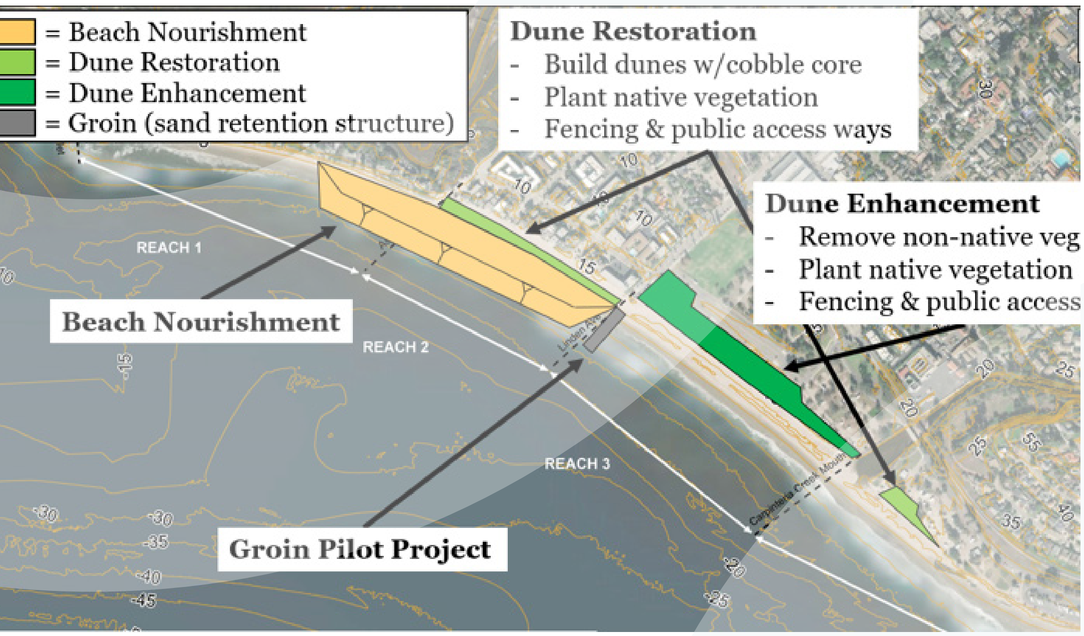
Final

City of Carpinteria Dune and Shoreline Management Plan

February 2022



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Acronyms and Abbreviations

ADA	Americans with Disabilities Act
AMP	Adaptive Management Plan
BEACON	Beach Erosion Authority for Clean Oceans and Nourishment
BRIC	Building Resilient Infrastructure and Communities
Cal OES	California Governor's Office of Emergency Services
Caltrans	California Department of Transportation
CCC	California Coastal Commission
CEQA	California Environmental Quality Act
City	City of Carpinteria
cm	centimeter
County	County of Santa Barbara
CREF	Coastal Resource Enhancement Fund
CSLC	California State Lands Commission
cy	cubic yard
EA	Environmental Assessment
EIR	Environmental Impact Report
EMHW	Extreme Monthly High Water
Enhancement Plan	Carpinteria Salt Marsh Enhancement Plan
ESHA	Environmentally Sensitive Habitat Area
FEMA	Federal Emergency Management Agency
Flood Control District	County Flood Control and Water Conservation District
ft	feet
GHAD	Geologic Hazard and Abatement District
GPS	Global Positioning System
H:V	Horizontal:Vertical
Harbor	Santa Barbara Harbor
IBank	California Infrastructure and Economic Development Bank
MARINe	Multi-agency Rocky Intertidal Network
MLLW	Mean Lower Low Water
NAVD 88	North American Vertical Datum 1988
NEPA	National Environmental Protection Act
NOAA	National Oceanic and Atmospheric Administration
OPC	Ocean Protection Council
Project	Dune and Shoreline Management Plan
SANDAG	San Diego Association of Governments
SLRVAAP	Sea Level Rise Vulnerability Assessment and Adaptation Plan
State	State of California
State Parks	California Department of Parks and Recreation
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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Executive Summary

The City of Carpinteria (City) is proposing to construct and maintain a "living shoreline" of vegetated sand dunes, perform major beach nourishment (i.e., sand importation), and install a sand retention structure to slow beach erosion and protect the Beach Neighborhood from wave attack and coastal flooding projected to occur with sea level rise (Project). The Project would also include targeted dune improvements in Carpinteria State Beach to protect those facilities. The Project would be constructed as early as 2025 and maintained in place through 2050 or 2070 through periodic beach nourishment and dune repair until projected sea level rise may render continued maintenance infeasible. The Project would cost an estimated $12 million or more to construct with annual maintenance costs of up to $250,000 per year. The City would seek funding for construction and maintenance from state and federal sources, as well as local revenues. While expensive, the Project would reduce or delay projected significant and extremely costly damage to the Beach Neighborhood and Downtown through 2050 or 2070, after which additional measures would need to be explored and implemented.

Key Elements of a Living Shoreline Project

1. Protect City's Beach Neighborhood from sea level rise through 2050-2070.
2. Construct and maintain roughly 1,500 feet of vegetated sand dunes fronting the City's Beach Neighborhood.
3. Import 500,000 cubic yards of sand to widen the City's beach.
4. Construct sheet pile wall groin at Linden Ave. to retain sand/ maintain Beach width.
5. Periodically maintain beach and dunes with imported sand nourishment.
6. Seek State and federal funds to defray costs.

The City is projected to experience increased coastal flooding and storm wave attack due to sea level rise, impacting the City's Beach Neighborhood, Downtown, Carpinteria State Beach, and other areas. This shoreline has experienced a reduction of beach and dune systems over time and a loss of natural sediment supply. This proposed Dune and Shoreline Management Plan or living shoreline was funded by the California Department of Transportation (Caltrans) through the Sustainable Transportation Planning – Adaptation Planning Grant to study potential shoreline management strategies to protect coastal transportation infrastructure and landward development through actions identified by coastal hazard modeling. The Project builds upon City efforts to plan for and adapt to projected sea level rise, including the Sea Level Rise Vulnerability Assessment and Adaptation Project (SLRVAAP) and pending updates to the City's General Plan/Local Coastal Plan. Key Project goals and components include the following:

- Reduce the vulnerability of the Beach Neighborhood and Downtown, particularly for disadvantaged communities and the City's central businesses, to projected sea level rise generated hazards, such as tidal inundation, flooding, wave attack, and coastal erosion;

- Identify the preferred Project design for a living shoreline based on site constraints, engineering feasibility, and long-term sustainability through at least 2050 and set forth other alternatives that were considered;
- Protect transportation infrastructure, including the California Coastal Trail, the main Amtrak-railroad line, Carpinteria Rail Station, and local City streets, which are projected to become vulnerable to flooding with up to two feet of sea level rise.
- Restore historic dune habitats that formerly lined the Carpinteria City Beach and restore and enhance existing dunes within the Carpinteria State Beach using nature-based solutions to protect landward neighborhoods, infrastructure, and Carpinteria State Beach campgrounds.
- Identify required future permits and environmental review for future Project implementation;
- Assess short-term (implementation) and long-term (maintenance and monitoring) costs for the Project;
- Identify available federal, state, and local funding sources; and
- Provide co-benefits to public health, public access, coastal habitats, and ecosystems.

This study identifies potential impacts to transportation and other infrastructure, landward development, and vulnerable populations within the City resulting from projected coastal hazards and flooding associated with sea level rise. The Dune and Shoreline Management Plan identifies a preferred design for a living shoreline that would improve the City's resilience to coastal hazards over the next 30 to 50 years (through 2050 or 2070), reduce threats to critical infrastructure, and restore historic dune habitats. This plan also presents preliminary information regarding required permits, environmental review, funding, and future study for the Project. Guidance from the California Coastal Act and California Coastal Commission (CCC) requires agencies to acknowledge and address sea level rise, avoid significant coastal hazards risks, and design adaptation strategies according to local conditions and existing development patterns.

This Dune and Shoreline Management Plan includes the following:

- The **Introduction** section summarizes the purpose of the Project and provides a description of the study area, relevant background information, and coastal processes affecting the City.
- The **Overview of Existing Shoreline Management Policies, Regulations, and Programs** section presents a summary of key programs, policies, and regulations most relevant to the project, including those from the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON) and the California Coastal Act. This section also discusses the City's pending update to its Coastal Land Use Plan/General Plan, including a new Coastal Resiliency Element.

- The **Project Constraints and Feasibility** section outlines natural and man-made constraints, offers design options, and evaluates the feasibility of a living shoreline, including constructability, resilience, affordability, permitting requirements, and acceptance by the public.
- The **Living Shoreline Design Alternatives and Modeling** section includes an analysis of several living shoreline alternatives that were developed based on a preliminary design and presents the results of the numerical modeling effort used to evaluate the best option, including a beach and nourishment plan. Based on modeling, the preferred living shoreline design alternative is presented, along with preliminary dune and beach design details, potential sediment sources, a sand retention plan, and construction details.
- The **Living Shoreline Adaptive Management Plan** section explains the permitting, maintenance, monitoring, and interagency coordination that may be required to manage the living shoreline.
- The **Funding and Costs** section outlines the costs of construction and implementation of the living shoreline and maintenance and provides an overview of ways to fund the project.

The discussion and analysis presented in these sections of the plan lead to the following conclusions:

- **Existing Coastal Threats.** Development of neighborhoods such as Sandyland Cove and coastal portions of the Beach Neighborhood, as well as a reduction in the natural sediment supply due to stream channelization and sediment debris basins, construction of the Santa Barbara Harbor, and coastal armoring, has led to a reduction and loss of naturally occurring beach and dune systems. Declines in natural sand supplies as a result of this development contributes to the narrowing of beaches in and near the City, resulting in increased exposure to coastal hazards and requiring the City to implement measures to reduce impact to shoreline development, such as the implementation of the City's winter sand berm program. However, in recent years, it has proven difficult to find and transport beach-quality sediments from debris basins or other sources to eroding beaches as a means of improving coastal resiliency.
- **Future Coastal Threats.** According to the City's SLRVAAP, by 2030 with ~1ft of sea level rise, beach and dune erosion could result in coastal floods extending further landward than existing conditions. By 2060 with ~2ft of sea level rise, increases in coastal erosion and flooding are projected to impact homes, condominiums, and infrastructure between Ash Avenue and Linden Avenue, with coastal flooding encroaching into the City's Beach Neighborhood and perhaps north of the Union Pacific Railroad (UPRR). At 2100 with ~5ft of sea level rise, routine monthly high tides could extend across significant portions of the Beach Neighborhood, inundating homes and roads.

- **Constraints.** The existing beach has several biological constraints, including protected/important species and environmentally sensitive habitat areas. The area is also restrained by topography, as almost half the beach is too narrow to support a dune system. Man-made constraints such as issues with land ownership, transportation infrastructure, public access and views, utility lines, and coastal structures limit the potential location of the dune system.
- **Proposed Project.** The City should pursue further planning and design of a living shoreline project fronting the Beach Neighborhood and a small portion of Carpinteria State Beach, including 1) beach nourishment to widen the shore, to buffer landward development, and create more space for coastal dynamics (accommodation space), 2) the establishment of vegetated dunes fronting existing beachfront homes and 3) installation of a temporary or experimental sand retention structure to retain sand, increase the life span of the nourished beach, and reduce maintenance costs. The preferred design would involve the placement of 500,000 cubic yards (cy) of imported sand (beach nourishment). The dunes would be constructed in the same location where the City's winter sand berm program is currently constructed annually, as well as at an approximately 350-foot-long segment of beach within Carpinteria State Beach. Under the Project, Carpinteria City Beach would be nourished with sand to widen the beach area to a width of approximately 170 feet with a gentle slope, similar to existing conditions. Sediments could be brought in from offshore, from Carpinteria Salt Marsh desilting, foothill ~~detention~~ debris basins, and certain construction projects.
- **Maintenance.** The most important aspect of maintenance of the living shoreline will be maintaining a wide sandy beach through beach re-nourishment activities. Maintenance of the living shoreline would require some added beach re-nourishment roughly every 10 years, or when the beach fronting the dunes narrows to less than 50 feet in width. Dune restoration would be needed if wave overtopping occurs at the dune crest, if the dune toe is exposed, or if a dune section is lost, though maintaining a wide sandy beach fronting the dunes will reduce the likelihood of such events. Periodically, the dunes would need to be revegetated to reestablish vegetative cover and the sheet pile groin may need to be repaired or adjusted, particularly if downcoast erosion is noted.
- **Monitoring.** Monitoring of the beach and dunes will also be a critical aspect of the Project. Monitoring will include observations of pre- and post-implementation site conditions to assess the post-nourishment equilibrium beach, installation and performance of the sheet pile wall groin, possible effects on downcoast beaches, and native dune plant installation, as well as other restoration components (e.g., sand fencing). Monitoring will also inform adaptive management actions, particularly the resiliency of the nourished beach, downcoast sand conditions in response to the sheet pile wall groin, and the longevity and durability of the nourished beach. Setting appropriate performance criteria for beach

nourishment and restoration projects, and assuring those criteria are met, helps assure that the shoreline protection criteria and ecological benefits of the project are realized.

- **Permitting.** The living shoreline and beach nourishment would require several federal, state, and regional/local permits. In addition to permitting requirements, living shoreline projects would also have to meet requirements of the California Environmental Quality Act (CEQA), and possibly the National Environmental Policy Act (NEPA) if federal permits are required. Partnering with the County of Santa Barbara Flood Control and Water Conservation District (Flood Control District) and/or BEACON ~~would~~ could enhance the ability of the City to acquire the necessary permits, and longer-term permits should be sought to better facilitate the Project, particularly maintenance and beach re-nourishment activities, and reduce costs and future permit burdens.
- **Costs.** Project costs would include planning and project initiation (e.g., planning, environmental review, permitting) and construction. Implementation of the Project has the potential to incur a total cost ranging from $9,00,000 to $12,000,000 or more. Though costly, the alternative of repeated damage to high-value residential properties and public infrastructure and required repeated clean-up, repairs, and expensive adaptation measures would likely dwarf the cost of Project implementation.
- **Funding.** Project funding would require the pursuit of a combination of federal and state grants, as well as the implementation of local and regional funding measures. Various actions could be taken by the City independently, or in collaboration with State and regional agencies such as the California Department of Parks and Recreation (State Parks) and the County of Santa Barbara (County), without grant monies to fund shoreline management. However, such measures are unlikely to provide sufficient funding for Project construction but may be able to offset maintenance costs and potentially help partially fund initial construction. Grant programs for living shoreline monitoring include federal grants such as those offered by the National Coastal Resilience Fund and the Federal Emergency Management Agency (FEMA), State grants such as those offered by the California Coastal Conservancy and Division of Boating and Waterways, and local grants such as those offered by the Santa Barbara County Coastal Resource Enhancement Fund (CREF). The City also has options to generate funding through the implementation of local measures, such as through expansion of City Assessment District No. 5, the establishment of a new Geologic Hazard Abatement District (GHAD), or a dedicated increase in Transit Occupancy Tax.

A Draft of the Dune and Shoreline Management Plan was published by the City and made available for public review on Monday, January 10th, 2022. Between Monday, January 10th, 2022 and Monday, January 31st, 2022, the City welcomed public and interested agency comments on the Draft Dune and Shoreline Management Plan. This Final Dune and Shoreline Management Plan has been revised based on comments provided by the public and interested agencies. Copies of all letters received, as well as written responses to discrete comments, is provided in Appendix F.

Introduction

> **Living Shoreline**- a shoreline management feature that utilizes natural materials and harnesses the resilience of live vegetation, sand dune creation, beach nourishment and harder natural materials (e.g., beach cobbles) to restore and/or protect a natural shoreline and landward development and infrastructure.

This Dune and Shoreline Management Plan includes the conceptual design and preliminary engineering feasibility analysis for the development of a living shoreline (Project) to address sea level rise impacts in vulnerable areas within the City of Carpinteria (City) and potentially Carpinteria State Beach. Project design would reduce the severity of projected increases in coastal flooding and storm wave attack associated with sea level rise in the City's Beach Neighborhood, Downtown, and Carpinteria State Beach. The Project includes proposed shoreline management actions, namely development of a vegetated dune complex (i.e., living shoreline) with a reinforced interior (e.g., beach cobbles) along the Carpinteria City Beach and Carpinteria State Beach shorelines to protect landward development, infrastructure, and resources while enhancing habitat value and maintaining public beach access, and public and private views. The proposed dune system will be designed to buffer the shoreline from storm wave attack and future sea level rise. The Project area extends from the Carpinteria Salt Marsh inlet to the southeast along the beach and shoreline area to the west end of Tar Pits Park. However, the proposed living shoreline development will likely be limited to Carpinteria City Beach and Carpinteria State Beach.

Carpinteria City Beach provides wide sandy beach use for sunbathers, recreational activities, and safe swimming access to local, regional, and national visitors. Tourism-related travel to the City is highly dependent on long-term coastal access and recreational opportunities.

The Project is driven by guiding principles of the California Coastal Act and California Coastal Commission (CCC) sea level rise policy guidance. This guidance requires agencies to acknowledge and address sea level rise, avoid significant coastal hazards risks, and design adaptation strategies according to local conditions and existing development patterns (Ocean Protection Council [OPC] 2018). The Project is also a community-driven strategy for building resiliency to sea level rise, which was first identified in the City's 2019 Sea Level Rise Vulnerability Assessment and Adaptation Project (SLRVAAP) and was subject to the review by the public and City decision-makers. The Project will provide the planning of an integrated climate adaptation approach using a combination of man-made and nature-based infrastructure solutions to adapt the existing sandy shoreline to increase coastal resiliency. The Project was created in coordination with the California Department of Transportation (Caltrans) through the Sustainable Transportation Planning - Adaptation Planning Grant program to study potential shoreline management strategies and designs to protect coastal transportation infrastructure and landward development through actions identified by coastal hazard modeling. The Project builds upon ongoing efforts by the City to plan for and adapt to coastal erosion and projected rates of sea level rise, including the SLRVAAP. This study identifies potential impacts to transportation and other infrastructure, landward development, and vulnerable populations within the City resulting from projected coastal hazards and flooding associated with sea level rise.

Beaches are broadly recognized and highly valued as cultural and economic resources and provide a major source of recreation for coastal residents and visitors to coastal regions (Dugan 2015). Within the City, the beach plays an important role in its identity as a small beach town, a major source of recreation, and a key part of the City's economy through the generation of sales tax revenues from visitors to the beach and the Carpinteria State Beach campgrounds. The Carpinteria State Beach campgrounds provide one of the largest sources of lower-cost, overnight, visitor-serving accommodations within southern Santa Barbara County, a key element in allowing lower and moderate-income families to access the coast. Demand for the campsites is high, with campsites that are semi-regularly reserved up to 6 months in advance and at capacity on weekends, particularly during summer months. Provision of new campgrounds in the coastal zone can be costly and challenging due to permit barriers and regulatory constraints, further increasing the need to preserve and/or protect the existing facilities.

However, the beaches' value as an ecosystem, particularly in well-developed urban environments where intact habitats are often limited, can often be less appreciated. Southern California beach systems, including Carpinteria City Beach and Carpinteria State Beach, are highly impacted by coastal threats, such as coastal erosion, interrupted sediment transport due to creek channelization and upstream ~~flood detention~~ debris basins, pollution, and loss of natural morphology due to beach grooming and other maintenance activities. Such threats have led to the decline, and even the extinction, of some native beach species and the loss of important ecosystem functions (Dugan 2003, 2010; Hubbard 2013). Dunes and other beach habitats are critical in managing sand transport along the shoreline to create resilient beach morphologies, which can naturally adapt to the impacts of climate change. These systems can also offer a nature-based adaptation approach, or living shoreline, as a form of protection for our coastlines. By restoring natural processes to the City's beaches, the Project aims to improve shoreline resiliency, protect landward development and infrastructure, and restore ecological functions as well as serve as a model for similar projects statewide.

Plan Purpose and Goals

The purpose of the Project is to protect the City's landward development, infrastructure, and coastal resources from sea level rise-related impacts, including coastal erosion, severe storm events, and flooding. The Project aims to restore impacted beach and dune habitat, including the establishment of a living shoreline, to address sea level rise impacts to the Project area and vicinity. The Project would develop adaptation mechanisms to protect critical transportation and other infrastructure, landward development, and provide benefits to City residents and vulnerable/disadvantaged communities through the protection of coastal resources and the enhancement of native dune habitat. Key Project goals and components include the following:

- Reduce the vulnerability of the Beach Neighborhood and Downtown, particularly for disadvantaged communities and the City's central businesses, to projected sea level rise generated hazards, such as tidal inundation, flooding, wave attack, and coastal erosion;
- Identify the preferred Project design for a living shoreline based on site constraints, engineering feasibility, and long-term sustainability through at least 2050 and set forth other alternatives that were considered;
- Protect transportation infrastructure, including U.S. Highway 101, the California Coastal Trail, the main Union Pacific Railroad (UPRR) Amtrak line, and Carpinteria Rail Station, which are projected to become vulnerable to flooding with up to two feet of sea level rise.
- Restore a portion of the historic dune habitats that formerly lined the Carpinteria City Beach and restore and enhance existing dunes within Carpinteria State Beach using nature-based solutions to protect landward neighborhoods, infrastructure, and Carpinteria State Beach campgrounds.
- Identify required future permits and environmental review for future Project implementation;
- Assess short-term (implementation) and long-term (maintenance and monitoring) costs for the Project; and
- Provide co-benefits to public health, public access, coastal habitats, and ecosystems.

Site Description

The sandy public beaches in the Project area are maintained by the City and the California Department of Parks and Recreation (State Parks) and are heavily used, with over 1,000,000 visitors estimated annually. The Project area for this shoreline plan includes beaches that extend for approximately 1.5 miles east from the mouth of the Carpinteria Salt Marsh at Sand Point, located to the west within the County of Santa Barbara (County) unincorporated area to the western end of Tar Pits Park, located to the east of Carpinteria State Beach at the end of Calle Ocho in the City.

The Project area is divided into four segments referred to as "Reaches" (see Figure 1). The first segment (Reach 1) is the most western segment, which includes nearly 0.5 miles of beach backed by a large-scale rock revetment and homes located within the unincorporated Sandyland Cove neighborhood between Sand Point and Ash Avenue. To the east, the second segment (Reach 2) consists of Carpinteria City Beach, which extends 0.3 miles from the south end of Ash Avenue to Linden Avenue and is owned and maintained by the City. Landward of Carpinteria City Beach lies the Beach Neighborhood, which primarily supports a mix of multiple- and single-family residential uses. The third study segment (Reach 3; north of the Carpinteria Creek outlet) and fourth study segment (Reach 4; south of the Carpinteria Creek outlet) are along Carpinteria State Beach and stretch for 0.7 miles along the shoreline. Carpinteria City Beach and Carpinteria State Beach extend for over 1-mile and are known for their gentle sandy slope and relatively calm conditions. To the east of the study area, the land rises to coastal bluffs and terraces that support Tar Pits Park and the Carpinteria Bluffs. This area hosts a public park, open space and trails, oil and gas facilities, and commercial research facilities. Beaches below the bluff are owned by the City and run another 1.5 miles east to the City limits near Rincon County Beach Park (City of Carpinteria 2019).

Please refer to *Project Constraints and Feasibility* below for specific natural and man-made site conditions.

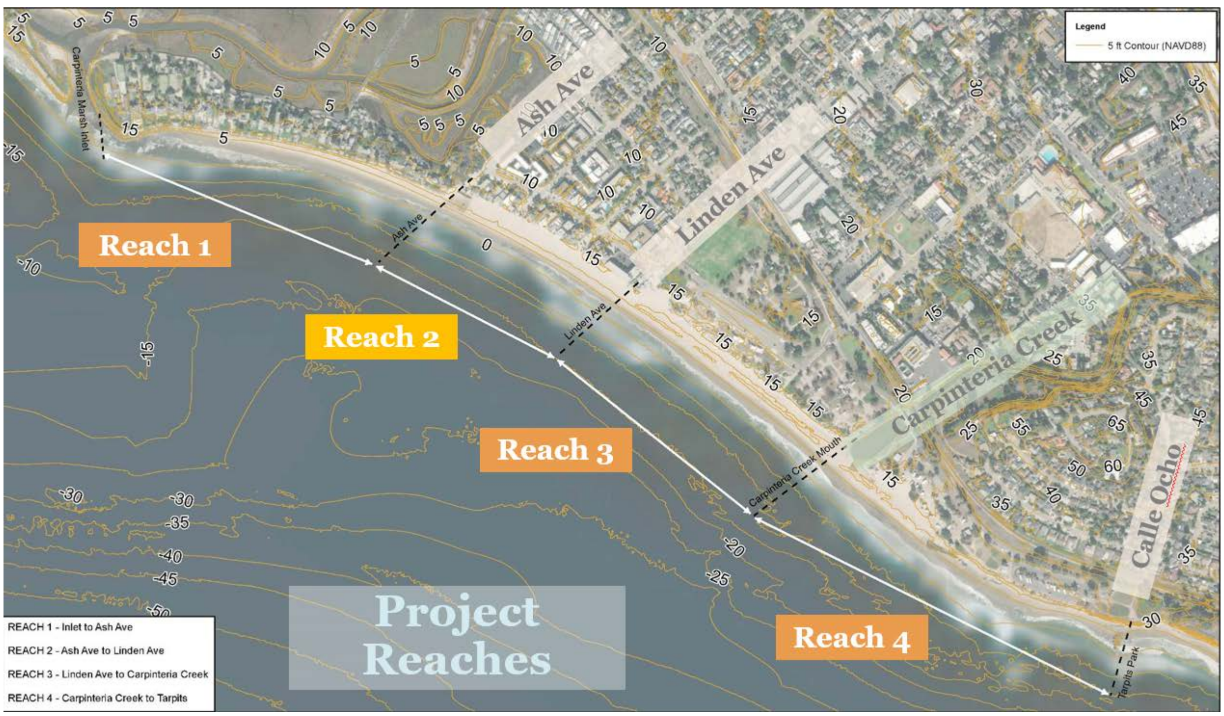

Figure 1. Project Location and Reaches

Santa Barbara Littoral Cell

The roughly 3-mile-long Carpinteria coastline faces south and is generally aligned in a northwest-southeast direction. The beaches transition from low-lying sandy beaches in the northwest fronting the City's Beach Neighborhood and Carpinteria State Beach, to rocky intertidal and limited sandy beaches backed by coastal bluffs in the southeast (City of Carpinteria 2019). The City is located within the Santa Barbara Littoral Cell, which extends for approximately 140 miles from the mouth of the Santa Maria River north of Point Conception to Mugu Submarine Canyon in Ventura County (Patsch and Griggs 2008) (Figure 2). The Mugu Submarine Canyon is the ultimate sediment sink for the littoral cell, where sand is transported offshore beyond the depth of closure (where beach sand is generally lost to the littoral cell) into the deep Santa Barbara Basin. Point Conception to the northwest and the Channel Islands to the south create a narrow swell window into the Santa Barbara Channel that shelters much of the Carpinteria's coast from extreme wave events and creates a nearly unidirectional sand transport from west to east.

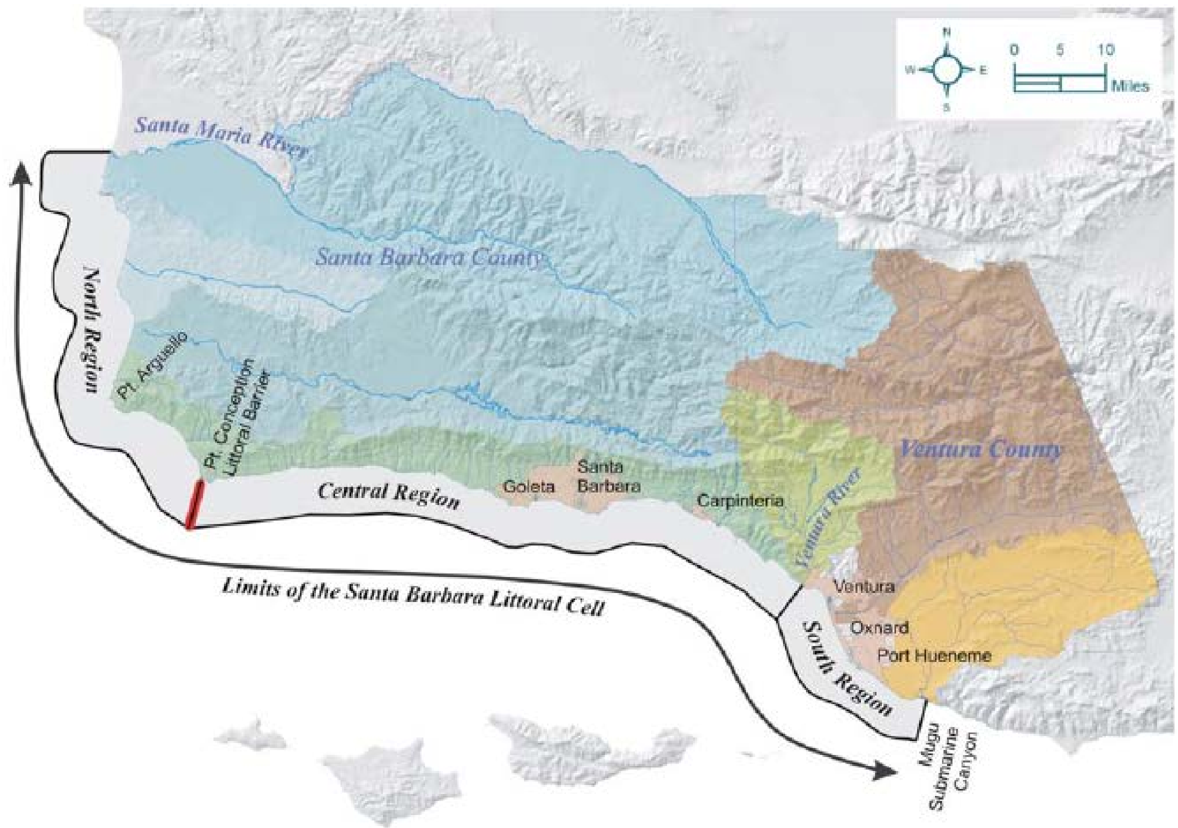

Figure 2. The Santa Barbara Littoral Cell and Watersheds (BEACON 2009).

Background

Historic Beach, Dune, and Wetland Habitats

The Project area once supported an extensive wetland and dune system with a wide sandy beach and dunes fronting the Carpinteria Salt Marsh and extending east to Tar Pits Park in the Carpinteria State Beach property (Grossinger et al. 2011; Appendix A). These dune systems allowed the formation of more extensive vegetated wetlands and intertidal sand and mudflats. The large dune field historically provided a natural buffer to low-lying areas from wave attack and flooding. Much of the City's Beach Neighborhood and portions of Carpinteria State Beach were constructed over these historic dunes and wetlands, leaving low-lying development vulnerable to wave attack and flooding.

Existing dune habitat along City Beach is limited in extent and is currently vegetated primarily with ice plant (Carpobrotus edulis), a non-native species, which provides less erosion protection than more deep rooted native dune plants.

Though historic losses of dune habitat have occurred throughout the study area, Carpinteria State Beach currently includes an existing dune system that is approximately five acres in size, managed by State Parks, and is integrated into the State Park's 2009 Carpinteria State Beach Interpretation Master Plan. This historic dune complex was improved by planting native vegetation and constructing an elevated boardwalk over the dunes in the 2010s in response to dynamic sand movements during high wind events that frequently resulted in costly maintenance for State Parks to prevent future damages to Carpinteria State Beach camping facilities and associated parking lot (Appendix A). While these dunes help protect landward Carpinteria State Beach facilities and provide valuable habitat, the dunes vary in width and height over the Carpinteria State Beach frontage, limiting protection of some landward areas, and are also disturbed in places with invasive non-native species, reducing habitat value. Although the dune system at Carpinteria State Beach is disturbed in places, these dunes and beach itself support resident and migratory shorebirds, rare plants (e.g., red sand verbena [*Abronia maritima*]), and rare invertebrates (e.g., globose dune beetle [*Coelus globosus*] and the western beach tiger beetle [*Cicindela latesignata*]).

History of Sand Supply Loss in Carpinteria

The reduction and loss of naturally occurring beach and dune systems over time were largely driven by human impacts, including the development of the Sandyland Cove neighborhood, the City's Beach Neighborhood, Carpinteria State Beach facilities, and the loss of natural sediment supply. Based on a prior study of the Santa Barbara Littoral Cell, there has been an estimated

1,476,000 cubic yard (cy) sediment reduction, or 41 percent reduction, from the damming of rivers, and an estimated 3,000 cy sediment reduction, or 19 percent reduction, from coastal armoring that has reduced bluff erosion. In total, this represents an approximate 1,479,000 cy of sediment deficit within the Santa Barbara Littoral Cell, or an approximate 40 percent reduction overall (Patsch and Griggs 2006). It is important to note that the total sediment deficit of 1,479,000 cy does not include any beach nourishments events as none were completed between 1990 to 1993 during the study period. The most significant contributor to the reduction in sand supply was the installation of Santa Barbara Harbor (Harbor) in 1932, which caused large downcoast erosion and resulted in the formation of substantial new land and beach area upcoast, adding protection for the Santa Barbara City College parking lots and stadium, Ledbetter Beach parking lots, lawn area, and a wide sandy Ledbetter Beach. The Harbor traps nearly all longshore sand transport through Santa Barbara and reduces the downcoast delivery. This effect is partially offset by Harbor maintenance dredging by the U.S. Army Corps of Engineers (USACE); however, the USACE only dredges and by-passes a portion of the sand trapped in the Harbor, estimated at approximately 315,000 cy of sand annually (Beach Erosion Authority for Clean Oceans and Nourishment [BEACON] 2009; Appendix A). Sand not bypassed accumulates on West Beach and in the Harbor and periodically begins to fill in the City's mooring and slip space.

Breakwater construction at the Harbor began in 1927 and was completed by 1930, during which approximately 2.6 million cy of sand were impounded updrift of the Harbor at Ledbetter Beach. Sand impoundment led to a well-documented erosion wave, an area of sand deficit that travels along the coast, that migrated downcoast at a pace of approximately 1 mile per year. The arrival of the erosion wave to Sandyland Cove Beach and the City, combined with storm waves arriving from a hurricane that made landfall in Long Beach in 1938, resulted in the erosion of the historic dune field at Sandyland Cove Beach and Carpinteria's beaches in the late 1930s. In addition, the natural underwater sand peninsula (known as a tombolo) between the dunes and Carpinteria Reef was eroded (City of Carpinteria 2019).

Coastal armoring in certain reaches within Santa Barbara and the City has also incrementally reduced natural sand supply to the area's beaches, estimated at 3,000 cy annually. In addition, damming of watersheds, such as the Santa Maria and Santa Ynez Rivers and San Antonio Creek near Vandenberg Space Force Base, has also incrementally contributed to sand loss at Carpinteria's beaches, although it is unknown specifically how much of this sand passes around Point Conception (BEACON 2009; Appendix A). Further, the damming of rivers is estimated to locally impound approximately 1,476,000 cy annually, which primarily affects beaches upcoast of Point Conception. Finally, the USACE constructed debris basins in the Santa Monica Creek and Carpinteria Creek watersheds in the 1970s to prevent flooding of the Carpinteria community below and to protect flood-prone areas downstream (Santa Barbara County Flood Control and Water Conservation District [Flood Control District] 2017). Though unintended, these projects along with other South Coast debris basins, such as those on Goleta, Santa Barbara, and Montecito creeks resulted in the interception and export of coastal sediment from South Coast watersheds, resulting in a reduction of coastal sediment and heavier items, such as cobble that previously replenished and protected the shoreline. Since the late 20th century, the loss of natural beach cobble has been most apparent and significant along Carpinteria City Beach, particularly from the severe El Niño generated storms in 1983, which removed much of its cobble.

The effect of this erosion changed the longshore currents in Carpinteria and likely allowed more swell energy to rotate Carpinteria beaches in a slightly clockwise direction. The long-term shoreline and beach responses to this erosion event were to erode the beach in front of Sandyland Cove and widen the beach in front of Tar Pits Park, effectively rotating the beach slightly to the southeast. Photogrammetric analysis of 16 historic aerial photographs shows long-term changes along the City's shoreline since the 1869 shoreline position was documented at Sandyland Cove Beach, Ash Avenue, Linden Avenue, and Tar Pits Park. Sandyland Cove Beach saw the largest changes, eroding by approximately 100 feet, and Ash Avenue narrowed by approximately 50 feet. Meanwhile, beach widening occurred on the beach at Linden Avenue (approximately 30 feet) and Tar Pits Park (approximately 60 feet) (City of Carpinteria 2019).

Historic Shoreline Management at Carpinteria Beach

Historically, large waves events during the winter have caused damage to local beaches and coastal structures. Since substantial damage to properties and facilities associated with wave attack and erosion during the severe 1983 El Niño occurred, the City has implemented an annual Winter Storm Berm Program to protect beachfront properties along the Carpinteria City Beach from wave action and related flooding during the winter storm season. The winter storm berm is a protection device that buffers landward residences and City facilities from coastal storm damage and erosion during the winter storm season.

The City-installs a seasonal sand berm along the shoreline during the winter season to protect near-shore residences, infrastructure, and Carpinteria City Beach from coastal winter storms.

The seasonal berm is approximately 1,400 feet long. Given an approximate width of 40 feet wide and a height of 12 feet (16 feet above sea level), the berm requires approximately 13,000 cy of sand for installation. This material is bulldozed from the upper tidal zone during low tide and placed in the backshore area of Carpinteria City Beach. The berm is constructed annually before the winter storm season and is removed by pushing sand back to the upper tidal zone by Memorial Day the following year, typically lasting from late November until early March the following year depending on beach conditions (City of Carpinteria 2019).

Funded by the City and an existing assessment district, which is comprised of potentially affected property owners, this ongoing measure reduces the probability of damage to development and infrastructure. Further, this program maintains a wider sandy beach for recreation and associated economic benefits in the summer season by minimizing the loss of sand during the winter storm season (City of Carpinteria 2019).

Winter Storm Berm Costs

Berm Costs

Winter Berm Annual Costs: ~$35,000*

Total District fees: $20,656.73

City Costs: ~$14,843.27 (remainder of costs)

**Dependent on environmental conditions*

The costs of installation, maintenance, and removal of the berm are borne by the City and beachfront property owners. Assessment District No. 5, formed by Resolution No. 3061 on December 14, 1992, levies fees on all shoreline properties immediately adjacent to the Carpinteria City Beach frontage to help fund these annual costs of approximately $35,000, which are paid by property owners. Property-specific assessments are based on fixed costs such as permit compliance and biological monitoring, as well as a variable cost based on the percent of Carpinteria City Beach shoreline the respective property occupies.

Failure to erect the berm in 1995 led to private property damage exceeding $300,000. Additionally, with sufficient preparation, the City can rebuild and support the existing temporary berm after it experiences large storm events. However, storms can exceed the protection offered by the berm, and the berm is not impervious to being destroyed itself, which requires additional berm maintenance in some major storm years.

Ongoing Shoreline Management Study

A reconnaissance study in 2007 was completed by the United States Geological Survey (USGS) to evaluate physical processes and long-term and seasonal changes to the stretch of Carpinteria City Beach fronting Sandyland Road (Barnard et al. 2007). The study identified public beach resources and at least 14 residential structures that were under threat from shoreline erosion (City of Carpinteria 2010). The USACE then conducted coastline modeling; however, USACE did not include parameters for anticipated sea level rise. Without any protective measures (including the annual Winter Storm Berm Program), USACE estimates total potential damages from seasonal storms and El Niño events to have a 2018 Net Present Value of $21.5 million (USACE 2018). Following this analysis, the USACE narrowed down a final array of alternatives for economic modeling and environmental analysis under the National Environmental Policy Act (NEPA). For this modeling, USACE has been preparing an ongoing independent feasibility study along the City shoreline; however, modeling challenges were encountered with an associated delay. USACE has requested a waiver to extend feasibility work, and if the extension is approved, the feasibility project will be converted to a smaller program under Continuing Authorities Program (CAP) 103 to expedite the planning process. (City of Carpinteria 2019).

The USGS also conducts a bi-annual (May and October) shoreline transect profile monitoring program along the City's beaches. The monitoring program works to monitor the health of the beach over time, including active dissemination of results and their impacts to regional shoreline management agencies (City of Carpinteria 2019).

Coastal Processes Effects on the Shoreline

A variety of ongoing coastal processes at Carpinteria City Beach and Carpinteria State Beach affect the shoreline's conditions, which impact the City's potential management strategy options as well as the feasibility of implementing and maintaining a living shoreline project.

Primary Coastal Processes Affecting the Carpinteria Shoreline

- Sediment Flow and Supply
- Tides and Waves
- Longshore Currents
- Coastal Erosion and Runoff
- Climate (e.g., El Niño's frequency/ severity)

Sediment Flow

Beach sediments within the Santa Barbara Littoral Cell come primarily from coastal streams delivering sediments to beaches and some cliff erosion. Beach widths, profiles (i.e., depth of sand), and natural supply of sediment along the South Coast and the City are governed by a range of natural and manmade factors, including several key factors discussed below. These factors could also directly affect the feasibility of construction and maintenance of a living shoreline (e.g., sediment availability, El Niño's).

1. Rainfall amounts and runoff – the greater the amount and intensity of rainfall and flooding, particularly post wildfires, the larger the amounts of sediment and sand generated that can reach area beaches (Hughes 2016).

2. Debris basins – Debris basins in the Santa Barbara Littoral Cell reduce risk to infrastructure and the public due to flooding and mudflows post-wildfire; however, debris basins located along many foothill streams in the region disrupt sediment delivery to the coast and can result in limited sediment delivery to beaches impacting beach widths and profile. area (Appendix A).

3. Sediment disposal and beach nourishment projects – Beach nourishment projects performed by the Santa Barbara County Flood Control District (Flood Control District) and historically by BEACON have played an important role in maintaining and restoring beach widths and profiles along the South Coast and in the City (Appendix A).

4. Droughts – Inadequate rainfall levels can decrease sediment runoff and input into the Santa Barbara Littoral Cell, which can result in beach erosion and beach narrowing (Hughes 2016).
5. Severe climatic and weather events – El Niño Events, such as the 2015-2016 El Niño resulted in severe wave attack along the shoreline causing severe coastal erosion in the Santa Barbara Littoral Cell (Hughes 2016).

Sediment Supply Inputs

Significant Carpinteria Sediment Supply Key Factors and Sources

- Longshore current from west to east
- Seasonal natural fluctuations of sand and cobble
- Wildfires and subsequent rain events
- Santa Barbara Harbor sand bypassing
- Flood Control District sediment disposal

Sediment that reaches the coast is transported generally unidirectional from west to east through the Santa Barbara Littoral Cell. Carpinteria City Beach and Carpinteria State Beach are dependent upon often limited sediment supply from small coastal watersheds. Thus, City beaches often consist of a relatively thin layer of sand (e.g., 2-6 feet deep) that overlay a rocky marine terrace or cobbles. Cobbles and bedrock that are seasonally exposed by larger swells in the wintertime move sand downcoast and offshore, particularly at the base of the Carpinteria Bluffs or on local beaches after large storm events (City of Carpinteria 2019). In the summer beaches are naturally replenished with sand that is transported back onshore by gentle swells and from upcoast sources.

Significant increases in sediment input from the mountains to the shoreline may result from major wildfires through stormwater runoff. For example, the 1955 Refugio Fire, which burned 79,000 acres is theorized to have been responsible for a dramatic beach accretion period that peaked between 1966 to 1973 (Noble 2017). However, wildfires and subsequent severe rainfall events in the Santa Ynez Mountains watershed are episodic and cannot be predicted with certainty as a sediment source.

Sand supply along the South Coast and within the City is strongly dependent on winter rains, particularly flooding events from storms, which can carry large amounts of sediment downstream to beaches, particularly in post-wildfire conditions (Noble 2017). Sediment delivery by creeks and rivers in the Santa Barbara Littoral Cell is generally extremely episodic with the majority of sediment discharged by a stream typically occurring during serval days of high flow each year following a rain event. Additionally, sediment discharge during a single year of extreme flood conditions may overshadow or exceed decades of low or normal flow (Patsch and Griggs 2006). However, little to no sediment discharge data is available for many streams in Santa Barbara, so it is difficult to adequately predict sand transport from water discharge records from rivers. In summary, high rainfall events and flooding from storm events, particularly post-wildfire when foothill and mountain soils can be exposed to dramatically increased erosion, can substantially increase watershed sediment supply to the coast, although manmade obstructions may intercept much of this.

Mechanical beach nourishment through sediment disposal of Carpinteria Salt Marsh dredged material has historically occurred under emergency placement conditions.

Mechanical beach nourishment events occur within the Santa Barbara Littoral Cell, including limited amounts at Carpinteria's beaches associated with the Flood Control District's Carpinteria Salt Marsh Enhancement Plan (Enhancement Plan) disposal program. To date, these depositions have only occurred only under emergency placement conditions. These placements have included 5,000 to 9,000 cy at the end of Ash Avenue in 2001 from the Franklin Creek channel, 22,512 cy placed at the end of Ash Avenue in 2018 from the Franklin Creek and Santa Monica Creek channels, and another 20,000 cy of outfall just east of the Carpinteria Salt Marsh mouth from hydraulic dredging of the main channel (Maureen Spencer 2020)[1]. The Enhancement Plan was developed to address both flood control needs and habitat enhancement goals. The Enhancement Plan has been under implementation since it was approved in 2003. Before 2003, the Carpinteria Salt Marsh was desilted (i.e., cleared of accumulated sediments) under emergency response in the 1990s and before that on an as-needed basis. While periodic sediment removal is required to maintain channel capacity, estuarine habitat, and water quality, the Santa Monica Debris basin and associated plunge pool catch the vast majority of obstructive material in the upper watershed. The 2019 Subsequent Environmental Impact Report (EIR) for the Enhancement Plan prepared by Flood Control District describes the plan would implement more routine surf zone disposal of sediment obtained from sediment basins in the east end of the Carpinteria Salt Marsh at Carpinteria City Beach or near the Carpinteria Salt Marsh mouth consistent with the Coastal Regional Sediment Management Plan, which would contribute to a wider beach.[2] This action would increase the beach area available for recreation (County of Santa Barbara 2019). The Flood Control District plans to update the Enhancement Plan to include several changes to existing routine maintenance practices. The Flood Control District's new Carpinteria Salt Marsh sediment

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[1] Sediment has been taken from Carpinteria Marsh and deposited at upland locations approximately every 5 to 10 years. These events happened in 1995 under emergency dragline (15,000 cy from Franklin), 1998 under emergency dragline (10,000 cy from Franklin and 8,000 cy from Santa Monica), 2005 under routine dragline (10,000 cy from Franklin), 2013 under routine dragline (14,160 cy from Franklin), and in 2018 under routine dragline (15,000 cy from Franklin and 20,000 cy from Santa Monica).

[2] The Enhancement Plan does not address sediment disposal and management in the western portions of the Carpinteria Salt Marsh which are managed by the University of California Natural Reserve System. This area potentially contains substantial volumes of sediment within marsh channels, which could be available for beach nourishment depending on coordination efforts and permitting.

disposal program will provide a more immediate and important source of sediment for City beaches.

Sediment Flow Restrictors

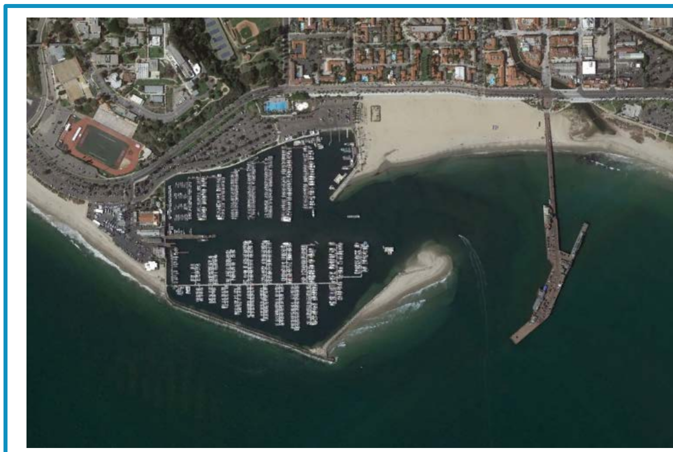
There are a total of 17 sediment and debris detention basins within Santa Barbara County in the Santa Ynez Mountains that drain to the Santa Barbara Littoral Cell (County of Santa Barbara 2017). These debris basins intercept large volumes of sediment, sand, and cobbles preventing these materials from reaching area beaches as they typically would have done under natural conditions. These basins are periodically desilted by Flood Control District and USACE, but regulatory barriers <u>and the absence of a specific program and permits to place debris basin materials on area beaches</u> prevent the deposition of this sediment on area beaches, depriving the City's beaches of a key source of sand, sediment, and cobbles (see below- *Prioritizing Sediment Supplies*).

<u>Carpinteria Sediment Restrictors</u>

- Sediment and debris basins
- Santa Barbara Harbor
- Upcoast large revetments (e.g., Sandyland)
- Major storms moving sediment offshore outside the littoral current

Area debris nets have prevented sediment, sand, and cobble from reaching beaches, and the deposition of this sediment on area beaches has been difficult to facilitate.

The Harbor within the Santa Barbara Littoral Cell requires annual sand bypassing to maintain safe navigational bathymetry and depths (City of Carpinteria 2019). The Harbor acts as a sand trap, requiring regular dredging to maintain sand supply to downcoast beaches. The annual volume of sand dredged from the Harbor is approximately 315,000 cy per year. While these dredge events provide large annual volumes of sand for downcoast beaches, the Harbor disrupts natural sand transport along the coast and can increase downcoast beach erosion.



The Santa Barbara Harbor requires twice annual dredging to ensure navigable passage and to provide downcoast beach nourishment.

Additionally, sand from harbor dredging events is typically placed on East Beach in Santa Barbara where it is gradually transported downcoast toward the City, although on occasion portions have been used for nourishment at Goleta Beach (City of Carpinteria 2019). For example, in 2021, Santa Barbara dredged roughly 80,000 cy of sand from West Beach and the Harbor for bypass downcoast. In particular, interception of sand transport upcoast at the Santa Barbara Harbor has in the past significantly affected sand supply to beaches within the City of Carpinteria and other downcoast South Coast communities, making sand bypass operations at Santa Barbara Harbor crucial to maintaining sand profiles and beach width within the Project area.

A smaller example of local manmade coastal armoring is the Casa Blanca revetment located at Santa Clause Lane; this revetment has improved the width of Santa Clause beach, acting similarly to a groin, as the revetment extends into the surf enough for pedestrian passage to be restricted except during substantially low tides.

Droughts can also seriously affect streamflow and substantially diminish or halt sediment transport to Carpinteria's beaches. The cumulative effects of the severe California drought from 2012 to 2017 greatly diminished or even ceased at some locations sediment flows from streams and rivers to the coast, substantially reducing sediment flow and causing an overall increase in erosion to the Santa Barbara Littoral Cell shoreline (Noble 2017). The drought, in combination with the severe El Niño event from 2015 – 2016, resulted in beach narrowing along the City's coast, which is still recovering today.

Prioritizing Sediment Supplies

Beach compatible sand and sediment supplies are often limited and constrained due to sediment flow conditions, ~~and~~ regulatory barriers (e.g., permitting), and the absence of a specific program and permits for the placement of unwashed debris basin material on area beaches which can result in limited availability of sediment supplies, while demand for such supplies may increase with major nourishment projects or due to climate change. Other agencies, such as the City of Santa Barbara, the City of Goleta, and the County of Ventura, are actively considering the use of sediment for beach nourishment as a future shoreline management strategy. While sediment placed at any beach nourishment site would eventually migrate downcoast, a competition for beach compatible fill and sediment may result if construction phasing overlaps within the Santa Barbara Littoral Cell. Additionally, sand supplies for beach nourishment and dune construction may be affected by any of these sediment availability factors which can sometimes limit quantities of sediment available, with regulatory restrictions posing substantial potential barriers, and

Sediment Priority Constraints

- Compatible fill and sediment are limited
- A specific program and permits do not exist for placement of unwashed debris basin material on area beaches
    - As a result, detention basin sediment is often diverted to landfills and quarries, outside emergencies

increasing demand for limited sediment also posing a challenge (Climate Adapt 2015). Precise future demand and timing for local sediment are unknown at this time due to the evolving nature of projected sea level rise and ongoing planning of projects across the region. Due to the potential conflicts in sand and sediment demand for shoreline management, regional coordination, particularly through BEACON, is critical for the success of the Project.

Beach quality sediments and sand from ~~detention~~ debris basins are often trucked to landfills or old quarries for disposal, rather than ~~placed on the beach~~ introducing sediment from debris basins into the surf zone at area beaches to be distributed more naturally by waves, ~~where~~as natural processes historically deposited them.[3] Only during emergencies is sediment from these basins allowed to be deposited on area beaches.[4] Although the Flood Control District and BEACON are coordinating to try to rectify this situation, obtaining regulatory permits can require substantive monetary and time commitments, which often result in sediment not being placed on beaches. However, as discussed below, the Flood Control District does have permits to ~~place beach quality sediments~~ introduce (e.g., mechanically push) material from both the Carpinteria Salt Marsh and Goleta Slough ~~on area beaches~~ into the surf zone at area beaches, and these programs will continue to play an important role in maintaining beach width and profiles at the City's beaches and area beaches such as Goleta Beach.

Tides

The tides in the City are mixed, predominantly semi-diurnal, and are composed of two low and two high water levels of unequal heights per 24.8-hour tidal cycle. Typical tide heights range from 5.4 feet during full and new moon spring tides and 3.6 feet during the neap (1/4 and 3/4 moon) tides. Maximum tide elevations are due to astronomical tides associated primarily with gravitational pull from the sun and the moon, wind surge, wave set-up, density anomalies, long waves (including tsunamis), climate-related El Niño events, and Pacific Decadal Oscillation events (a long-lived El Niño-like pattern of Pacific climate variability) (National Oceanic and Atmospheric Administration [NOAA] 2021). The maximum tidal water level elevation recorded at the nearby Santa Barbara tide station was 10.79 feet above mean lower low water (MLLW) on

Tide Considerations

- Maximum tide elevations, and those during El Niño conditions, flood areas near the coast
- High tide levels are anticipated to increase with sea level rise

[3] After the Thomas Fire and Montecito Debris Flows, over 300,000 cy of sand, sediment, cobble and other material were removed from the Santa Monica Creek Debris Basin by USACE and trucked to landfills and quarries, depriving City beaches of the equivalent of several years of typical sediment supply.

[4] In 2018 and 2019, under emergency permits, the Flood Control District deposited approximately 90,000 cy of sand, sediment, and cobble at Goleta Beach from foothill ~~detention~~ debris basins, substantially benefiting beach width and profile at Goleta Beach. Over the coming decade, Goleta Beach sediment is anticipated to gradually transport south over the coming decade.

December 13, 2012. On longer time scales, sea level rise will become increasingly important, as extreme high tide elevations become more common (City of Carpinteria 2019).

The largest tide ranges in a year typically occur from late December to early January and are known as "king tides." In the City, king tides can reach up to 7.2 feet in elevation above MLLW. The tidal inundation projections used in this study assume Extreme Monthly High Water (EMHW) levels, calculated by averaging the maximum monthly water level for every month recorded at the Santa Barbara tide gauge. The elevation of this tide level is 6.5 feet above MLLW and can be expected to be the area that gets inundated once a month. This elevation was modeled and mapped as part of Santa Barbara County's 2016 Coastal Resilience efforts and approved by involved public agency stakeholders (City of Carpinteria 2019). The combination of high tides with major storms waves has a high potential for wave shoreline damage as occurs in major El Niño events.

Waves

Wave Considerations

- Area wave heights do not often reach extremes
- Area wave action trends west to east
- More intense storms, with associated wave action, are likely with sea level rise

Two dominant types of waves approach the City's shoreline, characterized by wave source and direction. First, northern hemisphere waves are typically generated by cyclones in the northern Pacific during the winter and bring the largest waves (up to 25 feet). Second, the southern hemisphere waves are generated in the southern Pacific during the summer months and produce smaller waves with longer wave periods (>20 seconds). However, due to the presence of the offshore Channel Islands, these long-period southern swells/waves are generally much smaller when they reach the City, supporting the City's claim as the "World's Safest Beach." Additionally, local wind waves are generated throughout the year either as a result of winter storms coming ashore, or strong sea breezes in the spring and summer (City of Carpinteria 2019).

There remains some uncertainty about the influence of climate change on wave heights, frequency of large events, and intensity. Presently, work by USGS indicates that there may be additional southern hemisphere wave energy (not likely to affect Carpinteria), a northerly shift in the average northern hemisphere wave direction (which may diminish the average winter wave heights), and more intense storms (City of Carpinteria 2019).

Longshore Currents and Sediment Transport

Longshore Currents: When a wave reaches a beach or coastline, it releases a burst of energy that generates a current, which runs parallel to the shoreline.

Currents in the Santa Barbara Channel drive nearly unidirectional longshore sediment transport from west to east, which moves sand downcoast toward Ventura County. Strong winter swells typically move sand offshore and downcoast, which causes beaches to narrow during the winter and spring (November to April). In contrast, more gentle summer swells move sand back onshore and reduce downcoast transport, typically causing beaches to widen during the summer and fall (May to October) (City of Carpinteria 2019).

Coastal Erosion and Runoff

Erosion and Runoff Considerations

- Long-term changes caused by variations in sediment supply and sea level rise
- Short-term changes can be caused by large storm events

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

Seasonal fluctuations and beach erosion and can result in changes to beach width and sediment content, and the beach berm (pictured) assists to prevent furthering erosion.

City beaches experience seasonal cycles in which winter storms move significant amounts of sand offshore, creating steep, narrow beaches. In the summer, gentle waves return the sand onshore, widening beaches and creating gentle slopes. Sandy beach widths on Carpinteria City Beach range between 65 and 200 feet, although width varies seasonally and along the coast. Because many factors influence coastal erosion, including human activity, sea level rise, seasonal fluctuations, and climate change, sand movement will generally be locally variable (City of Carpinteria 2019).

Coastal hazards and processes have contributed to incremental shoreline erosion and have historically occurred throughout Carpinteria's shoreline. Significant wave events in 1938, 1943, 1958, 1982–83, 1988, 1997–1998, 2002, 2007, and 2015-2016 demonstrate the dynamic coastal environment with associated periodic hazards from major storm seasons. While many of these storm events are associated with El Niño, other causes of shoreline erosion can occur in tandem. In such situations, due to the absence of vegetation and resultant soil erosion, large fluxes of sediment can be rapidly transported downcoast, substantially contributing to gains in beach sand depth and width profile (City of Carpinteria 2019).

The installation of the Santa Monica Creek debris basin in 1970 and other debris basins, such as those in Montecito have interrupted the migration of natural coarse sediments, such as cobbles to the shoreline, reducing the amount of cobble transported to the City's beaches (see above *Sediment Flow Sinks*). Lack of cobble significantly reduces the shoreline's natural resilience to wave attack during high-energy events. In localized spots, the construction of a large-scale revetment at Sandyland Cove upcoast of Carpinteria City Beach also causes seasonal impacts to the sandy beach width, including a narrowing of the beach, an acceleration of sand transport, and a seasonal erosion hotspot at the end of Ash Avenue near the lifeguard tower (Revell et al. 2008). Armoring of the coastline upcoast from the City also incrementally reduces sediment input to the shoreline. The Sandyland Revetment has had an "end effect" of reducing the sandy beach width on Carpinteria City Beach, particularly at Ash avenue. When combined with historic losses associated with the construction of the Harbor, and particularly upcoast watershed debris basins, which traps sand and cobble from the system, the developments have had the unintended consequence of starving the City shoreline of natural sediments that are critical to providing shoreline resiliency (City of Carpinteria 2019).

Overview of Existing Shoreline Management Policies, Regulations, and Programs

A variety of existing agencies provide relevant policies, regulations, and programs related to shoreline management and sea level rise, which guide development in the California Coastal Zone. The Project is guided by applicable policies, regulations, and programs, and allows such policies to partially inform the design and development of the Project. The Project would balance existing policies, regulations, and programs related to improvement and retention of existing coastal access, infrastructure protection, equal public access, and biological and hydrological co-benefits (e.g., enhanced ecosystems and improved water quality). Overall, the Project is driven by guiding principles of the California Coastal Act and CCC sea level rise policy guidance. Additional guidance from BEACON, the California Coastal Act, and the City General Plan/Local Coastal Plan, including its pending update, were considered in Project design and are summarized below.

Beach Erosion Authority for Clean Oceans and (BEACON)

BEACON was established in 1986 as a California Joint Powers Agency, which works to address coastal erosion, beach nourishment, and clean oceans within California's Central Coast from Point Conception to Point Mugu within Santa Barbara and Ventura counties (BEACON 2021). BEACON is involved in coastal studies and projects within Central California, as well as coordination with parks and planning and public works departments. BEACON is supported by – and partners with – a range of nearby member agencies, which include the County of Santa Barbara, County of Ventura, City of Carpinteria, City of Goleta, City of Oxnard, City of Port Hueneme, City of Santa Barbara, and the City of San Buenaventura. BEACON contributes and works on coastal studies and projects within the region in coordination with local parks and planning and public works departments of member agencies. BEACON's staff includes member agency staff and consulting coastal processes specialists. BEACON holds virtual monthly Board meetings and Science Advisory

Committee meetings, which the public can attend. Funding for BEACON is provided by annual agency membership dues and state and federal grant funding.

In recent years, BEACON and its member agencies have focused on climate change planning, particularly related to hazard mitigation and adaptation strategies. Since the 2017 Thomas Fire, BEACON has also focused on wildfire-related impacts to the region, including sediment issues, rocks, and boulders at creek mouth concerns, beach growth, and water quality impacts from wildfires. Key BEACON projects and reports include (Resilient California 2021):

- The Coastal Regional Sediment Management Plan,
- The Kelp Anchor Demonstration Project,
- Debris Basin Project,
- The Oil Piers Artificial Reef Project, and
- The South Central Coast Beach Enhancement Program.

A key report for this Project and other coastal planning documents is the 2008 Coastal Regional Sediment Management Plan, which provides region-wide guidance on planning approaches to sediment management to address existing and future coastal sediment processes, describes sand and sediment sources, and challenges and opportunities in sediment management across the region (BEACON 2009). As an example, the 2001 South Central Coast Beach Enhancement Program provides an overview of ongoing beach nourishment at six different beaches in Ventura and Santa Barbara counties as well as the placement of a combined maximum of 791,500 cy of beach quality fill material annually at five beach receiver sites.

Currently, BEACON is working on the Santa Barbara County Coastal Resiliency Project in coordination with the County, which includes Countywide modeling and mapping, public outreach, and a vulnerability assessment. The vulnerability assessment includes residential, transportation, and utility infrastructure vulnerability from climate change-related hazards.

California Coastal Act

The California Coastal Act includes specific policies that address issues such as shoreline public access and recreation, marine habitat protection, visual resources, and water quality. The Project would comply with all applicable policies in the California Coastal Act, particularly:

Section 30210. Maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resources areas from overuse.

Section 30240. Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.

Section 30221. Oceanfront land suitable for recreational use shall be protected for recreational use and development unless present and foreseeable future demand for public or commercial recreational activities that could be accommodated on the property is already adequately provided for in the area.

Important sections of the Coastal Act to consider for Caltrans projects include:

Section 30235. Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fish kills should be phased out or upgraded where feasible.

Section 30236. Channelizations, dams, or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible, and be limited to (1) necessary water supply projects, (2) flood control projects where no other method for protecting existing structures in the floodplain is feasible and where such protection is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat.

Section 30253. New development shall: (a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard. (b) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.

City of Carpinteria Pending Coastal Resiliency Element

The City's General Plan/Local Coastal Plan is currently being updated to include a new Coastal Resiliency Element and is likely to be adopted with the below policies. The City's General Plan/Local Coastal Plan will include specific policies that address coastal resiliency concepts, including specifics on the types of management devices that are encouraged along the shoreline, coordination, and long-term maintenance. The Project would be designed with consideration for these pending policies, including the following:

CR-3a. Shoreline protective devices, including but not limited to shoreline armoring, such as seawalls, groins, breakwaters, and other such construction that alters natural shoreline processes, shall be prohibited unless consistent with the policies and provisions of the

City's Local Coastal Program, non-structural protection alternatives are infeasible, there is no less environmentally damaging alternative, and no waiver of rights to a shoreline protective device (as described in Policy CR-3b) applies to the property. For the purposes of this policy, "existing structure" means a principal structure (e.g., residential dwelling or accessory dwelling unit) that was legally permitted and in existence prior to the effective date of the Coastal Act (January 1, 1977) and that has not subsequently undergone major redevelopment.

CR-3b. Shoreline protective devices shall be sited and designed to avoid adverse impacts on coastal resources, including the beach, rocky points, or intertidal areas, to the maximum extent feasible. Such impacts may include but are not limited to erosion or loss of sand supply, destruction of the rocky substrate, smothering of a significant number of organisms, loss of public access, loss of recreation facilities, or destruction or loss of coastal ecosystems. If there is no feasible alternative that avoids all impacts, then the alternative that would result in the fewest or least significant impacts shall be selected and impacts to resources shall be mitigated. Mitigation shall not be used as a substitute for the selection of the least damaging alternative. Such devices shall avoid encroachment onto public trust lands and interference with the natural migration of the public trust lands boundary.

CR-3c. Shoreline protective devices shall only be authorized until the time when the existing principal structure that is protected by such a device:

a) Is no longer present;

b) No longer requires armoring; or,

c) Is majorly redeveloped.

CR-3d. Non-exempt repair and maintenance of existing, legally permitted shoreline protective devices may be permitted as repair and maintenance only if the activities do not result in an enlargement or extension of armoring. Repair and maintenance activities shall not result in a seaward encroachment of the shoreline protective device, or substantial impairment of public trust resources. Repair and maintenance projects shall include measures to address and mitigate all coastal resource impacts that the repair and maintenance activities may cause, including with respect to local sand supply, public views, and public recreational access. Replacement of 50 percent or more of the protective device shall not be considered repair and maintenance but instead constitutes a replacement structure subject to provisions applicable to new or replacement shoreline protective devices.

CR-3e. For coastal storm preparedness until other adaptation options are triggered, and with permit approval from the CCC and USACE, the City may continue to construct the winter sand berm on the City Beach in the fall and demolish the berm in spring, or other timing as required by the Coastal Development Permit.

CR-3f. The City shall support and facilitate the current USACE feasibility study and examine other long-term solutions for beach nourishment and establishment of a vegetated dune system at the City Beach and/or State Beach.

CR-3g. The City shall encourage the use of soft or natural shoreline protection methods, such as dune restoration, beach/sand nourishment, living shorelines, horizontal levees, and other "green" infrastructure as alternatives to hard shoreline protective devices. Soft shoreline protection devices shall be fully evaluated for coastal resource impacts and shall only be approved if found consistent with the Local Coastal Program policies related to shoreline protection. The City should consider how these options may need to change over time as sea level rises.

CR-3h. Beach nourishment programs and/or projects shall be designed to minimize adverse impacts to beach, intertidal and offshore resources with consideration of sourcing of material, nourishment location(s), method and timing of placement, water quality best management practices, and shall be subject to appropriate testing for grain size, shape, color, sorting, constituent materials, and contaminants. Use of a broad natural range of grains sizes from fines to cobbles should be considered to mimic natural processes. Programs and projects shall include comprehensive monitoring plans that address water quality, monitoring and avoiding sensitive species and habitats during nourishment events, and post-event evaluation.

CR-3i. The City shall pursue beneficial reuse of sediments removed from local flood control facilities for beach nourishment as a priority adaptation measure. In addition:

a) The City shall continue to support regional initiatives for implementation of a comprehensive beach sand replenishment and retention program to protect the shoreline of the City and State Beach and maintain and enhance public recreation, coastal access, and beach habitats;

b) The City shall continue to coordinate with appropriate responsible agencies, such as Flood Control, University of California Reserve System, BEACON, USACE, and the Federal Emergency Management Agency (FEMA) to ensure that beach compatible sediment, including suitable fines and cobbles, removed from local flood control facilities as part of ongoing maintenance is transported to area beaches and used for habitat enhancement, and sustainability of dune and marsh habitats; and

c) The City shall continue to work with appropriate responsible agencies, such as BEACON, Regional Water Quality Control Board, State Lands Commission, California Coastal Commission, U.S. Environmental Protection Agency, and USACE to streamline permitting for beach nourishment projects.

Implementation Measure: The City should investigate the feasibility of a "living shoreline" project with a restored dune system, including use of cobbles and restoration of coastal habitat along the Carpinteria shoreline, in coordination with regional and state agencies.

- Timing: Within 2 years of Coastal Land Use Plan/General Plan adoption.

CR-6a. The City shall prioritize adaptation projects and programs that address the social and economic needs of vulnerable populations, such as maintenance of low-cost recreation and public access to the coast, low-cost visitor accommodations within Carpinteria State Beach, and affordable housing.

CR-6b. The City shall consider environmental justice concerns in the analysis of adaptation measures and alternative project designs, and ensure that all communities, including low-income and underserved, are meaningfully involved throughout the decision-making and planning process.

CR-6c. The City shall pursue opportunities to adapt critical transportation infrastructure used by transit-dependent populations to avoid isolation and economic loss.

Project Constraints and Feasibility

The construction and maintenance of a viable and effective living shoreline are subject to a wide variety of natural and man-made constraints that must be considered in its design. This Project, like the limited number of other living shoreline projects throughout the State, will face challenges. In particular, the costs of future implementation, securing adequate funding and a difficult regulatory agency permitting process are challenging. To identify these constraints and inform Project design, the City's coastal engineering consultant Moffatt & Nichol prepared a Constraints and Feasibility Analysis Report (Appendix A).

This report identifies the reach of the beach where living shorelines may be feasible based on existing conditions (e.g., beach width), supportive policies, and locations where existing development and infrastructure require protection. The Constraints and Feasibility Analysis Report also summarizes the process of identifying the priority pilot project extent based on feasibility and describes the public benefits of the proposed living shoreline. The conclusions of this report concerning constraints and feasibility are summarized below Refer to Appendix A, Constraints and Feasibility Analysis Report, for more detailed information.

Constraints

Constructing a highly visible project along the beach in Carpinteria may impact several aspects of the existing conditions of the City, both natural and man-made. Existing environmental conditions must be considered in the planning and design to prevent unintended impacts. Existing anthropogenic conditions (land ownership, property boundaries, transportation, public access and viewshed, utilities, and coastal structures) may conflict with the proposed Project, as the beach draws a diverse set of public and private interests. These potential constraints are discussed below to identify the potential challenges to Project planning.

Natural Constraints

Natural constraints within the Project area that influence the design and feasibility of the Project include the geomorphology and drainage, beach conditions, coastal processes, and wave dynamics as discussed in *Background* and *Coastal Processes Effects on the Shoreline*. However, natural constraints also include biological resources (e.g., environmentally sensitive habitat areas [EHSA]), topography, and subdrainage (e.g., existing function of creek mouths and tidal areas) which are discussed below (see Figure 3 below; refer to Appendix A).

Biological Resource Constraints

Biological resource constraints in the Project area include special-status plant or animal species, riparian and wetland habitats, sensitive natural communities, estuaries, or habitats protected under federal, state, and local regulations, and important wildlife movement corridors. Determination of Project impacts to biological resources depends on the proposed Project footprint, proposed materials and construction techniques, and modeled interactions with upcoast and downcoast beaches. Biological resources are not a reason to avoid work in any specific area because the resources may be degraded and might benefit from restoration actions, but the planning and permitting process may be more complex in areas with certain biological resources.

An existing dune system fronts Carpinteria State Beach in Reach 2 that is managed and maintained to provide habitat for sensitive native dune plant species. A living shoreline project within this reach would need to be closely coordinated with State Parks to maintain the quality and extent of habitat provided by these

Generally, the existing biological resources in the study area are greatest in Reaches 1 and 3. Reach 1 extends for more than 2,000 feet from the mouth of the Carpinteria Salt Marsh to Ash Avenue in the City, While the Carpinteria Salt Marsh supports habitat for several state- and federally-listed special-status species, the beach itself is backed by a 16-foot-high rock revetment and approximately 35 single-family homes largely separating this reach from habitats within the Carpinteria Salt Marsh. Reach 3 includes Carpinteria State Beach, with the beach along this reach backed by southern California coastal dune habitat supporting a mix of native dune plants (particularly beach bur [*Ambrosia chamissonis*]) and also extensive areas of non-native plants, including ice plant, myoporum, and eucalyptus. The beach in this reach is wide and sandy, supporting all ecological zones of the beach/dune system. This reach of the Project area is not mechanically groomed. On the east end of this reach is the mouth of Carpinteria Creek, which is often blocked by a sand berm much of the year, but can be open during periods of high tides and winter storms. Although lined by rock revetments on both banks, the creek lagoon provides habitat for listed species, including the federally endangered tidewater goby (*Eucyclogobius newberryi*) and steelhead trout (*Oncorhynchus mykiss*). Carpinteria State Beach also supports limited areas of important rocky intertidal habitat east or downcoast of the Carpinteria Creek mouth, within Reach 4 of the Project area.

Reach 2 includes the shoreline fronting the City's Beach Neighborhood and this beach is mechanically groomed to remove trash and seaweed, lacks dunes, or other significant native habitats, but continues to support some beach invertebrates (e.g., sand crabs), as well as foraging shorebirds. The area is also disturbed annually for construction and removal of the winter beach berm using heavy equipment with additional periodic disturbances if post-storm maintenance is required.

Reach 4 includes the eastern extent of Carpinteria State Beach from Carpinteria Creek to the western edge of Tar Pits Park. Within this reach, the sandy beach tends to decrease in width towards the east as the shoreline bends and the back beach transitions from a dune system to a low bluff. The western end of this reach supports an upper beach ecological zone and dune habitat. Rocky intertidal habitat is also present within this reach, including a Multi-agency Rocky Intertidal Network (MARINe) long-term monitoring site.

The Project area also contains several ESHAs as identified in the City's Local Coastal Plan. ESHAs support protected biological resources and are regulated under the California Coastal Act (Section 30420) and the City's Local Coastal Plan. Projects within ESHAs may require a more rigorous permit process and are subject to environmentally protective policies. The largest ESHA within the Project area is the sandy beach habitat, which is often intertidal in Reach 1, is broad and sandy within Reaches 2 and 3, and narrows to pocket coves and sandy/rocky intertidal in Reach 4. Cobble is present throughout area beaches, particularly in winter, but is typically limited except after major storms. Rocky intertidal and subtidal habitats are present along Carpinteria State Beach and are home to marine species dependent on these habitats. Placement of beach fill and its subsequent dispersion can cover these rocky habitats, leading to adverse impacts until natural littoral processes remove the new overlying sediment. Any turbidity plumes resulting from sand placement can also impact beach and tidal habitats, particularly if plumes occur over an extended period.

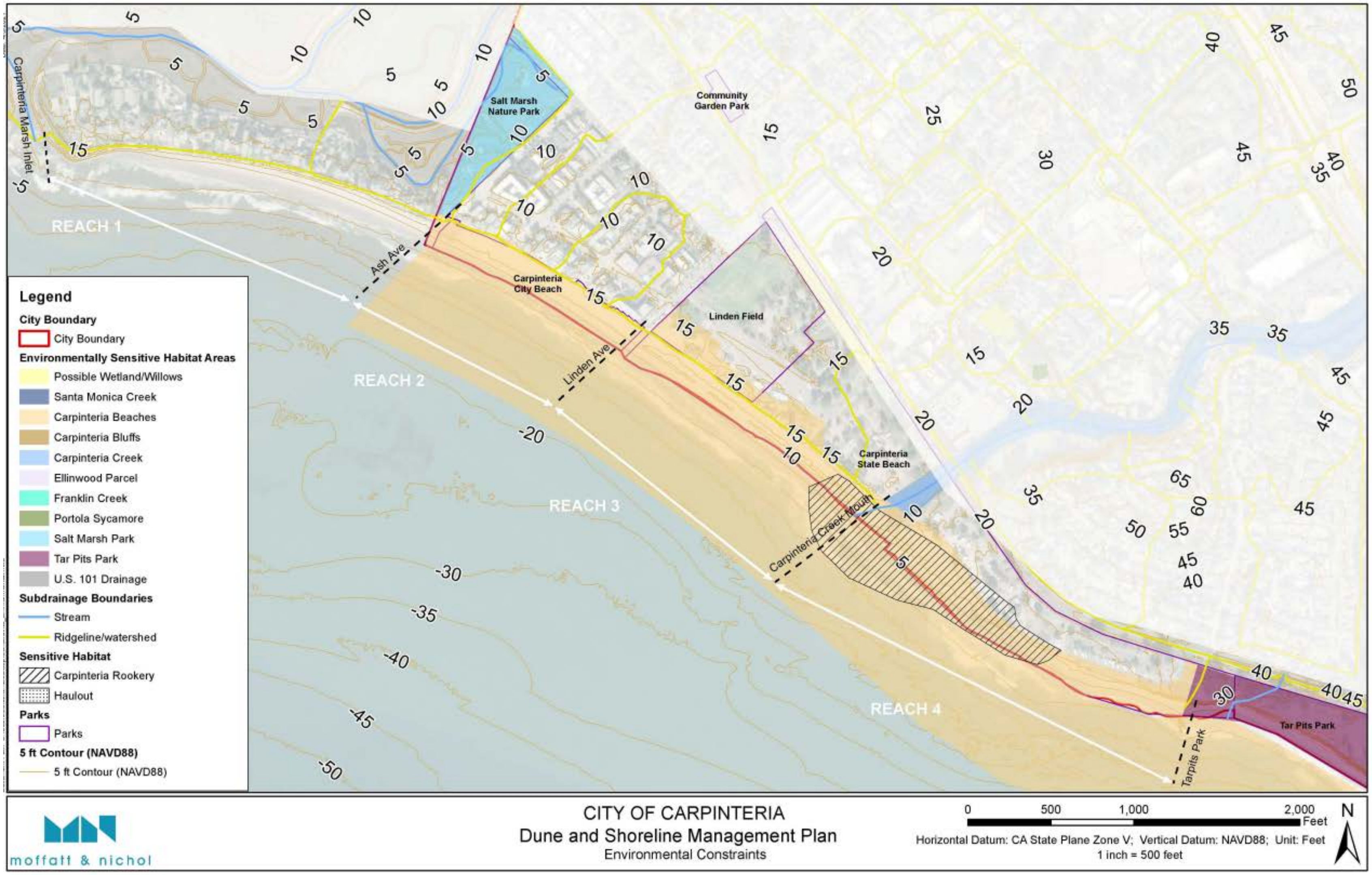


Figure 3. Natural Constraints in the Project Area

ESHAs are also present inland of the coastline. Carpinteria Salt Marsh Nature Park, part of the larger Carpinteria Salt Marsh, lies along Ash Avenue within the Beach Neighborhood, extending inland to 3rd Street. This marsh habitat serves as important habitat for both shorebirds and migratory waterfowl. A small estuary at Carpinteria Creek is located at the transition point from Reach 3 to Reach 4 along Carpinteria State Beach, supporting fish species listed as threatened and/or endangered (tidewater goby and steelhead trout). Sand placement upcoast of the creek mouth could potentially move downcoast and extend the duration of creek mouth closures, with possible effects on sensitive species. Tar Pits Park and areas of rocky intertidal and subtidal habitat are located immediately downcoast of Reach 4 and could also be affected by increased sand transport. The Carpinteria seal haul-out and rookery lie east of the Carpinteria Pier, at the foot of Carpinteria Bluffs although offshore seal activity extends along the coast and includes occasional seal landings.

The Carpinteria Creek estuary can become blocked by a sand berm created during periods of natural sediment accumulation during the winter season, or following beach nourishment activities. Any beach nourishment activities under the Project would need to monitor effects on the estuary so as not to adverse effect the estuary.

The importance of the inlet dynamics at the Carpinteria Salt Marsh in Reach 1 and Carpinteria Creek in Reach 3 must be considered when developing sediment nourishment approaches in the study area. The functions of existing estuaries are dependent on the tidal exchange through inlets, as well as beach width or sediment compositions that can alter these dynamics. The design and implementation of shoreline projects should consider potential effects of nourishment approaches and other actions (sand retention) on sandy beach habitat supporting native dune species, spawning grunion, migratory and overwintering shorebirds, special-status invertebrates, and macroalgae, as well as nearshore habitats such as eelgrass beds and kelp forests throughout all four reaches.

Topography

Determination of Project impacts to existing topography is dependent on the location and extent of the proposed Project footprint. As depicted in Figure 3, much of the City is a relatively low-lying community located between a saltmarsh to the northwest and bluffs to the southwest. Along Carpinteria City Beach, the back beach is the prime location for a dune system, as the most successful dune systems are fronted by a relatively wide sand beach buffering the dune from storm wave impacts, providing a source of windblown sand for dune growth, and providing an area of relatively high elevation for dune vegetation to establish above the tide line.

Within Reach 1, the existing beach is very narrow and low and backed by a revetment and residential community built on top of the historic dune system. A new dune within this area would be severely restricted by lack of space, a narrow beach, landward revetment, and development. Further, due to the existing coastal process and beach configuration, nourishment activities would only temporarily widen the beach within Reach 1. Within Reach 2, the existing beach is wider and could potentially accommodate a dune system if sufficient space exists between private property lines and the beach. While several residences and Ash Avenue are at a substantially lower elevation than the beach and development to the southeast, Ash Avenue has been the site of localized flooding in recent years and could benefit from a combined widened beach and dune protection system. While Reach 3 supports an existing dune system that sets a precedent for the continued use of the area as a vegetated dune, two constraints in this area include: an existing pedestrian boardwalk that restricts the dune crest elevation and the Carpinteria Creek, at which the addition of sand to the area could increase sand deposition in the creek mouth, with potential thereby adverse effects to wildlife. Along Reach 4, the shoreline orientation bends, the existing sandy beach width narrows, and shoreline elevations gradually rise to low bluffs towards Tarpits Park, greatly reducing the potential for a viable dune system fronting the bluffs.

Based on these constraints, Reach 1 is considered too narrow to sustain a living shoreline, and nourishment would only temporarily widen that beach, thus precluding a living shoreline option. Reach 2 is suited for a living shoreline; however, it would need significant beach nourishment to be sustainable. Reach 3 is well-suited for dunes but changes to the function of the Carpinteria Creek mouth would need to be minimized. Reach 4 is not well-suited for dunes along the bluffs; however, a short sub-reach fronting the Carpinteria State Beach campground would be a logical site for a living shoreline. Any dune construction should be ideally paired with, or closely follow, a significant beach nourishment project. However, it should also aim to minimize the potential impacts of grading and fill activities.

Man-Made Constraints

Potential man-made constraints within the Project area are illustrated in Figure 4 and discussed in the sections below. It is important to note that, although the existing conditions in the Project area may bring about certain constraints, the ultimate intent of the living shoreline project is to serve as a protective, nature-based infrastructure for the City. The Project is aimed at reducing the vulnerability of infrastructure and resources throughout the City to coastal flooding, including residences, Linden Field, campgrounds, roadways, access ways, utilities, habitat, and more.

Land Ownership

Developed areas of the City along the coastline begin at Ash Avenue and extend downcoast across Reach 2, Reach 3, and Reach 4, with the latter two lying within Carpinteria State Beach. The key landownership constraint involves homes are located close to the shore in the unincorporated neighborhood landward of Reach 1 and the City’s Beach Neighborhood backing Reach 2, thus preventing the living shoreline from being located where it would function best, along the rear area of the beach where homes have been constructed on the historic dunes and where it can be protected from waves and protect the backshore.

Reach 1, including the Sandyland Cove neighborhood backing this narrow beach is not located within the City boundary, representing a significant constraint to the City's ability to develop a living shoreline and requiring coordination with the County to conduct beach nourishment. Along Reach 2, private parcels extend into the natural beach area. The obligations and allowances of the respective parties concerning the use of public and private beaches, including addressing periodic erosion, view protection, etc., are addressed in the County of Santa Barbara Superior Court Roberts Judgement No. 79328 (*Roberts v. City of Carpinteria* [1974]). The existence of parcel boundaries within the beach area stems from the determination that the "Judgement Line" be drawn parallel with and distant southwesterly 30 feet, measured at right angles, from the northeasterly line of Ocean Avenue. Ocean Avenue was a proposed 100-foot-wide oceanfront roadway that was never constructed in the City. The public beach is designated as seaward of the Judgement Line, while "private beach" is located landward of the line.

For the proposed Project, the use of the private beach area along Reach 2 by the City is allowable, as discussed in Paragraph 7 of the judgment. Specifically, the area is open for "erosion control (but not including the right to interfere with pedestrian access to the ocean and shore from the property situated between the Judgment Line and Sandy Land Road, nor to block the view of the ocean and shore from said property with sand except when temporarily required by seasonal or storm conditions for the preservation of the public or private beach, nor to build any structures except as may be hereinafter permitted under Paragraphs 7(b), 7(c) or 8 hereof)." Although the proposed Project is intended for erosion control, the Project may not be intended as temporary. Therefore, potential conflicts could arise should the dune footprint overlap with the private beach. The annual winter berm program currently aims to construct the winter berm just seaward of the private beach, though Judgement No. 79328 explicitly allows the winter berm program within the private beach area, as it is temporary. Private owners along the waterfront are in favor of the winter berm program and will need to be approached regarding the proposed Project.

Reaches 3 and 4 largely fall within Carpinteria State Beach are under the jurisdiction of State Parks. Existing dune habitat is present in Reaches 3 and 4, therefore the proposed Project could further enhance these areas. Should this be proposed, coordination with State Parks will be required to ensure that the proposed concept is agreeable to all parties.

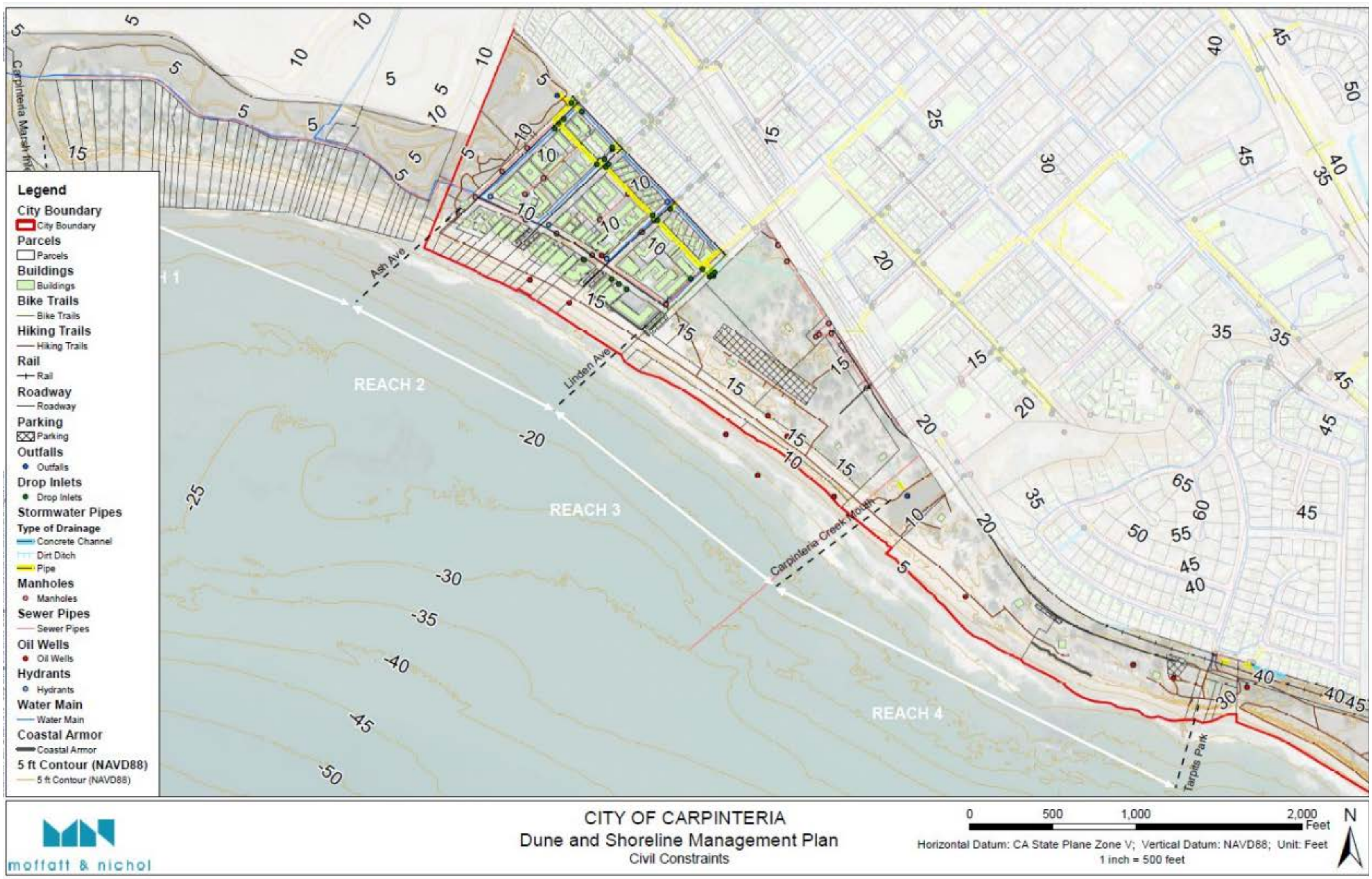


Figure 4. Man-made Constraints in the Project Area

Based on these constraints, a living shoreline within Reach 2 would present the least land ownership constraints to the City if the living shoreline is constructed seaward of the private beach. However, ideally, a living shoreline would be at least partially located within this private beach area due to its position on the back beach. Further, beach fill and dune design should consider this potential secondary effect of pooled water on the beach from extremely high tides seeping into the ground and under beachfront homes and underground structures along Reach 2. Improvement of the existing dune habitats within Reaches 3 and 4 will require close coordination with and approval by State Parks to ensure the proposed concept is agreeable to all parties.

Transportation Infrastructure

A proposed project must evaluate its potential to impact existing transportation infrastructure to best minimize and/or improve existing conditions. Along Reach 1, transportation infrastructure is primarily limited to Avenue Del Mar and Sandyland Cove Road, which provide access to Sandyland Cove neighborhood and are the jurisdiction of the County. Roadways within Reach 2 include Ash, Holly, Elm, and Linden Avenues, which run perpendicular to the shoreline. Street parking areas are also located at the end of these streets and provide access to the local beaches. Within Reaches 3 and 4, roadways and sidewalks are largely absent from the area, except for Palm Avenue, 4^{th} Street, and Sandy Land Road, which provide access to Carpinteria State Beach and Tarpits Park. Reach 3 contains the majority of the parking areas for Carpinteria State Beach.

In addition to roadways, hiking trails exist along Reaches 2, 3, and 4. From Salt Marsh Park in Reach 2, a hiking/walking trail exists inland along Ash Avenue before it transitions into the open beach area and continues eastward along the beach through Reach 2 and Reach 3. Atop the dunes in Reach 3 within Carpinteria State Beach is a pedestrian boardwalk. In Reach 4, the trails shift landward atop the rising blufftop.

Based on these constraints, measures to prevent windblown sand from accumulating on roadways, sidewalks, and paved trails should be considered. Any dune improvement activities within Carpinteria State Beach must also consider the existing pedestrian boardwalk, with avoidance of impacts to the boardwalk likely being preferred, unless State Parks agrees otherwise.

Public Access and Views

The conceptual design of the Project must consider a method to maintain beach access across all reaches and minimize or avoid impacts to public views of the beach and ocean where possible. Currently, public access to coastal areas is provided at the endpoints of Ash, Holly, Elm, and Linden Avenues within the Beach Neighborhood in Reach 2 and Carpinteria State Beach in Reaches 3 and 4. A characteristic of coastal access within Reach 2 is the ease in which pedestrians can access beach areas directly from the roadways and the ample coastal viewshed provided to waterfront residences. Additionally, visitors and homeowners of beachfront property currently have front-door access directly to the beach. Within Reach 2, the City also maintains American's with

Disabilities Act (ADA) access to Carpinteria City Beach and offers beach wheelchairs for handicapped or mobility impaired persons, as well as a boat launch ramp, at the end of Ash Avenue. State Parks also maintains ADA access to the State Beach and similarly offers beach wheelchairs by reservation.

Coastal views are already seasonally obstructed in Reach 2 as a result of the winter berm program. A living shoreline within this reach would prolong impacts on coastal views, but could be less adverse compared to a new dune in other reaches where coastal views are unobstructed year-round.

During the winter season, in Reach 2, City's winter berm program temporarily impacts public access ways and viewshed in favor of coastal erosion protection. When in effect, the majority of beachfront properties lose direct access to the beach unless pedestrians climb over the berm and viewsheds from the street ends and access from private residences are greatly impacted, as the berm reaches heights several feet above the beach surface. Additionally, cobble material is often exposed during winter periods, which can be difficult material for beach recreational activity. This program is seasonal, whereas a living dune system would be in place year-round.

Dune systems, beach nourishment activities, and dune restoration throughout the Project area would need to account for any impacts to coastal access and viewsheds at this location and ensure that recreational impacts from the use of materials such as cobble are mitigated appropriately. Particular attention should be given to the design of a living shoreline for maintaining public and ADA access at existing areas as much as possible, as well as being designed to continue to accommodate the boat launch at Ash Avenue.

Utilities

Should utilities exist within a proposed project footprint, they must be managed appropriately to avoid significant impact and maintain function. Utilities within the Project area that must be considered in the design and implementation of a living shoreline project include stormwater, wastewater, water supply, electricity, and natural gas infrastructure. Generally, within the Project area, utility infrastructure is largely set back from the coastline. The nearest sewer pipes, water mains, electrical mains, and natural gas pipelines are located along Avenue Del Mar in Reach 1 and Sandyland Road in Reach 2. Drop inlets, hydrants, and manholes are distributed throughout the Beach Neighborhood in Reach 2, though none are present west of Sandyland Road. Utility infrastructure along the coastline in Reaches 3 and 4 exists primarily along 4th Street northeast of the campground areas. Implementation of a living shoreline along any of the four reaches is not anticipated to substantially affect utility infrastructure, as the infrastructure exists inland from the beach. However, a stormwater outfall and sewer pipe do extend offshore at the Carpinteria Creek mouth but are similarly unlikely to be adversely affected by a living shoreline project.

In addition to stormwater, wastewater, water supply, electricity, and natural gas infrastructure, oil wells were historically distributed near the coastline in Reaches 2, 3, and 4. However, oils wells within the City are currently inactive and are no longer present as they have been appropriately plugged and abandoned. As such, oil wells are not anticipated to pose a constraint to the Project.

Coastal Structures

Coastal armoring provides a hardened line that must be considered in Project conceptual design as it largely inhibits the width of a living shoreline, particularly in areas where the beach area is already narrow. Coastal armoring is located at three sites within the Project area: Reach 1 fronting the Sandyland Cove neighborhood, Reach 2 involving a short extent of decorative wall, and Reach 4 fronting Carpinteria State Beach and Tarpits Park. Although armoring may present a barrier to certain Project designs, the coastal armoring present along these reaches is not considered to present a constraint to the Project, and there is an opportunity to fold it into the design to provide a last line of defense for the protection of landside assets if a living shoreline is be installed seaward of the armored area.

Existing coastal armoring in Reach 1 could reduce feasibility of a living shoreline due to more limited beach widths and increased costs of construction of removal of armoring were required.

Feasible Design Options

Variable factors affect the feasibility and success of a potential living shoreline project. These include those natural and man-made constraints identified above as well as project constructability, resilience, affordability, ability to obtain permits, and acceptance by the public. However, perhaps one of the most significant variables in the feasibility of a living shoreline project is whether sufficient sand is available, affordable, and can be permitted to be placed at Carpinteria City Beach and whether it can be retained. To assess that, this section provides a reminder of what this feature needs to accomplish, followed by discussions of sand availability and affordability, permit feasibility, and funding.

Based on the primary purpose, goals, and components of the Project, as well as the natural and man-made constraints to the Project, provided is a list of preliminary criteria for the design and function of a living shoreline project in the City. These criteria listed below were utilized to develop the list of living shoreline alternatives discussed in later sections of this report.

Design

- Develop a design that will not compromise the quality of nearshore reefs and rocky intertidal habitats.
- Determine an appropriate vegetative cover and composition.
- Determine the beach and dune dimensions needed for success.
- Assume episodic damage and repair/maintenance will be required for the beach and dunes and determine the target frequency of repair/maintenance of both (the first suggestion is every 10 years).
- Assume wind or wave runup/overtopping transport of sand or cobble inland and periodic maintenance after storms to clear private property, and transportation and access routes.

Public and Private Access

- Maintain access by well-marked pathways from public access points at all four street ends (Ash, Holly, Elm, and Linden Avenues), as well as from multiple private pathways designated for beachfront residences.

Establish and Enhance Dune Habitat Areas for Biological Resources

- Determine the appropriate mix of vegetation type, vegetation cover, and growth rates to sustain the living shoreline.
- Minimize damage or removal of native vegetation to maintain beneficial ecological functions and promote the establishment of dunes.
- Establish dunes on native sand if feasible; if imported sand must be used it should match the native grain size and be free of excessive fines (i.e., less than three percent silt and clay combined).
- Temporarily stabilize sand while plants are established.

Feasibility of a Living Shoreline

As discussed above, the considerations for the feasibility of a living shoreline consist of whether the project can be constructed, is resilient, is affordable, can be permitted, and can be accepted by the public. Each consideration is addressed below.

Constructability

Due to the presence of coastal armoring, relatively narrow beach widths, and lack of City jurisdiction over Reach 1, a living shoreline in this area is not considered to be feasible. A living shoreline at Reaches 2, 3, and 4 can be physically constructed due to the wider beach area available seaward of the homes, the private beach line, and State Park facilities; however, construction of a living shoreline at Reach 2 is likely to be the most feasible due to City jurisdiction over the area and avoidance of State Park jurisdiction over Carpinteria State Beach along Reaches 2 and 3. Although narrow, a living shoreline could be built without widening the beach. Further, the shoreline's resilience would be minimal due to exposure to wave attack during winter storms, and it would likely be damaged frequently and require extensive maintenance, especially as sea level rises. Widening the beach through nourishment will render the Project more resilient and long-lasting and, therefore, less vulnerable to damage and the need for repair.

The availability of sand sources is also a key issue to building a nourishment and dune project, given that beach-compatible sand is the primary construction material in a living shoreline and nourishment project. Beach-compatible sand exists within the area from several sources that have been identified for placement at the Ash Avenue area specifically. These include sediment from flood control debris basins in the foothills of the Santa Ynez Mountains, sediment from the Carpinteria Salt Marsh, sediment from landslides, accumulated sand supplies within and around the Harbor, and other sources such as upland construction or offshore sources (BEACON 2009); however, available sand supplies should be researched in more detail as needed in the design process to confirm sufficient quantity of material exists to support the construction of a living shoreline and initial beach nourishment. For a project of this size, offshore sand deposits may be particularly important as they are often the largest available sand source. Decadal renourishment may be possible using smaller upland sources, depending on the level of maintenance needed.

Regarding physical construction activities, construction can be done using conventional construction equipment such as trucks, scrapers, earthmovers, bulldozers, front-end loaders, and possibly other equipment. All equipment and construction personnel will require access to the site, and adequate access exists at Reaches 2, 3, and 4.

The timing of construction would likely be in the off-season beach use period, such as from Fall through Spring, avoiding spring break weeks.

Resilience

Resilience is being defined as the period over which the dune and beach system can naturally erode and repair itself while limiting coastal flooding of built areas. Project resilience will be greatest in the near term at existing sea level and then would likely decrease over time as sea level rises. Assuming the Project can be built by the year 2025, based on sea level rise projections, a living shoreline along the City's coastline should be resilient through the year 2050 or perhaps 2070 and be capable of protecting infrastructure from flooding. However, the resilience of the Project is ultimately dependent upon its design and whether sufficient beach nourishment occurs to establish a sufficiently wide beach (e.g., 250-feet-wide) fronting the dune system. A combination of beach nourishment and sand retention will be key to improving the Project's resilience and should be considered. The rapidity of sea level rise could also affect project consistency.

Another factor to consider is how to prolong retention of sand placed through beach nourishment for as long as possible as renourishment events are extremely expensive. A common form of sand retention structure is a groin, a structure oriented perpendicular to the coastline that is designed to trap sediment that would normally move downcoast. Structures can be built from a variety of materials, including rock or sheet pile walls. During the installation of a groin, sand is placed upcoast of the retention structure to create the sand deposit that would form naturally. Once filled, the sand on the upcoast side of a groin forms a "fillet", which helps to widen beaches and mitigate potential impacts from erosion and wave hazards. An example of this process can be seen in the County of Ventura at Ventura Beach where a field of seven groins retain sand upcoast, maintaining a wide beach capable of supporting coastal strand and dune habitat. While groins are typically the most common form of sand retention structures built in the State, other forms of sand retention structures exist. One other type of sand retention feature involves the construction of nearshore reefs or headlands which can be used to retain sediment by dissipating wave energy and reducing erosive forces.

Affordability

Projects along the coast are expensive and can be challenging for local agencies to afford. Funds necessary to implement a living shoreline project are variable depending on specific design and construction requirements. The most recent project at Cardiff in Encinitas cost nearly $700,000 per acre ($2,700,000 over 4 acres) for just the living shoreline itself, and that project had the benefit of a 300,000-cy beach nourishment project immediately seaward and which was funded separately (Appendix A). Locally, the cost of beach nourishment can be anticipated to cost roughly $15-$20 per cy of sand, a considerable expense when hundreds of thousands of cy of sand would be required. These costs would be greater if sand retention is required. Groins can vary in size and material resulting in a varying range of costs, though they are typically much less costly when compared to alternative sand retention measures. For instance, nearshore reefs or headlands require larger size rocky material to feasibly withstand and reduce offshore wave energy and also require a much larger footprint, thereby making such features more costly.

While initial implementation and ongoing maintenance costs may be significant, the use of living shorelines as a coastal protection strategy has risen in popularity in recent years due to the potential for multiple benefits to surrounding coastal communities and ecosystems. State agencies such as the California State Coastal Conservancy, CCC, and California Natural Resources Agency have provided funding for past living shorelines projects. Agencies such as Caltrans have also supported living shorelines projects as a means to protect transportation infrastructure from coastal hazards over time. Federal funding opportunities are also available through agencies such as the NOAA and the National Fish and Wildlife Foundation. Thus, it is reasonable to assume that the City could reasonably afford/fund Project implementation through a combination of funding measures.

Permitting Requirements

Although the Project would be subject to rigorous and expensive permit processes, it can be permitted given sufficient time and funding resources. Construction and maintenance of a living shoreline will require permits or determinations from several resource agencies. The general list of anticipated permits for a living shoreline and beach nourishment project is summarized in Table 1 and includes several federal, state, and regional/local permits. In addition to permitting requirements, living shoreline projects would also have to meet requirements of the California Environmental Quality Act, and possibly the National Environmental Policy Act if a federal nexus is identified. More specific permitting requirements for the preferred design of the Project are discussed under *Living Shoreline Adaptive Management* below.

Table 1. Living Shoreline and Beach Nourishment Permitting and Actions

Resource Agency	Permit
Federal	
U.S. Army Corps of Engineers	• Section 404 Permit, Clean Waters Act, 33 USC Section 1344, Section 404 • Section 10 Permit, River and Harbors Act of 1899, 33 USC Section 403
State	
Central Coast Regional Water Quality Control Board	• Section 401 Water Quality Certification, Clean Water Act, 33 USC Section 1344
California Coastal Commission	• Coastal Development Permit
State Parks	• Memorandum of Agreement o If Project construction and maintenance occurs within State Parks jurisdiction • Right of Entry Permit o If Project construction and maintenance requires access to State Parklands
California State Lands Commission	• Lease Agreement o If sediment for beach nourishment or dune construction is acquired from tidelands outside of City jurisdiction (e.g., 4H Platform "Shell Mounds")
Regional/Local	
City of Carpinteria	• Encroachment Permit • Grading Permit • Noise Variance or Exemption Letter
County of Santa Barbara	• Encroachment Permit o If Project construction and maintenance occurs within Reach 1 • Grading Permit o If Project construction and maintenance occurs within Reach 1 • Noise Variance or Exemption Letter

Concerning sand retention structures, they have often been difficult to permit in the recent past, with the primary disapproval coming from the CCC, which often deems such projects in conflict with the Coastal Act of 1972. Key issues that tend to arise surround the impacts that groins may have on downcoast areas. While a groin will promote beach growth upstream, the downstream end can suffer from erosion if not addressed in the design and construction to mitigate the impact. The design can minimize these impacts by over-nourishing (i.e., pre-filling) the site following groin construction to promote sand transport downcoast or installing a low elevation and short length groin, which allows sediment to pass once a certain beach width is obtained upcoast. However, recent research has identified groins as an effective sea level rise adaptation measure, and groins may become more favorable or permittable as additional studies are completed and their effectiveness is demonstrated. For example, a study recently completed in 2020 on the subject (Griggs et al. 2020) found that:

> *"While groins have been generally discouraged in recent decades in California, and there are important engineering and environmental considerations involved prior to any groin construction, the potential benefits are quite large for the intensively used beaches and growing population of southern California, particularly in light of predicted sea-level rise and public beach loss. Stabilizing and widening the beaches would add valuable recreational area, support beach ecology, provide a buffer for back beach infrastructure or development, and slow the impacts of a rising sea level. All things considered, in many areas groins or groin fields may well meet the objectives of the California Coastal Act, which governs coastal land-use decisions."*

In addition to this research, many local jurisdictions such as the cities of Imperial Beach, Del Mar, and San Francisco are all exploring sand retention as part of adaptive management planning to address seal level rise.

Acceptance by the Public

The acceptability of a project by the public is difficult to assess but is an important aspect of any sea level rise resiliency project. Public sentiment may be mixed with feelings of wanting to be protected from flooding and feelings that the status quo of building a winter dike is sufficient. Sentiments may vary but be less supportive until local ocean water levels show definitive increases. Thus far, sea level rise has remained more of an abstract concept rather than a tangible reality for many residents due to its less than obvious presence at this time. Severe coastal flooding has not occurred since the 1988 storm, and even more prominent since the 1982/82 El Niño event. If a significant El Niño winter threatens property, local feelings may be more supportive

It is worth noting that throughout the process of preparing this plan, local stakeholders and the public have thus far shown support for the Project. It will be important for the City to be able to continue to garner public support at every step of the process to maintain a sufficient level of public support to implement the Project. The issues that may raise public questions may be related to views, access, costs, and other potential concerns. Keeping these issues at the forefront of planning and analyses during the Project design and reporting will help secure a supportive position of the public that can be used to apply political pressure on funding agencies.

Living Shoreline Design Alternatives and Modeling

To aid in the refinement of the design of the proposed Project and determine the performance of various shoreline adaptation and resiliency improvements proposed to address conditions such as sea level rise and major storm extreme wave events, a site-specific numerical model was prepared to support the preparation of this plan. This section of the plan summarizes the modeling performed, alternative shoreline design measures, and the recommended living shoreline design based on predicted performance, and project design details. A preliminary design of the dune system was prepared with different strategies in early 2021 (Appendix B), and a modeling analysis was completed in late 2021 (Appendix C). Preliminary recommended Project design is presented below, based on modeling of alternatives, public and stakeholder feedback, and existing site and design constraints. Further study, coordination, planning, and permitting are required to fully develop and implement the Project.

Preferred Model

The effects of storm conditions on shore-normal overtopping and erosion along Carpinteria City Beach for existing and proposed beach profiles were evaluated with a cross-shore profile using the numerical model XBeach rev. 5834 (released May 11, 2021). Xbeach is a widely applied numerical model developed by the USACE in collaboration with European scientists at Deltares. The model predicts wave runup and overtopping on the beach and the changes in the beach profile (the cross-sectional elevation of the beach) using input data of beach profile, tidal elevations, ocean wave height, and period. The model is useful in predicting the changes in the beach profile and consequent changes in wave runup over the beach. These predictive capabilities are suitable for determining the elevation of wave runup at the living shoreline location at the back of the beach and any residual wave overtopping. It enables a relative comparison of the dissipative properties of alternative cross-shore profile configurations of alternative projects (Appendix D).

Alternatives

Based on the Project constraints, feasibility, and preliminary concept design options, four different alternatives were developed with the City and project team for analysis. Each of these four alternatives is intended to reduce potential flooding of and wave attack damage to the Beach Neighborhood, and a portion of Carpinteria State Beach, but not prevent it entirely. Although the Project study area extends for almost one mile from the Carpinteria Marsh outlet, the primary focus of major improvements would extend for approximately 1,440 feet within Reach 2 from Ash Avenue to Linden Avenue within areas under City jurisdiction for beach nourishment, and dune construction. The Project would also include non-native vegetation removal and replanting with native species in a small extent of Reach 3 around the creek mouth and construction of a short, 350-foot-long living shoreline within Reach 4 from Carpinteria Creek to near Tarpits Park. Any improvements within Carpinteria State Beach would require coordination with and approval of State Parks. Of those alternatives that consider the construction of a living shoreline, the same living shoreline design is proposed at both the Beach Neighborhood and a portion of Carpinteria State Beach east of Carpinteria Creek.

Alternatives Considered and Discarded

Two alternatives were considered and discarded due to permit challenges, cost, and biological resource concerns. One alternative would involve the construction of a breakwater or artificial reef within City-owned tideland offshore of Reach 2 made of rock or potentially other sources (e.g., geotubes) to decrease wave energy, slow downcoast transport of sand causing sand to deposit offshore, protect the beach from wave attack, and increase overall beach width. Challenges with this alternative include the initial cost of breakwater or reef construction and anticipated major challenges with permitting. No recent permits for breakwaters have been issued in the State and none have been approved by CCC since the 1960s leading to concern that such a project could not reasonably be permitted. The second alternative considered but discarded from detailed analysis would involve the construction of an artificial headland at the southernmost end of Reach 4. This alternative would increase sand retention northward of the headland, creating an extended wider beach and new shoreline alignment. This alternative was ultimately discarded from further evaluation due to potentially higher costs associated with material acquisition and construction, as well as concerns with challenging permitting and impacts to biological resources.

Alternatives Carried Forward for Analysis

A brief description of the alternatives carried forward for analysis is provided below. The primary Project reach for beach nourishment and dune construction would extend from Ash Avenue to Linden Avenue within areas under City jurisdiction, with vegetation management along Reach 3 and a short 350 feet long segment of Reach 4, from Carpinteria Creek to near Tarpits Park at Carpinteria State Beach.

Alternative 1 – Existing Winter Berm

Alternative 1 would involve the continuation of the City’s existing winter berm program. The City’s existing practice of erecting a winter berm/dike generally protects the Beach Neighborhood under existing typical storm and tidal conditions but requires maintenance and repair during and after major storms. It was first developed in 1983 during an extreme El Nino winter of high waves and very high tides. Construction of the winter berm involves the use of approximately 20,000 cy of existing beach sand, as well as approximately 10,000 cy of cut and 10,000 cy of fill. The berm is constructed by using heavy equipment to move sand from the intertidal and dry sandy beach area to the landward edge of the beach fronting existing residences to build an approximately 9.5-foot-tall berm to an elevation of +19 feet relative to North American Vertical Datum 1988 (NAVD

88). Berm side slopes are relatively steep at approximately 2:1 or 3:1 (horizontal:vertical, or H:V). The berm extends the entire length of Reach 2 from Ash Avenue to Linden Avenue. Under Alternative 1, no changes to the City's existing program are proposed. The winter berm would continue to be erected at the beginning of the winter season, then removed in the spring, annually. Maintenance of the berm occurs during the winter season on an as-needed basis in response to erosive storm/wave events to maintain the size, height, and slope of the berm. No other improvements to the shoreline outside the winter season would be proposed under Alternative 1.

This alternative was selected for modeling as it represents an existing baseline condition for which other alternatives can be compared against, as well as to model the effectiveness of the existing winter berm program at protecting the City's Beach Neighborhood under future sea level rise conditions.

Alternative 2 – Wider Beach from Nourishment

Alternative 2 would involve extensive beach nourishment within Reach 2 to create a wider beach. The existing beach of approximately 100 feet wide at Ash Avenue would be widened through a one-time beach nourishment event involving the placement of approximately 500,000 cy of sand in the area between Ash Avenue and Linden Avenue. This amount of beach nourishment would create a beach anticipated to be nearly 250 feet wide from the back of the beach to the mean high-water line and maintain a maximum elevation of +12 feet NAVD 88, consistent with the natural elevation of similar beaches in southern California. Following beach nourishment under Alternative 2, the beach would slope seaward at 5:1 H:V toward the water. This sand volume would be adequate to fully nourish the City beach and provide sufficient sand to maintain a protective wide beach after the beach reaches equilibration wave adjusted post-construction profile. Sediment for nourishment would be delivered to the site likely from a combination of offshore or onshore sand sources. Sand would disperse both offshore and downcoast from the newly widened beach with the beach narrowing within one season. The beach width after one season of ocean waves and tides reworking would be approximately 170 feet from the back of the beach and the beach profile would flatten to approximately 10:1 H:V.

Alternative 3 – Single Ridge Dune with Wider Beach

Alternative 3 would involve the design and construction of a single ridge dune fronted by a wider nourished beach. The dune would be slightly lower in crest elevation than the existing winter berm and involve an approximately 6-foot-tall dune (up to +16 feet NAVD 88), and be wider and relatively flatter in grade. Alternative 3 would also involve nourishing the beach with approximately 500,000 cy of sand during a one-time nourishment event before construction of the dune, similar to Alternative 2. The side slopes of the dune would be designed to mirror natural dunes with a slope of 4:1 or 5:1 and the dune footprint would be 60 feet wide at the base. It would extend the full length of Reach 2 (approximately 1,440 feet). In addition, if approved by State Parks, an approximately 350-foot-long dune of the same design would be constructed along a short reach of Carpinteria State Beach in Reach 4 downcoast from the mouth of Carpinteria Creek towards Tar Pits Park. Dune habitats at both sites would consist of California native southern foredune plant species that would be installed on these new dunes to promote its natural resilience and re-building properties. The dunes would be reinforced with a cobble core and/or within a cobble apron at their toe as needed to improve resilience. Access would be provided over the dune at each street end in the form of a ramp that angles up the face of the dune, reaches the crest, and then angles down the other side. An ADA and boat launch ramp will be installed at the foot of Ash Avenue with a very gradual slope and an artificial surface to maintain existing access to the City Beach at this location. The crest elevation of the dune would not drop at the location of access points.

Alternative 3 would also involve regular monitoring, dune maintenance (e.g., potential repair after major storms), and beach nourishment activities such as periodic re-nourishment to maintain the wider beach and dune through 2050 or 2070.

Alternative 4 – Double Ridge Dune with Wider Beach

Alternative 4 would involve a variation of Alternative 3, with the construction of a double ridge dune fronted by a wider beach. The dunes would also be lower in crest elevation than the existing winter berm and involve an approximately 6-foot-tall dune (up to +16 feet NAVD 88), and be wider and relatively flatter in grade. Within the same footprint, there would be two dune peaks rather than one proposed under Alternative 3. The concept is based on increasing friction on incoming waves to reduce their energy in an attempt to reduce their runup elevations. Alternative 4 would involve all the same elements of Alternative 3, including beach nourishment, slope, location, length, construction techniques, monitoring, and maintenance.

Methods

Using the XBeach model, each of the four alternatives was analyzed for their ability to block water from storm waves, high tides exacerbated by sea level rise, overtopping the beach, and flooding the neighborhood. Each storm simulation required two model runs to estimate both erosion of beach and dunes and overtopping the beach under each alternative. These results from each model run were compared to identify which alternative configurations lowered the wave runup elevation the most at the rear end of the beach. Overtopping depths for each scenario formed the basis of quantitative comparisons between proposed beach profile alternatives, and morphological results formed the basis of qualitative comparisons between alternatives.

Storm conditions considered include the combined storm wave and tidal event that would occur every 10 years, every 20 years, and every 100 years (in two different wave/tide combinations). In addition, these environmental conditions were also run for existing sea level and a projected sea level rise scenario of up to two feet (expected to occur in 30 to 50 years, or by 2050 to 2070), consistent with OPC guidance at the City's SLRVAAP.[5] More weight was given to the results for more frequent storms such as the 10- and 20-year storm events because this project is intended to function during the near-term of sea level conditions and thus the more frequent storm events. It is assumed that under 100-year storm conditions and combined with sea level rise that significant damage would occur along the shoreline and the living shoreline would need replacement or significant repair.

Model Results

The four alternatives were compared for results of wave runup elevations at the rear of the beach for the four different wave and tide combinations. Results for the 10-year and 20-year storms are shown in the Carpinteria Living Shoreline Concept and Analysis Memorandum (Appendix C). The order of performance of the alternatives in reducing wave runup elevations and subsequent overtopping is presented from best to worst below. It should be noted that under every alternative, whitewater overtops the dune/beach and could result in damage to facilities landward of the back beach; however, the elevation of that water is minimized under the scenario of the single ridge dune with a wider beach (Alternative 3).

1. Alternative 3 – Single Ridge Dune with Wider Beach;
2. Alternative 1 – Existing Winter Berm;
3. Alternative 4 – Double Ridge Dune with Wider Beach; and
4. Alternative 2 – Wider Beach from Nourishment.

Recommended Alternative and Detailed Design

As presented above, Alternative 3 would reduce wave runup elevations and subsequent overtopping to the greatest degree when compared to the other three alternatives. It is therefore recommended that the City pursue a living shoreline design consistent with that described for Alternative 3 (hereafter referred to as the "Project").

The Project is designed to increase the resilience of the area to coastal erosion and flooding driven by storms, swells, and sea level rise, and would also provide ample beach access, recreation space, and habitat. The Project relies on three components: 1) beach nourishment to widen the shore, increase sediment volume, and create more space for coastal dynamics (accommodation space), 2) installation of a sand retention structure to increase the life span of sand put in place in the nourishment component, and 3) the establishment of vegetated dunes on the backshore (see Figure 5; depicted in light green).

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[5] It is noted that recent scientific work has identified the potential for an extreme sea level rise scenario referred to as the H++ scenario. Under this scenario, two feet of sea level rise could occur sooner than 2050 (City of Carpinteria 2019).

Beach and Dune Nourishment Plan

The proposed Project would involve the placement of 500,000 cy of imported sand (beach nourishment) in Reach 2 on the City's Beach. The addition of sand to the site would create a wider beach that could buffer the new dunes and inland structures from wave attack, provide more recreational space, and serve as a natural sand source for the dunes and living shoreline over time. New sand would be delivered to the site from another location to build this beach, either from offshore deposits or onsite sources such as ~~flood detention~~ debris basins, construction sites, and possibly the Carpinteria Marsh. Sand would disperse out of the placement site through natural wave action and longshore transport after placement and leave a narrower beach within one season. The initial width of the City beach between Ash Avenue and Linden Avenue immediately following placement of 500,000 cy of sand is estimated to be approximately 250 feet from the back of the beach with a 5:1 H:V seaward slope. This nourished beach would be reworked after one season of ocean waves and tides to approximately 170 feet in width from the back of the beach and flatten to approximately 10:1 (H:V). The 170-foot-wide beach would be adequate to support the width of the proposed dune system/living shoreline, support beach recreation, and buffer the living shoreline from frequent wave attack. The imported sand grain size would generally match that of sand currently on the site to support dune-building processes.

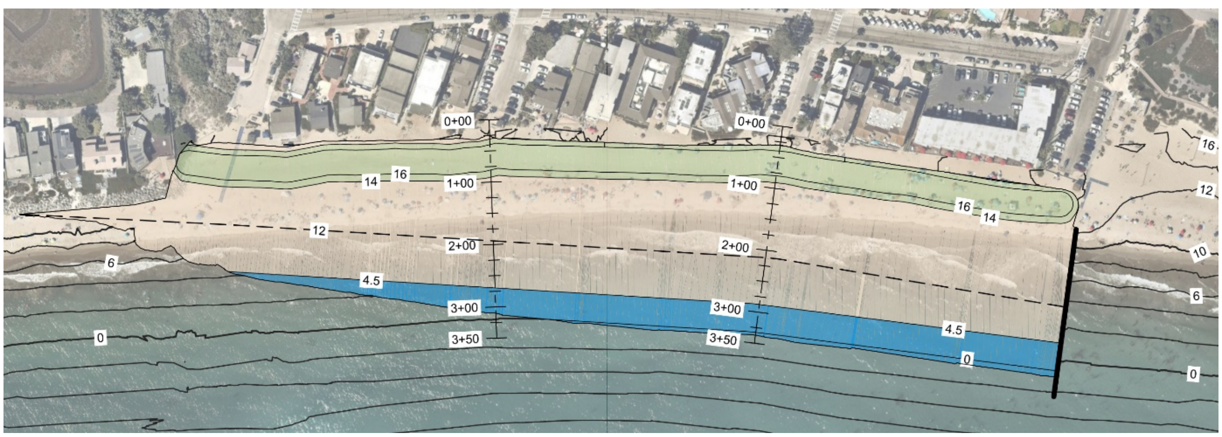


Figure 5. Recommended Project Extent and Location

Dune Design Details

The proposed design of the dune would feature uneven, natural appearing hummocks and saddles topped with native dune vegetation, similar in design to the recently completed Cardiff Beach Living Shoreline (pictured). Sand fencing would be utilized to guide pedestrians along designated pathways and protect native dune vegetation.

Preliminary design of the proposed dunes/living shoreline as described for Alternative 3 above would involve a single ridge dune approximately 40 feet in width at the dune crest (Figure 6). The dunes would be constructed in roughly the same location where the City's winter sand berm is currently constructed annually. The dune crest should be variable and naturalized with hummocks and saddles, but should generally be constructed to a crest elevation of +16 NAVD 88 (6 feet above existing beach elevation) with a seaward slope of 5:1 H:V. The design of the dune should include accessways at each street end (Ash Avenue, Holly Avenue, Elm Avenue, and Liden Avenue), and a combined boat launch and ADA ramp at Ash Avenue to maintain existing beach access provided at these locations. Similar to sediment used for beach nourishment, the dunes should be constructed with sand that has a grain size characteristic generally equivalent to natural sand existing at the site.

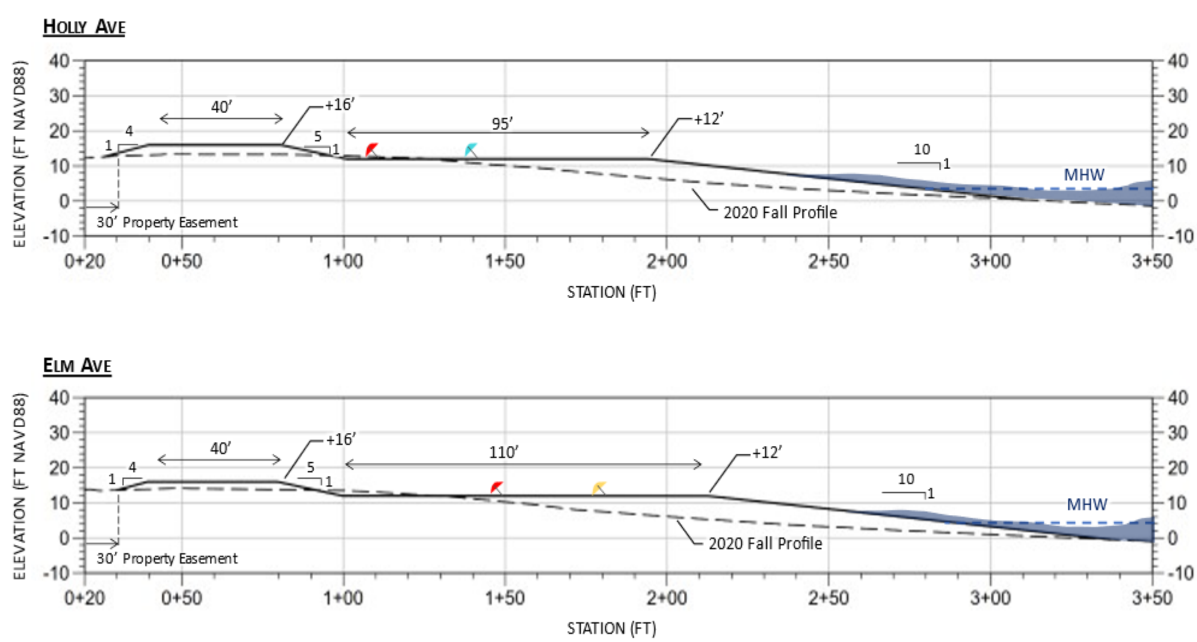


Figure 6. Cross-Section of the Project with a Temporary Pilot Groin with Wider Beach and Single Ridge Dune

Beach Design Details

The Project would maintain existing beach characteristics, except for the creation of a wider beach area through beach nourishment and construction of a 60-foot-wide dune. Under existing conditions, Carpinteria City Beach ranges between 65 and 200 feet in sandy beach width, depending on the season, sand supply, and overall climatic and weather conditions. Under the Project, the sandy beach width would be approximately 170 feet wide with a gentle slope, similar to existing conditions. Project implementation would result in a more uniform wider sandy beach width due to the proposed sand retention pilot groin, which would reduce downshore drift of sand. If funded adequately, re-nourishment is anticipated to occur every 5-10 years to maintain a wide sandy beach, along with periodic dune repair as needed.

Planting Design and Palette

Dune establishment would involve placement of sand, seeding with native plant seeds, and installation of symbolic fencing (e.g., post and ropes) to reduce disturbance from foot traffic and City lifeguard and maintenance vehicles. The dunes would be vegetated with California native dune plants. Native dune plants are well adapted for retaining and building coastal dunes in California with no irrigation required and seeds sourced from the local area. Most dune plant seeds remain viable for many years but the germination rates of native dune plant seeds will be low in any given year. If the performance of planted seeds is poor following the first year after seeding as a result of very low rainfall (less than 6 inches), the City should consider re-seeding in the second year. Subsequent seeding and replanting each year depending on performance would be crucial to dune vegetation's successful establishment. Symbolic fencing will help prevent damage to dune planting from trampling by beachgoers, City beach grooming activities, and lifeguard and maintenance vehicles driving on the beach. Native dune plant species recommended for planting on the dunes include typical locally occurring dune species along with other plant species adapted to more stable sands inland of the dune, with a typical seeding rate in pounds per acre (Table 2). Planting would typically involve the preparation of the sand surface using a rock rack to create deep grooves in the sand, scattering of the seeds/fruits by hand, and burying with rock rakes.

Table 2. Dune Planting Palette and Seeding Rates

Common Name	Species Name	Seeding Rate (Pounds Per Acre)
Dune Forming Plant Species		
Red beach verbena	*Abronia maritima*	10
Beach bur	*Ambrosia chamissonis*	6
Beach saltbrush	*Atriplex leucophylla*	8
Other Plant Species		
California poppy (coastal)	*Eschscholzia californica*	--
Beach evening primrose	*Camisoniopsis cheiranthifolia*	--

During initial dune planting, some form of sand stabilization may help plants establish such as sand fencing or crimped straw mulch. Sand fencing is an effective technique for stabilizing areas with high levels of blowing sand and for building dune volume in the short term. However, it is not a permanent solution. Sand fencing can be effectively used along the seaward dune perimeter and walkways alongside re-vegetation techniques to delineate restoration areas, slow sand movement, build topography and create areas suitable for plant establishment. The use of sand fencing should increase the resilience of the Project area against storm erosion and sea level rise. Crimped straw mulch helps retain sand around dune pants and within the dune system itself.

Beach Access Design

Both public and private beach access will be maintained in all phases of construction and maintenance of the Project. During Project construction, heavy equipment would be operating across the beach as well as potentially trucks hauling sand down City streets to the beach, barges operating offshore and pumping sand onshore, and potentially sand pumped to the beach from the Carpinteria Salt Marsh. Construction management, in general, would include flaggers to direct traffic, temporary orange construction fencing where needed, construction monitors to ensure beachgoers remain safe around heavy equipment, directional signage, and potentially short-term beach closure.

The dune shall be designed to provide adequate spacing between the dune and private residences along Reach 2 to allow continued access to the beach. Long-term management of access through the dunes would employ using symbolic fencing such as bollards and ropes to direct public access from street ends and parking areas along four pathways through the dunes. The proposed fencing would guide access across the dunes and minimize trampling of the dunes and vegetated areas. While boardwalks are effective for providing good public access, they are expensive and can change the character of beach access compared to post and rope fencing. Similarly, rubber or plastic matting along the four proposed access paths. Rubber mats are currently utilized to support ADA access and boat launch activities at the end of Ash Avenue and could continue to be utilized at this location under the Project. A preliminary design for proposed fencing and location/orientation of beach access points is depicted in Figure 7. As shown, the dunes (portrayed by tan features) would be fenced on all sides (portrayed by bright pink line features) and access paths are proposed to be set at an angle (north to south or north-northwest to south-southeast) so that they do not line up with the angle of strong winds at the site. Installation of sand fencing on the seaward and landward sides of the dunes and possibly along pathways for some interim period would reduce sand movement, improve retention, and could improve plant establishment.

Figure 7. Proposed Fencing and Beach Access Locations

Potential Sediment Sources

A preliminary review of potential sources of beach quality sand within the region has identified four potential sources. To support the construction of the living shoreline, initial beach nourishment, and future maintenance activities, the City could acquire sand from either one or a combination of the identified sources. Currently, the most abundant source of sediment appears to be from offshore sources. However, other sediment sources are also available and have historically been utilized for beach nourishment activities within Santa Barbara County (e.g., foothill debris basin cleanout) and would present opportunities for use of sediment that would otherwise be disposed of at the County landfill.

Offshore Sources. Several large subsurface sources of sand exist offshore of the County's coastline. Past research identifies the general location, quantity, and quality of sand of potential offshore subsurface sand supplies (BEACON 1989). These are generally large pockets. A preliminary review of available BEACON data identifies four significant reserves of fine sand offshore of Goleta Beach County Park, Santa Barbara East Beach, Carpinteria City Beach, and the Santa Clara River delta. These deposits, totaling in the millions of cy, constitute the most significant source of sand that is available for beach re-nourishment (BEACON 2009). An additional potential offshore source off of Carpinteria Creek may also exist. All potential offshore sand sources may need to be more thoroughly investigated to determine suitability and feasibility. This type of work is costly and should be done in collaboration with a regional entity such as BEACON in the context of regional sediment management.

Carpinteria Salt Marsh Desilting. The Carpinteria Salt Marsh, located just west of the City, presents a potential source of sediment for both beach nourishment and dune construction. Sediment from Franklin Creek and Santa Monica Creek, as well as that washed in through the marsh's outlet, accumulate within the marsh. The Flood Control District manages the desilting of debris basins located in the upper reaches of Santa Monica and Franklin creeks and a siltation basin located on Via Real north of the marsh (Ferren et al. 1997). In 2020, the Flood Control District updated the Carpinteria Salt Marsh Enhancement Plan to allow for surf zone disposal (beach nourishment) of sediments from Santa Monica and Franklin creeks by trucking to the terminus of Ash Avenue or by hydraulic dredge and transport by pipeline to the beach (Flood Control District 2020). Completion of the plan update facilitates this desilting program and represents a significant opportunity for the City, in coordination with the Flood Control District, to utilize this sand for initial and episodic beach nourishment under the Project. The Flood Control District estimates that dredging/desilting of the marsh could result in deposition of 6,000 to 40,000 cy of sediment per event (Flood Control District 2020). Given the nature of this program and planned disposal of dredged materials at the Project site, the City should coordinate with the Flood Control District to utilize this sediment. However, the amount of sediment generated by this program is not enough to fulfill the needs of the Project.

In addition to sediments in ~~detention~~ debris basins in the eastern end of the marsh discussed above, substantial but unquantified amounts of apparently beach quality sediment exist in the central and western portions of the marsh that are under the management of the University of California Natural Reserve System. As part of its work on the State Oil & Gas Lease PRC 1824 & PRC 3150 Terminations and Disposition of 4H Shell Mounds, the California State Lands Commission (CSLC) considered a possible enhancement of the marsh through the removal of an estimated tens of thousands of cy of sediment from the marsh. Chevron, the entity responsible for addressing the offshore shell mounds, offered to pay $3,000,000 in fees to enhance essential fish habitat within the marsh by removal of sediment and its disposal on the beach. The outcome of this project, any required mitigation, or potential payment of fees remains unclear, but the removal of sediment from within the University of California Natural Reserve may offer an important source of sediment for beach nourishment and/or dune creation in the future.

Flood Control ~~Detention~~ Debris Basins. The Flood Control District supports beach nourishment at Goleta Beach through the desilting and deposition of sediments accumulated within the Goleta Slough as part of its mission of flood protection. This program for disposal of sediments from the Goleta Slough detention basins in Los Carneros and Tecolotito creeks, as well as desilted material from designated areas within the drainage channels of San Jose, San Pedro, and Atascadero creeks, at Goleta Beach is fully permitted. Obtaining these permits required a multi-year effort of almost a decade and cost hundreds of thousands of dollars in permitting fees, environmental review, and extensive technical studies. Although this sediment is restricted to Goleta Beach, this program, along with the Carpinteria Salt Marsh program described above, offers a model for the potential use of sediment from foothill debris basins located within 13 of the South Coast's watersheds.

The County currently has permits to desilt foothill ~~detention~~ debris basins but does not have permits for regular disposal of this sediment on area beaches, depriving South Coast beaches of a major source of sediment that would naturally nourish these beaches. This program is coordinated through the Flood Control District's ~~Final Updated Debris Basin maintenance and Removal Plan (2017)~~ 2021 Debris Basin Maintenance and Management Plan. Over the last decade alone, due to lack of expensive and difficult to obtain permits, hundreds of thousands of cy of beach quality sediment have been sent to landfills or quarries rather than to area beaches, depriving South Coast beaches of a major source of sand for beach nourishment. While emergency disposal of a small portion of these sediments occurs on occasion, in general, this major source of sediment is lost to the littoral system. While sediment within the foothill debris basins is typically suitable for beach nourishment, the barrier of extremely expensive and difficult to obtain state and federal permits has discouraged the Flood Control District from pursuing such permits. This existing program presents another opportunity for the City to coordinate with the Flood Control District for the acquisition of sediment for Project beach nourishment and dune construction.

Opportunistic Construction Sources (e.g., Carpinteria Rincon Multi-Use Trail). Sediment for Project beach nourishment and dune construction activities may also become available as a result of local construction projects occurring within the City or surrounding areas. Construction projects often involve grading, with excess cut material disposed of at local landfills or used as construction fill. Depending on the location and scale of the project, they may be opportunities to utilize excess fill material from these construction sites, if the material can be sorted and is determined to be beach compatible. One such opportunity is the City's recently proposed Carpinteria Rincon Multi-Use Trail project. This project, to be constructed from the eastern end of Carpinteria Avenue to Rincon Beach County Park, would involve an estimated 104,000 cy of cut. Only 10,300 cy of this material would be used for fill on-site, while the remaining 94,100 cy is proposed to be exported offsite (City of Carpinteria 2021). Approximately 50 percent of this material is anticipated to consist of beach compatible material

Sand Retention

The importance of sand retention in improving resilience to coastal hazards has been well-studied throughout the State, as well as other coastal communities throughout the U.S. Within California, approximately 49 groins have been built to stabilize and/or widen beaches across seven coastal counties. Nearly 42 of these groin projects, or 84 percent, are located within the Southern California counties of Santa Barbara, Ventura, Los Angeles, Orange, and San Diego. Many groins have proven successful in sand retention on upcoast beaches and prolonging wider beach conditions upcoast. For instance, at West Newport Beach, eight rubble mounds and sheet pile groins were installed in the 1960s and 1970s and have since been proven effective in maintaining a wider beach with both structural and recreational benefits (Griggs, et. al. 2020). One of the chief concerns over the use of groins is the interruption of downcoast sand transport with potential deleterious impacts to and erosion of downcoast beaches. For example, with the construction of the Santa Barbara Harbor breakwater in the 1930s, large-scale downcoast beach erosion occurred, including along City beaches, with substantial damage to shoreline homes and facilities. To address such concerns, many modern sand retention projects often include upcoast beach nourishment and the overfilling of the upcoast beach to permit sand to drift downcoast. Sand retention features can also be designed to limit but not block sand transport to reduce impacts to downcoast beaches. All types of sand retention structures face this challenge, although as discussed below, the ease of addressing such impacts through design vary.

Sand retention is also being proposed as part of many local agency adaptive management plans (AMPs) to address shoreline management and retain wider beaches to address projected increased beach erosion associated with sea level rise. For example, the AMPs for the cities of Imperial Beach, Del Mar, and San Francisco all include recommendations that sand retention plays an important role to improve resiliency to sea level rise, while the County of Los Angeles recommends considering extending existing groins (Santa Barbara County Community Services Department, Parks Division 2019).

A sand retention structure, potentially at Linden Avenue at the eastern extent of Reach 2, would help retain sand along the nourished beach, increasing longevity of the wider beach resulting from proposed beach nourishment activities, reducing the need for more frequent beach re-nourishment and associated costs (e.g., sediment acquisition, construction). However, the exact design and effectiveness of a sand retention structure on maintaining sand on the upcoast beach, as well as its potential impacts on downcoast beaches, remains to be determined and would require further study. The following discussion presents general information regarding key issues regarding sand retention structures, potential sand retention structure design options, and recommendations for a preferred sand retention design option that should be considered by the City as part of this Project.

Sand Retention Design Options

Sand retention structures along the coast of California vary in design, but they generally fall within three classifications: 1) sheet pile walls, 2) rock groins or “jetties”, and 3) permeable piers. Offshore breakwaters also exist which interrupt wave attack and energy and reduce sand transport downcoast, such as the large structure north of Santa Monica Pier, but they are less common. Presented below is a brief discussion of each of these design options that could be suitable for the City and effective in supporting wider beach conditions, improving resilience and effectiveness of the proposed living shoreline.

Sheet Pile Wall. Sheet pile wall sand retention devices involve the installation of interlocking sheet pile walls comprised of either concrete, steel, or fiberglass perpendicular to the coastline to trap sediment upcoast. The sheet pile walls are driven into the beach using either pile driving or vibrating methods to form a lengthy wall and can be constructed to a height that matches existing beach grade, or to a height that extends above existing beach grade, forming a wall-like structure. An example of such a groin exists on the western portion of Seal Beach Municipal Pier in the City of Seal Beach. This groin was installed in 1956 to offset the longshore sediment transport and loss of the beach area east of the pier. The City of Seal beach estimates that without this structure in place, erosion rates in the area would increase by approximately 50 percent (City of Seal Beach 2019). Sheet pile walls can be designed at an elevation to permit passage of sand over the sheet pile wall, minimizing impacts to downcoast beaches while still retaining upcoast sand. Sheet pile walls can also be relatively easy to remove if unacceptable downcoast beach erosion occurs.

Rock Groin. Rock groins or jetties are the most common and traditional form of sand retention devices. They typically involve the construction of a wall of large rocks perpendicular to the coastline to trap sediment upcoast. Examples of structures can be found in the County of Ventura at Pierpoint or San Buenaventura State Beach. Unlike sheet pile wall sand retention devices, most rock groins are constructed on top of the beach and create a wall-like structure that can be difficult to navigate over without dedicated public access points or stairways. For example, recent large rock groins installed to facilitate tidal interchange at Bataquitos Lagoon in the County of San Diego block lateral access along the beach, forcing lateral access up onto the Highway 1 bridge. Further, rock groins are not permeable structures that allow bypass of sediment through the structure. Instead, sand must move around the seaward point of the structure, where the sediment can sometimes be lost offshore and does not move downcoast. In such cases, increased rates of downcoast erosion, sediment loss, and narrowing of beaches may be observed. It is unclear if rock groins can be designed in a manner that facilitates sand passage through using a lower elevation or shorter seaward extent. One advantage of rock groin sand retention structures is that they are widely utilized throughout the U.S., and as such, their behavior and impacts are well documented and studied.

Permeable Pier. A permeable pier involves timber or composite/fiberglass piles arranged in rows perpendicular to the coastline typically in support of an overlying recreational pier. The piles are installed by pile driving equipment. The permeable pier function is similar to a regular sheet pile wall or rock groin in that its function is to slow downcoast sand transport, facilitating retention of a wider upcoast beach. However, unlike a regular groin, a permeable pier is designed to be permeable, or in other words, allow some sand passage through the opening in the structure, thus regulating the rate of sediment movement. The primary intent of the permeable design is to avoid resulting in additional rates of erosion of downcoast beaches. This style of sand retention system remains largely experimental. As such, little data exists to refer to the potential success of these types of sand retention structure designs or the effects they have on downcoast erosion. In 2009, the County proposed a permeable pier sand retention at the existing Goleta Beach Pier in response to a long-standing shoreline erosion problem at Goleta Beach. The County's proposed project was ultimately rejected by CCC due to concerns regarding uncertain impacts from erosion of downcoast beaches, despite CCC staff approval. However, in recent years, CCC has seemingly become more open to the idea of permeable pier sand retention devices due to the projected impacts of sea level rise and the increasing need for sand retention devices as a means to reduce coastal hazards.

Potential Adverse Effects of Sand Retention

The use of sand retention structures can raise regulatory agency concerns or opposition due to potential effects on downcoast beaches and lateral coastal access. Sand retention structures trap sand or slow its passage, resulting in sand accretion and upcoast beach widening. However, past groins have resulted in detrimental impacts on downdrift beaches. By slowing the littoral movement of sediment, groins can result in a decline of sand supplies downdrift, causing increased rates of sediment loss, beach narrowing, loss of habitats and recreational beaches, coastal erosion, and even damage to landward facilities. Some groins have been documented to disrupt littoral sand transport and increase threats to coastal development and infrastructure from wave attack, bluff erosion, coastal flooding, and sea level rise. In addition, increased erosion and decrease of sediment supplies negatively impact lateral coastal access and beach recreation. Further, in some cases, groins that extend further off the coastline can result in loss of sediment offshore, not only slowing the downdrift movement of sediment but effectively removing these sand supplies from the littoral drift system. Each of these issues is particularly concerning to property owners, agencies responsible for the management of the coastline, and permitting agencies such as CCC. As such, littoral drift rates, location within a littoral cell, the local orientation of the shoreline, sand supply, and engineering specifications must be considered in the design of sand retention structures to reduce the impact on the downdrift shoreline (Griggs et al. 2020).

In addition to potential impacts on the downdrift coastline, sand retention structures can result in other impacts which are particularly concerning to the public. Most traditional rock groins were designed as large structures that can be considered unsightly, obstruct views, negatively impact the natural look of the coastline. Depending upon their design, they may result in wall-like structures that are either difficult or impossible to safely navigate over if dedicated access points are not incorporated in the design, obstructing access along the coast. Onshore sand retention structures can also be large, resulting in the dedication of a large area of the beach for these structures and removing the total area of available recreational space along the beach. Under some conditions, groins may interrupt wave action and cause rip currents that can be dangerous for swimmers and affect other recreational water sports (e.g., surfing, kayaking, paddle boarding).

As an engineered structure, groins are also subject to damage over time, requiring some degree of maintenance which can be costly. As time goes on and sand retention structures are exposed to the natural forces of the ocean, damage can result to the structure, and components of the structure may be exposed which can become unsightly or unsafe (e.g., exposure of steel rebar, sheet piles). Consideration of a new sand retention structure as part of the Project must be designed to address and mitigate these potential impacts, its benefits, acceptance by the public and permitting agencies, and plan for the maintenance or potentially eventual removal of the structure.

Preferred Sand Retention Option

Based on the concerns and potential impacts surrounding sand retention structures, as well as the various designs for sand retention structures that exist within the State, this report recommends that the City install an experimental sheet pile wall groin as part of the Project. The preferred design of the experimental, or potentially temporary, sheet pile wall groin would be comprised of either steel or fiberglass. Sheet pile groins tend to be more adjustable in their design compared to rock groins or permeable pile groins, and a relatively narrow vertical structure requires less space on the beach compared to other groin designs. A key additional benefit of a pilot sheet pile groin is that it could be relatively easily removed if it is determined to cause adverse impacts, particularly on downdrift beaches such as Carpinteria State Beach. A sheet pile wall groin could also be "tuned" or adjusted to optimize its performance, minimize downcoast impacts as determined by monitoring. Construction of such a groin would involve driving interlocking sheets that fit together to form a wall into the beach using vibrating methods. The groin's length and elevation are still to be determined, but example dimensions could be:

1. A length out to a depth of -3 feet NAVD 88 to trap sand close to shore but not entirely block sand from reaching the downcoast beach. Such a sheet pile groin would extend roughly from the upper dry sand beach near the terminus of Linden Avenue roughly 200 feet seaward into the lower intertidal zone. Sand would still be able to move around the groin and pass downcoast.

2. A maximum crest elevation on the horizontal beach berm of +12 feet NAVD 88 to enable the sand to be trapped by the groin, but to still allow sand to pass over the groin under average wave and tide conditions. Sand movement over the landward end of the groin (called the "root") would nourish the downcoast beach and minimize the formation of any downcoast embayment. The crest elevation of the groin could gradually drop towards the water to follow the profile of the beach to minimize visual impacts and maintain existing access along the beach.

3. The orientation of the groin should be perpendicular to shore to maximize the sand trapping effects and to create the longest possible sand deposit upcoast toward Ash Avenue.

4. The location of the groin should remain on City property and thus be located at the end of Linden Avenue at the property boundary adjacent to the State Beach.

5. Monitoring of the performance of the groin should occur after construction with beach profile and beach width measurements being taken monthly to determine its effects.

a. Beach profiles can be wading profiles out to the depth able to be reached by a person wading from shore at low tide. The locations of beach width and profile measurements should coincide with the upcoast and downcoast sides of the groin within 100 yards of the structure and then be spaced ¼ mile both up- and downcoast for a distance of approximately 1 mile if possible or to the tidal inlet of Carpinteria Marsh on the upcoast end and Carpinteria Creek on the downcoast end.

b. Beach width measurements can be done by pacing the width of the beach from the base of the dune out to the waterline at low tide once a month at the beach profile locations.

c. Drone images of the beach planform should also be taken monthly in the first year to record images of the beach and then quarterly thereafter for up to five years to create a database of images through all seasons to visually determine beach changes.

Responsible Parties

The City would ultimately be responsible for the construction of the Project, as well as for the acquisition of all necessary permits, although it is recommended that the City consider a partnership with BEACON on this effort. Depending on the source of sediment for beach nourishment and dune construction, as well as a source of funds for Project construction and maintenance, various other local, state, or federal agencies may have either permitting authority over the Project or a role in Project construction such as BEACON or the ~~Flood Control District~~ County. The Channel Coast District of State Parks would be engaged regarding any aspect of the Project involving State Park property, as well as during Project monitor or modification of the groin. As presented in Table 1 under *Permitting Requirements*, permits for construction and maintenance of the Project may be required from the following agencies:

- U.S. Army Corps of Engineers
- Central Coast Regional Water Quality Control Board
- California Coastal Commission
- State Parks
- California State Lands Commission
- County of Santa Barbara

Given the Project's scope, cost, and benefit, it may be beneficial for the City to partner with other agencies to help fund or implement the Project. For instance, the County has several programs that could support the acquisition of sediment for beach nourishment and dune construction.

BEACON may also be a prospective partner in terms of Project funding, sediment acquisition, construction management, maintenance, and episodic beach re-nourishment.

Living Shoreline Adaptive Management Plan (AMP)

The Project is anticipated to require maintenance and will need to be adapted over time, as shoreline damage occurs and performance decreases after major storms and as sea level rises. This preliminary AMP was developed for the Project to identify preliminary recommended actions for Project implementation, and maintenance and monitoring of the widened sandy beach and living shoreline. The AMP also identifies opportunities for further collaboration with key stakeholders. Adaptive management is a tool for achieving success where there is uncertainty as to what actions will be needed to accomplish specific goals. Designing and implementing this Project using an adaptive management approach will lead to better outcomes and help the Project meet its goals. The preliminary AMP plan for the Project includes:

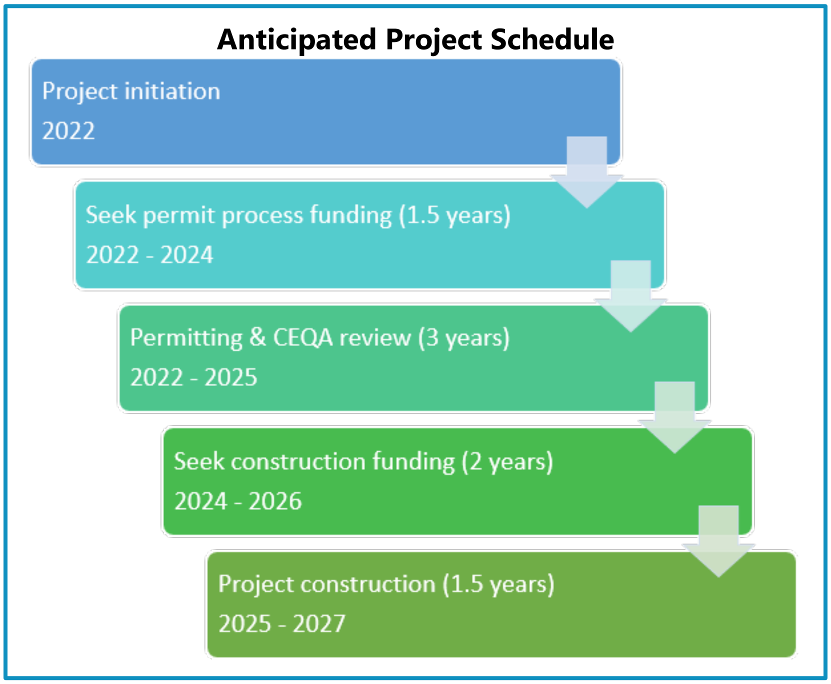
1. Identification of permitting requirements;
2. Development of long-term maintenance strategies based on defined maintenance triggers;
3. Description of Project monitoring and reporting requirements;
4. Identification of opportunities for interagency coordination and roles/responsibilities; and
5. Description of preliminary plans for abandonment of the dune system.
6. Future actions that may be required to be taken by the City, affected property owners, and interested agencies, if or after the living shoreline is abandoned, based on the City's adopted SLRVAAP.

As discussed above, this document summarizes a preliminary plan for Project design and implementation based on analysis of constraints and feasibility, modeled performance of a living shoreline under severe wave events and projected sea level rise, and the potential availability of funding. More detailed engineering design, study, and coordination efforts are required which would further inform each aspect of the Project, including the AMP.

Permitting

The Project will require federal, state, and regional/local permits (refer to Table 1 under *Permitting Requirements)*. To acquire the necessary permits, the City will need to perform early coordination with regulatory agencies, including outreach to address agency concerns. Partnering with the ~~Flood Control District~~ County and/or BEACON would enhance the ability of the City to acquire the necessary permits by providing additional expertise and resources. Potential requirements would include a Section 404 permit under the Clean Water Act, a Coastal Development Permit from CCC, a Section 401 Certification from the Regional Water Quality Control Board, a lease agreement with

CSLC if sand supplies are acquired from offshore tidelands, an encroachment permit from California State Parks if the action occurs on State Parks land, local encroachment, grading, and haul permits. Additional permit issues could include issues such as potential noise ordinance issues for the City and possibly from the County.



Obtaining State and federal regulatory agency permits can represent a major expense and challenge for beach nourishment projects and require several years or longer. Thus, to construct the Project in 2025, the City would likely need to acquire funding and initiate the permit process for initial Project construction in 2022, as it seems likely that to acquire funding for planning and permitting, as well as the permits themselves, a minimum of 3 years would be required. Given permit process complexity and challenges of acquiring funding, Project construction may be delayed until 2026 or 2027, even if the Project is initiated by the City in 2022 after approval of this initial study. Similarly, depending on the terms and duration of permits acquired, re-nourishment event permitting would also need to anticipate permit costs and timelines well in advance of the actual planned nourishment events. Typical permit duration horizons are 5-10 years and unless the City can acquire a 20-year permit (with appropriate monitoring and reporting requirements), new permits or a major permit extension could be required for each re-nourishment event. Thus, over the life of the Project through 2050 or 2070, three to five or additional permit and funding acquisition processes, each requiring 2-3 years, may be required. Assembling the hundreds of thousands of dollars that may be required for each permit process would also require time to identify and seek grants or other funding sources, requiring the City to initiate planning for re-nourishment several years in advance of the triggers for the actual re-nourishment activities. These matters are discussed further below. To facilitate the Project, the City should:

1. Request 20 year permits from State and federal agencies that address both Project construction and all re-nourishment activities, with required reporting and monitoring to reduce future permit burdens.

Environmental Review

The proposed Project will require local, state, and likely federal permits which will in turn trigger environmental review under CEQA and potentially NEPA. Because of the Project's scope and potential for impacts, the likely CEQA document may be an Environmental Impact Report (EIR) accompanied perhaps by a NEPA Environmental Impact Statement (EIS) or Environmental Assessment (EA), both of which would likely need to be supported by technical studies for issues such as air quality, water quality, biological resources, transportation, coastal hazards, and downcoast beach erosion. The scope of such studies is unknown, but similar projects completed at the Goleta Slough and Carpinteria Salt Marsh provide useful data for comparison. Based on these past projects, completion of environmental review and technical studies can be anticipated to require roughly 3 years and hundreds of thousands of dollars. Because of the City's limited budget, it would likely need to seek State funding for this process through agencies such as the CCC. To facilitate the environmental review, the City should:

1. Consider use of a Program EIR to address Project impacts, as well as re-nourishment over a 20-year horizon.

Maintenance

Project resilience will be greatest in the near term (e.g., to 2030 or 2035) at existing sea level, and then would likely decrease over time if sea level rise proceeds as projected. Assuming the Project can be built in the year 2025, existing sea level conditions would likely guide its design. If Project construction occurs later, future predicted conditions may become more influential in Project design. A project built in 2025 should be resilient to the year 2050 or as late as 2070 and protect Beach Neighborhood residences and more landward infrastructure (e.g., Downtown, Highway 101) from flooding if the beach fronting the dune is sufficiently wide (e.g., 170 to 200-feet-wide). A 250-foot beach width stipulation, though arbitrary, was applied by Dr. Craig Everts as a rule of thumb in southern California for sufficient protection from the 100-year storm wave event (San Diego Association of Governments [SANDAG] 1993).

Assuming longshore transport of sand continues at the current rate, the beach will also gradually rise and retreat at the same rate as sea levels are projected to gradually rise. That phenomenon is called the Bruun rule, developed by Per Bruun in 1962 (Bruun 1962). As the beach retreats, dunes may also retreat at the same rate if natural dune-building processes exist. If sufficient beach width can be maintained along Reaches 2, 3, and 4, the dunes will not retreat in response to changing conditions, particularly erosion from periodic wave attack. Periodic re-nourishment of the beach and sand retention will be key to maintaining beach width in response to storm-induced erosion, particularly if sea level rises as projected. Further, the frequency and/or volume of re-nourishment will have to increase if sea levels rise proceeds if projected. Therefore, the frequency of re-nourishment would need to be adjusted in response to beach erosion from major storm events (e.g., severe El Nino seasons) as well as projected sea level rise. Re-nourishment is assumed to be decadal and may need to become more frequent or more voluminous over time if sea level rise proceeds as projected. The volume of re-nourishment would depend upon the severity of erosion, but given the costs of beach nourishment, the amount of mobilization required and the challenges of acquiring beach quality sand, larger, less frequent maintenance events may be preferred (e.g., every 5-10 years).

Sea level rise is projected to continue to be an issue for the City. The City recently completed the SLRVAAP report (City of Carpinteria 2019), which provides detailed projections of the potential impacts of and which provides a detailed summary of planning efforts to date, adaptive management measures, and results that raise significant concerns for the City. The County's recently completed Sea Level Rise Vulnerability Assessment affirms these concerns and adaptative management responses (County of Santa Barbara 2017). Both the City and the County reports examined potential sea level rise at three time horizons for potential sea level rise: 2030 (~1 ft), 2060 (~2 ft), and 2100 (~5 ft) based on the current best available sea level rise science and projections within California at the time of its writing. Since that time, OPC has released sea level rise projections and probabilities for specific regions along the coast, and the projections vary from those originally prepared for the City (OPC 2018). The primary concern, particularly in the near term, is that existing coastal hazards driven by severe storms will increase both in frequency and duration as a result of sea level rise. This includes coastal erosion, storm-related flooding, and tidal inundation of coastal areas. Projected impacts become more severe over time as sea level rise increases. According to the City's SLRVAAP, at the 2030-time horizon (~1ft sea level rise) beach and dune erosion could result in coastal floods extending further landward than existing conditions, increasing the chance that infrastructure within Carpinteria State Beach along with residences in the Beach Neighborhood could sustain damage. By 2060 (~2ft sea level rise) increases in coastal erosion and flooding are projected to have the potential to impact structures, land uses, and infrastructure between Ash and Linden Avenues extending north of the UPRR, with coastal flooding beginning to encroach directly upon the Beach Neighborhood. At 2100 (~5ft sea level rise), routine monthly high tides could extend across significant portions of the Beach Neighborhood, resulting in regular inundation events. These sea level rise projections and resultant potential damage do not account for beach nourishment and construction of a living shoreline but demonstrate the need for the completion of beach nourishment and a living shoreline and its maintenance as long as feasible into the future.

Maintenance of the Project's wider beach and dunes will likely be needed over the mid-to-long-term, and potentially episodically in response to large storms or severe erosion events. The timing and frequency of maintenance are also highly dependent upon the success of the proposed experimental sheet pile wall groin. Should the sheet pile wall groin fail or be determined to result in adverse rates of sediment loss and coastal erosion downdrift and ultimately be removed, the need for more frequent beach re-nourishment activities would increase, or the groin could be "tuned" to reduce impacts by lowering the crest elevation to allow more sand passing over it, or shortening the groin to allow more sand bypassing around it. Maintenance of dune vegetation is likely to be required at least every year for the first five years following completion of initial dune plant effects.

Maintenance Triggers

The need for beach and dune maintenance would be triggered by several dune performance metrics, which will be determined through the use of future monitoring data and reporting described below, as well as through more detailed engineering and design of the proposed Project. Nevertheless, preliminary maintenance triggers and actions that should be considered are summarized for each aspect of the Project below.

Beach Re-nourishment

Maintaining adequate beach width to buffer the new dune system and protect the Beach Neighborhood is central to the Project's long-term effectiveness in improving resiliency. The primary indicator of the need for beach re-nourishment will be the measured width of the sandy beach area fronting the dune. Based on the preliminary design of the proposed experimental sheet pile groin and the observed rate of littoral drift of sediment along the coast, re-nourishment of the beach is currently expected to be required every 10 years. Episodic re-nourishment activities may also be required following a large storm or erosion event (e.g., extreme El Niño events). Generally, the need for nourishment of the beach should be determined through monitoring of beach profile and width conditions. Should monitoring show that the beach fronting the dunes has narrowed to less than 50 feet in width at any point between Ash Avenue and Linden Avenue, re-nourishment of the beach should occur. However, this performance standard would need to account for the duration of the permit issued for the original Project (e.g., 5-10 years) as well as obtaining subsequent permits which will be expensive and potentially require several years. This could delay the City's response to a narrowing beach and potentially leave the dunes and Beach Neighborhood vulnerable to unanticipated severe storms that could occur in the interim between the narrowing beach and obtaining any new required permits. Therefore, this study recommends that the City initiate planning, funding acquisition, and permit applications when the beach has narrowed to less than 100 feet in width at any point between Ash Avenue and Linden Avenue. This is reflected in the following actions or triggers:

1. Periodic Planned Decadal Re-nourishment: As noted above, it is anticipated that periodic re-nourishment (e.g., every decade) will be required when the beach narrows to 50 feet. Because permitting can potentially require several years, it is recommended that the City initiate permitting processes for re-nourishment when the beach narrows to 100 feet to ensure that re-nourishment occurs promptly.

2. Re-nourishment in Response to Major Events: Major storms may cause accelerated beach erosion or even damage to the dunes. Re-nourishment should be planned for and implemented if needed and the City should begin preparation when El Nino seasons are predicted.

3. Opportunistic Re-nourishment: Periodically, sediment can become available from the Flood Control District during emergencies. The City should coordinate with the ~~Flood Control District~~ County to allow deposit of such sediments on the beach as these re-nourishments could decrease the need for and costs associated with periodic nourishments.

Dune Restoration

Numerical modeling of the proposed dune was conducted to understand dune performance under several extreme wave events with consideration of sea level rise. Based on this modeling the dune system will likely require maintenance and repair over time, with more maintenance required in response to major storms and if sea levels rise as projected until a point is reached at which the wider beach and dune system may no longer be as effective during storms in the long-term future (30 to 50 years such as 2050 to 2070). The exact timing and need for dune maintenance would be triggered by several dune performance metrics, which will be determined through the use of monitoring data described below. However, key maintenance triggers and actions are as follows:

1. Wave Overtopping of the Dune Crest – Wave overtopping of the dune is expected to occur based on the results of numerical modeling. If topographic monitoring of the dune following wave overtopping events shows that the dune crest has been lowered or eroded, maintenance of the dune should be required.
2. Exposure of the Dune Toe - If topographic monitoring of the dune following severe extreme wave events shows that the dune toe has been substantially exposed, maintenance of the dune should be required.
3. Loss of Full Dune Section – If loss of a full section of the dune occurs, maintenance of the dune should be required.

Over time, either through the erosion of the dunes during extreme wave events, wind erosion, or trampling of vegetation and disturbance of the dunes, maintenance of native dune vegetation will be required. Invasive non-native species control will also be required to maintain appropriate native vegetation cover. Ecological restoration is inherently uncertain. There are simply too many variables to control, especially in dynamic systems in a landscape being managed for multiple purposes, with high public visitation. As such, specific maintenance triggers for revegetation and landscape management are difficult to define. Rather than identifying specific triggers, under the project, maintenance of the native dune vegetation should be implemented on an as-needed basis based on the results of monitoring of the dunes (see discussion under *Monitoring and Reporting* for more detail).

Experimental Sheet Pile Groin Repair/Adjustment

Monitoring of the experimental groin and downcoast beaches will be critical to determining its success and identifying the necessary adjustments of the groin feature to reduce impacts downcoast. While detailed engineering and design of the groin are still required, lowering of the groin crest should be considered if the downcoast beach retreats by more than 50 feet over a distance of 100 feet or more. Further, shortening of the groin should be considered if downcoast erosion persists or grows more significantly. Before adjusting the groin, the City should consider beach re-nourishment if consistent with other triggers, as the groin is key to maintaining a wide sandy beach upcoast. The City should also closely coordinate with USGS and Channel Coast District of State Parks on monitoring and BEACON and State Parks on the management of both the Carpinteria City Beach and Carpinteria State Beach.

Street End Parking Lot Maintenance

Over time, the dunes may sustain gradual erosion from the wind. Wind-blown sand may accumulate at the street ends of Ash, Holly, Elm, and Linden avenues. There is no specific trigger for maintenance of the street ends and parking lot areas. Generally, maintenance should occur when an amount of sand accumulates within the street ends and parking lots to such a degree that it begins to obstruct the use of the street ends and parking lots.

Maintenance Responses

Provided below is a discussion of expected responses to maintenance triggers described for each aspect of the Project. Details regarding these maintenance responses are preliminary and would be refined through further design, study, and modeling of the Project.

Beach Re-nourishment

Beach re-nourishment frequency would be based on results of monitoring, but a rough estimate is decadal (every 10 years) at a volume of 50 percent of the initial placement volume for 250,000 cy. The success of the experimental groin feature will heavily influence the frequency and need for re-nourishment, except after major coastal storm wave events. If a major storm or erosion event occurs and the beach narrows to a width of 50 feet or less, nourishment of the beach with 250,000 cy is expected to be required.

Dune Restoration

Maintenance of the dune in response to each corresponding maintenance trigger will depend upon the amount of erosion or exposure measured through monitoring efforts. The exact amount of restoration and placement of sand to repair the dune will also depend upon the final design of the Project. However, provided are some preliminary calculations for the amount of sediment required to repair the dune based on the initial proposed design of the Project:

1. Wave Overtopping of the Dune Crest – Assuming wave overtopping results in lowering or erosion of the dune crest by 1 foot across a 350-foot-long segment of the dune, approximately 519 cy, or approximately 32 truckloads, of material will be required to restore the dune to its initial built condition.
2. Exposure of the Dune Toe – Under some circumstances, toe exposure may naturally be restored over time through accretion of beach sand along the dune toe, or through natural fluctuation in the dune formations and shifting of sediment by wind and wave actions. As such, the amount and extent of repair of the dune toe following severe exposure will be highly dependent and would be informed through regular monitoring efforts.
3. Loss of Full Dune Section – Based on the preliminary design of the Project, loss of a full section of the dune is assumed to involve lowering of the dune crest by 4 feet across a 350-foot-long and 40-foot-wide segment of the dune. Based on these dimensions, approximately 2,075 cy, or approximately 130 truckloads, of material will be required to restore the dune to its initial build condition.

Under all dune repair activities, trucks would need to travel along the beach to access the repair/placement sites. Safety personnel, signage, and flaggers should be present during maintenance activities to minimize impacts to coastal access and beach recreation. The material should be placed in small mounds and scattered using earthmoving equipment or hand tools, depending on the amount of repair required. Before the commencement of any repair or maintenance work, the City may be required to obtain written authorization from CCC through submission of a maintenance and repair report.

Native dune plants are the best sustainable long-term choice for building coastal dunes in California and elsewhere. In dune areas, the most effective strategy for re-introducing or replanting native species is to seed the areas in the late fall and to let the seeds germinate with winter rains. Timing is very important, as irrigation is not usually effective. Similar to initial planting techniques described under *Planting Design and Palette,* the sand surface of the revegetation area should be prepared using a rock rake (leave deep grooves). Seeds/fruits should then be scattered by hand and buried with rock rakes. Re-seeding rates for native dune forming plant species and other plant species are the same as those presented in Table 2. The recommended seeding rates presented therein account for the low germination rates in any single year. If the performance of revegetated areas is poor the first year after reseeding because of very low rainfall (less than 6 inches), the City considers re-seeding the following year.

To establish appropriate vegetation cover with native plants in the Project area, non-native plants will need to be controlled at low levels on at least an annual basis. Non-native plants on dunes should be controlled by hand or with hand tools. Where weeds are sparse and when they are growing close to mature native plants, weeds should be removed by hand by turning the weeds upside down to or dispose of off-site. Sea rocket (*Cakile maritima*) should be removed annually by hand-pulling large plants in April and May before seeds fall from the plants. Other non-native plants that must be controlled at low levels include non-native annual grasses (e.g., ripgut brome [*Bromus diandrus*]), ice plant (*Carpobrotus edulis*), sweet clovers (*Melilotus* species), Russian tumbleweed (*Salsola kali*), and New Zealand Spinach (*Tetragonia tetragonioides*). Any non-native plants that have visible seeds should be disposed of offsite.

Experimental Sheet Pile Groin Repair/Adjustment

Where the beach downcoast of the experimental sheet pile wall groin is observed to have retreated by more than 50 feet over a distance of 100 feet or more, the sheet pile wall groin crest should be lowered by 1 foot and/or additional nourishment initiated to offset the downcoast sand loss. If lowering of the groin crest is not sufficient to reduce rates of downcoast erosion, the seaward extent of the groin should be shortened by 25 feet. If these adjustments to the groin continue to be insufficient to reduce or prevent downcoast erosion, complete removal of the groin may need to be considered and/or additional beach nourishment initiated.

Street End Parking Lot Maintenance

Sand should be removed where it accumulates at these street ends or parking lots. Removal of this sediment should be viewed as an opportunity for beneficial re-use and should be moved to designated areas seaward of vegetated dunes for beach enhancement and dune restoration. Any trash or debris collected in the accumulated sand shall be removed and disposed of before redeposition on the beach.

Monitoring and Reporting

Accurate scientific monitoring and reporting is a vital part of the proposed Project, particularly for beach width and the potential need for re-nourishment. Monitoring includes observations of pre- and post-implementation site conditions that will assess the post-nourishment equilibrium beach, installation, and performance of the sheet pile wall groin, and plant installation, as well as other restoration components (e.g., sand fencing). Monitoring also informs adaptive management actions, particularly the resiliency of the nourished beach, downcoast sand conditions in response to the sheet pile wall groin, and the longevity and durability of the nourished beach. Monitoring of the dunes will also be important, such as the success of the establishment of native plants and non-native plant cover that may need to be controlled. Monitoring the Project success criteria over time, and comparing the site to ‘control’ conditions in adjacent areas that have had no nourishment or restoration actions will also be important. Performance/success criteria for each Project component, the types of monitoring and reports that should be completed post-construction, report frequency, and regulatory agency submittal requirements are discussed below.

Performance/Success Criteria

Setting appropriate performance criteria for beach nourishment and restoration projects, and assuring those criteria are met, helps assure that the shoreline protection criteria and ecological benefits of the project are realized. Additionally, performance criteria should be sufficient for measuring whether or not the project goals have been achieved. Performance criteria for the Project should include beach profile and width, the effectiveness of the sheet pile wall groin on retaining sand, any downcoast impacts, and vegetation cover goals. Monitoring the site and assessing whether those criteria have been met will help assure that the benefits of the Project are realized. Performance criteria should focus on measuring appropriate physical changes with regards to coastal processes related to beach performance and biological ecosystem establishment and survival. The monitoring information will be used to assess whether the Project is functioning in the short term and how it might be expected to be self-sustaining in the long term. Any performance criteria used should be quantitative and measurable. Any performance criteria should be quantitative and measurable.

Objective measures of topography and vegetation should be used in assessing restoration success. Monitoring should be done in Years 1 to 5. Project monitoring should support the evaluation of success in meeting interim and final goals (Year 5). If any of the Year 1 to 4 goals are not being met, the implementation contractor should, in the annual report, either 1) explain why they still expect Year 5 goals to be met, or 2) trigger adaptive management actions. If any of the Year 5 quantitative goals are not met, the implementation contractor should continue work on the site and monitor project performance until the goals are met.

The ecosystem monitoring strategy for the Project should be closely tied to the performance criteria. The specific goals of ecosystem monitoring include: 1) quantitatively assessing progress towards achieving performance criteria during the initial implementation phase, 2) quantitatively documenting achievement of performance criteria at the end of implementation, and 3) informing the adaptive management process during implementation.

Types of Monitoring/Reporting

Monitoring of success of the Project will require the monitoring and reporting of annual beach width, performance of the sheet pile wall groin, dune topography, and overall ecosystem health/success. Provided is a detailed description of the monitoring and reporting requirements for each of these monitoring efforts. The description of the monitoring and reporting efforts is based on the preliminary preferred design of the Project and should be refined as necessary through the final design.

Annual Beach Width and Dune Monitoring

Annual beach width and dune monitoring shall involve topographic monitoring of the shoreline, beach, and dune system once before Project implementation and then annually between May 1 and June 30 for a total period of five years. All monitoring shall be conducted by a qualified oceanographer or coastal engineer familiar with beach and dune dynamics. The monitoring protocol shall involve the use of a minimum of 12 shore-normal transects extending from the back beach to the intertidal zone, including points downcoast of the proposed sheet pile wall groin as well as within Reach 2. These transects will consist of lines perpendicular to shore with an established inland endpoint and a fixed compass orientation. The inland endpoints shall be located in a stratified-random manner along the shore. During monitoring, fiberglass measuring tapes should be placed on the lines with the zero-meter end at the inland endpoint. At a minimum, elevations shall be taken every meter along each transect. Elevations may be captured with an auto-level or total station and tied to a benchmark of known elevation, or with a GPS accurate to +/- 5 centimeters in elevation could be used. Changes in topography shall be estimated by comparing the elevations of the profile during annual monitoring to the profile of that transect as measured pre-Project (and also to the most recent year). The change for each of the transects shall be averaged at each site to provide estimates of change in the cross-sectional profile which shall allow for the estimation of changes in sand volume. This data shall be used to assess beach profile and width, whether the beach is stable or eroding, and whether the dunes are increasing in volume (accreting) or decreasing in volume (eroding). Identification and location of problem areas (erosion hotspots) both within Reach 2 and 4 and downcoast of the sheet pile wall groin and within the dunes. This information will be particularly important in Years 4 and 5 to assess the resiliency of the nourished beach in Reach 2 and help inform City planning for potential re-nourishment. Where feasible, the location of shore-normal transects shall coincide with existing transects established by USGS, and monitoring and reporting efforts shall use the most recently available topographic data from USGS to reduce duplication of efforts.

The location and elevation of the dune crest (the high point along the transect) shall be measured on each transect. The location and height of the crest in Years 1 to 5 shall be compared to pre-Project conditions. For areas without existing dunes in the pre-Project period, the location and elevation of the highest point along the transect should be recorded. The maximum elevation for each transect in annual monitoring shall be compared to pre-Project conditions and data from the previous year. This shall inform the understanding of dune dynamics at the site and help with prioritizing adaptive management and maintenance actions.

Photographic monitoring points shall be established to support the assessment of project success. The condition of the site shall be Locations of the points shall be recorded using GPS. Each photo-point should be re-visited each year at the time of monitoring.

Monitoring of Downcoast Beaches

Although monitoring the performance and resiliency of the primary beach area along Reach 2 is critical, also important are the effects of both Reach 2 nourishment and the sheet pile wall groin on downcoast beach width. Potential initial effects of large-scale nourishment in Reach 2 on beaches in Reaches 3 and 4 and further downcoast may be beneficial, as the Reach 2 nourished beach reaches equilibrium and releases sand to downcoast beaches. This potential effect would be monitored, particularly in Years 1-3. However, after the initial release of sand from the nourished beach, the focus of monitoring downcoast of the sheet pile wall groin would be on potential erosive effects as the groin potentially intercepts natural littoral downcoast sand flow. While such monitoring would focus on Reach 3, the City should coordinate with USGS regarding any potential for downcoast erosion within Reaches 3 and 4, as well as those beaches further downcoast outside the Project area and which are part of the USGS monitoring program to inform potential adaptive management actions.

Ecosystem Monitoring

Ecosystem monitoring (e.g., monitoring of dune vegetation) should occur before Project implementation and then annually between May 1 and June 30 for a total period of five years. All monitoring shall be conducted by qualified ecologists familiar with the native and non-native plant species. The report shall characterize the cover and diversity of native plants and weeds. Ecosystem monitoring shall occur along the same transects used for topographic monitoring. During monitoring, fiberglass measuring tapes should be placed on the lines with the zero-meter end at the inland endpoint. Data shall be collected along the line using a one-meter by one-meter quadrat placed every two meters following the tape. In each quadrat, the cover of each living plant species present shall be estimated to the nearest percent.

This data shall be summarized to allow assessment of Project success. Percent cover of vegetation shall be calculated (including zero values) for each species on each transect. The overall cover should be calculated by averaging the means for each transect for each species, total natives, total annual non-natives, and total perennial non-natives. Native species richness shall be calculated for each transect by totaling the number of different native species observed. Overall, average species richness shall be calculated by averaging the total for each transect.

Reporting Frequency and Requirements

A monitoring report shall be prepared annually that summarizes the work to date, data collected during monitoring (presented in graphs and tables as appropriate), and present a discussion of progress towards quantitative goals of the Project. The time series of each photo-monitoring sequence should be included as an appendix. Raw monitoring data should be included as Microsoft (MS) Excel files.

The annual monitoring report shall be submitted by the City to the CCC. The City may also be required to submit quarterly and annual reports to the Regional Water Quality Control Board

Interagency Coordination and Roles

The City will be the primary agency responsible for the construction, maintenance, and monitoring of the Project. However, opportunities may exist for interagency coordination and assistance with such a large-scale project. Due to the high cost of construction and beach nourishment, collaboration with a regional entity such as BEACON for management and potentially the ~~Flood Control District~~ County for construction and offshore sediment sourcing, in the context of regional sediment management is recommended. Further, both BEACON and USGS may provide helpful data for identifying large sources of sediment offshore for initial dune construction and beach nourishment activities, as well as future maintenance and re-nourishment. The USGS also currently conducts surveys of the City's beaches and those downcoast along pre-existing transects to monitor shoreline conditions and sand supplies. Collaboration with USGS for monitoring of the shoreline along Reach 2, and Reach 3 and 4 downcoast, following Project implementation, as well as the use of existing beach profile data collected by USGS, may help to alleviate monitoring costs. As a regional entity regularly engaging in the acquisition and beach nourishment activities, a partnership between the City and the ~~Flood Control District~~ County is also highly recommended to coordinate nourishment activities necessary for the Project. Lastly, given the proximity of the proposed living shoreline to existing coastal dunes on State Parks property, as well as potential effects of the Project on the downcoast Carpinteria State Beach, coordination between the City and State Parks, both in terms of dune planting and maintenance and beach monitoring will be either required or highly encouraged.

As the Project moves forward and receives additional study, the City should at a minimum coordinate with each of the agencies, as well as the permitting agencies, to identify opportunities for interagency coordination and determination of key roles and responsibilities.

Abandonment Plan

At some point in the projected sea level rise curve, the cost of maintaining the beach and dunes may become too great or flooding in the City may occur via other pathways (e.g., from the salt marsh or due to rising groundwater). Before that point, the City will need to make decisions on other approaches to handling the coastal flooding problem as outlined in the City's SLRVAAP. In other words, the living shoreline's effective lifespan is not unlimited if sea level rise proceeds as currently projected or accelerates. The proposed Project's expected lifetime is considered to be 30 to 50 years (until 2050 – 2070).

Should the Project result in exorbitant maintenance costs or unforeseen impacts to Coastal Act resources, maintenance of the dune might be discontinued and the long-term strategies outlined in the SLRVAAP accelerated. Abandonment of the Project would not occur before close coordination with the Executive Director of the Coastal Commission. Details on triggers for the potential abandonment of the dune system are provided below:

1. Reoccurring Maintenance Costs - Maintenance costs are anticipated to be high should spot maintenance be required at frequent intervals. Should the beach be severely and repeatedly eroded and/or the vegetated dune system, pedestrian pathway, or landward development be repeatedly damaged, maintenance costs would compound, potentially exceeding the City's existing maintenance budget at the time. The City will compile and

monitor maintenance costs to assess if such reoccurring Project repairs are sustainable. Should the beach and dune be repeatedly overtopped and the Beach Neighborhood subject to repeated wave attack and flooding over several successive years, the City should assess maintenance costs and begin planning for a long-term solution Additionally, maintenance costs are anticipated to be high should all sand from the restored dune be completely eroded twice within a 5-year monitoring period, resulting in a large-scale rebuild and replanting events. The costs to stabilize the beach and dune via beach nourishment shall be considered before abandonment.

2. Unforeseen impacts to Coastal Act resources – Should the project result in significant negative impacts to Coastal Act resources related to the physical dune system, the Project could be abandoned. Close coordination with the Executive Director of the Coastal Commission would occur should such unforeseen impacts occur. Beyond the physical monitoring presented in this document, a Dune Creation and Biological Monitoring Plan will be monitoring biological resources which should be referenced for such Coastal Act impacts.

A record of why the Project is proposed to be abandoned and the timeline for completion of the long-term strategy would be provided to CCC in the annual monitoring reports once one or more of these triggers are met. The interim condition of the beach would also be detailed in this document as well as justification for the proposed abandonment. The request will include proposed Project elements to be abandoned, elements to be retained, and continuation or changes to associated projects. The City would apply for a permit or permit amendment to restore the beach to a pre-Project condition, or agreed upon condition that reflects the current condition of the site within 30 days of this request.

While a detailed plan for abandonment of the dune, if required, will be developed through more detailed design and study of the Project, the preliminary recommended or preferred method for abandonment of the living shoreline should involve passive/natural abandonment of the dune, "do nothing" approach. Under this approach, the City would largely leave the living shoreline in place, allowing natural coastal processes to erode the feature. The only minor effort would be taken to remove features from the beach and dune system (e.g., signage, fencing). Given the living shoreline is proposed to be constructed to materials compatible with the shore environment and consistent with materials that currently exist within this reach (e.g., sand, cobbles), there is little concern or need to actively remove or deconstruct the dune system. The dune system would remain in place and gradually erode, allowing sediment to naturally re-enter the littoral system and move downcoast, helping to supply downdrift beaches. By taking a "do nothing" approach, the dune system would provide a longer-lasting level of protection of landward structures and facilities when compared to active removal and deconstruction of the dune system.

Funding and Costs

Funding beach nourishment and dune enhancement living shoreline creation along Carpinteria City Beach and Carpinteria State Beach will require combined local, state, and federal funding sources if this Project is to be completed and maintained. Several federal, state, and local programs administered by multiple agencies may have funding that could support beach nourishment and dune/ living shoreline creation and maintenance. To inform decision-makers and the public about funding options, this section provides a general summary of Project estimated construction and maintenance costs and potential funding options. A more detailed discussion of specific funding mechanisms, including available grant opportunities, is presented in Appendix E.

Construction and Implementation Costs

Implementation of the proposed Project would result in a variety of costs, including those required for planning and project initiation (e.g., planning, environmental review, permitting) and construction. Key costs associated with Project implementation and construction are discussed below. In summary, implementation of the Project has the potential to incur a total cost ranging from $9,000,000 to $12,000,000 or more as discussed below.

Planning and Permitting

Before Project construction, the City will need to complete a detailed engineering design and environmental review to receive the necessary approvals and permits from local, state, and federal regulatory agencies. Given the scope of the proposed Project, the City may be required to prepare an EIR under CEQA. Costs for the preparation of a CEQA-compliant EIR will include supporting technical studies. For a project of this type and magnitude, costs for the EIR and technical studies for issues such as water quality, air quality, transportation, and biological resources could be roughly $500,000 or more. If federal permits are required, environmental review under NEPA may be needed. In such a scenario, a joint NEPA/CEQA document could include either a joint EIS and EIR or EA, which may further increase costs.

The estimated cost for permit acquisition is also variable and depends upon the types of permits required. However, primary costs will be associated with environmental review and technical studies, and the permits themselves, while time-consuming, would likely only add tens of thousands of dollars in costs to the Project, as well as substantial time.

Additional costs will be incurred on a reoccurring basis as the City will likely be required to apply for new permits or permit extensions. State and federal permits for major beach nourishment and shoreline management projects typically are authorized for a 5- or 10-year period, with some potential for possible extension. The City may be able to seek longer-term permits, but even for a project with a potential 50-year lifespan, permits with a lifespan longer than 5 or 10 years may be difficult to obtain. However, these costs can be reduced if the City could negotiate longer permit lifetimes, which is highly recommended. The City should:

1. Requests a 20-year renewable permit from State and federal regulatory agencies with the ability to seek extensions if monitoring and reporting conditions are met, without applying for new permits.
2. If a 20-year permit cannot be obtained, request a minimum 10-year permit from State and federal regulatory agencies with the ability to seek extensions if monitoring and reporting conditions are met, without applying for new permits.
3. Seek acceptance of the use of a single Program EIR and associated NEPA documentation from State and federal regulatory agencies with administrative updates only for permit extensions to the extent consistent with CEQA and NEPA standards (e.g., no new impacts; no major changes in conditions).

Beach Nourishment and Dune Construction Material Transport

Beach nourishment and dune construction costs vary by location and type of project. Based on past Flood Control District projects, sand transport costs in the County are roughly $20 per cy of sand, which may not include sorting to remove material not suitable to place on beaches or required testing for grain size and chemical compatibility or contamination. If sediment for beach nourishment and dune construction can be acquired from a nearby source, sand transport costs may be reduced (e.g., $15 per cy), but this cannot be assured. Based on preliminary design estimates for the Project, approximately 500,000 cy of sediment would be required for initial beach nourishment, and 25,000 cy of sand and cobble material is conservatively assumed to be required construction of the dune. Therefore, based on an estimate of $15 to $20 per cy, beach nourishment and dune construction costs may range from $8,000,000 to $10,500,000 for sand and cobble transportation only, with the later higher-end figure being more conservative and realistic.

Vegetation & Restoration

Costs associated with initial dune vegetation and restoration activities following beach nourishment and dune construction are largely dependent upon the cost of materials, equipment, and labor hours. Generally, initial dune vegetation and restoration (e.g., weeding and re-seeding) would be done by hand and no irrigation would be required. Assuming dune construction would involve the creation of two acres of dune habitat with a perimeter of 3,000 feet, labor costs may range from $6,500 to $18,500. The estimated cost of seed materials is provided by S&S Seeds, a commercial supplier of locally-sourced native plant seeds, and is roughly $10,000. Further, the cost of installation and maintenance of symbolic fencing and interpretive signs may range from $9,000 to $27,000. In total, costs for initial dune vegetation and restoration activities in the first five years following construction could range from $25,500 to $55,500, with the later higher-end figure being more conservative and realistic. It is important to note that these estimated costs do not account for additional costs that may be incurred to maintain the dunes (e.g., storm damage repair, graffiti abatement, trash pick-up) or whether work would be performed by the City (e.g., Public Works Department) or outside contractors.

Maintenance Costs

Typical beach maintenance activities would include regular re-nourishment projected to be needed at least every decade and potentially in response to erosion from major storm events. The frequency of re-nourishment is closely linked to the inclusion of the proposed sand retention component. If sand retention is not included, the re-nourishment frequency may increase. A possibility also exists that the Flood Control District could provide periodic re-nourishment from Carpinteria Salt Marsh desilting (e.g., every 10 years or so) or from foothill ~~detention~~ debris basins under emergency conditions, but these sources cannot be counted on. Although less intensive and expensive, dune maintenance is also required annually to maintain the dune feature, sand fencing, revegetation of dune plants, and nonnative species control, as well as larger costs associated with major episodic dune maintenance and repair following severe wave or storm events. In the first few years following Project construction, costs associated with annual maintenance are expected to be low. However, after major storms or 5-10 years passes, major beach re-nourishment will be required. In addition, if sea levels rise as projected and the beach is subject to higher water levels, more frequent and severe storms, beach erosion is expected to accelerate, particularly by 2040 or 2050. Similarly, although buffered by a wider sandy beach, the living shoreline dunes could become more frequently exposed to wave action, particularly after major beach erosion events or if re-nourishment does not keep pace with erosion. Although annual dune maintenance costs are expected to increase, such costs would be far lower than those for beach maintenance. Based on the below summary of annual maintenance and major episodic maintenance costs, the proposed Project is expected to incur an annual cost of $190,000 to $265,000. However, it should be noted that major storm events such as during severe El Niño seasons could increase costs if major beach erosion happens. Further, if sea level rise proceeds as projected and is accompanied by more severe and frequent severe storms as anticipated, these costs would likely increase by 2040 or 2050.

Annual Maintenance Costs

The cost of annual maintenance of the living shoreline feature is difficult to predict and highly variable. The primary factor in determining the cost for maintenance is damage caused to the beach by average annual erosion, and perhaps even more importantly, beach erosion following major storm events such as during a severe El Niño season. If or as the beach is eroded and narrows, the dunes could become more exposed to wave attack, particularly if beach nourishment is delayed or cannot be implemented. Damage to the dunes from wind erosion, trampling of the dune, other human-related impacts, and erosion of the dunes during high wave and winter storm events are also of concern. While the need for and extent of maintenance of both the beach and dunes will be identified and refined as part of the annual monitoring efforts, as discussed below, it is initially believed that beach re-nourishment may be required every 10 years. For dunes, approximately 5 percent (70 linear feet) of the dune feature would need to be repaired or replaced each year, requiring placement of approximately 1,000 cy of sediment. Based on typical sand transport costs in the County, annual maintenance costs of the dunes may range from $15,000 to $20,000 per year.

Annual maintenances costs associated with vegetation maintenance, restoration, and nonnative species control will depend upon the amount of maintenance necessary based on annual monitoring, cost of materials (e.g., seeds, sand fencing material), and labor. Costs associated with these maintenance activities are typically much cheaper than those associated with sand placement and dune restoration and can range from a couple thousand to $15,000 annually.

Major Episodic Costs

Beach re-nourishment under the Project is assumed to be required every 10 years, based on the rate of sediment transport along the coast and the assumption that the experimental sheet pile groin is effective in trapping sand and remains in place. Approximately 100,000 cy of sand is assumed to be required to re-nourish the beach every 10 years. Assuming the same cost of $15 to $20 per cy described above, beach re-nourishment activities are estimated to cost $1,500,000 to $2,000,000 every 10 years for sand transport alone. This amount would increase due to construction costs for the re-nourished beach (e.g., heavy equipment), construction and water quality monitoring, and any associated permit and environmental review costs, which are difficult to predict. Conservatively, this could then result in average annual costs of $175,000 to $250,000 per year or up to $2,500,000 every 10 years for beach re-nourishment alone.

Funding Options

Funding of Project costs would require the pursuit of a combination of federal and state grants, as well as the implementation of local and regional funding measures. While beach nourishment and living shoreline projects are recognized as key "green" solutions to improve coastal resiliency, these programs are expensive. However, the alternative of repeated damage to high-value residential properties and public infrastructure and required repeated clean-up, repairs, and expensive adaptation measures would likely dwarf these costs. Various actions could be taken by the City independently, or in collaboration with State and regional agencies such as State Parks and the County, without grant monies to fund shoreline management. However, such measures are unlikely to provide sufficient funding for Project construction but may be able to offset maintenance costs and potentially help partially fund initial construction. Grant programs for living shoreline construction, maintenance, and monitoring include federal grants such as those offered by the National Coastal Resilience Fund and FEMA, state grants such as those offered by the California Coastal Conservancy, and local grants such as those offered by the Santa Barbara County Coastal Resource Enhancement Fund (CREF). Each of these potential funding options is summarized below.

Funding sources and amounts vary annually for coastal resiliency and are dependent on State and federal funding allocations. Therefore, the following information is preliminary and would have to be reviewed during assembling a project funding package.

Local Funding Options

Expand City Assessment District No. 5

Every winter, the City implements a winter protection berm located along the entire length of Carpinteria City Beach between Linden Avenue and the western limits of the City along the coastline. The berm consists of approximately 13,200 cy of sand, stretching from 1,440 linear feet between Linden and Ash avenues. The City created Assessment District No. 5 to fund the Winter Protection Berm Program through Resolution Number 3061 on December 14, 1992 (City of Carpinteria 2020a). Assessment District No. 5 was enacted to fund the annual storm wave damage reduction program. In the past few years, strong storms have generated flood and erosion along the beach, and the berm has effectively reduced and prevented damage. The berm was intended to serve as a temporary solution, facilitated by USACE until an alternate optimal solution could be devised. In Fiscal Year 2019/2020, Assessment District No. 5 collected $20,228.34 from oceanfront landowners along Carpinteria City Beach and $15,271.66 from the City for its coastal parcel for total revenue of $35,500.00.

Property owners with parcels fronting the shoreline pay into Assessment District No. 5 depending on the length of beach frontage for their parcels (City of Carpinteria 2020a). The annual fees paid by the property owners range from $193.80 to $500.92, with most annual payments being around $200. Each property owner pays into fixed and variable costs: fixed costs are spread evenly amongst all parcels equally and include permit compliance, biological monitoring, administration, and maintenance; variable costs are distributed to parcels proportionally to their beach frontage and include actual machine time required to move the sand.

There are a few options for adjusting Assessment District No. 5 to support a living shoreline and beach nourishment project. First, the funds from Assessment District No. 5 could be used for living shoreline construction and maintenance, although, at existing assessment rates, this would constitute a minor fraction of construction and annual maintenance costs. If the living shoreline were implemented, an annual winter berm would not need to be constructed. Second, rates could be increased for existing property owners within Assessment District No. 5, as the cost of annual maintenance of a living shoreline is expected to be much larger than what is currently collected from Assessment District No. 5. Finally, Assessment District No. 5 could be expanded to include parcels projected to be threatened by flooding under sea level rise projections because more than just beachfront properties would receive benefits from beach nourishment. Similar to the existing fee structure for variable costs, parcels closer to the coast could be charged more than those further away.

An expansion of Assessment District No. 5 over the entire Beach Neighborhood, the neighborhood most threatened by sea level rise induced flooding, would benefit those City residents projected to be most impacted by sea level rise. However, such an expansion, even with adjusted or increased assessment rates, would not generate sufficient revenue to fund construction of the proposed Project's beach nourishment and living shoreline components but could provide matching funds for grants to support construction, as well as an important component of maintenance revenues. In addition, maintaining wider and accessible City beaches would generate direct and indirect benefits to residents throughout the City who use the beach or receive benefit from business or employment opportunities generated by beach visitors. In summary, expansion of Assessment District No. 5 would be a highly suitable funding source for the proposed Project, but would almost certainly need to be combined with other local, state, or federal funding sources.

Establish New Geologic Hazard Abatement District

Assessment districts are common funding mechanisms for utilities, such as water supply, park and recreation, lighting and utility providers and more than thirty such districts exist throughout the County, including the Flood Control District. City Assessment District No. 5, if expanded, would provide an important, but potentially limited local funding source. Because shoreline management and beach nourishment are regional issues that affect all coastal communities dealing with sea level rise, consideration of regional funding mechanisms may make sense as all jurisdiction and regional groups such as BEACON will require new funding sources to actively manage the shoreline in response to projected sea level rise. The existing Countywide Flood Control Benefit Assessment District discussed below is one potential regional vehicle that could be modified to address coastal flood and sea level rise impacts rather than just riverine flooding. The Flood Control District is already actively involved in targeted shoreline management and beach nourishment in the Goleta Slough and adjacent Goleta Beach and within the Carpinteria Salt Marsh and adjacent beaches; this District also periodically performs emergency desilting of flood control debris basins along area creeks and frequently deposits portions of this sediment at Goleta Beach and Carpinteria City Beach at Ash Avenue.

Geologic Hazard and Abatement Districts (GHADs) are also opportunities for beach and bluff front property owners to establish an assessing entity to implement one or more of the priority adaptation strategies described above. There are over 35 GHADs in California that address a variety of hazards. GHADs can be used to address broad-based geological hazards, including coastal erosion. GHADs are often formed to fund repairs to address landslides such as that at La Conchita in Ventura County but have been used to address coastal erosion and potential beach nourishment such as at Broad Beach in the City of Malibu. By accumulating a funding reserve for future maintenance and rehabilitation, GHADs can provide the financial resources necessary for potential future expansion, maintenance, or repairs of flood or erosion control structures. Further, because of the relative safety of GHAD revenues, which are typically financed through the collection of supplemental tax assessments, such districts can borrow from lenders or issue bonds with very attractive credit terms. Because the impacts of projected sea level rise affect all coastal communities in the County, a multi-jurisdictional GHAD could be established between the City, BEACON, the County, cities of Santa Barbara and Goleta, and other stakeholders (e.g., Ventura County coastal communities) to better raise funds for improvements for issues that affect a larger regional area, resulting in greater reserves of funding for improved shoreline management and adaptation to improve resilience and ongoing maintenance or repair. Given the threat from coastal hazards extends well beyond the City, the possibility exists for the establishment of a GHAD that includes particularly at-risk areas of the City, as well as threatened adjacent unincorporated communities or neighborhoods, such as the Sandyland Cove Neighborhood. Similar to the potential expansion of Assessment District No. 5 described above, different zones could pay different rates depending on their risk level (i.e., properties near or on the coast could pay fees higher than properties farther away).

Formation of a local or regional GHAD would require careful interagency coordination, a public outreach campaign to inform voters and taxpayers of the need for such an action, and consideration of its relationship to other service providing/ taxing districts (e.g., Assessment District No. 5). Most such GHADs have a direct relationship to addressing a problem that immediately threatens a limited number of homes or a single neighborhood such as active landslides with a clear nexus to a direct and immediate threat, even such as beach erosion at Broad Beach. The boundaries of a GHAD would need to be carefully considered such as whether it would be confined to oceanfront properties only or be expanded more broadly a wider range of properties potentially impacted by sea level rise induced flooding or bluff erosion over the long term. Further, if used for funding the proposed Project, depending on boundaries and configuration, using a GHAD may grant undue authority over managing public beaches to a limited number of property owners as opposed to a public agency. A GHAD would need to be crafted so as not to overlap with Assessment District No. 5 as well.

Coordinate with County Flood Control District

The Flood Control District was formed to provide for the control and conservation of flood and stormwaters, the protection of watercourses, watersheds, public highways, life, and property from damage or destruction from such waters, and the prevention of waste, degradation, or diminution of the water supply, and the development and importation of water for beneficial use. The primary flood protection service provided by the Flood Control District is operating and maintaining the existing flood protection system and correcting existing problem areas as required.

The Flood Control District implements a program of creek and river channel maintenance and capital improvements to mitigate the threat to life and property from riverine flooding~~, but does not specifically address coastal oceanic flooding~~. As part of this program, the Flood Control District maintains more than 13 foothill debris basins along South Coast streams as well as removing sediments from channels ~~and debris basins~~ in the Carpinteria Salt Marsh and the Goleta Slough, with sediments removed from these marshes permitted for disposal on the Carpinteria

City Beach at Ash Avenue and Goleta Beach. However, large quantities of sediment removed from foothill debris basins are not permitted for regular beach disposal and are available for beach nourishment only after emergencies, such as after the 2018 Montecito Debris Flows when sediments were deposited on at Ash Avenue and Goleta Beach (Melinda Burns 2018).

To supplement the declining revenues after Proposition 13 was enacted in the late 1970s and to enable the Flood Control District to maintain and operate the system and construct some capital improvements on a reduced scale, the Flood Control District, under the authority of Assembly Bill 549, formed the Flood Control Benefit Assessment Program in 1980 following majority approval by County voters and levied benefit assessments on each parcel in the County (Flood Control District 2021). Assessment rates are based upon the proportionate amount of stormwater runoff generated by individual properties. These rates vary by Flood Zone and are based on the long-range cost of system operation and maintenance and of the remaining needed capital improvements for the Flood Zones. Parcels with higher stormwater runoff, determined by the size and land use of the parcel, are charged higher fees, called the Benefit Assessment Rate.

The Flood Control District's boundaries coincide with those of the County; the Board of Supervisors of the County of Santa Barbara is also the Board of Directors of the Flood Control District; and various officers, assistants, deputies, and employees of the County also perform their same duties for Flood Control District. The Flood Control District is divided into 10 active flood control zones; the City of Carpinteria falls into the South Coast zone.

The Flood Control District is already actively involved in the management of flood risks in channels upstream that feed into the Carpinteria Salt Marsh and Goleta Slough. Although it is not the primary intent of these programs, these management activities benefit beaches at sediment deposition sites at Ash Avenue and Goleta Beach by providing some degree of beach nourishment. Sediment deposition activities as part of these programs are supported by a robust monitoring program that shows no negative impacts on area beaches from resulting sediment deposition and resulting beach nourishment ~~in targeted shoreline management and beach nourishment activities through sediment removal from the Carpinteria Salt Marsh with disposal at Ash Avenue and at the Goleta Slough and Goleta Beach~~. ~~The~~ As a result of these programs, the Flood Control District has the experience with required permitting, staff, and access to equipment and contractors experienced with ~~such~~ sediment deposition and beach nourishment projects. The Flood Control District also periodically performs emergency desilting of foothill flood control debris basins along South Coast creeks and sometimes deposits portions of this sediment at Ash Avenue in Carpinteria and at Goleta Beach. However, over the last decade alone, hundreds of thousands of cy of beach quality sediment have been sent to landfills or quarries due to a lack of specific programs and permits for the regular ~~disposal~~ introduction of such sediment into the surf zone at area beaches, depriving the City's beaches of a major source of sand for beach nourishment.

Support for the Project from the County could be realized through coordination with both the City and BEACON on the preparation of a regional sediment management program, completion of required environmental documentation (e.g., CEQA), and acquisition of new permits for the delivery of sediment to area beaches. Such coordination on completion of a specific program and acquisition of new permits for disposal of sediments at area beaches could greatly benefit the City and serve as a major contributing source of sediment for initial and/or reoccurring beach nourishment for the Project.

~~Restructuring the Flood Control District could provide a secure regional funding source to provide funding and technical support for beach nourishment and construction of living shoreline projects throughout the South Coast. Any such restructuring of the district would need to be done in close coordination with the County and be designed to ensure that the Flood Control District's funding for and ability to respond to riverine flooding remains undiminished. In addition, strong support for the Flood Control District from South Coast cities and the County would be required to promote public understanding of the importance of beach nourishment to address sea level rise, protect homes and businesses, and protect the City's recreational beaches. Although the City does not have authority to direct restructuring of the Flood Control District, the City could work with the County to develop a program expanding the Flood Control District's mission and funding to address shoreline management and beach nourishment as a means to address sea level rise. Any such program would need to be done in coordination with local cities and BEACON to coordinate sediment management and deposition.~~

Dedicated Transient Occupancy Tax Increase

Transit Occupancy Tax and Sales Tax make up a large portion of the City's General Fund. For the fiscal year ending June 30, 2020, the City received $4,714,243 from Sales Tax and $2,023,128 from Transient Occupancy Taxes, together making up 49 percent of the City's General Fund revenues (City of Carpinteria 2020b). Presently, the Transient Occupancy Tax is set at 12 percent on room charges in a hotel, inn, tourist home or house, motel, or other lodgings for 30 consecutive days or less (City of Carpinteria 2021a).

A dedicated tax increase could be used to fund living shoreline construction and maintenance. Transient Occupancy Taxes usually range from 8 to 15 percent in coastal cities in California. The Cities of Santa Barbara and Goleta charge a Transient Occupancy Tax of 12 percent, the City of Ventura charges 10 percent. The City of Malibu recently increased its Transient Occupancy Tax from 12 to 15 percent in 2020. Increasing the City of Carpinteria Transient Occupancy Tax from 12 to 14 percent could yield an additional $340,000, using 2020 revenue numbers. A regionally coordinated increase in transient occupancy taxes to provide regional funding for coastal improvements, maintenance, or repairs could also be coordinated with other jurisdictions in the County. Such increases would require a vote of the residents of the City or region depending on scope.

Sand Mitigation and Public Recreational Impact Fees

Impact mitigation may be a way to generate funds for adaptation measure implementation. Certain structured fees could be established to generate revenues for covering the necessary planning, technical studies, design, and implementation of adaptation strategies for construction and maintenance of the beach and living shoreline.

The CCC uses Sand Mitigation Fee and Public Recreation fees to mitigate impacts to sand supply and coastal access. The Sand Mitigation Fee mitigates for the loss of sand supply and loss of recreational beaches in front of coastal protection structures. The Public Recreation Fee addresses impacts of the loss of public recreation based upon the loss of beach area physically occupied by the coastal structure. An additional fee for ecosystem damages is under consideration by the CCC, which could assess a fee based on the cost of restoration or replacement value of the damaged habitat.

Sand Mitigation Fee: The City could consider the creation of a Sand Mitigation Fee to help fund shoreline maintenance activities such as beach nourishment. While CCC's sand mitigation fees are intended to offset the loss of beach quality sand which would otherwise have been deposited on the beach but was interrupted by a coastal protection structure. However, the City's bluffs are generally not sandy and as such are not major contributors to beach sand supply and the City has extremely limited blufftop development, all of which lies landward of UPRR. Therefore, any such fee would need to be restructured and it may not be applicable in the City.

Public Recreation Fee: Similar to the methodology used by the CCC for the Sand Mitigation Fee, the CCC has used a methodology for calculating a statewide public recreation fee. Using a similar approach, the City could require applicants to pay a mitigation fee for public access and recreation impacts caused by bluff retention devices or other coastal structures to mitigate impacts to public beach access and recreation that are expected to result from development. For example, the City of Solana Beach adopted a Public Recreation Impact Fee rate schedule based on the number of visitors, the City's usable beach area, and the monetary value of the beach (City of Solana Beach 2019). However, the City has extremely limited blufftop development, does not typically approve coastal protection structures, and most shoreline development lies landward of the UPRR. Therefore, any such fee would need to be restructured and it may not be applicable in the City. Further, the Project is specifically designed to avoid the use of hard shoreline protection structures such as rock revetments.

Parking and Camping Fees

The City could consider pursuing collecting additional revenue to fund living shoreline creation and maintenance from visitors and residents who utilize the City's beaches. Much of the parking in the City is free on-street parking – the City could install parking meters, particularly on roads close to coastal access, and use the money to fund shoreline management. Such a program could generate revenue but could be controversial with area residents. Net revenue generation, impacts to Beach Neighborhood residents, and local businesses would all need to be considered.

The City could also collaborate with State Parks to levee fees on visitors to Carpinteria State Beach. State Parks currently charges $10 for day use parking and $70-80 per night for camping. These fees could be raised slightly, with added revenue dedicated to the shoreline management. As the state campground abuts Carpinteria State Beach, shoreline protection would greatly benefit the campground.

California Infrastructure and Economic Development Bank

The California Infrastructure and Economic Development Bank (IBank) was created in 1994 to finance public infrastructure and private development that promote a healthy climate for jobs, contribute to a strong economy, and improve the quality of life in California communities. IBank has broad authority to issue tax-exempt and taxable revenue bonds, provide financing to public agencies, provide credit enhancements, acquire or lease facilities, and leverage state and federal funds. Current IBank programs relevant to the City include the Infrastructure State Revolving Fund (ISRF) Loan Program and the Bond Financing Program, including Public Agency Revenue Bonds.

The ISRF Loan Program is authorized to directly provide low-cost public financing to government entities for a wide variety of public infrastructure and economic expansion projects. ISRF financing is available in amounts ranging from $50,000 to $25,000,000 with loan terms for the useful life of the project up to a maximum of 30 years. A few examples of ISRF financed projects include water and wastewater treatment plant upgrades or construction, venue or airport construction, or street repair and upgrades. Eligible applicants must be located in California and include any subdivision of a local government, including cities, counties, special districts, assessment districts, joint powers authorities, and nonprofit organizations sponsored by a government entity.

Public Agency Revenue Bonds provide bond financing for various government entities' economic or public development projects and programs. These funds can be used for the furtherance of governmental and qualified purposes including the construction of transportation/transit, water/wastewater systems, power generation/transmission system, sewer system, schools as well as facilities and equipment used in providing related qualified services to such entities.

The City would need to consider the applicability of such programs and identify a revenue stream that could be used to pay off loans or bonds from either of these programs. Such funds could potentially be used to fund shoreline management, but the City would need to explore if shoreline management falls under regular City duties, similar to how cities provide water and transportation systems. Regardless, potential revenue sources such as those discussed above would need to be explored to pay off any bonds or loans.

State Bond Measures and Grants

The State currently has only one ongoing program specifically dedicated to beach nourishment that is managed by the California State Parks Division of Boating and Waterways (DBW). It is the Shoreline Erosion Control and Public Beach Restoration grant program. Separate grant funding applications are submitted for projects that apply under either the Shoreline Erosion Control Program or the Public Beach Restoration Program. The Shoreline Erosion Control Program can assist in the planning and construction of all types of beach erosion control and shoreline stabilization measures, including hard structures like seawalls, while the Public Beach Restoration Program can assist in the planning and construction of engineered placement of sand on the beach or in the nearshore environment. Aspects of the proposed Project appear to be highly eligible under each of these programs, and both programs formed a key component of major past beach restoration projects in San Diego sponsored by the San Diego Association of Governments. While applications for funding cycles for Fiscal Year 2022-2023 and 2023-2024 were due in 2021, funding was not available in prior years and future funding levels and cycles remain uncertain.

Other grant programs may apply to living shoreline construction, but it is unclear if such programs would fund beach nourishment, a major portion of Project costs, and effectiveness in shoreline protection. Presented in Table 3 is a summary of potentially viable State grant programs, funding amounts, and a preliminary review of Project eligibility.

Table 3. Potentially Viable State Grant Funding Programs

Agency/Grant Program	Available Funding Amount	Project Eligibility
Ocean Protection Council		
Proposition 1 Grant Program	Min: $100,000, but strongly encourages projects over $250,000 Max: $5,000,000	Programs may be more focused on habitat restoration such as the living shoreline. The City's application would need to focus on potential impacts to the environment if Carpinteria's beaches were damaged, and Disadvantaged Community needs for coastal access.
California Governor's Office of Emergency Services (Cal OES)		
Hazard Mitigation Grant Program	No min/max	The City is currently updating its Local Hazard Mitigation Plan which when completed would make the City eligible for funding under this program. The City would apply as a subapplicant to the State's application. This program may apply to both beach nourishment and the living shoreline. The City's application would need to focus on

		potential flood hazard reduction benefits.
Building Resilient Infrastructure and Communities (BRIC) and Flood Mitigation Assistance (FMA) Grant Programs	BRIC Min: N/A Max: $3,000,000 FMA Individual planning grants using FMA funds cannot exceed $50,000 to any Applicant or $25,000 to any subapplicant	Program may apply to both beach nourishment and the living shoreline. The City's application would need to focus on potential hazard reduction benefits.
California Coastal Conservancy		
Coastal Resources and Public Access Program	No min/max	The Coastal Conservancy has funded portions of "green" shoreline management projects such as Surfers Point in Ventura and the Cardiff Living Shoreline in Encinitas (beach nourishment component funded separately). So, at least the living shoreline portion of the Project may be eligible and possibly portions of the beach nourishment component.
Climate Ready Program	No min/max	
Explore the Coast	Min: N/A Max: $50,000	
California Division of Boating and Waterways		
Shoreline Erosion Control and Public Beach Restoration Grant Programs	No min/max, but small grants for studies typically range from $40,000 to $50,000, and large grants for restoration typically range from $5 million to $6.5 million	The Shoreline Erosion Control and Beach Restoration Programs are highly suitable funding sources for the proposed living shoreline and beach nourishment program. These programs formed a key component of major past beach restoration projects in San Diego sponsored by the San Diego Association of Governments.
California Department of Water Resources		
Floodplain Management, Protection, and Risk Awareness Grant Program	No min/max	It is unclear if the proposed Project would be eligible for funding under this program. The City's eligibility would need to be further explored.
California Wildlife Conservation Board		
Habitat Enhancement and Restoration Program	No min/max	This program is focused on habitat restoration such as the Living Shoreline. The City's application would need to focus on potential habitat restoration benefits to be eligible for funding under this program.
California Coastal Commission		

Whale Tail Grants	Min: N/A Max: $50,000	The proposed Project does not appear suitable for funding under this program.
California Natural Resources Agency		
Urban Greening Program	No min/max	Under this program, the living shoreline portion of the Project may be eligible due to its habitat restoration/ "greening" benefits. The Project would preserve access to the shoreline including that for Disadvantaged Communities, including some enhanced protection for low-cost overnight campsites.

In addition to the programs listed above, as previously discussed, CSLC may have access to funding for beach nourishment and living shoreline projects in the City through payment of mitigation fees from the currently dormant Chevron Shell Mounds Project. The CSLC is not an agency that typically administers grants and thus does not typically fund beach nourishment of living shoreline creation projects. However, between 2013-2015, as part of the plan for abandonment of four offshore oil platforms (referred to as the "Chevron 4H Platforms Shell Mounds Project"), two of which are located within City offshore lands, Chevron proposed payment of $3,000,000 in mitigation fees to CSLC to leave the "shell mounds" in place around the base of abandoned platforms to provide a rare complex of hard bottom habitats within a naturally occurring soft-bottom habitat area. These funds were proposed to be allocated for the removal of tens of thousands of cy of potential beach quality sediment to enhance fish habitat in the Carpinteria Salt Marsh. The project appears to be on hold and the status of any mitigation payments, which could support the delivery of significant sand to the City's beach, is unclear.

Federal Grant Funding Assistance

Only two ongoing federal grant funding programs are currently available to local agencies that could present suitable funding opportunities for the City for beach nourishment and construction and maintenance of a living shoreline. They are NOAA's Coastal Resilience Grant Program and the National Fish and Wildlife Foundation's Coastal Resilience Grant Program. Each of these programs is highly competitive, and there are no minimum or maximum limits to the requested funding amount. However, some percentage of the requested funding amount under each grant program would need to be matched through cash or in-kind services by the grant applicants (e.g., City). Each of these federal grant programs appears to be highly suitable, as many projects similar to this proposed Project have been partially or fully funded through these grant programs. In addition, the recently enacted federal Infrastructure Investment and Jobs Act may provide funding to address climate change and resiliency. However, as of this publication, how these new federal funds will be distributed and their applicability to the Project is unclear.

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