOT Increase: TOT from hotel stays and short-term vacation rentals already provides a source of General Fund revenues for the City. A dedicated increase in this TOT (e.g., 2 percent for sand) could be reserved for specifically for adaptation approaches that maintain the City Beaches and Open Spaces. Presently the TOT rate is 12 percent; a potential increase of 2% percent could yield an additional $400,000 annually. A regionally coordinated increase in TOT to provide regional funding for coastal improvements, maintenance, or repairs could also be coordinated with other jurisdictions in the County.

Sales Tax Increase: The City may consider this approach or coordinate on a Countywide approach such as a quality of life initiative to generate local revenues to be used to finance long-term coastal resiliency strategies. The City of Del Mar (San Diego County) recently

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1 For more information on Enhanced Infrastructure Financing Districts, see http://www.eifdistricts.com/.

instituted a one percent sales tax increase that is used as a dedicated source of funding for coastal resiliency building.

Hazard Mitigation and Pre-Disaster Assistance

There is overlap between LCP planning and Local Hazard Mitigation Plan (LHMP) as both address a potential range of hazards in a given City. California Governor's Office of Emergency Services' (Cal OES') Hazard Mitigation Planning Division and FEMA's Hazard Mitigation Assistance grant programs provide significant opportunities to adapt by reducing or eliminating potential losses to the City's assets through hazard mitigation planning and project grant funding. Much of the funding of specific projects must be tied to an approved LHMP, which in the City's case was updated in 2017 and approved by FEMA as an annex to the larger Santa Barbara County Multi-jurisdictional Hazard Mitigation Plan (MJHMP). Another update would be required to add sea level rise and climate change related hazards to the MJHMP to make adaptation projects eligible for federal funding. Currently, Cal OES and FEMA have three grant programs: Hazard Mitigation Grant Program, Pre-Disaster Mitigation, and Flood Mitigation Assistance. The total value in each of the grants vary annually based on federal funding authorization, but typically each is in the 10s to 100s of million dollars.

Impact Mitigation Fees or In Lieu Fees - Sand Mitigation and Public Recreational Impact Fees

Impact mitigation or in lieu fees are another way to generate monies for adaptation measure implementation. Certain structured fees could be established to generate revenues for: 1) covering the necessary planning of, technical studies for, design of, and implementation of adaptation strategies, or 2) developing an emergency cleanup fund to be able to respond quickly and opportunistically following disasters. Disasters, through a different lens, are opportunities to implement changes.

There are currently two structured fees that the CCC uses to address the impacts of shoreline protection – a Sand Mitigation Fee and a Public Recreation fee. The Sand Mitigation Fee is a fee intended to mitigate for the loss of sand supply and loss of recreational beaches in front of structures. The Public Recreation Fee addresses impacts to the loss of public recreation based upon the loss of beach area physically occupied by the coastal structure. An additional fee for ecosystem damages is under consideration by the CCC, which could assess a fee based on the cost of restoration or replacement value of the damaged habitat.

Sand Mitigation Fee: Such a fee would mitigate for actual loss of beach quality sand which would otherwise have been deposited on the beach. For all development involving the construction of a bluff retention device, a Sand Mitigation Fee could be collected by the City to be used for sediment management purposes. The fee could be deposited in an interest-bearing account designated by the City in lieu of providing sand directly to replace the sand that would be lost due to the impacts of any protective structure. Consideration of sand volumes lost over time should factor into whether actual sand placement is preferred or whether the volume/$ should be retained until a substantial volume can be contributed. The methodology used to determine the appropriate mitigation fee has been approved by the CCC in past cases. The funds should solely be used to implement projects which provide sand to the City's beaches, not to fund other public operations, maintenance, or planning studies.

Public Recreation Fee: Similar to the methodology used by the CCC for the Sand Mitigation Fee, the CCC has used a methodology for calculating a statewide public recreation fee. The City could include such a methodology in the CLUP/General Plan Update and develop administrative processes consistent with CCC guidance, including development of impact mitigation fees for public access and recreation, proposing a public recreation/access project in lieu of payment of Public Recreation Fees to provide a direct recreation and/or access benefit to the general public, and project prioritizations.

California Infrastructure and Economic Development Bank

The California Infrastructure and Economic Development Bank (IBank) was created in 1994 to finance public infrastructure and private development that promote a healthy climate for jobs, contribute to a strong economy, and improve the quality of life in California communities. IBank has broad authority to issue tax-exempt and taxable revenue bonds, provide financing to public agencies, provide credit enhancements, acquire or lease facilities, and leverage state and federal funds. IBank's current programs include the Infrastructure State Revolving Fund Loan Program, California Lending for Energy and Environmental Needs Center, Small Business Finance Center, and the Bond Financing Program.[2]

Green Bonds

Bonds are debt instruments that allow governments and other entities to borrow money from investors and repay that investment over a certain time at a certain rate. Government bonds often remain tax exempt, meaning the interest that investors earn is tax exempt. Bonds are a very traditional and familiar platform for financing public infrastructure and government programs, and recently the market has developed "green" bonds to finance green adaptation infrastructure.

[2] For more information on IBank, see http://www.ibank.ca.gov/.

California Department of Fish and Wildlife – 2019 Proposition 1 & Proposition 68 Grant Opportunities

Recently, California Department of Fish and Wildlife (CDFW) has announed funding opportunities for multi-benefit ecosystem restroation and protection projects under both Proposition 1 (Water Quality, Supply, and Infrastructure Improvement Act of 2014) and Proposition 68 (California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018). These grant funding opportunities makes available funds for public agencies for planning activities that lead to specific on-the-ground implementation projects, funds for implementation activities (e.g., construction and monitoring) of restoration and enhancement projects, and funds for acquisition or purchases of interests in land or water.

Cultural, Community and Natural Resources Grant Program – Proposition 68

Following passage of the California Drought, Water, Paks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018 (Proposition 68), $40 million has been appropriated to the California Natural Resources Agency for competitive grant funds that protect, restore, and enhance California's cultural, community, and natural resources. Funding under this program is available to local agencies and other eligible applicants for projects qualifying under a number of categories including resource protection, enhancement of park, water, and natural resources, and improvement of community and cultural venues or visitor centers.

California Department of Transportation Adaptation Planning Grant Program

As part of production of this Report, the City received adaptation planning grant funds from Caltrans under their Transportation Planning Grant Program for Fiscal Year (FY) 2018-2019. Caltrans has recently announced an additional $6 million is available for eligible climate change adaptation planning for FY 2019-2020. Further grant funding through the Caltrans Transportation Adaptation Planning Grant Program is available for projects or programs relating to:

- Climate vulnerability assessments;
- Extreme weather event evacuation planning;
- Resilience planning;
- Transportation infrastructure adaptation plans;
- Natural and green infrastructure planning;

- Integration of transportation planning considerations into existing plans;
- Evaluation of or planning for other adaptation strategies; and/or
- Developing educational resources, trainings and workshops for local jurisdictions and transportation service provides.

8.6 Recommendations and Next Steps

This section signals the beginning of the City's efforts to begin to build coastal resiliency and adapt to sea level rise by reducing risks and exposure to coastal hazards. Reviewing current City programs and policies associated with sea level rise risk reduction such as those around shoreline protection is the first step to identify immediate adjustments to alleviate or eliminate risks. Where adjustments to current practices will not sufficiently address the risks, then more substantial actions must be identified and should be implemented within the CLUP/General Plan Update. This effort will be ongoing in the coming years as our understanding of the variables involved in climate science continues to improve.

Financing Strategy

It is imperative that the City develop a coastal hazard improvements and financing strategy to address sea level rise hazard impacts. However, implementation of resiliency-building and adaptation policies, plans, and programs will take substantial time and investment to reduce risk to the City. The impacts of climate change such as sea level rise and increased coastal erosion and flooding will require extensive and ongoing coordination with federal, state, and regional agency partners, investment in community resiliency, and a financial program to be able to ensure that the City's long-term community vision is maintained now and in the future.

As next steps, the City would identify, evaluate, and pursue all feasible potential sources of revenue for funding within Section 8.5, *Funding Mechanisms*. The costs of priority adaptation strategies would be allocated and shared in proportion to the benefits realized by the affected parties, including the public, the City, and the beachfront and bluff property owners, respectively. The City's financing strategy could include the following:

- Coordinate with the County and cities of Santa Barbara and Goleta to explore sustainable local funding sources for shoreline management and adaptation measures such as uniform increases in TOT, local bond measures, changes to the County Flood Control District's Benefit Assessment program to include shoreline management, etc.
- Actively continue to seek state and federal funding for expedited implementation of priority adaptation strategies and prioritize the creation of a wider beach and a beach profile that can feasibly be established and maintained on City beaches for shoreline protection and recreation benefits.

- Work with the League of California Cities, BEACON, and the County to lobby state and federal legislators to create sustainable long-term funding programs for adaptation planning and capital improvements, including beach nourishment.
- Support formation of a CHAD and/or GHAD.

Future Technical Study

This Report generates information about potential hazards to the City from sea level rise and associated erosion and flooding damages. Given the significant vulnerabilities identified in this Report, the City may consider a more detailed analysis of certain hazards or site-specific study to inform implementation of an adaptation strategy. Therefore, this Report recommends additional study to support City adaptation planning efforts prior to implementation of the above adaptation measures. Specifically, the following issues warrant further investigation.

- **Additional Hazard Modeling:** This effort could include fluvial flood hazards and modeling hazards with adaptation in place (e.g., a living shoreline). Such modeling would inform design and implementation of adaptation measures and show the effectiveness of a particular measure. Site-specific modeling should also be conducted to determine potential sea level rise impacts on a parcel level for specific development proposals.
- **Cost-Benefit Analysis:** This Report could not precisely quantify specific values or cost estimates for priority adaptation strategies. Modeled physical responses to the potential strategies could be evaluated to determine potential economic trade-offs, fiscal impacts, and changes to tax revenues over time. Cost-Benefit Analysis would show which strategies would be more cost effective and yield greater benefits.
- **Critical Infrastructure Master Plans:** This Report identifies infrastructure that may be vulnerable to coastal hazards, including transportation, water and sewer, and storm water, but does not identify the cost or specific condition and maintenance needs of this infrastructure. Future coastal hazards, especially erosion, may require realignment or relocation of infrastructure. Even a small length of eroded pipeline may necessitate removal or relocation. Critical Infrastructure Master Plans can identify these segments and address issues of land acquisition/right-of-way, potential upgrades, and timing for such capital improvements considering sea level rise.
- **Improved Recreational Amenity Data:** A full analysis of the impact from beach and campsite erosion, as well as an analysis of the impacts of flooding on recreation, parking, and access to hotels and short-term vacation rental properties is recommended. Specific locations of camp sites and amenities would improve the analysis. This Report indicates that Carpinteria's beaches would erode, which could significantly impact future public recreational opportunities unless the beaches are allowed to transgress. This Report also indicates that a number of multi-family units, and many short-term vacation rentals, are also at risk to coastal erosion and coastal flooding, which may affect recreational use and

demand. Finally, both City and State parking lots near both beaches are subject to periodic flooding. As parking is impacted, future recreation, and associated spending and tax revenues for the City may be expected to show a corresponding decrease depending on the adaptation strategies implemented.

- **Oil and Gas Infrastructure Analysis:** The City has a large number of legacy oil wells within the City limits as well as the 55-acre Bluffs 0, which is anticipated to be decommissioned and redeveloped in the future. The potential exposure for the City from oil spills, or the leakage of oil or other hazardous materials into groundwater, is significant, and the costs of mitigation after leakage has occurred will almost certainly be much higher than if proactive remediation and closure of the site were to be initiated. The dispersal mechanism of the hazardous materials has also not been considered. This Report recommends that a more extensive analysis of the potential liabilities and the costs of mitigation for potential release of hazardous materials be completed.
- **Future Development of Bluffs 0:** The 55-acre Bluffs 0 parcel is relatively safe from future coastal hazards and represents a potential opportunity for the City and County. The site is in a highly desirable area which could potentially be redeveloped (following remediation of soil and groundwater resources) into property which would generate economic activity and taxes for the City, County, and State. For example, this site could be used to expand coastal camping and recreational opportunities. It could also potentially become part of a larger redevelopment effort in the City to relocate key aspects of the community to higher ground. This Report recommends a further investigation of the potential economic, social, and land use opportunities of developing this site with uses that could be lost to future coastal hazards elsewhere in the City, as well as potential costs and Citywide impacts should the site not be remediated.
- **ESHA:** The vulnerability of ESHA is limited based on available habitat mapping data and does not consider the evolution of habitats. Additional work could be completed to evaluate the potential impacts of the full suite of climate change variables (e.g. temperature, precipitation, drought and sea level rise) to provide a better understanding of the potential future impacts to ESHA.
- **Short-term Vacation Rental TOT Revenues:** The loss of short-term rentals near the beach could result in a significant loss in TOT for the City and warrants additional refined further investigation.

Public Outreach

The City will continue to solicit input, comments and feedback from the public, agencies, and interested parties on these proposed adaptation strategies. Successful implementation of any adaptation strategy requires communication of vulnerabilities, potential adaptation trade-offs, costs, and alternatives.

Multi-Agency Coordination

Adaptation planning for priority strategies is anticipated to require significant regional or multi-jurisdictional coordination and funding. The City cannot adapt to the impacts of sea level rise alone given the regional and global effects of sea level rise and the commensurate need to have regional or larger-scale adaptation strategies. The City will need to address coastal hazards by establishing collaborative regional solutions and partnerships with adjacent and affected jurisdictions and entities. The City should take the following actions to work with local, regional, state, and federal agencies.

- Establish and actively coordinate with regional partners on a regular basis to promote essential regional adaptation strategies and pursue cost-sharing agreements. Such agencies should include, but are not limited to, Santa Barbara and Ventura counties, BEACON, and cities (e.g., Santa Barbara, Goleta, Ventura, and Oxnard).
- Lobby state and federal legislators to implement legislation that requires California Public Utilities Commission (CPUC) and UPRR coordination with local jurisdictions on sea level rise and adaptation planning, protection of coastal habitats, and preservation of public lateral and vertical coastal accesses.
- Continue to coordinate with the CUSD on adaptation planning and initiate a joint-study to further investigate hazard risks and additional adaptation strategies for Aliso Elementary School.
- Continue to coordinate with the CSD and CVWD on adaptation planning for critical facilities, including the WWTP and future recycled water facility.
- Continue to coordinate with Caltrans on agency-specific vulnerability assessments and future planning/implementation of key infrastructure, such as U.S. 101.
- Continue to coordinate with the County Flood Control District to investigate and pursue installation of tide gates, flaps, coffer dams, or other flood control systems at strategic creek and culvert locations to manage floodwaters.

Monitoring Sea Level Rise and Triggers

Implementing adaptation measures will require coordination, planning, permitting, engineering, and financing. Each strategy will have a certain lead time from initial concept to implementation that varies depending on the scale and type of strategy, and the amount of sea level rise that the strategy can accommodate. Once the strategies are prioritized, then conservative estimates of lead times before implementation will be developed as part of this program. These lead times should then inform policy triggers that are then monitored through measurable objectives (see section 7.5, *Triggers and Monitoring*) to act as a catalyst for the planning process.

- Install a local tide gauge as part of the City's efforts to conduct sea level rise monitoring.

- Support the twice yearly (May and October) USGS shoreline transect profile monitoring program to monitor the health of the beach over time, including the active dissemination of results and their implications to regional shoreline management agencies. Integrate long-term shoreline and beach profile data into monitoring programs that include measurable policy triggers.

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Appendix A
Key Decisions Memo

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MEMORANDUM

Date: November 17, 2017 (amended *italics* February 6, 2018)

To: Steve Goggia, AMEC Foster Wheeler Team

From: David Revell, PhD

Subject: Key Assumptions for the Sea Level Rise Vulnerablity Assessment

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Purpose

The purpose of this memorandum is to recommend to City decision-makers the use of the below technical assumptions for development of the City of Carpinteria Sea Level Rise Vulnerability Assessment. This includes key assumptions regarding coastal hazards, sea level rise scenarios, models, and resource sectors (Table 1 and Table 2). These assumptions were selected to ensure that the project aligns with City General Plan and LCP goals as well as achieve consistency with the California Coastal Commission Sea Level Rise Policy Guidance.

Coastal Hazards

The project will evaluate 4 different coastal hazards affected by Sea Level Rise.

1. **Coastal Wave Flooding** – episodic impact from a 100 year wave storm event
2. **Coastal Erosion** – permanent loss of land from potential dune and cliff erosion
3. **Tidal Inundation** - periodic flooding caused by predictable high monthly tides
4. **Coastal Confluence**[1] – episodic creek flooding from Carpinteria Creek affected by changes in both precipitation and sea level rise. *So as not to under represent fluvial hazards, Franklin and Santa Monica Creeks will consider an existing FEMA 100 year and 500 year fluvial flood event in the absence of additional coastal confluence modeling.*

Coastal Hazard Models

The project evaluated the two available models of coastal hazards: 1) the Santa Barbara County Coastal Resilience Hazard Models (2016), and 2) the USGS COSMOS 3.0 (2017). Both models were evaluated for data availability for each hazard in a GIS format suitable for analysis (closed polygon shapefiles). 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 existing conditions flood potential was reviewed with observations of previous storm flooding.

In addition, results from both models were reviewed and compared for key parts of the City under existing 100 year storm conditions by knowledgeable local experts including Dr. Jim Bailard, technical advisor for BEACON, to assess the accuracy for a large storm event under existing conditions. The review and evaluation focused on two primary questions.

[1] Please note that Franklin and Santa Monica Creek which flow into the Carpinteria Salt Marsh does not have models available and is not included in the analysis of this hazard

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1. Does the extent of the mapped hazards in existing conditions represent on the ground observations during large storm events?
2. Does the mapped flood extents show that the beach gets flooded during large wave events?

Results of this comparative analysis resulted in the selection of the Coastal Resilience model for use in the Vulnerability Assessment. Below is a summary by each coastal hazard for why the model was selected. See attached figures for Coastal Wave Flooding Comparison.

1. Coastal Wave Flooding – USGS COSMOS model projects inland extent of flooding under existing conditions into the neighborhood above the train tracks which has never had coastal flood impacts (A). The COSMOS model does not realistically flood the beach during a 100 year wave event under existing conditions. The maximum run-up points mapped by COSMOS are not in a format conducive to vulnerability assessment (points not polygons). Coastal Resilience modeling noted that one area was mapped as surface flow connection uncertain whether there was a surface flow pathway in Carpinteria Salt Marsh adjacent to Ash Avenue (B). This area has a flow pathway through a culvert and so correction to that location (outside of the City Limits and Study area) should be made.

2. Coastal Erosion – USGS COSMOS model does not explicitly map any low lying dune erosion in the model. There is no existing cliff erosion hazard zone. Cliff erosion hazard zones are not in a suitable GIS format for analysis (line versus polygon). Neither the COSMOS or Coastal Resilience modeling directly consider the City's berm building practices, which provides some erosion and flood protection and thus the model outputs may overpredict the extent of existing dune erosion or coastal flood potential.

3. Tidal Inundation – USGS COSMOS model does not explicitly map tidal inundation and thus is not applicable to the analysis of tidal inundation. The Coastal Resilience model explicitly maps an extreme monthly tide condition in an appropriate format for the vulnerability assessment (closed polygons).

4. Coastal Confluence – USGS COSMOS model uses an average streamflow associated with a large coastal wave event to drive their creek flood model. From their 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 reduced creek flow event is inconsistent with the FEMA Existing 100 year (1% annual chance) storm or the Coastal Resilience modeling which assesses potential precipitation changes on 100-year stream flows and sea level rise in its coastal confluence modeling which are explicitly mapped in a suitable GIS polygon format for Carpinteria Creek. For Franklin and Santa Monica Creeks, we recommend utilizing the existing FEMA 100 year and 500 year extents to represent these coastal confluence flood extents.

Sea Level Rise Scenarios

As a result of the comparative analysis and needs of the City, the Coastal Resilience Modeling was selected for use in the Vulnerability Assessment. The Coastal Resilience model uses sea level rise and time horizon estimates of 10 inches by 2030, 27 inches by 2060, and 60 inches by 2100. Based on the guidance from the CCC Sea Level Rise Policy Guide to evaluate a "range of possible scenarios", the following sea level rise elevations were selected to be included in the Vulnerability Assessment (Table 1 – gray shading). As the science of sea level rise improves, additional information has

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become available which provides approximate probabilities of sea level rise for various times in the future (Griggs et al 2017). Unfortunately, both of the available models have utilized other elevations of sea level rise than those in the Griggs report, so the relative probabilities of the Coastal Resilience modeling occuring at that specific time in the future is shown in Table 1 for comparison.

Table 1. Sea Level Rise Scenarios Selected for Carpinteria Vulnerability Assessment

Model/year	SLR - in			% Probability [2]		
	2030	2060	2100	2030	2060	2100
Coastal Resilience - High	10	27	60	<0.5%	>5%<67%	>5%<67%
Science Range - Low	5	15	26	67%	67%	67%
Science Range - High	9	35	74	0.5%	0.5%	0.5%

Note: gray shaded is the model proposed for use in the vulnerability analysis

Table 2. List of Resource Sectors Selected for Carpinteria Vulnerability Assessment

- *Land Use Parcels and Structures*
- *Camping and Visitor Accommodation*
- *Coastal Trails and Access*
- *Hazardous Materials and Oil and Gas Infrastructure*
- *Storm Water*
- *Roads and Parking*
- *Wastewater*
- *Water Supply*
- *Public Transportation*
- *Community Facilities and Critical Services*
- *Sensitive Biological Resources*

[2] Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). Rising Seas in California: An Update on Sea-Level Rise Science. California Ocean Science Trust, April 2017.

Carpinteria 100 year event NO SLR

COSMOS 3.0

Coastal Resilience

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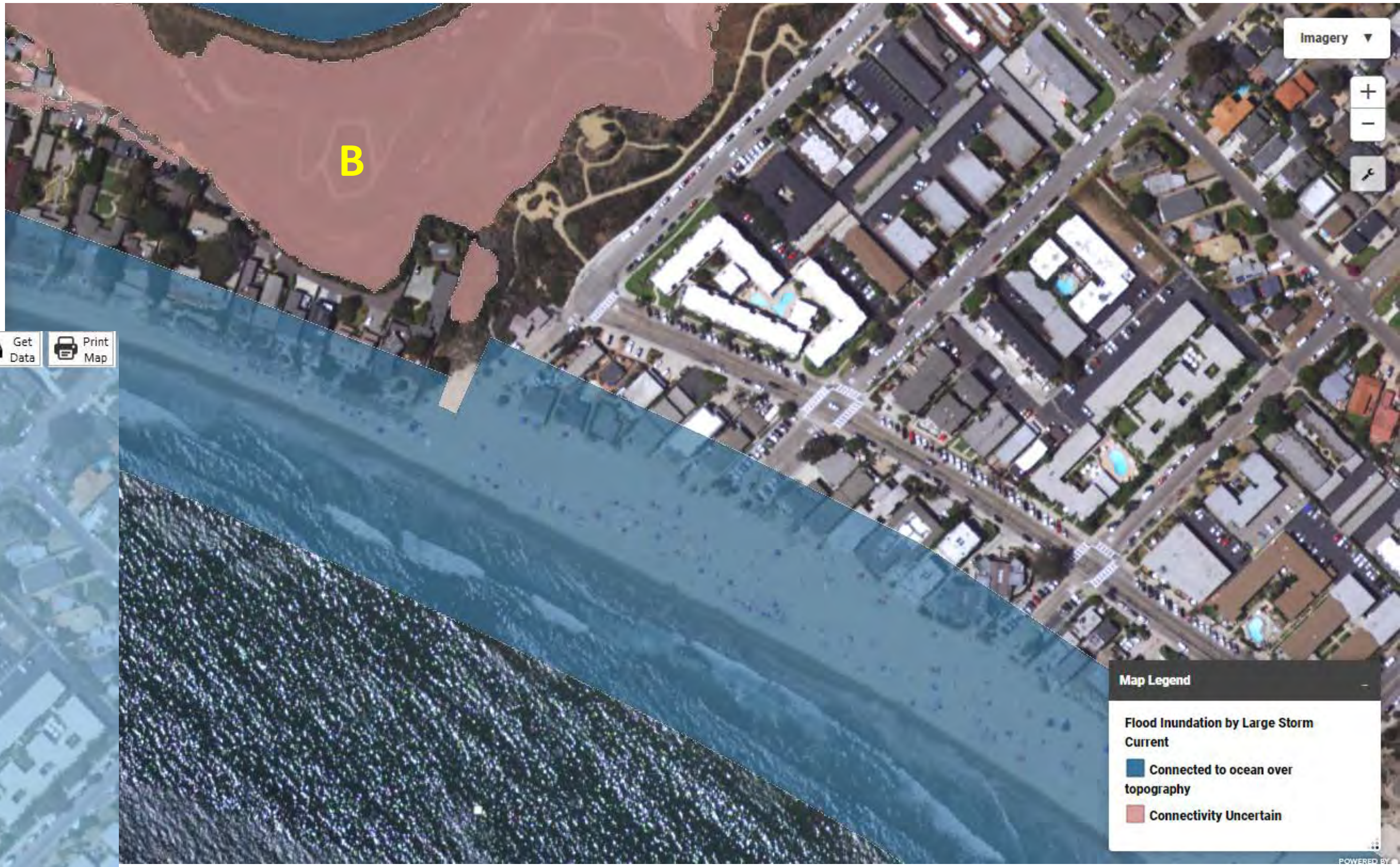
Carpinteria 100 year event NO SLR

COSMOS 3.0



Coastal Resilience

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Appendix B
Vulnerabilities Data Spreadsheet

Sector							
METRIC	# of Parcels						
TYPE	Agricultural	Commercial	Common	Facilities	Industrial	Mixed	Open Space
UNITS	count	count	count	count	count	count	count
Dune erosion							
Existing conditions	0	0	10	0	0	0	16
10.2 in	0	0	0	0	0	0	2
27.2 in	0	0	0	0	0	0	0
60.2 in	0	0	1	0	0	0	2
Total	0	0	11	0	0	0	20
Cliff erosion							
Existing conditions	0	0	0	0	0	0	18
10.2 in	0	0	0	0	0	0	0
27.2 in	0	2	0	0	0	0	0
60.2 in	1	1	0	0	1	0	6
Total	1	3	0	0	1	0	24
Tidal inundation							
Existing conditions	0	0	2	2	1	0	20
10.2 in	0	0	2	0	0	0	1
27.2 in	0	0	14	1	2	0	6
60.2 in	0	5	20	5	6	0	7
Total	0	5	38	8	9	0	34
Fluvial							
Existing conditions	5	27	90	19	7	3	56
60.2 in	0	27	7	8	2	1	4
Total	5	54	97	27	9	4	60
Coastal wave flooding							
Existing conditions	0	1	11	3	1	0	42
10.2 in	0	1	12	1	3	0	4
27.2 in	0	3	7	3	2	0	5
60.2 in	1	15	82	2	4	1	8
Total	1	20	112	9	10	1	59

Land Use							
				Commercial		Facilities	
Residential	Right of Way	Vacant	Total	Commercial	Commercial Out Building	Facilities	Facilities Out Building
count	count	count	count	count	count	count	count
8	0	0	34	0	0	0	0
46	0	0	48	0	0	0	0
15	1	0	16	0	0	0	0
40	0	0	43	0	0	0	0
109	1	0	141	0	0	0	0
0	2	0	20	0	0	0	0
0	0	0	0	0	0	0	0
0	3	0	5	0	0	0	0
28	1	2	40	1	0	0	0
28	6	2	65	1	0	0	0
7	14	0	46	0	0	0	0
7	0	0	10	0	0	0	0
115	1	2	141	0	0	0	0
503	7	3	556	3	2	6	2
632	22	5	753	3	2	6	2
978	31	12	1,228	19	3	23	13
504	4	0	557	33	1	17	4
1,482	35	12	1,785	52	4	40	17
79	18	0	155	0	0	0	0
164	1	2	188	0	0	0	0
234	7	1	262	2	0	0	1
292	8	8	421	10	3	8	4
769	34	11	1,026	12	3	8	5

# of Buildings								
Industrial	Mixed	Open Space		Residential		Total	Parkland and Open Space	
		Open Space	Open Space Out Building	Residential	Residential Out Building			
count	count	count	count	count	count	count	count	acres
0	0	0	0	7	0	7	4	18.64
0	0	0	0	8	0	8	0	2.16
0	0	0	1	4	0	5	0	3.28
0	0	0	4	7	0	11	0	6.38
0	0	0	5	26	0	31	4	30.46
0	0	0	0	0	0	0	2	8.75
0	0	0	0	0	0	0	0	1.39
0	0	0	2	0	0	2	0	4.01
0	0	0	1	21	2	25	2	22.08
0	0	0	3	21	2	27	4	36.23
0	0	0	0	0	0	0	3	7.30
0	0	0	0	4	0	4	1	1.11
1	0	0	0	101	13	115	0	3.96
2	0	0	5	236	29	285	1	27.28
3	0	0	5	341	42	404	5	39.66
18	4	0	5	596	76	757	6	52.58
1	6	0	3	329	39	433	1	18.91
19	10	0	8	925	115	1,190	7	71.49
1	0	0	0	19		20	5	38.48
0	0	0	5	131	15	151	0	11.62
1	0	0	4	102	14	124	0	16.37
9	1	0	2	258	37	332	3	27.96
11	1	0	11	510	66	627	8	94.43

Roads				Public Transportation							
length of roads		Parking		# of bus stops	length of routes by type					# of rail stations (platform)	# of lift/pump stations
					bike	bike	bus	bus	rail		
ft	miles	count	acres	count	ft	miles	ft	miles	ft	count	count
0	0.00	0	0.00	0	0	0.00	0	0.00	0	0	0
9	0.00	1	0.00	0	0	0.00	0	0.00	0	0	0
316	0.06	6	0.16	0	62	0.01	0	0.00	0	0	0
2,117	0.40	0	0.20	0	132	0.03	0	0.00	100	0	1
2,442	0.46	7	0.36	0	194	0.04	0	0	100	0	1
0	0.00	0	0.00	0	0	0	0	0	388	0	0
0	0.00	0	0.00	0	0	0	0	0	1,835	0	0
0	0.00	0	0.19	0	0	0	0	0	2,171	0	0
1,291	0.24	2	1.23	0	0	0	0	0	2,937	0	0
1,291	0.24	2	1.42	0	0	0.00	0	0	7,332	0	0
81	0.02	0	0.00	0	0	0.00	0	0.00	79	0	0
94	0.02	0	0.00	0	0	0.00	0	0.00	1	0	0
4,195	0.79	1	0.02	0	0	0.00	0	0.00	7	0	0
11,616	2.20	7	2.07	0	3,469	0.66	0	0.00	40	0	2
15,987	3.03	8	2.10	0	3,469	0.66	0	0	127	0	2
42,328	8.02	7	0.92	7	11,998	2.27	19,959	3.78	1,108	0	3
23,199	4.39	3	2.56	1	3,726	0.71	6,356	1.20	1,927	1	2
65,527	12.41	10	3.47	8	15,724	2.98	26,316	4.98	3,036	1	5
433	0.08	7	0.14	0	56	0.01	0	0.00	511	0	0
5,610	1.06	1	0.28	0	209	0.04	0	0.00	1,839	0	0
4,578	0.87	0	1.92	0	408	0.08	0	0.00	2,176	0	1
14,717	2.79	3	1.26	2	5,584	1.06	4,647	0.88	3,132	0	2
25,339	4.80	11	3.61	2	6,257	1.19	4,647	0.88	7,659	0	3

Sewer			Water Supply							Stormwate	
length of pipe		# of manholes	length of pipe		# of hydrants	# of wells (active)	# of pressure regulators	# of meters	# of valves	length of storm drains	# of drop inlets
ft	miles	count	ft	miles	count	count	count	count	count	miles	count
261	0.05	0	0	0.00	0	0	0	0	0	0.00	0
30	0.01	0	0	0.00	0	0	0	0	0	0.00	0
46	0.01	0	0	0.00	0	0	0	0	0	0.00	0
1,422	0.27	4	1,668	0.32	1	0	0	44	14	0.02	4
1,759	0.33	4	1,668	0	1	0	0	44	14	0.03	4
0	0	0	0	0.00	0	0	0	0	0	0.05	0
0	0	0	0	0.00	0	0	0	0	0	0.05	0
0	0	0	0	0.00	0	0	0	0	0	0.40	2
906	0	8	786	0.15	0	0	0	3	1	0.47	0
906	0.00	8	786	0.15	0	0	0	3	1	0.98	2
104	0.02	0	73	0.01	0	0	0	0	0	0.47	3
140	0.03	0	224	0.04	0	0	0	3	3	0.13	7
3,173	0.60	13	3,928	0.74	2	0	0	76	32	0.53	24
13,042	2.47	43	11,326	2.15	16	0	0	223	93	1.39	48
16,459	3.12	56	15,550	3	18	0	0	302	128	2.52	82
35,360	6.70	139	34,805	6.59	49	1	0	596	261	7.65	116
22,947	4.35	94	24,496	4.64	27	0	0	471	174	1.81	38
58,307	11.04	233	59,301	11	76	1	0	1,369	435	9.46	154
803	0.15	0	129	0.02	0	0	0	0	0	0.68	2
3,970	0.75	20	5,242	0.99	4	0	0	136	38	0.67	41
5,730	1.09	12	3,966	0.75	5	0	0	58	29	0.90	19
14,367	2.72	63	14,420	2.73	18	0	1	250	115	1.97	33
24,870	4.71	95	23,757	4	27	0	1	444	182	4.23	95

er	Public Access						
# outfalls	# of access locations	length of trail					
		VERTICAL		LATERAL		ALL OTHER DEDICATED	
count	count	ft	miles	ft	miles	ft	miles
0		666	0.13	4,067	0.77	89	0.02
0		138	0.03	0	0.00	67	0.01
0		318	0.06	0	0.00	45	0.01
0		567	0.11	0	0.00	487	0.09
0	0	1,688	0.32	4,067	0.77	687	0.13
1		81	0.02	948	0.18	686	0.13
0		196	0.04	0	0.00	3,235	0.61
0		389	0.07	0	0.00	3,386	0.64
2		11	0.00	0	0.00	9,065	1.72
3	0	677	0.13	948	0.18	16,372	3.10
36		0	0.00	48	0.01	0	0.00
13		0	0.00	0	0.00	0	0.00
12		0	0.00	50	0.01	295	0.06
38		573	0.11	2,951	0.56	3,242	0.61
99	0	573	0.11	3,049	0.58	3,537	0.67
186		1697	0.32	4,509	0.85	3,942	0.75
22		456	0.09	505	0.10	1,033	0.20
208	0	2,154	0.41	5,015	0.95	4,975	0.94
60		1,147	0.22	5,015	0.95	910	0.17
9		959	0.18	0	0.00	3,704	0.70
16		192	0.04	0	0.00	6,037	1.14
31		233	0.04	0	0.00	10,142	1.92
116	0	2,532	0.48	5,015	0.95	20,793	3.94

Armoring		Hazardous Materials			Critical Facilities and Em		
length of coastal armor		# of sites by type			# of entire (grouped) of		
		EPA - SQGs	Geotracker ESI Reporting Sites	Cleanup program Sites (Active)	Health Care (Clinic)	School Buildings	School Campus
ft	miles	count	count	count	count	count	count
0	0.00	0	0	0	0	0	0
395	0.07	0	0	0	0	0	0
0	0.00	0	0	0	0	0	0
0	0.00	0	0	0	0	0	0
395	0.07	0	0	0	0	0	
588	0.11	0	1	0	0	0	0
0	0.00	0	0	0	0	0	0
0	0.00	0	0	1	0	0	0
0	0.00	0	0	0	0	0	0
588	0.11	0	1	1	0	0	
0	0.00	0	0	0	0	0	0
0	0.00	0	0	0	0	0	0
0	0.00	0	0	0	0	0	0
0	0.00	0	1	0	0	7	1
0	0.00	0	1	0	0	7	
821	0.16	2	2	0	0	24	2
67	0.01	2	0	1	1	10	2
888	0.17	4	2	1	1	34	4
984	0.19	0	1	0	0	0	0
0	0.00	0	0	0	0	0	0
0	0.00	0	0	1	0	1	1
0	0.00	1	2	0	0	7	0
984	0.19	1	3	1	0	8	

ergency Services		Sensitive Biological Resources						Energy Infrastruct
facilities by type		Environmentally Sensitive Habitat Area (ESHA)			Sensitive Habitat			# of facilities
Water Treatment Buildings	Water Treatment Campus							Oil Wells (All)
count	count	sq ft	acres	count	sq ft	acres	count	count
0	0	840,708	19.3	3	445,369	10.22	1	0
0	0	80,432	1.85	1	283	0.01	0	0
0	0	98,281	2.26	0	0	0.00	0	1
0	0	129,238	2.97	0	0	0.00	0	0
0	0	1,148,659	26.5	4	445,652	10.23	1	1
0	0	679,536	15.6	4	149,754	3.44	2	0
0	0	166,247	3.82	0	6,444	0.15	0	0
0	0	397,763	9.13	0	9,024	0.21	0	1
0	0	1,180,300	27.10	0	2,238	0.05	0	3
0	0	2,423,846	55.6	4	167,460	3.84	2	4
0	0	439,956	10.1	7	185,613	4.26	1	2
0	0	68,337	1.57	0	10,846	0.25	0	0
0	0	133,631	3.07	1	21,879	0.50	0	0
0	0	635,601	14.59	0	99,249	2.28	0	4
0	0	1,277,525	29.4	8	317,586	7.29	1	6
7	1	12,979,737	297.98	15	630,244	14.47	2	2
0	0	302,128	6.94	0	12,779	0.29	0	3
7	1	13,281,865	304.91	15	643,023	14.76	2	5
0	0	2,025,540	46.5	9	599,847	13.77	2	19
0	0	317,580	7.29	1	2,647	0.06	0	0
0	0	562,643	12.92	0	1,386	0.03	0	2
2	1	1,316,578	30.22	3	752	0.02	0	3
2	1	4,222,341	96.9	13	604,632	13.88	2	24

Camping	
# by areas	area
count	acres
2	1.09
0	0.48
0	0.75
0	1.79
2	4.10
0	0
1	0
1	0
0	0
2	2.23
0	0.00
0	0.00
1	0.26
1	5.50
2	5.76
4	6.33
0	3.78
4	10.11
2	3.00
2	2.48
0	4.19
0	2.72
4	12.39

Appendix C
Fluvial Flood Hazards

Contents

Figures

Tables

Definitions, Acronyms, & Abbreviations

Definitions

100-Year/500-Year FEMA Flood Event: A fluvial flooding event based on extreme value analysis of historic storms with a 1% (100-Year)/0.2% (500-Year) chance of occurring in a given year; or a 1 in 100/1 in 500 chance of occurring in a given year.

Coastal Confluence: The combination of fluvial flooding and high tides elevated by sea level that expands river flooding extents.

Fluvial Flooding: Fluvial (or riverine) flooding occurs when rainfall over an extended period of time causes a river, stream, or creek to exceed its channel capacity. Fluvial floods are usually described by their volume of streamflow. Actual flood extents may also be influenced by sedimentation, material obstruction of a water corridor (e.g., debris blocking culverts), and extreme high tides, although these are not typically included in fluvial flood mapping.

Acronyms and Abbreviations

City	City of Carpinteria
ESI	Electronic Submittal of Information
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
NFIP	National Flood Insurance Program
WWTP	Wastewater Treatment Plant
TOT	Transient Occupancy Tax

Fluvial Flood Hazard Summary

While the vulnerability assessment focused on sea level rise and coastal hazards, the City of Carpinteria (City) felt it important to identify the potential magnitude of community impacts of creek flood hazards, particularly following the 2017 Thomas Fire and subsequent debris flows. Creek flood extents are assessed to compare the importance of existing flood hazards to climate change-influenced coastal hazards. The potential effects of fluvial hazards are estimated using a variety of possible future scenarios. However, the influence of existing development and/or future adaptation decisions are not considered within this analysis.

Fluvial flooding vulnerabilities identified outside of Carpinteria Creek are based on existing Federal Emergency Management Agency (FEMA) 100-year and 500-year flood maps. **All fluvial flooding impacts could occur under existing conditions.** Discussion of existing fluvial flooding threats given existing conditions (100-year FEMA flood event) and the 2100 time horizon (500-year FEMA flood event) is continued below.

Creek Flood Hazards Expansion

Creek (fluvial) flood hazards associated with a 100-year or 500-year storm as mapped by FEMA could cause more damage to City resources and infrastructure than 5 feet of sea level rise and a 1% annual chance storm.

Fluvial flood hazards (e.g., creek flooding) associated with the existing 500-year FEMA flood event (0.2% annual chance) currently expose more properties, land uses, schools, and infrastructure to potential damages than future coastal hazards with ~5 feet of sea level rise by 2100. Climate change impacts to fluvial flooding along Carpinteria Creek show expanded potential for flooding near the commercial shopping center located at Carpinteria Avenue and Casitas Pass Road, and inland of the Union Pacific Railroad tracks toward Linden Avenue and 7th Street. However, data on climate change impacts to flood hazards on Franklin and Santa Monica Creeks is unavailable. In addition, this study does not access climate change impacts on catastrophic events such as floods and debris flows such those that occurred due to the 2017 Thomas Fire and 2018 Montecito Debris flows.

Existing Fluvial Flood Hazards

FEMA mapped a regulatory fluvial (creek) flood using a 100-year FEMA flood event (1% annual chance) and 500-year FEMA flood event (0.2% annual chance) to determine regulatory flood insurance rates. Both FEMA-mapped fluvial floods could have devastating impacts to residential and commercial land uses and infrastructure within the City. Under a 500-year FEMA flood event, transportation corridors including U.S. Highway 101, the Union Pacific Railroad, numerous surface streets, and bicycle and bus/transit routes could be affected. In addition, important community facilities including the Sansum Health Clinic, the Wastewater Treatment Plant (WWTP), Carpinteria State Beach Service Yard, Post Office, 3 churches, and 4 schools encompassing 34 school buildings could be vulnerable to flooding. Vulnerabilities to the community from existing fluvial flood risks are greater than those associated with future coastal hazards from high tides, wave run-up, ocean-related flooding, and coastal erosion, even with ~5 feet of sea level rise.

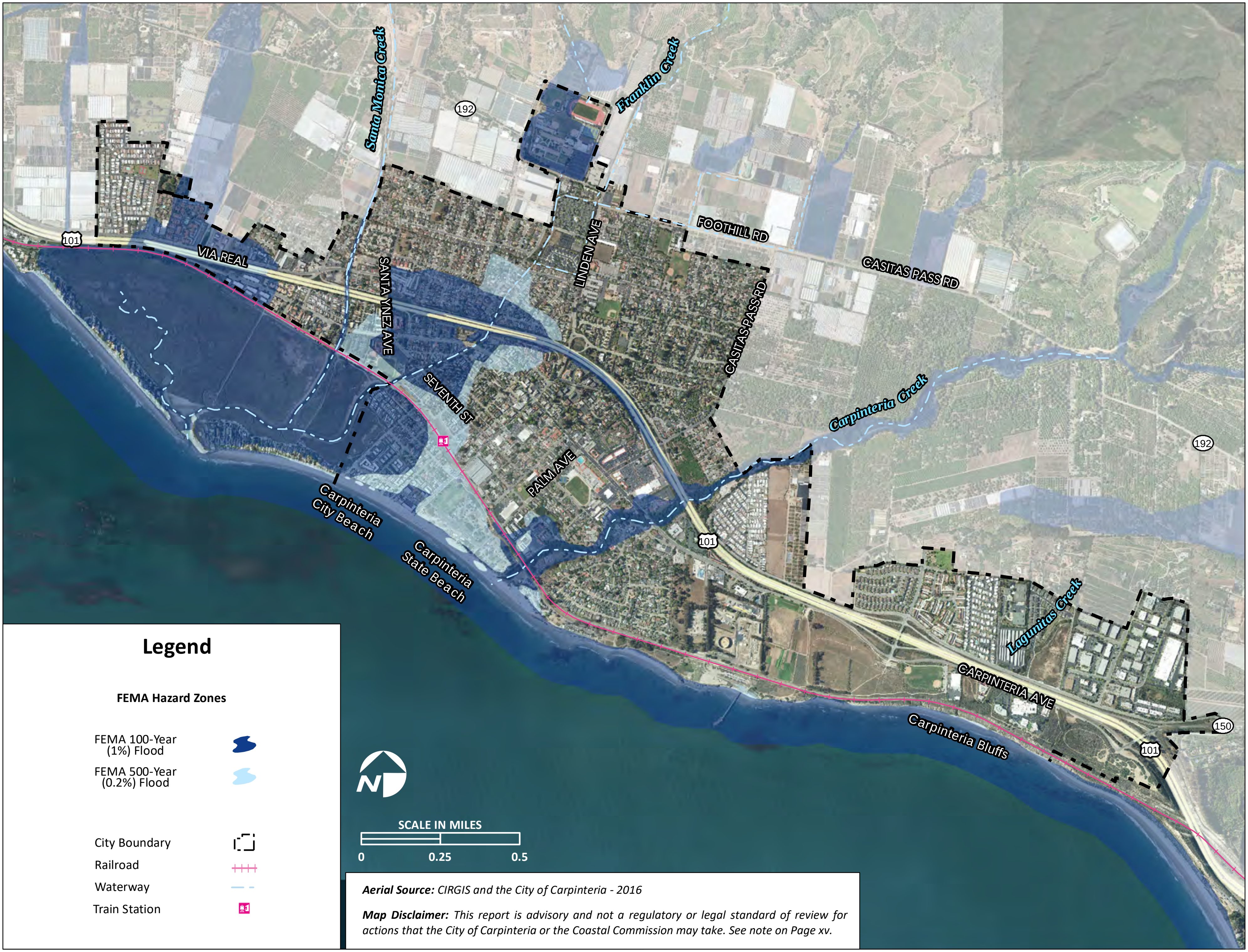
1. Existing Conditions & Physical Setting

1.1 Existing Fluvial Hazards

FEMA maps delineate creek (fluvial) flood hazards as part of the National Flood Insurance Program (NFIP). This program requires highly-specific technical analysis of watershed characteristics, topography, channel morphology, hydrology, and hydraulic modeling to map the extent of existing watershed-related flood hazards. These maps, representing the existing 100-year and 500-year FEMA flood events (1% and 0.2% annual chance of flooding), are known as FEMA Flood Insurance Rate Maps (FIRMs), and determine the flood extents and flood elevations across the landscape. Figure 1 illustrates the adopted FEMA flood event hazards across the City. Please note that FEMA flood maps are based only on existing conditions and do not account for coastal processes, climate change, or the interaction of fluvial and coastal processes in the analysis of fluvial flood hazards. It is noted, however, FEMA is currently in the process of updating all floodplain maps in the state of California.

Historic fluvial flooding has occurred in various parts of the City (Figure 2). FEMA flood maps and base flood elevations for the major watersheds at the downstream end are shown in Table 1 and Figure 1.

Figure 1 - Adopted FEMA Flood Insurance Rate Map



Aerial Source: *CIRGIS and the City of Carpinteria - 2016*

Map Disclaimer: *This report is advisory and not a regulatory or legal standard of review for actions that the City of Carpinteria or the Coastal Commission may take. See note on Page xv.*

Figure 2. Fluvial Flooding along Via Real in Carpinteria in January 2018 (photo courtesy, W. Swing)

Table 1. FEMA Fluvial Flood Elevations for Major Watersheds in Carpinteria

Water Body	Base Flood Elevations (NAVD 88)
Carpinteria Creek	11 feet
Franklin Creek	13 feet
Santa Monica Creek	8 feet

2. Vulnerability Methodology

2.1 Coastal Hazards Projections

The modeling work for the 2016 *Santa Barbara County Coastal Resilience Project* (Coastal Resilience model) includes modeling of fluvial flooding and coastal confluence. Creek flood extents were initially assessed to provide estimates of the relative importance of existing flood hazards compared to climate change influenced coastal hazards.

Coastal Confluence and Fluvial Flooding

Coastal confluence modeling projects the influence of climate change on fluvial flood hazards. As sea levels rise, fluvial flooding is backwatered during high tides, which can cause additional flooding in previously unflooded areas upstream/upland beyond the riverine channel banks. An initial model used the downscaled climate modeling developed during the 2008-2009 Second California Climate Assessment to derive these precipitation and flood flow changes because the Fourth Climate Assessment data were not available at the time the Coastal Resilience model was run (2016).

This initial coastal confluence modeling was conducted only for Carpinteria Creek, using the existing FEMA flood model (Revell Coastal and Revell Coastal and ESA 2016). The locations that appear to be affected by this coastal confluence modeling occur with 1-2 feet of sea level rise, resulting in potential expansion of creek flooding along Carpinteria Creek over the tracks along Maple Avenue up to Linden Avenue and 7th Street. With ~5 feet of sea level rise, the influence of climate change expands fluvial flood hazards to Carpinteria Middle School, into the Downtown area from Palm Avenue to 8th Street and Linden Avenue to the Union Pacific Railroad tracks, and into the commercial shopping center as shown in Figure 3. Results of this initial modeling were not included in the vulnerability assessment, which focused on sea level rise and coastal hazards.

Figure 3 - Coastal Confluence Hazards

Modeling Assumptions

As with all modeling, assumptions had to be made to complete the work. Below are the modeling assumptions of the *Santa Barbara County Coastal Hazard Modeling and Vulnerability Assessment*, which were used for this analysis (Table 2; Revell Coastal and ESA 2016).

Table 2. Hazard Model Assumptions and Biases

Geospatial Data	Potential Bias	Type of Bias	Reason
Fluvial flooding combined with coastal confluence	Too Low	Spatial and Temporal	The influence of changes in precipitation and higher sea level rise, with the effects of expanding fluvial flood extents in all creeks and the Carpinteria Salt Marsh, has not been fully analyzed. FEMA maps indicate a 100-year and 500-year FEMA flood event could occur today; these have not been evaluated with sea level rise.

Fluvial flooding modeling for Santa Monica and Franklin Creeks 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 Santa Barbara County (aside from Carpinteria Creek). Therefore, the influence of changes in precipitation and higher sea levels on the overall extent of flooding in the various creek mouths and sloughs has not been fully analyzed.

To represent the remaining fluvial hazards on Santa Monica Creek and Franklin Creek, the existing 100-year FEMA flood event was used to characterize existing conditions. The 500-year FEMA flood event was used to characterize future fluvial flooding hazards. This likely underestimates the future potential flood extents along Franklin Creek and Santa Monica Creek which flow into the Carpinteria Salt Marsh. ***It is important to note that the mapped extents of the 500-year FEMA flood event could occur at any time between now and 2100.*** The assumption that climate change will have no impact on flooding likely results in under prediction of the combined costal and creek flood extents.

3. Sector Results

Overall, the existing fluvial flooding hazards appear to be a larger hazard threat to the City over coastal hazards, even with ~5 feet of sea level rise.

The sector profiles and analysis for this discussion are provided in Chapter 1.0, *Sector Profiles,* of the **2019 Sea Level Rise Vulnerability Assessment and Adaptation Project.**

3.1 Camping and Visitor Accommodations

Two hotels, the Best Western Plus Carpinteria Inn and the Sandyland Reef Hotel, are currently vulnerable to FEMA mapped creek fluvial flooding hazards. These hotels charge a Transient Occupancy Tax (TOT) which goes to the City. This Report does not estimate the loss in TOT due to fluvial flooding impacts; however, given the location of these two hotels within the fluvial flood hazard zone, the potential loss of TOT is considered to be a key vulnerability.

3.2 Hazardous Materials Sites and Oil and Gas Wells

Of the onshore oil wells, two are located within the existing fluvial flooding hazard zone near the mouth of Carpinteria Creek. Under existing conditions, fluvial flooding hazards pose a risk to two Electronic Submittal of Information (ESI) sites, one located at an industrial metalsmithing building on Carpinteria Avenue and Reynolds Avenue and the other is the WWTP. Fluvial hazards also pose a risk to two businesses storing hazardous materials, including one at a light industrial building on Carpinteria Avenue and exit 87B and a metal smith on Palm Avenue. Further, the shopping plaza is vulnerable to an existing 500-year flood event. One active cleanup site, a former (and now vacant) automobile repair shop off of Carpinteria Avenue, is also exposed to fluvial flooding.

3.3 Infrastructure

Stormwater Infrastructure

Currently, fluvial flooding from a FEMA 100-year flood event could substantially affect storm drains, inlets, and outfalls. Most of this infrastructure is located along the Highway 101 corridor and in the Franklin Creek and Santa Monica Creek floodplains. Compared to the 100-year flood event, fluvial flooding from a FEMA 500-year flood could affect an additional 38 inlets (154 total), 22 outfalls (208 total), and 1.8 miles (9.5 miles total) of storm drains. Additional exposure would occur in the Downtown Beach Neighborhood, 6th Avenue east of Linden Avenue, and near the Albertsons Shopping Center. A 500-year FEMA flood event could be more damaging to stormwater infrastructure than coastal flooding under 5 feet of sea level rise.

Wastewater Infrastructure

Substantial fluvial flood hazards exist to the wastewater system today from a 100- or 500-year flood event, and potential damage from these events increases as climate change and sea level rise advances. Fluvial flooding from a FEMA 100-year flood event may affect wastewater infrastructure along all three creeks in Carpinteria, specifically in neighborhoods along Franklin Creek north of the Union Pacific Railroad, the west side of the Beach Neighborhood, and north of the Salt Marsh. As compared to a 100-year storm, fluvial flooding from a FEMA 500-year flood event may affect 7 buildings at the WWTP, as well as an additional 94 manholes (233 total), 2 lift stations (5 total), and 4.4 miles (11.1 miles total) of pipe inland of the Salt Marsh along Santa Monica Creek and 7th Avenue.

3.4 Community Facilities and Critical Services

The largest threat to this sector is existing fluvial flooding hazards as mapped by FEMA. Fluvial flooding under a FEMA 100-year flood event could inundate 24 buildings at Aliso Elementary School and Carpinteria High School, St. Joseph’s Chapel and the Redeemer Community Church, 7 buildings at the WWTP, and the Carpinteria State Beach Service Yard. Fluvial flooding from a FEMA 500-year flood event could impact an additional 10 buildings at Main Elementary School, the Post Office, and the Sansum Health Care Clinic. In total, a FEMA 500-year flood event could impact 4 schools, 34 school buildings, 3 churches, the Sansum Health Care Clinic, and 4 community facilities, including the Post Office and WWTP.

4. Future Studies

Recommended Future Studies

Given the significant vulnerabilities identified in this Report, the City should consider a more detailed analysis of coastal confluence and fluvial hazards. Changes in the local climate could affect precipitation intensity, peak streamflows, and bottom of the watershed tailwater elevations, and could combine to impact the extents of future fluvial flooding hazards. Given the lack of modeling of coastal confluence flooding for Santa Monica Creek and Franklin Creek, using the existing 100-year and 500-year FEMA floodplains as a substitute may under-predict the future risk of future fluvial flooding hazards. This may be particularly true for fluvial flood hazards associated with additional bridge upgrades along U.S. Highway 101 at Carpinteria Creek. Improved modeling of these coastal confluences particularly as they drain into the Carpinteria Salt Marsh is recommended in any future update to this type of vulnerability assessment or to the City's Local Hazard Mitigation Plan.