Administrative Draft

CITY OF DEL MAR SEA-LEVEL RISE ADAPTATION PLAN

Del Mar, CA

Prepared for
The City of Del Mar

August 2016 – updated September 2016

Source: Robin Crabtree, March 8, 2016

Administrative Draft

CITY OF DEL MAR SEA-LEVEL RISE ADAPTATION PLAN

Del Mar, CA

Prepared for
The City of Del Mar

August 2016 – updated September 2016

550 W C Street
Suite 750
San Diego, CA 92103
619.719.4200
www.esassoc.com

Irvine

Los Angeles

Oakland

Orlando

Pasadena

Petaluma

Portland

Sacramento

San Diego

Santa Monica

Seattle

Tampa

Woodland Hills

D150347.00

Services provided pursuant to this Agreement are intended solely for the use and benefit of the City of Del Mar.

No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without the express written consent of ESA, 550 Kearny Street, Suite 800, San Francisco, CA 94108.

This information is intended to be used for planning purposes only. All model results are subject to uncertainty due to limitations in input data, incomplete knowledge about factors that control the behavior of the system being modeled, and simplifications of the system. Site-specific evaluations may be needed to confirm/verify information presented in these data. Inaccuracies may exist, and Environmental Science Associates (ESA) implies no warranties or guarantees regarding any aspect or use of this information. Further, any user of this report and associated data, findings, recommendations, etc. assumes all responsibility for the use thereof, and further agrees to hold ESA harmless from and against any damage, loss, or liability arising from any use of this information. Commercial use of this information by anyone other than ESA is prohibited.

OUR COMMITMENT TO SUSTAINABILITY | ESA helps a variety of public and private sector clients plan and prepare for climate change and emerging regulations that limit GHG emissions. ESA is a registered assessor with the California Climate Action Registry, a Climate Leader, and founding reporter for the Climate Registry. ESA is also a corporate member of the U.S. Green Building Council and the Business Council on Climate Change (BC3). Internally, ESA has adopted a Sustainability Vision and Policy Statement and a plan to reduce waste and energy within our operations. This document was produced using recycled paper.

TABLE OF CONTENTS
City of Del Mar Sea-Level Rise Adaptation Plan

Page

Figures

Tables

EXECUTIVE SUMMARY

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 Local Coastal Program (LCP) via a LCP Amendment. The Adaptation Plan draws on the City of Del Mar's Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016, http://www.delmar.ca.us/DocumentCenter/View/2455), guidance provided by the City's Sea-Level Rise Stakeholder Technical Advisory Committee (STAC), and the California Coastal Commission's (2015) *Sea Level Rise Policy Guidance* for addressing sea-level rise in LCPs.

The Adaptation Plan provides a framework for the City to manage risks and take actions based on specific triggers and monitoring of sea-level rise and its effects (Section 4). The Adaptation Plan provides flexibility for the City to choose from an array of adaptation measures over time as specified triggers are met. The Adaptation Plan therefore provides adaptation scenarios or paths towards managing risks, rather than proscribing a specific plan of action. Project-level planning and approvals will be required to further develop and implement the adaptation measures included in the Adaptation Plan. 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 the following components and adaptation measures to reduce risks associated with future sea-level rise.

High priority adaptation: 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

North Beach District coastal (ocean) flooding and beach erosion adaptation:

- Beach and dune nourishment 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 facilitate raising private buildings in the near-term and over time.
- Sand retention measures such as groins or artificial reef may help maintain the beach, but would likely require mitigation and affect surfing resources.
- Raising/improving the existing sea wall and revetments (i.e., "holding the line") would reduce flood risks with sea-level rise, but would likely result in beach loss over time and would require future removal of the sea walls and revetments for consistency with Coastal Act prohibitions against protection in perpetuity.
- Raising City infrastructure including buildings, utilities, and roads will likely be required to accommodate the increase in flood risk with sea-level rise.
- In the long-term with higher amounts and rates of sea-level rise, removing structures will likely be required to meet the guiding adaptation principles of maintaining a relatively low flood damage risk and a walkable beach.

Note that the STAC has not yet given their formal recommendations on the above North Beach flooding and erosion adaptation measures and scenarios and these are therefore subject to revision.

Bluff erosion adaptation:

- Beach nourishment and 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, thereby maintaining a beach below the bluff and providing access along the bluff top.
- Removal of bluff top buildings, sewer lines, and roads will eventually be required as the bluff continues to recede inland.

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.

- As an alternative to levees, structures can be raised in the mid-term and removed in the long-term; this would apply to large sections of the North Beach District and Del Mar Fairgrounds due to the extent of the River floodplain.
- If Lake Hodges reservoir management is not possible, the timeframe for other measures may be sooner.

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.

Other adaptation measures were considered and discussed with the STAC, but were not recommended by the STAC for inclusion in the AP:

- Construction of a sea wall or other armor to protect the southern bluffs was not recommended by the STAC because the sea wall/bluff would lead to the loss of the beach below the bluff, which would be in conflict with the guiding principles established for the Adaptation Plan.
- Constructing levees to reduce the River flood risk without partial retreat/wetland floodplain restoration was considered as an adaptation measure, but was not recommended by the STAC because this option was less desirable than construction levees with partial retreat/wetland restoration.

This Administrative Draft of the Del Mar Sea-Level Rise Adaptation will be revised in response to comments from the public and the California Coastal Commission. A formal amendment to the LCP including sea-level-rise related policies and regulations will then be drafted based on the Adaptation Plan and CHVR (ESA 2016). The LCP Amendment will then be reviewed before the City Planning Commission and City Council for approval prior to submitting the LCP Amendment to the California Coastal Commission for review and approval.

A Del Mar Sediment Management Plan and a San Dieguito Lagoon Wetland Habitat Migration Assessment will also be prepared to further analyze and detail beach nourishment, channel dredging, and wetland adaptation measures. These will serve as companion documents to the Adaptation Plan and LCP Amendment.

CHAPTER 1
Introduction

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 Local Coastal Program (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 draws on the City of Del Mar's Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016, http://www.delmar.ca.us/DocumentCenter/View/2455) and guidance provided by the City's Sea-Level Rise Stakeholder Technical Advisory Committee (STAC). The City established the STAC to provide oversight and ensure the 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.) This Adaptation Plan was developed over a series of public STAC meetings in which the STAC and public provided input and feedback. To date, the City has completed ten STAC meetings including a community forum on sea-level rise issues.

The Adaptation Plan is consistent with the California Coastal Act and relevant City and State policy, plans, and guidelines (Section 2). The guiding principles behind the Adaptation Plan (Section 3) are to minimize risks to Del Mar's assets, including property and infrastructure, and protect Del Mar's coastal resources, which, as defined by the California Coastal Act, 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, but also for ecosystem services such as storm damage protection.

The Adaptation Plan provides a framework for the City to manage risks and take actions based on specific triggers and monitoring of sea-level rise and its effects (Section 4). The Adaptation Plan provides flexibility for the City to choose from an array of adaptation measures over time as specified triggers are met. The Adaptation Plan therefore provides adaptation scenarios or paths towards managing risks, rather than proscribing a specific plan of action. Project-level planning and approvals will be required to further develop and implement the adaptation measures included in the Adaptation Plan. 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 following three general categories of adaptation:

- **Accommodation:** “Accommodation strategies refer to those strategies that employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of sea-level rise.” (CCC 2016)
- **Protection:** “Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself.” (CCC 2016)
- **Retreat:** “Retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas.“ (CCC 2016)

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 single-purpose solutions to protection, such as traditional shoreline armoring.

The Adaptation Plan identifies high priority adaptation measures for City assets for which near term actions are recommended to reduce high vulnerabilities and risks (Section 5), The Adaptation Plan also includes components that specifically address the following areas and vulnerabilities:

- North Beach flooding and erosion adaptation
- Bluff erosion adaptation
- San Dieguito River flooding adaptation
- San Dieguito Lagoon wetland adaptation

The Adaptation Plan also discusses other adaptation measures that were considered, but not recommended by the STAC for inclusion in the Adaptation Plan based on community priorities and potential impacts of the actions on coastal resources (Section 6).

1.1 Sea-Level Rise

The rate of sea-level rise is projected to accelerate in the future. Table 1 includes 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 rise scenarios. The mid-range sea-level rise scenario is based on reducing fossil fuel use, with a balance between fossil fuels and alternative energy sources; whereas the high-range sea-level rise scenario assumes 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
SEA LEVEL RISE (SLR) PROJECTIONS

	2030	2050	2070	2100
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 triggers based on amounts of sea-level rise of up to 5.5 ft and responses to sea-level rise, such as flood frequency and erosion.

1.2 Del Mar Vulnerability and Risk Summary

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, 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:

- 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.

Del Mar Adaptation Plan . D150347

SOURCE: ESA

Figure 1
Railway on Top of Bluff

CHAPTER 2
Relevant Plans and Guidelines

The Adaptation Plan is consistent with the California Coastal Act and relevant City and State policy, plans, and guidelines as described below.

2.1 Del Mar Community (General) Plan

The City of Del Mar Community (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.

Adaptation measures recommended in this Adaptation Plan are consistent with the following key Community Plan goal and objectives:

Environmental Management Goal 1: Establish, without delay, a comprehensive program to preserve and acquire permanent open space sufficient to meet the long-range needs of the community, preserve and enhance natural resources, and protect areas and people susceptible to seismic and flooding hazards.

- Conserve the natural character of land, water, vegetative, and wildlife resources within the community (Objective H).
- Retain and enhance natural benefits within the San Dieguito River Floodway and Lagoon Habitat (Objective I).
- Minimize the loss of life and destruction of property from seismic and geological occurrences (Objective O).
- Insures public safety within the San Dieguito River Floodplain (Objective P).

2.2 Del Mar Local Coastal Program (LCP)

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: the Land Use Plan (a compilation of goals, policies, and recommended programs) and Implementing Ordinances (regulations that implement the provisions of the Land Use Plan and the California Coastal Act) (City of Del Mar, 1993;

2001). The Implementing Ordinances have been codified into Del Mar's municipal code as individual chapters in Title 30 Zoning (City of Del Mar, 2016).

Del Mar's LCP establishes goals, policies, and regulations for the following five overlays: beach overlay, coastal bluff overlay, floodplain overlay, bluff, slope and canyon overlay, and lagoon overlay. Key policies and standards for each overlay are described below:

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.

<u>Development within the shoreline protection area, west of the SPA line:</u> Development is limited to only privately-owned protective structures, publicly-owned protective structures, and construction and maintenance of lifeguard facilities. Sand replenishment projects are not considered development and are allowed, provided no structure or material is placed on the beach other than sand and the proposed replenishment program is approved by the City.

New shoreline protective structures are limited pursuant to the following standards:

- To serve a coastal dependent use, to protect existing structures, or to protect public beaches in danger from erosion and only when designed to eliminate or mitigate adverse impacts to local sand supply
- Will assure stability and structural integrity
- Does not create or significantly contribute to erosion, geologic instability, or destruction of the site or surrounding area
- Does not substantially alter natural landforms along bluffs
- Has material and design which are consistent with good engineering practices

If the shoreline protective structure has a vertical wall element:

- The seaward face of the wall cannot be more than five feet westward of the SPA line
- The seaward face of the wall is located in the shoreline protection area only if there is no other feasible location for effectively protecting a principle structure
- There is no feasible, less environmentally damaging alternative
- Feasible mitigation measures have been provided

<u>Development within the shoreline protection area, east of the SPA line:</u>

Development within 15 feet east of the SPA line is limited in the following manner:

- o Reconstruction or remodeling of a structure when 50 percent or more of the lot's permitted floor area is involved is prohibited

- New construction is prohibited
- Development is limited to privately owned or publically owned protective structures and publically owned development

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. Key standards are outlined below.

- New or redeveloped structures (including accessory structures and supporting foundations) must be setback 40 feet from the top edge of the coastal bluff (*Note: a 40 foot setback from the top edge of the coastal bluff is equal to or less than the width of the developed railroad right-of-way in the southern part of the city; therefore, structures built landward of the railroad right-of-way are not required to be setback any farther*). Fences, windscreens, and benches must be setback 10 feet from the top edge of the coastal bluff provided they are constructed primarily above grade, use light-weight materials, and do not require grading and/or continuous foundation components.
- Grading is not allowed within 40 feet of the top edge of the coastal bluff.
- Grading or construction activities on the face of a coastal bluff is allowed only if the City Council or Planning Commission find that the proposed grading has been minimized to the extent feasible to implement the authorized shoreline protection and a Shoreline Protection Permit or Setback Seawall Permit has been approved.
- Projects within the Coastal Bluff Overlay Zone must submit a polluted runoff control plan and an erosion and sedimentation control plan which must include provisions for site drainage, temporary erosion control measures, and construction timing (e.g., avoid cut and fill during the rainy season for projects involving more than 25 cubic yards).
- Areas that must be retained in their natural state must be recorded in an open space deed restriction, conservation easement, or open space easement to ensure protection.
- Subdivisions are not allowed if the proposed lots would require the construction of a shoreline protective device or cannot meet the required coastal bluff setbacks and other coastal resource protection measures required in the zone. A deed restriction must be placed on the property that waives all rights to future protective devices for new development.

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. Key standards are outlined below.

- Fill (temporary or permanent) and permanent structures are prohibited in the San Dieguito River Floodway.
- Uses which would constitute an unreasonable, unnecessary, undesirable, or dangerous impediment to the flow of floodwaters, or would cause a cumulative increase in the water surface elevation of the base flood of more than one foot at any one point are prohibited in the San Dieguito River Floodway.
- Proposed development must be located so as to eliminate the need for protective devices.
- New construction or substantial improvements to existing structures within the floodplain overlay zone must meet certain design and construction standards, including anchoring the structure, using certain construction materials, placing the lowest floor (including basement) of any structure at or above base flood elevation (flood proofing is allowed instead for nonresidential structures that have floors below the base flood elevation), and not requiring the construction of flood protective works, including artificial flood channels, revetments, or levees.
- New construction or substantial improvements located in a Coastal High Hazard sub-zone must be located landward of the reach of mean high tide, not require fill for structural support of buildings, and be elevated on pilings or columns so that the lowest floor is elevated at or above the base flood elevation and the pile or column foundation is anchored.

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. Key standards are outlined below:

- Uses in wetlands are limited to aquaculture, scientific research, passive recreation, education uses, and wetland restoration projects.
- Uses in wetland buffer areas are limited to passive recreational access paths and viewpoints, improvements necessary to provide protection, preservation, or enhancement of adjacent wetland areas, and uses permitted in wetlands.
- Wetland buffers must be a minimum of 100 feet in width. A wetland buffer that is less than 100 feet is allowed provided certain provisions are met, but in no event can be less than 50 feet.
- An open space deed restriction, conservation easement, or open space easement must be recorded to protect wetlands and buffers.
- Development within the Lagoon Overlay Zone must comply with grading standards and drainage and erosion control standards.
- The maximum amount of native vegetation on a development site must be retained. Revegetation or landscaping must include non-invasive, drought tolerant species native to the San Diego coastal region and which are compatible with adjacent wetland habitat species.

- Subdivisions are not allowed if the proposed lots would not be capable of supporting the construction of an allowed use or cannot meet the required wetland setbacks and other coastal resource protection measures required in the zone.

2.3 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.

2.4 California Coastal Commission Sea Level Rise Policy Guidance

The California Coastal Commission issued guidance in August 2015 on how to apply the Coastal Act to the challenges presented by sea-level rise through Local Coastal Program certifications and updates and Coastal Development Permit decisions (California Coastal Commission, 2015). 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 Del Mar Adaptation Plan was prepared consistent with the guidelines in this document.

2.5 Safeguarding California Plan: Reducing Climate Risk

The Safeguarding California Plan provides policy guidance for state decision makers to address climate risks in nine sectors in California, describes progress to date, and identifies sector-specific recommendations. Risk management strategies to reduce climate risk are identified for the following nine sectors: agriculture, biodiversity and habitat, emergency management, energy, forestry, ocean and coastal ecosystems and resources, public health, transportation, and water. Applicable risk management strategies were incorporated into this Adaptation Plan.

CHAPTER 3
Guiding Principles

The following principles were established with input from the STAC to guide the Adaptation Plan. These principles provide the guidance for developing, evaluating, and selecting adaptation measures and plans.

1. **Limit the risk of extreme coastal and river flooding and damage to less than approximately a 5% chance of occurring in a given year (i.e., 5% annual-chance of occurrence).** Extreme flooding is defined as flooding that has a 1% annual-chance of occurrence today, such as the January 1983 El Nino ocean storm event that caused flooding and structural damage to North Beach District properties (Figure 2) and the Federal Emergency Management Agency's (FEMA) estimate of the 1%-chance San Dieguito River flood event. (Note that the FEMA 1%-chance River flood event is more extreme than the February 1980 River flood event that caused flooding and damage to the North Beach and Valley Districts and Del Mar Fairgrounds. On average, a 1%-annual-chance-of-occurrence event will occur once in 100 years, whereas a 5%-chance event will occur five times in 100 years or once in 20 years. While these events could occur in any given year, one of the Adaptation Plan's guiding principles is to manage flood risk so that a 1%-chance event does not become a 5%-chance event with sea-level rise or, in other words, that extreme flooding that could occur about once every 100 years on average does not become a risk that could occur once every 20 years.
2. **Maintain a walkable beach for as long as possible for recreational use, economic benefit, and to reduce flooding.** 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 (Figure 3). The intent of this guiding principle is to maintain these values and the character of Del Mar's beach for as long as possible with sea-level rise. 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.
3. **Maintain continuous horizontal coastal access and vertical water access points to North and South Beach.** As an extension of the guiding principle 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.

4. **Maintain San Dieguito Lagoon wetland habitat functions.** 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.

Del Mar Adaptation Plan . D150347

SOURCE: Fletcher 1983

Figure 2
Coastal Damage Following 1983 Storm

Del Mar Adaptation Plan . D150347

Figure 3
Wave Runup in Del Mar, February 12, 2016

CHAPTER 4
Adaptation Plan Overview and Process

The Adaptation Plan provides a framework for the City to manage risks (Section 4.1) and take actions based on specific triggers (Section 4.2) and monitoring of sea-level rise and its effects (Section 4.3). The Adaptation Plan provides flexibility for the City to choose from an array of adaptation measures over time as specified triggers are met. The Adaptation Plan therefore provides potential adaptation scenarios or paths towards managing risks, rather than proscribing a specific plan of action. The City will choose an adaptation pathway within the framework of the Adaptation Plan 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 4.4). 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 (Section 4.4).

The Adaptation Plan includes a range of sea-level rise adaptation measures within the three general categories of adaptation defined as follows by the California Coastal Commission (2016). Figure 4 summarizes these adaptation categories.

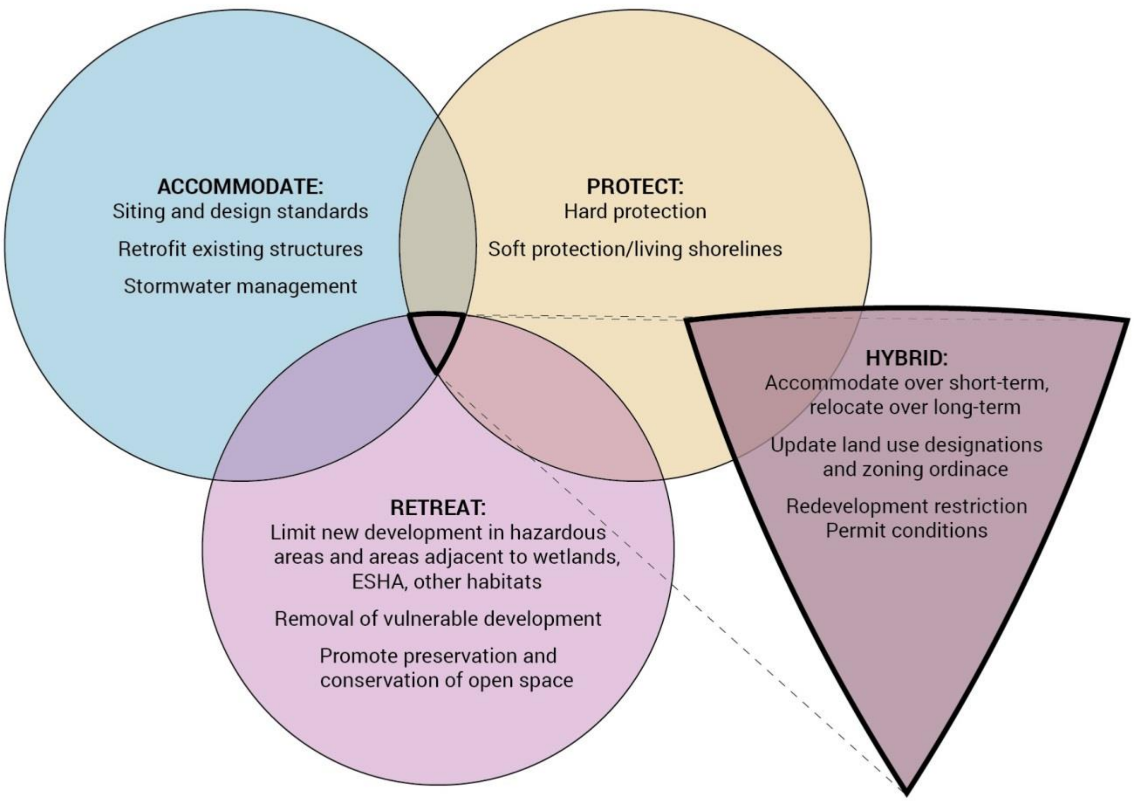
- **Accommodation:** “Accommodation strategies refer to those strategies that employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of sea-level rise. (CCC 2016)
- **Protection:** “Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be further divided into “hard” and “soft” defensive measures or armoring. “Hard” armoring refers to engineered structures such as seawalls, revetments, and bulkheads that defend against coastal hazards like wave impacts, erosion, and flooding. … “Soft” armoring refers to the use of natural or “green” infrastructure like beaches, dune systems, wetlands, and other systems to buffer coastal areas. Strategies like beach nourishment, dune management, or the construction of “living shorelines” capitalize on the natural ability of these systems to protect coastlines from coastal hazards while also providing benefits

such as habitat, recreation area, more pleasing visual impacts, and the continuation or enhancement of ecosystem services." (CCC 2016)

- **Retreat:** "Retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include land use designations and zoning ordinances that encourage building in more resilient areas or gradually removing and relocating existing development. " (CCC 2016)

Figure 4 shows conceptual examples of accommodation, protection, and retreat.

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 single-purpose solutions to protection such as traditional shoreline armoring.



SOURCE: Adapted from the CCC (2016) Sea Level Rise Policy Guidance

Del Mar Adaptation Plan . D150347

Figure 4
Examples of Protection, Accommodation, and Retreat Adaptation Strategies

4.1 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 2 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:

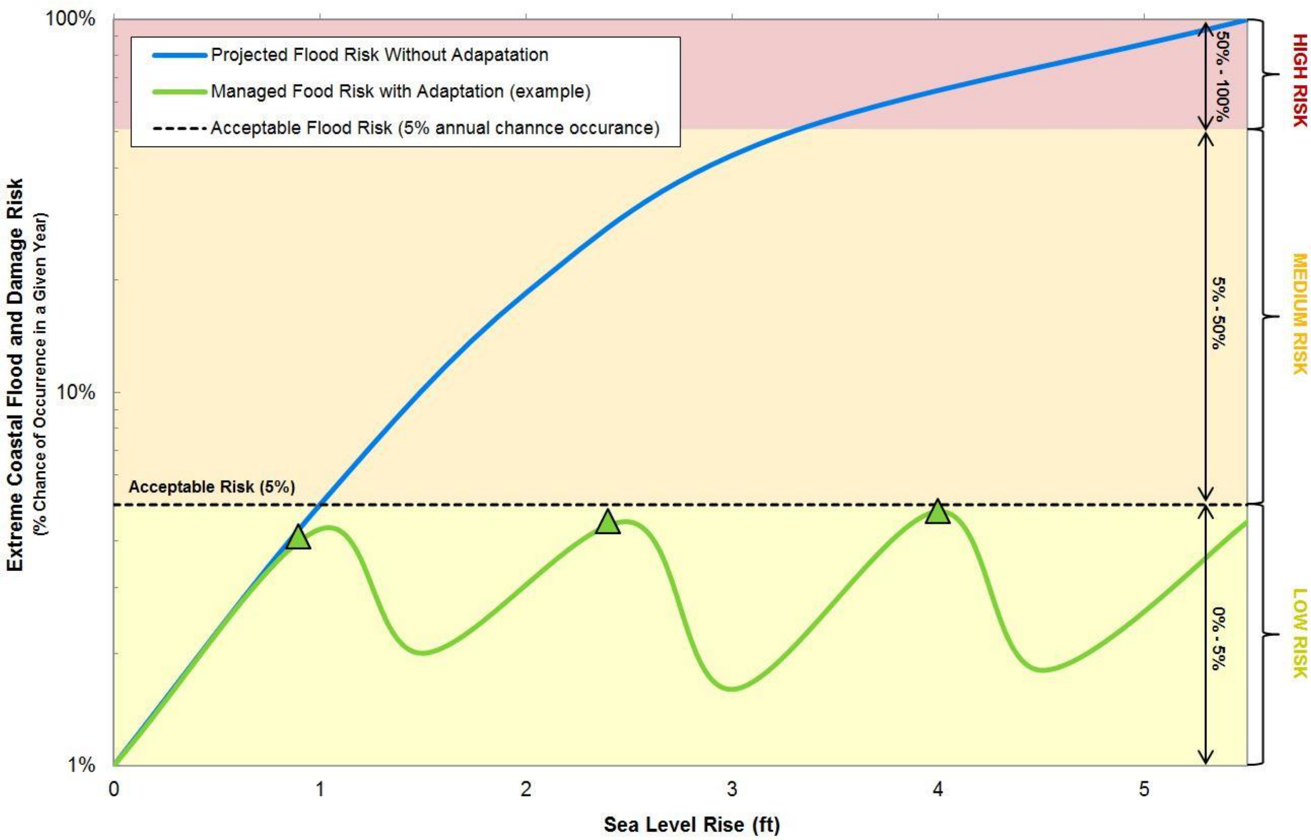
- Low: 0% - 5% chance of occurrence in a given year
- Moderate: 5% - 30% chance
- High: 30% - 100% chance

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 2
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%		
	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%
	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 5)



Del Mar Adaptation Plan . D150347

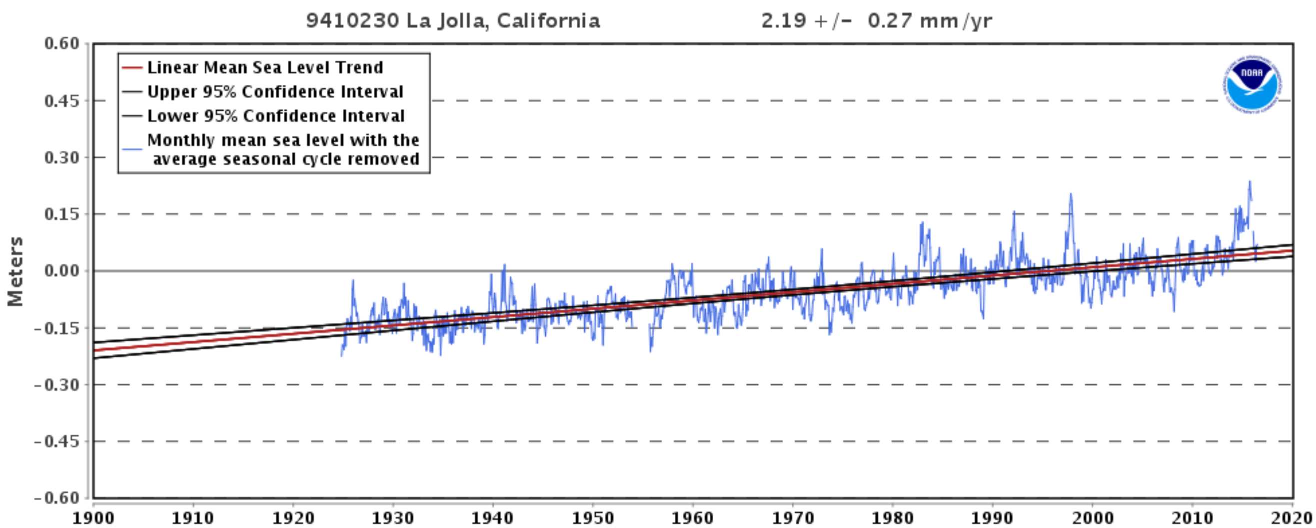
Figure 5
Concept of Adaptation to Manage Del Mar's Risks with Increasing Sea Level Rise

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 2). 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.

4.2 Triggers and Monitoring

The Adaptation Plan includes measureable triggers which, if and when they occur, call for the implementation of adaptation measures to limit risks. The Adaptation Plan sets conceptual planning-level adaptation triggers 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 triggers to track whether and when these triggers are met. The Adaptation Plan triggers and monitoring are summarized below. Section 5 includes additional discussion of triggers for beach, bluff, river, and wetland adaptation plan components.

- **Amount of sea-level rise** (e.g., 1 ft, 2 ft, and 3 ft of sea-level rise). Certain adaptation measures will be triggered when sea-level rise has risen by a certain amount. To monitor sea-level rise and progress towards the sea-level rise amount triggers, 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, which is updated annually (Figure 6). 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.



SOURCE: NOAA

Del Mar Adaptation Plan . D150347

Figure 6
Sea Level Rise Trend at La Jolla Tide Gage

- **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 trigger 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 re-calculated to quantify the increase in flood risk for comparison against risk-based triggers.

- **Beach width**. Given that a guiding principle is to maintain a walkable beach, beach width is used as a trigger for considering when beach adaptation measures would be implemented. Specific beach width triggers are discussed in Section 5 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 ft (depending on the location on the beach) 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 Southern California Edison's and SANDAG's beach surveys and assess the results against beach width triggers. A supplemental beach monitoring program including Del Mar's South Beach is also 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 trigger for bluff adaptation measures. When the bluff top reaches the trigger 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 of the bluff (see Section 5.3.1.3), the City will consider a supplemental bluff top erosion monitoring program to track erosion towards the sewer line and property along the bluff against the offset trigger.
- **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 trigger 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 triggers are reached and will consider supplemental channel monitoring if/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 trigger 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 triggers and the process for implementing adaptation measures when triggers 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 brief sea-level rise Adaptation Plan Monitoring and Triggers Assessment Report on a regular cycle (e.g., every two to five years) and/or when significant changes or progress towards a trigger are observed. The City will evaluate if and when triggers are reached and identify and plan next steps towards implementing triggered adaptation measures. The City may conduct this process in consultation with technical experts and with opportunities for 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.

4.3 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. The Adaptation Plan approximates lead times to allow for the City to begin advance planning in anticipation of when adaptation measures would be required to be in place to limit risk.

4.4 Re-Evaluation

The Adaptation Plan is intended to establish a process in which new data and information are assessed to inform adaptation decisions and actions. As such, it is anticipated that the Adaptation Plan may be re-evaluated and updated based on new science, technology, and practices. For example, the Adaptation Plan may be re-evaluated and updated every 10 to 15 years or when new major developments in the field of sea-level rise adaptation occur.

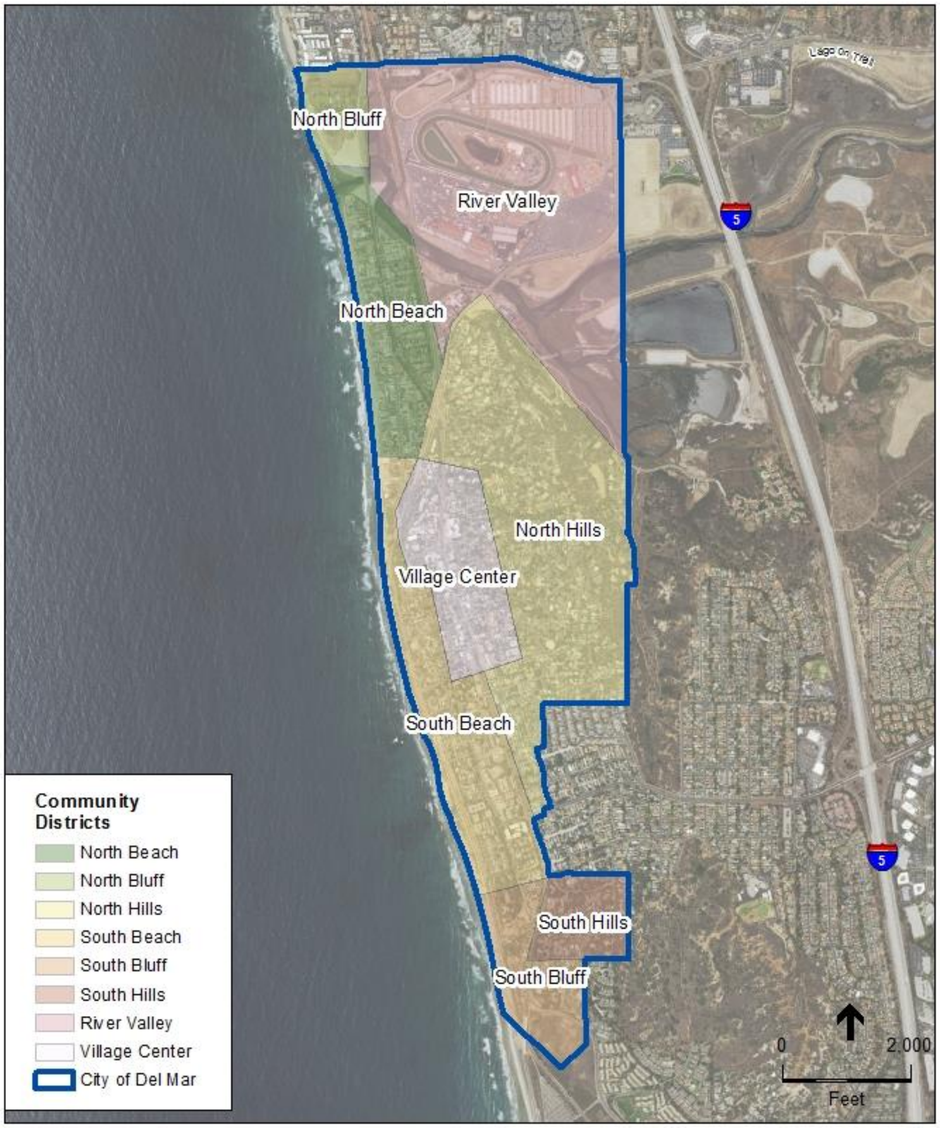
Section 9 discusses the next steps in the Sea-Level Rise Adaptation Plan and LCP Amendment process, which include the development of LCP policies and regulations and additional studies that will provide further detail on adaptation measures and their implementation.

CHAPTER 5
Adaptation Plan Components

The Adaptation Plan identifies high priority near-term adaptation measures (Section 5.1) and includes the following components to address specific areas, vulnerabilities, and risks. Figure 7 shows the City District areas. The components of the Adaptation Plan are:

- North Beach Flooding and Erosion Adaptation Plan (Beach Adaptation Plan, Section 5.2)
- Bluff Erosion Adaptation Plan for the South Bluffs, bluffs along South Beach, and North Bluffs (Bluff Adaptation Plan, Section 5.3)
- San Dieguito River Flooding Adaptation Plan for North Beach and the River Valley Districts including the Del Mar Fairgrounds (River Adaptation Plan, Section 5.4)
- San Dieguito Lagoon Wetland Adaptation for the River Valley District (Wetland Adaptation Plan, Section 5.5)

Each component of the Adaptation Plan includes a framework that identifies a range of adaptation measures, the benefits and constraints/limitations of each adaptation measure, and potential impacts. Note that as discussed in Section 4.3, Project-Level Planning, additional studies would need to be performed to fully evaluate the design, environmental impacts, and costs of a given adaptation measures.



SOURCE: SanGIS 2016, USGS 2015

Del Mar Adaptation Plan . D150347
Figure 7
City Districts in Del Mar

5.1 High Priority Measures

High priority sea-level rise adaptation measures for the City to begin planning for now include relocating 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 8). 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).

Del Mar Adaptation Plan . D150347
Figure 8
High Priority Infrastructure

City of Del Mar Fire Station Relocation. 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. Moderate exposure of the Fire Station to flooding will make emergency services highly vulnerable with 1 ft of deposition because the Fire Station will be impacted when flooding is occurring and emergency response is needed, as occurred in the 1980 flood.

City of Del Mar Public Works Yard. The City 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. Relocating 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.

Sewer lift station. The sanitary sewer lift station along San Dieguito Drive is subject to extreme flooding (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 above 100-year flood level). Other flood-proofing options include enclosing and water-proofing the pump motor and other vulnerable parts of the lift station.

5.2 North Beach Flooding and Erosion Adaptation

The Beach Adaptation Plan includes a range of adaptation measures and scenarios. These measures were discussed with the STAC; however, the STAC has not yet given their formal recommendations on which scenarios are preferred and which are not recommended for the City. It is anticipated that as part of the STAC's review of the Draft Adaptation Plan, the STAC may decide to not recommend certain measures and scenarios, which may then be removed from the Adaptation Plan.

The Beach Adaptation Plan covers the City Districts and vulnerabilities:

District: North Beach

Vulnerabilities: 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. For properties west of Camino Del Mar, including the City's 17th St Beach Safety Center, 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. Ocean Front and Camino Del Mar/Coast Blvd. roads and properties west of Camino Del Mar will also be highly vulnerable to coastal flooding. Note that the blocks between Ocean Front and Camino Del Mar/Coast Blvd. and these roads will be increasingly vulnerable to both coastal and river flooding.

The following sections describe adaptation measures (Section 5.2.1), triggers (Section 5.2.2), and the Beach Adaptation Plan framework and scenarios (5.2.3).

5.2.1 Beach Adaptation Measures

The Beach Adaptation Plan includes the following adaptation measures described in the sections below:

- Beach and dune nourishment
- Raise/improve sea walls and revetments
- Sand retention measures
- Raise structures
- Remove structures

5.2.1.1 Beach and Dune 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 9). Sand can be obtained from inland sources (e.g., sand trapped in dam reservoirs, construction projects) and can be dredged from offshore.

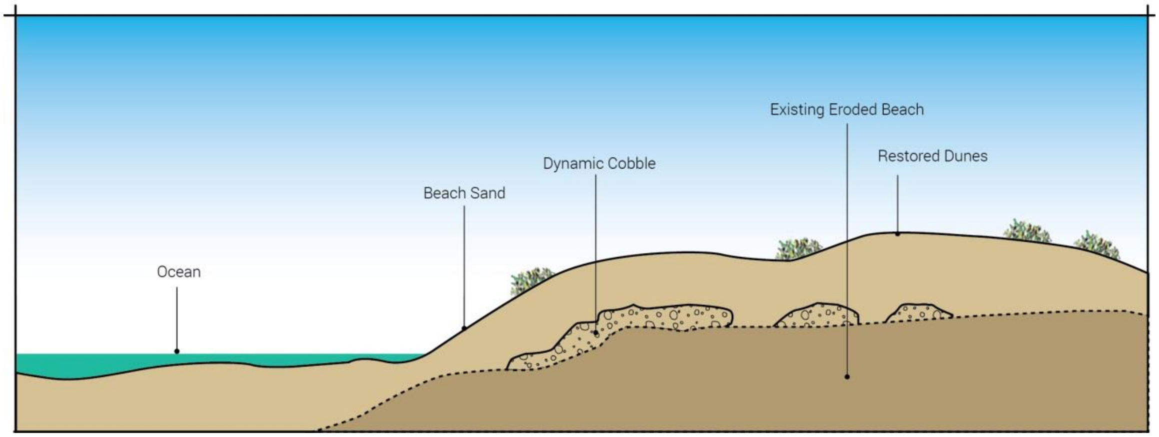
SOURCE: SANDAG

Del Mar Adaptation Plan . D150347

Figure 9
Beach Sediment Placement at Carlsbad

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 deposit[1] below beaches in California (Figure 10). Burying a layer of cobble provides a "backstop" that is more erosion resistant and dissipates waves to a greater degree.

[1] Lag deposit refers to coarser sediments that accumulate over time at lower elevations during periods of eroded beaches, which are subsequently covered by sand after the beaches recover.



Del Mar Adaptation Plan . D150347

Figure 10
Beach Nourishment, Dune Restoration, and Cobble Placement Illustration

Table 3 summarizes benefits and constraints of 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. Unless the beach is allowed to retreat landward as sea-level rises, the frequency of required nourishment increases, because, in addition to widening the beach to offset erosion, additional sand is needed to raise the elevation of the beach up to the increased sea level. Potential problems with beach nourishment include loss of beach use during construction and impact to beach ecology (Peterson & Bishop 2005; Schlacher et al 2012), 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).

TABLE 3
BEACH AND DUNE NOURISHMENT BENEFITS AND CONSTRAINTS SUMMARY

Benefits	Constraints
• Preserves beach • "Living shoreline" provides beach and dune habitat • Reduces flood and erosion risks	• Limited sand sources • Less effective over time with increasing sea-level rise • Transportation of sediment to receiver sites • Short-term 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 also adversely affect habitat and recreation such as surfing. 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.

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.

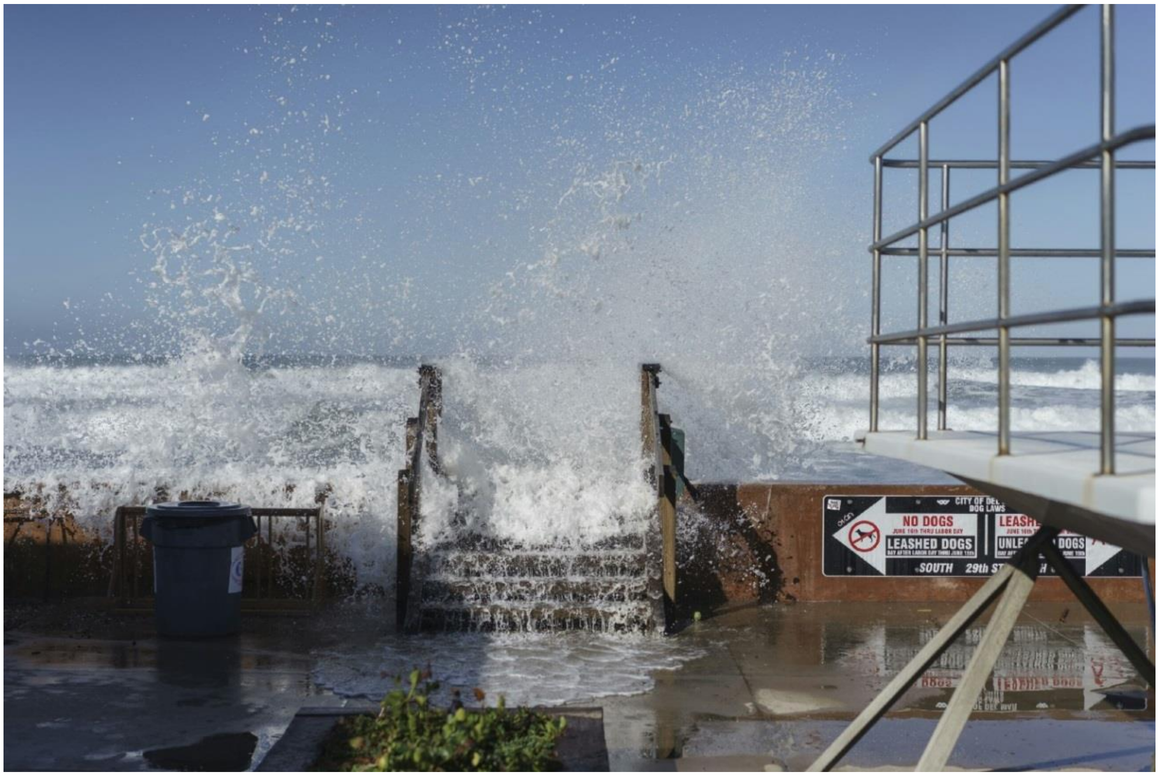
Monitoring plays an important role in identifying the need for re-nourishments. Monitoring is typically focused on the annual maximum and minimum beach width and minimum dune width. The minimum dune width should provide an acceptable buffer for storm erosion (e.g., 2- to 5-year storm). At any time, beach 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 (see Section 5.4.1.1). 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/).

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.

5.2.1.2 Raise/Improve Sea Walls and Revetments

The existing sea walls and rock (i.e., rip rap) revetments 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 sea walls and revetments as in March 2016 (Figure 11) and cause damage as in the 1983 El Nino storm event (Figure 2). Raising and 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.



SOURCE: Dwight Worden 2016

Del Mar Adaptation Plan . D150347

Figure 11
Overtopping in Del Mar, March 8, 2016

Table 4 summarizes benefits and constraints of raising/improving sea walls and revetments.

TABLE 4
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 • “Holds the line” and buys time to implement other adaptation measures	• Potential for loss of beach with sea-level rise and without other measures • Potentially accelerates beach erosion with sea-level rise • May require more frequent maintenance or reconstruction with sea-level rise • Level of protection provided decreases with loss of beach

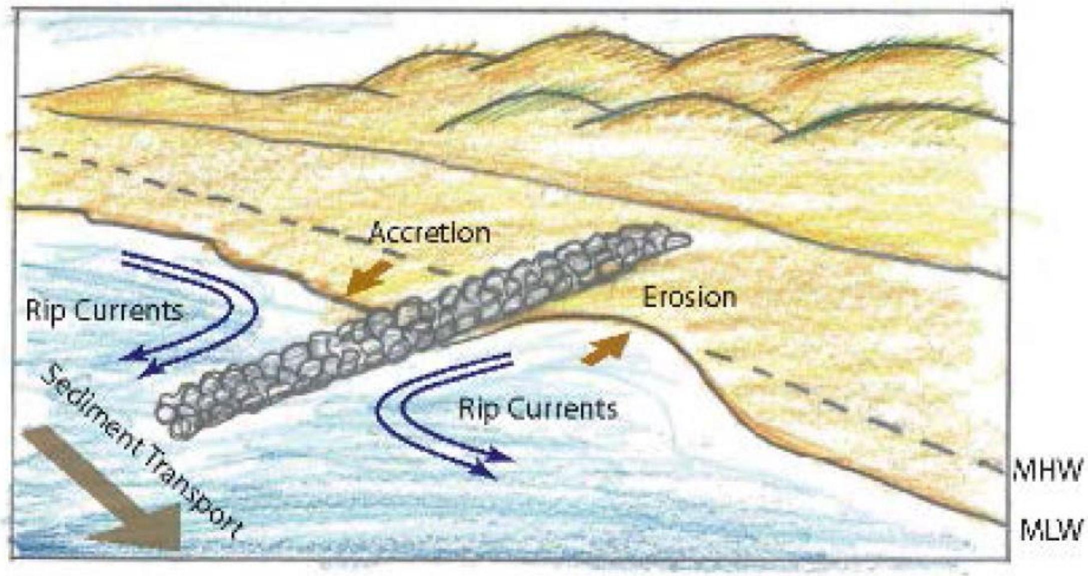
While sea walls and revetments provide protection to the existing property slopes, these structures can contribute to erosion and accelerate beach loss when the beach width narrows and wave run-up frequently reaches the structure. As the beach lowers and sea-level rises, wave run-up and overtopping of the structure will also increase as the waves begin to break near or on the structure, which 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 with a sea wall or revetment will eventually lead to the loss of the beach seaward of the structure. Using raised sea walls and revetments to "hold the line" on Del Mar's eroding shoreline with sea-level rise may not be sustainable due to increasing wave action and overtopping associated with loss of the fronting beach.

Sea wall and revetment construction is regulated by the CA Coastal Act and Del Mar LCP. The Coastal Act and LCP 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.

5.2.1.3 Sand Retention Measures

Sand retention measures include structures that prevent sand transport away from the beach (and encourage sand deposition on the beach). Types of structures include groins, breakwaters, and artificial reefs.

Groins extend perpendicular to the beach and trap sand from drifting downcoast (Figure 12). Where wave conditions are ideal, groins have been successfully used in California and other locations to maintain a wider beach. However, public access across or over the groins has the potential to negatively affect horizontal access along the beach. Constructing rock groins and other rock structures on the beach and/or in the ocean typically requires habitat mitigation (e.g., restoration of comparable habitat in another location) and could alter the character of Del Mar's natural shoreline.

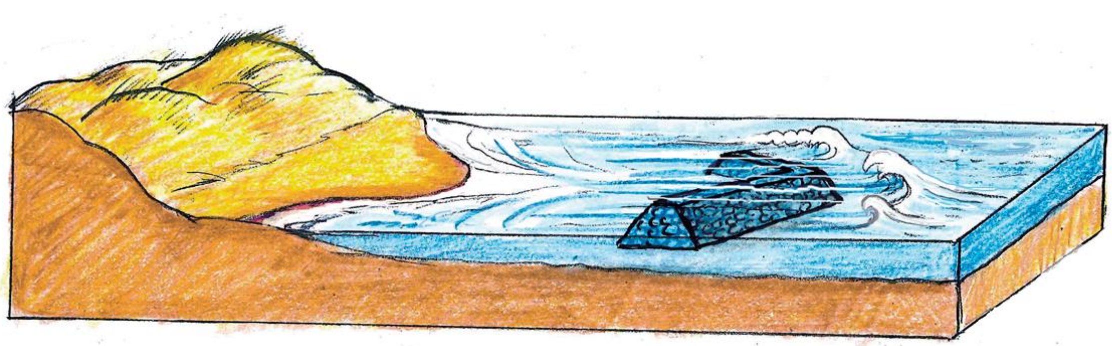


SOURCE: ESA PWA 2012

Del Mar Adaptation Plan . D150347

Figure 12
Examples of Groins

Breakwaters are offshore structures constructed parallel to the beach to reduce wave action (Figure 13). Breakwaters are built to extend from the ocean floor to above the ocean level, thereby acting as a wall that blocks waves at the shoreline by causing the waves to break at the breakwater. Breakwaters have been used to shelter shorelines and harbors (e.g., the Long Beach Breakwater, Figure 14), have been built in shorter segments to encourage sand accumulation behind the breakwater segments (e.g., Venice breakwater, Figure 15), and in some instances can provide access and recreation. However, breakwaters completely change wave patterns and destroy surfing resources, which may be an unacceptable impact for Del Mar. Due to permitting and mitigation requirements, few if any new breakwaters are being considered in California and the trend is to explore the removal of breakwaters (e.g., City of Long Beach's East San Pedro Bay Ecosystem Restoration Feasibility Study to remove the Long Beach Breakwater). Due to the degree of potential impacts, breakwaters are not recommended as an adaptation measure.

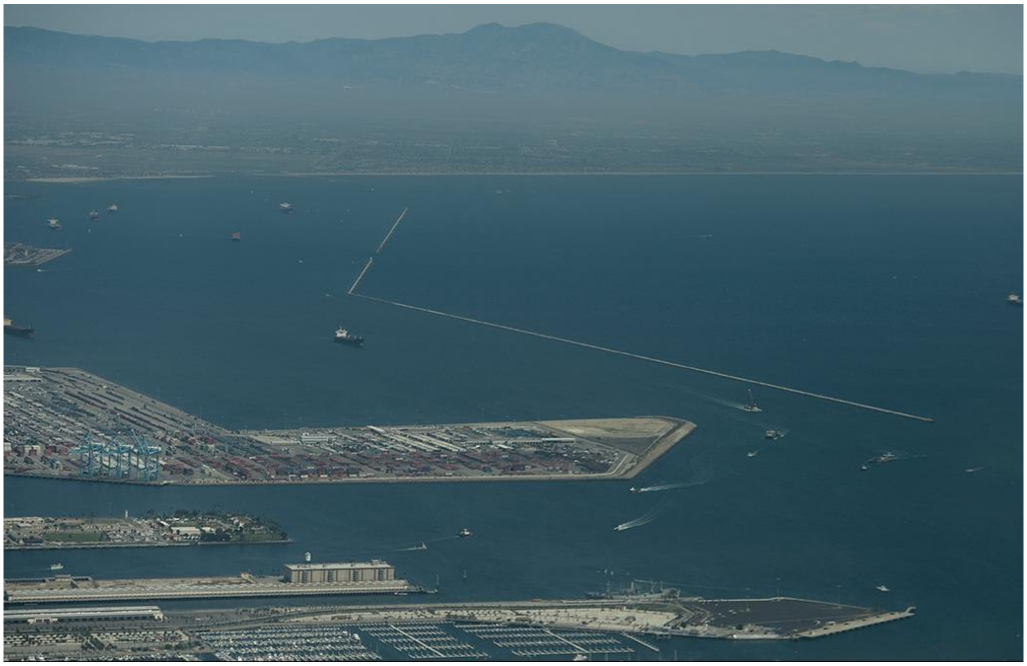


SOURCE: ESA PWA 2012

Del Mar Adaptation Plan . D150347

Figure 13
Schematic of Generic Offshore Breakwater with a Low Crest

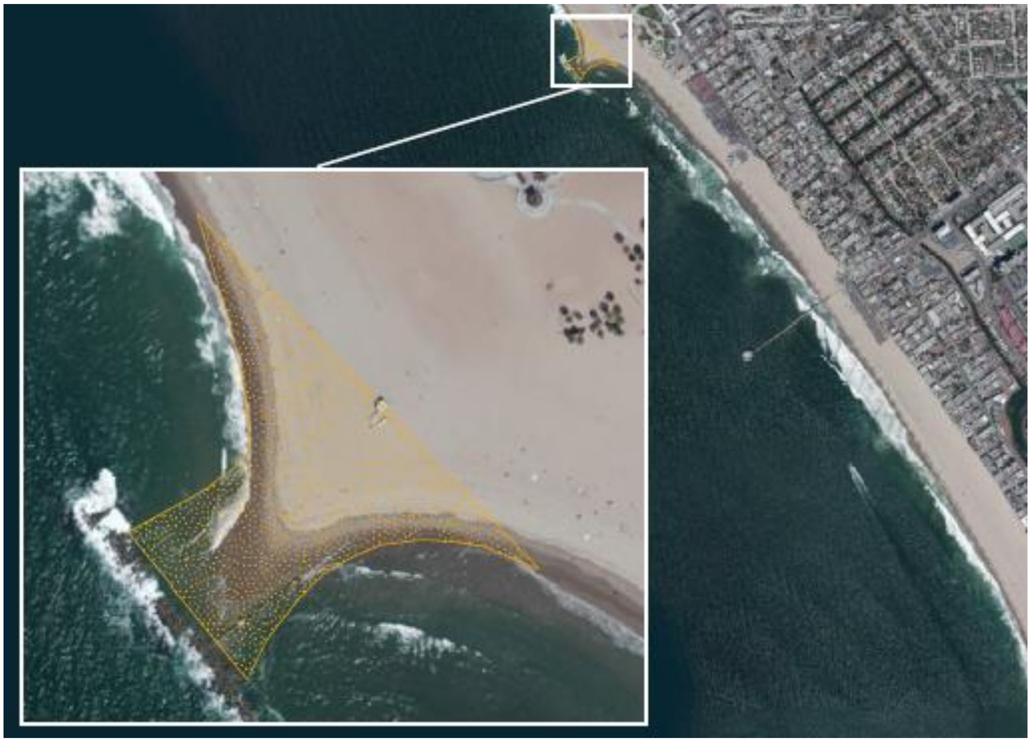
Preliminary – Subject to Revision



SOURCE: J. Gritchen 2014

Del Mar Adaptation Plan . D150347

Figure 14
Long Beach Breakwater Example



Del Mar Adaptation Plan . D150347

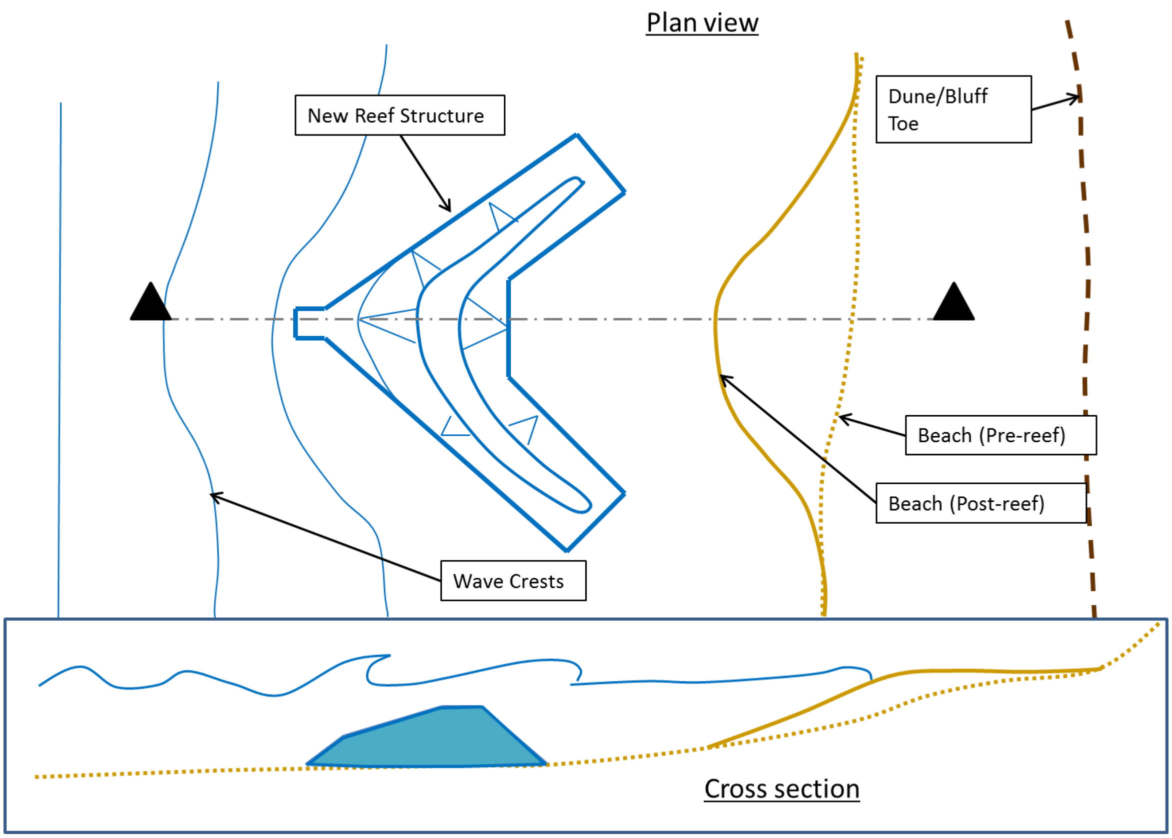
Figure 15
Venice Breakwater with Sand Accumulation behind It

Artificial reefs are underwater offshore reef structures constructed of rock or other materials (Figure 16). The multi-purpose artificial reefs are intended to encourage sand retention behind the reef, provide rocky reef habitat, and can provide or enhance surfing resources. 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, but there is not enough experience with successful reef installation to ensure that reef implementation will provide the intended benefits.

Table 5 summarizes the benefits and constraints of sand retention measures.

TABLE 5
SAND RETENTION MEASURES BENEFITS AND CONSTRAINTS SUMMARY

Type of Sand Retention Structure	Benefits	Constraints
All	Retain sand	Require mitigation
Groins	Maintains a wider beach	Effects horizontal access along the beach
Breakwater	Maximizes wave reduction and sand retention	Destroys surfing resources
Artificial reefs	Create rocky reef habitat Potential to enhance surfing resources	Experimental / limited experience



SOURCE: ESA 2015

Del Mar Adaptation Plan . D150347

Figure 16
Schematic of Multi-Purpose Reef Intended to Create a Surfing Break

5.2.1.4 Raise Structures

The elevation of homes, buildings, and infrastructure, such as roads, can be raised to above flood levels with sea-level rise (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 buildings on pile foundations so that the beach can move landward with sea-level rise without necessarily requiring armoring (e.g., a sea wall or revetment) (Figure 17). Raising structures allows for some limited migration and persistence of a fronting beach in the near term. If additional measures such as beach and dune nourishment are not taken, the shoreline will continue to migrate past homes and potentially damage roads, infrastructure, and even the homes if the pilings are undermined. There may also be challenges with height restrictions and other codes. However, compared to maintaining sea walls or revetments, this option allows for the flexibility to retain structures while maintaining the beach.

Building design/construction can also be modified so that the second floor is above the target flood level and contains all flood-sensitive features, while the first floor is used for parking and/or storage and is designed to be durable and resilient to flood damage.

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 6 summarizes the benefits and constraints of raising structures.

TABLE 6
SUMMARY OF BENEFITS AND CONSTRAINTS OF RAISING STRUCTURES

Benefits	Constraints
• Maintains beach and allows for limited landward migration of the beach	• Beach erosion and flooding continues to migrate inland, requiring additional adaptation

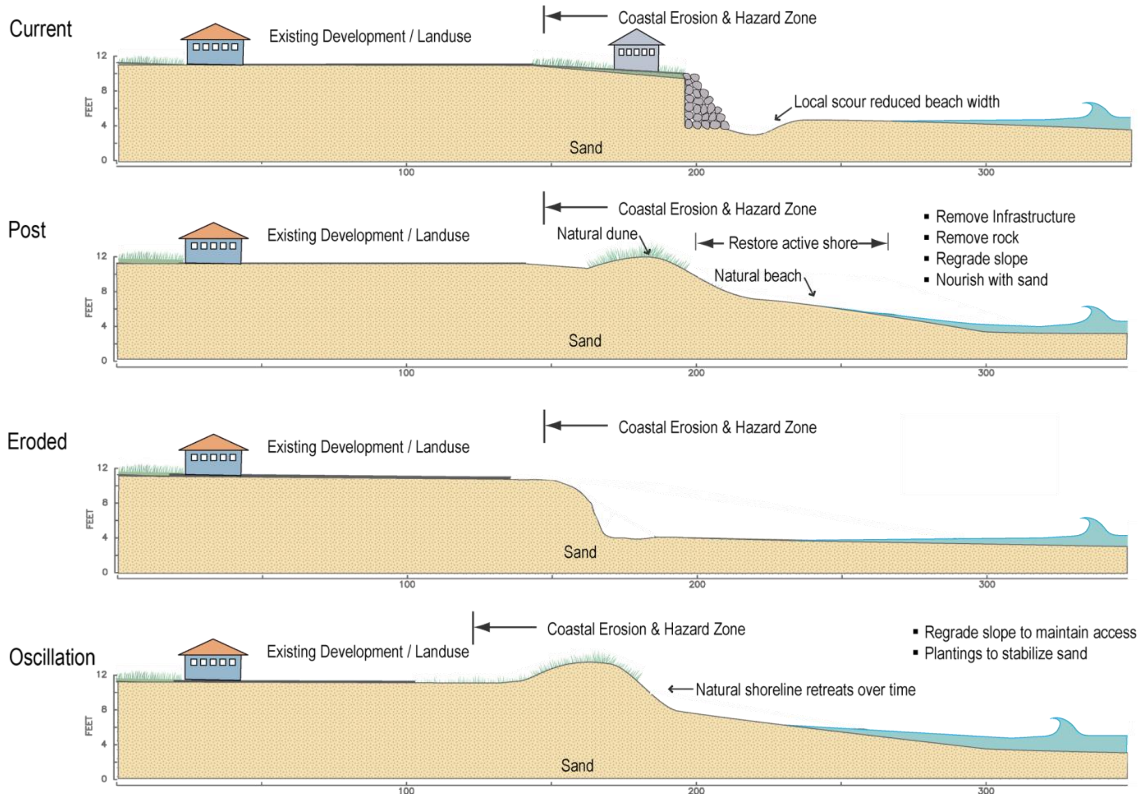
Del Mar Adaptation Plan . D150347

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

Figure 17
Examples of Buildings on Pile Foundations in Stinson Beach, CA

5.2.1.5 Remove Structures

Removing structures such as homes, buildings, roads, and utilities is a retreat measure that allows the shoreline to move inland, thereby maintaining the beach with sea-level rise. Figure 18 illustrates how buildings and associated armoring (revetments or sea wall) can be removed from the coastal erosion and hazard zone. An active beach and dune shoreline can be restored with space for seasonal oscillation between beach erosion and accretion and progressive shoreline retreat over time with sea-level rise.



Del Mar Adaptation Plan . D150347

SOURCE: ESA

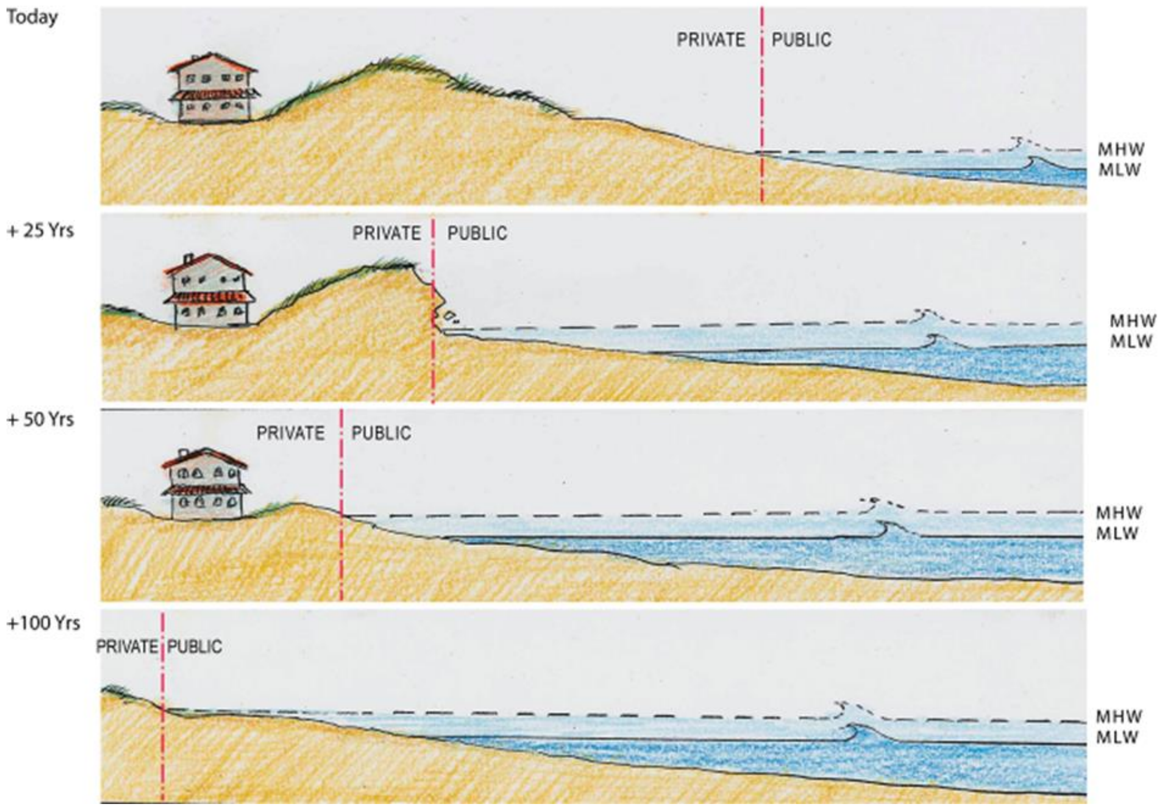
Figure 18

Illustration of Structure Removal Retreat Adaptation Measure

The City can consider removal of public buildings, utilities, and other infrastructure and relocation opportunities as the risk to public structures increases with sea-level rise. For private property and structures, 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 that are resilient to flooding. Examples or model local-government-lead programs for coordinated removal of private property do not currently exist for the City to follow or implement. State-wide policy and legal guidance and funding mechanisms are likely needed to support the development of a private property removal program in the City. The City can follow the development of removal or managed retreat programs and pursue studies of how such programs could be implemented in the City of Del Mar. The following options for removal or retreat are identified as possible mechanisms in the California Coastal Commission (2016) Sea-Level Rise Policy Guidance:

- Rolling easements
- Relocation incentive programs
- Transfer of development rights programs
- Programs for acquisition, buyout, or equity transfer between private and public ownership in situations where doing so provides a commensurate public benefit.

Rolling easements are open space or conservation easements that move or ambulate with some identified reference feature, such as the mean high water mark, as illustrated in Figure 19.



SOURCE: ESA

Del Mar Adaptation Plan . D150347

Figure 19
Rolling Easement and Structure Removal Illustration

Table 7 summarizes the benefits and constraints of removing structures.

TABLE 7
STRUCTURE REMOVAL BENEFITS AND CONSTRAINTS

Benefits	Constraints
• Removes at risk development • Allows for beach preservation and restoration	• Higher cost due to property values • Private property rights considerations

5.2.2 Beach Adaptation Triggers

Triggers for beach adaptation include the amount of sea-level rise, associated risk or chance of extreme coastal flooding and storm damage, and approximate beach widths (Table 8). 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 not anticipated to be great enough to provide a walkable beach or storm protection and the risk of flooding and damage will exceed an acceptable level. Therefore, the triggers for beach adaptation are:

1. Initially, sea-level rise approaching 1 ft
2. Flood and damage risk approaching a moderate level (5% annual-chance of extreme flooding and damage)
3. Average or successive winter beach widths approaching 25 ft and/or
4. 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 with future sea-level rise. Sea-level rise, the associated increase in flood/damage risks, and beach widths would then continue to be monitored and compared against the above triggers 2 - 3 above.

TABLE 8
BEACH ADAPTATION TRIGGERS

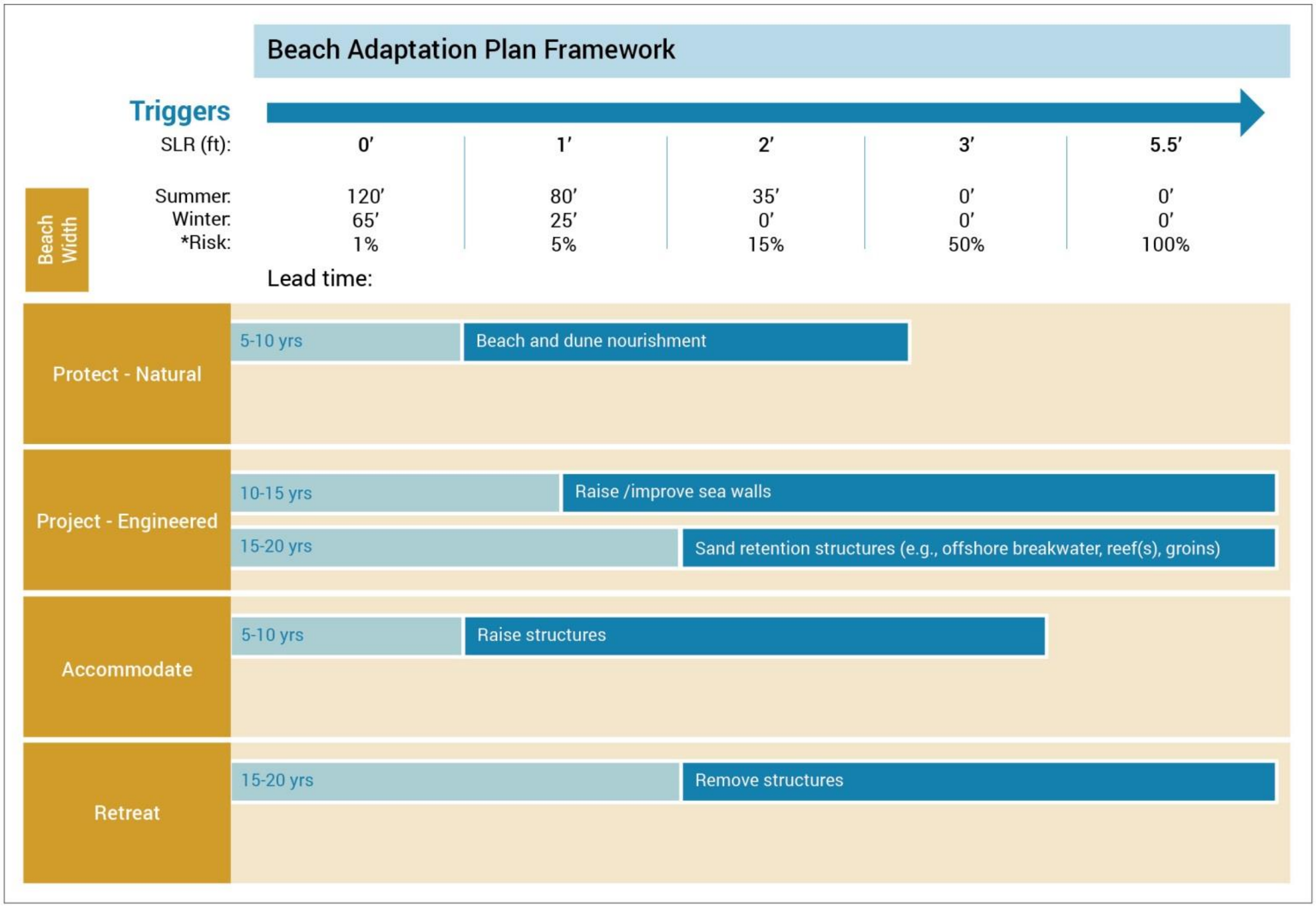
Sea-Level Rise (ft)	0'	1'	2'	3'	5.5'
Annual chance of extreme flooding/damage (1983 event)	1%	5%	15%	50%	100%
Winter/spring beach width	65 ft	25 ft	0 ft	0 ft	0 ft
Summer/Fall beach width	120 ft	80 ft	34 ft	0 ft	0 ft

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

- 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.

5.2.3 Beach Adaptation Framework and Scenarios

Figure 20 presents the Beach Adaptation Plan framework including triggers and adaptation measures with lead times and the range over which the measures are anticipated to be effective (see Section 4 for an overview of the Adaptation Plan process). As discussed previously, the STAC has not yet provide formal input to identify preferred beach adaptation measures and scenarios. The Beach Adaptation Plan will be revised based on STAC review of the draft plan.



** Annual chance of extreme flooding and damage (1983 event) without adaptation.*

Del Mar Adaptation Plan . D150347

Figure 20

Beach Adaptation Plan Framework

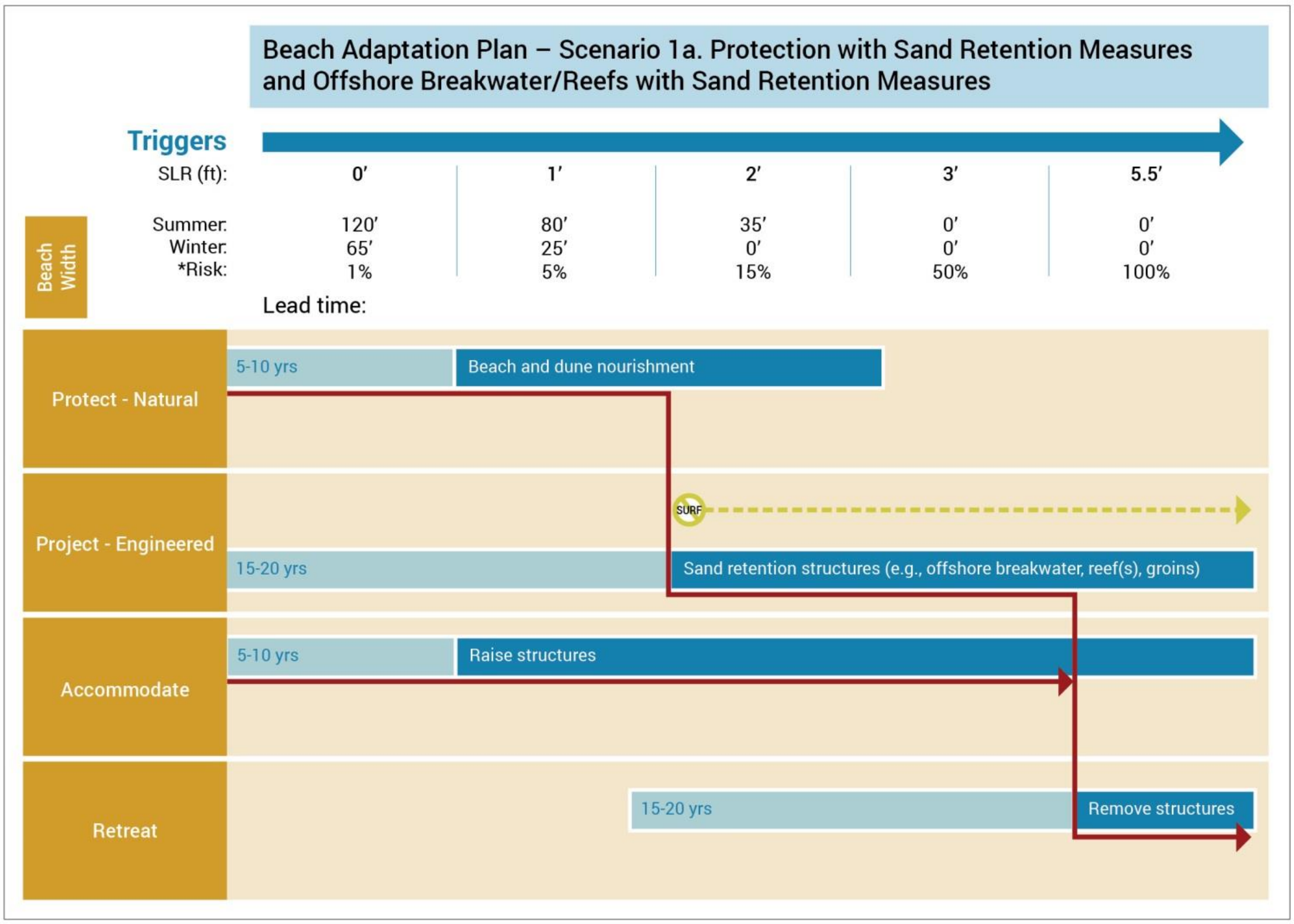
As the beach narrows with sea-level rise, the beach and dunes could be nourished to improve beach access, aesthetics and habitat function, as well as limit future damages in areas that are eroded during storm events. Generally, with any adaptation strategy and enough sea-level rise (e.g., 3 ft of sea-level rise), the required shoreline adaptation measures to maintain existing structures would be so intensive that beachfront and adjacent homes and buildings would need to be raised. For example, once the raised sea walls or revetments are so high that they limit the view of oceanfront homes, focus could instead be placed on raising structures and modifying infrastructure accordingly. With greater than around 3 ft of sea-level rise, the first seaward row of buildings and homes would likely need to be removed.

Possible beach adaptation scenarios within the framework are described below. Other scenarios are also possible within the framework and the following scenarios are presented as examples of giving different priorities to different adaptation measures to illustrate how the Adaptation Plan could be implemented.

5.2.3.1 Beach Adaptation Scenario 1a. Protect with Sand Retention Measures

Figure 21 shows Scenario 1a, in which adaptation measures could be implemented in the following sequence:

1. Beach and dune nourishment beginning in the near-term and continuing until these measures become ineffective due to the rate of sea-level rise
2. Raise structures over time through the implementation of LCP Amendment regulations for development/re-development
3. Sand retention measures in the in the medium-term to improve the effectiveness of nourishment measures. Depending on the type of sand retention structure (e.g., breakwaters or artificial reefs), there is the potential for surfing resources to be negatively impacted. Groins would likely have the least impact to surfing resources, but may be less effective in reducing flood and damage risks.
4. Remove structures when the prior measures become ineffective.



** Annual chance of extreme flooding and damage (1983 event) without adaptation.*

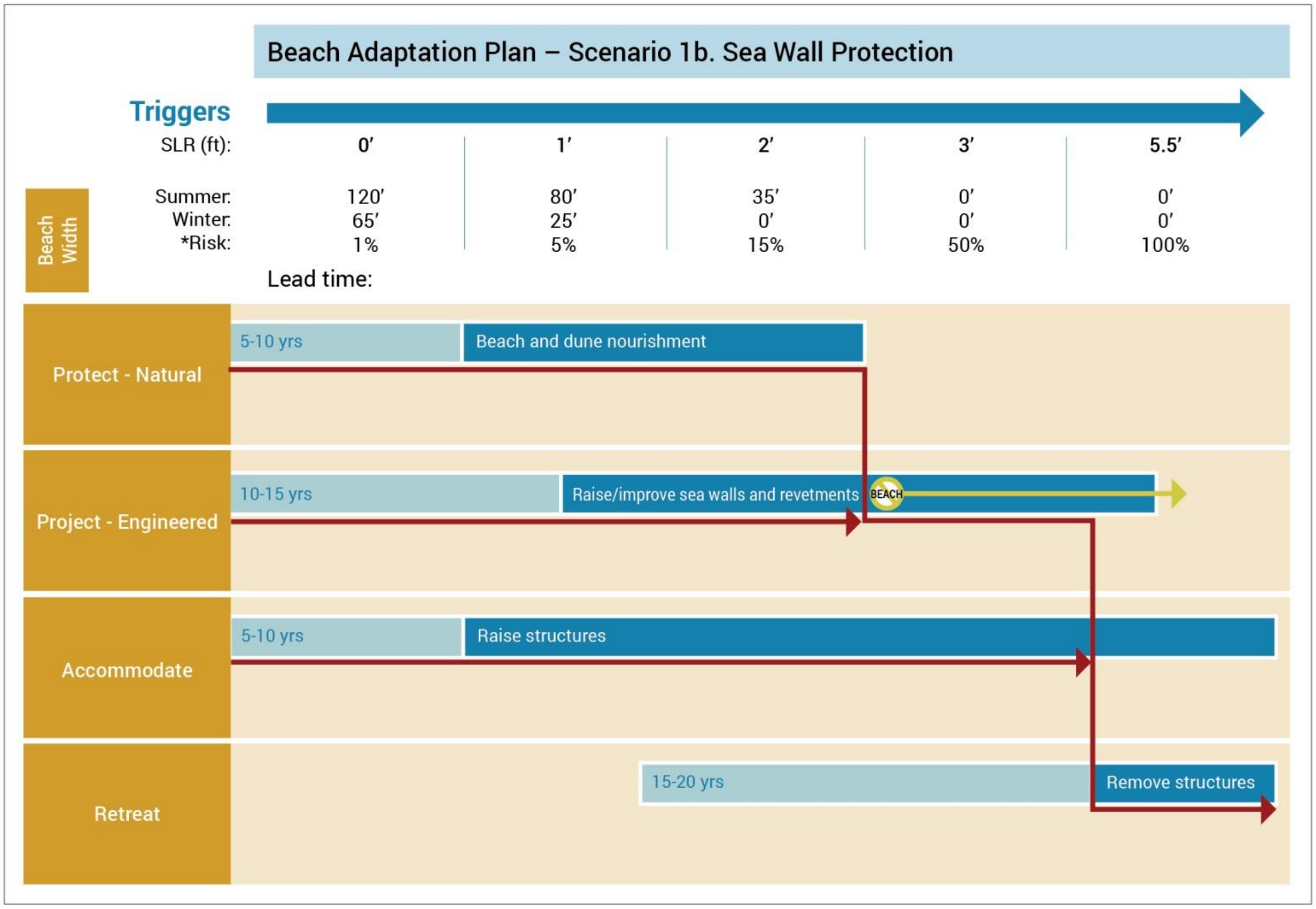
Del Mar Adaptation Plan . D150347

Figure 21

Beach Adaptation Scenario 1a: Sand Retention Measures

5.2.3.2 Beach Adaptation Scenario 1b. Sea Wall Protection

Figure 22 shows Scenario 1b, in which adaptation measures could be implemented in the same sequence as Scenario 1a, except that the existing sea walls and revetments would be raised/improved in the medium-term instead of implementing sand retention measures. In this scenario, the beach would likely be lost over time as the beach and dune nourishment become ineffective with higher rates of sea-level rise. Once prior measures become ineffective and structures are removed, the beach and dunes could be restored; however, there is the potential for an interceding period in which the beach could be lost unless structures are removed sooner.



** Annual chance of extreme flooding and damage (1983 event) without adaptation*

Del Mar Adaptation Plan . D150347

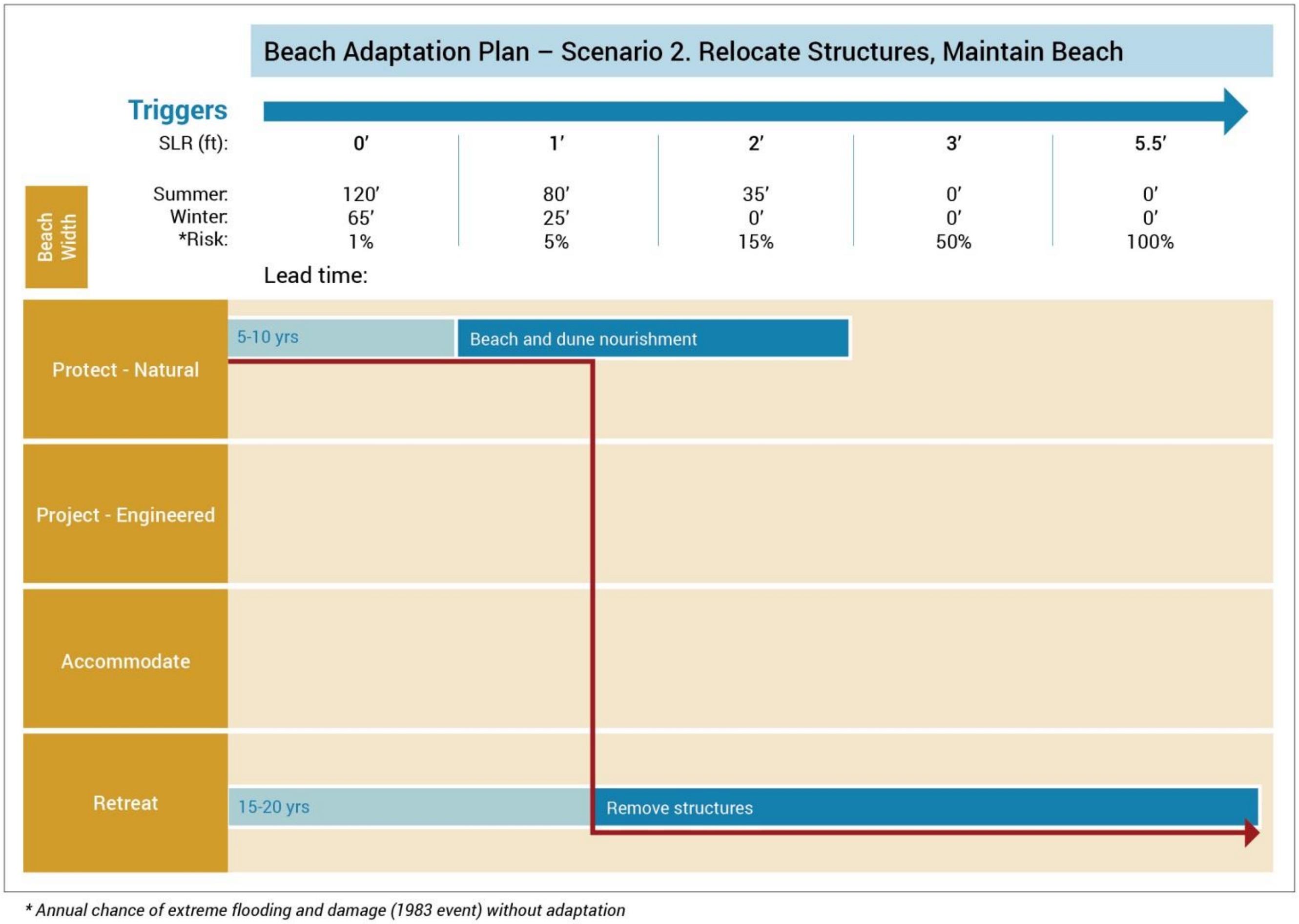
Figure 22

Beach Adaptation Scenario 1b: Sea Wall Protection

5.2.3.3 Beach Adaptation Scenario 2. Remove Structures, Maintain Beach

Figure 23 shows Scenario 2, in which adaptation measures could be implemented in the following sequence:

1. Beach and dune nourishment beginning in the near-term and continuing until these measures become ineffective due to the rate of sea-level rise
2. Remove structures in the medium-term.



Del Mar Adaptation Plan . D150347

Figure 23
Beach Adaptation Scenario 2: Remove Structures, Maintain Beach

This scenario would reduce impacts to the beach, but would require the implementation of a program to remove structures as higher priority.

5.2.4 Beach Adaptation Coastal Permitting

The Coastal Development Permit review and approval for beach adaptation measures would be processed by either the City of Del Mar through the LCP and/or by the California Coastal Commission, pursuant to the California Coastal Act. In general, adaptation measures that involve construction or disturbance above the Mean High Water (MHW) line are within the City's LCP jurisdiction, while adaptation measures taken below MHW is within the California Coastal Commission's jurisdiction. The likely coastal permitting mechanisms for beach adaptation measures are summarized below for the purpose of informing the development of the LCP Amendment as a next step. For measures that would be permitted through the California Coastal Commission rather than the LCP Amendment, policies developed by the City within the LCP Amendment that support particular adaptation measures may be considered by the California Coastal Commission in their review process. However, the Coastal Act would remain the standard of review for measures within the CCC's retained jurisdiction. Other approvals and permits would also be required and would need to be addressed separately.

TABLE 9
SUMMARY OF LIKELY CALIFORNIA COASTAL ACT APPROVAL AND PERMITTING PROCESS

Beach Adaptation Measure	LCP Jurisdiction	CCC Jurisdiction	Note
Beach and dune nourishment	✓	✓	• LCP review for above water portion • CCC Coastal Development Permit required for below water portion
Sand retention measures	✓	✓	• Contingent on CCC approval and funding • Likely to require mitigation
Raised/improved sea walls and revetments	✓		• Can be implemented through LCP redevelopment policies and regulations • Coastal Act limitations may apply
Raise structures	✓		• LCP redevelopment policies and regulations
Remove structures	✓		• LCP policies

5.3 Bluff Erosion Adaptation

The STAC has provided recommendations on which bluff adaptation measures and scenarios are preferred and which are not recommended for the City. Recommended adaptation measures are included in the Bluff Adaptation Plan. Bluff adaptation measures and scenarios that were not recommended by the STAC are discussed in Section 6.

The Bluff Adaptation Plan covers the City Districts and vulnerabilities:

District: North Bluff, South Beach, and South Bluff

Vulnerabilities: The current localized vulnerability of the LOSSAN railroad to bluff erosion will increase in extent in the near-term and extend along almost the entire bluff with 1 foot of sea-level rise. By this timeframe, the railroad would need to be moved inland or armored with a seawall to reduce the risk of the railroad collapsing (as a section of railroad collapsed and cause a train wreck in 1940 as shown in Figure ES-4). If a seawall is constructed, the beach will erode back to the seawall over time until little to no beach exists. If the railroad is moved inland and bluff erosion is allowed to continue, bluff-top property and sewer infrastructure in the South Beach and South Bluff Districts would be vulnerable to erosion with 2 feet of sea-level rise. North Bluffs properties would be similarly vulnerable to erosion.

The following sections describe adaptation measures (Section 5.3.1), triggers (Section 5.3.2), and the Beach Adaptation Plan framework and scenarios (5.3.3).

5.3.1 Bluff Adaptation Measures

The Bluff Adaptation Plan includes the following adaptation measures described in the sections below:

- Beach nourishment
- Best Management Practices (BMPs)
- Railroad relocation
- Structure removal

5.3.1.1 Beach Nourishment

Beach nourishment along the southern bluffs (South Beach and South Bluff Districts) would be similar and would have similar benefits and constraints to beach nourishment described for North Beach (see Section 5.2.1). Nourishing the beach below the southern bluffs could provide short 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 will become more expensive as sand sources are limited and the amount of sand required will increase with sea-level rise. 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 would likely not last. Additionally, beach nourishment 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 on the Lagoon inlet would need to be fully considered.

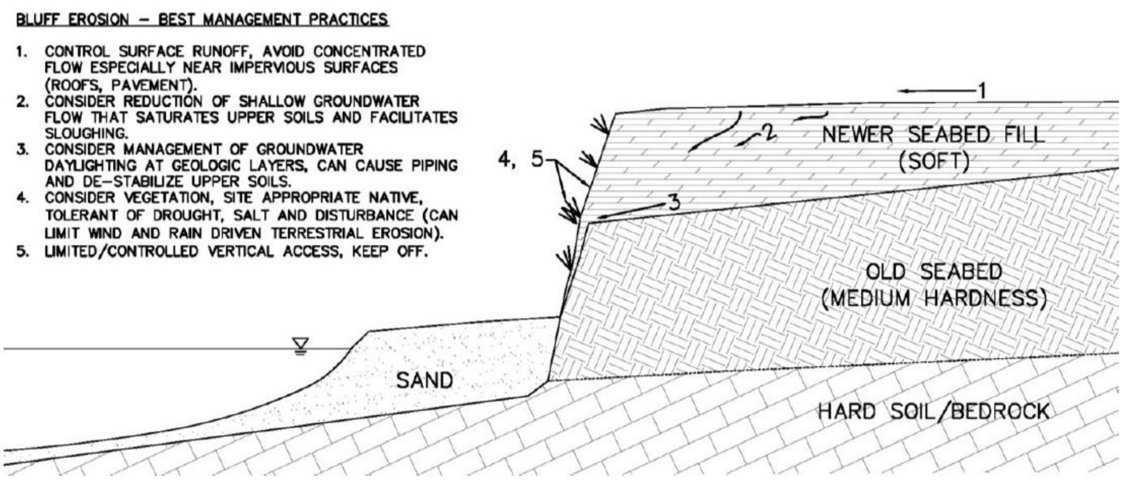
Beach nourishment for the North Bluff is not likely to be effective if limited to the City limit given the relatively short length of bluff shoreline and proximity to the San Dieguito Lagoon mouth; however, beach nourishment could be pursued in coordination with the City of Solana Beach.

TABLE 10
BEACH NOURISHMENT BENEFITS AND CONSTRAINTS SUMMARY

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

5.3.1.2 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. NCTD and SANDAG are already employing surface and subsurface drainage control measures to reduce erosion. 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 as generally depicted in Figure 24.



SOURCE: ESA

Del Mar Adaptation Plan . D150347
Figure 24
General Depiction of Bluff Erosion BMPs

In addition to these surface water and groundwater BMPs, the City could investigate whether over-watering of landscaping within the South Beach and South Bluff Districts 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 pursuing 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. The City will pursue these and/or other options with NCTD and SANDAG as part of the Adaptation Plan.

Revegatating/restoring bluff vegetation on existing pathways may be effective in reducing erosion, if new vertical crossings and pathways (e.g., stairways) are installed and access on the existing pathways is effectively stopped. A program to restore/revegetate large sections of the bluffs with more erosion-resistant vegetation is not recommended because revegetation activities on the bluffs could potential de-stabilize the bluffs during installation and/or the period over which plants are establishing.

Note that NCTD and SANDAG have performed several bluff stabilization projects that involve constructing vertical soldier piles with tie backs into the bluffs, and plan to install additional stabilization projects if and when needed to protect the railroad. These stabilization measures are effective in the near-term until the railroad can be relocated per the NCTD/SANDAG plan as a long-term bluff erosion adaptation strategy (see the following section).

5.3.1.3 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 the Adaptation Plan and consistent with prior plans. 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 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 in full force and effect; however, this process is not currently followed by NCTD, SANDAG, and the City. The railroad right-of-way is within the current LCP's Shoreline Protection Area line and Beach Overlay Zone.

As discussed in Section 2, the LCP does not allow for sea walls within the Shore Protection Area and Beach Overlay Zone. Construction of a permanent sea wall by NCTD and/or SANDAG to protect the railroad from bluff erosion (e.g., using the soldier piles installed for bluff stabilization as the foundation for constructing a sea wall once bluff top erosion reaches the soldier piles) would not be consistent with or allowed by the LCP or the California Coastal Act. In considering a full range of possible bluff erosion adaptation, a bluff sea wall or other armoring (that would be removed in the future) was considered as part of the Adaptation Plan; however, a sea wall was not recommended by the STAC for inclusion in the Adaptation Plan (see additional discussion in Section 6). The STAC's recommendation was for the Adaptation Plan to include railroad relocation and allow landward bluff erosion in order to maintain the beach below and the natural character of the Del Mar bluffs and beach. Bluff stabilization structures installed by NCTD and/or SANDAG should be linked to a commitment to remove them as part of a plan to relocate the railroad and accommodate bluff erosion.

5.3.1.4 Remove Structures

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. Per the STAC recommendation discussed above, the Adaptation Plan does not include a sea wall or other armoring of the bluffs and removing structures from the bluff top will therefore be required.

As discussed for the Beach Adaptation Plan removing structures measure (Section 5.2.1), the City can consider removal of public buildings, utilities, and other infrastructure and relocation opportunities as the bluff erosion risk to public structures increases. For private property and structures, the City could consider options for facilitating structure removal where there is a public benefit, such as removing structures to allow for bluff and beach recession and access along the bluffs. In some cases, a structure can be moved landward or otherwise modified to allow for bluff recession before removal is required. Given the lack of example or model local-government-lead programs for coordinated removal of private property, the City can follow the development of State-wide removal or managed retreat programs and pursue studies of how such programs could be implemented in the City of Del Mar. Per Section 5.2.1, options for facilitating structure removal could include rolling easements, relocation incentive programs, transfer of development rights programs, and programs for acquisition, buyout, or equity transfer between private and public ownership in situations where doing so provides a commensurate public benefit.

5.3.2 Bluff Adaptation Triggers

The trigger for bluff adaptation is the distance between the top of the bluff and the bluff top asset. This trigger 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 trigger distance 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 the adaptation trigger 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 25). Actual bluff top recession during this event is to be determined and may have been between 5 and 20 ft. To summarize, the trigger distance is based on the following"

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

Del Mar Adaptation Plan . D150347

SOURCE: CNS/KFMB

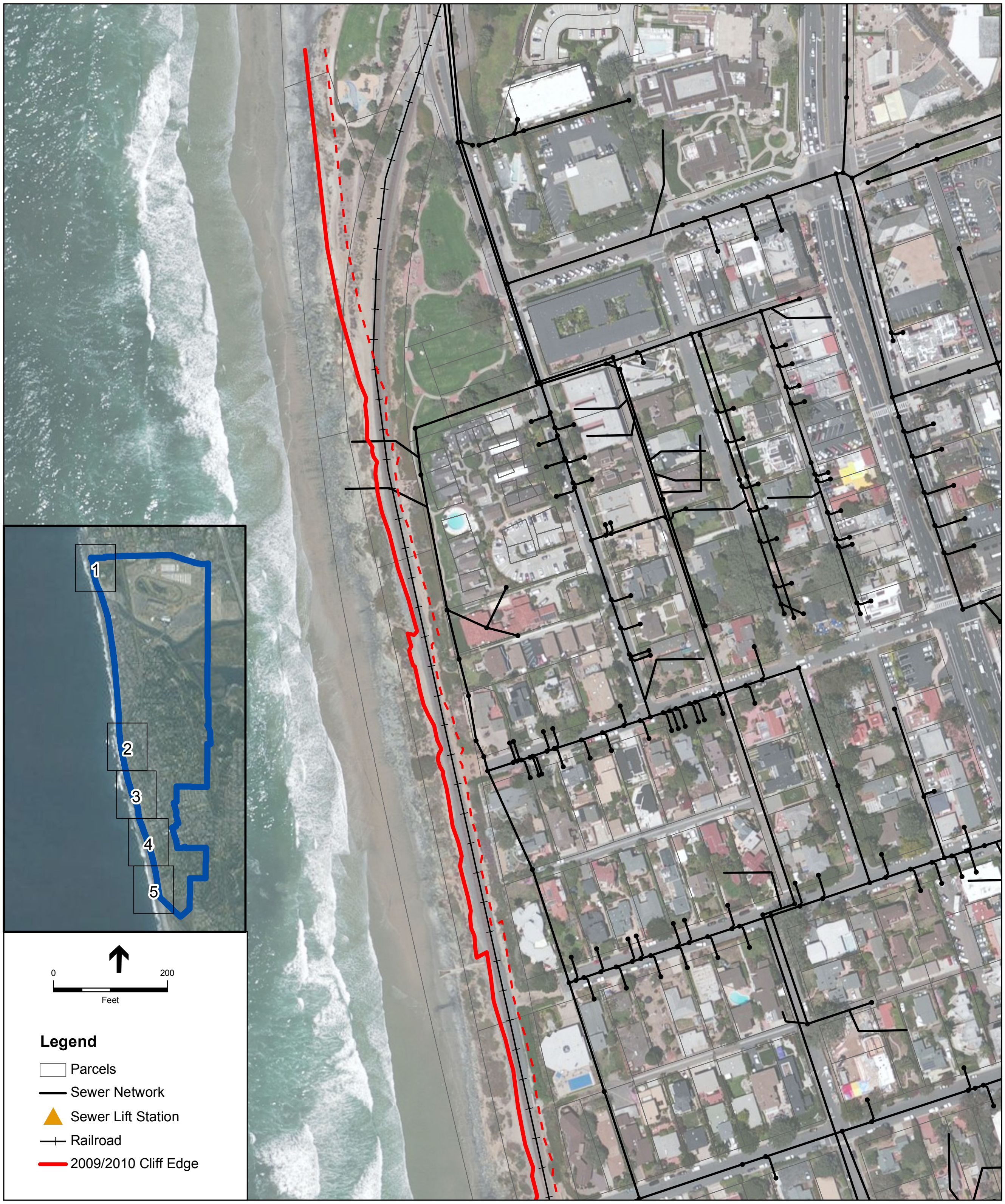
Figure 25
Bluff Collapse near 10th Street in Del Mar

Figure 26 shows the trigger distance from the current (2010) bluff top position. Note that sections of the railroad are currently within the trigger distance; however, NCTD and SANDAG have already installed and anticipate additional bluff stabilization projects.

SOURCE:

Del Mar Adaptation Plan . D150347

Figure 26.1
Bluff Erosion Trigger Distance (Dashed Line)
from Current Bluff Top Position (Solid Line)



SOURCE:

Del Mar Adaptation Plan . D150347

Figure 26.2

Bluff Erosion Trigger Distance (Dashed Line) from Current Bluff Top Position (Solid Line)

SOURCE:

Del Mar Adaptation Plan . D150347

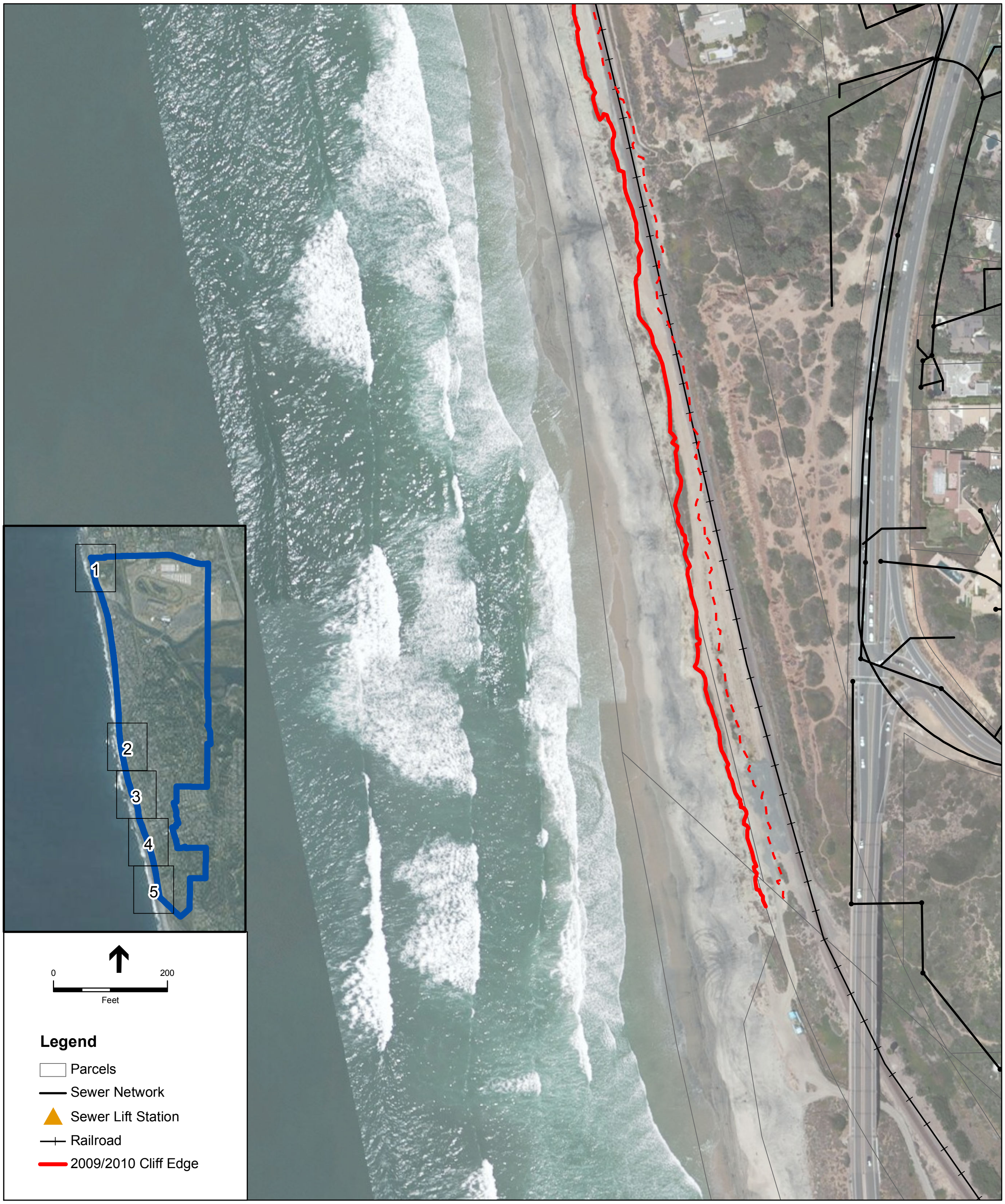
Figure 26.3

Bluff Erosion Trigger Distance (Dashed Line) from Current Bluff Top Position (Solid Line)

SOURCE:

Del Mar Adaptation Plan . D150347

Figure 26.4
Bluff Erosion Trigger Distance (Dashed Line) from Current Bluff Top Position (Solid Line)



SOURCE:

Del Mar Adaptation Plan . D150347

Figure 26.5

Bluff Erosion Trigger Distance (Dashed Line) from Current Bluff Top Position (Solid Line)

Table 11 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. These projected distances provide an indication of the amount of sea-level rise that would likely trigger bluff erosion adaptation 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/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 buildings and 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: some of the buildings in the first row; 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). With 5.5 ft of sea-level rise, adaptation would likely be triggered for the entire first row of buildings, the full length of the sewer line, and portions of the second, third and fourth rows of buildings.

Table 11 shows 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 that are below the trigger distance (35 ft) are shown in red and indicate that bluff erosion adaptation would be triggered for some or all of the asset class.

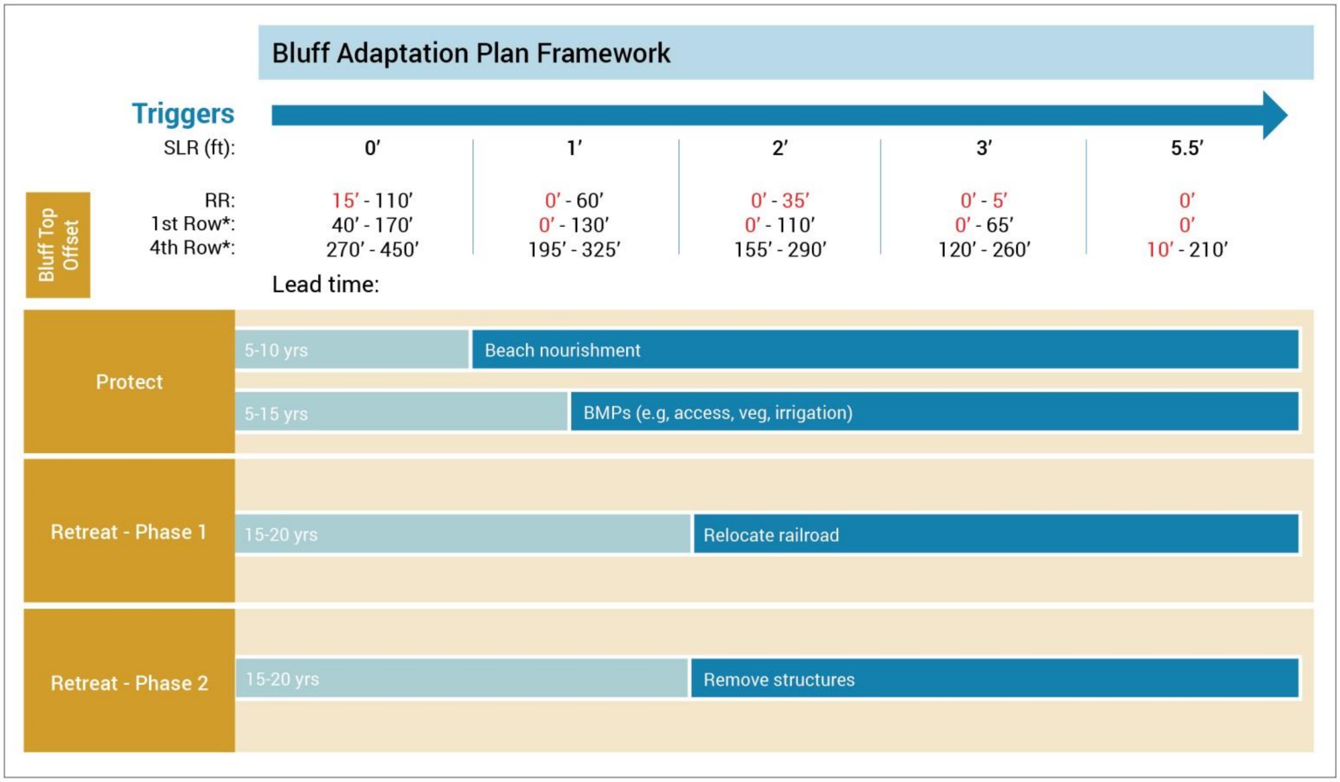
TABLE 11
APPROXIMATE PROJECTED DISTANCE BETWEEN THE BLUFF TOP OF RAILROAD, THE FIRST AND FOURTH ROWS OF BUILDINGS, AND THE SEWER LINE ALONG THE BLUFFS WITH SEA-LEVEL RISE

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 Line	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

Note that these projections are approximate and could be greater or less due to uncertainties in the projections. The actual distance will be monitored over time (see Section 4) and compared to the trigger distance as part of the Adaptation Plan process.

5.3.3 Bluff Adaptation Framework and Scenario

Figure 27 presents the Bluff Adaptation Plan framework including triggers and adaptation measures with lead times and the range over which the measures are anticipated to be effective (see Section 4 for an overview of the Adaptation Plan process). The STAC has provided input on the Bluff Adaptation Plan and recommendations to include the following scenario. A bluff sea wall with public access was considered as an adaptation measure, but was not recommended by the STAC as discussed in Section 6.



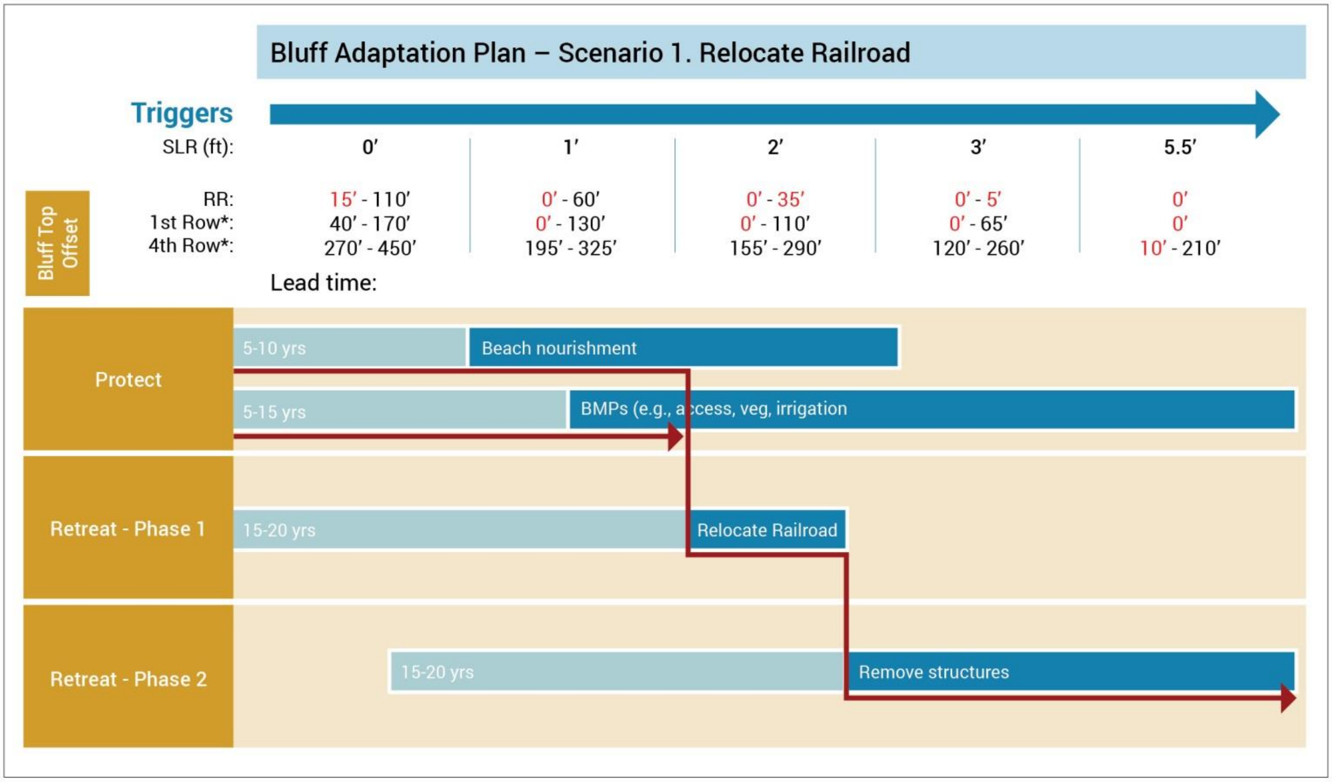
Del Mar Adaptation Plan . D150347
Figure 27
Bluff Adaptation Plan Framework

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, some buildings and portions of the sewer line would also likely need to be relocated. With higher amounts of sea-level rise (e.g., 3 to 5 ft of sea-level rise), the sewer line and the first and subsequent rows of buildings would need to be removed to reduce bluff erosion risk. Relocating structures will provide a buffer from erosion and for public access (e.g., an open-space/park).

Figure 28 shows a possible bluff adaptation scenario within the framework. Other scenarios are also possible within the framework and the following scenario is presented as example to illustrate how a sequence of adaptation measures could be implemented. This example sequence is as follows:

1. Beach nourishment and bluff erosion BMPs beginning in the near-term and continuing until these measures become ineffective due to the rate of sea-level rise.

2. Relocation of the railroad by NCTD/SANDAG consistent with the City's Adaptation Plan.
3. Remove structures landward of the railroad once the railroad is removed and structures become threatened by bluff erosion.



Del Mar Adaptation Plan . D150347

Figure 28

Bluff Adaptation Scenario 1: Relocate Railroad

5.3.4 Bluff Adaptation Coastal Permitting

As discussed for the Beach Adaptation Plan, Coastal Development Permit review and approval for bluff adaptation measures may 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 (see Section 5.2.4). The likely coastal permitting mechanisms for bluff adaptation measures are summarized below for the purpose of informing the development of the LCP Amendment as a next step. Other approvals and permits would also be required and would need to be addressed separately.

TABLE 12
SUMMARY OF LIKELY CALIFORNIA COASTAL ACT APPROVAL AND PERMITTING PROCESS FOR BLUFF ADAPTATION MEASURES

Adaptation Measure	City LCP Jurisdiction	CCC Jurisdiction	Note
Beach nourishment	✓	✓	• LCP review for above water portion • CCC Coastal Development Permit required for below water portion
Relocate railroad	✓	✓	• Implemented by NCTD/SANDAG
Remove structures	✓		• Can be implemented through LCP redevelopment policies and regulations

5.4 San Dieguito River Flooding Adaptation

The STAC has provided recommendations on which river adaptation measures and scenarios are preferred and which are not recommended for the City. Recommended adaptation measures are included in the River Adaptation Plan. River adaptation measures and scenarios that were not recommended by the STAC are discussed in Section 6.

Note that rather than sea-level rise alone, the increased risk of San Dieguito River flooding is driven by potential changes in extreme precipitation and river discharge with climate change and the potential for increased deposition of sand in the River channel with sea-level rise, which would raise the elevation of the channel bed and the flood level. Increased channel deposition could occur as sea level rises and the beach responds by receding landward, with waves driving an increase in sand transport “up” into the channel. The increase in channel depth with sea-level rise 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.

The River Adaptation Plan covers the City Districts and vulnerabilities:

Districts: River Valley/Fairgrounds, North Beach

Vulnerability to San Dieguito River flooding and damage. The present low exposure of the Fairgrounds to significant flooding will become highly exposed with 2 to 3 feet of channel deposition; however, the vulnerability of the Fairground’s land uses to flooding may be less than for other public and private development due to the reduced consequences of the flooding. Roads and bridges, including Camino Del Mar, Jimmy Durante Blvd. and bridge, the east ends of North Beach District streets, and San Dieguito Drive, will be highly vulnerable 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 in these areas would also be exposed to both River and coastal flooding, but is not highly vulnerable to flooding.

The following sections describe adaptation measures (Section 5.4.1), triggers (Section 5.4.2), and the River Adaptation Plan framework and scenarios (5.4.3).

5.4.1 River Adaptation Measures

The River Adaptation Plan includes the following adaptation measures described in the sections below:

- Channel dredging
- Reservoir management
- Levees with partial retreat
- Raise structures
- Remove structures

5.4.1.1 Channel Dredging

The River Adaptation Plan includes dredging of the River channel to maintain the channel bed near its current elevation and maintain 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) as discussed in Section 5.5.1.2, 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 and 16,800 cubic yards in 2015 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, the City will review channel survey data and deposition monitoring from the San Dieguito Lagoon Restoration and coordinate with Southern California Edison on the channel dredging program.

5.4.1.2 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.

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 and the San Diego County Water Authority (SDCWA) to explore 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 Hodge 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 consider including transporting (e.g., trucking) sediment.

5.4.1.3 Levees with Partial Retreat

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 in combination with partial retreat assets away from the River flood corridor. Retreat would consist of removing structures and restoring developed land to wetlands to expand wetland floodplain habitat, thereby reducing flood levels and providing new habitat that can be designed to be resilient to sea-level rise. Figure 29 shows an example of potential levee alignments and partial retreat/habitat restoration areas. As shown in this example, the Public Works Yard south of the River could be relocated (per the High Priority adaptation measures in Section 5.1) and portions of the Fairgrounds (e.g., to the west) could be restored to wetland. The Fairgrounds has already completed the Phase 1 wetland restoration at the South Overflow Parking Lot (south of Jimmy Durante Blvd. and east of Jimmy Durante Bridge) and plans to restore the rest of the lot to wetlands in Phase 2, which is scheduled to be implemented soon. 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, for example, so that the levees tie into high ground.

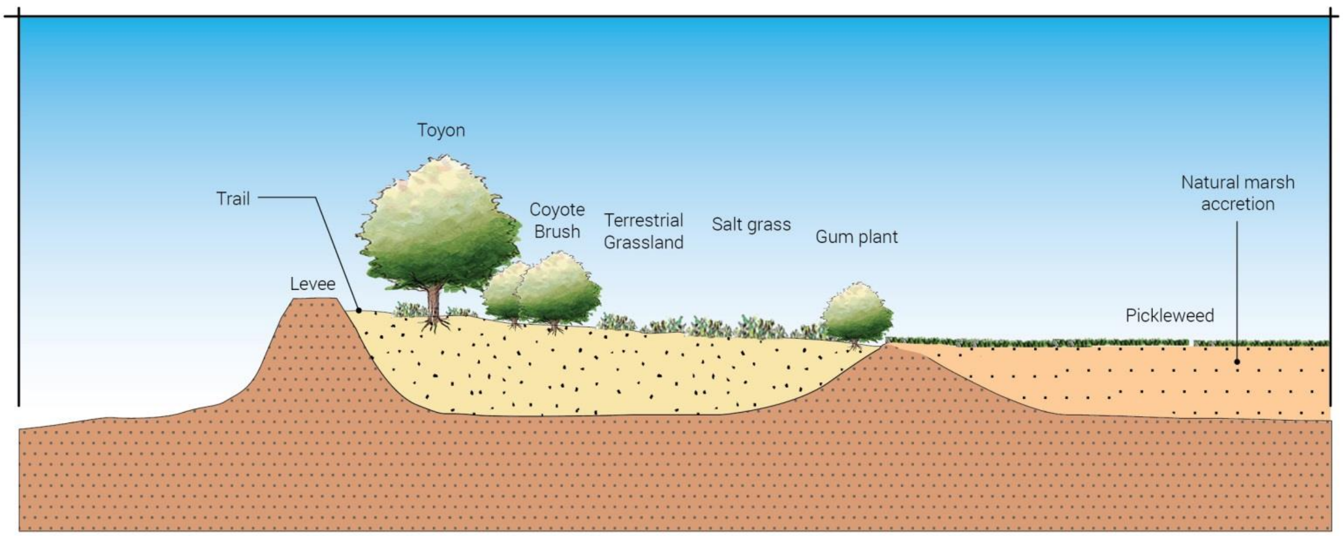
Del Mar Adaptation Plan . D150347

Figure 29

Living Levees

The levees could be designed as "living levees" by creating gently-sloping upland, transition, and wetland habitats between the levee and the River (Figure 30). 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.

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 partial retreat and habitat restoration, the intent would be to construct the levees in currently developed areas, 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.



Del Mar Adaptation Plan . D150347
Figure 30
Living Levee Cross Section

5.4.1.4 Raise Structures

The elevation of homes, buildings, and 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 (see Section 5.2.1.4). 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 need to be raised. Raising structures can include raising buildings on pile foundations and/or modifying building design/construction so that the second floor is above the target flood level and contains all flood-sensitive features, while the first floor is used for parking and/or storage and is designed to be durable and resilient to flood damage.

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.

As part of the City's existing floodplain management program, the City already requires that the construction or re-construction of North Beach buildings in the current River floodplain raise buildings 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 the raising of structures over time through redevelopment.

5.4.1.5 Remove Structures

As discussed for the Beach Adaptation Plan removing structures measure (Section 5.2.1.5), the City can consider removal of public buildings, utilities, and other infrastructure and relocation opportunities as the River flood risk to public structures increases. For private property and structures, the City could consider options for facilitating structure removal where there is a public benefit, such as removing structures to allow for wetland restoration along the River. As noted above, a greater number of structures are within the River flood risk area than the coastal flood risk area and a greater number of structures would therefore need to be removed for River flood adaptation compared to coastal flood adaptation.

Given the lack of example or model local-government-lead programs for coordinated removal of private property, the City can follow the development of State-wide removal or managed retreat programs and pursue studies of how such programs could be implemented in the City of Del Mar. Per Section 5.2.1.5, options for facilitating structure removal could include rolling easements, relocation incentive programs, transfer of development rights programs, and programs for acquisition, buyout, or equity transfer between private and public ownership in situations where doing so provides a commensurate public benefit.

5.4.2 River Adaptation Triggers

The triggers 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 13 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 13
PROJECTED RIVER FLOOD RISK WITH SEA-LEVEL RISE, CHANNEL BED DEPOSITION, AND CLIMATE CHANGE AS BASIS FOR RIVER ADAPTATION TRIGGERS

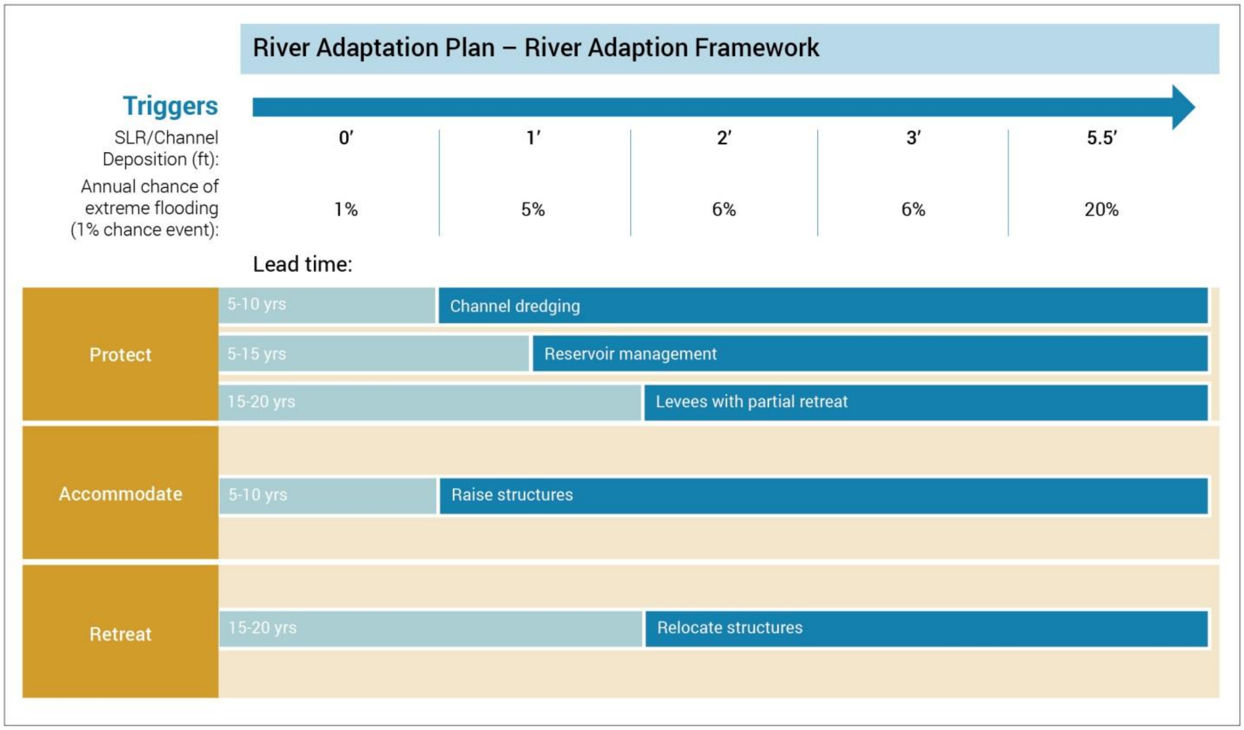
Sea-Level Rise / Channel Deposition (ft)	0’	1’	2’	3’	5.5’
Annual chance of extreme flooding (1% chance event)	1%	5%	6%	6%	20%
Annual chance of significant flooding (1980 event)	5%	15%	25%	50%	100%

Based on the guiding principles (Section 3), the flood risk trigger is set to limit the risk of extreme River flooding and damage to less than approximately a 5% chance of occurring in a given year (i.e., 5% annual-chance of occurrence). Per Table 13, adaptation would be triggered as sea-level rise and/or channel deposition approach 1 ft.

The risk of more frequent, less severe, but still significant flooding such as the 1980 River flood event is estimated to currently be around a 5% annual-chance. Adaptation to reduce extreme flood risk would reduce the risk of more frequent flooding.

5.4.3 River Adaptation Framework and Scenarios

Figure 31 presents the River Adaptation Plan framework including triggers and adaptation measures with lead times and the range over which the measures are anticipated to be effective (see Section 4 for an overview of the Adaptation Plan process). The STAC has provided input on the River Adaptation Plan and recommendations to include the following scenarios. Levees without partial retreat was considered as an adaptation measure, but was not recommended by the STAC as discussed in Section 6.



Del Mar Adaptation Plan . D150347

Figure 31
River Adaptation Plan Framework

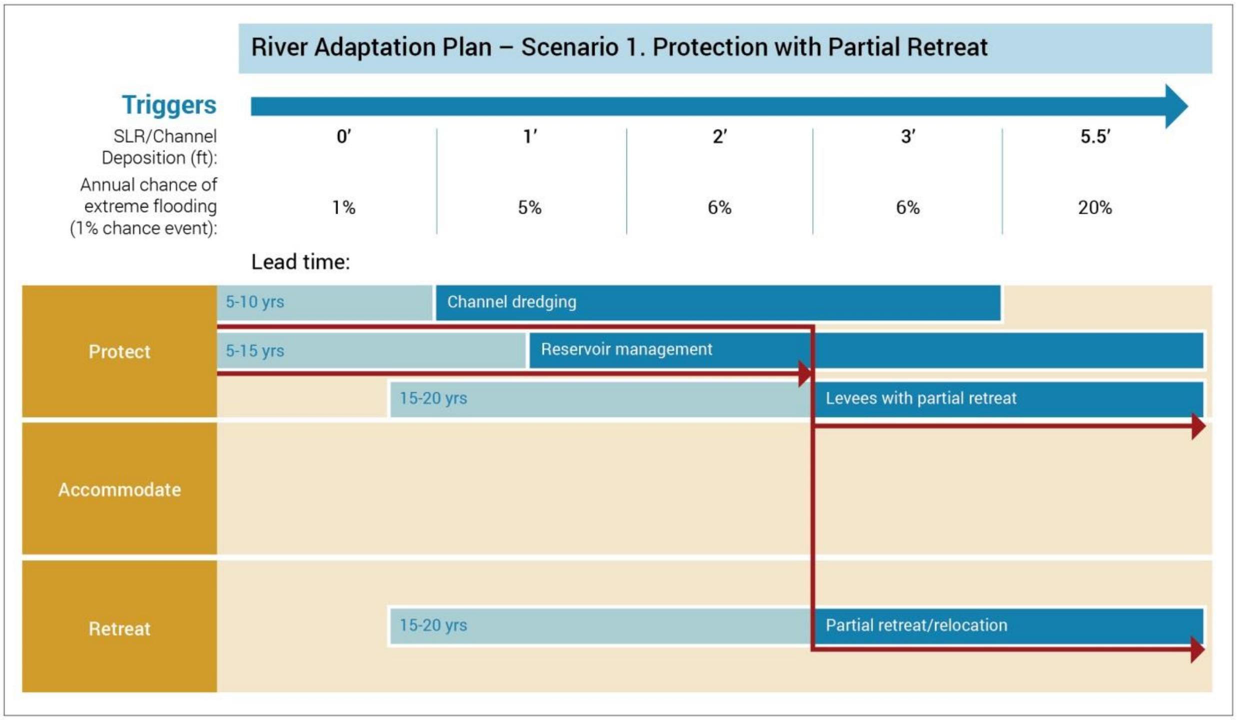
5.4.3.1 River Adaptation Scenario 1. Levee Protection with Partial Retreat

Figure 32 shows Scenario 1, Levee Protection with Partial Retreat, in which adaptation measures could be implemented in the following sequence:

1. Channel dredging beginning in the near-term and continuing until this measure become ineffective due to the rate of sea-level rise

2. Reservoir management in the near- to medium-term and continuing as long as it is effective

3. Living levees with partial retreat and wetland floodplain restoration to provide long-term protection from higher amounts of sea-level rise.



Del Mar Adaptation Plan . D150347

Figure 32

River Adaptation Scenario 1: Protection With Partial Retreat

5.4.3.2 River Adaptation Scenario 2. Remove Structures

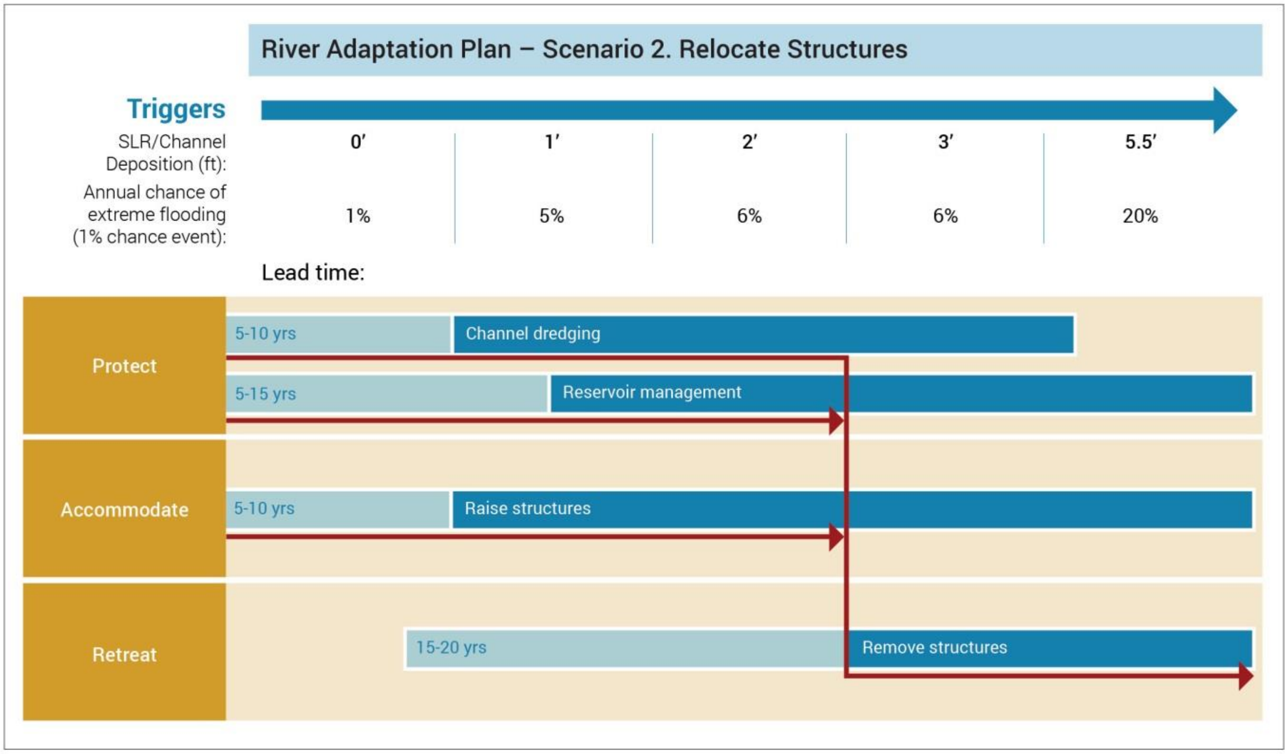
Figure 33 shows Scenario 2, Remove Structures, in which adaptation measures could be implemented in the following sequence:

1. Channel dredging beginning in the near-term and continuing until this measure become ineffective due to the rate of sea-level rise.

2. Reservoir management in the near- to medium-term and continuing as long as it is effective.

3. Raise structures over time through the implementation of LCP Amendment regulations for development/re-development.

4. Remove structures when the prior measures become ineffective.



Del Mar Adaptation Plan . D150347

Figure 33

River Adaptation Scenario 2: Remove Structures

5.4.4 River Adaptation Coastal Permitting

As discussed previously, Coastal Development Permit review and approval for River adaptation measures may 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 (see Section 5.2.4). The likely coastal permitting mechanisms for River adaptation measures are summarized below for the purpose of informing the development of the LCP Amendment as a next step. Other approvals and permits would also be required and would need to be addressed separately.

TABLE 14
SUMMARY OF LIKELY CALIFORNIA COASTAL ACT APPROVAL AND PERMITTING PROCESS FOR RIVER ADAPTATION MEASURES

Adaptation Measure	LCP	CCC	Note
River channel dredging		✓	• Below water
Reservoir management			• Partnering with City of San Diego
Raise structures	✓		• LCP redevelopment policies and regulations
Remove structures	✓		• LCP policies

5.5 San Dieguito Lagoon Wetland Adaptation

The Wetland Adaptation Plan includes a range of adaptation measures and scenarios that were discussed with and recommended by the STAC. The Wetland Adaptation Plan covers the City Districts and vulnerabilities:

District: River Valley/San Dieguito Lagoon

Vulnerabilities: With sea level rise, existing wetland habitats will be inundated more frequently and vegetated wetland habitats will be "drowned out" and convert to intertidal mudflats and subtidal habitat. Existing pickleweed marsh habitat could drown out and be lost with 3 feet of sea-level rise. 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.

The following sections describe adaptation measures (Section 5.5.1), triggers (Section 5.5.2), and the Marsh Adaptation Plan framework and scenarios (5.5.3).

5.5.1 Wetland Adaptation Measures

The Wetland Adaptation Plan includes the following adaptation measures described in the sections below:

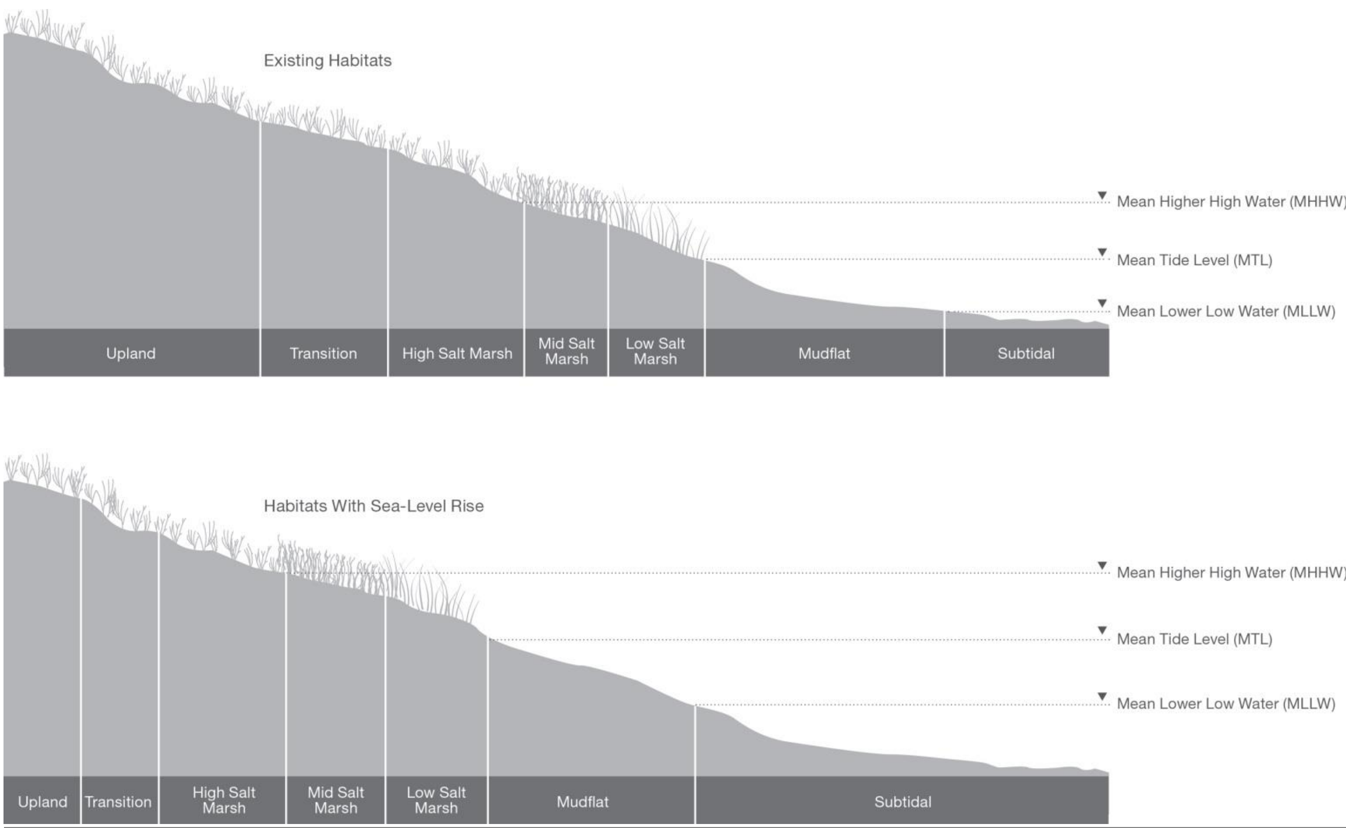
- Allow/facilitate wetland conversion and transgression
- Sediment placement
- Wetland expansion/restoration

5.5.1.1 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, if they establish at higher elevations, can survive. In this way, wetlands can "migrate" or transgress upslope (Figure 34).

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 actively removing existing structures as they begin to flood more frequently (Section 5.2.1.5) or as they near the end of their lifespan, or 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.



Del Mar Adaptation Plan . D150347

Figure 34
Wetland Transgression with Sea-Level Rise

Table 15 summarizes benefits and constraints of allowing and facilitating wetland conversion and transgression. Creating space for wetlands to migrate into will preserve wetland habitat until the rate of sea-level rise is faster than the rate at which marshes can migrate. 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 15
WETLAND CONVERSION AND TRANSGRESSION BENEFITS AND CONSTRAINTS SUMMARY

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

As a next step (see Section 8), a detailed San Dieguito Lagoon Wetland Habitat Migration Assessment will be performed 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.

5.5.1.2 Sediment Placement

Sediment placement on the marshplain is an adaptation strategy that would allow wetland accretion to keep up with sea-level rise. As discussed in Section 5.5.1.1, 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 (Section 5.5.1.1) 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 35). Monitoring is being completed to track the outcomes of the project and inform future projects.

Table 16 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 also 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 (see Section 5.4.1.1) as an integrated wetland/River flood management adaptation strategy.

TABLE 16
SEDIMENT PLACEMENT BENEFITS AND CONSTRAINTS SUMMARY

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

SOURCE: USFWS 2016

Del Mar Adaptation Plan . D150347
Figure 35
Sediment Placement on the Marsh at Seal Beach

5.5.1.3 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 5.5.1.1) 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 the levees with partial retreat adaptation measure for River flooding (see Section 5.4.1.3). In this scenario, developed areas could be restored to a mix of wetland, transition, and upland areas that front new levees. 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 17 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 17
WETLAND EXPANSION/RESTORATION BENEFITS AND CONSTRAINTS SUMMARY

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

5.5.2 Wetland Adaptation Triggers

Triggers for wetland adaptation include the amount of sea-level rise and 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 (Figure 36). Under 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.

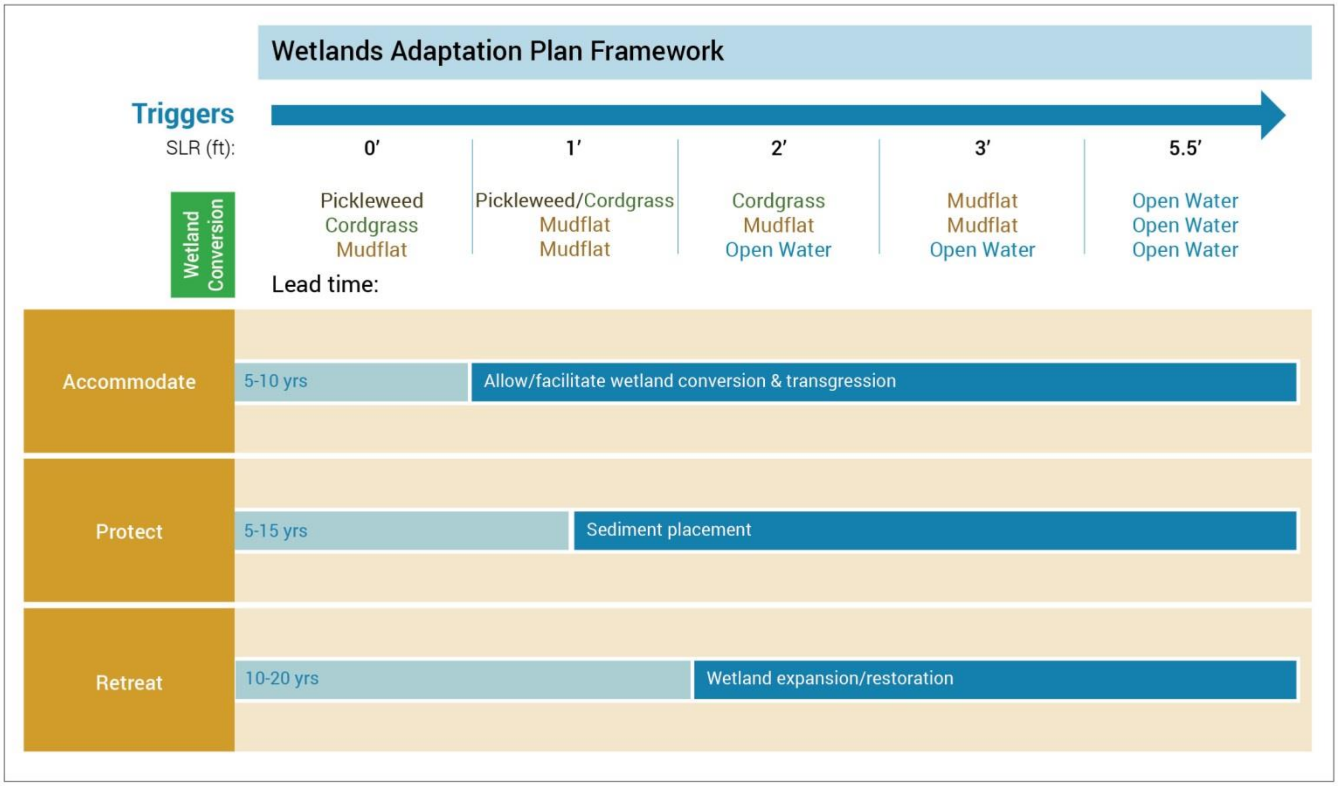
TABLE 18
WETLAND CONVERSION WITH SEA-LEVEL RISE (SLR)

	Existing Elevations (ft NAVD)	Existing Habitat	1 ft of SLR	2 ft of SLR	3 ft of SLR	5.5 ft of SLR
Existing upland areas Smaller portion of the Lagoon is at these elevations and available for wetland transgression	13	Upland	Upland	Upland	Upland	Upland
	12	Upland	Upland	Upland	Upland	Transition
	11	Upland	Upland	Upland	Upland	High Marsh
	10	Upland	Upland	Upland	Transition	Mid Marsh
	9	Upland	Upland	Transition	High Marsh	Low Marsh
	8	Upland	Transition	High Marsh	Mid Marsh	Mudflat
Existing wetland elevations Majority of Lagoon area is at these elevations	7	Transition	High Marsh	Mid Marsh	Mid Marsh	Mudflat
	6	High Marsh	Mid Marsh	Mid Marsh	Low Marsh	Mudflat
	5	Mid Marsh	Mid Marsh	Low Marsh	Mudflat	Subtidal
	4	Mid Marsh	Low Marsh	Mudflat	Mudflat	Subtidal
	3	Low Marsh	Mudflat	Mudflat	Mudflat	Subtidal
	2	Mudflat	Mudflat	Mudflat	Subtidal	Subtidal
	1	Mudflat	Mudflat	Subtidal	Subtidal	Subtidal
	0	Mudflat	Subtidal	Subtidal	Subtidal	Subtidal

Per the guiding principles (Chapter 3) and Table 18, adaptation would be triggered as sea-level rise approach 1 to 2 ft and/or as existing high marsh is converted to mid marsh and squeezed into the transition zone, which is likely to result in loss of high marsh habitat functions (e.g., loss of high tide refugia).

5.5.3 Wetland Adaptation Framework and Scenarios

Figure 36 presents the Wetland Adaptation Plan framework including triggers and adaptation measures with lead times and the range over which the measures are anticipated to be effective (see Section 4 for an overview of the Adaptation Plan process). The triggers assume an average starting elevation of mid and high marsh pickleweed habitat 5 ft NAVD, low marsh cordgrass habitat at 3 ft NAVD, and mudflat at 1 ft NAVD.



Del Mar Adaptation Plan . D150347

Figure 36
Wetlands Adaptation Plan Framework

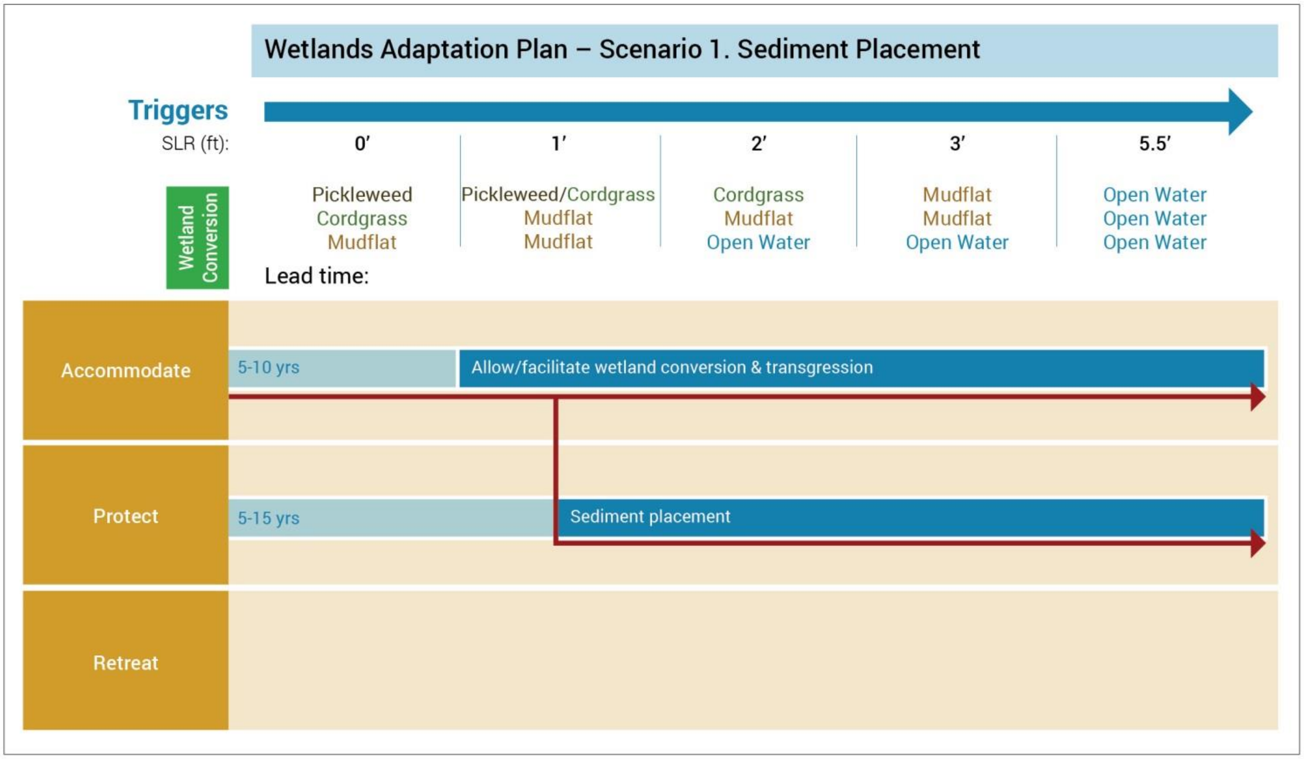
As wetland conversion continues with sea-level rise, upland and transitional areas could be allowed to convert to marsh through wetland transgression. With enough sea-level rise (e.g., 1 ft of sea-level rise), this adaptation strategy is not expected to be effective and restoration in other higher elevation areas or placement of sediment in existing marshes would be needed.

Possible wetland adaptation scenarios within the framework are described below. Other scenarios are also possible within the framework and the following scenarios are presented as examples to illustrate how a sequence of adaptation measures could be implemented.

5.5.3.1 Wetland Adaptation Scenario 1. Sediment Placement

Figure 37 shows Scenario 1, in which adaptation measures could be implemented in the following sequence:

1. Allow/facilitate wetland conversion and transgression.
2. As existing wetlands begin to drown due to increasing rates of sea-level rise, place sediment in the marsh to raise elevations.



Del Mar Adaptation Plan . D150347

Figure 37

Wetlands Adaptation Scenario 1: Sediment Placement

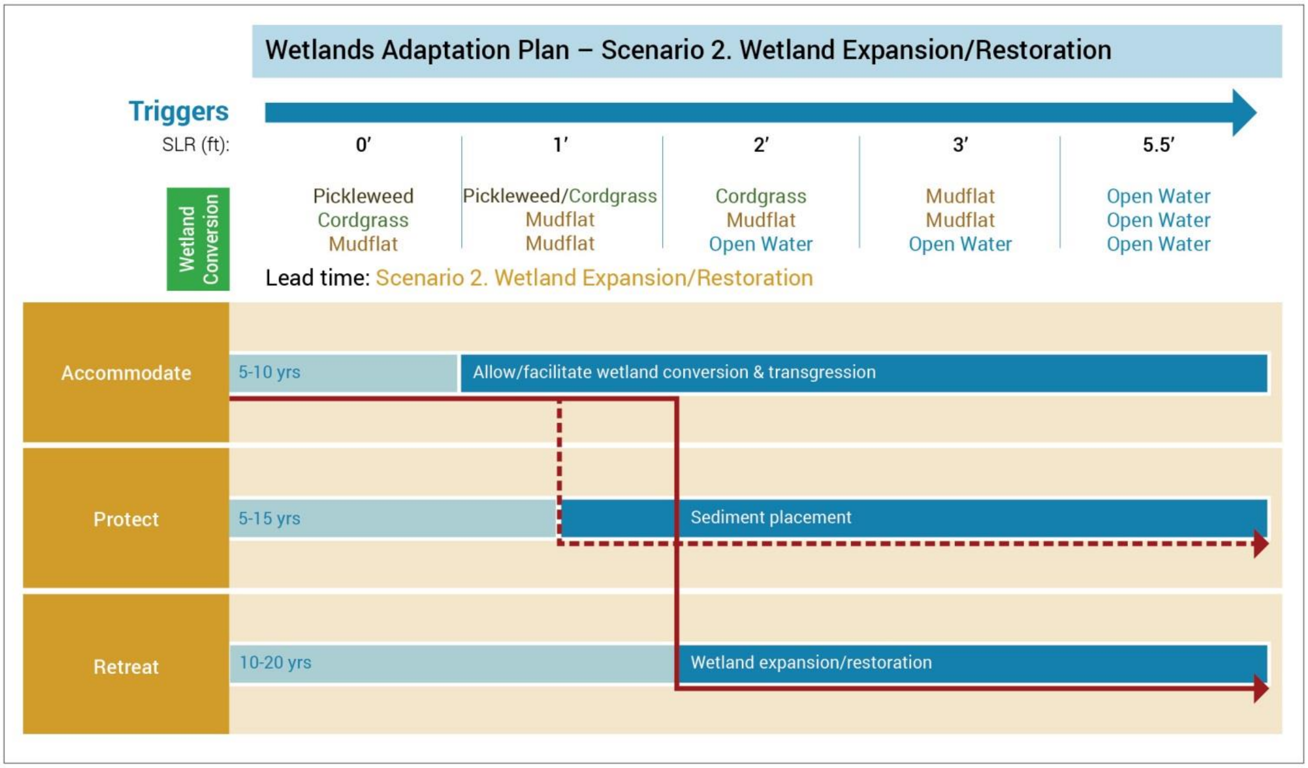
5.5.3.2 Wetland Adaptation Scenario 2. Wetland Expansion/Restoration

Figure 38 shows Scenario 2, in which adaptation measures would be implemented in the same sequence as Scenario 1, except that restoration would be included. If marshes were not able to keep pace with sea-level rise, or if the areas surrounding the existing wetlands were not available for wetland transgression, restoration could be used to create new marsh in alternative locations. This adaptation measure could be implemented in the following sequence:

1. Allow/facilitate wetland conversion and transgression as long as accommodation space is available and wetland transgression can keep pace with sea-level rise.

2. As existing wetlands begin to drown due to increasing rates of sea-level rise, place sediment in the marsh to raise elevations.

3. As sea-level rise continues, identify areas available for restoration and expand the marsh into these locations.



Del Mar Adaptation Plan . D150347

Figure 38

Wetlands Adaptation Scenario 2: Wetland Expansion/Restoration

5.5.4 Wetland Adaptation Coastal Permitting

As discussed previously, Coastal Development Permit review and approval for wetland adaptation measures may be processed through either the City of Del Mar's LCP and/or by the California Coastal Commission. The likely coastal permitting mechanisms for wetland adaptation measures are summarized below for the purpose of informing the development of the LCP Amendment as a next step. Other approvals and permits would also be required and would need to be addressed separately.

TABLE 19
SUMMARY OF LIKELY CALIFORNIA COASTAL ACT APPROVAL AND PERMITTING PROCESS

Adaptation Measure	LCP Jurisdiction	CCC Jurisdiction	Note
Allow/facilitate wetland conversion & transgression	✓	✓	• Future wetland area zoning • Expand lagoon overlay zone to accommodate sea-level rise • San Dieguito Lagoon Restoration / SONGS Mitigation Project consideration
Sediment placement		✓	• Below mean high water • Component of Sediment Management Plan
Wetland expansion / restoration	✓	✓	• Future wetland area zoning • Component of partial Valley/Fairgrounds retreat

CHAPTER 6

Adaptation Measures Considered but not Recommended

Adaptation measure that were considered and discussed with the STAC, but were not recommended by the STAC for inclusion in the Adaptation Plan are discussed below.

6.1 Bluff Sea Wall with Public Access

Construction of a sea wall or other armor to protect the southern bluffs was not recommended by the STAC because the sea wall/bluff would lead to the loss of the beach below the bluff, which would be in conflict with the guiding principles established for the Adaptation Plan (Section 3). If the bluff location were fixed with a sea wall, beach loss would occur as the beach is “squeezed” and “drowned” out against the sea wall in response to ongoing beach erosion and sea-level rise. While bluff erosion is not the only source of sand supply, a sea wall would cut of sand supply from the bluff to the beach. Loss of the beach and sea-level rise would also increase wave loadings on a sea wall and complicate sea wall design and maintenance.

Options for providing public access on the sea wall to compensate for the loss of beach access were considered. Figure 39 shows existing access along the southern bluffs, where the existing beach below the bluff provides horizontal beach access and unauthorized crossings of the railroad and vertical access down the bluffs to the beach occurs. Figure 40 shows the sea wall with access that was considered for adaptation, with authorized access along the sea wall providing horizontal access in place of beach access once the beach is lost. Authorized railroad crossings and access paths (e.g., stairways) down the bluffs to the ocean to provide vertical access (e.g., for surfing) were also considered. Figure 41 shows an example of a sea wall with a stairway to illustrate the concept.

Del Mar Adaptation Plan . D150347

Figure 39

Existing Southern Bluff Access

Del Mar Adaptation Plan . D150347

Figure 40

Bluff Sea Wall with Public Access Adaptation Measure - Not Recommended

Del Mar Adaptation Plan . D150347

SOURCE: SAGE Engineers 2010

Figure 41

Pleasure Point Seawall in Santa Cruz, CA (Example Considered, but not Recommended)

Consideration of a sea wall acknowledged that per the California Coastal Act, if a sea wall was installed to provide bluff protection, coastal permitting would require that the sea wall be removed in the future. Thus, the loss of the beach would not be permanent and the bluff and beach could be restored after the sea wall is removed (i.e., after bluff top structures are removed); however, this "temporary" loss of beach is still in conflict with the guiding principles.

As discussed in Sections 2 and 5.3.1.3, the City's current LCP does not allow for sea walls within the Shore Protection Area and Beach Overlay Zone. Construction of a permanent sea wall to protect the railroad from bluff erosion would not be consistent with or allowed by the LCP or the California Coastal Act.

6.2 River Levee Protection without Partial Retreat

Constructing levees to reduce the River flood risk without partial retreat/wetland floodplain restoration was considered as an adaptation measure, but was not recommended by the STAC because this option was less desirable than construction levees with partial retreat/wetland restoration. Figure 42 shows an example levee alignment without retreat. This approach was not desirable because it forgoes opportunities to restore areas that are highly vulnerable to flooding to wetlands, thereby creating habitat that improves resiliency to sea-level rise and expanding the River floodplain.

Del Mar Adaptation Plan . D150347
Figure 42
Levee Protection without Partial Retreat – Not Recommended

CHAPTER 7
Summary and Conclusions

In summary, the Del Mar Sea-Level Rise Adaptation Plan includes the following components, findings, and conclusions:

High Priority Adaptation Measures

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

North Beach Flooding and Erosion Adaptation Plan

- Beach and dune nourishment 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 facilitate raising private buildings in the near-term and over time.
- Sand retention measures such as groins or artificial reef may help maintain the beach, but would likely require mitigation and affect surfing resources.
- Raising/improving the existing sea wall and revetments (i.e., "holding the line") would reduce flood risks with sea-level rise, but would likely result in beach loss over time and would require future removal of the sea walls and revetments for consistency with Coastal Act prohibitions against protection in perpetuity.
- Raising City infrastructure including buildings, utilities, and roads will likely be required to accommodate the increase in flood risk with sea-level rise.
- In the long-term with higher amounts and rates of sea-level rise, removing structures will likely be required to meet the guiding adaptation principles of maintaining a relatively low flood damage risk and a walkable beach.

Bluff Erosion Adaptation Plan

- Beach nourishment and 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, thereby maintaining a beach below the bluff and providing access along the bluff top.
- Removal of bluff top buildings, sewer lines, and roads will eventually be required as the bluff continues to recede inland.

San Dieguito River Flooding Adaptation Plan

- 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.
- As an alternative to levees, structures can be raised in the mid-term and removed in the long-term; this would apply to large sections of the North Beach District and Del Mar Fairgrounds due to the extent of the River floodplain.
- If Lake Hodges reservoir management is not possible, the timeframe for other measures may be sooner.

San Dieguito Lagoon Wetland Adaptation Plan

- 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.

CHAPTER 8

Next Steps

This Administrative Draft of the Del Mar Sea-Level Rise Adaptation Plan will be revised in response to comments from the public and the California Coastal Commission. A formal amendment to the LCP including sea-level rise-related policies and regulations will then be drafted based on the Adaptation Plan and Coastal Hazards, Vulnerability, and Risk Assessment (ESA 2016). The LCP Amendment will then be reviewed before the City Planning Commission and City Council for approval prior to submitting the LCP Amendment to the California Coastal Commission for review and approval.

A Del Mar Sediment Management Plan will also be prepared to further analyze a beach and dune nourishment plan optimized to maintain the Del Mar beach, coastal access, and to protect development. The Sediment Management Plan will consider dredged material reuse as well as other potential sources of sand. The Sediment Management Plan will serve as a companion document to the Adaptation Plan and LCP Amendment that provides the framework for implementing sediment management adaptation measures and associated LCP Amendment policies.

Also, a San Dieguito Lagoon Wetland Habitat Migration Assessment will be performed 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. The assessment will inform and serve as a companion to the LCP Amendment.

CHAPTER 9
References

California Coastal Commission (CCC), 2015. Sea Level Rise Policy Guidance – Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits, State of California Natural Resource Agency.

California Coastal Commission (CCC), 2005. San Dieguito Wetland Restoration Plan, Coastal Development Permit Application No. 6-04-88. Filed September 29, 2005.

City of Del Mar, 1976. The Community Plan for the City of Del Mar, California. http://www.delmar.ca.us/DocumentCenter/View/250

City of Del Mar, 1993. Land Use Plan. City of Del Mar Local Coastal Program. March 18, 1993.

City of Del Mar, 2001. City of Del Mar Local Coastal Program (LCP) Implementing Ordinances. September 11, 2001.

City of Del Mar, 2016. Title 30 – Zoning. City of Del Mar Municipal Code. Del Mar, CA.

Crabtree, R., 2016. Photo of High Tide at 25th Street. March 8, 2016.

ESA PWA, 2012. Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay. Prepared for the Monterey Bay Sanctuary Foundation and the Southern Monterey Bay Coastal Erosion Working Group. May 30, 2012.

ESA, 2015. San Francisco Littoral Cell Regional Coastal Sediment Management Plan. Prepared for the U.S. Army Corp of Engineers and the Coastal Sediment Management Workgroup. August, 2015.

ESA, 2016. Coastal Hazards, Vulnerability, and Risk Assessment. Prepared for the City of Del Mar. July, 2016.

Fletcher, K., 1983, Photos of Del Mar Waterfront During and After 1983 El Niño Storm.

Gritchen, J., 2014. Photo of Long Beach Breakwater. The Orange County Register. February 3, 2014. http://www.ocregister.com/articles/breakwater-600078-army-beach.html

Lynn, J., 2016. Frames from Video of Wave Overtopping Along Seawall at 29th Street. January 7, 2016.

Peterson, C. and Bishop, M., 2005. Assessing the Environmental Impacts of Beach Nourishment. *BioScience*. DOI: 10.1641/0006-3568(2005)055[0887:

Moffatt & Nichol, 2009. Coastal Regional Sediment Management Plan for the San Diego Region. Prepared for SANDAG and the California Coastal Sediment Management Workgroup. March 2009. http://www.dbw.ca.gov/csmw/pdf/FinalRSM_SANDAG_4_1_09BOEMRE.pdfSAGE Engineers, 2010. Photo of Pleasure Point Seawall Project. Santa Cruz, CA. http://sageengineers.com/portfolio/east-cliff-drive-bluff-protection-parkway-improvements/

SANDAG, 2011. 2050 Regional Transportation Plan. October, 2011. http://www.sandag.org/uploads/2050RTP/F2050rtp_all.pdf

San Diego County Water Authority (SDCWA), 2016. Lake Hodges Project. SDCWA Website. http://www.sdcwa.org/lake-hodges-projects

Schlacher, T. et al., 2012. The effects of beach nourishment on benthic invertebrates in eastern Australia: impacts and variable recovery. *Sci Total Environ*. October, 2012. DOI: 10.1016/j.scitotenv.2012.06.071

USFWS, 2016. Quarterly Progress Report as of March 31, 2016 for the Initiation of Thin-Layer Sediment Augmentation on the Pacific Coast. Agreement No. P1496011 00. April 18, 2016. https://www.fws.gov/uploadedFiles/Jan%20-%20March%202016%20CDFW%20Quarately%20Report%20w%20USGS%20att.pdf

APPENDIX A
Carbon Sequestration in Wetlands

Coastal wetlands, including mangroves, tidal marshes, and seagrasses, are highly productive and valuable ecosystems that contribute an important part of regional and global carbon cycles. The concept of "coastal blue carbon" recognizes that improved management of marshes, mangroves, and seagrasses can result in protection of vulnerable stocks of sequestered atmospheric carbon dioxide (CO_2), now held in biomass and soils, and ongoing sequestration capacity. Particular focus has centered on wetlands, which occupy less than 2% of the ocean surface, but represent almost 50% of the ocean's transfer of carbon to burial in sediment sinks (Duarte et al. 2005).

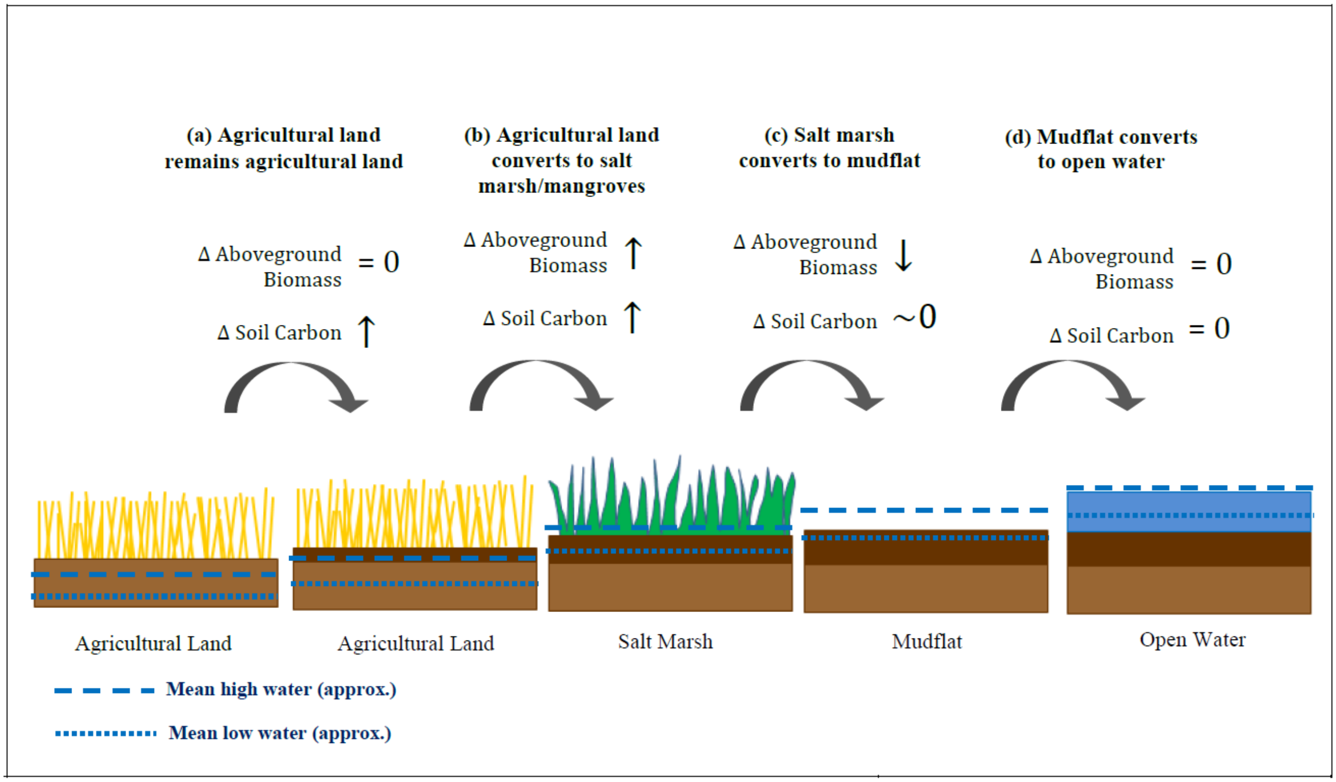
To calculate GHG emissions and removals, the Intergovernmental Panel on Climate Change (IPCC) developed guidance on how to incorporate management of wetlands within national accounts of GHG emissions (IPCC 2014). Using the IPCC guidance, a GHG accounting framework could be developed for Del Mar to quantify future changes in GHG fluxes due to sea-level rise and different coastal management strategies. Changes in CO_2 and methane (CH_4) fluxes[2] can be estimated over time as habitats evolve as a result of sea-level rise. To calculate these values, the framework would use locally and/or regionally appropriate values or estimates of biomass, soil carbon sequestration rates, and methane emission rates for each habitat type to estimate GHG fluxes based on land use changes (habitat acreages over time).

With sea level rise, existing wetland habitats in Del Mar will be inundated more frequently and vegetated wetland habitats will be "drowned out" and convert to intertidal mudflats and subtidal habitat. Existing pickleweed marsh habitat could drown out and be lost by 2070. Cordgrass low marsh habitat could be lost by 2090, 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.

Using habitat acreages, changing carbon stocks can be tracked through time as sea level rises and marshes migrate inland. For example, when land is covered with vegetation, there is a stock of carbon in the biomass and the soil, and the soil carbon increases according to the soil sequestration rate of the habitat, due to the incorporation of dead organic matter back into the soil (Figure A1). When a habitat converts to another habitat (e.g., from transition habitat to salt marsh), aboveground biomass changes (may increase or decrease) due to the different type of vegetation, and soil sequestration continues, but at the rate of the new habitat type (Figure A1).

2 A GHG flux is the combination of emissions and removals of GHGs.

With sea-level rise, when salt marsh converts to mudflat, aboveground biomass is lost and soil sequestration halts, but some soil carbon stored prior to the conversion remains sequestered within the mudflat (Figure A1).



Del Mar Adaptation Plan . D150347

Figure A1

Conceptual Model of GHG Accounting Framework

Note: This is an example and does not show all possible habitat conversions. Mean sea level shown for reference only. Time between transitions is not specified and depends on land elevations, rate of sea level rise and accretion rate.

References

Duarte, C.M., Middelburg, J.J. & Caraco, N. 2005. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences, 2, 1–8.

IPCC. 2014. 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands. Methodological Guidance on Lands with Wet and Drained Soils, and Constructed Wetlands for Wastewater Treatment.