Executive Summary

The Adaptation Plan serves as the City's "toolbox" to help property owners (public and private) plan for and address future sea-level rise, storm surge, coastal flooding, and erosion. In 2016, the City of Del Mar prepared a Coastal Hazards, Vulnerability and Risk Assessment that identified the degree of vulnerability posed to City beaches, lagoons, coastal bluffs, visitor-serving amenities, public access areas, residential and commercial areas, and public infrastructure. In consideration of the vulnerabilities and risks, the Adaptation Plan provides tools for owners to manage risks and take actions based on measurable changes in conditions.

The Adaptation Plan provides flexibility for owners to choose from an array of adaptation options, rather than prescribing a specific plan of action. Project-level planning and approvals will be required to further develop and implement specific adaptation measures.

Adaptation measures are typically categorized within the following categories:

- **Protection strategies,** which employ some sort of engineered structure or other measure to defend development (or resources) in its current location without changes to the development itself. Examples include "hard" armoring via structures such as seawalls, revetments, groins and breakwaters that defend against coastal hazards like wave impacts, erosion, and flooding; "soft" armoring using natural or "green" method like beach nourishment and artificial dunes to buffer coastal areas; and hybrid approaches using both hard and natural infrastructure.

- **Accommodation strategies,** which modify existing development or design new development in a way that decreases hazard risks and thus increases the resiliency of development. Examples include elevating structures, retrofitting structures, using materials that increase the strength of development, or incorporating extra setbacks from hazards.

- **Retreat strategies,** which relocate existing development as necessary out of hazard areas and limit the construction of new development in vulnerable areas. Examples where this strategy could be used for public property include relocation of public facilities, roads, and infrastructure.

Adaptation strategies should not be considered in isolation. Different types of strategies will be appropriate in different locations, and in many cases a hybrid approach with strategies from multiple categories will be necessary. Additionally, the suite of strategies chosen may need to change over time.

The following principles were established to provide guidance for developing, evaluating, and analyzing adaptation measures:

- Limit the risk of extreme coastal and river flooding and damage.
- Maintain a walkable beach for recreational use, economic benefit, and to reduce flooding.
- Maintain continuous horizontal coastal access and vertical water access points to North and South Beach.
- Maintain continuous coastal access from North Beach to South Beach.
- Maintain San Dieguito Lagoon wetland habitat functions.

In terms of City assets, the Adaptation Plan identifies high priority adaptation measures for which near term actions are recommended to reduce high vulnerabilities and risks. The Plan also discusses sediment management and sand retention measures and identifies potential adaptation measures to address the following areas and vulnerabilities:

- San Dieguito Lagoon wetland adaptation for the River Valley
- San Dieguito River flooding adaptation for the North Beach and River Valley including the Del Mar Fairgrounds
- Bluff and adjacent beach erosion adaptation for the South Bluffs, and bluffs along South Beach and North Bluffs
- Beach erosion and flooding adaptation (north from 15th St to the San Dieguito River mouth)

The Adaptation Plan is based on the best science and adaptation practices available today. However, sea-level rise science and practices are evolving and environmental conditions along the beach, bluffs, and San Dieguito Lagoon are changing; therefore, it is anticipated that this document will be updated over time as needed.

The Sea Level Rise Technical Advisory Committee (STAC) evaluated retreat as an adaptation option and determined it is too early in the process to include retreat as an adaptation strategy in Del Mar. At this time, retreat is intentionally not included as an adaptation option for private property. STAC recommends that the City prioritize beach nourishment in conjunction with sand retention.

STAC recognizes that additional reports will be generated over time, including a Sediment Management Plan and a Wetlands Habitat Migration Assessment. Analyses of the financial and legal impacts of adaptation measures will be performed when any future project is initiated and details for a given project are available. It is expected that the City will reevaluate options, including retreat, as appropriate and using updated scientific and monitored data when amendments to the Adaptation Plan are considered at a future date.

CHAPTER 1

Planning for Sea-Level Rise in Del Mar

1.1 About the City of Del Mar

Del Mar is a beach city in San Diego County, California. Del Mar is Spanish for "of the sea" or "by the sea," which reflects its location on the coast of the Pacific Ocean (Figure 1). Del Mar's climate is considered Mediterranean-subtropical with warm, dry summers and mild, humid winters. The city has a total area of 1.8 square miles (4.7 km^2), where 1.7 square miles (4.4 km^2) of it is land and 0.1 square miles (0.26 km^2) of it (4%) is water. The entire western boundary of the city is on the oceanfront, from north to south, and includes bluff, lagoon river mouth, open beach and developed beach. Del Mar has a continuous wide beach stretching over two and a half miles from near the Los Penasquitos Lagoon on the south to San Dieguito Lagoon on the north, with additional walkable beach north of San Dieguito Lagoon rivermouth to Del Mar's boundary with the City of Solana Beach. The beaches are walkable from end-to-end, especially in the summer when wider. The southern area of Del Mar is located atop and to the east of oceanfront bluffs, as is the area north of the San Dieguito lagoon. The northern area, known as North Beach, up to the river includes topography with oceanfront homes at a higher elevation than adjacent homes to the east, where the elevation declines eastward from the ocean front lots toward the LOSSAN rail line.

1.2 Planning Process and Goals

Rising sea level increases the risk of hazards to coastal communities from storms, flooding, and erosion. In response to the increased risks of coastal hazards, the California Coastal Commission has a priority goal to coordinate with local governments, such as the City of Del Mar (City), to complete a Local Coastal Program (LCP) amendment that addresses the impacts of sea level rise. An updated LCP can help cities address new coastal management challenges that result from sea level rise and climate change.

Planning for sea level rise includes identifying and applying different adaptation mechanisms based on Coastal Act requirements, Del Mar's voter-approved Beach Preservation Initiative (BPI) incorporated in the certified LCP, acceptable levels of risk, and community priorities. By planning ahead, communities can reduce the risk of costly damage from coastal hazards, can ensure the coastal economy continues to thrive, and can protect coastal habitats, public access and recreation, and other coastal resources for current and future generations. Adaptation strategies should be chosen based on the specific risks and vulnerabilities of a particular region or project site, in the context of applicable Coastal Act and LCP requirements.

Figure 1
Del Mar Map

1.3 Amending Del Mar's Local Coastal Program

The California Coastal Act requires local governments, such as the City of Del Mar, in the state's Coastal Zone to create and implement Local Coastal Programs (LCPs). Given that a majority of Del Mar lies within the Coastal Zone, the City's LCP is an integral component of many planning processes. Each local government's LCP consists of a Coastal Land Use Plan (referred to as LUP or General Plan) and an Implementation Plan (Zoning Code). Using the California Coastal Act, the California Coastal Commission (CCC) and local governments manage coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion.

The purpose of this report is to complete some of the steps outlined in the CCC's Sea Level Rise Policy Guidance document. These steps include the following:

Step 1. Establish the Projected Sea Level Rise Ranges

Table 1.1 shows projected future sea-level rise from the National Research Council (NRC) study Sea-Level Rise for the Coasts of California, Oregon, and Washington (NRC 2012) for the mid-range and the high-range sea-level. The rate of sea-level rise is projected to accelerate in the future.

The mid-range sea-level rise projections are based on reducing fossil fuel use, with a balance between fossil fuels and alternative energy sources; whereas the high-range sea-level rise projections assume intensive fossil fuel use will continue in the future. The NRC sea-level rise projections are considered "best available science" for/by the State of California.

Table 1.1
Sea level rise scenarios used in this Study

	2030	2050	2070	2100
Low SLR	2in	5in		17in (1.4 ft)
Mid SLR	5 in	12 in	20 in (1.7 ft)	37 in (3.1 ft)
High SLR	12 in	24 in	38 in (3.2 ft)	66 in (5.5 ft)

The Del Mar Adaptation Plan acknowledges that the processes causing sea-level rise and the science of projecting sea-level rise are inherently uncertain. For example, the rate of sea-level rise is highly dependent on whether global greenhouse gas emissions will continue to increase or whether global emissions will be reduced. The rate of sea-level rise could be higher, or lower, than the above projections. Given the uncertainties, the Adaptation Plan is therefore not tied to specific timeframes or years, but rather uses thresholds based on amounts of sea-level rise of up to 5.5 ft and responses to climate change such as flood frequency and erosion.

Step 2. Identify Potential Impacts from Sea Level Rise

Based on available modeling from SPAWAR and USGS (CoSMoS 1.0 and 3.0 preliminary), the potential hazards for the City were identified and include storm induced dune erosion, coastal flooding from wave run-up, and tidal inundation. Given the boundaries and setting of the City, the most dominant hazards are the following: coastal flooding associated with major wave events, river flooding and coastal erosion.

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

The following sectors were determined to experience some form of existing or future risk and related vulnerability to sea level rise (e.g., bluff erosion and/or coastal flooding):

A. Land Use
B. Roads
C. Public Transportation
D. Wastewater
E. Storm water
F. Schools and Parks
G. Hazardous Materials
H. Other Utilities (e.g. water, electricity, gas)

Per the City of Del Mar's Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016,http://www.delmar.ca.us/DocumentCenter/View/2455), the City of Del Mar is currently vulnerable to river and coastal flooding and erosion, with significant damages in the recent past (late 1970s to present). Along the Del Mar bluffs (Figure 1), the cliff top has retreated to a point where it is a safety concern for the LOSSAN (Los Angeles-San Diego-San Luis Obispo) railroad along the bluff top, and the San Diego Association of Governments (SANDAG) and North County Transit District (NCTD) have responded by installing multiple bluff stabilization projects.

With future climate change and sea-level rise, studies suggest that the City of Del Mar's current vulnerabilities are projected to increase in both frequency and intensity, resulting in increased damage to much of Del Mar including low-lying areas and areas near coastal bluffs, summarized as follows:

- The beach above high tide will be lost to erosion with approximately 1 to 2 ft of sea-level rise, at which point beach erosion and coastal storms will threaten sea wall integrity, affecting the City's North Beach District.
- Bluffs will erode and impact the LOSSAN railroad as well as the South Beach and South Bluff Districts; or, if the railroad were to be armored with a seawall, little to no beach will exist.
- San Dieguito River flooding will inundate the City's North Beach and Valley Districts, including the Del Mar Fairgrounds, more frequently and with greater depths.

The increased future sea-level rise and hazards will impact coastal resources and assets in Del Mar, including properties, roads and bridges, infrastructure, emergency services, coastal access, and San Dieguito River lagoon wetland habitats. The Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016, http://www.delmar.ca.us/DocumentCenter/View/2455) includes additional details, analysis, and discussion of Del Mar's vulnerabilities to sea-level rise.

Step 4. Identify Adaptation Measures

The Del Mar Sea-Level Rise Adaptation Plan serves as the City of Del Mar's long-range planning guide to address future sea-level rise and its effects on storm surge and coastal flooding and erosion. This Adaptation Plan will provide the basis for developing new sea-level rise policies that will be integrated into the City's LCP via a LCP Amendment.

Preparation of the Adaptation Plan is funded by the City and a planning grant awarded to the City by the Ocean Protection Council and administered by the California Coastal Commission. This Adaptation Plan follows the California Coastal Commission's (2015) *Sea Level Rise Policy Guidance* for addressing sea-level rise in LCPs. Additional information on the City's sea-level rise LCP Amendment is available at: http://www.delmar.ca.us/sealevelrise.

The Adaptation Plan is consistent with the California Coastal Act and relevant City and State policy, plans, and guidelines (reviewed in Chapter 2).

1.4 Del Mar's Sea-Level Rise Stakeholder Technical Advisory Committee (STAC)

The City established the Sea- Level Rise Stakeholder Technical Advisory Committee (STAC) to provide oversight and ensure the LCP amendment process is open, inclusive, and develops consensus amongst the many stakeholders involved. (For more details on the STAC, see: http://www.delmar.ca.us/499/Sea-Level-Rise-Stakeholder-Committee.) STAC developed the following guiding principles for the development of the Adaptation Plan:

- Limit the risk of extreme coastal and river flooding and damage to less than approximately a 5% chance of occurring in a given year.
- Maintain a walkable beach for recreational use and economic benefit, and to reduce flooding.
- Maintain continuous horizontal coastal access and vertical water access points to North and South Beach.
- Maintain continuous coastal access from North Beach to South Beach.
- Maintain San Dieguito Lagoon wetland habitat functions.

1.5 Summary of the Adaptation Plan

The Adaptation Plan includes the following components and adaptation measures to reduce risks associated with future sea-level rise. Any adaptation measure when implemented may introduce new needs for additional mitigation.

- **Public Facilities, Infrastructure and Beaches:** high priority sea-level rise adaptation measures for the City to begin planning for now include:
    - Relocating the City of Del Mar Fire Station
    - Relocating the City of Del Mar Public Works Yard
    - Flood-proofing the sewer lift station along San Dieguito Drive
    - Beach sand retention, replenishment, and management
- **San Dieguito Lagoon wetland adaptation:**
    - Conversion of vegetated wetland to mudflat and open water habitats with sea-level rise could be partially accommodated and offset by allowing and facilitating the conversion of higher elevation area to tidal wetland habitat, such as the tern nesting island, adjacent upland habitats, and upstream riparian habitats.
    - Placement of sediment to raise the elevation of the wetlands (e.g., "spraying" material dredged from the River channel as a thin layer of sediment across the vegetated marshplain) has the potential to reduce or slow wetland habitat conversion.
    - Wetland expansion/restoration can create new wetlands with higher elevation areas that are more resilient to sea-level rise; wetland restoration is compatible with partial retreat and construction of "living" levees to reduce flood risks along the River.
- **San Dieguito River flooding adaptation**:
    - San Dieguito River channel dredging and Lake Hodges reservoir management have potential to reduce river flood risks in the near- to mid-term.
    - A hybrid approach with restoration of developed area adjacent to the River to expand the San Dieguito Lagoon wetland floodplain and construction of new levees between the wetlands and development can provide longer-term flood risk reduction; "living" levees can be designed to incorporate restored wetland transition and upland habitats that improve wetland resiliency to sea-level rise.
    - If Lake Hodges reservoir management is not possible, the timeframe for other measures may be sooner.
- **Bluff/beach erosion adaptation**:
    - Beach nourishment and sand retention strategies as well as installation of access paths down the bluffs (e.g., stairways) in conjunction with authorized pedestrian crossings at railroad under- or over-passes may provide some near-term reduction in bluff erosion; investigating whether landscape irrigation in City neighborhoods east of the bluffs is contributing increased groundwater flow and associated erosion and the potential to reduce irrigation affects may also be beneficial.

- Relocating the LOSSAN railroad will allow for continued landward bluff erosion, and thereby maintain a beach below the bluff and provide access along the bluff top.
- Removal of bluff top sewer lines, drainage ditches, and fiber optic cables will eventually be required as the bluff continues to recede inland.

- **Beach coastal (ocean) flooding and beach erosion adaptation:**
  - Beach and dune nourishment and sand retention strategies may provide near-term protection, but their effectiveness is likely to decrease over time with higher amounts and rates of sea-level rise.
  - Redevelopment policies and regulations can be developed for the LCP Amendment to make feasible the option of elevating structures.
  - Sand retention measures such as groins or artificial reef may help maintain the beach, but would likely introduce need for additional mitigation.
  - Raising/improving the existing sea wall and revetments (i.e., "holding the line") would reduce flood risks with sea-level rise.
  - Raising City infrastructure including buildings, utilities, and roads will likely be required to accommodate the increase in flood risk with sea-level rise.

1.6 Purpose of the Adaptation Plan

This Adaptation Plan will provide the basis for developing new sea-level rise policies that will be integrated into the City's Local Coastal Program (LCP) via a LCP Amendment. This report provides technical analysis using flood risk and shoreline change modeling. Preparation of the Adaptation Plan has been funded by the City and a planning grant awarded to the City by the Ocean Protection Council and administered by the California Coastal Commission. This Adaptation Plan follows the CCC's (2015) *Sea Level Rise Policy Guidance* for addressing sea-level rise in LCPs. Additional information on the City's sea-level rise LCP Amendment is available at: http://www.delmar.ca.us/sealevelrise.

This project will inform the City's long-term effort to address a range of coastal and climate change hazards in planning and regulatory processes. This information will assist the City in making informed decisions regarding land use and development standards from the project level to the plan and policy level.

The guiding principles behind the Adaptation Plan seek to be consistent with the voter-approved BPI to regulate the uses of the Del Mar beach area, a distinct and valuable resource, for the benefit of present and future generations, so as to protect public access to and along the shoreline, while promoting public safety, health and welfare, and providing for the protection of private property; minimize risks to Del Mar's assets, including property and infrastructure; and to protect Del Mar's coastal resources. The California Coastal Act defines coastal resources to include coastal development and hazards; public access and recreation; coastal habitats; Environmentally Sensitive Habitat Areas and wetlands; water quality and supply; archaeology and paleontological resources; and scenic and visual resources. A key coastal resource is the sandy beach, both for public enjoyment and community wellbeing, and also for ecosystem services such as storm damage protection.

Consistent with the California Coastal Commission Sea-Level Rise Policy Guidance and current environmental practice, the Adaptation Plan includes hybrids between these approaches, nature based or green infrastructure solutions, and multi-objective measures that incorporate environmental considerations, rather than focusing on independent solutions to protection.

1.7 Definitions

Adaptation: means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the vulnerabilities and reduce the fiscal impacts.

Coastal Erosion: erosion of the coast caused by wave attack.

Coastal Flooding: flooding along the coast caused during a large storm wave event and typically includes wave uprush with momentum that can cause damages.

Economic Benefits: can be measured in two ways – market and non-market benefits. Market benefits are measured using market values. For example, to value a private residence one would use the market price of the home. Many of the benefits in this study are non-market benefits. Economists have developed a number of techniques to measure benefits when the price is set at zero. For example, beaches are free in California, but numerous studies indicate that visitors are willing to pay to go to the beach. This willingness to pay is non-market value. Our study incorporates the literature on non-market valuation to measure these changes.

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

Economic Impacts: measure the spending and economic activity resulting from a policy change. This study estimates the changes in spending from changes in beach recreation caused by changes in beach width.

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

Tidal Inundation: flooding caused during predictable high tides that occur with some regularity.

Net Benefits: estimate the economic benefits minus the economic costs. Typically, these net benefits are discounted over time.

Nuisance Flooding: recurring flooding caused by high tides and potentially exacerbated with stormwater or precipitation.

Planning Horizon: The planning horizon is the future time that forecasts of climate impacts are made and the time that an organization will look into the future when preparing a strategic plan.

Tax Revenue Impact: measures the changes in taxes as a result of a policy change. This study estimate changes in sales taxes and transient occupancy taxes (TOTs) resulting from changes in beach tourism/recreation.

Vulnerability Assessment and Sector Profiles: A vulnerability assessment is the process of identifying, quantifying, and prioritizing (or ranking) the vulnerabilities in a system. There are a variety of vulnerable "sectors" within the City, ranging from building structures, stormwater, beach accesses, wastewater, and transportation.

CHAPTER 2

Relevant Plans and Guidelines

2.1 California Coastal Act

The Legislature declares that the basic goals of the state for the coastal zone are to:

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

2.2 Del Mar Community Plan

The City of Del Mar Community Plan (General Plan) establishes the community's vision for future growth through goals, objectives, and policies that address the following topics: environmental management, transportation infrastructure, and community development, including land use and housing (City of Del Mar, 1976). The Community Plan also references specific provisions for 16 specific plans that apply to certain areas of the city, natural or hazardous features, and provision of certain infrastructure.

1.E.1 Preserve, as open space, areas such as the 100-year floodway and the beach bluffs west of the railroad tracks that are too hazardous to justify permanent construction.

1.E.7 Open space areas should be managed with erosion control and pollution prevention measures in the forefront.

1.H.1 Participate in regional and/or statewide efforts to evaluate and control beach and bluff erosion problems.

1.I.10 Maintain existing public uses of beaches.

From the guiding principles above, the adaptation plan recognizes that Del Mar's beach, particularly North Beach but also including South Beach along the bluffs, provide significant recreational, economic, and flood and erosion protection values. The beach is walkable for most of the year and most stages of the tide, with the exceptions being particularly high tides occurring in the winter when seasonal erosion of the beach has occurred. The intent of this guiding principle is to maintain these values and the character of Del Mar's beaches. Through adaptation, the goal is to avoid extended periods of time or successive years where these uses and values are significantly compromised (e.g., periods of days or weeks when the beach is not walkable or only walkable at the lowest tides). Given that the beach is continually changing throughout the year and from year to year, it is difficult to measure or specify a minimum beach width and this guiding principle is therefore focused on maintaining the beach's values.

1.E.4 Preserve and where necessary acquire easements for the protection of access to the beach and other public open space.

2.A.5 Preserve and improve pedestrian access to and along beaches and sea cliffs by use of all public rights-of-way and prescriptive easements.

As an extension of the guiding principles above, the City's adaptation goal is to maintain continuous horizontal coastal access along Del Mar's North and South Beach between Solana Beach to the north and Torrey Pines State Beach to the south. The Adaptation Plan also seeks to maintain and provide vertical access down to the Del Mar beach at existing access points and potentially new controlled and legal railroad crossing(s) and access down the South Bluff.

1.J.1 Establish a comprehensive master plan and management program for the lagoon including biological productivity potential, health controls, future water supply, the preservation and enhancement of wildlife, and opportunities for educational and recreational enjoyment.

1.J.2 Land use policies established within the San Dieguito River Floodway and Lagoon Habitat should be consistent with the long-range goal of returning the entire area to the natural lagoon condition.

In regard to the above Del Mar Community Plan goal, the Adaptation Plan seeks to maintain San Dieguito wetland habitat functions for wetlands within the City limits and to provide guidance and coordination for maintaining the Lagoon ecosystem as a whole, including upstream wetlands in the City of San Diego. The Del Mar Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016) indicates that vegetated salt marsh habitat will convert to unvegetated mudflat and open water habitat with sea-level rise. The Adaptation Plan seeks to maintain a diverse array of wetland habitats including vegetated salt marsh habitat for critical salt marsh species, which could otherwise be lost. Southern California Edison (SCE) currently maintains the San Dieguito Lagoon Restoration as part of the mitigation program for the San Onofre Nuclear Generating Station (SONGS); however, SCE is not currently required to address the potential effects of sea-level rise and at some point in the future the management of the restoration may be transferred to another entity. The Adaptation Plan therefore seeks to improve the resiliency of the entire San Dieguito Lagoon wetland ecosystem to sea-level rise, including the San Dieguito Lagoon Restoration.

2.3 Del Mar Local Coastal Program

Del Mar's Local Coastal Program (LCP) guides development and protects coastal resources within the Coastal Zone. LCPs must be consistent with the California Coastal Act of 1976, as amended. Del Mar's LCP is made up of two parts: (1) the Land Use Plan (a compilation of goals, policies, and recommended programs), and (2) Implementing Ordinances (regulations that implement the provisions of the Land Use Plan and the California Coastal Act) (City of Del Mar, 1993; 2001).

Del Mar's LCP establishes goals, policies, and regulations for the following four overlays: beach overlay, coastal bluff overlay, floodplain overlay, bluff, and lagoon overlay.

The Beach Protection Initiative (BPI) was adopted on April 12, 1988, by the Del Mar voters. It was subsequently certified as part of the City's LCP and codified in the Del Mar Municipal Code (DMMC) LCP as the Beach Overlay Zone at Chapter 30.50. The stated purpose of the Beach Overlay Zone created by the BPI is "to regulate the uses of the Del Mar beach area, a distinct and valuable natural resource, for the benefit of present and future generations". The regulations aim "to protect public access to and along the shoreline, while promoting public safety, health and welfare, and providing for the protection of private property". On November 14, 1988 the City Council, as authorized by the BPI, adopted Guidelines to interpret the BPI.

Additional key policies and regulations relevant to the Adaptation Plan are the following:

- **Beach Overlay Zone (Land Use Plan, Chapter III; Implementing Ordinances, Chapter 30.50):** The purpose of this zone is to protect public access to and along the shoreline, while promoting public safety, health and welfare, and providing for the protection of private properties. The zone establishes a Shoreline Protection Area (SPA) line within the Beach Overlay Zone.
- **Coastal Bluff Overlay Zone (Land Use Plan, Chapter III; Implementing Ordinances, Chapter 30.55):** The purpose of this zone is to protect Del Mar's fragile coastal bluffs as a visual resource and avoid the risks to life and property associated with bluff failure and shoreline erosion.
- **Floodplain Overlay Zone (Land Use Plan, Chapter III, Implementing Ordinances, Chapter 30.56):** The purpose of this zone is to promote public health, safety, and general welfare by ensuring that new development is appropriately sited and constructed so as to avoid hazards to those who will occupy the development, and to avoid damage or hazards to the surrounding area. The purpose is also to ensure development will not obstruct flood flow; will be designed to reduce the need for construction of flood control facilities that would be required if unregulated development were to occur; and to minimize the cost of flood insurance to Del Mar's residents.
- **Lagoon Overlay Zone (Land Use Plan, Chapter VI; Implementing Ordinances, Chapter 30.53):** The purpose of this zone is to protect the wetland resources of the Los Peñasquitos and San Dieguito Lagoons and their sensitive upland habitats by requiring that all development activities are designed and implemented in a manner that is consistent with wetland habitat protection and enhancement

2.4 Del Mar Climate Action Plan

The Del Mar Climate Action Plan provides a roadmap for the Del Mar community to reduce greenhouse gas emissions. The Climate Action Plan includes a greenhouse gas emission inventory for 2012 (defined as the baseline) and emission reduction targets for 2020 and 2035. Actions to meet emission reduction targets are grouped by the following community sectors: energy and buildings, water and waste, transportation, and urban tree planting. The Climate Action Plan identifies the process for implementing and monitoring success of the reduction measures included in the plan. Adaptation strategies to help the city reduce vulnerabilities and build resilience to the anticipated effects of climate change are also included. Adaptation strategies that relate to the measures identified in this Adaptation Plan include:

- Coastal Flooding
  - Conduct a sea-level rise study to understand the risks and cost/benefits of development within flood hazard zones and potential long term mitigation recommendations.
  - Explore protecting existing and construct new natural buffers to protect the coastline from flooding.
  - Explore preservation of shorelines through beach replenishment and nourishment to address impacts of sea-level rise on shorelines.
- Natural Systems and Wildlife
  - Monitor the health of coastal wetlands/river habitats that filter polluted runoff.
  - Protect, preserve, and restore native habitats.

2.5 CCC Sea-Level Rise Policy Guidance

In 2015, the California Coastal Commission (CCC) adopted the Sea Level Rise Policy Guidance document to aid jurisdictions in incorporating sea level rise into LCPs, Coastal Development Permits, and regional strategies. The document outlines specific issues that policymakers and developers may face as a result of sea level rise, such as extreme events, challenges to public access, vulnerability and environmental justice issues, and consistency with the California Coastal Act. It organizes current science, technical, and other information and practices into a single resource to facilitate implementation of the Coastal Act by coastal managers at the state and local level. The policy guidance document also lays out the recommended planning steps to incorporate sea level rise into the legal context and planning strategies to reduce vulnerabilities and guide adaptation planning. The policy guidance has a strong emphasis on using soft or green adaptation strategies.

CHAPTER 3

Coastal Processes and Human Adaptations

This Chapter examines the Oceanside Littoral Cell along with implications of human intervention, including sediment management, beach nourishment and the construction of groins, breakwaters, and seawalls.

3.1 Oceanside Littoral Cell

Coastal processes drive the movement of littoral sediment, leading to beach erosion, beach stability, or beach accretion. Coastal erosion and accretion has always existed and these Coastal processes have long contributed to the present coastline. The California coast can be separated into discrete geographic areas called littoral cells. Littoral cells are the areas where sediment moves in various directions along the coast. Other features such as submarine canyons and headlands are also part of the coastal environment. The littoral cells within San Diego County (Figure 3.1.1) are the Oceanside Littoral Cell to the north, the Mission Bay Littoral Cell, and the Silver Strand Littoral Cell. Patsch et al (2007) provides a broad overview the Oceanside littoral coastal processes as follows:

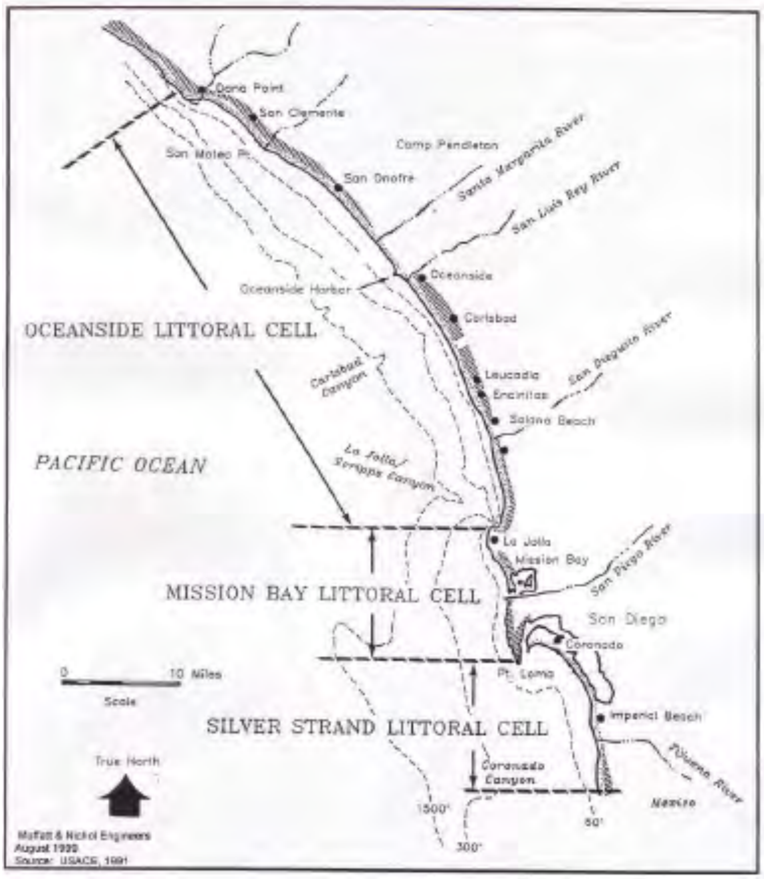
"The Oceanside littoral cell extends approximately 50 miles from Dana Point Harbor south to La Jolla and Scripps Submarine Canyons. The large Oceanside Littoral Cell is artificially divided by Oceanside Harbor's north jetty, which effectively eliminates significant transport of littoral sand from the northern portion of the littoral cell to down coast of the Harbor. The shoreline of this cell consists of a continuous, narrow beach backed by sea cliffs or bluffs with the exception of the mouths of coastal rivers, streams, and harbors. Rocky headlands form the northern and southern boundaries of this cell. Sand entering the Oceanside littoral cell moves southward in the direction of the net alongshore transport and eventually enters the heads of La Jolla and Scripps submarine canyons, which are within a few hundred yards of the shoreline, just offshore from Scripps Institution of Oceanography. These canyons extend offshore in a southwesterly direction for approximately 33 miles, eventually depositing sediment into San Diego Trough, although it is widely believed that La Jolla Submarine Canyon is not a functioning sink for beach sand at the present time."[1]

"San Juan Creek and the Santa Margarita, San Luis Rey and San Dieguito rivers are the major sources of fluvial sand to the Oceanside littoral cell. San Juan Creek and the Santa Margarita and San Luis Rey rivers each contribute on average ~40,000 cubic yards/yr of sand, while the San Dieguito River contributes an average of ~12,500 cubic yards/yr of sand to the littoral budget(sediment coarser than 0.0625 mm). The Santa Margarita, San Luis Rey and San Dieguito rivers have had their natural sand yields reduced by 31%, 69% and 79%, respectively, (a reduction of ~154,000 cubic yards/yr) through damming. Fluvial sources originally provided

~66% of the sand to this littoral cell. Post-damming, the rivers now provide only ~33% of sand to the overall littoral cell budget." [1]

Figure 3.1.1

Littoral Cells within San Diego County



Large portions of the Oceanside littoral cell consist of sea cliffs and bluffs that range in height from 25 to 100 feet. The Torrey Pines area has cliffs and bluffs which reach heights of over 300 feet. In the Oceanside cell, approximately twenty percent of the sea cliffs have some type seawalls or revetments. Up to 80% of the sand from the erosion of sea cliffs and bluffs is of the grain size or that contributes directly to the coastal beaches. Table 3.1.1 from Patsch et al (2007)[1] provides details on cubic yards (cy) of sand per year (yr) contributed to the Oceanside littoral cell from major sources. The difference in contribution from rivers indicates reductions in sand sources to the Oceanside littoral are due to the damming of rivers and the armoring of sea cliffs. As described by Leighton and Associates (2001), "*Since 1919, dams have been built across all the major rivers systems in San Diego County that provides sediment to the beaches. With the construction of Lake Hodges in 1919, the effective sediment producing area of the San Dieguito River watershed was reduced from 346 square miles to 43 square miles. We can conclude that the beach width generally ha[s] been reduced since 1910 when the railroad was placed on the bluffs".*

Table 3.1.1
Overall sand contributions and reductions since 1910 to the Oceanside littoral cell[1]

Oceanside Littoral Cell			
Inputs	**Natural (cy/yr)**	**Actual (cy/yr)**	**Reduction (cy/yr)**
Rivers	286,500 (66%)	132,500 (33%)	154,000 (54%)
Bluff Erosion	118,000 (27%)	100,000 (25%)	18,000 (15%)
Gully/Terrace Erosion	31,500 (7%)	31,500 (7%)	0
Beach Nourishment		138,000 (34%)	+ 138,000 (0%)
Total Littoral Input	435,700 (100%)	401,700 (100%)	34,000 (8%)

Patsch et al (2007) provides a description of the reductions in the sand budget in the Oceanside littoral as follows: *"'Actual' sand yield refers to the estimated volume of sand reaching the coast under present day conditions taking into account reductions in sand supply from dams and sea cliff armoring as well as additions (e.g., sand provided by the dredging of Oceanside Harbor) to the budget from beach nourishment. In total, beach nourishment (not including bypassing from Oceanside Harbor) has provided approximately 7.2 million cubic yards of fill on the beaches in this cell, which is approximately 138,000 yd^3/yr over the last 65 years (1940-2005), representing 34% of the sand in the overall littoral budget. There appears to be a significant reduction in sand input to the cell compared to the original natural conditions as a result of most of the historic sand nourishment took place several decades ago."*[1]

"Loss of sand from the region's beaches has occurred continually since:

- *Implementation of flood control and other infrastructure throughout the coastal watersheds that reduces supply of sand from rivers;*
- *Construction of Oceanside Harbor in the early 1960s (which added sand to the regionover the short-term, but significantly interrupted sand delivery from upcoast over the long-term);*
- *Proliferation of hard structures (e.g., seawalls) that prevent bluff sand from being deposited on the beach;*
- *Natural change to a more energetic wave climate since 1978;*
- *Reduced rates of beach nourishment since the 1960's; and*
- *Dense urbanization in the coastal zone."*[6]

In the Moffatt & Nichol (2009) study for SANDAG, they noted the following recent SANDAG beach nourishment effort as follows: *"SANDAG performed beach nourishment from September to December 2012, including placements at Solana Beach. According to SANDAG, it is estimated that the southern Oceanside Littoral Cell needs 25 million cubic yards of sand nourishment for restoration and 320,000 of cubic yards of sand nourishment for maintenance"*[6].

3.2 Sediment Management

As described in section 3.1, the Oceanside littoral has a problem inadequate sediment delivery to the coast. Using sand from offshore deposits can serve to nourish stripped sand beaches as a public benefit. The objective would be to use sediment that is presently trapped upstream or up coast, or sequestered in offshore and terrestrial sand deposits. This may be effective for offsetting existing sediment losses from the coastal zone. In addition, the removal of existing surplus sediment from impacted areas such as clogged harbor entrances, lagoon mouths, and degraded wetlands can also benefit these natural features. Moffatt & Nichol (2009), evaluated Oceanside Harbor's northern jetty sediment transport impacts for SANDAG as follows:

"The interruption of sediment transport by Oceanside Harbor's northern jetty has created an extensive deposit of high quality sand up coast of the jetty, representing a large potential nearshore source if SANDAG and MCB Camp Pendleton can reach agreement on the procurement of that sand. This material would have naturally migrated to the southern portion of the Oceanside littoral cell had the jetty not halted its migration. Therefore, it represents a sediment sink, and restoration of natural littoral cell dynamics could provide a large-scale source of "new" sediment for the southern littoral cell. Sediment bypassing from this fillet represents one, if not the most potentially productive contributions to the coastal sediment budget for the San Diego region. SANDAG investigated this potential source in late 2008 and found it suitable for nourishment, but concluded that additional investigation is needed to better define the highest quality portions of the deposit." Restoration of sediment movement past the Oceanside Harbor jetty would contribute significantly to the region's sediment budget. Bypassing of sediment from up coast of Oceanside Harbor is recommended to increase sediment volumes along North County beaches. Oceanside Harbor jetty retains a wide sandy fillet formation extending several miles north of the jetty into MCB Camp Pendleton (DBW/ SANDAG 1994)"[6].

The objective should be that nourishment rates at least equal loss rates. This rate should serve as the target for nourishment for future inputs to the region. Nourishment rates that exceed the loss rates should promote beach widening. Implementation of groins, breakwaters, and reefs to retain sand along the coastline should be investigated as a means to reduce the on-going need for sand nourishment. A Del Mar Sediment Management Plan will be prepared as a next step to further study and detail beach and dune nourishment as an adaptation measure.

3.3 Del Mar Shoreline Change Analysis

In Del Mar, approximately 66% of sediments in the sea cliffs have a grain size that is large enough to contribute to the beaches. Table 3.3.1 summarizes the quantity of beach-sand-sized material, based on the grain size that contributes to the beach. These sand volumes were averaged over a 6-year time span to calculate average annual sediment volumes of beach-sand-sized materials.

Table 3.3.1
Average annual eroded volumes (m^3/yr) - April 1998 to April 2004

Section Name	Total Eroded Sediment: Gully	Total Eroded Sediment: Seacliff	Beach-Sand Content (total reduced for grain size[1]): Gully	Beach-Sand Content (total reduced for grain size[1]): Seacliff
Torrey Pines	8300	26,400	3500	11,100
Del Mar	600	4900	500	3700
Solana Beach	0	8300	0	6200
Cardiff	0	5800	0	4600
Leucadia	0	5900	0	4700
Carlsbad	0	4000	0	3200
Camp Pendleton	7600	5500	4100	2900
San Onofre	16,700	57,100	11,900	40,500
Oceanside Littoral Cell	33,200	117,900	20,000	76,900
San Clemente[2]	4700	7600	3800	6100
Dana Point[2]	0	4500	0	3600

2006 - Adam P. Young and Scott A. Ashford

[1] Grain size of sediments in the sea cliffs large enough to contribute to the coastal beaches.
[2] The total for the Oceanside Littoral Cells excludes the San Clemente and Dana Point sections.

Table 3.3.2 summarizes calculated south bluff retreat rates for the Del Mar area. A high percentage of the bluff erosion and retreat results from periods of substantial rainfall which tend to saturate portions of the bluffs and weaken the bluff materials to the point of failure. One can anticipate that similar magnitude of retreat rates of up to 12 feet of bluff erosion may occur in the next 20 years. Therefore, in several sections along the tracks, bluff retreat may impact the existing rails if mitigation measures are not implemented. The North County Transit District (NCTD) determined that installing soldier piles was the least environmentally damaging feasible alternative for an interim approach to track bed stabilization. Soldier piles can be considered to be underground, reinforced concrete columns. In the SANDAG Del Mar Bluffs Stabilization Project 3 (2010) submission to the California Coastal Commission, SANDAG defined soldier piles as follows: *"Soldier piles are essentially underground, reinforced concrete columns. Spacing the soldier piles along a bluff provides improved support, provided that the soldier piles are anchored in a relatively stable geological formation".* [10]

Table 3.3.2
Historical Del Mar calculated south bluff retreat rate [2,9]

Del Mar Calculated Bluff Retreat Rate		
Report	**Years**	**Bluff Retreat Rate**
AT&SF	1943-78	0.14 ft/yr
L&A	1978	0.22ft/yr
Benumof & Griggs	1999	0.4 to 0.6 ft/yr
FEMA	2000	< 1ft/yr

Figure 3.3.1
Beach width history from 1978-2015 for monitoring point 1[5]

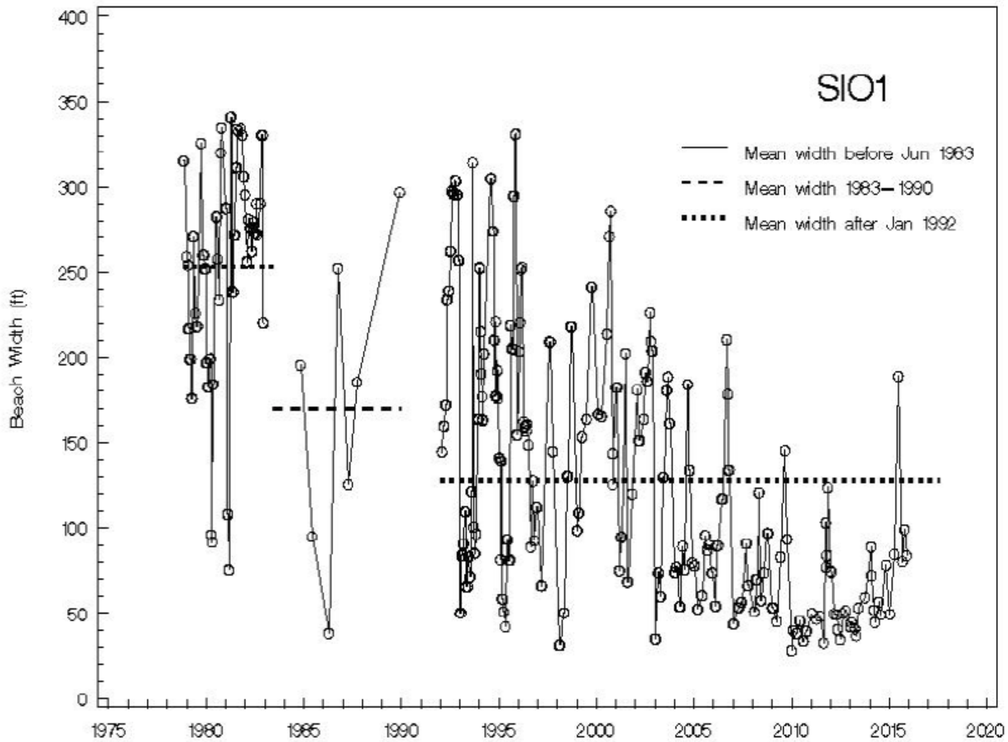
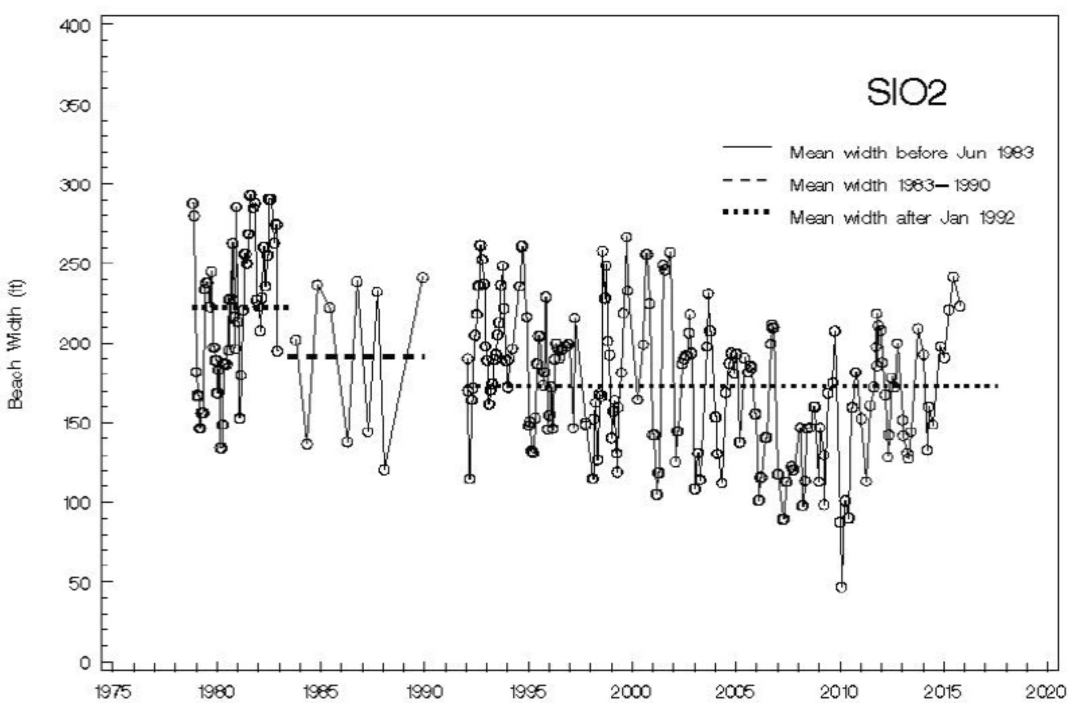


Figure 3.3.2
Beach width history from 1978-2015 for monitoring point 2[5]



The underlying structure of the beaches in most northern San Diego County is a rock platform with a very thin coating of sand and sometimes cobble. Many of the northern San Diego County beaches have very little sand depth because of sand undernourishment caused by the reductions of sand from inland sources and local geology. Figures 3.3.1 and 3.3.2 show the average decline in Del Mar beach width just south of the San Dieguito river mouth from two monitoring stations since 1978. As outlined by Elwany, Hany of Coastal Environments (2016) in the annual the San Dieguito Lagoon Restoration Project Report, "*A study conducted in 2010 concluded that the rate of beach width decrease is about 2.0 ft/yr to 4.5 ft/yr.*"[5]

3.4 Human Alterations to the Shoreline

3.4.1 Beach Nourishment

Beach and dune nourishment is an adaptation strategy that provides protection against coastal storm erosion while maintaining the natural condition, beach habitat, and processes (such as the ability of the beach to erode in response to winter storms and build up sand in response to summer wave conditions). Beach nourishment refers to placement of sand to widen a beach, which can be accomplished by placing a sediment-water slurry directly on the beach and/or mechanical placement of sediment with construction equipment (Figure 3.4.1.1). Sand can be obtained from inland sources (e.g., sand trapped in dam reservoirs, construction projects) and can be dredged from offshore.

Dune restoration would include placement of sand, grading, and planting to form "living" back beach dunes. Dune restoration is recognized as a natural way of mitigating backshore erosion as well as maintaining a wider beach through sacrificial erosion of the dunes. Dune restoration can provide aesthetic, ecology, and recreation benefits. A variant includes placement of cobble (rounded rock), which is often naturally present as a lag deposit1 below beaches in California (Figure 3.4.1.2). Burying a layer of cobble provides a "backstop" that is more erosion resistant and dissipates waves to a greater degree.

Figure 3.4.1.1
Beach Sediment Placement at Carlsbad

Figure 3.4.1.2
Beach Nourishment, Dune Restoration, and Cobble Placement Illustration

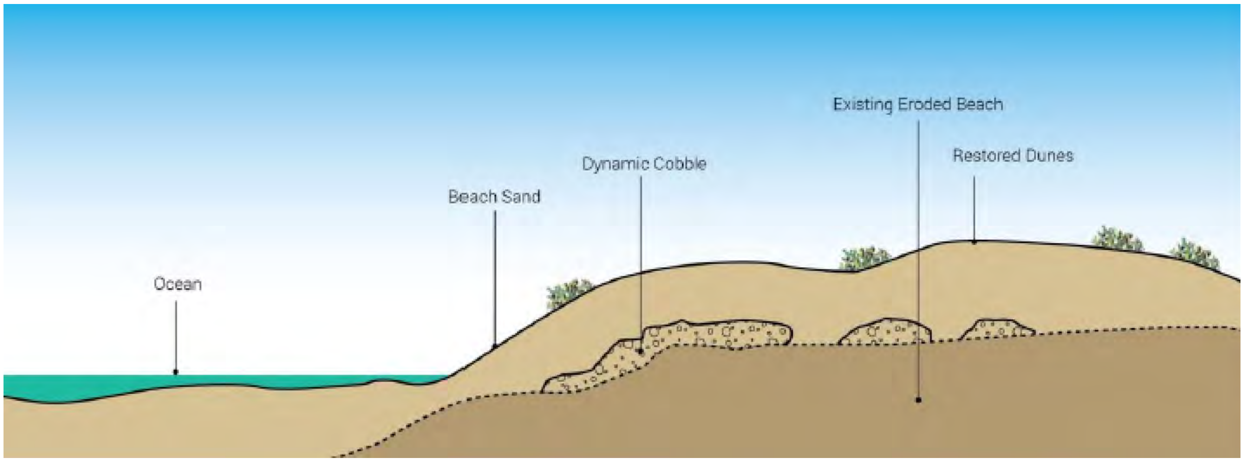


Table 3.4.1.1
Beach and dune nourishment benefits and constraints summary

Benefits	Constraints
• Preserves beach	• Limited sand sources
• "Living shoreline" provides beach and dune habitat	• Less effective over time with increasing sea-level rise
• Reduces flood and erosion risks	• Transportation of sediment to receiver sites
	• Short-term beach use and ecology impacts

Table 3.4.1.1 summarizes benefits and constraints of beach and dune nourishment. Potential problems with beach nourishment include loss of beach use during construction and impact to beach ecology[11,12], which are generally considered short term negative effects. Beach nourishment can also change beach conditions (e.g., texture and slope), if and when the placed sand is different than the “native” beach sand, which typically occurs due to the difficulty in finding sand with the same grain sizes. The success of the nourishment depends on the volume of nourished material, the grain size, and the proximity or use of sand retention measures (discussed separately in the next section).

Placement of sand typically provides a temporary benefit until the sand erodes and migrates away from the placement area. It is therefore important to consider the fate of the sand and implications of deposition in other areas. In general, increased sand supply is considered beneficial to most beach areas, but can be problematic at lagoon inlets and storm drain outlets. Sand deposition on rocky substrate may also adversely affect habitat and recreation such as surfing.

Key feasibility constraints to beach nourishment and dune restoration include the availability of appropriate sand sources and the required amount and frequency of nourishment. With a certain amount or rate of sea-level rise, the amount and frequency of nourishment may make the measure unsustainable. For the purposes of the Adaptation Plan, it is assumed that beach nourishment will be effective with up to 1 ft of sea-level rise based on the results of the Coastal Hazards, Vulnerability, and Risk Assessment and is, therefore, not included as an adaptation measure for sea-level rise above 1 ft.

Monitoring plays an important role in identifying the need for re-nourishments. Monitoring is typically focused on the annual maximum and minimum beach width and minimum dune width. The minimum dune width should provide an acceptable buffer for storm erosion (e.g., 2- to 5-year storm). At any time, beach nourishment may be required in response to erosion from a major storm event.

If beach-sized material becomes available via construction or other activity, the City will consider whether the material could be beneficially re-used on the Del Mar beach. Southern California Edison placed sand dredged from the San Dieguito Lagoon on the northern portion of

North Beach in 2011 (40,000 cubic yards) and 2014 (15,000 cubic yards). Similarly, beach and dune nourishment can be combined with dredging of sediment from the San Dieguito River as a future adaptation measure to reduce river flood risks. SANDAG has conducted beach nourishment in San Diego County through the Regional Beach Sand Project. SANDAG performed beach nourishment from September to December 2012, including placements at Solana Beach. The City of Del Mar did not participate in the SANDAG Program, but could consider participating in any future nourishment to implement this adaptation measure. Additional information on regional sand management can be found via the Coastal Sediment Management Workgroup (CSMW, http://www.dbw.ca.gov/csmw/).

According to Van Rijn *et al* (2007), "*Overall, it is concluded from field practice that shore face nourishments have an efficiency (defined as the ratio of volume increase of the nearshore zone and the initial nourishment volume) of 20% to 30% after about 3 to 5 years*"[7]*.* This seems consistent with studies of nourishment projects in Californian which have shown that about 20% of the projects survived less than 1 year, 55% lasted only 1 to 5 years and about 20% survived over 5 years.

3.4.2 Groins

The principle objective of groins is sand retention. Groins are thin and long structures perpendicular to the shoreline extending into the surf zone. Groins typically extend slightly beyond the low water line. Groins are used to reduce the longshore currents and littoral drift in a surf zone and to retain the beach sand between the groins. Groins are used to stabilize and widen the beach or to extend the lifetime of beach fills. A groin field is a series of similar groins that may be constructed to protect a stretch of coast against erosion. Groins should be prefilled with sand upon construction, otherwise the groins will have adverse impacts when a structure-retained beach is allowed to develop with sand from the littoral system.

Van Rijn *et al* (2007) define two major types of groins, as follows:

- *"impermeable, high-crested structures: crest levels above +1 m above MSL (mean sea level); sheet piling or concrete structures, grouted rock and rubble-mound structures (founded on geotextiles) with a smooth cover layer of placed stones (to minimize visual intrusion) are used; these types of groins are used to keep the sand within the compartment between adjacent groins; the shoreline will be oriented perpendicular to the dominant wave direction within each compartment (saw-tooth appearance of overall shoreline);*
- *permeable, low-crested structures: pile groins, timber fences, concrete units, rubble-mound groins, sand-filled bags are used; permeability can increase due to storm damage; these types of groins are generally used on beaches which have slightly insufficient supplies of sand; the function of the groins is then to slightly reduce the littoral drift in the inner surf zone and to create a more regular shoreline (without saw-tooth effect); groins should act as a filter rather than as a blockade to longshore transport."*[7]

3.4.3 Detached Breakwaters and Reefs

Breakwaters are parallel structures that are used to protect a section of the shoreline by forming a buffer or barrier to the waves. Breakwaters obstruct the wave energy. There are two major categories of breakwaters: those that are positioned above the still water level (emerged); and breakwaters below the still water level (submerged Van Rijn *et al* (2007) define the various variants of breakwaters, as follows:

"There are many variants in the design of detached breakwaters, including single or segmented breakwaters with gaps in between, emerged (crest roughly 1 m above high water line) or submerged (crest below water surface), narrow or broad-crested, etc. Submerged breakwaters are also known as reef-type breakwaters and are attractive as they are not visible from the beach. A reef (hard or soft) is a relatively wide, submerged structure in the shallow nearshore zone.

Submerged structures cannot stop or substantially reduce shoreline erosion (dune-cliff erosion) during storm conditions, as most of the waves will pass over structure to attack the dune or cliff front. Supplementary beach nourishments are required to deal with local storm-induced shoreline erosion (especially opposite to gaps). Down drift erosion generally is manageable as longshore transport is not completely blocked by low-crested structures. A major problem of submerged breakwaters and low-crested emerged breakwaters is the piling up of water (wave-induced setup) in the lee of the breakwaters resulting in strong longshore currents when the breakwater is constructed as a long uninterrupted structure (no gaps) or in strong rip currents through the gaps when segmented structures are present. Other disadvantages of detached breakwaters are the relatively high construction and maintenance costs, inconvenience and danger to swimmers, and small boats and aesthetic problems (visual blocking of horizon)."[7]

3.4.4 Seawalls and Revetments

Seawalls and revetments are structures to armor the shore to protect the land behind it. They are shore-parallel structures that protect against storm-induced erosion and/or long-term chronic erosion by the sea. These structures have various shapes such as vertical, concave or sloping designs. When natural beaches can no longer prevent erosion due to high waves, seawalls are typically built along a limited section of the shoreline as a last defense line against the waves. If no other solution helps to solve the problems of erosion or flooding during high surge levels, the building of seawalls or revetments is considered to be a necessary and "end of the line" solution. Van Rijn *et al* (2007) define the various variants of breakwaters, as follows:

"A seawall is a vertical (or almost) retaining wall with the purpose of coastal protection against heavy wave-induced scour; it is not built to protect or stabilize the beach or shore face in front of or adjacent to the structure. Thus, chronic erosion due to gradients of longshore transport will not be stopped or reduced. A revetment is an armor protection layer (consisting of light to heavy armor layer, underlying filter layer and toe protection) on a slope to protect the adjacent upland zone against scour by current and wave action. To reduce scour by wave action and wave reflection at the toe of the structure, the slope of the revetment should be as mild as possible

(not steeper than 1 to 3). The crest of the revetments should be well above the highest storm surge level resulting in a crest level at +5 m above mean sea level along open coasts and up to +7 m at locations with extreme surge levels.

Seawalls and revetments are very effective in stopping local shoreline erosion (dunes and soft cliffs), but these types of structures hardly change the longshore transport gradient often being the basic cause of chronic erosion. Hence, erosion of the beach and shore face in front of the structure will generally remain to occur. Down drift erosion will usually occur at locations where no structures are present. Continuing shore face erosion may ultimately lead to an increased wave attack intensifying the transport capacity and hence intensified erosion (negative feed-back system). Groins are often constructed to reduce scour at the toe of the revetment by deflecting nearshore currents". [7]

Table 3.4.4.1
Effectiveness of Hard Structures (adapted from Van Rijn et al, 2010[7])

Type of Structure	***Effectiveness***		
	Reduce shoreline erosion	***Stop shoreline erosion***	***Beach width***
Seawall Revetment	*yes*	*yes*	*none or very small*
Groins	*yes, especially at beaches of relatively coarse sediment (0.3 to 1 mm)*	*no, dune and cliff erosion will continue during major storms with high water*	*wider for narrower cells; smaller and saw tooth effect for wider cells*
T-head Groins	*yes, especially at very exposed, eroding beaches of fine sand*	*no, dune and cliff erosion will continue during major storms with high water levels*	*medium wide*
Submerged detached breakwater/reef	*yes, but minor*	*no, dune and cliff erosion will continue during major storms with high water levels*	*small*
Emerged breakwater (low crested)	*yes at lee side*	*no , dune and cliff erosion will continue during major storms with high water levels*	*medium to wide at lee side*
Emerged breakwater (high crested)	*yes at lee side*	*no, dune and cliff erosion will continue during major storms with high water levels*	*medium to wide at lee side*

Table 3.4.4.1 provides a comparison of hard shoreline protection measures and their effectiveness to reduce or stop shoreline erosion and their impacts on beach width. As described by Everts Coastal (2002*), "In Southern California, the most effective shore-connected sediment-blocking structures, such as groins, are located where the bearing of the open coast shoreline is between 240 and 310-320 degrees and there is a substantial net longshore sand transport rate."[13]* It should be noted that Del Mar's bearing averages 348 degrees, and

therefore is not optimum for groins, since the length of the groins would need to be relatively long to be effective. In summary, beach nourishment in conjunction with detached breakwaters or reefs that retain sand might warrant further investigation by the City of Del Mar.

3.5 References

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CHAPTER 4

About this Adaptation Plan

This Adaptation Plan draws on the City of Del Mar's Coastal Hazards, Vulnerability, and Risk Assessment (ESA2016, http://www.delmar.ca.us/DocumentCenter/View/2455) and guidance provided by the STAC. This Adaptation Plan was developed over a series of public STAC meetings in which the STAC and public provided input and feedback.

4.1 Adaptation Plan Overview and Process

The recommended approach for the City of Del Mar planning for sea level rise involves phasing in short and long term adaptation strategies. This phased approach provides a structure for sequencing adaptation measures using expected sea-level rise thresholds, and provides a way to manage uncertainty in timing and extent of sea level rise impact. Thresholds guide in the planning and implementation stages of adaptation strategies. For example, thresholds related to the extent of flooding or frequency of damages might be used to initiate new adaptation options. The process should involve the local community, and reflect the Del Mar community's risk tolerance, local conditions, and adaptation vision.

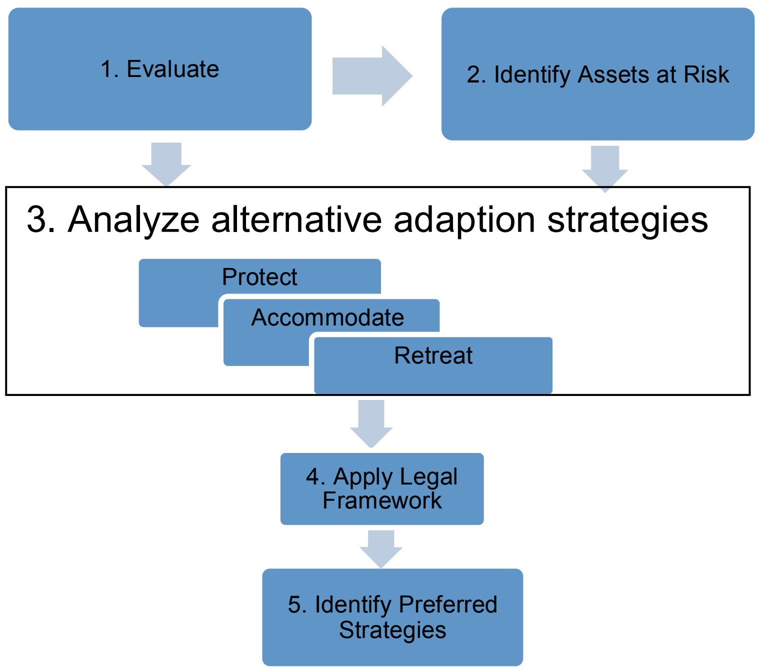
The Adaptation Plan provides a framework for the City to manage risks (Section 4.2), to monitor effects of sea-level rise (Section 4.3), and choose from a toolbox of adaptation options (Section 4.4). The Adaptation Plan provides flexibility for the City to choose from an array of adaptation measures over time as specified thresholds are met. The Adaptation Plan therefore provides potential adaptation options for managing risks, to be incorporated into specific plans of action when needed. The City will choose among adaptation options as the projected effects of sea-level rise are realized. Project-level planning and approvals will be required to further develop and implement the adaptation measures included in the Adaptation Plan (Section 4.5). The Adaptation Plan identifies the lead times for project-level planning of adaptation measures so that the City can begin planning the implementation of adaptation measures in advance of when implementation is needed.

The Adaptation Plan is based on the best science and adaptation practices available today; however, the Adaptation Plan acknowledges that sea-level rise science and practices are evolving and the intent of the Adaptation Plan is that the City will evaluate future decisions and take action based on the best-available science and technology at the time.

The Adaptation Plan includes a range of sea-level rise adaptation measures within the three general categories of adaptation defined by the California Coastal Commission (CCC) in 2016: Protect, Accommodate, Retreat.

The CCC further guides, after evaluating vulnerability and establishing policies to be used throughout hazardous areas, communities can begin the process of evaluating and choosing adaptation strategies for specific areas. In most cases, especially for LCP land use and implementation plans, multiple adaptation strategies will be needed and every community will need to assess their risks and their potential options. There are a number of options for how to address the risks and impacts associated with sea level rise. Choosing to "do nothing" or following a policy of "non-intervention" will likely lead to unacceptable exposure to hazards and impacts to coastal resources, so the strategies for addressing sea level rise hazards will require proactive planning to ensure protection of coastal resources and development. Figure 4.1 illustrates the process of selecting and implementing proactive adaptation strategies.

Figure 4.1
Process to Evaluate, Select and Plan Adaption Options



Consistent with the California Coastal Commission Sea-Level Rise Policy Guidance and current environmental practice, the Adaptation Plan includes hybrids between these approaches, nature based or green infrastructure solutions, and multi-objective measures that incorporate environmental considerations while also remaining consistent with the relevant plans and guidelines listed in Chapter 2, rather than focusing on independent solutions to protection.

4.2 Risk Management

The goal of the Adaptation Plan is to manage sea-level rise-related risks by keeping these risks within an acceptable limit. Table 4.1 summarizes risk for extreme (infrequent) and significant (more frequent) flooding from the Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016). "Low, moderate, and high" risks are defined for the purposes of the Risk Assessment and Adaptation Plan as follows:

- Low: 0% - 5% chance of occurrence in a given year
- Moderate: 5% - 30% chance
- High: 30% - 100% chance

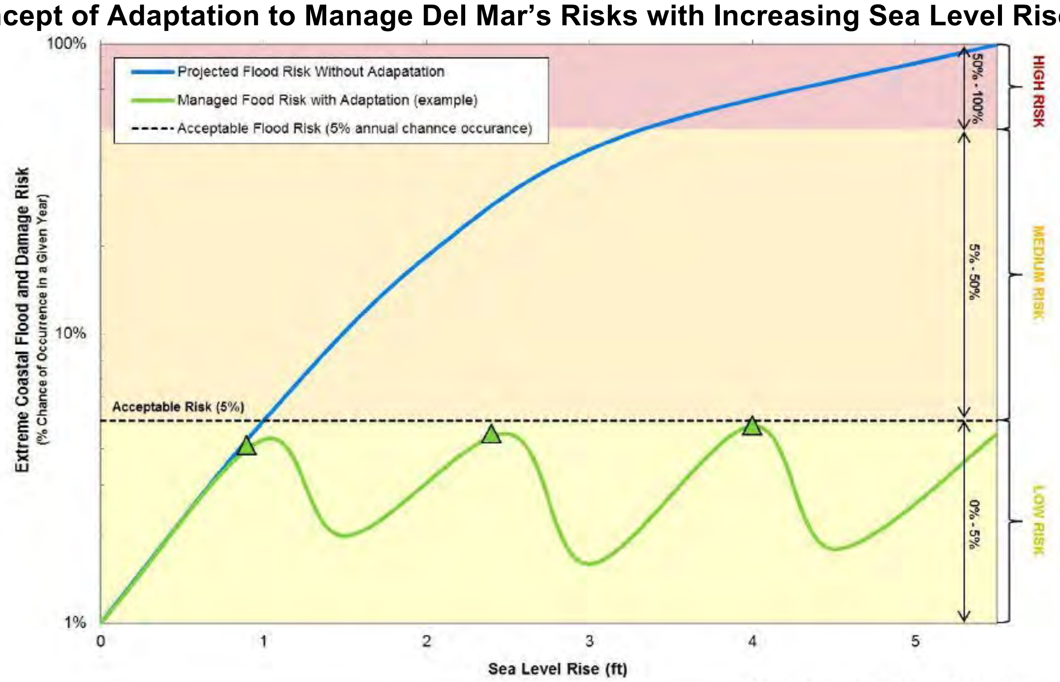
A guiding principle of the Adaptation Plan is to limit the risk of extreme flooding and damage to a low risk level (i.e., less than 5% chance of occurrence in a given year).

TABLE 4.1
Summary of North Beach Asset Vulnerability to Flooding and Damage

Type and degree of flooding and damage		Risk				
		Present (0 ft of sea-level rise)	1 ft of sea-level rise	2 ft of sea-level rise	3.2 ft of sea-level rise	5.5 ft of sea-level rise
Coastal	Significant (e.g., 2016 storms)	Moderate 10%	High 50%	High 100%		
Coastal	Extreme (e.g., 1983 storm)	Low 1%	Mod. 5%	Mod. 15%	High 50%	High 100%
River	Significant (e.g., 1980 flood)	Low 4%	Mod. 15%	Mod. 25%	High 50%	High 100%
River	Extreme (e.g., FEMA 1% chance flood)	Low 1%	Mod. 5%	Mod. 6%	Mod. 6%	Mod. 20%

Risks to Del Mar's assets increase with sea-level rise. The goal of the Adaptation Plan is to plan a sequence of adaptation measures that can be taken to reduce the risk of extreme flooding, thereby maintaining the risk at a low or acceptable level (Figure 4.2).

Figure 4.2
Concept of Adaptation to Manage Del Mar's Risks with Increasing Sea Level Rise



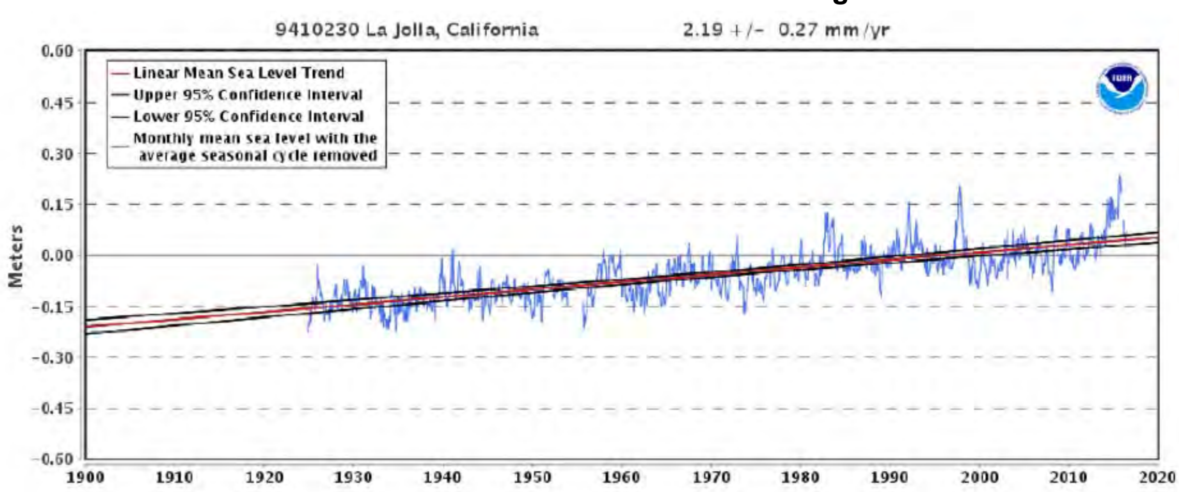
The Adaptation Plan includes accommodating some increase in flood risks. For significant flooding (i.e., flooding that occurs more frequently than extreme flooding, but is still significant), the current low – moderate risk will increase to moderate – high levels with 1 ft of sea-level rise or more (Table 4.1). Thus, the Adaptation Plan focuses on limiting extreme flood risks to low levels, but an increase in significant flooding is expected with sea-level rise.

4.3 Monitoring Change

The Adaptation Plan includes measurable thresholds that, if and when they occur, call for the implementation of adaptation measures to limit risks. The Adaptation Plan sets conceptual planning-level adaptation thresholds such that adaptation measures can be implemented to reduce risks before the acceptable target level of risk is exceeded. The City will need to monitor and evaluate the trajectory towards these thresholds to track whether and when these thresholds are met. The Adaptation Plan thresholds and monitoring are summarized below.

- **Amount of sea-level rise** (e.g., 1 ft, 2 ft, and 3 ft of sea-level rise). Certain adaptation measures will need to be taken when sea-level rise has risen by a certain amount. To monitor sea-level rise and progress towards the sea-level rise amount thresholds, the City will follow sea-level rise reports from the State and Scripps Institute of Oceanography (SIO) and sea level rise data from the nearby NOAA tide gage at Scripps Pier at La Jolla Shores (Figure 4.3). Sea level is inherently variable in response to predictable astronomical tides and less-predictable atmospheric events such as El Nino and individual storms; however, given that extreme flooding occurs infrequently, sea-level rise may be realized before extreme flooding occurs. Tracking sea-level rise may therefore allow the City to anticipate and act in advance of the projected effects of sea level rise.

Figure 4.3
Sea Level Rise Trend at La Jolla Tide Gage



SOURCE: NOAA

- **Flooding and storm damage frequency.** In addition to the amount of sea-level rise, the frequency or risk of flooding and storm damage is used as a threshold in the Adaptation Plan. To monitor the frequency of flooding and storm damage, the City will track and keep records of coastal and River flooding and storm damage events and information. This could be a collaborative effort between City staff and residents in which reports, pictures, and videos are collected. The date, type, location, and severity of flooding (e.g., depth, duration, wave height), and damages can be collated into a file. The intent will be to track the frequency, extent, and severity of flooding to assess if and how the frequency of flooding is increasing. If significant and/or extreme flood events occur, then storm data (e.g. water levels, wave conditions) can be collected and storm frequencies can be recalculated to quantify the increase in flood risk for comparison against risk-based thresholds.

- **Beach width**. Given that a guiding principle is to maintain a walkable beach, beach width is used as a metric for considering when beach adaptation measures would be implemented. Specific beach width thresholds are discussed in Chapters 8 and 9 and will be further detailed as part of subsequent analyses including the preparation of a Sediment Management Plan. Southern California Edison and SANDAG currently perform beach profile surveys to monitor beach width. Southern California Edison is required to maintain a minimum beach width of 32.4 ft to 180.0 ft (depending on the location on the beach) at least through 2025, assuming no adverse impacts from the project are found, as part of the California Coastal Commission Coastal Development Permit for the San Dieguito Lagoon Restoration; however, this requirement and Southern California Edison's beach maintenance program do not account for future sea-level rise. SANDAG measures four profiles in Del Mar. Profiles are surveyed two times per year, from 1999 to present. The City will review the results of beach surveys from Southern California Edison and SANDAG, and assess the results against beach width thresholds. Supplemental and long-term beach monitoring programs, including all of Del Mar's beaches, is recommended for consideration as part of the implementation of the Adaptation Plan.

- **Bluff top offset.** The Adaptation Plan uses the offset or distance between the top of the bluffs and assets such as the LOSSAN railroad track, sewer line, and the edge of bluff top properties as a threshold for bluff adaptation measures. When the bluff top reaches the threshold set based on the distance at which the safety of the asset is at risk, the Adaptation Plan calls for implementation of bluff adaptation measures. The North Coast Transit District and SANDAG currently monitor the condition of the bluff relative to the safety of the railroad track. Dr. Adam Young of the Scripps Institute of Oceanography has also performed research on the erosion of Del Mar's bluff. The City will review and track bluff-top erosion monitoring and results from NCTD, SANDAG, and/or Dr. Young. If and when the railroad is relocated off the bluff, the City will consider supplemental and long term bluff top erosion monitoring programs to track erosion towards the sewer line and property along the bluff against the offset threshold.

- **San Dieguito River channel deposition.** Per the Coastal Hazards, Vulnerability, and Risks Report (ESA 2016), the potential for increased deposition of sand in the San Dieguito River channel with sea-level rise is a significant factor in increasing the City's risk of River flooding. The amount of channel deposition is therefore used as a threshold for River flooding adaptation measures in the Adaptation Plan. Southern California Edison currently surveys channel cross-sections and is required to maintain a certain tidal flow (tidal prism), but is not required to maintain a channel bed elevation for the purposes of reducing flood risk to Del Mar. The City will review and track Southern California Edison's channel surveys and assess if deposition thresholds are reached and will consider supplemental channel monitoring if and when necessary.

- **San Dieguito Lagoon wetland conversion.** The Adaptation Plan uses conversion of San Dieguito Lagoon wetland habitats with sea-level rise (e.g., conversion of vegetated wetland habitat to mudflat and open water habitat) as a threshold for wetland adaptation measures. As part of the San Dieguito Lagoon Restoration, wetland habitat acreages are monitored by UC Santa Barbara on behalf of the California Coastal Commission, and Southern California Edison is required to maintain certain wetland acreages; however, these requirements and maintenance do not account for future sea-level rise. The City will review and track the Restoration habitat monitoring and coordinate with the California Coastal Commission and Southern California Edison on evaluating thresholds and the process for implementing adaptation measures when thresholds are reached. The City will also consider monitoring of wetland areas outside of the Restoration and coordination with the City of San Diego on upstream wetland habitat monitoring and adaptation.

The City will consider preparation of a sea-level rise Adaptation Plan Monitoring and Thresholds Assessment Report on a regular cycle, recommended to be annual. The City will use the report to identify significant changes or progress towards thresholds. The City will evaluate if and when thresholds are reached and identify and plan next steps towards implementing adaptation measures. The City may conduct this process in consultation with technical experts and will seek public input and review. The City will also consider participating in regional efforts, if initiated, to monitor and track sea-level rise and related effects.

4.4 Analysis of Adaptation Options

The adaptation plan identifies near-term measures for City assets and addresses specific vulnerabilities and risks for the City District areas illustrated in Figure 4.4. Each chapter presents a range of adaptation options with the benefits, constraints, limitations, and potential impacts for each. A figure for each of the four City areas (beach, bluff, river, and wetlands) illustrates available adaptation measures together with criteria to be monitored to assess rate and amount of change, lead times and anticipated time ranges when each measure would be effective. The plan has the following five parts:

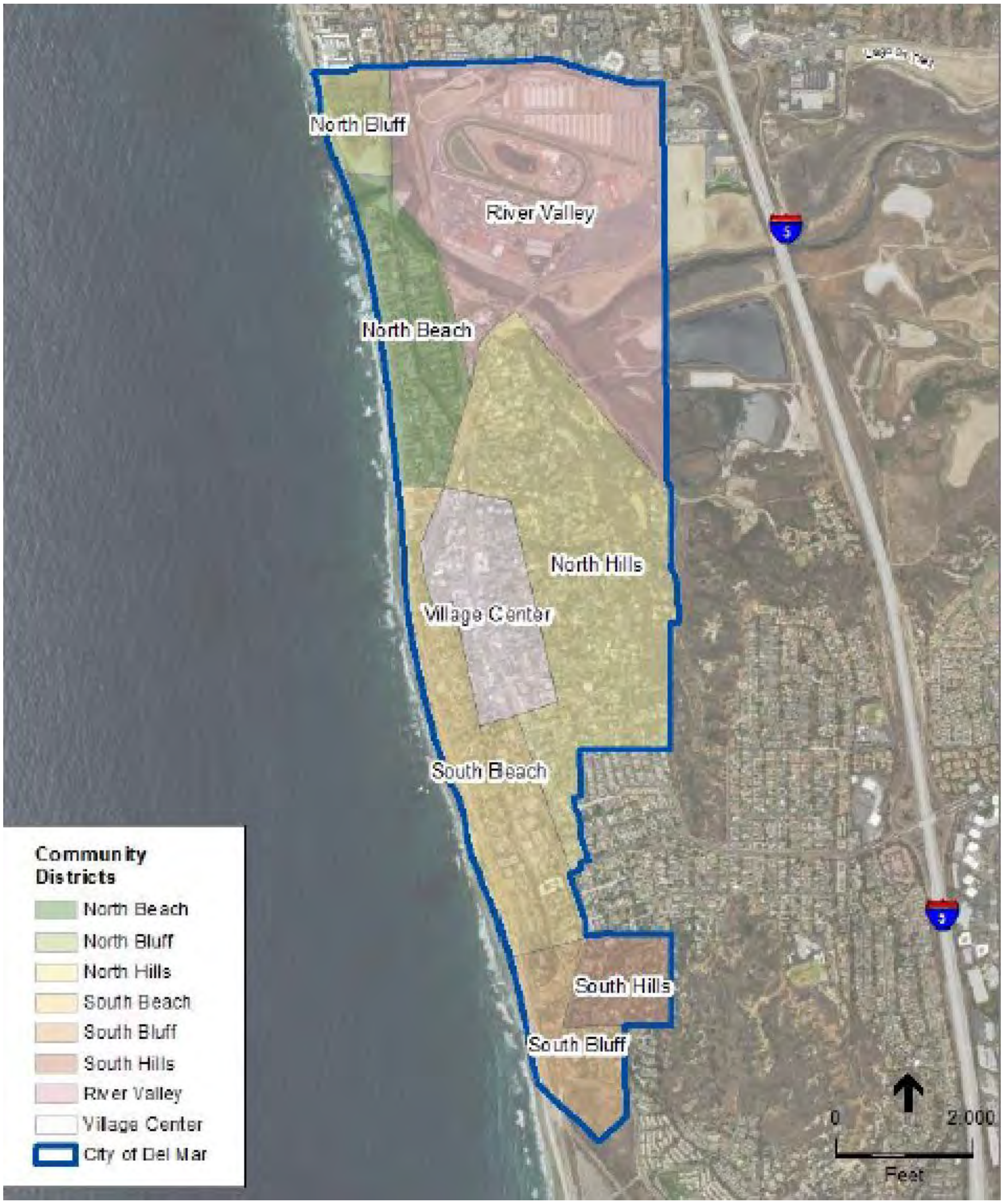
- **Chapter 5 - High Priority Measures for Public Resources**: High priority measures to relocate and flood-proof public safety and public works facilities, and plan for beach nourishment and sand retention.
- **Chapter 6 - San Dieguito Lagoon wetland adaptation**: Relevant to the river valley and San Dieguito lagoon.
- **Chapter 7 - San Dieguito River flooding adaptation:** Relevant to the river valley, Del Mar Fairgrounds, and North Beach (north from 15th St to the San Dieguito river mouth).
- **Chapter 8 – Bluff and adjacent beach erosion adaptation:** Relevant to the South Bluffs, bluffs along South Beach, bluffs along Powerhouse Park, and the North Bluffs.
- **Chapter 9 - Beach erosion and flooding adaptation**: Relevant for North Beach (north from 15th street to the San Dieguito River mouth)

Criteria for considering an adaption measure include degree of loss of beach, bluff, or wetland, frequency of damaging storms, and river channel deposits. As discussed in Section 4.3, “Monitoring Change”, as changes happen and progress, full evaluation of design, environmental impacts, and costs of any given adaptation measure will require additional studies. Adaptation strategies also need to be evaluated for conformance with the relevant City and state policy, plans and guidelines detailed in Chapter 2, which include the following:

- Del Mar Community (General) Plan
- Del Mar Local Coastal Program
- Del Mar Climate Action Plan
- California Coastal Commission Sea Level Rise Policy Guidance
- Safeguarding California Plan

Coastal Development Permit review and approval for adaptation measures will fall within the California Coastal Commission and/or the City’s coastal permitting jurisdiction and, depending on the jurisdiction, may be processed through either the City of Del Mar’s LCP and/or pursuant to the California Coastal Act. For the four City areas listed above (beach, bluff, river, and wetlands), a table at the end of each Adaptation Plan chapter summarizes the likely coastal permitting mechanisms for available adaptation measures. These tables provide information for the development of the LCP Amendment as a next step. Other approvals and permits beyond those listed in Chapters 5 - 9 may also be required and would need to be addressed separately.

Figure 4.4
City Districts in Del Mar



4.5 Project-Level Planning and Lead Times

The Adaptation Plan identifies adaptation measures at a conceptual planning-level of detail and discusses potential benefits and effects of adaptation measures. Additional detailed project-level planning and design would be required to implement adaptation measures. For adaptation measures involving construction, the project-level planning and design may include:

- Feasibility study including additional technical analyses, development and assessment of project alternatives and details, conceptual and preliminary engineering design, and cost estimating
- CEQA and possibly NEPA environmental review and regulatory permitting
- Final engineering design.

Lead time is required to perform project-level planning, secure funding, and implement or construct an adaptation measure. All adaptation options discussed in the Adaptation Plan require substantial lead time. For example, levees, comprehensive sea wall strategies, sand retention strategies, and wetland management strategies can require significant lead time. With anticipated lead times the City will be able to begin advance planning before adaptation measures could be in place to limit risk.

4.6 Re-Evaluation

The Adaptation Plan is intended to establish a process in which new data and information are assessed as needed to inform adaptation decisions and actions. As such, it is anticipated that the Adaptation Plan may be re-evaluated and updated.

After much discussion, STAC determined that it is too early in the process to include managed retreat as an adaptation option for Del Mar.

Each Adaptation Plan chapter for Lagoon, River, Bluff and Beach includes a final section that summarizes anticipated permitting requirements. Overall, the next steps in the Sea-Level Rise Adaptation Plan and LCP Amendment process, which include the development of LCP policies and regulations and additional studies that will provide further detail on adaptation measures and their implementation

CHAPTER 5

High Priority Measures for Public Resources

High priority sea-level rise adaptation measures for the City to begin planning now include relocating or otherwise flood adapting the City's Fire Station and Public Works Yard on Jimmy Durante Boulevard, as well as flood-proofing the sewer lift station along San Dieguito Drive (Figure 5.1). These facilities already have a medium to high risk of San Dieguito River flooding (i.e., 5% annual chance of flooding) or greater, as evidenced by the San Dieguito River flooding the fire station and public works yard in February 1980 (see the Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016) for additional information). It is recommended the city should immediately begin evaluation of beach nourishment and sand retention strategies to maintain recreational opportunities for the citizens of Del Mar as well as enhanced protection of public infrastructure and private property. Beyond the vulnerabilities addressed in this chapter, the City should evaluate and monitor risks to all other public resources including roads, bridges, sewer lines, water supplies, storm drainage systems, parks, and public structures.

Figure 5.1
High Priority Infrastructure

City of Del Mar fire station. The fire station is an essential services building that should be operable during flooding in order to respond to flood-related calls and other emergencies. Given that flood risk has the potential to increase with sea-level rise, the adaptation plan calls for beginning a process to relocate the fire station to a location that is not anticipated to flood and would still allow the fire department to respond to an emergency. The alternative is to flood proof the facility, for example through berms, elevation, or other strategies, so it can continue to operate on a fully functional basis. Moderate exposure of the fire station to flooding will make emergency services highly vulnerable with 1 ft of sediment deposition because the fire station will be impacted when flooding is occurring and emergency response is needed, as occurred in the 1980 flood. Some flood-proofing could be accomplished by raising facilities above the 100-year flood level (12.8 ft NAVD per FEMA 2016) with an allowance for future sea-level rise (e.g., to an elevation of 15.8 ft NAVD with a 3 ft of sea-level rise allowance above the current 100-year flood level). Other flood proofing options include enclosing and water-proofing vulnerable equipment.

City of Del Mar public works yard. The City has an office building housing public works staff, a garage and work areas, and uses the public works yard for storage of City maintenance vehicles, equipment, and other supplies, some of which may be required to perform City services during or after flood and/or erosion events. The adaptation plan calls for beginning a process to relocate the public works yard to a location that is not flood-prone or to flood proofing it on its current site. Relocating or reconfiguring the public works yard also provides the opportunity to construct a portion of a new levee system south of the San Dieguito River to reduce flood risk in combination with restoring wetland and upland habitat on the public works yard as described as an adaptation measure in Section 5.4, San Dieguito River Flooding adaptation plan.

City of Del Mar sewer lift station. The sanitary sewer lift station along San Dieguito Drive is subject to extreme flooding with a 1% annual chance of occurrence. The potential consequences of flooding are high, as the flooding of the pump machinery could potentially cause pump failure. The adaptation plan calls for flood proofing the lift station as a near-term measure to reduce this risk, which will otherwise increase with sea-level rise. Flood-proofing could be accomplished by raising the lift station above the 100-year flood level (12.8 ft NAVD per FEMA 2016) with an allowance for future sea-level rise (e.g., to an elevation of 15.8 ft NAVD with a 3 ft of sea-level rise allowance above the current 100-year flood level). Other flood-proofing options include enclosing and water-proofing the pump motor and other vulnerable parts of the lift station.

City of Del Mar beach access points. Beach access points along the City's beaches from 15th St north to San Dieguito Lagoon (North Beach) should be protected with seasonal berms to protect against storm surge and flooding.

Beach sand retention, replenishment, and management. The City's beaches from 15th St north to San Dieguito Lagoon (North Beach) and all beaches adjacent to the bluffs provide a first line of protection against river flooding and bluff erosion due to sea level rise. River flooding in the beach area could affect nearly four hundred homes. Bluff erosion would lead to increased risk of damage to the City’s sewer, drainage, and fiber-optic cabling along the bluff-tops. Chapters 8 and 9 give details on vulnerabilities and adaptation options for both areas. A Sedimentation Plan is expected in early 2018 and will inform beach and sand management strategies.

Beach nourishment is an adaptation option that can be acted upon immediately. It has the strongest potential to minimize damage risk while helping to maintain the City’s valuable broad beaches. Natural and non-structural sand retention strategies include adding berms in winter or establishing dune fields. Seasonal berming is a strategy the City has used for years with Coastal Commission approval. Sand is pushed into a berm in winter to help protect public and private property and to help protect sand by moving it out of the regularly active surf zone. These activities should be continued and possibly expanded. Sand retention strategies, including groins, breakwaters, dune fields, seasonal berming, and artificial reefs, have limitations that must be studied carefully in the context of their benefits and the risks to the City’s beachs. General benefits and limitations for these sand retention strategies are given in Chapter 9, Section 9.1.3 (Table 9.1.3).

Rather than wait until beaches shrink further due to changes in the river channels, flooding, erosion, and storm damage, the City should establish a Beach Retention Advisory Committee (BRAC). The committee would receive reports on monitored sand levels, beach width, and distance from bluff-top to infrastructure; assess adaptation options that replenish or retain sand; and recommend timely pro-active and, as needed, reactive actions. The committee would be further charged to study and report on the costs and expected lifespan of sand replenishment or retention interventions. Such a committee would be positioned to study the suitability of sand-retention strategies in the context of the City’s Community Plan and other relevant guidance documents reviewed in Chapter 2, and receive feedback and suggestions from City residents and property owners. The BRAC could be realized initially as a subcommittee of STAC.

CHAPTER 6

San Dieguito Lagoon Wetland Adaptation

This chapter includes a range of adaptation measures to address flooding along the San Dieguito lagoon. This is relevant to the River Valley and San Dieguito lagoon. Permitting for some adapation measures may be processed through federal, state or City entities as summarized in Section 6.3.

Vulnerability assessment:

- As sea level rises and flooding increases, the lagoon will experience "habitat creep" as the various habitat ranges are more frequently flooded. For example, as existing wetland habitats experience more frequent flooding, vegetated wetland habitats will be "drowned out" and convert to intertidal mudflats and subtidal habitat.
- Existing pickleweed marsh habitat could drown and be lost with 3 feet of sea-level rise unless the habitat bands are allowed and able to "migrate" upland as sea level rise and flooding increase
- Cordgrass low marsh habitat could be lost with 3 to 5.5 feet of sea-level rise, such that almost all of the San Dieguito Lagoon Wetland Restoration would be converted to intertidal mudflat and subtidal open water.
- Salt marsh habitats are expected to migrate upstream along the San Dieguito River with sea level rise; however, the River corridor is relatively narrow and the overall vegetated marsh acreage will be greatly reduced.

Wetland adaptation options:

- Allow/facilitate wetland conversion and transgression
- Sediment placement
- Wetland expansion/restoration

Wetland adaptation monitoring:

- Wetland habitat loss

6.1 Adaptation options

6.1.1 Adaptation option: allow/facilitate wetland conversion and transgression

Allowing and facilitating wetland conversion and transgression is an adaptation strategy that would allow wetlands to grow into higher elevation areas as sea-level rises. Wetland vegetation establishes in areas of certain elevations relative to the tidal water levels to achieve a certain frequency of tidal inundation. As sea-level rises, the frequency of inundation increases and

plants in these elevation ranges drown out. However, the seeds of the next generation of plants can survive if they establish at higher elevations. In this way, wetlands can “migrate” or transgress upslope.
Allowing wetland transgression to happen naturally could be done in areas with existing transitional and upland habitat. In areas with development, wetland conversion could be facilitated by setting back infrastructure and development in certain key areas to leave room for marshes to migrate in the future. This could be done by setting policy that prevents any new development in the uplands surrounding wetland habitat.

Within the existing marsh basins in San Dieguito Lagoon, the salt marsh is expected to move upslope as water levels rise. However, the steep slopes will limit the amount of salt marsh in these areas. Salt marsh is also expected to move further upstream along the San Dieguito River to keep up with sea-level rise; however, the River corridor is relatively narrow and the overall vegetated marsh acreage will be greatly reduced. Acquiring upland areas near the existing marsh will be key to the sustainability of wetland habitat.

Table 6.1.1 summarizes benefits and constraints of allowing and facilitating wetland conversion and transgression. Creating space for wetlands to migrate will preserve wetland habitat until the rate of sea-level rise exceeds the migration rate. While allowing wetlands to migrate will provide more wetland habitat over time, this would come at the expense of transitional and upland habitats or developed areas. Wetlands also provide benefits such as flood and erosion protection and sequestration of greenhouse gases in the vegetation and wetted soils (see Appendix A for additional information).

Table 6.1.1
Wetland conversion and transgression benefits and constraints summary

Benefits	Constraints
• Preserves wetland habitat	• Potential loss of upland and transitional habitat
• Reduces flood and erosion risks	• Potential loss of development area
• Sequesters additional greenhouse gases in the new vegetation and soils	• Less effective over time with increasing rates of sea-level rise
	• Limited existing areas for transgression

As a next step subsequent to this Adaptation Plan, a detailed San Dieguito Lagoon Wetland Habitat Migration Assessment should be performed in conjunction with the City of San Diego and other lagoon stakeholders to further assess the potential for San Dieguito Lagoon wetland habitats to migrate upstream and to upland areas adjacent to Lagoon to further develop adaptation measures that facilitate habitat migration. This assessment will include a spatial wetland migration analysis to identify areas where salt marsh habitats will or could migrate to. It will also identify and evaluate measures to preserve these potential habitat migration areas and corridors, including potential land acquisition, use designations, zoning buffers, setbacks, and conservation easements.

6.1.2 Adaptation option: sediment placement

Sediment placement on the marshplain is an adaptation strategy that would allow wetland accretion to keep up with sea-level rise. Wetland vegetation establishes in very specific elevation zones relative to tidal water levels. If/when the tidal water levels increase, the vegetation needs to establish at higher elevations as well. This can either be done through natural transgression if there is accommodation space or by placing sediment to actually raise the surface elevations.

Sediment placement in a marsh is a relatively new, but promising adaptation measure. The first sediment placement project on the West Coast was completed in April 2016 at the Seal Beach Wetlands in Huntington Beach. Clean dredged material from the Huntington Harbor was placed in an 8-10 inch layer over a roughly 7 acre area (USFWS 2016, Figure 6.1). Monitoring is being completed to track the outcomes of the project and inform future projects.

Figure 6.1
Sediment Placement on the Marsh at Seal Beach

SOURCE: USFWS 2016

Table 6.1.2 summarizes benefits and constraints for sediment placement. Sediment placement would allow marshes to keep up with sea-level rise, reduce flood and erosion risks, and provide an opportunity for beneficial reuse of sediment. However, because sediment placement is a relatively new method, there are still many unknowns related to the impacts to the marsh. Additionally, permitting is likely to be challenging until this becomes a more common practice. Placing sediment in wetlands requires careful and unique consideration, engineering, and construction. Over time, more and more sediment would need to be placed to keep up with sea-level rise, so sediment placement would become more expensive over time. Sediment placement has the potential to be compatible with River channel dredging as an integrated wetland/River flood management adaptation strategy

Table 6.1.2
Sediment placement benefits and constraints summary

Benefits	Constraints
• Preserves wetland habitat	• Potential temporary impacts to the march
• Reduces flood and erosion risks	• Potentially challenging to permit
• Option for beneficial reuse of sediment	• More expensive way to dispose of sediment
	• More expensive over time as increasing rates of sea-level rise will require more sediment

6.1.3 Adaptation option: wetland expansion/restoration

Wetland expansion or restoration is an adaptation strategy that increases the area of marsh. Restoration can range from planting native plants in upland or transition zones to significant grading of marshplain or channels to achieve the appropriate elevations for tidal inundation. Restoration can be combined with allowing wetland transgression (Section 6.1.1) as upland and transitional areas become available. For example, grading channels into a site might be necessary to bring tidal waters further back, but revegetation could occur through natural recruitment.

Wetland restoration is compatible with levees-with-partial-retreat adaptation measures for River flooding, for example as described in Chapter 5. In this scenario, the transition and upland habitat areas could be designed to allow for wetland habitat migration with sea-level rise, thereby increasing wetland resiliency to sea-level rise.

Table 6.1.3 summarizes the benefits and constraints of wetland restoration. Creating new wetlands through restoration will preserve wetland habitat until the rate of sea-level rise is faster than the rate at which marshes can migrate. While restoring wetlands will provide more wetland habitat over time, this would come at the expense of transitional and upland habitats or developed areas.

Wetlands also provide benefits such as flood and erosion protection and sequestration of greenhouse gases in the vegetation and wetted soils.

Table 6.1.3
Wetland expansion/restoration benefits and constraints summary

Benefits	Constraints
• Creates new wetland habitat	• Potential loss of upland and transitional habitats
• Reduces flood and erosion risks	• Potential loss of development area
• Sequesters additional greenhouse gases in new vegetation and soil	• Less effective over time with increasing rates of sea-level rise

6.2 Wetland adaptation monitoring

The main criterion for initiating consideration and planning for wetland adaptation is habitat loss/conversion. With 2 ft of sea-level rise, existing high marsh (pickleweed) habitat is expected to drown out and move upslope into the existing transitional habitats. With 3 ft of sea-level rise, low marsh habitat (cordgrass) will move into areas that are currently mid marsh (pickleweed) and high marsh. As a result, mid and high marsh will be squeezed into the transition zone. With 5.5 ft of sea-level rise, all salt marsh habitat will be squeezed into the elevation band where transitional habitat occurs today, which is a smaller area than the existing wetland area.

Adaptation planning would be needed when existing high marsh converts to mid marsh and squeezes into the transition zone, which is likely to result in loss of high marsh habitat functions (e.g., loss of high tide refugia). As wetland conversion continues with sea-level rise, upland and transitional areas could be allowed to convert to marsh through wetland transgression. With enough sea-level rise (e.g., 1 ft of sea-level rise), this adaptation strategy is not expected to be effective and restoration in other higher elevation areas or placement of sediment in existing marshes would be needed. Table 6.2.1 presents monitoring criteria with wetland conversion thresholds to initiate consideration of adaptation measures. Table 6.2.2 provides lead times to begin advance planning before adaptation measures could be in place to limit risk.

Table 6.2.1
Wetland monitoring criteria to consider adaptation options

Criteria & Thresholds	Wetland Conversion	Pickleweed / Cordgrass Mudflat	Cordgrass Mudflat Open Water	Mudflat Open Water	Open Water
Adaptation Options	**Protect**		Sediment placement		
	Accommodate	Conversion and transgression			
	Retreat		Wetland expansion, migration and restoration		

Table 6 2.2
Possible lead times for planning wetland adaptation options

Risk	Actions	Lead Times	Adaptation Options
Lagoon wetlands	**Protect**	**5-10 years**	Sediment placement
	Accommodate	**5-10 years**	Wetland conversion and transgression
	Retreat	**10-20 years**	Wetland expansion, migration and restoration

6.3 Wetland adaptation coastal permitting

The Coastal Development Permit review and approval for wetland adaptation measures may be processed by the City of Del Mar through the Local Coastal Program (LCP) and/or by the California Coastal Commission, pursuant to the California Coastal Act. Additional approvals may be required from the U.S. or California Fish and Wildlife Service, the U.S. Army Corps of Engineers, the California State Lands Commission, the U.S. Coast Guard, the California Department of Boating and Waterways, and California Regional Water Quality Control Boards.

CHAPTER 7

San Dieguito River Flooding Adaptation

This chapter includes a range of adaptation measures to address vulnerabilities from flooding along the San Dieguito River, including the river valley, Del Mar Fairgrounds, and North Beach (north from 15th St to the San Dieguito river mouth). Permitting for some adaptation measures may be processed through federal, state or City entities as summarized in Section 7.3.

The increased risk of San Dieguito River flooding is driven by changes in extreme precipitation and river discharge and increased deposition of sand in the river channel which would raise the elevation of the channel bed and the flood level. Increased channel deposition could occur as sea level rises, with waves driving an increase in sand transport "up" into the channel. The increase in channel depth could also increase deposition due to tidal flows into the San Dieguito River Lagoon and the interaction of river and tidal flows in the estuary. Increased precipitation and river discharge in the face of a rising sea level will also increase flood levels.

Vulnerability assessment:

- Roads and bridges, including Camino Del Mar road and bridge, Jimmy Durante Blvd. road and bridge, the railroad bridge, the North Beach District streets and San Dieguito Drive, will be highly vulnerable to flooding with 2 to 3 feet of deposition.
- Low-lying central portions of the North Beach District (blocks bounded by Camino Del Mar, 28th St, and Railroad; general vicinity of Coast Blvd. and Santa Fe between 17th St. and 23rd St.), which currently have low vulnerability to river flooding, would be highly vulnerable with 2 to 3 feet of deposition.
- The sewer lift station along San Dieguito Drive would be increasingly exposed to flooding and risk of failure.
- Other water and sewer infrastructure, coastal access parking, and recreation areas including tennis and basketball courts in these areas would also be exposed to both river and coastal flooding.
- The Fairgrounds west of I-5 will become highly exposed and vulnerable to flooding with 2 to 3 feet of channel deposition.

River flooding adaptation options:

- River channel dredging
- Reservoir management
- Levees
- Elevate structures

River flooding adaptation monitoring:

- River channel deposition
- Chance of extreme flooding

7.1 Adaptation options

Del Mar's Beach Preservation Initiative was drafted and adopted by voters in 1988 to remove private seawall encroachments from public property while providing protection for ocean front homes from wave attack. The seawalls provide protection from wave attack, to some extent, to the lower-lying landward properties, but the primary risk to these properties is river water flooding. The adaptation options in this section provide mechanisms to protect Del Mar's low-lying homes from increased flood risk due to sea level rise.

7.1.1 Adaptation option: river channel dredging

River channel dredging maintains the channel bed near its current elevation and maintains the river flood risk near the current risk level. This could be accomplished using marine-based floating dredges and barges and/or land-based equipment operated from the channel bank. Assuming the dredged material is primarily sand, the dredged material could be placed on the beach to provide nourishment as a beach adaptation measure. Material could also be placed to raise the elevation of wetlands as a wetland adaptation measure (e.g., using "spray" dredging), especially for finer-grained dredged material.

Southern California Edison has dredged the River channel as part of the San Dieguito Lagoon Wetland Restoration. Southern California Edison dredged approximately 40,000 cubic yards of sand from the channel in 2011, 16,800 cubic yards in 2015, and approximately 19,000 cubic yards in 2017 to maintain the tidal flow (tidal prism) required by mitigation permits. Southern California Edison is required to maintain a minimum tidal prism, which is achieved by maintaining a certain minimum channel cross-section; however, the permits and maintenance program do not account for future sea-level rise or require a certain channel bed elevation to be maintained. With sea-level rise, the tidal prism could be maintained for the restoration, while the channel bed elevation and flood risk increase. Modifying the channel dredging program to maintain the channel bed elevation as a river flood adaptation measure is therefore expected to be required..

As part of the Adaptation Plan, it is recommended that the City review ongoing channel survey data and deposition monitoring from the San Dieguito Lagoon Restoration and communicate with Southern California Edison on the channel dredging program to influence its benefit toward protecting City properties. It is encouraged that the city coordinate with Southern California Edison to identify optimal times and placements for dredging such that dredged material would remain in place for as long as possible. Past dredging has not been designed to optimize benefit to the beach and protection from flooding.

7.1.2 Adaptation option: reservoir management

The City of San Diego's Lake Hodges Reservoir controls flows from approximately 87% of the San Dieguito River watershed. The primary purpose of the Lake Hodges Reservoir is water storage; however, the Reservoir can provide ancillary flood management benefits. In the past, extreme river flooding has occurred when the reservoir is full and extreme rainfall runoff events overtop the dam spillway and is conveyed downstream. The majority of the extreme river discharge at Del Mar has been contributed by the flow spilling over the dam spillway, as occurred in floods in 1978 and the early 1980's.

In 2012, The San Diego County Water Authority (SDCWA) completed the Lake Hodges Projects that connected Lake Hodges to SDCWA's new Olivenhain Reservoir for the purpose of improving water supply and storage (SDCWA 2016). The connection also allows water to be pumped back and forth between Hodges Reservoir and Olivenhain Reservoir (SDWCA 2016). While the primary purpose is water storage, the improved reservoir system and operations could provide improved flood management.

As part of the Adaptation Plan, the City can coordinate with the City of San Diego, the San Diego County Water Authority (SDCWA) and the Olivenhain Municipal Water District (OMWD) to explore Olivenhain and Lake Hodges reservoir management and operations options for improving river flood management at present and with climate change. Increasing reservoir storage has the potential to at least partially offset the projected increase in River flood risk with climate change and sea-level rise-induced channel deposition. Storage volume could be increased through management of the Lake Hodges Project via pump operation or by dredging sediment from the reservoir that has been delivered by the River and accumulated in the reservoir. Dredging reservoir sediment could potentially be compatible with beach nourishment and wetland sediment placement adaptation measures. This approach is logical in that it moves sediment trapped in the reservoir to the coast, where it is needed and would have naturally deposited without the reservoir; however, there are a range of constraints and feasibility issues that would need to be considered including transporting (e.g., trucking) sediment.

7.1.3 Adaptation option: levees

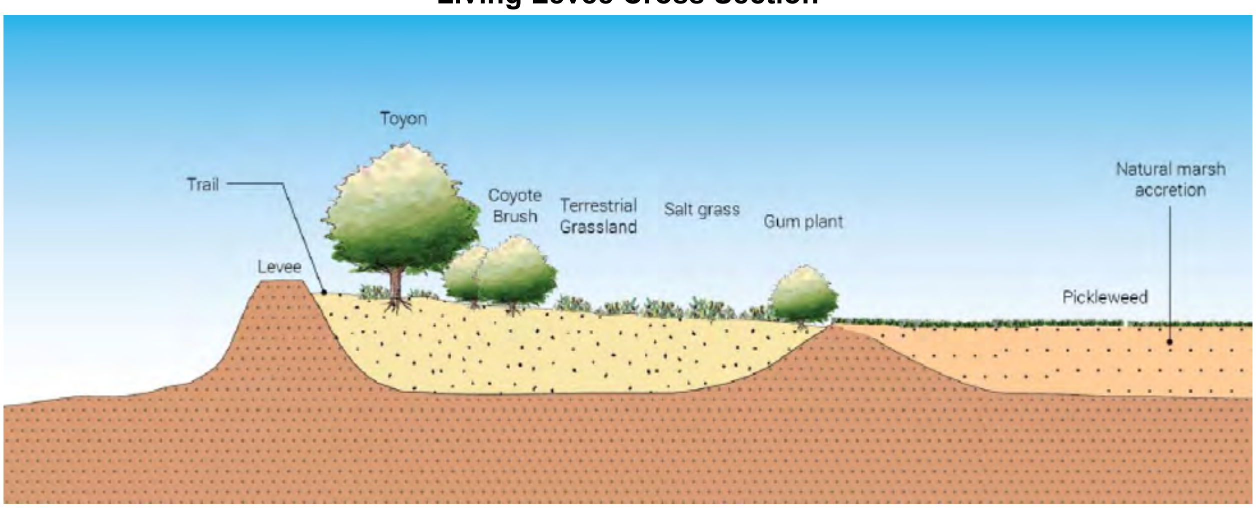
Levees, such as engineered earth embankments, can be built along the river corridor up to elevations above flood levels to reduce the flood risk to areas behind the levees. The Adaptation Plan includes levees along the River flood corridor. Figure 7.1 illustrates how levees could be aligned with habitat restoration areas; specific locations of levees would require careful design, permitting and planning in conjunction with the Fairgrounds. The actual proposed levee alignments and wetland restoration areas would need to be planned in greater detail and would be different than shown in the example. The locations of the levees would also need to be assessed and planned in greater detail so that any levees tie into high ground.

The levees could be designed as "living levees" by creating gently-sloping upland, transition, and wetland habitats between the levee and the river (Figure 7.2). This approach is being adopted in wetland restoration practice to enhance habitat diveristy and provide wetland buffers and high tide refuge. Higher elevation transition and upland areas also provide space for wetland to migrate to with sea-level rise. Constructing living levees may be compatible with channel dredging if dredged materal can be placed to build the habitat slope adjacent to the levee. Soil for levee construction would need to meet specific engineering criteria and may need to be imported from off-site.

Figure 7.1
Example to illustrate Living Levees along the San Dieguito River

[can this Figure be revised to remove the northern yellow line on Fairgrounds property?]

Figure 7.2
Living Levee Cross Section



The levees would need to be planned and designed to avoid potential impacts to existing habitats, sediment transport, and flood levels upstream and downstream. By combining levees with habitat restoration, the intent would be to avoid construction in existing wetland areas and create new restored upland and wetland habitats that could mitigate for potential habitat impacts. The effects of levees and restored areas on river sediment transport, deposition, and scour during storm events would also need to be analyzed. For example, the effect of the San Dieguito Lagoon Restoration on sediment transport and the potential to reduce sand supply to the beach during storm events was an important consideration in the project evaluation and design. Constructing levees to protect portions of the City and Fairgrounds that would otherwise flood during storm events could potentially increase sand transport to the beach, however this would need to be fully evaluated. Confining river flows within a levee system also has the potential to increase flood levels upstream and downstream of the levee system, which would also need to be fully evaluated and addressed in planning and design. Within the levee system (i.e., between the levees), River flood levels would also likely increase and a plan and design to reduce any potential increase in flood risk to bridges crossing the river would need to be developed.

7.1.4 Adaptation option: elevate structures

The ground floor elevation of homes and buildings or infrastructure such as roads can be raised to above river flood levels in the future, similar to the adaptation measure for raising structures to address North Beach coastal flooding, as described in Chapter 9. A key difference is that the area of potential river flooding is larger than the area of coastal flooding and a greater number of structures would be affected.

Raising roads and vulnerable utilities can be accomplished by placing fill to rebuild roads and replace utilities at higher elevations. Other options for raising roads and utilities may include replacing at-grade roads with pile-supported causeways. The Fairgrounds have proactively elevated structures they identified as vulnerable. Vulnerabilities to existing and planned railroad infrastructure will require coordination with NCTD and SANDAG.

As part of the City's existing floodplain management program, the City already requires that new construction in the current river floodplain be elevated above the existing 100-year river flood elevation to meet Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) requirements. FEMA is in the process of revising the effective Flood Insurance Rate Maps and accompanying flood levels; however, the NFIP does not currently consider sea-level rise and climate change. The City can consider modifying floodplain development policies and regulations to address sea-level rise and facilitate elevating structures over time through redevelopment.

7.1.5 Adaptation option: relocate public infrastructure

The City can consider relocating public buildings, utilities, and other infrastructure as the river flood risk to public structures increases. For at-risk private property and structures, the City could consider incentives for facilitating relocation to allow for wetland restoration along the river. As noted above, a greater number of public structures are within the river flood risk area than the coastal flood risk area.

7.2 River adaptation monitoring

The monitored criteria for river adaptation are channel deposition (e.g., driven by sea-level rise) and the flood risk due to sea-level rise, channel deposition, and potential for climate change to increase extreme precipitation and river discharge. Table 7.2.1 includes the projected increase in flood risk with sea-level rise/channel deposition and climate change from the Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016). These projections assume that deposition is not limited by sediment supply and that the river bed profile and flood profiles would increase in elevation with sea-level rise, with a rate and amount of deposition equal to the rate and amount of sea-level rise.

Table 7.2.1
Projected river flood risk with sea-level rise

Sea-level rise and channel deposition	0 ft	1ft	2 ft	3 ft	5.5 ft
Annual chance of extreme flooding (1% chance event)	1%	5%	6%	6%	20%
Annual chance of significant flooding (1980 event)	5%	15%	25%	50%	100%

Table 7.2.2 presents criteria to initiate planning for adaptation measures and anticipated extreme risk of flooding ranges over which measures will be effective. Based on the guiding principles, the flood risk criteria and thresholds are set to limit the risk of extreme river flooding and damage to less than 5% annual-chance of occurrence. Adaptation planning would be needed as river flooding and damage increases to 5%.The risk of more frequent, less severe, but still significant flooding such as the 1980 San Dieguito river flood event is estimated to currently be around 5% annual-chance. Adaptation to reduce extreme flood risk would reduce the risk of more frequent flooding. Table 7.2.3 provides estimated lead times to begin advance planning before adaptation measures could be in place to limit risk.

Table 7.2.2
River flooding monitoring criteria to consider adaptation options

Criteria & Thresholds	Annual risk of extreme flooding*	5%	15%	50%	100%
Adaptation Options	Protect	Channel dredging			
			Reservoir management		
			Levees		
	Accommodate	Elevate structures			
	Retreat		Relocate public infrastructure		

**Risk of flooding without adaptations*

Table 7.2.3
Possible lead times for planning river flooding adaptation options

Risk	Actions	Lead Times	Adaptation Options
River flooding	Protect	5-10 years	Channel dredging
		5-15 years	Reservoir management
		15-20 years	Levees
	Accommodate	5-10 years	Elevate structures
	Retreat	15-20 years	Relocate public infrastructure

7.3 River adaptation coastal permitting

The Coastal Development Permit review and approval for river adaptation measures may be processed by the City of Del Mar through the Local Coastal Program (LCP) and/or by the California Coastal Commission, pursuant to the California Coastal Act. Additional approvals may be required from the U.S. or California Fish and Wildlife Service, the U.S. Army Corps of Engineers, the California State Lands Commission, the U.S. Coast Guard, the California Department of Boating and Waterways, and California Regional Water Quality Control Boards.

CHAPTER 8

Bluff and Adjacent Beach Erosion Adaptation

This chapter includes a range of adaptation measures to address vulnerabilities from erosion of bluffs and their adjacent beaches. This is relevant to the South Bluffs, bluffs along South Beach including low bluffs fronting Powerhouse Park, and the North Bluffs. Permitting for some adaptation measures may be processed through federal, state or City entities, as summarized in Section 8.3

Vulnerability assessment:
- With 1 foot of sea-level rise, the current localized vulnerability of the LOSSAN railroad to bluff erosion will increase and extend along almost the entire southern bluffs. The railroad would need to be moved inland or other adaptation measures, for example with underpinnings, cassons, or soldier piles, would be required to reduce the risk of the railroad collapsing.
- If a seawall is constructed to protect the railroad, it will cause the beach to narrow and over time little to no beach will exist along the southern bluffs.
- If the railroad is moved inland and bluff erosion is allowed to continue, bluff-top property and sewer infrastructure in South Beach and along South Bluff would be vulnerable to erosion with 2 feet of sea-level rise.
- North Bluff properties and the low bluffs at Powerhouse Park would be similarly vulnerable to erosion.

Bluff adaptation options:
- Beach nourishment and retention
- Best management practices (BMPs)
- Railroad relocation
- Public infrastructure relocation

Bluff adaptation monitoring:
- Distance between coastal bluff edge and development
- Beach width adjacent to the bluffs

8.1 Bluff adaptation options

8.1.1. Adaptation option: beach nourishment and retention

Nourishing and retaining the sand on the beach below the southern bluffs could provide short-to-medium term benefits of maintaining a beach for ecology and recreational use and reducing wave run-up onto and erosion of the bluff toe. In the long term, beach nourishment and retention may become more expensive if sand sources become limited or if the amount of sand required increases with sea-level rise. Current studies indictate dune restoration may not be an effective solution for reducing erosion of the bluff toe, as the beach is already squeezed in front of the bluff toe and sand placed for dune creation may not last. Additionally, beach nourishment and retention would not affect the erosion processes at the bluff top. Given the proximity of the southern bluffs to the Los Peñasquitos Lagoon inlet, the effects of beach nourishment and retention on the Lagoon inlet would need to be fully considered.

Beach nourishment for the North Bluff is not likely to be effective if limited to the City limit given the relatively short length of bluff shoreline and proximity to the San Dieguito Lagoon mouth; however, beach nourishment could be pursued in coordination with the City of Solana Beach. Table 8.1.1 summarizes benefits and constraints of beach nourishment adjacent to bluffs.

Table 8.1.1
Bluff beach nourishment and retention benefits and constraints summary

Benefits	Constraints
• Preserves beach • Reduces bluff toe risk	• Limited sand resources • Less effective over time with increasing sea-level rise • Transportation of sediment to receiver sites • Short-term beach use and ecology impacts

8.1.2. Adaptation option: best management practices (BMPs)

Best management practices (BMPs) for reducing bluff erosion include management of surface drainage as well as shallow subsurface groundwater drainage to the bluff edge and face to control local erosion and slope failure due to drainage. The goal of these practices should be to control surface runoff and avoid concentrated flow down the bluffs, reducing shallow groundwater flow that saturates upper soils and facilitates erosion, and management of groundwater daylighting at geologic layers. NCTD and SANDAG are already employing surface and subsurface drainage control measures to reduce erosion.

In addition to these surface water and groundwater BMPs, the City could investigate whether over-watering of landscaping within the South Beach and bluffs along South Bluff could be contributing to elevated groundwater flows to the southern bluffs and whether reducing this irrigation could potentially reduce bluff erosion.

It is possible that public access down the bluffs could be contributing to increased bluff erosion, as people frequently walking down bluff foot paths may be de-stabilizing soil, both directly and by preventing vegetation from establishing on the paths given that vegetated bluff is more erosion-resistant than bare soil. Access down the southern bluffs by crossing the LOSSAN railroad track or walking along the tracks is unauthorized; however, multiple paths down the bluffs are currently used. Public access and associated bluff erosion (if any) could be controlled by installing authorized pedestrian crossings of the railroad, with pedestrian under-passes (or over-passes), and constructing stairways down the bluffs to the beach. The Adaptation Plan recommends exploring one or more authorized railroad crossings and vertical access paths down the southern bluffs to reduce erosion. For example, two crossings and pathways could be installed at 7th and 11th Streets, where there is more space between the railroad tracks and the top of the bluff. Railroad crossings and beach access stairways are difficult to implement and feasibility may be challenging. Even so, the City should investigate these and/or other options together with NCTD and SANDAG as part of the Adaptation Plan.

Revegetating/restoring bluff vegetation on existing pathways may be effective in reducing erosion. New vertical crossings and pathways (e.g., stairways) could be installed to replace beach access via bluff-side pathways. A program to restore/revegetate large sections of the bluffs with more erosion-resistant vegetation could potentially de-stabilize the bluffs during installation and/or the period over which plants are establishing.

8.1.3 Adaptation option: railroad relocation

The LOSSAN railroad track is currently at risk of bluff erosion, which is why NCTD and SANDAG have installed bluff stabilization projects. Removing the LOSSAN railroad track from the southern bluffs and relocating the track to an inland tunnel or other location would allow the natural processes of landward bluff erosion and beach migration to occur. While bluff erosion is not the only source of sand to the beach below, bluff erosion will continue to supply sand to the beach, in turn increasing the buffer the beach provides from wave action on the bluff toe.

The SANDAG 2050 Regional Transportation Plan (SANDAG, 2011) includes plans to remove and relocate the railroad; however, implementation of the planned project is not currently funded. The City supports railroad relocation as part of SANDAG plans and as a matter of City policy. The City Community General Plan (1976) includes zoning that designates the railroad property and right of way as a future open-space park area.

The City's current zoning and Local Coastal Program (LCP) includes a Railroad land use designation for the railroad property and right-of-way. The Railroad designation allows railroad facilities and related structures provided a Conditional Use Permit is obtained from the City and is in full force and effect; however, this process is not currently followed by NCTD, SANDAG, and the City. The railroad right-of-way is complex. Rail operations engaged in interstate commerce are considered not subject to state or local permit jurisdiction. Even so, the right-of-way is located within the current LCP's Shoreline Protection Area line and Beach Overlay Zone.

Railroad relocation would allow landward bluff erosion in order to maintain the beach below and the natural character of the Del Mar bluffs and beach. Currently, about 50 trains per day use the rail line, and SANDAG plans to increase this number to over 100 trains per day with double tracking of the corridor. On average, about 12 people per year are killed by trains in the San Diego corridor. Railroad relocation would further rail safety and operations, address an immediate safety problem, eliminate the need for reduced speeds due to bluff instability and service interruptions due to bluff inspections, and make increased traffic more feasible.

8.1.4 Adaptation option: relocate public infrastructure

After railroad relocation, the bluff will continue to erode landward through the current location of the railroad. With 1 ft of sea-level rise or more, the bluff is projected to erode and threaten buildings, roads, and the sewer line along the bluff landward of the railroad. The LCP as ammended by the BPI allows sea walls only as a last resort within the Shore Protection Area and Beach Overlay Zone. The City can consider relocation of public buildings, utilities and other infrastructure as the bluff erosion risk to public structures increases. Proactively, the City could consider options for facilitating public infrastructure removal where there is a public benefit, such as removing public structures to restore or preserve bluff trails or parks. As the low bluffs along Powerhouse Park erode due to sea level rise, an option would be to armor in the short run to preserve the park for public use, but the armoring will become expensive and less effective with extreme levels of SLR and could accelerate beach erosion.

8.2 Bluff adaptation monitoring

The criteria to initiate consideration and planning for bluff adaptation is the distance between the the bluff top edge and the bluff top asset. A minimum buffer distance is based on an approximate structural buffer distance between the bluff top and a structure, which is required to provide enough bluff width to laterally support the structure. A structural buffer distance of approximately 10 ft is used based on a SANDAG study (Leighton & Associates 2010) of the distance within which bluff erosion presents a risk to railroad track stability (per the Coastal Hazards, Vulnerability, and Risk Assessment). The minimum buffer distance between the bluff top edge and a bluff top asset includes an additional safety buffer based on the approximate width of bluff that could collapse in a single erosion event. Adding this safety buffer to the structural buffer allows for the occurrence of an erosion event after monitoring criteria threshold has been reached and while the adaptation measure is being planned and implemented. A safety buffer of approximately 25 ft is used based roughly on the July 13, 2016, bluff collapse near 10th Street (Figure 8.1). Actual bluff top recession during this event is to be determined and may have been between 5 and 20 ft. To summarize, the minimum buffer distance is based on the following:

- Structural buffer distance = 10 ft
- Safety buffer distance = 25 ft
- Minimum buffer distance = structural buffer distance + safety buffer distance = 35 ft

These projected distances provide an indication of the amount of sea-level rise at which minimum buffer distances would be insufficient for some portion or all of the railroad, rows of buildings, and the sewer line. With 1 ft of sea-level rise, additional adaptation (e.g., beach nourishment and retention and/or BMPs) is expected to be required to reduce the risk of erosion to the railroad. If and when the railroad is relocated and the bluff is allowed to erode, adaptation would be required to reduce the risk to some public infrastructure including sections of the sewer line (e.g., south of Seagrove Park and near 10th Street) with 1ft of sea-level rise. With 3 ft of sea-level rise, the following assets are expected to be at risk: portions of the sewer line; and the entire railroad along the bluffs. This indicates that the railroad may need to be relocated by or before this point (depending on the effectiveness of beach nourishment and BMPs). Table 8.2.1 shows the approximate projected distance between the bluff top and the railroad, the first and fourth rows of buildings, and the sewer line along the bluffs with sea-level rise (distances below the minimum of 35 ft shown in red indicate potential need for bluff erosion adaptation for some or all of asset class). The sewer line changes locations along the Del Mar bluff. It is located between the railroad and the first row of buildings in some areas and between or under first to fourth row buildings in other areas. Table 8.2.1 shows distances for areas where the sewer is located east of the first row of buildings.

Figure 8.1
Bluff Collapse near 10th St. in Del Mar on July 13, 2016

Projections in Table 8.2.1 are approximate and could be greater or less due to uncertainties. Actual distances will be monitored over time as part of the adaptation plan process. Table 8.2.2 presents monitoring criteria and adaptation measures with anticipated erosion ranges over which measures will be effective. Table 8.2.3 provides lead times to begin advance planning before adaptation measures could be in place to limit risk.

Table 8.2.1
Projected distances from bluff top to railroad, sewer line, 1st and 4th rows of buildings with sea-level rise (for areas with sewer between buildings)

Sea-level rise:	0 ft	1 ft	2 ft	3 ft	5.5 ft
RR	15 - 110 ft	0 - 70 ft	0 - 40 ft	0 - 10 ft	0 - 0 ft
1st row	40 - 170 ft	0 - 140 ft	0 - 120 ft	0 - 80 ft	0 - 0 ft
Sewer	65 - 175 ft	10 - 190 ft	0 - 150 ft	0 - 100 ft	0 - 50 ft
4th row	270 - 450 ft	170 - 340 ft	140 - 300 ft	100 - 280 ft	10 - 210 ft

Table 8.2.2
Bluff erosion monitoring criteria to consider adaptation options

Criteria & Thresholds	**Railroad setback from bluff edge**	**15 - 110 ft**	**0 - 60 ft**	**0 - 35 ft**	**0 - 5 ft**	**0 ft**
	Sewer setback from bluff edge	**40 - 170 ft**	**0 - 130 ft**	**0 - 110 ft**	**0 - 65 ft**	**0 ft**
	1st row setback from bluff edge	**65 - 175 ft**	**10 - 190 ft**	**0 - 150 ft**	**0 - 100 ft**	**0 - 50 ft**
Adaptation Options	**Protect (soft measures)**	Beach and dune nourishment and retention				
			Best management practices			
	Retreat (Phase 1)		Relocate Railroad			
	Retreat (Phase 2)			Remove sewer, storm drains, fiber optic cables		

Table 8.2.3
Possible lead times for planning bluff erosion adaptation options

Risk	Actions	Lead Times	Adaptation Options
Bluff	**Protect**	**5-10 years**	Beach and dune nourishment
erosion	**Retreat**	**5-10 years**	Relocate sewer, storm drains, fiber optic cables
	Retreat		Relocate railroad

As bluff erosion continues with sea-level rise, the beach below the bluffs could be nourished to reduce erosion at the bluff toe and improve beach access, aesthetics and habitat function. BMPs could also be implemented to reduce bluff erosion, such as installing vertical access paths (e.g., stairs) down the bluffs with authorized railroad under-pass (or over-pass) crossings and pursuing studies and measures to potentially reduce irrigation and groundwater flow-related erosion effects. With enough sea-level rise (e.g., 2 ft of sea-level rise), these adaptation strategies are not expected to be effective and the railroad would need to be relocated. Relocating the railroad would provide some buffer within which bluff erosion could occur without posing a risk to landward assets; however public infrastructure such as portions of the sewer line would also likely need to be relocated.

8.3 Bluff adaptation coastal permitting

The Coastal Development Permit review and approval for bluff adaptation measures may be processed by the City of Del Mar through the Local Coastal Program (LCP) and/or by the California Coastal Commission, pursuant to the California Coastal Act. Additional approvals may be required from the U.S. or California Fish and Wildlife Service, the U.S. Army Corps of Engineers, the California State Lands Commission, the U.S. Coast Guard, the California Department of Boating and Waterways, and California Regional Water Quality Control Boards.

CHAPTER 9

Beach Erosion and Flooding Adaptation

This chapter includes a range of adaptation measures to address vulnerabilities from beach erosion and flooding in North Beach (north from 15th street to the San Dieguito river mouth). The beach level community in the City of Del Mar comprises a century-old beach front neighborhood that is fully developed with approximately 600 properties in a densely populated area, a major U.S. coastal route (101), and railroad tracks supporting commuter and interstate passenger and freight traffic. It serves visitors with direct public beach access at each street from 15th to 29th. Permanent lifeguard towers with public restrooms at 17th St, 20th St, & 25th St are supplemented with temporary towers during busy tourist seasons. This region has unique neighborhood features, topographies, and vulnerabilities. It is already subject to both coastal and river flooding. The homes and public infrastructure throughout the area benefit from sea-walls along almost the entire beachfront. The oceanfront homes have a higher elevation than homes to the east, where elevations decline from the oceanfront eastward toward the LOSSAN rail line. The beach in this area is an important part of Del Mar's continuous, wide, walkable beach that stretches over two and a half miles from near Los Penasquitos Lagoon on the south to San Dieguito Lagoon to the north. Permitting for some adaptation measures lies within the jurisdiction of federal, state or City entities, as summarized in Section 9.3.

Vulnerability assessment:
- Public access along the beach (horizontal access) will be lost due to beach erosion with 1 to 2 feet of sea-level rise.
- Beach erosion and coastal storms will threaten sea wall integrity and increase flooding and storm damage.
- Low-lying roads and properties in North Beach will be highly vulnerable to coastal and river flooding, including the blocks between Ocean Front and Camino Del Mar/Coast Blvd and the blocks directly east of Camino Del Mar/Coast Blvd.
- The present low to moderate vulnerability to coastal flooding and wave damage will become a high vulnerability with 1 to 2 feet of sea-level rise, for low-lying roads and properties in North Beach, including the City's 17th St Beach Safety Center.

Beach adaptation options:
- Beach and dune nourishment
- Sand retention
- Raise/improve sea walls and revetments
- Elevate structures
- Relocate public infrastructure

Beach adaptation monitoring:
- Beach width
- Flooding and storm damage frequency

9.1 Beach adaptation options

9.1.1 Adaptation option: beach and dune nourishment

Widening North Beach would reduce the risk of flooding and erosion of property along the beach. However, the width of the beach will diminish with time and sea-level rise, requiring an ongoing cycle of “re- nourishment” to maintain beach width. As sea-level rises, the frequency of required nourishment is likely to increase, because, in addition to widening the beach to offset erosion, additional sand will be needed to raise the elevation of the beach up to the increased sea level. For all these reasons, beach nourishment should be considered in conjunction with sand retention measures (Section 9.1.2).

The dominant direction of sand transport along the Del Mar coast is from north to south. Beach nourishment could therefore contribute to closure of the Los Peñasquitos Lagoon inlet to the south, and could also affect the San Dieguito Lagoon inlet to the north (during south swells that transport sand from south to north). With sea-level rise, increased sediment supply may be a net benefit to the extent that it mitigates rapid shoreline and ecological changes. The Coastal Hazards, Vulnerability and Risk Assessment indicates beach nourishment will be effective up to 1 ft of sea-level rise. Thus, the Adaptation Plan prioritizes beach nourishment as the primary and immediate strategy for Del Mar’s North Beach area. Table 9.1.1 summarizes benefits and constraints of beach and dune nourishment.

Table 9.1.1
Beach and dune nourishment benefits and constraints summary

Benefits	Constraints
• Preserves beach	• Limited sand sources
• "Living shoreline" provides beach and dune habitat	• Less effective over time with increasing sea-level rise
• Reduces flood and erosion risks	• Transportation of sediment to receiver sites
	• Beach use and ecology impacts

Placement of sand typically provides a temporary benefit until the sand erodes and migrates away from the placement area. It is therefore important to consider the fate of the sand and implications of deposition in other areas. In general, increased sand supply is considered beneficial to most beach areas, but can be problematic at lagoon inlets and storm drain outlets. Sand deposition on rocky substrate may adversely affect habitat and recreation. The dominant direction of sand transport along the Del Mar coast is from north to south. Beach nourishment could therefore contribute to closure of the Los Peñasquitos Lagoon inlet to the south, and could also affect the San Dieguito Lagoon inlet to the north (during south swells that transport sand from south to north). However, with sea-level rise, increased sediment supply may be considered a net benefit in terms of mitigating rapid shoreline and ecological changes.

9.1.2. Adaptation option: sand retention

Sand retention measures include structures that prevent sand transport away from the beach and encourage sand deposition on the beach. Types of structures include the following:

- **Groins**: These structures serve to maintain a wider beach but have the potential to diminish horizontal access along the beach. Constructing groins and other structures on the beach or in the ocean typically requires habitat mitigation (e.g., restoration of comparable habitat in another location) and could alter the character of Del Mar's natural shoreline. New groin designs may become available in the future, so this option should be evaluated over time.
- **Breakwaters**: These structures maximize wave reduction and sand retention but can disrupt and alter wave patterns and interfere with surfing resources, which may negatively impact Del Mar. Current permitting and mitigation requirements ,and the degree of potential negative impacts, may restrict use of breakwaters as an adaptation measure. New breakwater designs may become available in the future, so this option should be evaluated over time.
- **Artificial reefs**: These structures create rocky reef habitat and have potential to enhance surfing resources; however, using artificial reefs to retain sand and enhance surfing is still in the experimental phase of development. They have been investigated, constructed, and tested in various locations including Orange County. Successful reef installation remains a work in progress to date. New reef designs may become available in the future to ensure that reef implementation will provide the intended benefits, so this option should be evaluated over time.

Table 9.1.2 summarizes benefits and constraints of sand retention measures.

Table 9.1.2
Sand retention measures benefits and constraints summary

Type of sand retention structure	Benefits	Constraints
All	Retain sand	Require mitigation
Groins	Maintains wider beach	Affects horizontal access along beach
Breakwater	Maximizes wave reduction and sand retention	Destroys surfing resources
Artificial reefs	Creates rocky reef habitat Potential to enhance surfing resources	Experimental / limited experience

9.1.3 Adaptation option: sea walls and revetments

The existing sea walls and rip rap along North Beach provide flood and erosion protection for beachfront properties during typical storms and seasonal erosion. During severe storms, which can be coupled with severe seasonal erosion of the beach, waves can overtop the protective structures as in March 2016 (Figure 9.1) and cause damage as in the 1983 El Nino storm event

(Figure 9.2). Improving North Beach sea walls and revetments provides an adaptation measure to offset the increase in flood risk with sea-level rise. This could be accomplished by adding a new section of sea wall or rock to the top of the existing walls/revetments; however, doing so may require significant modifications or a rebuilding of the existing walls/revetments. While beach access points along the City's beaches from 15th Street north to the lagoon can be currently protected with seasonal berms, it may be important to consider improved sea wall protection for these locations.

Figure 9.1
Overtopping in Del Mar on March 8, 2016

While sea walls and rip rap provide protection to the existing property slopes, some studies show that these structures can contribute to erosion and accelerate beach loss when the beach width narrows and wave run-up frequently reaches the structure. As the beach narrows and sea-level rises, wave run-up and overtopping of the sea wall structures will also increase as the waves begin to break near or on the structures, and will require more frequent maintenance or reconstruction. With ongoing beach erosion and sea-level rise and without any other mitigating measures, fixing the shoreline location in one place with a sea wall or revetment will eventually lead to the loss of the beach seaward of the structure.

Sea wall and revetment construction is regulated by the CA Coastal Act and Del Mar LCP. The Coastal Act and LCP, which includes Del Mar's Beach Preservation Initiative, allow for construction and maintenance of sea walls or revetments when necessary to protect existing structures or public beaches in danger from erosion, when designed to eliminate or mitigate adverse impacts on the local shoreline sand supply. New development may not rely upon protective devices (e.g., sea walls and revetments) that would substantially alter natural landforms. Table 9.1.3 summarizes benefits and constraints of raising/improving sea walls and revetments.

Figure 9.2
Coastal Damage Following 1983 Storm

Table 9.1.3
Raise/improve sea walls and revetments benefits and constraints summary

Benefits	Constraints
• Protects property and reduces flood and erosion risks for the design lifespan and conditions	• Potential for loss of beach with sea-level rise and without other measures
• "Holds the line" and buys time to implement other adaptation measures	• Potentially accelerates beach erosion with sea-level rise
• In Del Mar, provides protection for properties throughout North Beach	• May require more frequent maintenance or reconstruction with sea-level rise
	• Level of protection provided decreases with loss of beach

9.1.4. Adaptation option: elevate structures

The ground floor elevation of homes and buildings or infrastructure such as roads can be raised to above sea-level rise flood levels (e.g., the 100-year flood level plus an allowance for sea-level rise) to reduce the risk of flooding with sea-level rise. Raising structures can include raising vulnerable buildings on pile foundations; however, there may be challenges with building height restriction, earthquake code compliance and other building codes. Further, while raising oceanfront structures could have potential to allow for some limited migration and persistence of a fronting beach, if it were done without accompanying beach and dune nourishment, shoreline migration would likely damage roads, infrastructure, and the many lower lying properties east of the shoreline.

Raising existing homes may not be feasible from an engineering and cost perspective, but is more feasible for new construction. However, this is likely an "all or nothing" plan, where the ocean ebb and flow and resulting shoreline migration would need to be enabled under all structures in the beach zone. If some structures are raised on pilings and others are not, the structures that are not raised are likely to be even more impacted and compromised by the lack of impediments to the ebb and flow of the ocean and migrating shoreline.

Building design and construction can be modified so that the second floor is above the target flood level and contains all flood-sensitive features, while the first (ground level) floor is used for parking and/or storage and is designed to be durable and resilient to flood damage. While this type of design is feasible for new construction, it may be unfeasible from a cost and engineering perspective as a retrofit to existing structures.

Raising roads can be accomplished by placing fill to rebuild roads at higher elevations. Utilities, that are vulnerable to flooding, erosion, or increased ground water levels with sea-level rise, such as sewer pipelines and storm drains, which are often buried along roads, can also be raised. Other options for raising roads and utilities may include replacing at-grade roads with pile-supported causeways. Table 9.1.4 summarizes the benefits and constraints of raising structures.

Table 9.1.4
Raising structures benefits and constraints summary

Benefits	Constraints
• Protects vulnerable structures.	• Beach erosion and flooding continues to migrate inland, requiring additional adaptation

9.1.5 Adaptation option: relocate public infrastructure

The City can consider relocation of public buildings, utilities and other infrastructure as the risk to public structures increases with sea-level rise. Proactively, the City could consider options for facilitating structure removal where there is a public benefit, such as removing structures to restore beach areas or parks. The roads and utilities in North Beach are located east of the oceanfront seawalls, so their more immediate vulnerability is flooding from the river.

9.2 Beach adaptation monitoring

Criteria to be monitored for beach adaptation include changes in risk or chance of extreme coastal flooding and storm damage, and approximate beach widths. Projected flood and damage risks and beach widths with sea-level rise and without adaptation are based on the Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016). With greater than 1 ft of sea-level rise, winter/spring beach widths are anticipated to be great enough to eliminate a walkable beach and its storm protection, and the risk of flooding and damage are anticipated to exceed an acceptable level. Therefore, thresholds for initiating consideration and planning of beach adaptations are any of the following:

- Flood and damage risk approaching a moderate level (5% annual chance of extreme flooding and damage)
- Average or successive winter beach widths approaching 25 ft
- Average or successive summer beach widths approaching 80 ft

Once adaptation measures are implemented to increase beach widths and/or reduce flood/damage risks, then the flood risk would be estimated for the adapted condition assuming future sea-level rise. Increasing flood/damage risks and decreasing beach widths would then continue to be monitored and compared against the beach width thresholds above. Table 9.2.1 shows projected beach widths with increasing chance of extreme flooding/damage.

Table 9.2.1
Projected beach width with increasing chance of extreme flooding/damage

Annual chance of extreme flooding/damage (1983 event)	1%	5%	15%	50%	100%
Summer/fall beach width	120 ft	80 ft	34 ft	0 ft	0 ft
Winter/spring beach width	65 ft	25 ft	0 ft	0 ft	0 ft

Other beach adaptation criteria may be considered or added through further refinement, application, and re-evaluation of the Adaptation Plan, which could include the following:

- Beach elevation at the toe of the sea walls and revetments to serve as an indication of the exposure of the structure to wave action.

- Risk of sea wall failure.

As the beach narrows with sea-level rise, the beach and dunes could be nourished to improve beach access, aesthetics and habitat function, as well as limit future damages in areas that are eroded during storm events. Even so, it must be noted that with enough sea-level rise (e.g., 3 ft, corresponding to 50% chance of extreme flooding), the shoreline adaptation measures that would be required to maintain existing structures would be insufficient. The ground floor elevation of beachfront and adjacent homes and buildings could instead be raised. Table 9.2.2 presents the Beach Adaptation monitoring criteria and adaptation measures and anticipated beach width ranges for which each measure would be effective. Table 9.2.3 provides lead times to begin advance planning before adaptation measures could be in place to limit risk.

Table 9.2.2
Beach erosion monitoring criteria to consider adaptation options

<table>
<tr><td rowspan="3">Criteria & Thresholds</td><td>Summer beach width</td><td>120 ft</td><td>80 ft</td><td>35 ft</td><td>0 ft</td></tr>
<tr><td>Winter beach width</td><td>65 ft</td><td>25 ft</td><td>0 ft</td><td>0 ft</td></tr>
<tr><td>Annual risk of extreme flooding (without adaptation)</td><td>5%</td><td>15%</td><td>50%</td><td>100%</td></tr>
<tr><td rowspan="5">Adaptation Options</td><td>Protect (soft measures)</td><td colspan="2">Beach and dune nourishment</td><td></td><td></td></tr>
<tr><td>Protect (hard measures)</td><td></td><td colspan="2">Raise and improve sea walls</td><td></td></tr>
<tr><td>Protect (hard measures)</td><td></td><td></td><td colspan="2">Sand retention strategies</td></tr>
<tr><td>Accommodate</td><td></td><td colspan="2">Elevate structures</td><td></td></tr>
<tr><td>Retreat</td><td></td><td colspan="2">Relocate public infrastructure</td><td></td></tr>
</table>

Table 9.2.3
Possible lead times for planning beach erosion adaptation options

Risk	Actions	Lead Times	Adaptation Options
Beach erosion	**Protect**	**5-10 years**	Beach and dune nourishment
	Protect	**10-15 years**	Raise and improve sea walls
	Protect	**15-20 years**	Sand retention strategies
	Accommodate	**5-10 years**	Elevate structures
	Retreat	**15-20 years**	Relocate public infrastructure

9.3 Beach adaptation coastal permitting

The Coastal Development Permit review and approval for beach adaptation measures may be processed by the City of Del Mar through the Local Coastal Program (LCP) and/or by the California Coastal Commission, pursuant to the California Coastal Act. Additional approvals may be required from the U.S. or California Fish and Wildlife Service, the U.S. Army Corps of Engineers, the California State Lands Commission, the U.S. Coast Guard, the California Department of Boating and Waterways, and California Regional Water Quality Control Boards.