

**DRAFT**

**City of Carpinteria**

**Coastal Vulnerability and Adaptation Project**



**City of Carpinteria**  
**5775 Carpinteria Avenue**  
**Carpinteria, CA 93013**

**wood.**



**July 2018**

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# Definitions, Acronyms, & Abbreviations

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## 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% Annual Chance Storm:** A single storm wave event with a 1% 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% 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% (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. A storm event of this magnitude on one day does not change the probability of another 1% 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% 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 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 tectonics 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.

**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

|                                |   |
|--------------------------------|---|
| <b>BEACON</b>                  | Beach Erosion Authority for Clean Oceans and Nourishment  |
| <b>BFE</b>                     | Base Floor Elevation                                      |
| <b>CCAMP</b>                   | California Coastal Analysis and Mapping Project           |
| <b>CCC</b>                     | California Coastal Commission                             |
| <b>CDP</b>                     | Coastal Development Permits                               |
| <b>CEC</b>                     | California Energy Commission                              |
| <b>CEVA</b>                    | Coastal Ecosystem Vulnerability Assessment                |
| <b>CIRGIS</b>                  | Channel Islands Regional Geographic Information System    |
| <b>City</b>                    | City of Carpinteria                                       |
| <b>CoSMoS</b>                  | Coastal Storm Modeling System                             |
| <b>County</b>                  | County of Santa Barbara                                   |
| <b>CP</b>                      | Coastal Plan  |
| <b>CRSMP</b>                   | Coastal Regional Sediment Master Plan                     |
| <b>CSBAT</b>                   | California Sediment Benefits Analysis Tool                |
| <b>CSD</b>                     | Carpinteria Sanitary District                             |
| <b>CVWD</b>                    | Carpinteria Valley Water District                         |
| <b>DOGGR</b>                   | California Division of Oil, Gas, and Geothermal Resources |
| <b>EFGS</b>                    | Ecological Functions Goods and Services                   |
| <b>EMHW</b>                    | Extreme Monthly High Water                                |
| <b>EPA</b>                     | U.S. Environmental Protection Agency                      |
| <b>ESA</b>                     | Environmental Science Associates                          |
| <b>ESH</b>                     | Environmentally Sensitive Habitat                         |
| <b>ESI</b>                     | Electronic Submittal of Information                       |
| <b>ESHA</b>                    | Environmentally Sensitive Habitat Areas                   |
| <b>ESRI</b>                    | Environmental Systems Research Institute                  |
| <b>FEMA</b>                    | Federal Emergency Management Agency                       |
| <b>FIRM</b>                    | Flood Insurance Rate Map                                  |
| <b>GCM</b>                     | Global Climate Model                                      |
| <b>GHG</b>                     | Greenhouse Gas  |
| <b>GP</b>                      | General Plan  |
| <b>GP/LCP Update Committee</b> | General Plan/Local Coastal Program Update Committee       |
| <b>GIS</b>                     | Geographic Information System                             |
| <b>GSW</b>                     | General Steel Works                                       |
| <b>HPI</b>                     | Housing Price Index                                       |
| <b>HMP</b>                     | Hazard Mitigation Plan                                    |
| <b>IPCC</b>                    | Intergovernmental Panel on Climate Change                 |
| <b>JPA</b>                     | Joint Powers Agency                                       |
| <b>LCP</b>                     | Local Coastal Program                                     |
| <b>LHMP</b>                    | Local Hazard Mitigation Plan                              |
| <b>LiDAR</b>                   | Light Detection and Ranging                               |
| <b>LPT</b>                     | Local Planning Team                                       |
| <b>LUP</b>                     | Land Use Plan   |
| <b>MHW</b>                     | Mean High Water   |

|                    |   |
|--------------------|---|
| <b>MJHMP</b>       | Multi-Jurisdictional Hazard Mitigation Plan                               |
| <b>MLLW</b>        | Mean Lower Low Water  |
| <b>MSL</b>         | Mean Sea Level  |
| <b>NAVD</b>        | North American Vertical Datum of 1988                                     |
| <b>NOAA</b>        | National Oceanic and Atmospheric Administration                           |
| <b>NRC</b>         | National Research Council   |
| <b>OPC</b>         | Ocean Protection Council  |
| <b>PDO</b>         | Pacific Decadal Oscillation   |
| <b>RCP</b>         | Relative Concentration Pathways   |
| <b>Report</b>      | 2018 Coastal Resiliency, Vulnerability Assessment, and Adaptation Project |
| <b>SBA</b>         | Santa Barbara Area  |
| <b>SCC</b>         | California Coastal Conservancy  |
| <b>SCE</b>         | Southern California Edison  |
| <b>SLR</b>         | Sea Level Rise  |
| <b>SMR</b>         | Salt Marsh Reserve  |
| <b>State Parks</b> | California Department of Parks and Recreation                             |
| <b>SQG</b>         | Small Quantity Generator  |
| <b>ToT</b>         | Transient Occupancy Tax   |
| <b>USACE</b>       | U.S. Army Corps of Engineers  |
| <b>USGS</b>        | U.S. Geological Survey  |
| <b>WTP</b>         | Willingness to Pay  |
| <b>WWTP</b>        | Wastewater Treatment Plant  |

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# Report, Map, & Data Disclaimer

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The data utilized for purposes of this Report was collected from various sources and is not to be construed as “legal description.” This Report is advisory and not a regulatory or legal standard of review for actions that the City of Carpinteria or the California Coastal Commission may take. This Report is part of an ongoing process to understand and prepare for future coastal hazards as a result of climate change. Substantial uncertainties associated with modeling and projecting future hazards and their potential impacts exist.

Although we strive to review all resource sector and infrastructure data received, we cannot verify the location or completeness of all spatial data. For this reason, Revell Coastal LLC, Wood PLC, and the City of Carpinteria cannot accept responsibility for any errors, omissions, or positional accuracy, and therefore, there are no warranties which accompany this product. Users of the information displayed in maps are strongly cautioned to verify all information.

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# Executive Summary

## ES.1 Purpose

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. Existing coastal hazards from severe storms cause erosion and wave flooding. Routine tidal inundation already affects community

This study examines coastal hazard vulnerabilities with ~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.

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. All of 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 **2018 Coastal Vulnerability Assessment and Adaptation Project (Report)** provides the City of Carpinteria (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 General Plan and Local Coastal Program (GP/LCP), which will ultimately lead to enhanced community resilience.

Funding for this Report has been provided by the City and an LCP planning grant received from the California Coastal Commission (CCC). The Report is being led by the City of Carpinteria Community Development Department, with assistance from Wood PLC and Revell Coastal consultants.

## ES.2 Report Overview

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

**Section 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 CCC's 2015 *Sea Level Rise Policy Guidance* document and the 2018 California Ocean Protection Council 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.

**Section 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.

**Section 4, *Climate and 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 4.4 *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**

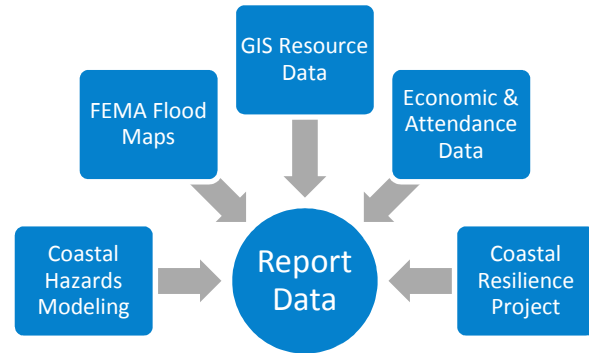
| Projected Horizon Year / Time | Sea Level Rise (inches/feet) | Probability of Occurring in Projected Year <sup>1</sup> |
|-------------------------------|------------------------------|---|
| 2030                          | 10.2 in/~ 1 ft               | < 0.5%  |
| 2060                          |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

Source: Revell Coastal and ESA 2016, and OPC 2018.

<sup>1</sup> 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. H++ scenario does not have a specific probability assigned and is presently considered the worst-case scenario.

## Section 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 City's GP/LCP Update Committee. Input also addressed key decisions including resource and service sectors to be included in the vulnerability assessment, during a public meeting in July 2017 (see Appendix A). As a result of the comparative analysis and needs of the City, the hazard model selected was the *County of Santa Barbara Coastal Resilience Project* (Coastal Resilience model), funded by the California 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 % 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 with adjusting 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 and other local sources was used to evaluate recreational revenues. Additionally, replacement costs for some key infrastructure was estimated based on readily available cost estimates from similar studies and City documents.



**Section 6, *Sector Results***, provides an overview of potential risks to eleven resource sectors for three planning horizons (2030, 2060, and 2100) for the current 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% annual chance storm.
- **Coastal Erosion:** Coastal erosion based on sea level rise and a 1% 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.

**Section 7, *Adaptation Planning***, 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. The challenges and secondary impacts 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.

## 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.





Historic coastal erosion along the City Beach, near Ash Ave. (Winter 1978 or Winter 1983).  
(Photo courtesy of City of Carpinteria)

## 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% 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, but additional work is needed on this topic. Further information on coastal confluence and fluvial hazards are within Appendix C.

With **~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 Downtown Beach Neighborhood and Carpinteria State Beach. Salt Marsh Park could also be affected during storm events. Cliff

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.

erosion along Carpinteria Bluffs may affect the railroad and recreational trails.

With **~2 feet of sea level rise**, more extensive coastal flooding and coastal beach erosion during storms could affect properties, land uses, and infrastructure between both Ash and Linden Avenues north of the railroad, as well as in the Carpinteria State Beach campgrounds. Coastal cliff erosion could continue to impact the railroad, recreational trails, and habitats along the Carpinteria Bluffs, but not any structures. Coastal flooding may also begin encroaching through the Carpinteria Salt Marsh 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 **~5 feet of sea level rise**, coastal beach erosion could extend through the first row of parcels to the inland side 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 of the Old Town District inland of the railroad, Carpinteria Salt Marsh and areas along Franklin Creek. Coastal cliff erosion could continue to impact the railroad, recreational trails, and habitats along the Carpinteria Bluffs and potential impact one commercial structure. Routine monthly high tides could inundate much of the Downtown Beach Neighborhood and Carpinteria State Beach inland to the Tomol Interpretative Park, even in areas not directly connected due to daylighting, or the surfacing, of groundwater due to tidal inundations. While this study used sea level rise scenarios and models that had ~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. Please also refer to Section 1, *Sector Profiles*, and Section 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% 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% 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 and sales tax revenues for the City.

- **Beaches and Dunes:** With ~5 feet of sea level rise by 2100, beaches and dunes would be severely eroded and frequently inundated. This would impact coastal recreation, 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% 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 ~5 feet of sea level rise (2100). By 2100, 34% of the campground area may be damaged by coastal erosion; 31% may be vulnerable to tidal inundation; and 67% of the campground area may be flooded during large wave events. Loss of the Carpinteria State Beach campground would result in the loss of lower-cost overnight accommodation 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 transient occupancy taxes 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:** Between the five land uses types (residential, commercial, industrial, open space, and public facilities), 914 parcels and 627 structures (including many that are multi-unit residential) on 223.6 acres may be exposed to the combined threats of erosion loss, inundation exposure or flood damages with ~5 feet of sea level rise. While most of these properties are only 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 railroad alignment along the Carpinteria Bluffs is highly vulnerable to coastal erosion; with ~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 the railroad in other parts of the City north of the Salt Marsh and in the Downtown core. Disruption of the railroad could have substantial economic impacts to the region.

- **Environmentally Sensitive Habitat Areas:** Coastal hazards and sea level rise could directly impact substantial acreage of existing ESHA in the City, including 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 ~5 feet of sea level rise (2100), more than 340 acres of ESHA may be potentially impacted by dune or bluff erosion, tidal inundation or coastal flooding, with some ESHAs dependent upon landward migration to remain viable.
- **Bluffs:** With 5' of sea level rise by 2100, the City's bluffs in Tar Pits Park and within Carpinteria Bluffs are projected to erode 360-460 feet, damaging parks and trails, ESHA, and exposing some neighborhoods, commercial industrial development, and the Union Pacific Railroad 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.

## Positive Findings

- No major emergency first response facilities (e.g., police, fire, or medical) are exposed to coastal hazards with up to ~5 feet of sea level rise. However, two lifeguard towers are currently vulnerable to coastal flooding and coastal beach erosion on the City Beach, and the Carpinteria State Beach Rangers Office/Visitors Center is vulnerable to coastal storm flooding with ~5 feet of sea level rise.
- No hotels or motels are vulnerable to coastal hazards with up to ~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 ~5 feet of sea level rise only affect three commercial parcels and one commercial structure within Carpinteria Bluffs.
- No municipal groundwater wells are exposed to coastal hazards with up to ~5 feet of sea level rise.

- The City has minimal shoreline protective devices across its 2.5 miles of shoreline, largely as a result of its active seasonal winter storm berm program.<sup>2</sup> This creates an opportunity to plan for natural resiliency efforts.
- Development within Bluff 0 would not be affected by coastal hazards with up to ~5 feet of sea level rise and represents an opportunity for future redevelopment when the site is remediated and repurposed.

## 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 6.10, *Recommended Future Studies*.

- **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) flood maps is recommended for a more comprehensive understanding of the extent of impacts.
- **Transportation and Environmental Justice Impacts:** The City is currently conducting a detailed analysis of potential sea level rise hazards to transportation facilities and environmental justice populations. The City was awarded grant funds by the California Department of Transportation Adaptation Planning Grant to pursue this study.
- **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 Bluff:** Bluff 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.

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<sup>2</sup> The City's temporary winter storm berm program is not incorporated under modeling projections of future coastal hazards.



- **Environmentally Sensitive Habitat Area:** Additional work could be completed 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. This analysis is forthcoming with the preparation of the Adaptation Plan. 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: do nothing, protect, accommodate, managed retreat, or a hybrid approach, 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 is doing it 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.



The next steps include discussing 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 an adaptation plan will be developed based on known vulnerabilities identified within the Report, dialog with the community, and coordination with local and state agencies.

# 1. Sector Profiles

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In order to address sea level rise and associated coastal hazards, the City of Carpinteria (City) and its consultant team prepared the Draft 2018 Coastal Vulnerability 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 and education. Each sector contains a vulnerability map and two-page summary of findings. They are as follows:

- **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, the overview section provides a summary of the key findings for each resource sector over time. The existing and future vulnerabilities sections highlight what is potentially vulnerable today, and projected to be at risk in the future from tidal inundation, coastal erosion, and coastal flooding. For each projected sea level rise elevation/ planning horizon, 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 ~5 feet of sea level rise by 2100 scenario identifies both what becomes vulnerable between ~2 and ~5 feet of sea level rise, as well as the cumulative totals for all planning horizons. Please note that under the worst-case H++, ~5 feet of sea level rise could occur as early as 2070.

The adaptation section provides a range of potential adaptation strategies to address potential vulnerabilities identified within the sector. Adaptation strategies will be further

refined as additional workshops and dialogs are held with the City, the public, and key stakeholders.

Potential next steps include examples of policy direction, monitoring needs, and potential adaptation projects. The forthcoming Adaptation Plan will 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) 2015 *Sea Level Rise Policy Guidance* document, and the City's General Plan/Local Coastal Program (GP/LCP).

# 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:

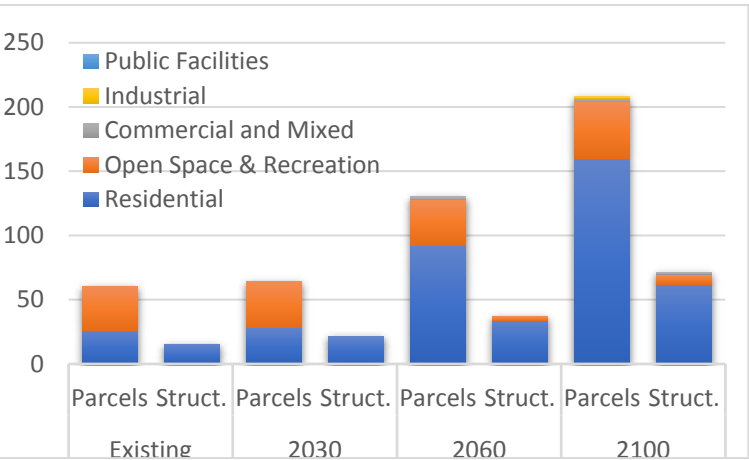
### Number of Parcels/Acreages/Number of Structures at Risk with 5’ of SLR

| 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

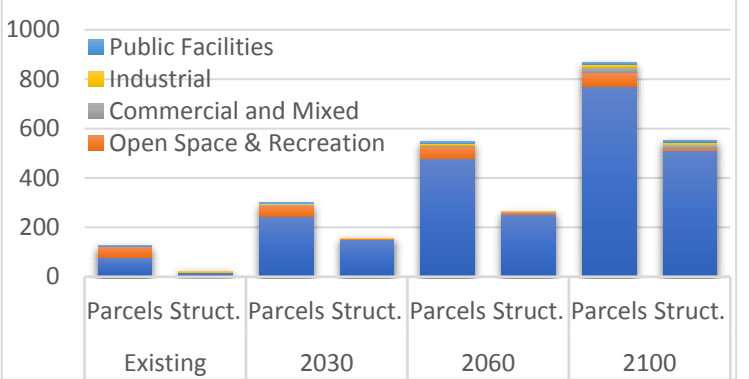


**Currently**, beach/dune erosion could damage 15 residential structures and State and City lifeguard towers are at risk. With 5’ of SLR, 132 residential parcels may be eroded, with homes damaged/ destroyed and restrooms on Ash Ave. and State Beach become vulnerable. No commercial or industrial structures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

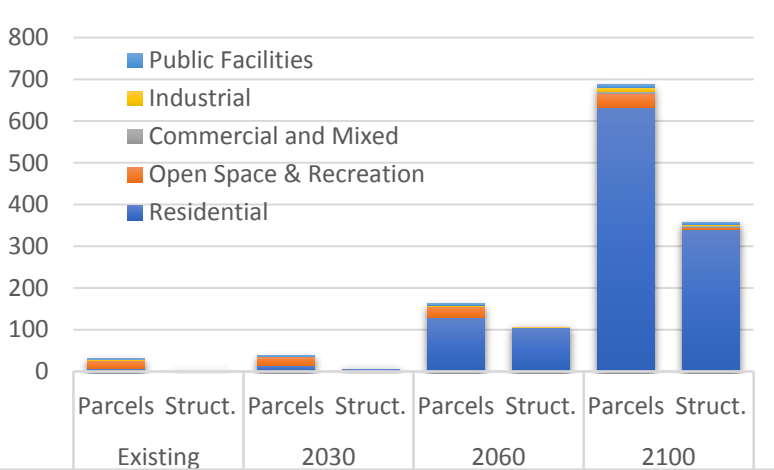


**Currently**, 20 structures (19 residential and 1 industrial) are vulnerable. This increases to 156 structures with 1’ of SLR, mainly in the Beach Neighborhood. With 2’ of SLR, 265 total structures become vulnerable extending north of the railroad and inland of the Salt Marsh. With 5’ of SLR, 553 total 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:

**Manage** - Transfer of highly vulnerable development out of hazard zones, rolling easements, or purchase of the vulnerable properties potentially with a lease back option.

**Accommodate** – Retrofit structures during major remodels to increase elevation or setbacks. Amend City building code and zoning ordinance to enable elevation to occur over time.

**Protect** – Install shoreline protection to prevent coastal erosion is a “gray” protection approach. Perform regular beach nourishment with sand and cobbles, augmenting sand dunes to create a “living shoreline” to protect against coastal erosion and large wave events as a “green approach”; major beach nourishment requires regional coordination/ funding.

**Secondary Impacts:** Management strategies have secondary impacts due to the loss of structures and property and subsequent impacts to City’s tax base/ revenues. Gray options (e.g., armoring) would protect structures but impacts the beach, coastal recreation and access, natural processes and habitats over time. Green protection strategies of beach nourishment may benefit beaches and homes by maintaining recreational uses but requires routine maintenance, regular secure funding and may less effective without other actions with 5’ of SLR.

## 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/ seek regular state/ federal f funding 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.

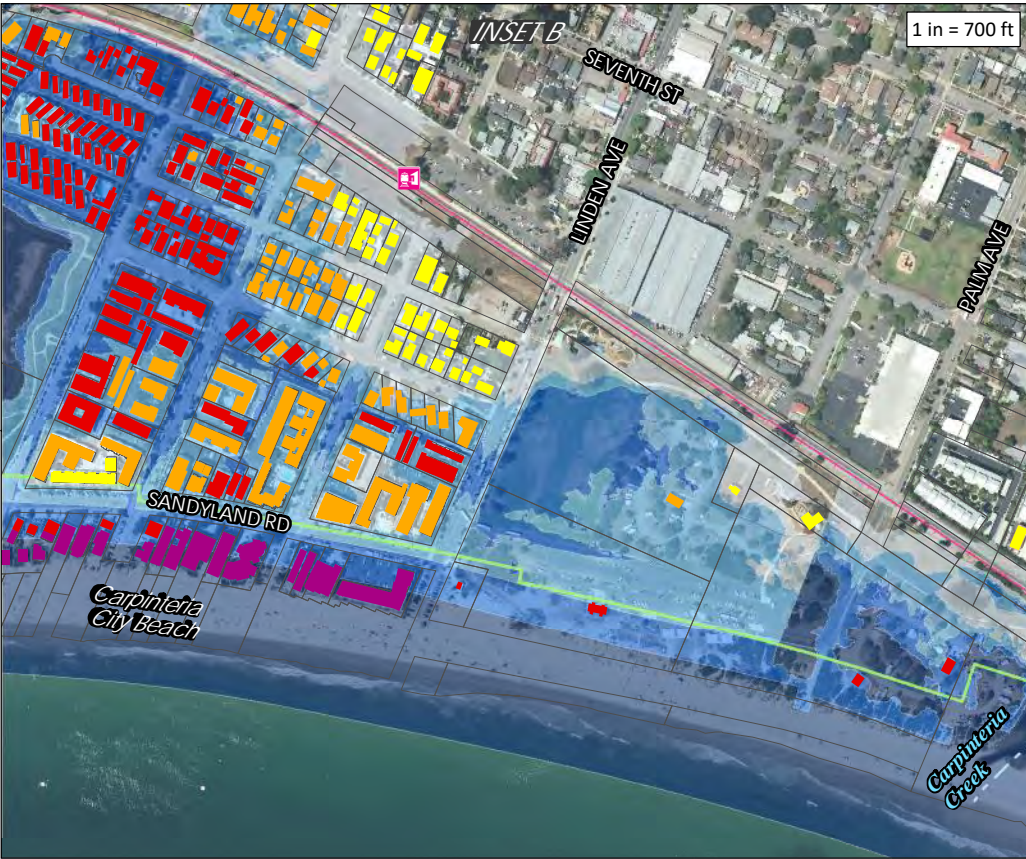
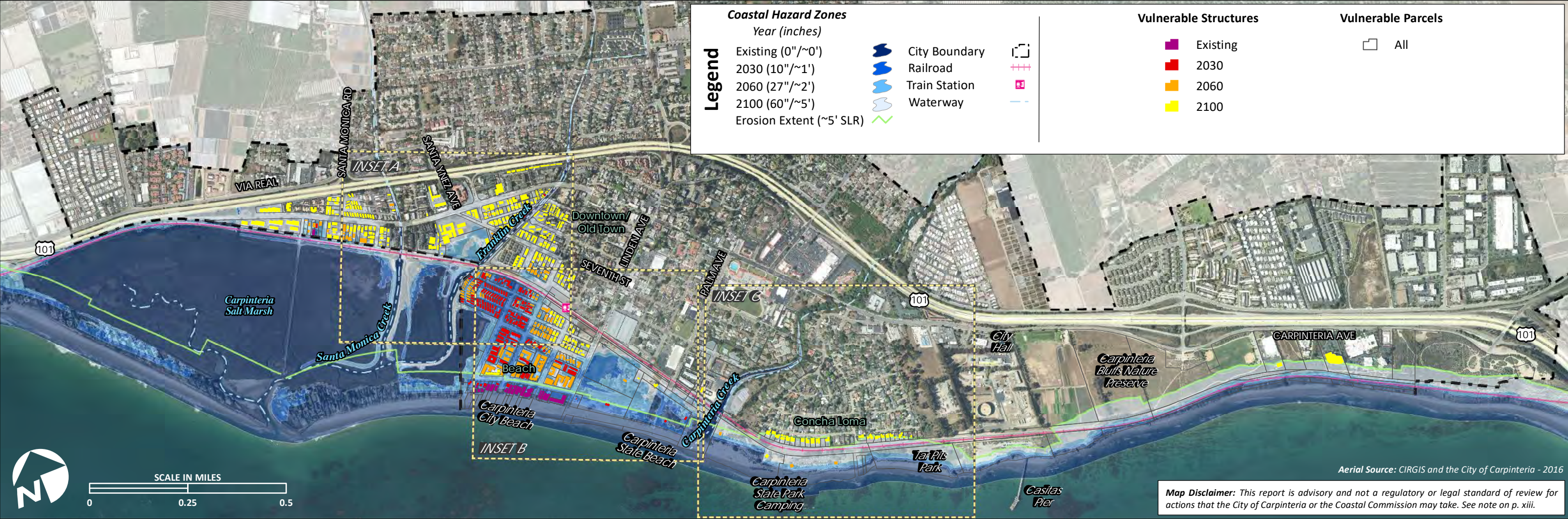
### Thresholds

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

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



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.

**Threshold:** With 2’ of SLR, tidal inundation impacts to roads and erosion impacts to parking lots escalate.

Existing Vulnerabilities

|  |   |  |
|--|---|--|
| <b>Tidal Inundation</b> <ul style="list-style-type: none"><li>● Roads – &lt;0.1 miles</li><li>● Parking Lots – 0</li></ul>   | <b>Coastal Erosion</b> <ul style="list-style-type: none"><li>● Roads – &lt;0.1 miles</li><li>● Parking Lots – 0</li></ul> | <b>Coastal Flooding</b> <ul style="list-style-type: none"><li>● Roads – 0.1 miles</li><li>● Parking Lots – 7</li></ul> |
| <b>Roads:</b> Roadways in the immediate vicinity of the City Beach and State Beach are the most vulnerable to coastal hazards.   |   |  |
| <b>Parking:</b> 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. |   |  |
| <b>ECONOMICS:</b> Damage to parking facilities may affect beach visitation and consumer spending.  |   |  |

Future Vulnerabilities

10.2 inches (~1 foot) by ~2030

|  |  |  |
|--|--|--|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>● Roads – &lt;0.1 mile</li><li>● Parking Lots – 0</li></ul>  | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>● Roads – &lt;0.1 mile</li><li>● Parking Lots – 1</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>● Roads – 1.1 miles</li><li>● Parking Lots – 8</li></ul> |
| <b>Roads:</b> 1.1 miles of roads become vulnerable to hazards along lower Linden and Elm Avenues.  |  |  |
| <b>Parking:</b> 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. |  |  |
| <b>ECONOMICS:</b> 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

|  |  |  |
|--|--|--|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>● Roads – 0.8 mile</li><li>● Parking Lots – 1</li></ul>  | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>● Roads – 0.1 mile</li><li>● Parking Lots – 7</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>● Roads – 2.0 miles</li><li>● Parking Lots – 8</li></ul> |
| <b>Roads:</b> Coastal hazards expand to impact Ash, Holly, Elm, and Linden Avenues further into the Beach Neighborhood.  |  |  |
| <b>Parking:</b> Additional parking facilities that were previously exposed to only coastal flooding become exposed to coastal erosion and tidal inundation.  |  |  |
| <b>ECONOMICS:</b> Potential road damage is estimated at \$90,000 (325 feet) from coastal erosion; recurring impacts to roads and parking areas expensive clean up and repair could impact City and State Park budgets. |  |  |

60.2 inches (~5 feet) by ~2100

|  |  |   |
|--|--|---|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>● Roads – 3.0 miles</li><li>● Parking Lots – 8</li></ul>   | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>● Roads – 0.7 mile</li><li>● Parking Lots – 9</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>● Roads – 4.8 miles</li><li>● Parking Lots – 11</li></ul> |
| <b>Roads:</b> 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 7 <sup>th</sup> Street near Franklin Creek.   |  |   |
| <b>Parking:</b> 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.  |  |   |
| <b>ECONOMICS:</b> 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:

**Manage** – Relocate or remove roads and parking lots from the hazardous areas along shoreline and/or install pumps to dewater the most vulnerable road segments and parking areas

**Accommodate** – Elevate roads and parking lots above future coastal flood levels through construction of raised causeways, or by incrementally elevating the road and parking area surfaces 2-3 inches during routine repaving.

**Protect** – Implement regular beach nourishment, and widen and increase elevation of beach, dunes or storm berm along the City Beach and integrate with restored dunes fronting Carpinteria State Beach as “green” protection. Nourish beach with cobbles or cobble berms to provide more robust natural protection. Combine green protection with gray shoreline protection (e.g., revetments) where needed to protect essential roads or parking.

Secondary Impacts:

Management strategies may impact traffic and coastal access, depending on location of realigned roads. Accommodation through increased road and parking elevation may flood adjacent properties. “Green” protection through beach and dune nourishment may require the recurring expense of frequent maintenance with 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 and beach nourishment and coastal access parking.
- Coordinate with Santa Barbara County, coastal cities, BEACON and local state legislators to create sustainable funding mechanism for beach nourishment.

Projects:

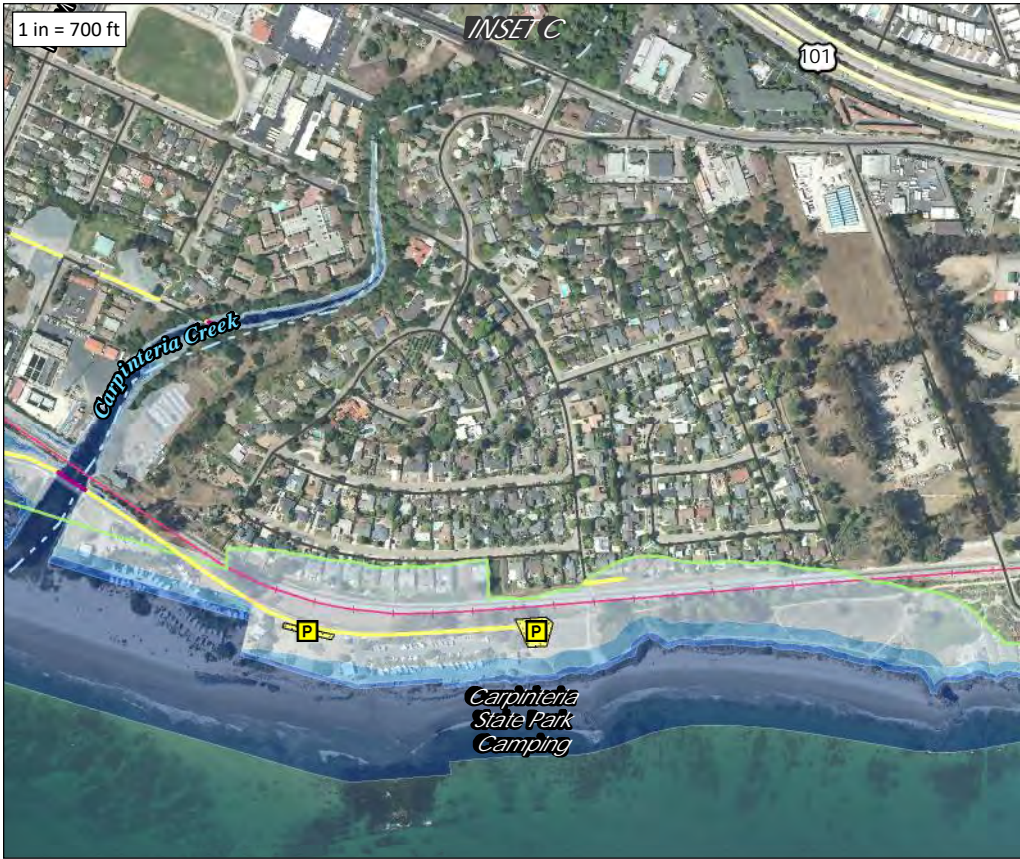
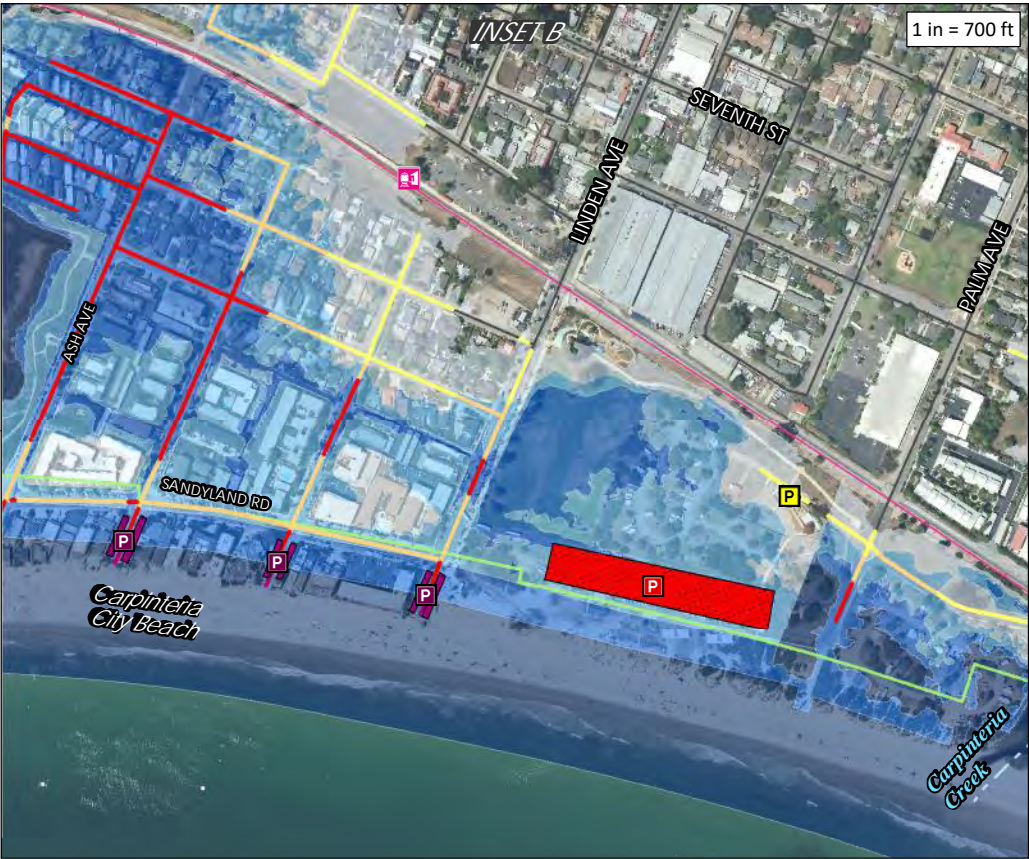
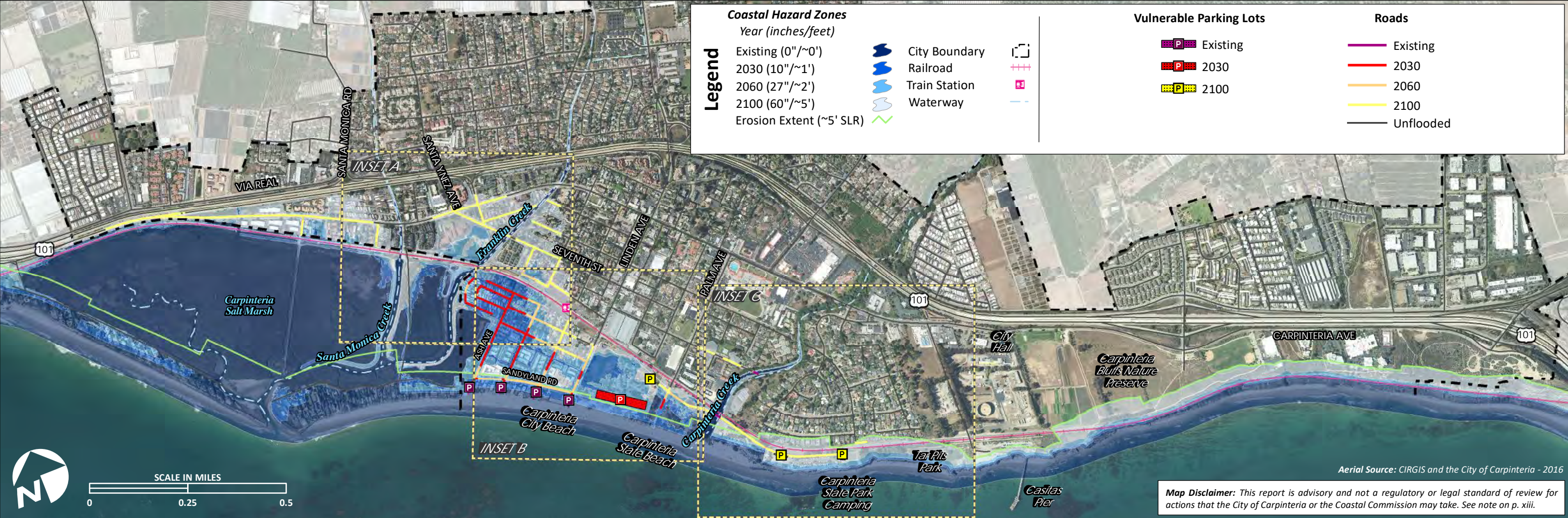
- Redesign, realign, or relocate critical roads and parking to increase resiliency.
- Amend the City’s Capital Improvement Plan to require street resurfacing to elevate roadways.
- Perform regular beach nourishment and dune restoration.

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**

**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 miles 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.

**Thresholds:** 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.



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

## Existing Vulnerabilities

| Tidal Inundation   | Coastal Erosion  | Coastal Flooding  |
|--|--|---|
| <ul style="list-style-type: none"><li>• Bike – 0 miles</li><li>• Bus – 0 miles</li><li>• Rail – &lt;0.1 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – 0 miles</li><li>• Bus – 0 miles</li><li>• Rail – 0.1 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – &lt;0.1 mile</li><li>• Bus – 0 miles</li><li>• Rail – 0.1 mile</li></ul> |

**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 are estimated at \$130,000 (388 feet) from coastal erosion. 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)   |
|---|--|--|
| <ul style="list-style-type: none"><li>• Bike – 0 miles</li><li>• Bus – &lt;0.1 mile</li><li>• Rail – &lt;0.1 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – 0 miles</li><li>• Bus – 0 miles</li><li>• Rail – 0.4 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – &lt;0.1 mile</li><li>• Bus – 0.3 mile</li><li>• Rail – 0.4 mile</li></ul> |

**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)   |
|---|---|--|
| <ul style="list-style-type: none"><li>• Bike – 0 miles</li><li>• Bus – 0.2 mile</li><li>• Rail – &lt;0.1 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – &lt;0.1 mile</li><li>• Bus – 0 miles</li><li>• Rail – 0.8 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – &lt;0.1 mile</li><li>• Bus – 0.7 mile</li><li>• Rail – 0.9 mile</li></ul> |

**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)  |
|--|---|---|
| <ul style="list-style-type: none"><li>• Bike – 0.7 mile</li><li>• Bus – 0.8 mile</li><li>• Rail – &lt;0.1 mile</li></ul> | <ul style="list-style-type: none"><li>• Bike – &lt;0.1 mile</li><li>• Bus – 0.3 mile</li><li>• Rail – 1.4 miles</li></ul> | <ul style="list-style-type: none"><li>• Bike – 1.2 miles</li><li>• Bus – 2.0 miles / 2 stops</li><li>• Rail – 1.5 miles</li></ul> |

**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 7<sup>th</sup> 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 miles (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:

**Manage** – Relocate or reroute bikeways, bus routes, and rail lines from the hazardous areas along shoreline and/or install pumps to dewater the most vulnerable road segments.

**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.

**Protect** – Control bluff face drainage and restore coastal bluff scrub vegetation to minimize bluff erosion. Build or augment sand dunes and cobble berms (“green” protection approach), and/or construct shoreline protective devices (“gray” protection approach) to protect against future coastal hazards.

### Secondary Impacts:

Management strategies may impact traffic and coastal access. Accommodation through increased road elevation may create additional stormwater drainage issues. “Green” protection through beach and dune nourishment may require frequent maintenance with higher levels of SLR. “Gray” protection strategies could impact beach and dune habitats, natural processes, and coastal access but would effectively protect public transportation facilities.

## Potential Next Steps

### Policy:

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

### Projects:

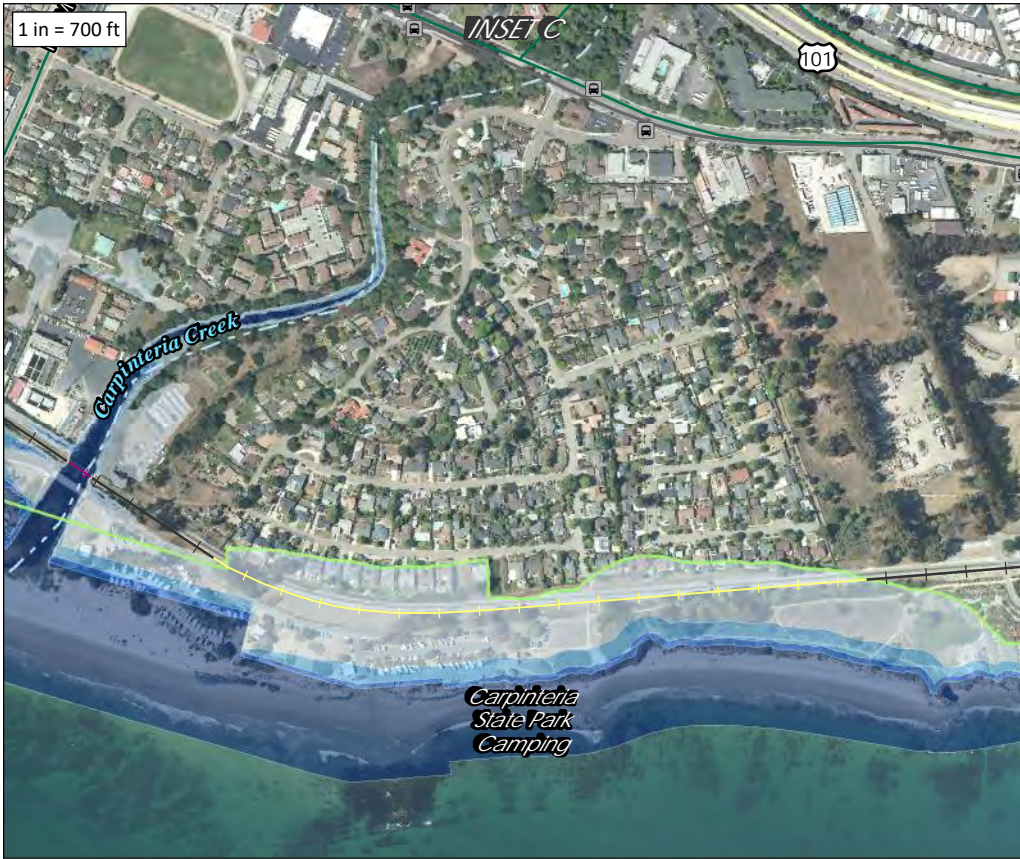
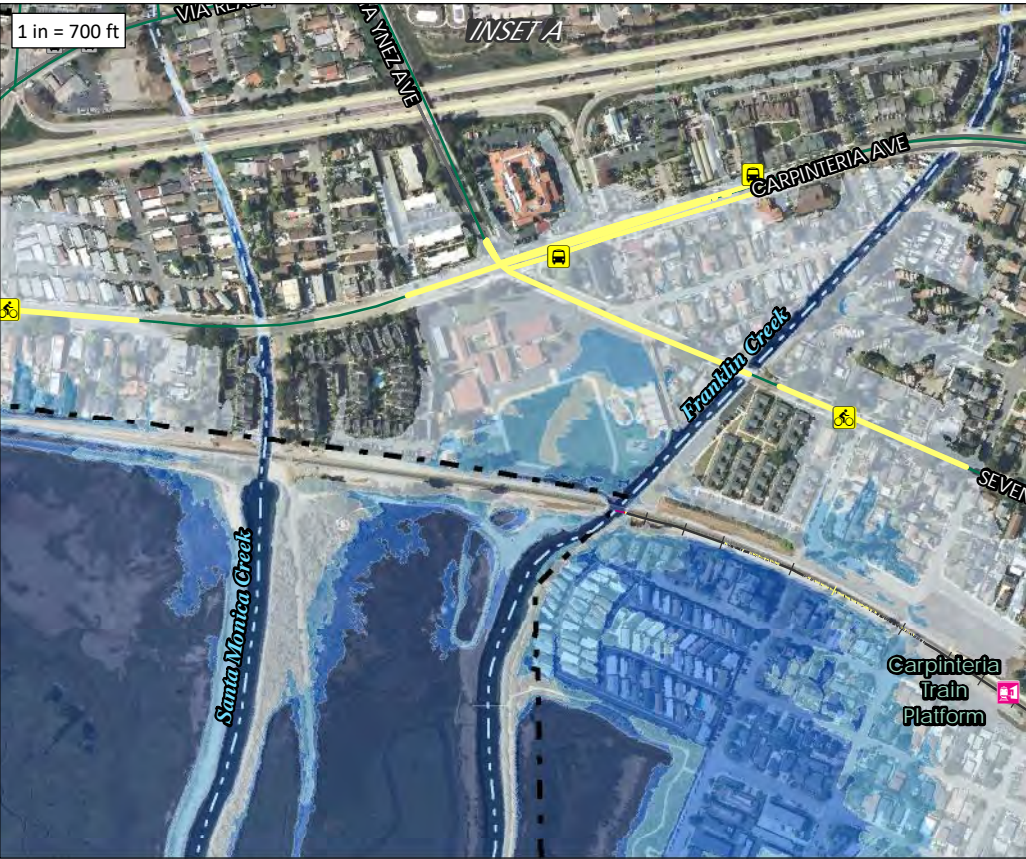
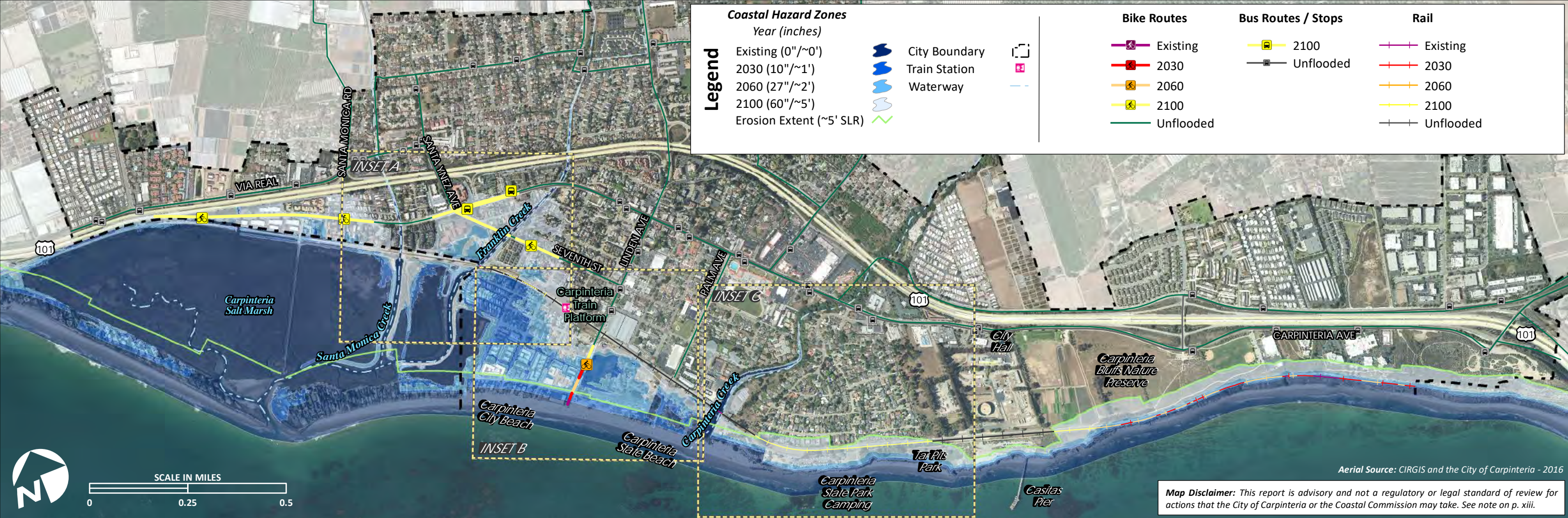
- Amend the City’s Capital Improvement Plan to add additional inches to the lift in street resurfacing to gain elevation at or greater than the pace of SLR.
- Coordinate with BEACON to develop strategic beach nourishment projects.

### Monitoring:

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



Figure 1-3. Public Transportation





# CAMPING AND VISITOR 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.

**Threshold:** 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

| <u>Tidal Inundation</u>     | <u>Coastal Erosion</u>        | <u>Coastal Flooding</u>       |
|-----------------------------|-------------------------------|-------------------------------|
| • 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, particulalry 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

| <u>Tidal Inundation (total)</u> | <u>Coastal Erosion (total)</u> | <u>Coastal Flooding (total)</u> |
|---------------------------------|--------------------------------|---------------------------------|
| • 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 acres (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

| <u>Tidal Inundation (total)</u> | <u>Coastal Erosion (total)</u> | <u>Coastal Flooding (total)</u> |
|---------------------------------|--------------------------------|---------------------------------|
| • Campgrounds – 1 / 0.3 acres   | • 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 4<sup>th</sup> 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

| <u>Tidal Inundation (total)</u> | <u>Coastal Erosion (total)</u> | <u>Coastal Flooding (total)</u> |
|---------------------------------|--------------------------------|---------------------------------|
| • 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:

**Manage** – Coordinate with State Parks to redesign or relocate campsites and facilities to less vulnerable areas of state property; adjust STR program as needed to shift allowable units to less vulnerable areas.

**Accommodate** – Elevate the grade of campgrounds and STR units to reduce imapcts of coastal flooding/ tidal inundation; flood proof and reinforce first floors of STRs; improve drainage in Beach Neighborhood.

**Protect** – Construct shoreline protective devices (e.g., seawalls) to reduce vulnerabilities (“gray” protection). Augment sand dunes and perform regular beach nourishment with sand and/or cobbles to protect against future coastal hazards.

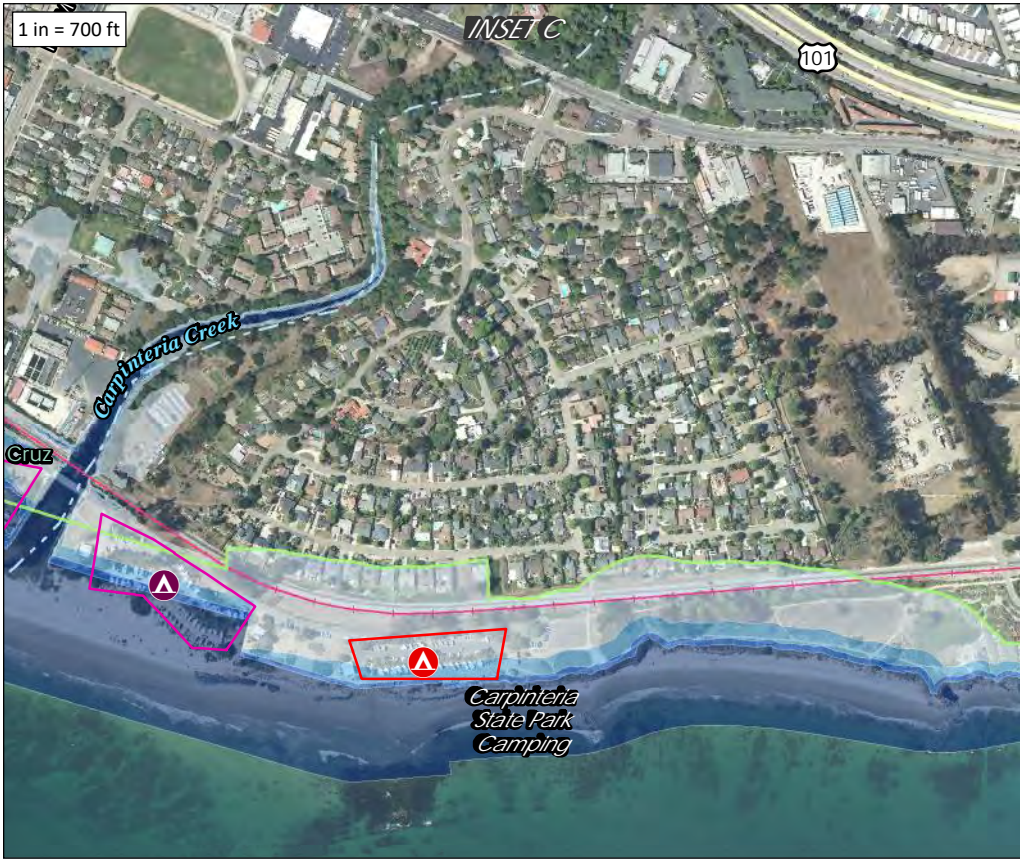
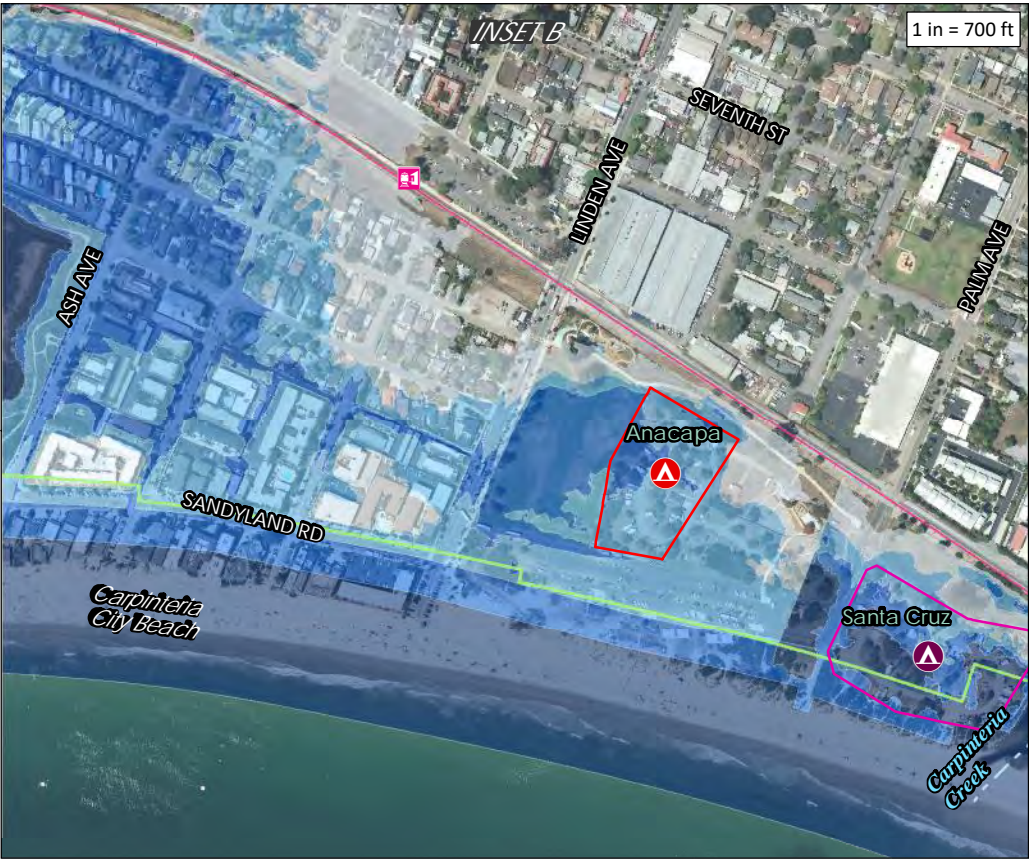
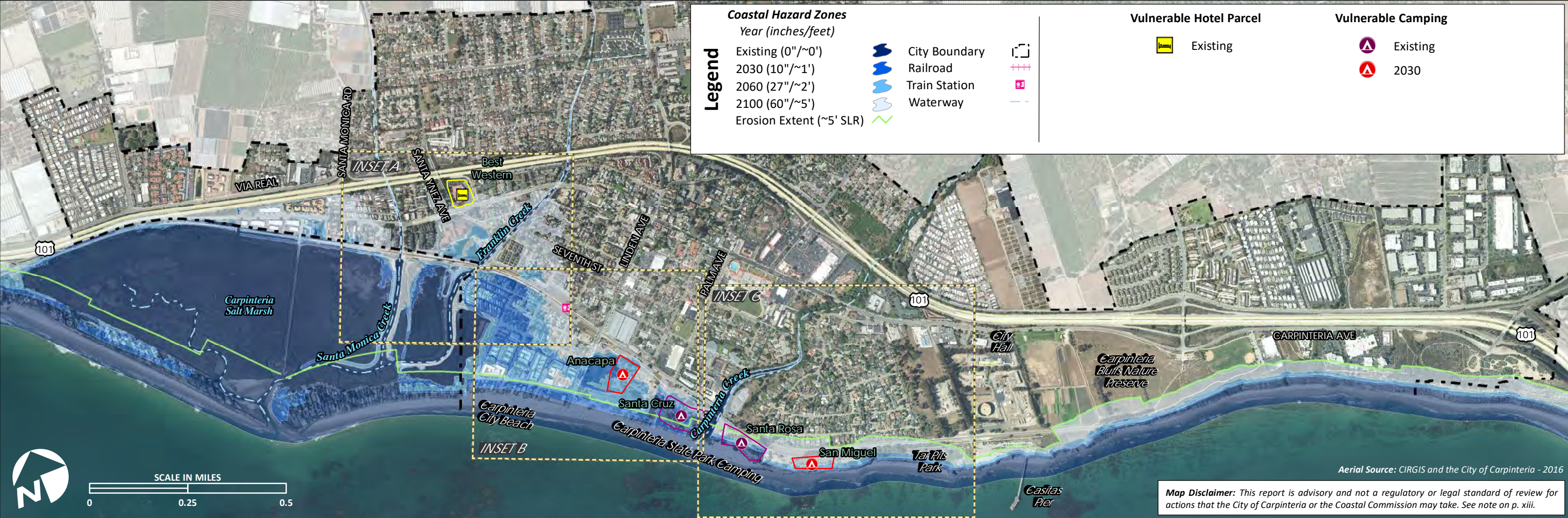
**Secondary Impacts:** Secondary impacts include loss of campgrounds, visitor accomodations, and loss of City’s tax and State Beach revenues. Beach and dune nourishment requires frequent maintenance and costs with higher SLR. Coastal armoring would impact beach/ dune habitats, natural processes and coastal access but may would protect campgrounds and STRs.

## Potential Next Steps

| <u>Policy</u>   | <u>Monitoring</u>   |
|---|---|
| <ul style="list-style-type: none"><li>• 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.</li><li>• Coordinate with Santa Barbara County, coastal cities, BEACON and local legislators to create sustainable funding mechanism for beach nourishment.</li></ul> | <ul style="list-style-type: none"><li>• Monitor depth, extent, and frequency of flooding within the State Park.</li></ul> <p><b>Data Gaps</b></p> <ul style="list-style-type: none"><li>• Precise campground/ amenity footprints.</li></ul> |



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)

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.

**Thresholds:** With 2’ of SLR, coastal erosion and flooding regularly impacts beaches, and dunes and cliff erosion impact lateral and vertical access trails.



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

Existing Vulnerabilities

|  |  |   |
|--|--|---|
| <b>Tidal Inundation</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – &gt;6</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – &lt;0.1 miles</li></ul> | <b>Coastal Erosion</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 1.2 miles</li></ul> | <b>Coastal Flooding</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 1.3 miles</li></ul> |
|--|--|---|

**Vertical Coastal Access:** At least half of the vertical access points west of Carpinteria 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 alongCitybeaches 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

|   |  |   |
|---|--|---|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – &lt;0.1 miles</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 1.9 miles</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 2.2 miles</li></ul> |
|---|--|---|

**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 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

|   |  |  |
|---|--|--|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 0.1 miles</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 2.7 miles</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13 additional</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 3.4 miles</li></ul> |
|---|--|--|

**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 miles (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

|   |  |   |
|---|--|---|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 1.4 miles</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 4.6 miles</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>• Vertical Coastal Access Points – 13</li><li>• Lateral Coastal Access – 2.5 miles</li><li>• Trails – 5.4 miles</li></ul> |
|---|--|---|

**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 subtidal, 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

Range of Strategies:

**Manage** – Relocate or remove trails and coastal access ways away from areas vulnerable to coastal hazards.

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

**Protect** – Augment sand dunes and nourish the beach with cobbles (“green” protection approach) and/or construct shoreline protective devices (“gray” protection approach) to protect coastal trails against future coastal hazards.

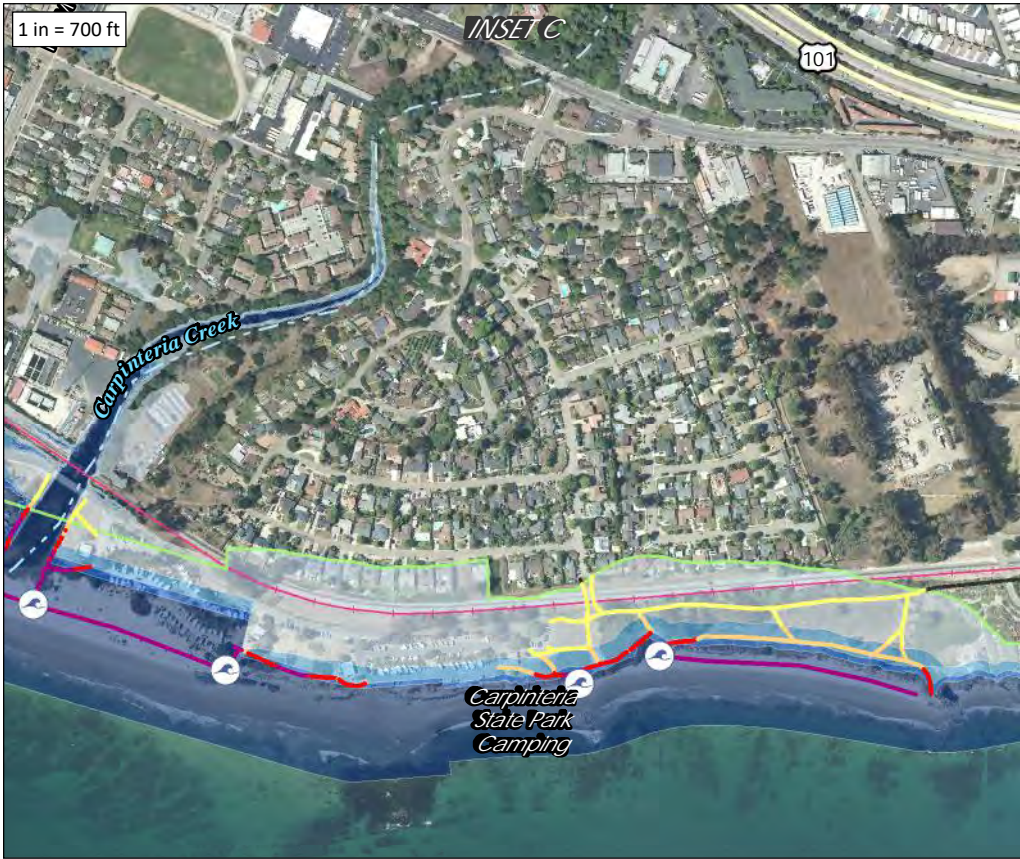
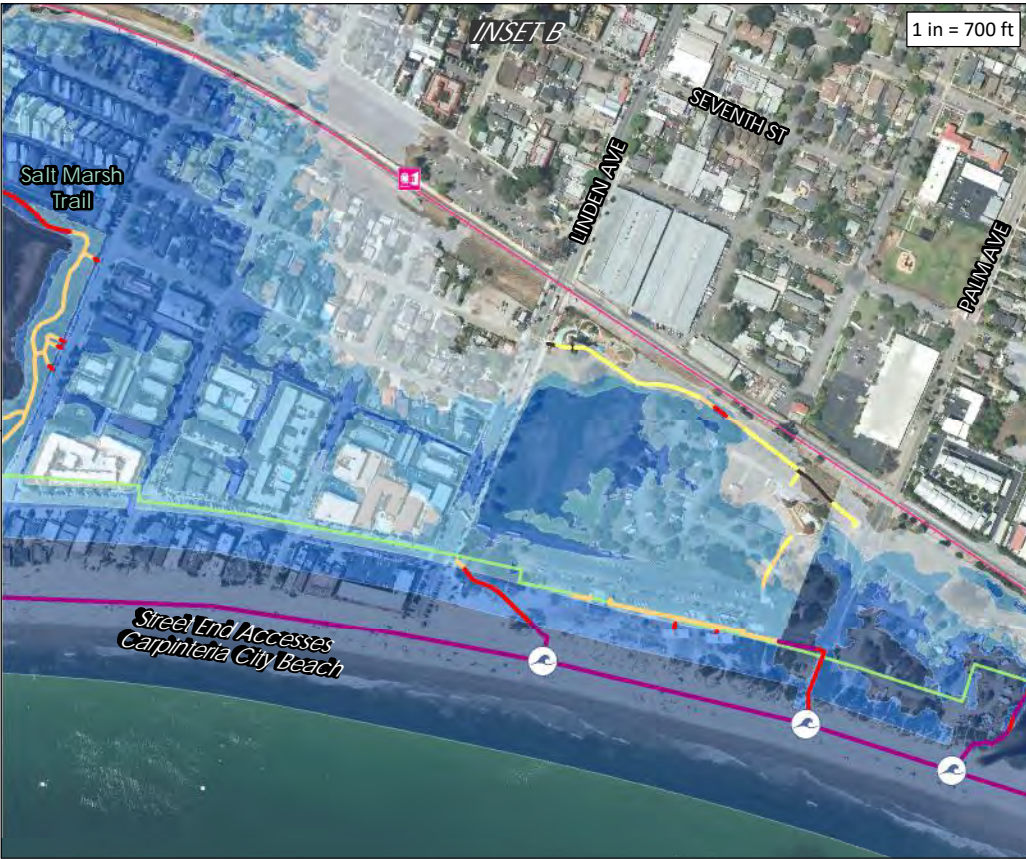
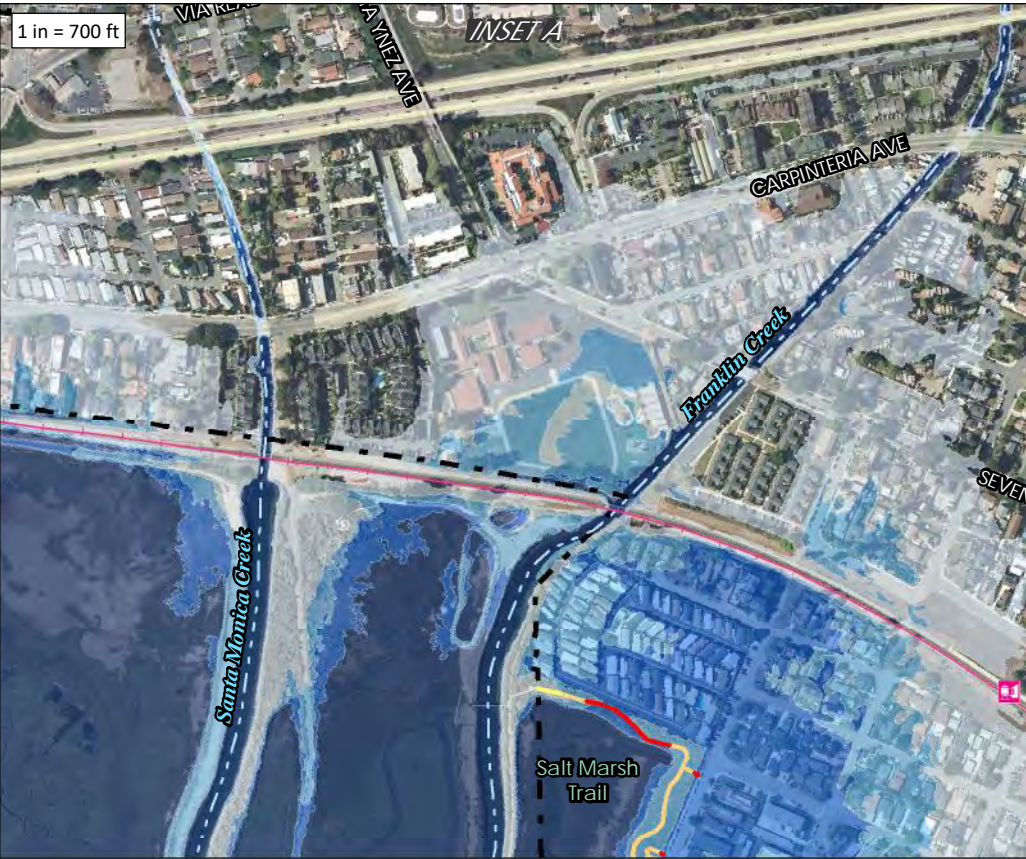
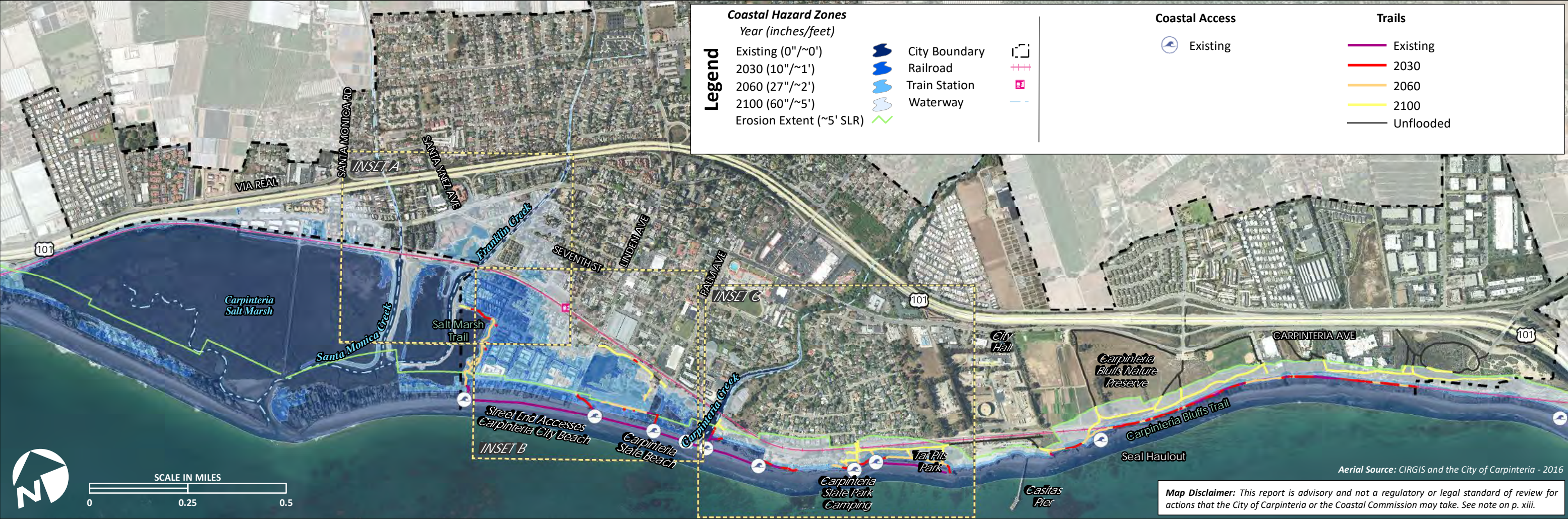
**Secondary Impacts:** Management strategies may impact tax base revenues due to the loss of structures and property. “Green” protection through beach and dune nourishment may require frequent maintenance with higher levels of SLR, but may benefit lateral access by maintaining dry sandy and intertidal beaches for recreational uses. “Gray” protection (e.g., revetments) would effectively protect coastal access and trails, but lead to drowning of beaches, resulting in a loss of beaches over time and limiting access to low tides.

Potential Next Steps

|   |   |
|---|---|
| <b>Policy</b> <ul style="list-style-type: none"><li>• Coordinate with State Parks and regional partners on shoreline management to maintain beach access</li><li>• Coordinate with Santa Barbara County, coastal cities, BEACON and local legislators to create sustainable funding mechanism for beach nourishment.</li><li>• Develop a long-range plan for the California Coastal Trail.</li></ul> <b>Projects</b> <ul style="list-style-type: none"><li>• Relocate portions of trails exposed to erosion.</li><li>• Perform regular beach nourishment/ dune restoration.</li></ul> | <b>Monitoring</b> <ul style="list-style-type: none"><li>• Monitor depth, extent, and frequency of flooding within the State Park.</li></ul> <b>Data Gap</b> <ul style="list-style-type: none"><li>• Designated alignment of the California Coastal Trail.</li><li>• Complete trail network in the City.</li></ul> |
|---|---|



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 in active 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.

**Threshold:** 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

|   |  |  |
|---|--|--|
| <b>Tidal Inundation</b> <ul style="list-style-type: none"><li>0 active cleanup sites</li><li>0 ESIs</li><li>0 businesses</li><li>22 wells</li></ul> | <b>Coastal Erosion</b> <ul style="list-style-type: none"><li>0 active cleanup sites</li><li>1 ESI</li><li>0 businesses</li><li>0 wells</li></ul> | <b>Coastal Flooding</b> <ul style="list-style-type: none"><li>0 active cleanup sites</li><li>1 ESI</li><li>0 businesses</li><li>22 wells</li></ul> |
|---|--|--|

**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**

|   |  |  |
|---|--|--|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>0 active cleanup sites</li><li>0 ESIs</li><li>0 businesses</li><li>22 wells</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>1 active cleanup site</li><li>1 ESIs</li><li>0 businesses</li><li>2 wells</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>1 active cleanup site</li><li>1 ESIs</li><li>0 businesses</li><li>24 wells</li></ul> |
|---|--|--|

**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**

|  |   |   |
|--|---|---|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>0 active cleanup sites</li><li>1 ESI</li><li>0 businesses</li><li>26 wells</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>1 active cleanup sites</li><li>1 ESIs</li><li>0 businesses</li><li>5 wells</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>1 active cleanup sites</li><li>3 ESIs</li><li>1 business</li><li>27 wells</li></ul> |
|--|---|---|

**Hazardous Materials:** The previously exposed ESI Venoco 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 largely avoidable.

**Range of Strategies:** Strategies related to businesses storing hazardous materials would range from a “do nothing” approach to protection of businesses with CUPAs, to policy options that would accommodate levels of flooding without exposing the hazardous materials, to requiring all businesses with a Hazardous Materials Business Plan (HMBP) to effectively retreat from the coastline.

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 City and cobbles below the Carpinteria Bluffs to protect oil and gas wells.

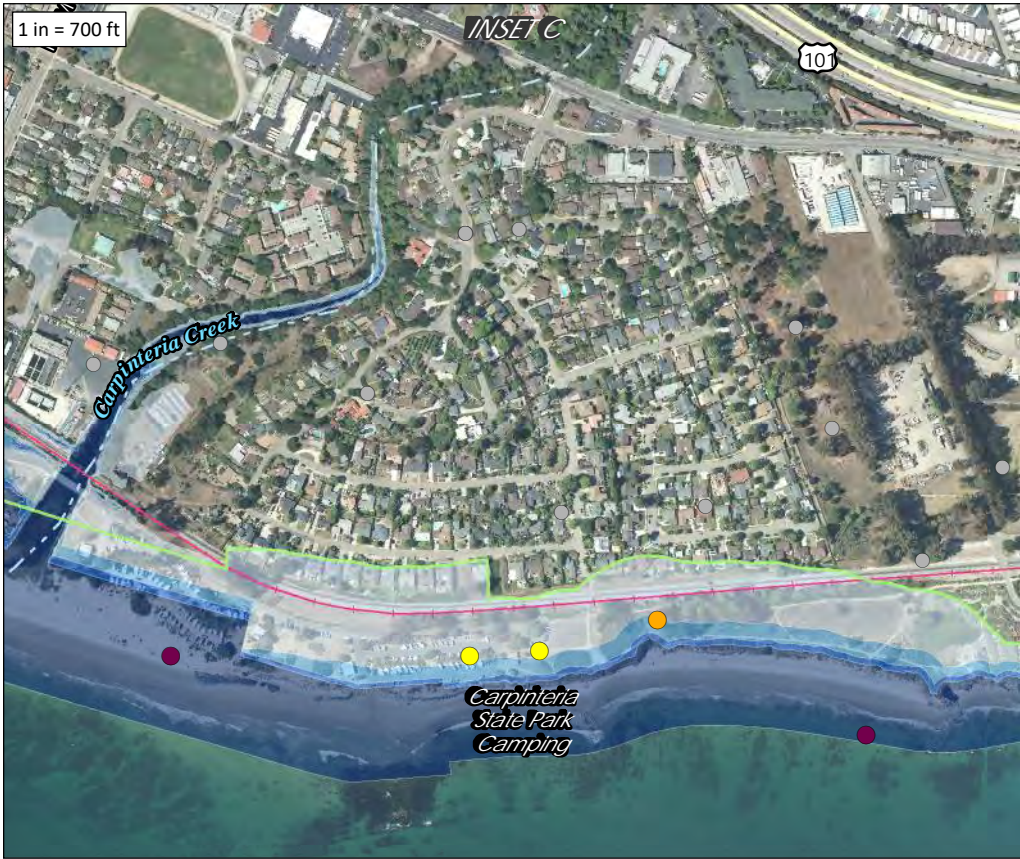
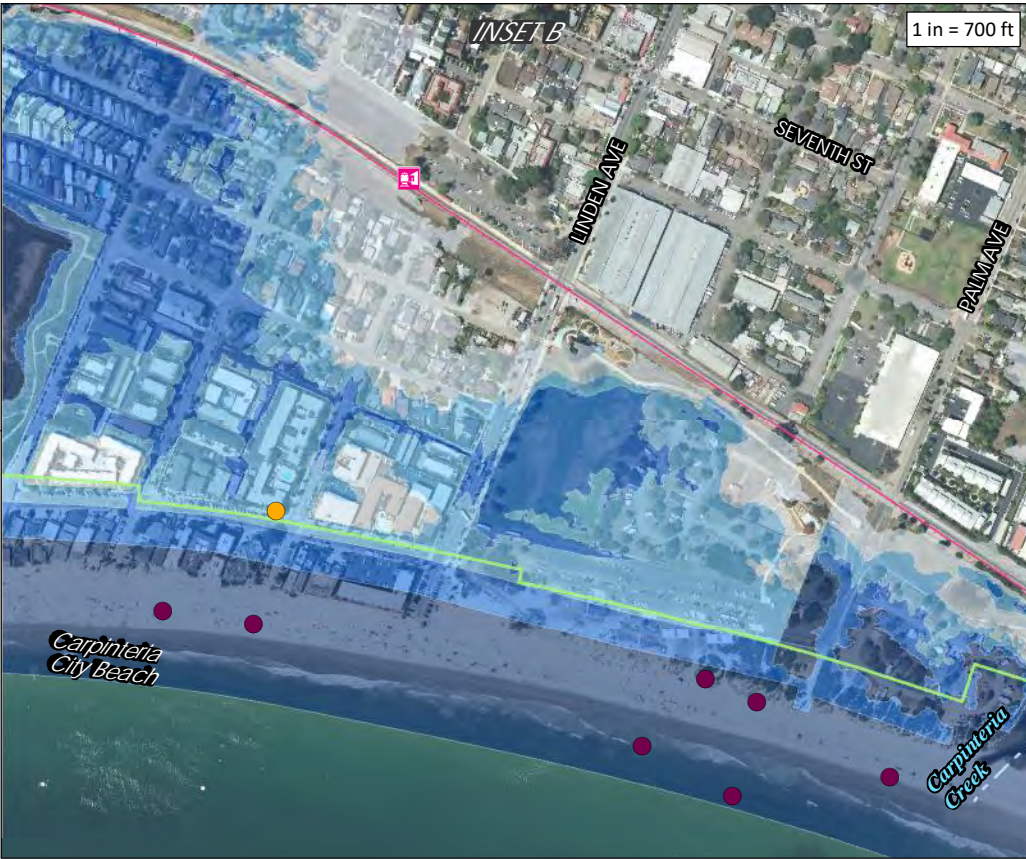
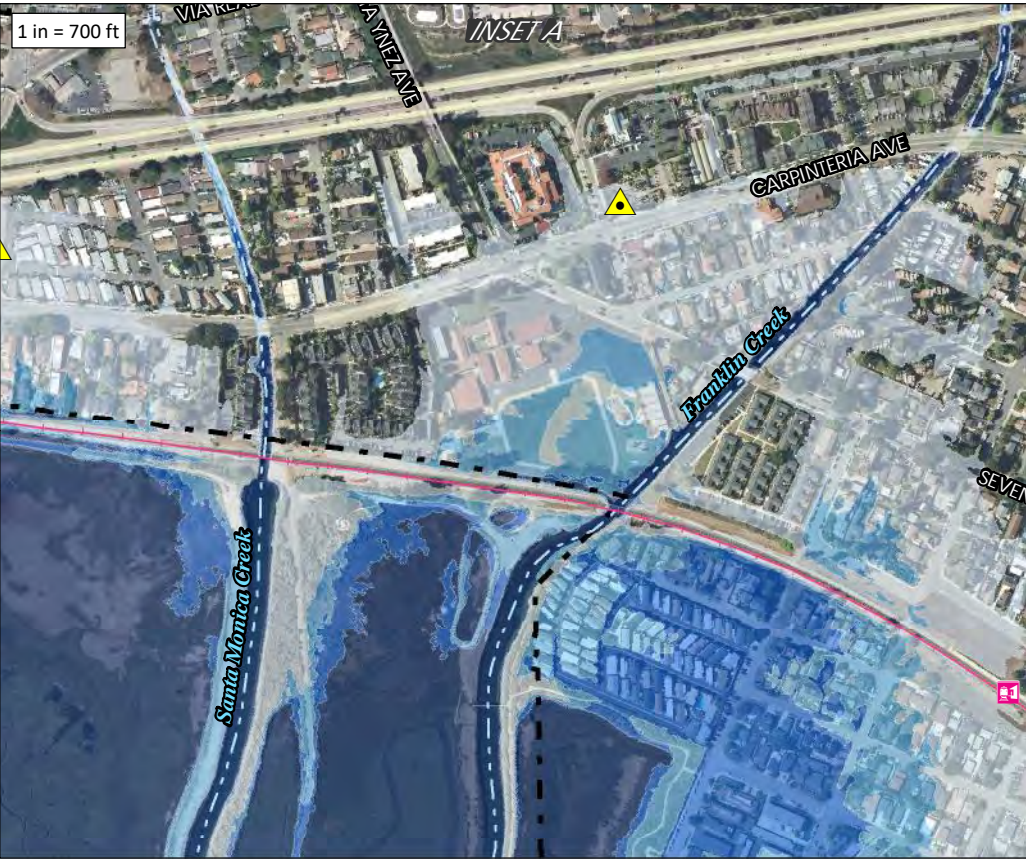
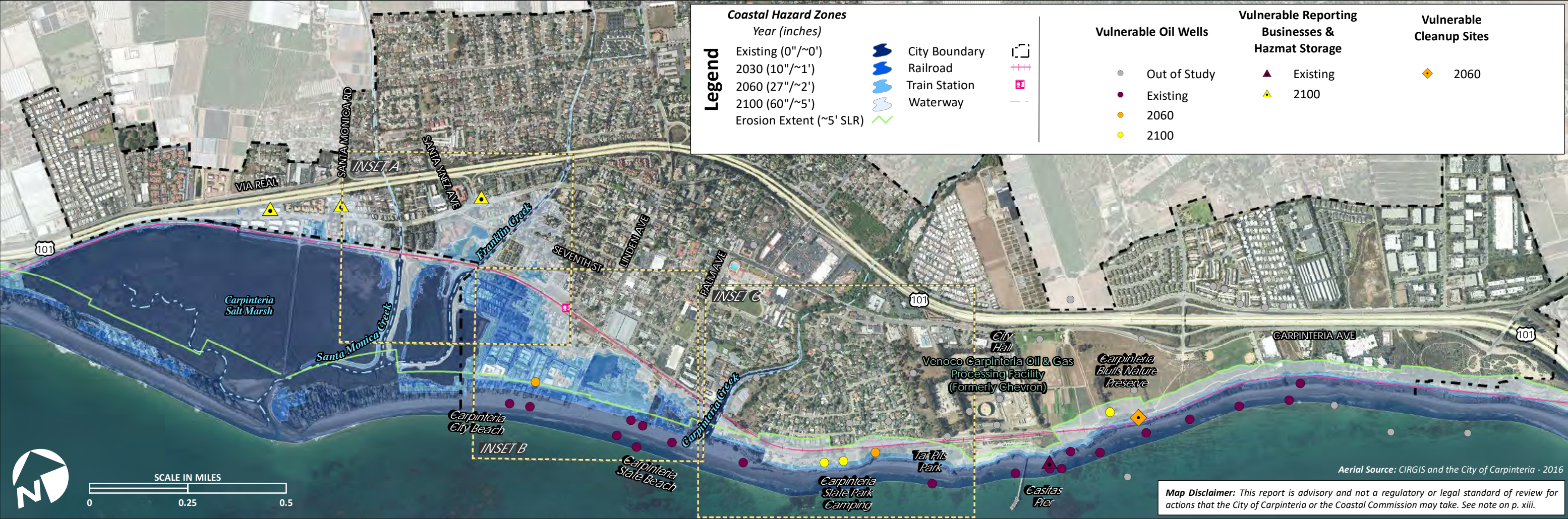
**Secondary Impacts:** The “do nothing” approach could have substantial cleanup impacts if spills or leaks occur, but there are relatively low-cost options to store materials in a more flood-proof manner by elevating, relocating or floodproofing the facilities or components. Delays in any response could result in oil spills and release of contaminants. Environmental remediation and permitting require substantial time and are high in cost.

## Potential Next Steps

|   |  |  |
|---|--|--|
| <b>Policy</b> <ul style="list-style-type: none"><li>Coordinating with California Department of Toxic Substances and Control (DTSC), improve hazardous materials storage, management, and remediation in the risk zones.</li><li>Formalize and participate in a regional Joint Powers Authority (JPA) with OSPER, CLSC, Coast Guard, and Santa Barbara County. A JPA would form a round table for oil and gas responses and lessons learned.</li><li>Develop a regional environmental and permit streamlining process for rapid remediation of legacy wells.</li></ul> | <b>Projects</b> <ul style="list-style-type: none"><li>Generate rapid response funds to remove damaged wells.</li><li>Upon decommissioning of active sites such as Venoco, require the removal of all shore protection, access roads, pipes and other oil and gas infrastructure should be required by the permit holder.</li></ul> | <b>Monitoring</b> <ul style="list-style-type: none"><li>Continue monitoring of remediation actions</li></ul> |
|---|--|--|



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.

**Threshold:** With 2’ of SLR, pipe, inlets, and outfalls become substantially vulnerable to coastal hazards, resulting in loss or damage.

Existing Vulnerabilities

|   |   |   |
|---|---|---|
| <b><u>Tidal Inundation</u></b> <ul style="list-style-type: none"><li>• Inlets – 3</li><li>• Outfalls – 36</li><li>• Pipe – 0.5 mile</li></ul> | <b><u>Coastal Erosion</u></b> <ul style="list-style-type: none"><li>• Inlets – 0</li><li>• Outfalls – 1</li><li>• Pipe – &lt;0.1 mile</li></ul> | <b><u>Coastal Flooding</u></b> <ul style="list-style-type: none"><li>• Inlets – 2</li><li>• Outfalls – 60</li><li>• Pipe – 0.7 mile</li></ul> |
|---|---|---|

**Tidal inundation** may reduce stormwater conveyance by potentially inundating a number of inlets and outfalls and 0.5 miles 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

|  |   |  |
|--|---|--|
| <b><u>Tidal Inundation (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 10</li><li>• Outfalls – 49</li><li>• Pipe – 0.6 mile</li></ul> | <b><u>Coastal Erosion (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 0</li><li>• Outfalls – 1</li><li>• Pipe – 0.1 mile</li></ul> | <b><u>Coastal Flooding (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 43</li><li>• Outfalls – 69</li><li>• Pipe – 1.4 mile</li></ul> |
|--|---|--|

**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

|  |  |  |
|--|--|--|
| <b><u>Tidal Inundation (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 34</li></ul> | <b><u>Coastal Erosion (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 2</li></ul> | <b><u>Coastal Flooding (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 62</li></ul> |
|--|--|--|

|   |  |   |
|---|--|---|
| <ul style="list-style-type: none"><li>• Outfalls – 61</li><li>• Pipe – 1.1 mile</li></ul> | <ul style="list-style-type: none"><li>• Outfalls – 1</li><li>• Pipe – 0.5 mile</li></ul> | <ul style="list-style-type: none"><li>• Outfalls – 85</li><li>• Pipe – 2.3 mile</li></ul> |
|---|--|---|

**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

|   |   |  |
|---|---|--|
| <b><u>Tidal Inundation (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 82</li><li>• Outfalls – 99</li><li>• Pipe – 2.5 miles</li></ul> | <b><u>Coastal Erosion (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 6</li><li>• Outfalls – 3</li><li>• Pipe – 1.0 mile</li></ul> | <b><u>Coastal Flooding (total)</u></b> <ul style="list-style-type: none"><li>• Inlets – 95</li><li>• Outfalls – 116</li><li>• Pipe – 4.2 miles</li></ul> |
|---|---|--|

**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 mile (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.

**Manage:** Phased relocation of stormwater infrastructure tied to a community-wide shoreline management strategy.

**Accommodate:** Increasing the pump capacity, use tide/ flap gates on outfalls and coffer dams on creeks, acquire land and construct new detention basins, and expand the size of conveyance are mid-term solutions, which may accommodate several feet of SLR.

**Protect:** Flood proof retrofits to vulnerable pump stations to protect electrical and system operations may provide a short-term, relatively low-cost option to accommodate SLR. Beach nourishment may help reduce bluff erosion and loss of storm drains; revetments may protect vulnerable bluff area storm drains.

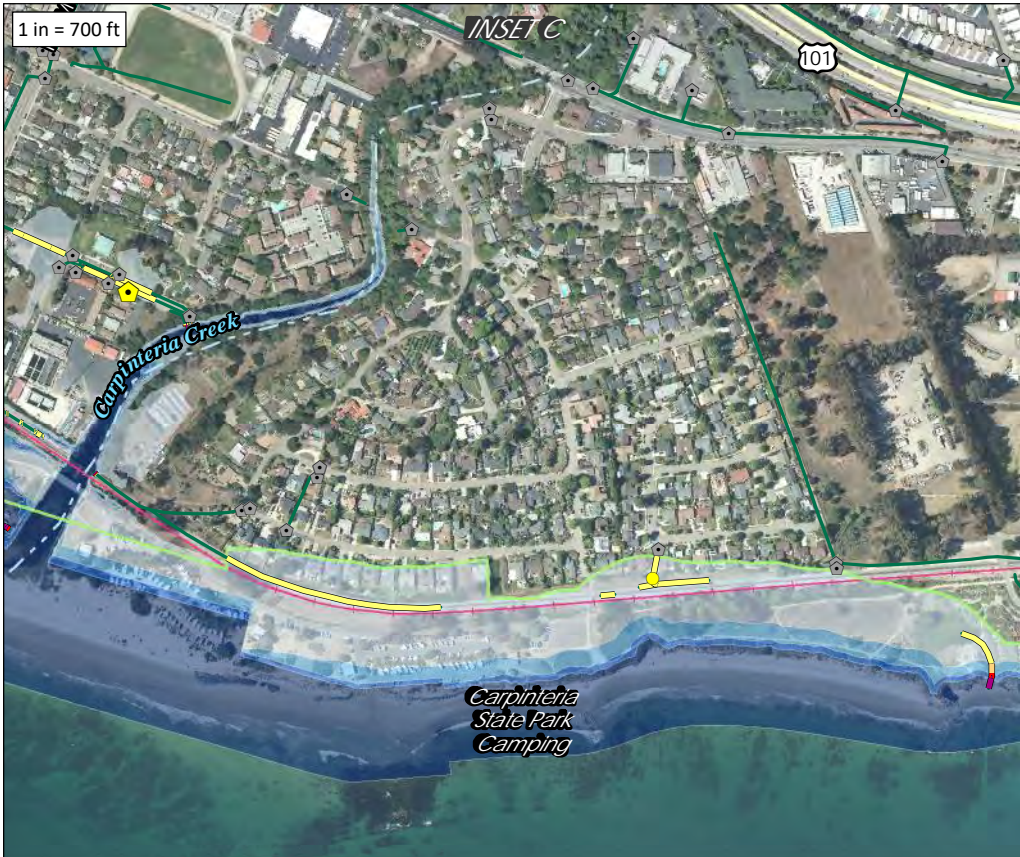
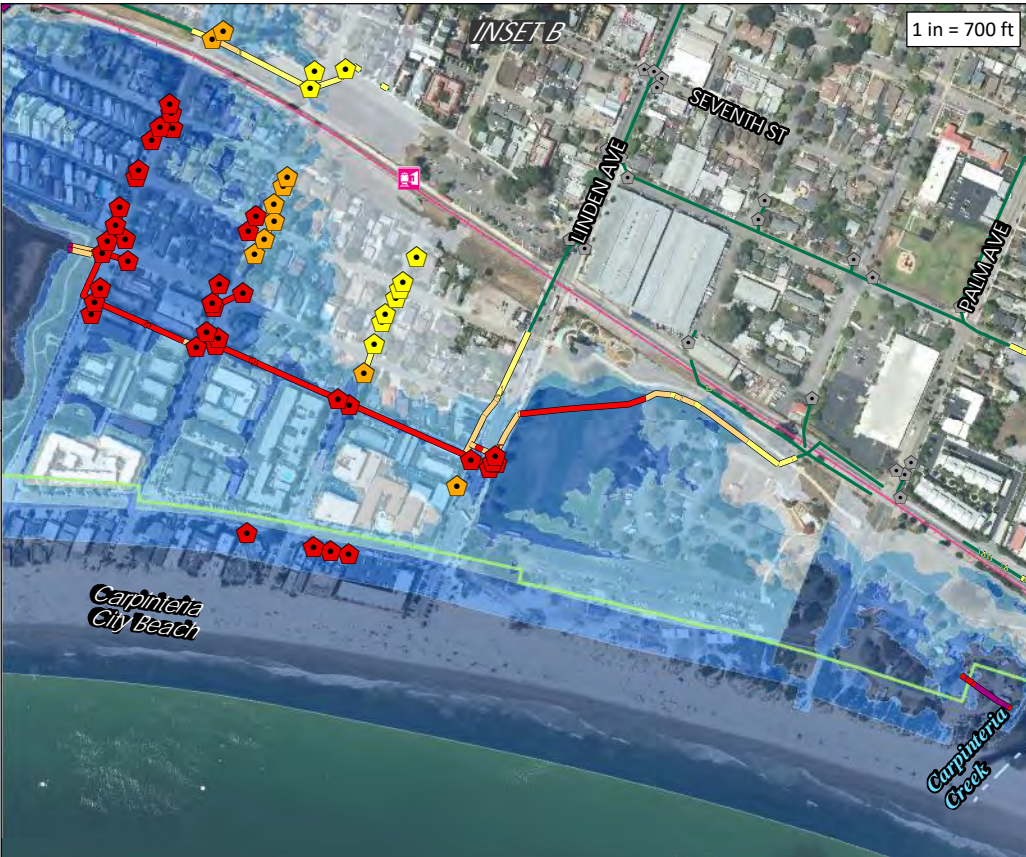
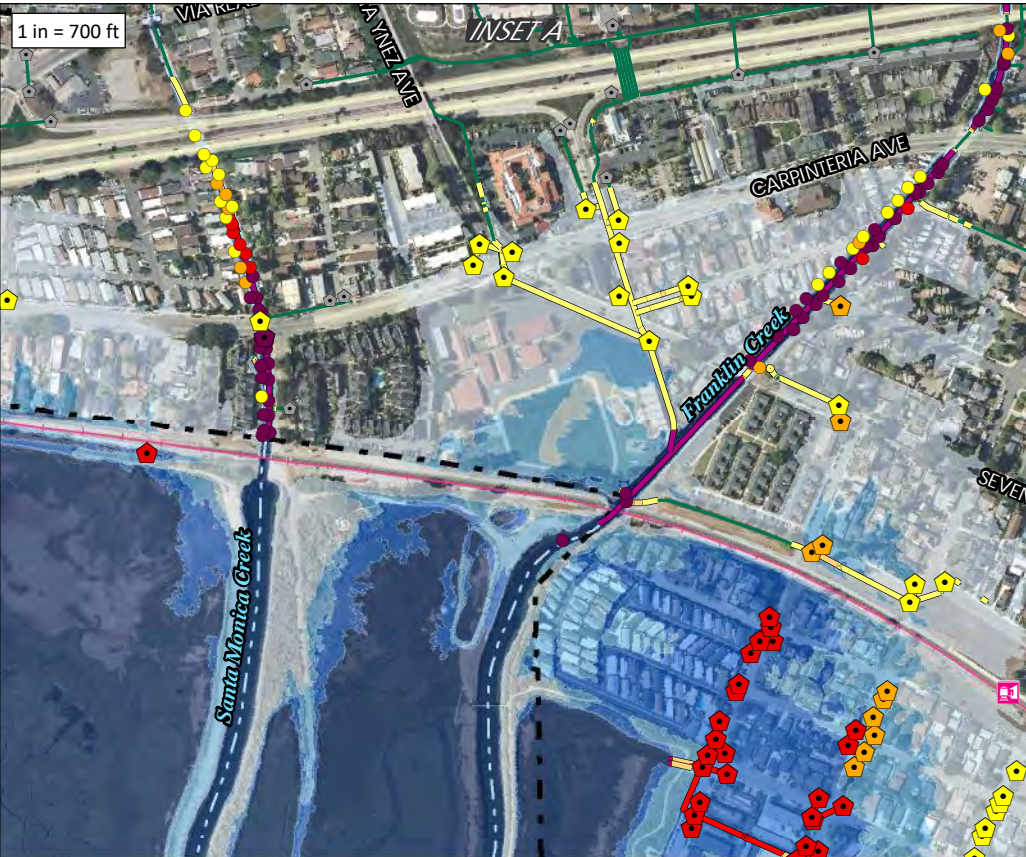
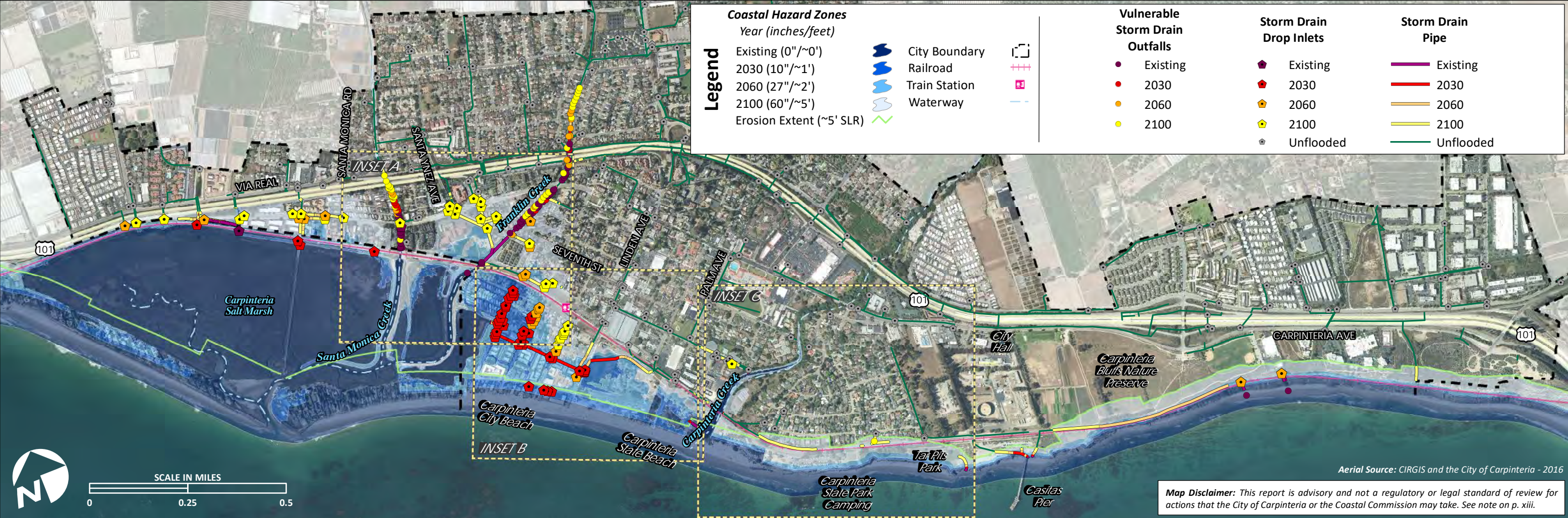
**Secondary Impacts:** Vary based on approach and integration of adaptation measures to community adaptation planning; gray approach of using revetments would cause secondary impacts to beaches, habitats and public recreation on beach.

Potential Next Steps

|   |   |
|---|---|
| <b><u>Data Gaps:</u></b> <ul style="list-style-type: none"><li>• Elevation information for the outfalls would allow more robust analysis of each drain and subdrainage basin.</li></ul> <b><u>Policy</u></b> <ul style="list-style-type: none"><li>• Increase base flood elevation of new development to reduce potential storm water flood impacts.</li><li>• Revise General Plan/Local Coastal Program drainage policies and Capital Improvements Plan to address SLR and future decline in conveyance.</li><li>• Coordinate with County Flood Control on regional drainage</li><li>• Develop a Stormwater Master Plan for low-lying areas in the City, such as the Beach Neighborhood.</li></ul> | <b><u>Projects</u></b> <ul style="list-style-type: none"><li>• Conduct a stormwater system analysis that examines potential pump locations.</li><li>• Add tide/flap gates/coffer dams, to reduce inflow from high tides and storm waves into neighborhoods.</li><li>• Develop culvert replacement and stormwater retention basins that allow for reuse or release once tides drop to efficient levels.</li></ul> <b><u>Monitoring</u></b> <ul style="list-style-type: none"><li>• Monitor frequency, duration, and flood depths at low-lying areas around the City.</li></ul> |
|---|---|



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**
- **6 Lift Stations**
- **762 Manholes**
- **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.

**Threshold:** 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

| <u>Tidal Inundation</u>  | <u>Coastal Erosion</u>   | <u>Coastal Flooding</u>  |
|--|--|--|
| <ul style="list-style-type: none"><li>● Pipe – &lt;0.1 mile</li><li>● Manholes – 0</li><li>● Lift Stations – 0</li></ul> | <ul style="list-style-type: none"><li>● Pipe – &lt;0.1 mile</li><li>● Manholes – 0</li><li>● Lift Stations – 0</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 0.2 mile</li><li>● Manholes – 0</li><li>● Lift Stations – 0</li></ul> |

**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

| <u>Tidal Inundation (total)</u>  | <u>Coastal Erosion (total)</u>   | <u>Coastal Flooding (total)</u>   |
|--|--|---|
| <ul style="list-style-type: none"><li>● Pipe – &lt;0.1 mile</li><li>● Manholes – 0</li><li>● Lift Stations – 0</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 0.1 mile</li><li>● Manholes – 0</li><li>● Lift Stations – 0</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 0.9 mile</li><li>● Manholes – 20</li><li>● Lift Stations – 0</li></ul> |

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

| <u>Tidal Inundation (total)</u>   | <u>Coastal Erosion (total)</u>   | <u>Coastal Flooding (total)</u>  |
|---|--|--|
| <ul style="list-style-type: none"><li>● Pipe – 0.6 mile</li><li>● Manholes – 13</li><li>● Lift Stations – 0</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 0.1 mile</li><li>● Manholes – 0</li><li>● Lift Stations – 0</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 2.0 miles</li><li>● Manholes – 32</li><li>● Lift Stations – 1</li></ul> |

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

| <u>Tidal Inundation (total)</u>  | <u>Coastal Erosion (total)</u>  | <u>Coastal Flooding (total)</u>  |
|--|---|--|
| <ul style="list-style-type: none"><li>● Pipe – 3.1 miles</li><li>● Manholes – 56</li><li>● Lift Stations – 2</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 0.5 mile</li><li>● Manholes – 12</li><li>● Lift Stations – 1</li></ul> | <ul style="list-style-type: none"><li>● Pipe – 4.7 mile</li><li>● Manholes – 95</li><li>● Lift Stations – 3</li><li>● WWTP</li></ul> |

**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, as well as 2 buildings at the WWTP.

**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 to protect existing system components.

**Manage:** Phased relocation of the wastewater infrastructure, tied to a community-wide shoreline management strategy and regional coordination with neighboring jurisdictions.

**Accommodate:** Elevate lift stations, shut off valves, and vulnerable components above future coastal flood levels. Install tide gates/flaps and at key drainage outfalls and coffer dams across creek channels

**Protect:** Install flood-proof retrofits to vulnerable lift stations to protect electrical and pump system operations. Seal manholes to prevent coastal flooding from overwhelming the sewage system. Fund regular sustained beach nourishment and restore sand dunes (“green” protection) and integrate with shoreline protective devices (“gray” protection) to protect from coastal erosion and flooding.

**Secondary Impacts:** Retrofits may provide a short-term, relatively low-cost option to protect from flood hazards. “Green” protection through 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 coastal access but could effectively protect wastewater infrastructure. Failure of the wastewater system may result in water quality impacts within the ocean, Carpinteria Salt Marsh, Carpinteria Creek.

## Potential Next Steps

### Policy:

- Update the 2005 Wastewater Master Plan to incorporate future vulnerabilities.
- Develop policies to require relocation or avoidance of coastal hazards to the extent possible.
- Coordinate with BEACON and state legislators to fund and perform regular beach and dune nourishment.

### Projects:

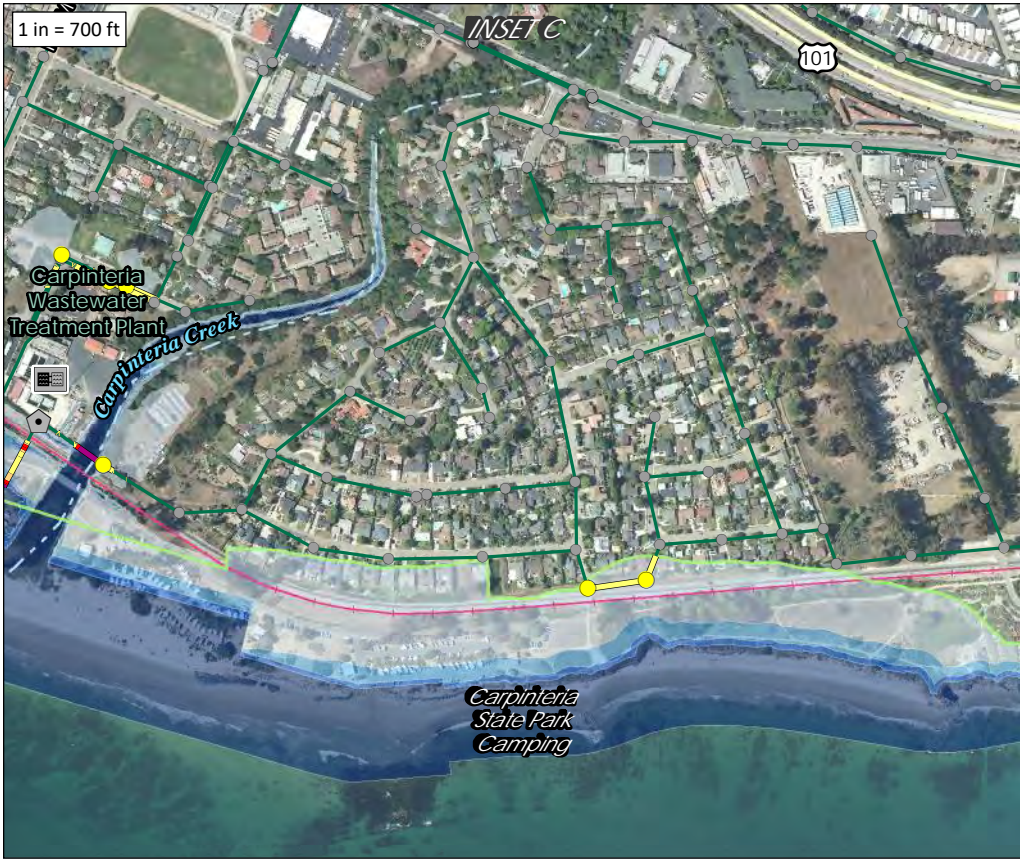
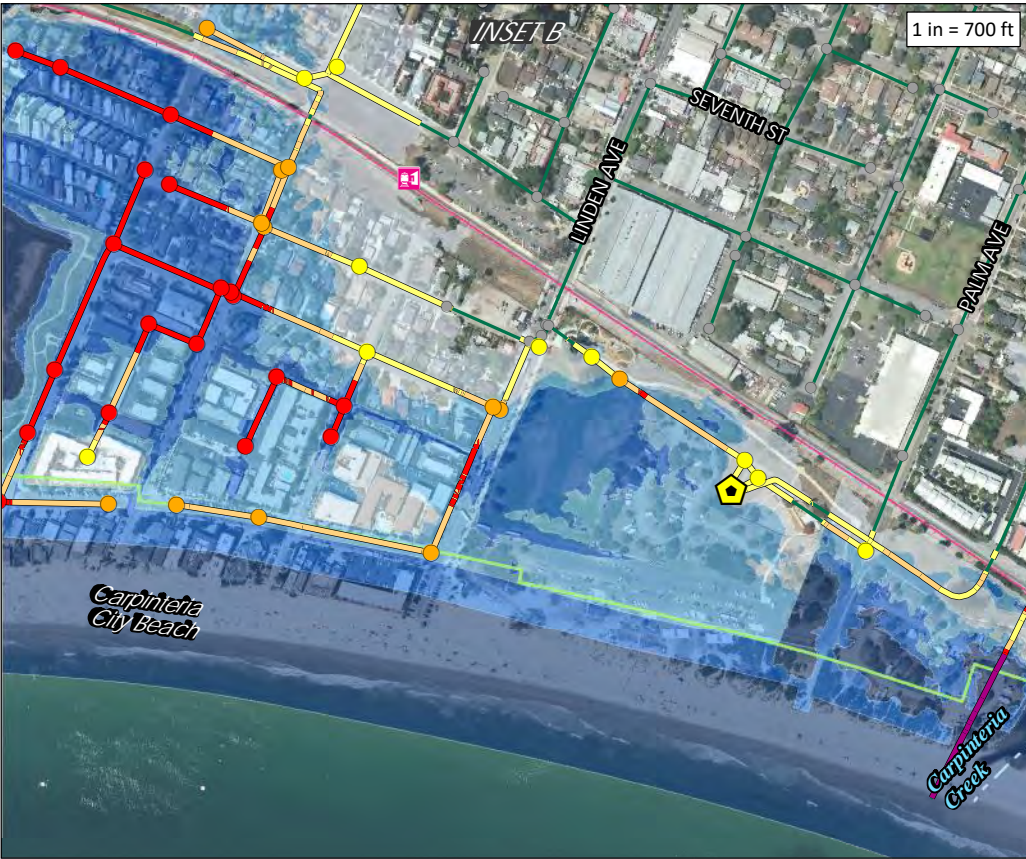
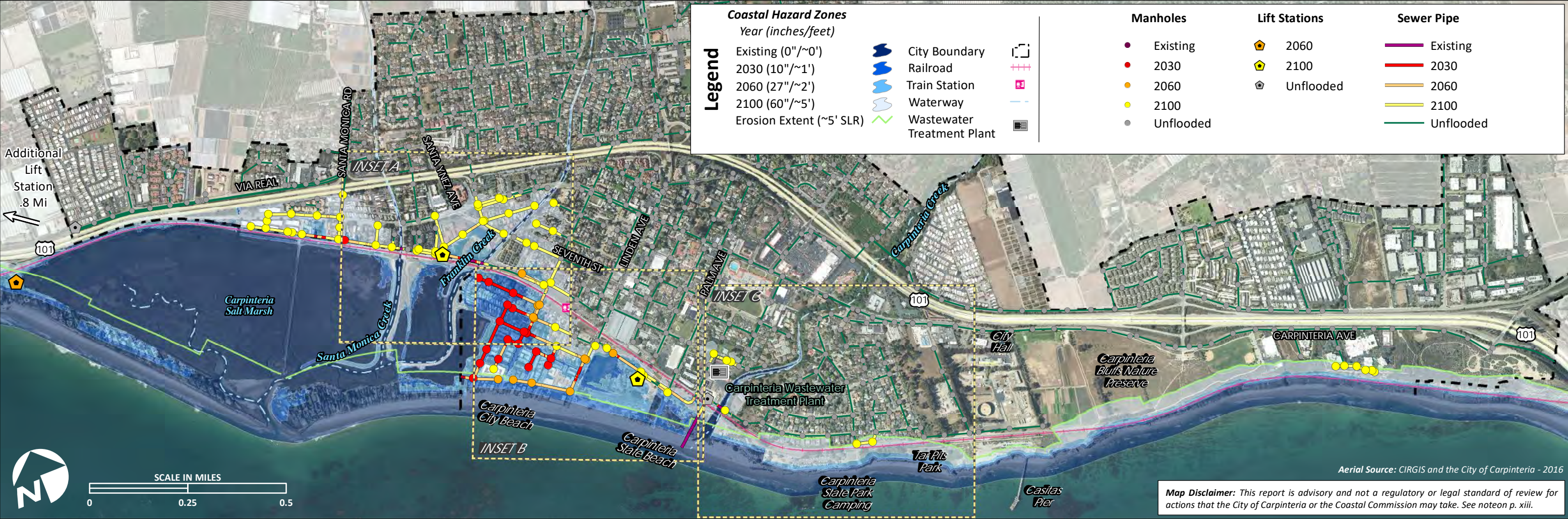
- Relocate sewer pipe segments susceptible to coastal erosion. Prioritize sections by timing of impact.
- Flood proof lift stations and WWTP; install tide gates/flaps at outfalls and coffer dams across creeks.
- Retrofit manholes to reduce flood waters into system.
  - Upgrades should consider additional elevation or setbacks.

### 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). **Threshold:** 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

|   |   |   |
|---|---|---|
| <b>Tidal Inundation</b> <ul style="list-style-type: none"><li>● Pipe – &lt; 0.1 mile</li><li>● Hydrants – 0/Valves – 0</li><li>● Pressure Regulators – 0</li><li>● Meters – 0/Wells – 0</li></ul> | <b>Coastal Erosion</b> <ul style="list-style-type: none"><li>● Pipe – &lt;0.1 mile</li><li>● Hydrants – 0/Valves – 0</li><li>● Pressure Regulators – 0</li><li>● Meters – 0/Wells – 0</li></ul> | <b>Coastal Flooding</b> <ul style="list-style-type: none"><li>● Pipe – &lt; 0.1 mile</li><li>● Hydrants – 0/Valves – 0</li><li>● Pressure Regulators – 0</li><li>● Meters – 0/Wells – 0</li></ul> |
|---|---|---|

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

|  |   |   |
|--|---|---|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>● Pipe – 0.1 mile</li><li>● Hydrants – 0/Valves – 3</li><li>● Pressure Regulators – 0</li><li>● Meters – 3/Wells – 0</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>● Pipe – &lt;0.1 mile</li><li>● Hydrants – 0/Valves – 0</li><li>● Pressure Regulators – 0</li><li>● Meters – 0/Wells – 0</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>● Pipe – 1.0 mile</li><li>● Hydrants – 4/Valves – 38</li><li>● Pressure Regulators – 0</li><li>● Meters – 136/Wells – 0</li></ul> |
|--|---|---|

**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

|  |   |  |
|--|---|--|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>● Pipe – 0.8 mile</li><li>● Hydrants – 2/Valves – 35</li><li>● Pressure Regulators – 0</li><li>● Meters – 79/Wells – 0</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>● Pipe – &lt;0.1 mile</li><li>● Hydrants – 0/Valves – 0</li><li>● Pressure Regulators – 0</li><li>● Meters – 0/Wells – 0</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>● Pipe – 1.8 miles</li><li>● Hydrants – 9/Valves – 67</li><li>● Pressure Regulators – 0</li><li>● Meters – 194/Wells – 0</li></ul> |
|--|---|--|

**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 miles 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

|  |   |  |
|--|---|--|
| <b>Tidal Inundation (total)</b> <ul style="list-style-type: none"><li>● Pipe – 2.9 miles</li><li>● Hydrants – 18/Valves – 128</li><li>● Pressure Regulators – 0</li><li>● Meters – 302/Wells – 0</li></ul> | <b>Coastal Erosion (total)</b> <ul style="list-style-type: none"><li>● Pipe – 0.5 mile</li><li>● Hydrants – 1/Valves – 15</li><li>● Pressure Regulators – 0</li><li>● Meters – 47/Wells – 0</li></ul> | <b>Coastal Flooding (total)</b> <ul style="list-style-type: none"><li>● Pipe – 4.5 miles</li><li>● Hydrants – 27/Valves – 182</li><li>● Pressure Regulators – 1</li><li>● Meters – 444/Wells – 0</li></ul> |
|--|---|--|

**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 3<sup>rd</sup> Street toward the railroad tracks. Water supply pipe (0.5 miles 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 miles). 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. **Manage:** Relocate distribution pipelines away from erosion hazard areas; consider future locations of pump stations and wells to avoid coastal hazards. **Accommodate:** Elevate key system maintenance components, or replace with remotely operated valves. **Protect:** Construct additional flood control channels or shoreline protective devices (“gray” protection approach). Augment, nourish and/or construct sand dunes or contour horizontal levees (“green” protection approach) to protect against future coastal hazards. **Secondary Impacts:** “Green” protection through beach and dune nourishment may require frequent expensive maintenance with higher levels of SLR. “Gray” protection strategies could negatively impact beach and dune habitats, natural processes and coastal access but would effectively protect water supply infrastructure.

Potential Next Steps

**Policy:**

- Develop policies to 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:**

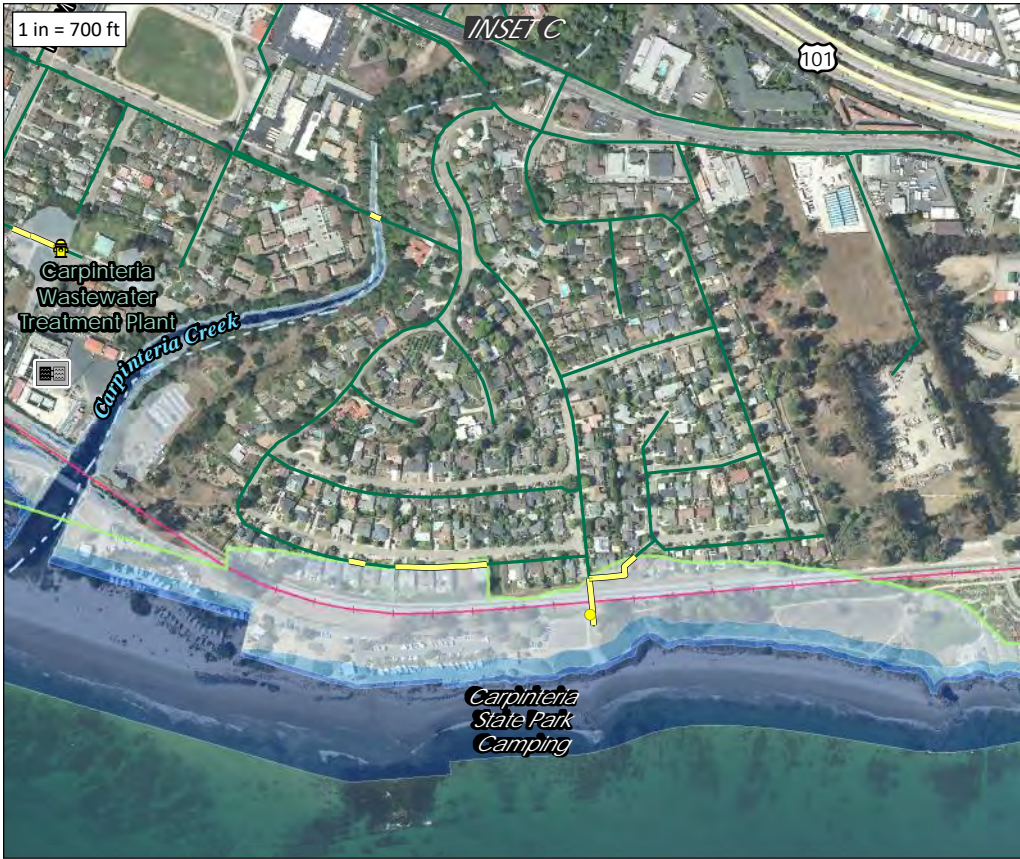
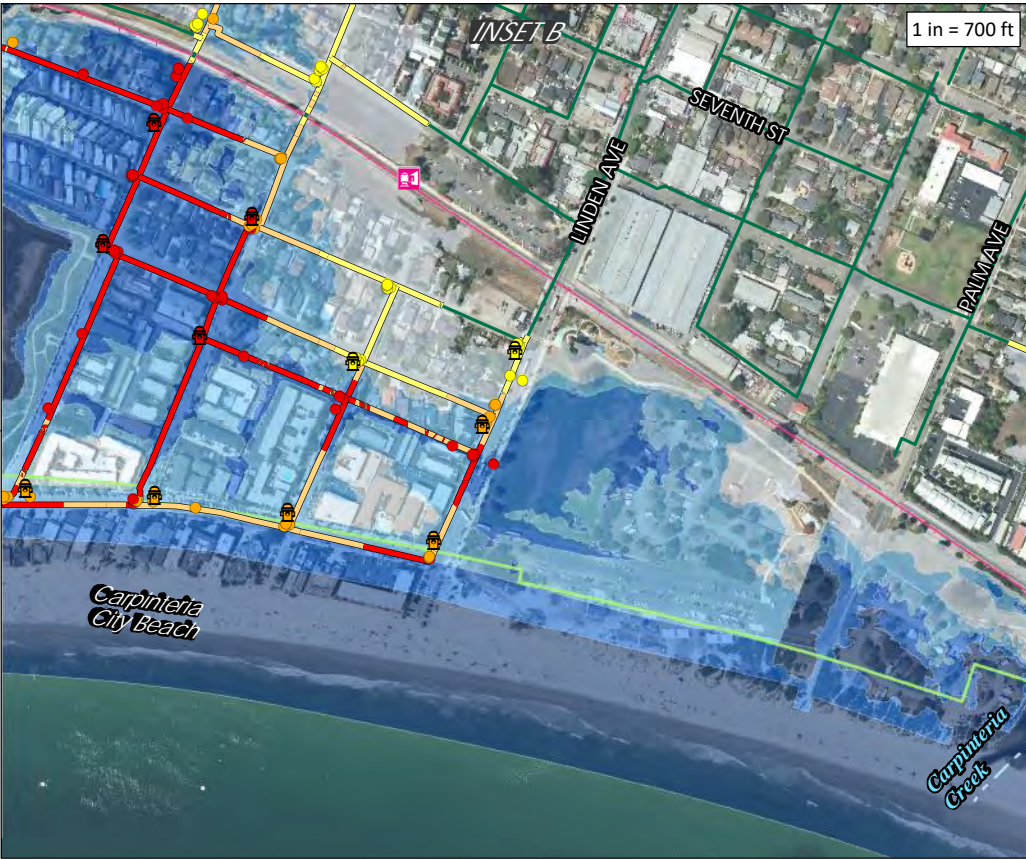
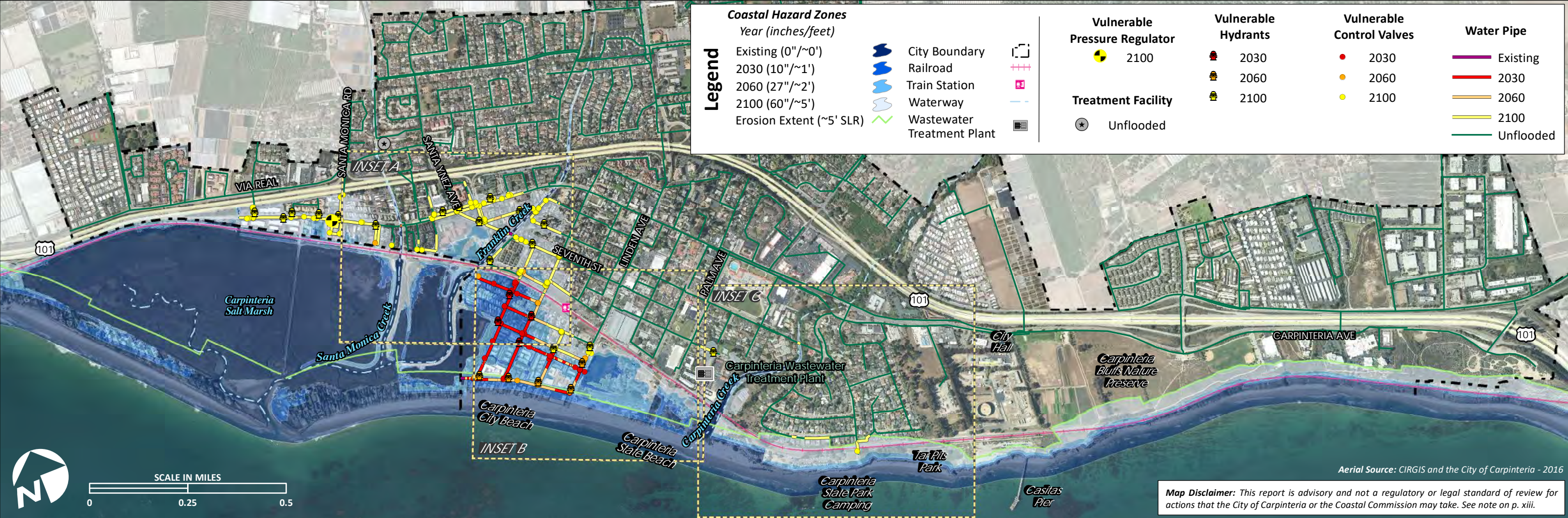
- Specific projects should be identified in other water supply planning documents such as updates to the Carpinteria Valley Recycled Water Facilities Plan or Groundwater Basin Master Plan.

**Monitoring:**

- Support CVWD efforts to develop a monitoring well to evaluate the 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**

**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 two buildings at the wastewater treatment plant may be damaged. In addition, 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.

- **Threshold:** 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.



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

## Existing Vulnerabilities

| Tidal Inundation   | Coastal Erosion  | Coastal Flooding   |
|--|--|--|
| <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> |

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)   |
|--|--|--|
| <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> |

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)   |
|--|--|--|
| <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• School Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• School Buildings – 1</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> |

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)  |
|--|---|---|
| <ul style="list-style-type: none"><li>• School Buildings – 8</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• Schools Buildings – 0</li><li>• Churches – 0</li><li>• Other Community Facilities – 0</li><li>• Critical Services – 0</li></ul> | <ul style="list-style-type: none"><li>• Schools Buildings – 9</li><li>• Churches – 0</li><li>• Other Community Facilities – 4</li><li>• Critical Services – 0</li></ul> |

**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 two buildings at 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

### Range of Strategies:

**Manage** – Relocate or remove school and WWTP buildings from hazardous areas. Develop evacuation routes that avoid existing and future coastal hazards.

**Accommodate** – Retrofit 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 and at key drainage outfalls and coffer dams across creek channels.

**Protect** – A “green” protection approach would be beach and dune nourishment with sand and cobbles to create a “living shoreline” and protect against coastal erosion and large wave events. Work with UPRR to elevate tracks to minimize inundation at Aliso Elementary School; install berms at perimeters of WWTP and Aliso Elementary School.

**Secondary Impacts:** Management strategies may negatively impact the schools and displace residents and children attending the school. Accommodation strategies that involve elevating structures could be costly depending on the types of structural foundation needed, although extended time period allows for planning. 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 from this hazard. Cofferdams and tide gates/ flaps require initial capital outlays and require operations and maintenance funding. Raising building elevations is expensive and may create aesthetic effects.

## Potential Next Steps

### Policy

- Work with School District to evaluate options - tide gates/ flaps/ berms, building elevations or alternative school locations.
- Coordinate with UPRR of increasing track elevations
- Coordinate with BEACON and local state legislators to create sustainable funding program for beach nourishment.
- Include language in policy updates to consider SLR and flood hazards in the renewal of future school or health care leases.

### Monitoring

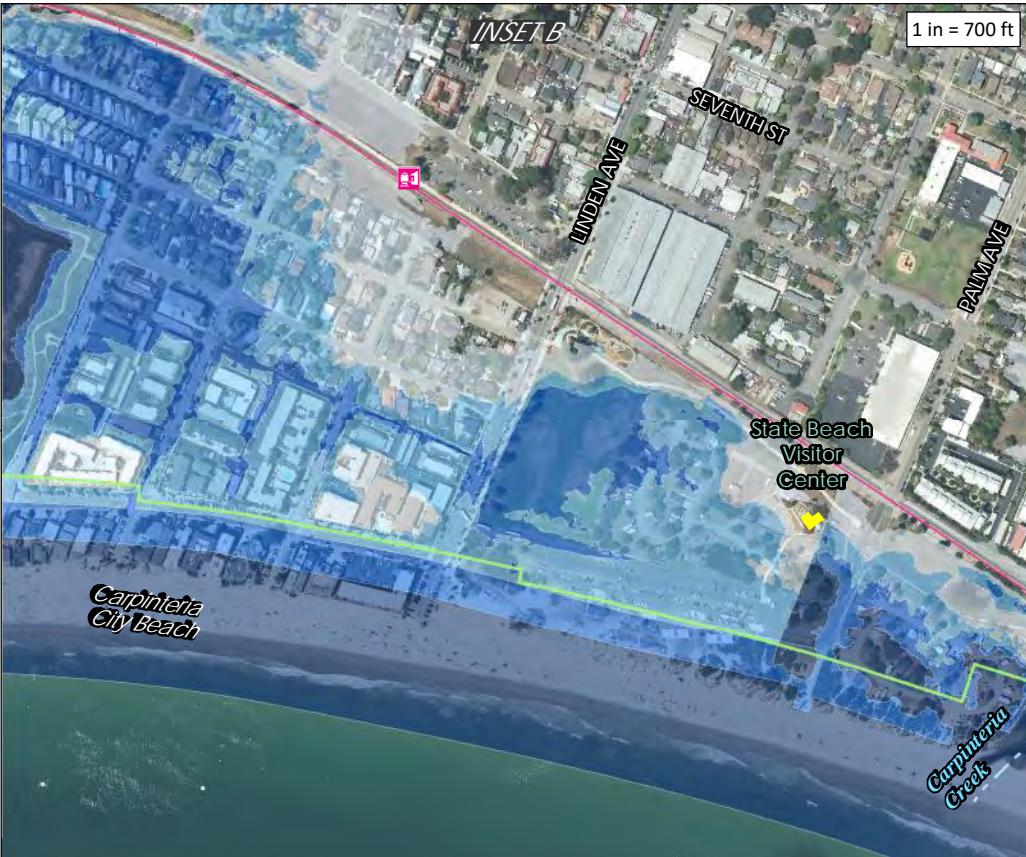
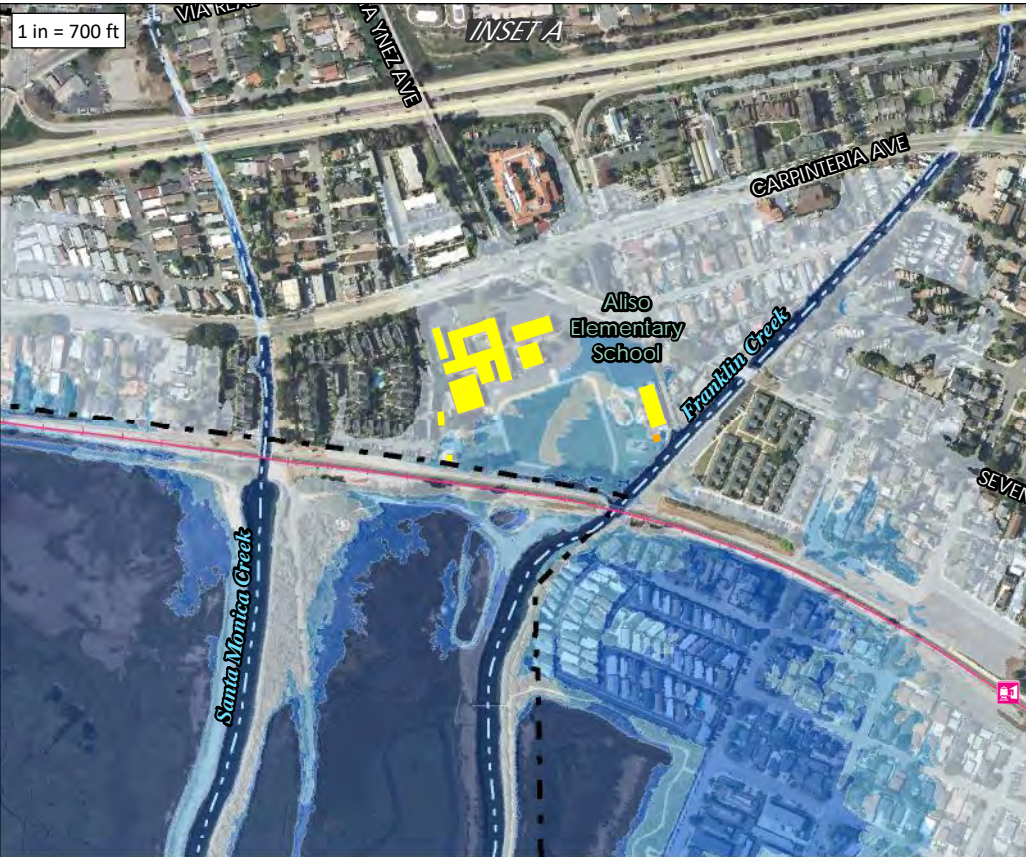
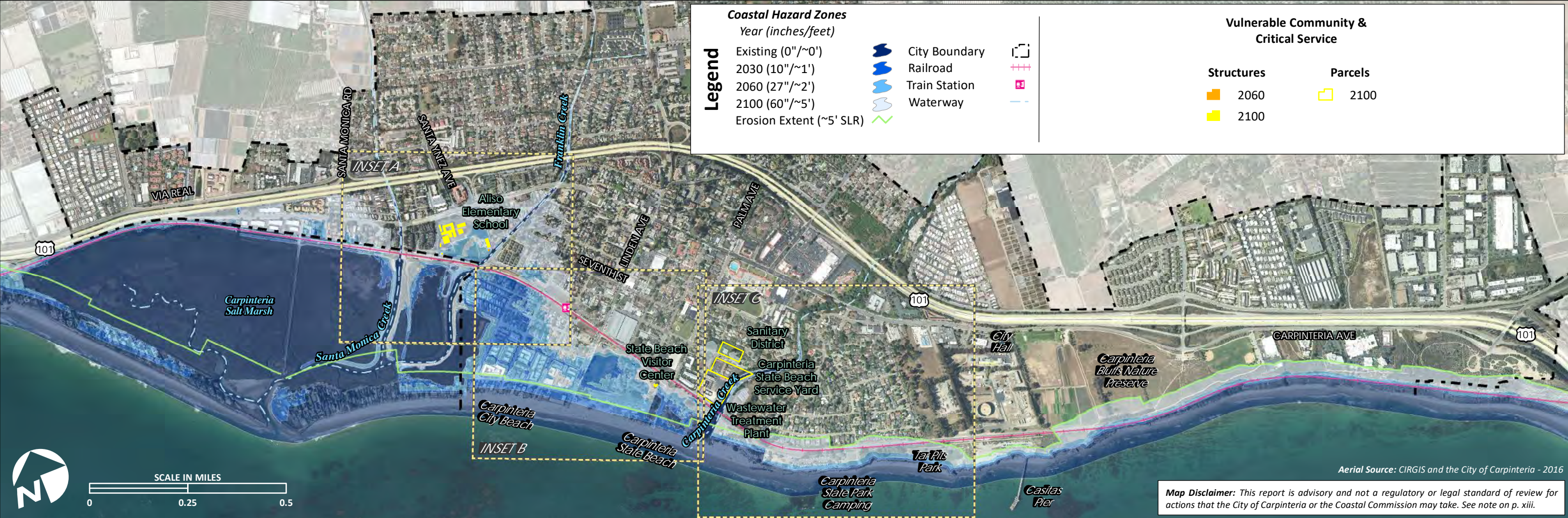
- Monitor extents, depths, and frequency of inundation at Aliso Elementary School.

### Data Gap:

- 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 rokeny 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 Vulnerabilities | 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).*

Peorting acreages of vulnerable ESHA may misrepresent habitat vulnerability. Quantitatively predicting of 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, it 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 SIR. With 5’ of SLR, riparian habitats south of 8<sup>th</sup> Street would be impacted by regular tidal inundation up Carpinteria Creek, which would reduce riparian vegetation. The extent of riparian habitat transition to esruarine 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:

**Manage** – Allow beach ecosystems and bluff habitats 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 into the City’s Salt Marsh Park where feasible, potentially converting existing walkways and use areas to raised boardwalks to maintain use and public access. Coordinate with State Parks to allow beach and dunes to retreat inland, as feasible.

**Accommodate** – Elevate vulnerable portions of Carpinteria Salt Marsh and protect Carpinteria Lagoon using excess sediment.

**Protect** – Fixing the landward boundary (e.g. use of shoreline protective devices) would reduce terrestrial habitat vulerability but increase inundation and loss of beach and dune ESHA. Use green approach to augment sand dunes and perform regular beach nourishment with sand and/or cobbles to sustain beach and dune systems, maintain seal haul out and reduce erosion and los of terretial habitats.

**Secondary Impacts:** “Green” protection through beach and dune nourishment may require frequent maintenance with higher levels of SLR, but may benefit habitats by maintaining beach width. “Gray” protection using shoreline protection could impact beach and dune habitats and natural processes by resulting in a loss of beaches over time, but may effectively protect bluff top and wetland habitat. For example, if the railroad armors the toe of the bluff, impacts to bluff face and bluff top habitats would be minimimized; however, secondary impacts would occur due to inundation and erosion of beach and other shoreline habitats.

## Potential Next Steps

### Policy:

- For ESHA policy development affecting Carpinteria Creek, maintaining hydraulic connectivity upstream and and coordinate with the County, other agencies and landowners to enourage replacent/expansion or riprian woodlands in ares not impacted by SLR.
- Coordinate with Santa Barbara County, coastal cities, BEACON and local legislators to create sustainable funding mechanism for beach nourishment

### Projects:

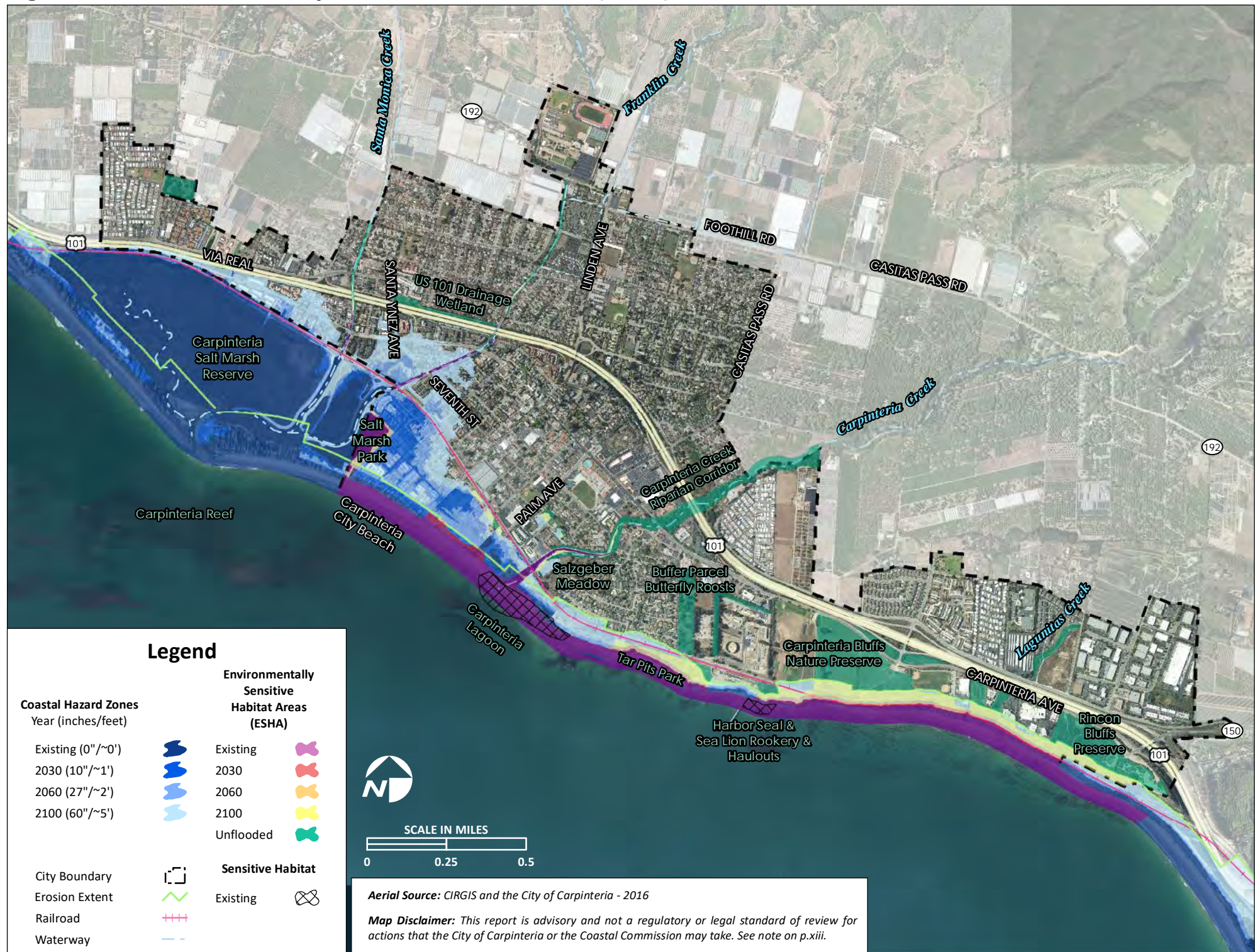
- Improve habitat mapping in the City and vicinity and restore and maintain terrestrial habits impacted by SLR (e.g., coastal bluff scrub).
- Allow more sediment from the watersheds to enter the Carpinteria Salt Marsh and littoral cell to provide additional material for evolutions of ecosystems; support 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) and developmexent of trigger points to inform timing of adaptation strategy implementation.



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



## 2. Background

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### 2.1 Introduction

The California Coastal Act (1976) requires local governments in the state's Coastal Zone to create and implement LCPs. Each LCP consists of a Coastal Land Use Plan and an Implementation Plan. Using the California Coastal Act, the 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.



**Figure 2-1. Regional Overview of the City of Carpinteria**



## 2.2 Carpinteria Local Coastal Program History & Status

The City's 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 Carpinteria Oil and Gas Processing Facility 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.

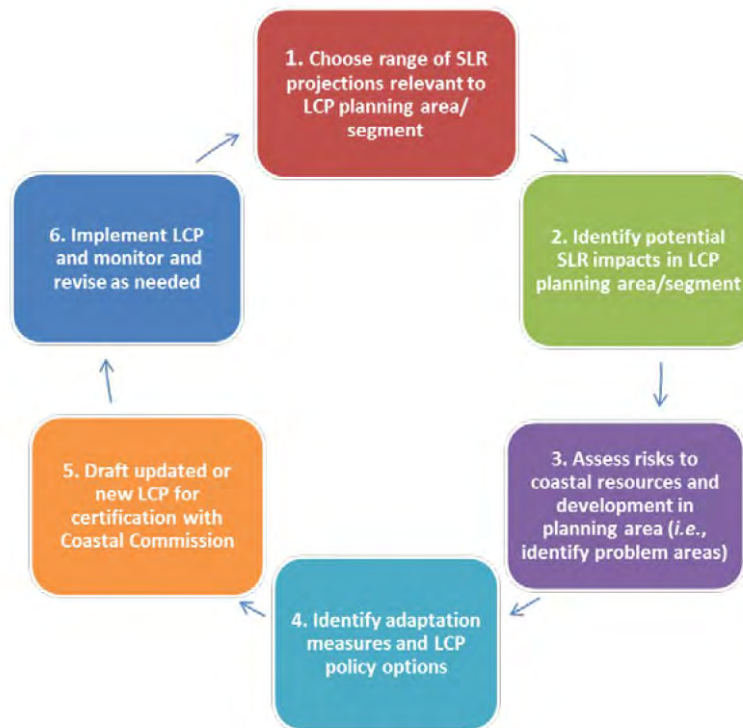
## 2.3 The Planning Process

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<sup>3</sup> 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 has selected 2030, 2060, and 2100 as the planning horizons for this Report because they align with the available modeling completed in 2016 to support coastal management, planning, and LCP updates in the County of Santa Barbara (County). 2010 represents the “existing conditions”, or topographic baseline used for the modeling and mapping of future coastal hazards. The 2100 timeframe is the furthestmost (or most distant) planning horizon since this is the last year that the coastal hazard models are available and is close to the ~75-year economic life of a typical structure. However, under the H++ worst-case scenario, ~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 <sup>4</sup> |
|-------------------------------|------------------------------|---|
| 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.

## 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):

<sup>3</sup> 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*.

<sup>4</sup> 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.

- **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(es), 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 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, 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 and the City, 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 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. Expected submittal of LCP language to the CCC is 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 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 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 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, which identified what is known about sand supplied to the coast 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 the City Beach between Ash Avenue and Linden Avenue. The study reach is about 0.24 miles 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 and Environmental Impact Statement 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 Carpinteria had a population of 13,040 and a total area of 7.3 square miles. Carpinteria 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 in the south. Between the foothills and the populated area of the City is an agricultural zone. Transportation corridors, including U.S. Highway 101 and the Union Pacific Railroad, 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 which 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 annual visitors. At the far northwest is the City owned and maintained public beach that extends 0.3 miles from the end of Ash Avenue to Linden Avenue. The neighborhood behind the City Beach is largely residential and is known as the Beach Neighborhood. Moving southeastward, the Carpinteria State Beach stretches 0.7 miles and is operated by State Parks. Combined, this 1.0-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, 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 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 helping to shadow 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 and is the terminus of both Santa Monica and Franklin Creeks. Finally, the Carpinteria bluffs and beach in the easternmost part of the City provide a harbor seal haulout area on the beach and sensitive upland habitats on the cliff tops.

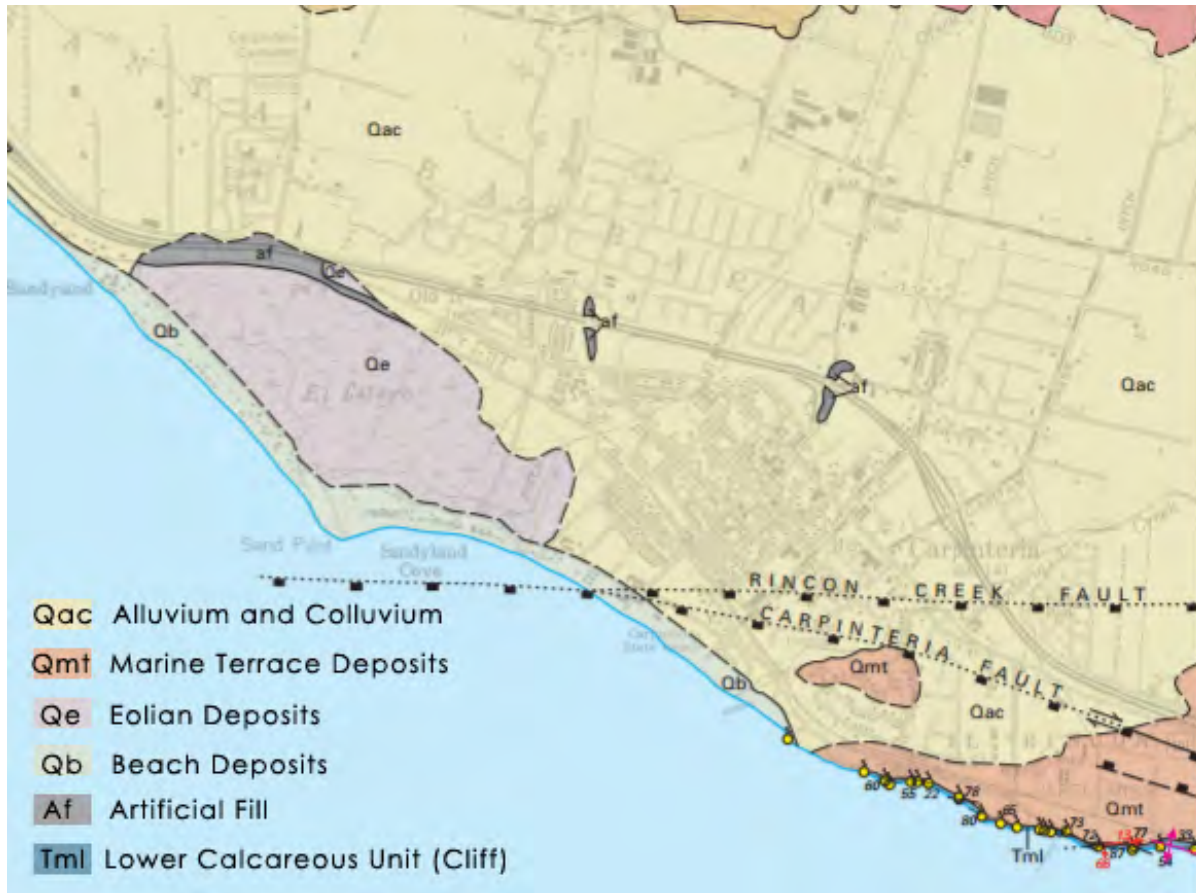
## 3.2 Climate

The climate in the study area is Mediterranean, characterized by dry summers and moderately wet winters. The annual average precipitation in the Santa Barbara region is approximately 18 inches based on data from 1985-2016. 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 is entering its seventh year between 2011 and 2018. The State has recently escalated the drought stage to Severe. Most of the precipitation in the last two years has occurred over two days triggering mudslides and debris flows in El Capitan Ranch in February 2017, and Montecito and Carpinteria in January 2018. Both of these debris flows resulted from a combination of large fires in the watershed followed by short intense rains.

## 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 which 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)**

The Carpinteria Tar Pits Park, which plays a role in the shape of the beaches in the City, is one of only five natural asphalt tar pits in the world (e.g. La Brea tar pits is the largest). The tar pits represent an area where oil deposits seep to the ground surface along various fault fractures. The deposits date back to the Pleistocene Age (2.6 million to 11,700 years ago). The tar has hardened portions of the shoreline, and like the La Brea Tar Pits, provides geologic evidence of now extinct species including mastodons and saber tooth tigers. The tar has also hardened some of the surrounding marine terrace deposits near the daylighted, or above surface Carpinteria and Rincon Creek faults and creates a small headland, which serves to trap sand and helps to maintain the 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 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 the 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. Many of these same historic wetland areas are likely to be subject to future coastal flooding and tidal inundation as sea levels rise based on recent sea level rise flood and inundation maps.

In the 1870s, a large dune field was present up coast from the entrance to the Carpinteria Salt Marsh. The historic dune field was the reason that the neighborhood adjacent to Carpinteria was called Sandyland, and the mouth to the salt marsh is called Sand Point. Discussion of shoreline change is provided below in Section 3.8, *Historic Shoreline Changes and Erosion*.

As physical processes and human alterations have affected these historic habitats, they have evolved into the current habitat areas which are being proactively managed. 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. ESHAs are habitats that have been specially designated by the City and the CCC to have special status (Table 3-1). These habitats are presently found throughout the City. Mapping of ESHAs, as depicted in the City's Environmentally Sensitive Habitat (ESH) overlay designation on land use plan and resource habitat maps, are intended to be representative general locations of known habitat meeting the LCP and CCC definition for ESHA and have not been updated since 1999, but remain the standard of review for habitats in the City's existing GP/LCP. The City's LCP acknowledges that all sensitive communities may not be known, or may migrate or otherwise change over time and therefore, the maps are intended to identify the existence but not extent of sensitive habitat areas and may require supplemental investigations for land use activities.

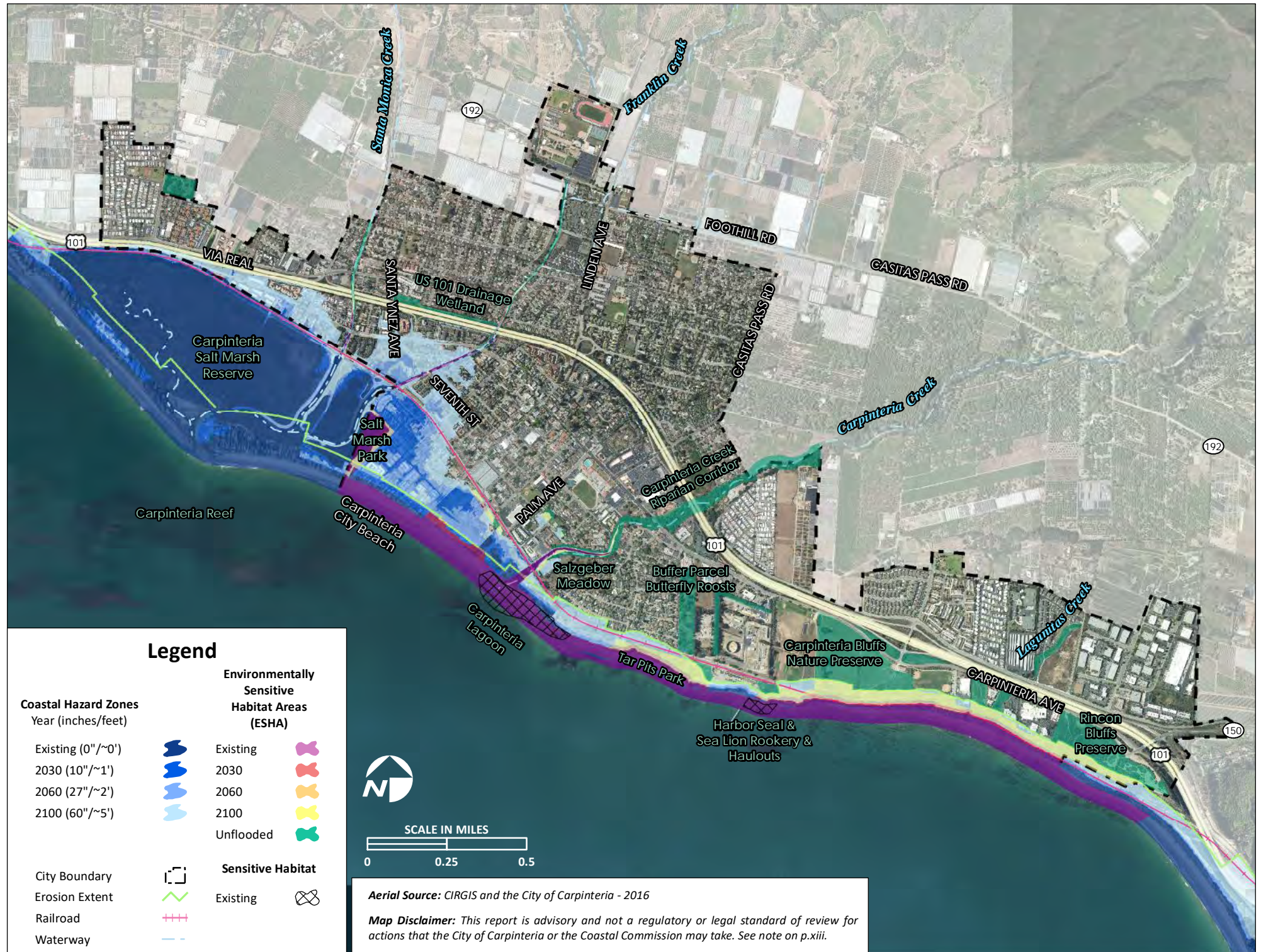
The habitats described here are required to be analyzed for any impacts prior to any permit approval. The location of existing mapped habitats are shown below (Figure 3-3), and the potential future changes to these habitats caused by climate change are described in Section 6.8, *Environmentally Sensitive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



**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   | 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   | City Beach, State Park Beach  |
| 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, Wardholme Torrey Pine   |
| Sensitive, Rare, Threatened or Endangered Species Habitat   | Carpinteria Bluffs, Carpinteria Creek, Carpinteria Salt Marsh   |

**Figure 3-3. Environmentally Sensitive Habitat Areas in the Carpinteria Planning Area**





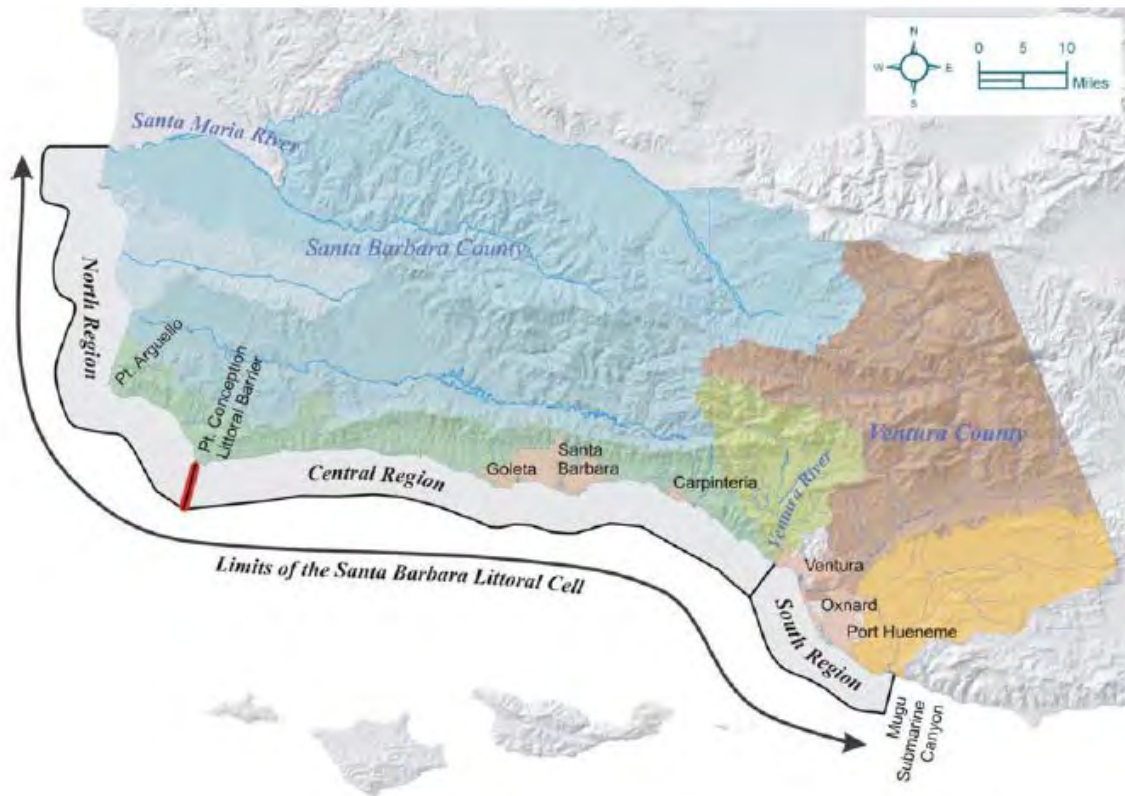
## 3.6 Littoral Cell and Sediment Budget

The Carpinteria coast is situated within the Santa Barbara Sandshed (watershed + littoral cell), which extends 145 miles from the Santa Maria River in the north and around Point Conception, where the north-south-trending U.S. West Coast takes an abrupt turn to a west-east-trending shoreline orientation into 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 into the deep Santa Barbara Basin (Figure 3-4; 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 are dominated by sediment from up coast beaches and by contributions from the small coastal watersheds. Cobbles and bedrock are often seasonally exposed in the wintertime especially at the base of the Carpinteria Bluffs, or on the beaches after large storm events. In the summer, beaches are then naturally replenished with sand and sediments that have been transported from up coast 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 coast of Carpinteria from extreme wave events and creates a near 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. All of these harbors are sand traps, and regular dredging is required to maintain sand supply to the downcoast beaches. The annual average volume of sand dredged from each harbor indicates 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 height ranges 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 primarily associated 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 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.



Typically, the largest tide ranges in a year occur in 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 in this study uses Extreme Monthly High Water (EMHW), 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 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 and are 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). 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. 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.” 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) shows that there will 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), but that there may be more intense storms (Erikson et al 2015).

## *Longshore Currents and Sediment Transport*

Currents in the Santa Barbara Channel drive an almost unidirectional longshore sediment transport from west to east in which beaches narrow during the winter and spring (November to April) and widen during the summer and fall (May to October). The sand 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, and large coastal storms as well as human activities. If sediment supply exceeds the gross longshore sediment transport rates then the coast will accrete seaward; if there is more sediment removed than supplied (i.e., gross longshore sediment transport rate exceeds

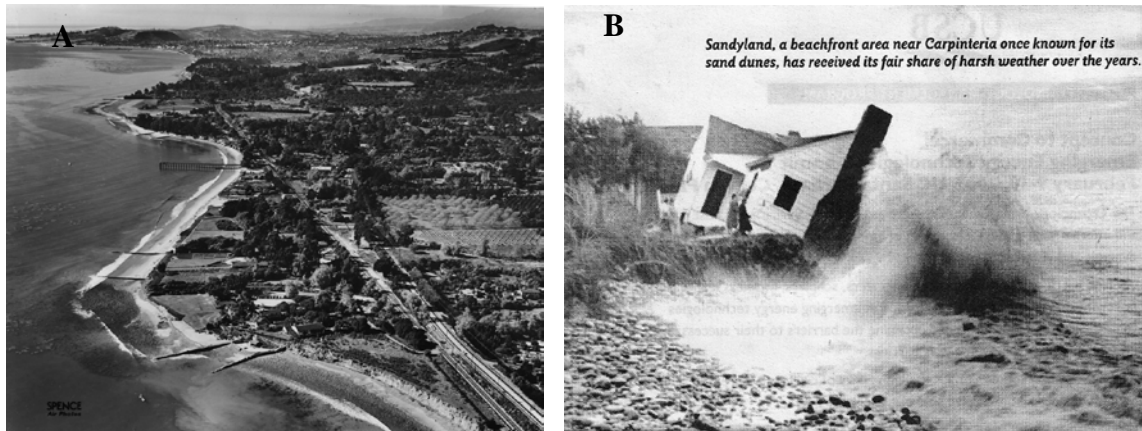
available sediment volume/supply), the coast will erode. Long-term changes in the shoreline are caused by sediment supply and sea level rise, whereas short-term or event-based erosion is caused by large storm events.

Carpinteria beaches experience seasonal cycles where winter storms may 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. Currently, the sandy beach width varies seasonally and along the coast; within the City beach, widths range between 65 and 200 feet. Because there are so many factors involved in 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 across Carpinteria. Significant wave events in 1938, 1943, 1958, 1982–83, 1988, 1997–1998, 2002, 2007, and 2015–2016 have demonstrated that the coast is a dynamic and hazardous environment. Many of these storm events and creek flooding hazards are associated with El Niño events. These hazards can be exacerbated following wildfire events when large fluxes of sediment can be transported to the coast, such as what occurred during the January 2018 debris flows.

The Carpinteria and Sandyland shoreline has changed dramatically since the late 1800s when the once large dune field was present (Figure 3-2). Carpinteria's shoreline changes are mostly due to indirect or direct human impact or influences. This includes downcoast erosion and loss of sediment supply caused by construction of the Santa Barbara Harbor ~10 miles to the west (Photo A, Figure 3-5), and loss of dune and wetland habitat due to development along the Carpinteria shoreline (Photo B, Figure 3-5). In localized spots adjacent to the City Beach, shoreline protection in the form of coastal armoring structures also causes seasonal impacts to the sandy beach width (Revell et al 2008), 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.



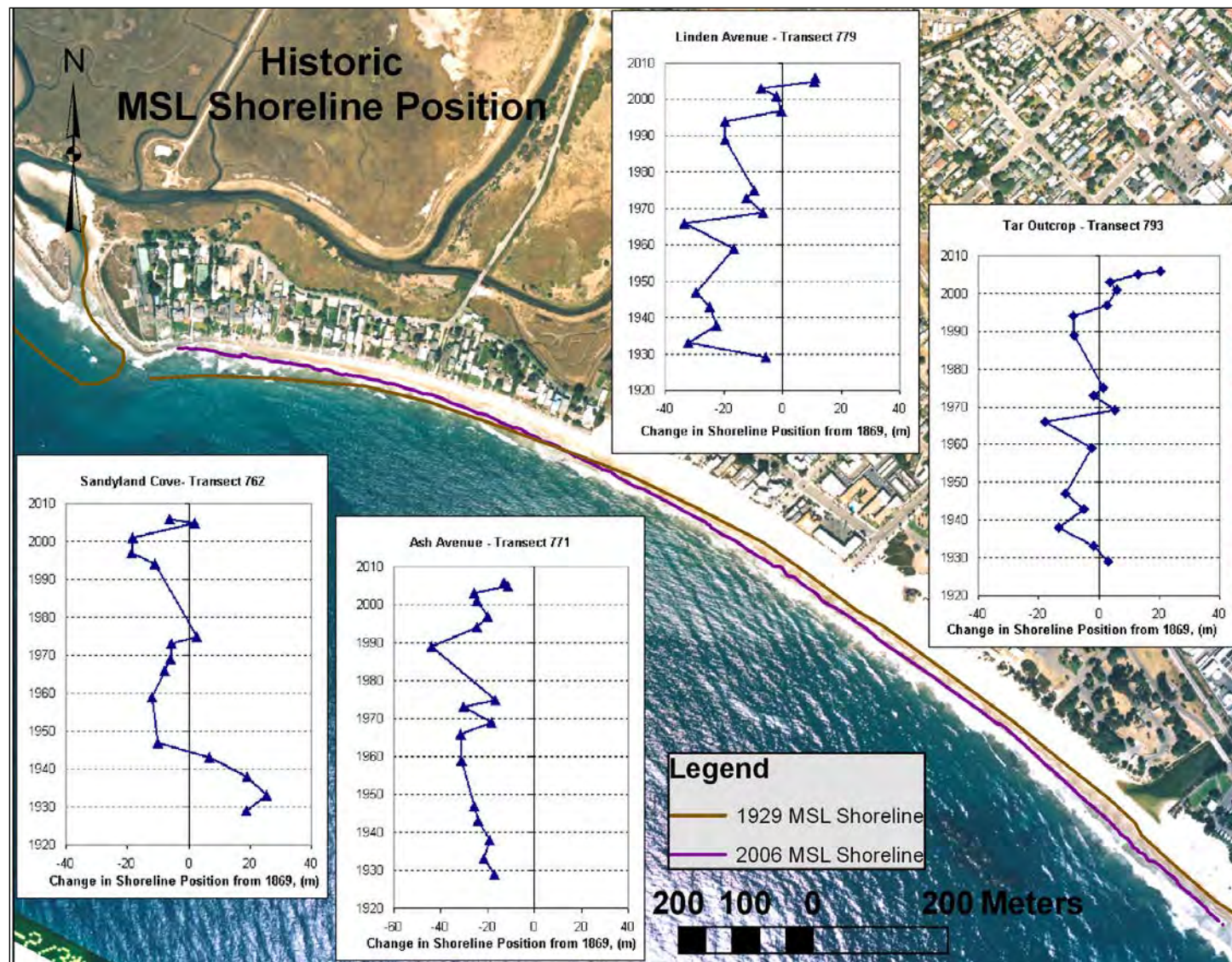


**Figure 3-5. Historic Photos a.) Erosion wave en route to Carpinteria in 1936 (photo source: Spence Collection – UCLA), b.) Updrift erosion at Sandyland circa late 1930s (photo source: Santa Barbara Independent)**

Breakwater construction at the Santa Barbara Harbor began in 1927 and was completed by 1930, during which ~2.6 million cubic yards of sand were impounded updrift of the Santa Barbara Harbor at Leadbetter Beach. Sand impoundment led to a well-documented erosion wave<sup>5</sup> that migrated downcoast at a pace of ~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, led to the erosion of the historic dune field at Sandyland and the beach at Carpinteria in the late 1930s. (Photo B, Figure 3-5; Bailard 1982; Komar 1998; Weigel et. al 2002). In addition, the natural underwater sand peninsula (tombolo) between the sand dunes and Carpinteria Reef had 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 (Figure 3-6). Sandyland Cove Beach saw the largest changes, eroding by ~100 feet, and Ash Avenue narrowed by ~50 feet. Meanwhile, accretion occurred on the beach at Linden Avenue (~30 feet) and Tar Pits Park (~60 feet) (Revell et. al 2008).

<sup>5</sup> Erosion wave is an area of sand deficit that travels along the coast.



**Figure 3-6. 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**

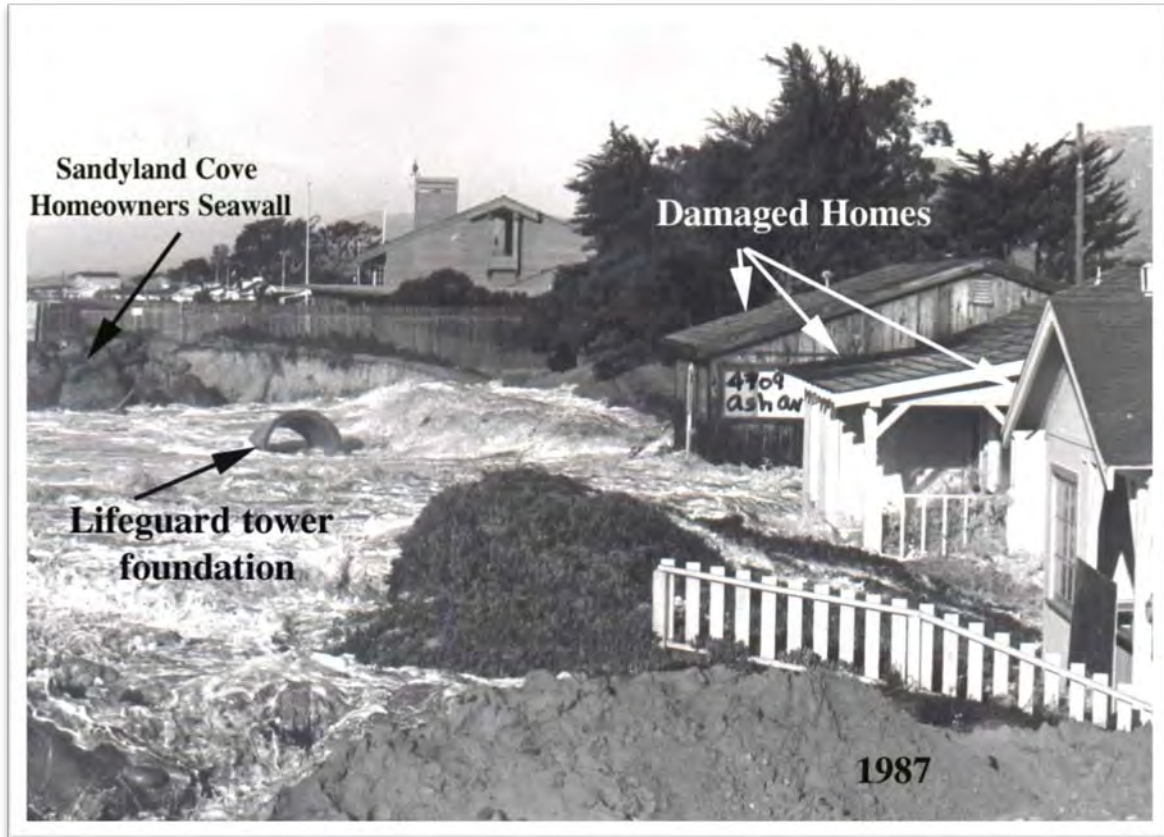


As a result of this large erosion, in the mid-1980s under an emergency permit issued by the County of Santa Barbara, Sandyland Cove residents built a revetment that partially encroached on the public beach seaward of the homes and resulted in burial of the beach due to the footprint of the structure (Figure 3-7). 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).



**Figure 3-7.** Placement loss of the beach in front of Sandyland Cove causing 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 same erosion hotspot caused damage to the City lifeguard facility at the terminus of Ash Avenue in 1987 (Figure 3-8).



**Figure 3-8. Storm damages at Ash Avenue at the end of the Sandyland Cove Revetment**

USACE, who constructed the Santa Barbara Harbor, has been studying the shoreline and potential strategies to restore the Carpinteria shoreline. A reconnaissance study was partially completed by the USGS and University of California, Santa Cruz 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 Feasibility Study to identify an appropriate mitigation project, as also described in Section 2.4, *Other Regional Sea Level Rise Planning Efforts*, of this Report.

## 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.



Additionally, every year the City installs a ~1,300-foot-long seasonal storm berm out of sand along the City Beach in the fall and winter to buffer against large wave events (Figure 3.9). In the spring, when the storm wave season has passed, the City pushes the sand back onto the beach.



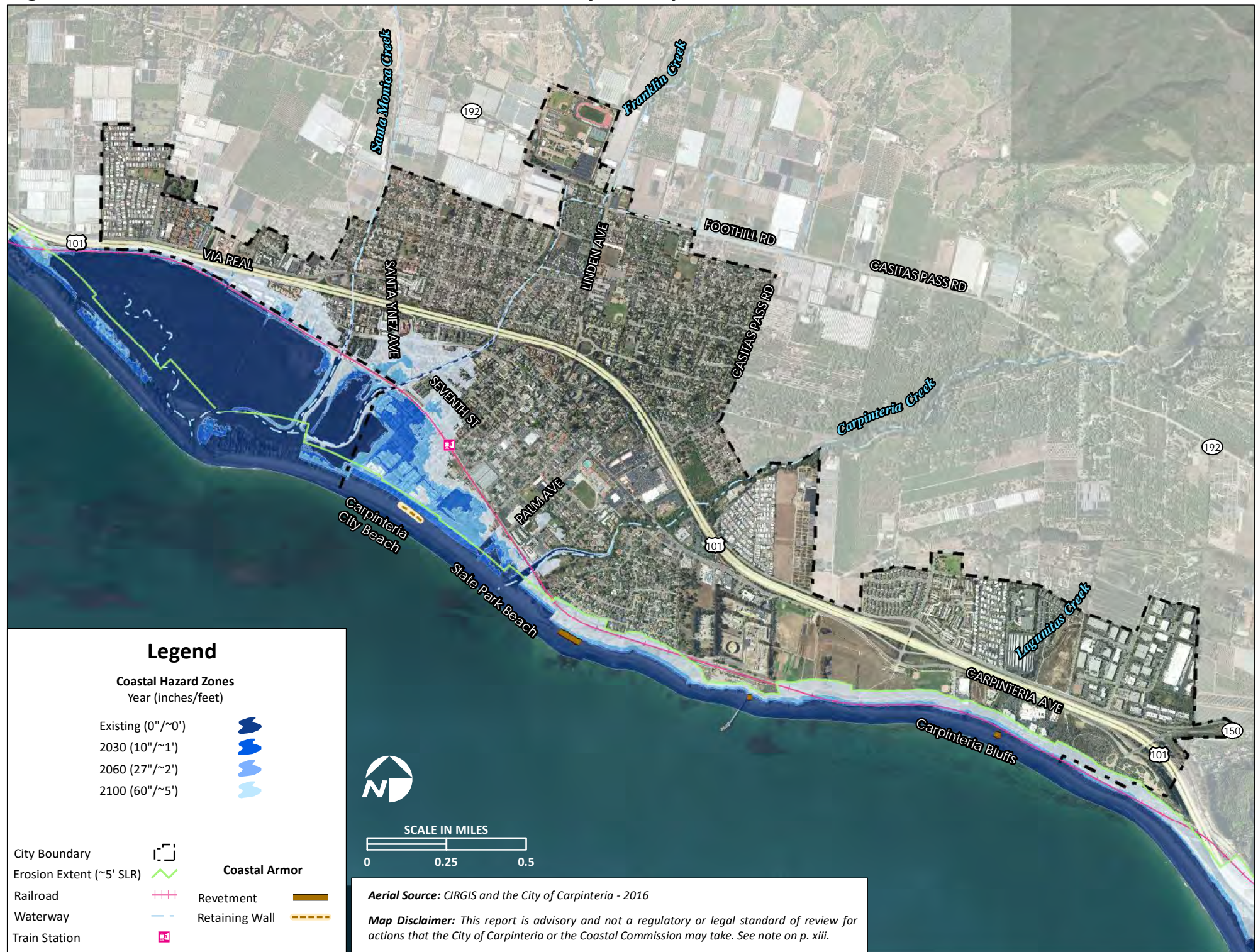
**Figure 3-9.** Seasonal Storm Berm along the City Beach (*photo courtesy, Matt Roberts*)

## Existing Shoreline Protection

Shoreline protection in the City is relatively minimal (Figure 3-10). This report does not include cost estimates to maintain existing shoreline protection devices. A sand retention wall originally constructed in 1977 is located along Carpinteria Shores apartments, and small portions of revetment at the base of Casitas Pier and under the Carpinteria Bluffs. Tar Pits Park, Carpinteria State Beach, and a small portion of San Miguel Campground also have a small amount of shoreline protection. The protective features at San Miguel Campground consist of material used as part of the former burn dump site and were installed in fall 2013 under a Development Plan and CDP issued by the City (Figure 3-11). Given the age of some of the other existing shoreline protection devices within the City and Carpinteria State Beach, permitting status is unclear and some of the structures may precede permitting requirements.



**Figure 3-10. Extent of Shoreline Protection in the City of Carpinteria**







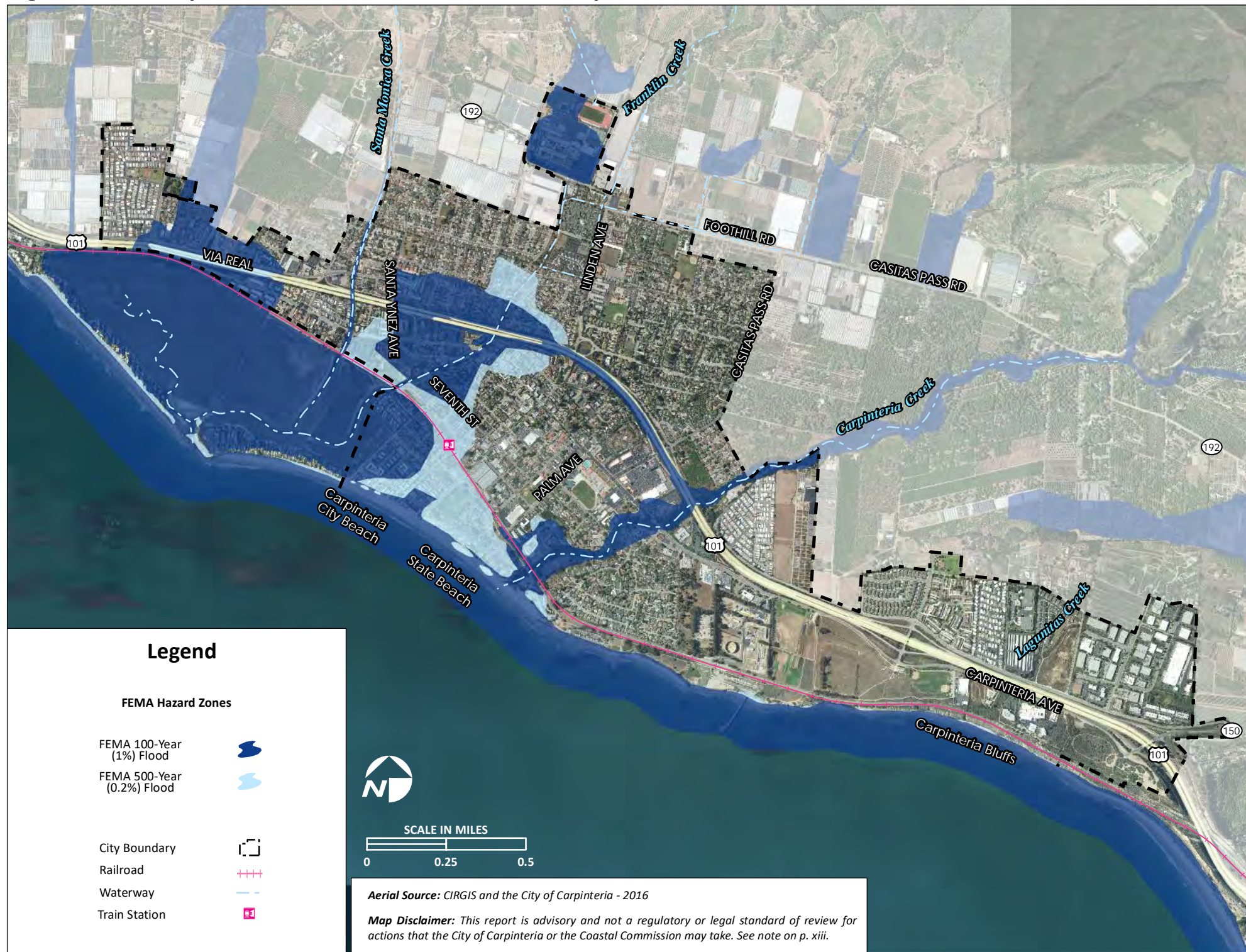
**Figure 3-11. Shoreline Protection at Tar Pits**

### 3.9 Existing Coastal Hazards

FEMA maps delineate coastal flood hazards as part of the National Flood Insurance Program (NFIP). This program requires very 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, representing the existing 100-year and 500-year FEMA flood events (1% and 0.2% annual chance of flooding), are known as the FEMA Flood Insurance Rate Maps (FIRMs), and determine the flood extents and flood elevations across the landscape. adopted Please note that FEMA flood maps are based only on existing conditions and do not account for coastal processes or climate change. FEMA is currently in the process of updating all coastal floodplain maps in the state of California and final updated maps are expected in 2018.



**Figure 3-12. Adopted FEMA Flood Insurance Rate Map**





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 flood maps with an emphasis on the high wave velocity (VE zone); the Santa Barbara County Preliminary maps were released in December 2016 with final regulatory maps expected from FEMA in 2018. The new 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 the 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 | 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 of these properties have had more than three insurance claims and one of them has had a total of six claims.

# 4. Climate and 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, 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 one 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 greenhouse gas (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. 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 ~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 scenario. 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.

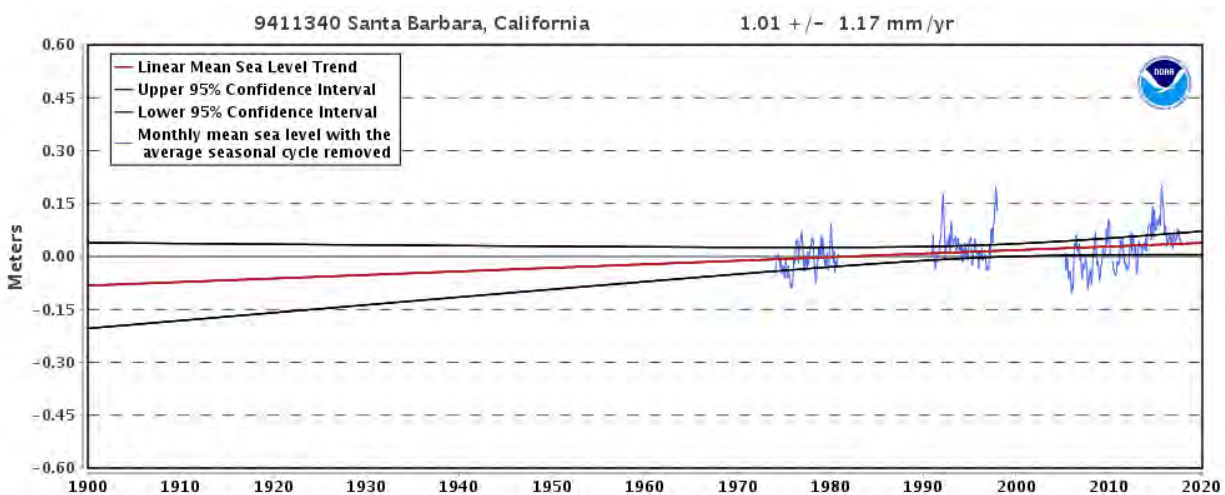
## Relative (Local) Sea Level Rise

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 gage (Santa Barbara Tide Gage) reports the local sea level rise rate at approximately 1.01 (+/-1.17) millimeters per 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 gage 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 gage was installed in the mid-1970s, nearly every major El Niño event has broken the gage 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 time period from 1961-1990. Four GCM models 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 GCM models 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% 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 time 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. Near the end of the century long periods may meet heat wave conditions.

### 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 winter 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 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.

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 (mm/yr) (based on Kopp et al. 2014) |  |   |   | H++ scenario<br>(Sweet et al.<br>2017)<br>*Single<br>scenario |
|----------------|-------------|---|--|---|---|---|
|                |             | MEDIAN  | LIKELY RANGE                                       | 1-IN-20 CHANCE  | 1-IN-200 CHANCE   |   |
|                |             | 50% probability<br>sea-level rise meets<br>or exceeds...      | 66% probability<br>sea-level rise<br>is between... | 5% probability<br>sea-level rise meets<br>or exceeds... | 0.5% probability<br>sea-level rise meets<br>or exceeds... |   |
| High emissions | 2030 – 2050 | 5.6   | 3.3 – 8.2  | 11  | 16  | 24  |
| Low emissions  | 2060 – 2080 | 4.1   | 1.9 – 7.0  | 10  | 21  |   |
| High emissions | 2060 – 2080 | 8.3   | 5.1 – 12   | 16  | 27  | 41  |
| Low emissions  | 2080 – 2100 | 3.9   | 0.91 – 7.8   | 12  | 27  |   |
| High emissions | 2080 – 2100 | 9.4   | 4.8 – 15   | 21  | 36  | 53  |

## 2017 CoSMoS 3.0

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 global climate models 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 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](http://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% storm event 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% 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 the 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 ~12 inches 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 ~20 inches of sea level rise, about 60% 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% 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% annual chance storm event (e.g. 1% 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. Final updated FIRM maps are anticipated to be issued later in 2018.

## 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 2nd California 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 Section 5, *Vulnerability Methodology*.



# 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 and consultant team with input from the City's General Plan/Local Coastal Program Update Committee (GP/LCP 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, CVWD, CSD, Santa Barbara County Planning and Development, Santa Barbara County Public Works, State Parks, CCC, California Division of Oil, Gas, and Geothermal Resources (DOGGR), State Water Resources Control Board, U.S. Environmental Protection Agency (EPA), and Environmental Systems Research Institute (ESRI). (Table 5-1)
- Economic and beach attendance data from BEACON and California 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 the measure of impact for each sector (Table 5-1). Data collection efforts began with available City data and 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. 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).

**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  |
|---|--|--|--|
| <b>Land Use Parcels and Structures</b>    | Agriculture                              | # of parcels, acreage of parcels   | Parcels – County Planning<br><br>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             |  |
| <b>Roads and Parking</b>                  | Roads                                    | length of road   | County Planning Department   |
|   | Parking Lots                             | # of lots, acreage of lots   | Revell Coastal with Input from Open Street Map   |
| <b>Public Transportation</b>              | Public Transportation                    | Length of: bike routes, bus routes, railroad lines; # of bus stops, # of train platforms | County Planning and Public Works Departments   |
| <b>Camping and Visitor Accommodations</b> | Hotels and Motels                        | # of parcels, # of structures  | County Planning Department   |
|   | Campgrounds                              | # of sites, acreage of sites   | Revell Coastal with input from State Parks   |



**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  |
|--|---|--|--|
| <b>Coastal Access and Trails</b>                       | Coastal Access and Trails   | # of access points, length of trail by type                                    | Revell Coastal with input from CCC and the City                    |
| <b>Hazardous Materials Sites and Oil and Gas Wells</b> | Geotracker Electronic Submittal of Information (ESI) Reporting Sites (Hazardous Business Materials Storage) | # of sites   | State Water Resources Control Board                                |
|  | EPA Small Quantity Generators (SQGs)  | # of sites   | EPA  |
|  | Cleanup Program Active Sites  | # of sites   | EPA  |
|  | Oil and Gas Wells   | # of wells   | DOGGR  |
| <b>Stormwater Infrastructure</b>                       | Stormwater Infrastructure   | # of drop inlets, # of outfalls, length of drains                              | County Public Works Department and City Public Works Department    |
| <b>Wastewater Infrastructure</b>                       | Wastewater Infrastructure   | # of lift stations, # of manholes, length of pipes                             | City Public Works Department and Sanitary District                 |
| <b>Community Facilities and Critical Services</b>      | 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 |
| <b>Environmentally Sensitive Habitat Area</b>          | ESHA  | Types of sensitive habitats  | City GP/LCP  |

## 5.3 Coastal Hazards Projections

The modeling work for the 2016 *Santa Barbara County Coastal Resilience Project* includes modeling of the following coastal processes:

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

The Coastal Resilience modeling methods are summarized here and more modeling details are available in the Technical Methods report produced as part of the Coastal Resilience modeling (Revell Coastal and ESA 2016; <https://maps.coastalresilience.org/california>).

### Coastal Resilience Hazard Modeling

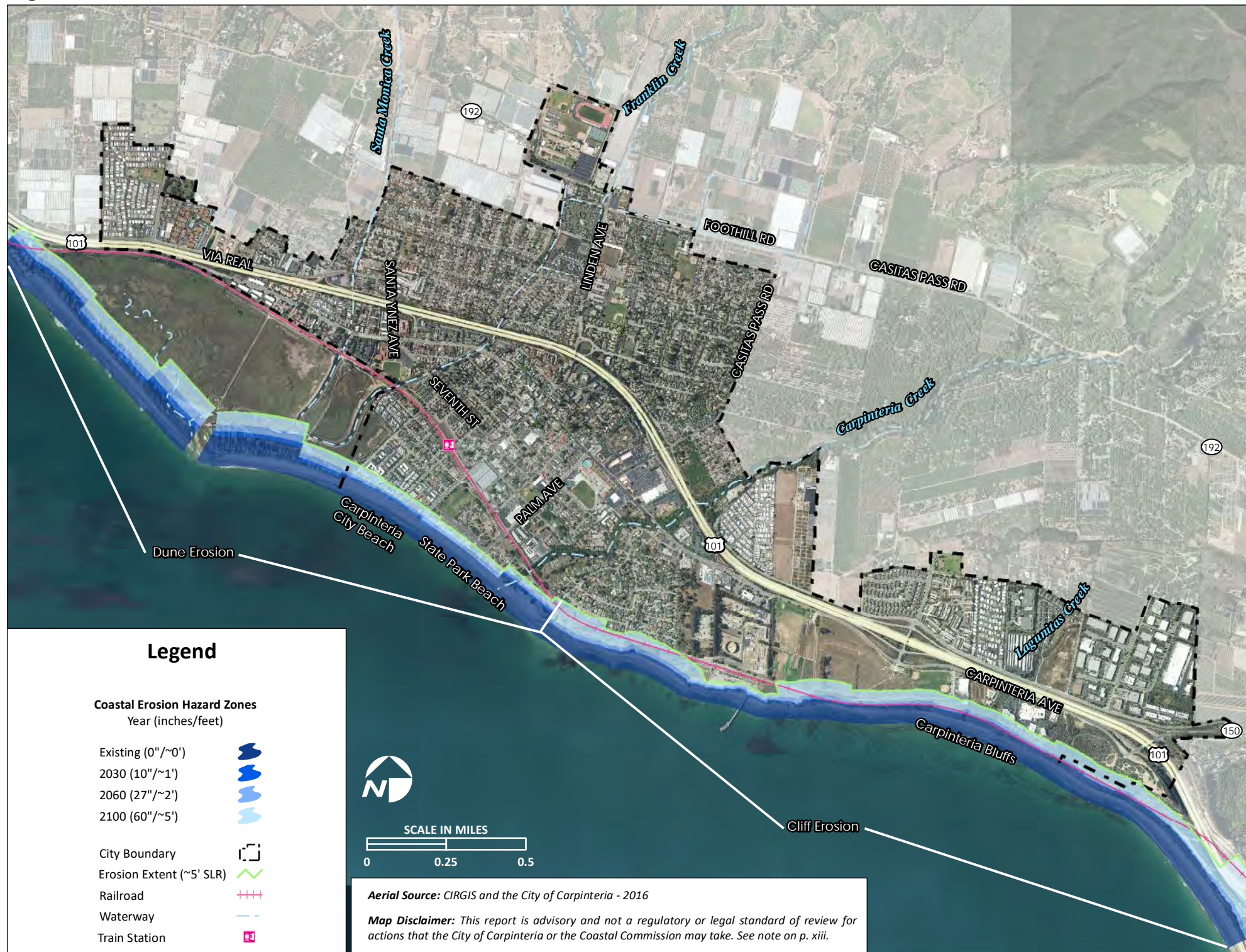
The Coastal Resilience modeling methodology relies on a detailed parcel-level backshore characterization that includes backshore type, geology, and local geomorphology (i.e., elevations, beach slopes). The backshore characterization spatially analyzed approximate 100-yard alongshore spacing and then statistically represented results at an approximate 500-yard alongshore distance. Calculations of wave run-up and tides are combined into 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 and cliff-backed shoreline erosion hazards (Figure 5-1).



**Figure 5-1. Extents of Dune and Cliff Erosion**





**Dune Erosion:** The coastal dune erosion hazard modeling considered a short-term response based on the erosion from a 1% annual chance storm. Dune erosion included three components – potential 1% annual chance storm erosion impact, erosion from sea level rise, and erosion caused by 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 is modeled using a model that considers the geology and geomorphic failure mechanism inherent in each geologic unit, and then accelerates 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 is 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 were calculated, the topography was updated to reflect the erosion, and the coastal storm flood model considered areas that were eroded during this time period and thus exposed to wave flooding through newly connected overland flow pathways.

Wave-induced coastal flood modeling assessed the inland extents of flooding using the method of Hunt (1959) and supported in the Shore Protection Manual (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 EMHW level based on the tidal statistics from water levels at the Santa Barbara Tide Gauge (EMHW = 6.55 feet NAVD88). These hazard zones show the projected maximum extent of what could be tidally inundated once a month with the appropriate sea level rise scenario added (Figure 5-3).

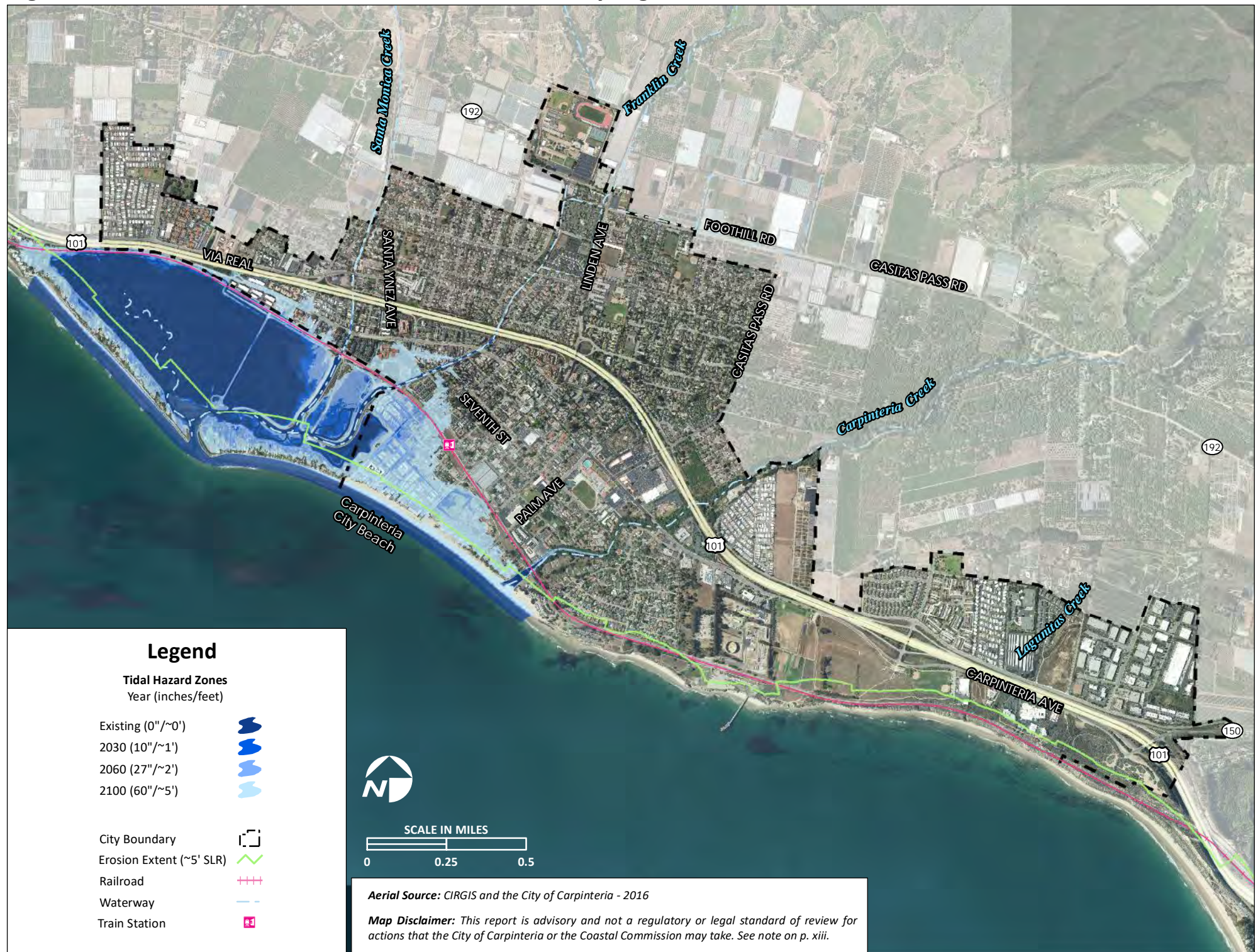


Figure 5-2. Coastal Storm Wave Flooding from a 1% Annual Chance Storm





**Figure 5-3. Tidal Inundation from an Extreme Monthly High Tide**





## Combined Hazards

For each planning horizon, all the 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 Section 1, *Sector Profiles*.

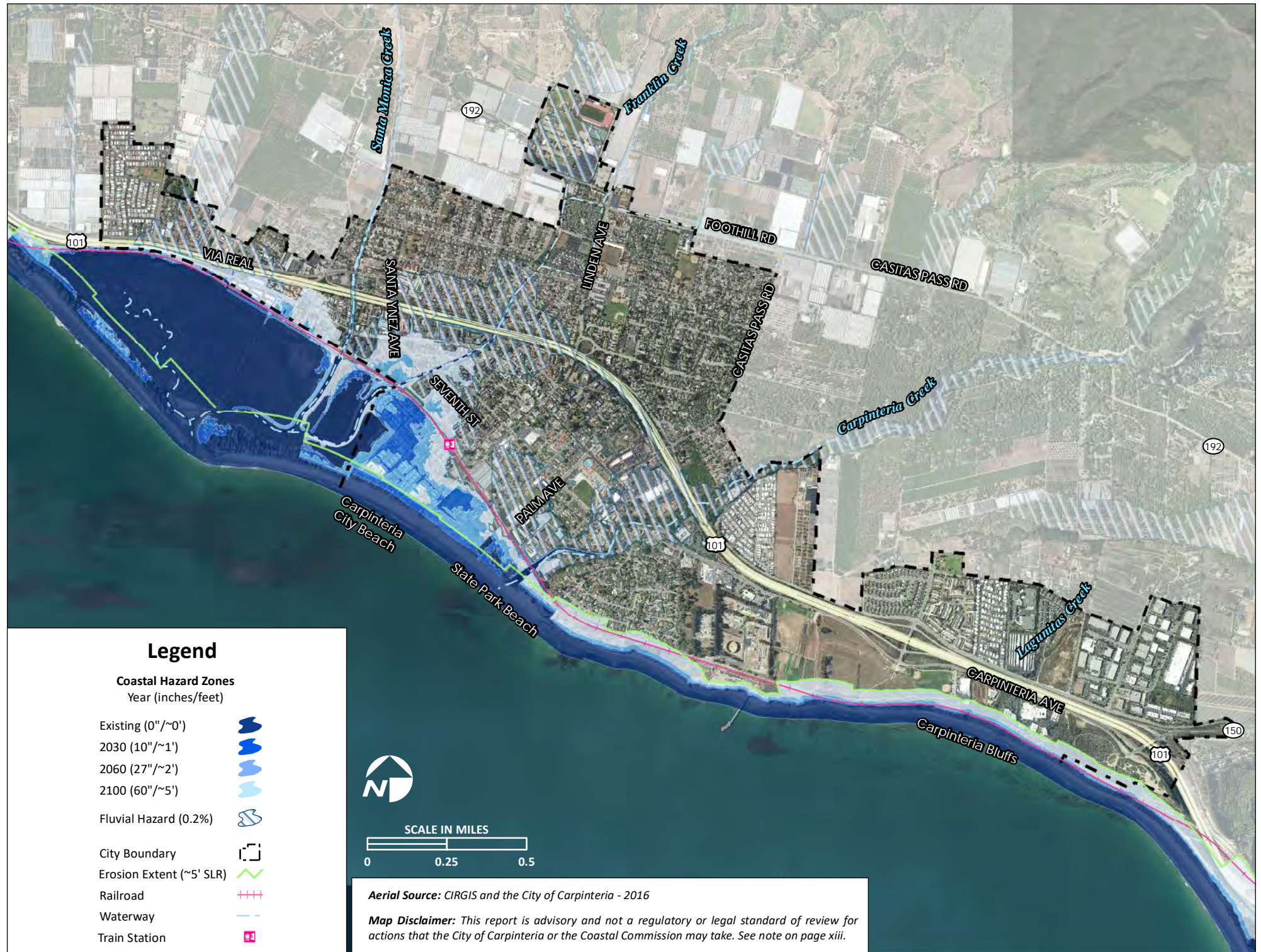
## Depth of Flooding Assumptions

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 (Note that presently the depth damage curves do not make a distinction between standing water and water with momentum, thus these estimates may be conservative because scour is not considered in the analysis).
- For parcels outside the coastal erosion/high wave velocity hazard zone but inside the coastal flood hazard zone, the depth of flooding is assigned 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.



**Figure 5-4. Combined Coastal Hazards considered in the Vulnerability Assessment**





## Modeling Assumptions

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

**Table 5-2. Hazard Model Assumptions and Biases**

| Geospatial Data                        | Potential Bias      |  | Type of Bias         | Reason   |
|--|---------------------|--|----------------------|--|
| Not accounting for existing structures | Too High            |  | Spatial              | Erosion of a sand dune would differ than erosion 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 any reductions occur, then beaches may be lost and hazards could expand.   |

### *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 overstate 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 should 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 recent comprehensive topographic data available was the State funded 2009-2011 LiDAR data. This data is a single snapshot in time and represented the best available elevation data. This data is used to map existing and future hazards. Any changes 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; thus, the beach elevations and beach widths would have similar capacity to rise in elevation with sea level rise, close off the barrier beach creek mouths, and buffer wave run-up. Additionally, it is assumed that the sand being bypassed from Santa Barbara Harbor would continue with similar sand 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 may not be completely accurate. 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 be under-estimating 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 and are documented in Appendix A. In addition, some data was obtained directly from CCC staff in order to identify the 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). The sources and potential errors and spatial biases are described in Table 5-3.



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.

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. Meaning, if a structure is flooded across multiple horizons, only the first instance is documented. Vulnerability for larger polygons (e.g. 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 Section 1, *Sector Profiles*. The complete vulnerability table of results is 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 broken out into the individual sectors. The sources of all spatial data analyzed are found in Table 5-1.

While not specifically assessed, any big flooding/storm event that damages the City would have a longer-term negative effect on tourism spending and tax revenue dollars that would have come to the City.

**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 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 and large apartments are an estimation based on general information details from parcel attribute tables and attributes which may under- or over-predict actual number of total 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/<br>Bike Routes/<br>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,<br>Cleanup<br>Program<br>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.   |

## Land Use Parcels and Structures

For land and structures subject to property tax (generally land/structures not owned by a governmental entity or non-profit entity like a church), this Report uses Santa Barbara County parcel data from 2017, which contains detailed information on the size of the parcel

Fiscal Land Use Impacts were assessed by:

3. Escalating County Assessors database to Fair Market Value (2017 \$)
4. 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

as well as the size of the structure. In California, any increase in the assessed value of the land/structure is capped at 2% a year by Proposition 13 until the parcel is either resold or

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

improved. Since the rate of housing inflation in Carpinteria has exceeded 2% for many years, this Report adjusted the original sale price of the parcel (land and structures) to estimate current market value of the property using a housing price index (HPI) created specifically for this Report from local housing sales data. Due to a lack of more reliable or adequately refined price indices, this Report also updated non-residential parcels using the Consumer Price Index for real estate sales (Zillow 2018; U.S. Bureau of Labor Statistics 2018).

For property subject to coastal erosion, this Report assumes a complete loss for small residential parcels (< 0.25 acre), but this Report 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).

Finally, 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 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" subject to 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 some parcels such as those owned by local, state, or federal government agencies (e.g. schools, post offices, city hall, administration buildings, etc.) or churches are not subject to property tax. For these properties, this study estimated the price of land using data provided by the County for recent acquisitions of land 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 loss should be considered a lower bound, as they may be worth substantially more if they were sold to private owners. Additionally, these non-assessed parcels typically do not have information regarding the structures onsite (if any) so it's 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, which will be further refined as part of the City's recently awarded California Department of Transportation Sea Level Rise Transportation Policy and Infrastructure Adaptation Planning Grant. Further, this Report does not estimate economic loss from delays due to impaired traffic on roads subject to flooding, or if employees working in the City cannot get to work from Santa Barbara or Ventura. Since 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 any 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) updated 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 coastal recreation. Coastal recreation generates a great deal of economic activity in addition to sales and transient occupancy taxes (ToT) for the City and its residents (the current ToT for Carpinteria is 12%). 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 the 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 Section 6.3, *Camping and Visitor Accommodations*.

## Coastal Access and Trails

Data on coastal trail use is extremely limited. This Report does report the length of coastal trails subject to flooding and erosion using the scarce available data. 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, one could estimate the replacement cost of the trail, assuming that the City would replace these trails. The City of Goleta *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 coastal trails or to improve existing trails (in order to accommodate increased capacity) rather than try to replace existing trails. Given this uncertainty, this Report only reports loss of trails by length of trail lost (see Section 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, it did not attempt to quantify all of the costs involved, such as permitting, mitigation, and site restoration, due to lack of data availability.

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 Venoco oil processing facility within Carpinteria Bluffs 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 still represent a danger, should the cap on these wells fail, 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 should not be seen as an indication that these issues can be ignored. The potential for serious groundwater contamination, leakage of toxic material, or other damages is potentially significant and should be studied further.

## Stormwater Infrastructure

Stormwater infrastructure data (Table 5-1) was evaluated for each hazard type, using the GIS methods described in Section 5.4, *Vulnerability Assessment Methodology*. Critical City infrastructure including stormwater pipes 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. While the cost of stormwater infrastructure replacement has been estimated, ongoing coordination with the City and County is being conducted to further refine the final accurate cost estimates of replacement. Given this ongoing coordination effort, economic costs of replacement of stormwater infrastructure is 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 people to get to work on time). Given the level of uncertainty, this Report provides no specific estimates for the costs of flood cleanup, though it does provide some 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 their respective 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 Section 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 Section 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 Section 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 GIS analysis of acreages on dated and generalized mapped habitats substantially lessens 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, CEVA 2017) as well as regional observations from the current extended drought were extrapolated. More work including revised mapping is strongly recommended.

However, 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. As with other items/issues where data is not



available, the fact that this Report is unable to quantify the economic value does not indicate a lack of economic value. The City should consider the loss or degradation in sensitive biological resources and economics when evaluating different adaptation options, although the economic valuation may be difficult given the more generalized mapped habitat data and climate sensitivities available for this analysis. Ongoing planning analysis related to the GP/LPC Update and the California Department of Transportation Sea Level Rise Transportation Policy and Infrastructure Adaptation Planning Grant, will refine the extent of sensitive resources and effects of sea level rise upon such resources as well as effects upon environmental justice populations.

## 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 our analysis. First, the analysis crucially depends 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 the railroad 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. In addition, two hotels identified in this Report are subject to fluvial flooding. Further study of the impacts of coastal erosion and flooding on beach recreation is warranted. This Report does provide preliminary estimates of potential camping loss due to erosion and flooding, but these results also need more refinement.

While the analysis of the Coastal Access and Trails sector examines the length of trails impacted by flooding and erosion, it does not, however, 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 Venoco plant. 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 stormwater, 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. 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 clean up 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.  |

## 6. Sector Results

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This section 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.

The purpose of this section of the Report is to describe the results and provide a basic understanding of the potential physical and fiscal impacts associated with inaction in the face of rising sea levels and coastal hazards in Carpinteria.

Based on the unique characteristics of the City's coastline and watersheds, and direction provided by the City, the GP/LCP Update Committee, and the public, 11 sectors were chosen specifically to support policy development.

The sectors analyzed include:

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

The OPC's 2018 OPC Sea Level Rise Guidance requires consideration of the H++ scenario for any critical facilities. The only identified sector with a vulnerable critical facility is the wastewater sector. 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.



## 6.1 Land Use Parcels and Structures

This section presents the Report's analysis of land uses based on County assessor's parcel data including structures. This section begins with an overview of this Report's results by land use type (residential, commercial, etc.) that identifies parcels, land area, structures, and structure area at risk. The section next discusses vulnerability to coastal erosion, coastal flooding, and tidal inundation by land use type. Finally, since residential properties are particularly vulnerable, this Report examines vulnerabilities to residential structures by type (e.g., condominiums, apartments, multi-family and single-family residences). 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 ~5 feet of sea level rise, which were not directly vulnerable and thus were not included in the analyses.

There are some important caveats that support understanding and interpretation of these land use results.

- 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 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 have multiple parcels per structure. Commonly held condominium parcels (parking and landscaped areas) are not included in the tally.
- Multiple homes may exist on one lot (e.g., mobile home parks).
- Multi-family can contain either multiple lots per structure or multiple structures per lot.

The economic analyses relied on the County assessor's parcels located within the City limits, and included all lots that intersected 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, Figure 5-4). 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. While this Report focuses upon coastal hazards, fluvial flooding hazards will be addressed in the GP/LCP update.

The combined area of parcels in the combined coastal hazard zone is 380 acres and encompasses approximately 23% of the land area in the City and 23% 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%), 13 Facilities (4%), 11 Industrial (6%), 1 Mixed Use (<1%), 11 Recreation (1%), and 579 Residential (83%). Of this total, 106 (17%) structures were coded as an outbuilding<sup>6</sup>, which includes garages, car ports, or storage sheds for all land uses (Table 6-1, Figure 6-1, and Figure 6-2). A total of 1,090 housing units were identified in the study area, including up to 218 short-term vacation rentals located primarily in the Beach Neighborhood (City 2018).

**Table 6-1. Vulnerable Land Uses and Structures<sup>7</sup>**

| Year            | Residential                            | Commercial and Mixed Use           | Industrial                         | Open Space & Recreational            | Public Facilities                 |
|-----------------|--|------------------------------------|------------------------------------|--------------------------------------|-----------------------------------|
|                 | (Parcel acres) / (# of Parcels)        |                                    |                                    |                                      |                                   |
|                 | (Structure sq. ft) / (# of Structures) |                                    |                                    |                                      |                                   |
| <b>Existing</b> | 2.99/79<br>44,365/19                   | <0.1/1<br>0/0                      | 0.15/1<br>3/1                      | 39.18/42<br>0/0                      | 0.36/3<br>0/0                     |
| <b>2030</b>     | 7.00/164<br>171,147/146                | <0.1/1<br>0/0                      | 0.04/3<br>1,010/0                  | 13.46/4<br>5,043/5                   | 0.14/1<br>0/0                     |
| <b>2060</b>     | 10.29/234<br>246,526/116               | 0.23/3<br>52/2                     | 0.17/2<br>3,683/1                  | 19.25/5<br>4,982/4                   | 3.45/3<br>348/1                   |
| <b>2100</b>     | 24.51/292<br>430,438/298               | 5.62/16<br>29,557/14               | 4.67/4<br>62,955/9                 | 33.93/8<br>3,809/2                   | 5.52/2<br>51,448/12               |
| <b>Total</b>    | <b>44.80/769</b><br><b>892,477/579</b> | <b>5.85/20</b><br><b>29,609/16</b> | <b>5.02/10</b><br><b>67,651/11</b> | <b>105.82/59</b><br><b>13,834/11</b> | <b>9.48/9</b><br><b>51,796/13</b> |

*Note: All counts and sums are non-cumulative across time horizons, 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 mixed use structure is attributed as a commercial land use.*

<sup>6</sup> 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.

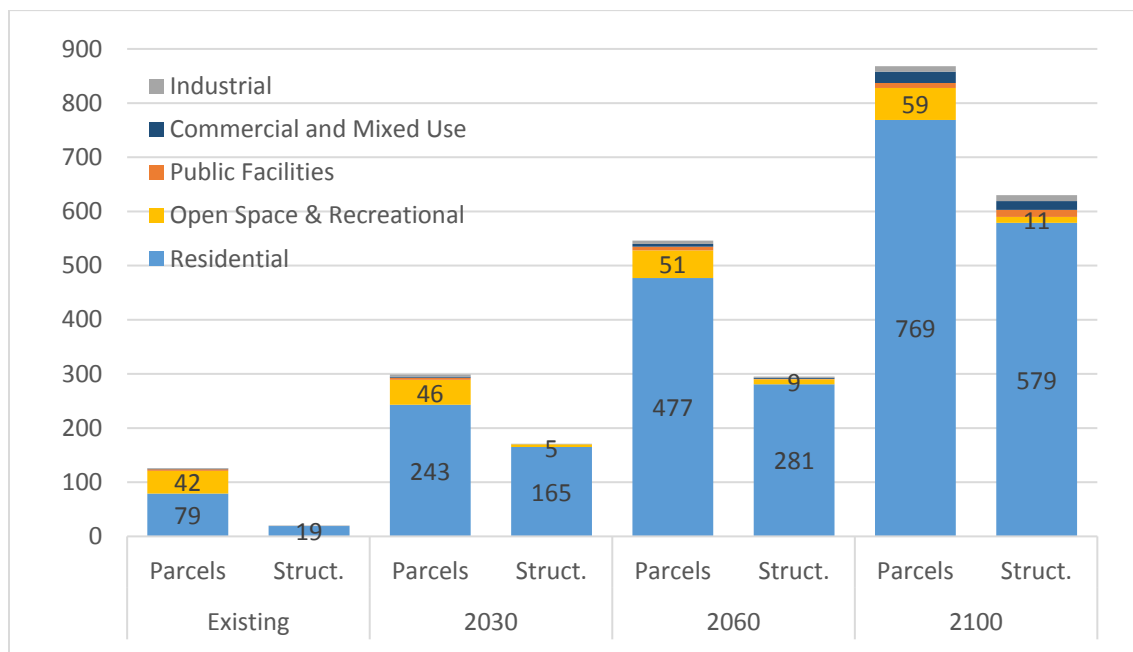
<sup>7</sup> Please note that there are an additional 15 large residential apartments encompassed within 2 complexes which are projected to become islands from combined coastal hazards and ~5 feet of sea level rise.



## Property and Facilities at Risk

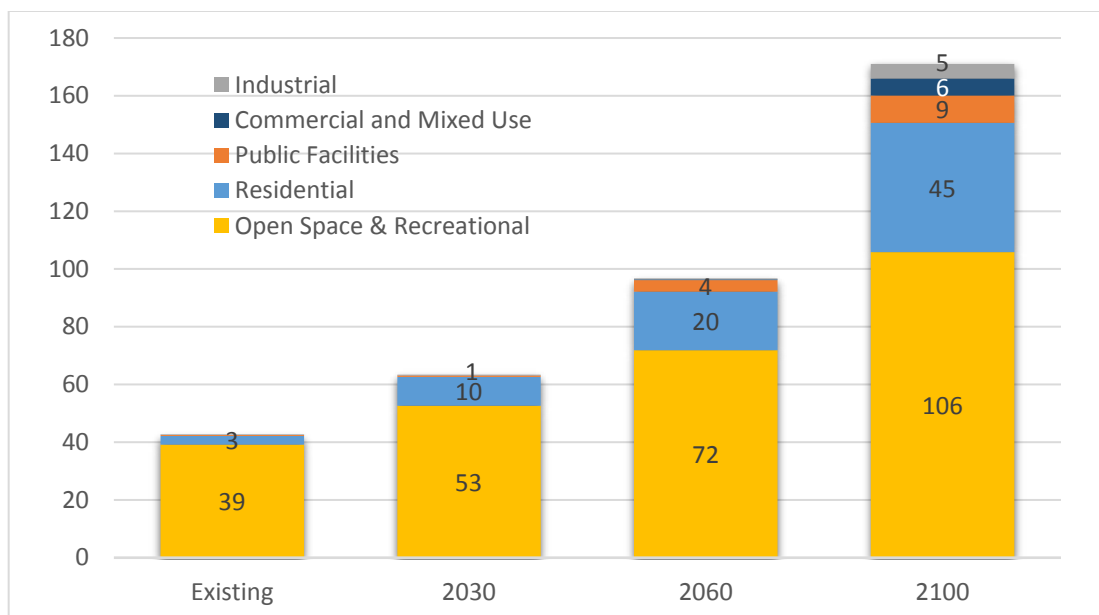
This section presents the results of the study's parcel data analysis of property at risk to coastal erosion and coastal flooding (not fluvial flooding) with up to ~5 feet of sea level rise. It begins with an analysis of all properties combined by type of coastal hazard. The next section considers these hazards by property type and land use.

Figure 6-1 illustrates the increased total exposure (to coastal erosion, coastal flooding and tidal inundation) to land parcels and structures over time, sub-divided according to property land use. The dominance of blue in this chart is an indication that most vulnerable parcels and structures are residential. Open space and recreational property is the second most vulnerable land use.



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

Figure 6-2, by contrast, illustrates the increase in vulnerable land area (measured in acreage) over time, also sub-divided according to property land use. Unsurprisingly, open space and recreational property constitute the majority of the vulnerable land, as measured by acreage. Residential land area is also well represented within this chart, especially in the later time horizons.



**Figure 6-2. Acres of Vulnerable Land Use and Structures**

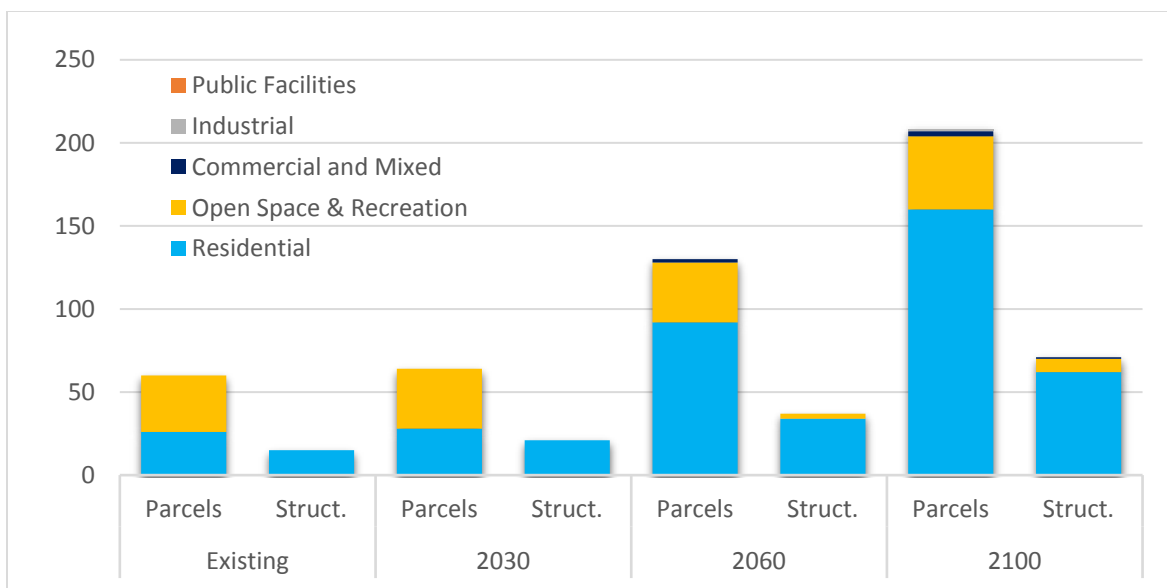
## Vulnerability of Property According to Land Use Type

The following three subsections present parcel and infrastructure losses to coastal erosion, damages and losses due to coastal flooding, and property exposure to tidal inundation, respectively. Because the clear majority of parcel losses, damages, and exposures occur to residential properties, three further subsections will then repeat these same analyses with an exclusive focus on residential land and structures. All estimates are in 2017 dollars.

### *Coastal Erosion Impacts to Land Uses, Structures, and Infrastructure*

Figure 6-3 illustrates the number of land use parcels and structures that become vulnerable to coastal erosion over the four time horizons. According to such counts, nearly all eroded parcels and structures are residential, or open space and recreation. Under existing conditions, 60 parcels and 15 structures are at risk to coastal erosion, which escalates by 2100, to 208 parcels and 71 structures potentially vulnerable to coastal erosion.





*Note: Counts 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 worth of property in the City is currently (as of 2017) at risk to potential erosion losses should a 1% 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 in 2030, \$114.8 million in 2060, and \$285.5 million in 2100. Unsurprisingly, the sector comprising residential property contains most of the vulnerability since the most vulnerable properties include valuable beachfront residences, including condominiums and apartments (see below for analysis of residential vulnerabilities). A maximum of 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.

### *ToT Revenue Implications to the City*

Currently, the City receives approximately \$2.3 million in ToT, from hotels, motels, and short-term vacation rentals, with an estimated \$400,000 of annual ToT from vacation rentals. Any damages to or other visitor serving properties may also affect tourism spending and associated sales tax revenues in the City.

By 2100, the multi-story office building 6267 Carpinteria Avenue along the Carpinteria Bluffs becomes vulnerable to cliff erosion. In addition, the properties at 6185 Carpinteria Avenue, 6305 Carpinteria Avenue, and 6155 Carpinteria Avenue become vulnerable to cliff erosion.

The 2100 erosion of agricultural land along the Carpinteria Bluffs are the only losses that were quantified for the entire agricultural sector (~\$400,000). Such losses do not include the losses or damages to crops, or other impacts from climate changes such as temperature or drought, but are instead limited to the loss of agricultural land to coastal erosion alone.

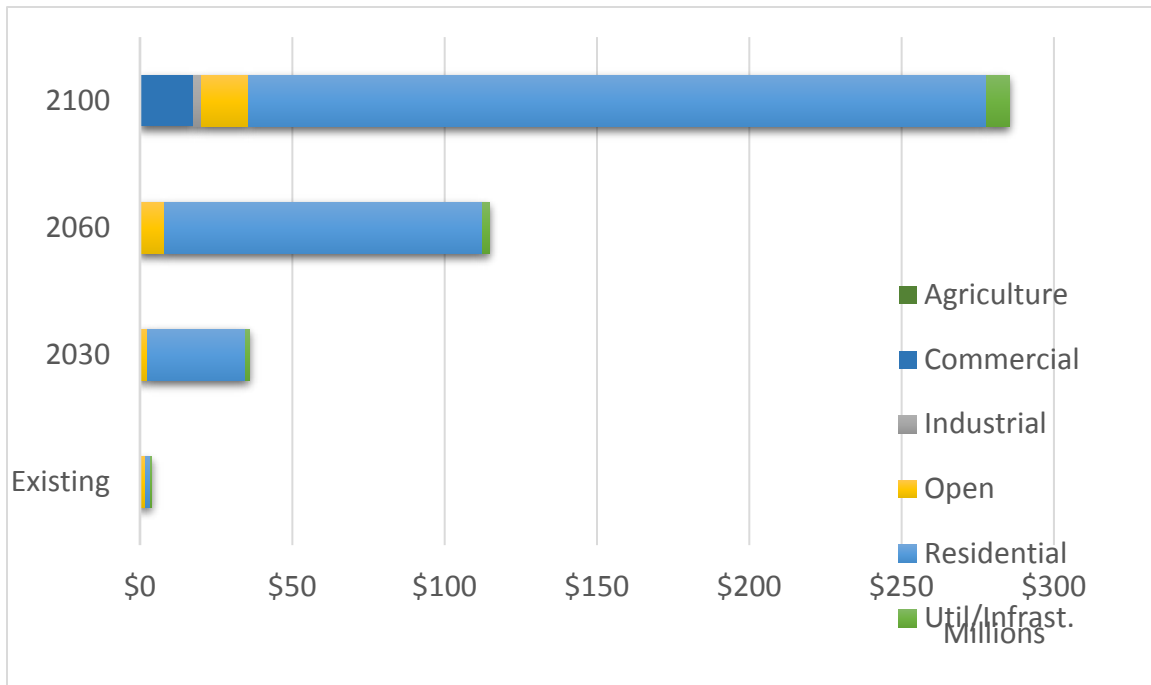
This report also estimated the potential property tax loss due to land and structure losses from erosion today and in 2030. These results are presented in Table 6-2. The estimated property tax loss today is zero even with a 1% storm. However, by 2030 the loss will be \$231,000 at today's assessment and \$299,000 assuming properties increase by 2% a year. For flooding losses, this report assumed 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**

| Existing Conditions   |     | 2030      |
|-----------------------|-----|-----------|
| Without a 2% Increase | \$0 | \$231,000 |
| With a 2% Increase    | \$0 | \$299,000 |

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.

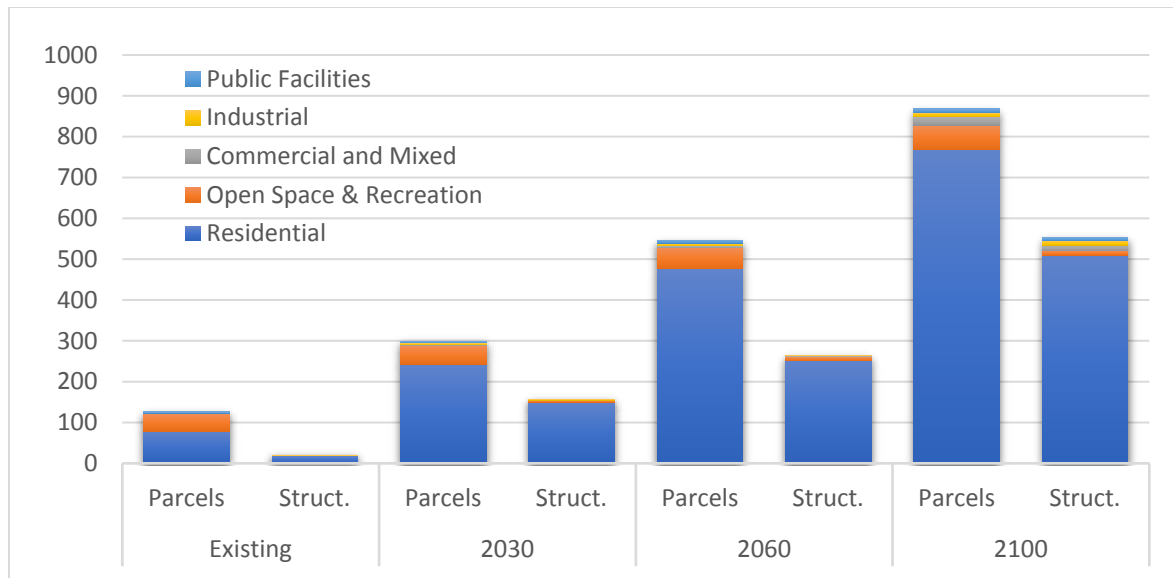




**Figure 6-4. Estimated Value of Property Loss Due to Coastal Erosion from a 1% Annual Chance Storm (2017 dollars)**

### *Coastal Flooding Impacts to Land Uses, Structures, and Infrastructure*

Figure 6-5 depicts the number of parcels and structures, sub-divided according to land use, vulnerable to coastal flooding during a 1% annual chance storm. Residential parcels now make up the strong majority, by number, of vulnerable structures and parcels. The number of open space parcels along with commercial and mixed-use parcels have also increased.



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

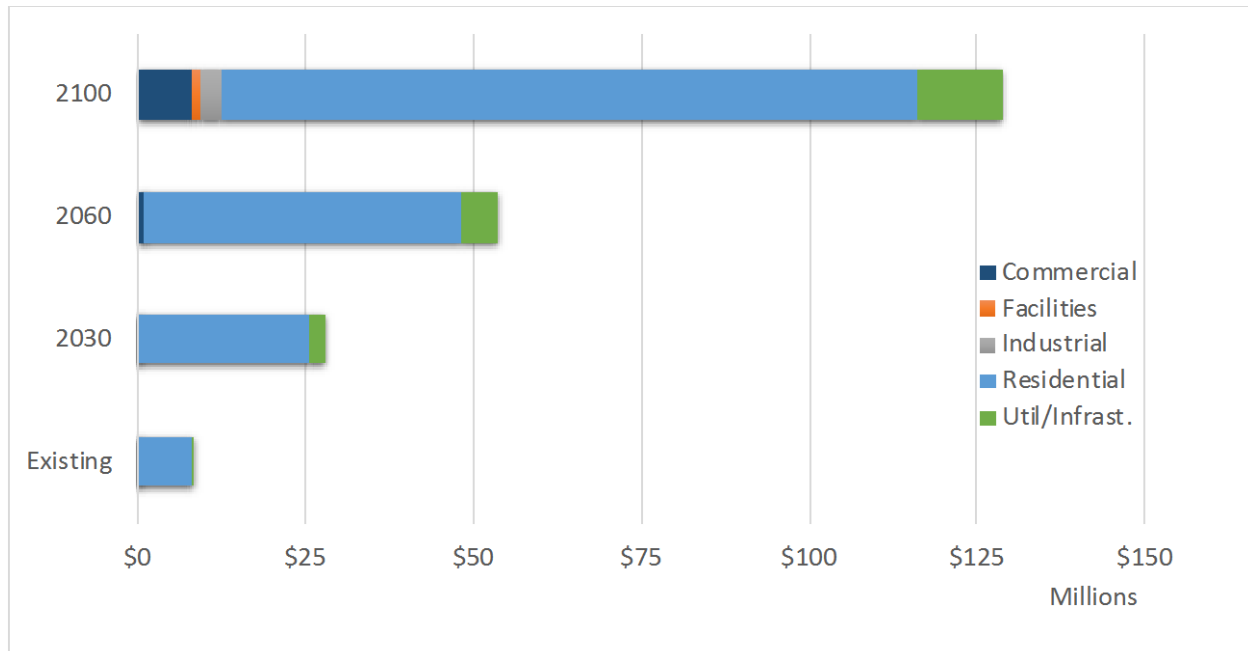
**Figure 6-5. Number of Land Use Parcels and Structures Vulnerable to Coastal Flooding During a 1% Annual Chance Storm**

Figure 6-6 presents estimates of property loss from coastal flooding (as opposed to erosion) from a 1% annual chance storm. Note that the results below reflect the vulnerability of damaged property to severe coastal flooding without consideration of coastal erosion damages. In other words, parcels that are vulnerable to coastal erosion (above) have not been removed from the results below. Unlike vulnerability to erosion, increases in damages are not only due to an expanded flood zone that includes more parcels, but also due to increased flood depths.

Currently \$8.5 million worth of property is at risk, rising to \$28 million in 2030, \$53.8 million in 2060, and \$128.8 million in 2100. Once again, the sector comprising residential property contains most of the vulnerability. The most valuable commercial assets that become



vulnerable by 2100 include the multi-story office buildings at the ends of 6155 and 6267 Carpinteria Avenue. By 2100, community facilities also become vulnerable to coastal flooding, a category which includes churches, medical facilities, lodges and schools.



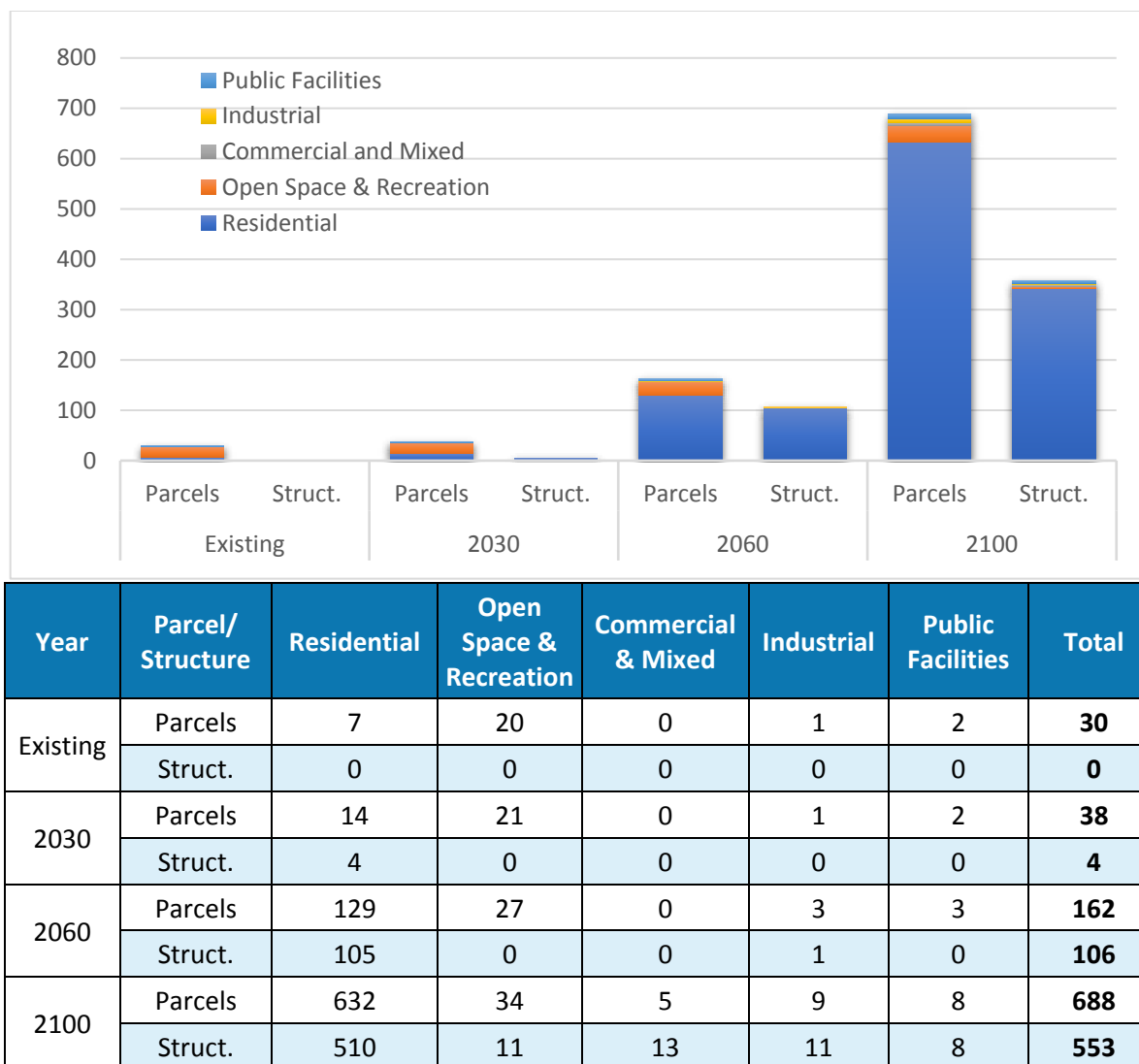
| Coastal Damages            | Existing           | 2030                | 2060                | 2100                 |
|----------------------------|--------------------|---------------------|---------------------|----------------------|
| Commercial                 | \$0                | \$0                 | \$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/<br>Infrastructure | \$300,000          | \$2,500,000         | \$5,500,000         | \$12,700,000         |
| <b>Grand Total</b>         | <b>\$8,500,000</b> | <b>\$28,000,000</b> | <b>\$53,800,000</b> | <b>\$128,800,000</b> |

*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, Structures, and Infrastructure*

Figure 6-7 depicts the number of parcels and structures (sub-divided according to land use) exposed or at risk to tidal inundation. The numbers remain comparatively low, consisting mostly of open space parcels until the 2060 time horizon, at which point residential parcels and condominium/apartment structures particularly in the Beach Neighborhood start to become exposed to tidal inundation. The dramatic increase in vulnerable residential parcels and structures between 2060 and 2100 contributes to a steep increase in the value of residential property vulnerable to tidal erosion (Figure 6-8).

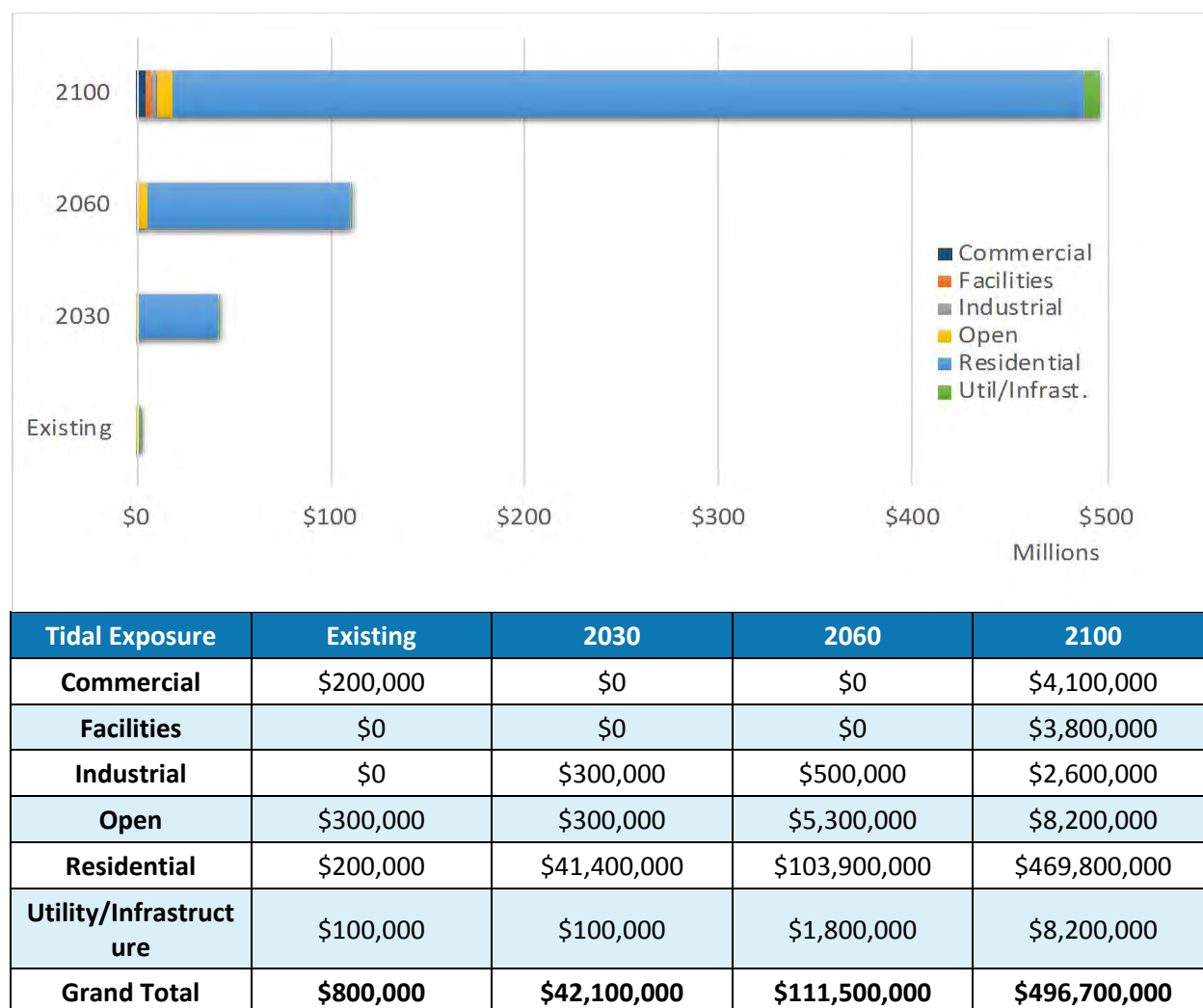


*Note: Estimates of losses are cumulative across all time horizons.*

**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. As noted earlier, since there are no current methods to evaluate tidal inundation, the figure below does not estimate actual damages or losses due to tidal inundation, but rather the total value of the property at risk.





*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)**

Currently, only \$800,000 in property value is exposed to tidal inundation risk. \$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 in 2030 and then jump up to \$111.5 million in 2060. By 2100, however, sea levels may have risen enough to 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 the 4300 block of Carpinteria Avenue, the Carpinteria Business Park on the 4100 block of Carpinteria Avenue, the Aliso Elementary School at Carpinteria Avenue and 7<sup>th</sup> Street, and the St. Joseph's Catholic Church building on 7<sup>th</sup> Street.

## Residential Property Vulnerabilities

Residential properties represent approximately 90% 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 designations can be confusing because on some parcels there are multiple structures, and in some structures, there can be multiple parcels. Table 6-3 below highlights these differences and identifies the number of dwellings in each of the residential land use types.

**Table 6-3. Residential Land Uses in Study Area**

| Year                  | Large Apartments (5+ units) <sup>1</sup> | Condominiums and Mixed Use <sup>2</sup> | Mobile Homes <sup>3</sup> | Multi-family (2-4 units) <sup>4</sup> | Single-family | Total       |
|-----------------------|--|---|---------------------------|---------------------------------------|---------------|-------------|
| <b>Parcels</b>        | 25                                       | 426                                     | 83                        | 74                                    | 166           | <b>774</b>  |
| <b>Structures</b>     | 46                                       | 75                                      | 154                       | 110                                   | 194           | <b>579</b>  |
| <b>Dwelling Units</b> | 210                                      | 426                                     | 154                       | 152                                   | 148           | <b>1090</b> |

*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.*

<sup>1</sup>Large apartments have multiple units per structure and can have multiple structures per parcel.

<sup>2</sup>Condominiums have multiple parcels per structure. Commonly held condominium parcels (parking and landscaped areas) are not included in the tally.

<sup>3</sup>Multiple homes may exist on one lot (e.g., mobile home parks).

<sup>4</sup>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 use, the analysis identifies the residential dwelling units by type of land use and are broken down by planning horizon year (Table 6-4).



**Table 6-4. Vulnerable Residential Dwelling by Categories<sup>8</sup>**

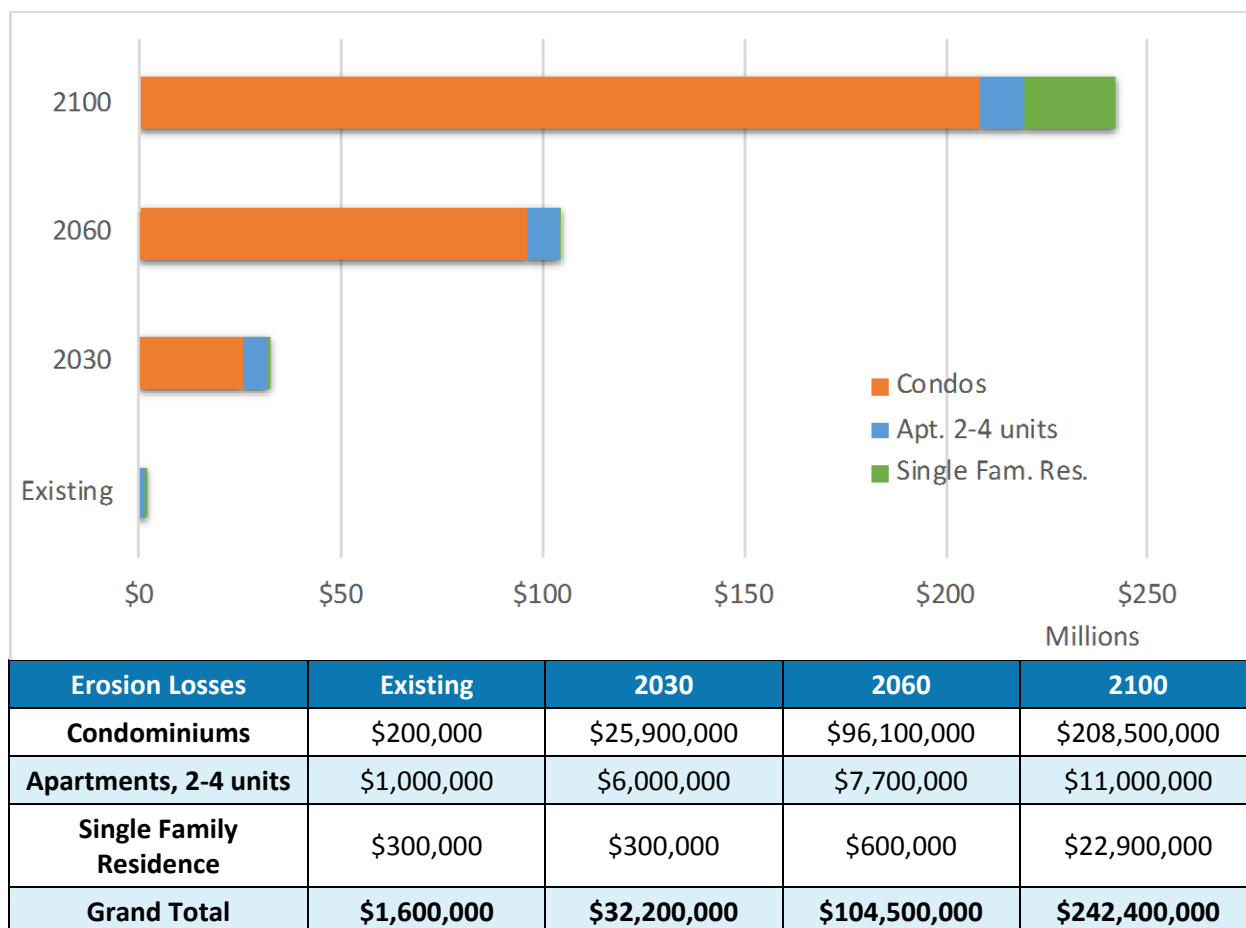
| Year            | Large Apartments (5+ units) | Condominiums and Mixed Use | Mobile Homes | Multi-family (2-4 units) | Single-family | Total       |
|-----------------|-----------------------------|----------------------------|--------------|--------------------------|---------------|-------------|
|                 | Number of dwellings         |                            |              |                          |               |             |
| <b>Existing</b> | 0                           | 73                         | 0            | 11                       | 2             | 86          |
| <b>2030</b>     | 49                          | 63                         | 63           | 32                       | 30            | 237         |
| <b>2060</b>     | 64                          | 217                        | 21           | 28                       | 33            | 363         |
| <b>2100</b>     | 97                          | 73                         | 70           | 81                       | 83            | 404         |
| <b>Total</b>    | <b>210</b>                  | <b>426</b>                 | <b>154</b>   | <b>152</b>               | <b>148</b>    | <b>1090</b> |

*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% annual chance storm. The estimated property values in Figure 6-9 increase substantially over time, topping out at \$242 million in vulnerable residential property in 2100. The majority of this property value occurs in the Beach Neighborhood condominium and apartment buildings on the 4700-4900 blocks of Sandyland Road. Single-family residences on the 5500-5600 blocks of Calle Arena, Calle Pacific, and Calle Ocho in the Concha Loma Neighborhood also become exposed by 2100.

<sup>8</sup> 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 ~5 feet of sea level rise.



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

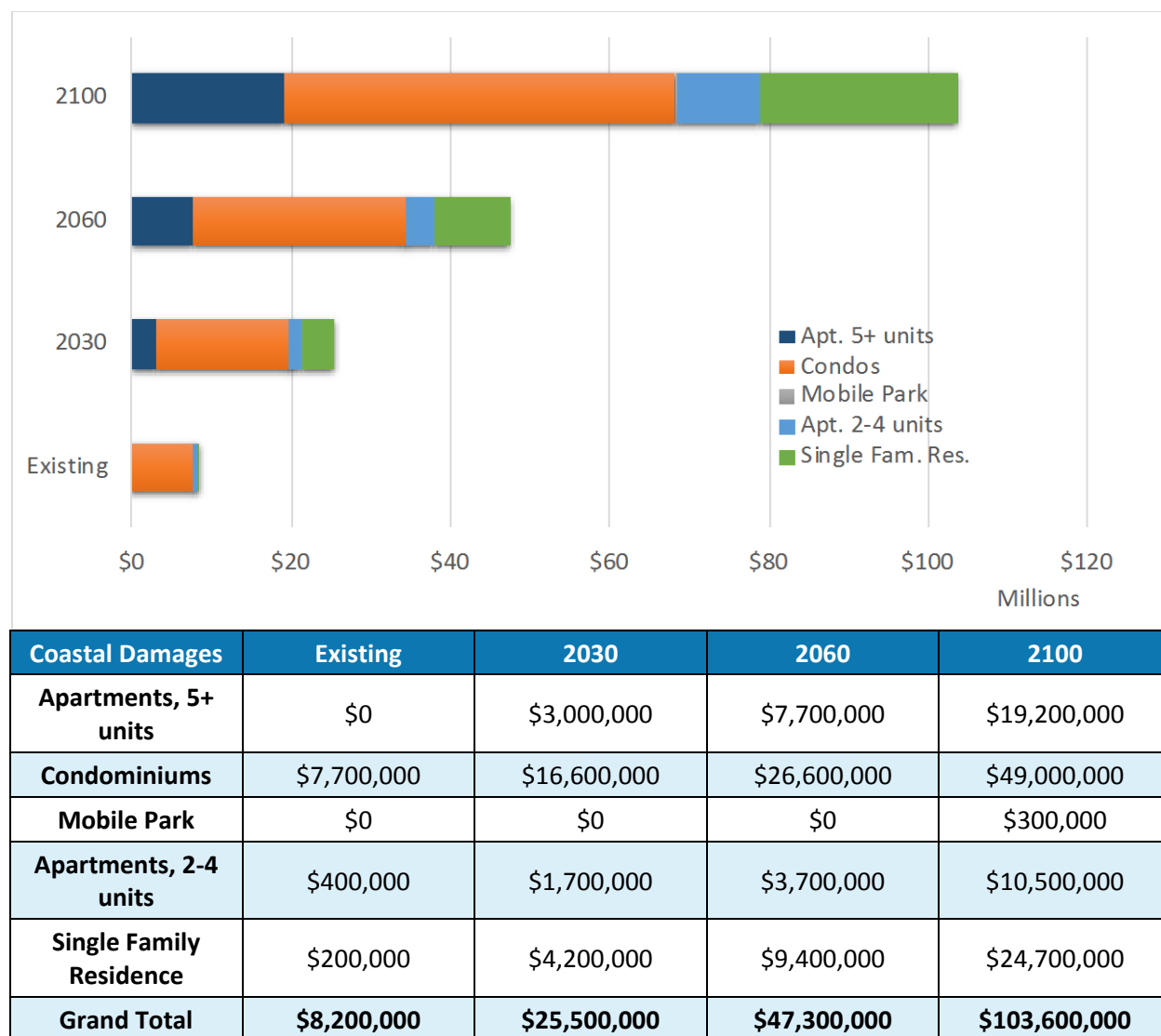
**Figure 6-9. Estimated Value of Infrastructure Vulnerable to Coastal Erosion from a 1% Annual Chance Storm (2017 dollars)**

### *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 oceanfront property. Such flooding also does not impact second- or third-story residences. For these reasons the damage estimates are more evenly distributed than above.

Under existing conditions, this Report estimates \$8.2 million in damages and losses to residential property due to a 1% annual chance storm. This figure increases dramatically by 2100 to over \$100 million. While ground floor residences on the 4700-4900 blocks of Sandyland Road, 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 3<sup>rd</sup> Street are also impacted as early as 2030 or 2060.



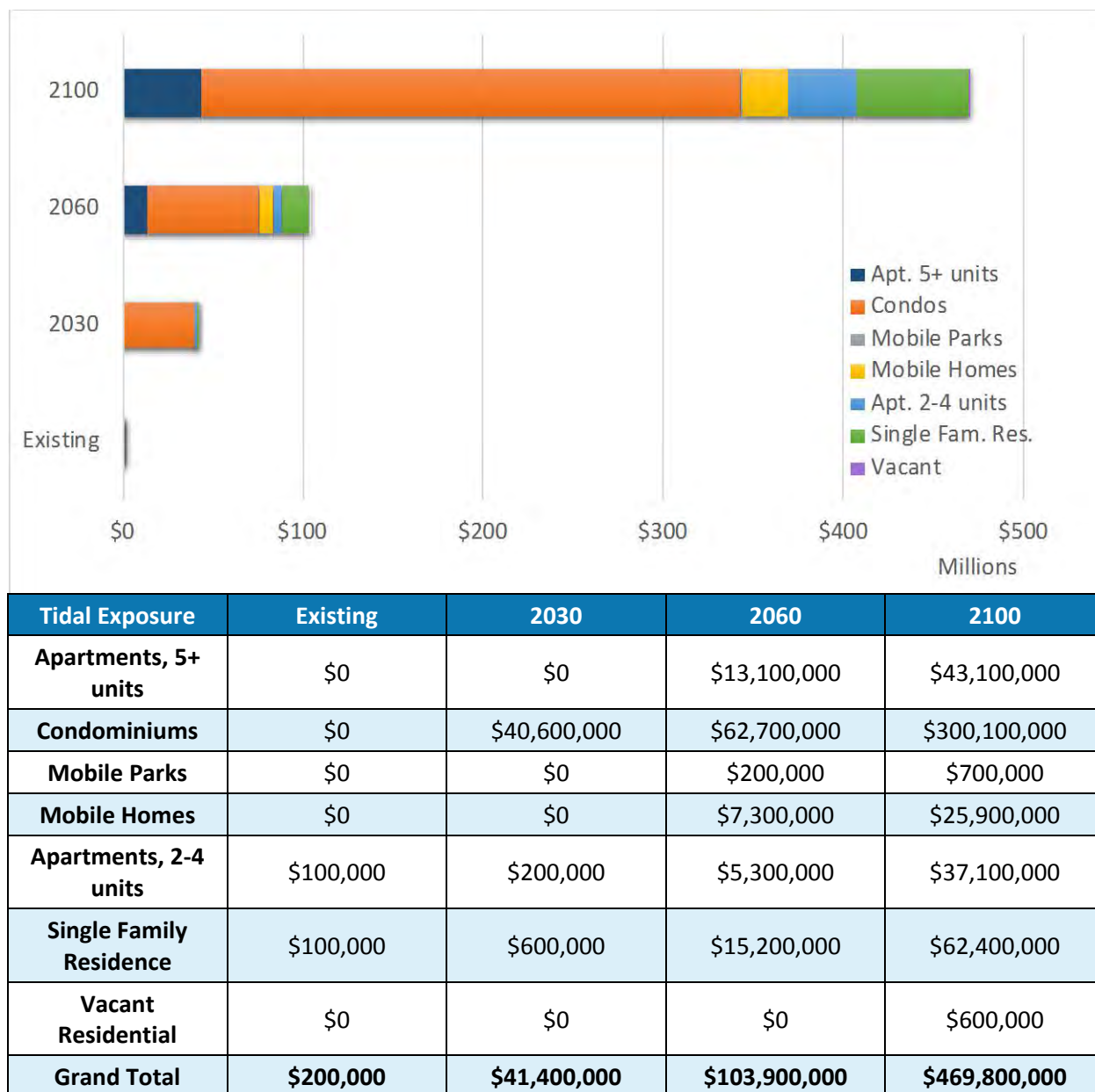


*Note: Estimates of losses are cumulative across all time horizons.*

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

### *Tidal Inundation Exposure to Residential Parcels and Structures*

Figure 6-11 considers the value of property that is vulnerable to tidal inundation, but again, due to a lack of data and damages metrics, this Report does not estimate the value of potential losses and damages. Instead, it estimates the land and structural value exposed to tidal inundation at each time horizon.



*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; this explains why the condominium exposure is so high. By 2060 or 2100, however, single-family residences and large apartment buildings (5 units or more) along Holly, Ash, and Elm Avenues, 3<sup>rd</sup> Street, and Dorrance Way also become exposed to tidal inundation. By 2060, mobile homes along Ash Avenue become increasingly inundated by tides.



## 6.2 Roads and Parking and Public Transportation

For simplicity of discussion, the results of the Roads and Parking sector and the Public Transportation sector (which includes roads as well) have been combined. The Public Transportation sector also includes railroads.

Table 6-5, Table 6-6, and Table 6-7 present the lengths (measured in miles) and value (measured in replacement costs) of roads and railroads losses to coastal erosion, coastal flooding and monthly tidal inundation, respectively. These figures are also included in the more general discussion of infrastructure vulnerability (see Section 6.6, *Infrastructure*). On one hand, the losses to coastal flooding and tidal inundation likely overstate the monetary losses (roads will likely be damaged rather than completely lost). On the other hand, they do not include losses to business activity, other losses associated with outages of infrastructure, or the closing of roads and railroad lines. Even closing a small portion of U.S. Highway 101 near and along exit 87B (southbound U.S. Highway 101 Carpinteria Ave 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 the railroad line.

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

| Erosion         | Roads       | Roads       | Railroads | Railroads   |
|-----------------|-------------|-------------|-----------|-------------|
| <b>Existing</b> | < 0.1 miles | \$0         | 0.1 miles | \$130,000   |
| <b>2030</b>     | < 0.1 miles | \$0         | 0.4 miles | \$760,000   |
| <b>2060</b>     | 0.1 miles   | \$90,000    | 0.8 miles | \$1,510,000 |
| <b>2100</b>     | 0.7 miles   | \$1,050,000 | 1.4 miles | \$2,550,000 |

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

Table 6-5 indicates that, currently, City roads and railroad lines are only mildly vulnerable to coastal erosion. Roads will not become significantly vulnerable to erosion until the 2100 time horizon at which point 0.7 miles of roads (\$1 million) become vulnerable to erosion during a 1% annual chance storm. The increasing vulnerability of railroad lines, however, is much more gradual in nature. By 2100, 1.4 miles of railroad lines (\$2.5 million) may be exposed to coastal erosion along the Carpinteria Bluffs.

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

| Coastal         | Roads     | Roads       | Railroads | Railroads   |
|-----------------|-----------|-------------|-----------|-------------|
| <b>Existing</b> | 0.1 miles | \$120,000   | 0.1 miles | \$180,000   |
| <b>2030</b>     | 1.1 miles | \$1,690,000 | 0.4 miles | \$810,000   |
| <b>2060</b>     | 2.0 miles | \$2,970,000 | 0.9 miles | \$1,560,000 |
| <b>2100</b>     | 4.8 miles | \$7,090,000 | 1.5 miles | \$2,630,000 |

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

Table 6-6 depicts the vulnerability of City roads and railroads to coastal flooding during a 1% annual chance storm listed according to time horizon. Unlike the case of coastal erosion, vulnerability to coastal flooding increases gradually for both roads and railroads. By 2100, 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 6-7. Length and Replacement Costs of Roads and Railroads due to Monthly Tidal Inundation**

| Tidal           | Roads       | Roads       | Railroads   | Railroads |
|-----------------|-------------|-------------|-------------|-----------|
| <b>Existing</b> | < 0.1 miles | \$20,000    | < 0.1 miles | \$30,000  |
| <b>2030</b>     | < 0.1 miles | \$50,000    | < 0.1 miles | \$30,000  |
| <b>2060</b>     | 0.8 miles   | \$1,220,000 | < 0.1 miles | \$30,000  |
| <b>2100</b>     | 3.0 miles   | \$4,480,000 | < 0.1 miles | \$40,000  |

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

Table 6-7 shows the length and value of the City roads and railroad lines vulnerable to monthly tidal inundation. Unlike coastal erosion or coastal flooding, tidal inundation is a chronic threat. As such, it is much more amenable to removal costs rather than total losses or replacement costs. That said, the recurring nature of this threat makes the indirect losses to redirected traffic more significant. By 2100, 3.0 miles of roads (\$4.5 million) may be exposed or at risk to tidal inundation, while less than 0.1 miles of railroad lines may be exposed, although these appear to be co-located with bridges, so damages may not be as severe.

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 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 2 feet of sea level rise coastal flooding impacts escalate and may impact 7 parking lots. With 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 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.

## 6.3 Camping and Visitor Accommodations

The City is a small beach community with an annual population of around 14,000. 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 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 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 employed data on beach visitation and spending from several sources. For Carpinteria State Beach, this Report used recent State Parks data for camping and other attendance. The Report also used data from the Coastal Regional Sediment Master Plan (CRSMP) prepared for BEACON (2009). These slightly older attendance estimates were updated for the growth within the population of Santa Barbara County as well as the State of California (since numerous visitors come from beyond Santa Barbara County).

Table 6-8 below presents the data/estimates for beach attendance and recreational value. This Report assumes that a typical day at the beach is worth \$40 per adult visitor, based on studies of non-market value for beaches in California and CCC guidance (California Coastal Commission 2015). Please keep in mind that economic benefits and economic impacts are two distinct categories. We based economic benefits on studies of how much individuals are willing to pay (WTP) for a day at the beach, based on numerous travel cost studies of beach attendance in southern California. As shown in Table 6-8, Carpinteria has approximately 1.5 million beach day visits per year. The total economic value of this activity is \$60.4 million per year.

**Table 6-8. 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             |
| <b>Total</b>            | <b>1,510,428</b>        | <b>420,828</b> |             | <b>\$60,417,120</b>      |

Table 6-9 presents data on economic and tax revenue impacts from consumer spending associated with beach recreation. The total estimated spending is just below \$48 million, generating \$445,000 in sales tax revenues for the City<sup>9</sup> and just under \$1.9 million in ToT (transient occupancy taxes).

**Table 6-9. 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                           |
| <b>Total</b>            | <b>1,510,428</b>        | <b>\$47,968,708</b>               | <b>\$445,051</b>    | <b>\$1,877,005</b>                  |

## Camping

Carpinteria State Park has four campgrounds (Anacapa, Santa Cruz, Santa Rosa, and San Miguel), named after the Channel Islands with an estimated total of 213 campsites (Table 6-10). These campgrounds draw an estimated 420,828 visitors per year (Table 6-8). These campgrounds are vulnerable to coastal hazards and sea level rise. Table 6-9 presents the analysis of the percentage of each individual camping area subject to dune erosion, cliff

<sup>9</sup> These estimates only include the City share (1%) of sales tax revenues, not the County share.



erosion, and coastal storms. This Report assumes that the camping attendance loss will be proportional to the size of the loss in campground area due to coastal erosion or coastal flooding (i.e., camping population density remains constant per square foot area). It also assumes that tidal inundation will disrupt camping at least six days a month (20% 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 too low. Ultimately, coastal erosion may lead to a permanent loss of some camping area at the State Park in the absence of any adaptation measures.

**Table 6-10. 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 did not estimate camping losses from wave run-up during 1% annual chance storms.<sup>10</sup> As indicated in Table 6-11, under existing conditions, 9% of all campground areas are vulnerable to dune or cliff erosion loss from a 1% annual chance storm; this loss increases over time to 33% by 2100, with those lost campground areas primarily reducing camping opportunities in the more southerly Santa Rosa and San Miguel campgrounds that have less dune protection. By 2100, nearly half (46%) of the entire campground areas may be subject to tidal inundation, and all campground areas (100%) could be subject to coastal flooding during a 1% annual chance storm.

<sup>10</sup> The analysis also 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 so seasonal closures of some of the sites may avoid these impacts.

**Table 6-11. 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 |
|-----------------|--|--------------------------------|---|--------------------------------|--|--------------------------------|
| <b>Existing</b> | 9  | 36,954                         | 0   | -                              | 0  | -                              |
| <b>2030</b>     | 13                                       | 53,206                         | 0   | 393                            | 0  | -                              |
| <b>2060</b>     | 19                                       | 78,598                         | 5   | 20,167                         | 2  | 1,768                          |
| <b>2100</b>     | 33                                       | 139,387                        | 18  | 75,906                         | 46   | 39,131                         |

*Note: Totals and losses are cumulative across horizon years.*

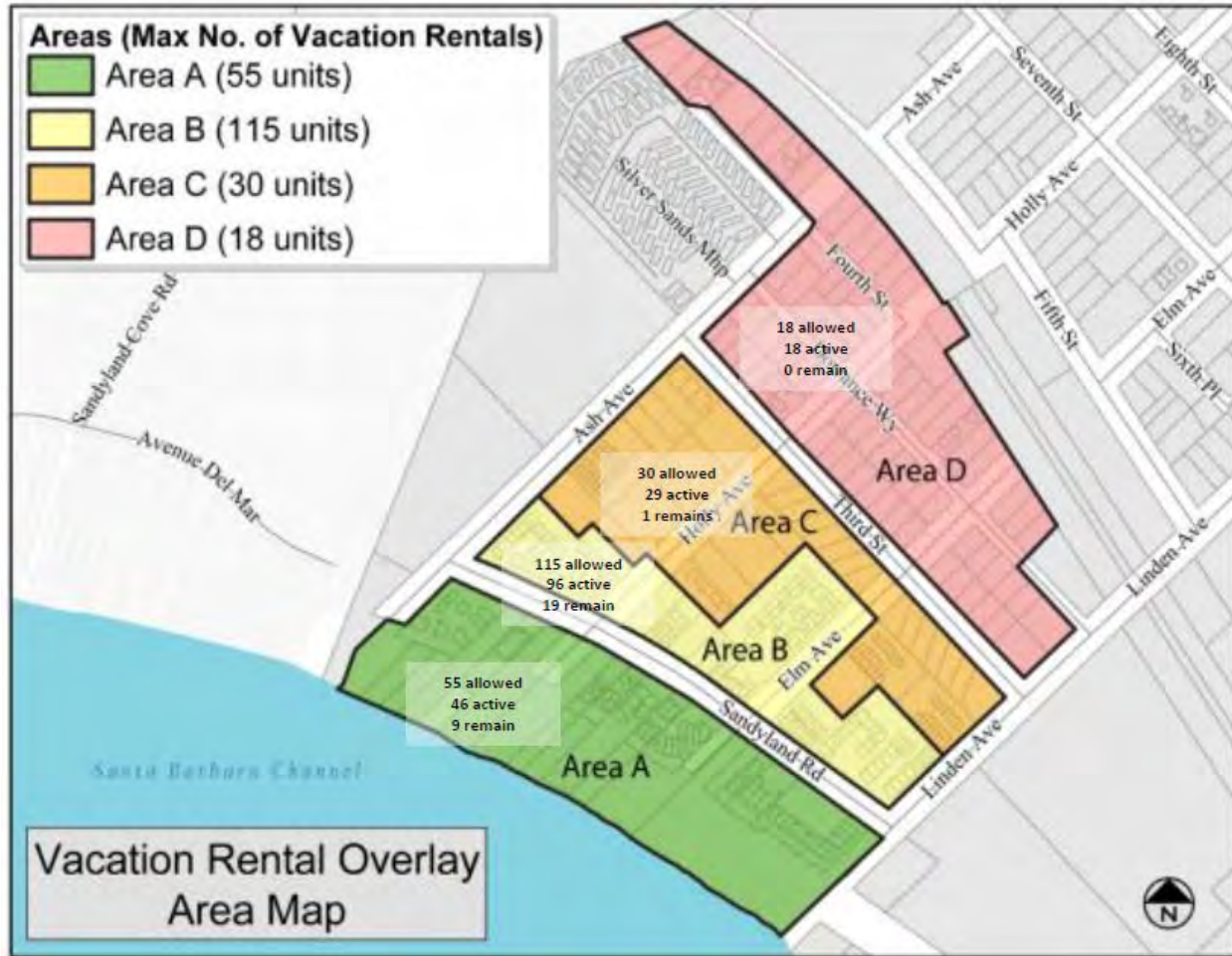
## Hotels, Motels and Short-term Vacation Rentals

Beach tourism generates a significant portion of the City's revenue. As indicated in Table 6-8, beach tourism generates \$1.9 million in ToT and \$445,000 in sales tax revenues, as not all visitors stay in the State Park campgrounds. A significant portion of visitors to the City Beach stay overnight, so any diminishment in 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 transient occupation taxes. City records show that 75 short-term (less than 30 day) 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 and that it was likely that these rentals were not all paying ToTs.

In November 2016, the City Short-Term Vacation Rental program was approved by the CCC (LCP Amendment No. LCP-4-CPN-16-0024-1). This program approved the licensing of 218 short-term vacation rentals in 4 areas in the City primarily in the Beach Neighborhood (Figure 2-1). In FY 2016-2017 and FY 2017-2018, 189 short-term vacation rentals have been licensed, generating about \$400,000 annually in ToT revenues.





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

The coastal hazard maps, as well as the analysis of vulnerable property in the land use section above, indicate that many short-term vacation rental properties in the City are currently vulnerable to coastal hazards particularly in Area A. With ~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, different types of coastal hazards may not necessarily disrupt short-term vacation rental revenues. Coastal flooding, which typically occurs in the winter may not disrupt much of 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 miles 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 6-12). The California Coastal Trail also traverses the City but no designated alignment was available for analysis despite data requests to the Coastal Commission.

**Table 6-12. Coastal Access Amenities and Coastal Trails**

| Park Name                      | Trail Name  | Total Miles of Coastal Trail | Coastal Access Points  | Facilities and Amenities                    |
|--------------------------------|---|------------------------------|--|---|
| <b>Salt Marsh Nature Park</b>  | Carpinteria Salt Marsh Trail                                  | 0.4                          | Access at terminus of Ash Ave  | Parking, Restroom, Junior Guard Shed        |
| <b>Carpinteria City Beach</b>  | City Beach  | 0.3                          | Access throughout Downtown Beach Neighborhood from Ash Ave to Linden Ave | Parking, Lifeguard towers (2), Restroom     |
| <b>Linden Field</b>            | 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               |
| <b>Carpinteria State Beach</b> | 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 4 <sup>th</sup> 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               | -   |
| <b>Tar Pits Park</b>           | Carpinteria Bluffs Trail                                      | 0.9                          | Access at western terminus of the park                                   | Tar Pits                                    |



**Table 6-12. Coastal Access Amenities and Coastal Trails (Continued)**

| Park Name  | Trail Name               | Total Miles of Coastal Trail | Coastal Access Points   | Facilities and Amenities          |
|--|--------------------------|------------------------------|---|-----------------------------------|
| <b>Carpinteria Bluffs Nature Preserve (Carpinteria Bluffs Area 1)</b>                                    | Carpinteria Bluffs Trail | 2.2                          | Access from trail descending from Carpinteria Bluffs Trail to Seal Sanctuary                    | Seal Sanctuary, Parking, Restroom |
| <b>Property between Carpinteria Bluffs Nature Preserve and Rincon Bluffs (Carpinteria Bluffs Area 2)</b> | Carpinteria Bluffs Trail | 0.7                          | -   | -                                 |
| <b>Rincon Bluffs (Carpinteria Bluffs Area 3)</b>   | Carpinteria Bluffs Trail | 0.9                          | -   | -                                 |
| <b>Rincon Beach Park (Unincorporated County Adjacent to City)</b>  | -                        | -                            | Access at trail descending from Rincon Parking Lot to the beach at the eastern edge of the City | -                                 |

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, all vertical coastal access points and all lateral coastal trails are vulnerable to coastal erosion, coastal flooding, and/or tidal inundation.

Table 6-13 presents projected public trail losses due to coastal erosion, coastal flooding, and tidal inundation. The portion of the Carpinteria Bluffs Trail along the entire extent of the Carpinteria Bluffs is particularly vulnerable to erosion, with potentially 0.1 miles at risk currently, 0.6 miles at risk in 2030, and 1.0 mile at risk in 2060 – encompassing most of the length of the trail along the bluffs. By 2100, many trails adjacent to the Carpinteria Bluffs Trail are also vulnerable, putting 2.3 miles at risk to cliff erosion. This Report did not estimate the loss in recreational value or the replacement costs of trails (which differs significantly by type of trail and terrain) due to the complexity involved in this type of analysis along with the challenge of assigning a value to a non-market commodity like public trail access. However, it is anticipated that by 2100 up to approximately 5.4 miles of Carpinteria’s coastal trails may be eroded, flooded, or periodically inundated.

**Table 6-13. Estimated Length of Public Trails Vulnerable to Storm Erosion, Storm Flooding and Chronic, Tidal Inundation**

| Trail Vulnerability | Coastal Erosion | Coastal Flooding | Tidal Inundation |
|---------------------|-----------------|------------------|------------------|
|                     | Miles           |                  |                  |
| <b>Existing</b>     | 1.2             | 1.3              | <0.1             |
| <b>2030</b>         | 1.9             | 2.2              | <0.1             |
| <b>2060</b>         | 2.7             | 3.4              | 0.1              |
| <b>2100</b>         | 4.6             | 5.4              | 1.4              |

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

## 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 with the potential to spill/leak hazardous materials consisting of legacy inactive oil wells and 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 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 6-14). 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 6-14. 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 of California and EPA (Table 6-15).

**Table 6-15. Hazardous Materials by Program**

| Category                       | Program  | Total in City | Total Affected |
|--------------------------------|--|---------------|----------------|
| <b>Hazardous Waste Storage</b> | 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              |
| <b>Cleanup Programs</b>        | 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 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 Venoco site.

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 may become vulnerable to both coastal erosion and flooding; this is the Conoco Phillips Kittie Ballard Well Site on the Carpinteria Bluffs in the Carpinteria Bluffs Nature Preserve. This site, an area of special biological significance (a harbor seal haulout and breeding ground), is located less than 600 feet to the south of the Dump Road/Venoco site. 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 Venoco, Inc. oil and gas processing facility situated on the Carpinteria Bluffs. This site contains oil storage, processing and cleaning facilities used to process offshore oil. Chevron 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 ~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 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 CSD. CSD owns and operates 40 miles of pipeline, 6 lift stations and the 2.5 million gallons per day WWTP. Maintenance to the system is accessed through 762 manholes. CSD provides service to a 3.1-square mile service area within the City and portions of the nearby unincorporated County within the Carpinteria Valley. This includes service to about 5,900 residential parcels and 500 non-residential parcels. Most of the system is gravity fed to the WWTP located just inland of the railroad tracks on Carpinteria Creek. The WWTP provides secondary treatment and chemical disinfection before discharge to the Pacific Ocean through an ocean outfall. A 2005 Master Plan identified 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.

### *Water Supply Infrastructure*

The City's water supply system is managed by the CVWD. CVWD's service area is approximately 11,300 acres 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. This Report used data from the City (2017) as well as cost estimates to measure the replacement costs (Table 5-4) of roads, railroads, pipelines, and infrastructure components that are vulnerable to coastal hazards. The analysis below presents the estimates for the replacement costs of such infrastructure. 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. This Report recommends a more complete analysis of the cost 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.

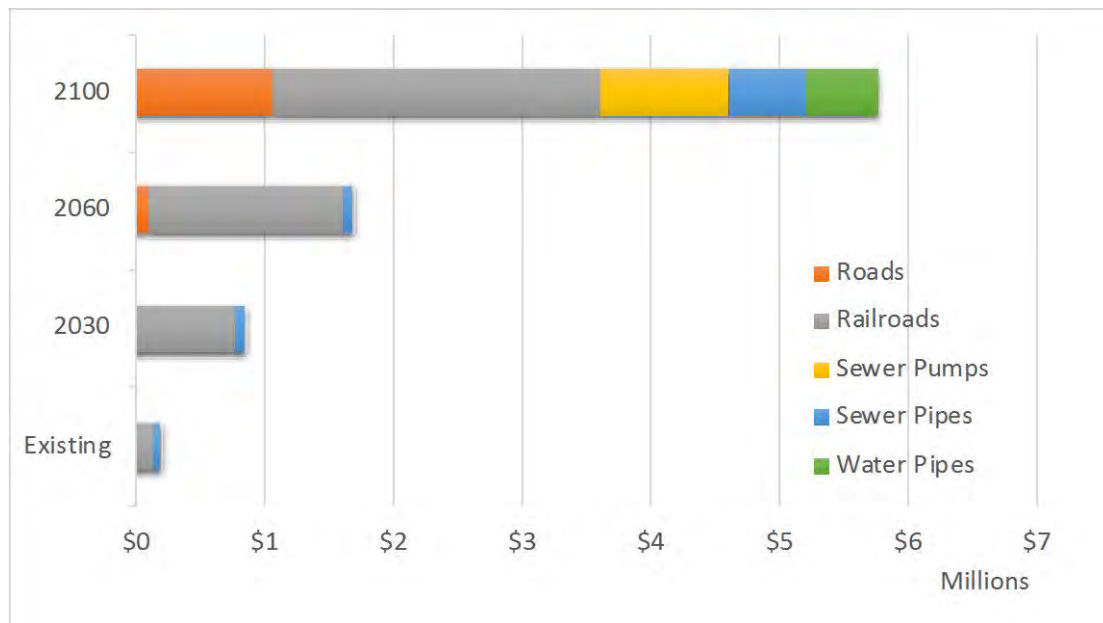
**Table 6-16. Major Infrastructure in the City of Carpinteria**

| Category                                | # or Length in City       | # or Length Affected by Coastal Flooding in 2100 |
|---|---------------------------|--|
| <b>Roads</b>                            | 50.3 miles                | 4.8 miles  |
| <b>Railway*</b>                         | 2.5 miles                 | 1.5 miles  |
| <b>Hiking Trail</b>                     | <i>Unknown</i>            | 5.4 miles  |
| <b>Sewer Pipe</b>                       | 36.5 miles                | 4.7 miles  |
| <b>Sewer Pump Stations</b>              | 6 in District / 4 in City | 3 in District / 2 in City                        |
| <b>Water Pipe</b>                       | 45.6 miles                | 4.5 miles  |
| <b>Water Supply Pressure Regulators</b> | 4                         | 1  |
| <b>Stormwater Drain</b>                 | 24.5 miles                | 4.2 miles  |
| <b>Stormwater Drain Inlets</b>          | 342                       | 95   |
| <b>Stormwater Drain Outlets</b>         | 316                       | 116  |

*\*Railway 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.*

Figure 6-17, Figure 6-18, and Figure 6-19 present 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 and Parking and Public Transportation*, while the results for recreational trails can be found above in Section 6.4, *Coastal Access and Trails*.

Figure 6-17 indicates that water and sewer pipelines and sewer pumps are not significantly exposed to coastal erosion until the 2100 time horizon. At that point, however, 0.5 miles of water pipelines (\$560,000) and 0.5 miles of sewer pipelines (\$610,000) primarily located under Sandyland Road and near the WWTP, and one sewer pump/lift station (\$1 million) at the private community 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 in 2100. Similarly, stormwater infrastructure would become substantially vulnerable to coastal erosion until the 2100 time horizon, 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   |
| 2030     | \$0         | \$760,000   | \$0         | \$70,000    | \$0         | \$830,000   |
| 2060     | \$90,000    | \$1,510,000 | \$0         | \$80,000    | \$0         | \$1,680,000 |
| 2100     | \$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 miles | 0.1 miles | 0           | < 0.1 miles | < 0.1 miles | 1.2 miles |
| 2030     | < 0.1 miles | 0.4 miles | 0           | 0.1 miles   | < 0.1 miles | 1.9 miles |
| 2060     | 0.1 miles   | 0.8 miles | 0           | 0.1 miles   | < 0.1 miles | 2.7 miles |
| 2100     | 0.7 miles   | 1.4 miles | 1           | 0.5 miles   | 0.5 miles   | 4.6 miles |

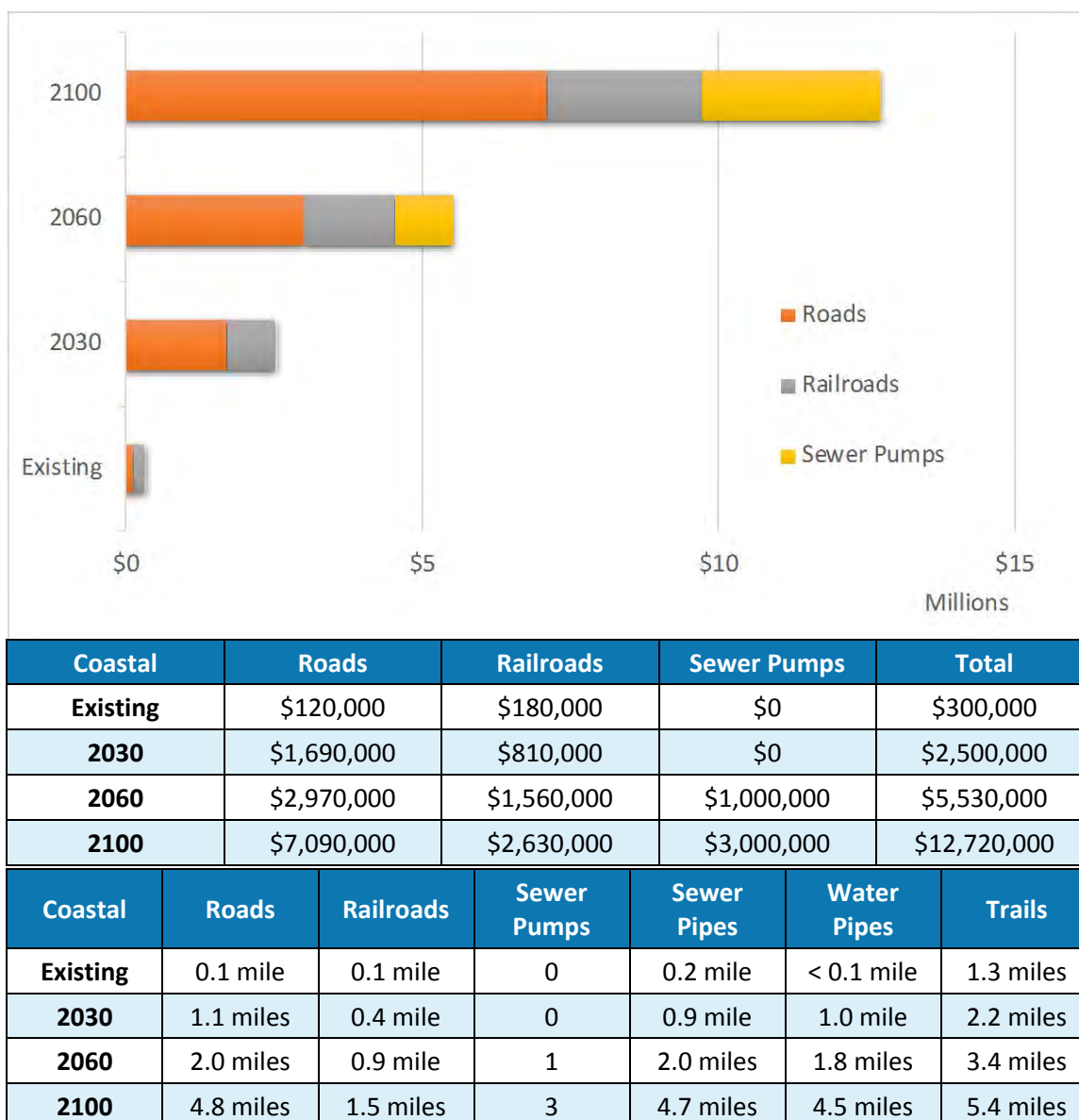
*Note: Totals are cumulative across horizon years.*

**Figure 6-17. Estimated Value and Length (in miles) of Infrastructure Vulnerable to Coastal Erosion from a 1% Annual Chance Storm (2017 dollars)**

Figure 6-18 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 miles and 0.2 miles, respectively. These numbers gradually grow over time, peaking by 2100 with 4.5 miles of water pipelines and 4.7 miles of sewer pipelines becoming vulnerable. More significantly, by 2100, 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 by 2100. 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, by 2100, an additional 52 storm drain inlets (95 total) and 47 outfalls (116 total), and 3.5 mile (4.2 miles total) of pipes across the City would be vulnerable to coastal flooding.

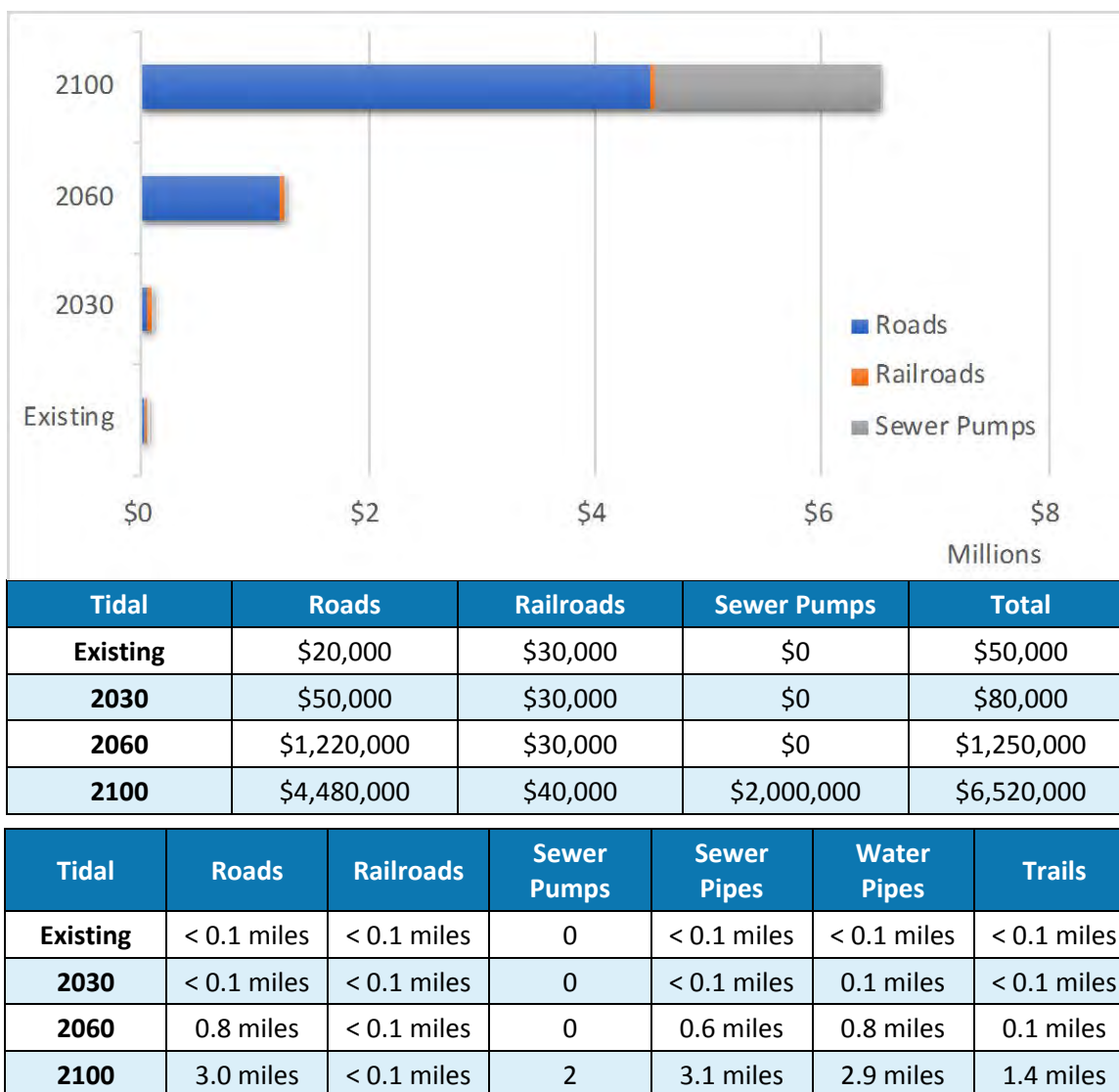
As in the case of coastal flooding of infrastructure, Figure 6-19 represents the replacement costs to infrastructure due to chronic tidal inundation according to time horizon. City pipelines and pumps are relatively safe from chronic tidal inundation until 2060. By 2100, approximately 2.9 miles of water 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 by 2100. City storm drains would be vulnerable to tidal inundation under existing conditions, with impacts being further exacerbated by sea level rise. By 2100, approximately 82 inlets, 99 outlets, and 2.5 miles of storm drains become vulnerable to tidal inundation.





*Note: Totals are cumulative across horizon years.*

**Figure 6-18. Estimated Value and Length (in miles) of Infrastructure Vulnerable to Coastal Flooding from a 1% Annual Chance Storm (2017 dollars)**



*Note: Totals are cumulative across horizon years.*

**Figure 6-19. Estimated Value of Infrastructure Vulnerable to Tidal Inundation from a 1% Annual Chance Storm (2017 dollars)**

## 6.7 Community Facilities and Critical Services

With 1 foot of sea level rise, coastal hazards are not anticipated to threaten any community facilities or critical services. With 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 ~5 feet of sea level rise. Up to eight buildings at Aliso Elementary School are vulnerable to tidal inundation hazards with ~5 feet of sea level rise and up to nine buildings at the school with a 1% annual chance storm and associated coastal flooding. At 5 feet of sea level rise, one church (St. Joseph's Chapel) two buildings at the WWTP, and the properties of the State

Beach Service Yard and the Sanitary District offices could also be impacted by a 1% annual chance storm. Finally, seawater infiltration into sewer lines throughout the years (from 1 foot to 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 ESHA (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 (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 of Carpinteria (Table 6-17). According to mapping acreages that consider the anticipated extent of coastal hazards, coastal flooding and cliff erosion affect the most amount of ESHA.

**Table 6-17. ESHA Directly Influenced by Coastal Hazards and Sea Level Rise**

| Hazard                  | Dune Erosion | Cliff Erosion | Tidal Inundation | Coastal Flooding |
|-------------------------|--------------|---------------|------------------|------------------|
|                         | Acres        |               |                  |                  |
| <b>Existing Onshore</b> | 19.3         | 15.6          | 10.1             | 46.5             |
| <b>2030</b>             | 1.9          | 3.8           | 1.6              | 7.3              |
| <b>2060</b>             | 2.3          | 9.1           | 3.1              | 12.9             |
| <b>2100</b>             | 3.0          | 27.1          | 14.6             | 30.2             |
| <b>Total</b>            | <b>26.5</b>  | <b>55.6</b>   | <b>29.4</b>      | <b>96.9</b>      |

*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 habitats severely misrepresents the habitat vulnerability. 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 City GP/LCP. 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
- Harbor Seal Rookery and Haulouts
- 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 ~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 miles, from Ash Avenue to Linden Avenue. Carpinteria State Beach Park is located to the east of the City Beach and includes approximately 0.8 miles 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 ~20 inches of sea level rise, approximately 60% 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 two 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.

## Harbor Sea Rookery and Haulouts

The Harbor Seal Hauling Ground 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 haulout area could be exposed to more frequent inundation and wave action. If coastal erosion is allowed to continue unabated, the seal haulout may migrate inland; however, if the rate of sea level rise exceeds the rate of bluff erosion, then the beach and the haulout may be inundated for more of the tide cycle. If shoreline protection is paced to slow erosion, then the harbor seal haulout 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 6<sup>th</sup> 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 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 Venoco 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, a large Monarch butterfly population in the eucalyptus grove along the Ellwood Mesa in the nearby City of Goleta. After the recent seven-year drought, a catastrophic die off of the eucalyptus trees occurred. 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 Venoco buffer parcels along the Carpinteria Bluffs may eventually become vulnerable to coastal cliff erosion.

## 6.9 Conclusions

This Report presented an analysis of projected current and future vulnerabilities to sea level rise. This Report generated a significant amount of information about potential hazards to the City from sea level rise and associated coastal erosion and flooding damages. The analysis has identified property and public resources vulnerable to coastal erosion and sea level rise for a variety of land use types and infrastructure.

Four summary figures have been created, one for each planning horizon (e.g. Existing, 2030, 2060 and 2100; Figure 6-15, Figure 6-16, Figure 6-17, and Figure 6-18, respectively). These figures depict the relative contribution in percentage of property and infrastructure damages at risk from each land use type (out of 100%). Each of the three concentric circles represent a different coastal hazard type – coastal erosion (outer layer), coastal flooding (middle layer), and tidal inundation (inner layer). These figures are followed by a bulleted list (similar to the Executive Summary) highlighting some of the key findings.

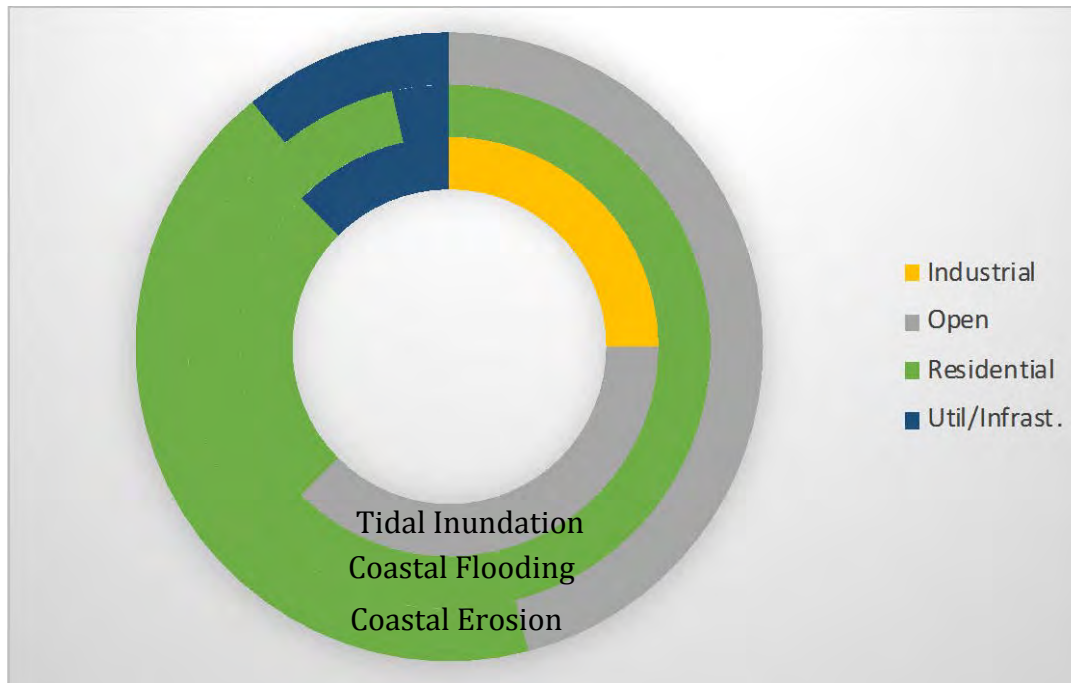
## Existing Conditions

The biggest issue in economic damages under existing conditions is residential property damage from coastal flooding.

Figure 6-15 illustrates the relative contribution to 100% of the economic vulnerabilities from each land use. The innermost ring of the figure shows that the existing vulnerabilities to tidal inundation are relatively evenly distributed among four different colors. This indicates that exposure to tidal inundation is, under existing conditions, somewhat evenly distributed (according to replacement costs) among residential property, commercial property, industrial property, and, to a lesser extent, open space parcels. By contrast, the middle ring's being almost entirely green indicates that the largest economic damages contributing to the City's vulnerability is coastal flooding damages to residential property. The outer ring, finally, indicates that, excepting moderate losses to utilities and City infrastructure, losses to coastal erosion are almost evenly distributed between residential property and open space.

Specifics of the impacts and key findings for existing conditions are highlighted below:

- Carpinteria has approximately 1.5 million beach day visits per year. The 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% of Carpinteria State Park campground area is vulnerable to coastal erosion loss from a 1% annual chance storm.
- 1.2 miles of trails are currently vulnerable to coastal erosion from a 1% 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% annual chance storm. The City is vulnerable to an estimated \$8.5 million in property and infrastructure damages from a 1% annual chance storm. \$800,000 is currently exposed to tidal inundation.



| Existing Conditions | Tidal     | Coastal     | Erosion     |
|---------------------|-----------|-------------|-------------|
| Totals              | \$800,000 | \$8,500,000 | \$3,700,000 |

**Figure 6-13. Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) under Existing Conditions**

- Less than 0.1 miles of railroad line are currently vulnerable to coastal erosion with a 1% annual chance storm. This Report estimated the cost of replacement at \$130,000 but this may be an underestimate. If the railroad line is disrupted, the economic consequences to the region could be serious.
- 0.1 miles of roads are subject to coastal flooding.
- In terms of property loss weighted by market value, residential property represents 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% annual chance storm, and \$800,000 is exposed to tidal inundation.
- Most of the property vulnerability (~90%) is represented by residential property. Multi-family units (apartments and condominiums) represent over 80% 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 (e.g., the Venoco site). While the City may not be directly liable for the



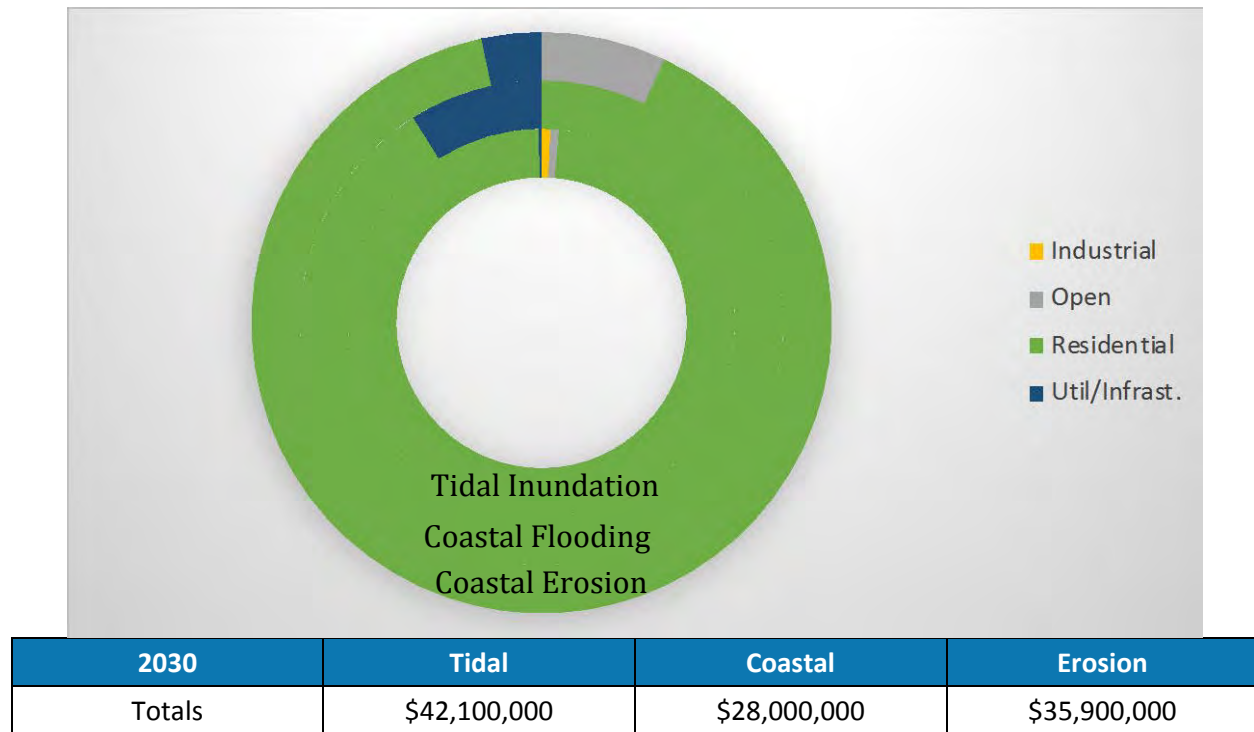
cleanup, bankrupt parties or impacts to tourism and habitats may result in a substantial economic impact to the City.

- This Report did not fully evaluate ESHAs given the dated and generalized ESHA maps; however, areal estimates and projected losses are qualitatively projected. 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.

## 2030

By 2030, the beach and dune erosion and increased extents of coastal flooding raise the vulnerabilities to the oceanfront dwellings and increase the likelihood of damages in the Beach Neighborhood and the Carpinteria State Park without implementation of any additional adaptation strategies. Salt Marsh Park could also be closed during storm events. Cliff erosion along the Carpinteria Bluffs may affect the railroad and recreational trails.

Figure 6-16 illustrates how the threat of coastal erosion has increased substantially (ten-fold) and is now larger than that of coastal flooding (increased three-fold). This disparity in increased vulnerability is caused by the prevalence of multi-story buildings (e.g. condominiums, apartments, etc.) that now fall within the tidal and erosion zones. While coastal flooding only impacts the ground floors of such units, all stories are impacted by the threats of routine tidal inundation and coastal erosion. 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% probability storm (outer and middle rings, respectively).



**Figure 6-14. Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) in 2030**

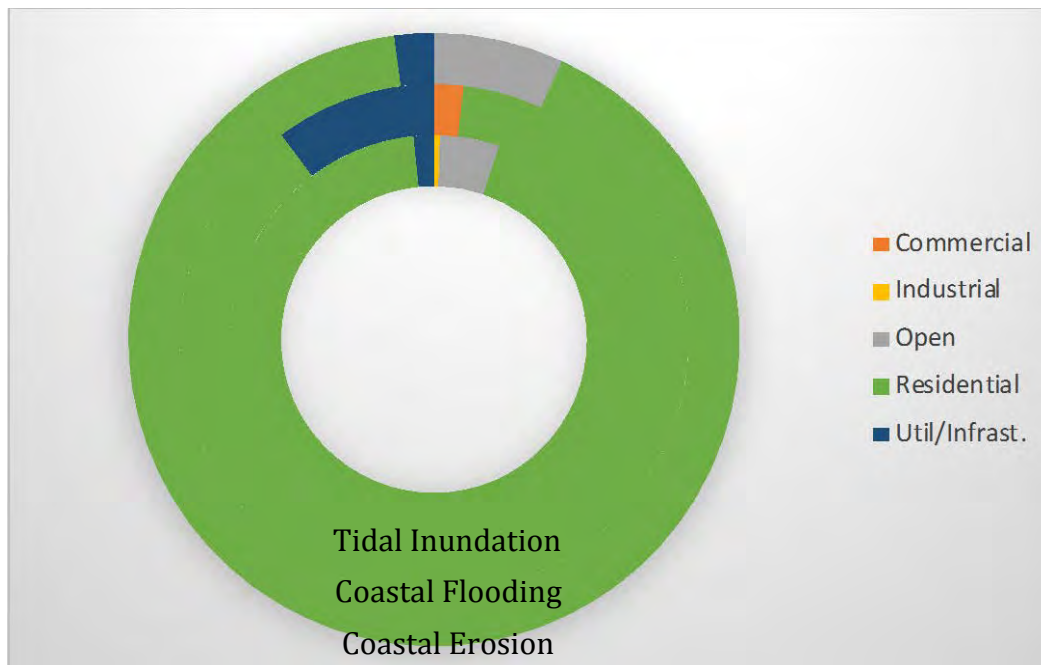
Specifics of the impacts and key findings for 2030 are highlighted below:

- 13% of the Carpinteria State Park campground is vulnerable to coastal erosion loss from a 1% annual chance storm.
- 1.9 miles of trails are vulnerable to coastal erosion from a 1% annual chance storm, and 2.2 miles of trails are vulnerable to coastal flooding.
- \$35.9 million in property and infrastructure is vulnerable to coastal erosion losses from a 1% annual chance storm. \$28 million is vulnerable to coastal flooding losses from a 1% annual chance storm and \$42.1 million is exposed to tidal inundation.
- 0.4 miles of railroad line is vulnerable to coastal erosion with a 1% annual chance storm.
- Less than 0.1 miles of roads are subject to coastal erosion from a 1% annual chance storm. 1.1 miles of roads are subject to coastal flooding and less than 0.1 miles of roads are subject to tidal inundation. Some of this length includes U.S. Highway 101.
- In terms of property loss weighted by market value, residential property represents the largest land use at risk. By 2030, \$32.2 million in residential property is vulnerable to losses from coastal erosion, \$25.5 million is vulnerable to losses from coastal flooding, and \$41.4 million is vulnerable to tidal inundation.

## 2060

By 2060, more extensive coastal flooding impacts could be expected in the Carpinteria State Beach campgrounds and in the Beach Neighborhood, affecting properties between Ash Avenue and Linden Avenue inland to the railroad tracks without additional adaptation strategies implemented. Routine monthly tidal inundation would largely be confined to the existing creek channels, but during rain events the increased elevations would likely back up stormwater drains and cause extensive flooding.

Figure 6-17 indicates that while the land uses vulnerable to coastal flooding have roughly doubled since 2030, land uses vulnerable to tidal inundation and coastal erosion have tripled during the same time period. The vulnerability to commercial parcels (orange) and infrastructure (dark blue) in the lower Downtown Area along Linden Avenue has increased, and the vast majority of vulnerable property values continue to be associated with residential properties (green).



| 2060   | Tidal         | Coastal      | Erosion       |
|--------|---------------|--------------|---------------|
| Totals | \$111,500,000 | \$53,800,000 | \$114,800,000 |

**Figure 6-15. Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) in 2060**

Specifics of the impacts and key findings for 2060 are highlighted below:

- 19% of Carpinteria State Park campground is vulnerable to coastal erosion loss from a 1% annual chance storm.

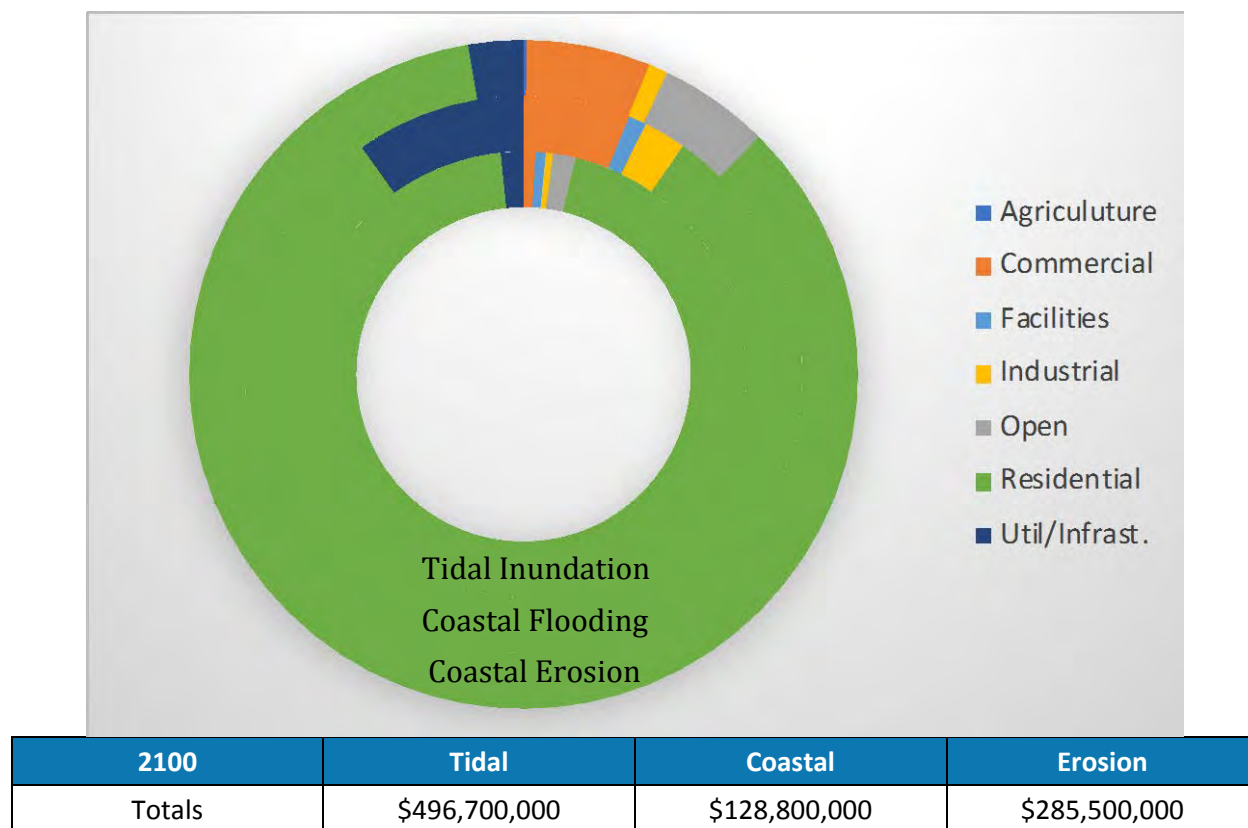


- 2.7 miles of trails are vulnerable to coastal erosion from a 1% annual chance storm, and 3.4 miles of trails are vulnerable to coastal flooding.
- \$114.8 million in property and infrastructure is vulnerable to coastal erosion losses from a 1% annual chance storm.
- \$53.8 million is vulnerable to flooding losses from a 1% annual chance storm and \$111.5 million is exposed to tidal inundation.
- 0.8 miles of railroad line are vulnerable to coastal erosion with a 1% annual chance storm.
- Less than 0.1 miles of roads are subject to coastal erosion from a 1% annual chance storm. 2.0 miles of roads are subject to coastal flooding and 0.8 miles are subject to tidal inundation.
- In terms of property loss weighted by market value, residential property represents the largest land use at risk. By 2060, \$104.5 million in residential property is vulnerable to losses from coastal storm erosion, \$47.3 million is vulnerable to losses from a coastal storm, and \$103.9 million in property is vulnerable to tidal inundation.

## 2100

By 2100, without implementation of any adaptation strategies, coastal erosion could extend to the inland side of Sandyland Road and begin to affect the Concha Loma neighborhood as well as some of the commercial research parks along the Carpinteria Bluffs. Coastal flooding during a large storm wave event could expand in depth and inland extent into the Downtown Core along Linden Avenue, affecting portions of the Old Town District inland of the railroad tracks, Carpinteria Salt Marsh, and areas along Franklin Creek. 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 due to daylighting of groundwater.

Figure 6-18 shows that land uses and property exposed to chronic tidal inundation could more than quadruple between 2060 and 2100 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 property (green) still accounts for the vast majority of vulnerable property values, that of commercial land uses (orange) continues to grow as well. Industrial parcels (yellow) and community facilities (light blue) also become exposed to coastal flooding and erosion (middle and outer rings, respectively).



**Figure 6-16. Distribution of Land Use Vulnerability to Coastal Erosion (outer layer), Coastal Flooding (middle layer), and Tidal Inundation (inner layer) in 2100**

Specifics of the impacts and key findings for 2100 are highlighted below:

- One-third of the Carpinteria State Beach campground may be subject to dune erosion and nearly half (46%) of the entire campground area may be subject to tidal inundation.
- \$285.5 million in property and infrastructure is vulnerable to coastal erosion losses from a 1% annual chance storm. \$128.8 million is vulnerable to coastal flooding losses from a 1% annual chance storm and \$496.7 million is exposed to tidal inundation.
- 4.6 miles of trails are vulnerable to coastal erosion from a 1% annual chance storm, and 5.4 miles of trails are vulnerable to coastal flooding.
- 1.4 miles of railroad line are vulnerable to coastal erosion with a 1% annual chance storm.
- 0.7 miles of roads are subject to coastal erosion from a 1% annual chance storm. 4.8 miles of roads are subject to coastal flooding and 3.0 miles of roads are subject to tidal inundation. Some of this length includes U.S. Highway 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 is vulnerable to losses from coastal erosion, \$103.6 million is vulnerable to coastal flooding losses from a coastal storm, and \$469.8 million is vulnerable to tidal inundation.

## 6.10 Recommended Future Studies

This Report generated a significant amount of information about potential hazards to the City of Carpinteria from sea level rise and associated erosion and flooding damages. Using publicly available parcel data, beach attendance surveys, and other available information, this Report evaluated, with reasonable accuracy, estimates of property losses and property at risk, as well as current recreational use and value. However, there were significant data gaps in this Report and this vulnerability analysis should be read and understood with these data gaps in mind.

Given the significant vulnerabilities identified in this Report, the City might want to consider a more detailed analysis of certain hazards. Specifically, the following issues warrant further investigation.

### Adaptation Tradeoffs

As the City moves forward from vulnerability assessment to the development of LCP policies and considers a range of sea level rise adaptation strategies, there are a variety of cost and benefit tradeoffs that could occur between different adaptation strategies. The integration of physical responses to various adaptation strategies could allow for a closer analysis of potential economic and ecological tradeoffs. The comparison could be based on the primary and secondary long-term impacts of different strategies and implementation mechanisms to help decision-makers determine the most effective policies and project-level adaptation strategies to advance.

This Report could not precisely quantify specific sensitive habitat types or attempt to quantify the value of the ecological goods and services for these ecosystems. Improved habitat mapping, identification of sensitive habitat and species tolerances to changing climate variables and cascading ecological affects should be evaluated further.

The CCC and NOAA recently completed an administrative draft “Beach Evaluation Study” which seeks to quantify the economic value of beaches, including the ecological value of beach habitats, and the City should continue to track progress on this assessment. The highly desirable recreational and ecologically significant beaches in Carpinteria could be lost without proper consideration of secondary impacts associated with adaptation strategies. While all habitat valuation has a level of speculation and uncertainty, by taking a sensitivity



analysis approach, the economics can highlight the need to protect the natural defenses and habitat support functions when considering future management directions.

## Transportation Impacts

More detailed analysis of the economic loss resulting from closures of major transportation corridors due to coastal flooding or erosion is recommended. This Report identified two major coastal hazards that could significantly disrupt transportation in the County and beyond: flooding of U.S. Highway 101, and erosion of a major railroad line through the City. These closures are likely to seriously disrupt economic activity in the greater Santa Barbara area and a fuller economic analysis of the potential losses is recommended. More information on average daily traffic trips, demographics on the commuters and visitors, and potential lengths of closure will be required. Further, this Report only included the costs of removal/replacement of railroad lines and roads; this Report did not estimate the costs of elevation or creating other structures which could mitigate against flooding or erosion.

## Opportunistic Sediment Management Plan

While BEACON has a coastal regional sediment plan (2009), the plan largely did not include climate change impacts nor did it get into any specifics on the development of a regional opportunistic sediment use program. Carpinteria Creeks have several sediment debris basins designed to drop out large coarse-grained sediments (e.g. coarse sand, gravels, cobbles). The effectiveness of these basins has had the negative effect of starving the beaches of these coarse-grained materials, which provide substantial storm buffering capabilities. Further examination of sediment fluxes and the range of conditions that contribute sediment to the coast is warranted. As these sediment fluxes are understood a program to opportunistically utilize the debris basin clean outs to improve beach and dune resiliency is likely warranted.

## Critical Infrastructure Master Plans

This Report also identified other infrastructure vulnerable to coastal hazards such as water and sewer lines. As with transportation, this Report did not identify the cost of specific components of this infrastructure or condition and maintenance needs. Moreover, the erosion may likely require a new alignment so issues of land acquisition/right-of-way for relocating this infrastructure, or the fact that even a small length of eroded pipeline may necessitate the removal/relocation of some pipelines needs to be considered further.

## Improved Recreational Amenity Data

Although this Report estimated the current recreational value of Carpinteria's beaches and campgrounds, as well as the tax revenues generated for the City, the estimates provided for the loss in recreational use due to coastal hazards is very limited. 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 for future work. Specific locations of camp sites and amenities would improve the analysis.

This Report indicates that Carpinteria's beaches will 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 Venoco site, 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 Redevelopment of Venoco Facility

The existing 55-acre Venoco site, recently re-acquired by Chevron Corporation is relatively safe from future coastal hazards and is currently being decommissioned, which represents a potential opportunity for the City and County. The site is in a highly desirable area on the coast 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 opportunities of developing this site as well as potential costs should the site fail to be remediated.

## Environmentally Sensitive Habitat Assessment and Evaluation

The vulnerability of ESHA was limited based on dated habitat mapping and did 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. This evaluation should be completed following the identification of preferred adaptation strategies as they may limit or open up room for habitats to transgress. Stormwater Infrastructure Master Plan

The analysis of stormwater infrastructure was limited to potential exposure of infrastructure relative to the mapped projections of future hazards. Elevation information, particularly for the stormwater outfalls, would allow for a better quantification of the potential impacts to the stormwater drainage system during future high tides and related stormwater improvement costs. An initial screening-level report could better characterize the problem and support the City in pursuing future grants related to upgrading and rehabilitating the existing stormwater systems to improve capacity and better identify if pumps or other mechanisms are more appropriate.

## Environmental Justice

Areas within the City containing the highest number of minority households and those below the poverty level within Carpinteria are at the most risk of being disproportionately impacted from sea level rise, as much of the City's affordable housing stock is located in areas vulnerable to coastal hazard. The City has recently been awarded a Caltrans Planning Adaptation grant, which will address sea level rise impacts to transportation infrastructure and environmental justice populations and develop actionable policies in the GP/LCP Update. The project would increase the City's resilience to SLR impacts, including protection of transportation infrastructure – U.S. Highway 101, Union Pacific Railroad (UPRR) and Amtrak corridor, local roads, California Coastal Trail, bike lanes, and public transit within City boundaries, many which are vulnerable to sea level rise and are essential services to environmental justice populations.

## Short-Term Vacation Rental ToT Revenues

A full analysis of the impact of the loss in short-term rentals on ToT taxes for the City was beyond the scope of this report; however, the loss of short-term rentals near the beach could result in a significant loss in transient occupancy taxes for the City and warrants additional refined further investigation.



# 7. Adaptation Planning

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## 7.1 Introduction

Most cities will likely consider a range of options in their adaptation strategy toolbox. Keeping a range of options on the table helps to ensure that the City retains maximum flexibility in determining how best to carry out its long-term vision for the community. Considering a range of options is also prudent as our understanding of climate science continues to improve in terms of both its predictive capabilities and its ability to identify the most probabilistic local scenarios. Monitoring of sea level rise is an important component of adaptation planning, and future updates to the GP/LCP will reflect updated climate science, predictions, scenario probabilities, and possibly a wider range of adaptation strategies to consider.

Adaptation to climate change involves a range of small and large adjustments to natural and/or human systems that occur in response to already experienced or anticipated climate change impacts. Adaptation planning involves a wide range of policy, programmatic, and project-level measures that can be implemented in advance of the potential impacts; or reactively, depending on the degree of preparedness and risk tolerance. Good adaptation planning should enhance community resilience to hazards and natural disasters and should stem from full disclosure and a solid understanding of the City's specific risks, projected timing of impacts, and physical processes responsible for causing the risk, now and in the future.

Adaptation measures that reduce the ability of communities to respond to climate change over time are referred to as “maladaptation”. Maladaptation, in contrast to adaptation, is a trait that is (or has become) more harmful than helpful. An example of maladaptation is the levee system for the City of New Orleans in Louisiana. While the levees provided short-term adaptation and allowed communities to remain in areas below sea level, they increased the long-term vulnerability, both by providing a false sense of security and underestimating the impact that storm events could cause.

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 change impacts. The forthcoming Adaptation Plan will review adaptation strategies based on preparedness, avoidance, and/or protection from the risks projected to occur over time. The objective of the Adaptation Plan will be to protect the community and natural resources that make Carpinteria such a desirable location to live, work, play, and visit.

## 7.2 Adaptation Planning

Adaptation planning requires considering each vulnerable sector and taking effective and timely action to alleviate the anticipated range of consequences. The City is currently working with USACE to develop a long-term program to address shoreline erosion; this is anticipated to remain one of the primary adaptation tools utilized by the City to maintain its shoreline and public beaches.

A selected adaptation measure may reduce the risk to one sector, but cause issues in another sector or lead to unintended secondary consequences. One of the most important secondary consequences that the City must consider is the impact of the various strategies on the long-term health of the beaches. Carpinteria's desirable beaches serve as a buffer that protects developed lands, provides substantial economic revenues for the City, and is an important part of community identity. Good adaptation planning considers these secondary impacts and how different adaptation measures used to alleviate vulnerability in one sector interact with the other measures in developing a sustainable community adaptation strategy.

Good adaptation planning is also "collaborative", considering interconnected ecological, social, political, and economic systems. Through collaboration with adjacent jurisdictions, including but not limited to the County, and other jurisdictions represented in BEACON, this planning process will leverage local resources and help avoid unintended secondary consequences between neighboring jurisdictions.

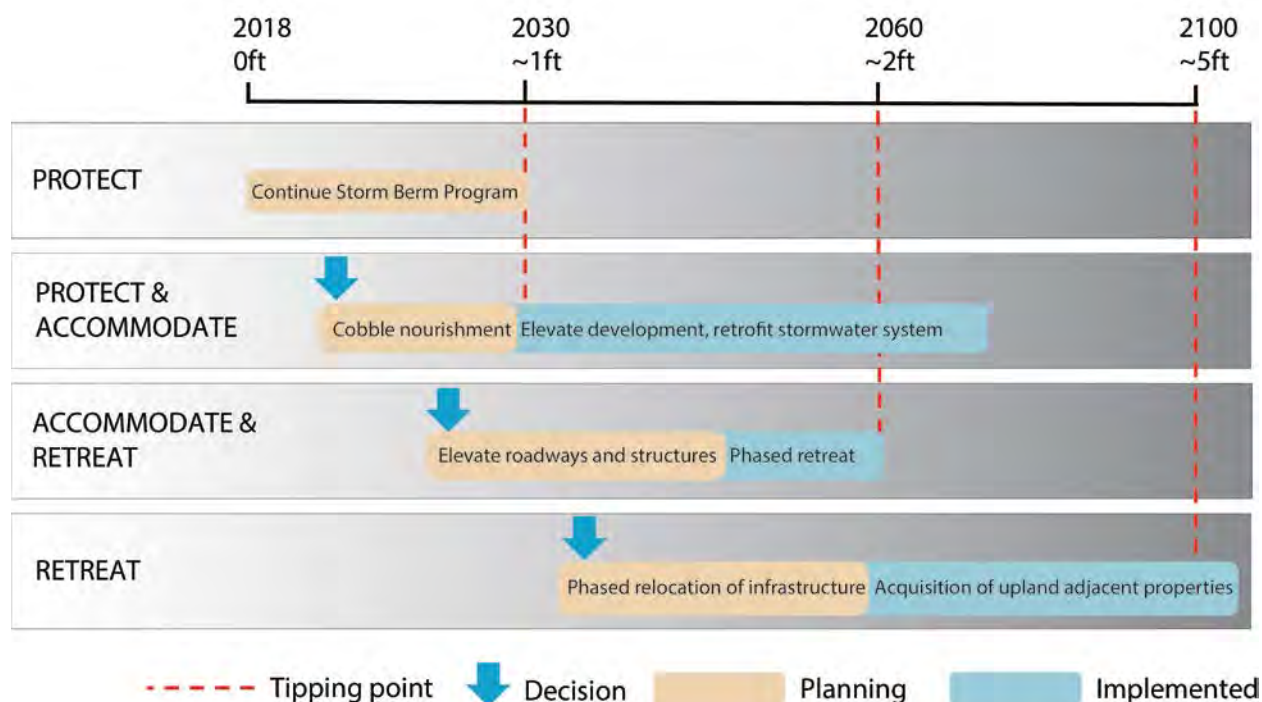
Risks can be addressed by reducing vulnerability or exposure. First, the City must choose what level of risk it is willing to tolerate. Increasing infrastructure resilience, transferring the risk, negating the risk through technological change, a conscious action to employ shoreline management or managed retreat, or revising policies can all help to accomplish these objectives.

Given limited resources, it is important that risks be prioritized and phased to maximize the use of City resources while avoiding a costly emergency response to the maximum extent feasible. An overarching adaptation strategy may take a variety of approaches ranging from protect, accommodate, and retreat, as the sea level rise impacts exceed the various strategies' capacity to reduce the vulnerabilities.

Many adaptation strategies take substantial time to implement. As a result, advanced planning and fundraising is key. Figure 7-1 provides an example of how a range of adaptation strategies could be coordinated and timed based on potential sea level rise triggers. Factors to consider when prioritizing projects include: public health and safety, available funding sources, planning consistency, capacity and level of service, cost-benefit ratio, environmental impacts, political will, and public support. Risks that present the most serious consequences

and are projected to occur first should be elevated to top priorities (i.e., capital improvement projects) for the City.

A goal of this Report is to increase the City's understanding of the vulnerabilities associated with coastal hazards and encourage decision-makers to consider 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.



**Figure 7-1. Example of a Potential Implementation Timeline and Sea Level Rise Accommodation**

Reviewing current City programs and policies associated with 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.

Successful implementation of an adaptation strategy will require communicating the issues and proposed responses to the community. Community education and outreach will be important aspects of the adaptation planning effort. An informed community is also more likely to implement programs and make decisions that reflect its knowledge of the projected changes, and enable the community to contribute to developing a prosperous and affordable City in the face of climate change.



## 7.3 Maladaptation

Maladaptation is a trait that is (or has become) more harmful than helpful, in contrast to adaptation, which is more helpful than harmful. One of the most significant concerns with maladaptation is that it reduces incentives to adapt while simultaneously diminishes the capacity to adapt in the future. 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.

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 characteristics that help identify when it is occurring.

- May result in sustained or increased hazardous conditions
- May result in additional vulnerabilities, loss of property, and resources
- May create a more rigid system with a false sense of security and severe consequences;
- May increase GHG emissions; and/or
- Reduces incentives to adapt.

## 7.4 Challenges and Opportunities

Adaptation planning is a challenging undertaking and a single jurisdiction cannot adapt to climate changes on its own. A successful process requires regional dialogue and state and federal partnerships to identify, fund, and implement solutions. Challenges range from acquiring the necessary funding for adaptation strategies, communicating the need for adaptation to elected officials and 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. Regional partnerships and dialogue between adjacent jurisdictions, Santa Barbara and Ventura Counties, and regional

organizations such as BEACON, will be essential in developing and implementing sound regional adaptation strategies.

## 7.5 Protect, Accommodate, and Retreat

According to the CCC, sea level rise adaptation generally falls into five main categories: do nothing, protect, accommodate, retreat, or a hybrid approach. These approaches are described below.

### The Do Nothing Approach

Choosing to “do nothing” or following a policy of “non-intervention” or “wait and see” may be considered a form of adaptation. However, in most cases, the strategies for addressing sea level rise hazards will require proactive planning to balance protection of coastal resources with development.

### The Protection Approach

Protection strategies typically 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” to “green” and include both “hard” and “soft” measures. A “grey”, “hard” approach is usually 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 tend to trap sand and widen the beach upcoast of the structure and must incorporate a downcoast pre-fill to prevent erosion.

A “soft” protection approach may be to nourish beaches, while a “green”, “soft” approach may be to restore sand dunes, or to develop a “living shoreline” which entails creation of a stabilized sand and cobble complex that would be vegetated with local, native species. Although the California Coastal Act provides for potential protection strategies for “existing development” (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. It is important to note that most protection strategies are costly to construct, require increasing maintenance costs, and have secondary consequences to recreation, habitat, and natural defenses. Many of these are forms of maladaptation, especially if applied as a long-term solution.

## The Accommodation Approach

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 designations, zoning ordinances, or other policy 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 actions such as elevating structures, performing retrofits, or using materials to increase the strength of development such as to handle additional wave impacts, building structures that can easily be moved and relocated, or using additional setback distances to account for acceleration of erosion.

## The Managed Retreat Approach

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 creating land use designations and zoning ordinances that encourage building in less hazardous areas, or gradually remove and relocate existing development. Acquisition and buy-out programs, transfer of development rights programs, and removal of structures are examples of strategies designed to encourage retreat.

## The Hybrid Approach

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

## 7.6 Secondary Impacts

Almost all adaptation strategies have secondary impacts associated with them. Some of these impacts are associated with construction or escalating maintenance costs. Other impacts can degrade ecology or limit recreational opportunities. Finally, others can affect community



aesthetics or property values. Often one of the most controversial impacts 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.

Secondary impacts could include short-term habitat impacts following removal of infrastructure or undergrounding of overhead power lines. Others can be quite confounding and expensive, such as the burial of beaches under rocks following construction of revetments, or a retrofit to a critical infrastructure component. Another example is the potential impacts to visual resources associated with accommodation strategies that elevate buildings or shoreline protection through increased height limits to protect against elevated levels of flooding.

Many communities have relied on setbacks in an effort to reduce hazard risk, and some are currently experimenting with establishing setback lines that are based on modeled predictions of where the new coastline will be in the future. Setbacks alone could be considered potentially maladaptive because they eventually lead to structures being at risk.

## Shoreline Protective Devices

Shoreline Protective Devices (e.g., flood control levees, revetments, groins, etc.) can adversely affect a wide range of other coastal resources and uses that the California Coastal Act protects. They often impede or degrade public access and recreation along the shoreline by occupying beach area or tidelands and by reducing shoreline sand supply.

Presently there is minimal shoreline protection within the City, however the City does experience some impacts to the City Beach at Ash Avenue as a result of the long revetment fronting Sandyland Cove (Figure 3-6).

Protecting the back of the beach through shoreline protective devices ultimately leads to the loss of the beach as sea level rise and coastal erosion continues adjacent to unarmored sections. Shoreline protective devices therefore raise serious concerns regarding consistency with the public access and recreation policies of the California Coastal Act. Such structures can also be placed in coastal waters or tidelands and harm marine resources and biological productivity, which is in conflict with California Coastal Act Sections 30230, 30231, and 30233. In addition, while California Coastal Act Section 30235 allows for shoreline protective devices in certain circumstances when designed to eliminate or mitigate adverse impacts on local shoreline sand supply, shoreline protective devices can degrade the scenic qualities of coastal areas and alter natural landforms, which may create conflicts with Section 30251. By halting or disrupting landscape connectivity, structures can prevent the inland migration of intertidal and beach species during large wave events. In urbanized areas, this disruption could prevent intertidal habitats, salt marshes, beaches, and other low-lying habitats from advancing landward as sea levels rise over the long-term.

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

### *Placement Loss*

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

### *Passive Erosion*

Wherever a hard structure is built along a shoreline undergoing long-term net erosion, the shoreline will eventually migrate landward to (and potentially beyond) the structure. The effect of this migration will be the gradual loss of beach in front of the seawall or revetment as the water deepens and the shore face moves landward. While private structures may be temporarily saved, the public beach is lost. This process of passive erosion is a generally agreed-upon result of fixing the position of the shoreline on an otherwise eroding stretch of coast and is independent of the type of seawall constructed. Passive erosion will eventually destroy the recreational and habitat beach area unless this area is continually replenished. Excessive passive erosion may impact the beach profile such that shallow areas required to create breaking waves for surfing are lost.

### *Limits on Beach Access*

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

### *Active Erosion*

Refers to the interrelationship between coastal structures and beach, whereby due to wave reflection, wave scouring, and enhanced "end effect" erosion and other coastal processes, the shoreline protection may actually increase the rate of loss of beach in front of the structure and escalate the erosion rate along adjacent unprotected sections of the coast. Active erosion is typically site-specific and dependent on sand input, wave climate, specific design characteristics, and other local factors. Visible evidence of a longshore scour trough occurs along the beach fronting the Sandyland Cove revetment.

## *Downcoast Erosion*

Some cross-shore structures such as groins and breakwaters are effective at trapping sand as it moves along the coast. This trapping (or impoundment) reduces the amount of sand supplied downcoast. These sediment retention structures can cause downcoast impacts. The City has already experienced this type of erosion as a result of the construction of the Santa Barbara Harbor in 1928.

## *Ecological Impacts*

Scientific studies have documented a loss of ecosystem services, loss of habitat, and reduction in biodiversity when seawall-impacted beaches were compared to natural beaches. Given the negative impacts of hard solutions, more attention is being focused on the implementation and resulting effectiveness of soft solutions. Soft options often include sediment management aspects such as sand dunes, cobble placement, and/or beach nourishment. Often maintenance costs can be higher than the hard solutions unless nearby sediment sources are abundant. Some soft options are considered “living shorelines” or natural infrastructure (e.g., dune restoration), as they restore or enhance existing habitat, and if done correctly should be self-sustaining, meaning minimal maintenance costs. These “soft” or “green” solutions tend to mimic natural processes and can help lessen erosion and flooding while also providing habitat, water filtration, and recreational opportunities.

## *Economic Impacts and Issues*

There are several challenges with the potential use of local, state, or federal subsidies for construction to protect private property or for obtaining subsidized insurance coverage. The City has been working with USACE for years to mitigate for damages from the Santa Barbara Harbor construction. Another impact of shoreline protection is that it can create environmental justice issues, as shoreline protection can lead to a loss of public access and beach narrowing. For example, the City and State Beaches are a coastal access resource that serve low-income and minority populations within the Carpinteria Valley, and shoreline protection devices could result in a loss of this public coastal access. Construction of shoreline protection devices should be confined to private property whenever possible, but as sea level rises, and the ambulatory ocean boundary moves inland, then this area becomes public property subject to a lease from the California State Lands Commission, and the public has historically not been compensated for this loss of valuable property, although recent fees have started to be assigned by the CCC and the California State Lands Commission.

The potential economic impacts (both private and public) of a seawall which should be considered in the assessment or potential adaptation strategies include:

- Changes to property values which typically increase when shoreline protection is in place;



- Capital costs from seawall construction and recurrent costs associated with seawall maintenance and managing any offsite erosion impacts;
- Erosion impacts on adjacent properties; and/or
- Visual amenity and beach access impacts.

## Sediment Management

Sediment management is another option to combat erosion by building wider beaches and higher sand dunes or increasing wetland accretion. However, sediment management can be costly, and ongoing sand supplies for large projects can become scarce over time. Due to the lack of a suitable dredge with capacity to handle the conditions on the U.S. West Coast, there are often extremely high mobilization costs which may continue to escalate in the future. Secondary impacts from sediment management vary depending on the volume, frequency, and method of sediment placing, but typically result in substantially degraded sandy beach ecosystems, temporary changes to flooding, changes to surfing resources, and limiting recreational use.

## Horizontal Levees

Horizontal levees are a form of natural green infrastructure that has been applied elsewhere, most notably in San Francisco Bay. The concept is usually part of a marsh restoration strategy in which the marsh slope is increased to provide higher elevations near the back of the marsh. This provides a natural levee while also providing marshes room to migrate vertically in elevation upslope. Secondary impacts could be related to costs or changing of existing habitat in exchange for future habitats.

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# Appendix A.

# Key Decisions

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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 Vulnerability 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**<sup>1</sup> – 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.

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<sup>1</sup> 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

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

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 occurring 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 <sup>2</sup> |         |         |
|----------------------------------|----------|------|------|----------------------------|---------|---------|
|                                  | 2030     | 2060 | 2100 | 2030                       | 2060    | 2100    |
| <b>Coastal Resilience - High</b> | 10       | 27   | 60   | <0.5%                      | >5%<67% | >5%<67% |
| <b>Science Range - Low</b>       | 5        | 15   | 26   | 67%                        | 67%     | 67%     |
| <b>Science Range - High</b>      | 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*

<sup>2</sup> 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



# Carpinteria 100 year event NO SLR

COSMOS 3.0



Coastal Resilience

# Appendix B.

# Vulnerability Table

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| Sector                       |              |            |        |            |            |       |            |
|------------------------------|--------------|------------|--------|------------|------------|-------|------------|
| METRIC                       | # of Parcels |            |        |            |            |       |            |
| TYPE                         | Agricultural | Commercial | Common | Facilities | Industrial | Mixed | Open Space |
|                              |              |            |        |            |            |       |            |
| UNITS                        | count        | count      | count  | count      | count      | count | count      |
| <b>Dune erosion</b>          |              |            |        |            |            |       |            |
| Existing conditions          | 0            | 0          | 2      | 0          | 0          | 0     | 16         |
| 10.2 in                      | 0            | 0          | 8      | 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         |
| <b>Cliff erosion</b>         |              |            |        |            |            |       |            |
| 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         |
| <b>Tidal inundation</b>      |              |            |        |            |            |       |            |
| 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         |
| <b>Fluvial</b>               |              |            |        |            |            |       |            |
| 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         |
| <b>Coastal wave flooding</b> |              |            |        |            |            |       |            |
| 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

| Residential | Right of Way | Vacant | Total | Commercial |                         | Facilities |                         |
|-------------|--------------|--------|-------|------------|-------------------------|------------|-------------------------|
|             |              |        |       | Commercial | Commercial Out Building | Facilities | Facilities Out Building |
| count       | count        | count  | count | count      | count                   | count      | count                   |
|             |              |        |       |            |                         |            |                         |
| 26          | 0            | 0      | 44    | 0          | 0                       | 0          | 0                       |
| 2           | 0            | 0      | 12    | 0          | 0                       | 0          | 0                       |
| 64          | 1            | 0      | 65    | 0          | 0                       | 0          | 0                       |
| 40          | 0            | 0      | 43    | 0          | 0                       | 0          | 0                       |
| 132         | 1            | 0      | 164   | 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 |       |            |                         |             |                          |       | Parkland and Open Space |       |
|----------------|-------|------------|-------------------------|-------------|--------------------------|-------|-------------------------|-------|
| Industrial     | Mixed | Open Space |                         | Residential |                          | Total |                         |       |
| count          | count | Open Space | Open Space Out Building | Residential | Residential Out Building | count | count                   | acres |
|                |       |            |                         |             |                          |       |                         |       |
| 0              | 0     | 0          | 0                       | 15          | 0                        | 15    | 4                       | 18.64 |
| 0              | 0     | 0          | 0                       | 6           | 0                        | 6     | 0                       | 2.16  |
| 0              | 0     | 0          | 1                       | 13          | 0                        | 14    | 0                       | 3.28  |
| 0              | 0     | 0          | 4                       | 7           | 0                        | 11    | 0                       | 6.38  |
| 0              | 0     | 0          | 5                       | 41          | 0                        | 46    | 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  | 1,439  | 0.27  | 100   | 0                             | 1                       |
| 2,442           | 0.46  | 7       | 0.36  | 0                     | 194                      | 0.04  | 1,439  | 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  | 38     | 0.01  | 1     | 0                             | 0                       |
| 4,195           | 0.79  | 1       | 0.02  | 0                     | 0                        | 0.00  | 1,011  | 0.19  | 7     | 0                             | 0                       |
| 11,616          | 2.20  | 7       | 2.07  | 0                     | 3,469                    | 0.66  | 3,071  | 0.58  | 40    | 0                             | 2                       |
| 15,987          | 3.03  | 8       | 2.10  | 0                     | 3,469                    | 0.66  | 4,120  | 1     | 127   | 0                             | 2                       |
|                 |       |         |       |                       |                          |       |        |       |       |                               |                         |
| 42,328          | 8.02  | 7       | 0.92  | 7                     | 11,998                   | 2.27  | 22,143 | 4.19  | 1,108 | 0                             | 3                       |
| 23,199          | 4.39  | 3       | 2.56  | 1                     | 3,726                    | 0.71  | 8,889  | 1.68  | 1,927 | 1                             | 2                       |
| 65,527          | 12.41 | 10      | 3.47  | 8                     | 15,724                   | 2.98  | 31,031 | 5.88  | 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  | 1,426  | 0.27  | 1,839 | 0                             | 0                       |
| 4,578           | 0.87  | 0       | 1.92  | 0                     | 408                      | 0.08  | 2,103  | 0.40  | 2,176 | 0                             | 1                       |
| 14,717          | 2.79  | 3       | 1.26  | 2                     | 5,584                    | 1.06  | 5,449  | 1.03  | 3,132 | 0                             | 2                       |
| 25,339          | 4.80  | 11      | 3.61  | 2                     | 6,257                    | 1.19  | 8,978  | 2     | 7,659 | 0                             | 3                       |

| Sewer          |       |               | Water Supply   |       |               |                     |                          |             |             | Stormwater             |                  |
|----------------|-------|---------------|----------------|-------|---------------|---------------------|--------------------------|-------------|-------------|------------------------|------------------|
| 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<br>ESI Reporting<br>Sites | Cleanup<br>program Sites<br>(Active) | Health Care<br>(Clinic)    | School<br>Buildings | School<br>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                          | 8                   | 1                |
| 0                       | 0.00  | 0                   | 1                                    | 0                                    | 0                          | 8                   |                  |
|                         |       |                     |                                      |                                      |                            |                     |                  |
| 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                          | 8                   | 0                |
| 984                     | 0.19  | 1                   | 3                                    | 1                                    | 0                          | 9                   |                  |

| Emergency Services              |                              | Sensitive Biological Resources                   |        |       |                   |       |       | Energy<br>Infrastruct |
|---------------------------------|------------------------------|--|--------|-------|-------------------|-------|-------|-----------------------|
| facilities by type              |                              | Environmentally Sensitive Habitat<br>Area (ESHA) |        |       | Sensitive Habitat |       |       | # of<br>facilities    |
| Water<br>Treatment<br>Buildings | Water<br>Treatment<br>Campus |  |        |       |                   |       |       | Oil Wells<br>(All)    |
| count                           | count                        | sq ft  | acres  | count | sq ft             | acres | count | count                 |
|                                 |                              |  |        |       |                   |       |       |                       |
| 0                               | 0                            | 1,409,609  | 32.36  | 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                            | 1,717,559  | 39.43  | 4     | 445,652           | 10.23 | 1     | 1                     |
|                                 |                              |  |        |       |                   |       |       |                       |
| 0                               | 0                            | 2,928,712  | 67.23  | 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                            | 4,673,022  | 107.28 | 4     | 167,460           | 3.84  | 2     | 4                     |
|                                 |                              |  |        |       |                   |       |       |                       |
| 0                               | 0                            | 975,480  | 22.39  | 7     | 185,613           | 4.26  | 1     | 22                    |
| 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                            | 1,813,049  | 41.62  | 8     | 317,586           | 7.29  | 1     | 26                    |
|                                 |                              |  |        |       |                   |       |       |                       |
| 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                            | 4,880,105  | 112.03 | 9     | 599,847           | 13.77 | 2     | 22                    |
| 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                            | 7,076,906  | 162.46 | 13    | 604,632           | 13.88 | 2     | 27                    |

| 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

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# Definitions, Acronyms, & Abbreviations

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## 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 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.

## Acronyms and Abbreviations

|             |  |
|-------------|--|
| <b>City</b> | City of Carpinteria                        |
| <b>ESI</b>  | <b>Electronic Submittal of Information</b> |
| <b>FEMA</b> | Federal Emergency Management Agency        |
| <b>FIRM</b> | <b>Flood Insurance Rate Map</b>            |
| <b>NFIP</b> | <b>National Flood Insurance Program</b>    |
| <b>WWTP</b> | Wastewater Treatment Plant                 |
| <b>ToT</b>  | 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 determine the magnitude of community impact of the creek flood hazards (particularly following the 2017 Thomas Fire and subsequent debris flows) when compared with future coastal hazards. Creek flood extents are initially assessed to provide estimates of the relative importance of existing flood hazards compared to climate change-influenced coastal hazards. The potential effects of fluvial hazards under a variety of future scenarios are identified. The influence of existing development and/or future adaptation decisions are not considered.

Identified fluvial flooding vulnerabilities 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 these existing fluvial flooding impacts occur under existing conditions (100-year FEMA flood event) and the 2100 time horizon (500-year FEMA flood event).

## Creek Flood Hazards Expansion

**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 on fluvial flooding along Carpinteria Creek show additional flooding around the Albertson Shopping Center located at

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.

Carpinteria Avenue and Casitas Pass Road, and inland of the Union Pacific Railroad tracks toward Linden Avenue and 7<sup>th</sup> Street. However, data is unavailable on climate changes to flood hazards on Franklin and Santa Monica Creeks. 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. Vulnerabilities to the community from existing fluvial flood risks are greater than the risks 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

---

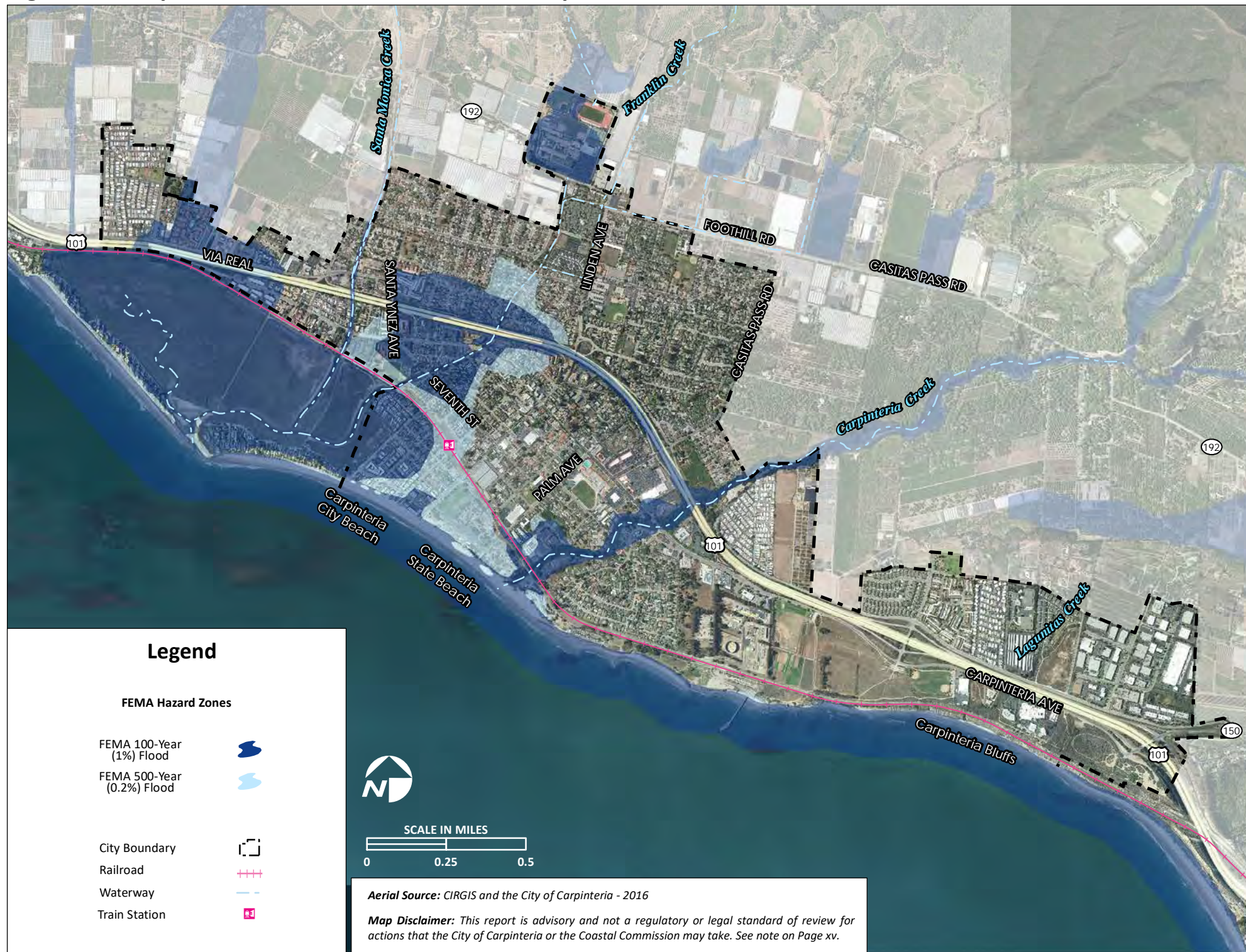
## 1.1 Existing Fluvial Hazards

FEMA maps delineate creek (fluvial) flood hazards as part of the National Flood Insurance Program (NFIP). This program requires very 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 the 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. FEMA is currently in the process of updating all floodplain maps in the state of California and final updated maps are expected in 2018.

Historic fluvial flooding has occurred in various parts of the City (Figure 3-13). 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**







**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

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### 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 soon to be outdated FEMA flood model and not for Franklin or Santa Monica Creeks (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 and expand creek flooding along Carpinteria Creek over the tracks along Maple Avenue up to Linden Avenue and 7<sup>th</sup> 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 8<sup>th</sup> 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 in the Santa Barbara County Coastal Hazard Modeling and Vulnerability Assessment, which were used in this current 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 from 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), so the influence of changes in precipitation and higher water levels from sea level rise in the various creek mouths and sloughs, with the resultant effects of expanding overall extent of flooding, 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.*** This assumption that there is no effect of climate change likely under predicts the combined costal and creek flood extents.

# 3. Sector Results

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***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 Section 1.0, *Sector Profiles*, of the **2018 Coastal Vulnerability Assessment and Adaptation Project**. Quantified information pertaining to each sector profile with regard to fluvial flooding impacts are contained in Appendix B.

## 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 did not estimate the loss in ToT due to fluvial flooding impacts as this was beyond the scope of the sea level rise analysis; 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 waste water treatment plan. 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, a dry cleaner in a 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 will be exposed to fluvial flooding. Additionally, two legacy oil wells near Carpinteria Creek are 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 these inlets and outfalls are located along the Highway 101 corridor and in the Franklin Creek and Santa Monica Creek floodplains. Fluvial flooding from a FEMA 500-year flood could affect an additional (compared to 100-year flood) 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, 6<sup>th</sup> 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; 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 the three creeks, 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. Fluvial flooding from a FEMA 500-year flood event may affect 7 buildings at the WWTP, as well as an additional (compared to 100-year storm) 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 along 7<sup>th</sup> Avenue.

## 3.4 Community Facilities and Critical Services

The largest threat to this sector is existing fluvial flooding hazards as mapped by FEMA. A 500-year fluvial flood could impact 4 schools, 34 school buildings, 3 churches, the Sansum Health Care Clinic, and 4 community facilities, including the Post Office and WWTP.

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 (compared to 100-year) 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, 6 other community facilities, and 1 critical service.

# 4. Future Studies

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## 4.1 Recommended Future Studies

Given the significant vulnerabilities identified in this Report, the City might want to consider a more detailed analysis of coastal confluence and fluvial hazards. Climate changes could combine to affect the extents of future fluvial flooding hazards through changes in precipitation intensity, peak streamflows, and bottom of the watershed tailwater elevations influenced by sea level rise. 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 and have bridge improvements along Carpinteria Creek is recommended in any future update to this type of vulnerability assessment or to the City's Local Hazard Mitigation Plan.