Final

CITY OF SANTA BARBARA
SEA-LEVEL RISE ADAPTATION PLAN

Prepared for
City of Santa Barbara

Adopted by City Council February 2, 2021

ESA

Funded by:

Coastal Conservancy

CALIFORNIA COASTAL COMMISSION

SEAL OF THE CITY OF SANTA BARBARA CALIFORNIA

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California Coastal Commission
California State Coastal Conservancy
City of Santa Barbara

626 Wilshire Boulevard
Suite 1100
Los Angeles, CA 90017
213.599.4300
esassoc.com

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Front page photo of Leadbetter Beach taken by David Davis during an approximate 6ft high tide in January 2020.

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ACKNOWLEDGEMENTS

City Council

Mayor Cathy Murillo
Eric Friedman
Alejandra Gutierrez
Oscar Gutierrez
Meagan Harmon
Mike Jordan
Kristen Sneddon

Sea-Level Rise Adaptation Plan Subcommittee

Kristen Sneddon, City Council, *Chair*
Dave Davis, Water Commission, *Vice Chair*
Jason Dominguez, City Council
Eric Friedman, City Council
Betsy Cramer, Harbor Commission
Jim Sloan, Harbor Commission
Beebe Longstreet, Parks and Recreation Commission
Deborah Schwartz, Planning Commission
Lesley Wiscomb, Planning Commission

Project Funders

California Coastal Commission
California State Coastal Conservancy
City of Santa Barbara

City Staff

Debra Andaloro
Timmy Bolton
Renee Brooke
Brian D'Amour
Matt Fore
Kathleen Goo
Daniel Gullett
Joshua Haggmark
Rich Hanna
Dan Hentschke
Melissa Hetrick, Project Manager
Sara Iza
Yoli McGlinchey
Jill Murray
Adam Nares
Tava Ostrenger
Rubi Rajbanshi
Robert Samario
Karl Treiberg
Krystal Vaughn
Carla Navarro Woods
Jill Zachary

Consultants

ESA
AECOM
Campbell Geo

Community Members

The City thanks the individuals and groups who gave up their personal time to participate in the Sea-Level Adaptation Plan process. The City appreciates the civic investment these individuals and groups have made in the future of Santa Barbara's shoreline.

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EXECUTIVE SUMMARY

INTRODUCTION

The City of Santa Barbara includes approximately six miles of shoreline. Although Santa Barbara has experienced a relatively small amount of sea-level rise to date from climate change, the rate of sea-level rise in the region is expected to accelerate significantly in upcoming years. The purpose of this Adaptation Plan is to identify vulnerabilities to coastal hazards expected from sea-level rise in the City of Santa Barbara and possible actions to prepare for and adapt to sea-level rise.

Preparation of a sea-level rise adaptation plan is identified as a priority in the Coastal Land Use Plan, Safety Element, and Hazard Mitigation Plan. Additionally, the State requires the City, as a trustee of state tidelands, to proactively plan for sea-level rise at the Harbor and Stearns Wharf and to consider sea-level rise as part of coastal development permitting. The 2019 Coastal Land Use Plan includes interim policies that begin to incorporate the effects of sea-level rise into coastal development permitting, but a more comprehensive plan for addressing sea-level rise was needed. The California Coastal Commission, therefore, partially funded the preparation of this Adaptation Plan as part of the City's efforts to update its Local Coastal Program.

A vulnerability assessment was prepared for this Adaptation Plan to identify the areas of the city that, in the absence of intervention, are projected to be exposed to sea-level rise and related coastal hazards. This Adaptation Plan provides the framework for the City to monitor sea-level rise impacts and reduce vulnerabilities in phases as specific thresholds for action are reached. A wide range of adaptation options are presented, providing the City flexibility to consider different adaptation strategies over time.

The study area includes portions of the city that are projected to be impacted by coastal hazards through the year 2100, except the Santa Barbara Airport and Goleta Slough, which have been studied separately.

Information surrounding sea-level rise and how to adapt to it is quickly evolving. While the plan provides a framework for decision-making and further study in the mid- and long-term, specific recommendations are focused on the near-term (i.e., the next 10 years). Reevaluation of the plan is recommended to occur approximately every five to ten years as major updates occur to the State of California Sea-Level Rise Guidance or other substantive changes in best available information occur. This Adaptation Plan presents an initial framework for planning for sea-level rise that will continue to evolve over time as conditions change.

SEA-LEVEL RISE VULNERABILITY

Sea levels in Santa Barbara have increased by 0.39 feet in the last 100 years (NOAA Tides and Currents Station #9411340). Under current sea levels, Santa Barbara is already vulnerable to bluff and beach erosion (Figures ES-1 and ES-2), coastal flooding and wave impacts (Figure ES-3), and flooding of low-lying areas (Figure ES-4). Historically, the worst flooding and erosion events have occurred as a result of winter storms occurring during El Niño conditions in the North Pacific Ocean when sea levels along the California coast often rise substantially for weeks at a time (Griggs and Russel 2012). The rate of sea-level rise is expected to increase over time due to the effects of climate change and global warming. This will result in increased flooding and erosion hazards along the City's shoreline, with the highest risks continuing to be during winter storms in El Niño years.

SOURCE: Griggs and Russel 2012

Figure ES-1
January 2008 Landslide at Shoreline Park

SOURCE: Griggs and Russel 2012

Figure ES-2
Beach Erosion at Leadbetter Beach Parking Lot from the March 1983 El Niño Event

SOURCE: Griggs and Russel 2012

Figure ES-3
Waves Overtopping West Cabrillo Boulevard in 1914

SOURCE: Griggs and Russel 2012

Figure ES-4
Southern Pacific Railroad Station Covered in Mud
Following Flooding in 1914

The *City of Santa Barbara Sea-level Rise Vulnerability Assessment Update* (Vulnerability Assessment Update) evaluated hazards for three sea-level rise scenarios: 0.8 feet by 2030,[1] 2.5 feet by 2060, and 6.6 feet by 2100. These amounts of sea-level rise are with respect to a baseline of the year 2000, or more specifically, the average relative sea level over 1991 – 2009. Since 2000, sea levels are estimated to have increased by just under an inch, as of the writing of this report, but the rate of sea-level rise is expected to increase in the coming decades.

The State of California, in the 2018 *State of California Sea-Level Rise Guidance* (OPC 2018), recommends using these precautionary and more risk adverse scenarios when planning for structures, infrastructure, and other development that is not easily moved. The state guidance estimates that these sea-level rise values have a 0.5% chance of being met or exceeded by the year 2100. The state guidance identifies these as the “medium-high risk aversion scenarios” which are based on the assumption that existing levels of greenhouse gas emissions continue and are not significantly reduced (“high emission scenarios”).

1 The 2018 *State of California Sea-Level Rise Guidance* recommends 0.7 feet at 2030. The closest Coastal Storm Modeling System (CoSMoS) Scenario, which has been used to generate maps and conduct vulnerability analyses is 25 cm, which is 0.8 feet. This difference is negligible at the scale of this study, and 0.8 feet at 2030 is used throughout.

The 2018 *State of California Sea-Level Rise Guidance* also includes much more likely scenarios that present sea-level rise values that have a 17% chance of being met or exceeded in the future ("low risk aversion scenarios") that can be used for planning for adaptable development with few consequences of being impacted (e.g., dirt trails). The state guidance also presents an "extreme risk aversion" scenario called the H++ scenario that is based on recent scientific studies that indicate that there is a possibility that sea levels could rise faster than originally anticipated due to the potential loss of large portions of the West Antarctic Ice Sheet. While the probability of this extreme scenario is not known at this time, the state guidance recommends considering the H++ scenario in the planning of very critical infrastructure (e.g., coastal power plant). For very critical infrastructure, therefore, this Adaptation Plan considers the possibility that 6.6 feet (2100) of sea-level rise may occur sooner, at 2080 rather than 2100, under the extreme H++ sea-level rise scenario. Table ES-1 and Figure ES-5 below present the low-rise, medium-risk, and extreme risk aversion scenarios. All of these aversion scenarios correspond to the high greenhouse gas emissions scenario.

The State of California has updated the sea-level rise projections for the Santa Barbara area contained in the State of California Sea-Level Rise Guidance approximately every five years based on best available information. While there is uncertainty in the timing of sea-level rise in any particular area, the amounts of sea-level rise considered in this Adaptation Plan are expected to occur at some time. Because of the timing uncertainty, this Adaptation Plan provides a framework of planning based on amounts of sea-level rise, rather than when those amounts of sea-level rise will occur.

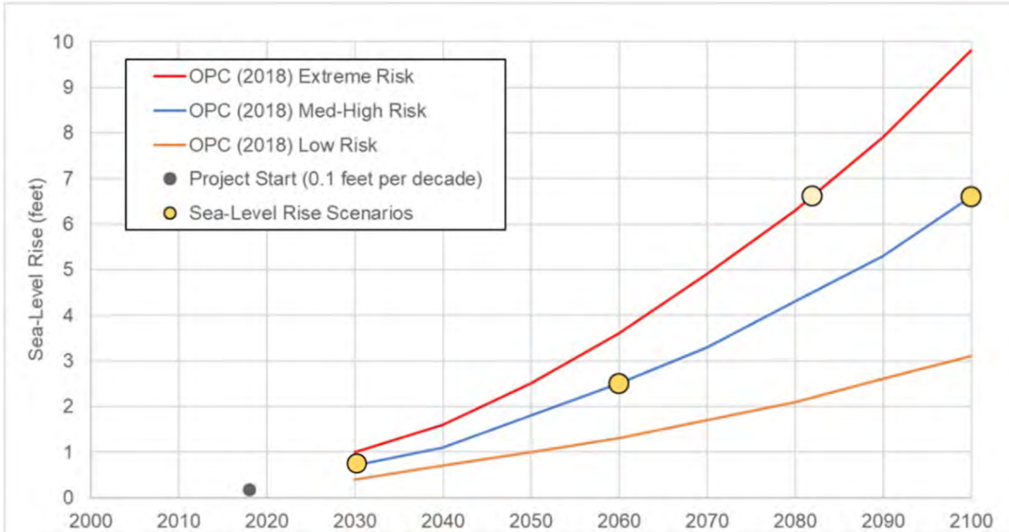
TABLE ES-1
SEA-LEVEL RISE SCENARIOS FOR CITY OF SANTA BARBARA

Scenario	Low Risk Aversion[a] *17% chance of being met or exceeded*	Med High Risk Aversion *0.5% chance of being met or exceeded*	Extreme Risk Aversion *Unknown probability*
0.8 feet of sea-level rise	Occurs by ~2040	Occurs by ~2030	Occurs before 2030
2.5 feet of sea-level rise	Occurs by ~2090	Occurs by 2060	Occurs by 2050
6.6 feet of sea-level rise	Occurs after 2150	Occurs by 2100	Occurs by ~2080

NOTES:

[a] Low Risk Aversion values were not used for this analysis

~ Approximately



SOURCE: OPC 2018

Figure ES-5
OPC (2018) Sea-Level Rise Guidance Curves, with Selected Scenarios

This Adaptation Plan considers potential impacts to public and private assets (e.g., buildings, roads, utilities, parks) from the following hazards:

- Coastal Erosion – permanent loss of sandy beaches, dunes, and the low-lying backshore that occurs with changing sea-level or sand supply.
- Coastal Bluff Erosion – permanent loss of coastal bluffs as material falls or collapses onto the beach or into the ocean below.
- Tidal Inundation – coastal flooding during regular high tides under non-storm conditions.
- Storm Waves – exposure of the coast to large waves generated by local and distant storms.
- Coastal Storm Flooding – high water levels that occur during coastal storm events. The Vulnerability Assessment Update analyzed the “100-year storm” event, which has a 1% chance of occurring each year.

Low-lying areas that may potentially be subject to tidal and storm flooding but are not directly connected to flooding sources were also identified in the Vulnerability Assessment Update. The hazards mapped were developed using the United States Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS), with some data augmented by a regional sea-level rise study called Coastal Resilience Santa Barbara (ESA 2016).

Figures ES-6 through ES-13 illustrate the hazard areas under existing and future sea-level rise scenarios. Note that coastal erosion, bluff erosion, storm waves, and storm flooding occur episodically, particularly in response to extreme coastal storms during El

Niño events (Griggs and Russel 2012). The hazard maps account for these extreme events and show the projected areas of flood risk and cumulative erosion over time.

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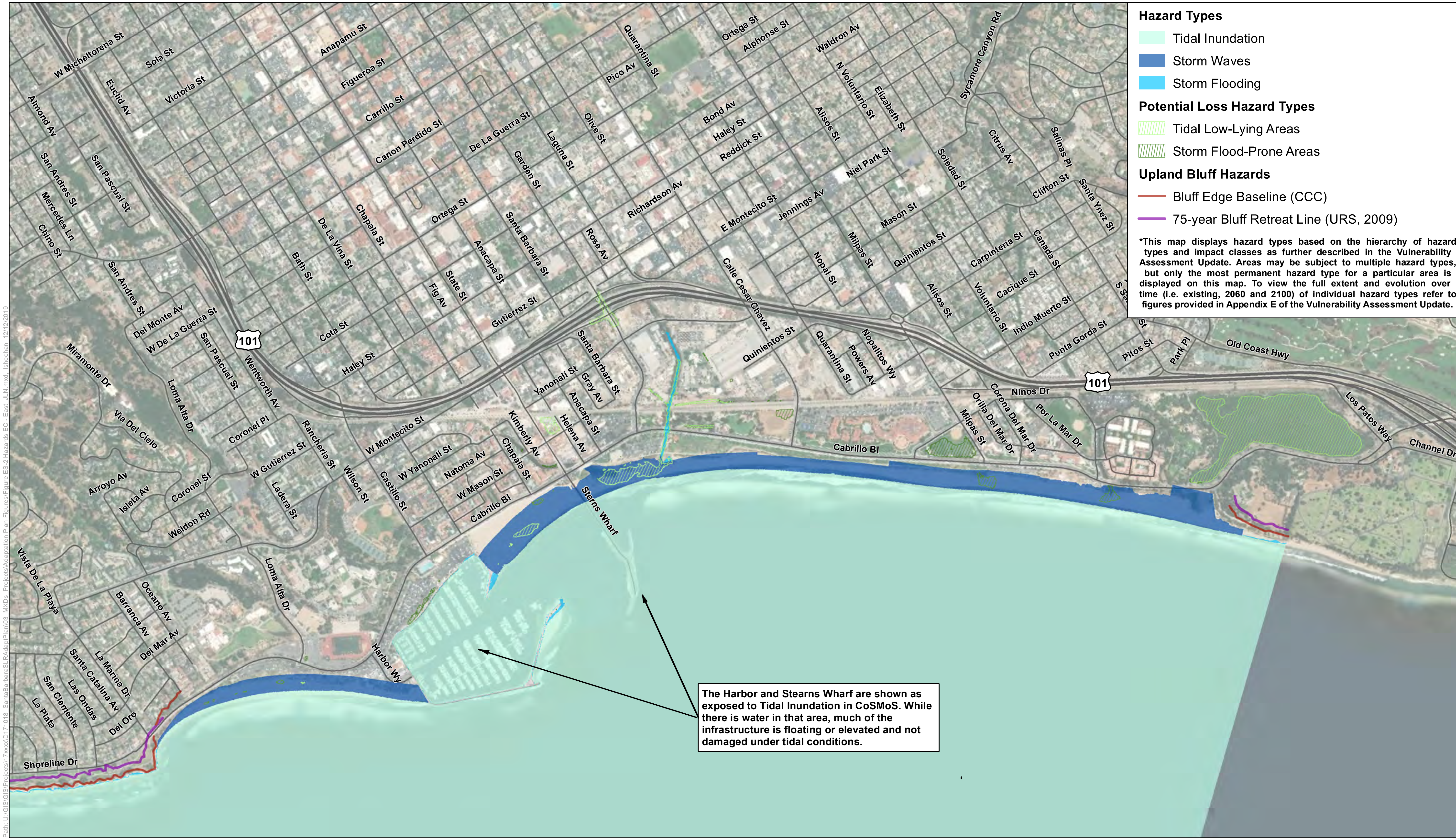


SOURCE: ESRI, 2018; USGS, 2018; ESA, 2018.

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-6
Existing Conditions Hazards (East)

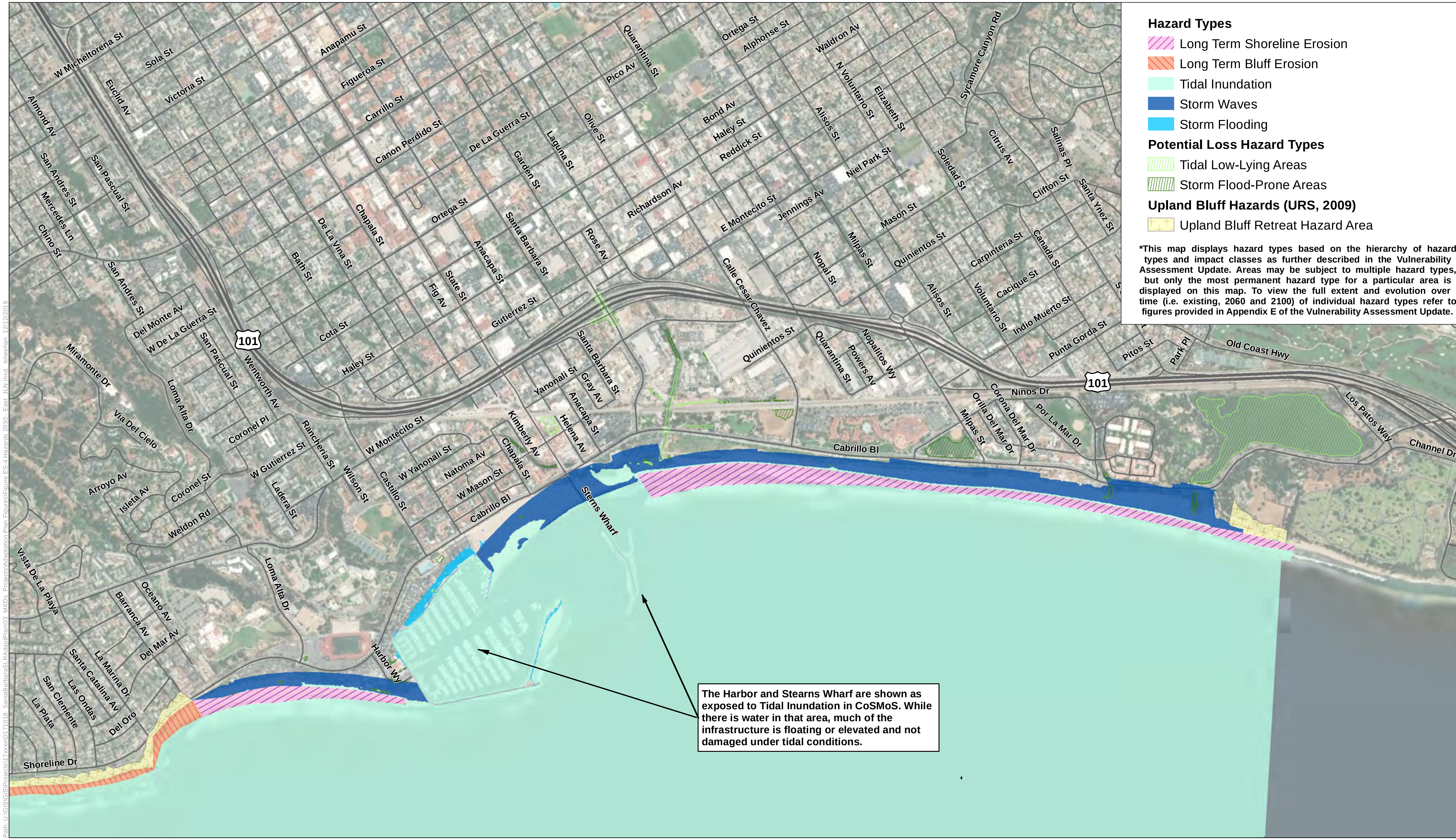
ESA

SOURCE: ESRI, 2018; USGS, 2018; ESA, 2018.

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-7
Existing Conditions Hazards (West)

ESA



SOURCE: ESRI, 2018; USGS, ESA, 2018.

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-8
Hazards with 0.8 Feet of Sea-Level Rise (±2030) (East)

ESA

SOURCE: ESRI, 2018; USGS, 2018; ESA, 2018.

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-9
Hazards with 0.8 Feet of Sea-Level Rise (±2030) (West)

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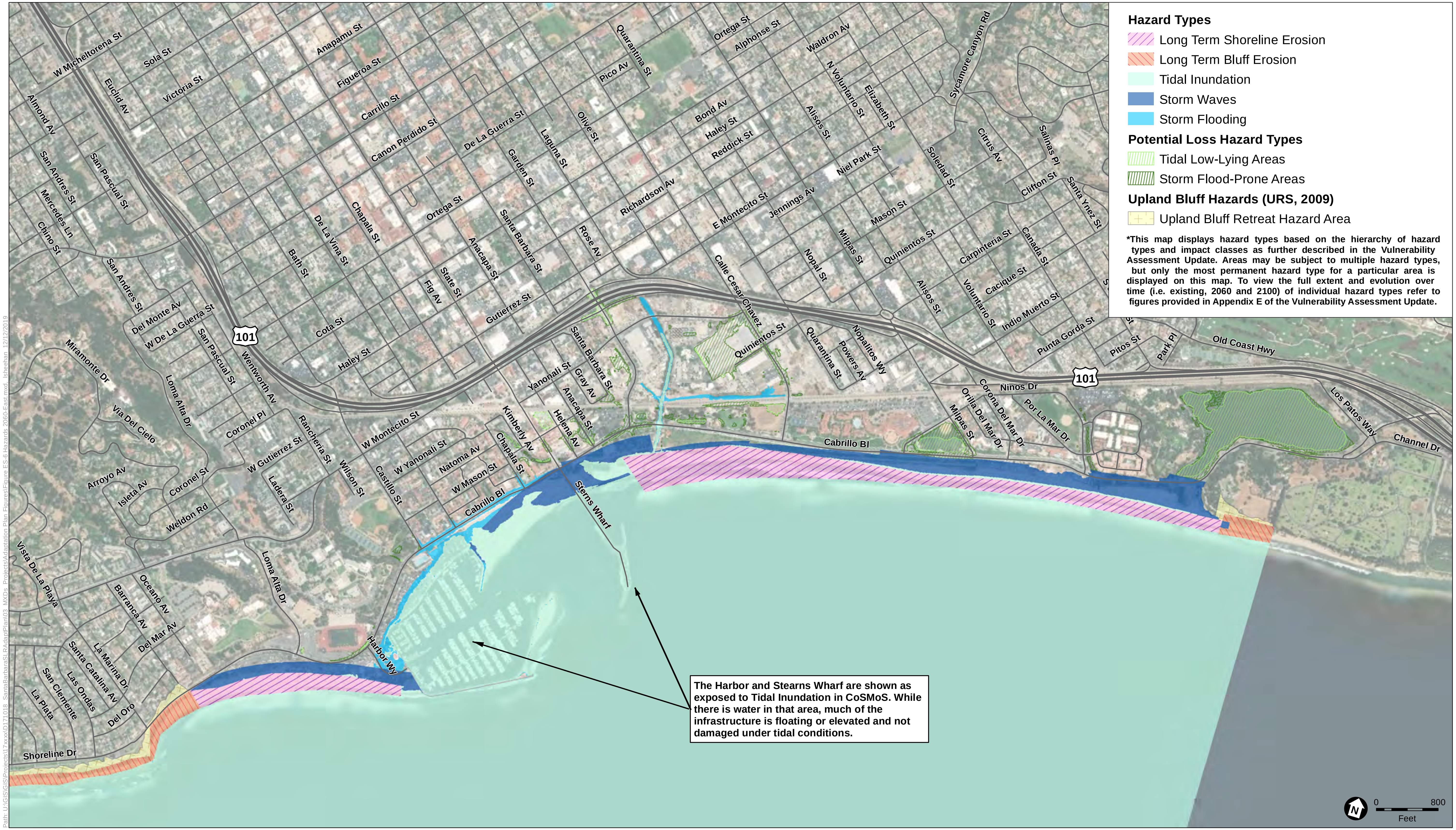

SOURCE: USGS, ESA

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-10
Hazards with 2.5 Feet of Sea-Level Rise (±2060) (East)

ESA

SOURCE: USGS, ESA

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-11
Hazards.with 2.5 Feet of Sea-Level Rise (±2060) (West)

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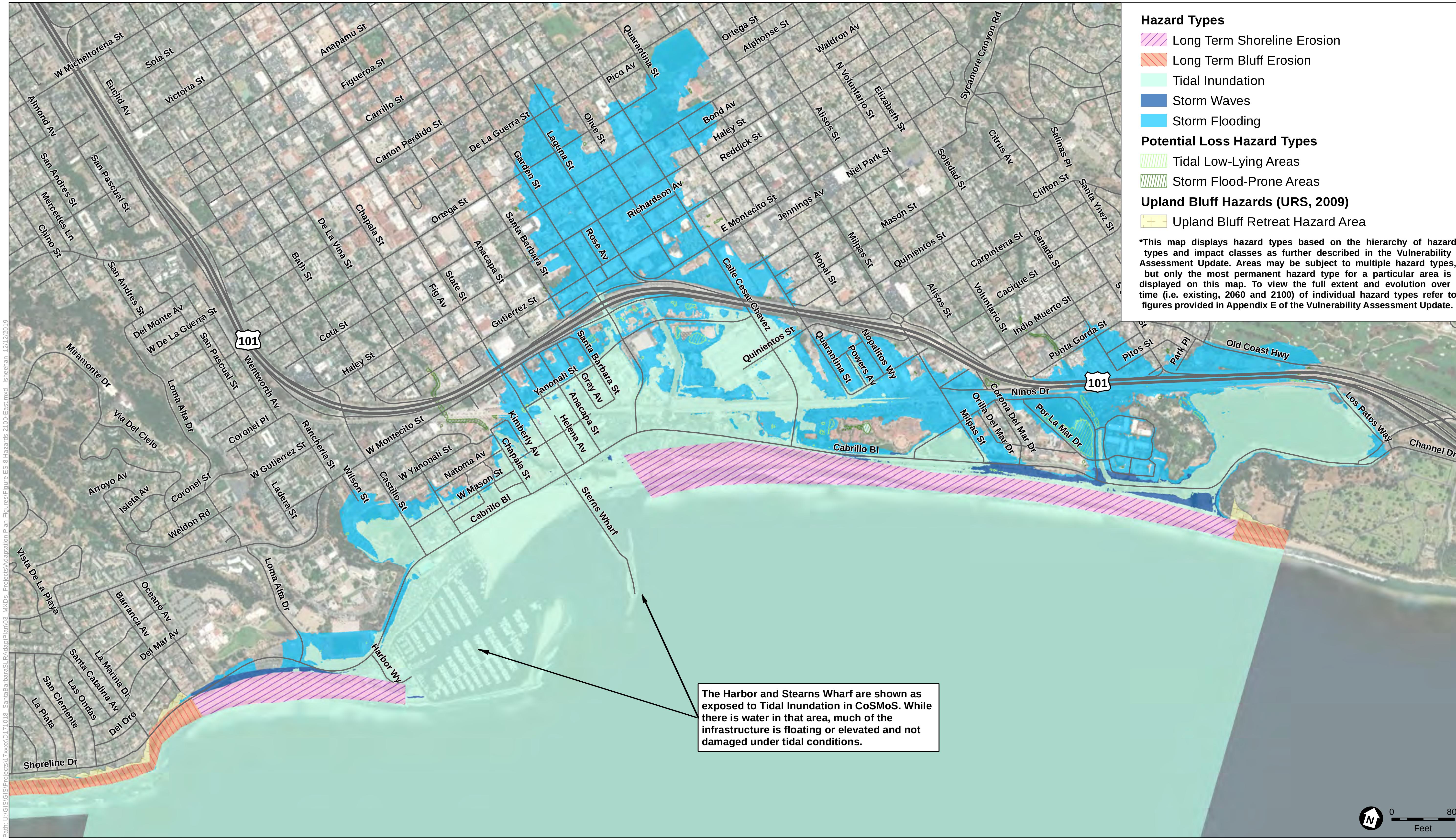

SOURCE: USGS, ESA

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-12
Hazards with 6.6 Feet of Sea-Level Rise (±2100) (East)

SOURCE: USGS, ESA

City of Santa Barbara Sea-Level Rise Adaptation Plan for the LCP Update

Figure ES-13
Hazards with 6.6 Feet of Sea-Level Rise (±2100) (West)

ESA

Guiding Principles for Adaptation

The City's Sea-Level Rise Adaptation Plan Subcommittee, in consultation with City staff, developed the following principles to guide the prioritization and selection of adaptation strategies. These Guiding Principles provide a foundation upon which future project decisions could be made and help in evaluating how well adaptation actions could help meet established community values and expectations:

1. Prioritize:
   a. Protection of human life, health, and safety
   b. Critical facilities, public transportation systems, and public services for basic city functions
2. Minimize the impacts of sea-level rise and related hazards to:
   a. Coastal-dependent development
   b. Public access to and along the shoreline, beaches, parks, open spaces, and recreation
   c. Existing and future development
   d. The local economy
   e. Coastal resources
3. Design adaptation strategies that:
   a. Use best available science and technology
   b. Are flexible and which have processes for updates based on new information.
4. Ensure that adaptation strategies:
   a. Minimize the risks of coastal hazards
   b. Are legally, technically, and financially feasible
   c. Are consistent with federal and state laws
   d. Avoid, where feasible, or minimize impacts to coastal resources
   e. Do not preclude or prevent implementation of future adaptation strategies to address longer-term hazards
5. Encourage:
   a. Adaptation strategies that broadly protect the community's health, safety, and welfare.
   b. Equitable sharing of costs and benefits of sea-level rise and related hazards
   c. Adaptation strategies that benefit or minimize impacts to vulnerable populations that may have a higher sensitivity and lower adaptive capacity to hazards
   d. Adaptation strategies that have co-benefits, such as greenhouse gas reduction, resiliency to other climate change impacts, habitat protection or creation, protection and creation of recreation opportunities, improvements to coastal resources, or economic enhancement

e. Emergency response and recovery coordination that factor in increased hazards due to sea-level rise

f. Greenhouse gas reductions as a key aspect of resiliency planning.

g. Voluntary and proactive resilience actions through incentives such as streamlining permitting.

h. Adaptation strategies and programs that build coastal resiliency partnerships.

Adaptation Approach

This Adaptation Plan considers three planning horizons which are consistent with the sea-level rise scenarios presented in the Vulnerability Assessment Update:

1. ***Near-term***: 0–0.8 feet of sea-level rise (approximately 2020–2030).
2. ***Mid-term***: 0.8–2.5 feet of sea-level rise (approximately 2030–2060).
3. ***Long-term***: 2.5–6.6 feet of sea-level rise (approximately 2060–2100).

Vulnerabilities and recommendations for adaptation are summarized below by area or resource (**Figure ES-14**) of the city affected. Tables and figures at the end of each section below also summarize the recommendations.

In the near-term, it is recommended that the City develop and implement a Shoreline Monitoring Program in coordination with other regional, state, and federal agencies. The program should include:

- Monitoring of sea-level-rise-related hazards, including tracking of sea levels, future sea-level rise projections, groundwater levels, beach width, and bluff top position;
- Identification of action thresholds; and
- Regular reassessment of the need for implementation actions.

The program should be designed to be cost-effectively maintained. The program should also emphasize transparency and communicating the results to the public. All data should be available for public use and the results readily available.

SOURCE: ESA

Figure ES-14
Adaptation Plan Hazard Areas

Coastal Bluff Areas

Coastal bluffs extend along the westerly portion of the city's coastal zone from Sea Ledge Lane to Santa Barbara Point by Leadbetter Beach. There are also coastal bluffs at the far easterly portion of the city by the Bellosguardo Estate. Only a few small portions of the bluff area along the City's shoreline are currently protected by shoreline protection devices. Shoreline protection devices, such as seawalls and rock revetments, are structures along the coast that can provide flood and erosion protection for properties, but which can result in accelerated erosion of sandy beach areas in front of (seaward) and adjacent to the devices.

Historic coastal bluff erosion rates could increase by 40% with 2.5 feet of sea-level rise and 140% with 6.6 feet of sea-level rise. The increased erosion rates would threaten bluff-top infrastructure, private development, and public development. By 2.5 feet of sea-level rise, bluff erosion is expected to affect properties in the bluff-top residential neighborhoods, infrastructure at Shoreline Park, and portions of Shoreline Drive. By 6.6 feet of sea-level rise, erosion could extend to Shoreline Drive, Cliff Drive, and other bluff-top streets at several locations.

Most of the sandy beaches along the city's westerly coastal bluff areas are likely to be lost from beach erosion by 2.5 feet of sea-level rise.

Recommended near-term actions along the bluffs include the following:

- Closely monitoring beach and bluff erosion.
- Expansion of existing drainage best management practices to reduce the rate of bluff erosion from runoff and irrigation.
- Continuation of current policies that require bluff setbacks for new development and substantial redevelopment and limitations on the use of revetments except to protect essential public services, major public roads, and public beach access stairways.
- Relocation or removal of non-critical assets (e.g., pathways, benches) in Shoreline Park and Douglas Family Preserve.

Beach nourishment and sand retention structures could possibly preserve the beaches along the bluffs and reduce bluff erosion to a certain extent; however, due to high sediment transport rates and a relatively steep slope of the beach along the bluffs, the effectiveness and feasibility of beach nourishment and sand retention structures is questionable and would need to be analyzed further. Multiple sand retention structures (e.g., a groin field) along the bluffs are not expected to be a practical or economical approach to reduce bluff erosion. Focused use of sand retention structures could possibly help to maintain beach sand in select locations along the bluff (e.g., for access), but would likely increase erosion immediately down-current of the structure.

Installation of revetments along the bluffs in the near-term would likely substantially increase the rate of beach loss and limit near-term public access along the beaches. Because of high costs and difficulties associated with permitting, revetments are not recommended unless used to protect major public roads, essential public services, or public beach access stairways.

In the mid-term, erosion of public and private assets will accelerate and public use of many of the bluff-backed beaches will likely be lost to erosion. During the mid-term, the City could consider:

- Use of revetments and slope stabilization on a larger scale to protect Shoreline Drive, Cliff Drive, public access along the top of the bluffs, or a useable portion of Shoreline Park, or
- Removal and relocation of infrastructure, roads, and development.

Additional information and studies will be needed to inform selection of options in the mid and long-term. **Figure ES-15** summarizes the vulnerabilities and adaptation options for the coastal bluff areas.

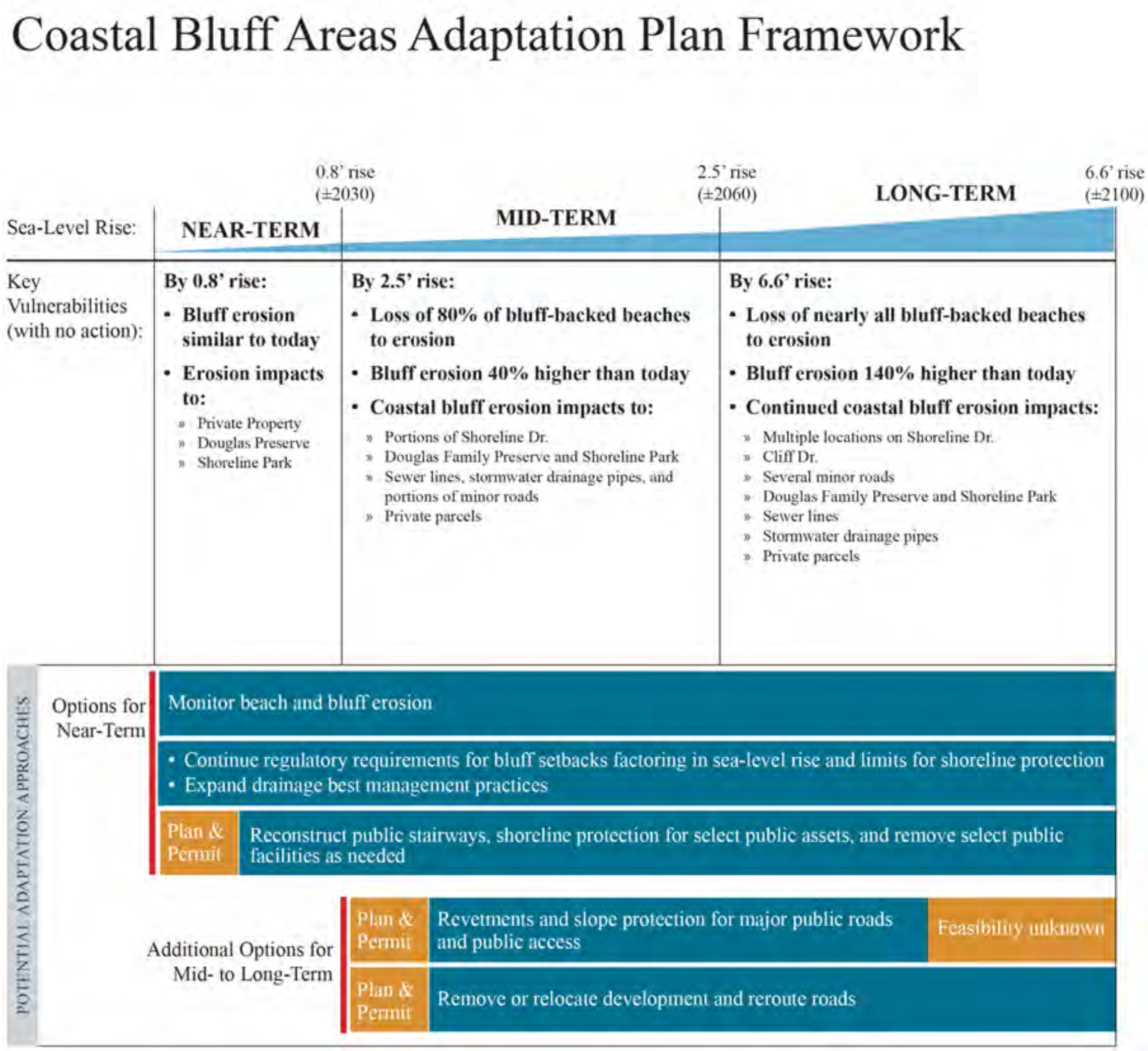

Figure ES-15
Bluff Adaptation Plan Framework

Low-Lying Waterfront and Beach Areas

The low-lying waterfront and beach areas are publicly owned and include Arroyo Burro Beach and the city's waterfront south of Cabrillo Boulevard spanning from Leadbetter Beach to East Beach.

While the beaches at the waterfront will not experience the same level of loss as the bluff areas due to the presence of the Harbor breakwater, sea-level rise will still cause increased levels of erosion, with East Beach most affected. If no action is taken, storm waves are expected to impact beach parking lots and Cabrillo Pavilion by 0.8 feet of sea-level rise. By 2.5 feet of sea-level rise, impacts from storm waves could extend to Shoreline Boulevard near Leadbetter Beach and Cabrillo Boulevard by Stearns Wharf. At 2.5 feet of sea-level rise, the Boathouse Restaurant at Arroyo Burro Beach could be impacted by erosion and storm flooding. By 6.6 feet of sea-level rise, tidal inundation could extend along much of Cabrillo Boulevard northward to Highway 101.

In the near-term, it is recommended that the City optimize its existing sand bypassing and study expansion of its beach nourishment and seasonal sand berm programs at East Beach, Leadbetter Beach, and Arroyo Burro Beach. Regardless of any beach nourishment that occurs, the City will need to plan for either the relocation, floodproofing, or protection of major wastewater and water pipelines that are located south of Cabrillo Boulevard and possibly other assets. As public assets in this area are redeveloped, options to avoid hazard areas or mitigation of hazards through elevation of structures or flood walls should be considered.

In the mid and long-term, the City could consider options such as:

- Installation of large-scale shoreline protection devices or levees along the city's waterfront, either by raising Cabrillo Boulevard and Shoreline Drive or by installing a seawall along the waterfront;
- Relocation or removal of waterfront assets;
- Rerouting portions of Shoreline Drive and Cabrillo Boulevard; and
- Installation of groins or artificial reefs if additional studies show them to be feasible and effective.

Additional information and studies will be needed to inform selection of options in the mid- and long-term. **Figure ES-16** summarizes the vulnerabilities and adaptation options for the low-lying waterfront and beach areas.

Low-Lying Flood Areas

The low-lying flood areas are the areas north of Cliff Drive by Arroyo Burro Creek, north of Shoreline Drive by Santa Barbara City College, and north of Cabrillo Boulevard that are projected to be impacted by increased flooding as a result of sea-level rise.

Impacts are projected to be mostly limited to the area seaward of Cabrillo Boulevard, Shoreline Drive, and Cliff Drive with 2.5 feet of sea-level rise. By 6.6 feet of sea-level rise, however, flooding from regular high tides and coastal storms could extend north of Cabrillo Boulevard to Highway 101. Low-lying areas north of Highway 101 that currently flood during extreme storms could see a higher frequency of flooding during large coastal storms.

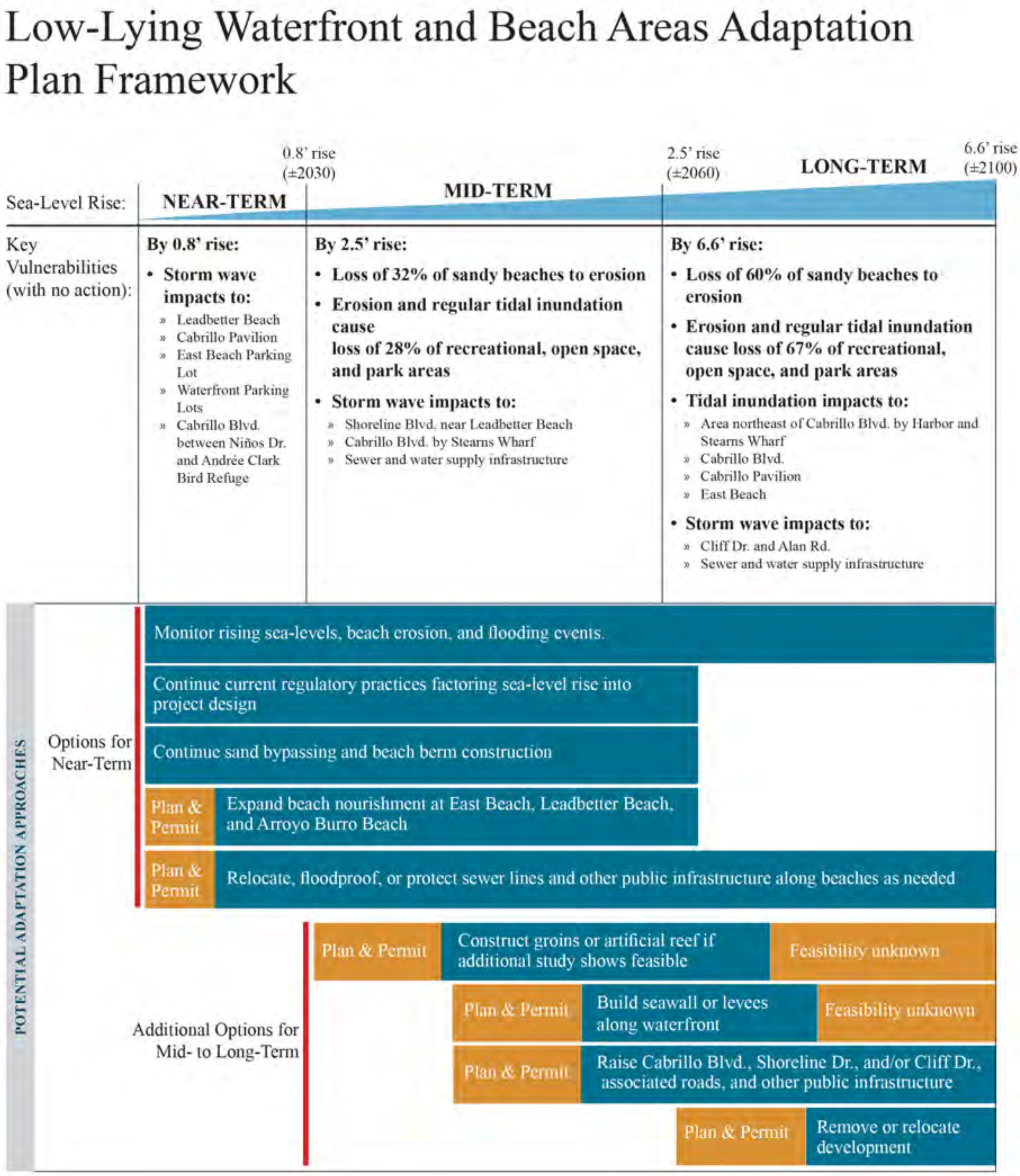

Figure ES-16
Low-Lying Waterfront and Beach Adaptation Plan Framework

In the near-term, it is recommended that the City reconstruct and redesign the tide gates and pumps at Laguna Creek. The City could also consider altering floodplain and building regulations to require new and substantially redeveloped buildings to be elevated or floodproofed to higher flood elevations, particularly south of Highway 101. The City could also consider changes to creek setbacks, particularly if additional studies on the interaction of sea-level rise and increased precipitation and creek flooding with climate change are conducted and indicate the need. Other additional studies needed include the effects of sea-level rise on groundwater levels, the potential for groundwater contamination to spread with changing water levels, and changes in rainfall patterns.

In the mid- and long-term, the City could consider options such as:

- Use of creek floodwalls,
- Groundwater pumping,
- Continuous seawalls or levees along the waterfront,
- Pumping of stormwater,
- Elevation and floodproofing of development, and
- Phased removal or relocation of development in tidal inundation areas.

Several additional studies will be needed to inform selection of options in the mid- and long-term. **Figure ES-17** summarizes the vulnerabilities and adaptation options for the low-lying flood areas.

Harbor and Stearns Wharf

By 2.5 feet of sea-level rise, the effects of sea-level rise could impede most Santa Barbara Harbor (Harbor) functions, high tides would exceed marina guide pile heights, and storm waves could significantly impact the Harbor if no action is taken. By 6.6 feet of sea-level rise, the Harbor would be unusable without major reconstruction.

Raising or modifying the Harbor breakwater, rock groin, and sandspit is recommended for the near-term and is the key to any other adaptation measures at the Harbor. The walkway and wall spanning from the breakwater to the Harbor commercial area should be raised or modified at the same time. The City should pursue U.S. Army Corps of Engineers (USACE) funding and assistance with these projects.

Renovation of the marinas and the City Pier (fueling dock) could be done in phases. All the marina piles need to be raised by the time 1 foot of sea-level rise occurs. The City Pier will need to be modified and raised by the time 0.5–1.0 foot of sea-level rise occurs.

At around 0.5 foot of sea-level rise, the City will need to consider how to protect the Harbor commercial area and parking lots. This could begin with raising the walkway or adding walls around the Harbor and along the beachfront. As structures are reconstructed, relocation and/or floodproofing should be considered. In the mid- and long-term, the City could consider options such as continuing to raise seawalls, floodproofing development, raising the grades of the Harbor commercial area and parking lots, or removal or relocation of certain Harbor facilities.

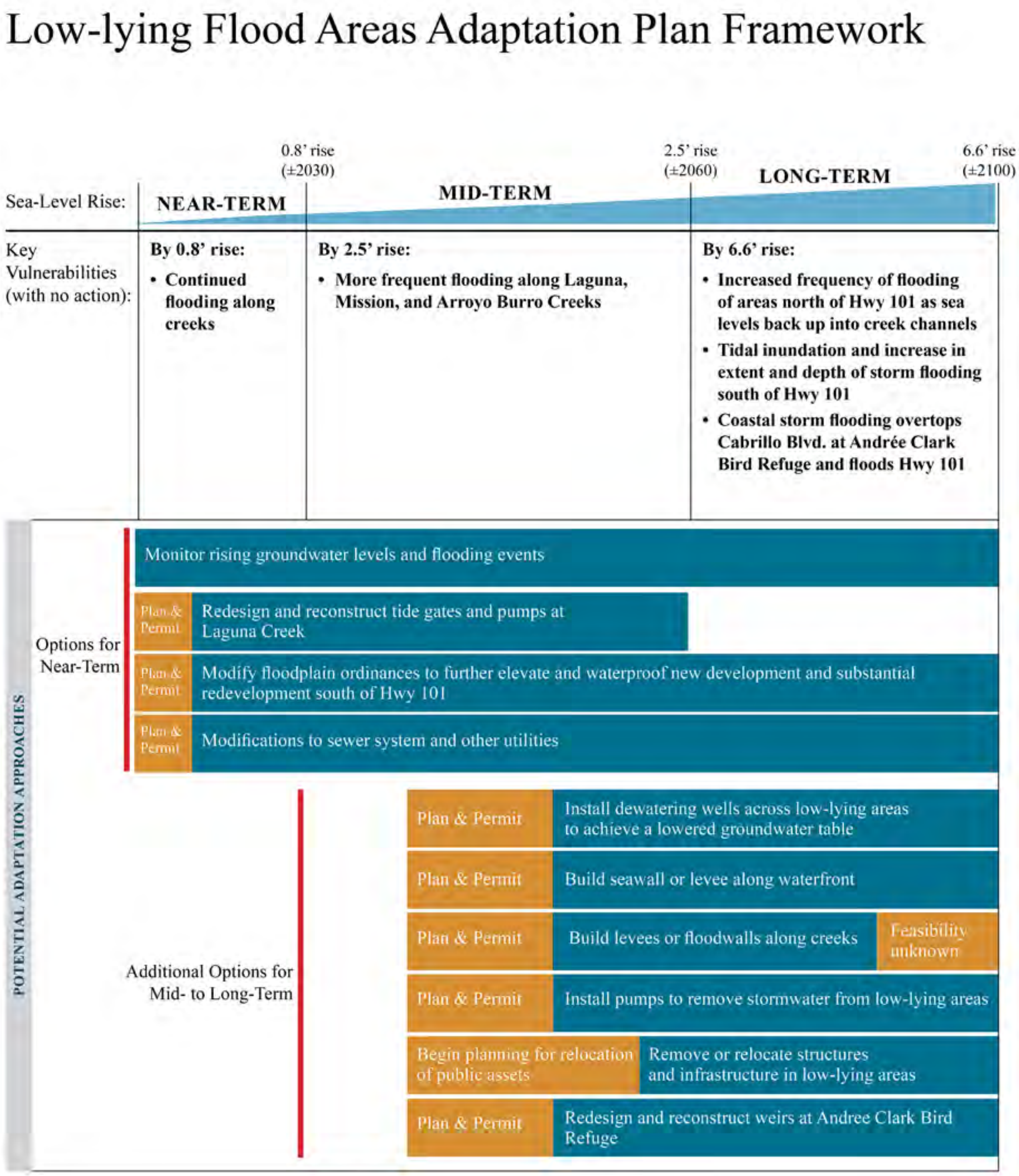

Figure ES-17
Low-Lying Flood Area Adaptation Plan Framework

Stearns Wharf is already at risk for damage under extreme coastal storm events. It is likely that by 2.5 feet of sea-level rise, storm waves would have already significantly damaged the wharf, as currently constructed. In the near-term, the City should initiate further studies to inform either reconstructing, relocating, or removing Stearns Wharf when the hazard impacts become too great. **Figure ES-18** summarizes the vulnerabilities and adaptation options for the Harbor and Stearns Wharf.

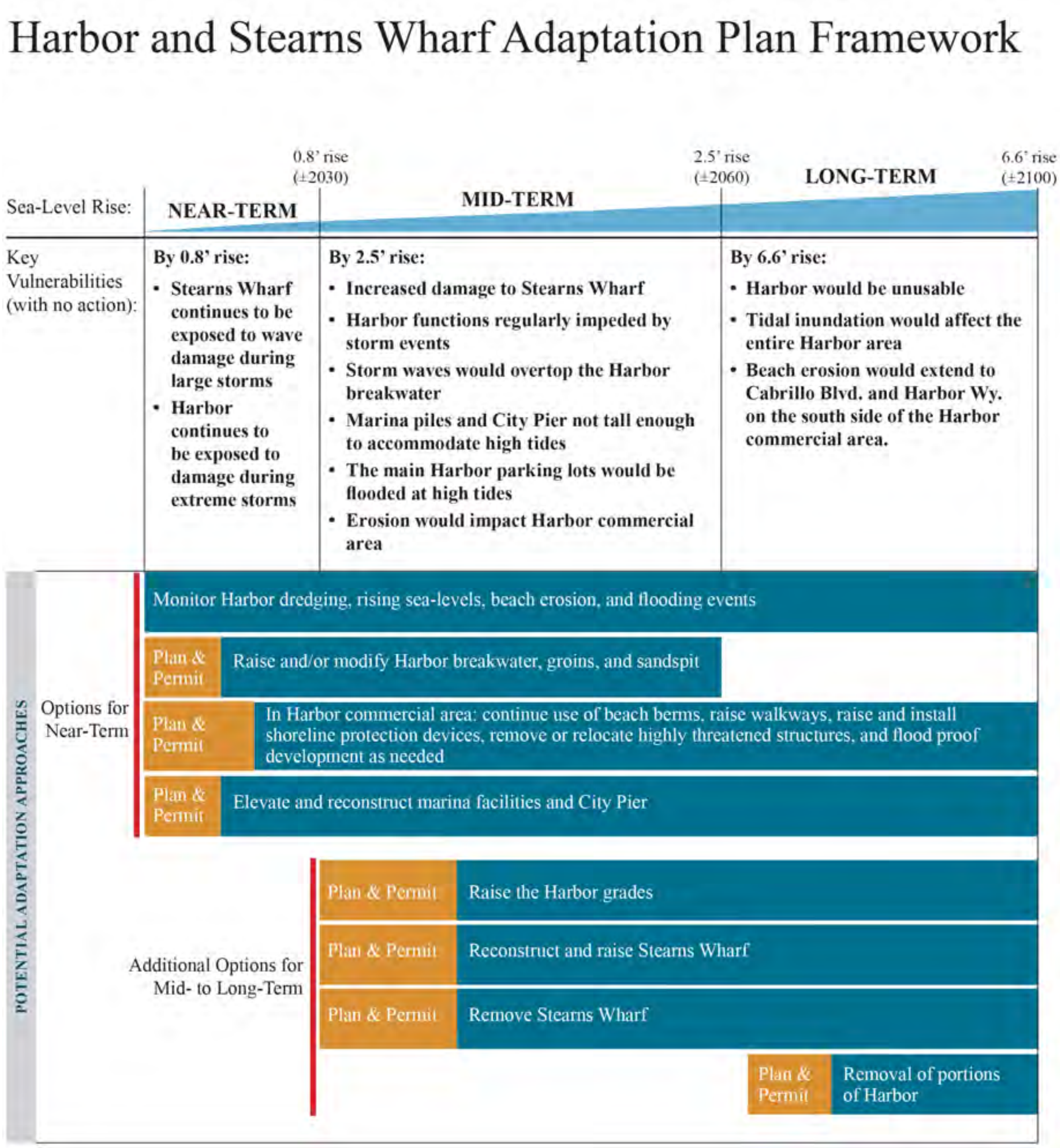

Figure ES-18
Harbor and Stearns Wharf Adaptation Plan Framework

Major Infrastructure

The El Estero Water Resource Center is located on a property higher in elevation than surrounding areas. The primary issue in the next thirty years or so, therefore, is not the plant itself, but the collection and distribution systems feeding into and out of the plant. By 2.5 feet of sea-level rise, portions of the wastewater system south of Cabrillo Boulevard could be affected by tidal inundation and storm flooding. If no action is taken, El Estero Water Resource Center would be permanently inoperable as currently designed by 6.6 feet of sea-level rise. This would impact wastewater service and recycled water service for the City's entire service area, including service to inland residential and commercial areas.

While the Vulnerability Assessment Update and this Adaptation Plan contain some information about exposure of the City's wastewater and recycled water systems, it is recommended that, in the near-term, the City initiate a comprehensive study of vulnerabilities and adaptation options for the wastewater, water, recycled water, and stormwater systems. The study should include possible redesign of portions of the systems, possible service point improvements, and options for the El Estero Water Resource Center. In the near-term, the City should also study specific options for relocation and/or floodproofing of major wastewater, water, and utility lines and infrastructure south of Cabrillo Boulevard.

The Charles E. Meyer Desalination Plant is located north of the El Estero Water Resource Center and is not likely to be exposed to increased hazards by 2.5 feet of sea-level rise, but is likely to be exposed to tidal inundation and storm flooding by 6.6 feet of sea-level rise if no action is taken. When the facility is due for major renovations (20–30 years), the City should consider options such as berms and floodwalls, or relocating the facility.

Most major streets in the coastal areas are not likely to be significantly impacted by 2.5 feet of sea-level rise; however, some protection may be needed at select locations along Shoreline Drive and Cabrillo Boulevard. However, by 6.6 feet of sea-level rise, portions of Cabrillo Boulevard, Shoreline Drive, Cliff Drive, and Highway 101 could be impacted by erosion, tidal inundation, or storm flooding if no action is taken. Additionally, the Union Pacific Railroad is projected to be exposed to tidal inundation and storm flooding at multiple locations by 6.6 feet of sea-level rise. Adaptation options for these transportation corridors match with the adaptation options identified for each hazard area they are located in (see above) and include options such as raising roads and the railroad, use of seawalls and revetments, and rerouting of transportation corridors as necessary.

Socioeconomic, Economic, and Fiscal Impacts

In total, approximately 1,250 parcels could be impacted by increased levels of flooding and erosion with 6.6 feet of sea-level rise. In addition, increased flooding could potentially impact socially and economically vulnerable populations in the lower westside and eastside neighborhoods that could have a lower capacity to respond and adapt to hazards.

A Benefit-Cost Analysis prepared by AECOM (Appendix B) estimates that if no action is taken to mitigate hazards, the cumulative economic, fiscal, business, and direct property impacts from now through to 6.6 of sea-level rise (approximately 2100) could be as much as $4.1 billion (2018 dollars and values). As analyzed in the Benefit-Cost Analysis, implementing adaptation strategies to protect development in place would result in the avoidance of many of these economic and fiscal impacts, but would also be very costly. In some cases, costs of protection can outweigh the economic and fiscal impacts avoided. Moving forward, the City will need to be selective in choosing adaptation actions. A key step moving forward with implementation will be prioritizing adaptation actions and closely looking at costs, funding options, and relative benefits of various projects as they are proposed.

Near-Term Actions and Next Steps

The following are recommended potential near-term (0–0.8 feet of sea-level rise; approximately 10 years) actions to address the hazards associated with sea-level rise. Actions that are important to initiate in the next five years are preliminary designated below as "high priority in the next five years." Actions that are of the highest priority to initiate in the first few years of implementation are bolded. In addition to the near-term actions listed below, all projects proposed near the potential hazard areas outlined in the Adaption Plan should be developed with consideration for how they affect or may be impacted by the phased sea-level rise adaptation approach presented in this plan.

The immediate next step that the City should take is the development of a Five-Year Implementation Plan that prioritizes and further refines these actions and identifies potential costs, funding options, timelines, resources needed, and responsible staff for each action. Implementation of adaptation actions will require continuous tracking to measure effectiveness. Changing conditions, changes in best available science, new technologies, new funding sources, and changes in community priorities will necessitate regular reevaluation of appropriate adaptation strategies and, potentially, identification of new strategies. The Five-Year Implementation Plan should be regularly updated as projects are scoped and undertaken and in response to finding from the proposed Shoreline Monitoring Program. Reevaluation of the overall Adaptation Plan is then recommended to occur approximately every five to ten years in response to substantive new information, such as major updates to the State of California Sea-Level Rise Guidance sea-level rise projections. As the City further develops its Adaptation Program, emphasis should be placed on public transparency and outreach.

During implementation, specific near-term actions recommended in this Adaptation Plan would be further scoped and developed by the City department with the expertise needed for the project, and the normal City approval process associated with each particular action would be undertaken. There is a need, however, for a central staff team to coordinate the Adaptation Program, including leading studies, developing the Shoreline Monitoring Program, developing the five-year implementation plan, tracking progress, tracking funding, sharing relevant information, and conducting public education and outreach.

Citywide Actions	
High Priority for Next Five Years	• Develop and regularly update a Five-Year Implementation Plan that further refines and prioritizes actions and identifies potential costs, funding options, timelines, resources needed, and responsible staff for each action. • Reevaluate the Adaptation Plan approximately every five to ten years and amend the plan based on changed conditions, changes in best available science, new technologies, new funding sources, and changes in community priorities. • **Develop and implement a Shoreline Monitoring Program in coordination with other regional, state, and federal agencies. The program should include: monitoring of sea-level-rise-related hazards; identification of action thresholds; and regular reassessment of the need for implementation actions. The program should emphasize public understanding and transparency. All data should be available for public use and the results readily available. *(Highest Priority)*** • Amend or create City administrative policies, procedures, initiatives, and staffing to implement the Adaptation Plan and ensure consistency in approach for addressing sea-level rise citywide. • Track grant programs and vigorously pursue other funding sources for implementation. • **Amend the City's Hazard Mitigation Plan to include potential adaptation actions so that the City is eligible for federal funding for adaptation projects. *(Highest Priority)*** • Initiate amendments to update the City's Local Coastal Program, General Plan, Climate Action Plan, and the Municipal Code to implement Adaptation Plan policies and to incorporate adaptation to sea-level rise into hazard maps and development standards. • Incorporate adaptation actions into the City's Capital Improvement Program. • Engage with the California State Legislature's office, the Governor's office, and California State Legislature Representatives on local needs, funding, and legislative changes related to sea-level rise adaptation. • Coordinate with regional, state, and federal agencies on monitoring, joint studies, and implementation of adaptation strategies. • Participate in regional and statewide climate collaboratives. • Maintain a working group composed of key City departmental staff involved in adaptation planning for the City. • Maintain a Sea-Level Rise Subcommittee comprised of members of City council and relevant City advisory bodies and commissions to guide adaptation planning for the City. • Engage with the community and stakeholders during Adaptation Plan and Local Coastal Program updates and implementation of adaptation projects. • Identify funding sources to assist property owners with adaptation. • Continue and expand public education on sea-level rise and adaptation. • Where appropriate, include hazard disclosures and risk indemnifications in conditions of approval for permits and other City documents such as parcel information documents and databases, leases, or service contracts to properties in hazard areas. • Consider amending the City's legislative platform and working with the State to include information about the hazards related to sea-level rise in real estate disclosures. • Research and monitor case studies, laws, and court cases that may affect implementation of the Adaptation Plan. • Further study the socioeconomic impacts of sea-level rise and potential adaptation options.

Coastal Bluff Areas (see Section 6)	
	• For new development and substantial redevelopment, continue the current regulatory practice of requiring bluff setbacks that factor in accelerated bluff erosion rates from • Continue the current regulatory practice of limiting the construction of shoreline protection devices where feasible, except when necessary to protect essential public
Additional Actions	• Expand best management practices to reduce the rate of bluff erosion as a result of runoff and irrigation. • Plan for removal, relocation, or, as needed, protection of public assets and natural resources in Shoreline Park and Douglas Family Preserve. • Plan for repairs or replacement of public access beach stairways as needed. • Plan for protection of Shoreline Drive at select locations when erosion levels trigger action. • Further study safe bluff setbacks and trigger distances, which will be used to inform the City on when adaptation measures are needed. • Further study whether slope protection measures along the upper bluff face (gunite, soldier piles, etc.) would be needed in addition to shoreline protection at the base of bluffs to protect major public roads and bluff-top access areas in the mid- and long-term.

Low Lying Waterfront and Beach Areas (see Section 7)	
High Priority for Next Five Years	• Monitor rising sea-levels, beach erosion, and flooding events (see Shoreline Monitoring Program above). • **Study and implement options to optimize existing sand bypassing and beach berm construction programs at East Beach and Leadbetter Beach. Monitor amounts of bypassed sand regionally. *(Highest Priority)*** • **Study and implement additional beach nourishment, additional seasonal sand protective berms, or formation of dunes at East Beach, Leadbetter Beach, and Arroyo Burro Beach. *(Highest Priority)*** • Work with the Beach Erosion Authority for Clean Oceans and Nourishment to update the 2009 Coastal Regional Sediment Management Plan to factor in changes associated with sea-level rise. • Continue current regulatory practice of limiting uses in the low-lying waterfront and beach areas and requiring that new development and substantial redevelopment be designed to avoid or mitigate hazards associated with sea-level rise.
Additional Actions	• As needed, consider options such as shoreline protection, floodproofing, and removal or relocation of select public facilities as they are redeveloped or become threatened. • Further study specific beach width thresholds for initiating consideration and planning for large-scale adaptation options along the waterfront and beach area.

Low Lying Flood Areas (see Section 8)	
	• Monitor rising groundwater levels and flooding events (see Shoreline Monitoring • **Redesign and reconstruct the Laguna tide gate and pump system. (Highest** • Study extreme rainfall runoff and creek discharge flooding in Laguna Channel with • Consider changes to the City's floodplain ordinance in flooding areas impacted by sea-level rise. In particular, consideration should be given to requiring additional floodproofing of new development and substantial redevelopment in the areas south of Highway 101 that could, as a result of sea-level rise through the long-term (6.6 feet of sea-level rise), experience tidal inundation and storm flooding levels that are deeper and more extensive than those currently mapped on FEMA Flood Insurance • Develop incentives for floodproofing and raising existing structures in areas at risk of increased flooding (e.g. potential permit streamlining or relief from design, zoning, or
Additional actions	• Study changes in flooding as a result of: (1) riverine flood events interacting with higher sea levels and (2) changes in rainfall and riverine flooding due to climate change. Develop monitoring and adaptation thresholds for creek flooding. • Evaluate whether existing creek and estuary development setbacks and other development regulations near creeks (e.g. bridge designs) are adequate based on impacts of sea-level rise and changes in riverine flooding from climate change. • Study existing groundwater elevations, the freeboard from typical levels up to a flood threshold, and potential impacts of sea-level rise. Study the potential of raised groundwater levels to spread contamination in soils and groundwater. Study the feasibility of groundwater pumping to lower the water table. • Further study feasibility of creek floodwalls, tide gates, continuous seawall, levees, or other identified measures to prevent inundation and storm flooding. Incorporate habitat considerations into designs to the extent feasible.

Harbor (see Section 9)	
High Priority for Next Five Years	• Monitor Harbor dredging, rising sea-levels, beach erosion, and flooding events (see Shoreline Monitoring Program above). • **Raise or modify the Harbor breakwater, rock groin, sandspit, and the walkway and wall spanning from the breakwater to the Harbor commercial area. Pursue Army Corps of Engineers feasibility studies, funding, and assistance with these projects. *(Highest Priority)*** • **Renovate marina facilities and the City Pier in phases. All marinas piles need to be raised by the time 1 foot of sea-level rise occurs. The City Pier needs to be modified and/or raised by the time 0.5–1.0 foot of sea-level rise occurs. *(Highest Priority)*** • Continue use of beach berms and consider additional beach or dune nourishment south of the Harbor commercial area. • Continue the current regulatory practice of limiting uses in the Harbor and requiring that new development and substantial redevelopment be designed to avoid or mitigate the impacts associated with sea-level rise.

Harbor (see Section 9)	
Additional Actions	• As needed, consider raising existing seawalls, adding new shoreline protection, floodproofing development, and removing or relocating structures as they are either redeveloped or become threatened. • At 0.5 foot of sea-level rise, start planning for the protection of the Harbor commercial area and parking lots. This could start with raising the walkway or raising/adding walls around the Harbor and along the beachfront. In the mid-term, options to study could include raising Harbor grades and elevating and floodproofing structures.

Stearns Wharf (see Section 9)	
High Priority for Next Five Years	• **Study appropriate triggers for temporarily closing Stearns Wharf during major storms and other safety measures. *(Highest Priority)***
Additional Actions	• At 0.5–1.0 foot of sea-level rise, prepare alternatives analysis considering raising, relocating, redesigning, or removing the Wharf. Study should also assess thresholds for initiating actions on Stearns Wharf based on acceptable levels of risk.

Major Infrastructure (see Section 10)	
High Priority for Next Five Years	• Monitor utility system and transportation system interruptions, rising sea-levels, beach erosion, and flooding events (see Shoreline Monitoring Program above). • **Study options for relocation and/or flood proofing of major wastewater, water, and utility lines and infrastructure south of Cabrillo Boulevard. *(Highest Priority)*** • Initiate a comprehensive study of adaptation options for threatened portions of the wastewater system, including redesign of portions of the system, adaptation options for El Estero Water Resource Center, and possible service point improvements.
Additional Actions	• Study the potential impacts to the stormwater system from sea-level rise and possible adaptation options. • Study the potential impacts to the water system from sea-level rise and possible adaptation options. • Coordinate with electrical and natural gas utility providers to further assess potential impacts and adaptation options for the energy transmission and distribution systems.

Section 1

INTRODUCTION

1.1 Purpose and Objective

Although Santa Barbara has experienced only a relatively small amount of sea-level rise to date from climate change, the rate of sea-level rise in the region is expected to accelerate significantly in upcoming years. Rising sea levels will result in increased hazards, including shoreline erosion and flooding. There is a need for the City and the community to better understand these vulnerabilities, to analyze the physical and economic risks, and to consider possible actions to prepare and adapt to the impacts of sea-level rise.

The City of Santa Barbara (City) prepared a Sea-Level Rise Vulnerability Assessment Update (Vulnerability Assessment Update) (Appendix A) that identifies areas of the city and public and private development that are projected to be affected by sea-level rise and related hazards through the year 2100 without any intervention. This document, the *City of Santa Barbara Sea-Level Rise Adaptation Plan* (Adaptation Plan), identifies a variety of adaptation strategies to help Santa Barbara plan for and address sea-level rise, coastal storm surge, coastal flooding, and erosion. It provides a framework for the City to plan for sea-level rise in phases through monitoring of impacts, tracking of new information, regular reevaluation of options, and implementation of adaptation strategies once specified thresholds for action are reached.

In accordance with the *California Coastal Commission Sea-Level Rise Policy Guidance* (CCC 2018), the Adaptation Plan:

- Is based on the best science and adaptation practices available today.
- Acknowledges that sea-level rise science and practices are evolving and that the City will evaluate future decisions and take action based on the best available science and technology at the time.
- Includes a range of sea-level rise adaptation strategies within the three general categories of adaptation: Protect, Accommodate, and Retreat.

*The members of **the Sea level Rise Interdepartmental Team** include staff from the following City departments: Planning Department, City Administrator's Office, City's Attorney's Office, Creeks Division, Finance Division, Parks and Recreation Department, Public Works Department, and Waterfront Department.*

***The Sea Level Rise Adaptation Plan Subcommittee** includes members of the City's Council, Water Commission, Harbor Commission, Parks and Recreation Commission, and Planning Commission. The members were appointed by the City Council in 2018. The Sea Level Rise Subcommittee met during a series of public meetings held in 2018 and 2019.*

The study area includes all portions of the city of Santa Barbara that are projected to be impacted by sea-level rise by the year 2100, with the exception of the Santa Barbara Airport and Goleta Slough, which have been the subject of separate studies.

The City's overall process for this Adaptation Plan includes: review by a City Sea-Level Rise Interdepartmental Staff Team; guidance from a Sea-Level Rise Adaptation Plan Subcommittee; consultations with the California Coastal Commission (CCC) and other regional, state, and federal agencies; and engagement with the community and various other stakeholders. Once all of these entities have provided comments on this Adaptation Plan, the plan will be revised. City Council will then consider approval of the revised plan and direct staff to begin any implementation actions necessary in the near-term.

The City's Local Coastal Program (LCP) is a planning and regulatory document that establishes a long-range vision for land use and regulates development in the city's coastal zone, consistent with the California Coastal Act. The City recently comprehensively updated its Coastal Land Use Plan that includes interim policies that begin to incorporate sea-level rise into development regulations.[2] An amendment to the City's LCP will be processed to include new policies and standards that will implement the adaptation strategies identified in this Adaptation Plan. The LCP Amendment will require approval by City Council and certification by the CCC. The City will take additional actions to facilitate the implementation of adaptation strategies as outlined in more detail in Section 14.

1.2 Plan Organization

The Adaptation Plan focuses on the following five hazard areas consistent with the organization of the Vulnerability Assessment Update (Figure 1-1):

1. Coastal bluff areas
2. Low-lying waterfront and beach area
3. Low-lying flood area
4. Santa Barbara Harbor and Stearns Wharf
5. Major infrastructure facilities (not displayed on the figure)

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2 An LCP Amendment to update the LCP Coastal Land Use Plan was certified by the CCC on August 9, 2019.

The Adaptation Plan is organized as follows:

- Section 1 identifies the purpose and objective of this Adaptation Plan, defines key terms and provides disclaimer and use restrictions for the information presented in this plan.

- Section 2 outlines the various plans and guidelines relevant to coastal hazard planning.

- Section 3 provides a framework for planning for sea-level rise.

  – Section 3.1 presents Guiding Principles for adaptation created by the Sea-Level Rise Adaptation Plan Subcommittee that guide the City in the prioritization and selection of adaptation strategies. These Guiding Principles provide a foundation upon which future project decisions can be made and help in evaluating how well adaptation actions will help meet established community values and expectations.

  – Section 3.2 outlines physical parameters that should be monitored over time, including sea levels, sea-level rise projections, beach widths, the locations of the toes and tops of bluffs, creek water levels, flood damages and frequency, and groundwater levels.

  – Section 3.3 and 3.4 discuss implementation and reevaluation.

- Section 4 describes the vulnerabilities to existing coastal resources in Santa Barbara.

- Section 5 describes adaptation strategies that could be considered for Santa Barbara. Three general categories of adaptation strategies were evaluated: (1) protection strategies that protect development in place through measures such as seawalls, revetments, breakwaters, groins, tide gates, and beach nourishment; (2) accommodation strategies that accommodate development in place through measures such as elevation, floodproofing, or modifications of structures; and (3) retreat strategies that avoid hazards through measures such as relocation of structures and development limitations.

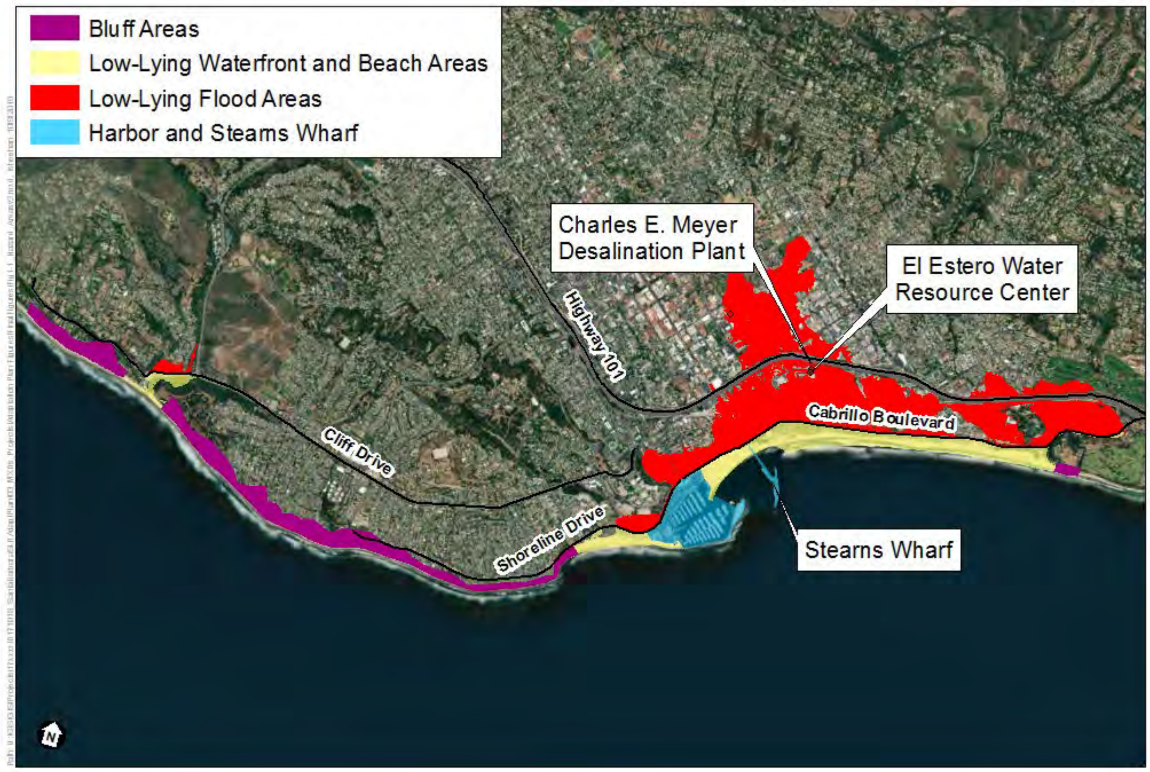
- Sections 6 through 10 evaluate the feasibility, effectiveness, relative costs, environmental impacts, and other key considerations associated with implementing strategies described in Section 5 in different areas of the city, as shown in Figure 1-1.

- Section 11 provides an analysis of the socioeconomic impacts of sea-level rise.

- Section 12 compares the potential hazards associated with a “no action scenario” presented in the Vulnerability Assessment Update with two potential adaptation scenarios that each employ different sets of Adaptation strategies in the near-, mid-, and long-term to address the impacts of sea-level rise. Section 11 also summarizes the results of a benefit-cost analysis (Appendix B) that compares the economic and fiscal impacts of the no action scenario with the relative costs and benefits of the two adaptation scenarios. The purpose of the adaptation scenario analysis is not to outline an exact proposed or preferred path forward for the City, but rather to bracket a wide range of possible actions the City could take to get a high-level understanding as to what is at risk economically and fiscally and the relative costs and benefits associated with actively planning for and adapting to sea-level rise.

- Section 13 presents tools for implementation of adaptation strategies such as policies, programs, regulatory mechanisms, education and outreach programs, agency resources, and potential funding options.

- Section 14 summarizes and prioritizes near-term adaptation actions that are recommended for the City in the next 10 years.



SOURCE: ESA

Figure 1-1
Adaptation Plan Hazard Areas

1.3 Key Terms and Definitions

The following terms are used throughout the document based on the definitions included in this section:

Riverine flooding refers to flooding originating from rainfall and high creek water levels.

Coastal flooding refers to flooding due to waves and high water levels originating from the ocean.

Coastal storms impact the shoreline through higher water levels and waves from the ocean and are commonly associated with low-pressure weather systems. Planning and analysis often occurs for the “100-year storm,” which is the storm estimated to have a 1% chance of occurring each year.

Coastal storm flooding refers to coastal flooding that occurs during coastal storm events.

Tidal inundation refers to coastal flooding during regular high tides under non-storm conditions.

Coastal erosion refers to loss of sandy beaches, dunes, and the low-lying backshore along the shoreline through natural processes such as waves, wind, or tides.

Coastal bluff erosion refers to loss of coastal bluffs as material falls or collapses onto the beach or into the ocean below.

Additionally, for the purposes of this Adaptation Plan, the terms near-term, mid-term, and long-term are defined as follows:

Near-term: 0–0.8 feet of sea-level rise (approximately 2020–2030).

Mid-term: 0.8–2.5 feet of sea-level rise (approximately 2030–2060).

Long-term: 2.5–6.6 feet of sea-level rise (approximately 2060–2100).

1.4 Disclaimer and Use Restrictions

1.4.1 Funding Agencies

These data and this report were prepared for the City of Santa Barbara and were partially funded by the CCC and the State Coastal Conservancy through the LCP Local Assistance Grant Program. The data and report do not necessarily represent the views of the funding agencies; their respective officers, agents, employees, and subcontractors; or the State of California. The funding agencies, the State of California, and their respective officers, employees, agents, contractors, and subcontractors make no warranty, express or implied, and assume no responsibility or liability, for the results of any actions taken or other information developed based on this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. These study results are being made available for informational purposes only and have not been approved or disapproved by the funding agencies, nor have the funding agencies passed upon the accuracy, currency, completeness, or adequacy of the information in this report. Users of this information agree by their use to hold blameless each of the funding agencies, study participants, and authors for any liability associated with its use in any form.

1.4.2 ESA

This information is intended to be used for planning purposes only. Site-specific evaluations may be needed to confirm/verify information presented in these data. Inaccuracies may exist, and Environmental Science Associates (ESA) implies no warranties or guarantees regarding any aspect or use of this information. Further, any user of these data assumes all responsibility for the use thereof, and further agrees to hold ESA harmless from and against any damage, loss, or liability arising from any use of this information.

Commercial use of this information by anyone other than ESA is prohibited.

1.4.3 Data Usage

These data are freely redistributable with proper metadata and source attribution. Please reference ESA as the originator of the datasets in any future products or research derived from these data.

The data are provided "as is" without any representations or warranties as to their accuracy, completeness, performance, merchantability, or fitness for a particular purpose. Data are based on model simulations, which are subject to revisions and updates and do not take into account many variables that could have substantial effects on erosion, flood extent and depth. Real-world results will differ from results shown in the data. Site-specific evaluations may be needed to confirm/verify information presented in this dataset. This work shall not be used to assess actual coastal hazards, insurance requirements, or property values, and specifically shall not be used in lieu of Flood Insurance Studies and Flood Insurance Rate Maps issued by the Federal Emergency Management Agency (FEMA).

The entire risk associated with use of the study results is assumed by the user. The City of Santa Barbara, ESA, and all of the funders shall not be responsible or liable for any loss or damage of any sort incurred in connection with the use of the report or data.

Section 2

RELEVANT PLANS, GUIDELINES, AND PERMITS

2.1 Relevant Plans and Guidelines

The following local, regional, and state plans, guidelines, and requirements informed the development of this Adaptation Plan.

2.1.1 California Coastal Act

In 1976, the California Legislature enacted the Coastal Act, which requires coastal cities and counties to protect coastal resources and maximize public access to the shoreline through a comprehensive planning and regulatory program by developing their own "local coastal programs" (i.e., LCPs). Pursuant to Section 30001.5 of the Coastal Act, the State's basic goals for the coastal zone are to:

1. Protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources.
2. Assure orderly, balanced utilization and conservation of coastal zone resources taking into account the social and economic needs of the people of the state.
3. Maximize public access to and along the coast and maximize public recreational opportunities in the coastal zone consistent with sound resource conservation principles and constitutionally protected rights of private owners.
4. Assure priority for coastal-dependent development over other development on the coast.
5. Encourage state and local initiatives and cooperation in preparing procedures to implement coordinated planning and development for mutually beneficial uses, including educational uses, in the coastal zone.

The Coastal Act requires all local governments located within the coastal zone to prepare an LCP. The two primary components of an LCP are the Coastal Land Use Plan and the Implementation Plan. The Coastal Land Use Plan establishes the kinds, locations, and intensities of new development allowed in the coastal zone, applicable resource protection and development policies, and other policies as necessary to achieve the objectives of the Coastal Act. The Implementation Plan typically consists of zoning regulations that establish development standards and procedural requirements that govern development within the jurisdictional area of the LCP. The Coastal Act states that once an LCP is certified by the CCC, the local government assumes responsibility for issuing coastal development permits for most of the development within its jurisdiction.

The City is certified to grant coastal development permits for nearly all development projects within the coastal zone. Portions of the city are subject to the permitting or appeals authority of the CCC based on criteria established in the Coastal Act. The CCC retains permitting authority over development occurring on tidelands, submerged lands (mean high tide line and seaward), and public trust lands, as stated in Section 30519(b) of the Coastal Act.

Coastal development permits for any development that constitutes a major public works project or a major energy facility may be appealed to the CCC. Action by the City on a coastal development permit within the Appeals Jurisdiction may also be appealed to the CCC.

2.1.2 City of Santa Barbara Local Coastal Program

The City's LCP guides the development review process within the coastal zone and promotes the protection and enhancement of coastal resources, including those that provide public access to the shoreline (City of Santa Barbara 1986 and 2019). Consistent with the California Coastal Act of 1976, the City's LCP includes policies that address land use and development, public access and recreation, coastal resource protection, coastal hazards and adaptation, and public services and facilities. The City's LCP consists of a Coastal Land Use Plan originally certified in 1981 and Implementation Plan originally certified in 1986. A comprehensive update to the Coastal Land Use Plan was certified by the CCC on August 9, 2019. The updated Coastal Land Use Plan includes interim policies that address hazards related to sea-level rise. Relevant policies from the updated Coastal Land Use Plan are described throughout this Adaptation Plan. The Coastal Land Use Plan directs the City to prepare this Adaptation Plan and a subsequent LCP Amendment with new policies, programs, and development standards that serve to implement the adaptation strategies identified in this Adaptation Plan.

2.1.3 City of Santa Barbara General Plan

The City's General Plan, comprising eight elements, serves as the blueprint for growth and development. Several of the elements address the preservation and management of coastal resources, including the Land Use Element, Environmental Resources Element, and Safety Element (City of Santa Barbara 2011). The General Plan identifies the waterfront area in particular as uniquely important to the economic base of the City and plays a major role in setting the character and quality of the community.

The Land Use Element states that maintaining open access and appropriate land uses in the coastal zone of the city is a high priority. The Land Use Element refers to the City's LCP as the guiding policy document for the city's shoreline.

The Environmental Resources Element includes several policies and goals addressing coastal preservation, including policies on coastal bluff habitat restoration and beach water quality improvement. In addition, the Environmental Resources Element directs the City to identify options, costs, and consequences for addressing sea-level rise issues. This includes identifying techniques to minimize wave energy and damage from coastal storm surges; reviewing city public improvements and utilities for consequences of sea-level rise and considering means of adaptation such as protect in place and managed retreat; and coordinating with private property owners along the waterfront on techniques for structural adaptation.

The Safety Element was fully updated in 2013 and identifies the city's waterfront area as the part of the city with the highest vulnerability to sea-level rise impacts. The Safety Element states that coastal bluff retreat and coastal flooding and inundation are known hazards for the city. The Safety Element includes several policies related to coastal bluff development, including coastal bluff development guidelines, investigations for coastal bluff retreat rates, structural setbacks for slope stability, bluff top drainage, and improvements to threatened coastal properties. The Safety Element also includes policies on coastal flooding and inundation, including monitoring for sea-level rise, identifying policies on sea-level rise adaptation, and developing a comprehensive Shoreline Management Plan.

2.1.4 Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan

The 2017 *Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan* (Hazard Mitigation Plan) was prepared as a joint effort between the Cities of Buellton, Carpinteria, Goleta, Guadalupe, Lompoc, Santa Barbara, Santa Maria, and Solvang and the County of Santa Barbara. The Hazard Mitigation Plan guides the County and cooperating Cities toward greater disaster preparedness and resistance. The purpose of the Hazard Mitigation Plan is to enhance public awareness and understanding of potential hazards, create a decision tool for management, promote compliance with state and federal program requirements, and provide inter-jurisdictional coordination of mitigation-related programming. The Hazard Mitigation Plan identifies relevant hazards in the region, including coastal storm surges, sea-level rise, coastal flooding, and erosion; describes the results of a vulnerability assessment of hazards; and recommends mitigation strategies. Mitigation strategies associated with coastal storm surges, sea-level rise, coastal flooding, and erosion include drainage improvements, incentives for flood-prone properties to retrofit homes or construct new homes to higher standards, floodplain management and mapping, and coastal bluff revegetation and stabilization.

2.1.5 City of Santa Barbara Municipal Code

Title 28 of the City's Municipal Code (SBMC) establishes regulations and procedural requirements for development within the coastal zone. Title 28 is part of the City's Implementation Plan of the LCP. The coastal zone is made up of different zoning districts, with each district establishing allowed land uses, dimensional standards, and parking standards. Chapter 22.24, Floodplain Management, of the SBMC establishes requirements for development in flood hazard areas citywide, including within the coastal zone. Title 30 of the SBMC is an update to Title 28 that is in effect outside the coastal zone, but has not yet been certified by the CCC for use in the coastal zone.

2.1.6 California Coastal Commission Sea-Level Rise Policy Guidance

The purpose of the 2018 *California Coastal Commission Sea-Level Rise Policy Guidance* document is to aid jurisdictions in incorporating sea-level rise into LCPs, coastal development permits, and regional strategies. The document outlines specific issues that policymakers and developers may face as a result of sea-level rise, such as extreme events, challenges to public access, vulnerability and environmental justice issues, and consistency with the Coastal Act. It organizes current scientific, technical, and other information and practices into a single resource to facilitate implementation of the Coastal Act by coastal managers at the state and local levels. The document also lays out the recommended planning steps to incorporate sea-level rise into planning strategies to reduce vulnerabilities and guide adaptation planning. The document has a strong emphasis on using soft or green (i.e., nature-based) adaptation strategies. It leverages best available science, consistent with other state guidance. This Adaptation Plan was prepared in accordance with the document.

2.1.7 State of California Sea-Level Rise Guidance

The 2018 *State of California Sea-Level Rise Guidance* document provides a science-based methodology for state and local governments to analyze and assess the risks associated with sea-level rise, and to incorporate sea-level rise into their planning, permitting, and investment decisions. The document provides a synthesis of the best available science on sea-level rise projections and rates for California; a step-by-step approach for state agencies and local governments to evaluate those projections and related hazard information in decision making; and preferred coastal adaptation approaches. This Adaptation Plan and associated Vulnerability Assessment Update uses the Santa Barbara–specific sea-level rise projections contained in the document.

2.1.8 Safeguarding California Plan

The 2018 *Safeguarding California Plan* provides a comprehensive suite of ongoing and needed Adaptation actions by state agencies responding to climate change. It serves as a roadmap of the ongoing actions and next steps being taken by the State to make its people, economy, and environment more resilient to the impacts of climate change. The document includes principles and recommendations that provide policy directives and a conceptual framework for state adaptation initiatives. The following are recommendations (or goal statements) for the ocean and coast sector:

1. Support planning and adaptation to reduce hazards and to increase the resilience of coastal communities, infrastructure, development, and other resources.
2. Design and implement nature-based projects to protect and enhance the adaptive capacity of coastal and marine ecosystems, including beaches and wetlands.

3. Develop actionable science that reflects the latest and evolving trends over a range of spatial and temporal scales.
4. Continue to assess community and ecosystem vulnerability to climate impacts.
5. Provide pathways for meaningful community engagement (such as education and outreach) in coastal decision-making processes.
6. Coordinate across agencies and external partners to ensure efficient problem solving and widely communicate resources for ocean and coastal adaptation strategies.

The document is not intended to establish guidelines for local governments on how to adapt to climate change, nor does it detail all actions that need to or should be taken by local governments. However, it does provide an extensive suite of goals and policies (or strategies) for various sector-specific areas.

2.1.9 California Adaptation Planning Guide

The 2012 *California Adaptation Planning Guide (APG)* provides a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development. The document is meant to be a resource for communities seeking to be in compliance with Senate Bill 379, which requires Safety Elements of General Plans to consider climate change.

The document includes a planning guide overview and three companion documents for use in various combinations:

- APG: Planning for Adaptive Communities – This document presents an overview for the basis for climate change adaptation planning and describes a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.
- APG: Defining Local and Regional Impacts – This document provides a more in-depth understanding of how climate change can affect a community. Seven “impact sectors” are included to support communities conducting a climate vulnerability assessment, including an ocean and coastal resources sector.
- APG: Understanding Regional Characteristics – The impact of climate change varies across the state. This document identifies climate impacts by region, including the central coast, as well as regional environmental and socioeconomic characteristics.
- APG: Identifying Adaptation Strategies – This document explores potential adaptation strategies that communities can use to meet varying adaptation needs. The adaptation strategies are organized by the following sectors: public health, socioeconomic and equity, oceans and coastal resources, water management, forest and rangeland, biodiversity and habitat, agriculture, and infrastructure. The following are the adaptation strategies identified for oceans and coastal resources:
    1. Develop an adaptive management plan to address the long-term impacts of sea-level rise.

2. Facilitate managed retreat from, or upgrade of, the most at-risk areas.
3. Require accounting of sea-level rise in all applications for new development in shoreline areas.
4. Preserve undeveloped and vulnerable shoreline.
5. Use transfer of development rights for the rebuilding of structures damaged or destroyed because of flooding in high-risk areas.

2.1.10 Coastal Regional Sediment Management Plan

Coastal Regional Sediment Management Plans are a statewide planning approach, led by the California Sediment Management Workgroup, that evaluate the interrelationships and impacts of coastal sediment processes within distinct littoral cells. The goals of Coastal Regional Sediment Management Plans are to inform regionally relevant sediment management policies that encourage conservation, restoration, and enhancement of sediment resources; reduction in coastal erosion; preservation of beaches; and development of solutions for areas impacted by excess sediment.

The 2009 *Santa Barbara Coastal Regional Sediment Management Plan* provides a detailed review of existing shoreline armoring and encroachment, shoreline trends, and shoreline processes within the Santa Barbara littoral cell, which spans from Point Conception to Pt. Mugu. Additionally, the document quantifies sediment sources from both riverine systems and episodic coastal bluff erosion within sub-littoral cell units and provides dredge estimates at the well-known sediment sinks (including the Santa Barbara Harbor (Harbor)).

Four primary challenges have been identified in the document: coastal processes and sand sources, upland watersheds, development, and governance. Based on these challenges, the document identifies both general region-wide opportunities and specific sub-littoral cell recommendations for activities, studies, management strategies, policies, and capital projects or proposals. For the City, which falls into both the Goleta and Santa Barbara Sediment Management sub-reaches, the document provides the following recommendations:

- Assess the feasibility of enhancing Arroyo Burro Beach using an offshore reef sand retention solution.
- Enhance the federal authority for the Harbor maintenance dredging project to dual purpose, navigation, and regional sediment management for beneficial reuse.
- Designate and permit West Beach as a regional beneficial reuse borrow site.
- Implement a multipurpose sand retention solution at Arroyo Burro Beach, as appropriate.
- Implement one of more feasible multipurpose offshore reef sand retention solutions.

The Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) plans to update the document in the near future to include sea-level rise impacts and the dynamics of cobbles and muds, in addition to sand transport. Additionally, BEACON plans to develop a Regional Opportunistic Sediment Placement Program as part of the update. This Adaptation Plan includes recommendations from the document. Once available, the Regional Opportunistic Sediment Placement Program should inform the adaptation strategies in subsequent updates to this Adaptation Plan as appropriate.

Beach Erosion Authority for Clean Oceans and Nourishment (BEACON)

Beacon is a California Joint Powers Agency 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

2.1.11 Waterfront Sediment Management Plan

The 2011 Waterfront Sediment Management Plan is a comprehensive, 10-year management program that describes maintenance dredging, sediment disposal, beach nourishment, storm drain outlet maintenance, and beach grooming at the Harbor and waterfront area. The goals of the document are to maintain the area for safe maritime traffic navigation; minimize risk of hazardous shoaling conditions; protect adjacent public, recreational, and commercial development from wave damage and flooding; maintain an appropriate sand balance to offset erosion; and maintain sandy beaches and area aesthetics. Sediment management activities occur on an as-needed basis depending on weather and the amount of natural sediment movement from up-coast sources. As part of the Waterfront Sediment Management Plan, the City received a coastal development permit (CDP #4-10-066) to establish a sediment management plan for Leadbetter Beach, West Beach, and East Beach. The permit was renewed for 10 years in 2011 and is composed of the following three parts related to beach sediment management:

Sediment management: A maximum of 500,000 cubic yards of material is dredged annually,[3] with actual amounts determined by USACE. Dredged sediments are tested for grain size and cleanliness prior to use in beach nourishment. Sand is added and removed to create “ideal” beach configurations as defined by the City. The ideal configuration of West Beach narrows a portion of the beach in the area of the small-boat sailing area. East Beach is managed to prevent Mission Creek from depositing sediment and debris around Stearns Wharf and in the navigation channel. The ideal configuration encourages the Mission Creek and Laguna Creek lagoons to merge and create a single large lagoon by maintaining a sand berm (since 2003) along the seaward side that extends from West Beach to just past the outlet of Laguna Creek. These ideal configurations are described in more detail and included as figures in the permit application (CCC 2011).

3 This is separate from the U.S. Army Corps of Engineers dredging quantity (Section 6.3.1)

Storm drain outlet maintenance: Five storm outlets on West Beach and three storm drains on East Beach drain during winter rainfalls, where they tend to pond and lead to poor water quality. The sediment management plan proposes to maintain open outlets during winter months by removing sand cover from the pipes and grading gentle slopes around the outlets approximately five times per year. The gentle slopes will encourage the water to spread and infiltrate into the sand rather than ponding or draining directly into the ocean.

Beach grooming: During the summer months, the beach is mechanically cleaned to remove debris/trash four days a week. Raking occurs in non-summer months to remove ruts and maintain a clean appearance (no debris removed). After major coastal or riverine storms, hazardous debris such as car and boat parts, broken glass, fiberglass, and metal are removed from the beach using specialized equipment. Beach grooming is restricted to dry sand areas no closer than 10 feet from the dry side of the wrack line. The beach is also manually cleaned by hand.

2.1.12 Climate Action Plan and Strategic Energy Plan

The Santa Barbara Climate Action Plan was prepared in 2012 in response to directives of the City General Plan (Section 2.1.3) and State Legislature (AB 32-Global Warming Solutions Act, SB 375-Sustainable Communities and Climate Protection Act, SB 97 – California Environmental Quality Act). The Climate Action Plan provides an inventory and forecasts of carbon dioxide and other greenhouse gas emissions generated by the Santa Barbara community that contribute to accelerated global climate change. Strategies to reduce carbon emissions are identified in the areas of energy, travel and land use, vegetation, waste reduction, and water conservation. The plan also identifies potential climate changes in Santa Barbara, and strategies to begin planning for adaptation to climate change effects. The City is currently in the process of updating the 2012 Climate Action Plan and has just approved a Strategic Energy Plan that provides a roadmap to meet the City's 100% renewable electricity goal by 2030.

2.1.13 Previous Vulnerability Assessments in Santa Barbara

In 2012, Gary Griggs and Nicole Russel of University of California, Santa Cruz prepared a vulnerability assessment study for the City of Santa Barbara that was partially funded by the California Energy Commission. The study analyzed the City's vulnerabilities to future sea-level rise and related coastal hazards (by 2050 and 2100) based upon past events, shoreline topography, and exposure to sea-level rise and wave attack. The study also included recommendations for potential adaptation responses. The results showed that by 2050, the risk of wave damage to shoreline development and infrastructure would be high and flooding and inundation of low-lying coastal areas would present a moderate risk to the City. The study noted cliff erosion has been taking place for decades, and as this process continues or increases, additional public and private property in the Mesa area would be threatened. Inundation of beaches presents a low threat to the City by 2050 but a high threat by 2100, according to the analysis.

U.C. Santa Barbra's Bren School's Masters Students prepared a *City of Santa Barbara Sea-Level Rise Vulnerability Assessment* as part of the LCP Update in May 2015. Their study included hazards modeling, vulnerability assessments, and preliminary adaptation strategies. The student team presented final results to City staff, LCP Update Subcommittee Members, and other stakeholders in May 2015.

2.1.14 Vulnerability Assessments, Hazard Modeling, and Adaptation Plans in Santa Barbara County

The City of Carpinteria, Santa Barbara County, and the Santa Barbara County Association of Governments are currently in the process of preparing adaptation plans to address impacts associated with sea-level rise:

- ESA prepared a *Sea-Level Rise and Management Plan for the Goleta Slough Area* in August 2015 for the Goleta Slough Management Committee. The purpose of the plan is to help decision-makers, planners, and land managers identify and prioritize adaptation strategies, including infrastructure improvements, policy changes, and management actions to adapt to sea-level rise related impacts. The adaptation strategies identified in this document were reviewed and considered for incorporation into this Adaptation Plan.

- The City of Goleta prepared a *Coastal Hazards Vulnerability Assessment and Fiscal Impact Report* that evaluates the community's vulnerability to sea-level rise, estimates the financial impact on the city, and identifies adaptation strategies to prevent or minimize the vulnerabilities and reduce the fiscal impacts. The adaptation strategies identified in this document were reviewed and considered for incorporation into this Adaptation Plan.

- In 2015 Santa Barbara County prepared a *Sea-Level Rise and Coastal Hazards Vulnerability Assessment* that identified potential coastal hazards and began planning for adaptation to these climate-related impacts with regards to important infrastructure, ecological resources, and community assets. ESA developed a model and mapped the coastal hazards for the County, portions of which were used for the City of Santa Barbara Vulnerability Assessment. The adaptation strategies identified in this document were reviewed and considered for incorporation into this Adaptation Plan.

- In 2016 ESA prepared an update of Santa Barbara County's Coastal Hazard Modeling and Vulnerability assessment that incorporated updated methods of analyses that better align with the current management practices along the Santa Barbara City waterfront.

- The Coastal Storm Modeling System (CoSMoS)[4] was developed by the United States Geologic Survey (USGS) with state funding for use in sea-level rise planning. The modeling effort focused on evaluating flood hazards associated with sea-level rise, as well as shoreline and bluff erosion. Coastal hazards were last mapped for the

[4] Details on the USGS CoSMoS model are accessible online at: https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos

Santa Barbara coastline with CoSMoS 3.0 in 2016. A total of 40 scenarios were run combining sea-level rise and storm type. Ten sea-level rise amounts (0 to 2 meters at 0.25 meter increments and 5 meters) were modeled with four coastal storm conditions (100-year, 20-year, and 1-year events and no storm). Hazard modeling outputs include the extent of inundation, wave run-up, and long-term erosion. The CoSMoS model results were used in the Santa Barbara Vulnerability Assessment (ESA 2018).

- In 2017, the Santa Barbara Area Coastal Ecosystem Vulnerability Assessment was prepared by California Sea Grant. The study investigated future changes to Santa Barbara's climate, beaches, watersheds, wetland habitats, and beach ecosystems.

- In 2019, the City of Carpinteria completed a Sea Level Rise Vulnerability Assessment and Adaptation Project that identifies resources that are vulnerable to sea-level rise and adaptation strategies to reduce those vulnerabilities (City of Carpinteria 2019). The adaptation strategies identified in that project were reviewed and considered for incorporation into this Adaptation Plan.

- In 2019 Santa Barbara County Association of Governments developed a *Multi-Modal Transportation Network Resiliency Assessment* that identifies transportation assets in the county that are vulnerable to climate change impacts (including sea-level rise) and resiliency solutions to mitigate those vulnerabilities (Energetics 2019).

- In 2019, Caltrans District 5 finished a *Climate Change Vulnerability Assessment* for the State Highway System located in Caltrans District 5, which includes Santa Barbara. The study determined which Caltrans assets were vulnerable to various climate-influenced natural hazards, including sea-level rise. The report also outlines a recommended framework for prioritizing projects that might be considered by Caltrans in the future.

- Santa Barbara County is in the process of updating the Seismic Safety and Safety Element of their Comprehensive Plan to account for climate-change-related hazards. The process includes developing an adaptation plan to address climate change impacts, including those associated with sea-level rise. Once available, the County's adaptation plan should inform the adaptation strategies in subsequent updates to this Adaptation Plan.

2.2 Permitting Requirements

As discussed in Section 1.1, an amendment to the City's LCP will be processed to include new policies and standards that will implement the adaptation strategies identified in this Adaptation Plan. The LCP Amendment will require approval by City Council and certification by the CCC. The City will take additional actions to facilitate the implementation of adaptation strategies as outlined in more detail in Section 13.

Implementation of adaptation strategies or projects, such as beach nourishment or shoreline protective devices, will likely require project-specific planning, California Environmental Quality Act (CEQA)/National Environmental Policy Act (NEPA) review, permitting, and design. The coastal development permit review and approval for adaptation projects may be processed by the City of Santa Barbara through the LCP and/or by the CCC, pursuant to the Coastal Act as discussed in Section 2.1.1. Additional approvals may be required from the U.S. Army Corps of Engineers (USACE), FEMA, U.S Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), California State Lands Commission, U.S. Coast Guard, the California Division of Boating and Waterways, and/or the California Regional Water Quality Control Boards. The required regulatory agency permits may include:

- Coastal development permit
- USACE Section 404 and Section 10
- FEMA Letter of Map Revision
- CDFW streambed alteration agreement and possibly 2081 incidental take permit
- Regional Water Quality Control Board Section 401 certification

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Section 3

ADAPTATION PLANNING FRAMEWORK

Successful adaptation planning is an ongoing process that requires implementation, monitoring, and reevaluation. This section establishes principles to guide the prioritization, selection, and implementation of adaptation strategies. It also identifies thresholds that should be regularly monitored to inform the timing for implementation of adaptation strategies, which will require revisions to existing City policy, regulatory, and procedural tools; creation of new tools and programs; identification of funding sources; and project-level planning, design, and construction. Changes in best available science, best practices, laws, case law, and community priorities will require regular reevaluation of this Adaptation Plan.

The information provided in this Adaptation Plan will guide more detailed, project-level planning of adaptation strategies to be implemented in the near-term and help the City prepare for strategies to be implemented in the long-term. Based on monitoring identified in Section 3.2, the City will track the impacts of sea-level rise and, at a later point, reevaluate and refine this Adaptation Plan using the monitored data and the best available science at that time.

3.1 Guiding Principles

The City's Sea-Level Rise Adaptation Plan Subcommittee, in consultation with City staff, developed the following principles to guide the prioritization and selection of adaptation strategies. These Guiding Principles provide a foundation upon which future project decisions could be made and help in evaluating how well adaptation actions would help meet established community values and expectations:

1. Prioritize:
    a. Protection of human life, health, and safety
    b. Critical facilities, public transportation systems, and public services for basic city functions
2. Minimize the impacts of sea-level rise and related hazards to:
    a. Coastal-dependent development
    b. Public access to and along the shoreline, beaches, parks, open spaces, and recreation
    c. Existing and future development

   d. The local economy
   e. Coastal resources
3. Design adaptation strategies that:
   a. Use best available science and technology
   b. Are flexible and which have processes for updates based on new information.
4. Ensure that adaptation strategies:
   a. Minimize the risks of coastal hazards
   b. Are legally, technically, and financially feasible
   c. Are consistent with federal and state laws
   d. Avoid, where feasible, or minimize impacts to coastal resources
   e. Do not preclude or prevent implementation of future adaptation strategies to address longer-term hazards
5. Encourage:
   a. Adaptation strategies that broadly protect the community's health, safety, and welfare.
   b. Equitable sharing of costs and benefits of sea-level rise and related hazards
   c. Adaptation strategies that benefit or minimize impacts to vulnerable populations that may have a higher sensitivity and lower adaptive capacity to hazards
   d. Adaptation strategies that have co-benefits, such as greenhouse gas reduction, resiliency to other climate change impacts, habitat protection or creation, protection and creation of recreation opportunities, improvements to coastal resources, or economic enhancement
   e. Emergency response and recovery coordination that factor in increased hazards due to sea-level rise
   f. Greenhouse gas reductions as a key aspect of resiliency planning.
   g. Voluntary and proactive resilience actions through incentives such as streamlining permitting.
   h. Adaptation strategies and programs that build coastal resiliency partnerships.

3.2 Monitoring Change

The Adaptation Plan begins to identify planning-level thresholds for when decisions on adaptation should be considered to reduce or avoid future risks (see Sections 6 through 10 for examples of thresholds). The City will need to monitor and evaluate the trajectory toward these thresholds to track whether and when these thresholds are met. The City, in consultation with other regional, state, and federal agencies, could create a Shoreline Monitoring Program to track changes in environmental conditions. Table 3-1 and the sections below identify some parameters that could potentially be monitored. Additional analysis is needed to determine which exact parameters should be monitored, given the priorities and goals of the City. As outlined in Section 13, the City could partner with the University of California, Santa Barbara, and other regional agencies to assist in tracking thresholds, developing a monitoring program, and conducting regular reporting. The program should be developed in coordination with others to ensure that it is cost effective to maintain over time and that the data can be used by others and/or scaled up to the regional or state level. All data should be made publically available to ensure transparency with the public and coordination with other entities.

Lead time is required to perform project-level planning, secure funding, and implement or construct an adaptation measure. All adaptation options discussed in this Adaptation Plan require substantial lead time; therefore, thresholds have been developed so that planning for these projects occurs before they are needed.

TABLE 3-1
SUMMARY OF POTENTIAL MONITORING PARAMETERS TO BE CONSIDERED

Parameter	Potential Monitoring Data
Sea-Level Rise	The monitoring program could track the following resources for science updates: • *California Coastal Commission Sea-Level Rise Policy Guidance* • CalNRA and OPC *State of California Sea-Level Rise Guidance* • California Climate Assessment • NOAA Tides and Currents, Santa Barbara station • Coordinate with Scripps Institute of Oceanography and follow any scientific reports they produce on sea-level rise in Southern California
Coastal and Riverine Storm Flooding and Storm Damage Frequency	The monitoring program could record coastal and creek flooding and storm damage events and information: • Photos, videos, reports of event or damage • Date, type, location, and severity of flooding (e.g., depth, duration, wave height), and damages
Beach Width	• The monitoring program could review BEACON beach transect data every 2 years (collected by USGS) • The monitoring program could consider obtaining additional beach transects of city beaches
Coastal Bluff-Top Offset and Bluff Slope	• The monitoring program could review available LiDAR data or aerial photography to track bluff edge relative to different assets and coastal bluff slope • The monitoring program could include regular surveys of transects along the bluffs of bluff slope and bluff edge if reliable and regular LiDAR data cannot be obtained
Creek Water Levels and Flood Frequency	• The monitoring program could assess water levels at Mission Lagoon, Laguna Creek, Sycamore Lagoon, and the Andrée Clark Bird Refuge through the deployment of new gauges
Groundwater Levels	• The monitoring program could track groundwater levels through the State Water Board's Groundwater Ambient Monitoring and Assessment Program or the City's existing monitoring well system

3.2.1 Sea-Level Rise

Sea levels in Santa Barbara have increased by 0.39 feet in the last 100 years (NOAA Tides and Currents, Station #9411340). However, the rate of sea-level rise is expected to increase over time. Available sea-level rise projections use the year 2000 as a baseline. Since 2000, sea levels are estimated to have increased by just under an inch[5], but sea-level rise is expected to accelerate in the coming decades. The City could consider monitoring the rate of sea-level rise and progress toward thresholds because certain actions will need to be taken when sea levels have risen by specific amounts, relative to a baseline of the year 2000, to maintain an acceptable level of vulnerability to coastal hazards. Currently, the best available sources for this information are found in the following state documents and the National Oceanic and Atmospheric Administration (NOAA) tide gage at Santa Barbara City Pier:

- *California Coastal Commission Sea-Level Rise Policy Guidance*: initially adopted August 2015, updated November 2018 (https://www.coastal.ca.gov/climate/slrguidance.html)
- California Natural Resources Agency (CalNRA) and Ocean Protection Council (OPC) *State of California Sea-Level Rise Guidance*: initially released in 2010, updated in 2013, and updated in 2018 (http://www.opc.ca.gov/updating-californias-sea-level-rise-guidance/)
- California Climate Assessment: initially released in 2006, updated in 2009, updated in 2012, and updated in 2018 (http://www.climateassessment.ca.gov/)
- NOAA Tides and Currents for Station ID 9411340 (or others): updated regularly (https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9411340)

3.2.2 Flooding and Coastal and Riverine Storm Damage Frequency

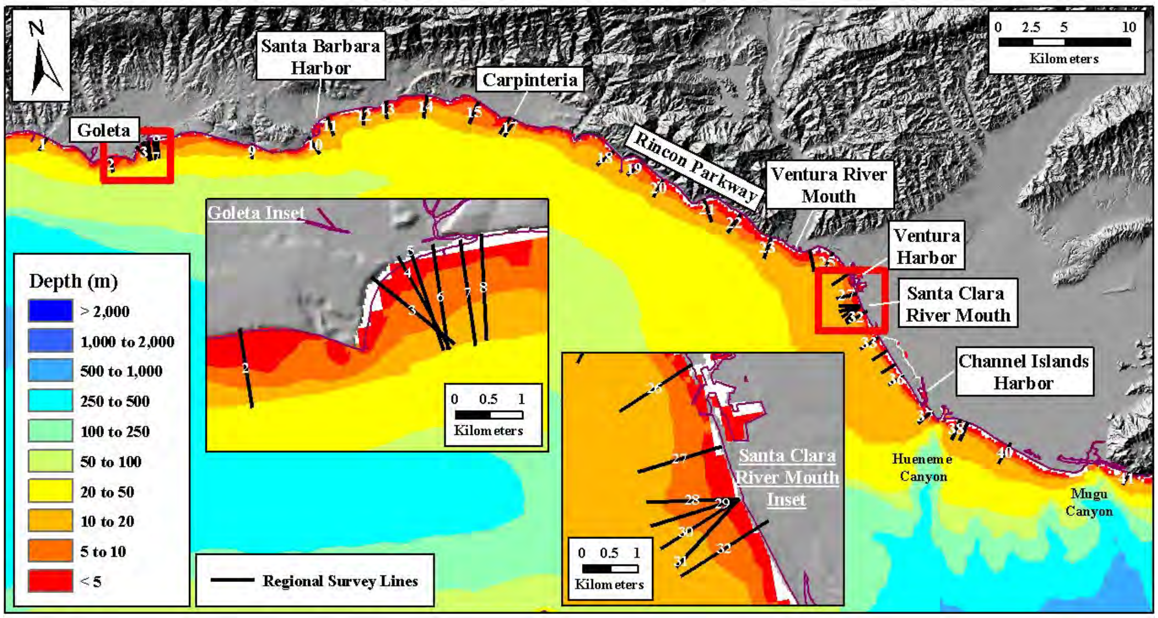
The City could monitor the frequency of flooding and coastal and riverine storm damage. To monitor the frequency of flooding and storm damage, the City can track and keep records of coastal and river flooding and storm damage events and information, including "king tide events," which are some of the highest and lowest tides of the year. This effort will require a framework for coordination between multiple departments, such as Community Development, Parks and Recreation, Public Works, and Waterfront. This effort could also be a collaborative effort between City staff and community members in which reports, pictures, and videos are collected. This would provide a secondary benefit of keeping the community engaged and increasing knowledge of the impacts of sea-level rise. It could also assist with obtaining funding to mitigate flood risks. The date, type, location, and severity of flooding (e.g., depth, duration, wave height), and damages can be collated into a file. The intent should be to track the frequency, extent, and severity of flooding to assess if and how the frequency of flooding is increasing. If the

5 This estimate is based on applying the rate of historic sea-level rise of 1.2 mm/yr published by NOAA Tides and Currents at Station #9411340 over a 20-year period (2000 to 2020).

tracking shows an increase in the flood and storm damage frequency, implementation of an adaptation measure could be considered.

3.2.3 Beach Width

The City could monitor beach width or participate in a regional program to monitor beach widths because the beach provides recreational and ecological value, as well as a buffer from erosion and flooding for beachfront development. The USGS monitors beaches in the area every 2 years through BEACON, including transects of Santa Barbara's beaches (Figure 3-1). It is recommended that a more frequent long-term monitoring program for all of Santa Barbara's beaches be implemented. These data could be analyzed regularly to evaluate beach trends and to identify the need for adaptation strategies.



SOURCE: Correspondence with Patrick Barnard at the USGS, April 19, 2019

Figure 3-1
USGS Survey Transects

3.2.4 Coastal Bluff-Top Offset and Bluff Slope

The City could monitor the coastal bluff-top offset[6] and slope because these parameters are a proxy for bluff failure risk and the associated vulnerabilities to development. The City could consider creating a monitoring program to track erosion of the coastal bluffs toward the roads and properties along the bluffs. The monitoring program could include work by a licensed surveyor to set up profiles of several survey transect locations (for example, at City-owned properties, such as the Douglas Family Preserve/Wilcox property, Shoreline Park, and the Bellosguardo site). These transects could then be surveyed by a licensed surveyor on an annual basis or some other frequent interval to

6 The coastal bluff offset is the distance between the top of the coastal bluffs and assets such as Shoreline Drive, Cliff Drive, and the edge of bluff-top structures.

monitor the change in coastal bluff location over time. Additionally, LiDAR can be used, as available through regional programs, to supplement these surveys or, if LiDAR data can be obtained on a more regular basis for the region, then LiDAR could replace the need for on-the-ground surveys.

3.2.5 Creek Water Levels and Flood Frequency

The City could monitor creek water levels and flood frequency to better understand the dynamics of riverine flood events combined with sea-level rise. The City could develop a water level monitoring program with gauges deployed in Mission Lagoon, Laguna Channel, Sycamore Lagoon, and the Andrée Clark Bird Refuge. These data could be analyzed regularly to evaluate water level trends and to identify the need for adaptation measures.

3.2.6 Groundwater Levels

The City could monitor groundwater levels to evaluate the changes in levels over time as sea levels rise. The City has an extensive existing groundwater monitoring program. The State Water Board's Groundwater Ambient Monitoring and Assessment Program also collates available groundwater data online at https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp. The City could use this data to track groundwater levels over time. These data could be analyzed regularly to evaluate water level trends and to identify the need for adaptation measures.

3.3 Implementation

This Adaptation Plan provides specific recommendations for necessary actions in the near-term (next ten years) and a structure for decision making and further study in the mid- and long-term (beyond ten years). Adaptation strategies are analyzed at a conceptual planning-level of detail for purposes of considering potential benefits and effects of adaptation strategies. Implementation of adaptation strategies will require a broad suite of tools, programs, and funding sources to help the City take action, as identified in more detail in Section 13. The next immediate step for the City is to develop a Five Year Implementation Plan that prioritizes the recommended near-term actions and identifies the potential costs, funding options, timelines, required resources, and staff responsible for each action.

As projects are developed in accordance with the Five Year Implementation Plan, additional detailed project-level planning and design would be required. For adaptation strategies involving construction, the project-level planning and design should consider:

- A feasibility study that includes additional technical analyses, development, and assessment of project alternatives and details, conceptual and preliminary engineering design, and cost estimating.

- Community and stakeholder engagement to solicit input on the project alternatives and design details.
- CEQA and possibly NEPA environmental review and regulatory permitting. Regulatory permitting could require approvals and permits from the USACE, USFWS, NOAA, California State Lands Commission, CCC, and CDFW, as well as other federal and state agencies.
- Final engineering design.

3.4 Reevaluation

The Adaptation Plan should be reevaluated and regularly updated to capture advances in sea-level rise science and best practices, and new or evolving community priorities. The Adaptation Plan should be updated approximately every five to ten years as substantive new information is available and as major updates occur to the State of California Sea-Level Rise Guidance.

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Section 4

SEA-LEVEL RISE AND THE VULNERABILITY OF COASTAL RESOURCES

ESA performed a vulnerability assessment to describe existing conditions and future vulnerability of the City's economic and physical coastal resources to increased levels of coastal flooding and erosion as a result of sea-level rise in the future if no action is taken. The assessment is documented in the Vulnerability Assessment Update (Appendix A) (ESA 2018). Sections 6 through 10 begin with a summary of vulnerabilities in the different areas of the city affected by sea-level rise.

Sea levels in Santa Barbara have increased by 0.39 feet in the last 100 years (NOAA Tides and Currents Station #9411340). Under current sea levels, Santa Barbara is already vulnerable to bluff and beach erosion, coastal flooding and wave impacts, and flooding of low-lying areas. Historically, some of the worst flooding and erosion events have occurred as a result of winter storms occurring during El Niño events when sea levels along the California coast often rise substantially for weeks at a time (Griggs and Russel 2012). The rate of sea-level rise is expected to increase over time due to the effects of climate change and global warming. This will result in increased flooding and erosion hazards along the City's shoreline, with the most risks being during El Niño conditions in the North Pacific Ocean.

The Vulnerability Assessment Update evaluated hazards to the coastal zone for existing conditions and three sea-level rise scenarios: 0.8 feet by 2030,[7] 2.5 feet by 2060, and 6.6 feet by 2100. These amounts of sea-level rise are with respect to a baseline of the year 2000, or more specifically, the average relative sea level over 1991 – 2009. Since 2000, sea levels are estimated to have increased by just under an inch, but the rate of sea-level rise is expected to increase in the coming decades.

[7] The 2018 *State of California Sea-Level Rise Guidance* recommends 0.7 feet at 2030. The closest Coastal Storm Modeling System (CoSMoS) Scenario, which has been used to generate maps and conduct vulnerability analyses is 25 cm, which is 0.8 feet. This difference is negligible at the scale of this study, and 0.8 feet at 2030 is used throughout.

The State of California, in the 2018 *State of California Sea-Level Rise Guidance* (OPC 2018), recommends using these precautionary and more risk adverse scenarios when planning for structures, infrastructure, and other development that is not easily moved. The state guidance estimates that these sea-level rise values have a 0.5% chance of being met or exceeded within the given timeframe. OPC identifies these as the "medium-high risk aversion scenarios" which is based on the assumption that existing levels of greenhouse gas emission continue and are not significantly reduced ("high emission scenarios").

The 2018 *State of California Sea-Level Rise Guidance* also includes much more likely scenarios that present sea-level rise values that have a 17% chance of being met or exceeded within the given timeframe ("low risk aversion scenarios") that can be used for planning for adaptable development with few consequences of being impacted (e.g., dirt trails). The state guidance also presents an "extreme risk aversion" scenario called the H++ scenario that is based on recent scientific studies that indicate that there is a possibility that sea levels could rise faster than originally anticipated due to the potential loss of large portions of the West Antarctic Ice Sheet. While the probability of this extreme scenario is not known at this time, the state guidance recommends considering the H++ scenario in the planning of very critical infrastructure (e.g., coastal power plant). For very critical infrastructure, therefore, this Adaptation Plan considers the possibility that 6.6 feet (2100) of sea-level rise may occur sooner, at 2080 instead of 2100, under the extreme H++ sea-level rise scenario. Table 4-1 and Figure 4-1 below present the low-rise, medium-risk, and extreme risk aversion scenarios. All of these aversion scenarios correspond to the high greenhouse gas emissions scenario.

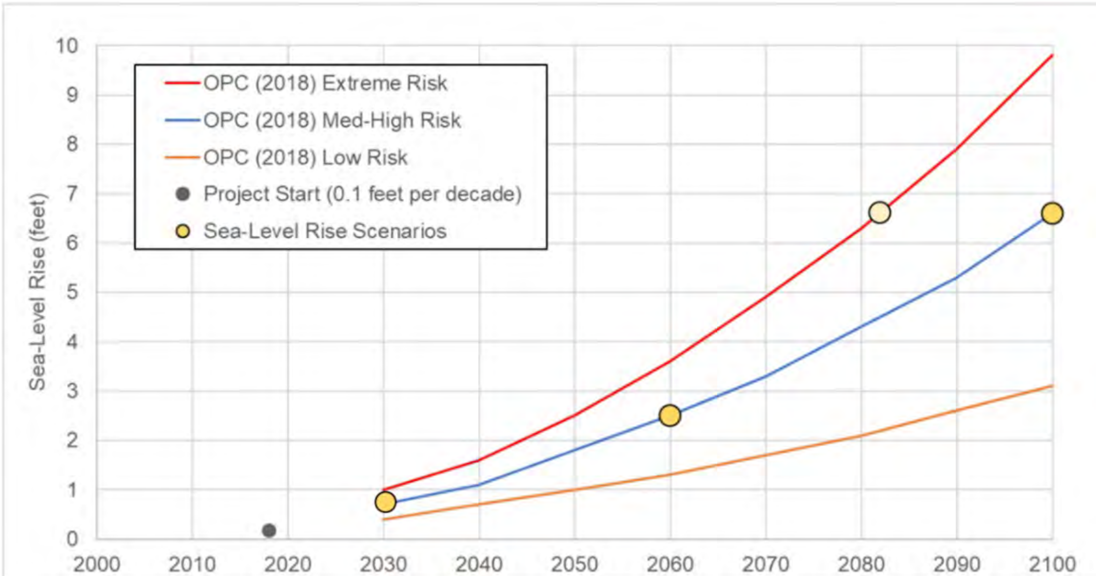
TABLE 4-1
SEA-LEVEL RISE SCENARIOS FOR CITY OF SANTA BARBARA

Scenario	Low Risk Aversion[a] *17% chance of being met or exceeded*	Med High Risk Aversion *0.5% chance of being met or exceeded*	Extreme Risk Aversion *Unknown probability*
0.8 feet of sea-level rise	Occurs by ~2040	Occurs by ~2030	Occurs before 2030
2.5 feet of sea-level rise	Occurs by ~2090	Occurs by 2060	Occurs by 2050
6.6 feet of sea-level rise	Occurs after 2150	Occurs by 2100	Occurs by ~2080

NOTES:

[a] Low Risk Aversion values were not used for this analysis

~ Approximately



SOURCE: OPC 2018

Figure 4-1
OPC (2018) Sea-Level Rise Guidance Curves, with Selected Scenarios

The State of California has updated the sea-level rise projections for the Santa Barbara area contained in the State of California Sea-Level Rise Guidance approximately every five years based on best available information. While there is uncertainty in the timing of sea-level rise in any particular area, the amounts of sea-level rise considered in this Adaptation Plan are expected to occur at some time. Because of the timing uncertainty, this Adaptation Plan provides a framework of planning based on amounts of sea-level rise, rather than when those amounts of sea-level rise will occur.

This Adaptation Plan considers potential impacts to public and private assets (e.g., buildings, roads, utilities, parks) from the following hazards:

- Coastal Erosion – permanent loss of sandy beaches, dunes, and the low-lying backshore that occurs with changing sea-level or sand supply.
- Coastal Bluff Erosion – permanent loss of coastal bluffs as material falls or collapses onto the beach or into the ocean below.
- Tidal Inundation – coastal flooding during regular high tides under non-storm conditions.
- Storm Waves – exposure of the coast to large waves generated by local and distant storms.
- Coastal Storm Flooding – high water levels that occur during coastal storm events. The Vulnerability Assessment Update analyzed the 100-year storm, which is estimated to have a 1% chance of occurring each year.

Low-lying areas that may potentially be subject to tidal and storm flooding but are not directly connected to flooding sources were also identified in the Vulnerability Assessment Update.

The Vulnerability Assessment Update used the United States Geological Survey's (USGS's) Coastal Storm Modeling System (CoSMoS) released in 2017 (v3.0) augmented by wave hazard zones from Coastal Resilience Santa Barbara, a study of sea-level rise impacts conducted by ESA for the County of Santa Barbara in 2015, and a 2009 geology and geohazards study of the city conducted by the URS Corporation.

It is important to note that new scientific information is being released every day on the mechanisms and rates of sea-level rise and how it may impact the shoreline. In upcoming years, as sea-level rise is tracked and new information emerges, the projections for how much sea-level rise may occur in Santa Barbara by any given time frame will certainly change. The Vulnerability Assessment Update and this Adaptation Plan present the best available information at this time. Moving forward, these documents will need to be regularly updated to reflect changes to the best available science. As sea-level rise projections are likely to change, this Adaptation Plan presents an approach of monitoring actual sea-level rise values and taking actions when certain amount of sea-level rise have been reached, rather than planning around a specific date when that amount of sea-level rise will occur.

Section 5
ADAPTATION MEASURES

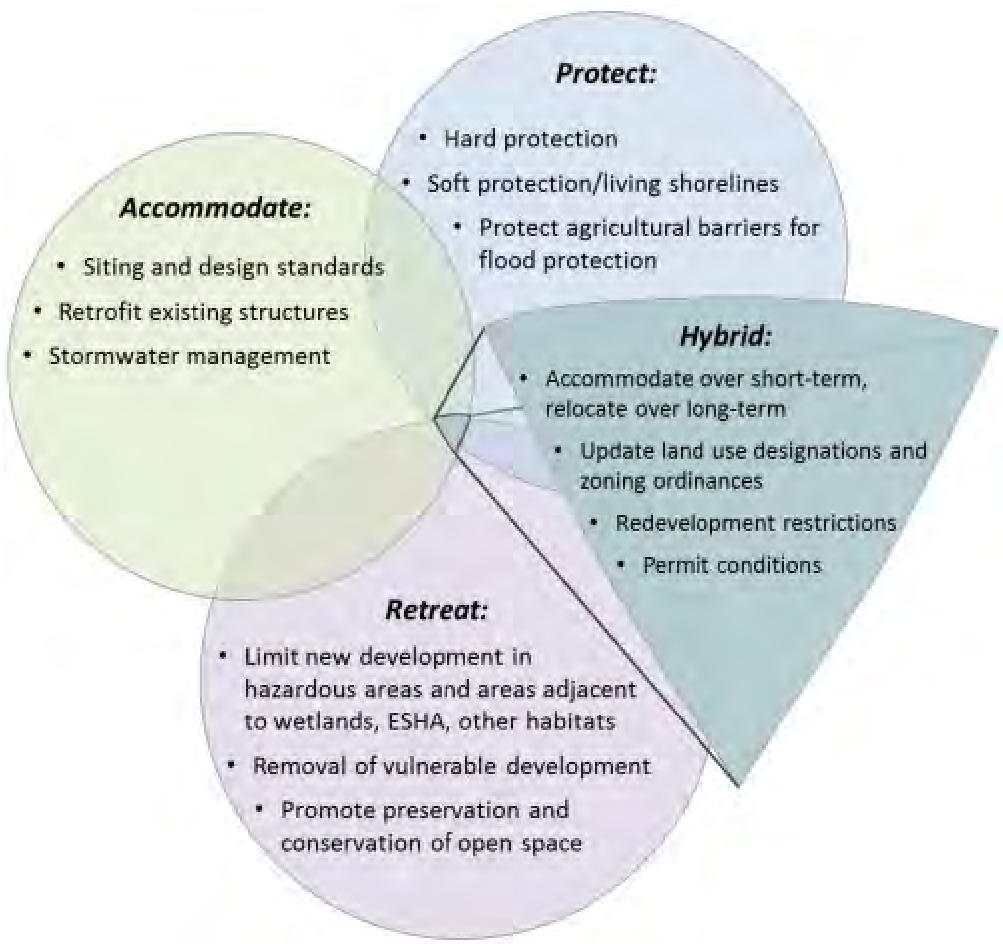
This section identifies adaptation measures based on industry best practices, CCC guidance (see Section 2.6), and input from the Sea-Level Rise Adaptation Plan Subcommittee and Sea-Level Rise Interdepartmental Team. Section 5 presents a range of strategies and in subsequent sections (Sections 6 through 10), strategies are evaluated for feasibility, effectiveness, and consistency with the City's Guiding Principles (Section 3.1). Considering a broad range of sea-level rise adaptation measures allows Santa Barbara to respond to the threat of rising sea levels with a variety of strategies that can work at different places and at different times.

5.1 Categories of Adaptation Strategies

Adaptation strategies are typically organized within the following categories (Figure 5-1):

- **Protection strategies,** which employ some sort of engineered structure or other measure to defend development (or resources) in its current location without changes to the development itself. Examples include: shoreline protective devices such as seawalls, revetments, groins, and breakwaters, which defend against coastal hazards like wave impacts, erosion, and flooding; natural or "green" methods like beach nourishment and artificial dunes to buffer coastal areas; and hybrid approaches using both artificial and natural infrastructure.
- **Accommodation strategies,** which modify existing development or design new development in a way that decreases hazard risks and increases the resiliency of development. Examples include elevating and/or retrofitting structures and using materials that increase the strength of development. In Santa Barbara, this could include floodproofing the first floor of buildings to accommodate high-water-level events.
- **Retreat strategies,** which relocate existing development, limit substantial redevelopment, and/or limit the construction of new development in vulnerable areas. Development setbacks are an example of a retreat strategy.

Different types of strategies will be appropriate in different locations, and, in some cases, a hybrid approach with strategies from multiple categories may be the best option. Additionally, the suite of strategies chosen may need to change over time as conditions change and previous areas of uncertainty and unknown variables become more certain.



Note: ESHA is defined as Environmentally Sensitive Habitat Area

SOURCE: CCC 2018

Figure 5-1
Examples of General Adaptation Strategies

5.2 Potential Adaptation Strategies for Santa Barbara

The Vulnerability Assessment Update identified the degree of vulnerability the Santa Barbara beaches, rivers, and creeks; visitor-serving amenities; public access areas; residential and commercial areas; and public facilities and infrastructure could face as a result of sea-level rise. This Adaptation Plan provides tools for the community and the City to manage risks and take actions focusing on five vulnerable areas (Figure 1-10):

- Coastal bluff areas
- Low-lying waterfront and beach areas, including the city's waterfront and Arroyo Burro Beach
- Low-lying flood areas, including the lower downtown area
- Harbor and Stearns Wharf
- Major infrastructure facilities, including El Estero Water Resource Center, Charles E. Meyer Desalination Plant, and major transportation corridors

The following subsections describe a variety of typical adaptation strategies that are considered in the Adaptation Plan. Sections 6 through 10 then discuss how these, and other more site-specific adaptations, can be applied to the different vulnerable areas of Santa Barbara.

5.2.1 Coastal Sediment Management – Beach and Dune Nourishment

Example of beach nourishment in Carlsbad, CA

Source: SANDAG

Beach nourishment is an adaptation strategy that provides protection against coastal storm erosion while maintaining the natural condition, beach habitat, and processes (such as the ability of the beach to erode in response to winter coastal storms and build up sand in response to summer wave conditions). Beach nourishment refers to placement of sand to widen a beach, which can be accomplished by placing a sediment-water slurry directly on the beach or mechanical placement of sediment with construction equipment (see photo to the right). Impacts to beach species can occur during construction, but are expected to be temporary. Sand can be obtained from inland sources (e.g., construction projects) and can be dredged from offshore, however, it can be difficult to find sand supplies of the right quality (e.g., grain size, color) for beach nourishment.

In addition to beach nourishment, dune restoration is recognized as a natural way of mitigating backshore erosion as well as maintaining a wider beach through sacrificial erosion of the dunes. Dune construction would include placing sand, grading, and planting to form "living" back beach dunes. Dune restoration can provide aesthetic, ecologic, and recreational benefits. A variant includes placement of cobble (rounded rock), which is often naturally present below beaches in California (Figure 5-2). Burying a layer of cobble provides a "backstop" that is more erosion resistant and dissipates waves to a greater degree.

While beach nourishment initially reduces the risk of flooding and erosion along the beach, the beach width is expected to diminish with time, requiring an ongoing cycle of "re-nourishment" to maintain the beach. Additionally, while a wider beach reduces wave energy that reaches the shore, nourishment may not protect against flooding during high water level events. During large coastal storm events, sand can be transported off the beach rapidly, reducing or eliminating the benefit of the nourishment. Additionally, the sand can be transported into estuaries and lagoons downcoast and impact the dynamics of those systems (e.g., causing lagoon mouth closures). Restored dunes can provide coastal storm protection, but can also be eroded and washed out during storm events, exposing landward areas to flood risks.

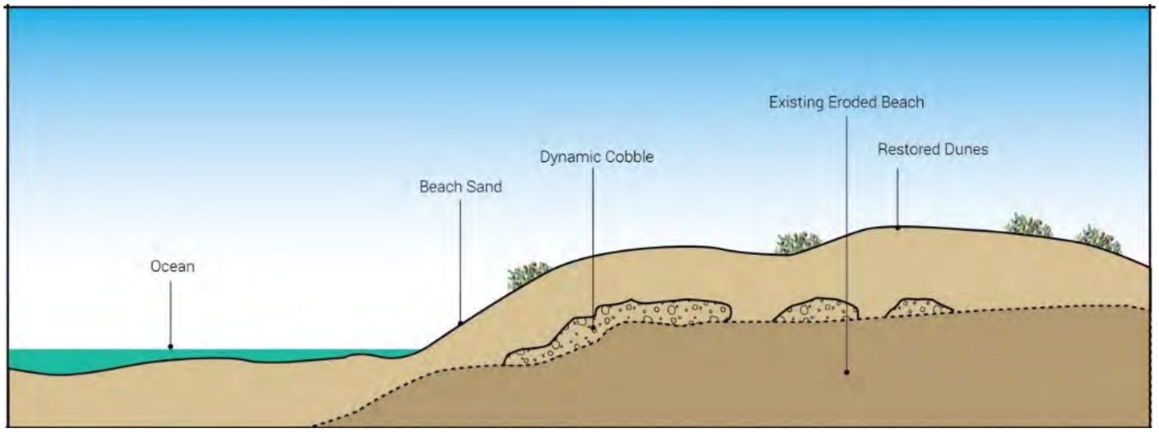


Figure 5-2
Cross-section of beach nourishment, dune restoration, and cobble placement

As sea level rises, the frequency of required nourishment is likely to increase. In addition to widening the beach to offset erosion, additional sand will be needed to raise the elevation of the beach up to the increased sea level. Beach nourishment can be considered in conjunction with sand retention measures to improve the longevity of sand placements (see Sections 5.2.3 and 5.2.4 below).

5.2.2 Coastal Sediment Management – Sand Bypassing

Similar to beach nourishment, sand bypassing is the placement of sand, removed from harbor or lagoon inlets, on down-shore beaches. Manmade structures, such as harbors, interact with longshore sand transport, with sand moving into and out of harbor inlets due to waves and currents. In general, harbor inlets act as sediment sinks and require dredging to maintain an open inlet. The sediment that ends up in the harbor is sediment that does not make it down-shore. Sand bypassing, therefore, allows sand to “bypass” the harbor.

5.2.3 Sand Retention Structures – Groins

Groins extend perpendicular to the beach and trap sand from drifting downcoast (Figure 5-3). Where wave conditions are ideal, groins have been successfully used in California and other locations to maintain a wider beach. In other cases, groins can induce and/or accelerate erosion downcoast of the groin, as shown in Figure 5-4. Groins are generally considered along stretches of coast with high net longshore sediment transport. In application, groins segment the beach and nourishment efforts into compartments, where sand is mostly limited to the compartment it is in.

SOURCE: Black Diamond Images

Figure 5-3
Photo of a series of groins in Sydney, AUS

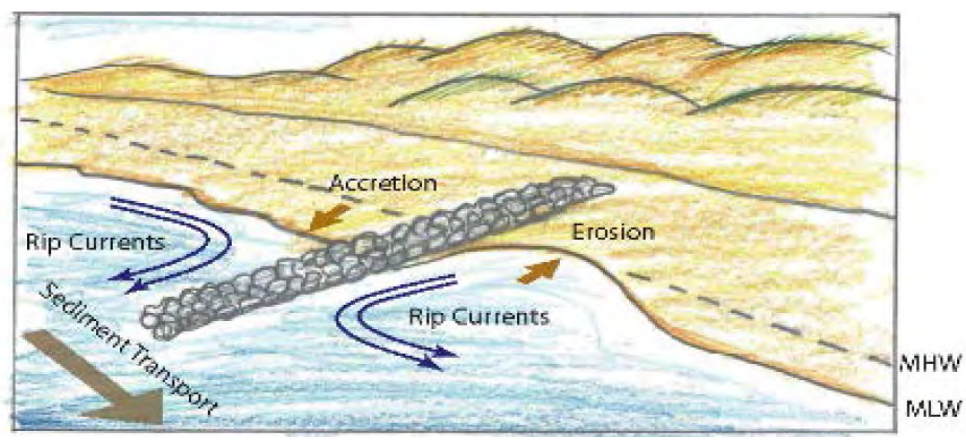


Figure 5-4
Example of the processes around groins

Public access across or over groins has the potential to negatively affect horizontal access along the beach. Constructing rock groins and other rock structures on the beach and/or in the ocean would alter the character of the natural shoreline and offshore habitats and have biological impacts to beach species. When first constructed, groins can significantly reduce the amount of sand transported down-current to neighboring beach areas as sand is trapped up-current of the groin. This impact can be somewhat mitigated if the area up-current of the groin is partially filled with sand as part of construction. This can require significant amounts of imported sand.

Because of the potential impacts to down-shore beaches, new groins are challenging to permit. At a minimum, the following would be required for there to be a chance at permitting success with CCC and other agencies with jurisdiction offshore: (1) a robust alternatives analysis showing that no other feasible, less damaging alternatives exist; (2) a clear demonstration of need; and (3) consistency with the goals of the Coastal Act and the Public Trust Doctrine which applies to public trust lands (tide and submerged lands and beds of navigable waters). Permitting conditions could include, among others, habitat mitigation and/or sand mitigation to address any impacts to sand transport downcoast. However, stabilizing and widening the beaches would add recreational area, support beach ecology, and provide a buffer for development, which could potentially meet the objectives of the California Coastal Act.[8]

5.2.4 Sand Retention Structures – Breakwaters

Breakwaters are offshore structures constructed parallel to the beach to reduce wave action. Typically built out of rock, breakwaters extend from the ocean floor to above the ocean level, thereby acting as a wall that blocks waves by causing them to break farther offshore. Breakwaters dissipate incident wave energy shoreward of the breakwater and change the pattern of sand transport in their lee (i.e., wave shadow), thereby reducing the transport of sand. These structures are generally applicable where there is a firm seabed and the need to create a calm area free from wave energy.

Breakwaters have been used to shelter shorelines and harbors, have been built in shorter segments to encourage sand accumulation behind the breakwater segments, and in some instances can provide access and recreation. However, breakwaters significantly change wave patterns and have the potential to change surfing resources. When first constructed they can also starve down-current areas of sand as sand accumulates in front of the breakwater. Breakwaters can also displace and change ocean habitats.

Due to permitting and mitigation requirements, few if any new breakwaters are being considered in California, and the trend is to explore the removal of breakwaters (e.g., City of Long Beach's East San Pedro Bay Ecosystem Restoration Feasibility Study to remove the Long Beach Breakwater). Similar to groins, the following would be required for there to be a chance at permitting success with CCC and other agencies with jurisdiction offshore: (1) a robust alternatives analysis showing that no other feasible less damaging alternative exist; (2) a clear demonstration of need, and (3) consistency with the goals of the State tidelands trust and Coastal Act. Permitting conditions could include, among others, habitat mitigation and/or sand mitigation (e.g., beach nourishment) to address any impacts to sand transport downcoast.

8 Griggs, G, K. Patsch, C. Lester, and R. Anderson. 2020. Groins, sand retention, and the future of Southern California's beaches. Shore and Beach, Vol 88, No 2. Spring 2020.

5.2.5 Sand Retention Structures – Offshore Reefs and Kelp Beds

Artificial reefs are underwater, offshore structures constructed of rock or other materials (Figure 5-5). Multipurpose artificial reefs are intended to encourage sand retention behind the reef, provide rocky reef habitat, and provide or enhance surfing resources (Figure 5-6). Because reefs are submerged, except under low tides, they do not provide much reduction in wave energy or flooding at the shoreline. Artificial reefs installed to act as submerged breakwaters have received increased attention in recent years as a means of shore stabilization and erosion control. This is primarily due to their low aesthetic impact, enhanced water exchange relative to traditional emergent breakwaters (Vicinanza et al. 2009), and potential to enhance local surfing conditions (Ranasinghe and Turner 2006).

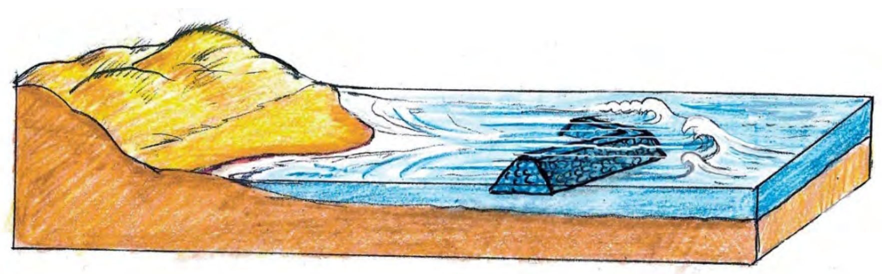


Figure 5-5
Example illustration of an offshore reef

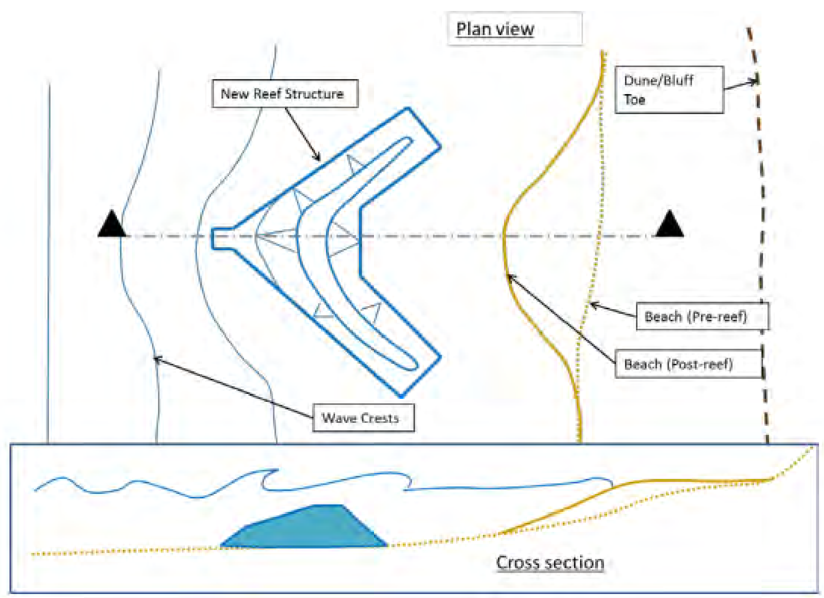


Figure 5-6
Schematic of multipurpose reef intended to create a surfing break

Use of artificial reefs to retain sand and enhance surfing is still in the experimental phase of development. Reefs have been investigated, constructed, and tested in various locations, including Orange County, but there is not enough experience with successful reef installation to ensure that reef implementation will provide the intended benefits. While reefs may impact sand transport downcoast less than groins and breakwaters, their purpose would still be to retain sand, which would have some impact, at least immediately after construction, to downcoast sand transport. Reefs could provide underwater habitats, but they could also displace and change existing ocean habitats at the reef site and shoreward of the reef.

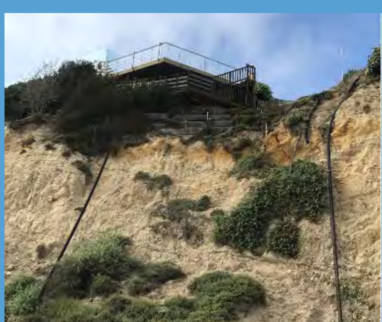
As with any sand retention structure proposed offshore, permitting would be complex. At a minimum, the following would be required for there to be a chance at permitting success with CCC and other agencies with jurisdiction offshore: (1) a robust alternatives analysis showing that no other feasible less damaging alternative exist; (2) a clear demonstration of need, and (3) consistency with the goals of the State tidelands trust and Coastal Act. Permitting conditions could include, among others, habitat mitigation and/or sand mitigation to address any impacts to sand transport downcoast.

Offshore kelp beds may dissipate waves to some extent, but would not be very effective at maintaining sand on the beach. Restoration of existing kelp beds can provide habitat benefits with some reduction in sand movement downcoast. Restoring kelp beds requires a rock substrate and can be accomplished in areas with existing submerged rock or by placing rock offshore. With a focus on restoration of habitat, permitting of this strategy would likely be less complex than other sand retention structures.

Examples of existing BMPs in Santa Barbara

Drainage drop inlet

Low irrigation landscaping



Drain pipes directing water to the toe of the bluff

5.2.6 Coastal Bluff Erosion BMPs

Best management practices (BMPs) for reducing coastal bluff erosion include management of surface drainage as well as shallow subsurface groundwater drainage to the bluff's edge and face to control local erosion and slope failure due to drainage (see photos to the left). The goal of these practices is to control surface runoff and avoid concentrated flow down the bluffs, reducing shallow groundwater flow that saturates upper soils and facilitates erosion, and to facilitate management of groundwater daylighting (i.e., reaching the surface) at geologic layers.

In addition to these surface water and groundwater BMPs, the City could investigate whether over-watering of landscaping within the bluff areas could be contributing to elevated groundwater flows to the bluffs. If this is the case, reducing this irrigation could potentially reduce bluff erosion.

In the City's updated Coastal Land Use Plan (Section 2.1), Policy 5.1-9 encourages continued support and coordination with local and regional entities on natural coastal bluff restoration, stabilization, and erosion control measures. Additionally, Policy 5.1-40 requires phasing out private accessways on coastal bluff faces due to safety concerns and the impacts to coastal bluff erosion and slope stability. Policies 5.1-65, 5.1-66, and 5.1-67 require evaluation of the potential erosive impacts of new development or substantial redevelopment on bluff-backed beaches, coastal bluff faces, and coastal bluff tops. The policies require mitigation measures, alternatives, or monitoring protocols to minimize coastal bluff erosion and slope failure.

5.2.7 Shoreline Protection Devices

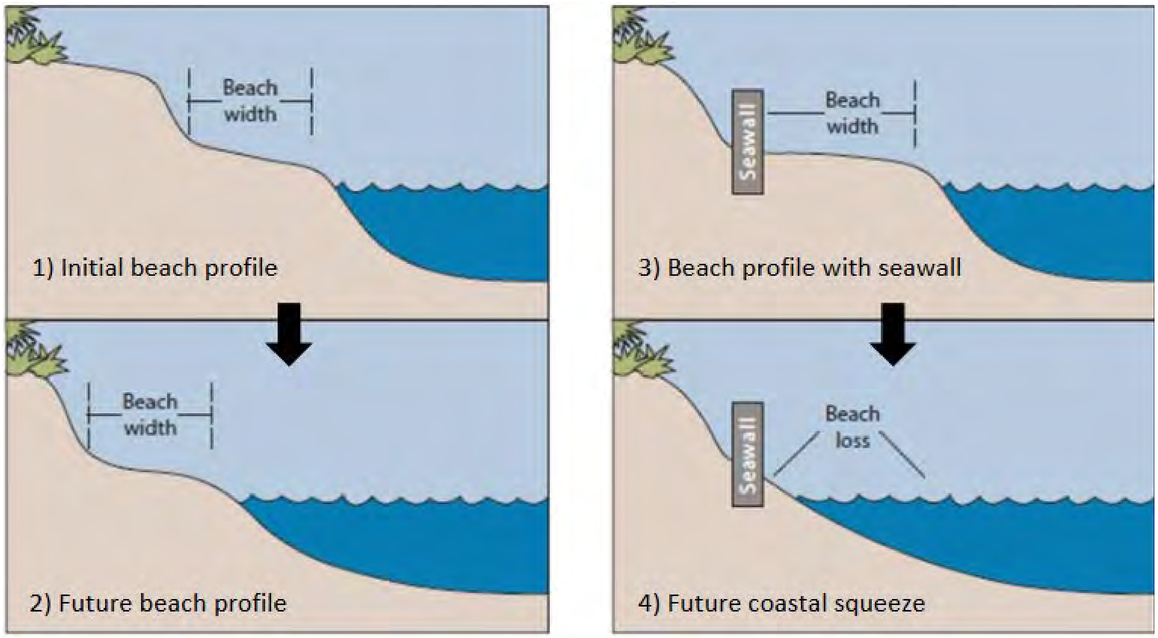
A photo of a seawall in San Diego, CA

Shoreline protection devices, such as seawalls and rock revetments, are structures along the coast that provide flood and erosion protection for properties by absorbing or dissipating wave energy. Seawalls are vertical structures along a beach or coastal bluff used to protect structures and property from wave action (see the photo to the right). A seawall works by absorbing or dissipating wave energy. They may be either gravity- or pile-supported structures and are normally constructed of stone or concrete.

Revetments provide protection to slopes and are constructed of sturdy materials, such as stone (Figure 5-7). Similar in purpose to a seawall, revetments work by absorbing or dissipating wave energy. Revetments are made up of an armor layer (e.g., rock rip-rap piled up or a carefully placed assortment of interlocking material, which forms a geometric pattern), a filter layer (which provides for drainage and retains the soil that lies beneath), and a buried toe (which adds stability at the bottom of the structure).

Figure 5-7
Photo of waves against a revetment in Pacifica, CA

While seawalls and revetments provide protection to existing shoreline development behind them, these structures can contribute to erosion and accelerate beach loss. The structures prevent the shoreline and bluffs from naturally eroding. Normally, waves lose momentum and energy as they run up a gently sloping shoreline, and sand is deposited to form beaches. Many shoreline protection devices make it so that there is a hard back-stop to the shoreline. Waves hit the devices and reflect backward, rather than dissipating, often causing increased sand erosion in front of the device. They can also increase beach and bluff erosion on either side of the device and impact down-shore sand supplies. With ongoing beach erosion and sea-level rise and without any other mitigating measures, fixing the shoreline location with a seawall or revetment will eventually lead to the loss of the beach seaward of the structure (Figure 5-8).



SOURCE: CCC 2018

Figure 5-8
Coastal squeeze process resulting in beach loss

Seawalls and rock revetments, in some cases, can have significant impacts on lateral acccess along the beach due to their displacement of beach area when they are constructed and the beach loss that can occur in front of and adjacent to these devices. In some cases they may also affect vertical access to the beach. Paths of access can be provided over and along the top of seawalls and revetments. It is more difficult, however, to climb one of these structures than to simply walk on the beach. Seawalls and rock revetments also can displace and change beach habitats.

Additionally, using seawalls or rock revetments to “hold the line” on an eroding shoreline with sea-level rise may not be sustainable due to increasing wave action and overtopping associated with the loss of the fronting beach. However, in some locations beach nourishment could be implemented in conjunction with a seawall or revetment to at least partially offset this process for some time. Additionally, sea-level rise will require more frequent maintenance or reconstruction of these structures. Over time, the rocks of a revetment can move around and get washed onto the beach, reducing the effectiveness of the revetment and causing increased impacts to beach access.

Note that shoreline protection devices are designed to protect and withstand coastal storm events up to a certain severity, such as the “100-year storm event.” Storm events that are more severe than the design events can cause flooding and damage.

Seawall and revetment construction is regulated by the Coastal Act (Section 30235) and the policies and regulations of the Santa Barbara LCP (which includes the recently updated Coastal Land Use Plan and the 1986 Implementation Plan). The Coastal Act and LCP allow for new or substantially redeveloped shoreline protection devices when necessary to protect existing public structures, existing principle private structures, public beaches, or coastal-dependent structures (e.g., Harbor, wastewater infrastructure, public shoreline access parking areas, public roads providing shoreline access, public parks providing coastal access and recreation) in danger from erosion.

There is ongoing discussion between the CCC and local agencies on identifying what is considered to be “existing” development that would be allowed to have shoreline protection devices. The Coastal Act does not define the term “existing development.” In previous permitting and legal cases (*California Coastal Commission v. Surfrider Foundation*, 2006), CCC had interpreted “existing development” to be that development legally existing at the current time (or time of requested permit review). Recently, CCC staff have started interpreting the term “existing development” to mean developments legally built prior to the Coastal Act of 1976. Some local agencies have applied the term “existing development” to development legally built prior to the certification of their LCPs. Permitting of shoreline protection devices often involves permits from both the CCC and local jurisdictions. The various interpretations of the term “existing development” between different agencies has made the permitting of shoreline protection devices for non-coastal-dependent development (e.g., private residential development and many commercial developments) uncertain.

Permit applications for shoreline protection devices is a complex and lengthy process. When allowed, seawalls and revetments would need to be designed to eliminate or mitigate adverse impacts on the local shoreline sand supply, habitats, and public access to and along the shoreline. Permitting conditions could include, among others, mitigation projects, in-lieu mitigation fees, and monitoring to address these concerns that can be expensive. If the shoreline protection devices are located on State tidelands, the projects would also have to be consistent with the goals of the State tidelands trust to be permitted.

5.2.8 Tide Gates, Weirs, and Pump Stations

Tide gates or weirs are typically built across creeks, rivers, and even major waterways to limit the impact of high tides. Tide gates close during high tide events to keep water out, while weirs block water from flowing in from the ocean except during high tide events and only allow flow out from the creek or river. Various types of gate and weir structures are available and a properly designed tide gate and weir can provide protection for a significant length of upstream shoreline relative to the length of the structure. However, tide gates can be very expensive to build and maintain and may require sophisticated control systems and large maintenance budgets. As sea level rises, the gates will be closed more often to be effective, which could cause impacts to habitat and water quality upstream. For weirs, higher sea levels will overtop the structures more and more frequently, allowing more water from the ocean to flow into the creek or river.

Tide gates are often paired with pump stations to lower the water behind the tide gate. Pump stations are centralized locations where one or more large-capacity pumps move stormwater from behind the tide gate to the creek or ocean. A common secondary impact of coastal barriers such as levees and seawalls is that they impede gravity drainage of flood flows from the land. Therefore, stormwater pumping facilities are needed to move stormwater over or through the barriers to prevent flooding. Pump stations tend to be expensive to design, build, and maintain. In critical drainage areas, an on-site power generator may be needed to maintain pumping in the event of electrical power outages.

Due to their location in creeks and tidal areas and potential impacts to aquatic species and habitats, permitting of tide gates is a long and complex process involving multiple local, state, and federal agencies.

5.2.9 Groundwater Pumping

As sea levels rise, groundwater elevations are expected to rise and may result in flooding, impacts to the structural integrity of infrastructure, or groundwater intrusion into pipes. Using pumps to lower the groundwater table is an adaptation strategy that could reduce these risks. Once the groundwater reaches a certain elevation, underground dewatering wells and pumps could be installed to lower groundwater and discharge it to the stormwater system. This would require additional conveyance pipes and outfalls to manage the higher pumping rate. Groundwater pumping is usually combined with other flood control measures (e.g., flood walls and seawalls) to effectively mitigate flood risks.

5.2.10 Creek Flood Walls or Levees

Flood walls or levees are flood and erosion protection measures along creeks that function similarly to how seawalls or revetments function along a shoreline (Section 5.2.7). Where creeks empty into the ocean, riverine or creek flows from upland sources combine with tidal ocean flows to create estuarine environments. As sea levels rise, increased tide elevations and high waves during coastal storms will combine with riverine creek flows and result in overtopping of creek channels inland of the shoreline and flooding of low-lying areas. Flood walls or levees limit flooding of low-lying areas from overtopped creek and estuary channels due to high tidal level and high rainfall or high wave events during coastal and riverine storms. Flood walls or levees could connect with shoreline protection devices along the shoreline. Creek protection devices would likely need to be paired with pump stations to convey stormwater that would typically drain directly to the creeks from the upland side of the flood wall or levee.

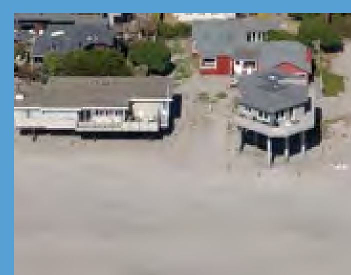
Levees could be designed as “living levees” or “horizontal levees” by creating gently sloping upland, transition, and vegetated habitats between the levee and the waterway. The habitats can provide natural flood protection benefits by reducing the destructive forces of storms.

5.2.11 Elevating or Waterproofing Structures and Infrastructure

Raising structures such as buildings, roads, and utilities is a measure that can shift infrastructure above coastal flooding elevations. Elevating structures can include raising buildings on pile foundations to allow for some limited migration and persistence of a fronting beach in the near-term (photo to the right). Raising roads and utilities could include replacing at-grade roads with pile-supported causeways. Associated utilities such as power, sewer, water, and electrical connections also need to be raised or waterproofed to avoid damage. Properties located in mapped flood hazard zones (pursuant to the FEMA Flood Insurance Rate Maps) are currently required to elevate the first floor above the base flood elevation. However, FEMA Flood Insurance Rate Maps do not account for the projected increases in flooding associated with sea-level rise or potential for increased flooding hazards in the future from changes in rainfall patterns as a result of climate change.

Examples of elevated development

Source: SPUR Report, 2011. https://www.spur.org/sites/default/files/publications_pdfs/SPUR_ClimateChangeHitsHome.pdf



Source: Copyright 2002 2016 Kenneth & Gabrielle Adelman, California Coastal Records project, www.californiacoastline.org

Raising buildings to address flooding as a result of less frequent coastal or riverine storm events allows use of the buildings in between storm events. However, as sea levels rise and areas become more inundated from regular high tides or more frequent small coastal storm events, raising buildings on piles becomes ineffective as an adaptation strategy by itself because access to the structures would be restricted due to flooding of surrounding streets. Additionally, it could become hard to maintain services (e.g., water, wastewater, and electricity) to the structures. If measures such as beach and dune nourishment (Section 5.2.1) are not taken, the shoreline could continue to migrate past structures and potentially damage roads, infrastructure, and even the buildings if the pilings are undermined. In order to raise buildings in some areas, it may also be necessary to change height restrictions and other municipal code requirements. For beachfront properties where retaining a beach is a priority, raising buildings could be preferable to installing seawalls or revetments as it allows for the retention of structures for some time while still maintaining some beach area.

Building designs can also be modified so that the second floor is above the target flood level and contains all flood-sensitive features, while the first floor is used for parking and/or storage and is designed to be durable and resilient to flood damage. Abandoning the lowest floor or elevating the lowest habitable floor are effective strategies to reduce damage to the buildings from coastal or riverine storm events, and is often employed to meet FEMA base flood-elevation minimums.

Roads could be raised to avoid flood hazards. Infrastructure such as water and wastewater pipelines could be redesigned to be waterproofed. Currently, the wastewater infrastructure in Santa Barbara is designed as a gravity fed system that includes manholes, which would be subject to flooding. These systems would need to be sealed, manholes potentially raised, and pumps utilized to move wastewater around.

5.2.12 Elevating Property Grade

Raising buildings or roads could also be accomplished by placing fill to rebuild the grades at higher elevations. Utilities such as sewer pipelines and storm drains that are vulnerable to flooding, erosion, or increased groundwater levels can also be raised, so long as gravity flow is maintained or pumps are installed. However, if one road is raised, all connecting roads, trails, and utilities would have to be rebuilt to slope up to the new grade. Elevating grades requires significant amounts of fill and, therefore, may only be feasible for areas of limited size. Additionally, filling an area changes the hydrology of both the area filled and the way rainfall runoff flows to neighboring areas. Stormwater would have to be managed effectively from the filled areas so as to not increase flood risks elsewhere.

5.2.13 Managed Retreat

Managed retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. As buildings, utilities, and other infrastructure are increasingly at risk along beaches, coastal bluffs, or tidally inundated areas, removal or relocation to a less hazardous area is an effective adaptation strategy. Relocation requires sufficient and appropriate space. In some cases, this could require land acquisition. Removal or relocation can also be phased to maintain at least some temporary use of the development or infrastructure as sea levels rise.

When considering removal or relocation of infrastructure and roads, a key consideration is how this would affect service and access to public and private properties remaining in hazard areas. If it becomes infeasible or uneconomical to maintain public services to private properties in hazard areas, many significant issues would need to be considered, including impacts to property owners and public safety.

Hazard avoidance can also be facilitated through development restrictions that are consistent with state statutes, including the Coastal Act, and the state and federal constitutions.

Programs and policy options for removal or retreat of private property are identified and discussed in detail in Section 13, and include:

- Acquisition and buyout programs
- Conservation easements
- Rolling easements
- Transfer of development right programs

Application of managed retreat to developed property may give rise to significant legal issues, including the potential for inverse condemnation liability. Implementation measures for managed retreat will require careful evaluation prior to adoption. Managed retreat in California has been most typically used for public property and by government agencies, which have applied it in Asilomar State Beach and Surfer's Point. Examples or models of local-government-led programs for coordinated removal of private development in California are limited.

Throughout the United States, there are some examples of development removal and/or relocation programs sponsored by the FEMA. As part of the Hazard Mitigation Grant Program Acquisition Project, FEMA provides funds for local governments to purchase properties based on the principle of fair compensation from a willing, voluntary seller that have a structure that may or may not have been damaged or destroyed as a result of a hazard event. There is no readily available information regarding the effectiveness of this program and the extent to which it has already been applied. However, communities in California could seek funding under this program following a Presidential Major Disaster declaration (the mechanism that unlocks Hazard Mitigation Grant Program funds).

Other issues that will need to be further considered in the future relating to retreat programs include existing federal and state laws concerning property ownership and takings of property. It is also unclear, based on current case law, how exactly property ownership boundaries (e.g., the location of state tidelands) could move as the shoreline erodes and the mean high tide moves inland from sea-level rise. The current state and federal laws governing property ownership, takings, and use of the coast were not written with consideration for large-scale changes such as sea-level rise. How these laws will be implemented and interpreted by the courts in the face of accelerated sea-level rise in the coming years is unknown. It is also possible that some of these laws will be amended in the future to address the issues caused by sea-level rise and other climate change hazards.

Additional federal and state-wide policy, legal guidance, and information on funding mechanisms for managed retreat programs are likely needed to support the establishment of a private development removal program in Santa Barbara. In upcoming years, the City could follow legal cases, legislative actions, and the development of removal or managed retreat programs in other jurisdictions throughout the United States and pursue studies of how such programs could be implemented in Santa Barbara as more information becomes available.

Section 6

COASTAL BLUFF AREAS

Much of the westerly portion of the city's coastal zone is situated on bluffs overlooking the beach, from approximately Sea Ledge Lane at the west end to Santa Barbara Point by Leadbetter Beach (Figure 6-1). There are also coastal bluffs on the far easterly portion of the city by the Bellosguardo Estate.

Section 6.1 summarizes the key vulnerabilities identified in the Vulnerability Assessment Update (Appendix A) for the coastal bluff areas of the city as a result of accelerated beach and bluff erosion from sea-level rise if no action is taken to mitigate the hazards. Section 6.2 describes the thresholds for determining when adaptation is needed along the bluffs. Section 6.3 considers the feasibility, effectiveness, and the tradeoffs associated with implementing the applicable adaptation strategies presented in Section 5.2 to the coastal bluff areas of Santa Barbara. Section 6.4 provides recommendations on which strategies and follow-up studies should be pursued in the near-term in the coastal bluff areas.

Figure 6-1
Coastal Bluff Hazard Areas

6.1 Vulnerability of Coastal Bluff Areas to Sea-Level Rise

The coastal bluffs of Santa Barbara are currently vulnerable to erosion caused by exposure to waves as well as rainfall runoff, weathering, geology, soil mechanics, and anthropogenic impacts (Figure 6-2). When bluffs collapse, they can threaten bluff-top property and they can be a risk to the public visiting the beach. The beaches in front of the coastal bluffs help protect the bluffs from wave attack, but are at risk of erosion as well. As sea levels rise, both beach and bluff erosion are expected to accelerate.

SOURCE: Griggs and Russel 2012

Figure 6-2
January 2008 Landslide at Shoreline Park

Table 6-1 presents the projected average beach widths over time as sea levels rise based on the erosion modeling results[9] presented in the Vulnerability Assessment Update (Appendix A). With 2.5 feet of sea-level rise, the city could lose 78% of its bluff-backed beaches to erosion. With 6.6 feet of sea-level rise, the city could lose 98% of its bluff-backed beaches. In locations where these beaches are lost, the bluffs behind them will be more exposed to waves and are expected to erode more quickly.

9 See Section 4.5 in the Vulnerability Assessment Update (Appendix A) for additional information on the two-line beach erosion model.

TABLE 6-1
PROBABLE BLUFF-BACKED BEACH WIDTHS WITH SEA-LEVEL RISE

City Areas	Projected Beach Width (ft)		
	Current Conditions (2019)	2.5 feet of Sea Level Rise (±2060)	6.6 feet of Sea Level Rise (±2100)
Sea Ledge Lane to west side of Arroyo Burro Beach	95	20 to 30	0
Arroyo Burro Beach to east edge of Douglas Family Preserve	65	0 to 10	0
West end of Medcliff Road to east end of El Camino de la Luz	50	0 to 10	0
Lighthouse	40	0 to 10	0
Meigs Road to Shoreline Park	35	0	0
Shoreline Park to Santa Barbara Point	30	0	0
Bellosguardo Estate	95	30	0

0.8 feet of sea-level rise (±2030) was not analyzed.

Historic bluff erosion rates vary from 0.2 to 1.0 feet per year in Santa Barbara[10]. With sea-level rise, the bluff erosion rates are expected to increase by 40% on average with 2.5 feet of sea-level rise and by 140% on average with 6.6 feet of sea-level rise. With 2.5 feet of sea-level rise, coastal bluff erosion is expected to affect the bluff-top infrastructure (including access roads, trails, and irrigation infrastructure) in the Douglas Family Preserve and Shoreline Park, if no action is taken. Additionally, by this time, coastal bluff erosion will affect proprieties in the bluff-top residential neighborhoods and damage sewer lines, stormwater drainage pipes, and roads, including those supporting the Santa Barbara Lighthouse. Shoreline Drive on the east side of Shoreline Park and in the vicinity of Lighthouse Place could be impacted by erosion. This trend will continue into the future, with more roads, properties, and infrastructure in the bluff-top residential neighborhoods exposed to erosion with 6.6 feet of sea-level rise, if no action is taken. By that time, erosion could reach portions of Cliff Drive in addition to the west and east ends of Shoreline Drive.

6.2 Coastal Bluff Areas Adaptation Thresholds

The threshold criteria that should be monitored for coastal bluffs are the distances between the top and toe of the bluff and the bluff-top asset (such as a residence or road) (Table 3-1). A trigger distance can be determined based on a structural distance (i.e., the distance which is required to provide enough bluff width to laterally support the asset) combined with a safety factor. Once monitoring shows this trigger distance has been met,

[10] CampbellGeo, Inc. 2018. Sea Level Rise Adaptation Plan for the LCP Update, Geologic Review of Seacliff Areas, City of Santa Barbara, California. Submitted to ESA. August 17, 2019.

planning for and implementation of an adaptation measure would begin. The safety factor provides the necessary lead time for the adaptation strategy to be planned and implemented so that the bluff top asset is not immediately at risk from an erosion event.

An area-wide geotechnical study could be prepared to determine the appropriate slope thresholds and other suitable triggers. Different thresholds could be established for different sections of coastal bluffs in the city for the purpose of monitoring potential risk and informing the City on the need for adaptation. This monitoring and planning process could be supplemented by site-specific geotechnical analyses for specific assets. City policies related to thresholds for adaptation can be developed further in subsequent phases of updating the LCP and implementing this Adaptation Plan.

6.3 Coastal Bluff Areas Adaptation Options

Adaptation options analyzed for the coastal bluff areas include:

6. Beach nourishment
7. Sand retention structures
8. Bluff erosion BMPs
9. Shoreline protection devices
10. Managed retreat

Section 5.2 describes these different adaptation strategies in detail. The following section analyzes whether these strategies would be feasible and effective to implement in the coastal bluff areas of the city and summarizes tradeoffs associated with each strategy and consistency with the City's Guiding Principles (Section 3.1).

6.3.1 Beach Nourishment

Nourishing the beach (Section 5.2.1) below the coastal bluffs in Santa Barbara is not expected to be effective due to the wave exposure and high rate of downcoast sand transport along the bluffs. Without retention structures (see Section 6.3.2), the sand would not stay in place for long, so beach nourishment would not significantly slow beach or bluff erosion. Additionally, nourishment in front of the west bluffs would likely be transported into the Harbor, which would increase the need for maintenance dredging of the Harbor. Table 6-2 summarizes these considerations, as well as others, and evaluates consistency with corresponding Guiding Principles (Section 3.1). Beach nourishment is not recommended for the coastal bluff areas of the city.

TABLE 6-2
BEACH NOURISHMENT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• If a wider beach could successfully be maintained, this would reduce waves reaching the coastal bluffs, and therefore reduce bluff erosion. However, it is unlikely that a wider beach could be maintained for any effective period of time.
Feasibility	#4b	• Not feasible due to high transport rate of beach sands along the bluff-backed beaches. • Would require structures to retain sand, which is not recommended for the coastal bluff areas (see Section 6.3.2).
Timeline to Implement		• 5–10 years lead time is needed to secure sand sources and for permitting.
Effectiveness over Time		• Less effective over time with increasing sea-level rise and erosion. • If beach could be maintained with retention structures, it could be effective up to 2–3 feet of sea-level rise (±2060).
Cost	#4b	• Recurring implementation cost. • Cost is expected to increase over time as sand erodes faster and sources become more limited. • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies, however, ultimate success of permitting is considered fair, depending on the buy in of stakeholders.
Coastal Resource Impacts	#4d	• Short-term beach use impacts. • Ecological impacts from pumping sand and bulldozing in place. • Downcoast impacts to Harbor.
Benefits to Community Groups	#5a	• Coastal bluff-top property owners. • Beach visitors. • Shoreline Drive users.
Co-benefits	#5c	• Preserves beach and coastal bluff for habitat and recreation/tourism. • Aesthetics.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

6.3.2 Sand Retention Structures

Artificial sand retention structures, such as groins, breakwaters, and offshore reefs (Sections 5.2.3–5.2.5) can be effective at maintaining a sandy shoreline by altering incident waves and longshore sediment transport. However, constructing new breakwaters is not currently recommended at this time due to very low likelihood of success in permitting (see Section 9.3.1 for discussion about improvements to the existing breakwater). Offshore reefs are not expected to be effective due to the high sediment transport rate in the bluff areas.

Groins are also not a recommended management option for the bluff-backed beaches in Santa Barbara at this time due to the potential impacts they would have on the sediment supply to the downcoast beaches, high costs, and limited effectiveness in reducing bluff erosion and retaining sand. Groins only build a wider beach up-current of the structure. Down-current groins can lead to increased beach erosion. Focused use of sand retention structures could possibly help to maintain beach sand in select locations along the bluff (e.g., for access), but would likely increase erosion immediately down-current of the structure. Multiple groins (e.g., a groin field) along the bluffs are not expected to be a practical or economical approach to reduce bluff erosion, given the high costs and potentially unacceptable impacts to beach ecology and public access. Note that beach nourishment could be used to backfill groins to reduce downcoast impacts. Groins and beach nourishment could possibly preserve the beaches along the bluffs and reduce bluff erosion to a certain extent; however, due to high sediment transport rates and a relatively steep slope of the beach along the bluffs, the effectiveness and feasibility of groins and beach nourishment would need to be analyzed further. Table 6-3 summarizes considerations for groins, and evaluates consistency with corresponding Guiding Principles (Section 3.1). Sand retention structures are not recommended for the coastal bluff areas of the city at this time.

TABLE 6-3
SAND RETENTION STRUCTURES CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Groins would extend perpendicular to the beach and slow or stop sand from moving downcoast. A wider beach system up-shore of the groin would reduce waves reaching the coastal bluffs. However, down-shore of the groin increased erosion would occur. • Does not protect against high water level erosion events once beach is submerged.
Feasibility	#4b	• Due to high transport rate along the bluff-backed beaches, once one groin is constructed, others would be needed to keep downcoast beaches from eroding.
Timeline to Implement		• 15–20 years lead time to design, permit, and install.
Effectiveness over time		• Less effective over time with increasing sea-level rise. • Expected to be effective up to approximately 2–3 feet of sea-level rise (±2060), at which point feasibility and effectiveness of new groins is uncertain and would need to be studied further. • Would require regular maintenance and replacement.
Cost	#4b	• Initial implementation costs. • Recurring maintenance costs, possibly including beach nourishment. • Comparative cost[1]: high given the number of groins that would be necessary.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies, with unknown success.

TABLE 6-3
SAND RETENTION STRUCTURES CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Coastal Resource Impacts	#4d	• Could impact offshore bottom species. • Would provide wider beach for shore species up-shore of the groin and a narrower beach down-shore of the groin. • Could potentially promote non-native species/ecosystems through conversion of sand bottom to rocky reef. • Would induce or accelerate downcoast erosion due to high transport rate along the bluff-backed beaches. • Impacts horizontal access along beach. • Could create rip currents, which can be dangerous to beach users. • Could change surfing resources significantly. • Degrades scenic qualities of coastal area.
Benefits to Community Groups	#5a	• Beach visitors in coastal bluff areas up-shore from the groin. • Property owners along coastal bluff-top up-shore from the groin. • Shoreline Park users. • Shoreline Drive users up-shore from the groin.
Co-benefits	#5c	• Preserves beach for habitat and recreation/tourism up-shore from groin.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

6.3.3 Coastal Bluff Erosion BMPs

The City could implement BMPs (Section 5.2.6) along the coastal bluffs to reduce the rate of bluff erosion. These could include items such as reducing irrigation, concentrated flow over bluffs, and groundwater flows through the bluffs. Table 6-4 summarizes key considerations and evaluates consistency with corresponding Guiding Principles (Section 3.1).

TABLE 6-4
COASTAL BLUFF EROSION BMP CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Reduced and managed surface drainage to the bluffs could reduce erosion and slumping caused by runoff and soil saturation. • Would not reduce erosion at the base of the bluffs from waves and high water levels or completely eliminate slope failure hazards caused by underlying geology and seismic hazards.
Feasibility	#4b	• Would require coordination with public and private property owners. • Small-scale projects could be more readily implemented.

TABLE 6-4
COASTAL BLUFF EROSION BMP CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Timeline to Implement		• 2–5 years lead time to permit and install.
Effectiveness Over Time		• Maintenance or replacement measures may be needed over time.
Cost	#4b	• Initial implementation cost. • Recurring maintenance costs. • Small-scale projects would have relatively low costs for implementation. • Comparative cost[1]: low.
Permitability and Legal Complexities	#4b, c	• Requires local permits only. Relatively easy to permit.
Coastal Resource Impacts	#4d	• Stabilization of bluff could encourage habitat establishment. • Stabilization and vegetation establishment may reduce unauthorized access to bluff-backed beaches.
Benefits to Community Groups	#5a	• Bluff-top property owners. • Beach visitors. • Shoreline Drive users.
Co-benefits	#5c	• Water conservation. • Water quality. • Stormwater management.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

Shoreline protection devices are subject to failure when bluffs collapse, as shown here in Ocean Beach, San Francisco

Source: Westside Observer 2014. http://www.westsideobserver.com/2014/climate.html

6.3.4 Shoreline Protection Devices

Shoreline protection devices placed along the coastal bluffs could provide erosion protection associated with wave action. Section 5.2.7 describes in detail the two main types of shoreline protection devices (seawalls and revetments) and the benefits and impacts of these devices.

Seawalls backed by bluffs can be overwhelmed and crushed by episodic bluff failure events (see photo to the left). Bluff erosion is driven in part by wave action but also by other erosional mechanisms (e.g., wind), geology, soil mechanics, geomorphology, and anthropogenic impacts. Failure or collapse of bluffs can occur either when bluffs are undercut along the base by wave-action and are no longer able to support the overlying soil and rock, or when increased drainage from rain events or stormwater runoff to the bluff saturates the soil and causes slumping. Regardless of the mechanism that triggers a portion of a bluff to collapse, these episodic events can result in blocks of large quantities of sediment (along with bluff-top assets) crashing to the beach and/or ocean below. For this reason, seawalls are not recommended for placement at the toe of bluffs.

Rock revetments could potentially protect the bottom or toe of bluffs from wave erosion. Protecting or armoring the bluff toe may slow the overall rate of bluff retreat with sea-level rise; however, bluff toe armoring would not reduce terrestrial erosion of the bluff face and top due to runoff, weathering, and underlying geologic conditions.

The entire bluff face could be protected from erosion by armoring the face (e.g., with shotcrete, gunite, or sprayed concrete with steel reinforcement with tie backs into the bluff). Bluff armoring often does not effectively reduce the risk of larger-scale landslides. Armoring may, therefore, be subject to risk of failure from landslides, although this cannot be confirmed until additional site-specific studies are completed. Bluff face armoring may require bluff stabilization measures, such as significant grading to reduce or flatten bluff slopes. Bluff stabilization could potentially require removal or relocation of bluff-top assets. While bluff toe and face armoring are included for consideration in this Adaptation Plan, assessing the feasibility of constructing stable bluff face armoring is beyond the scope of this Adaptation Plan and would need to be evaluated through further study.

As discussed in detail in Section 5.2.7, shoreline protection devices can lead to accelerated loss of the beach seaward and on either side of the device, and can impact coastal beach access, recreation, habitats, sand transport rates, and visual resources. Permitting for shoreline protection devices is a complex process with uncertain outcomes, particularly when the shoreline protection device is intended to protect private residential development that is not considered “coastal dependent.” Shoreline protection is more frequently permitted for bluff-top development that is clearly coastal dependent, which could include development such as public coastal access stairways and paths, public parks, and public coastal access roads (see Section 5.2.7 for a detailed discussion of permitting for shoreline protection devices). Seawalls are preferred by the CCC because they allow for better public access to the beach, when compared to revetments. Seawalls should be used instead of revetments in areas where they are feasible, given the CCC preference.

Table 6-5 summarizes the key considerations for use of shoreline protection devices in the coastal bluff areas and evaluates consistency with corresponding Guiding Principles (Section 3.1). The analysis in the table distinguishes between shoreline protection devices used to protect private versus public development along the bluffs.

TABLE 6-5
SHORELINE PROTECTION DEVICE CONSIDERATIONS

<table>
<tr><th>Consideration</th><th>Guiding Principle</th><th>Benefits and Constraints for Protecting Public Development</th><th>Benefits and Constraints for Protecting Private Development</th></tr>
<tr><td>Hazard Protection</td><td>#4a</td><td colspan="2">• Shoreline protection devices (seawalls, revetments) would reduce waves reaching the bluffs, and therefore reduce bluff erosion associated with wave action in the vicinity of where they are placed. In some cases, shoreline protection devices can increase wave energy and erosion of beaches and bluffs on either side of the device.</td></tr>
<tr><td>Feasibility</td><td>#4b</td><td colspan="2">• Seawalls are not feasible along bluffs as they can be displaced by landslides.
• Revetments are commonly used engineering solutions that can be effective when built and maintained properly and could provide bluff toe protection from wave action, even after bluff failure events.
• In some locations, revetments would need to be combined with bluff face armoring and/or bluff stabilization to effectively reduce bluff erosion rates. The feasibility of protecting the entire bluff face requires further assessment and evaluation.</td></tr>
<tr><td>Timeline to Implement</td><td></td><td colspan="2">• 5–15 years lead time to design, permit, and install.</td></tr>
<tr><td>Effectiveness over time</td><td></td><td colspan="2">• Expected to be effective against wave action in the near- and mid-term, and possibly the long-term, at which point the feasibility and effectiveness of new revetments is uncertain and would need to be studied further.
• Subject to failure when design conditions or structure life are exceeded. Would need to be regularly maintained and replaced.
• Level of protection decreases with loss of beach.
• Would need to increase height of structure with sea-level rise; at some point, the foundation may become inadequate and need to be rebuilt to remain effective.</td></tr>
<tr><td>Cost</td><td>#4b</td><td>• Initial implementation cost.
• Recurring maintenance costs.
• May require more frequent maintenance or reconstruction with increased sea-level rise.
• Comparative cost1: medium to high.</td><td>• Would likely not be economically justifiable for the City to protect the bluffs solely for the purpose of protection of private property (see Section 11).
• Comparative cost: high.</td></tr>
</table>

TABLE 6-5
SHORELINE PROTECTION DEVICE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints for Protecting Public Development	Benefits and Constraints for Protecting Private Development
Permitability and Legal Complexities	#4b, c	• Properties with existing shoreline protection devices can seek permits for repair and maintenance, with moderate success. • New shoreline protection devices to protect existing or new coastal dependent development could be permitted; however, permitting process is complex and can be costly.	• Properties with existing shoreline protection devices can seek permits for repair and maintenance, with moderate success. • New shoreline protection devices to protect existing private residential bluff development may be possible, although outcomes are unknown due to changes in interpretations of regulations by some agencies. Permitting process would be complex and costly. • New shoreline protection devices to solely protect new private residential bluff development not currently allowed.
Coastal Resource Impacts	#4d	• Accelerates beach erosion, resulting in impacts to beach habitat, public access along the beach, beach recreation, and tourism impacts. • Can affect lateral and vertical public access by occupying beach area. • Degrades scenic qualities of coastal area. • Loss of sandy input from bluff face to the littoral system.	
Benefits to Community Groups	#5a	• Public infrastructure users. • Shoreline and Cliff Drive users. • Shoreline Park users. • When used to protect public access stairways, would benefit beach users.	• Bluff-top owners. • If, due to location, shoreline protection devices have the added benefit of also protecting public infrastructure and roads in addition to private development, then public infrastructure and road users would benefit.
Co-benefits	#5c		

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

6.3.5 Managed Retreat

Section 5.2.13 discusses in detail methods and issues associated with managed retreat on private and public property. Removal and relocation of threatened existing development along the bluffs could occur in phases as sea-level rise progresses. In addition, the City could restrict new development and substantial redevelopment in certain, projected hazard areas. The City currently has policies in its LCP limiting new development and substantial redevelopment within required bluff setback areas that factor in the effects of sea-level rise.

Removal, relocation, or rerouting of public infrastructure, facilities, roads, and parks must be done with close consideration of temporary and permanent impacts to public services, transportation, and public access and recreation. As discussed in detail in Section 5.2.13, managed retreat on private property is much more legally complex and can place hardships on private property owners, particularly when the entirety of a property is potentially at risk.

Figure 6-3 illustrates how buildings and infrastructure can be removed from the coastal erosion and hazard zone to allow progressive bluff retreat over time with sea-level rise. Managed retreat along the bluffs would allow the bluffs to continue to erode backward, which would facilitate retention of beach widths below the bluffs for a longer period of time. However, even with erosion of the bluffs occurring at higher rates, 78% of beaches along the bluffs are anticipated to be lost with 2.5 feet of sea-level rise due to the fact that sea-level rise and beach erosion will outpace the rate of bluff erosion.

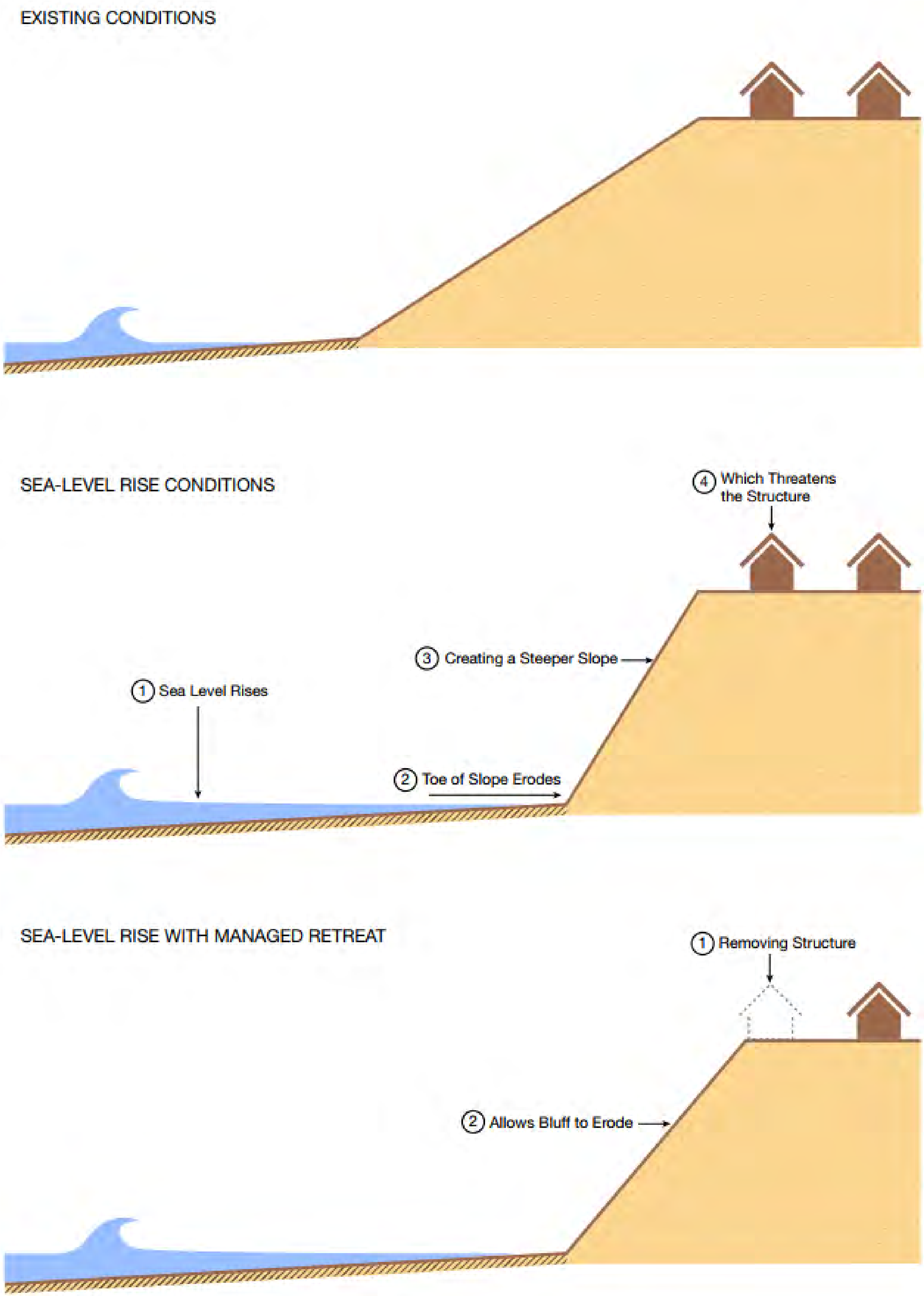


Figure 6-3
Illustration of bluff managed retreat adaptation measure

Table 6-6 summarizes the considerations for managed retreat.

TABLE 6-6
MANAGED RETREAT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Removes structures and infrastructure from hazard zone.
Feasibility	#4b	• On public properties, managed retreat is feasible, assuming City services can be maintained or modified to acceptable levels, such as through rerouting of roads. • Bluff setbacks for new development and substantial redevelopment are already employed. • Removal of existing private development and development restrictions that affect entire properties are legally complicated. • There are no current examples in California of local-government-led programs or coordinated removal of private property in advance of a hazard-related disaster; however, FEMA funding to acquire property may be available. • Could require many home owners to agree to move. • Uncertainty around who pays and who benefits. • Uncertainty around legal possibility under certain conditions.
Timeline to Implement		• Lead time varies greatly between 2 and 10 years depending on the type of development being removed or relocated, whether there is space on the existing property to relocate it, and if major public infrastructure is involved (e.g., major arterial roads). • Redevelopment regulations can take a long time to result in existing development being moved away from bluffs. • Large-scale, proactive managed retreat programs for private property would likely take 15–20 years to develop.
Effectiveness over time		• Bluff erosion will continue to migrate inland, requiring additional adaptation for the next line of structures and infrastructure. • Likely to become more necessary in the long-term as protection of development in place becomes less economical and feasible.
Cost	#4b	• Costs for retreating (allowing bluff erosion) are low if no structures or infrastructure exist (e.g., allowing retreat at Douglas Family Preserve) or if simple removal (without replacement) of a structure is proposed. • Rebuilding structures and infrastructure elsewhere is expensive due to property costs. • If necessary, buying out property owners would be very expensive, but could become less expensive over time as increased risk levels affect property values • Comparative cost1: high; low, if structure would not be relocated.
Permitability and Legal Complexities	#4b, c	• Permitting would only be complex if replacement sites involve significant potential impacts. • Low to moderate legal risks for public properties. • High legal risk for private properties.

TABLE 6-6
MANAGED RETREAT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Coastal Resource Impacts	#4d	• Allows for preservation of beach widths for longer and associated ecological resources. • Preserves natural character of bluff area. • Loss of bluff-top open space and park facilities could occur. • Rerouting of roads and relocation of public infrastructure could impact service levels and traffic in other areas of the city. • Impacts of re-establishing development elsewhere. • Reduces the likelihood of damaged material entering the ocean.
Benefits to Community Groups	#5a	• Beach visitors.
Co-benefits	#5c	• Preserves beach and bluff for habitat and recreation/tourism. • Aesthetics. • Seismic safety.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

6.4 Coastal Bluff Areas Adaptation Recommendations

The adaptation strategies proposed in Section 6.3 were evaluated in detail and also compared against the City's Guiding Principles (Section 3.1). Table 6-7 summarizes the strategies, whether they are recommended, the extent to which they align with the Guiding Principles, and the timeframes through which they are likely to be effective.

In the near-term, the City could consider the following along the bluffs:

- Closely monitoring beach and bluff erosion.
- Expanding existing BMPs to reduce the rate of bluff erosion due to directed runoff and irrigation.
- Continuing current regulatory practices requiring bluff setbacks for new development and substantial redevelopment that factor in accelerated bluff erosion from sea-level rise.
- Continuing to limit the use of revetments except when necessary to protect essential public services, major public access roads, and to protect public access stairways.
- Planning for removal, relocation, or, as needed, protection of public assets in Shoreline Park and Douglas Family Preserve.
- Encouraging relocation of existing private development out of hazard areas to the extent feasible.

TABLE 6-7
SUMMARY OF ADAPTATION STRATEGIES FOR BLUFF AREAS

Adaptation Strategy	Recommendation	Key Considerations
BMPs	Recommended for further consideration in the near-, mid-, and long-term.	Could reduce bluff erosion rates where there are currently high rates of erosion from uncontrolled drainage. However, not likely to significantly reduce bluff hazards on its own. Lead time to implement is 2–5 years.
Shoreline Protection Devices	Seawalls not feasible along bluffs. Revetments could be considered for use in the near- and mid-term, and potentially in the long-term. In the near- and mid-term, this Adaptation Plan recommends that the City limit investment in revetments to those that protect major public roads, public beach accessways, critical infrastructure, and some level of public coastal recreation and access along the bluff tops. Feasibility and effectiveness of new revetments uncertain after 3–5 feet of sea-level rise (approximately between 2060 and 2100).	Would only address wave-induced bluff erosion. May need to combine with bluff stabilization measures to address upland erosional hazards. Would cause accelerated erosion of beaches. Revetments for private residential structures are very hard to permit and not economically beneficial to the community. Revetments for coastal dependent uses (major public access roads, coastal recreation, beach access stairways, etc.) are more likely to be permitted and more economically beneficial to the community. Once bluff backed beaches are already lost due to sea-level rise (around 2.5 feet of sea-level rise or ±2060), there would be somewhat fewer impacts associated with placing revetments at the toe of bluffs. Lead time to implement is 5–15 years.
Managed Retreat	Could be considered for use in the near-, mid-, and long-term.	Retreat of public properties meets all Guiding Principles (Section 3.1) if essential public services can be maintained or replaced. The legal and financial feasibility of retreating entire private properties is uncertain. Lead time to implement is 2–20 years depending on the area and asset involved.
Beach Nourishment	Not recommended at this time.	Not feasible due to high transport rate of beach sands along bluff-backed beaches
Sand Retention Structures	Not recommended at this time.	Not recommended due to impacts to downcoast beaches and bluffs, the number of structures that would be needed to protect all bluff areas, and the compartmentalization of the shoreline that would occur

Both beach nourishment and sand retention structures would not be feasible or effective to preserve the beaches in front of the bluffs or to effectively reduce bluff erosion, due to the high sediment transport rate in the coastal bluff area, the number of sand retention structures needed, and cumulative impacts of those structures. As a result, none of the currently recommended strategies would effectively address beach loss along the coastal bluffs. It is projected, therefore, that by 2.5 feet of sea-level rise (±2060) approximately 80% of the beach area below the bluffs will be lost.

Installing revetments at a large scale along the bluffs in the near-term to protect public and private assets is likely to substantially increase the rate of beach loss and limit public access along the beaches. Beaches provide lifestyle and economic benefits to the community through tourism, public access, and recreation. Installing and maintaining revetments and bluff slope protection in the near-term for the sole purpose of protecting private residential development benefits only a limited number of people, could result in the accelerated loss of beaches used by the general public, and, as discussed in detail in Section 11, will not likely provide net economic benefits to the community. Additionally, there is significant uncertainty associated with the ability to permit revetments to protect private residential development. However, in the near-term the City could consider use of revetments to protect important public assets (such as to protect public beach accessways and major public roads) that cannot easily be relocated.

Moving into the mid- and long-term, the City may want to reconsider the broader use of shoreline protection along the bluffs when more erosion has occurred and there is less room on private properties to relocate private development, large portions of major public roads are threatened, much of Shoreline Park is threatened, and many of the beaches have already lost their recreational value.

The City will need to make a decision in the mid-term on whether to:

(1) Further retreat and relocate major public infrastructure and reroute Shoreline Drive and Cliff Drive; or

(2) Use revetments and slope stabilization on a larger scale to try to retain the use of Shoreline Drive and Cliff Drive, public access along the top of the bluffs, and a portion of Shoreline Park large enough to still provide public coastal recreation and access opportunities.

Triggers for planning and implementing either adaptation approach in the mid- and long-term will need to be further developed based on a geotechnical study and recommendations. Possible triggers could be when bluff edge erosion reaches within about 100 feet of larger portions of Shoreline Drive (or when bluff toe erosion reaches within about 150 feet of Shoreline Drive). For Cliff Drive, possible triggers could be when bluff edge erosion reaches within about 400 feet or when bluff toe erosion reaches within about 450 feet of larger portions Cliff Drive.

Additional studies needed include:

- Research to further define a safe bluff setback and trigger distance, which will be used to inform the City on when an adaptation measure is needed.

- Research and continued monitoring of case studies, case law, and funding concerning managing retreat and other adaptation strategies.
- Study of whether slope protection measures (gunite, soldier piles, etc.) along the upper bluff face would be needed in addition to shoreline protection at the base of the bluffs to protect major public roads and bluff-top access areas due to underlying geologic conditions and landslide risk.

Figure 6-4 shows the major vulnerabilities along the city's coastal bluffs and some options for sequencing adaptation strategies.

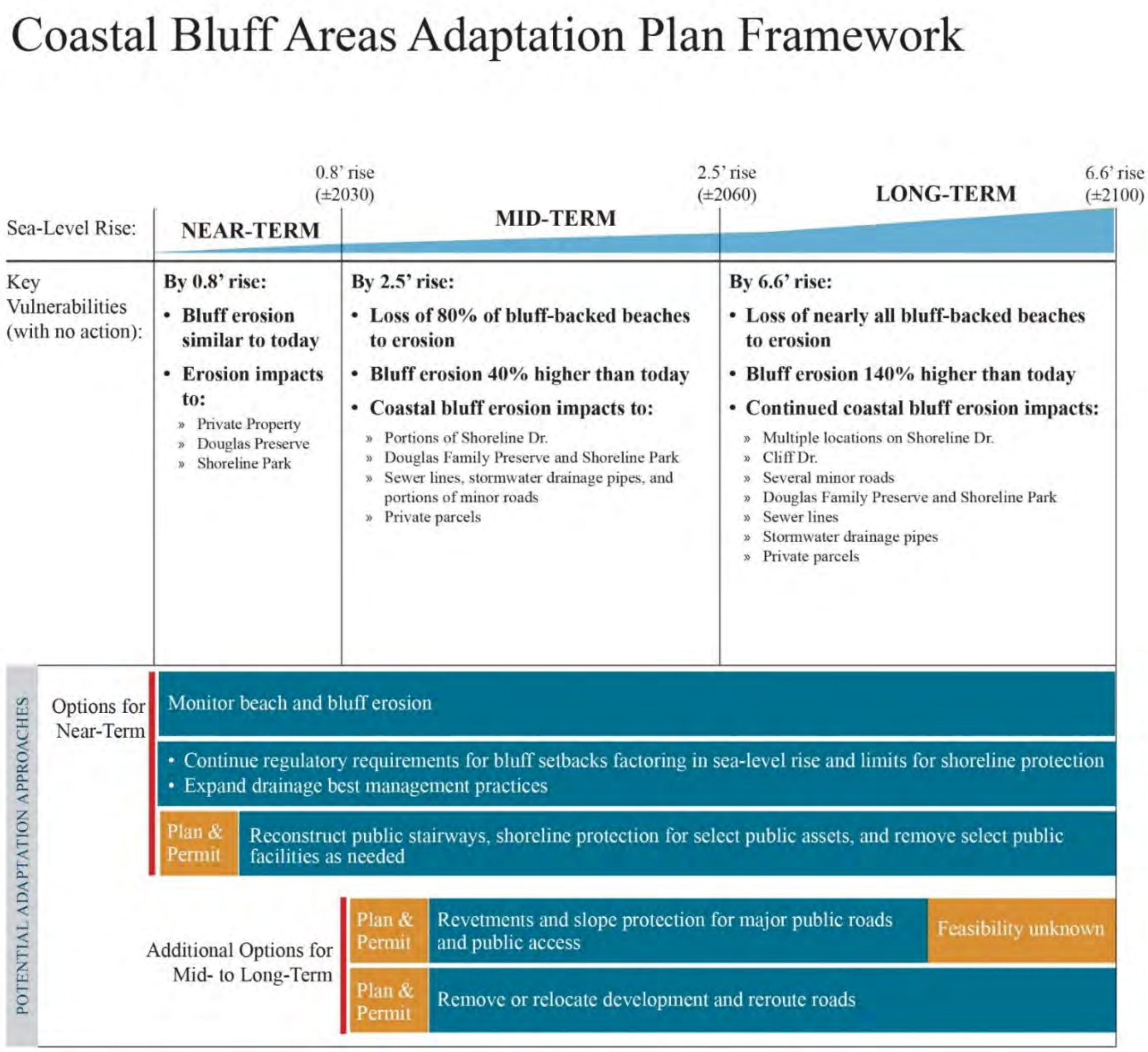


Figure 6-4
Bluff adaptation plan framework

Section 7

LOW-LYING WATERFRONT AND BEACH AREAS

The low-lying waterfront and beach areas of the city include the city's waterfront south of Cabrillo Boulevard spanning from Leadbetter Beach to East Beach and Arroyo Burro Beach on the west side of the city (Figure 7-1). The Harbor and Stearns Wharf are discussed in more detail in Section 9. Section 8 addresses the low-lying flood areas of Shoreline Drive, Cabrillo Boulevard, and Cliff Drive by Alan Road. Because the major creeks that outflow in the low-lying waterfront and beach areas directly contribute to the flooding of the low-lying flood area, adaptation options for these creeks are discussed in Section 8.

Figure 7-1
Low-Lying Waterfront and Beach Hazard Areas

Section 7.1 summarizes the key vulnerabilities identified in the Vulnerability Assessment Update (Appendix A) for the low-lying waterfront and beach areas of the city as a result of accelerated beach erosion and flooding from sea-level rise. Section 7.2 describes the thresholds for determining when adaptation is needed along the low-lying beaches. Section 7.3 considers the feasibility, effectiveness, and the tradeoffs associated with implementing the applicable adaptation strategies presented in Section 5.2 to the low-lying beach areas. Section 7.4 provides recommendations on which strategies and follow-up studies should be pursued in the near-term for these areas.

7.1 Vulnerability of Low-Lying Waterfront and Beach Areas to Sea-Level Rise

The low-lying waterfront and beach areas of Santa Barbara are currently vulnerable to tidal inundation, coastal storm flooding (Figure 7-2), wave impact, and beach erosion (Figure 7-3). The configuration of the Harbor plays a major role in determining sand transport and accumulation in the waterfront area, with West Beach consistently filling with sand that is then placed on East Beach as part of City sediment management activities to prevent erosion. As described in Section 2 of the Vulnerability Assessment Update (Appendix A), extreme coastal flood events, which have caused significant damage in the low-lying beach areas, have occurred in Santa Barbara, including in 1983, 1995, 1998, 2005, 2008, and 2017.

SOURCE: Griggs and Russel 2012

Figure 7-2
Waves Overtopping West Cabrillo Boulevard in 1914

SOURCE: Griggs and Russel 2012

Figure 7-3
Beach Erosion at Leadbetter Beach Parking Lot from the March 1983 El Niño Event

If no adaptation measures are taken, sea-level rise will cause increased levels of erosion at the city's low-lying beaches, with the beaches east of Stearns Wharf most affected. Table 7-1 presents projected average beach widths over time if no adaptation measures are implemented based on erosion modeling results[11] used in the Vulnerability Assessment Update.

[11] See Section 4.5 in the Vulnerability Assessment Update (Appendix A) for additional information on the two-line beach erosion model.

TABLE 7-1
SANTA BARBARA BEACH WIDTHS WITH SEA-LEVEL RISE

Average Beach Width by Area	Projected Beach Width (ft)		
	Current Conditions (2019)	2.5 feet of Sea Level Rise (±2060)	6.6 feet of Sea Level Rise (±2100)
Leadbetter Beach	120	95	65
West Beach	430	395	345
Chase Palm Park	170	45	0
East Beach	280	180	30

0.8 feet of sea-level rise (±2030) was not analyzed.

With 0.8 feet of sea-level rise, storm waves are expected to impact portions of the Leadbetter Beach parking lot, the Cabrillo Pavilion, East Beach Parking Lot, Waterfront Parking Lot, and Cabrillo Boulevard between approximately Niños Drive and the Andrée Clark Bird Refuge. With 2.5 feet of sea-level rise, storm waves are anticipated to extend to Shoreline Boulevard near Leadbetter Beach and Cabrillo Boulevard by Stearns Wharf and impact sewer and water supply infrastructure. With 6.6 feet of sea-level rise, tidal inundation is anticipated to extend along much of Cabrillo Boulevard and the area northeast of Cabrillo Boulevard by the Harbor and Stearns Wharf (extending from approximately Castillo Street to Calle Cesar Chavez, and in some places reaching Highway 101).

In the western portion of the city in the area stretching from Arroyo Burro Beach to the Douglas Family Preserve, coastal storm flooding and beach erosion is expected to impact the Boathouse Restaurant and west side of the beach park by 2.5 feet of sea-level rise. With 6.6 feet of sea-level rise, erosion is projected to extend into the western portion of the beach parking lot and storm waves are expected to flood Cliff Drive and lower Alan Road and impact sewer and water supply infrastructure.

7.2 Low-Lying Waterfront and Beach Adaptation Thresholds

The threshold criteria to be monitored for low-lying waterfront and beach areas include sea-level rise and approximate beach widths (Table 3-1). Most locations in the waterfront have significant beach width currently. The Vulnerability Assessment Update (Appendix A) projected that the waterfront beaches would narrow, but would still be present with 2.5 feet of sea-level rise. However, without intervention and with more than 2.5 feet of sea-level rise, the beach in front of Chase Palm Park (East Beach) is expected to disappear or be too thin to provide the recreational and coastal storm protection benefits the beach offers today (Table 7-1). A specific trigger distance should be developed for each beach based on the projections in Table 7-1 and an acceptable level of risk as determined by the City. While further analysis is needed, the thresholds for initiating consideration and planning for larger-scale beach adaptation along the waterfront could be:

1. Sea-level rise approaching 1 to 2 feet
2. Average or successive winter/spring beach widths approaching 80 feet
3. Average or successive summer/fall beach widths approaching 225 feet

Note that the beach erosion in front of the Santa Barbara Yacht Club and parking lot west of the Harbor likely already results in beach widths that are narrower than these thresholds. Site- specific adaptation planning at this location and any other locations that exceed these thresholds is recommended in the near-term.

7.3 Low-Lying Waterfront and Beach Adaptation Options

Adaptation options for low-lying waterfront and beach areas include:

1. Coastal sediment management (e.g., beach and dune enhancement, sand bypassing)
2. Sand retention structures (e.g., groins, breakwaters, offshore reefs)
3. Shoreline protection devices (e.g., seawalls, revetments)
4. Elevating or waterproofing structures
5. Elevating property grade
6. Managed retreat

Section 5.2 describes these different adaptation strategies in detail. The following section analyzes whether these strategies would be feasible and effective to implement in the low-lying beach areas of the city, and summarizes tradeoffs associated with each strategy and consistency with the City's Guiding Principles (Section 3.1).

7.3.1 Coastal Sediment Management

Coastal sediment management is a combined strategy involving the use of both beach and dune enhancement and sand bypassing.

Beach and Dune Nourishment

The City currently builds season beach berms and nourishes East Beach and Leadbetter Beach. Beach and dune enhancement (Section 5.2.1) could be used more extensively in the low-lying beach areas of the city, including at Arroyo Burro, Leadbetter, and East Beaches. The City could pursue additional sand sources such as opportunistic beach nourishment (surplus sand from various sources, including inland construction or development projects), additional offshore dredging, or regional nourishment programs such as Santa Barbara's Coastal Regional Sediment Management Plan and BEACON (Section 2.10). It is important to note, however, that it can be difficult to find sand supplies of the right quality (e.g., grain size, color) for beach nourishment.

The 2009 *Santa Barbara Coastal Regional Sediment Management Plan* includes a recommendation to establish, permit, and maintain a regional sediment management source site at West Beach. BEACON's update to the 2009 *Santa Barbara Coastal Regional Sediment Management Plan* (Section 2.10) should be reviewed for new recommendations when it becomes available. Additionally, the City should support and participate in the Regional Opportunistic Sediment Placement Program as a way to utilize available sand sources for nourishment.

Sand Bypassing

The Harbor is regularly dredged, with sand placed in areas with decreasing beach widths (Figure 7-4). The USACE has been responsible for dredging the federal navigation channel within the Harbor since 1972. The City is responsible for dredging the non-federal navigation channel in the Harbor.

Figure 7-4
Sand bypassing concept

On average, USACE dredges approximately 250,000 cubic yards annually, during a spring and fall dredge. The USACE is authorized to dredge a potential annual total of 600,000 cubic yards. The dredged material is placed at either East Beach or between Mission Beach and the East Side Channel surf zone. In the winter, the City uses this material to build a berm to protect the low-lying waterfront areas from winter coastal storms. Sand bypassing is recommended at these locations and not Arroyo Burro or Leadbetter Beach since placement at those locations would be back-passing sand (i.e., moving sand against the natural current), and the sand would eventually end up back in the Harbor.

Since 1990, the City has dredged approximately 500,000 cubic yards of sediment (ESA PWA 2013). Since 1985, the City's dredging activities have been regulated through a series of coastal development permits that have been limited to 5-year terms. In 2011, the City developed the Waterfront Sediment Management Plan, a comprehensive 10-year management program that describes maintenance dredging, sediment disposal, beach nourishment, storm drain outlet maintenance, and beach grooming at the Harbor and waterfront areas (see Section 2.11 for further details).

The 2009 *Santa Barbara Coastal Regional Sediment Management Plan* recommends that sand bypassing (Section 5.2.2) from the region's harbors continue and that opportunities are maximized for beach nourishment. In response to this recommendation, the City could modify its current sand bypassing program to adapt to sea-level rise induced erosion hazards and risks. For example, the City could:

- Increase the amount of dredging if the rate of sand deposition in the navigation channel increases with sea-level rise or if additional sand is needed to nourish downcoast beaches.
- Modify where and how dredged sand is placed on the beach downcoast to adapt to changes in beach erosion patterns with sea-level rise. This could include modifying the existing construction of protective sand berms in the winter to protect key facilities such as the Cabrillo Bathhouse.

Additionally, the 2009 *Santa Barbara Coastal Regional Sediment Management Plan* recommends establishing a regional sediment management authorization or permit for the Harbor to increase maintenance dredging funding for beneficial reuse and coordinated management activities.

Table 7-2 summarizes considerations for both beach and dune enhancement and sand bypassing, and analyzes consistency with Guiding Principles (Section 3.1).

TABLE 7-2
COASTAL SEDIMENT MANAGEMENT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• A wider beach and/or dune system would reduce waves reaching the backshore. • Does not protect against high water level events once beach is submerged. • Can erode during coastal storm events, exposing landward areas to flood risks. • Sand retention structures would improve effectiveness (see Section 7.3.2).
Feasibility	#4b	• Sand bypassing and beach nourishment already occur in Santa Barbara. • Material dredged from the Harbor must be evaluated for suitability for beach placement. • If more sand is needed beyond what is removed from the Harbor, feasibility would depend on availability of sand sources of appropriate quality.
Timeline to Implement		• Is currently being implemented and could be modified or expanded in the near-term. • 5–10 years lead time to secure sand sources and for permitting additional beach nourishment and/or sand bypassing.
Effectiveness over time		• Less effective over time with increasing sea-level rise. • Expected to be effective up to about 2–3 feet of sea-level rise (±2060). However, implementing multiple adaptation strategies in combination could increase the lifespan of the sand on the beach and the level of effectiveness.
Cost	#4b	• Recurring implementation cost. • Cost is expected to increase over time as sand erodes faster and sources become more limited. • Regional and federal funding sources may be available. • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies, but likelihood of success is high.
Coastal Resource Impacts	#4d	• Short-term beach use impacts when sand is placed on beach. • Ecological impacts from pumping sand and bulldozing in place. • Downcoast impacts, such as contributing to closure of lagoon mouths.
Benefits to Community Groups	#5a	• Beach visitors. • Property owners and businesses along shoreline. • Cabrillo Boulevard users.
Co-benefits	#5c	• Preserves beach for recreation/tourism and habitat. • Maintains beach aesthetics. • Reduces inundation of sewer system.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

7.3.2 Sand Retention Structures

Groins

One or more groins could be placed along East Beach to maintain a wider beach (Section 5.2.3), which could be implemented in conjunction with beach and dune nourishment (Section 5.2.1) to improve the effectiveness of nourishment. Groins would decrease sand transport downcoast of the city for some time after initial construction, which could impact downcoast areas. However, groins in conjunction with beach nourishment could possibly partially mitigate potential downcoast impacts.

Installing a groin east of Laguna Creek could help prevent sand from traveling west into the Harbor entrance and would build up sand at East Beach (ESA 2013, 2014). While sand in Santa Barbara typically travels west to east, occasional swell from the south directs sand west along the coastline (Figure 7-5). Sand moving west in the vicinity of the Laguna Creek and Mission Creek mouths is likely to end up in the entrance to the Harbor, which will then need to be pumped out to maintain safe navigation access. The current sand pumping deposits sand just east of Laguna Creek, so a groin could prevent this sand from returning back into the Harbor. Occasional beach nourishment between the Harbor entrance and the groin (i.e., in front of Mission Creek) would be needed to maintain sand in that area. The new groin would be expected to increase the width of the beach in the vicinity of Laguna Creek. The increased beach width could impact the desalination plant intake and the wastewater outfall in the area, so further studies would be needed. A full sediment transport study would need to be done to determine the feasibility of a groin east of Laguna Creek.

Figure 7-5
Example of groin and sand movement during south swell

Table 7-3 summarizes considerations for using groins as an adaptation strategy and analyzes consistency with Guiding Principles (Section 3.1).

TABLE 7-3
GROINS CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Groins would extend perpendicular to the beach and slow or stop sand from moving downcoast; a wider beach system would reduce waves reaching the backshore. • Does not protect against high water level events once beach is submerged. • Could diminish sand sources downcoast, thereby impacting downcoast areas.
Feasibility	#4b	• Groin structures already exist in Santa Barbara (West Beach Harbor Groin). • Prior studies have shown groins may be beneficial at East Beach with minimal downcoast impacts (ESA 2013, 2014).

Consideration	Guiding Principle	Benefits and Constraints
Timeline to Implement		• 15–20 years lead time to design, permit, and install.
Effectiveness over time		• Less effective over time with increasing sea-level rise. • Expected to be effective up to 2–3 feet of sea-level rise (±2060), at which point the feasibility and effectiveness of new groins is uncertain due to the accelerated rate of sea-level rise and beach erosion. Implementing multiple adaptation strategies in combination could increase lifespan of the structure and the level of effectiveness. • Would need to be maintained, repaired, and possibly raised as sea level rises.
Cost	#4b	• Initial implementation costs. • Recurring maintenance costs, possibly including beach nourishment. • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies, with unknown success.
Coastal Resource Impacts	#4d	• Could impact offshore bottom species. • Would provide wider beach for shore species up-coast but diminish beaches downcoast. • Could potentially promote non-native species/ecosystems through conversion of sand bottom to rocky reef. • Could induce or accelerate downcoast erosion. • Impacts lateral access along beach. • Could create rip currents, which can be dangerous to beach users. • Degrades scenic qualities of coastal area.
Benefits to Community Groups	#5a	• Beach visitors in East Beach Area or up-shore from the groin. • Property owners and businesses along shoreline up-shore from the groin. • Cabrillo Boulevard users up-shore from the groin.
Co-benefits	#5c	• Preserves beach for habitat and recreation/tourism in East Beach Area or up-shore from the groin.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

The Santa Barbara Harbor breakwater protects the harbor behind it.

Source: Santa Barbara Paddle Sports Center, 2018

Breakwaters

Santa Barbara currently has a breakwater, which is used to shelter the Harbor (photo to left). While breakwaters often destroy surfing resources (Section 5.2.4), the Santa Barbara Harbor breakwater has created a world-class surf break. Section 9.3.1 discusses raising and improving the existing breakwater as a Harbor adaptation strategy. However, permitting in California for new breakwaters has become rare, so building a new breakwater may be infeasible.

Table 7-4 summarizes considerations for constructing new breakwaters as an adaptation strategy and analyzes consistency with Guiding Principles (Section 3.1; see Section 9.3.1 for discussion about improvements to the existing breakwater). Due to very low likelihood of success in permitting, construction of new breakwaters that are not associated with the existing Harbor breakwater are not currently recommended at this time.

TABLE 7-4
NEW BREAKWATER CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Breakwaters shelter shorelines and harbors by causing waves to break before the shoreline and maintaining a wider beach where they are. • Could induce downcoast erosion.
Feasibility	#4b	• Breakwater already exists in Santa Barbara at the Harbor
Timeline to Implement		• 15–20 years lead time to design, permit, and install
Effectiveness over time		• Expected to be effective up to 2–3 feet of sea-level rise (±2060) and then would need to be raised. • Would need to be maintained, repaired, and possibly raised as sea levels rise.
Cost	#4b	• Initial implementation costs. • Recurring maintenance costs. • In-water work is expensive. • Comparative cost[1]: medium.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies, with unknown success. • Trend is for permitting agencies to want to remove existing breakwaters.

TABLE 7-4
NEW BREAKWATER CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Coastal Resource Impacts	#4d	• Could impact offshore bottom species. • Could potentially promote non-native species/ecosystems through conversion of sand bottom to rocky reef. • Changes wave patterns and destroys surfing resources. • Could induce or accelerate downcoast erosion. • Degrades scenic qualities of coastal area.
Benefits to Community Groups	#5a	• Beach visitors in vicinity of breakwater (downstream beaches, and therefore visitors could be impacted). • Property owners and businesses along shoreline in vicinity of breakwater. • Cabrillo Boulevard users in vicinity of breakwater.
Co-benefits	#5c	• Preserves beach for habitat and recreation/tourism.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

Offshore Reefs and Kelp Beds

The 2009 *Santa Barbara Coastal Regional Sediment Management Plan* (Section 2.10) recommends seeking ways to demonstrate and implement new and innovative sand retention technologies, such as reefs (Section 5.2.5), that are compatible with the Santa Barbara shoreline setting. The plan identifies Arroyo Burro Beach as a location for a potential offshore reef sand retention pilot project. East Beach could also be a location for a pilot project.

Restoration of existing kelp beds offshore of the bluffs where the habitat is patchy could provide habitat benefits with some reduction in sand movement downcoast. However, while offshore kelp beds may dissipate waves to some extent, they would not be very effective at maintaining sand on the beach.

The effectiveness and feasibility of reefs and kelp beds in conditions similar to those in Santa Barbara have not been established. They remain, to date, experimental adaptation strategies. More studies are necessary to prove feasibility, but it is possible reefs and kelp bed restoration could be pursued further based on results of pilot projects in Santa Barbara or other similar locations. Table 7-5 summarizes considerations for using artificial reefs or kelp beds as an adaptation strategy and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 7-5
OFFSHORE REEFS AND KELP BED CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Offshore, submerged reefs encourage sand retention behind them which maintains a wider beach. • Does not protect against high water level and wave events when reef would be less effective. • Offshore kelp beds may provide some sand retention behind them.
Feasibility	#4b	• Artificial reefs are in the experimental phase of development, and there has not been enough experience with successful reef installations to date.
Timeline to Implement		• 15–20 years lead time to design, permit, and install.
Effectiveness over time		• Expected to be effective up to 2–3 feet of sea-level rise (±2060), at which point feasibility and effectiveness are uncertain. Implementing multiple adaptation strategies in combination could increase time period and level of effectiveness. • Would need to be maintained, repaired, and possibly raised as sea levels rise.
Cost	#4b	• Initial implementation costs. • Temporary (5+ years) monitoring costs. • Recurring maintenance costs. • Grant funding sources may be available if new habitat is created. • Comparative cost[1]: low to medium.
Legal Complexities	#4b, c	• Low to moderate legal risk depending on potential impacts.
Permitability		• Complex permitting requirements from state and federal agencies for artificial reefs. • Less complicated permitting for kelp bed restoration.
Coastal Resource Impacts	#4d	• Could impact offshore bottom species. • Could potentially promote non-native species/ecosystems through conversion of sand bottom to rocky reef. • Could induce or accelerate downcoast erosion.
Benefits to Community Groups	#5a	• Beach visitors in vicinity of reefs (downstream beaches, and therefore, visitors could be impacted). • Surfers. • Property owners and businesses along shoreline in vicinity of reefs. • Cabrillo Boulevard users in vicinity of reefs.
Co-benefits	#5c	• Creates new rocky reef habitat. • Preserves beach for habitat and recreation/tourism. • Could improve surfing resources.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

7.3.3 Shoreline Protection Devices

Seawalls and revetments could be used in the low-lying beach areas, including Arroyo Burro, Leadbetter, West, and East Beaches, to mitigate the threat of erosion and flooding, as discussed in detail in Section 5.2.7. Existing shoreline protection structures of various construction and condition are buried along East Beach and have been observed during coastal storm events that have caused large amounts of erosion (ESA 2014). Additionally, there is an existing revetment protecting the Boathouse Restaurant and a portion of Shoreline Park at Arroyo Burro Beach County Park. Raising and improving seawalls and revetments (Section 5.2.7) along the city's waterfront and in the vicinity of Arroyo Burro Beach Park is an adaptation measure that could protect parking lots, restroom and recreational facilities, and Cabrillo Boulevard from erosion and flood impacts. This could be accomplished with new shoreline protection devices at select threatened areas or by adding a new section of seawall or rock to the top of the existing walls/revetments; however, doing so may require significant modifications or a rebuilding of the existing buried walls and revetments.

Seawalls could be installed along the waterfront beaches to reduce the coastal storm flooding and tidal inundation that is anticipated to extend significantly north of Cabrillo Boulevard past Highway 101 in the period between 2.5 and 6.6 feet of sea-level rise (approximately between 2060 and 2100). However, the seawall would have to be approximately 10 to 15 feet high and nearly extend from the bluffs at the west end of Leadbetter Beach east to the bluffs at the Bellosguardo Estate to effectively address coastal storm flooding and tidal inundation north of Cabrillo Boulevard past 2.5 feet of sea-level rise. Additionally, in order to function properly and effectively mitigate inland flooding hazards, the seawall(s) would have to be combined with groundwater pumping, stormwater management and pumping, tide gates, and creek floodwalls.

Different alignments for a large-scale seawall system could be considered to protect all infrastructure along the waterfront or to allow certain areas to retreat so as to delay the need for the wall and associated potential visual, beach, and hydrologic impacts as long as possible. For example, the seawall could be placed south of the bike path to protect all infrastructure, including buried wastewater mains, but this would result in the need for the seawall soon. The seawall could be built along the bike path to retain some park space and infrastructure north of the bike path or retreat of Chase Palm Park lawn could be allowed and the bike path relocated to allow space for each to migrate. In this scenario, the seawall would be constructed at around 2 to 3 feet of sea-level rise. The seawall could also be directly adjacent to east Shoreline Drive and Cabrillo Boulevard, but then infrastructure and park facilities south of Cabrillo would not be protected. See also Section 7.3.5, which discusses options to raise all of Cabrillo Boulevard and the eastern section of Shoreline Drive, essentially making the roads a levee. Sand nourishment could be used to avoid the need for the seawall (or levee) for as long as possible in each scenario.

Table 7-6 summarizes the considerations for use of a seawall or revetment and analyzes consistency with Guiding Principles (Section 3.1).

TABLE 7-6
SHORELINE PROTECTION DEVICE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Shoreline protection devices (seawalls, revetments) would reduce impacts to shoreline assets from erosion, waves, and flooding.
Feasibility	#4b	• Commonly used engineering solution that are effective when built and maintained properly. • Shoreline protection devices already exist in Santa Barbara.
Timeline to Implement		• 5–15 years lead time to design, permit, and install.
Effectiveness over time		• Expected to be effective up to 3–5 feet of sea-level rise (approximately between 2060 and 2100) if located along Shoreline Drive and Cabrillo Boulevard. After that point feasibility and effectiveness is uncertain. Implementing multiple adaptation strategies in combination could increase the time period and level of effectiveness. • Level of protection decreases with loss of beach and increasing sea-level rise. • Would need to be regularly maintained, repaired, and replaced. • Would need to increase height of structure with sea-level rise; at some point, the foundation may become inadequate and need to be rebuilt to remain effective.
Cost	#4b	• Initial implementation cost. • Recurring maintenance costs. • May require more frequent maintenance or reconstruction with increased sea-level rise. • Comparative cost1: medium to high depending on scope.
Permitability and Legal Complexities	#4b, c	• Properties with existing shoreline protection devices can seek permits for repair and maintenance, but new structures may be more difficult to permit, particularly for non-coastal-dependent structures (e.g., residential and commercial uses). • Given that the low-lying waterfront areas contain predominantly coastal dependent uses (coastal recreation and public access facilities and roads), shoreline protection could be allowed, but permitting is still likely to be complex. • Permitting of a large-scale seawall system in conjunction with additional flood protection measures would be very complex (see Section 8).
Coastal Resource Impacts	#4d	• Leads to beach erosion, resulting in habitat and recreation/tourism impacts. • Impedes public access by occupying beach area. • Degrades scenic qualities of coastal area. • Could protect public coastal recreation and park facilities behind the devices. However, shoreline views and direct visual connection from the facilities to the beach would be lost.

TABLE 7-6
SHORELINE PROTECTION DEVICE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Benefits to Community Groups	#5a	• Property owners and businesses along shoreline. • Cabrillo Boulevard users. • Property owners north of Cabrillo Boulevard in projected flood hazard area.
Co-benefits	#5c	• Could reduce inundation of sewer system.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

7.3.4 Elevating or Waterproofing Structures and Infrastructure

Structures and infrastructure in the low-lying waterfront and beach areas, including Arroyo Burro, Leadbetter, West, and East Beaches, could be raised or waterproofed as discussed further in Section 5.2.11. This would be an effective strategy, particularly to address temporary coastal storm flooding. When areas are subject to regular tidal inundation, however, access and services to the structure would also need to be raised or waterproofed in order to maintain use. Additionally, maintenance of structures regularly flooded by seawater can require significant resources and frequent repairs. By the time erosion and wave impacts reach an area, additional adaptation strategies such as seawalls would need to be combined with elevating structures to effectively mitigate hazards.

Table 7-7 summarizes the considerations for elevating structures and analyzes consistency with Guiding Principles (Section 3.1).

TABLE 7-7
ELEVATING OR WATERPROOFING STRUCTURES AND INFRASTRUCTURE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Elevating impacted assets removes structures and infrastructure from direct flooding or floodproofs them. • Most commonly used to mitigate temporary flooding during coastal storms.
Feasibility	#4b	• Most effective if associated utilities and roads are also raised. • Not all slab on-grade buildings can be raised, so structures might have to be demolished and rebuilt. • Could require agreement across several property owners. The low-lying waterfront and beach areas are all publicly owned and consensus could likely be achieved unless properties outside the waterfront area are also involved. • As structures are rebuilt, there will be more opportunities to raise and floodproof development.

TABLE 7-7
ELEVATING OR WATERPROOFING STRUCTURES AND INFRASTRUCTURE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Timeline to Implement		• 2–7 years to elevate or waterproof a single structure. • 10–20 years lead time to design, permit, and implement larger-scale changes to an entire area. • If the program is based on changes to floodplain and zoning regulations that apply only to new development and redevelopment, elevation of all structures in an area could take a long time to cumulatively occur.
Effectiveness over time		• Shoreline will continue to migrate inland, requiring additional adaptation for the next line of structures or infrastructure. • As sea-level rises, accessing buildings on piles will be more difficult if the area is tidally inundated. • As flooding becomes more frequent, increased levels of maintenance, repair, and replacement will be needed. • Most structures in the low-lying waterfront and beach areas will see impacts from waves, erosion, and tidal inundation with at least 2–3 feet of sea-level rise (±2060) with some infrastructure affected sooner. When this occurs, this adaptation strategy would need to be combined with other adaptation strategies, like shoreline protection devices, to remain effective.
Cost	#4b	• Initial implementation costs. • Elevating structures and roads can be costly. • Over time, frequent flooding could require significant maintenance, repair, and replacement costs. • Comparative cost1: medium to high.
Permitability and Legal Complexities	#4b, c	• Low legal risk as City predominantly owns low-lying waterfront and beach area properties. • Would need to be compliant with the Americans with Disabilities Act. • Some projects would only require local permits. • May require changes to design and height regulations to be permitted.
Coastal Resource Impacts	#4d	• Could allow for beach preservation and restoration and associated ecological resources if implementation of this strategy avoids the need for shoreline protection devices and other measures with more impacts. If additional adaptation measures such as seawalls would need to be combined with raising the building, then beach could be negatively impacted. • Potential scenic, visual, and community character impacts. • Could be used to retain structures supporting public coastal recreation and park uses for some time.
Benefits to Community Groups	#5a	• City and other property owners and businesses along shoreline. • Users of coastal recreation and park facilities. • Cabrillo Boulevard and Cliff Drive users.
Co-benefits	#5c	• None

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

7.3.5 Elevating Property Grade

Cliff Drive near Arroyo Burro Creek could be raised on fill (Section 5.2.12) to remove the road out of the future flood zone projected to start impacting the area with more than 2.5 feet of sea-level rise. The City could also pursue raising the east side of Shoreline Drive and Cabrillo Boulevard as an alternative to building a flood wall to protect the road (see Section 7.3.3 and Section 8). This strategy would also require the City to raise any additional roadways that are connected to Shoreline Drive, Cabrillo Boulevard, and surrounding infrastructure.

As discussed in detail in Section 5.2.12, raising property grades changes runoff patterns and the hydrology of an area, and can cause increases in flooding in adjacent lower areas if stormwater flows are not managed effectively.

Table 7-8 summarizes the considerations for elevating property grades and analyzes consistency with corresponding Guiding Principles (Section 3.1).

TABLE 7-8
ELEVATING PROPERTY GRADE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Elevating property grade removes structures and infrastructure from hazard zone or floodproofs them. • Stormwater runoff from raised areas needs to be effectively managed so as to not contribute to flooding and erosion of surrounding lower areas.
Feasibility	#4b	• Can be effective if done properly and associated utilities and roads are also raised. • Could require significant fill material. If a large area is involved, feasibility could be limited due to the amount of fill required and number of structures that need to be rebuilt. • Would require agreement across all landowners involves. The properties in the low-lying waterfront and beach areas are publicly owned. Therefore, agreement could likely be achieved, unless properties north of Cabrillo Boulevard, Shoreline Drive, or Cliff Drive are involved. • Temporary impacts to private businesses that lease City and County properties would have to be considered. • As structures are rebuilt, there will be more opportunities to rebuild in a way that adapts to sea-level rise.
Timeline to Implement		• 10–20 years lead time to design, permit, and implement for larger areas.
Effectiveness over time		• As sea-level rises, accessing buildings will be more difficult if the surrounding areas are not also raised. • Most areas in the low-lying waterfront and beach areas will see impacts from waves, erosion, and tidal inundation with at least 2–3 feet of sea-level rise (±2060) with some areas affected sooner. When this occurs, this adaptation strategy may need to be combined with other adaptation strategies like shoreline protection devices to remain effective.

TABLE 7-8
ELEVATING PROPERTY GRADE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Cost	#4b	• Initial implementation costs. • Would require rebuilding structures on the higher grades. • Comparative cost1: high.
Permitability and Legal Complexities	#4b, c	• Low to moderate legal risk depending on stakeholder buy-in. • Permitting would depend on location and whether fill of wetlands or tidelands would be required.
Coastal Resource Impacts	#4d	• Potential scenic, visual, and community character impacts. • Filling an area changes the hydrology, which could cause additional flooding in other lower areas if not effectively managed. • Could preserve coastal recreation and park facility uses along the waterfront and beach areas for some time.
Benefits to Community Groups	#5a	• City, County, and other property owners and businesses along shoreline, although businesses would be temporarily impacted during construction. • Cabrillo Boulevard, Shoreline Drive, and Cliff Drive users. • Users of coastal recreation and park facilities raised.
Co-benefits	#5c	• None

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

7.3.6 Managed Retreat

All of the land in the low-lying waterfront and beach areas is publicly owned. The City and County can consider removal of public buildings, utilities, and other infrastructure and relocation opportunities, as the risk to public structures along the waterfront increases with sea-level rise. Figure 7-6 illustrates how buildings and associated armoring (revetments or seawalls) can be removed from the coastal erosion and hazard zone to allow progressive shoreline retreat over time with sea-level rise.

Relocation of major public infrastructure, like wastewater and water mains, inland could be preferable to trying to maintain this infrastructure south of Cabrillo Boulevard. Relocation could require design changes in the wastewater and water systems, like the addition of pumps. Removal or relocation of waterfront and beach park facilities could impact public access and recreational use of the area, but this method of managed retreat would allow space for the beach to migrate inland and encourage retention of a wider beach. Beach nourishment and construction of sand dunes could occur in retreated areas to enhance hazard protection for inland areas.

Relocation or removal of portions of Cabrillo Boulevard, Cliff Drive, or Shoreline Drive would significantly impact existing transportation patterns and access to properties.

Rerouting of traffic and impacts to public access along and to the shoreline would be a significant concern.

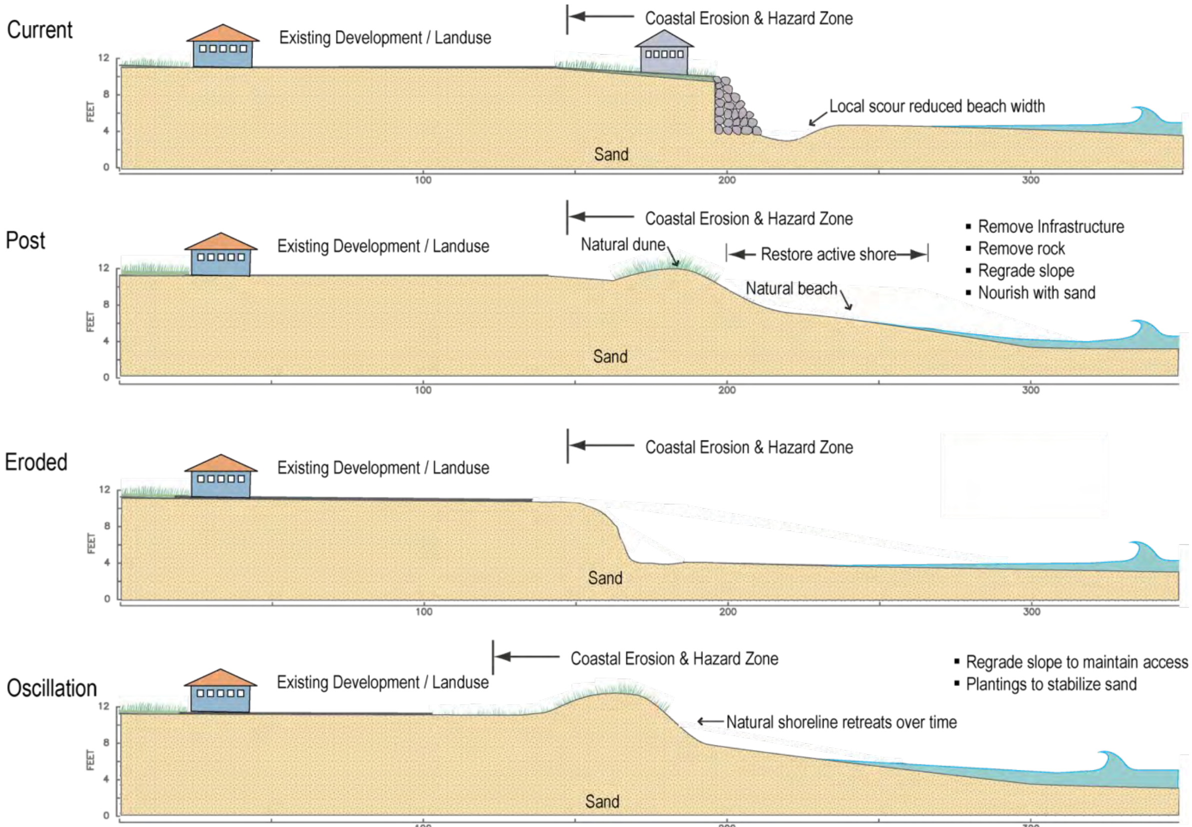


Figure 7-6
Illustration of managed retreat adaptation measure

Section 5.2.13 discusses many of the issues associated with managed retreat. Table 7-9 summarizes the considerations for managed retreat in the low-lying waterfront and beach areas and evaluates consistency with the City's Guiding Principles (Section 3.1).

TABLE 7-9
MANAGED RETREAT AND/OR LAND CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Managed retreat removes structures and infrastructure from hazard zone. • Could be combined with beach nourishment and beach dune formation in area retreated.
Feasibility	#4b	• Because the low-lying waterfront and beach areas are publicly owned, retreat in these areas is more feasible. • Retreat of major public roads, however, has many implications for private property owners, shoreline access, and transportation in the city.

TABLE 7-9
MANAGED RETREAT AND/OR LAND CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Timeline to Implement		• 2–5 years for specific structures if project involves only removal or relocation to areas already available and owned by the City. • 5–15 years where relocation or replacement facilities or infrastructure would require major redesigns or acquisition of property. • Large-scale rerouting or relocation of major public roads would take significant planning (15–20 years).
Effectiveness over time		• Shoreline erosion and flooding will continue to migrate inland, requiring additional adaptation for the next line of structures and infrastructure.
Cost	#4b	• Costs for retreating are low if no structures or infrastructure exist or simple removal is considered. • Rebuilding structures and infrastructure elsewhere can be expensive, especially if new property acquisition is required. • Comparative cost1: high, if relocation to new property is required. Low, if a minor development relocated to currently available public property or simple removal proposed.
Permitability and Legal Complexities	#4b, c	• Permitting for removal is relatively easy. Permitting of relocation would depend on any issues associated with the new location. • Low to moderate legal risk for public properties. • Moderate to high legal risk if private properties involved or services/access to private properties affected.
Coastal Resource Impacts	#4d	• Allows for beach preservation and associated ecological resources. • Loss of open space and parks, recreational facilities, roads, infrastructure, and basic public services, unless these are relocated. • Relocation could have impacts related to developing on a new site. • Reduces the likelihood of damaged material entering the ocean and creating hazards elsewhere.
Benefits to Community Groups	#5a	• Beach visitors.
Co-benefits	#5c	• Preserves beach for habitat and recreation/tourism. • Aesthetics. • Public safety, seismic safety.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

7.4 Low-Lying Waterfront and Beach Adaptation Recommendations

The adaptation strategies proposed in Section 7.3 were evaluated in detail and reviewed for consistency with the City's Guiding Principles (Section 3.1). Table 7-10 summarizes the strategies, whether they are recommended, the extent to which they align with the Guiding Principles, and the timeframes through which they are likely to be effective.

Table 7-10
Summary of Adaptation Strategies for Low-Lying Waterfront and Beach Areas

Adaptation Strategy	Recommendation	Key Consideration
Beach and Dune Nourishment	Recommended for use in the near- and mid-term at East Beach, Leadbetter Beach, and Arroyo Burro Beach. Expected to be effective up to about 2–3 feet of sea-level rise (±2060).	Would help maintain beach. Would not completely stop flooding, particularly during large coastal storm events when the beach would be inundated and can erode quickly. City already nourishes East Beach and Leadbetter Beach. This program could be modified and expanded. Lead time to implement a new or modified program is 5–10 years.
Sand Bypassing	Recommended for use in the near- and mid-term at East Beach. Expected to be effective up to about 2–3 feet of sea-level rise (±2060).	Would help maintain beach. Would not completely stop flooding, particularly during large coastal storm events when the beach would be inundated and can erode quickly. City and USACE already conduct a sand bypassing program. This program could be modified and expanded. Lead time to implement a new or modified program is 5–10 years.
Groins	If additional study shows that impacts could be effectively mitigated, could be an option for use in the mid-term. Expected to be effective up to about 2–3 feet of sea-level rise (±2060).	Difficult to permit and potential impacts to downcoast beaches. Lead time to implement is 15–20 years.
Offshore Reefs	If additional studies support, could be an option for use in the mid-term. Expected to be effective up to 2–3 feet of sea-level rise (±2060).	Largely experimental at this time. More studies are necessary to prove if feasible and effective in conditions similar to Santa Barbara, but could be pursued further based on results of pilot projects. Lead time to implement is 15–20 years.

TABLE 7-10
SUMMARY OF ADAPTATION STRATEGIES FOR LOW-LYING WATERFRONT AND BEACH AREAS

Adaptation Strategy	Recommendation	Key Consideration
Shoreline Protection Devices	Could be considered for use in the near-, mid-, and long-term. Feasibility and effectiveness after 3–5 years of sea-level rise (approximately between 2060 and 2100) uncertain if located along Shoreline Drive and Cabrillo Boulevard. Implementing multiple adaptation strategies in combination could increase the time period and level of effectiveness.	Would provide protection for public infrastructure, but at the potential expense of the beach and beach access. Large scale use could help mitigate flood hazards north of Cabrillo Boulevard if combined with other flood control measures (see Section 7), however this could be costly and change the visual character of the waterfront. Lead time to implement is 5–15 years.
Elevate and Waterproof Structures	Recommended for use in the near-, mid-, and long-term. After about 2–3 feet of sea-level rise (±2060), this strategy would have to be combined with other adaptation strategies, like shoreline protection devices, to remain effective in this area.	Would waterproof structures from flooding, but access could be restricted if surrounding areas are flooded regularly. Would have to be combined with other strategies to effectively mitigate erosion or tidal inundation hazards. Lead time to implement is 2–20 years depending on scope of project.
Elevate Property Grade	Could be considered for use in the mid- and long-term.	Would remove structures from flood hazards, but could increase flooding in surrounding lower areas. In long-term, would need to be combined with other strategies like shoreline protection to be effective in some areas. Lead time to implement is 10–20 years depending on scope of project
Managed Retreat	Could be considered for use in the near-, mid-, and long-term.	Would provide space for the beach to migrate, but at the expense of other coastal recreation facilities and public parks. Impacts to public services need to be considered. If relocation is required, property acquisition could be expensive. Lead time to implement is 2–20 years depending on scope of project.
New Breakwaters	Not recommended at this time.	New breakwaters would be very difficult to permit at this time. See Section 9.3.1 for discussion of potential extensions to the existing Harbor breakwater.

The City should monitor rising sea-levels, beach erosion, and flooding events in the low-lying waterfront and beach areas.

The City already conducts sand bypassing and beach nourishment in portions of the low-lying waterfront and beach areas. These programs could be modified and expanded in the near- and mid-term to maintain the existing assets and character of the low-lying beach areas as long as feasible. Groins could potentially be pursued if or when beach and dune nourishment becomes less effective. However, there is significant uncertainty associated with the ability to permit new groins and concern about impacts to downcoast beaches. Relying on beach and dune nourishment without other protective or adaptation measures in the long-term is expected to be infeasible given the risks and consequences of extreme coastal storm events potentially breaching and washing out dunes and flooding large areas.

Regardless of any beach nourishment that is occurring, the City will need to plan for either the relocation, floodproofing, or protection of major wastewater and water pipelines that are located south of the beach bike path in the near-term. In addition, the City should continue its current regulatory practice of limiting uses in the low-lying waterfront and beach areas and requiring that new development and substantial redevelopment be designed to avoid or mitigate hazards associated with sea-level rise.

As sea-level rise gets closer to 2 feet (approximately between 2030 and 2060) and beach widths narrow (see beach width adaptation triggers discussed in Section 6.3), assets closest to the shore, such as the beach parking areas, bike path, and Cabrillo Pavilion, will become vulnerable even with increased beach nourishment. Some combination of protecting, elevating, waterproofing, removal, relocation, and realigning assets could be implemented on a case-by-case basis. However, between 2 and 3 feet of sea-level rise (±2060), large portions of Shoreline Drive and Cabrillo Boulevard become vulnerable to increasing coastal storm flooding, and erosion could threaten several major assets at East Beach and Leadbetter Beach. Between approximately 3 and 6.6 feet of sea-level rise (approximately between 2060 and 2100), erosion could reach Shoreline and Cabrillo Drive, coastal storm flooding could reach north of Highway 101, and tidal inundation could extend from the beach to Highway 101. Therefore, the City will need to decide whether to: (1) pursue large-scale relocation and removal of waterfront assets, Shoreline Drive, and Cabrillo Boulevard or (2) install large-scale shoreline protection devices or levees along the city's waterfront. This decision point will likely need to occur at about 1 to 1.5 feet of sea-level rise given that a lead time of about 10 to 20 years is likely to be needed.

To mitigate flood hazards in the long-term, a continuous seawall protecting major waterfront assets north of the bike path, Shoreline Drive, and Cabrillo Boulevard would likely need to be roughly 10 to 15 feet above the level of the existing road and combined with other flood control measures such as groundwater pumping, tide gates, creek floodwalls, and stormwater pumps to prevent wide-scale flooding impacts in the low-lying flood areas of the city (see Section 7 for more details). The feasibility of many of these flood control measures depends on interaction with stormwater and creek flooding during high rainfall events, which could change in future years as a result of climate change.

Raising Shoreline Drive and Cabrillo Boulevard could also be pursued, but would need to be combined with raising other roads and infrastructure that connect to these major roads. Additionally, assets currently located south of Shoreline Drive and Cabrillo Boulevard would need to either be abandoned or relocated.

The feasibility and effectiveness of shoreline protection devices or levees located along Shoreline Drive and Cabrillo Boulevard are uncertain after about 3 to 5 feet of sea-level rise (approximately between 2060 and 2100) and would need to be further studied. Locating shoreline protection further inland and/or implementing multiple adaptation strategies in combination could extend the lifespan of the structures and the degree of effectiveness.

In the long-term, retreat of the waterfront and major roads is also an option, but could eventually require retreat of large areas inland of Cabrillo Boulevard that are projected to be at risk to tidal inundation with 6.6 feet of sea-level rise (±2100).

Additional studies needed include:

- BEACON update to the 2009 *Santa Barbara Coastal Regional Sediment Management Plan* to include sea-level rise impacts.
- Study on Santa Barbara–specific beach width thresholds for initiating consideration and planning for beach adaptation.
- Sediment management plan to further analyze dredging and bypassing program and beach nourishment along low-lying beaches.
- Further feasibility study of a shoreline protection and flood system along Shoreline Road and Cabrillo Boulevard (see Section 8 for more details).
- Feasibility study for relocating or waterproofing the wastewater and water assets south of the bike path.
- Research and continued monitoring of case studies and case law concerning managing retreat and other adaptation strategies.

Figure 7-7 shows the major vulnerabilities along the city’s low-lying waterfront and beach areas, three options for adaptation approaches, and lead times to begin advance planning before the recommended adaptation measures could be in place to limit risk. The figure also shows how long each strategy is expected to be effective.

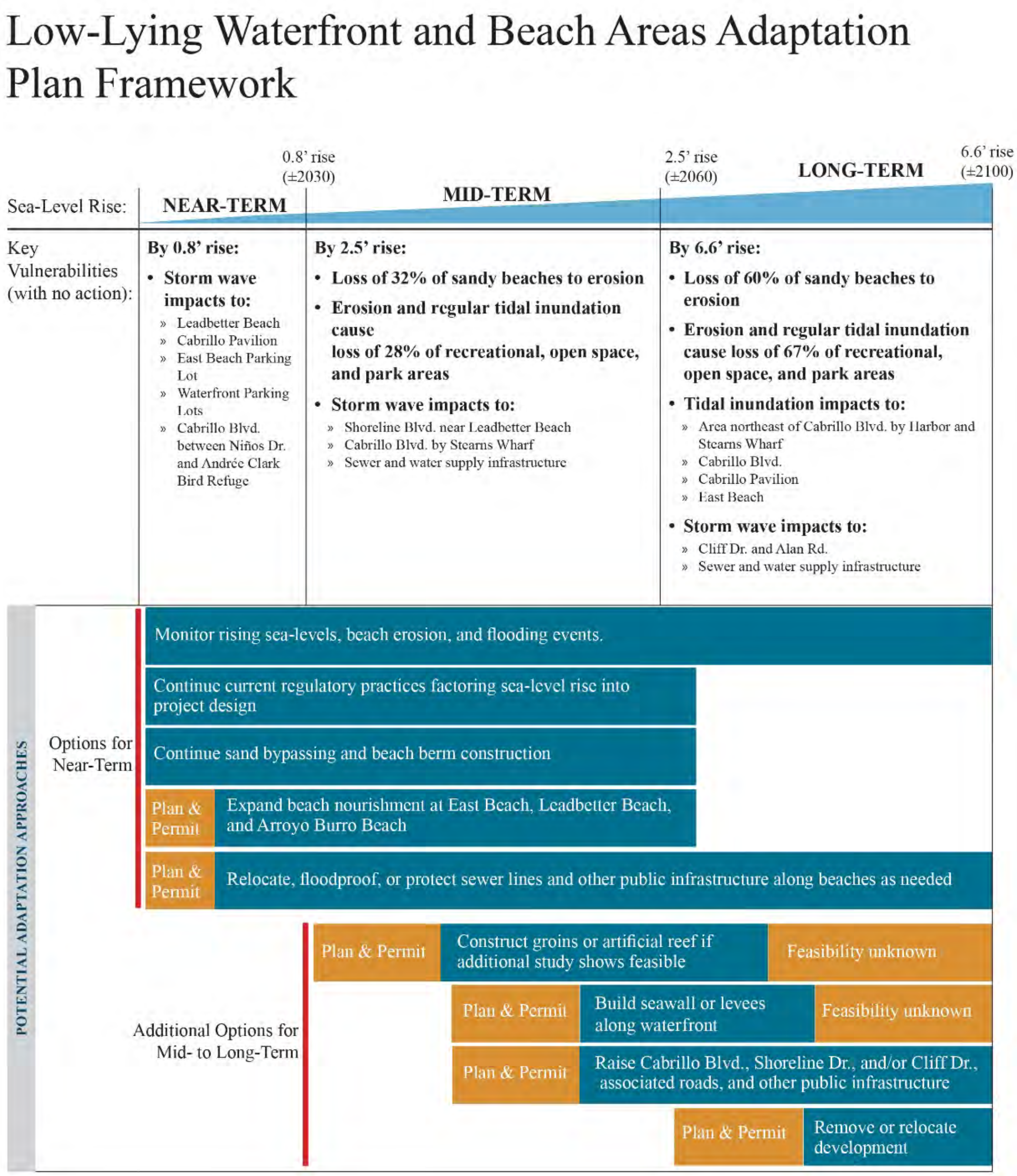


Figure 7-7
Low-Lying Waterfront and Beach Adaptation Plan Framework

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Section 8

LOW-LYING FLOOD AREAS

The low-lying flood areas of Santa Barbara include the low-lying areas north of Cliff Drive by Arroyo Burro Creek, north Shoreline Drive by Santa Barbara City College, and north of Cabrillo Boulevard in the downtown and Milpas Street area (Figure 8-1). These areas are projected to be impacted by regular tidal inundation and flooding during riverine storms with 6.6 feet of sea-level rise. This section includes discussion of adaptation measures for the city's major creeks given that management of these creeks directly affects inland flooding. Adaptation options for controlling flooding are inextricably linked with adaptation options in the low-lying waterfront and beach areas discussed previously in Section 7.

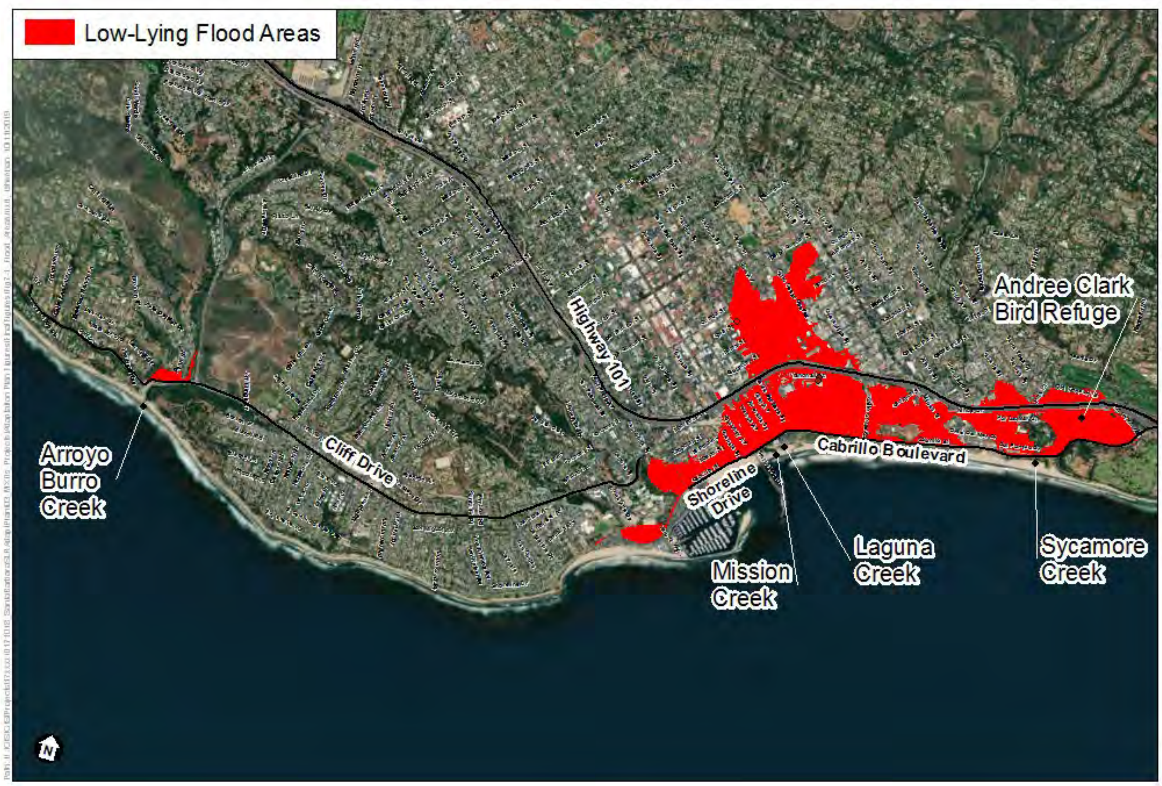

Figure 8-1
Low-Lying Flood Hazard Areas

Section 8.1 summarizes the key vulnerabilities identified in the Vulnerability Assessment Update (Appendix A) for the low-lying flood areas from sea-level rise. Section 8.2 describes the thresholds for determining when adaptation is needed along the low-lying flood areas. Section 8.3 considers the feasibility, effectiveness, and tradeoffs associated with implementing the applicable adaptation strategies presented in Section 5.2 to the low-lying flood areas and presents some adaptation strategies specific to only flood control. Section 8.4 provides recommendations on which strategies and follow-up studies should be pursued in the near-term for these areas.

8.1 Vulnerability of Low-Lying Flood Areas

Many of the areas mapped in Figure 8-1 already flood during high rainfall events and are mapped by FEMA Flood Insurance Rate Maps as being affected by the 100-year riverine storm. The eastern portion of these low-lying areas was a historic tidal wetland system, called El Estero, that was filled with debris from the 1925 earthquake and subsequently filled further, eventually becoming the current urban grid of lower Santa Barbara. Flooding during major riverine storms currently occurs in the low-lying flood areas as a result of multiple sources: overtopping of Arroyo Burro, Mission, Laguna, and Sycamore Creeks during high rainfall events (Figures 8-2 and 8-3); storm waves and high tides affecting the water levels of estuarine outlets of these major creeks; and flooding of low-lying areas not directly connected to a creek, but that pond with water during high rainfall events that result in high groundwater and stormwater flowing into low-lying areas.

SOURCE: Griggs and Russel 2012

Figure 8-2
Southern Pacific Railroad Station Covered in Mud
Following Flooding in 1914

SOURCE: Griggs and Russel 2012

Figure 8-3
State and Yanonali Streets Covered in Mud Following Flooding in 1914

The Vulnerability Assessment Update (Appendix A) mapped and considered only areas where flooding would be exacerbated by sea-level rise. This included interaction of high sea levels and waves during coastal storms with average creek flows that occur during high wave events. The vulnerability assessment did not analyze potential flood hazards resulting from a 100-year rain event and how those creek flood flows could interact with future higher sea levels.[12] Additionally, the vulnerability assessment did not investigate potential changes to rainfall patterns and associated creek flooding events as a result of climate change. While these additional studies are outside the scope of this current work effort, they should be conducted in the near-term to assess the potential future riverine flood hazard in Santa Barbara and to fully assess the feasibility and effectiveness of the flood control measures presented in this chapter.

With 2.5 feet of sea-level rise, regular tidal inundation and flooding during riverine storms predominantly occurs south of Cliff Drive, Shoreline Drive, and Cabrillo Boulevard, except for exacerbated flooding up Laguna Creek (see discussion regarding Laguna Tide Gate

[12] Note that the while coastal storm events and rainfall storm events can and often do occur together, the statistical estimates of a 100-year coastal flood event and a 100-year rainfall runoff and river flood event are such that these are different extreme events that do not coincide with each other. The analysis of 100-year coastal flooding used for this Adaptation Plan includes an estimate of coincident river flooding, which is less extreme than the 100-year river flood event.

below). This would affect public infrastructure south of these major roads (including wastewater infrastructure), but would not directly affect large areas of private property.

Between 2.5 and 6.6 feet of sea-level rise, flooding during major coastal storm events begins to advance north of these major roads, if no action is taken. With 6.6 feet of sea-level rise, regular inundation from high tide events extends north of Cabrillo to Highway 101, and flooding during a 100-year coastal storm (or high wave event) could extend north of Highway 101 to approximately De La Guerra Street. This area north of Highway 101 is currently at risk of 100-year riverine flooding per FEMA maps. With 6.6 feet of sea-level rise, this area is expected to also be subject to 100-year coastal flooding, with coastal flood depths that are about as deep as current riverine base flood elevations mapped by FEMA. This area is therefore likely to flood more frequently, given it is expected to be subject to both river and coastal flooding. With 6.6 feet of sea-level rise, many private and public parcels would be affected by tidal inundation and riverine storm flooding (Table 5 of the Vulnerability Assessment Update presents the counts of impacted parcels). Additionally, with 6.6 feet of sea-level rise, the El Estero Water Resource Center and the associated wastewater and water systems would be affected by flooding, if no action is taken (see Section 10). The railroad would be affected by tidal inundation and Highway 101 would be affected during coastal storms in the vicinity of the Andrée Clark Bird Refuge.

Higher ocean water levels will impact the operation of the existing tide gate system on Laguna Creek. The Laguna Creek tide gate structure plays an important flood management role in the city. Located at the southern terminus of the low-lying Laguna Creek drainage, the tide gates prevent the waters from the Mission Creek Lagoon from extending landward. Riverine flooding already occurs in the low area downstream of Highway 101 (and in some locations upstream) when the flood control system is conveying more than the 10-year recurrence river storm event. In addition, the functionality of the gate is already extremely limited by the need to manually open and close it, and it is predominantly acting more as seawall than a tide gate at this time. Even under existing sea levels, the gate needs to be upgraded to increase functionality.

As discussed in the Vulnerability Assessment Update, the Laguna Creek tide gate system would be exposed to more frequent flooding with increased sea-level rise. This means that the flood conveyance capacity will become progressively less than the 10-year event and flooding will increase. This means that the City will have to pump more often and for longer periods of time to manage water levels as they are managed today, in order to reduce the increased in flood frequency and severity. Additionally, the seaward location of the tide gates also exposes them to the forces of waves, which will become greater in the future with sea-level rise. With 3 feet of sea-level rise, the mean higher high water level would reach the point where Laguna Creek would not open during high tides and would only drain during lower tides because the water level in the ocean would be higher than the water level in the creek. With about 6 feet of sea-level rise, the tide gate would not be able to function at all as designed.

Sea-level rise and will also impact the Andrée Clark Bird Refuge. Cabrillo Blvd. is currently vulnerable to flooding during extreme rainfall runoff events when Andrée Clark Bird Refuge fills with rainfall runoff and inundates Cabrillo Blvd. This flooding occurs before the water level in Andrée Clark Bird Refuge overtops the beach berm that forms across the bird refuge outlet channel. When the water level in the bird refuge overtops the beach berm, outflow from the bird refuge scours the beach berm and allows outflow from the bird refuge to the ocean over a weir (that ponds water in the bird refuge) and through five 36-inch culverts under Cabrillo Blvd. to the ocean. Sea-level rise may increase the height of the beach berm and increase the risk of flooding. The City is planning a project to enhance Andrée Clark Bird Refuge, which the City expects will reduce the current and future risk of the water level in the bird refuge causing flooding. The Vulnerability Assessment (ESA 2016) indicates that the portion of Cabrillo Boulevard that crosses the Andrée Clark Bird Refuge outlet is vulnerable to storm waves during an extreme coastal flood event with 0.8 ft of sea-level rise. This vulnerability to storm waves increases with 2.5 feet of sea-level rise. With 6.6 feet of sea-level rise, the Andrée Clark Bird Refuge and the portion of Cabrillo Blvd. across the bird refuge outlet and along the east side of the bird refuge are vulnerable to regular tidal inundation. Additionally, Highway 101 is expected to flood during coastal storm events on the northwest side of the Andrée Clark Bird Refuge with 6.6 feet of sea-level rise.

The groundwater table is also directly influenced by ocean water levels, so it is expected to rise with sea-level rise, and areas below the tidal flooding elevation may experience inundation due to groundwater seepage. Additionally, the structural integrity of surface infrastructure could be threatened, maintenance would become more challenging for buried infrastructure (such as electrical or natural gas infrastructure), and groundwater could infiltrate into buried pipes. In some locations, infrastructure is already experiencing these impacts and there are several existing sump pumps in basements and parking lots. Groundwater may begin to seep into subsurface or low-lying areas, such as basements or underground parking. Additionally, areas below the riverine or coastal storm flooding elevation may experience flooding from precipitation or wave overwash that is unable to drain to the ocean because water levels are too high.

To address the vulnerability due to flooding in low-lying areas, this section presents monitoring to identify increasing risks, adaptation options to address the risk, and the recommended adaptation strategies for Santa Barbara.

8.2 Low-Lying Flood Area Adaptation Thresholds

The threshold criteria to be monitored for the low-lying flood areas include sea-level rise, groundwater elevations, and creek flood levels and frequencies (see Section 3 and Table 3-1).

Flooding from Laguna Creek and Mission Creek is likely already at the threshold of acceptable risk (i.e., they already cause frequent flooding) and projects are currently under way to reduce the risk of flooding. The Vulnerability Assessment Update, which uses the USGS CoSMoS results, shows extreme (i.e., 100-year) coastal storm flooding will increase with sea-level rise, but does not provide results showing how creek flooding during extreme rainfall runoff events will increase due to higher sea-levels at the mouths of creeks. In order to develop monitoring and adaptation thresholds for creek flooding, a risk tolerance could be established for each creek (for example, flooding every 10 years from Laguna Creek could be deemed acceptable, but flooding more frequently would not be). Extreme creek flood levels, frequencies, and channel capacities should be modeled for baseline conditions and with future projected sea-level rise. The amount of sea-level rise that exceeds the acceptable level of flood risk could be estimated, and that estimation could be used as a threshold to trigger implementation of adaptation measures for the creeks.

Laguna Creek tide gate already needs to be upgraded, and any amount of sea-level rise will continue to decrease functionality. Therefore, the trigger for action to upgrade the tide gate is now.

If the beach and lagoon are maintained via sand management and or other adaptation strategies with sea-level rise, the beach and sand berm are expected to increase in elevation along with sea-level rise. This would increase the lagoon water level and compromise Laguna Creek flood management, as well as flood management at the Andrée Clark Bird Refuge. The increase in elevation of the beach berm could therefore be monitored as a threshold for adaptation.

To determine an appropriate trigger for groundwater flooding, a study should be done to analyze existing groundwater elevations and the freeboard from typical levels up to a flood threshold, in order to determine the vertical capacity.

As discussed in Section 7.2 and 7.4, in the near-term or with about 1 foot of sea-level rise, a decision needs to be made about large-scale shoreline protection or other adaptation strategies along Shoreline Drive and Cabrillo Boulevard. With approximately 2 to 3 feet of sea-level rise coastal storm flooding begins to impact areas north of Cabrillo Boulevard, if no action is taken. With around 3 to 4 feet of sea-level rise, tidal inundation begins to impact areas north of Cabrillo Boulevard, if no action is taken.

8.3 Low-Lying Flood Area Adaptation Options

Adaptation options for low-lying area flooding include:

1. Tide gates and weirs
2. Groundwater pumping
3. Creek flood walls or levees
4. Elevating or waterproofing structures
5. Elevating property grade
6. Shoreline protection devices

7. Managed retreat

The following sections describe these different adaptations and discuss feasibility, effectiveness, and consistency with the City's Guiding Principles (Section 3.1).

The following section analyzes whether these strategies would be feasible and effective to implement in the low-lying flood areas of the city and summarizes tradeoffs associated with each strategy and consistency with the City's Guiding Principles (Section 3.1). Additional information on many of these strategies is included in Section 5.2.

Laguna Creek tide gate looking north (upstream) during period of closed lagoon with high water.

Source: ESA

8.3.1 Tide Gates and Weirs

Creek channel management could include new or improved pump stations and upgraded tide gates or weirs (Section 5.2.8). The following sections discuss upgrading the existing tide gates and weirs for Laguna Creek and the Andrée Clark Bird Refuge. Hydraulic structures and pump stations could theoretically be added to other creeks. However, this is unlikely to be feasible for Mission Creek, Arroyo Burro Creek, or Sycamore Creek due to the amount of flow going down these creeks during high rainfall events and potential impacts to the creek's habitat, threatened/endangered species, and processes, which could result in permitting constraints. Other measures such as creek floodwalls are more likely to be successful for these creeks, although they would need to be designed to avoid increasing flow velocities beyond the range of the federally endangered steelhead.

Upgraded Tide Gates and Pump System on Laguna Creek

To address the vulnerability to the operations on Laguna Creek, a new pump station with higher capacity could be constructed to address the more frequent need for pumping when the tide gates are closed (to maintain the same water level). Pump stations tend to be expensive to design, build, and maintain. However, since the City already operates a pump station at Laguna Channel (photo on previous page), updating the existing station to a higher capacity could be cost effective. Additionally, beach priming (e.g., moving sand to lower the beach berm prior to a major riverine storm event) could be managed to allow the Mission Creek Lagoon to breach a little earlier. This would result in lower water levels in Laguna Creek, thereby reducing flood risk.

Alternatively, the tide gates could be moved further inland to a higher elevation along the channel and the pump station infrastructure adjusted to the new location (Figure 8-4). This would allow the tide gates to be open more of the time, and would reduce the need for pumping (ESA 2014). Figure 8-4 (bottom plot) illustrates how the water levels would influence the gate closure. Under existing conditions, when the tide rises, the gate closes and stays closed until the tide drops (bottom-left plot). With sea-level rise, if the tide gate stays at the same location, the amount of time that the gate would be open would be much shorter (bottom-middle plot). If the gate is moved upstream (as shown in the top figure), the time that the gate is open could be extended (bottom-right plot), allowing more flow from the creek to flow to the ocean.

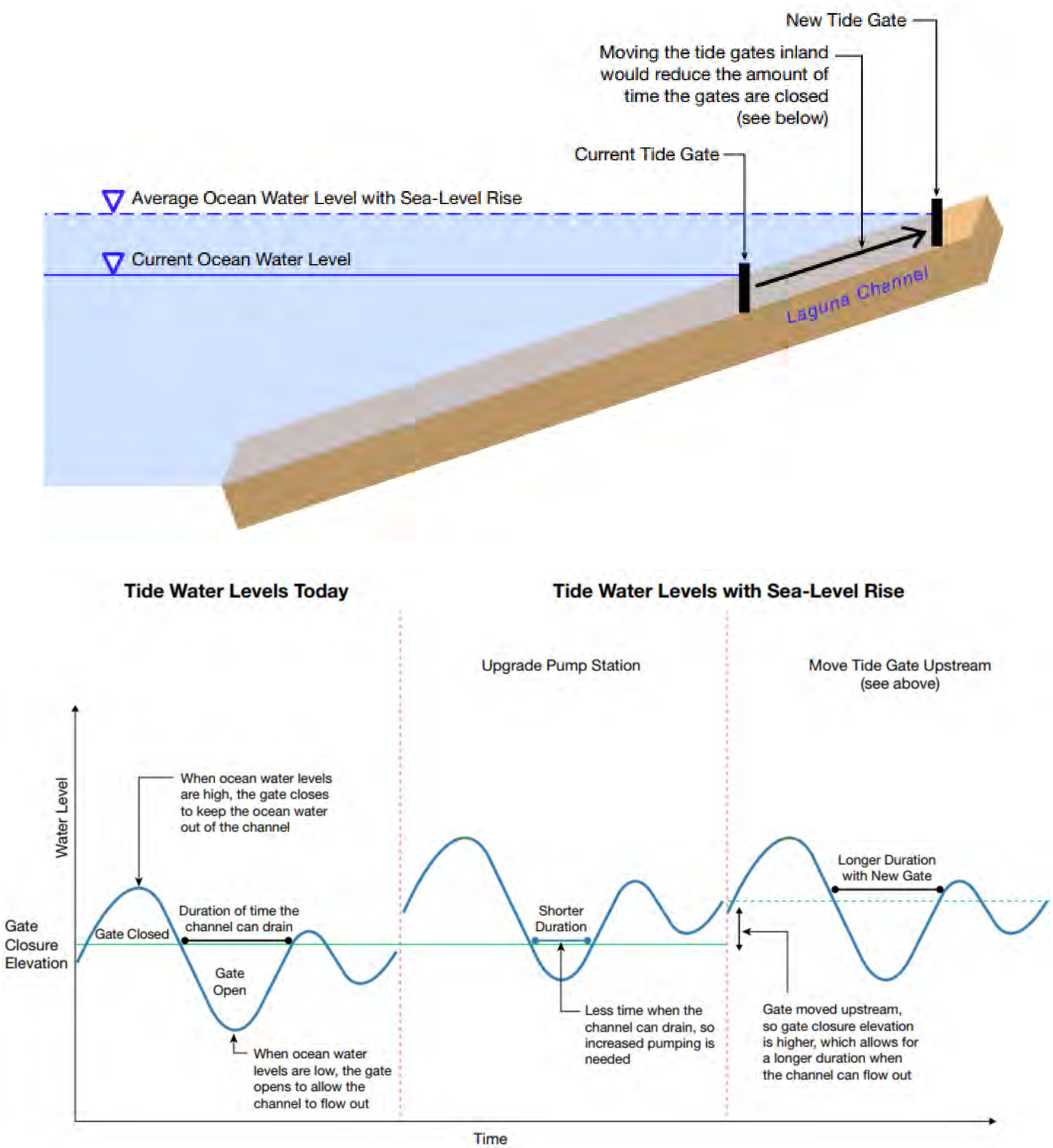

Figure 8-4
Cross-section and water level graph of Laguna Creek with proposed tide gate shift upstream

The area between the existing tide gate and a more inland one (e.g., Palm Park parking lot) would need to be raised or protected. This area could then be restored to provide more wetland habitat.

As sea levels continue to rise, the gates would have to be closed more often to be effective, so they are likely only effective through the mid-term. At some point, the gates would be closed all of the time, effectively becoming seawalls.

Table 8-1 in the next section summarizes the considerations for updated tide gates and weirs at both Laguna Creek and the Andrée Clark Bird Refuge and evaluates consistency with the corresponding Guiding Principles (Section 3.1).

Upgraded Weir and Weir Gate Structures at Andrée Clark Bird Refuge

The Andrée Clark Bird Refuge operates as a freshwater/brackish lake with limited tidal exchange due to a weir structure at Cabrillo Boulevard. In 2015, the City began researching restoration alternatives to improve water quality conditions at the bird refuge. The City Council approved the final restoration alternative on January 30, 2018, and the project is currently moving forward with the final design and permitting. The City anticipates construction in the summer of 2021. The final alternative includes the following features:

1. Removal of the weir and weir gate at Cabrillo Boulevard and replacement with an improved, mechanical weir/weir gate design.
2. Dune restoration at the mouth of the Andrée Clark Bird Refuge on East Beach.
3. Periodic mechanical priming of the Andrée Clark Bird Refuge mouth at East Beach.
4. Construction of an upstream treatment wetland at the Municipal Tennis Courts.
5. Trail improvements around the north side of the lake.
6. Restoration of 5 acres of upland and wetland habitat.

A focused coastal hazard analysis on the effects of sea-level rise on the Andrée Clark Bird Refuge under the proposed restoration has been completed. The removal and replacement with an updated weir and weir gate system, dune restoration, and periodic mechanical opening of the lake mouth at East Beach is being designed to accommodate sea-level rise and allow for adaptation.

As sea levels rise, the new weir/weir gate may need to be raised to address the higher ocean water levels. This would mean higher water levels would be impounded in the Andrée Clark Bird Refuge, so a pump system may need to be installed in the long-term, similar to the one used at Laguna Creek. The pump would be used when water levels in the Andrée Clark Bird Refuge reach a certain elevation that could cause flooding of the highway, and would pump water from the pond out to the ocean. Additionally, if a seawall is built along Cabrillo Boulevard in the mid- or long-term (see Section 7.3.3), a tide gate at the refuge would be necessary to regulate flows on either side of the seawall.

Table 8-1 summarizes the considerations for updated hydraulic structures at both Laguna Creek and the Andrée Clark Bird Refuge and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 8-1
UPDATED HYDRAULIC STRUCTURES AT LAGUNA CREEK AND ANDRÉE CLARK BIRD REFUGE

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Pumps remove water from Laguna Creek and/or Andrée Clark Refuge and discharge in the ocean, lowering the creek or pond to water surface elevations that will not flood the adjacent areas. • Updated tide gates/weirs limit the amount of ocean water that can enter the Creek or Refuge, so there is more capacity for stormwater runoff.
Feasibility	#4b	• Commonly used engineering solutions that are effective when built and maintained properly. • Pump stations and tide gates already exist and are in operation in Santa Barbara. • Can be subject to power outages and complete loss of pumping capabilities.
Timeline to Implement		• 5–10 years lead time to design, permit, and install.
Effectiveness over time		• Tide gates and weirs would become less effective over time with increasing sea-level rise. • Tide gates and weirs are expected to be effective up to about 2–3 feet of sea-level rise (±2060). • Pumping would need to increase over time with sea-level rise. • Pumping could be effective up to about 2–3 feet of sea-level rise (±2060).
Cost	#4b	• Initial implementation cost for pump station or tide gate upgrades, or multiple costs if pump station or tide gates are upgraded multiple times as sea levels increase. • Recurring operations and maintenance costs. • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Low to moderate legal risk depending on stakeholder buy-in. • Complex permitting requirements from multiple agencies.
Coastal Resource Impacts	#4d	• Alters flow regimes, which can have physical, chemical, and biological impacts on creeks/ponds.
Benefits to Community Groups	#5a	• Home owners. • Businesses. • Transportation networks (roads). • El Estero Water Resource Center.
Co-benefits	#5c	• Maintains recreation/tourism at refuge. • Reduces inundation of sewer system.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

8.3.2 Groundwater Pumping

In Santa Barbara, groundwater pumping (Section 5.2.9) could be used in low-lying areas with belowground assets, such as parking or basements.

Eventually, dewatering wells may need to be spread across the low-lying areas to achieve a lowered groundwater table. The feasibility of maintaining a lowered groundwater table through pumping is outside the scope of this Adaptation Plan and would need to be further assessed. Deposition of the pumped groundwater (e.g., to the storm drain, wastewater system, or a surface water body) and any water quality treatment considerations are beyond the scope of this Adaptation Plan. Table 8-2 summarizes the considerations for groundwater pumping and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 8-2
GROUNDWATER PUMPING CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Groundwater pumping would lower groundwater levels, which would reduce flooding of low-lying or underground areas. Because this measure only addresses flooding from high groundwater levels, it would have to be paired with other flood control measures, such as seawalls, to effectively mitigate flood risks in the low-lying flood area.
Feasibility	#4b	• Engineering solution that can be effective when built and maintained properly. • Pump stations already exist and are in operation in Santa Barbara. • Can be subject to power outages and complete loss of pumping capabilities. • The feasibility of maintaining a lowered groundwater table through pumping requires further assessment. • Energy intensive.
Timeline to Implement		• 5–10 years lead time to design, permit, and implement.
Effectiveness over time		• Could be effective at lowering groundwater levels up to about 6 feet of sea-level rise (±2100) if paired with other flood control measures that address other sources of flooding. • Less effective over time with increasing sea-level rise. • Pumping would need to increase over time with sea-level rise.
Cost	#4b	• Initial implementation costs. • Ongoing operations and maintenance costs. • May require more frequent maintenance or reconstruction with increased sea-level rise. • Comparative cost1: medium to high.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies.

TABLE 8-2
GROUNDWATER PUMPING CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Coastal Resource Impacts	#4d	• Alters groundwater flow regimes, which can have physical, chemical, and biological impacts.
Benefits to Community Groups	#5a	• Property owners. • Businesses. • Transportation networks (roads). • El Estero Water Resource Center.
Co-benefits	#5c	• Reduces inundation of sewer system.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

8.3.3 Creek Flood Walls or Levees

A levee or berm (Section 5.2.10) could be built around Andrée Clark Bird Refuge to reduce the flood risk to areas behind the levee or berm. A levee or berm could also be built along portions of Arroyo Burro Creek. If and where space allows, the levees could be designed as “living levees” by creating gently sloping upland, transition, and vegetated habitats between the levee and the refuge or creek. This area could provide riparian and/or wetland habitat. At the refuge, levees could be designed as “horizontal levees,” which could provide a gradual slope transition to dissipate waves within the refuge and for wetland habitat to move into with sea-level rise. This approach is being adopted in wetland restoration practice to enhance habitat diversity and provide wetland buffers and high-water refuge.

Soil for levee construction would need to meet specific engineering criteria and may need to be imported from off-site. The levees would need to be planned and designed to reduce potential impacts to existing habitats and flood levels upstream.

In certain areas, such as along Mission Creek, Laguna Creek, or Sycamore Creek, there may not be sufficient room for a levee system and flood walls may be more appropriate, although they could impact riparian habitat and wildlife species. If a seawall is built along Cabrillo Boulevard or the road is raised, the seawall or high ground would need to tie into the creek levee system or flood walls to provide continuous flood protection. Creek flood walls or levees would also need to be tied to stormwater management and pumping, since the areas protected by the structures would no longer be able to drain to the creeks. Table 8-3 summarizes the considerations for creek protection devices and analyzes consistency with the City’s Guiding Principles (Section 3.1).

TABLE 8-3
CREEK FLOOD WALLS OR LEVEES CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Creek protection devices (flood walls, levees) along Arroyo Burro Creek, Mission Creek, Laguna Creek and/or Sycamore Creek, as well as around the Andrée Clark Bird Refuge, would reduce overtopping and flooding. • Would need to be tied to stormwater management and pumping so areas behind the wall can still drain.
Feasibility	#4b	• Commonly used engineering solution that is effective when built and maintained properly.
Timeline to Implement		• 5–15 years lead time to design, permit, and install.
Effectiveness over time		• Expected to be effective in the near- and mid-term and possibly in the long-term, at which point feasibility and effectiveness uncertain. However, implementing multiple adaptation strategies in combination could increase the time period and level of effectiveness. • Less effective over time with increasing sea-level rise. • Could need to increase height of structure with sea-level rise; at some point, the foundation may become inadequate and need to be rebuilt to remain effective.
Cost	#4b	• Initial implementation cost. • Recurring maintenance costs. • May require more frequent maintenance or reconstruction with increased sea-level rise. • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from multiple agencies.
Coastal Resource Impacts	#4d	• Could impact riparian habitats. • Levee footprint, in particular, could impact habitats. • Potentially impedes public access to creeks. • Degrades scenic qualities of area. • Changes hydrology and stormwater flows. • Because this approach relies on stormwater pumping inland of the walls, failure of pumps could be an issue.
Benefits to Community Groups	#5a	• Property owners. • Businesses. • Transportation networks (roads). • El Estero Water Resource Center.
Co-benefits	#5c	• Reduces inundation of sewer system.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

8.3.4 Elevating or Waterproofing Structures

Development and infrastructure in the low-lying flood areas could be raised or waterproofed (Section 5.2.11) to protect them from riverine storm flooding. When areas are subject to regular tidal inundation or high groundwater levels, however, access and services to the structure would also need to be raised or waterproofed to maintain use, or additional adaptation measures could be used to fully mitigate flood hazards. Additionally, maintenance of structures regularly flooded by seawater can require significant resources and frequent repairs.

Currently the city's floodplain regulations require elevating or waterproofing structures located in areas mapped as located in the 100-year floodplain on Flood Insurance Rate Maps approved by FEMA. The Flood Insurance Rate Maps show current hazards and do not account for additional potential future flooding from sea-level rise. The City could alter its floodplain or building regulations to require buildings to be elevated or waterproofed in all of the projected low-lying flood areas factoring in sea-level rise, whether or not the area is already regulated under the FEMA Flood Insurance Rate Maps. South of Highway 101, building elevation and waterproofing higher than existing base flood elevations could be required to account for the potential impacts of sea-level rise. If the regulations apply only to new development and substantial redevelopment, the new regulations should be implemented in the near-term since it could take a long time for the development in the low-lying flood area to be cumulatively raised. The City could also consider providing incentives to property owners who voluntarily raise or waterproof their structures, including permit streamlining and/or relief from design or height requirements.

Table 8-4 summarizes the considerations for elevating structures and identifies the corresponding Guiding Principles (Section 3.1). See Section 7.3.4 for a more detailed discussion.

TABLE 8-4
ELEVATING OR WATERPROOFING STRUCTURES CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Waterproofs structures and infrastructure from flooding. • Most commonly used to mitigate temporary flooding during riverine storms.
Feasibility	#4b	• Most effective if associated utilities and roads are also raised. • Not all slab on-grade buildings can be raised, so some might need to be demolished and rebuilt. • Could require agreement across several landowners. • As structures are rebuilt, there will be more opportunities to rebuild in a way that adapts to sea-level rise.

TABLE 8-4
ELEVATING OR WATERPROOFING STRUCTURES CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Timeline to Implement		• 2–7 years to elevate or waterproof a single structure. • 10–20 years lead time to design, permit, and implement larger-scale changes to an entire area. • If the program is based on changes to floodplain and zoning regulations that apply only to new development and redevelopment, elevation of all structures in an area could take a long time to cumulatively occur.
Effectiveness over time		• North of Highway 101 could be effective in the near-, mid-, and long-term. • South of Highway 101, tidal inundation hazards and high groundwater levels after 4–5 feet of sea-level rise (approximately between 2060 and 2100) would require implementation of additional adaptation measures, such as seawalls, to effectively mitigate hazards.
Cost	#4b	• Initial implementation costs. • Elevating structures and roads can be costly. • Over time frequent flooding could require significant maintenance, repair, and replacement costs. • Comparative cost1: medium to high.
Permitability and Legal Complexities	#4b, c	• Would need to be compliant with the Americans with Disabilities Act. • Some projects would only require local permits. • May require changes to design and height regulations to be permitted.
Coastal Resource Impacts	#4d	• Could allow for creek preservation and restoration and associated ecological resources. • Potential scenic, visual, and community character impacts.
Benefits to Community Groups	#5a	• Property owners and businesses.
Co-benefits	#5c	• Preserves more natural creek for habitat and recreation/tourism.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

8.3.5 Elevating Property Grade

In areas that flood from stormwater or the creeks, the grade under structures could be raised (Section 5.2.12) to protect them from flooding. Surrounding roads and infrastructure would need to be raised as well. Given the expanse of the low-lying flood area, it would likely not be feasible to fill the entire area to raise grades. However, select areas, such as Cliff Drive near Arroyo Burro Creek, could be raised to protect certain assets or smaller areas. Table 8-5 summarizes the considerations for elevating property grades and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 8-5
ELEVATING PROPERTY GRADE CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Elevating property lifts structures and infrastructure above hazard zones or floodproofs them. • Stormwater runoff from raised areas needs to be effectively managed so as to not contribute to flooding and erosion of surrounding lower areas.
Feasibility	#4b	• Can be effective if done properly and associated utilities and roads are also raised. • Could require significant fill material. If a large area is involved, feasibility would be limited due to the amount of fill required and number of structures that need to be rebuilt. • Would require agreement across all landowners involved, which could be difficult to achieve. • Temporary impacts to rebuild buildings on new grades would have to be considered. • As structures are rebuilt, there would be more opportunities to rebuild in a way that adapts to sea-level rise.
Timeline to Implement		• Would be implemented over time through redevelopment. • 15–20 years lead time to design, permit, and implement. • If accomplished through regulations for new development or redevelopment of sites, could take a long time to cumulatively implement in an area.
Effectiveness over time		• As sea-level rises, accessing buildings will be more difficult if the surrounding areas and utilities are not also raised.
Cost	#4b	• Initial implementation costs. • Would require rebuilding structures on the higher grades. • Comparative cost1: high.
Permitability and Legal Complexities	#4b, c	• Low to moderate legal risk depending on stakeholder buy-in. • Permitting would depend on location and whether fill of wetlands or tidelands would be required. However, for most of the low-lying flood area, only local permits would be needed.
Coastal Resource Impacts	#4d	• Could allow for creek preservation and restoration and associated ecological resources. • Potential scenic, visual, and community character impacts. • Filling an area changes the hydrology, which could cause additional flooding in other lower areas if not effectively managed.
Benefits to Community Groups	#5a	• Property owners and businesses.
Co-benefits	#5c	• None

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

Additionally, Section 7.3.5 and Table 7-8 discuss the possibility of raising Shoreline Drive and Cabrillo Drive, making these roads double as levees that could mitigate coastal storm flooding and tidal inundation that is projected to extend north of these roads in the long-term (between 2.5 and 6.6 feet of sea-level rise). In the long-term, a levee system would have to be combined with other adaptation strategies such as creek flood walls, tide gates, and groundwater and stormwater pumping to effectively mitigate flood hazards in the low-lying flood areas.

8.3.6 Shoreline Protection Devices

Section 7.3.3 discusses the possibility of building a seawall along Shoreline Drive and Cabrillo Boulevard (or along the bike path south of these roads) to mitigate coastal storm flooding and tidal inundation that is projected to extend north of these roads in the long-term (between 2.5 and 6.6 feet of sea-level rise). For a seawall system at this location to effectively mitigate coastal storm flooding and tidal inundation in the low-lying flood area, it would have to be approximately 10 to 15 feet in height, be somewhat continuous from the bluffs on the west side of Leadbetter Beach east to the bluffs at the Bellosguardo Estate, and be combined with other adaptation strategies such as creek flood walls, tide gates, and groundwater and stormwater pumping. It is uncertain whether seawalls along these roads would be feasible or effective after 3 to 5 feet of sea-level rise. This would require additional study. Additionally, the structure lifespan and level of effectiveness could be greater if several adaptation strategies are used in combination. A seawall system could be sited farther inland of Shoreline Drive and Cabrillo Boulevard and be effective for higher levels of sea-level rise. That scenario would require acquisition and coordination amongst many property owners and development seaward of the wall would likely need to be removed or relocated. See Table 7-6 for a summary of considerations for a seawall system along Shoreline Drive and Cabrillo Boulevard.

8.3.7 Managed Retreat

The City can consider removal of buildings, utilities, and other infrastructure and relocation opportunities (Section 5.2.13) in low-lying, flood-prone areas as the risk to structures increases with sea-level rise. With 6.6 feet of sea-level rise, large areas are projected to be subject to tidal inundation. Managed retreat could, therefore, potentially involve the relocation or removal of a significant area and many public and private assets.

Section 5.2.13 discusses in detail methods and issues associated with managed retreat on private and public property. Removal, relocation, or rerouting of public infrastructure, facilities, and roads would have to be done with close consideration of temporary and permanent impacts to public services, transportation, and public access and recreation. Removal and relocation could occur in phases as sea-level rise progresses. In addition, the City could restrict new development and substantial redevelopment in certain projected hazard areas. For example, larger creek and estuary setbacks could be developed to consider the effects of climate change and sea-level rise. As discussed in detail in Section 5.2.13, managed retreat on private property is much more legally complex and can place hardships on private property owners, particularly when the entirety of a property is potentially at risk.

Table 8-6 summarizes the considerations for managed retreat and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 8-6
MANAGED RETREAT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Managed retreat removes structures and infrastructure from hazard zone.
Feasibility	#4b	• Removal of existing private development and development restrictions that affect entire properties are legally complicated. • Could require many home owners to agree to move. • Removal or relocation of major public infrastructure and roads would impact access to and services provided at parcels. Could be legally complicated if use of entire private properties affected. • Uncertainty around who pays and who benefits. • Given current government funding structures, buyouts of large numbers of private parcels would not likely be feasible in advance of a sea-level-rise-related disaster. • There are no current examples in California of local-government-led programs or coordinated removal of private property in advance of a hazard-related disaster; however, FEMA funding to acquire property may be available. • Larger creek and estuary setbacks could be more feasible.
Timeline to Implement		• Lead time varies greatly between 2 and 10 years, depending on the type of development being removed or relocated, whether there is space on the existing property to relocate it, and if major public infrastructure is involved (e.g., major arterial roads). • Redevelopment regulations can take a long time to result in existing development being moved. • Large-scale proactive managed retreat programs for private property would likely take 15–20 years to develop.
Effectiveness over time		• Tidal inundation will continue to migrate inland, requiring additional adaptation for the next line of structures and infrastructure. • Likely to become more necessary in the long-term as protection of development in place becomes less economical and feasible. • Feasibility could increase over time with increased hazards, lowered property values, increased willingness of landowners, and potential changes in funding opportunities.
Cost	#4b	• Costs for retreating are low if no major structures or infrastructure exist or if simple removal (without replacement) of a structure is proposed. • Rebuilding structures and infrastructure elsewhere is expensive due to property costs. • If necessary, buying out property owners would be very expensive, but could become less expensive over time as increased risk levels affect property values. • Comparative cost1: high; low, if structure would not be relocated.

TABLE 8-6
MANAGED RETREAT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Legal Complexities	#4b, c	• Permitting for a removal is relatively easy. Permitting of relocation would depend on any issues associated with the new location. • Low to moderate legal risk for public properties. • Moderate to high legal risk if private properties involved or services/access to private properties affected.
Coastal Resource Impacts	#4d	• Allows for creek preservation and associated ecological resources. • Loss of open space and parks, recreational facilities, roads, infrastructure, and basic public services, unless these are relocated. • If roads affected, could impact public access to the beach. • Relocation could have impacts related to developing on a new site. • Reduces the likelihood of damaged material entering the ocean and creating hazards elsewhere.
Benefits to Community Groups	#5a	• Potential economic benefits of eliminating flood management costs to City and residents.
Co-benefits	#5c	• Preserves creek for habitat and recreation/tourism. • Aesthetics. • Seismic safety. • Stormwater management.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

8.4 Low-Lying Flood Area Adaptation Recommendations

The adaptation strategies proposed in Section 8.3 were evaluated in detail and reviewed for consistency with the City's Guiding Principles (Section 3.1). Table 8-7 summarizes the strategies, whether they are recommended, the extent to which they align with the Guiding Principles, and the timeframes through which they are likely to be effective.

The sources of flooding in the low-lying flood areas include riverine or river flooding, high groundwater, and tidal inundation and storm waves. Studies of the interactions of these flooding sources over time with sea-level rise and changes to rainfall patterns from climate change are needed to fully understand the feasibility and effectiveness of flood control measures over the mid- and long-term. The City should also closely monitor rising groundwater levels and flooding events over time.

Improving the existing tide gates on Laguna Creek is recommended for the near-term to continue managing water levels in these areas. Improving the existing weir and weir gate at the Andrée Clark Bird Refuge is recommended for the mid- or long-term, when overtopping into the refuge becomes more frequent.

TABLE 8-7
SUMMARY OF ADAPTATION STRATEGIES FOR LOW-LYING FLOOD AREAS

Adaptation Strategy	Recommendation	Key Considerations
Tide Gates and Weirs	Reconstruction of existing tide gates and pumps at Laguna Creek recommended in the near-term. The weir for the Andrée Clark Bird refuge may need to be modified in the mid- or long-term. Expected to be effective up to about 2–3 feet of sea-level rise (±2060). Implementing multiple adaptation strategies in combination, however, could increase the time period and level of effectiveness.	Would reduce flooding but would require continued maintenance and operation. Lead time to implement is 5–10 years.
Groundwater Pumping	Could be considered for use in the mid- or long-term. Could be effective at lowering groundwater levels up to about 6 feet of sea-level rise (±2100), if paired with other flood control measures.	May reduce flooding, but more studies are needed. Would only address flooding from high groundwater. In the long-term, would need to be combined with other adaptation measures such as seawalls, creek floodwalls, tide gates, and raising structures to effectively mitigate riverine storm flooding and tidal inundation hazards. Lead time to implement is 5–10 years.
Creek Flood Walls or Levees	Could be considered for use in the near-, mid- and possibly long-term. Expected to be effective up to 3–5 feet of sea-level rise (approximately between 2060 and 2100), at which point feasibility and effectiveness are uncertain. Implementing multiple adaptation strategies in combination, however, could increase the time period and level of effectiveness.	Would reduce riverine flooding, but would need to be paired with stormwater management and pumping to drain areas behind the structures. In the long-term, would need to be paired with shoreline protection or levee along Shoreline Drive and Cabrillo Boulevard to mitigate riverine storm flooding and tidal inundation. Lead time to implement is 5–15 years.
Elevate Structures	Recommended for use in the near-, mid-, and long-term. In the long-term would need to be combined with other adaptation strategies to remain effective south of Highway 101.	Would waterproof structures from riverine storm flooding, but access could be restricted if surrounding areas are flooded. Once an area is being flooded regularly, structures would be hard to maintain, service, and access without utilization of additional adaptation strategies. Lead time to implement is 2–20 years. If achieved through regulations for new development and redevelopment, would take a long time to cumulatively occur.

TABLE 8-7
SUMMARY OF ADAPTATION STRATEGIES FOR LOW-LYING FLOOD AREAS

Adaptation Strategy	Recommendation	Key Considerations
Elevate Property Grade	Not feasible to apply over large areas. Could be considered for use in particular areas, such as Cliff Drive near Arroyo Burro Creek, or to raise Shoreline Drive and Cabrillo Boulevard to create a levee for flood control in the long-term (see Section 6). Expected to be effective where implemented up to 3–5 feet of sea-level rise (approximately between 2060 and 2100), at which point feasibility and effectiveness uncertain. Implementing multiple adaptation strategies in combination, however, could increase the time period and level of effectiveness.	Would remove structures from inundation, but increase flooding in surrounding low areas if stormwater not effectively managed. Likely not feasible to raise entire downtown grade. Would require reconstruction of structures at higher grades. Timeline to implement is 15–20 years.
Shoreline Protection Devices	Could be considered for use in the long-term along Shoreline Drive and Cabrillo Boulevard for flood protection purposes. Feasibility and effectiveness after 3–5 years of sea-level rise (approximately between 2060 and 2100) is uncertain. Implementing multiple adaptation strategies in combination could increase the time period and level of effectiveness.	See Section 6 for details. Would need to be combined with other flood control measures including creek floodwalls, groundwater pumping, and stormwater pumping to effectively mitigate flood hazards in the long-term. Could be costly, change visual character of the waterfront, and impact beaches. Lead time to implement is 10–15 years.
Managed Retreat	Could be considered for use in the near-, mid-, and long-term.	Retreat of public properties meets all Guiding Principles (Section 3.1) if essential public services can be maintained or replaced. The legal and financial feasibility of retreating entire private properties is uncertain. Lead time to implement is 2–20 years depending on the area and asset involved.

In the near-term, the City could also consider altering floodplain or building regulations to require new and substantially redeveloped buildings to be elevated or waterproofed in the projected low-lying flood areas factoring in sea-level rise. Much, but not all, of this area is already regulated under FEMA Flood Insurance Rate Maps. South of Highway 101, to the City could consider requiring building elevation and waterproofing higher than existing base flood elevations to account for the potential impacts of sea-level rise. Changes to the City's stormwater requirements may be needed in the low-lying flood areas to reduce the risk of flooding during rain events. The City could also consider changes to the creek and estuary setbacks, particularly after more information is known about potential changes in riverine flooding due to increases in rainfall.

Further studies are needed to assess the feasibility of groundwater pumping as an adaptation strategy in the mid- and long-term.

Creek flood walls or levees are recommended for further study and possible implementation in the mid-term, as the tide gates become less effective. The flood walls or levees could tie into shoreline protection devices (e.g., seawalls or levees along Shoreline Drive and Cabrillo Boulevard) and would need to be implemented in coordination with pumping, since drainage would be restricted behind the walls. Additionally, the flood walls or levees should be designed to maintain both riparian and in-stream habitat for steelhead and other species as much as possible. If the City chooses to elevate and waterproof structures, the extent of this pumping could be less than the pumping used to lower the groundwater table and would only be needed during rain events.

Further planning will be needed throughout the near-, mid-, and long-term to understand the possible mechanisms, legal context, and funding options associated with managed retreat, particularly of private property.

Additional studies needed include:

- Study to assess freeboard in Laguna Creek.
- Study to assess groundwater elevations, freeboard, and the potential impacts of sea-level rise on the groundwater table in low-lying areas.
- Study of the potential flooding hazards associated with a 100-year creek or riverine flood event (and smaller events) interacting with higher sea levels.
- Study of the potential changes to rainfall patterns and creek or riverine flooding as a result of climate change (the City may want to wait until more reliable data is developed on this subject in California to launch this study).
- Study of potential changes to creek and estuary setbacks and bridge design requirements once more is known about changes in rainfall patterns and the resulting riverine flooding potential.
- Study of potential impacts of changing groundwater levels in spreading existing groundwater contamination to new areas.
- Research and continued monitoring of case studies and case law concerning managing retreat and other adaptation strategies.

Figure 8-5 shows the major vulnerabilities along the city's low-lying flood areas, three options for adaptation approaches, and lead times to begin advance planning before the recommended adaptation measures could be in place to limit risk. The figure also shows how long each strategy is expected to be effective.

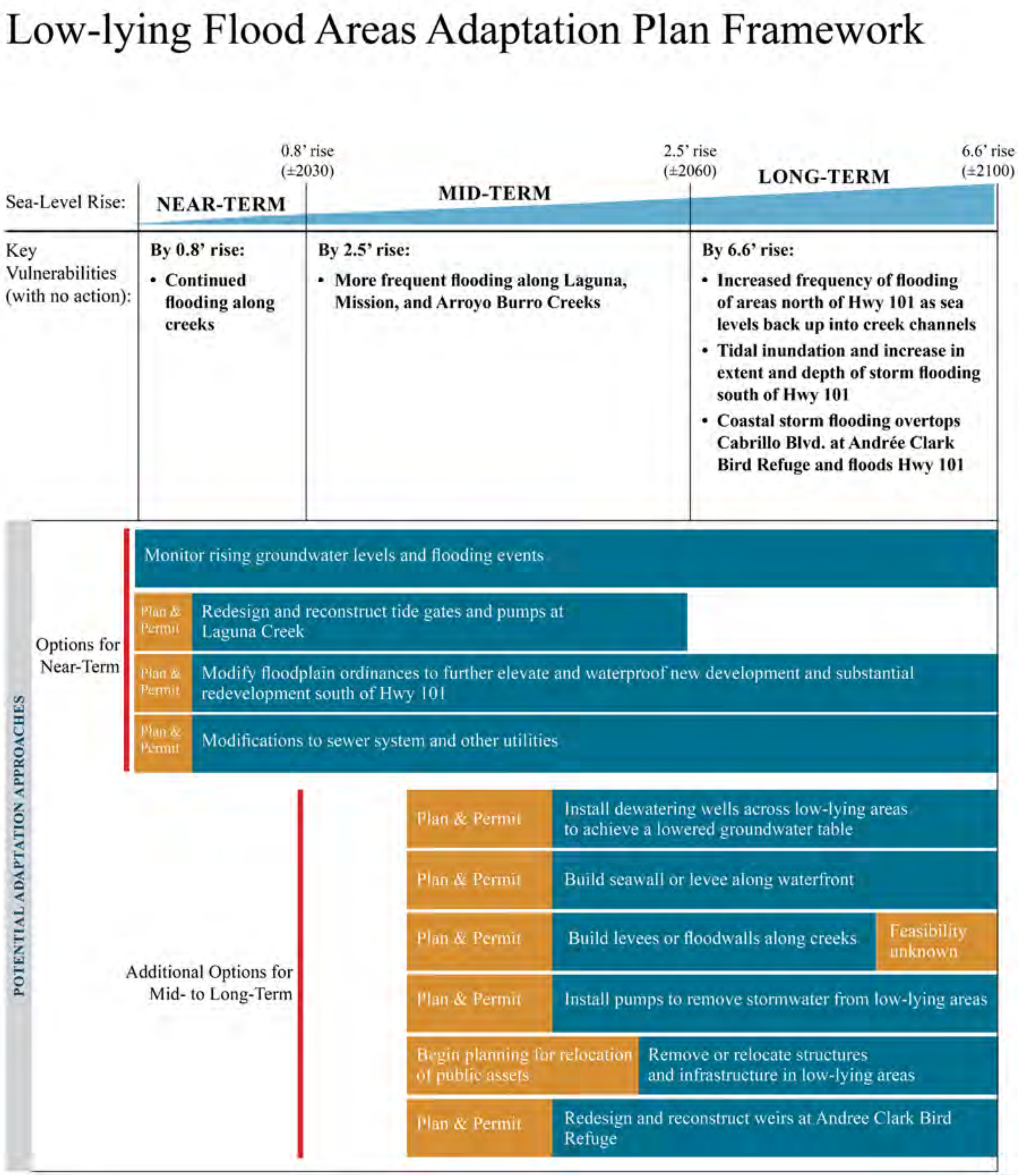

Figure 8-5
Low-lying flood area adaptation plan framework

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Section 9

HARBOR AND STEARNS WHARF

This section addresses adaptation options specific to the Harbor and Stearns Wharf (Figure 9-1). Both the Harbor and Stearns Wharf are owned and operated entirely by the City of Santa Barbara. The Harbor includes: a breakwater; a sandspit that is essentially a rock groin that extends out from the breakwater; a rock groin on the west side of West Beach; the City Pier, which supports a fuel dock and Coast Guard facilities; several marinas; parking lots; and the Harbor commercial area west of the breakwater, which includes City and Coast Guard offices, several restaurants, a fish market, kayak rentals, the Santa Barbara Yacht Club, a boat yard, and other commercial uses.

Figure 9-1
Harbor and Stearns Wharf Hazard Areas

Section 9.1 summarizes the key vulnerabilities identified in the City of Santa Barbara Sea-Level Rise Vulnerability Assessment Update (Appendix A) for the Harbor and Stearns

Wharf as a result of accelerated beach erosion and flooding from sea-level rise. Section 9.2 describes the thresholds for determining when adaptation is needed. Section 9.3 considers the feasibility, effectiveness, and the tradeoffs associated with implementing applicable adaptation strategies from Section 5.2 and other more-specific measures regarding harbors and piers. Section 9.4 provides recommendations on which strategies and follow-up studies that should be pursued in the near-term for these public assets.

Section 7 addresses, in detail, adaptation options for all of the waterfront beach areas that would also apply to the portion of the Harbor commercial area that is located on Leadbetter Beach west of the breakwater, and includes assets such as the Santa Barbara Yacht Club, Harbor West Parking Lot, and the boat yard.

9.1 Vulnerability of Harbor and Stearns Wharf

The Harbor and Stearns Wharf are valuable and important assets. Under existing conditions, Stearns Wharf is exposed to wave damage during large coastal storms (Figure 9-2), and a 100-year coastal storm event is expected to require temporary closure and significant structural repairs. As sea level rises, events large enough to damage Stearns Wharf are expected to become more common. With 6.6 feet of sea-level rise, the wharf deck is not projected to be exposed to regular high tides under non-storm conditions, but would not be able to withstand high waves during coastal storm events.

SOURCE: Griggs and Russel 2012

Figure 9-2
Stearns Wharf Impacts from Large Wave Event during the March 1983 El Niño Event

At the Harbor, under existing conditions, coastal storm events and high tides (e.g., king tides) can dislocate pile caps at the floating docks, and waves can overtop the Harbor breakwater, temporarily limiting public access. Through current management practice, the Harbor accommodates these relatively minor impacts from small to moderately sized coastal storms. Under an extreme 100-year coastal storm event with existing sea levels, damages to the Harbor would likely be severe. Erosion and wave runup during coastal storms is a concern in the vicinity of the Santa Barbara Yacht Club (Figure 9-3), and the City currently builds a sand berm every year to protect the south side of the Harbor commercial area to mitigate these hazards.

SOURCE: Griggs and Russel 2012

Figure 9-3
Beach Erosion at the Santa Barbara Yacht Club from the March 1983 El Niño Event

In the future, these impacts are expected to occur more frequently with sea-level rise. With 0.5 foot of sea-level rise, Harbor functions could likely be managed with increasing risks during coastal storms. If no action is taken by 1 foot of sea-level rise, risks during storms would be high as storm waves would overtop the breakwater. Additionally, with 1 foot of sea-level rise, the marina piles and City Pier would be too low to accommodate high tide conditions. If no action is taken with 2.5 feet of sea-level rise, several major assets that allow the Harbor and the Harbor commercial area to function are projected to be impacted by storm waves and high tides. By this time, tidal inundation is projected in the main Harbor parking lots and erosion is projected to impact the south side of the Harbor commercial area where the Santa Barbara Yacht Club, portions of the Harbor West Parking lot, and the boat yard are located. With 6.6 feet of sea-level rise, the Harbor would not be usable in its existing configurations and design without major modifications through adaptation. By this time, tidal inundation is projected to affect the entire Harbor area and beach erosion is projected to extend to Cabrillo Boulevard and Harbor Way on the south side of Harbor commercial area.

9.2 Harbor and Stearns Wharf Adaptation Thresholds

The criteria to be monitored for the Harbor and Stearns Wharf are sea-level rise and beach widths on the south side of the Harbor commercial area, west of the breakwater. While further detailed analysis is needed, the Waterfront Department projects that the following triggers may apply:

- Start in the next few years to plan for replacement or modification of the Harbor breakwater, walkway, and seawall that spans from the breakwater to the waterfront offices in the Harbor commercial area as well as the sandspit and rock groin, with expectation that these are raised by the time 0.5–1 foot of sea-level rise occurs. Continue beach berm construction by Harbor commercial area and when marinas are replaced, make sure to raise piles.
- With 0.5–1 foot of sea-level rise, plan for raising the City Pier and fuel dock, all the marinas that have yet to be raised, and the sidewalk around the Harbor.
- With 0.5–1 foot of sea-level rise, additional adaptation options beyond existing beach berm may be needed on the beach side of the Harbor commercial area to address erosion and wave runup during coastal storms.
- With 0.5–1 foot of sea-level rise, begin planning for large-scale adaptation options (e.g., elevation on fill, raising structures) for the entire Harbor area, including the Harbor commercial area, parking lots, and possibly surrounding areas. Given the scope of work to be done, project planning and implementation are likely to take some time to address hazards present with 2.5 feet of sea-level rise.

To determine an appropriate trigger for adaptation at Stearns Wharf, the City could prepare a more detailed study that assesses the level of coastal storm damage that could occur to the wharf under a range of storm events for current and future conditions with sea-level rise. Triggers could then be developed based on the damage risks. As stated above, Stearns Wharf is already at high risk for major damage during a 100-year coastal storm event. The elevation of the deck is currently at 19.5 feet NAVD. According to the Vulnerability Assessment Update (Appendix A), the wave crest elevation (not including wave runup) for the 100-year coastal storm event is estimated to be around 18.5 feet NAVD under existing conditions, 21 feet NAVD with 2.5 feet of sea-level rise, and 25 feet NAVD with 6.6 feet of sea-level rise. The City, therefore, should start planning in the near-term for either removing or raising Stearns Wharf.

9.3 Harbor and Stearns Wharf Adaptation Options

Adaptation options for flooding, erosion, and damage of the Harbor and Stearns Wharf include:

1. Raise and/or modify Harbor breakwater, rock groin, and sandspit
2. Elevate and reconstruct marinas and City Pier
3. Elevate Harbor grades
4. Other adaptation options for the Harbor commercial area and parking lots
5. Managed retreat at the Harbor
6. Raise Stearns Wharf
7. Managed retreat of Stearns Wharf

The following sections describe these different adaptations and discuss feasibility, effectiveness, and consistency with the City's Guiding Principles (Section 3.1).

9.3.1 Raise and/or Modify the Harbor Breakwater, Groins, and Sandspit

The existing breakwater cap and parapet wall (Figure 9-4, Section 5.2.4) could be raised and improved to offset the increase in sea levels. This could be accomplished by raising the elevation of the underlying rock, which forms the breakwater; raising the cap on the top of the existing breakwater; or increasing the height of the parapet wall. If the breakwater is raised, the breakwater cap would require modification or reconstruction to maintain access. The cap was recently reconstructed between 2004 and 2009 to replace the cap that was constructed in the 1970s. Historically, breakwaters need to be replaced every 30 years or so; however, this timeframe is likely to require more frequent replacement with rising sea levels.

At the same time the breakwater is raised, the sidewalk and parapet wall that runs from the breakwater up to the City offices in the Harbor commercial area should be raised and/or reconstructed as waves tend to overtop this area during coastal storms.

SOURCE: Google Maps Street View, Anne Marie Millar, Nov 2015

Figure 9-4
Existing Santa Barbara Harbor breakwater cap and parapet wall

The existing sand spit (Figure 9-5) on the east end of the breakwater could also be improved, by raising the structure and adding a cap with a parapet wall for both public access and additional protection.

SOURCE: Google Maps, Google Maps Street View, Steve Hayden, Nov 2016

Figure 9-5
Existing Santa Barbara Harbor Sandspit

The rock groin, located along West Beach (Figure 9-6), has a cap for public access, but no parapet walls. A parapet wall could be added to provide additional protection and/or the groin and cap could be raised.

SOURCE: Google Maps, Google Maps Street View, Luke Faraone, 2014

Figure 9-6
Existing Santa Barbara Harbor rock groin

There may be other modifications, reconfigurations, or extensions to the abovementioned structures that may further protect the Harbor from the changes associated with climate change, including changes in weather patterns, swell direction, and sea level, that are outside the scope of the analysis in this document and require further study.

The USACE conducts feasibility studies for infrastructure projects such those listed above that affect harbors, navigation, and water resources. The City should pursue USACE involvement in these improvements.

Table 9-1 summarizes the considerations for raising or modifying the Harbor breakwater and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 9-1
RAISE OR MODIFY THE HARBOR BREAKWATER, GROINS, AND SANDSPIT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Breakwaters and groins shelter harbors by causing waves to break and limiting waves from entering harbors. • The breakwater and Harbor results in increased beach widths at West Beach and Leadbetter Beach and prevent erosion and coastal storm flooding inland of the Harbor on Shoreline Drive, Cabrillo Boulevard, Pershing Park, and the West Beach neighborhood.
Feasibility	#4b	• Raising breakwaters and groins is a common engineering solution that is effective when built and maintained properly. • Breakwaters and groins may need to be rebuilt or significantly modified to support increased height.
Timeline to Implement		• 5–10 years lead time to design, permit, and install breakwater and groin upgrades.

TABLE 9-1
RAISE OR MODIFY THE HARBOR BREAKWATER, GROINS, AND SANDSPIT CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Effectiveness over time		• Expected to be effective up to about 2–3 feet of sea-level rise (±2060). • After 2–3 feet of sea-level rise (±2060), could potentially be effective if major reconstruction completed and implemented with other strategies. • Less effective over time with increasing sea-level rise. • Additional height could be added to the breakwater over time.
Cost	#4b	• Initial implementation costs. • Recurring maintenance costs (already existing). • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies, but likelihood of success is high if just improving structures in existing locations.
Coastal Resource Impacts	#4d	• Impacts to offshore bottom species if base of breakwater is expanded. • Increased height could degrade scenic qualities of coastal area. • If expansion or reconfiguration proposed, impacts to sand transport downcoast could be an issue.
Benefits to Community Groups	#5a	• Harbor businesses. • Harbor users. • Coast Guard and the public they serve. • Shoreline Drive and Cabrillo Boulevard users. • West Beach neighborhood. • Beach users at Leadbetter and West Beach. • Los Baños pool users.
Co-benefits	#5c	• Preserves Harbor for recreation, tourism, commercial fishing, and Coast Guard uses. • Additional public access opportunities. • Protects Shoreline Drive, Cabrillo Boulevard, Los Baños Pool, Pershing Park and West Beach neighborhood. • Configuration of breakwater and groins helps maintain sand on Leadbetter Beach and West Beach. • Sand that accumulates at West Beach and in Harbor from breakwater is used for sand bypassing and beach nourishment at other locations in the city.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

9.3.2 Elevate and Reconstruct Marinas and City Pier

Facilities within the marina, such as docks and other floating infrastructure, could be reconstructed with longer guide piles and support piles (see photo to the right) to allow infrastructure to float higher with higher water levels (Section 5.2.11).

Guide piles allow docks and other floating infrastructure to move up and down with changing water levels.

Source: Harbor Technologies, www.harbortech.us/guide piles

The marinas at the Harbor are periodically repaired and reconstructed. The marinas on the south side of the Harbor were recently improved. The guide piles are tall enough to withstand approximately 1 foot of sea-level rise, although this varies by marina, and some may need to be reconstructed sooner. The City already has plans to improve the marinas on the north side of the Harbor in coming years, and should design the new marinas to accommodate rising sea levels when that project is launched.

The City Pier, which supports Coast Guard facilities and the fuel dock, also need to be raised between 0.5 and 1 foot of sea-level rise. The fuel pipelines and valves under the pier are of concern as access to shutoff valves under the pier will become limited by sea-level rise. These facilities may need to be raised, redesigned, and/or protected.

Table 9-2 summarizes the considerations for elevating or waterproofing the marina facilities and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 9-2
ELEVATE AND RECONSTRUCT MARINAS AND CITY PIER CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Elevating and reconstructing infrastructure allows marinas and pier to continue to float and operate with increasing sea levels.
Feasibility	#4b	• Effective if done properly and associated utilities are also raised • As marinas are rebuilt, there will be more opportunities to rebuild in a way that adapts to sea-level rise. • Would need to be combined with improvements to the breakwater, rock groin, and sandspit to mitigate hazards to marinas and City Pier.
Timeline to Implement		• 3–10 years lead time to design, permit, and implement depending on scope of project.
Effectiveness over time		• Limits damage to marinas for design conditions, which can be exceeded during extreme events. • As sea levels rise, marina and pier piles would have to be raised. • Would need to be combined with other adaptation strategies to maintain access and function of marinas over time.

TABLE 9-2
ELEVATE AND RECONSTRUCT MARINAS AND CITY PIER CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Cost	#4b	• Initial implementation costs. • Maintenance costs. • Would need to be periodically raised. • Comparative cost1: medium.
Permitability and Legal Complexities	#4b, c	• Straightforward permit process associated with typical marina improvements.
Coastal Resource Impacts	#4d	• None
Benefits to Community Groups	#5a	• Harbor users. • Coast guard and the public they serve.
Co-benefits	#5c	• Preserves marinas for recreation, tourism, commercial fishing, and Coastal Guard uses.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

9.3.3 Elevate Harbor Grades

The City could raise the grades of the Harbor commercial area, including the launch ramp and parking lots (Section 5.2.12). Fill could be obtained from debris basins and other storm related sediments or from further dredging the Harbor or offshore areas. Inland sources of soil could also be used. Fill could also be obtained from Harbor expansion (e.g., north into parking lots, the West Beach area, or westward into the existing Harbor commercial area). This option, however, would eliminate existing uses on these sites, could require permission from multiple landowners, could require reconstruction of roads and infrastructure, and, in some of these areas, could impact archaeological resources potentially present.

Buildings and roads adjacent to the Harbor, such as the Santa Barbara Maritime Museum and Shoreline Drive, could also be raised, for example by placing fill and rebuilding buildings and roads at higher elevations. Raising grades around the Harbor could protect adjacent areas from flooding, with sloping transitions from raised areas to adjacent infrastructure.

Table 9-3 summarizes the considerations for elevating the grade of the Harbor facilities and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 9-3
ELEVATE HARBOR GRADES CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Elevating the Harbor grade removes structures and infrastructure from hazard zone or floodproofs them. • Stormwater runoff from raised areas needs to be effectively managed so as to not contribute to flooding and erosion of surrounding lower areas.
Feasibility	#4b	• Can be effective if done properly and associated utilities are also raised. • Not all slab on-grade building can be raised, so might have to be demolished and rebuilt. • Could require significant fill material. • Harbor itself is entirely publicly owned. However, if surrounding areas north of Shoreline Drive are involved, it could require agreement across public entities, private landowners, and private businesses. • As structures are rebuilt, there will be more opportunities to rebuild in a way that adapts to sea-level rise.
Timeline to Implement		• 5–20 years lead time to design, permit, and implement depending on scope of project.
Effectiveness over time		• Limits flooding and damage for design conditions, which can be exceeded during extreme events. • Flood management is reduced as sea-level rises. • Mid- to long-term protection against temporary flooding and inundation.
Cost	#4b	• Initial implementation costs. • Elevating structures and roads can be costly. • Comparative cost1: high.
Permitability and Legal Complexities	#4b, c	• Moderate permit complexity due to the scale of the project. • Medium to high legal risk, depending on scope of project and stakeholder buy-in.
Coastal Resource Impacts	#4d	• Potential scenic, visual, and community character impacts.
Benefits to Community Groups	#5a	• Harbor businesses. • Harbor users. • Shoreline Drive users. • Landowners north of the elevated Harbor who would be more protected.
Co-benefits	#5c	• Preserves Harbor for recreation, tourism, commercial fishing, and Coast Guard uses.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

9.3.4 Other Adaptation Options for the Harbor Commercial Area and Parking Lots

A number of adaptation options described in Section 7 for the low-lying waterfront and beach areas would also apply for the Harbor commercial areas, boat yard, and parking lots. The sidewalk and parapet wall spanning from the breakwater to the main Harbor commercial area (in the vicinity of City offices) needs to be raised in the near-term to prevent storm waves from overtopping the wall and entering the Harbor and Harbor commercial area.

The south side of the Harbor commercial area that faces Leadbetter Beach includes the Santa Barbara Yacht Club, Harbor West Parking Lot, and boat yard. A beach berm is constructed on the beach every year in front of the yacht club, parking lot, and boat yard. Construction of this berm could continue and there is also the possibility of constructing beach dunes or expanding the berm at this location (see Section 7.3.1). There is an existing seawall that runs landward of the yacht club, which bisects the Harbor West Parking Lot and boat yard. In the mid-term, this seawall could be raised or a new seawall constructed seaward to protect all development along the Harbor commercial area (see Section 7.3.3). A new seawall closer to the beach could accelerate beach erosion and loss in this area, however. The far west side of the Harbor commercial area could also be relocated or removed.

In the mid-term, the sidewalk around the Harbor that adjoins the Harbor commercial area and the parking lots on the north side of the Harbor should be raised or a parapet wall could be added to it to prevent storm waves from flooding the Harbor commercial area resources. Buildings and infrastructure in the Harbor could be elevated or the bottom levels floodproofed higher than current floodproofing requirements (see Section 7.3.4). These two measures, however, are likely to only mitigate flood damages in the near- and mid-term. In the mid-term or long-term, grades of the entire Harbor commercial area and parking lots could also be raised (see Sections 9.3.3 and 7.3.5).

See the tables in Section 7 for more details.

9.3.5 Managed Retreat at the Harbor

The City can consider the removal and relocation of specific buildings, utilities, and other infrastructure (Section 5.2.13) in the Harbor area as the risk to structures increases with sea-level rise. In the future, when flooding becomes frequent and hard to manage, the Santa Barbara Harbor could be abandoned or removed. The area could be restored to provide coastal habitat and the natural coastal sediment processes could be restored to the Santa Barbara Littoral Cell.[13] Without additional adaptation strategies, removing or abandoning the Harbor breakwater, groins, or sandspit could potentially increase flood risks to Cabrillo Boulevard, Shoreline Drive, Los Baños pool, Pershing Park, and the

[13] The Santa Barbara Littoral Cell, which spans approximately 94 miles from Point Conception to the Mugu submarine canyon, is a coastal compartment that contains a complete cycle of sedimentation, including sources (e.g., Ventura River), transport paths, and sinks (e.g., the Mugu submarine canyon).

development to the north of the Harbor in the West Beach neighborhood. The hazards maps and analysis contained in the Vulnerability Assessment Update (Appendix A) assume that the Harbor breakwater, groins, and sandspit are maintained. Significant analysis would be needed to understand how hazards would change with the loss of the Harbor and how the beaches in the area would respond.

The Santa Barbara Harbor is the only sheltered harbor on the West Coast between Port San Luis 100 miles to the north, and Ventura, 27 miles to the southeast. The loss of commercial fishing, recreational boating, visitor-serving, and Coast Guard uses at the Harbor would impact the region on many levels, including impacts to tourism, the economy, and resources for emergency response.

Table 9-4 summarizes the considerations for managed retreat and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 9-4
MANAGED RETREAT AT THE HARBOR CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Managed retreat removes Harbor structures and infrastructure from hazard zone. • Removal or abandonment of the Harbor breakwater, rock groin, and sandpit could potentially increase flood and erosion hazards Cabrillo Boulevard, Shoreline Drive, Los Baños pool, Pershing Park, and the development to the north of the Harbor in the West Beach neighborhood.
Feasibility	#4b	• Because the Harbor is entirely publicly owned, retreat of specific structures is more feasible. • Large-scale removal or abandonment of the Harbor needs further study to determine associated impacts and feasibility.
Timeline to Implement		• 2–5 years for specific structures if project involves only removal or relocation to areas already available and owned by the City. • 5–15 years where relocation or replacement of specific buildings or facilities would require major redesigns or acquisition of property. • 15–20 years lead time to remove or abandon the Harbor itself (breakwater, rock groin, sandspit, marinas, fuel dock, and other support facilities).
Effectiveness over time		• Flooding and erosion will continue to migrate inland, requiring additional adaptation for the next line of structures and infrastructure.

TABLE 9-4
MANAGED RETREAT AT THE HARBOR CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Cost	#4b	• Costs for retreating are low if simple removal of a specific development is considered. • Rebuilding structures and infrastructure elsewhere can be expensive, especially if new property acquisition is required. • Managed removal of breakwater, rock groin, sandspit, or major portions of the Harbor would be high. • Loss of tax, lease, and fee revenues. • Potential economic impacts depending on scope of project. • Comparative cost1: Low to high depending on scope of project.
Permitability and Legal Complexities	#4b, c	• Permitting for a removal of a specific development is relatively easy. Permitting of large-scale removal could be complex. • Low to high legal risk depending on scope of project.
Coastal Resource Impacts	#4d	• Initial impacts to re-establish development elsewhere. • Could reduce the likelihood of damaged material entering the ocean and creating hazards elsewhere. • Loss of community identity. • Loss of coastal dependent use, recreation facilities, and visitor-serving uses. • Loss of Coastal Guard uses. • Removal of Harbor breakwater, rock groins, and sandspit would change sand transport and beach widths in the area.
Benefits to Community Groups	#5a	• None
Co-benefits	#5c	• None

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

9.3.6 Raise Stearns Wharf

Adaptation of Stearns Wharf would consist of reconstructing the wharf with a higher deck and deck structural supports (Section 5.2.11). Reconstruction may need to occur more than once through the year 2100. An alternative would be to design the reconstruction to accommodate structural modification consisting of raising the deck to accommodate higher sea levels, although assessing the feasibility of this approach is beyond the scope of this Adaptation Plan. Raising the wharf would require reconstruction of buildings and infrastructure on the wharf and the ramp up to the wharf.

Stearns Wharf is currently vulnerable to damage during moderate coastal storm events. A raised wharf would still be vulnerable to damage during more extreme coastal storm events. In addition, access to the wharf could become limited with rising sea-levels without additional adaptation measures employed on the waterfront (see Section 7).

Over time as sea-level rise rates begin to accelerate, costs and risks associated with replacement of the wharf could potentially begin to outweigh economic, public access, visitor-serving, and social benefits of maintaining the wharf. However, more detailed cost-benefit analysis for the wharf would need to be conducted to make that determination.

Table 9-5 summarizes the considerations for raising Stearns Wharf and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 9-5
RAISE STEARNS WHARF CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Raises the deck of the wharf to reduce potential impacts from waves during coastal storms. • As is the case for the existing wharf, there would still be risks of damage associated with extreme coastal storms.
Feasibility	#4b	• Can be effective if done properly and associated utilities and access are also raised. • As the wharf ages and reaches the end of its design life, there would be the opportunity to rebuild and raise the wharf.
Timeline to Implement		• 15–20 years lead time to design, permit, and implement.
Effectiveness over time		• Reconstruction may need to occur more than once through the year 2100. • Repair and maintenance could become burdensome with increased rates of sea-level rise.
Cost	#4b	• Initial (or multiple) implementation costs. • Elevating structures can be costly. • Costs for flood protection would be reduced. • Comparative cost1: high.
Permitability and Legal Complexities	#4b, c	• Complex permitting requirements from state and federal agencies. • Moderate to high legal risk, depending on stakeholder buy-in.
Coastal Resource Impacts	#4d	• Short-term impacts during construction. • Potential scenic, visual, and community character impacts.
Benefits to Community Groups	#5a	• Stearns Wharf. • Businesses on Stearns Wharf.
Co-benefits	#5c	• Maintains recreational characteristics.

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

9.3.7 Managed Retreat of Stearns Wharf

The City can consider the removal of Stearns Wharf as the risk to the structure increases with sea-level rise. Stearns Wharf is an important asset to the City and community, drawing large numbers of visitors and serving important services to the local tourism industry. Uses on the wharf, such as the Santa Barbara Museum of Natural History Sea Center and restaurants, could potentially be relocated to new locations onshore. Costs of new locations and the change in setting could reduce feasibility and revenues for some businesses. Removal of the wharf could potentially have some impact on sand transport and coastal processes along the waterfront. While the degree of impact is not anticipated to be large, further study is advised prior to consideration of removal of the wharf.

Table 9-6 summarizes the considerations for managed retreat and identifies the corresponding Guiding Principles (Section 3.1).

TABLE 9-6
MANAGED RETREAT OF STEARNS WHARF CONSIDERATIONS

Consideration	Guiding Principle	Benefits and Constraints
Hazard Protection	#4a	• Managed retreat removes structures and infrastructure from the hazard zone.
Feasibility	#4b	• As the wharf is entirely owned by the City, removal is feasible but would affect existing leases on the wharf.
Timeline to Implement		• 10 years lead time to plan for removal of wharf and relocation of assets.
Effectiveness over time		• N/A
Cost	#4b	• Removal costs. • Costs to businesses to relocate. • Potential losses to tourism and associated economic impacts. • Loss of tax, lease, and fee revenues. • Comparative cost1: medium to high.
Permitability and Legal Complexities	#4b, c	• Moderate legal risk depending on stakeholder buy-in. • Many permitting requirements, but likelihood of success is high.
Coastal Resource Impacts	#4d	• Initial impacts to re-establish development elsewhere. • Reduces the likelihood of damaged material entering the ocean and creating hazards elsewhere. • Loss of community resource and public access opportunities. • Loss of visitor-serving and educational uses.
Benefits to Community Groups	#5a	• None
Co-benefits	#5c	• None

1. A high-level, comparative cost category is presented for each adaptation strategy to allow comparison across strategies. More detailed costs for specific strategies are provided in Section 11.

9.4 Harbor and Stearns Wharf Adaptation Recommendations

The adaptation strategies proposed in Section 9.3 were evaluated in detail and reviewed for consistency with the City's Guiding Principles (Section 3.1). Table 9-7 summarizes the strategies, whether they are recommended, the extent to which they align with the Guiding Principles, and the timeframes through which they are likely to be effective.

Table 9-7
Summary of Adaptation Strategies for the Harbor and Stearns Wharf

Adaptation Strategy	Recommendation	Key Considerations
Raise and/or Modify the Harbor Breakwater, Groins, and Sandspit	Recommended in the near- and mid-term. Further study needed for long-term use. Expected to be effective up to about 2–3 feet of sea-level rise (±2060), after which could potentially be effective if major reconstruction completed and implemented with other strategies.	Raising these structures is key to protecting the Harbor. The sidewalk and wall running from the breakwater to the city waterfront offices in the Harbor commercial area should be raised at the same time as the breakwater. The City should pursue feasibility studies through the USACE in the next few years. Lead time to implement is 5–10 years.
Elevate and Reconstruct Marina Facilities and City Pier	Recommended in the near-, mid-, and long-term. Depends on modifications of the breakwater, groins, and adaptation to allow access from the Harbor commercial area to remain effective.	The City has a regular schedule of replacing and repairing marinas. The next set of marinas to be replaced are on the north side of the Harbor. When these are replaced, they should be raised to account for sea-level rise. All marinas will need to be raised by approximately 1 foot of sea-level rise. City Pier needs to be raised between 0.5 and 1 foot of sea-level rise. Lead time to implement 3–10 years.
Elevate Harbor Grades	Could be considered for use in specific areas in the near-term and for larger scale use in the mid- and long-term.	Could require significant fill material and reconstruction of buildings and infrastructure. Lead time to implement is 5–20 years depending on scope of project.
Other Adaptation Options for the Harbor Commercial Area and Parking Lots	Recommend continuing use of beach berms or dunes; raising walkways and walls, seawalls, revetments, elevation of buildings; and floodproofing buildings and infrastructure in the near-, mid-, and long-term as described further in Section 6. In the long-term, adaptation options would likely have to be combined with raising grades to be effective.	See Section 7 for more details. Lead time to implement depends on strategy and scope of project, but generally between 2 and 15 years.

TABLE 9-7
SUMMARY OF ADAPTATION STRATEGIES FOR THE HARBOR AND STEARNS WHARF

Adaptation Strategy	Recommendation	Key Considerations
Managed Retreat at Harbor	Removal or relocation of specific, highly threatened structures in the Harbor commercial area could be considered in the near-, mid-, and long-term. Large-scale removal of key Harbor structures (breakwater, rock groin, sandspit, marinas) not recommended in the near- or mid-term, but could be an option further considered in the long-term.	Could reduce or eliminate commercial fishing, recreational boating, visitor serving uses, and Coast Guard uses and could be detrimental to the local economy if done at a large scale. Removal of Harbor breakwater, rock groin, and sandspit could increase erosion and flood hazards north of Harbor. More studies would be necessary to understand impacts of removing or abandoning Harbor. Lead time to implement is 2–20 years depending on scope of project.
Raise Stearns Wharf	Could be considered for use in the mid- and long-term.	Existing wharf is at risk during extreme coastal storm events. Raised wharf would still be at risk during large coastal storm events. Feasibility of raising the wharf needs to be further evaluated. Additionally, costs of raising and maintaining wharf over time as sea-level rise rates begin to accelerate may begin to outweigh economic, public access, visitor-serving, and social benefits of maintaining the wharf. A more detailed benefit-cost analysis for the wharf is needed.
Managed Retreat of Stearns Wharf	Could be considered for use in the mid- and long-term.	Would result in loss of public access, visitor-serving, and educational resources on the wharf that provide City revenues and encourage tourism that bolsters the local economy. Some of these amenities could potentially relocate inland, although change in setting may affect businesses.

The City should closely monitor Harbor dredging, rising sea-levels, beach erosion, and flooding events at the Harbor and Stearns Wharf.

Raising or modifying the Harbor breakwater, rock groin, and sandspit is recommended for the near-term and is the key to any other adaptation measures at the Harbor. The walkway and parapet wall spanning from the breakwater to the Harbor commercial area should be raised and/or modified at the same time. The City should pursue USACE funding and/or assistance with these projects.

Certain marina facilities, such as guide piles, could also be raised in the near-term. Renovation of the marinas could be done in phases, as the north side marinas could be planned for reconstruction by 2030. All the marinas need to be raised by the time 1 foot of sea-level rise occurs. The City Pier will need to be modified and/or raised by the time 0.5 to 1.0 foot of sea-level rise occurs.

At around 0.5 foot of sea-level rise (±2030), the City will need to start considering how to protect the Harbor commercial area and parking lots. This could start with raising the walkway or raising/adding walls around the Harbor and along the beachfront. Raising roads and buildings may be more appropriate in the mid-term after further planning. In the mid-term, the City will need to decide whether to continue raising marina facilities including raising grades, or whether to begin retreating certain Harbor facilities.

At around 0.5 foot of sea-level rise, the City should conduct a detailed alternatives and cost/benefit analysis for Stearns Wharf that considers options such as reconstruction, relocation, resdesign, or removal of the wharf.

Additional studies needed include:

- Detailed wave runup and feasibility studies for modifications to the Harbor breakwater, rock groin, and sandspit.
- Study of detailed cost/benefits to raise and maintain Stearns Wharf over time versus removal of the wharf, in response to sea-level rise. Study should analyze the potential effects of removing the wharf and appropriate triggers for action based on acceptable risks.
- With 0.5 to 1 foot of sea-level rise, begin study of wide-scale adaptation options for Harbor commercial area and parking lots, including potentially raising Harbor grades.

Figure 9-7 shows the major vulnerabilities for the Harbor and Stearns Wharf, two options for adaptation approaches, and lead times to begin advance planning before the recommended adaptation measures could be in place to limit risk. The figure also shows how long each strategy is expected to be effective.

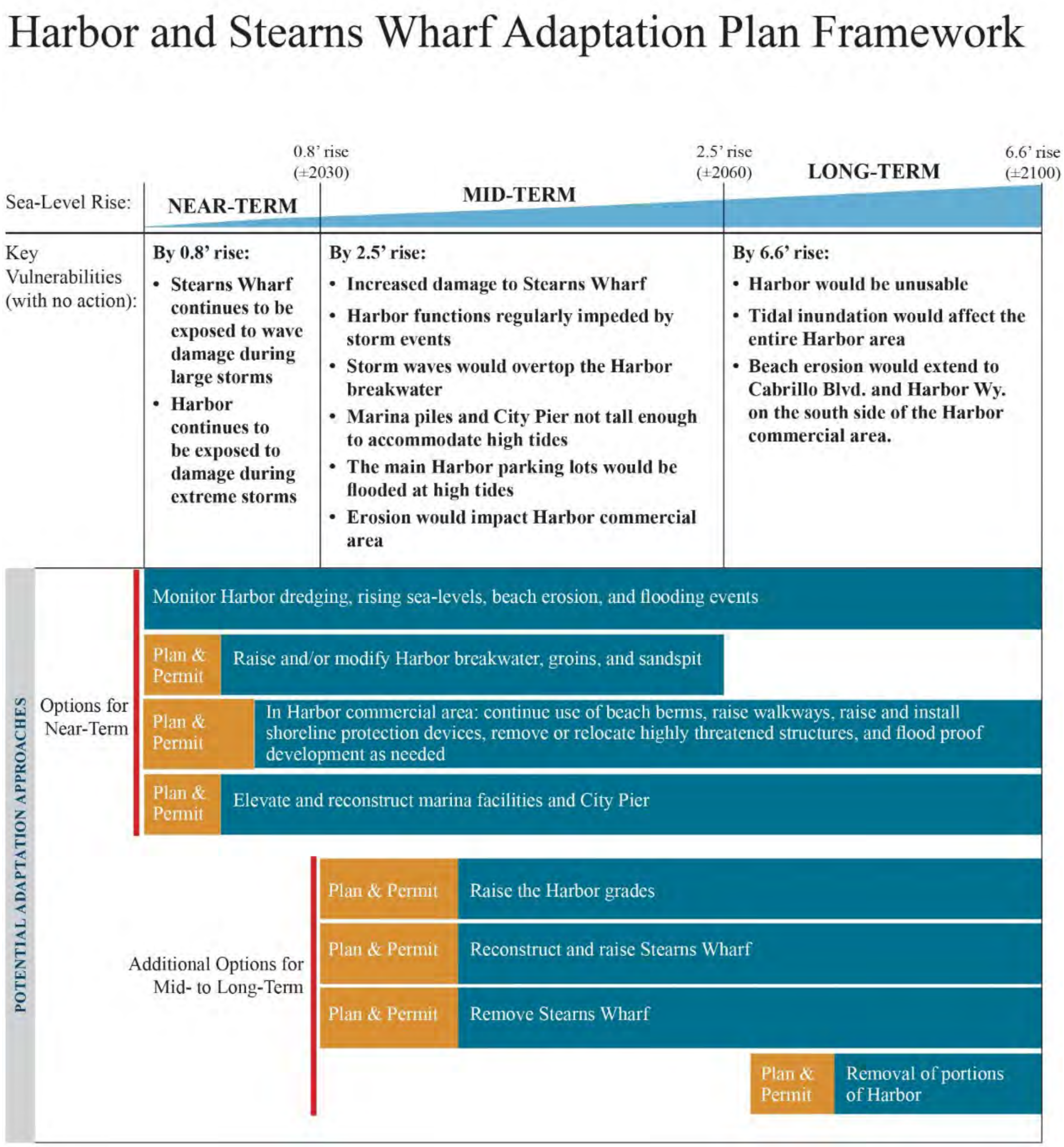

Figure 9-7
Harbor and Stearns Wharf Adaptation Plan Framework

Section 10

MAJOR INFRASTRUCTURE

This section summarizes the vulnerability to major infrastructure from sea-level rise and the adaptation strategies that could apply to this infrastructure. Major infrastructure discussed below includes the El Estero Water Resource Center and the associated wastewater system, the Charles E. Meyer Desalination Plan, and major transportation corridors, including the railroad, Highway 101, Cabrillo Boulevard, Shoreline Drive, and Cliff Drive (Figure 10-1). This infrastructure is located in the hazard areas discussed in Sections 6 through 9, and more information on adaptation options for each of these areas is discussed in further detail in these sections.

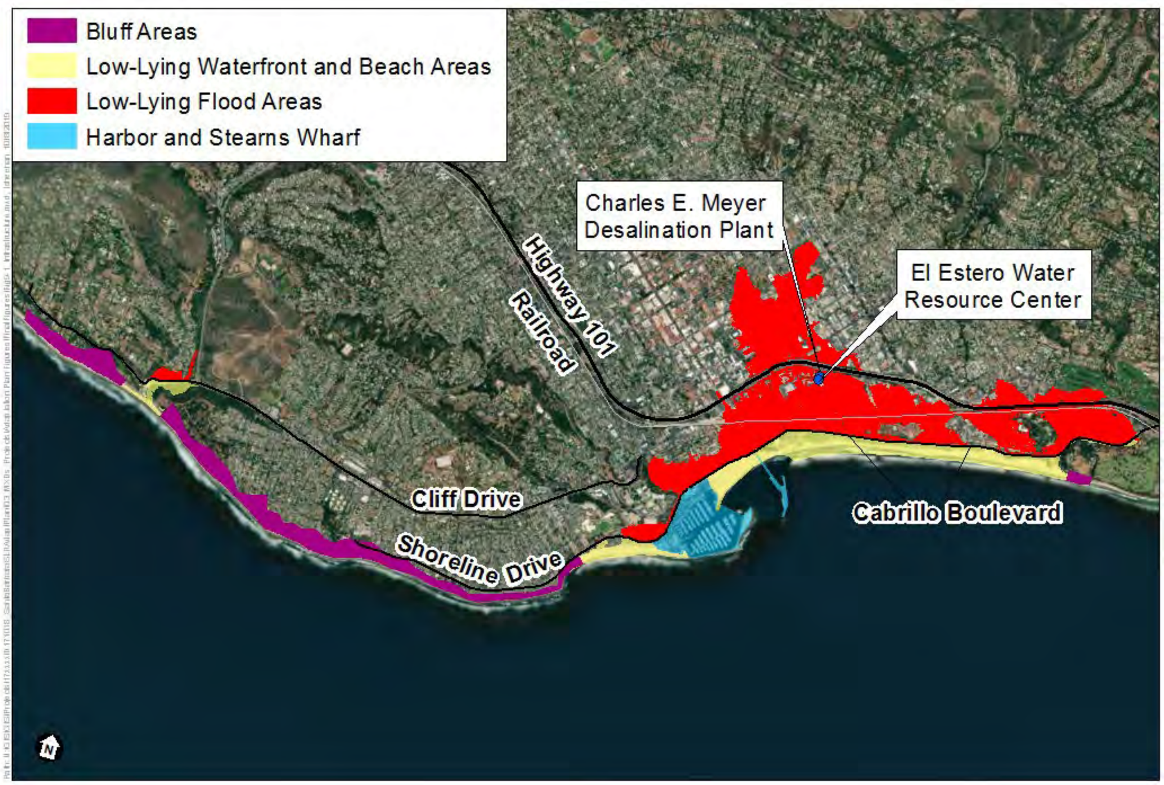

Figure 10-1
Major Infrastructure Hazard Areas

10.1 El Estero Water Resource Center, the Wastewater System, and the Recycled Water System

The El Estero Water Resource Center treats all of the wastewater from the City's collection system. The City operates and maintains approximately 255 miles of collection system gravity-fed sewers serving a population of approximately 92,000. The wastewater from the collection system flows to El Estero Water Resource Center through sewer mains, including mains that are located south of Cabrillo Boulevard in the beach. The El Estero Water Resource Center treats approximately 6 million gallons of wastewater per day from homes and businesses. Some of the treated wastewater is mixed with brine from the desalination facility across the street and then released 1.5 miles offshore via an ocean outfall. Recycled water from the tertiary-treatment plant is used to irrigate schools, parks, and other sites. Biosolids produced at the site are composted and used at farms and parks. Bio-gas generated in the treatment process is converted to electricity and used to offset the electrical needs of the plant.

The El Estero Water Resource Center is located adjacent to Laguna Creek, but is built on an area that was filled higher than surrounding areas in the 1970s. However, operations of the El Estero Water Resource Center rely on the wastewater collection system and access roads that could be affected sooner than the operations of the treatment plant. Sewer trunk mains and manholes that run along the beach south of Cabrillo Boulevard are currently exposed to flooding by seawater during extreme coastal storms and can temporarily halt operations of the El Estero Water Resource Center. With 0.8 feet of sea-level rise, flooding of manholes along these trunk mains will increase in frequency during coastal storms making them temporarily inoperable. With 2.5 feet of sea-level rise, if no additional action is taken, flooding of the trunk mains would result in extended shutdowns of the El Estero Water Resource Center. The treatment process is not designed to handle the extra flows or to treat saline water. As a result, the flooding would cause a backup of sewer flow in other parts of the system and the city.

As discussed in the Vulnerability Assessment Update (Appendix A), after 3 to 4 feet of sea-level rise, the areas surrounding the El Estero Water Resource Center, including the major access roads to the plant, would be progressively impacted by tidal inundation and flooding during coastal storms. With 6.6 feet of sea-level rise, coastal storm flooding would impact the El Estero Water Resource Center site itself, if no action is taken, and the plant would be inoperable as the sewer collection system would be regularly inundated during high tides.

In the near-term, the City should plan for either moving the sewer trunk mains that are in the beach areas or making them floodproofed and more stable from possible earth movement during flooding events.

In the mid-term, the City must start planning for flood protection measures for the sewer collection system and access roads to the El Estero Water Resource Center that are projected to be impacted with 3 to 4 feet of sea-level rise. Sections 7 and 8 discuss adaptation measures that address increased inundation and erosion of the waterfront and beach and flooding of the low-lying flood areas, and could also address increased inundation of the sewer system. Among other measures, raising Shoreline Drive and Cabrillo Boulevard or building a seawall along the city's waterfront are options that should be explored. Manholes and the sewer trunk mains could also be raised (e.g., in conjunction with raising Cabrillo Boulevard); however, the current sewer pipeline system drains by gravity to the trunk main, and raising the trunk main could interrupt the gravity drainage. Low-lying portions of the sewer system may need to be disconnected from the gravity drainage system and modified to be pumped into the trunk main. As sea levels rise, groundwater elevations are expected to rise and may result in flooding, impacts to the structural integrity of infrastructure, or groundwater intrusion into pipes. As discussed in Section 8.3.2, groundwater pumping may be needed in low-lying areas to protect buried infrastructure. Higher groundwater levels may also impact the ease of maintenance and require new or modified operations for the El Estero Water Resource Center.

In the mid-term, the City should also plan for adaptation of the El Estero Water Resource Center itself. Perimeter berms or floodwalls and pumps could be installed around the facility. The berm or floodwalls would protect the El Estero Water Resource Center from off-site floodwaters. However, pumps would be required to remove rainwater from the site to the storm drain system on the other side of the berms or floodwalls. Additionally, pumps may be needed to address high groundwater levels on the site.

The location of El Estero Water Resource Center places it at risk from both flooding from high rainfall events, riverine flooding, and flooding from high wave events and tides as a result of sea-level rise. Given these complexities, the City could consider the removal and relocation of portions of the El Estero Water Resource Center from low-lying areas, as the risk of inundation and coastal storm flooding rise with sea-level rise. Planning for such a relocation would need to begin by the time 1 foot of sea-level rise occurs, given that significant advanced planning would be required. Not only would a new site be required for the El Estero Water Resource Center, but major portions of the sewer collection system would also require modification. In adjacent areas lower than the El Estero Water Resource Center, the sewer system would need to be redesigned with pumps and other measures to prevent backflow of the system. Additionally, the outfall system and recycled water system would require extensive modification. Alternate wastewater management strategies could also be considered. Strategies will continue to change with changing technologies, but water recycling, low-impact development strategies, and decentralized treatment options could address both broader water management issues and sea-level rise vulnerabilities.

Additional study of the wastewater outfall is needed as erosion of the coastal profile with sea-level rise could expose portions of the pipeline and supports, and sediment deposition and changes to the seafloor could impact the outfall.

Given the complexities associated with the wastewater system and El Estero Water Resource Center, it is advised that in the near-term the City should initiate a specific study of detailed adaptation options for the sewer system and El Estero Water Resource Center.

Additional studies needed in the near-term include:

- As discussed in Section 8, further studies are needed to address how groundwater may be affected by sea-level rise, how riverine flooding may change as a result of changes in rainfall patterns as a result of climate change, and how changes in flooding may occur due to the interaction of riverine flooding during 100-year rainfall event with higher sea levels.
- Project-level studies to assess salinity and hydraulics associated with flooding of the El Estero Water Resource Center infrastructure, particularly trunk mains and other infrastructure south of Cabrillo Boulevard.
- Detailed study of adaptation options for threatened portions of the sewer and recycled water systems, including options for El Estero Water Resource Center

10.2 Charles E. Meyer Desalination Plant and the Water System

The City's Charles E. Meyer Desalination Plant is located north of the El Estero Water Resource Center along the east side of Laguna Creek. The plant itself is not likely to be exposed to coastal hazards under existing conditions or with 2.5 feet of sea-level rise, but is likely to be exposed to tidal inundation and coastal storm flooding with 6.6 of sea-level rise. Access roads to the plant are expected to be exposed to progressive flooding during coastal storms and then from tidal inundation starting with around 3 to 4 feet of sea-level rise. As with El Estero Water Resource Center, the adaptation options discussed in Section 7 and 8 could address flooding at and around the plant. Additionally, a berm or floodwall could be built around the plant, in combination with stormwater pumps to remove water that ponds at the plant and direct it into the stormwater system, assuming the system's capacity is improved. When the desalination facility is due for major renovations (approximately 20 to 30 years from present), the City may also want to consider relocating the facility further inland. Further study in the mid-term is warranted to understand if the offshore intake for the desalination plant might be affected by erosion of the coastal profile and sediment deposition and changes in seafloor configurations offshore.

In the near-term, adaptation options including relocation and floodproofing should be considered for water conveyance infrastructure south of Cabrillo Boulevard. A system specific study should also be conducted of all threats from sea-level rise to the various specific portions of the water system. Additionally, impacts related to salt water intrusion and groundwater pumping should be studied in relation to the City's water supply system.

10.3 Stormwater and Other Utilities

It was outside the scope of this Adaptation Plan to assess potential impacts and adaptation options to the City's very intricate stormwater system. It is therefore recommended that a study be conducted of the potential impacts of sea-level rise to that system and possible adaptation options.

Additional coordination is also needed to electrical and natural gas utility providers to further assess potential impacts and adaptation options for the energy transmission and distribution systems. This is particularly true of any infrastructure south of Cabrillo Boulevard.

10.4 Major Transportation Corridors

As described in the Vulnerability Assessment Update (Appendix A) and Sections 6 through 9 of this report, many of the city's major public roads and the Union Pacific Railroad show little exposure at 2.5 feet of sea-level rise. Select areas of Shoreline Drive could be exposed to bluff erosion and portions of Cabrillo Boulevard could flood with 2.5 feet of sea-level rise. With 6.6 feet of sea-level rise, roads south of Highway 101, such as Cabrillo Boulevard, Garden Street, and Milpas Street, would be exposed to tidal inundation, if no action is taken. Roads north of Highway 101, such as Garden Street, Guiterrez Street, Haley Street, and Cota Street, would be subject to storm flooding during both high rainfall and high ocean water level/wave events. Large portions of Shoreline Drive and a portion of Cliff Drive would be threatened by bluff erosion. With 6.6 feet of sea-level rise, Highway 101 would be exposed to coastal storm flooding west of Andrée Clark Bird Refuge, potentially disrupting traffic at a regional scale. Additionally, the Union Pacific railroad through the city is exposed to tidal inundation and coastal storm flooding at multiple locations.

As discussed in Sections 7 and 8, roads and railroads can be raised to move them out of hazard zones. Raising vulnerable roads can be accomplished by placing them up on fill or replacing them with pile-supported causeways. Utilities, which are often buried along roads, can also be raised. However, if one road is raised, all connecting roads, trails, and utilities would have to be rebuilt to slope up to the new grade.

Other adaptations discussed for beach areas (Section 7) and the low-lying flood areas (Section 8) could be used to reduce the vulnerability of transportation corridors, such as Shoreline Drive, Cabrillo Boulevard, and Highway 101.These include coastal sediment management (Section 7.3.1) and shoreline protection devices (Section 7.3.3). For example, a seawall could be built to protect Leadbetter Beach parking lot, Garden Street parking lot, and Cabrillo Boulevard from Leadbetter Beach to Cabrillo Pavilion and parking lot.

Adaptation measures for bluff-top transportation corridors, such as Shoreline Drive and Cliff Drive, could include bluff erosion BMPs (Section 6.3.3) or shoreline protection devices (Section 6.3.4). With about 1 to 2.5 feet of sea-level rise, the bluffs along Shoreline Drive could be armored at the west and east ends to protect the road. With 6.6 feet of sea-level rise, the full stretch of bluffs along Shoreline Drive may need to be armored to protect from erosion. Additionally, between 2.5 and 6.6 feet of sea-level rise, the portion of Cliff Drive west of Arroyo Burro Creek would need to be armored to protect it from erosion and the portion of Cliff Drive at Arroyo Burro Creek would need to be raised.

In the long-term, as risks to major transportation corridors increase, the City should consider removal of roads and other infrastructure and relocation opportunities (see Sections 6.3.5, 7.3.6, and 8.3.7). A seawall could be built along Shoreline Drive and Cabrillo Boulevard, in combination with retreating portions of Leadbetter Beach parking lot, Garden Street parking lot, and the Cabrillo Pavilion parking lot.

Potential example adaptation scenarios for the major transportation corridors are evaluated in terms of economic costs and benefits in Section 11; however, the feasibility of these potential scenarios are contingent on further planning and policy development and decisions by the City. The Santa Barbara County Association of Governments is also in the process of developing a vulnerability assessment and adaptation plan for Santa Barbara County's multi-modal transportation network, which could help inform future planning for transportation in the region.

Section 11

SOCIOECONOMIC ANALYSIS

The following provides current demographic information on households anticipated to be affected by increased flooding and erosion from 6.6 feet of sea-level rise. Project-specific analysis of vulnerable populations and socioeconomic benefits and costs will be provided during the development of each major adaptation project.

Several factors have been shown to correlate with a higher sensitivity and/or lower adaptive capacity to hazards that should be factored into planning for the impacts of sea-level rise. These factors include, among others: income and poverty, race, language spoken, age, housing type (percent rentals), and household type.

11.1 U.S. Census Bureau

Figures 11-1 through 11-3 show the area of potential impact of increased flooding and erosion hazard from 6.6 ft of sea-level rise in relation to census block groups within the City of Santa Barbara identified by the U.S. Census Bureau 2018 Five-Year American Community Survey as being lower income, not proficient in the English language, and high percentage of minority populations.

11.2 USGS Hazard Exposure Reporting and Analytics

The USGS has developed the Hazard Exposure Reporting and Analytics (HERA) application to analyze a community's exposure to hazards related to sea-level rise. The application utilizes the CoSMoS 3.0 hazard model and U.S. Census Bureau data. Table 11-1 shows a comparison of the overall demographics of the City of Santa Barbara to the demographics of the areas potentially impacted by erosion and 100-year storm flood hazards from 6.6 feet of sea-level rise. Additional information can be obtained from accessing the HERA application at www.usgs.gov/apps/hera/#close

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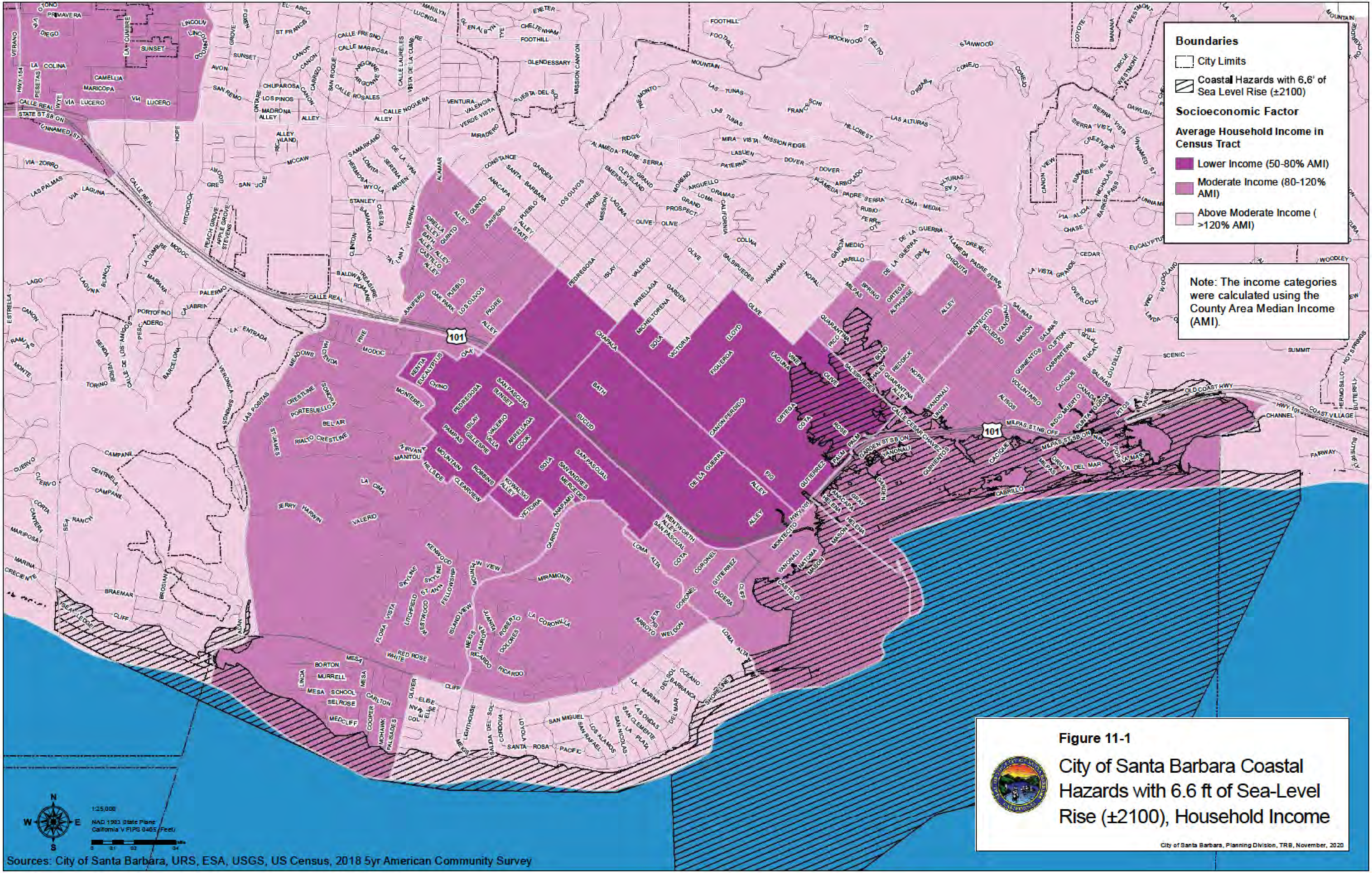

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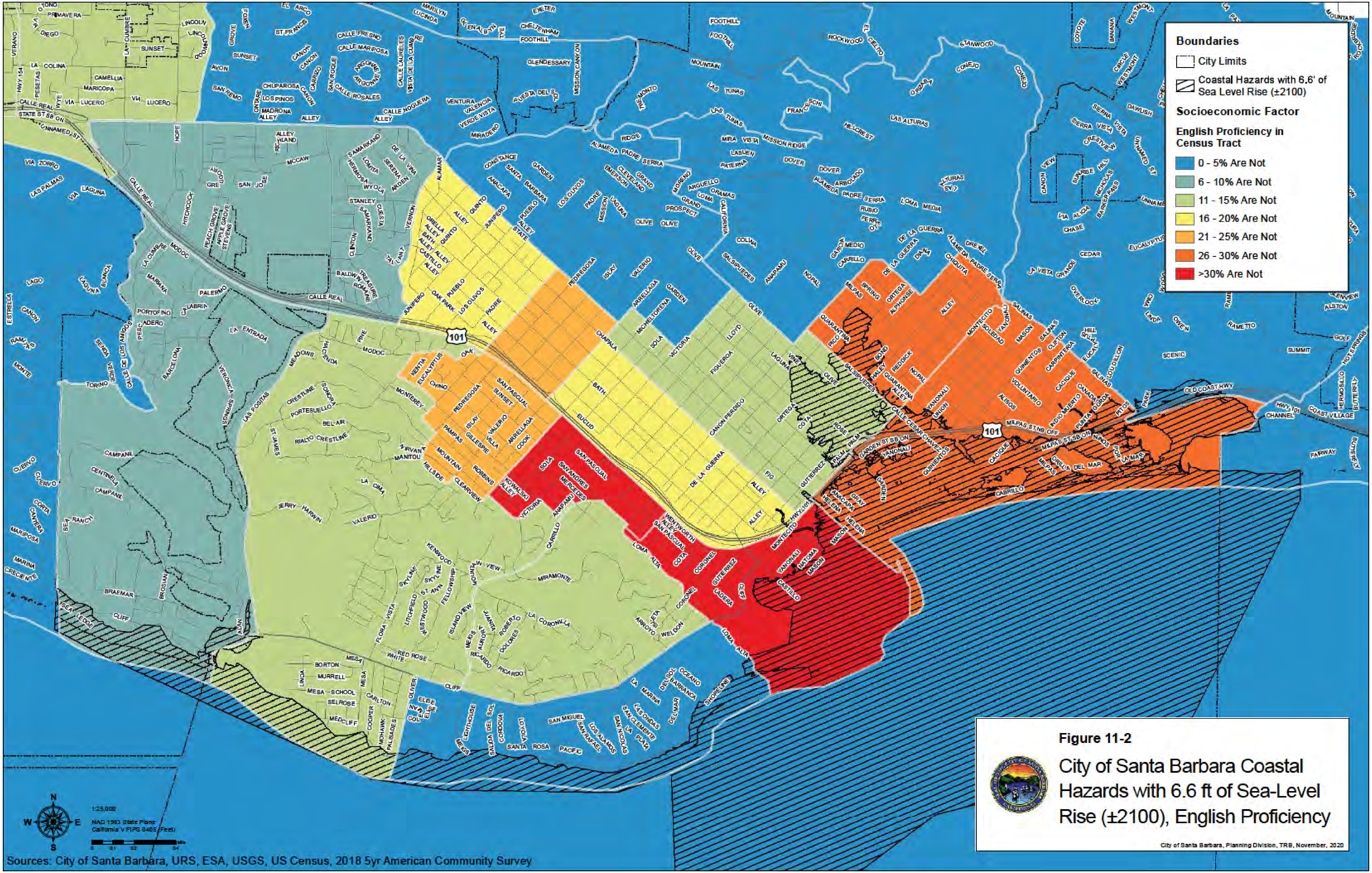

Figure 11-2

City of Santa Barbara Coastal Hazards with 6.6 ft of Sea-Level Rise (±2100), English Proficiency

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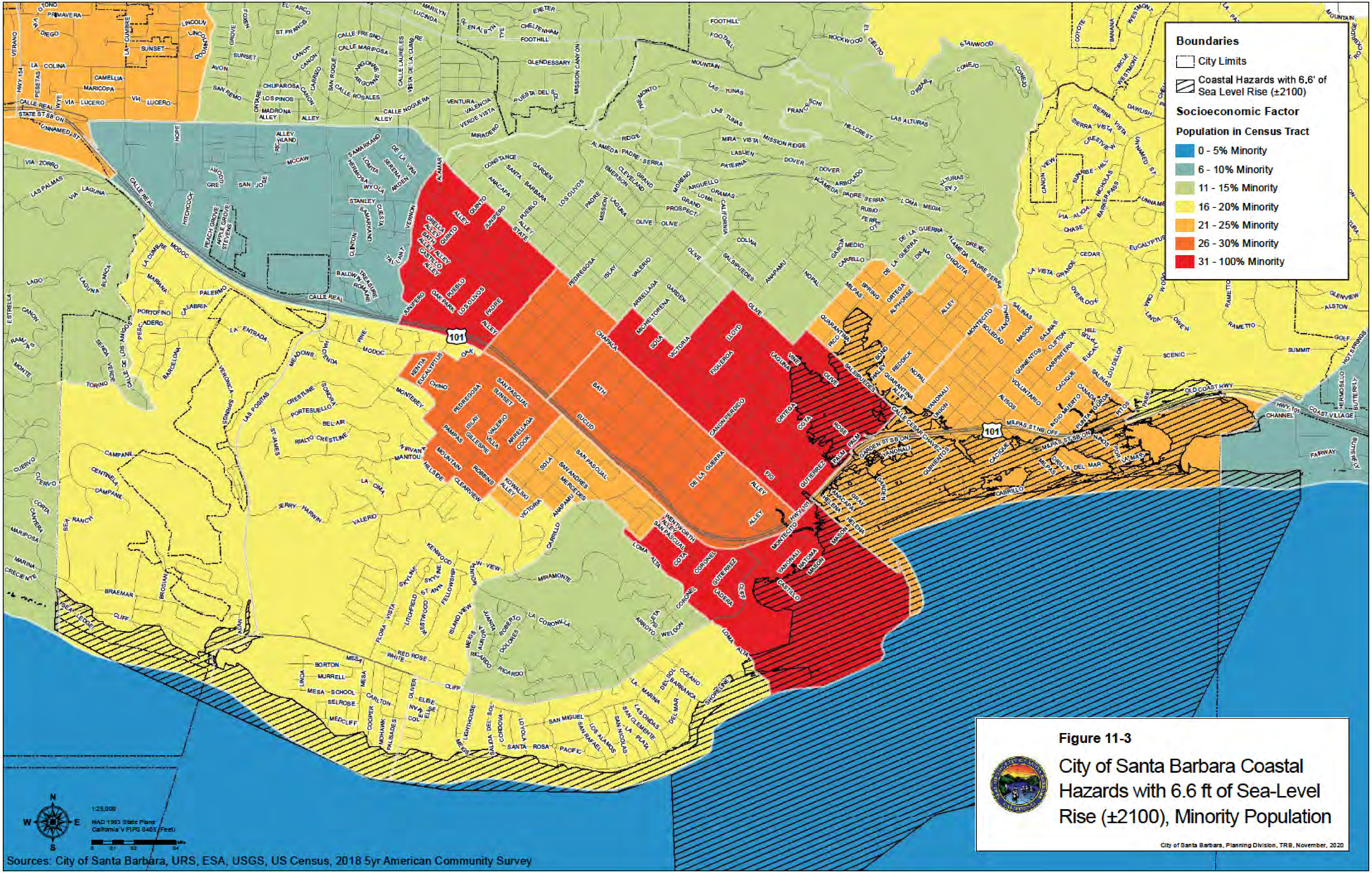

Figure 11-3

City of Santa Barbara Coastal Hazards with 6.6 ft of Sea-Level Rise (±2100), Minority Population

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TABLE 11-1
COMPARISON OF DEMOGRAPHICS WITHIN HAZARD ZONE TO ENTIRE CITY

Demographics		Residing Within City's SLR Hazard Zone (6.6 of SLR; 100 year storm)	Residing Within Entire City of Santa Barbara
Residents Total		2,802 residents (3%)	100%
Age	Age over 65	15%	14%
	Age under 5	5%	5%
Ethnicity	Hispanic	42%	38%
Race	American Indian	3%	2%
	Asian	4%	5%
	Black	4%	2%
	Native Hawaiian	0%	0%
	Other	17%	16%
	White	76%	79%
Housing Occupancy	Owner	31%	39%
	Renter	69%	61%
Female Head of Household w/ Child		5%	6%

Source: USGS Hazard Exposure and Analysis (July 2020) *www.usgs.gov/apps/hera/#close*

11.3 SB 535 AND AB1550 DISADVANTAGED AND LOW-INCOME COMMUNITIES

SB 535 and AB 1550 require the State of California to invest certain percentages of climate cap and trade mitigation funds to identified disadvanted and low-income communities. CalEPA developed a tool called CalEnviroscreen for assessing what constitutes a disadvantaged community. The City of Santa Barbara does not contain any disadvantaged communities as defined by SB 535 and CalEnviroScreen, but does contain low-income communities as defined by AB1550. As defined in AB1550, "low-income communities" are census tracts with median household incomes at or below 80 percent of the statewide median income or with median household incomes at or below the threshold designated as low income by HCD's State Income Limits. Figure 11-4 shows low-income communities as defined by AB1550 within the portion of the City of Santa Barbara potentially impacted by increased flooding and erosion as a result of 6.6 feet of sea-level rise.

11.4 Proposition 68 Disadvantaged Communities

Proposition 68, passed in 2018, authorizes $4.1 billion for state and local parks, natural resources protection, climate adaptation, water quality, and flood protection. Projects that benefit disadvantaged and severely disadvantaged communities are given priority for funding. A severely disadvantaged community is defined as a census block group with a median household income less than 60% of the California statewide average. A disadvantaged community is a census block group with a median household income less than 80% of the California statewide average. Other State grant funding opportunities also use these same definitions. Figure 11-5 shows severely disadvantaged and disadvantaged communities as defined in Proposition 68 within the City of Santa Barbara that could be impacted by increased storm flooding and erosion with 6.6 feet of sea-level rise.

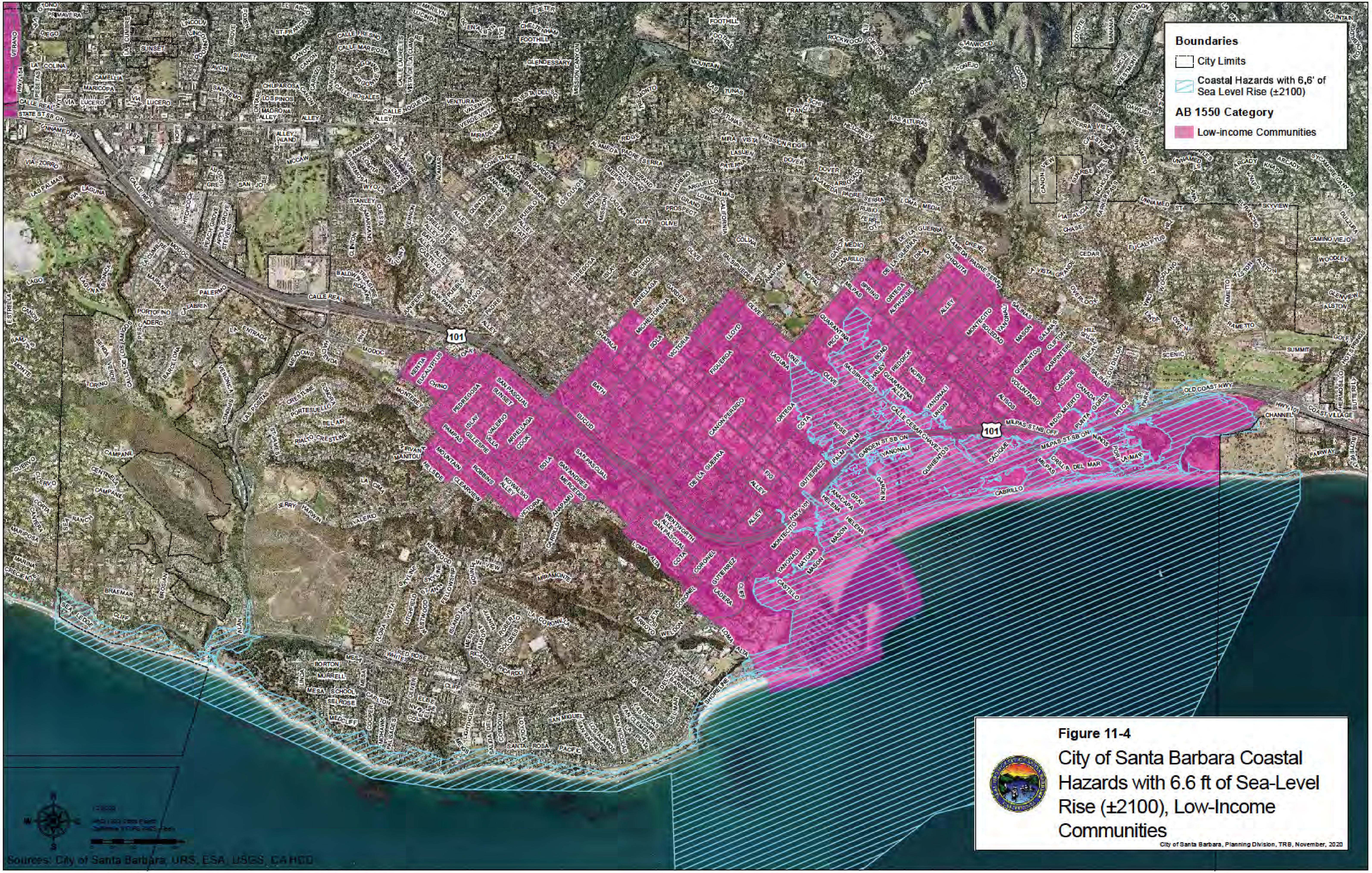

Figure 11-4

City of Santa Barbara Coastal Hazards with 6.6 ft of Sea-Level Rise (±2100), Low-Income Communities

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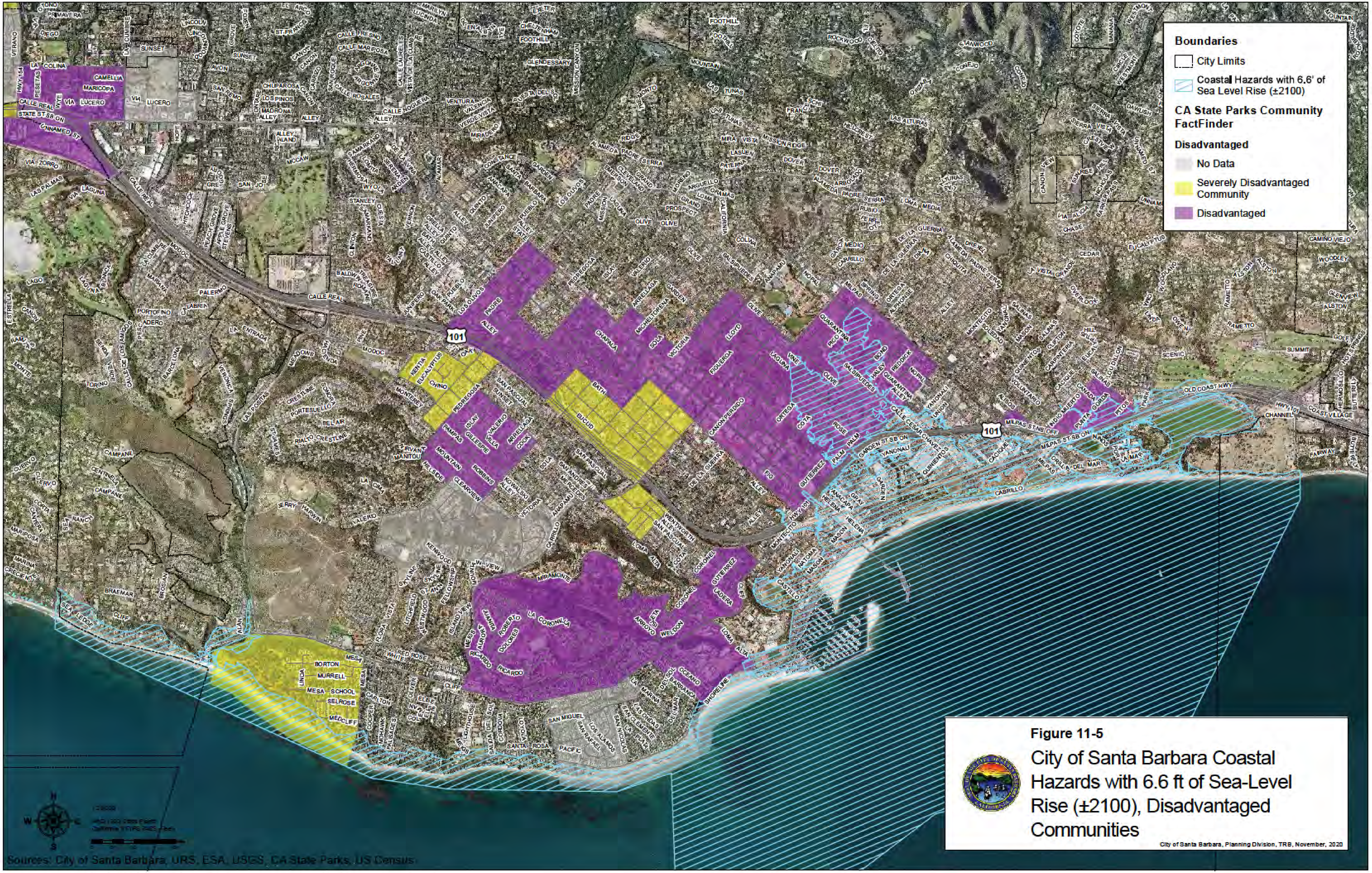

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Section 12
POTENTIAL ADAPTATION SCENARIO ANALYSIS

The Vulnerability Assessment Update (Appendix A) presents the potential impacts of sea-level rise through the year 2100 if no action is taken to mitigate the additional hazards posed by sea-level rise. The study area was divided into 11 planning subareas based on land use composition and shore type morphology (e.g., bluff versus low-lying beach and backshore) for discussion purposes and to investigate the spatial variability of sea-level rise vulnerability in these areas. This section compares this “no action scenario” with two potential adaptation scenarios designed to mitigate future coastal hazard risks. These include a “protect scenario” and a “retreat/protect hybrid scenario” that each employ different sets of adaptation strategies in the near-, mid-, and long-term to address the impacts of sea-level rise. The relative hazard exposure is mapped for each scenario. This section also includes a summary of the results of a benefit-cost analysis, conducted for the City by AECOM (Appendix B), that compares the economic and fiscal impacts of the no action scenario with the relative costs and benefits of the two adaptation scenarios.

This Adaptation Plan identifies a range of adaptation strategies that the City could take in the future to reduce risks associated with sea-level rise. The City will then have the flexibility to select and implement different adaptation strategies as the effects of sea-level rise reach certain thresholds over time. None of the scenarios presented in this section are intended to reflect the City’s exact proposed or preferred approach to adaptation in the future. It is very unlikely that the City would either do nothing or completely protect in place every asset threatened as described in the scenarios presented in this section. It is more likely that a mix of protection, accommodation, and retreat strategies will be implemented. The purpose of this section is not to outline the exact path forward for the City, but rather to bracket a wide range of possible actions the City could take to get a high-level understanding as to what is at risk economically and fiscally and the relative costs and benefits associated with actively planning for and adapting to sea-level rise.

The quantitative analysis conducted for the economic and fiscal impacts study employs many large-scale assumptions that may or may not be realized in the future. It does not include costs such as buying land to relocate facilities or redesigning specific infrastructure as there are too many unknowns associated with these decisions for specific assets. Detailed benefit-cost analysis for each adaptation action is outside the scope of this initial citywide planning level document, but can be conducted in the future as part of project specific studies.

12.1 Scenario Description

The adaptation scenario analysis and benefit-cost analysis results summarized below are a comparison of approaches to sea-level rise adaptation and the “no action scenario” represented in the Vulnerability Assessment Update (Appendix A) (ESA 2018). The “no action scenario” results from the Vulnerability Assessment Update do not represent a complete adaptation scenario in this analysis, but rather represent the property and infrastructure damages and associated economic impacts that are avoided by implementation of the adaptation scenarios. The comparative analysis in this section uses the same sea-level rise projections as the rest of this Adaptation Plan, the California Natural Resource Agency and OPC (2018) medium-high risk sea-level rise scenario that projects 2.5 feet of sea-level rise by 2060 and 6.6 feet of sea-level rise by 2100. While the timing (i.e., triggering) of individual adaptation measures in the two theoretical scenarios in the analysis are based on this sea-level rise projection, the actual timing of adaptation actions in the future will depend on monitoring of sea-level rise and erosion that occurs in the future, as described in Section 3.1.

Each scenario includes multiple adaptation strategies at multiple timeframes. The adaptation alternatives were developed separately for the western and eastern portions of the city, as described below. The estimated costs and benefits are quantified for 2060 (2.5 feet of sea-level rise) and 2100 (6.6 feet of sea-level rise). Near-term adaptation (i.e., 2030 or 0.8 feet) was considered in the analysis of costs and benefits over time, but benefit-cost results are not separately reported for the near-term.

12.1.1 West City

The west portion of the city (west city) is defined for the adaptation scenarios as the area west of Leadbetter Beach to the western city limit. These areas are composed of bluffs and include Arroyo Burro Beach. Two adaptation scenarios were developed for the west city with the following themes:

1. **Protect**: Armor bluffs and build flood control to protect all public and private assets in place.
2. **Retreat/Protect Hybrid**: Retreat public and private assets up to major public roads, then armor bluffs to protect major roads in place while also preserving 25-foot-wide lateral public access along road/bluff top.

Adaptation strategies included in these potential adaptation scenarios are listed in Table 12-1 and shown in Figures 12-1 to 12-5.

Note that the feasibility and effectiveness of protecting the bluff face with armoring in both adaptation scenarios described above is uncertain and requires further evaluation of landslide risk. Landslide risk is not addressed by sea-level rise adaptation measures and should be evaluated on a site-by-site basis.

SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

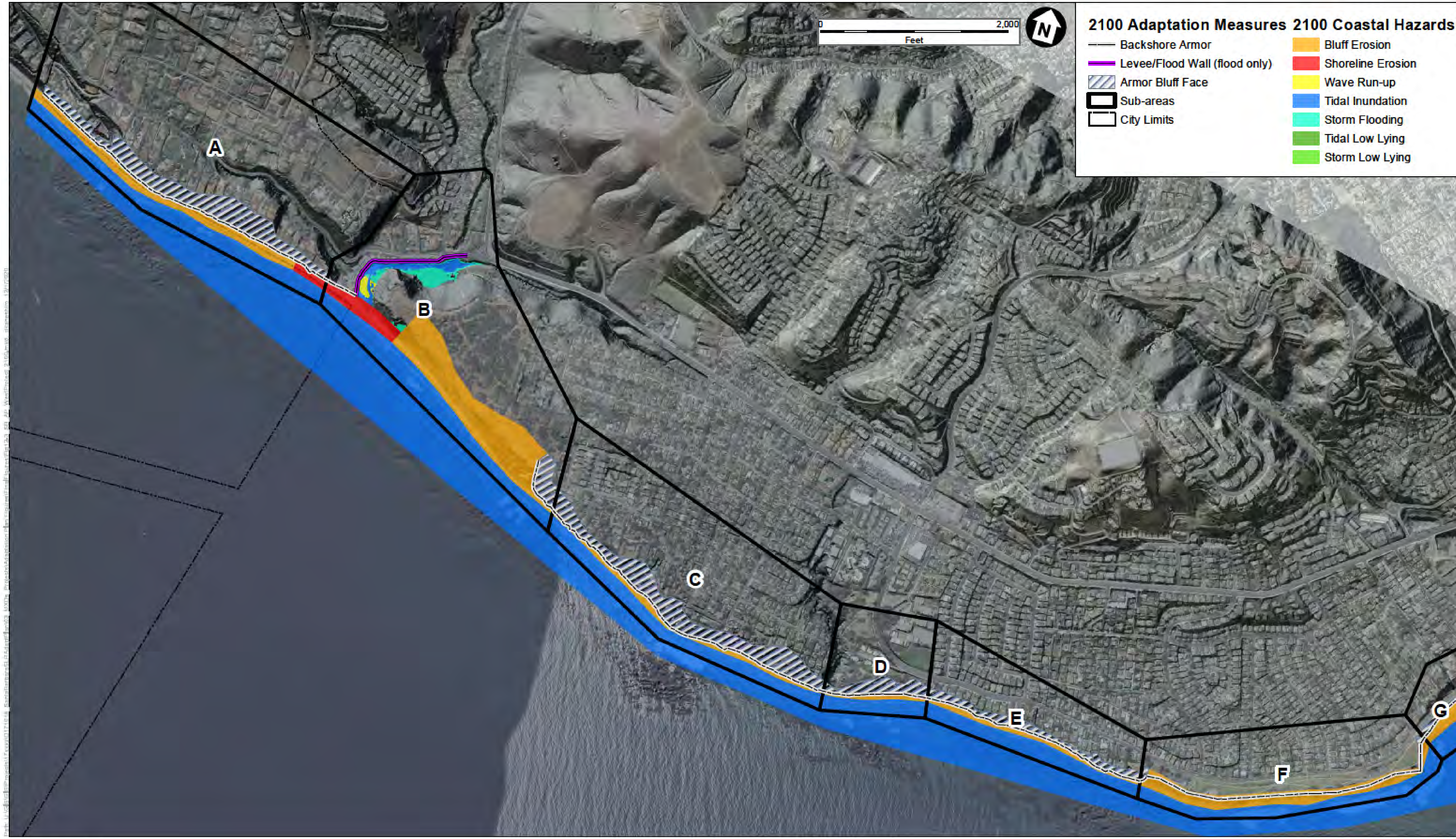
Figure 12-1
West Santa Barbara Adaptation Plan - Existing Conditions

ESA

SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-2
West Santa Barbara Adaptation Plan - Protect 2060



SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-3
West Santa Barbara Adaptation Plan - Protect 2100

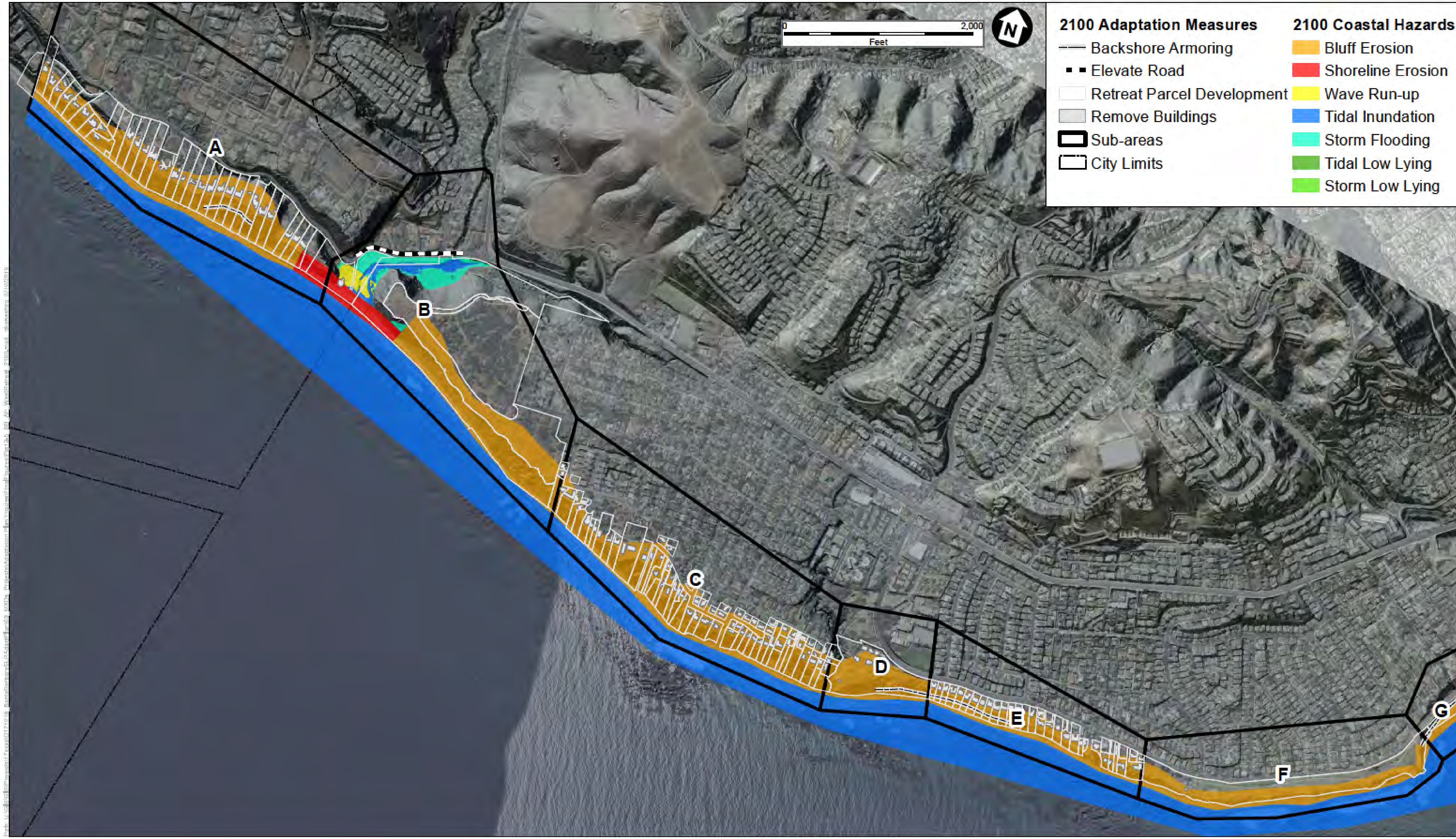
ESA

SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-4
West Santa Barbara Adaptation Plan - Retreat 2060

ESA



SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-5
West Santa Barbara Adaptation Plan - Retreat 2100

ESA

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TABLE 12-1
POTENTIAL ADAPTATION SCENARIOS ANALYZED FOR WEST CITY

Timeframe Key vulnerable assets (if no action is taken)	Protect Scenario (Scenario 1)	Retreat/Protect Hybrid Scenario (Scenario 2)
Near-term, 2030, 0.8 feet sea-level rise **Parcels**	• Armor existing bluff toe and face at private parcels with shoreline protection devices and maintain vertical access. • Allow erosion at bluff-top open spaces to allow beaches to migrate and persist longer.	• Retreat parcels at risk of damage from bluff erosion to allow beaches to migrate and persist longer. • Where needed before 2.5 feet of sea-level rise, protect west and east ends of Shoreline Drive on the bluff by armoring bluff toe. • Allow erosion at bluff-top open spaces to allow beaches to migrate and persist longer.
2060, 2.5 feet sea-level rise **Parcels** **Shoreline Drive, west & east ends**	• Maintain/upgrade private bluff face armor and maintain access (O&M). • Armor bluff toe along Shoreline Park to preserve a portion of the park after beach at bluff toe is lost. Allow terrestrial erosion of bluff face. • Allow erosion of bluff-top open space at Douglas Family Preserve.	• Retreat parcels at risk of damage from bluff erosion. • Maintain/upgrade and extend bluff toe armor at west and east ends of Shoreline Drive. Armor bluff toe along section of Cliff Drive. • Allow erosion of bluff-top open space at Douglas Family Preserve.
2100, 6.6 feet sea-level rise **Parcels** **Shoreline Drive** **Cliff Drive erosion** **Cliff Drive flooding at Arroyo Burro**	• Maintain/upgrade bluff face armor and maintain access (O&M). • Build floodwall to protect Cliff Drive from coastal storm flooding at Arroyo Burro Creek with reconfiguration of parking. • Allow erosion of bluff-top open space at Douglas Family Preserve.	• Retreat parcels at risk of damage from bluff erosion. • Maintain/upgrade armor protecting Shoreline Drive and Cliff Drive while preserving 25-foot-wide seaward area for lateral public access. • Raise Cliff Drive at Arroyo Burro Creek on fill and accommodate coastal storm flooding of parking. • Allow erosion of bluff-top open space at Douglas Family Preserve.

12.1.2 East City

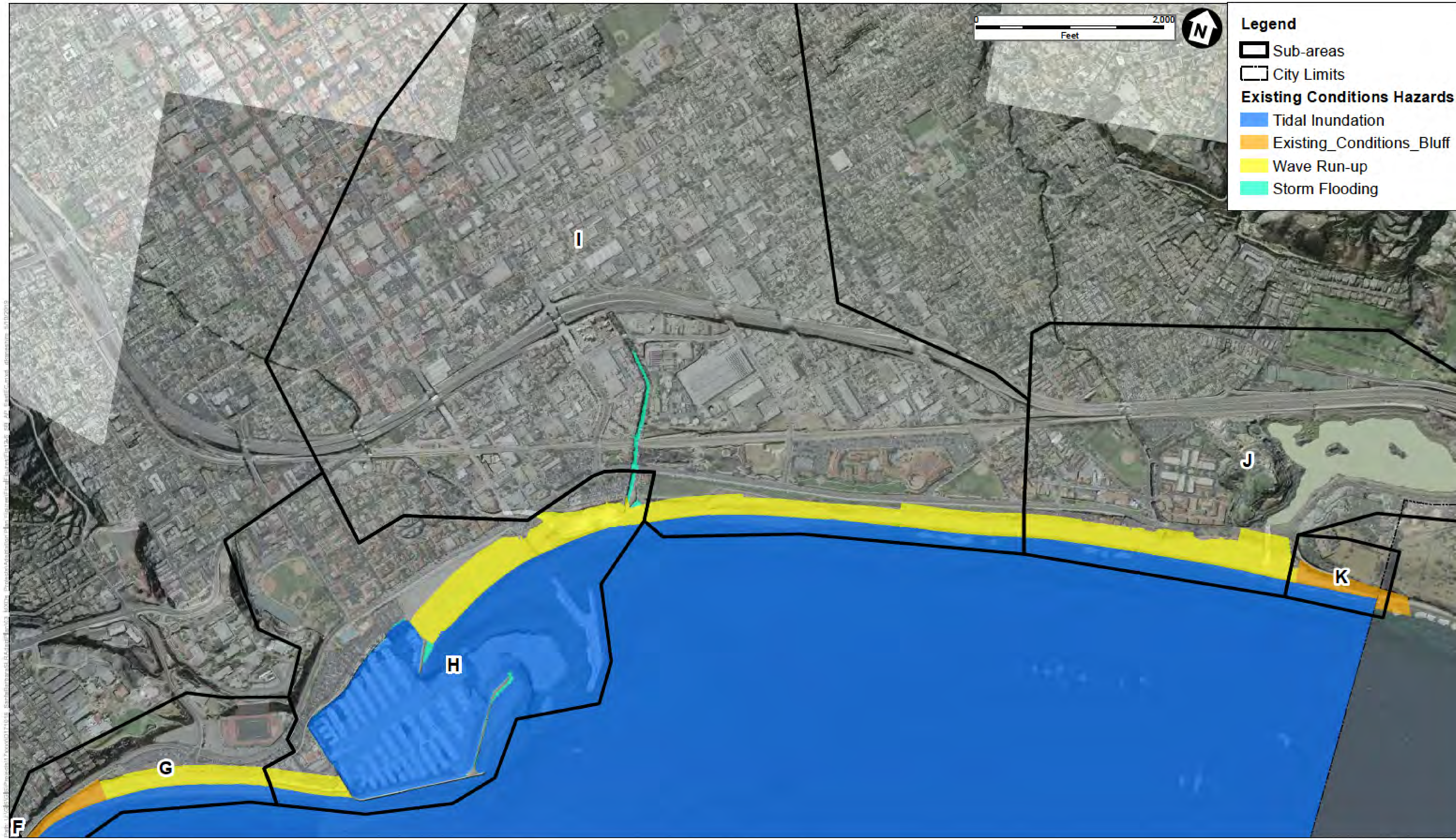
The eastern portion of the city (east city) is defined as lands east of and including Leadbetter Beach to the city's easterly boundary at Belloguardo Estate. One adaptation scenario was developed for the east city with the following theme:

1. **Protect**: Maintain and expand existing coastal structures to mitigate erosion and flooding hazards, increase beach nourishment beyond ongoing sand bypassing, build/upgrade flood protection structures, raise breakwater and lands around the Harbor, rebuild Stearns Wharf, and manage rising groundwater in the low-lying flood area.

Adaptation strategies included in the east city protect scenario are listed in Table 12-2 and shown in Figures 12-6 to 12-8. This adaptation scenario for the east side of the city is used in both the protect scenario and retreat/protect hybrid scenario analyzed in the rest of this section.

TABLE 12-2
POTENTIAL ADAPTATION SCENARIO ANALYZED FOR EAST CITY

Timeframe Key vulnerable assets	Protect Scenario
Near-term, 2030, 0.8 feet sea-level rise **Parcels**	• Continue existing sand bypassing. • Laguna Creek tide gate/pump improvements. • Additional beach nourishment at East beach using sand dredged from the Harbor or imported from elsewhere.
2060, 2.5 feet sea-level rise **Beach loss** **Coastal storm flooding (e.g., Cabrillo Blvd)**	• Continue sand bypassing. • Additional beach nourishment using sand dredged from the Harbor or imported from elsewhere at Leadbetter, West, and East beaches. • Construct seawall segment along back of beach along bike path from the Harbor to East beach public restroom on E Cabrillo Boulevard. Relocate wastewater and other infrastructure buried under beach in this area inland. • Laguna Creek tide gate/pump improvements/maintenance. • Raise lands surrounding the Harbor above tidal inundation, raise bulkheads, groins, and breakwater. Renovate/rebuild marina facilities. • Floodwalls up Mission, Laguna, and Sycamore Creeks. • Rebuild and raise Stearns Wharf.
2100, 6.6 feet sea-level rise **Beach loss** **Coastal storm flooding** **Tidal flooding (Cabrillo and large low-lying flood areas)**	• Continue sand bypassing. • Additional beach nourishment using imported sand at Leadbetter, West, East beaches. • Maintain seawall from Harbor to East Beach public restroom on E Cabrillo Boulevard. • Construct/extend seawall east along East beach to Clark Estate along bike path. • Laguna Creek tide gate/pump improvements/maintenance. • Add tide gate and pump station at Andrée Clark Bird Refuge. • Raise lands around the Harbor above tidal inundation, raise bulkheads, groins, and breakwater to protect against coastal storm flooding. Renovate/rebuild marina facilities. • Raise Leadbetter Parking lot. • Dewater with groundwater wells and pumps along section of Shoreline Drive behind the Harbor. • Expand floodwalls up Mission Creek, Laguna Creek, and Sycamore Creek. • Dewatering wells and pumps to manage rising groundwater in low-lying flood areas. • Maintain/upgrade Stearns Wharf.

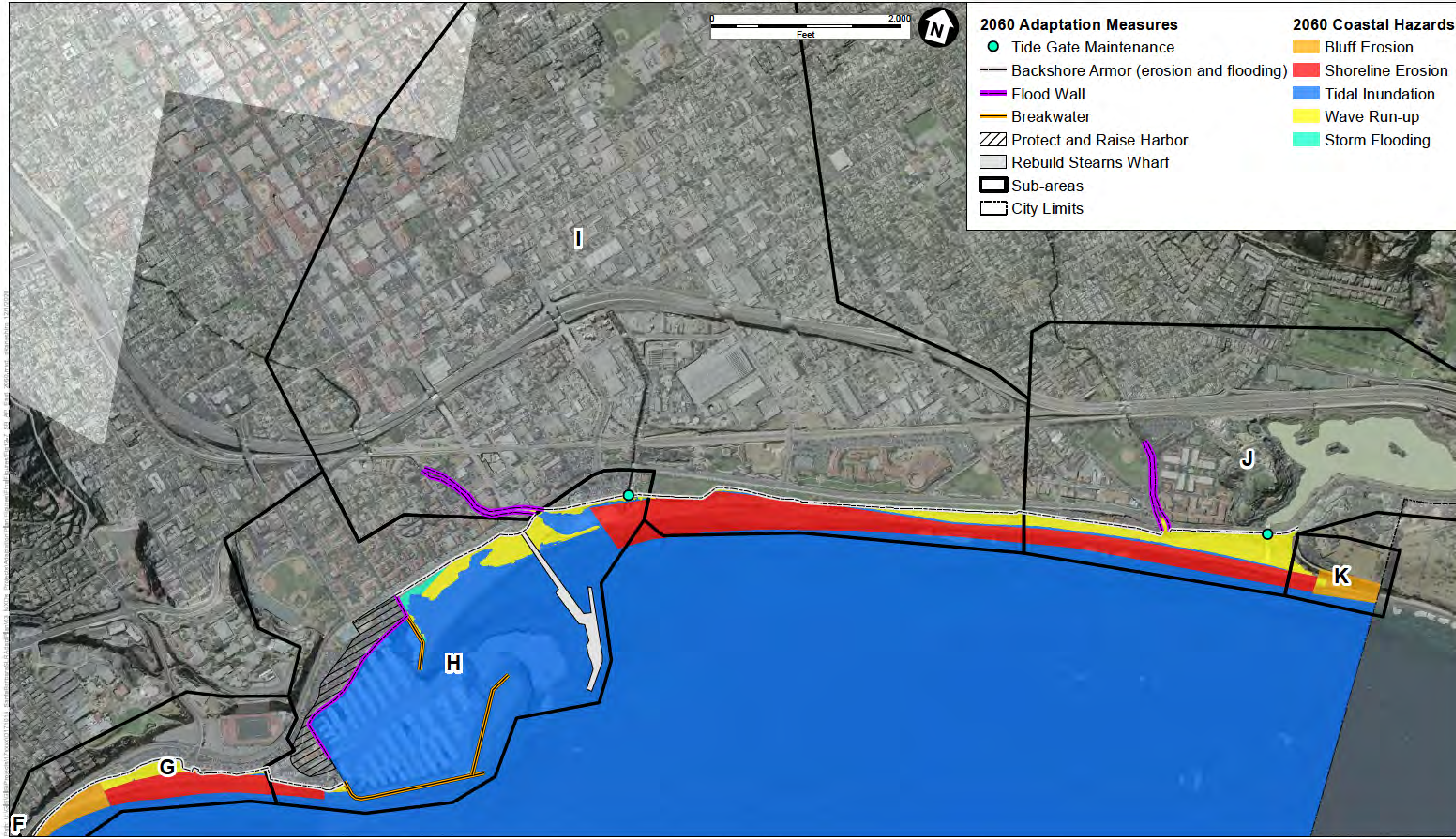


SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-6
East Santa Barbara Adaptation Plan - Existing Conditions

ESA

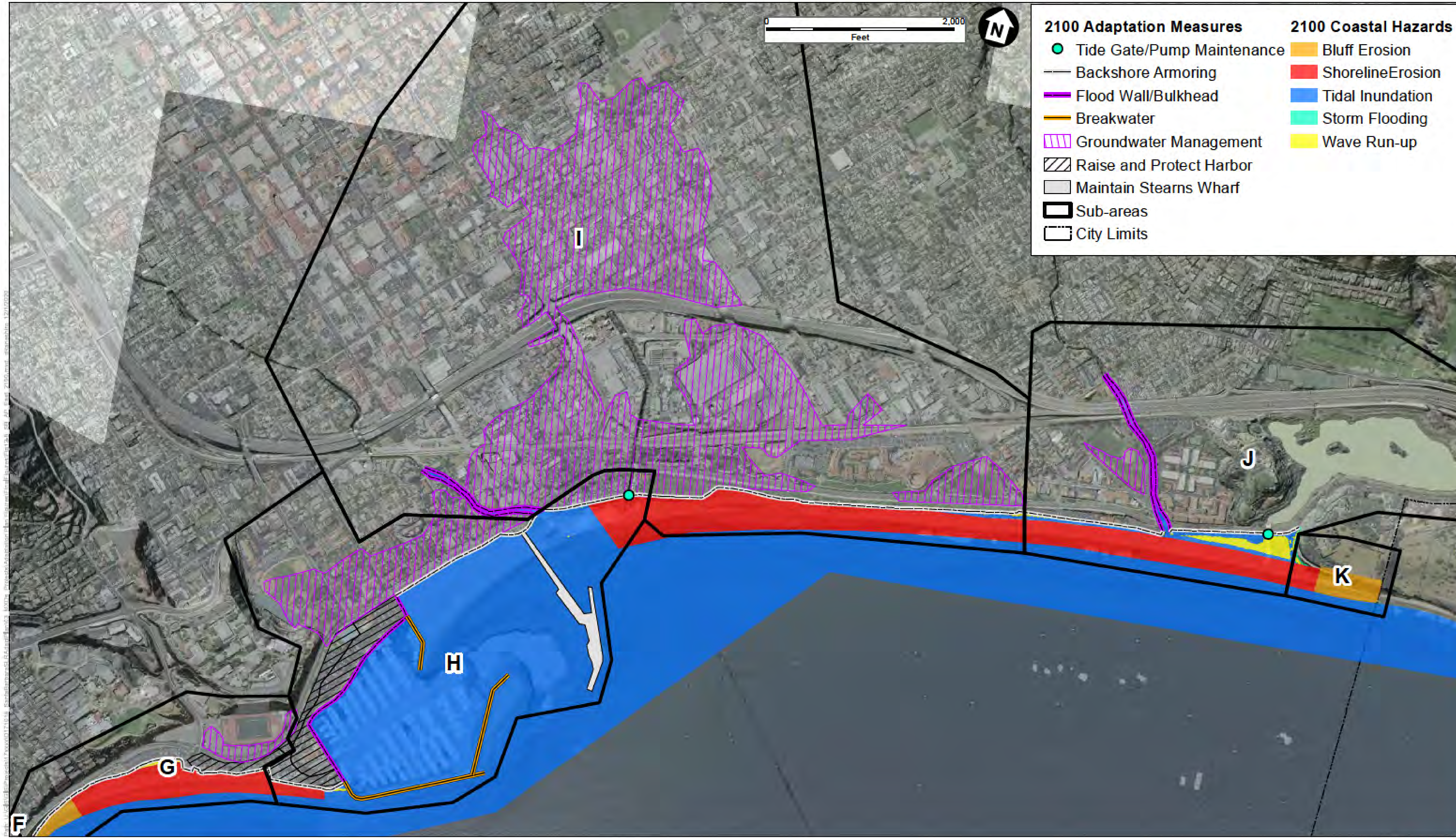


SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-7
East Santa Barbara Adaptation Plan - 2060

ESA



SOURCE: USGS, ESA

Santa Barbara SLR AP and LCPA

Figure 12-8
East Santa Barbara Adaptation Plan - 2100

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Note that the feasibility of maintaining a lowered groundwater table through pumping is outside the scope of this Adaptation Plan and requires further assessment in terms of the required conveyance, storage and treatment, and disposal of groundwater associated with such a management system.

Two citywide adaptation scenarios were created by combining the approaches for the west and east portions of the city. While the two scenarios differ in their approach on the west side of the city, they employ the same approaches for the east side of the city. The protect scenario combines the west city protect scenario and the east city protect scenario. The retreat/protect hybrid scenario combines the west city retreat scenario with the east city protect scenario. Vulnerability reduction and associated economic costs and benefits were evaluated at 2060 (0.8 feet of sea-level rise) and 2100 (6.6 feet of sea-level rise) for both the protect and retreat/protect hybrid scenarios. Sea-level rise hazard vulnerability reduction and adaptation benefit-cost analysis are discussed in the following sections.

12.2 Adaptation Scenario Analysis Methodology

To estimate the total cost of each adaptation scenario over the study period for the purpose of the benefit-cost analysis, the adaptation scenarios were defined through time by assigning schedules for individual adaptation measures (at what year to build/ maintain armor, (re)nourish beach, build floodwall etc.). The schedules were determined based on the projected coastal erosion, coastal storm flooding, and tidal inundation hazard extents examined in the Vulnerability Assessment Update (Appendix A).

12.2.1 Timing of Adaptation Measures

For erosion-specific adaptation measures, a shoreline evolution model was applied to track beach width, shoreline erosion and backshore erosion (where applicable) through time. This approach relied on bluff erosion extents projected by CoSMoS, historic shoreline erosion rates, and the sea-level rise amounts considered for this study. For the east portion of the city, a 20-foot threshold for dry beach width was used to set the schedule for beach nourishment in each relevant. The model output of beach width also enables the valuation of recreational benefits and discussion of ecology. For coastal storm flooding, and inundation-specific adaptation measures, specific sea-level rise thresholds were identified by reviewing the coastal hazard maps used for the study.

Coastal armor structures such as rock revetments and seawalls are subject to degradation over time and require maintenance (USACE 1984). Coastal structures are designed for a particular condition, such as wave height, which may be exceeded due to an occurrence of a more severe coastal storm event. Consequently, it is assumed that the useful life of existing coastal armoring structures in the city are limited, and that:

- Existing coastal armoring structures will be reconstructed at 2030 (0.8 feet of sea-level rise) along with the addition of new structures where applicable.

- Structures will be rebuilt at 2060 (2.5 feet of sea-level rise).
- With higher sea-level rise amounts projected after 2060 we assume these structures will be reconstructed every 20 years to maintain protection against the increasing intensity and frequency of wave loads.

12.2.2 GIS Exposure Analysis of Adaptation Scenarios

The benefit-cost analysis (Appendix B) prepared for this Adaptation Plan is based on geospatial analysis of property, asset, and sea-level rise hazard exposure data. All of the land, structures, and infrastructure analyzed have specific geospatial references, which can be overlaid with the hazard zones to assess impacts from coastal flooding, inundation, and erosion. The benefit-cost analysis employed Santa Barbara Assessor's parcel data and city land use data to identify property boundaries, locations and sizes of the parcels. The geospatial analysis also provides the length and width of beaches, coastal trails, access points, and other pertinent information about coastal recreation.

Following the development of adaptation scenarios and timing for each area, new sets of coastal hazard maps were produced to reflect changes in hazard exposure associated with adaptation strategies described in Tables 12-1 and 12-2. For example, under a protection strategy where backshore armor is built and or maintained to limit bluff erosion, the associated erosion hazard for that area was clipped at the armoring structure. Similarly, if flooding prevention measures were applied for an adaptation strategy, such as raising structures or building floodwalls/levees, the flooding hazard layer for that area was clipped. The resulting adaptation strategy-specific exposure maps were then overlaid with the assets in geographical information systems (GIS) to calculate impacts to property and assets for each alternative. These impacts were then valued using asset replacement costs. These economic values or cost of impacts were then combined with the cost of engineering measures described in Tables 12-1 and 12-2 above to calculate the total cost of each adaptation strategy. The asset exposure counts estimated for each adaptation scenario are provided in Appendix B These exposure counts were used to assess the economic impacts of each alternative as described below.

Figures 12-1 to 12-8 illustrate the revised hazard zones that correspond to the two adaptation alternatives described above.

12.2.3 Valuing Infrastructure and Adaptation Measures

The adaptation scenarios discussed above were used to develop conceptual level engineering cost estimates using the unit costs provided in Table 12-3 below. Replacement costs are provided for similarly-designed infrastructure types in the same location, and were vetted by City staff. Detailed engineering cost schedules for the two adaptation alternatives in each area are provided in Appendix B. Table 12-3 also includes infrastructure replacement costs used to estimate damages where applicable. These costs were compiled from past studies and/or estimated for this project by ESA or provided by the City. The goal of engineering cost estimates is to achieve an understanding of the order of magnitude of costs. These conceptual estimates are not meant to substitute for a detailed engineering cost estimate. The actual costs may be 50% less to 100% greater than the costs developed for this study (AACE 2016), which is consistent with the industry standard practice for this planning level of analysis. Due to the isolated nature of Santa Barbara, the benefit-cost analysis includes an additional 35% construction market location adjustment on all engineering costs estimated for adaptation, except for City-provided estimates for select facilities.

TABLE 12-3
ENGINEERING COST ESTIMATES (BY UNIT) FOR INFRASTRUCTURE REPLACEMENT AND ADAPTATION MEASURES

Adaptation Measure	Cost	Unit	Description
Construction costs			
Elevate Buildings	$ 150	per SF	In Flood Zone
Elevate Buildings	$ 250	per SF	In Wave Zone
Raise Ground	$ 70	per CY	Deliver and compact fill
Groundwater Well	$ 45,000	per unit	Dewatering well and pump
New Pavement	$ 4	per SF	Parking pavement, with 6-inch aggregate base
Rock Revetment	$ 7,576	per LF	Quarry stone
Seawall	$ 18,371	per LF	Reinforced concrete
Breakwater	$ 14,394	per LF	Quarry stone
Bulkhead/Floodwall	$ 5,000	per LF	Floodwall for creeks, bulkhead for Harbor
Beach Nourishment	$ 30	per CY	Imported sand (2030–2060)
Beach Nourishment	$ 50	per CY	Imported sand (2060–2100)
Bluff Face Protection	$ 635	per SF	Tiebacks, coated rebar mesh with gunite
Demolish Building	$ 16	per SF	Demolish buildings
Demolish Parking	$ 1	per SF	Demolish parking lot
Demolish Bluff Wall	$ 350	per LF	Demolish concrete bluff wall and haul nearby
Demolish Revetment	$ 640	per LF	Demolish revetment and haul nearby
Asset replacement costs			
Water	$ 360	per LF	Main (average pipe replacement cost)
Communications	$ 100	per LF	Comcast Conduit replacement estimate
Wastewater	$ 200	per LF	Wastewater Gravity Pipe
Wastewater	$ 450	per LF	Wastewater Force Main
Marina Rebuild	$ 60,000,000	bulk	Rebuild berths in marina, includes gangways, floats, guide piles, and utilities
Transportation	$ 400	per LF	Roads (typical 2-lane road with curbs, including demo)

NOTE: Costs are in 2018 dollars

12.2.4 Assumptions and Considerations

The engineering cost estimates developed for each adaptation scenario do not include all potential costs. Key assumptions are stated below:

- Sand management in Harbor: Beach nourishment specified for the east portion of the city does not include the costs for ongoing management actions (bypassing) in the Harbor that is already occurring.

- Imported sand: Sand sources may become scarce in the future as the demand for sand increases to address erosion issues in other nearby locations. To account for this, we applied increased unit costs for imported sand for years after 2060 as reflected in Table 12-3. The cost and availability of sand for beach nourishment could be better understood with a more detailed feasibility study on beach nourishment in Santa Barbara.

- Bluff protection: Bluff armoring assumed to occur at private parcels is included in this scenario analysis to illustrate potential costs of adaptation for the City and its residents; this does not imply private bluff armoring shall be funded by the City.

- Landslide hazards: Geotechnical stabilization for landslide hazards is not included in the adaptation scenarios. The bluff toe and face armoring structures considered in the adaptation scenarios will not prevent landslides. Additional measures and studies are needed to manage landslides and associated risks to bluff-top assets.

- Groundwater management: The number of groundwater pumps needed to manage a rising water table were estimated assuming a 100-foot spaced grid of wells with pumps. This estimate provides an indication of the magnitude of this issue, but this estimate does not include any associated transmission lines and treatment/storage that will be needed for a comprehensive groundwater management system. It is possible that pumped groundwater water could be discharged into stormwater system at lower volumes; however, additional conveyance pipes and outfalls would be needed to manage higher pumping rates.

- Laguna Creek: The Laguna creek likely may not function as currently designed with 6.6 feet of sea-level rise. It was assumed the existing channel system can be managed as a dewatering sump for the surrounding low areas, but the feasibility and cost need to be further studied. Pump system maintenance and upgrades were estimated as the replacement cost of the tide gate and pump station. The estimated pump station is assumed to be able to adequately convey precipitation runoff into Laguna creek during rainstorms; in the future, a second and/or larger pump station to manage groundwater and stormwater in this area is likely necessary.

- Residential retreat: This hypothetical adaptation scenario assumes that retreated properties are acquired at market value. Under the retreat scenario where bluffs and shorelines are allowed to erode, buildings and infrastructure will require demolition and removal to avoid impacts to public safety and the environment, and property ownership transferal. It is difficult to estimate these costs precisely since the necessary actions can vary from property to property. The transaction costs can include, among other things, appraisals of the property value, prior damages if any, utility shut-off, structure demolition and site clearing, staff time, permits and approvals, and legal consultation. A review of recent hazard mitigation grant applications prepared by the City of Pacifica indicates that a budget allowance of 50% of the appraised property value is appropriate; however, potential transaction costs could be significantly lower or potentially higher.

The demolition costs associated with retreat of buildings were estimated using demolition unit cost in Table 12-3. Other assets such as roads and utilities are valued at their replacement costs reported in Table 12-3. The costs associated with finding a new location for residential development is not included in the benefit-cost analysis.

12.3 Adaptation Benefit-Cost Analysis Results

A benefit-cost analysis was undertaken to quantify and compare the potential economic and fiscal impacts in a no action scenario to the costs and benefits of two adaptation scenarios designed to mitigate future coastal hazard risk (Appendix B). While effort was taken to account for the broad types of impacts that could result under the modeled coastal hazards, limited data, time, and resources made a full cost accounting of each potential impact infeasible in the context of this analysis. More detailed descriptions of the scenarios evaluated, and the analytical approaches used to develop results, can be found in subsequent sections of this report.

Table 12-4 below shows the estimated event-based impacts (i.e., tidal inundation, shoreline and bluff erosion, 100-year coastal storm) for the no action scenario. Table 12-5 reports the estimated event-based impacts *avoided* for the protect scenario, a scenario focused on protecting vulnerable assets by armoring bluffs and building protective flood control devices. Table 12-6 reports the estimated event-based impacts *avoided* for a scenario that combines elements of retreat and protection, referred to as the retreat/protect hybrid scenario. *Avoided* impacts were calculated by subtracting the impacts estimated for the protect and the retreat/protect hybrid scenarios from the impacts estimated for the no action scenario. Results are reported for three distinct time horizons (i.e., 2018, 2060 and 2100) and reflect the impacts that could be expected if the modeled hazards conditions were to occur in the city of Santa Barbara today. In other words, the modeled coastal hazard conditions were superimposed on the existing built environment and economy. As shown in Table 12-4 below, the City's economy faces increasing vulnerability as coastal hazard risks increase in the future.

Event-based impacts for the no action scenario (Table 12-4) were estimated at nearly $31 million for 2018 modeled conditions and $710 million and $1.46 billion for 2060 and 2100 modeled conditions, respectively. Under 2060 modeled conditions, a majority of impacts are associated with vulnerable infrastructure assets (~$403 million) and property (~$207 million). Under the 2100 modeled conditions, estimated impacts to property increase measurably (~$817 million) and account for a majority of the modeled impacts.

TABLE 12-4
SUMMARY OF IMPACTS: NO ACTION SCENARIO (2018 DOLLARS, $MILLIONS)

Summary of Impacts at Each Time Horizon			
Impact Type	**2018 Conditions**	**2060 Conditions**	**2100 Conditions**
Direct Property	$26.6 M	$206.9 M	$816.8 M
Displacement	$1.1 M	$0.7 M	$12.2 M
Business	$2.4 M	$57.6 M	$127.8 M
Infrastructure	$0.0 M	$402.7 M	$444.3 M
Fiscal	$0.7 M	$15.2 M	$24.4 M
Non-Market (Beach Recreation)	NA	$27.0 M	$34.9 M
TOTAL	**$30.8 M**	**$710.2 M**	**$1460.3 M**

NOTES:
Results account for temporary storm impacts as well as permanent tidal inundation and erosion impacts.
Impacts are not adjusted to account for the probability of the modeled hazards occurring.
Results are not adjusted to account for financial discounting.
NA = Impacts not applicable based on methodological framework; NE = Impacts not evaluated based on scope of the analysis.
Due to rounding, results may not add up precisely to the totals presented.

Event-based avoided impacts (or benefits conveyed) for the protect scenario (Table 12-5) were estimated at $662 million and $1.38 billion for 2060 and 2100 modeled conditions, respectively. Under 2060 modeled conditions, a majority of avoided impacts are associated with vulnerable infrastructure assets (~$396 million) and property (~$203 million). For the 2100 modeled conditions, avoided impacts to property increase measurably (~$789 million). The protect scenario provides significant mitigation benefits across all the impact types evaluated except for the non-market recreational value provided by the city's beaches. This scenario includes measures that help to reinforce the bluffs on the northern part of the city, resulting in the narrowing of beaches in the near term, which further limits recreational opportunity and results in nominal adverse non-market recreational impacts under 2060 modeled conditions.

Event-based avoided impacts (or benefits conveyed) for the retreat/protect hybrid scenario (Table 12-6) were estimated at $496 million and $1.16 billion for 2060 and 2100 modeled conditions, respectively. Under 2060 modeled conditions, a majority of avoided impacts are associated with vulnerable infrastructure assets (~$394 million). For the 2100 modeled conditions, avoided impacts to property increase measurably (~$572 million); these benefits are less pronounced than those estimated for the protect scenario because of the allowance of bluff erosion up to 25 feet of major roads. The retreat/protect scenario provides significant mitigation benefits across all the impact types evaluated except for the non-market recreational value provided by the city's beaches, similar to the protect scenario.

TABLE 12-5
SUMMARY OF AVOIDED IMPACTS: PROTECT SCENARIO (2018 DOLLARS, $MILLIONS)

Summary of Impacts at Each Time Horizon			
Impact Type	**2018 Conditions**	**2060 Conditions**	**2100 Conditions**
Direct Property	No Change	$202.5 M	$788.6 M
Displacement	No Change	$0.7 M	$12.2 M
Business	No Change	$48.0 M	$117.4 M
Infrastructure	No Change	$395.5 M	$435.4 M
Fiscal	No Change	$14.9 M	$23.8 M
Non-Market (Beach Recreation)	No Change	-$0.1 M	$5.5 M
TOTAL	**No Change**	**$661.5 M**	**$1382.9 M**

NOTES:
Results account for temporary storm impacts as well as permanent tidal inundation and erosion impacts.
Impacts are not adjusted to account for the probability of the modeled hazards occurring.
No change in impacts is observed for the 2018 modeled conditions because adaptation measures are not implemented until after this point in time.
Results are not adjusted to account for financial discounting.
Due to rounding, results may not add up precisely to the totals presented.

TABLE 12-6
SUMMARY OF AVOIDED IMPACTS: RETREAT/PROTECT HYBRID SCENARIO
(2018 DOLLARS, $MILLIONS)

Summary of Impacts at Each Time Horizon			
Impact Type	**2018 Conditions**	**2060 Conditions**	**2100 Conditions**
Direct Property	No Change	$38.9 M	$572.1 M
Displacement	No Change	$0.7 M	$12.2 M
Business	No Change	$48.3 M	$117.3 M
Infrastructure	No Change	$393.8 M	$431.7 M
Fiscal	No Change	$13.0 M	$21.5 M
Non-Market (Beach Recreation)	No Change	$0.9 M	$5.5 M
TOTAL	**No Change**	**$495.6 M**	**$1160.2 M**

NOTES:
Results account for temporary storm impacts as well as permanent tidal inundation and erosion impacts.
Impacts are not adjusted to account for the probability of the modeled hazards occurring.
No change in impacts is observed for the 2018 modeled conditions because adaptation measures are not implemented until after this point in time.
Results are not adjusted to account for financial discounting.
Due to rounding, results may not add up precisely to the totals presented.

Tables 12-4 through 12-6 above, as noted, illustrate the expected impacts if no action is taken to mitigate coastal hazards as well as the expected benefits conveyed by adaptation for the discrete time horizon years evaluated (i.e., 2018, 2060, 2100). However, it is important to acknowledge that the adaptation measures evaluated start to provide benefits once they are implemented, and that these benefits recur year after year into the future, provided that appropriate operations, maintenance, and renewal actions are taken. To capture the cumulative benefits provided by investments in adaptation, impacts for the no action scenario were estimated for each year in this study's period of analysis (i.e., 2018 – 2100). These values were then adjusted to account for the likelihood of the modeled hazard occurring[14] and summed to develop an estimate of cumulative impacts. A similar process was undertaken to estimate the impacts expected under the Protect scenario and the retreat/protect hybrid scenario, the results of which are then subtracted from the no action scenario to develop an estimate of the cumulative impacts avoided as a result of investment in adaptation.

The results of the cumulative impact analysis are presented in Table 12-7. For the no action scenario, total impacts are estimated at $4.1 billion, with over half of these impacts associated with changes in business activity. These business losses are primarily associated with buildings in the Harbor and other low-lying areas of the waterfront that are subject to tidal inundation by 2060 and were assumed to close permanently, resulting in annual, recurring losses. The next most significant impact estimated was for property (~$624 million). Estimated fiscal impacts were also significant (~$620 million) and are linked to property and sales tax revenues associated with residences and businesses exposed to the modeled hazards.

Approximately $3.6 billion and $3.4 billion in impacts were estimated to be avoided through implementation of the protect and retreat/protect hybrid scenarios, respectively. This is equivalent to the protect scenario preventing nearly 90% of the impacts that were estimated to occur under the no action scenario, while the retreat/protect hybrid scenario was estimated at mitigating over 80% of the impacts estimated for the no action scenario. A majority of the difference in avoided impacts between the protect scenario and the retreat/protect hybrid scenario are associated with property and associated fiscal impacts. In particular, the retreat/protect hybrid scenario allows for bluff erosion, which would result in the removal of vulnerable property overtime. When this occurs, the value of these properties would be lost and they would be removed from the County Assessor's tax roll, resulting in the City no longer securing annual property tax revenues for these impacted parcels. Neither the protect scenario nor the retreat/protect hybrid scenario were determined to be effective at mitigating non-market impacts associated with the city's beach recreational resources.

[14] Consider, for example, a 100-year storm event, which has 1% chance of occurring in any given year. If the estimated impacts are $100,000, then this value is multiplied by 0.01 (1% chance), resulting in an expected annual impact of $1,000.

TABLE 12-7
SUMMARY OF CUMULATIVE IMPACTS AND AVOIDED IMPACTS (2018 DOLLARS, $MILLIONS)

Summary of Cumulative Impacts and Impacts Avoided from 2018 to 2100			
Impact Type	**No Action Scenario Impacts**	**Protect Scenario Avoided Impacts**	**Retreat/Protect Hybrid Scenario Avoided Impacts**
Direct Property	$623.8 M	$592.4 M	$375.9 M
Displacement	$1.9 M	$1.7 M	$1.7 M
Business	$2143.8 M	$2010.2 M	$2006.7 M
Infrastructure	$444.3 M	$435.4 M	$431.7 M
Fiscal	$619.5 M	$615.6 M	$535.7 M
Non-Market (Beach Recreation)	$289.1 M	-$13.2 M	$0.4 M
TOTAL	**$4122.3 M**	**$3642.2 M**	**$3352.2 M**

NOTES:

Results account for temporary storm impacts as well as permanent tidal inundation and erosion impacts.

Impacts are adjusted to account for the probability of the modeled storm occurring.

Non-market beach recreation avoided impacts are negative for the Protect scenario because of the armoring of bluffs which will accelerate shoreline erosion and reduce recreational opportunities for both residents and tourists.

Results are not adjusted to account for financial discounting.

Due to rounding, results may not add up precisely to the totals presented.

The estimated costs to implement the protect and Retreat/protect Hybrid scenarios are presented in Table 12-8 below. Costs were estimated by decade, starting in 2020 and ending in 2100. The costs reported account for the initial investments required for the construction of identified adaptation measures, as well as ongoing maintenance and renewal costs intended to ensure that initial investments can continue to provide effective coastal hazard mitigation benefits. The total protect scenario costs were estimated at approximately $8.4 billion, while the Retreat/protect hybrid costs were estimated at roughly $2.4 billion. The significantly higher price tag for the protect scenario is closely tied to constructing and maintaining bluff faces in the city to prevent erosion.

Standard practice in a benefit-cost analysis is to account for the “opportunity cost” or the time value of money. This is done by applying a discount rate to estimated benefits and costs of an identified policy, program, or project, which then allows for the comparison of future costs and benefits in present dollars. From a financial perspective, discounting is used to reflect that a dollar today is more valuable than a dollar in the future due to the ability to invest now and create more wealth than a dollar invested in a future year. Or, extended to a social perspective as it relates to this study, the benefits provided by adaptation are more valuable in the near-term than they are in the longer-term.

TABLE 12-8
SUMMARY OF CUMULATIVE ADAPTATION COSTS (2018 DOLLARS, $MILLIONS)

Adaptation Scenario Implementation Costs by Decade		
Year	**Protect Scenario**	**Retreat/Protect Hybrid Scenario**
2020	$0.0 M	$1.1 M
2030	$2089.9 M	$81.7 M
2040	$7.5 M	$7.5 M
2050	$10.7 M	$10.7 M
2060	$2789.5 M	$934.9 M
2070	$34.3 M	$34.3 M
2080	$492.0 M	$359.4 M
2090	$2086.3 M	$93.5 M
2100	$860.9 M	$831.5 M
TOTAL	**$8371.2 M**	**$2354.7 M**

NOTES:
A 35% construction mark-up contingency is included in the cost estimates.
Results are not adjusted to account for financial discounting.
Due to rounding, results may not add up precisely to the totals presented.

For the purpose of estimating the cost-effectiveness of the modeled adaptation strategies, the cumulative costs of the modeled adaptation strategies and their estimated cumulative avoided impacts were discounted in future years at a 4% rate, consistent with federal agency benefit-cost analysis guidelines. The discounted avoided damages associated with the modeled adaptation scenarios were subtracted from the discounted adaptation scenario costs to arrive at an estimate of net (present value) impacts. Benefit-cost ratios (BCRs) were then estimated by dividing the cumulative avoided damages provided by adaptation to the cumulative costs of adaptation.

As Table 12-9 shows, the protect scenario has an estimated net present value impact of -$1.7 billion and a BCR of 0.18, while the retreat/protect hybrid scenario was estimated to provide a net impact of $29 million and have a BCR of 1.1. From an economic perspective, a project would be considered justified or cost effective if it has a BCR that is greater 1. As such, only the retreat/protect hybrid scenario would be considered an economically justified project.

TABLE 12-9
SUMMARY OF BENEFIT-COST ANALYSIS RESULTS (NET PRESENT VALUE, $MILLIONS)

Summary of Adaptation Alternatives Net Impacts and Benefit Cost Ratios		
Adaptation Scenario	**Net Impacts**	**Benefit Cost Ratio**
Protect	**-$1,700 M**	**0.18**
Retreat/Protect Hybrid	**$29 M**	**1.10**

NOTES:
To avoid double counting impacts, wage losses have not been included as they are assumed to be paid from sales revenues, and business output has been discounted to account for relevant tax payments that are captured in the fiscal impact models.
Results are presented in net present value terms using a 4% discount rate over the period of the analysis from 2018 to 2100.

It is important to note that the assessment of net impacts and BCRs for the modeled adaptation scenarios account for a number of near-term and longer-term projects across the city. This portfolio approach to assessing the costs and benefits of adaptation provides a high-level perspective of the economic returns on investment in adaptation. However, future analysis should be conducted on a project-by-project basis to better design and optimize the benefits that can result from investment in adaptation. Further, it is important to acknowledge that a majority of the cumulative impacts estimated for the no action scenario are associated with risks posed by tidal inundation and erosion. This does not imply that the City does not face risks from coastal storms now and in the future, but that future efforts should be taken to evaluate ways to keep rising seas at bay. And, as noted above, both the protect scenario and the retreat/protect hybrid scenario prove highly effective at mitigating future coastal hazard impacts to property, business, and infrastructure. However, these adaptation scenarios, as modeled, are not effective at preserving the city's beaches, which provide significant economic benefits to users and the local economy. As such, the City could evaluate additional detail management practices that can help to maintain the city's beaches and the broader benefits they convey to residents, visitors, businesses, and the City.

12.4 MANAGED RETREAT DISCUSSION

This Adaptation Plan includes managed retreat as an adaptation strategy. This Adaptation Plan allows the flexibility to select managed retreat as an adaptation strategy in the future as the effects of sea-level rise reach certain thresholds based on City policy decisions and project-specific adaptation planning. The scenarios analyzed above include an analysis of a partial retreat strategy. A full managed retreat scenario was not analyzed, but is discussed below.

Note that the impacts associated with the no action scenario developed for the Vulnerability Assessment Update (Appendix A) represent only a portion of the costs associated with managed retreat. In general, the no action scenario is not a complete scenario because management actions would be taken by the City and property owners to respond to the migrating shore and flooding impacts as they occur, whether actions are proactive (asset removal/relocation before impacts occur) or reactive (asset cleanup after impacts occur).

The following engineering and management actions would be needed in addition to the no action scenario:

- Infrastructure decommission/removal/realignment (roads, utilities) – Roads and utility lines would require removal or realignment along the coast as needed to avoid erosion and flooding impacts. Depending on the land use of landward adjacent properties, realignment could require easements or land acquisition to maintain public assets, such as a frontage road with utilities. Utilities that are damaged or proactively decommissioned require deconstruction and disposal of materials, whether or not the utility is relocated.
- Property deconstruction and cleanup (bluff top or low-lying) – Managed retreat of built assets requires cleanup and disposal of materials on the property. Actions include site demolition and disposal/cleanup, utility disconnection and removal of later connections, and remediation depending on use (e.g., gas stations). Relocation possibilities depend on available land (area and zoning).
- Removal of existing coastal armoring structures (part of infrastructure decommissioning and/or property deconstruction discussed above) – Existing armoring structures should be removed as part of any property retreat to restore and maintain beach area along the retreated shoreline.
- Restoration of low-lying flood prone areas (e.g., Arroyo Burro, downtown) – Flood risk in the downtown area could be incrementally reduced by restoring floodplain area to accommodate flood flows from the watershed and provide marsh habitat with greater amounts of sea-level rise.
- Harbor/Pier removal – Managed retreat of the Harbor and Stearns Wharf would include the removal of all associated buildings, utilities, parking lots, coastal armoring, and bulkheads, etc.

As identified above, there are several types of costs that would be estimated to provide an accurate accounting of the financial commitments that could be required to support managed retreat. Many of these costs can be estimated with standard cost-engineering (e.g., decommissioning, deconstruction) and real estate (e.g., land acquisition) accounting principles and methods. However, other cost implications are more uncertain.

If managed retreat policies are implemented on private property, agreements would likely be necessary to address when vulnerable property is removed and potential opportunities for relocation. If relocation is a feasible alternative, it would be important to account for the substitution of use at another location and the associated economic and fiscal implications. For example, if a private residence is moved inland, there could be a loss in property value (and associated tax revenues) if the new location is not adjacent to amenities of similar value to those provided by coastal real estate. Alternatively, if a business is relocated to a site that will not result in similar consumer demand, there could be a change in revenue earned (and associated tax revenues). Additionally, implementing managed retreat policies could affect the market value of property as well as the appetite of potential buyers. There are also potential insurance implications from managed retreat related to cost and access to coverage. Some managed retreat policies, such as the removal of coastal armoring, which could help maintain a beach area, could result in increased recreational use opportunities and associated economic benefits. The financial implications of managed retreat will depend on the specifics of the agreements that are developed as well as local economic conditions. These agreements will need to address, in some form, the burden of payment for specific actions and how funds will be raised, while accounting for equity and the ability to pay. They will also need to address potential legal issues related to takings, eminent domain, and condemnation where applicable. Fundamentally, changes in regulatory policy will result in economic and fiscal impacts that should be considered systematically.

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Section 13

IMPLEMENTATION TOOLS

This section describes the tools, programs and policies, and potential funding sources that can help the City take action and implement the adaptation strategies identified in this Adaptation Plan.

13.1 City Tools to Facilitate Implementation

The City can choose from a variety of existing policy, regulatory, and procedural tools to facilitate the implementation of the adaptation strategies identified in this Adaptation Plan. Amendments to plans and programs can help to establish a policy and regulatory framework for implementation and improve the City's ability to seek funding from state and federal agencies. Possible implementation tools could include:

1. **General Plan** – The goals, objectives, policies, and implementation measures that relate to sea-level rise in the General Plan, particularly the Safety Element, could be reviewed for consistency with this Adaptation Plan and revised as appropriate.
2. **Local Coastal Program (LCP) –** The City will be reviewing the LCP and amending policies and regulations as needed to incorporate adaptations strategies from this Adaptation Plan.
3. **Hazard Mitigation Plan –** The vulnerabilities and mitigation measures that relate to sea-level rise in the Hazard Mitigation Plan could be reviewed for consistency with this Adaptation Plan. The City should consider incorporating new mitigation measures as part of the next update to the Hazard Mitigation Plan to facilitate federal funding for adaptation projects.
4. **Capital Improvement Program –** For adaptation strategies that require capital expenditures, the capital improvement program is an appropriate place to address priorities, funding, and scheduling of implementing adaptation strategies.
5. **Administrative policies, procedures, and initiatives –** The City could amend or create administrative policies, procedures, and initiatives that would direct City staff efforts toward implementation of certain adaptation planning actions, such as:
    a. Establishing a process and responsibility for monitoring the trajectory toward planning-level adaptation threshold criteria (identified in Section 3.2).
    b. Participating in regional coordination efforts.
    c. Engaging state and federal agencies and the state legislature in planning, funding, and assistance with adaptation.

d. Facilitating public education, outreach, and assistance efforts.

e. Tracking current information on sea-level rise, adaptation measures, legal context, and planning by other jurisdictions.

f. Ensuring consistency in approach and methodologies for addressing sea-level rise citywide.

g. Preparing and regularly updating a short-term action plan internal to the City which details key steps to take over the next 2 to 5 years. The action plan could be directly linked to annual City budgets, updates to the capital improvement plan, and daily work. Parameters could include: strategy type; process or implementation mechanism; implementation steps; responsible agency/department/staff; partners; priority level; cost estimate; potential funding source; and timeline to implementation.

13.2 Implementation Programs and Policies

The following are programs, policies, and standards that would serve to implement the adaptation strategies identified in this Adaptation Plan.

13.2.1 Local, Regional, State, and Federal Coordination

There are several key agencies and stakeholders that the City should coordinate with as it moves forward with adaptation planning. These include:

- Flood Emergency Management Agency – The City should continue to communicate and coordinate with FEMA regarding updates to Flood Insurance Rate Maps, funding opportunities, and any available technical guidance and resources for hazard planning.
- U.S. Army Corps of Engineers – The City should continue to coordinate with the USACE to facilitate the ongoing dredging of the federal navigational channel in the Harbor. The City could also explore and purse partnerships with the USACE in reconnaissance and feasibility studies for new projects related to navigation, coastal flood hazard reduction, and/or habitat restoration that would serve as adaptation strategies. The USACE partners with local jurisdictions in joint local-federally sponsored projects and can provide federal funding for implementation for projects that are shown to have a federal interest based on feasibility studies and CBRs following USACE guidelines.
- California Department of Transportation – Although coastal-storm-related flooding of Highway 101 is not anticipated until after 2.5 feet of sea-level rise in the vicinity of the city boundaries, the City can begin discussions with the California Department of Transportation to discuss feasible adaptation strategies.
- California Ocean Protection Council (OPC), Governor’s Office of Planning and Research (OPR), California Coastal Commission, California State Lands Commission, Coastal Conservancy, and other state agencies – In an effort to stay ahead of major changes, the City should coordinate with OPC and OPR as they seek to update the best available science on sea-level rise projections and adaptation approaches for California. The City should continue to coordinate with the CCC on updates to the LCP and permitting issues related to sea-level rise.

- California State Legislature and the Governor's Office – The City should coordinate and engage with the California State Legislature's office, the Governor's office, and local representatives on local needs, funding, and legislative changes related to adaptation. The City could also include issues related to sea-level rise adaptation on its legislative platform regularly updated by the City Council. The City could also work with the League of Cities and other similar entities toward common legislative needs associated with sea-level rise adaptation.
- Regional and State Climate Collaboratives – The City could consider participating in regional and state climate collaboratives to share best practices and information with other local and regional agencies.
- BEACON – As a member agency of BEACON, the City should participate in the update to the 2009 *Santa Barbara Coastal Regional Sediment Management Plan*, which will account for sea-level rise. The City should also consider participating in the Regional Opportunistic Sediment Placement Program once it is launched. BEACON already conducts regular beach monitoring and the City could work with BEACON to expand and continue monitoring as needed.
- Santa Barbara Association of Governments – The City should continue participation with the Santa Barbara Association of Governments on studies regarding the effects of sea-level rise on the transportation network and other topics of common interest.
- Bren School of Environmental Science and Management of University of California, Santa Barbara – The City could partner with the Bren School of Environmental Science and Management to receive assistance with monitoring various parameters (as outlined in Section 3.2 above). For example, the City could receive assistance with conducting beach surveys to track changes in beach width.
- Neighboring Jurisdictions – The City could stay in regular communication with neighboring jurisdictions to share best practices and information on adaptation planning, to jointly conduct needed monitoring, and to coordinate on issues that cross jurisdictional boundaries (e.g., sand nourishment).
- Union Pacific Railroad – Although coastal storm-related flooding of the Union Pacific Railroad is not anticipated until after 2.5 feet of sea-level rise within the city boundaries, the City can begin discussions with Union Pacific Railroad to discuss feasible adaptation strategies.
- Utilities – Electric, gas, cable, telephone, and other utility companies contain assets within the sea-level rise hazard boundaries that would also be affected by adaptation options. The City should coordinate with these utilities to discuss feasible adaptation strategies.
- Local Community Groups – Local community and interest groups play key roles in implementation of adaptation. The City could establish mechanisms for regular updates and input from these groups including neighborhood associations, the board of realtors, the Downtown Organization, Citizens Planning Association, environmental groups, etc.

13.2.2 Education and Outreach Programs

Engaging and communicating with the community on an ongoing basis is essential to ensuring that adaptation strategies can be successfully and efficiently implemented. Public engagement offers the opportunity to educate and build commitment and consensus among decision-makers and community members. The following are outreach materials and programs the City could implement:

1. Alert community members of the hazards expected as a result of sea-level rise by distributing information regarding hazards through a variety of communication tools (e.g., social media, City website, emails to City list servs, presentations to community groups and other stakeholders, pop-up booths at community events).
2. Develop and distribute technical information and guidance on home and business retrofitting options, which could include elevation, wet/dry floodproofing, flood gates, drainage improvements, etc.
3. Establish a citizens advisory group or stakeholder group that meets regularly to discuss issues related to adapting to sea-level rise.
4. Continue to pursue funding and partnerships to formalize a sea-level rise public education program.

13.2.3 Subarea Plans

The City could facilitate the development of subarea plans for adapting to coastal hazards in conjunction with community members and asset managers for smaller-scale planning centered around vulnerable assets of community-wide importance. The development of such plans would require the following steps:

- Identify subarea boundaries for prioritization, possibly based on timing, area of impact, costs, equity, environment, economy, etc.
- Develop planning timeframes around the point at which flooding or erosion create significant problems.
- Evaluate adaptation alternatives with cost estimates in more detail, which may include armoring, elevation, realignment, etc.

13.2.4 Overlay Zones

An overlay zone is a land use planning tool that establishes additional regulations and incentives over an existing base zone. Special provisions, identified as part of the overlay zone, would supersede those provisions of the base zone, where applicable, to promote orderly planned development and to provide protection of the public's health, safety, and general welfare. An overlay zone could provide a singular reference for coastal hazard and sea-level rise land use regulations. For example, studies, disclosures, or development standards could be required for properties located within the overlay zone. The process for designating overlay zones could include the development of coastal flood and erosion maps that include areas that will be subject to tidal inundation, wave action, coastal storm flooding, and erosion due to sea-level rise. The maps would need to be regularly updated to reflect best available science on sea-level rise projections and associated hazard areas.

13.2.5 Downzoning

This strategy refers to changing the existing zoning of land to a zoning district that is less intense than its previous zone. More often, this measure is taken to limit sprawl in unincorporated areas or to limit over-intensification of cities; however, it could be used to limit redevelopment and development in hazardous areas in order to lessen the amount of damage incurred due to a flood event.

13.2.6 Setbacks for Development

A commonly used tool for guiding development farther away from coastal hazards are setbacks. Setbacks ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea-level-rise-induced erosion) over the life of the structure, without the use of a shoreline protective device. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway. Setback standards can be prescriptive by defining a specific distance that development must be placed, or they can be defined based on site-specific analyses that determine the appropriate size of the setback based on established criteria.

The City's Coastal Land Use Plan currently makes use of setback standards for properties in low-lying beach and backshore areas and bluff-top properties (City of Santa Barbara 2018). It requires new development and substantial redevelopment of properties in the low-lying beach and backshore areas to be located outside of areas subject to beach erosion and wave impacts over the expected life of the development factoring in the effects of sea-level rise to the extent feasible. New development and substantial redevelopment of properties located in bluff-top areas must be located outside a coastal bluff edge development buffer. The buffer must be of sufficient size to ensure that the proposed development would not be threatened by erosion or slope instability over the life of the development factoring in the effects of sea-level rise.

13.2.7 Flood Hazard Standards

Applicable building codes could be revised to enable structures to withstand higher water levels within areas susceptible to sea-level rise hazards. Standards could require:

- Additional setbacks
- Increased base flood elevations
- Limited first-floor habitable space
- Floodable or waterproofed best management practice standards
- Elevating electrical or mechanical equipment above flood elevations
- Limiting or prohibiting basement additions

As described in Section 7.3.4, elevating structures would help to limit damage from coastal flooding. Standards for new development and redevelopment could require structures to account for additional freeboard elevation to accommodate anticipated levels of sea-level rise. This requirement would be in addition to the existing requirement that structures be raised above the base flood elevation as established on FEMA National Flood Insurance Program Maps. Abandoning the lowest floor or elevating the lowest habitable floor are also effective in reducing damage to the buildings.

Floodable standards involve adapting a home to allow floodwaters to enter and exit without causing major damage to the home or its contents. Floodable, or wet floodproofing, measures include flood openings, elevating building utilities, floodproofing building utilities, or the use of flood-damage-resistant materials. Waterproofing, or dry floodproofing, measures involve sealing the structure to prevent floodwaters from entering. Barrier measures can be built around a structure to contain or control flood waters, including floodwalls or levees with or without gates (FEMA 2019).

13.2.8 Hazard Mitigation Grant Program Acquisition Project

This grant program is administered by FEMA and is associated with funds in the Hazard Mitigation Grant Program (described below). Local governments can use funds from this program to purchase properties based on the principle of fair compensation for property from a willing, voluntary seller that has a structure that may or may not have been damaged or destroyed as a result of a hazard event. The structure can be demolished or relocated to an area outside of a hazard-prone area. The purchased property must be restricted to open space, recreational, or wetlands management uses in perpetuity (FEMA 2015a; 2015b).

13.2.9 Fee Simple Acquisition and Purchase with Lease Back Option Programs

A fee simple acquisition program is the purchase of vacant or developed land in order to prevent or remove property from the danger of coastal hazards, such as erosion. As an erosion avoidance measure, for example, this technique would transfer the erosion risks from the current property owner to the group or entity willing to acquire the property. Typically, a fee simple acquisition is done to remove the property from being developed and prevent the construction of buildings or other capital improvements that would eventually be in danger from erosion. It could be used for purchasing developed properties at-risk from sea-level-rise-related hazards that would require the demolition and removal of existing structures and improvements, and restoration of the site to support natural physical processes. Restoring habitat and providing improved public access could be additional actions that are taken. Fee simple acquisition of coastal properties can, in some cases, be prohibitively expensive.

However, one hybrid approach could involve the creation of a public acquisition program in which an entity purchases the property and leases or rents back the land to the previous landowner until the property becomes uninhabitable. This hybrid may enable public investment to recover some of the initial purchase cost. The program could target areas that could be eroded or inundated by tides within a few decades. The private landowners who are willing to sell early would receive market-rate returns on their real estate investment. Ideally, a 30-year mortgage would be paid in full prior to the property experiencing severe sea-level rise and/or coastal storm events.

13.2.10 Conservation Easements

A conservation easement is a legally enforceable agreement attached to the property deed between a landowner and a government agency or a non-profit organization that restricts development in certain areas. The allowable activities and uses within the conservation easement could be restricted so as to allow flooding and erosion processes to occur.

The cost of conservation easements depends on willingness of seller, costs associated with maintenance and monitoring of easements, as well as the implementing mechanism. In general, someone has to file, hold, and enforce a conservation easement on the parcel to ensure that future land use planning bodies do not decide to allow development in the conservation easement. Either local government or a third party (e.g., a non-governmental organization, or NGO) could hold the easement. Filing/management/enforcement of the easement can have costs. There may not be a public cost to acquire the easement if the easement is included as a condition to a coastal development permit for some related development activity. There may be administrative cost to filing, managing the holding of, and enforcing the easement, depending on whether the local government or a third party (e.g., an NGO) holds the easement. Also, there could be lost property tax revenue and altered property values (ESA 2015).

13.2.11 Rolling Easements

Another strategy recommended in the *California Coastal Commission Sea-Level Rise Policy Guidance* to facilitate nature-based sea-level rise adaptation is rolling easements. Rolling easements are open space or conservation easements that move or ambulate with some identified reference feature, such as the mean high water line for coastal properties. As the coast retreats, the easement line migrates along with it, inland on a parcel, then any development is removed and becomes part of that easement. This approach ensures maintenance of beach width and protection of the natural shoreline by allowing the shoreline to retreat gradually. Implementation of this strategy could be through a permit condition that restricts the use of shoreline protective structures, limits new development, and encourages the removal of structures that are seaward (or become seaward over time) of a designated boundary. Rolling easements could be implemented by statute or by specifying that a conservation easement “roll” or move landward as the shore erodes. Like all easements, rolling easements would require some regular inspection and potential enforcement that requires removal of existing structures. Although recommended as an adaptation strategy by the CCC in the *California Coastal Commission Sea-Level Rise Policy Guidance*, rolling easements have legal and logistical constraints that have prevented their use in the state. Depending on the lot configuration and the rate of coastal retreat, at some point in time, the easement could deprive a property owner of all economically beneficial use of the property (e.g., such as a single-family home), which has the potential to be considered a regulatory taking.

13.2.12 Transfer of Development Rights

Transfer of Development Rights (TDR) programs allow the transfer of the development rights from one parcel to another parcel. These programs are tools to direct development away from certain sensitive areas and into areas that can better accommodate it. Through TDRs, development rights could be transferred from undeveloped or underdeveloped sensitive or hazardous parcels to areas suitable for development. TDR programs are widespread throughout the country and vary based on local land use planning priorities and needs. While the design specifics are left to the discretion of a local government, in general a TDR program identifies source sites (from which development rights are taken away) and receiver sites (to which a development right is added). The owner of a source site can sell a TDR to the owner of a receiver site. The seller typically retains ownership of the “sending” property, but relinquishes the right to develop or redevelop it, while the buyer is able to intensify development on the receiver site more than would otherwise be permitted under existing zoning. Source or sending sites may be sensitive land areas, such as areas prone to coastal hazards. Owners of source sites receive monetary compensation from the sale of the TDR and in the form of potentially lower property taxes, while owners of receiver sites have assurance of future development rights on their site.

13.2.13 Hazard Disclosures

The purpose of hazard disclosures is so that city customers, applicants, landowners, renters, lease holders, and potential future buyers of property understand the potential future hazards associated with a property, the restraints there may be in developing the property in the future, and how public services may change in the future. The City could include hazard disclosures and risk indemnifications as conditions of approval for permits, on parcel information documents and databases, or when providing services to properties. The state currently mandates a variety of disclosures during real estate transactions, including geologic and existing flood hazard risks as mapped by FEMA. The current state-mandated real estate disclosures do not include disclosures of hazards related to sea-level rise. This is an issue the City could potentially add to its legislative platform and work with the State to change.

13.3 Funding Sources and Mechanisms

Adaptation planning is a challenging undertaking, and substantial funding could be needed to design, permit, implement, and maintain adaptation strategies through the long-term. There are state and federal grant programs currently available to support adaptation planning. Additional funding programs are likely to emerge in coming years as more and more communities face the impacts of sea-level rise. Over time, communities should develop a layered funding strategy that includes local investments and leverages those monies with grants, loans, and private sector investments. This section identifies some of the grant funding opportunities available as well as some local funding strategies. The list below is not comprehensive, but highlights some key funding sources currently available to local communities.

13.3.1 State and Federal Funding Sources

FEMA Hazard Mitigation Assistance

FEMA administers three programs that provide assistance to local governments (as well as state and tribal governments) for reducing the risk of loss of life and property from future disasters (FEMA 2019).

1. The Hazard Mitigation Grant Program assists in implementing long-term hazard mitigation planning and projects following a Presidential Major Disaster declaration. Typical mitigation projects funded through the Hazard Mitigation Grant Program include:
   - Acquisition and structure demolition/relocation
   - Preparation of hazard mitigation plans
   - Mitigating flood conditions, such as through floodplain and stream restoration or “green” infrastructure methods
   - Elevating homes or structural retrofitting existing buildings
2. The Pre-Disaster Mitigation Program provides funds for hazard mitigation planning and projects on an annual basis, including the development and implementation of hazard mitigation plans. The goal is to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on federal funding in future disasters. This program awards planning and project grants and provides opportunities for raising public awareness about reducing future losses before disaster strikes. Grants are funded annually by congressional appropriations and are awarded on a nationally competitive basis.
3. The Flood Mitigation Assistance Program provides funds for planning and projects to reduce or eliminate risk of flood damage to buildings that are insured under the National Flood Insurance Program (NFIP) on an annual basis. Generally, local communities will sponsor applications on behalf of homeowners and then submit the applications to the State. Funding is appropriated by Congress annually. Currently, the NFIP focuses on existing flood hazards depicted on Flood Insurance Rate Maps. These maps do not factor in future changes in flooding that could result from sea-level rise. However, many of the FEMA Flood Insurance Rate Maps delineate flood hazard areas that overlap with the areas potentially impacted in the future from sea-level rise.

U.S. Army Corps of Engineers – Feasibility Studies and Water Resource Projects

The USACE partners with local jurisdictions to conduct feasibility studies for infrastructure projects that affect harbors, navigation, and water resources. The City could pursue this avenue of funding for adaptation planning, particularly at the Harbor, where USACE already conducts a dredging program.

National Oceanic Atmospheric Administration – Coastal Resilience Grants

This highly competitive grant program funds projects that are helping coastal communities and ecosystems prepare for and recover from extreme weather events, climate hazards, and changing ocean conditions.

California Department of Fish and Wildlife – 2019 Proposition 1 & Proposition 68 Grant Opportunities

Proposition 1 (Water Quality, Supply, and Infrastructure Improvement Act of 2014) and Proposition 68 (California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018) are new funding opportunities available through CDFW to support multi-benefit ecosystem restoration and protection projects. Proposition 1 funds ecosystems and watershed protection and restoration, and water supply infrastructure projects and are distributed via grant programs by multiple state and regional agencies. Proposition 68 funds environmental protection and restoration projects, water infrastructure projects, and flood protection projects. Projects eligible for funding under these grants include: planning activities that lead to specific on-the-ground implementation projects, funds for implementation activities (e.g., construction and monitoring) of restoration and enhancement projects, and funds for acquisition or purchases of interests in land or water.

California Department of Transportation Adaptation Planning Grant Program

The Road Repair and Accountability Act of 2017 established a transportation funding bill that provides a reliable source of funds to maintain and integrate the State's multimodal transportation system (California Department of Transportation, Division of Transportation Planning 2018). A portion of the funds was allocated to an adaptation planning grant program that is intended to advance adaptation planning on California's transportation infrastructure, including roads, railways, bikeways, trails, bridges, ports, and airports. The overarching goal of this grant program is to support planning actions at local and regional levels that advance climate change adaptation efforts on the transportation system, especially efforts that serve the communities most vulnerable to climate change impacts. Example adaptation planning grant project types include:

- Climate vulnerability assessments
- Extreme-weather event evacuation planning
- Resilience planning
- Transportation infrastructure adaptation plans
- Natural and green infrastructure planning
- Integration of transportation adaptation planning considerations into existing plans, such as a climate mitigation or adaptation plan, LCP, Local Hazard Mitigation Plan, General Plan (including meeting Senate Bill 379 requirements), or other related planning efforts

- Evaluation of or planning for other adaptation strategies
- Developing educational resources, trainings and workshops for local jurisdictions and transportation service providers on any of the above-listed adaptation planning activities

California Coastal Commission and California Coastal Conservancy – Local Coastal Program Local Assistant Grant Program and Climate Ready Grants

The LCP Local Assistance Grant Program provides funds to support local governments in completing or updating their local coastal programs consistent with the California Coastal Act, with special emphasis on planning for sea-level rise and climate change. The Climate Ready Grant Program generally funds planning and implementation of managed retreat, natural shoreline infrastructure, living shorelines, and habitat enhancement projects.

13.3.2 Potential Funding Mechanisms

Assessment and Abatement Districts

The purpose of an assessment or abatement district is to establish a mechanism by which a City or County can finance the prevention, mitigation, abatement, or control of some type of pest, nuisance, or hazard. For the purposes of hazards related to beach and bluff front property, Coastal Hazard Assessment Districts (CHADs) and Geologic Hazard and Abatement Districts (GHADs) can be established to implement adaptation strategies described above. CHADs provide a funding reserve for future maintenance, expansion, and rehabilitation of flood and/or erosion control structures. Often financed through the collection of supplemental tax assessments, CHAD revenues are relatively safe with the option to borrow from lenders or issue bonds with attractive credit terms. The establishment of a CHAD or GHAD would allow for the better assessment of hazards, as well as increase funding for maintenance, repairs, or other similar improvements. This would result in greater a funding reserve and often improved maintenance or repair services.

Infrastructure Financing Districts

Enhanced infrastructure financing districts allow for incremental property tax revenues to be devoted to a specific purpose. In 2014, the passage of Assembly Bill 313 and Senate Bill 628 both: (1) further defined enhanced infrastructure financing districts to include, brownfield restoration and other environmental mitigation; transit priority projects; and projects to implement a sustainable communities' strategy; and (2) streamlined the requirements for the establishment of these districts. Once an infrastructure financing district is established and priority projects have been identified as part of the business plan, funds can be drawn from changes in local tax revenues occurring as part of a redevelopment or rezone, or can be used to apply for grant funds.

Establishment of a Shoreline Account

A "Shoreline Account" could be established to serve as the primary account where funds generated for future adaptation programs would be kept in reserve. Funds, subject to the restrictions of any terms of the funding sources, may be used to pay for adaptation-related projects identified in this Adaptation Plan, including repair and maintenance costs, and to pay for conducting surveys and monitoring programs.

Development Impact Mitigation Fees or In-Lieu Fees

Impact mitigation fees or in-lieu fees can generate funds for implementing adaptation strategies. Fees could be established to generate revenues for covering the cost to plan for and implement adaptation strategies. The City could consider establishing structured fees similar to the sand mitigation fee that the CCC currently administers. The sand mitigation fee mitigates for the loss of sand supply and loss of recreational beaches in front of shoreline protective structures. Solana Beach developed a public recreation fee, certified by the CCC and approved by the Solana Beach City Council, which addresses the loss of public recreation based on the loss of beach area physically occupied by a coastal structure.[15] The CCC has administered fees for habitat damages, including impacts to hard-substrate marine habitat (rocky reefs), aquatic vegetation (eelgrass, kelp, etc.), and soft-bottom habitats in bays and harbors, and permanent loss of open water foraging opportunities, or altered water circulation. The CCC uses an equation for calculating a mitigation fee based on the area (square footage) of affected habitat and the fee is typically directed toward the removal of marine debris or lost fishing gear from similar habitats.

The City could consider establishing similar fee programs based on the methodologies used by the CCC. Funds from these fees could be used to implement projects that provide sand to the city beaches, public recreation/access projects that direct recreation and/or access benefit to the general public, and habitat restoration projects.

Bonds

Bonds allow municipalities and other entities to borrow money from investors, which is then repaid to the investor over an established period at a certain rate. Often, interest earned on government-issued bonds is tax exempt, and they are a common mechanism for financing public infrastructure and government programs. Green bonds are a new market that has emerged to specifically fund green adaptation infrastructure.

Service Charges and Fees

The City currently administers utility rates, which are fees for utility services charged to users who pay for City-provided water, sewer, and other utility services. Utility rates cover some or all of the cost of providing the service, which may include operations, maintenance, overhead, capital improvements, and debt service. The City could increase utility rates to cover the costs associated with adaptively managing the City's water and wastewater infrastructure (e.g., manholes, pipelines).

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15 The Solana Beach public recreation fee is now subject to a lawsuit, which was filed in January 2019 (The Coast News Group, 2019).

Taxes

The City may impose a special tax with two-thirds majority voter approval to fund adaptation strategies. The taxing agency must publish an annual report including: (1) the tax rate, (2) the amounts of revenues collected and expended, and (3) the status of any project funded by the special tax (Institute for Local Government 2016).

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Section 14

SUMMARY OF POTENTIAL NEAR-TERM ACTIONS

The following are recommended potential near-term (0–0.8 feet of sea-level rise; approximately 10 years) actions to address the hazards associated with sea-level rise. Actions that are important to initiate in the next five years are preliminary designated below as “high priority in the next five years.” Actions that are of the highest priority to initiate in the first few years of implementation are bolded. In addition to the near-term actions listed below, all projects proposed near the potential hazard areas outlined in the Adaption Plan should be developed with consideration for how they affect or may be impacted by the phased sea-level rise adaptation approach presented in this plan.

The immediate next step that the City should take is the development of a Five-Year Implementation Plan that prioritizes and further refines these actions and identifies potential costs, funding options, timelines, resources needed, and responsible staff for each action. Implementation of adaptation actions will require continuous tracking to measure effectiveness. Changing conditions, changes in best available science, new technologies, new funding sources, and changes in community priorities will necessitate regular reevaluation of appropriate adaptation strategies and, potentially, identification of new strategies. The Five-Year Implementation Plan should be regularly updated as projects are scoped and undertaken and in response to finding from the proposed Shoreline Monitoring Program. Reevaluation of the overall Adaptation Plan is then recommended to occur approximately every five to ten years in response to substantive new information such as major updates to the State of California Sea-Level Rise Guidance sea-level rise projections. As the City’s develops further it’s Adaptation Program emphasis should be placed on public transparency and outreach.

During implementation, specific near-term actions recommended in this Adaptation plan would be further scoped and developed by the city department with the expertise needed for the project and the normal City approval process associated with each particular action would be undertaken. There is a need, however, for a central staff team to coordinate the Adaptation Program, including leading studies, developing the Shoreline Monitoring Program, developing the five-year implementation plan, tracking progress, tracking funding, sharing relevant information, and conducting public education and outreach.

Citywide Actions	
High Priority for Next Five Years	• Develop and regularly update a Five-Year Implementation Plan that further refines and prioritizes actions and identifies potential costs, funding options, timelines, resources needed, and responsible staff for each action. • Reevaluate the Adaptation Plan approximately every five to ten years and amend the plan based on changed conditions, changes in best available science, new technologies, new funding sources, and changes in community priorities. • **Develop and implement a Shoreline Monitoring Program in coordination with other regional, state, and federal agencies. The program should include: monitoring of sea-level-rise-related hazards; identification of action thresholds; and regular reassessment of the need for implementation actions. The program should emphasize public understanding and transparency. All data should be available for public use and the results readily available.** ***(Highest Priority)*** • Amend or create City administrative policies, procedures, initiatives, and staffing to implement the Adaptation Plan and ensure consistency in approach for addressing sea-level rise citywide. • Track grant programs and vigorously pursue other funding sources for implementation. • **Amend the City's Hazard Mitigation Plan to include potential adaptation actions so that the City is eligible for federal funding for adaptation projects.** ***(Highest Priority)*** • Initiate amendments to update the City's Local Coastal Program, , General Plan, Climate Action Plan, and the Municipal Code to implement Adaptation Plan policies and to incorporate adaptation to sea-level rise into hazard maps and development standards. • Incorporate adaptation actions into the City's Capital Improvement Program. • Engage with the California State Legislature's office, the Governor's office, and California State Legislature Representatives on local needs, funding, and legislative changes related to sea-level rise adaptation. • Coordinate with regional, state, and federal agencies on monitoring, joint studies, and implementation of adaptation strategies. • Participate in regional and statewide climate collaboratives. • Maintain a working group composed of key City departmental staff involved in adaptation planning for the City. • Maintain a Sea-Level Rise Subcommittee comprised of members of City council and relevant City advisory bodies and commissions to guide adaptation planning for the City. • Engage with the community and stakeholders during Adaptation Plan and Local Coastal Program updates and implementation of adaptation projects. • Identify funding sources to assist property owners with adaptation. • Continue and expand public education on sea-level rise and adaptation. • Where appropriate, include hazard disclosures and risk indemnifications in conditions of approval for permits and other City documents such as parcel information documents and databases, leases, or service contracts to properties in hazard areas. • Consider amending the City's legislative platform and working with the State to include information about the hazards related to sea-level rise in real estate disclosures. • Research and monitor case studies, laws, and court cases that may affect implementation of the Adaptation Plan. • Further study the socioeconomic impacts of sea-level rise and potential adaptation options.

Coastal Bluff Areas (see Section 6)	
	• For new development and substantial redevelopment, continue the current regulatory practice of requiring bluff setbacks that factor in accelerated bluff erosion rates from • Continue the current regulatory practice of limiting the construction of shoreline protection devices where feasible, except when necessary to protect essential public
Additional Actions	• Expand best management practices to reduce the rate of bluff erosion as a result of runoff and irrigation. • Plan for removal, relocation, or, as needed, protection of public assets and natural resources in Shoreline Park and Douglas Family Preserve. • Plan for repairs or replacement of public access beach stairways as needed. • Plan for protection of Shoreline Drive at select locations when erosion levels trigger action. • Further study safe bluff setbacks and trigger distances, which will be used to inform the City on when adaptation measures are needed. • Further study whether slope protection measures along the upper bluff face (gunite, soldier piles, etc.) would be needed in addition to shoreline protection at the base of bluffs to protect major public roads and bluff-top access areas in the mid- and long-term.

Low Lying Waterfront and Beach Areas (see Section 7)	
High Priority for Next Five Years	• Monitor rising sea-levels, beach erosion, and flooding events (see Shoreline Monitoring Program above). • **Study and implement options to optimize existing sand bypassing and beach berm construction programs at East Beach and Leadbetter Beach. Monitor amounts of bypassed sand regionally. *(Highest Priority)*** • **Study and implement additional beach nourishment, additional seasonal sand protective berms, or formation of dunes at East Beach, Leadbetter Beach, and Arroyo Burro Beach. *(Highest Priority)*** • Work with the Beach Erosion Authority for Clean Oceans and Nourishment to update the 2009 Coastal Regional Sediment Management Plan to factor in changes associated with sea-level rise. • Continue current regulatory practice of limiting uses in the low-lying waterfront and beach areas and requiring that new development and substantial redevelopment be designed to avoid or mitigate hazards associated with sea-level rise.
Additional Actions	• As needed, consider options such as shoreline protection, floodproofing, and removal or relocation of select public facilities as they are redeveloped or become threatened. • Further study specific beach width thresholds for initiating consideration and planning for large-scale adaptation options along the waterfront and beach area.

Low Lying Flood Areas (see Section 8)	
High Priority for Next Five Years	• Monitor rising groundwater levels and flooding events (see Shoreline Monitoring Program above). • **Redesign and reconstruct the Laguna tide gate and pump system. (Highest Priority)** • Study extreme rainfall runoff and creek discharge flooding in Laguna Channel with climate change and sea-level rise. • Consider changes to the City's floodplain ordinance in flooding areas impacted by sea-level rise. In particular, consideration should be given to requiring additional floodproofing of new development and substantial redevelopment in the areas south of Highway 101 that could, as a result of sea-level rise through the long-term (6.6 feet of sea-level rise), experience tidal inundation and storm flooding levels that are deeper and more extensive than those currently mapped on FEMA Flood Insurance Rate Maps. • Develop incentives for floodproofing and raising existing structures in areas at risk of increased flooding (e.g. potential permit streamlining or relief from design, zoning, or height requirements).
Additional actions	• Study changes in flooding as a result of: (1) riverine flood events interacting with higher sea levels and (2) changes in rainfall and riverine flooding due to climate change. Develop monitoring and adaptation thresholds for creek flooding. • Evaluate whether existing creek and estuary development setbacks and other development regulations near creeks (e.g. bridge designs) are adequate based on impacts of sea-level rise and changes in riverine flooding from climate change. • Study existing groundwater elevations, the freeboard from typical levels up to a flood threshold, and potential impacts of sea-level rise. Study the potential of raised groundwater levels to spread contamination in soils and groundwater. Study the feasibility of groundwater pumping to lower the water table. • Further study feasibility of creek floodwalls, tide gates, continuous seawall, levees, or other identified measures to prevent inundation and storm flooding. Incorporate habitat considerations into designs to the extent feasible.

Harbor (see Section 9)	
High Priority for Next Five Years	• Monitor Harbor dredging, rising sea-levels, beach erosion, and flooding events (see Shoreline Monitoring Program above). • **Raise or modify the Harbor breakwater, rock groin, sandspit, and the walkway and wall spanning from the breakwater to the Harbor commercial area. Pursue Army Corps of Engineers feasibility studies, funding, and assistance with these projects. *(Highest Priority)*** • **Renovate marina facilities and the City Pier in phases. All marinas piles need to be raised by the time 1 foot of sea-level rise occurs. The City Pier needs to be modified and/or raised by the time 0.5–1.0 foot of sea-level rise occurs. *(Highest Priority)*** • Continue use of beach berms and consider additional beach or dune nourishment south of the Harbor commercial area. • Continue the current regulatory practice of limiting uses in the Harbor and requiring that new development and substantial redevelopment be designed to avoid or mitigate the impacts associated with sea-level rise.
Additional Actions	• As needed, consider raising existing seawalls, adding new shoreline protection, floodproofing development, and removing or relocating structures as they are either redeveloped or become threatened. • At 0.5 foot of sea-level rise, start planning for the protection of the Harbor commercial area and parking lots. This could start with raising the walkway or raising/adding walls around the Harbor and along the beachfront. In the mid-term, options to study could include raising Harbor grades and elevating and floodproofing structures.

Stearns Wharf (see Section 9)	
Five Years	• **Study appropriate triggers for temporarily closing Stearns Wharf during major**
Additional Actions	• At 0.5–1.0 foot of sea-level rise, prepare alternatives analysis considering raising, relocating, redesigning, or removing the Wharf. Study should also assess thresholds for initiating actions on Stearns Wharf based on acceptable levels of risk.

Major Infrastructure (see Section 10)	
High Priority for Next Five Years	• Monitor utility system and transportation system interruptions, rising sea-levels, beach erosion, and flooding events (see Shoreline Monitoring Program above). • **Study options for relocation and/or flood proofing of major wastewater, water, and utility lines and infrastructure south of Cabrillo Boulevard. *(Highest Priority)*** • Initiate a comprehensive study of adaptation options for threatened portions of the wastewater system, including redesign of portions of the system, adaptation options for El Estero Water Resource Center, and possible service point improvements.
Additional Actions	• Study the potential impacts to the stormwater system from sea-level rise and possible adaptation options. • Study the potential impacts to the water system from sea-level rise and possible adaptation options. • Coordinate with electrical and natural gas utility providers to further assess potential impacts and adaptation options for the energy transmission and distribution systems.

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