# Venice
# Sea Level Rise Vulnerability Assessment

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# Acronyms & Abbreviations

| Acronym/Abbreviation | Term |
|---|---|
| BFE | Base Flood Elevation |
| CCC | California Coastal Commission |
| CDIP | Coastal Data Information Program |
| CEQA | California Environmental Quality Act |
| cm | centimeter |
| CNDDB | California Natural Diversity Database |
| COAST | Coastal One-line Assimilated Simulation Tool |
| CoSMoS | Coastal Storm Modeling System |
| FEMA | Federal Emergency Management Company |
| FIRM | Flood Insurance Rate Map |
| ft | feet |
| GIS | Geographic Information System |
| gpm | Gallons per minute |
| H++ | Extreme SLR scenario due to rapid Antarctic ice sheet mass loss (Sweet et al, 2017) |
| HD | Historic District |
| in | inch |
| IP | Implementation Plan |
| LA | Los Angeles |
| LAUSD | Los Angeles Unified School District |
| LCP | Local Coastal Program |
| LUP | Land Use Plan |
| m | meter |
| mcy | million cubic yards |
| M&N | Moffatt & Nichol |
| MHHW | Mean Higher High Water |
| MLLW | Mean Lower Low Water |
| MSL | Mean Sea Level |
| NAVD 88 | North American Vertical Datum of 1988 |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | National Research Center |
| OCOF | Our Coast, Our Future |
| OPC | Ocean Protection Council |
| PFIRM | Preliminary Flood Insurance Rate Map |
| PP | Pumping Plant |
| SLR | Sea Level Rise |
| SVI | Social Vulnerability Index |
| TAG | Technical Advisory Group |
| USACE | United States Army Corps of Engineers |

| | |
|---|---|
| USGS | United States Geological Survey |
| VCA | Venice Canals Association |
| VA | Vulnerability Assessment |
| VAPP | Venice Auxiliary Pumping Plant |
| VSPP | Venice Stormwater Pumping Plant |
| VPP | Venice Pumping Plant |
| yr | year |

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# 1. Introduction

This vulnerability assessment presents a Venice-specific sea level rise (SLR) analysis to support an update to the city's Local Coastal Program in the Venice Coastal Zone. The assessment evaluates the degree to which important community assets are susceptible to, and unable to, accommodate adverse effects of projected SLR. The assessment identifies the assets that are likely to be impacted and the causes and components of each asset's vulnerability. The findings of this study will inform policy and adaptation efforts for the Venice area to be incorporated into an updated Local Coastal Program (LCP).

## 1.1 Scope of Work

The consultant team hired by the City of Los Angeles to assist with the LCP update consists of Dudek (prime), Moffatt & Nichol (M&N) and Kearns & West. M&N's role on the project team is to prepare a Sea Level Rise Vulnerability Assessment following the scope of work defined in Task 1 of the final work program for Coastal Commission Grant LCP 14-09. A brief description of Task 1 is provided below:

1.1. Identify five (5) SLR scenarios with input from the project team and based upon information available in the regional studies. These scenarios will be selected to provide a basis for understanding how hazards and vulnerabilities change with each increment of SLR.

1.2. M&N will evaluate previous studies and published SLR hazard data to understand the assumptions and limitations of the data, model(s), or method(s) used and whether said limitations or assumptions lead to overestimation, underestimation, or unknown impacts on the mapped hazard zones in Venice.

1.3. M&N will compile spatial data on City assets and resources to create a GIS basemap from which the various coastal hazards will be overlain. These maps will provide the basis for a Venice vulnerability assessment (VA) and provide a valuable resource for City staff to communicate the potential coastal hazards to stakeholders, resource agencies, and the public.

1.4. M&N will prepare a memorandum to summarize the previous studies and identify how SLR hazard information available from previous studies can be applied in the Venice VA. This memorandum will discuss the assumptions and limitations of the data, model, or method and whether said limitations or assumptions lead to overestimation, underestimation, or unknown impacts on the mapped vulnerabilities.

1.5. M&N will create a qualitative and quantitative assessment of consequences/risks/impacts on coastal resources.

1.6. M&N will prepare a Venice VA that will build from the previous regional SLR studies. Results of the Venice VA will inform preparation of the Land Use Plan (LUP) Coastal Hazards policies and Implementation Plan (IP) standards by identifying "triggers" at which significant planning areas, assets, or coastal resources could be impacted by SLR. The consequence of the identified impacts will also inform the policies and programs to minimize risk to important infrastructure, basic services, and valuable resources. The vulnerabilities and consequences identified in this assessment will help prioritize planning efforts to account for the urgency (time horizon) of each impact, and the importance of each impact on the community and resources. M&N will prepare a matrix that evaluates potential risks and impacts of SLR to asset categories by rating and describing the exposure, sensitivity, and adaptive capacity.

1.7. M&N will develop presentation materials in coordination with the project team and present the findings of the Venice VA to the Technical Advisory Group (TAG) and to the Community at two public workshops.

## 1.2 Vulnerability Assessment Approach

The purpose of this assessment is to identify potential significant physical impacts and their various externalities to better understand current and future local hazard conditions that influence local resources, as defined for the study area. A resource's vulnerability to SLR is a product of its exposure to hazards (potential damage or loss of function), its sensitivity to said hazards, and its adaptive capacity (ability to restore function or avoid damage). Resiliency can come from increasing an asset's adaptive capacity by reducing exposure to hazards (e.g. through protection). Some of the resources identified in this study have reduced exposure to hazards, such as inland flooding because of protective measures such as tide gates. In the case of these protective resources that have an unknown potential for failure, this assessment looks at an asset's exposure to SLR in the case of a failure of these protective resources. This approach allows for a greater understanding of the impact of protective resources on the coastal zone's vulnerability and resiliency to SLR.

The approach for this study is as follows:

1. Identify coastal resources within the Venice coastal zone.
2. Choose appropriate SLR scenarios that allow for the identification of critical thresholds, as well as short-term and long-term issues.
3. Use the best available models to understand the type, extent, and location of physical hazards to identified resources.
4. Assess each resource's vulnerability by considering exposure, sensitivity, and adaptive capacity.

## 1.3 Background

Venice was founded as a resort town in 1905 and was an independent city until it merged with the City of Los Angeles in 1926. The town's founder, Abbot Kinney, dredged several canals in the former saltwater marshes of an area known as "La Ballona" (see Figure 1.1) to drain areas for development. Some historic canals were filled after it was decided to turn them into streets (Masters, 2013). The Venice Canals are the only remaining canals in the community today and are a popular attraction for locals and visitors to the area (VCA, 2009). Tourism has been a driving economic engine for the area since its inception, with an amusement pier, shown in Figure 1.1 and Figure 1.2, functioning as the center of beachfront activity in the 1920s (Stanton, 1998). The amusement pier was later demolished in the 1940s, but the rock breakwater along the seaward edge of the pier was left intact and continues to function as an effective sand retention structure.


*Figure 1.1: Historic Aerial of Venice, August 1927*
*(Special Research Collections, University of California Santa Barbara Library)*

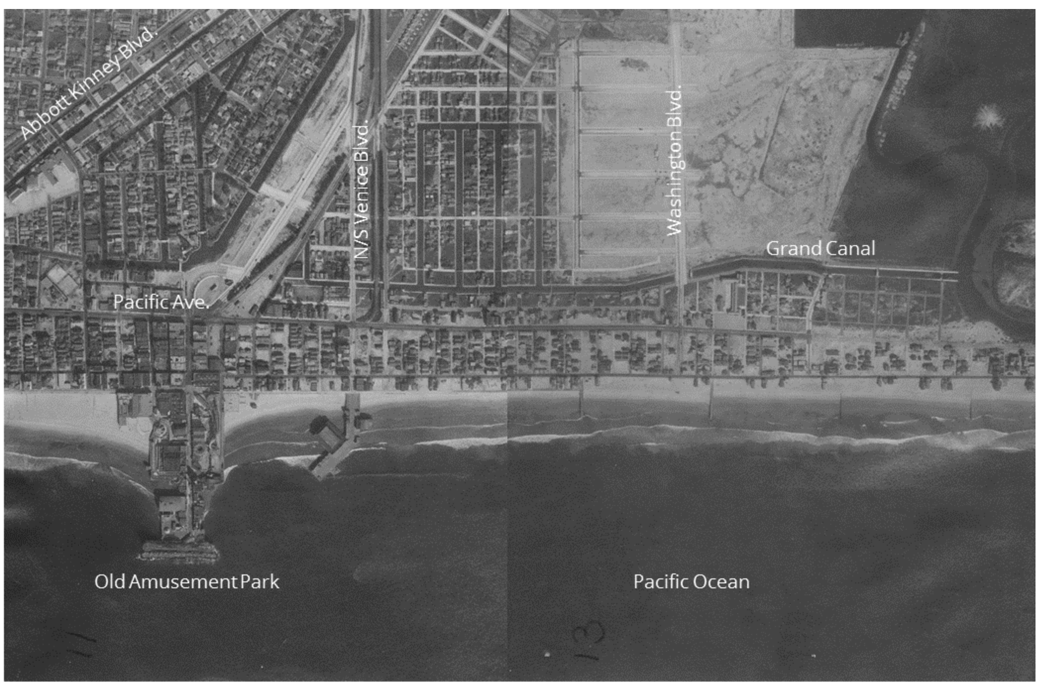



*Figure 1.2: Historic Aerial of Venice, January 1928*
*(Special Research Collections, University of California Santa Barbara Library)*

## 1.4 Coastal Setting

The Venice coastal zone sits within the historic Ballona Marsh and is characterized by its wide and sandy beaches backed by beachfront development. It’s important to note that prior to the 1930s beaches were much narrower than they are today. Much of the coastal development shown in Figure 1.1 and Figure 1.2, which lined the back beach, were subject to coastal erosion and flooding during extreme storm events. Artificial sand nourishments between 1945 and 1960 placed over 14 million cubic yards (mcy) of sand on Venice beach, which widened the beach by ~500 feet (Orme et al, 2011). Most of the sand came from excavation of the coastal dunes during construction of the Hyperion Treatment Plant. In addition to these large historic nourishments, coastal structures like the Santa Monica and Venice breakwaters, rock groin north of Venice Pier and the Marina del Rey Jetty have stabilized the artificially-widened beaches. The effect of these structures on the shoreline configuration is evident in Figure 1.3, especially near the Venice breakwater.


*Figure 1.3: Oblique Aerial of modern Venice Beach (Perry, 2012)*

Venice and nearby Marina del Rey and Playa del Rey are among the lowest lying elevations along Santa Monica Bay (Figure 1.4). Throughout this report elevations are referenced to North American Vertical Datum of 1988 (NAVD88) unless otherwise noted. Elevations near the beach range from 15 feet to 25 feet (NAVD88), giving way to the Ballona Lagoon in the south and a low-lying area approximately bounded by Abbot Kinney Boulevard, Pacific Avenue, and Washington Boulevard with elevations ranging from 3 feet to 9 feet (NAVD88) (Figure 1.5). The canals have access to the ocean via Grand Canal and Ballona Lagoon, and have water levels managed by two tide gates.

The Venice Canals Historic District (HD) is known for its picturesque man-made canals and homes. The HD was placed on the National Register of Historic Places in 1982 (VCA, 2009). The Venice Canals Association (VCA) was established in 1976 and works with city officials to "protect, preserve, and enhance" the district and includes property owners, residents, and non-residents or "Friends of the Canals." The canal banks have suffered severe deterioration in the past with multiple efforts to try and restore or clean up the canals. In 1993, the canal banks were upgraded with Loffelstein blocks and dredged to remove contaminated sediment and debris.


*Figure 1.4: Map of Regional Elevations Relative to Venice*
*(Screen Capture from NOAA Sea Level Rise Viewer DEM)*

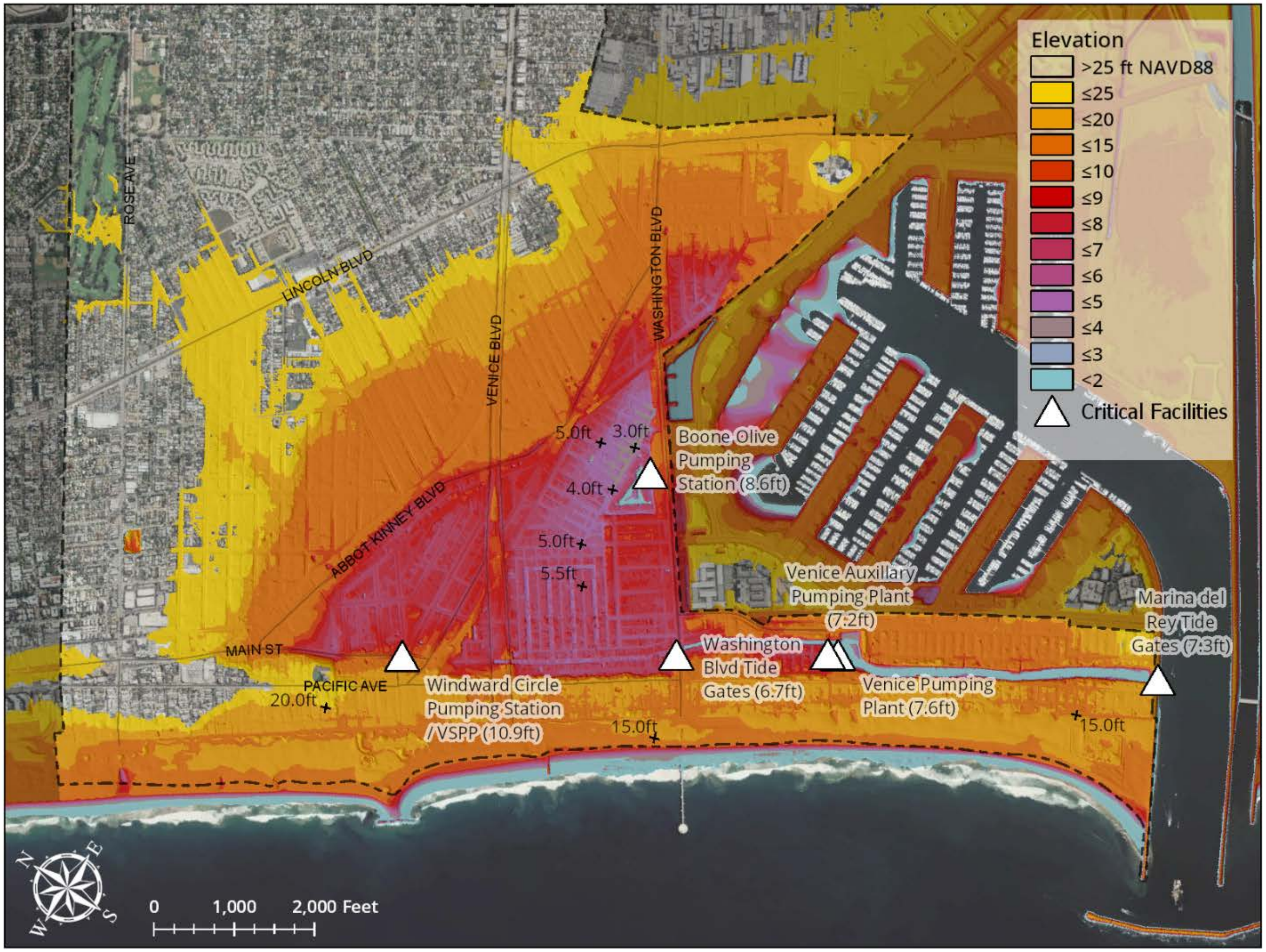



*Figure 1.5: Map of Low-lying Areas in Venice*
*(Using CoSMoS COAST 3.0 Digital Elevation Model)*

CALIFORNIA COASTAL COMMISSION

# 2. Inventory of Coastal Resources

An inventory of coastal resources was created to capture particular assets, communities, land uses, and infrastructure potentially at risk within the Venice coastal zone. These resources were identified through a variety of methods, including publicly available government databases, reports, and aerial imagery. The list focuses on all resources within the maximum extent of modeled hazard layers discussed in Section 5.

*Table 2.1:Inventory of Coastal Resources*

| Type | Resource | | Data Source |
|---|---|---|---|
| Infrastructure | Tide Gates | • Marina del Rey<br>• Washington Boulevard | LA City geohub |
| | Stormwater Pumping Plants | • Venice Stormwater Pumping Plant (VSPP) & Westward Stations<br>• Boone & Olive | LA County GIS |
| | Wastewater Pumping Plants | • Venice Pumping Plant (VPP)<br>• Venice Auxiliary Pumping Plant (VAPP) | LA County GIS |
| | Storm Drain Outfalls | • Three beach outfalls (excluding additional outfall not identified in County GIS data), 1 in Marina del Rey connected to Boone & Olive Pumping Plant (PP) | LA County GIS |
| | Utilities | • Water and electricity | LA County GIS |
| | Sewage and Stormwater Network | | LA County GIS |
| | Transportation Infrastructure | • Pedestrian, bike, and auto | LA County GIS |
| | Coastal Structures | • Venice breakwater, marina jetty, groins | LA County GIS |
| Property | Residential | • Parcels and buildings | LA City geohub |
| | Commercial | | LA City geohub |
| | Industrial | | LA City geohub |
| | Open Space/Civic Facilities | | LA City geohub |
| Cultural | Historic Districts (HD) | • Venice Canals HD<br>• Lost Venice Canals HD, North Venice Walk Streets HD, Milwood Walk Streets HD, Windward-Pacific Commercial HD | LA City geohub<br>SurveyLA |
| | Coastal Historic Monuments | • Venice West Café, Warren Wilson Beach House, Venice Arcades (aka Windward Arcades) | LA City geohub |
| | Abbot Kinney and Venice Boulevard. Historic Resources | • Kinney-Tabor House, Venice Branch Library, Venice Division Police Station, Sturtevant Bungalow, Venice City Hall, Venice of America House | LA City geohub |

| Type | Resource | | Data Source |
|---|---|---|---|
| Civic | Bus Lines | • Metro: 108, 33, 733<br>• Santa Monica Big Blue Bus (SMBBB): 1, 18<br>• LADOT: CE437<br>• Culver City: 1 | LA City geohub, SMBBB, Culver City Bus, and LADOT |
| | LA Metro Division 6 Lot | | LA Metro |
| | Parking (City-owned) | | LA City geohub |
| | Parking (County-owned) | | LA County GIS |
| | Coastal Path/Bike Path | | LA County GIS |
| | Lifeguard HQ | | LA County Fire |
| Civic | Lifeguard Towers | • 22 in total | LA City geohub |
| | Schools – LAUSD | • Coeur d'Alene Elem.<br>• Westminster Avenue Elem.<br>• Westside Global Awareness Magnet<br>• Broadway Elem./ Venice Skills Center (not affected) | LA City geohub |
| | Schools – Private/Charter | • Acton Academy Venice Beach, Ánimo Venice Charter High School, St. Mark School, Venice Lutheran School (not affected) | LA City geohub |
| | Police Stations | • LAPD Venice Substation | LAPD |
| | Fire Stations | • LAFD Station 63 | LA City geohub |
| Coastal Amenities | Recreation Centers | • Venice Beach<br>• Oakwood | LA City geohub |
| | Venice Beach Ocean Front Walk | | |
| | Municipal Fishing Pier | | LA City geohub |
| | Beach Recreation | | |
| Ecological | Sandy Beach Habitat | • Grunion, Least Tern, Snowy Plover, etc. | California Natural Diversity Database (CNDDB) |
| | Ballona Lagoon Marsh Preserve | • Orcutt's Pincushion, Least Tern, subtidal and intertidal habitat, etc. | CNDDB |
| | Canals Area Environmentally Sensitive Habitat Area (ESHA) | • Subtidal and intertidal habitat | Venice Land Use Plan 2001 |

These resources were mapped using GIS and can be found in Figure 2.1.


*Figure 2.1: Map of Coastal Resources in the Venice Coastal Zone*

# 3. Coastal Processes

## 3.1 Historical and Existing Coastal Hazards

Venice has historically been at risk of flooding from coastal storms as well as tidal flooding in the low-lying inland areas. One of the most well-recorded incidents of coastal storm-related damage occurred during the 1982-1983 El Niño (see Figure 3.1). During this winter season, Southern California was hit by several large storms, which eroded the beach and caused flooding along Washington Boulevard up to Pacific Avenue. Many of the coastal structures and the bike path were severely damaged due to direct exposure to wave action or undercutting of the sand foundations, including the Municipal Fishing Pier, lifeguard headquarters and coastal trail.

*Figure 3.1: Damage to Venice Coastal Trail from 1982-1983 El Niño Season*
*(January 1983, Treasurenet.com)*

Historical records of flooding in the canals are unclear and tidal flooding has, for the most part, been limited due to the dual tide gate system. Flood hazard vulnerability for the low-lying region, including the canals, are two-fold: first, from high tide events and second, from heavy rainfall. During a high tide event, a failure of the tide gate systems can result in flooding from the Pacific Ocean due the area's low elevation. In August 2017, a technical issue with the Marina del Rey tide gate caused flooding up to the sidewalk in and around the canals area until authorities could rectify the situation (see Figure 3.2). The reported maximum tide height was 6 feet mean lower low water (MLLW) and no damage was reported (DuFay, 2017). During large rainfall events, stormwater in the areas around the canals is gravity-drained to the canals. This runoff is then drained to the ocean during low tide. When ocean water levels are high, the canals are mechanically closed off from the ocean. This means that stormwater can accumulate in the canals and cause stormwater-related flooding.

*Figure 3.2: Flooding at Intersection of Sanborn Avenue and 28th Avenue Due to Tide Gate Failure (Photo from VeniceUpdate.com (Dufay, 2017))*

## 3.2 Wave Climate

Waves act to carry sand in both the cross-shore and longshore directions and can also cause short-duration flooding events by causing dynamic increases in water levels. Thus, the wave climate (or long-term exposure of a coastline to incoming waves) and extreme wave events are important in understanding future SLR vulnerabilities.

For Venice, storms can cause extreme nearshore wave heights of 13.8 feet (5-yr return period) and 22.6 feet (100-yr return period) (Station 132: USACE, 2010). These can cause shoreline runup reaching 3 feet to 6 feet in vertical elevation on the beach (Terra Costa, 2016). The damage caused by the January 1983 El Niño storm was in part due a sequence of major storms starting in November 1982. The waves associated with these storms were exceptional because of their height, long periods, and more westerly approach. Coastal damage was aggravated by the synchronization of the January 1983 wave event with unusually extreme water levels. The frequency of these storms also reduced the beach width and left the backshore more vulnerable to wave attack and runup, which in combination caused a significant amount of damage to beach amenities (bike path) and the Lifeguard Headquarters building in Venice.

## 3.3 Water Levels

The tides in Venice are mixed semidiurnal, with two high tides and two low tides of differing magnitude occurring each day. Astronomical tides make up the most significant amount of the total water level. Typical daily tides range from MLLW to mean higher high water (MHHW), a tidal range of about 5.5 feet based on the tidal station at Santa Monica Municipal Pier (NOAA Station 9410840). During spring tides, which occur twice per lunar month, the tide range increases to about 7 feet due to the additive gravitational forces of the sun and moon. During neap tides, which also occur twice per lunar month, the forces of the sun and moon partially cancel out, resulting in a smaller tide range of about 4 feet. The largest spring tides of the year are sometimes referred to as “king tides” and result in high tides of 7 feet or more above MLLW and tidal ranges of more than 8 feet.

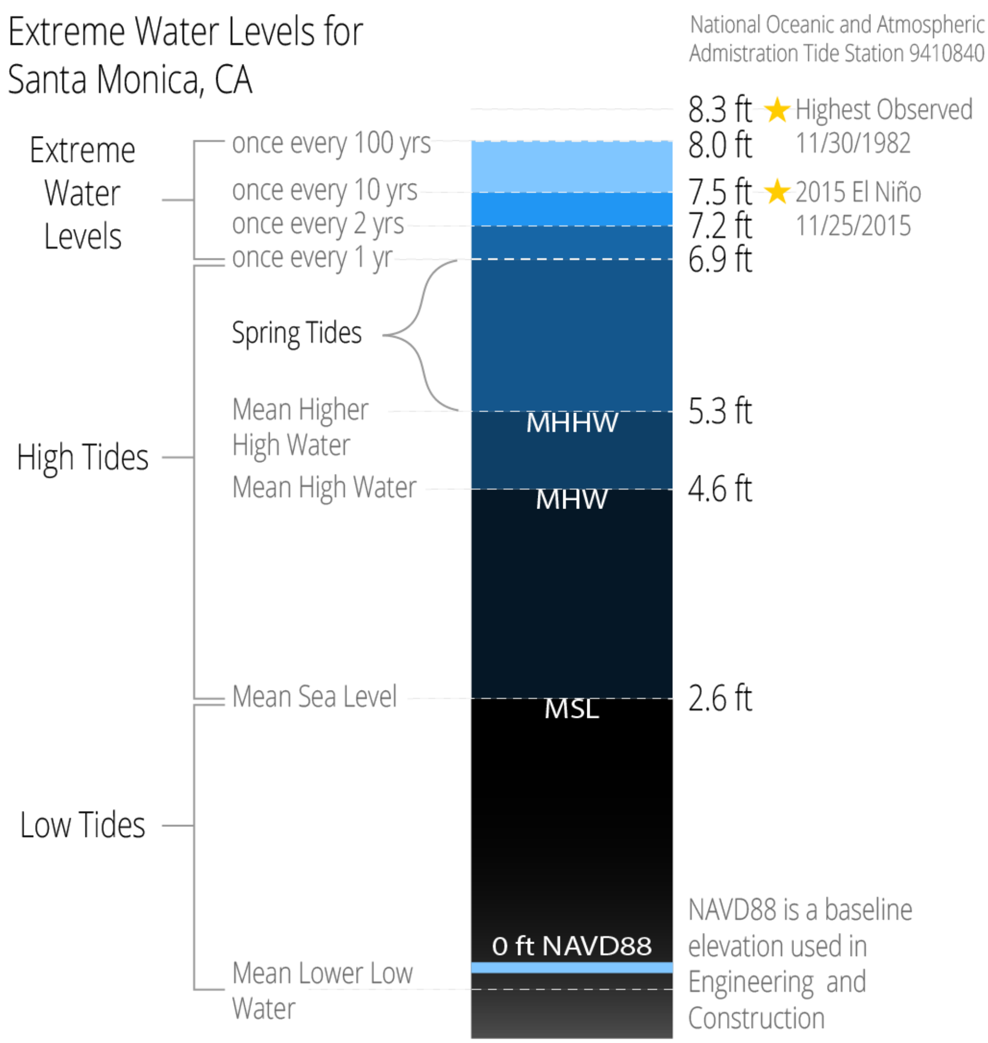



*Figure 3.3: Tidal Datums for Santa Monica Municipal Pier NOAA Tide Station No. 9410840*

## 3.4 Littoral Processes and Shoreline Change

The Venice shoreline has been greatly shaped by human activity and development in the 20th century. From the 1930s to 1963, more than 32 mcy of sand were placed on the beaches of Santa Monica Bay. This sand nourishment came from large construction projects, such as those at Marina del Rey, the Los Angeles International Airport, and the Hyperion Wastewater Plant (Terra Costa, 2016). Over 14 mcy were placed on Venice Beach mainly from excavation of the Hyperion Treatment Plant. The historic nourishments increased the beach width in Venice by ~500 feet (Orme et al, 2011). Coastal structures such as the old piers, Santa Monica and Venice breakwaters, smaller groins, and the marina jetty have slowed the transport of this sand out of the system and maintained areas of very wide beaches.

While the beach has been kept artificially wide for decades, SLR has the potential to increase beach erosion. A widely accepted consequence of SLR is a landward and upward shift of the beach profile in response to higher waves and water levels. This landward shoreline response to SLR is described by the Bruun Rule, illustrated in Figure 3.4. This long-term shoreline retreat results in a process known as "coastal squeeze," in which resources on the sandy beach are squeezed between rising seas and a fixed line of development along the back beach.

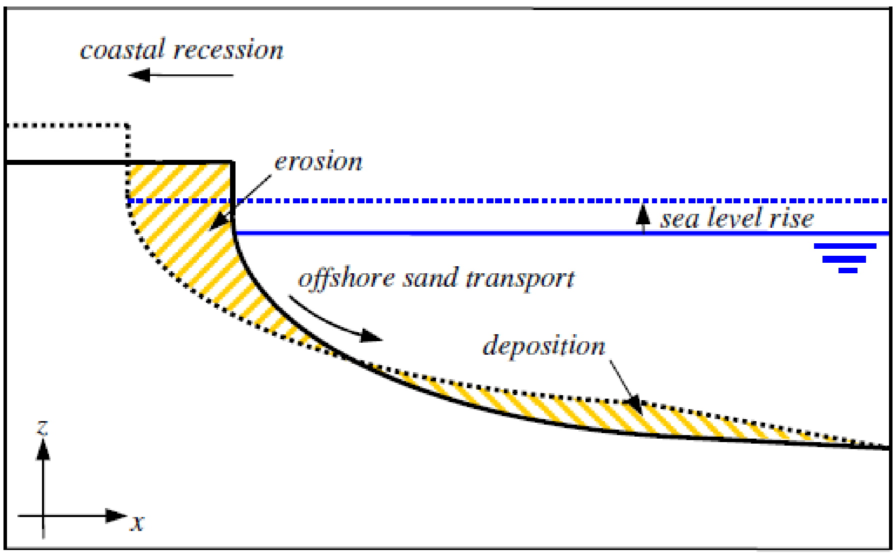



*Figure 3.4: Schematic of Beach Profile Changes due to SLR (Bruun Rule)*

The long-term rate of shoreline retreat is also a function of sediment supply. The natural supply of sediment to beaches in Santa Monica Bay from fluvial discharges has been reduced by development in the watershed (i.e. channelization of the Los Angeles River, construction of dams and debris basins). The natural supply of sediment from littoral drift (transport of sand along a shoreline) has been reduced by retreat of the Mugu Submarine Canyon, which captures the majority of sediment moving south along beaches of Ventura County (Griggs & Patsch, 2018). Artificial nourishment has been the main source of sand to the beaches of Venice and Santa Monica over the last century. Given the limited natural supply of sediment from streams and littoral drift, artificial nourishments will likely be the main source of sediment to mitigate the effects of coastal squeeze.

## 3.5 Venice Canals Tide Gate System

The Venice Canals District and nearby low-lying areas are protected from tidal flooding through a dual tide gate system. The first line of defense is the Marina del Rey tide gate (Figure 3.5), which is located on the northern Marina del Rey jetty and directly connects the Ballona Lagoon to the Pacific Ocean. The second tide gate is located at Washington Boulevard and directly connects the Venice Canals to the Grand

Canal, which opens to Ballona Lagoon. Both tide gates are owned by the City of Los Angeles and serve to mute the lower and upper limits of the ocean tidal range. This reduction in tide range allows for increased stormwater drainage capacity and prevents flooding that would otherwise occur during astronomical high tides.

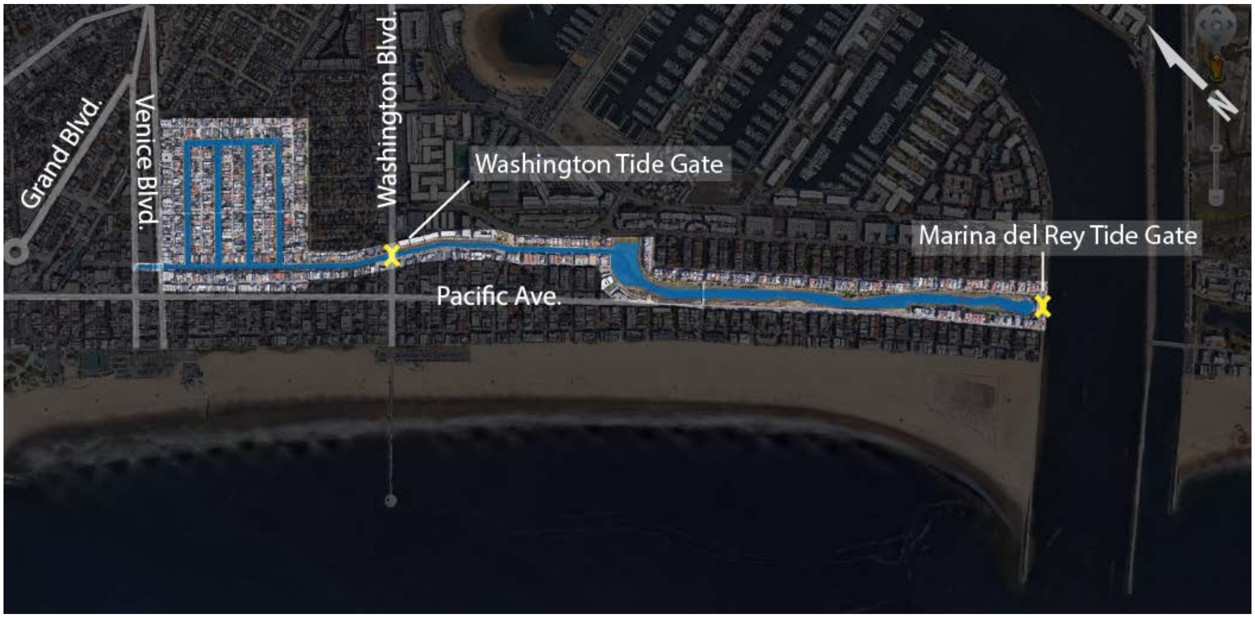



*Figure 3.5: Plan View of Tide Gate System*

The two tide gates operate on separate schedules. The Marina del Rey tide gate has two modes: dry mode and wet mode. These modes are based on seasonal precipitation according to a 2007 report by Phillip Williams and Associates (PWA). During a dry mode, the Marina del Rey gate is closed when the following conditions are met:

- Marina water level exceeds 2.25 feet mean sea level (MSL)
- Marina water level is more than 0.25 feet higher than Ballona Lagoon water level

During a wet mode, the Marina del Rey tide gate reduces the upper tide range by closing when the following conditions are met:

- Marina water level exceeds 0.0 feet MSL
- Marina water level is more than 0.25 feet higher than Ballona Lagoon water level

The Washington Boulevard tide gate is opened during a low tide for 2-6 hours approximately twice a week (PWA, 2007).

Neither tide gate is certified by the Federal Emergency Management Agency (FEMA) as a flood control infrastructure, impacting the 2017 Preliminary Flood Insurance Rate Map (PFIRM) analysis, and resulting base flood elevation (BFE) for the low-lying areas. As important flood prevention infrastructure for the coastal zone area, any failure in the operation of both tide gates can result in flooding.

The barriers that allow the tide gates to close the Ballona Lagoon and Canals from the ocean are also important when considering SLR. The existing grade above the MR tide gate has a relatively high crest elevation of approximately 16 feet (NAVD88)(see Figure 3.6) and is sheltered from direct ocean waves due to the Marina del Rey breakwater. Note, this crest elevation provides roughly 8 feet of freeboard above the current 100-year BFE. Washington Boulevard, which separates Ballona Lagoon from the canals, has a relatively lower elevation of 6.9 feet (NAVD88).

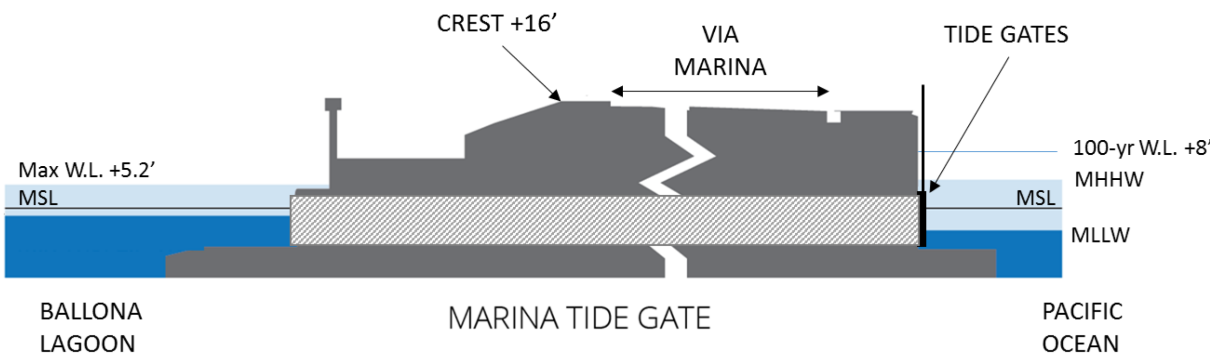



*Figure 3.6: Diagram of Marina del Rey Tide Gate*
*(Based off 2007 as-built drawings)*

## 3.6 Groundwater

When a low-lying coastal area has intermediate to shallow groundwater level (<6.6 feet below the surface) SLR can cause what is known as shoaling. Shoaling is caused when a rise in sea level causes groundwater to rise as well. It can cause groundwater to emerge at the surface, resulting in chronic flooding (Hoover et al., 2016). Additionally, even if groundwater is relatively deep in the low-lying area, existing lower groundwater can rise to shallow elevations causing challenges to existing infrastructure or new development (Hoover et al., 2016). For example, construction projects requiring excavation may encounter the water table at higher elevations causing a need for the pumping of water out of a construction site. In a study of select sites in California by Hoover et al. in 2016, Marina del Rey was identified as a site, noting that little was known about the groundwater elevations and citing extensive groundwater pumping as a factor limiting its vulnerability to SLR. However, a report in 2011 about the feasibility of groundwater extraction in the area describes that the basin once had a deep groundwater table due to extensive pumping, but recently experienced groundwater elevations rising to above sea level and progressing seaward. It also describes the groundwater as having areas of gravel with enough permeability to allow infiltration of saltwater into the groundwater, citing recent increases in salinity (Kennedy/Jenks Consultants, 2011). This suggests that the vulnerability of Venice to groundwater shoaling may be higher than previously thought.

# 4. Sea Level Rise

## 4.1 What is Sea Level Rise?

SLR science involves both global and local physical processes. Models are created based on science's best understanding of these processes on global and local scales; therefore, they are dynamic and periodically updated to reflect these changes. On a global level, the most recent predictions come from the *International Panel on Climate Change's Fifth Assessment Report* (AR5) released in 2013. The AR5 projections for SLR were 50% higher than the *International Panel on Climate Change's Fourth Assessment Report* (AR4) (released 2007) due to the addition of ice sheet dynamics on SLR. At the state level, the California Coastal Commission (CCC) previously recommended the 2012 National Research Center (NRC) *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* report (2012). This report predicts 17 in to 66 inches (42 cm to 167 cm) by the year 2100 (CCC Guidance Document 2015).

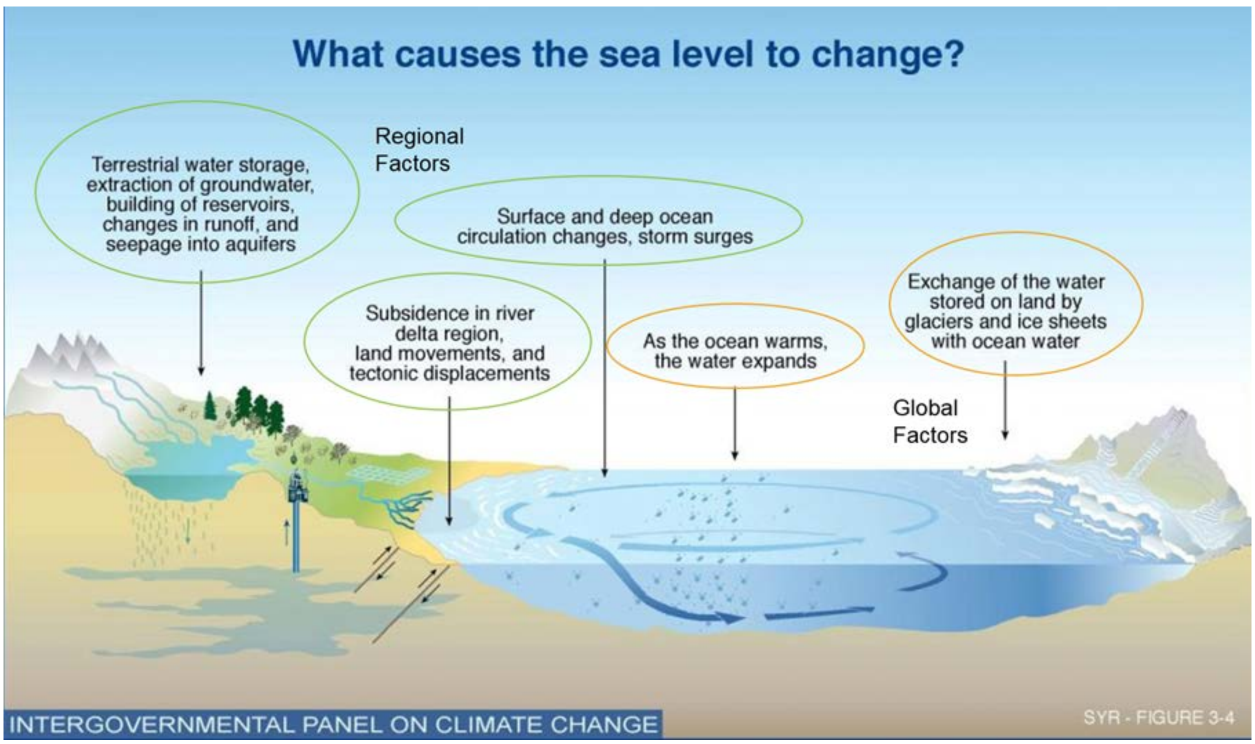



*Figure 4.1: Regional and Global Factors that can Contribute to Changes in Sea Level*
*Source: IPCC (2001)*

However, the State of California Ocean Protection Council (OPC) incorporated the best available science through the *Rising Seas in California: An Update on Sea Level Rise Science* report, released in April 2017. This report was then used to update the OPC's California State Guidance in 2018 (OPC 2018). The 2018 Guidance projects SLR for multiple emissions scenarios using a probabilistic approach. For both low- and high-emission scenarios, a "likely range" was determined for which there is a 67% probability that SLR will fall within that range. For the low-emissions scenario, the likely range of SLR for 2100 is 0.9 feet to 2.3

feet and for the high-emissions scenario; the likely range for 2100 is 1.5 feet to 3.3 feet. The OPC's 2017 report and 2018 guidance include a specific singular scenario (called H++), which represents recent scientific findings of faster rates of SLR due to previously unknown glacial dynamics by Sweet et al., 2017, which predicts 10 feet by the year 2100. The likelihood of this scenario is unknown, and is recommended by the OPC to be considered for long-term, high-stakes decisions (OPC, 2018).

Climate science is a constantly changing field, often with high degrees of uncertainty. In the case of California's SLR, the OPC has high confidence in estimates for SLR to around year 2050, after which emissions scenarios cause predictions to diverge. Therefore, this assessment focuses on key sea levels based on the location and coastal dynamics of the city to provide consistent reference points across scenarios and predictions. Planning for a varying degree of SLR can be challenging and requires continual or periodic updates based on the most recent predictions.

## 4.2 Selected Sea Level Rise Scenarios

Due to the high degree of uncertainty associated with predicting when and at what rate SLR will occur, this study looks at a range of five scenarios starting with present day conditions and including extreme SLR. Five scenarios have been selected for this study that consider increments of SLR between 0 and 6.6 feet (0 cm to 200 cm). This range of scenarios is based on available data for the region.

The five SLR scenarios identified for this study were selected based on a review of existing data and observed vulnerability thresholds (i.e., tipping points of where coastal hazard exposure changes substantially). The selected SLR scenarios for the study area are described in Table 4.1 below.

*Table 4.1: Venice Vulnerability Assessment Sea Level Rise Scenarios*

| Scenario | Sea Level Rise, ft | Sea Level Rise, cm | Approximate Time Horizon for Sea Level Rise Projection* | Justification |
|---|---|---|---|---|
| 1 | 0 | 0 | Current | Establish existing (baseline) conditions |
| 2 | 1.6 | 50 | 2040 to 2080 | Identify vulnerabilities within LCP planning horizon |
| 3 | 3.3 | 100 | 2060 to 2100+ | Potential threshold for inland flooding & coastal recreation |
| 4 | 4.9 | 150 | 2080 to 2100+ | Consistent with upper range of projections in 2100 |
| 5 | 6.6 | 200 | 2090 to 2100+ | Characterize vulnerabilities from extreme SLR |

**Time horizon from ourcoastourfuture.org using OPC's An Update on Sea Level Rise Science for California (Griggs, et al. 2017) RCP 8.5 projections, ranges are conservative due to uncertainty of H++ timing*

## 4.3 Projections and Probability

The OPC 2018 Guidance incorporates probability and risk tolerance into its SLR projections. Figure 4.2 illustrates three risk tolerance projection curves for SLR. The 2018 CA State Guidance Document lays out a risk decision framework that explains when to use low or high-risk aversion in the planning process (see Figure 4.2). For example, the low-risk aversion curve represents the upper limit of a range that is considered to have a 67% probability. The state recommends this high-risk tolerance (low aversion) to be used when considering resources where the consequences of SLR are limited in scale and scope with minimum disruption and where there is low impact on communities, infrastructure, or natural systems. The extreme risk aversion curve should be used for unacceptable consequences with extensive scale and scope that are irreversible or threats to public health and safety. With this framework, the probabilistic projections inform a decision-making process rather than trying to estimate the exact rate or occurrence of SLR.

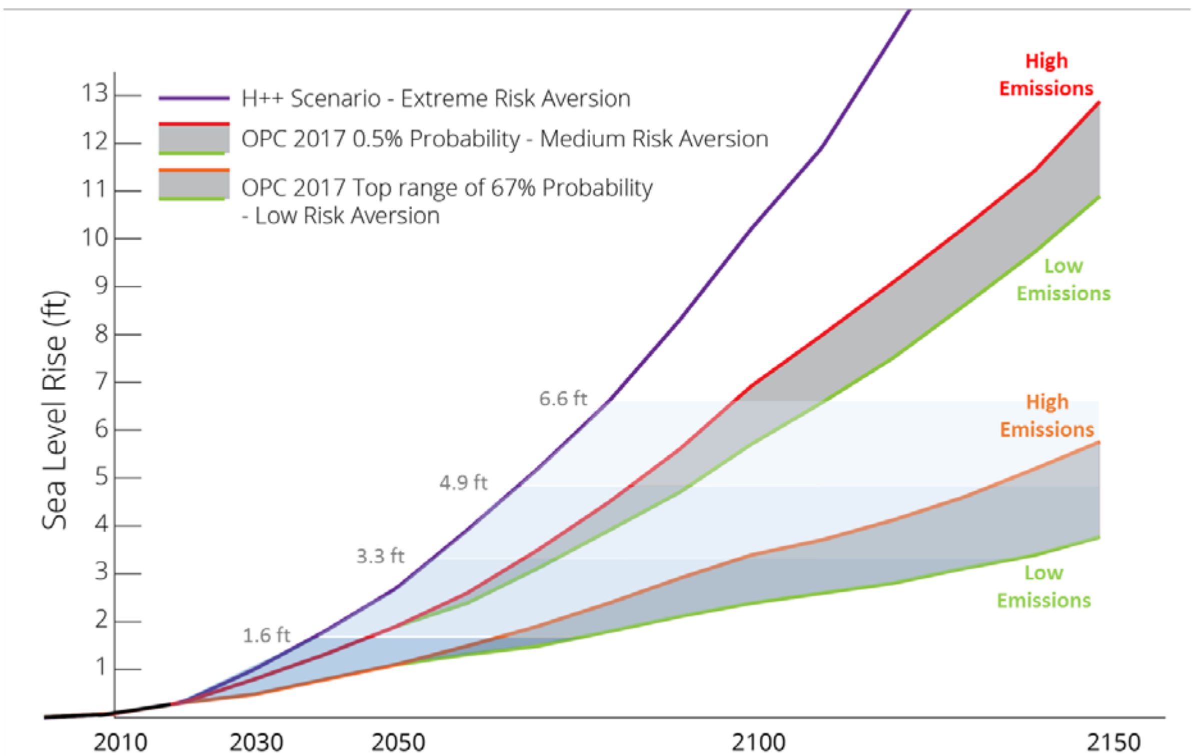



*Figure 4.2: Approximate Sea Level Rise Projections for Three Risk Aversion Levels (Based on OPC-SAT 2018 State Guidance, these projections are not "low, medium, and high" curves, but reflect probabilistic projections for recommended risk tolerances.)*

# 5. Sea Level Rise Hazard Mapping

## 5.1 CoSMoS Coastal One-line Assimilated Simulation Tool (COAST) Model 3.0

Coastal Storm Modeling System (CoSMoS) Version 3.0 Phase 2 is the latest version of the U.S. Geological Survey (USGS) coastal storm modeling system that utilizes global, regional, and local models to assess coastal flooding and erosion. CoSMoS includes 40 combinations of SLR and storm scenarios that apply wave projections, storm surge, sea level anomalies, river discharge, tides, and SLR to predict long-term coastal evolution.

A total of 10 SLR scenarios are available, including 0.8 feet (0.25 m) increments from 0 to 6.6 feet (0 to 200 cm) and an extreme SLR scenario of 16.4 feet (500 cm). Management scenarios include with and without beach nourishment and coastal armoring (Hold-the-Line or Not). Flood hazards are only available for the "Hold-the-Line and No Beach Nourishment" management scenario. More information on the CoSMoS data available and the hazard selection process is provided in a Sea Level Rise Memorandum that was prepared for this study, included in its entirety as Appendix B.

In summary of the findings of this memo, CoSMoS 3.0 Phase 2 model results were selected for use in this study because these data incorporate the most recent and comprehensive SLR hazard maps developed for the study area. Use of AdaptLA data for this effort would result in data gaps (e.g. SLR scenarios) that would require additional effort to fill. The advantages of using CoSMoS 3.0 Phase 2 are summarized below:

- A wide range of SLR scenarios.
- Flooding modeled with forecasted wave conditions and shoreline change for the 1-yr, 20-yr, and 100-yr coastal storm with layers for 2-minute sustained water level flooding and maximum wave runup extents.
- Includes shoreline management scenarios that consider "Beach Nourishment" and "Hold-the-Line" at the urban/beach interface.
- Erosion modeling comprises multiple methods that consider future erosion resulting from historic trends, long-shore and cross-shore sediment transport, and changes due to SLR; additionally, historic data was used to tune these models to account for site-specific erosion and accretion trends driven by natural and anthropogenic causes.

## 5.2 Inland Flood Potential

The existing studies identify inland flooding potential in the low-lying areas around the Venice Canals. Although these areas are set back from the active shoreline, the low topography requires a system of tide gates to control water levels and prevent flooding from the canals. These gates may not provide the same functionality as SLR because higher water levels could prohibit drainage and circulation that is currently achieved during low tides. SLR will reduce and eventually eliminate the potential for the release of stormwater during low tides. A rising groundwater table will also pose challenges to managing water levels in the Canal District.

The detail provided by existing studies does not accurately capture the potential for inland flooding in the Canal District because they do not account for tide gate operation, stormwater storage and drainage capacity, and the influence of groundwater. The complexity of the existing system requires a focused study that accounts for the different functions of the tide gates and potential hazards associated with rising sea levels. This type of study was beyond the scope of previous studies and is also beyond the scope of this report.

To capture the potential for inland flooding during a scenario in which the tidal gates are opened or damaged during a high tide event, a “bathtub” model was used to map flood hazards for the 1.65 feet (50 cm) increment scenarios. The same water level assumptions (extreme monthly high water level of 6.5 ft NAVD88) used by ESA in the AdaptLA study to model flood risk for the Canals District were applied but modified the hazard maps based on the SLR scenarios selected for this study.

Without further investigation into the capacity, design, and operation of the tide gates, the “bathtub” model approach was determined to be the preferred method for depicting the potential for inland flooding from high water levels in the canals. For this reason, a “bathtub” approach consistent with the method ESA applied for the AdaptLA study was used for the study.


*Figure 5.1: Coastal and Inland Flooding for Baseline Scenario (no Sea Level Rise)*

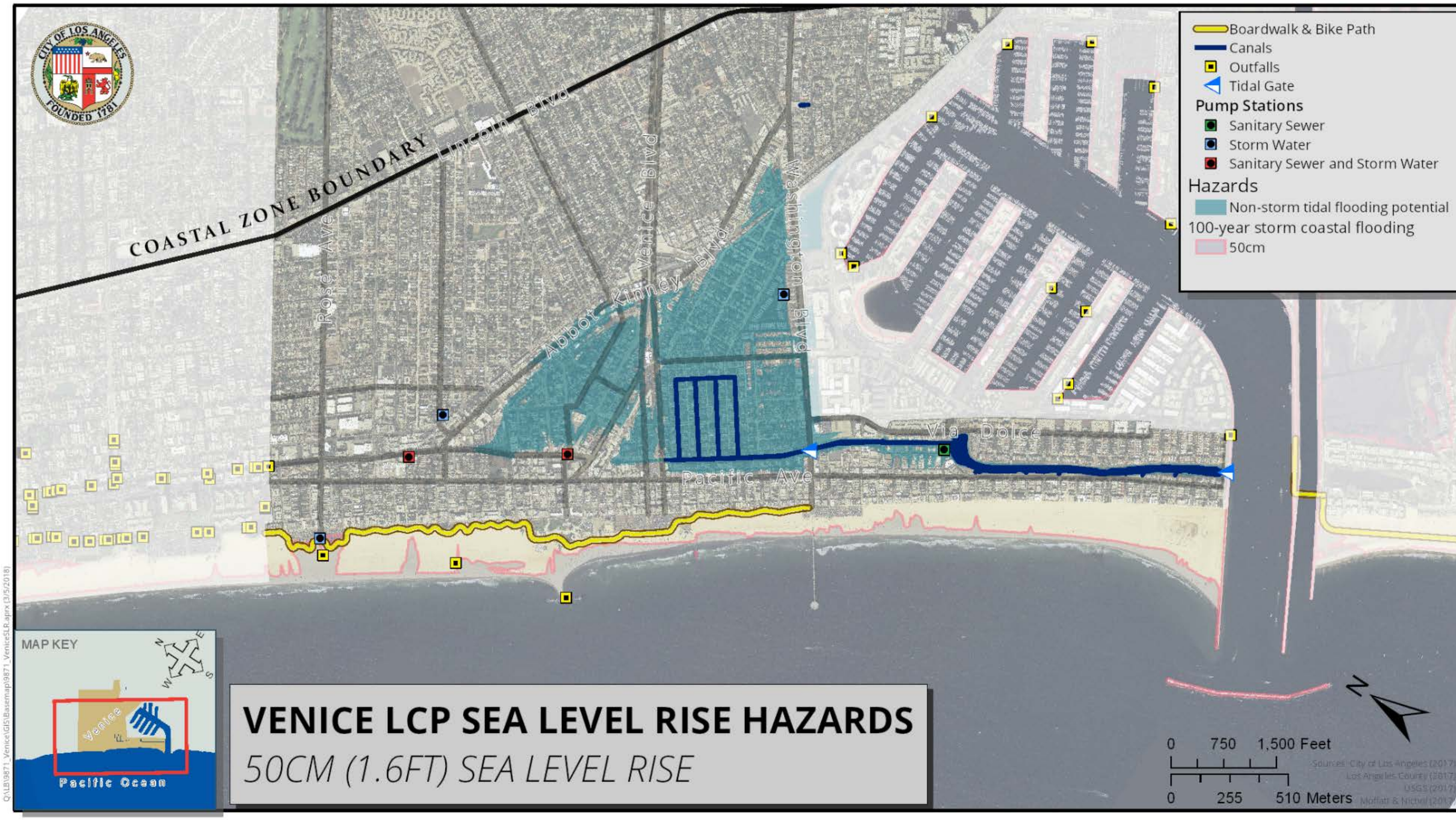



*Figure 5.2: Coastal and Inland Flooding for 1.6-ft Sea Level Rise Scenario*

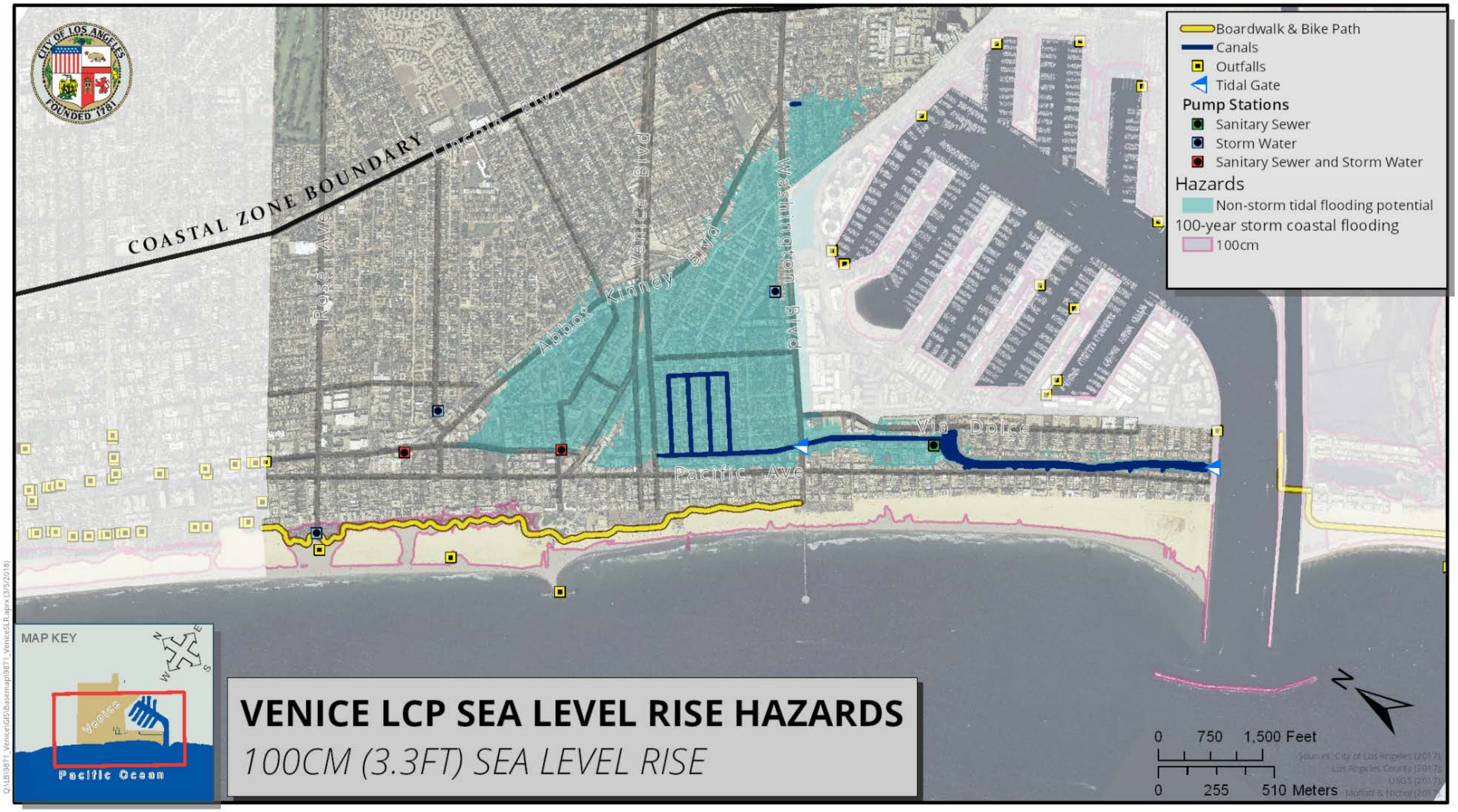



*Figure 5.3: Coastal and Inland Flooding for 3.3-ft Sea Level Rise Scenario*

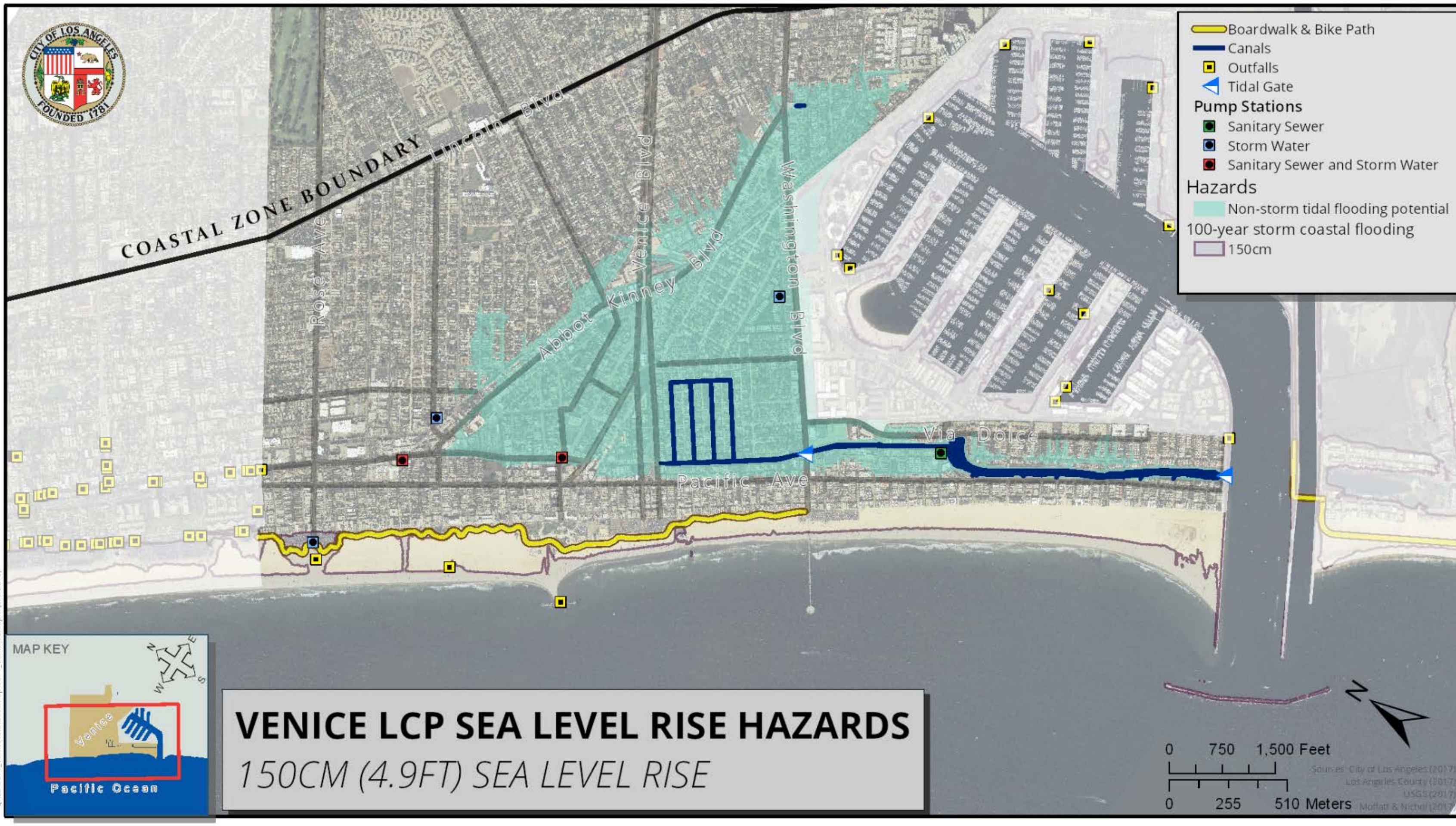



*Figure 5.4: Coastal and Inland Flooding for 4.9-ft Sea Level Rise Scenario*

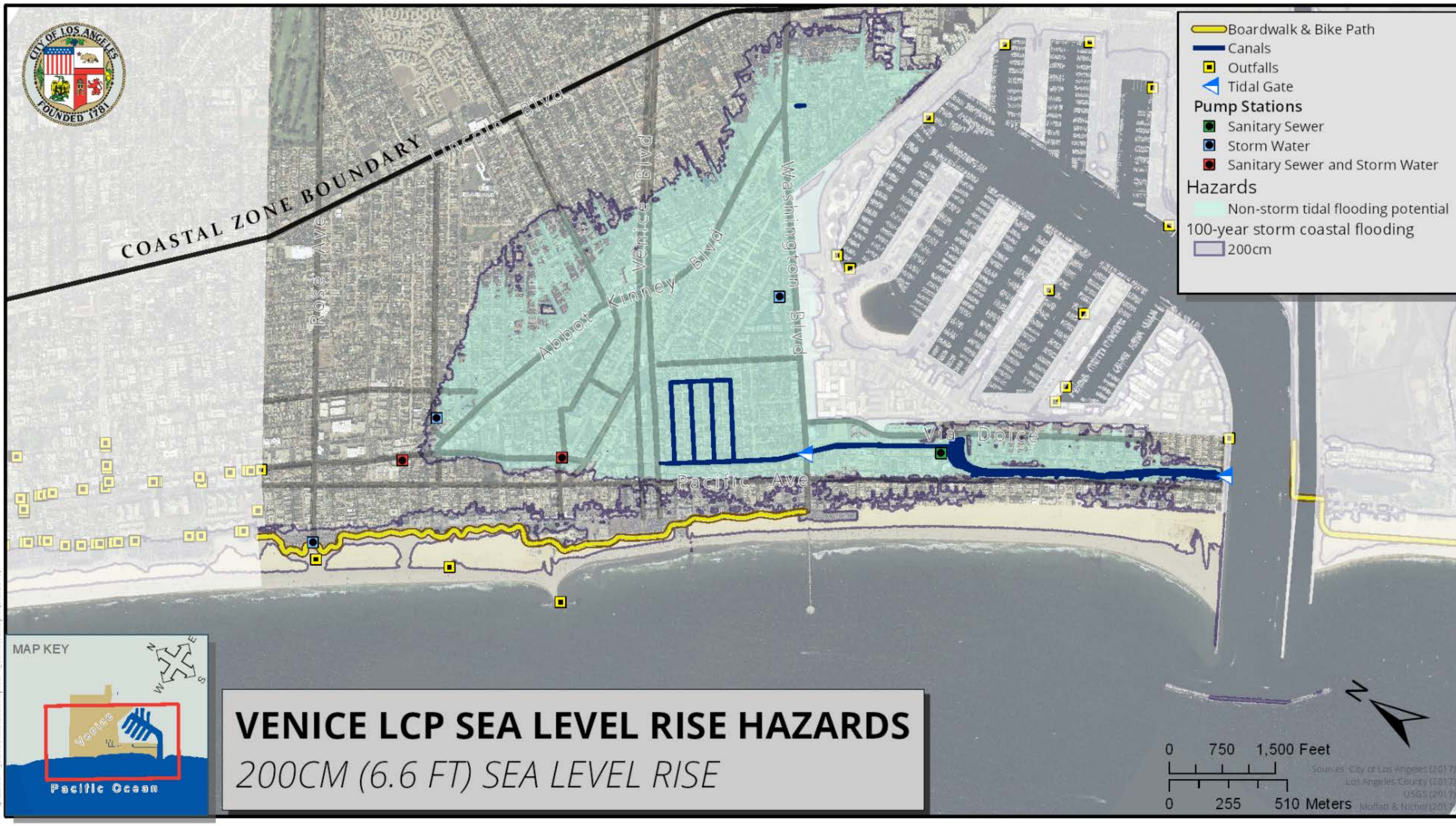



*Figure 5.5: Coastal and Inland Flooding for 6.6-ft Sea Level Rise Scenario*

# 6. Vulnerability Assessment

The purpose of this assessment is to identify potential significant physical or functional impacts to both natural and man-made coastal resources under a range of SLR scenarios. A resource's vulnerability to SLR is a product of its exposure, sensitivity, and adaptive capacity, which are defined as follows:

- **Exposure** refers to the type, duration and frequency of coastal hazard a resource is subject to under a given SLR scenario. A resource that experiences daily wave and water level fluctuations would be considered more exposed than a resource that only experiences some minor flooding during an extreme event.
- **Sensitivity** is the degree to which a resource is impaired by exposure to a coastal hazard. For example, a parking lot would be less sensitive to temporary flooding than a residential or commercial building because once a flood subsides, the parking lot could resume normal operation with perhaps some minor clean up required. A residential or commercial building is more sensitive to temporary flooding due to the cost of damage and disruption of normal activity or operation.
- **Adaptive capacity** is the ability of a resource to adapt to evolving coastal hazards. Beaches can be thought to have a natural ability to adapt because the sand will migrate upward and landward in response to rising sea levels if sufficient sand exists in the system and landward space is available for this migration. Infrastructure typically has a low adaptive capacity because increased coastal hazards that exceed the design capacity often require significant improvements to maintain the same level of protection.

These three factors are discussed throughout this section to provide a general overview of the VA findings for each category of resources described in Section 2. The VA findings specific to each resource/asset are provided in Appendix A.

The findings presented here inform the adaptation planning process by identifying the SLR threshold at which impacts occur and the factors (exposure, sensitivity, adaptive capacity) contributing to a resource's vulnerability. The factors dictating a resource's vulnerability provide a starting point for adaptation planning. For a resource with high exposure, adaptation strategies that reduce exposure through protection or relocation may be considered. In other cases, strategies that reduce sensitivity to hazards and improve resiliency (ability to recover from hazard event) may be the most effective way to mitigate impacts.

## 6.1 Infrastructure

The assets evaluated include the tide gates, wastewater, stormwater, transportation, and utilities (water & power) systems, and coastal protection infrastructure. Almost all resources in the infrastructure category are located throughout developed areas of the planning area and are most vulnerable to inland flooding potential. The exceptions are coastal protection structures and stormwater outfalls within the surf zone and beach areas.

### 6.1.1 Exposure

The primary source of exposure to infrastructure assets is from inland flooding that could occur from a variety of potential hazards and includes tide gate malfunction, an extreme rainfall event, tsunami, or extreme coastal storm event. For current sea levels up to 1.6 feet of SLR, the exposure to flooding will be temporary and caused by one of these potential hazards. Assets such as the VPP and proposed VAPP, which sit at low elevations, could experience flooding during these events that will test the resiliency of this critical infrastructure to flooding, potential power outages, and limited access to the facility for maintenance.

Over the long-term, if sea levels rise by more than 3.3 feet, there is potential for permanent inundation of large portions of the low-lying areas of Venice due to a higher groundwater table. The upper SLR scenarios result in significant exposure of major infrastructure systems like transportation, stormwater and wastewater collection systems, and other utilities. The 6.6-foot SLR scenario indicates up to 35 miles of roadway and 5.7 miles of bikeway could be flooded (see Table 6.1 and Table 6.2). Many of these are main roadways like Venice Blvd, Washington Blvd and Abbot Kinney.

*Table 6.1:Length of Bikeways Impacted by Hazard Type*

| Inland Flooding | | Coastal Flooding (CoSMoS 3.0 Phase 2) | |
|---|---|---|---|
| SLR | Total (mi) | SLR | Total (mi) |
| Current Sea Level | 0.03 | Current Sea Level | 0.22 |
| +1.6 ft | 1.41 | +1.6 ft | 0.18 |
| +3.3 ft | 2.30 | +3.3 ft | 0.82 |
| +4.9 ft | 3.40 | +4.9 ft | 0.52 |
| +6.6 ft | 3.82 | +6.6 ft* | 5.74 |
| | | *Overlap with Inland Flooding | |

*Table 6.2:Length of Roadway Impacted by Hazard Type*

| Inland Flooding | |
|---|---|
| SLR | Total (mi) |
| Current Sea Level | 8.7 |
| +1.6 ft | 17.3 |
| +3.3 ft | 21.7 |
| +4.9 ft | 28.4 |
| +6.6 ft | 35.0 |

Exposure from beach-side hazards to infrastructure assets are far lesser in comparison and are limited in terms of their exposure until 3.3 feet+ SLR or more based on the CoSMoS results. Present and short-term hazards include a buildup of sand further landwards on the beach, potentially reducing capacity of beach stormdrain outfalls. SLR-related beach erosion is projected to be 10-20% with 3.3 feet SLR and 25-50% with 6.6 feet SLR (Noble Consultants, 2016). This means beach erosion could be a greater issue in the long-term, but have limited impacts on infrastructure in the short term.

A key uncertainty of the beach loss projections are the long-term effectiveness of coastal structures like the Venice breakwater and groin near the former lifeguard headquarters building. These structures have a significant effect on current shoreline processes and the movement of sand alongshore. As sea levels rise, the influence of these structures on nearshore dynamics will also change. The evolution of these dynamics with respect to existing coastal structures was not captured in the previous modeling efforts. If it is assumed that the Venice breakwater is not maintained and allowed to deteriorate over time, a reduction in the amount of sand retained by the structure and possibly greater long-term erosion on the upcoast side of the breakwater can be expected. Monitoring of future shoreline changes will be an effective way to understand how SLR and the function of the existing coastal structures will shape the future beaches of Venice.

Secondary sources of exposure include higher water levels in the Marina, which reduce the capacity of the stormwater system in Southeast Venice (Boone-Olive PP), as well as higher groundwater levels that have the potential to cause more chronic flooding and/or structural issues for the low-lying areas of Venice. Higher groundwater levels can also disrupt buried infrastructure such as utility, stormwater, and wastewater networks.

### 6.1.2 Vulnerability

When discussing the vulnerabilities of a community like Venice, it is critical to consider the concept of cascading impacts. For example, Venice currently relies on the Marina del Rey tide gates to prevent tidal flooding in its low-lying areas. A failure of this singular piece of infrastructure can have cascading impacts on the infrastructure systems that keep both Venice and the region operating safely. Flooding from a tide gate malfunction could result in temporary outages in the area. These outages require emergency services and utility repairs that rely on access to the sites via the road network. Roads flooded at depths greater than 1.6 feet can reduce or completely block access from large vehicles and trucks, resulting in potentially delayed service repairs (Pregnolato et al., 2017). Reduced service or repairs could result in further failures of key infrastructure, such as utilities and pump stations, and could magnify the damages and danger of a flood event.

These cascading impacts are important to consider in adaptation and resilience planning, and make it difficult to forecast or predict a specific range of conditions when infrastructure will be exposed to this type of flooding. Given that vulnerabilities exist today, and SLR will only increase these vulnerabilities, the near-term adaptation planning should focus on making the infrastructure more resilient to temporary flooding events through measures aimed at improving redundancy of key systems and emergency planning procedures to maintain operations despite temporary flooding or power outages.

#### 6.1.2.1 Tide Gates

The Marina del Rey tide gates (also referred to as Venice Marina tide gates or marina gates) are the most critical components of flood prevention infrastructure in the study area. The road elevation above the gate is high enough (approx. 16 feet NAVD88) where SLR of less than 6.6 feet is not a concern in terms of overtopping (Figure 6.1). This provides a significant amount of adaptive capacity against tidal flooding. The primary vulnerability to the marina gates is the effect of higher water levels on its functionality. As sea levels rise, the duration the tide gates will need to remain closed will increase. For example, after +1.6 feet SLR, water levels in the marina will rarely be lower than the present minimum water level kept in the Ballona Lagoon. This could reduce the amount of flushing and affect water quality.

The tide gates need to serve the dual function of keeping high water levels out but also providing stormwater drainage for the Canals area. The tide gates have proven effective at preventing high water levels from flooding the community and there is sufficient freeboard above the gates to accommodate a significant amount of SLR. However, the short-term vulnerability will be a gradual reduction in the stormwater storage and conveyance capacity provided by the existing canals system. The timing of this impact could not be determined due to limited information available about the hydrologic and hydraulic capacity of the existing drainage infrastructure that services the tributary area of the canals.

Another vulnerability of the tide gates is the operational reliability of the system. As sea levels rise, the cascading impact of a tide gate malfunction increases significantly. The functionality of the tide gates as flood prevention infrastructure presently has varying degrees of uncertainty related to their adaptive capacity. According to recently updated California Environmental Quality Act (CEQA) documents, the gates are equipped with sensors and can be operated remotely; however, currently, the City of Los Angeles and its contractors operate the gates electronically on-site. Implementing a formal operations plan for the gates with roles, responsibilities, and emergency procedures assigned would be a good step toward increasing the operational reliability of this critical piece of infrastructure.

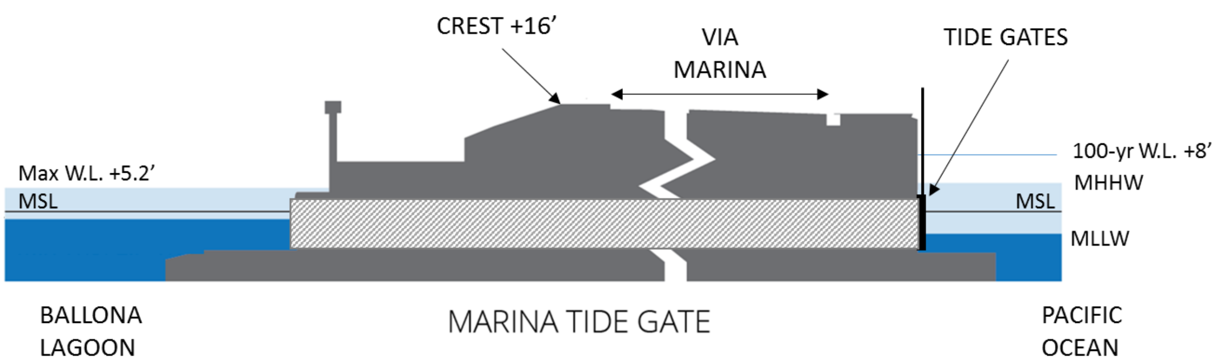



*Figure 6.1: Diagram of Marina del Rey Tide Gate*

#### 6.1.2.2 Venice Pumping Plant and Auxiliary Pumping Plant

A Climate Risk and Resilience Assessment for Infrastructure Technical Memorandum No. 5.5 by One Water LA (2017) found the VPP and VAPP were at risk of inundation during a 500-yr flood or tsunami event. The VPP is the largest in the City with a capacity of 45,000 gallons per minute (gpm) and has a replacement value of about $31.6 million. The VAPP, designed to complement the VPP, will increase the capacity of the two plants to over 60,000 gpm at an estimated cost of $17 million. The technical memorandum recommended $1.6 million in resilience improvements for the VPP and that design of the VAPP include additional resilience improvements to protect the backup power supply for the pumps and waterproof the first level of the electrical building. The flood hazard information used in the One Water LA study (FEMA & CoSMoS) was recently updated. FEMA released draft Flood Insurance Rate Map (FIRM) panels along coastal Los Angeles County that placed the VPP and VAPP within the current 100-yr flood zone. CoSMoS and Adapt LA released updated SLR hazards for Los Angeles County that place the facility within a SLR hazard zone. In other words, more recent SLR hazard information suggests risks to these existing and proposed facilities are higher than stated in Technical Memorandum No 5.5.

#### 6.1.2.3 Venice (aka Windward or Kinney Circle) Stormwater Pumping Plant

The One Water LA memorandum also flagged the Kinney Circle PP as a facility at risk of inundation during 500-yr flood and tsunami events. Due to the updated hazard information, the risk to this facility is higher than stated in Technical Memorandum No 5.5. The Bureau of Sanitation is planning a $5.5 million upgrade to the facility and the One Water LA memorandum recommends an additional $600,000 in resilience improvements along with an evaluation of conveyance capacity under impacts from increased precipitation due to climate change.

The stormwater PP is situated at a higher elevation than the VPP and VAPP, and thus is not exposed or sensitive to potential inland flooding until the 3.3 feet SLR threshold. Although the facility is not directly exposed to inland flooding, the drainage area serviced by the pump station is exposed to inland flooding potential for SLR scenarios higher than +1.6 feet. Since the pump station was not designed to handle tidal flooding, it’s not clear how much adaptive capacity is available to mitigate potential flooding under these scenarios.

#### 6.1.2.4 Other Infrastructure

Due to Venice’s proximity and connection to the ocean, SLR will impact almost every component of infrastructure. The potential for inland flooding could result in damage to networks of stormwater and sewer pipes, transportation, electrical lines, and traffic control equipment. In the longer term, rising groundwater levels could damage buried infrastructure and increase the amount of water needed to be pumped out of the low-lying areas during both the dry and wet seasons, potentially requiring additional pumps or upgrades.

The outfalls on the beach could also experience more frequent sand blockages, and in the long-term, require adaptation to an eroded shoreline. The Venice Force Main, also located on the beach (buried), is farther inland than the beach erosion projected by CoSMoS for all scenarios evaluated and, therefore, is not considered vulnerable to SLR impacts. Coastal protection infrastructure such as the Venice breakwater and groin are expected to lose effectiveness as shoreline protection under rising sea levels and increased wave heights. As they lose effectiveness, the sand retained upcoast of these structures would be subject to more wave action that will change the current sand transport patterns and surf along the beach, if steps to maintain, repair, and elevate this infrastructure are not taken. Under this scenario there may be more long-term shoreline erosion upcoast of these structures but less erosion downcoast as the sand lost from the upcoast side of these structures is transported south toward the marina jetty.

## 6.2 Civic

This resource category includes assets that provide a civic service to the Venice community such as public transportation, public parking, schools, and emergency services. The assets evaluated include bus lines, public parking, coastal paths, lifeguard HQ/towers, schools, the LAPD Venice substation, and LAFD Station 63. Some of the civic services are provided by the City while others are provided by the County or other agencies. Vulnerability assessment findings specific to each asset are provided in Appendix A.

### 6.2.1 Exposure

Several bus line routes (Metro 108, 33, and 733) could be exposed to the inland flooding at the +1.6 feet SLR scenario. Four city-owned parking lots are exposed with SLR greater than +1.6 feet due to inland flooding potential. Westminster Avenue Elementary and Westside Global Awareness Magnet schools are within low lying areas and could be exposed to inland flooding starting at +1.6 feet SLR. Additionally, portions of Coeur d'Alene Elementary could be exposed to flooding with SLR greater than +4.9 feet. The LAPD and LAFD stations are exposed physically (meaning the sites are within mapped hazard areas) for the +6.6 feet coastal flooding scenario, but functionally (ability to service Venice community) could be impacted earlier by access challenges associated with inland flooding.

The Lifeguard HQ is primarily exposed to direct wave action and coastal flooding and is within mapped +4.9 feet coastal hazard area. However, the actual timing of this hazard could be affected by the evolution of the shoreline in response to the performance of coastal protection infrastructure. Portions of the coastal path could be flooded at current sea level during an extreme event near the Venice Beach Recreation Center county parking lot and the Rose Avenue county parking lot.

### 6.2.2 Vulnerability

The sensitivity of parking lots to flooding is relatively lower than other assets, as temporary flooding typically only requires some maintenance and clean up to resume normal operations. Temporary impacts to parking lot function can be expected due to closures during forecasted storms. However, in the case of a tide gate malfunction, flooding could occur rather suddenly (within a few hours) and cars parked in inland parking lots could be damaged. Similarly, bus routes themselves have few potential physical impacts but would be limited in function. Disruption of major bus routes such as Metro Rapid Line 733 could impact regional mobility and result in consequences to the mobility of riders and the regional network.

The coastal path and bikeway offers lateral coastal access and mobility along the beach from Venice to Santa Monica and is exposed at current sea level to a large storm. Flooding of the path may temporarily reduce the function of the affected portions, though direct wave attacks paired with high water levels could pose threats of permanent damage. This could occur in the northern portions of the path along Rose Ave county parking lot where flooding is projected to extend further inland.

Schools can be very sensitive to flooding and are often used as shelters during disaster events. Additionally, all the schools potentially impacted in Venice have limited capacity to adapt or retrofit without significant investment to improve flood protection. In the short-term, flood damage and disruption could be mitigated through sandbagging or site-specific flood proofing, but long-term solutions might require additional resources.

LAFD Station 63 services the study area and while not directly exposed, flooding of the transportation network could limit access of emergency services to both low-lying areas and relatively isolated areas such as the Marina Peninsula. The LAPD Venice substation is an off-site facility geared toward community engagement and is a place to report non-emergency crimes as well as speak to LAPD officers. The facility is within the mapped coastal flooding hazard for +6.6 feet SLR. Damage to the substation may impact policing services in the Venice community.

Lastly, the LA County Lifeguard HQ/Beaches & Harbors building has historically been damaged by high surf activity, such as the 1982-83 El Niño, and houses beach maintenance equipment and rescue equipment for Venice Beach. The facility is protected by a seasonally buried revetment and is sensitive to direct wave action paired with high water levels. The facility could experience scour during a strong winter season with intensified erosion due to SLR, causing structural damage and potentially requiring adaptation or retrofitting measures.

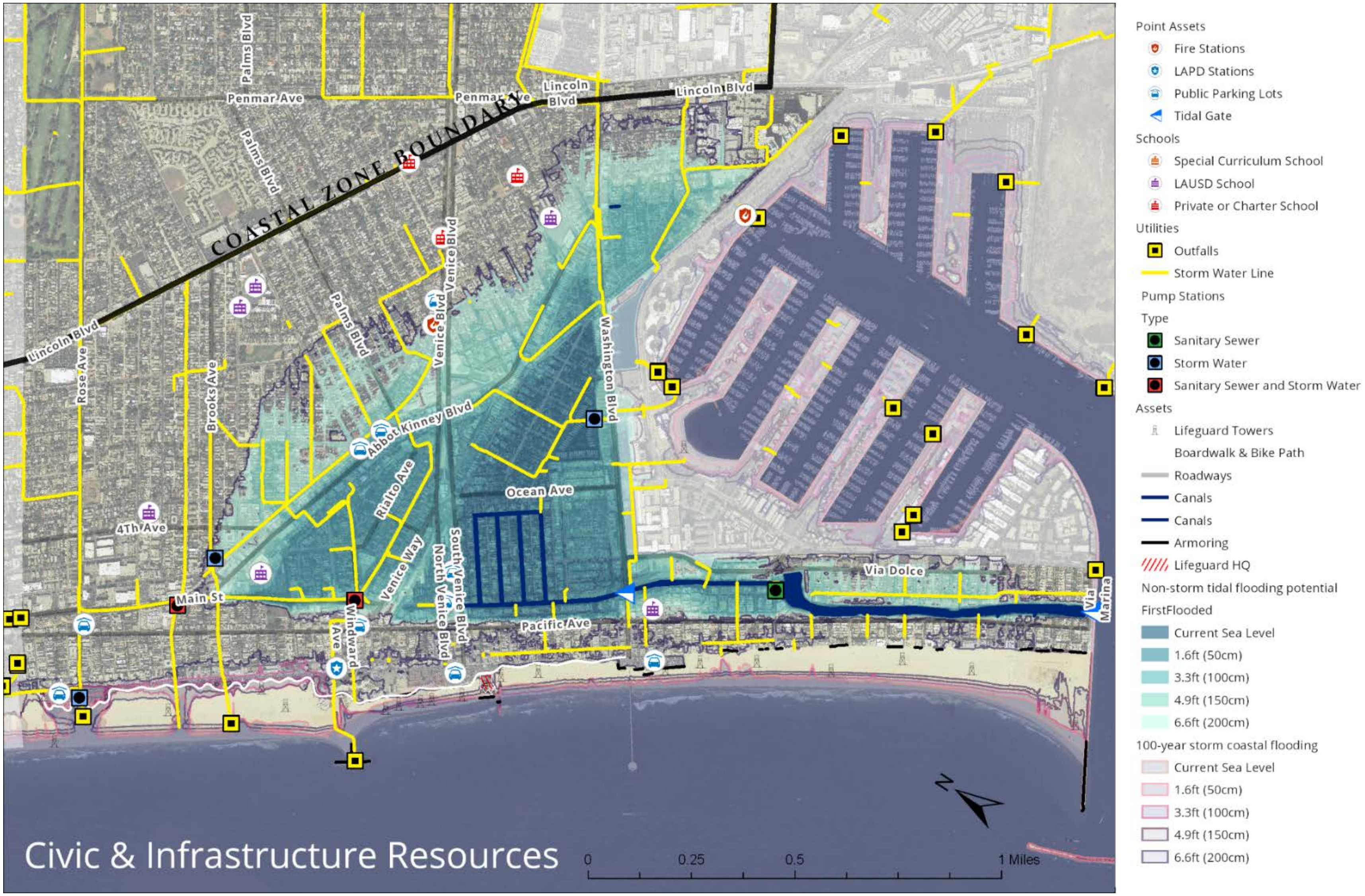



*Figure 6.2: Exposure Map of Civic and Infrastructure Resources*

## 6.3 Property

This category looks at parcels of land within the Venice Coastal Zone including open space, commercial, industrial, and residential development. Results from the parcel analysis were broken up by sub-area as designated by the 2001 LUP to better inform the LUP update. This section provides an overview of the vulnerability of parcels in Venice. Detailed results specific to each sub-area are provided in the Asset Profiles attached in Appendix A.

### 6.3.1 Exposure

To capture the exposure of property, land use parcel data from LA City Geohub was overlaid with the hazard layers to identify potentially affected parcels. A parcel was considered “affected” if 20% or more of the parcel by area was covered by the hazard layer. This value does not necessarily correlate to specific flood damage; rather, it was chosen because of its consistency (i.e. parcels at similar elevations were determined “affected” at the same hazard exposure).

The primary source of exposure to property in Venice is vulnerability to flooding from a tide gate malfunction or from reduced stormwater capacity with SLR. The hazard scenario used to quantify impacted parcels includes a malfunction of the tide gate during an extreme monthly high tide (~6.5 feet tide) in addition to each increment of SLR as described in Section 5.2. Under this hazard scenario, flooding could enter through the failed marina tide gate, into the Ballona Lagoon, under/over Washington Blvd and into the low-lying areas north and east of the Venice Canals. At current sea level, this hazard scenario could impact over 750 parcels, the majority of which are residential. The exposure increases significantly with each SLR increment due to the low and flat topography surrounding the Canals. Over 4,000 parcels are affected under this hazard scenario combined with +6.6 feet SLR.

According to the CoSMoS results, beachfront development could experience flooding during large storms with +3.3 feet SLR. The exposure is higher in the northern beachfront areas than the southern areas, according to CoSMoS results. The threshold for widespread flooding from an extreme coastal storm is near the +6.6 feet SLR scenario, in which flooding not only affects beachfront development but also extends into the low-lying areas around the Canals. Over 5,000 parcels could be affected under this scenario with significant flooding in North Venice, Southeast Venice, Venice Canals, and the Oxford Triangle sub-areas.

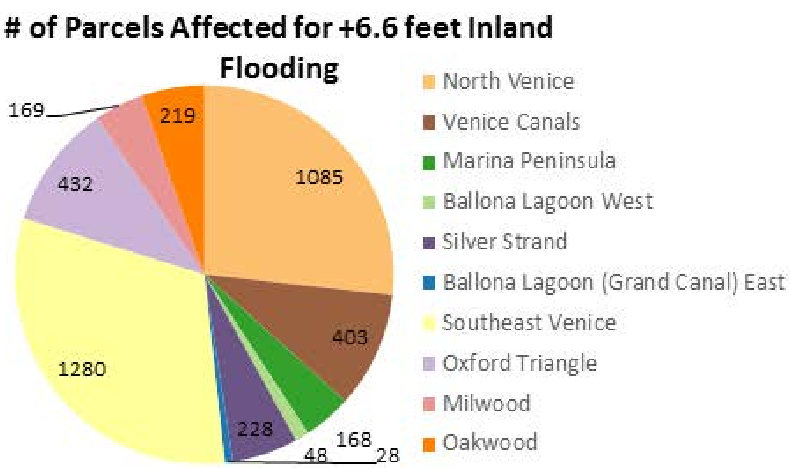
Public property, including land from the oceanfront walk to the Pacific Ocean, is directly exposed to inundation due to shoreline change and damage from storms. This exposure is covered in Coastal Amenities (Section 6.5).

### 6.3.2 Vulnerability

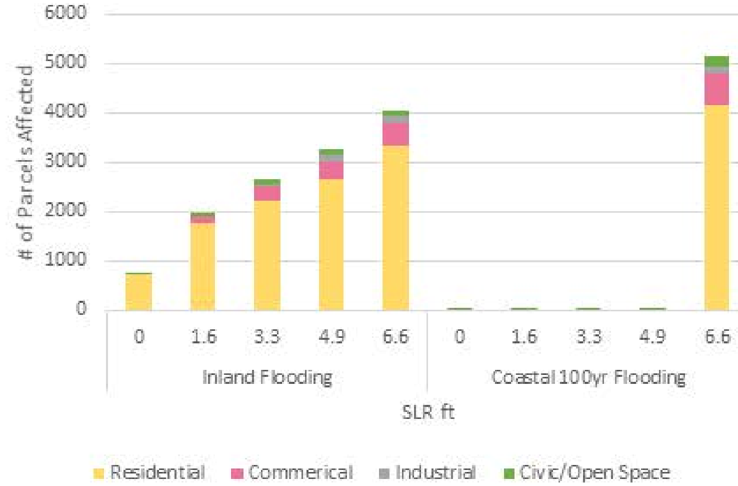
The sensitivity of property to flooding (i.e. damage inflicted) varies depending on factors related to the elevation of the first floor and structural conditions, in addition to flood depth and duration. Generally, property in Venice has not been constructed to withstand flooding, resulting in greater sensitivity to flood exposure. Additionally, property damage, loss of inventory (commercial/industrial), repairs, and retrofitting are often costly and time consuming. Historic and other building requirements for a portion of properties in Venice make the adaptive capacity of property generally low. Additionally, flood damage can impact renters by resulting in temporary or permanent loss in tenancy with no relocation benefits. Renters who live in rent stabilized housing are impacted as well, although they will need to file for a Reduction in Housing Services in order to be safely accommodated through the disaster.

Flooding depths of up to about 1 foot can often be mitigated through temporary measures such as sand bags, while flooding of greater depths can be more difficult to mitigate and can cause permanent damage. However, advance warning is needed to allow residents time to install these measures to be effective. Such warning is typically provided for large rainfall events or coastal storms, but a tide gate malfunction during a rising tide would not likely allow sufficient time to install temporary flood-proofing measures.

## Description


## Parcel Analysis



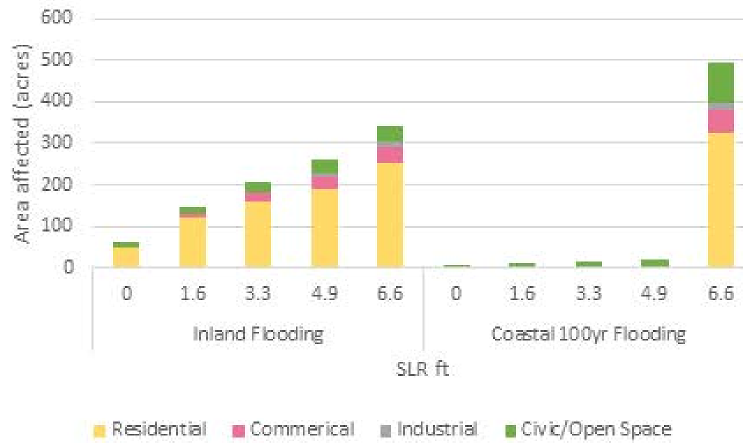




*Figure 6.3: Property Exposure Summary*

## 6.4 Cultural Resources

The assets identified in this category include cultural resources designated by the State of California, City of Los Angeles, and Federal Register.

### 6.4.1 Exposure

Cultural assets within the low-lying areas of Venice are exposed to inland flooding. These include the Venice Canals Historic District, the Lost Venice Canals Historic District, the Southwestern portion of the Milwood Venice Walk Streets Historic District, and the Abbot Kinney Area Historic Monuments. Similar to the exposure of parcels, a tide gate malfunction or extreme rainfall event during a high tide could result in flooding of the low-lying areas in the Venice Canals Historic District. Impact thresholds to each asset from this potential flooding vary depending on their location and elevation.

Closer to the beach, three historic monuments and two historic districts: North Venice Walk Streets Historic District and Windward-Pacific Commercial Historic District, are potentially exposed to flooding and wave runup from large storms with +6.6 feet SLR.

### 6.4.2 Vulnerability

The culturally significant buildings and districts exposed to flooding can be highly sensitive to damage. Older foundations and wood construction can be damaged and require repair or reconstruction. Additionally, an inherent historic component to the Venice Canals is the water level in the canals, which currently is muted from the tides to maintain water and, therefore, aesthetic quality. How the tide gates are operated in response to SLR will have direct impacts on the water levels and water quality in the canals.

## 6.5 Coastal Amenities

The coastal amenities resource category includes the beach area, Venice Beach Boardwalk and Recreation Center, and the Municipal Fishing Pier. These resources offer a wide range of low cost recreational opportunities and other experiences that make Venice Beach a major draw for locals and tourists.

### 6.5.1 Exposure

The primary exposure to coastal amenities comes from the open coast. SLR increases the potential for damage due to direct wave attack for assets like the Municipal Fishing Pier when extreme storm waves coincide with higher water levels. Higher water levels during large storm events is also projected to increase potential for runup up to the Ocean Front Walk. Additionally, the protective function of the beach itself will decrease with SLR, as sandy beaches are projected by CoSMoS to erode 10-20% for +1.6 feet and 25-50% with +3.3 feet SLR (Noble Consultants, 2016). A key uncertainty of the beach loss projections is the long-term effectiveness of coastal structures like the Venice breakwater and groin, as discussed in

Section 6.1.1. These structures have a significant effect on current shoreline processes and the movement of sand alongshore. As sea levels rise, the influence of these structures on nearshore dynamics will also change. Monitoring of future shoreline changes will be an effective way to understand how SLR and the function of the existing coastal structures will shape the future beaches of Venice.

### 6.5.2 Vulnerability

Some coastal amenities, such as the Ocean Front Walk and Venice Beach Recreation Center, may be able to tolerate temporary flooding from extreme events with only minor damage and disruption. More permanent damage to coastal amenities would occur when these assets are exposed to beach erosion and direct wave attack that can undermine foundations and cause significant structural damage to park facilities, bike paths, and other hardscape.

Presently, large beach widths and winter berms protect assets such as the Ocean Front Walk from direct wave action and overtopping. The dynamic factors of beach width are accounted for to a degree within the CoSMoS COAST model; however, monitoring of beach conditions is critical to inform future vulnerability assessments due to uncertainties surrounding the performance of existing coastal structures. The current projections depict a threshold of +3.3 feet SLR where flooding along the oceanfront and Venice Beach Recreation Center increases considerably. This exposure could result in temporary flooding and damage to beach facilities through relatively high elevations, although wide beaches make this exposure limited to large storm events that can be forecasted and prepared for by LA County Department of Beaches and Harbors.

To more accurately assess the vulnerability threshold of assets like the Municipal Fishing Pier, further information about the design, history of repairs, and current conditions of the pier are necessary to identify critical wave and water level conditions with respect to SLR. This is an important low-cost visitor-serving amenity to the City.

Venice's beaches provide large amounts of revenue for the City and County and are a major economic driver as a tourist destination. The estimated total annual spending for Venice Beach in 2000 was found to be approximately 880 million US dollars (in 2010 USD) with annual recreational and habitat value estimated near 80 million dollars (King et al. 2011). This data illustrates the economic value of Venice Beach and the coastal amenities. In this study, beach erosion is shown to correlate to loss of value and annual spending; therefore, beach recreation as a resource for the City should be considered sensitive to erosion.

## 6.6 Ecological

The ecological resources category evaluated habitat and species with special status. Resources were informed using the California Natural Diversity Database (CNDDB) developed by the California Department of Fish and Wildlife. The identified ecological assets in the scope of this study include sandy beach habitat, the Ballona Lagoon Marine Preserve, the canals' subtidal habitat, and rocky outcropping habitat. Species with special status include the California Snowy Plover, California Least Tern, Orcutt's Pincushion, and the California Brown Pelican.

### 6.6.1 Exposure

For sandy beach habitat, exposure to SLR hazards is primarily related to beach loss. The largest areas of erosion are projected by CoSMoS to be the southern portion of the study area, where protected habitat for California Least Tern and Snowy Plover sits today.

For the Ballona Lagoon and Canals habitat, the largest concern is how SLR will change the management of the tide gate system resulting in changes to water levels and water quality. As sea level rises, circulation, drainage, and tidal connection will be impacted, posing threats to water quality and the intertidal system.

### 6.6.2 Vulnerability

When thinking about ecological assets, in particular the coastal habitats that exist in Venice, one should consider the phenomenon of “coastal squeeze.” Habitat such as intertidal marshland is directly tied to water levels. For example, certain species can only exist within narrow bands of the tide range (e.g. MSL to mean high tide). So, as sea levels rise, the ecosystems gradually shift up with rising water levels. In a natural system, this migration of species upwards can occur relatively easily. However, where habitat is directly backed by coastal development, such as around the Canals or Ballona Lagoon, this upward migration is blocked and can result in a net loss of intertidal habitat.

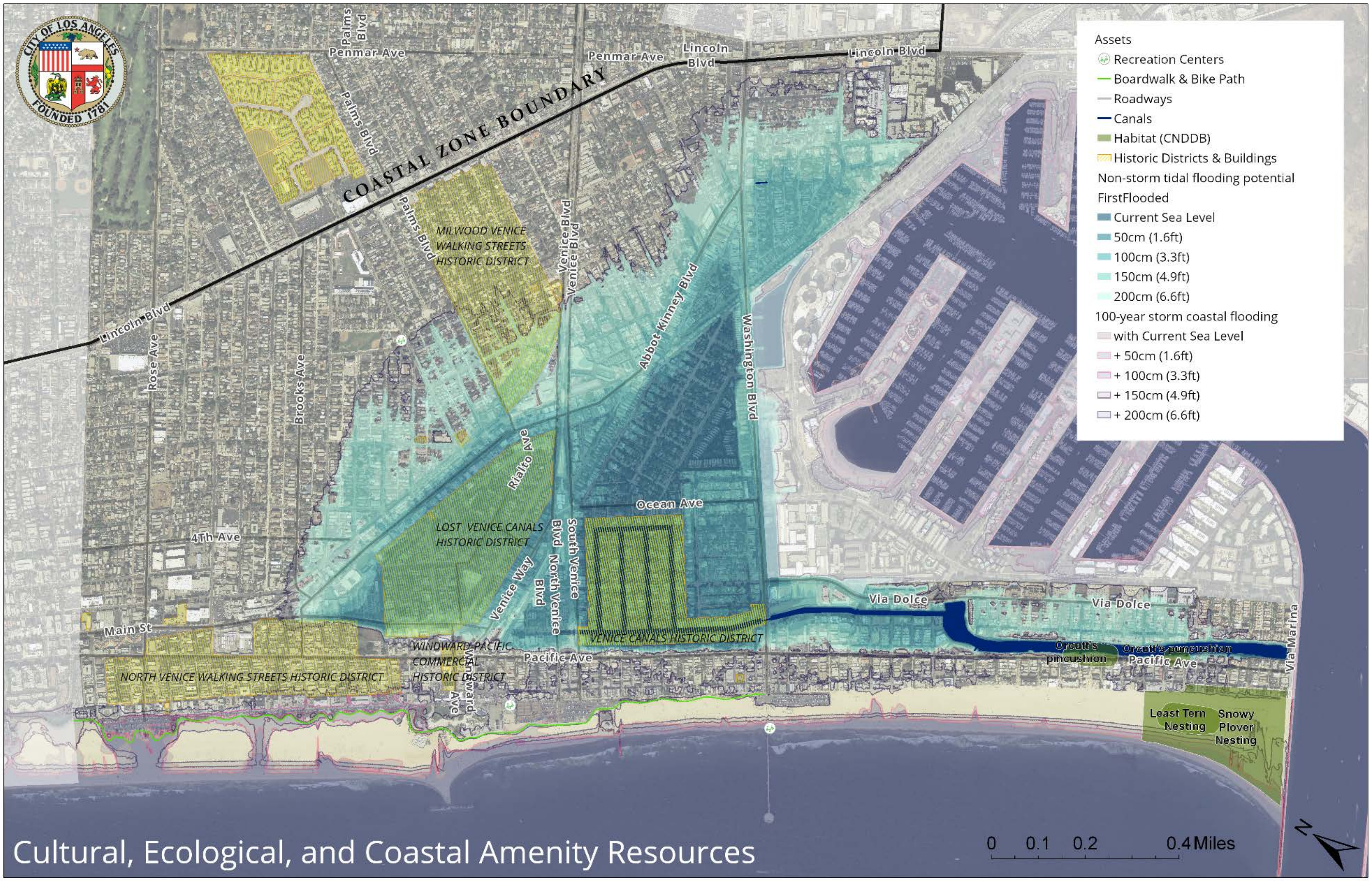



*Figure 6.4: Exposure Map of Cultural, Ecological, and Coastal Amenity Resources*

## 6.7 Social Vulnerability and Environmental Justice

### 6.7.1 What Is Social Vulnerability

Social vulnerability is a broad term referring to how the impacts of physical hazards such as flooding can be amplified by social characteristics. These characteristics can include income, poverty, education, females as head of household, race, linguistic isolation, age, housing type and age, and physical and mental illnesses and disabilities. These characteristics are associated with higher sensitivity and/or lower adaptive capacity to flooding and SLR and, thus, can be used to inform adaptation planning (USC Sea Grant, 2013).

### 6.7.2 What Is Environmental Justice

With the passage of California Assembly Bill 2616, environmental justice was recognized as a component to consider when issuing coastal development permits. Environmental justice refers to the equitable distribution of environmental benefits throughout the state and is described in the bill as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies (Burke, 2016). Environmental justice, as applied to SLR, can guide decisions with tradeoffs that affect coastal access and recreation, economic opportunity, or unequal exposure to environmental hazards.

*Key findings from Adapt LA SLR Vulnerability Study, 2013*

- *Venice may have reduced capacity to adapt to the impacts of sea level rise because of an older housing stock and high percentage of renters.*

- *The Social Vulnerability Index (developed by Cutter et al. 2003), which calculates a vulnerability index based on a combination of 32 census-based population characteristics, corroborates findings that communities in Venice, San Pedro and Wilmington are the most socially vulnerable coastal communities in the City.*

### 6.7.3 Vulnerable Populations

Flooding hazards can have disproportionate effects on populations with factors that make communication of emergency services or notifications, ability to evacuate to safe areas, and capacity to recover or adapt to hazards difficult. Such factors include age, disability, family status, homelessness, and linguistic isolation as well as populations who are institutionalized or burdened by poverty (Cutter et al, 2003). These factors are used to determine a Social Vulnerability Index (SVI) and are mapped in Figure 6.5 and Figure 6.6. Additionally, in Venice (and statewide), the burden of high costs of living can cause displacement and drive populations to live far away from their place of employment or public resources, such as the coast. SLR can exacerbate this displacement through additional costs of adaptation, flood insurance, or repair. Consideration of these populations should be included in the development of adaptation strategies and emergency response plans.

### 6.7.4 Homelessness

Venice (and the region as a whole) has been dealing with an increasing homelessness crisis in recent years. The 2017 Greater Los Angeles Homeless Count surveyed Venice and reported a total of 1,191 homeless persons (Los Angeles Homeless Services Authority, 2017). Homeless encampments frequently occur along the oceanfront walk and near the beachfront and commercial centers on Lincoln Ave, but can also be found throughout the Venice Community Planning Area. Encampments within the hazard areas identified in this study cause concern for the safety of these populations. Hazards can appear suddenly and without notice, such as a tide gate failure, or can be forecasted, such as a large storm. Evacuations and emergency sheltering can be difficult and costly for the community and should, therefore, be considered in adaptation strategies or emergency response plans.

### 6.7.5 Dynamic Demographics

The Venice community has expressed concerns with issues such as gentrification, changing demographics, and increasing cost of living. SLR can take place over a long period time relative to the speed at which community demographics can change. When planning for SLR, it is important to consider the dynamic nature of community demographics.

Important questions to consider going forward include:

- How do the dynamic issues of gentrification, displacement, and population growth affect Venice's vulnerability to SLR?
- How might tide gate failure, flood insurance, storm-related coastal flooding, or other SLR issues affect displacement or community make up?
- How will vulnerable populations be impacted by hazards and potential adaptation strategies?

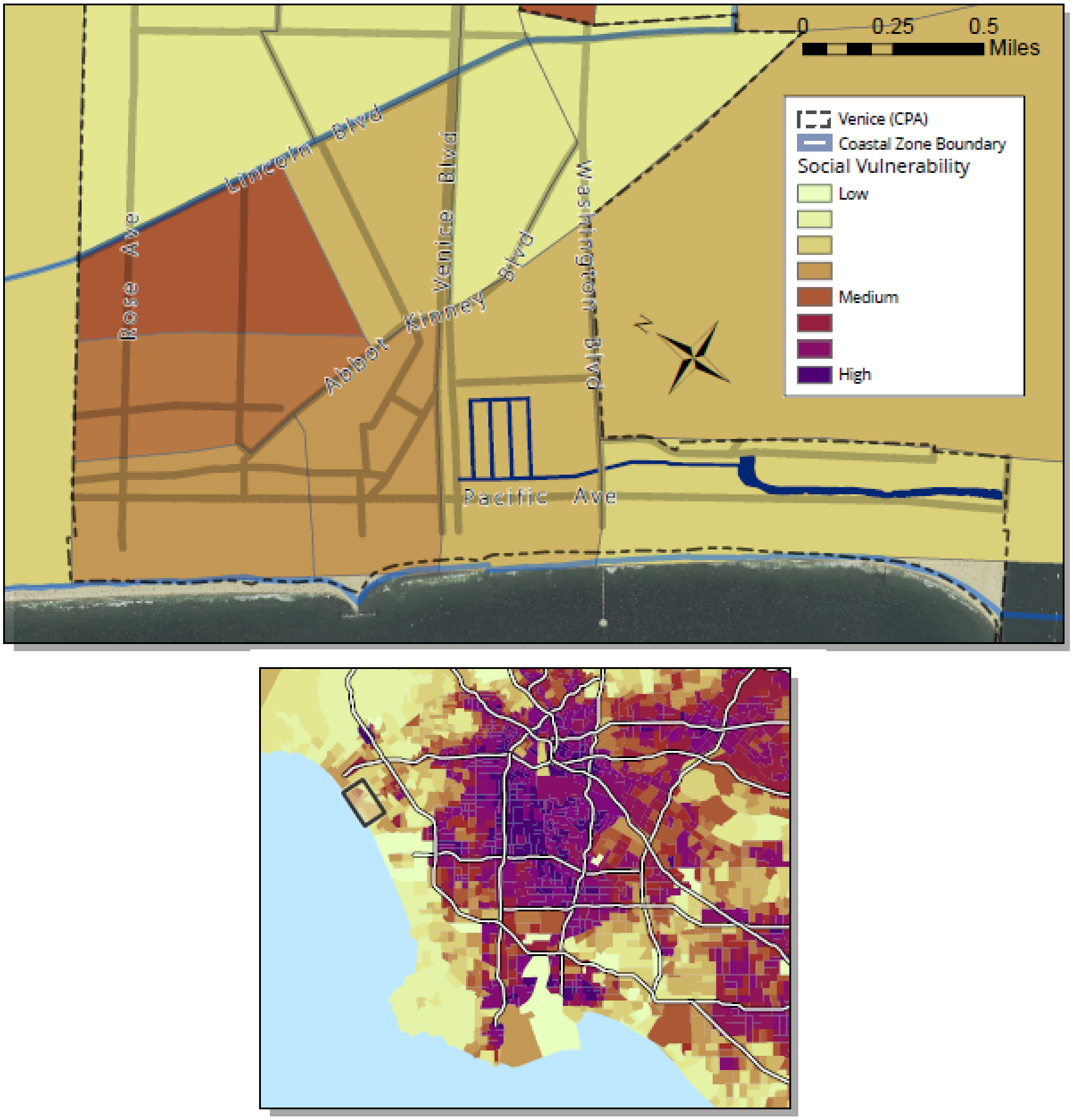



*Figure 6.5: Map of 2016 Social Vulnerability Index for Venice and Region by Census Tract (Data provided by Agency for Toxic Substances & Disease Registry)*


*Figure 6.6: Map of Minority Status and Language Isolation Index*
*(Used in 2016 Social Vulnerability Index. Data provided by Agency for Toxic Substances & Disease Registry)*

# 7. Risk Assessment Matrix

For this study, risk was determined to be a product of both consequence and urgency. A simple scoring matrix was developed to assess the risk to coastal resources, presented in Table 7.1. The risk scores range from R1 (lowest risk) to R4 (highest risk). Risk can be difficult to define because consequences are subjective and the accuracies of the probabilities are unknown. The goal of this section is to organize the findings of the VA in a way that can help focus the adaptation planning efforts on short-term impacts that have a high consequence.

Consequences were determined for each asset qualitatively based on the vulnerability of each asset category. Consequences were determined to be either "low," "medium-low," medium-high or "high" based on criteria outlined in Table 7.1.

Urgency was determined by distinguishing between long-term and short-term SLR thresholds. Short-term SLR thresholds refer to impacts identified for the current sea level or +1.6 feet SLR scenario, which represents a conservative estimate of SLR by mid-century. Long-term thresholds refer to impacts identified for the +3.3 feet and higher SLR scenarios expected to occur toward the end of the century or beyond. This approach focuses on specific SLR increments so the study can be interpreted and updated with future and more accurate projections about the timing of each increment.

*Table 7.1:Definition of Risk Assessment Scoring System*

| Consequence | Risk Score | |
|---|---|---|
| | Short-term SLR Threshold<br>SLR ≤ 1.6 ft | Long-term SLR Threshold<br>SLR ≥ 3.3 ft |
| High: Permanently damaged, large impact on system, large loss of value or life | R4 | R3 |
| Medium: Temporarily damaged but moderate impact on system, medium loss of value | R3 | R2 |
| Low: Temporarily damaged, low impact to system, small loss of value | R2 | R1 |

R1 = Low Risk, R2 = Medium Low Risk, R3 = Medium High Risk, R4 = High Risk

## 7.1 Infrastructure

Infrastructure systems throughout Venice provide important services to the community. In general, all assets in this category have some degree of exposure either currently, or with SLR of +1.6 feet. Most infrastructure has a limited adaptive capacity to accommodate the evolving hazards identified in this study. The tide gate system is subject to functional and operational vulnerabilities identified in Section 6.1.2 that could lead to cascading impacts that affect infrastructure and other resources in the low-lying areas of Venice. Assets like the VPP/VAPP provide a critical service to the Venice community, and impacts to the operations would result in significant consequences for public health and the environment. The

VPP and VAPP service both a large area and amount of sewage making any damage to the facility, its power supply, or increased demand felt throughout the system. Over 20% of the parcel of the facility intersects with the inland flood zone for present day sea level, with increased potential flood depths as sea level rises.

The VSPP and Westward Pump Stations service low-lying areas at risk to inland flooding with SLR of 1.6 feet. The pump stations themselves could experience a similar kind of flooding before 3.3 feet of SLR. The consequence of even temporary damage to the stations could result in decreased capacity for stormwater management, resulting in damages to nearby property. Similarly, the Boone & Olive PP and its service area could flood at present day, temporary interruptions in service during a flood event could damage nearby property. These risks increase with SLR as the potential flood depth increases and puts additional pressure on the conveyance capacity of these engineered systems. The results of this analysis are shown in Table 7.2 below.

*Table 7.2:Infrastructure Resource Risk Assessment Matrix*

| Asset | SLR Threshold | Consequence | Justification | Risk Score |
|---|---|---|---|---|
| Tide Gates | Short-term (SLR ≤ 1.6 ft) | High | Critical facility & potential for cascading impacts | R4 |
| VPP/VAPP | Short-term (SLR ≤ 1.6 ft) | High | Large regional impact, potential for damaging pollution | R4 |
| VSPP and Westward Pump Stations | Short-term (SLR ≤ 1.6 ft) | High | Large impact on drainage area | R4 |
| Boone & Olive PP | Short-term (SLR ≤ 1.6 ft) | High | Large impact on drainage area | R4 |
| Outfalls | Short-term (SLR ≤ 1.6 ft) | Medium | Moderate impact, easier to adapt/repair | R3 |
| Electric Infrastructure | Short-term (SLR ≤ 1.6 ft) | Medium | Temporary impact on communities and emergency services | R3 |
| Waste and Stormwater Collection Network | Short-term (SLR ≤ 1.6 ft) | Medium | Temporary impact on communities and emergency services | R3 |
| Transportation Infrastructure | Short-term (SLR ≤ 1.6 ft) | High | Large impact on communities and emergency services | R4 |
| Coastal Infrastructure | Short-term (SLR ≤ 1.6 ft) | Medium | Loss of function gradual but important for beach system | R3 |

R3 = Medium High Risk, R4 = High Risk

## 7.2 Civic

Access related assets, such as bus lines and parking, have a low potential for severe damage with flooding. The consequences associated with them involve the temporary loss of function and are, therefore, considered to have medium consequences with SLR. Schools and emergency services are considered to have high consequences, as any loss of service has a major impact to vulnerable populations and/or public safety. The results of this analysis are shown in Table 7.3 below.

*Table 7.3:Civic Resource Risk Assessment Matrix*

| Asset | SLR Threshold | Consequence | Justification | Risk Score |
|---|---|---|---|---|
| Bus Lines | Long-term (SLR > 3.3 ft) | Medium | Temporary loss of service | R2 |
| Parking (City-owned) | Short-term (SLR ≤ 1.6 ft) | Medium | Temporary loss of use, minor damage | R3 |
| Parking (County-owned) | Long-term (SLR ≥ 3.3 ft) | Medium | Temporary loss of use, minor damage | R2 |
| Lifeguard HQ | Long-term (SLR ≥ 3.3 ft) | High | Non-movable resource for safety and emergency services | R3 |
| Lifeguard Towers | Short-term (SLR ≤ 1.6 ft) | Low | Easily movable | R2 |
| Coeur d'Alene Elementary (LAUSD) | Long-term (SLR ≥ 3.3 ft) | High | Place of education | R3 |
| Westminster Ave Elementary (LAUSD) | Short-term (SLR ≤ 1.6 ft) | High | Place of education | R3 |
| Westside Global Awareness Magnet (LAUSD) | Long-term (SLR ≥ 3.3 ft) | High | Place of education | R3 |
| LAPD Venice Substation | Long-term (SLR ≥ 3.3 ft) | High | Non-movable resource for safety and emergency services | R3 |
| LA Fire Station 63 | Long-term (SLR ≥ 3.3 ft) | High | Loss of access would affect emergency services | R3 |

R2 = Medium Low Risk, R3 = Medium High Risk

## 7.3 Property

Damage to large segments of the Venice Canals and Southeast Venice sub-areas are possible from coastal hazards today. These impacts expand significantly with each increment of SLR, affecting a portion of all the sub-areas in Venice. Damage to property from flooding was characterized as a high consequence impact due to the resulting economic and social costs the community would face. Indirect impacts to property use also result from impacts to infrastructure and emergency services for these areas. The results of this analysis are shown in Table 7.4 below.

*Table 7.4: Property Resource Risk Assessment Matrix*

| Sub-area (as defined in LUP) | SLR Threshold | Consequence | Justification | Risk Score |
|---|---|---|---|---|
| North Venice | Short-term (SLR ≤ 1.6 ft) | High | Large impact on community | R4 |
| Marina Peninsula | Short-term (SLR ≤ 1.6 ft) | High | Large impact on community | R4 |
| Ballona Lagoon West | Short-term (SLR ≤ 1.6 ft) | High | Large impact on community | R4 |
| Ballona Lagoon (Grand Canal) East | Short-term (SLR ≤ 1.6 ft) | High | Large impact on community | R4 |
| Silver Strand | Long-term (SLR ≥ 3.3 ft) | Medium | Large impact on community | R3 |
| Southeast Venice | Short-term (SLR ≤ 1.6 ft) | High | Large impact on community | R4 |
| Venice Canals | Short-term (SLR ≤ 1.6 ft) | High | Large impact on community | R4 |
| Oxford Triangle | Long-term (SLR ≥ 3.3 ft) | Medium | Large impact on community | R3 |
| Millwood | Long-term (SLR ≥ 3.3 ft) | Medium | Large impact on community | R3 |
| Oakwood | Long-term (SLR ≥ 3.3 ft) | Medium | Large impact on community | R3 |

R3 = Medium High Risk, R4 = High Risk

## 7.4 Cultural Resources

The Venice Canals Historic District has a short-term SLR threshold due to its low elevation and direct proximity to the canals. The consequence of flooding to these cultural resources is considered medium because the impacts to the accessibility and character of the Canals are expected to be temporary, at least in the short-term. The Abbot Kinney & Venice Boulevard Historic Resources are also considered to have a short-term SLR threshold due to the inland flood potential at the +1.6 feet SLR scenario. The Coastal Historic Monuments are considered to have a long-term SLR threshold based on CoSMoS flood projections that indicate a 100-yr storm would not reach the monuments until the +3.3 feet SLR scenario. The consequences of damage to these coastal monuments is considered medium due to the ability to repair moderate damage from infrequent and short duration flooding associated with short-term SLR exposure. These consequences would have a limited effect on the Venice community. The results of this analysis are shown in Table 7.5 below.

*Table 7.5: Cultural Resource Risk Assessment Matrix*

| Asset | SLR Threshold | Consequence | Justification | Risk Score |
|---|---|---|---|---|
| Venice Canals Historic District | Short-term (SLR ≤ 1.6 ft) | Medium | Range of damage, possible for historic aspects to be repaired | R3 |
| Coastal Historic Monuments | Long-term (SLR ≥ 3.3 ft) | Medium | Range of damage, possible for historic aspects to be repaired | R2 |
| Abbot Kinney & Venice Boulevard Historic Resources | Short-term (SLR ≤ 1.6 ft) | Medium | Range of damage, possible for historic aspects to be repaired | R3 |

R2 = Medium Low Risk, R3 = Medium High Risk

## 7.5 Coastal Amenities

The iconic beaches and recreation centers of Venice are visited and used by multiple residents both local and regional, as well as tourists. The impact of erosion and flooding to these assets could have large cultural and economic impacts and are, therefore, considered to have a high consequence. The Municipal Fishing Pier has been damaged by coastal storms before, and SLR will increase the potential from storm-related damage. The results of this analysis are shown in Table 7.6 below.

*Table 7.6: Coastal Amenities Resource Risk Assessment Matrix*

| Asset | SLR Threshold | Consequence | Justification | Risk Score |
|---|---|---|---|---|
| Venice Beach Recreation Center | Long-term (SLR ≥ 3.3 ft) | High | Valuable resource for vulnerable population, center for tourism | R3 |

| | | | | |
|---|---|---|---|---|
| Oakwood Recreation Center | Long-term (SLR ≥ 3.3 ft) | High | Valuable resource for vulnerable population | R3 |
| Venice Beach Boardwalk | Long-term (SLR ≥ 3.3 ft) | High | Iconic center for tourism, local economy | R3 |
| Municipal Fishing Pier | Long-term (SLR ≥ 3.3 ft) | Medium | Can and has been repaired or rebuilt | R2 |
| Beach Recreation | Short-term (SLR ≤ 1.6 ft) | High | Major source of revenue for the area and cultural value of Venice | R4 |

R2 = Medium Low Risk, R3 = Medium High Risk, R4 = High Risk

## 7.6 Ecological

The sandy beach habitat is considered to have a short-term SLR threshold due to SLR-related erosion and increased potential for damaging storms. The Ballona Lagoon Marsh Preserve is considered to have a short-term threshold for SLR due to a decreased connection with ocean from tide gates causing potential changes in water quality and salinity. The endangered species associated with these habitats make consequences high. The Canals Area ESHA is considered to have a short-term SLR threshold for similar reasons as the Ballona Lagoon Preserve, but was assigned a medium consequence because there is less intertidal habitat in the Canals Area ESHA due to the limited tide range and landscape/hardscape features which line the canals. The coastal rocky nesting habitat is considered to have a long-term SLR threshold due to the height of the marina breakwater and jetties and lower consequence due to adaptive capacity of the de-listed California Brown Pelican. The results of this analysis are shown in Table 7.7 below.

*Table 7.7:Ecological Resource Risk Assessment Matrix*

| Asset | SLR Threshold | Consequence | Justification | Risk Score |
|---|---|---|---|---|
| Sandy Beach Habitat | Short-term (SLR ≤ 1.6 ft) | High | Loss of habitat for endangered species | R4 |
| Ballona Lagoon Marsh Preserve | Short-term (SLR ≤ 1.6 ft) | High | Loss of habitat for endangered species | R4 |
| Canals Area ESHA | Short-term (SLR ≤ 1.6 ft) | Medium | Less existing intertidal habitat | R3 |
| Coastal Rocky Nesting Habitat | Long-term (SLR ≥ 3.3 ft) | Low | De-listed species, similar rocky revetments nearby | R1 |

R1 = Low Risk, R3 = Medium High Risk, R4 = High Risk

# 8. Conclusion

This assessment identifies potentially significant vulnerabilities to the Venice Coastal Zone both with present conditions and future SLR. A resource's vulnerability to SLR is a product of its exposure to coastal hazards (direct physical exposure or cascading impacts to system), its sensitivity to said hazards (potential damage or loss of function), and its adaptive capacity (ability to restore function or avoid damage).

Assets in low-lying areas (3 to 8 feet NAVD88) are vulnerable to potential inland flooding. Potential exposure to inland flooding is the result of three vulnerabilities: 1) Canal tide gate malfunction; 2) large rainfall event coinciding with high ocean water levels; and 3) groundwater shoaling. While this study investigates each of these components to the extent possible within the allocated time and budget, further studies are recommended to understand Venice's exposure to items 2 and 3. Flooding of these low-lying areas is currently prevented and mitigated by two tide gates and several stormwater pump stations. Tide gate malfunction during high ocean water levels could result in flooding of varying depths, damaging critical infrastructure, property, and reducing access to emergency services. These high water levels will occur more frequently as sea level rises.

Higher water levels will also present challenging tradeoffs with regards to adaptation. The tide gates currently open for a limited window during the tide cycle to mute the effects of the ocean tides on the Ballona Lagoon and Venice Canals' water levels. SLR may require a change in the operation of these tide gates that could impact the exposure of inland assets to flooding, water quality, or habitat. If water levels are muted further in the future to prevent flooding then circulation in the canals could suffer, impacting water quality and habitat. On the other hand if the tide range is maintained in the canals, then the potential for flooding of developed areas around the canals would increase with each SLR increment.

Existing wide beaches generally protect Venice from coastal hazards. Coastal assets along or near the beachfront are potentially vulnerable during a large storm event in combination with SLR greater than 3.3 feet. After 4.9 feet SLR, beachfront assets are more vulnerable to damage from flooding or potential erosion of the beach. A SLR of 6.6 feet is a tipping point for Venice's exposure to extreme coastal wave events. Beachfront and coastal assets could flood annually, beaches could be greatly reduced in width, and high water levels could greatly increase potential for flooding of inland low-lying areas.

This report was based on the best available SLR science published by the OPC and consistent with CCC guidelines. SLR hazards were projected by CoSMoS, a multi-agency effort led by the USGS. The coastal processes affecting the City's shoreline are always changing and the hazards and projections depicted in this report are limited by the inherent difficulties in predicting future climate conditions, wave patterns, sediment supply, and development patterns.

There is considerable uncertainty around the timing of SLR, how future coastal processes may be affected, and what adaptation approaches will be applied in the future. The most effective way for the City to address the vulnerabilities described in this report is to implement policies and programs that are flexible and can be adapted in response to SLR, future beach conditions, and future development.

Recommended areas to focus primary efforts on include reducing current exposure to low-lying assets such as:

- Resilience improvements to the VPP and proposed VAPP per recommendations in the One Water LA Technical Memorandum No 5.5.
- Resilience improvements to the stormwater pump stations per recommendations in the One Water LA Technical Memorandum No 5.5.
- Improve resilience and redundancy of the Marina del Rey and Washington Boulevard tide gate systems.
- Investing in further analysis of stormwater system capacity for the Venice Canals' sub-area in combination with high ocean water levels and storm events.
- Investing in further analysis of existing and projected groundwater conditions and associated hazards with regards to SLR.

Venice's low-lying elevation makes it one of the most vulnerable communities in the region to SLR. Developing strategies for financing further studies and adaptation efforts in the short-term will contribute to increasing the resilience of the Venice coastal zone overall. In the long-term, increasing coordination with LA County and stakeholder groups will help inform regional approaches to adaptation to include nearby communities such as Santa Monica, Marina del Rey, and Playa del Rey.

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# Appendix A
# ASSET PROFILES

# Venice
# Sea Level Rise
# Vulnerability Assessment

## Asset Profiles

Funded in part by CCC Grant LCP-14-09

Assets evaluated:

- Tide gates
- Wastewater
- Stormwater
- Transportation
- Utilities (water & power)
- Coastal protection

# Infrastructure

## Stormwater Pump Plants ☆

Critical for flood protection.

Service areas and pump stations could flood with +1.6 ft SLR during tide gate failure.

Maintenance issues exacerbated by SLR affects on beach outfalls.

## Tide Gates △

Critical for flood protection.

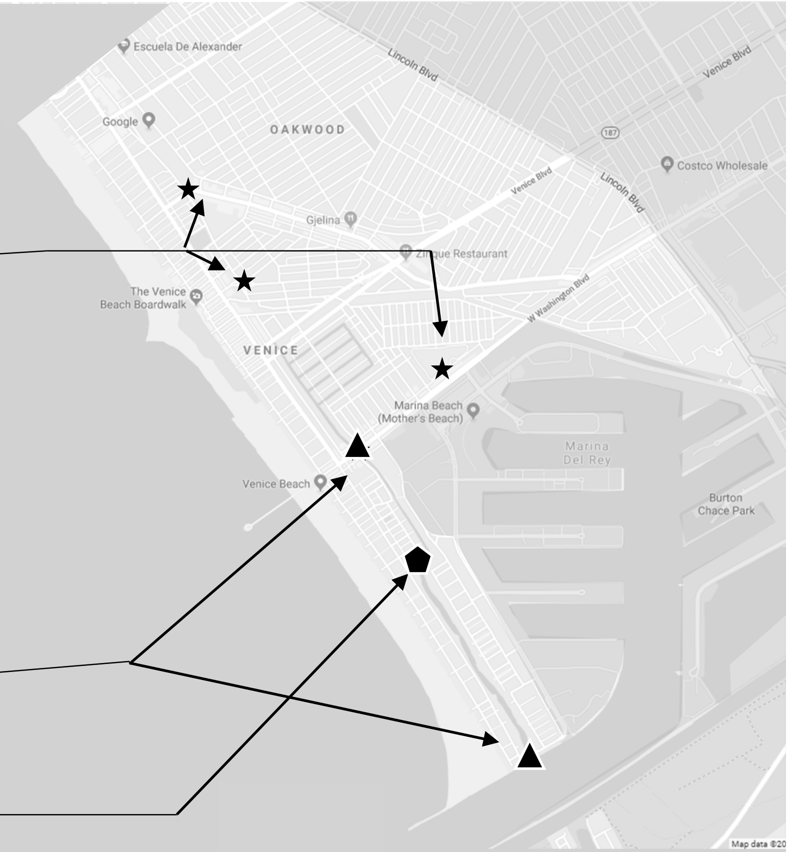
Prevent flooding at high tides / drain stormwater during low tides

Tide gate operations sensitive to SLR

## VPP/ VAPP ⬠

Critical wastewater facility / large service area

Venice Pumping Plant at risk to flooding from tide gate failure +1.6 ft SLR




## Transportation

Length streets flooded:
- 8+ miles (no SLR)
- 35+ miles (+6.6 ft SLR)

~6 miles of bikeways could be flooded.

Exposure: High exposure for infrastructure within inland low lying areas

Sensitivity: physical vs functional

- Physical – damage resulting from flooding, erosion or wave impact
  Example: Coastal protection sensitive to physical damage, leads to functional impact
- Functional – service or operation provided by asset is impaired
  Example: Tide gates – function/operation highly sensitive to SLR

Adaptive Capacity: limited / improvements needed to build in added capacity

# Marina del Rey Tide Gate

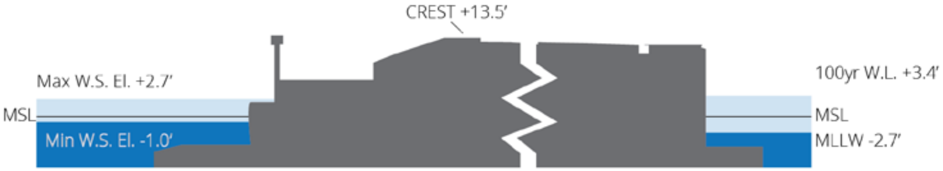
## Description

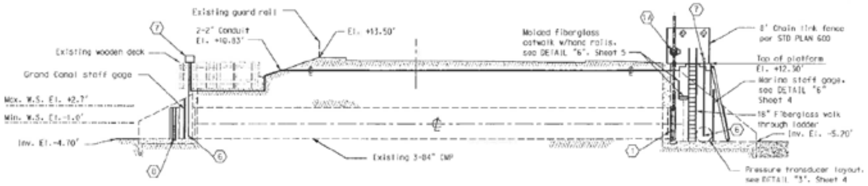
- Critical flood protection infrastructure.
- Prevents flooding of low-lying areas during high tide.
- Dampen high and low tides based on set operating schedule which has a wet and dry mode.

## Analysis

- SLR will force a change in operating regime.
- Reduced drainage capacity during large rain event
- Reduce flushing opportunities for Canals and Ballona Lagoon – water quality issues
- The elevation of the revetment which separates the Ballona Lagoon and the Marina is around 15ft NAVD88. This would mean overtopping of the gate would not be an issue until SLR >6.6 ft

## SLR Exposure



# Washington Blvd. Tide Gate

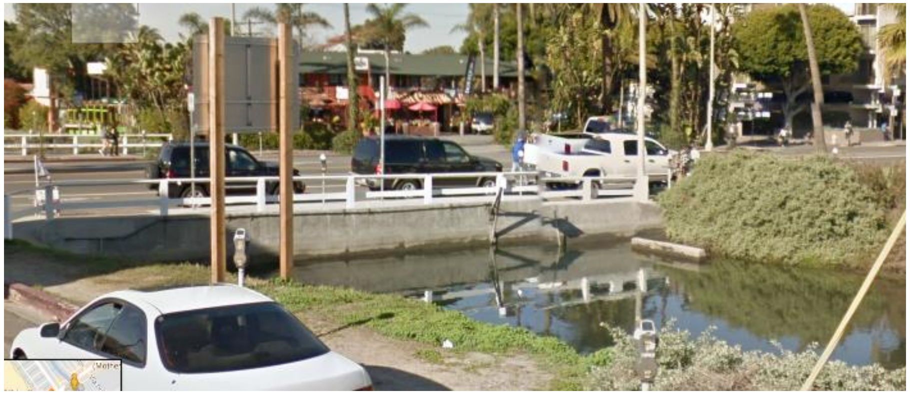
## Description

- Barrier between Ballona Lagoon and Venice Canals.
- Provides redundancy to MdR gates
- Used to manage water levels in Venice Canals.
- Operated by Mariposa Landscaping (in partnership with City of LA) opened ~bi-weekly in coordination with City and predicted tides

## Analysis

- The sensitivity of this tide gate is greater than the Marina gate because it is the last line of defense for the inland areas of Venice.
- Water quality management could be challenging with reduced flushing opportunities.
- The elevation surrounding the tide gate is close to present day MHHW, meaning a breach of the Marina gate could mean flooding on extreme high tides for inland areas even without SLR.

## SLR Exposure



# Venice Storm Water Pumping Plant (VSPP) & Westward Pump Stations

## Description

The Venice Storm Water / Urban Runoff Pumping plant (also referred to as Windward Circle) is a low flow diversion pump designed to move urban runoff and storm water to processing at a treatment plant during low flows and discharge into the ocean during storm flows (Adapt LA).


## Analysis

- Service area exposed to potential tidal flooding with 1.6 ft SLR
- Pumps would be key infrastructure for relieving tidal flooding
- Sensitive to supply of electricity, outfall maintenance, limits in pumping capacity
- VSPP is central hub, though level of support of surrounding pump stations is unknown

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
Windward service area in potential flood zone if tide gates were to fail at +1.6 ft.

Storm: (6.6 ft +)
Potential flood zone could be increased with high tide + storm surge. With 100 year storm flooding could come from coast side with +6.6 ft SLR.

# Boone & Olive Pumping Plant

## Description

Stormwater pump station serving low lying area of Southeast Venice (south of Abbot Kinney Blvd and North of Washington).

Pump station discharges to outfall in Marina del Rey


## Analysis

- Service area could flood at present day high tide
- Unknown storage/pumping capacity
- SLR could create a higher tailwater at the outfall in the marina, reducing drainage capacity during storm events.
- Sensitive to:
    - Groundwater flooding of low-lying areas
    - Limits in pumping capacity
    - Power supply
    - Water levels in Marina del Rey

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Current)
If tide gates were to fail, the pump station and service area could be impacted by flooding at present day, drastically increasing demand

Storm: (Long-term threshold)
Large rain event combined with high tide and storm surge will put maximum demand on station.

# Wastewater Pumping Stations (VPP & VAPP)

## Description

Venice Pumping Plant (VPP) and Venice Auxiliary Pumping Plant (VAPP) discharge to the Venice Dual Force Main, an important sewer line responsible for delivering sewage from large areas of the westside to the Hyperion Water Reclamation Plant.

VAPP will provide increased capacity & redundancy for this critical facility.


## Analysis

- VPP surrounded by walls but not flood-proofed. $1.6M of resilience improvements recommended in TM 5.5 (One Water LA, 2017).
- VAPP will include more flood-proofing measures
- Underground infrastructure (pipes & tanks) sensitive to changes in groundwater, liquefaction layer
- Sensitive to higher peak flows due to elevated groundwater levels or during a flood event

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
With 1.6 ft SLR, area surrounding VPP could experience flooding at high tide with tide gate failure.

Storm: (Long-term threshold)
Potential flood zone could be increased with high tide + storm surge. With 100 year storm flooding could come from coast side with +6.6 ft SLR.

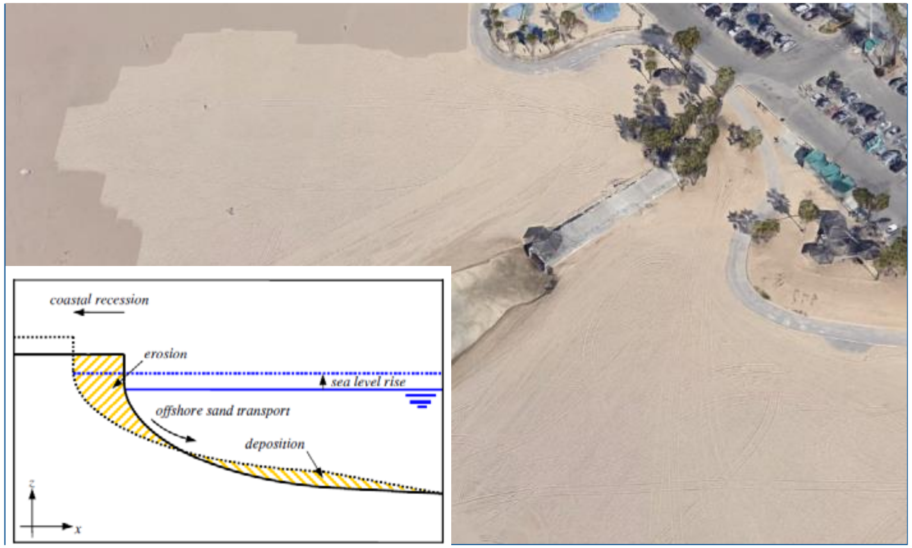
# Beach Storm Drain Outfalls

## Description

Three outfalls located along Venice Beach:

- Venice breakwater
- Brooks Ave
- Rose Ave

Outfall maintenance is currently a challenge and limits storm drain capacity if not adequately cleared prior to a storm event (One Water 2017).




## Analysis

- SLR will push beach upward and landward
- Outfalls will experience higher potential for sand blockage
- Outfalls could be damaged or exposed due to beach erosion (long-term)
- Outfalls could be reconstructed to adapt to changing beach conditions

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Unknown threshold)
With greater SLR, beach erosion could damage outfalls. (High uncertainty in erosion rates)

Storm: (1.6 ft +)
With 100-year storm at +1.6 ft SLR, higher water levels could reduce drainage capacity of outfalls. With a large rain event, drainage demand will be at highest resulting in increased demand and decreased capacity.

# Electric Infrastructure

## Description

- Overhead power lines throughout Venice
- 428 traffic signal cabinets, 3 communications hubs, 5 CMS cabinets, and 30 camera transceivers
- 230kV Scattergood-Olympic Cable underground
- Distribution stations at intersection of Culver Blvd. and Centinela Ave. (outside of Venice CZ/CPA)


Getty Images

## Analysis

- Flooding prohibits access or work space which would be problematic in power restoration efforts until flooding subsides
- Corrosion would be amplified in consistent flooding cycles
- No physical exposure for transmission stations for SLR <6.6 ft
- Any electrical infrastructure along boardwalk could be damaged in 100yr flood with 3.3 ft SLR
- Electrical grid is critical resource and has potential for impact on tide gate and pump plant system.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Short-term threshold)
Inland flooding could prevent maintenance and amplify corrosion

Storm: (Long-term threshold)
Coastal flooding during large storm could damage beachfront infrastructure and reduce access for repair

# Waste and storm water network

## Description

Includes storm water and wastewater collection systems pulled from LA City geohub.

Most of the storm drain collection systems drain to pump stations, except for Venice Canals and Ballona Lagoon and coastal areas (higher in elevation).

Wastewater collection systems convey sewage to VPP and VAPP


## Analysis

- Stormwater network is resilient to minor flooding and experiences large tidal influence according to County report (2014).
- Possibility for reverse flooding from tide gate failure (short-term) and from open coast or Marina outfalls (long-term)
- Possibility for biofouling inside pipes or network as tidal range increases in elevation
- Higher groundwater could result in more inflow & infiltration into the wastewater collection system

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Short-term threshold)
Higher groundwater levels, possibility for reverse flooding from outfalls, biofouling, potential instability of infrastructure (pipes & tanks).

Storm: (Short-term threshold)
Reduced capacity in storm event, higher tailwater, reverse flooding from outfalls

# Transportation Infrastructure

## Description

Auto infrastructure: street network, major thoroughfares such as Highway 1/PCH/Lincoln Blvd., Venice Blvd, Washington Blvd, etc., traffic control systems

Bike infrastructure: Class I, II, and III bikeways as well as Cycle Tracks

Pedestrian infrastructure: sidewalks, boardwalk

## Analysis

- Potential for significant temporary impacts to function/service provided by transportation infrastructure
- Bikeways and roads could be elevated to act as flood prevention infrastructure in key areas.

| | Inland Flood Potential | | | | | 100yr Coastal Flooding (CoSMoS) | |
|---|---|---|---|---|---|---|---|
| | 0 ft | 1.6 ft | 3.3 ft | 4.9 ft | 6.6 ft | 3.3 ft | 6.6 ft |
| Length of Street Affected (miles) | 8.7 | 17.3 | 21.7 | 28.4 | 35.0 | 0.7 | 35+ |
| Length of Bikeways Affected (miles) | 0.03 | 1.4 | 2.3 | 3.4 | 3.8 | 0.8 | 5.7 |

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Short-term threshold)
Temporary flooding of major roads and bikeways could lead to reduction in access for emergency services.

Storm:
SLR increases potential for wave overtopping, scouring, and direct wave attack on existing infrastructure such as boardwalk/coastal bike trail as well as limiting access for emergency services.

# Coastal Infrastructure

## Description

Includes breakwater and groin at Windward Ave, armoring and groin at Lifeguard HQ and jetty and breakwater at marina entrance

## Analysis

- Reengineering may be required to update designed water levels  of coastal infrastructure with SLR
- SLR may worsen potential damage of large storm events
- Use of "hard" coastal infrastructure can be effective in protecting sandy beach but can also have negative impacts on surf and aesthetic quality of beach.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Short-term threshold)
With greater SLR, effectiveness of existing infrastructure is diminished

Storm:
SLR increases potential for wave overtopping, scouring, and direct wave attack on existing infrastructure.

Exposure

- High for inland low-lying areas - flood potential exists today
- Lower for coastal storm flooding / 6.6 ft SLR (2090 – 2100+)

Sensitivity

- Highly sensitive to flooding / cost of damage / disruption to community

Adaptive capacity

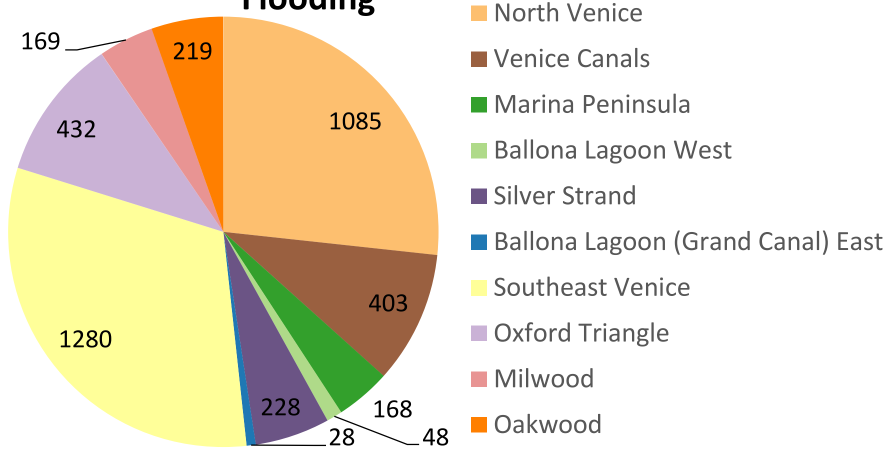
- Temporary flood proofing (sand bags/elevate valuables): flooding <1 ft deep
- Limited adaptive capacity for flooding > 1 ft

# Property

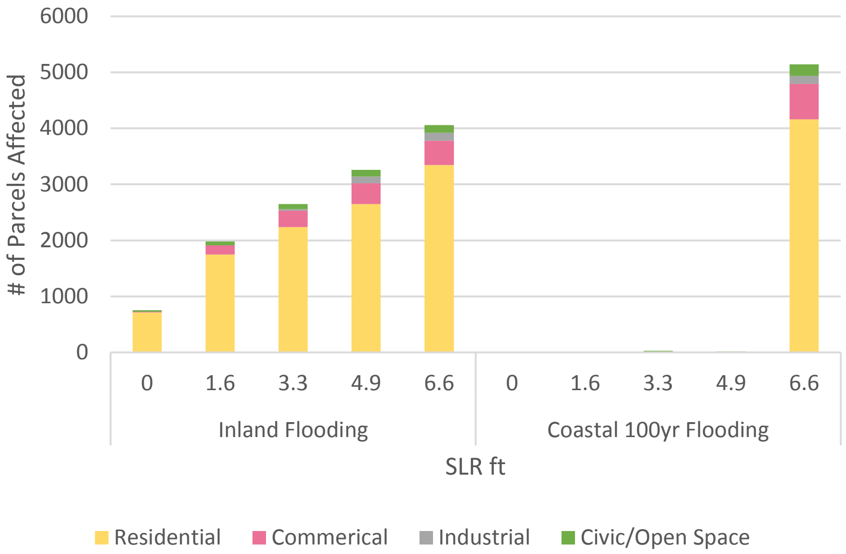
# Summary

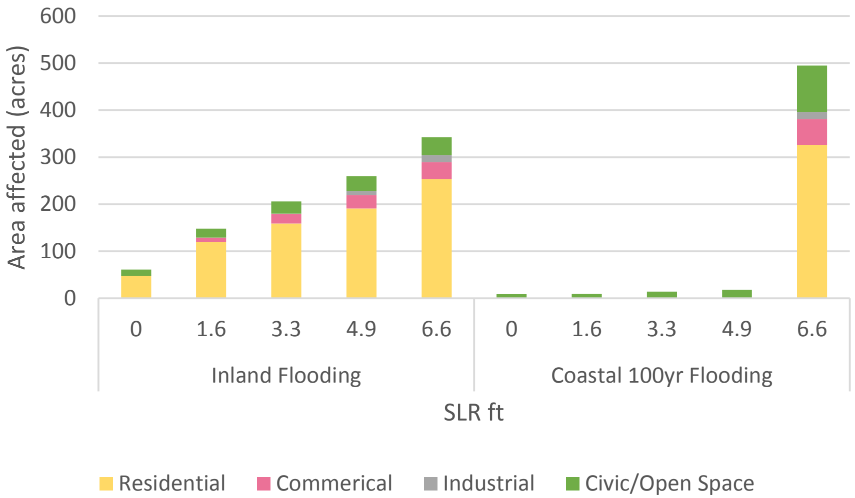
## Description


### # of Parcels Affected for +6.6 feet Inland Flooding




## Parcel Analysis



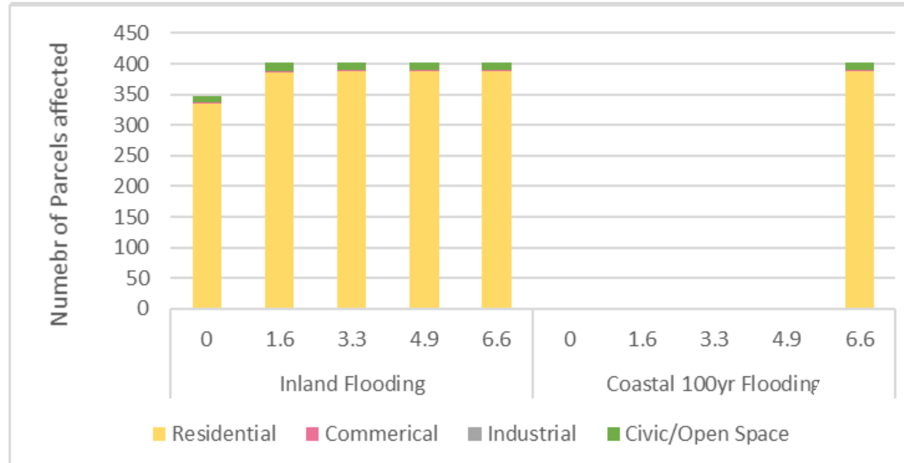
# Venice Canals

## Description

Historic District surrounding Venice Canals.

+0.0 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Sensitive to access from emergency services due to bridges and limited road network, historical character of property.

Adaptive Capacity:
Limited adaptive capacity due to historical designation limitations.

Short-term SLR Threshold (Current Sea Level)
Potentially first properties to flood in the case of tide gate failure.

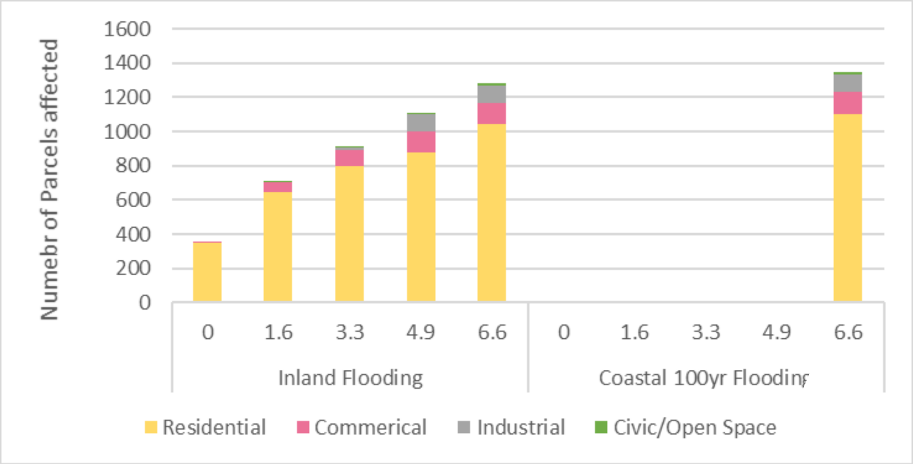
# Southeast Venice

## Description

Central Venice subarea extending from Grand Canal to Lincoln Blvd.. Includes lowest lying areas of the coastal zone.

+0.0 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Sensitive to Adaptation efforts in MdR. Sensitive to higher groundwater levels.

Adaptive Capacity:
Limited adaptive capacity due to cost of construction and present height limitations.

Short-term SLR Threshold (Current Sea Level)
Low-lying residential and commercial centers most vulnerable to inland flooding.

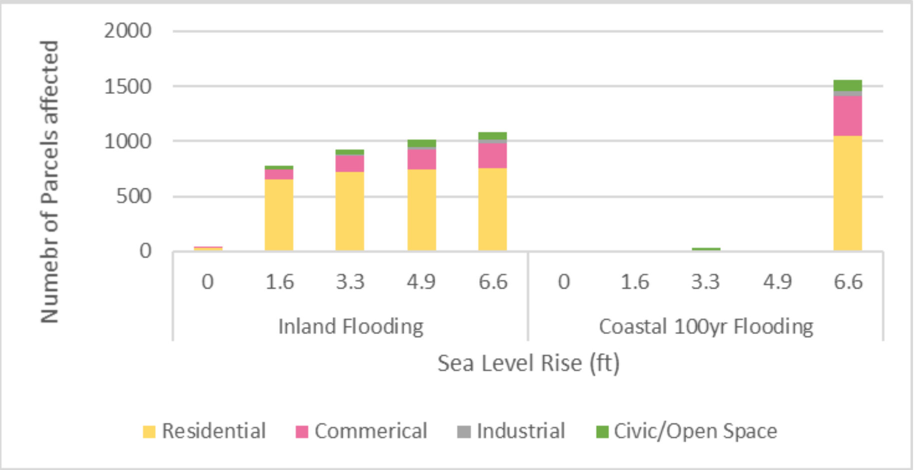
# North Venice

## Description

Central area including Abbot Kinney and Boardwalk commercial areas as well low-medium density residential areas.

+1.6 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Beach area is sensitive to storm-related flooding and damage to beachfront.

Adaptive Capacity:
Generally limited adaptive capacity due to factors such as ground level retail and cost of repair.

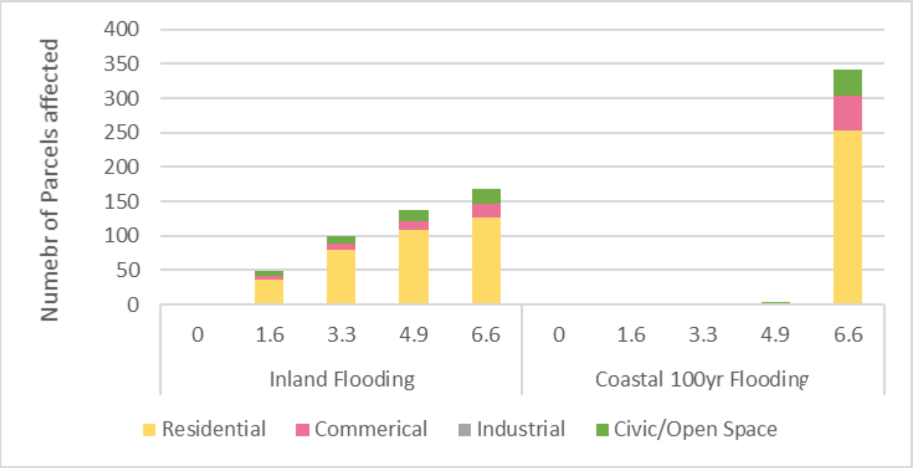
Short-term SLR Threshold (+1.6 ft)
Low-lying residential and commercial centers most vulnerable to inland flooding. Beachfront areas on north and south side of recreation center vulnerable to 100 year storm with +6.6 ft SLR.

# Marina Peninsula

## Description

Beachfront community of Venice from Washington Blvd. to the Marina Jetty.

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Beach area is sensitive to storm-related flooding though less storm related damage projected for beachfront.

Adaptive Capacity:
Limited due to cost of repair, some development has covered ground floor parking and elevated living spaces reducing exposure.

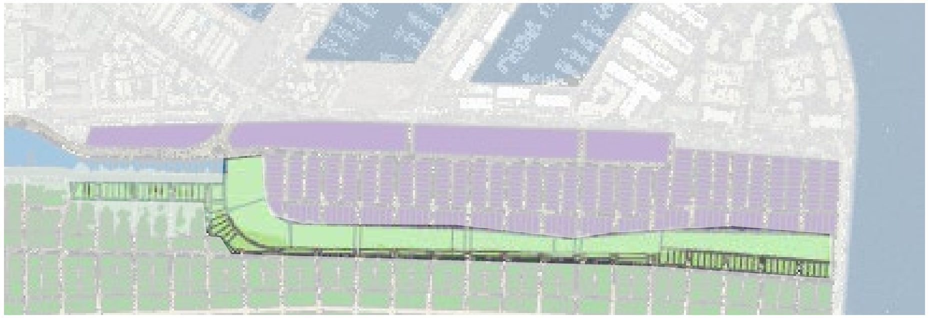
Short-term SLR Threshold (+1.6 ft)
Low-lying residential most vulnerable to inland flooding.
Beachfront areas in northern reach of subarea at risk to coastal flooding.

+3.3 ft

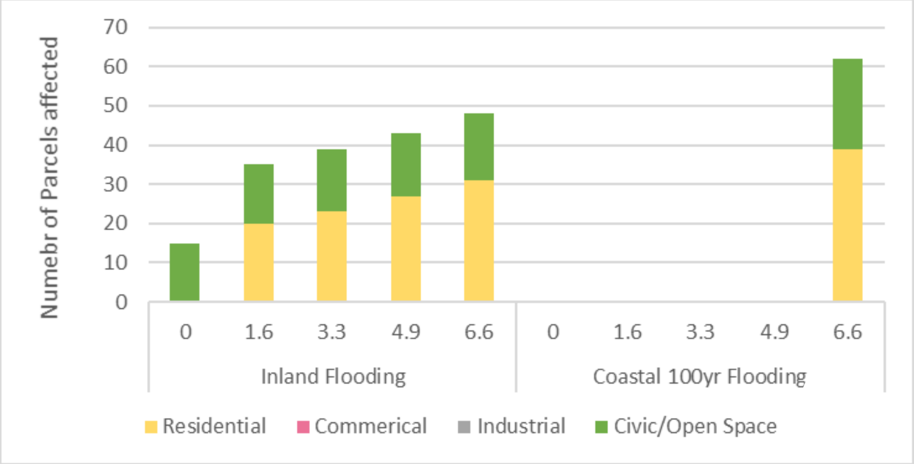
# Ballona Lagoon West

## Description

Includes Ballona Lagoon including westward adjacent properties.



## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Open space sensitive to higher water level. Highly dependent on MdR tide gates.

Adaptive Capacity:
Limited adaptive capacity of residential parcels, Ballona Lagoon provides some buffer for adaptation measures.

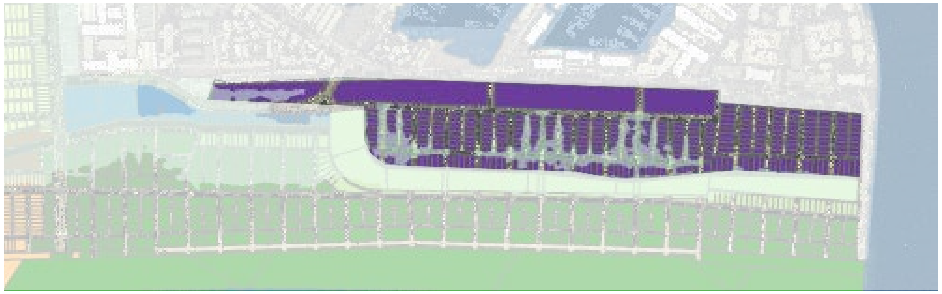
Short-term SLR Threshold (+1.6 ft)
Low-lying residential and open space most vulnerable to flooding.

+1.6 ft

# Silver Strand

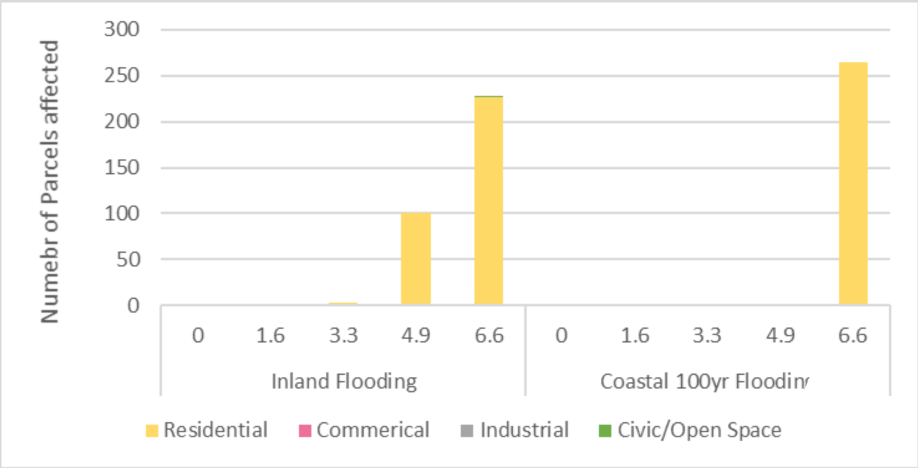
## Description

Residential area east of Ballona Lagoon and West of Via Dolce



+4.9 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Sensitive to adaptation efforts of MdR.

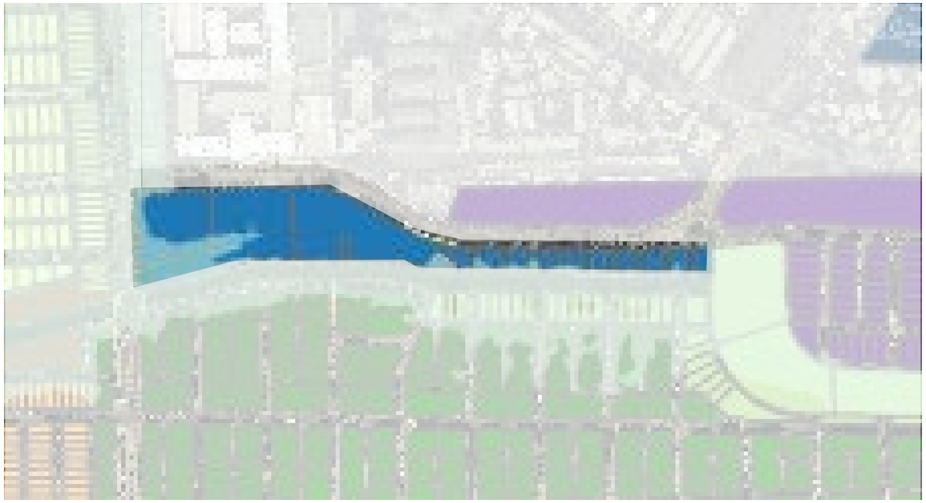
Adaptive Capacity:
Limited, higher elevations may improve drainage to Ballona Lagoon

Long Term SLR Threshold (+4.9 ft)
Low-lying residential properties vulnerable to flooding from larger sea level rise. Adjacent to lowest point between inland area and the ocean (Via Marina and Tahiti way).

# Ballona Lagoon (Grand Canal) East

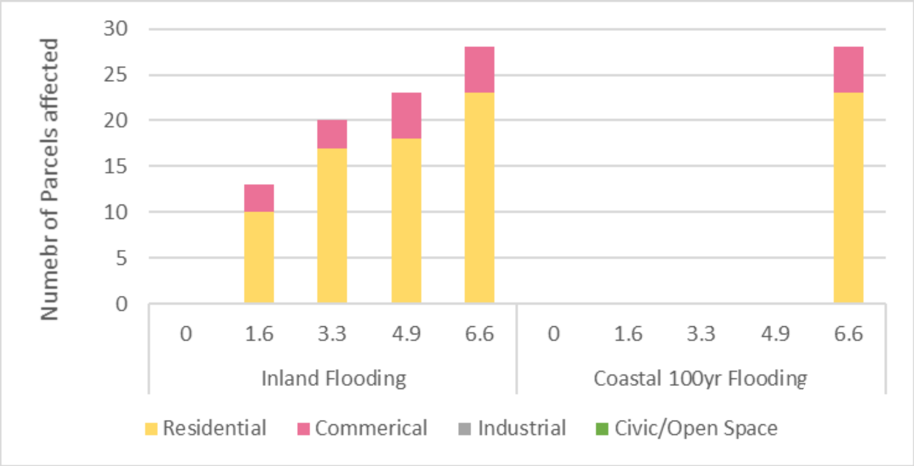
## Description

Mixed-use area east of grand canal between Via Dolce and Washington Blvd with relatively higher density development.



+1.6 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents.

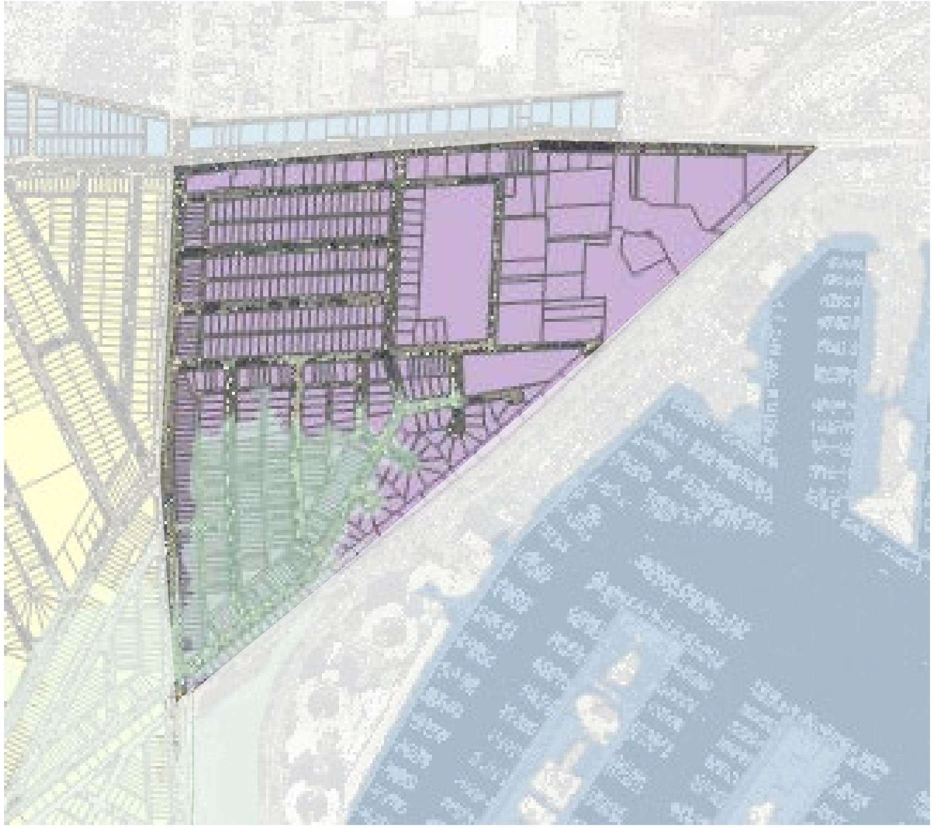
Adaptive Capacity:
Due to multi-story development, first floors may be retrofitted to handle temporary flooding.

Short-term SLR Threshold (+1.6 ft)
Low-lying residential and commercial centers most vulnerable to inland flooding..

# Oxford Triangle

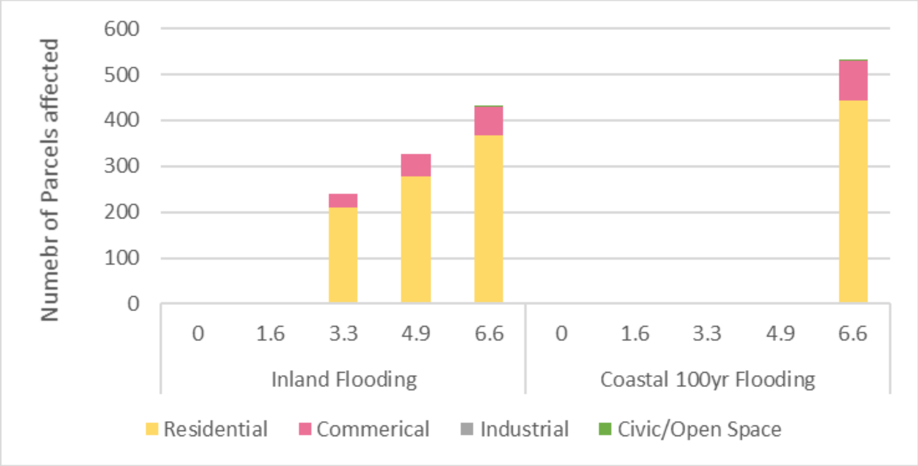
## Description

Bounded by Marina del Rey, Washington, and Lincoln Blvd. Includes higher density development and commercial use.



+3.3 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Sensitive to adaptation efforts of MdR.

Adaptive Capacity:
Limited capacity due to cost of construction, large city-owned lot midway down Admiralty way could be adapted for water storage or flood prevention infrastructure.

Long-term SLR Threshold (+3.3 ft)
Low-lying low density residential most vulnerable to inland flooding.

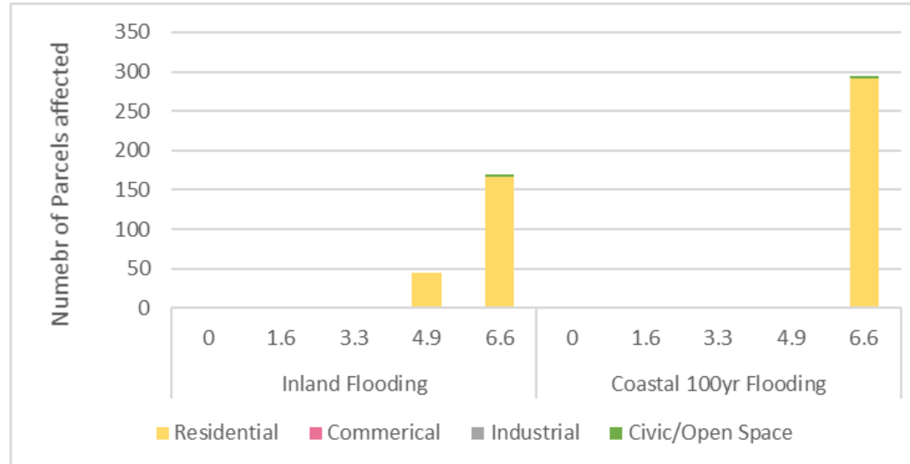
# Milwood

## Description

Mainly residential area bounded by Lincoln Blvd, South Venice and Electric Ave.

+4.9 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents.

Adaptive Capacity:
Limited adaptive capacity though higher elevations could provide better drainage.

Long-term SLR Threshold (+4.9 ft)
Low-lying residential most vulnerable to inland flooding.

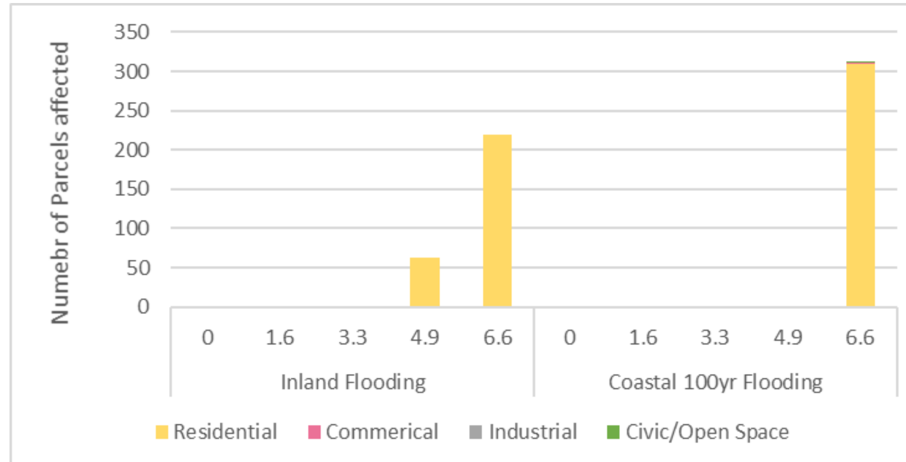
# Oakwood

## Description

One of few historically African American neighborhoods in West Los Angeles, historically area of vulnerable populations and communities of color.

+4.9 ft

## Parcel Analysis




## Vulnerability Assessment

Sensitivity:
Potentially sensitive to damage from inland flooding that could threaten safety and property of residents. Vulnerable populations sensitive to high cost of repair or flood insurance.

Adaptive Capacity:
Limited adaptive capacity though higher elevations could provide better drainage.

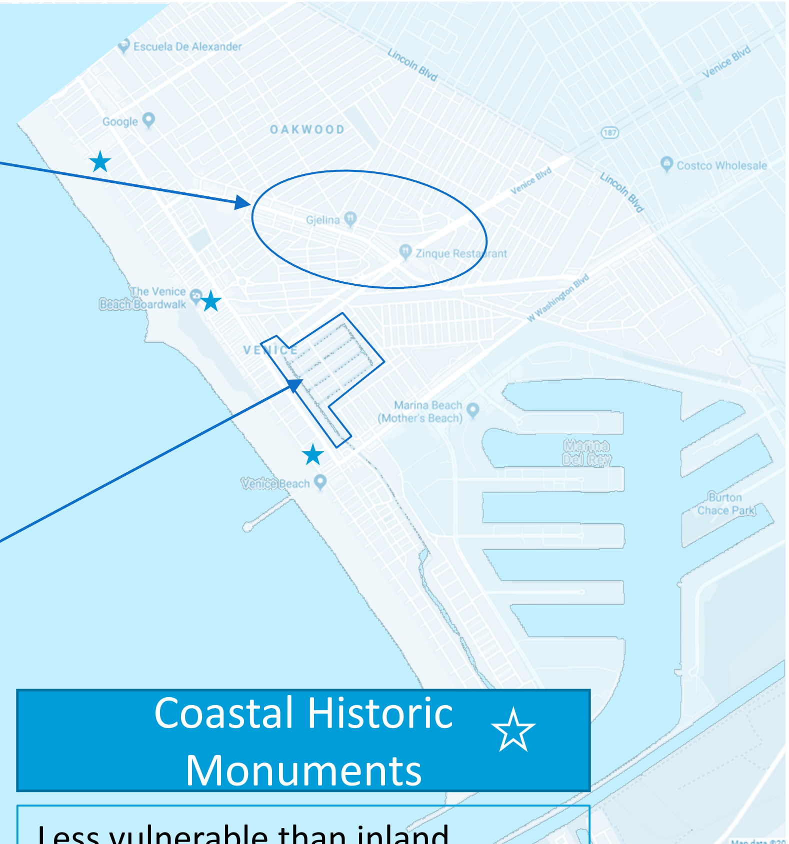
Long-term SLR Threshold (+4.9 ft)
Low-lying residential most vulnerable to inland flooding.



# Cultural

Assets evaluated:

- Venice Canal Historic District
- Kinney-Tabor House
- Venice Branch Library
- Venice Division Police Station
- Sturdevant Bungalow
- Venice City Hall
- Venice of America House
- *Venice West Café*
- *Warren Wilson Beach House*
- *Venice Arcades*




## Abbot-Kinney & Venice Blvd Historic Monuments

Monuments such as Venice of America House could be flooded with tide gate failure and +1.6 ft SLR

Others within potential flood zone with higher SLR increments

## Venice Canals Historic District

Potential for flooding today if tide gates were to fail.

Tide gate operations may raise average water level in the district changing aesthetic quality.

Water quality impacts from reduced flushing.

## Coastal Historic Monuments ☆

Less vulnerable than inland monuments

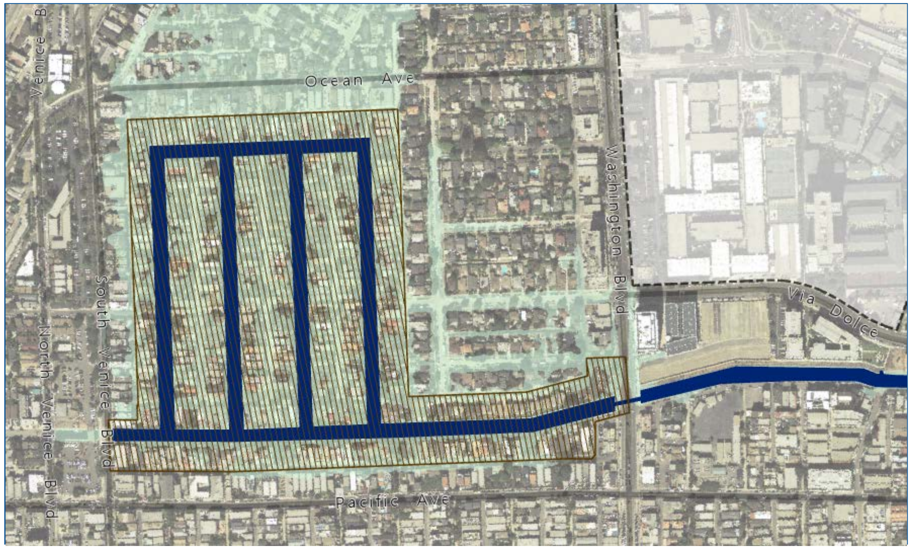
Venice West Café borders modeled 100yr flood of CoSMoS +3.3 ft SLR (2060 – 2100+)

Potential for temporary flooding of first floors during 100-year coastal storm +6.6 ft SLR (2090 – 2100+)

# Venice Canal Historic District

## Description

Residential district listed on National Register of Historic Places in 1982, originally constructed in 1905.




## Analysis

- Water levels inside the district are controlled by the Washington Blvd. Tide Gate with no redundancies
- Aesthetic and historic character of district is sensitive to protective infrastructure such as bulkheads
- Center for tourists and high home prices
- Sensitive to large rain events in combination with higher SLR
- District is the first area to be flooded in the case of tide gate failure

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

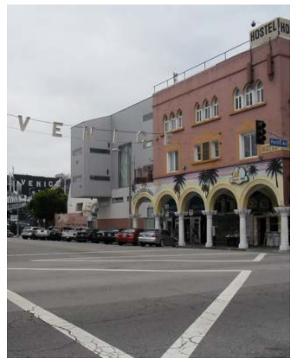
Non-storm: (Current)
Present day high tides could flood the community with tide gate failure. Rising groundwater levels due to SLR could result in flooding or sea water infiltration.

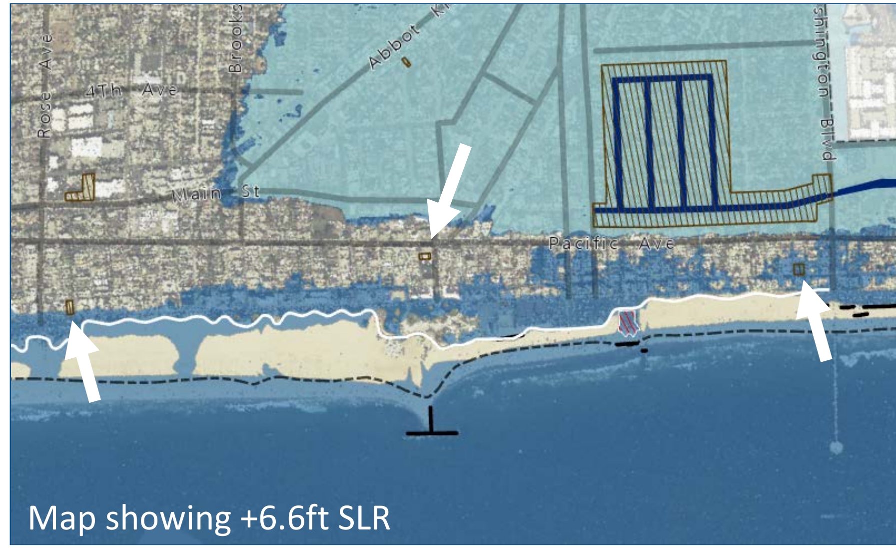
Storm: (Current)
A large rain event in combination with storm surge and high tide could reduce the capacity of the canals to store stormwater, possibly resulting in flooding for the district.

# Coastal Historic Monuments

## Description

Venice West Café, Warren Wilson Beach House, Venice Arcades




Map showing +6.6ft SLR

## Analysis

- The main hazards for these resources are storm related an dependent on the beach conditions and wave conditions for each scenario
- The historic nature of these monuments are tied to their location near the beach and have limited adaptive capacity in terms of possible relocation
- The sensitivity to damage is dependent on the magnitude of flooding or overtopping, higher elevations and large beach could reduce damage from flooding

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Long-term Threshold)
Extreme scenarios of beach erosion could put some of these monuments at risk with greater SLR

Storm: (3.3 ft +)
The northern most historic monument: Venice West Café, is at edge of modeled flood extent starting at +3.3 ft SLR
The remaining two show exposure from the coastal side starting at 6.6 ft SLR

# Abbot Kinney and Venice Blvd Historic Resources

## Description

Includes Kinney-Tabor House, Venice Branch Library, Venice Division Police Station, Sturdevant Bungalow, Venice City Hall, Venice of America House


## Analysis

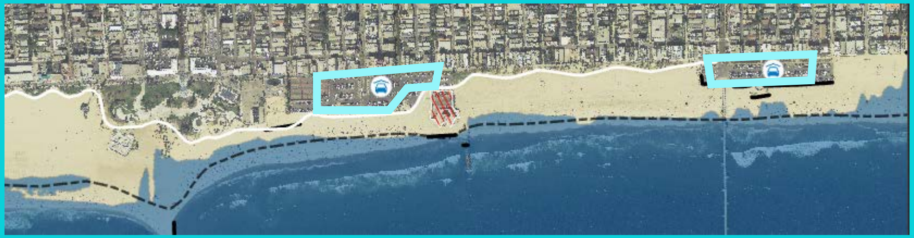
- Historic monuments in the Abbot Kinney area are at risk to potential flooding at +1.6 ft SLR
- These resources have high sensitivity due to the limitations on repairs and construction
- Developing in situ infrastructure may be more difficult due to historic nature of buildings

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
Potentially at risk to flooding in the case of tide gate failure.

Storm: (Long-term Threshold)
A large rain event in combination with the reduced capacity of stormwater system due to SLR could result in temporary flooding of these resources.



Assets evaluated:
- Bus Lines
- Parking Lots
- Lifeguard HQ & Towers
- Low-Lying Schools:
  - Coeur d'Alene
  - Westminster
  - Westside Global Awareness Magnet
- LAPD Venice Substation
- LA Fire Station #63

# Civic

## Lifeguard HQ ◇

Beach often narrowest in front of Lifeguard HQ

Damaged in ‘82-83 storms

Increased potential for wave and storm related damage with SLR

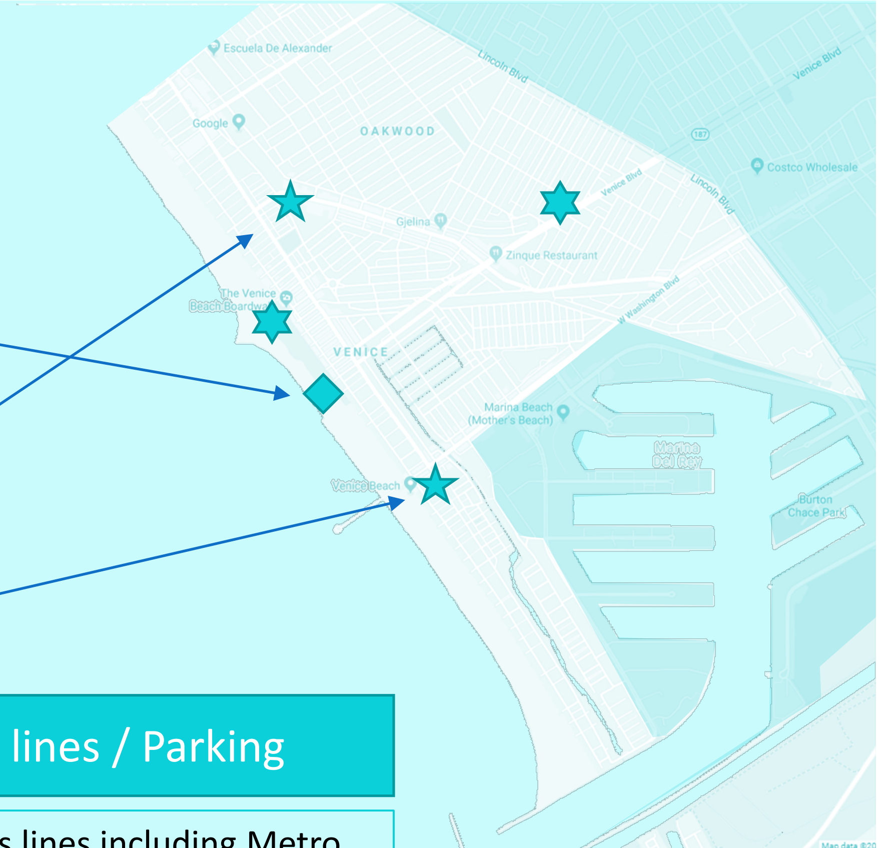
## Low-lying Elementary Schools ☆

Tide gate failure could flood portions of Westminster and Westside Global Magnet elementary schools.

## Fire and Police Stations ✡

With +4.9 ft SLR, Fire Station 63 could have reduced access due to flooding from tide gate failure

Access to LAPD Substation at Venice Beach could be impacted by 6.6ft 100 yr storm.




## Bus lines / Parking

Several bus lines including Metro 108/33/733 could be temporarily interrupted by flooding from tide gate failure

City and County parking lots at risk of temporary flooding with +1.6 ft SLR

Exposure
- High exposure to inland flooding for parking lots, bus lines, and Westminster Elementary
- Sustained coastal or inland flooding could affect service areas.

Sensitivity
- Emergency services highly sensitive to loss of access
- Schools considered highly sensitive resource

Adaptive capacity
- Lifeguard towers highly mobile
- Civic centers such as schools have limited resources to adapt

# Civic

# Bus Lines


## Description

Regional and local bus lines serving Venice community and beyond including:

- Metro: 108, 33,733
- Santa Monica Big Blue Bus: 1, 18
- LA DOT: CE437
- Culver City: 1

## Analysis

Some routes lie within the potential flood zone at +1.6 ft SLR at Washington Blvd and Venice Blvd.
With greater SLR, the potential flood area expands along Washington while Via Marina and Pacific Ave remain at higher elevations.
At +6.6 ft SLR, overtopping from the beach could affect Pacific Ave. The ability to adapt to inundate areas varies depending on severity
33 and 733 could be critical to regional mobility for Venice residents and commuters though more information would needed from Metro.

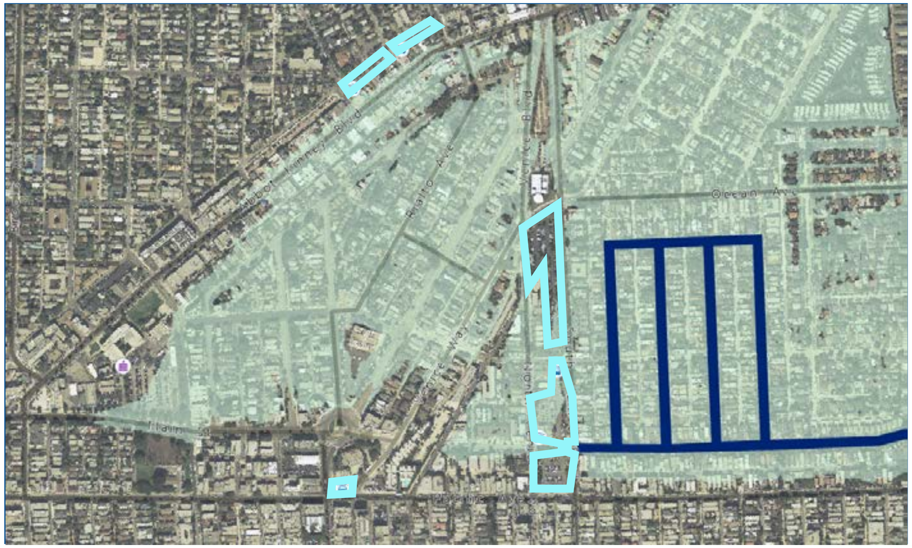
## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (3.3 ft+)
With 3.3 ft SLR, the route may be disturbed by tide gate failure.

Storm: (6.6 ft+)
The capacity of the stormwater and flood prevention systems will affect the potential for storm related flooding. At +6.6 ft SLR, flooding from the coast may disrupt the line during a 100-year storm.

# Parking (city-owned)



## Description

City owned parking lots throughout coastal zone

## Analysis

The parking lots along Venice Blvd. are in potential inland flood zone with +1.6 ft SLR
Parking lots along the edge of Abbot-Kinney are within zone at +3.3 ft SLR
Flooding of parking lots may result in minor damages but are generally easily repairable.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
With 1.6 ft SLR, parking lots may be flooded by tide gate failure.

Storm: (6.6 ft +)
The capacity of the stormwater and flood prevention systems will affect the potential for storm related flooding.

# Parking (county-owned)

## Description

Three county-owned parking lots (need verification) along the beach

## Analysis

- The vulnerability of these parking lots is difficult to determine due to the limitations of the CoSMoS model.
- Hazards include periodic flooding with higher SLR and wave damage with large storm events.
- Lots sensitive to erosion, but can accommodate temporary flooding.
- The revenue and access provided by these parking lot is tied to the value of the beaches below.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Long-term Threshold)
With greater SLR, the beach will erode and be pushed up and back onto the parking lots.

Storm: (3.3 ft +)
The Rose Ave parking lot is within the 100-year coastal flood extent starting at +3.3 ft SLR and could be at risk to damage from storm events (I.e. wave energy, scouring, and flooding)

# Lifeguard HQ

## Description

Local headquarters for LA County Lifeguards, storage of vehicles and equipment used for safety and beach maintenance. Protected by buried revetment and jetty.

## Analysis

- Historical damage from 1983 El Nino storms.
- Exposed to wave runup, potential beach erosion, direct wave action
- Storage of county assets and role in providing safety makes areas sensitive to damage
- Can be relocated or reconstructed to reduce exposure

## SLR Exposure

| Current | 50 cm/<br>1.6 ft | 100 cm/<br>3.3 ft | 150 cm/<br>4.9 ft | 200cm/<br>6.6 ft |
|---|---|---|---|---|

Non-storm: (Short-term Threshold)
Potentially at risk to beach erosion, reducing access and resulting in possible damage

Storm: (4.9 ft +)
CoSMoS model results show potential for flooding during a 100-year storm. Potential for damage from direct wave action.

# Lifeguard Towers

## Description

Variable number of lifeguard towers (~19) moved with changing beach conditions

## Analysis

- Potential for damage from large storm events
- Potential loss of beach area from beach erosion
- Highly adaptive due to mobility
- Sensitive to beach conditions, visibility, storm frequency, visitors, and beach loss

## SLR Exposure

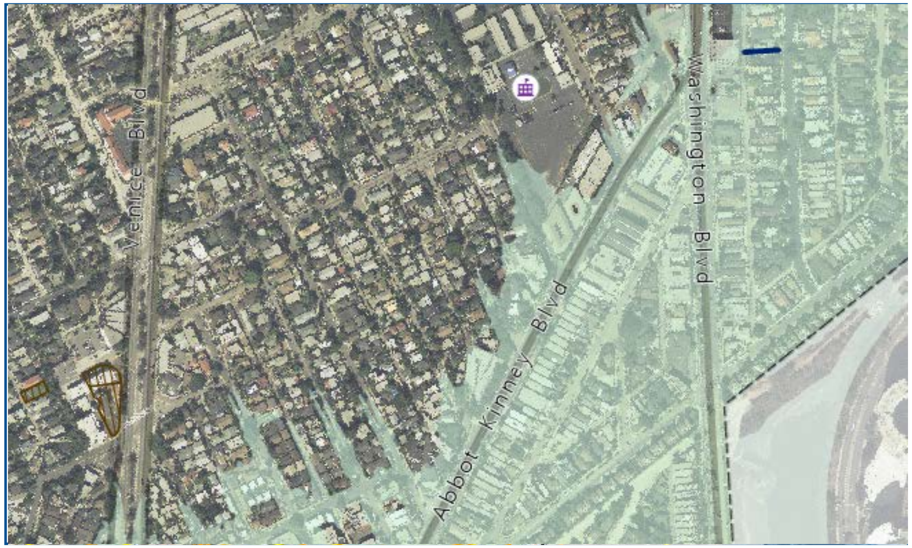
| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

While exposure is high at any SLR condition, towers can be relocated to adapt

# Coeur d'Alene Elementary (LAUSD)

## Description

LAUSD Elementary School




## Analysis

- Western portion of campus at risk to flooding at 4.9 ft SLR
- Highly sensitive to flooding due to function
- Can be reconstructed or retrofitted to reduce exposure

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

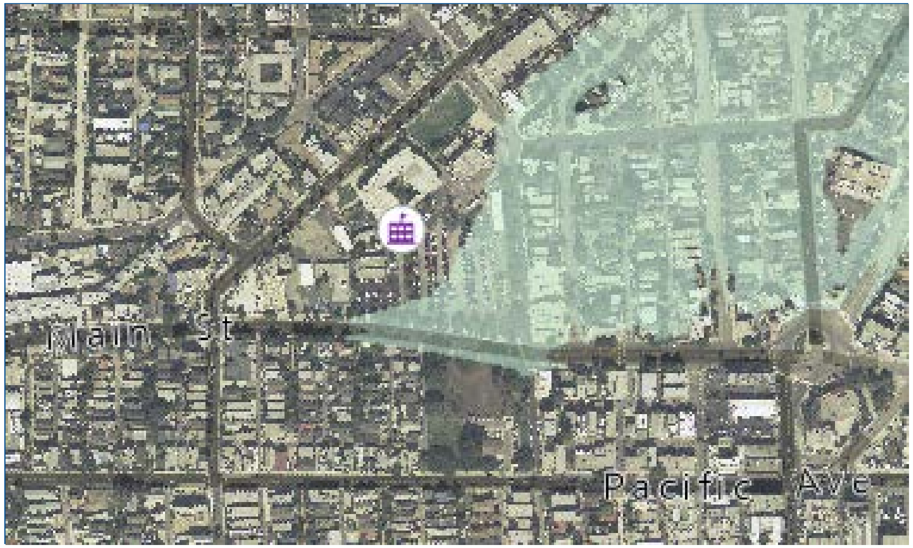
Non-storm: (4.9 ft +)
Portions of school yard could flood in the case of tide gate failure.

Storm: (Long-term Threshold)
Large rain events in combination with decreased capacity of stormwater management system due to SLR could result in temporary flooding.

# Westminster Elementary (LAUSD)

## Description

LAUSD Elementary School




## Analysis

- Portions of campus potentially at risk to flooding at 1.6 ft SLR
- Highly sensitive as a school
- Extent of potential flood exposure increases with SLR due to low elevation
- Much of buildings are single story, increasing potential damages from flooding
- Can be reconstructed to adapt

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
Potential for flooding of property in the case of tide gate failure.

Storm: (Short-term)
Large rain events in combination with reduced capacity for stormwater management due to SLR could result in flooding.

# Westside Global Awareness Magnet (LAUSD)

## Description

LAUSD Magnet School near ocean


## Analysis

- Campus at risk to flooding from tide gate failure at 1.6 ft SLR
- Campus at risk to flooding from 100-year storm event from overtopping of coast at 6.6 ft SLR
- Highly sensitive as a school
- Only protected by Marina del Rey tide gate

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200 cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
Potential for flooding in the case of tide gate failure

Storm: (6.6 ft +)
CoSMoS model results show potential for flooding during a 100-year storm. Potential for damage from flooding, no direct wave action.

# LAPD Venice Substation

## Description

LAPD Substation at Venice Boardwalk and recreation area, located directly on boardwalk and deals with non-emergency crimes

## Analysis

- Limited direct exposure at elevation of 14-17 ft NAVD88
- Surrounding area could be impacted by coastal flooding starting at 6.6 ft SLR
- Low sensitivity due to nature of non-emergency focus
- Can be relocated or reconstructed to adapt to future beach conditions & hazards

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

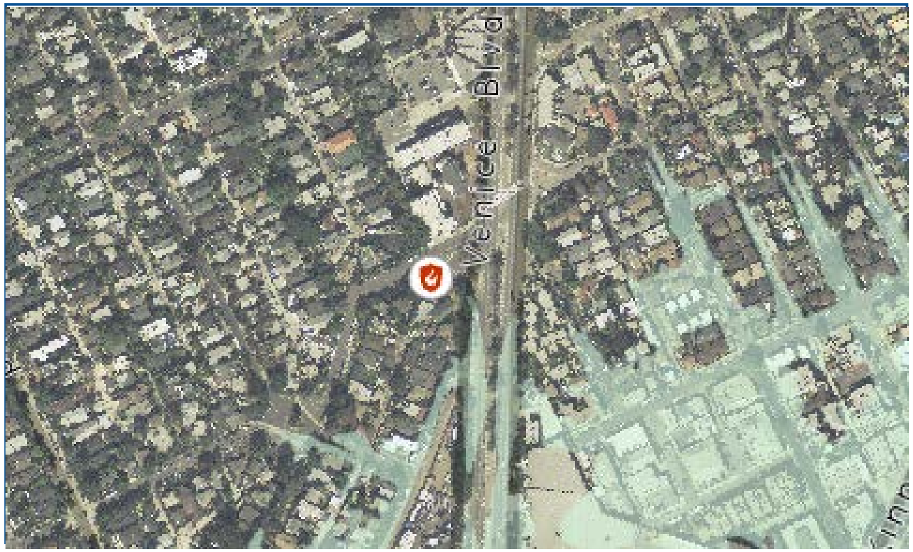
Non-storm: (Long-term Threshold)
Potentially at risk to beach erosion, reducing access and resulting in possible damage

Storm: (6.6 ft +)
CoSMoS model results show potential for flooding during a 100-year storm. Potential for damage from direct wave action.

# Los Angeles Fire Station 63

## Description

LA Fire station part of West Bureau servicing Venice Beach area




## Analysis

- Risk to response times in service area with potential inland flooding
- Direct exposure to facility at 4.9 to 6.6 ft SLR
- Sensitive to neighborhood flooding due to potential service impacts
- Future adaptations could include relocation, or service supplemented by neighboring stations

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (4.9 ft)
Potential for reduced access due to flooding in the case of tide gate failure.

Storm: (Long-term Threshold)
Potential for flooding during large rain event with reduced capacity for stormwater management due to SLR

Assets evaluated:

- Venice Beach Recreation Center
- Oakwood Recreation Center
- Venice Beach Boardwalk
- Venice Fishing Pier
- Beach Recreation

# Coastal Amenities

## Venice Boardwalk

Boardwalk could temporarily flood during 100yr storm +3.3ft

Potential for storm-related damages.

Impacts to tourism economy, vendors and retailers

## Venice Recreation Center

Low-lying portions of recreation center could flood during 100yr storm +3.3 ft SLR (2060 – 2100+)

Reduced effect of breakwater could alter beach width & shoreline configuration

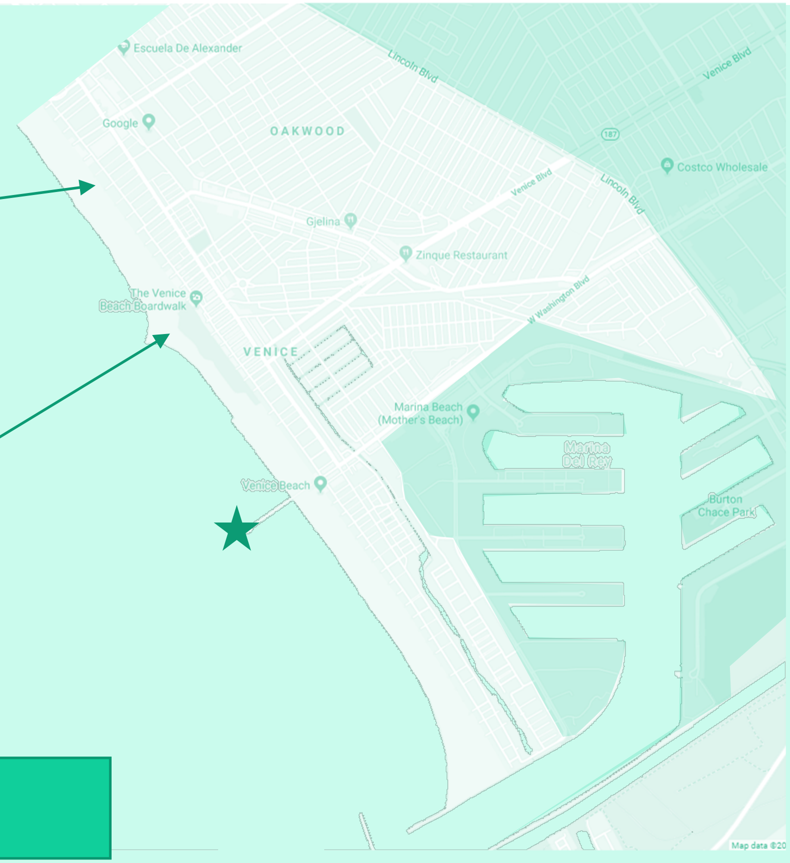
## Venice Fishing Pier ☆

Pier damaged by storms in the 80s
SLR increases potential damage from large wave events

## Beach Recreation

Erosion of beach due to SLR could have major economic impacts on tourism & visitor serving commercial industries

SLR increases potential loss of beaches & amenities during large storms



Exposure

- Beachfront amenities and Oakwood Recreation center could experiences damage due to erosion or storm-related flooding in long term (3.3ft+ of sea level rise)
- Beach Recreation could be affected by erosion of 50ft (short term) to 300ft (long term)

Sensitivity

- Beach recreation sensitive to storm frequency and chronic erosion
- Recreation Centers important resource for Venice and LA Region, therefore sensitive to loss of capacity or damage

Adaptive capacity

- Repairs and nourishment may be expensive but can restore full functionality

# Coastal Amenities

# Venice Beach Recreation Center

## Description

Public cultural and recreational complex adjacent to Venice Boardwalk Basketball Courts (Unlighted / Outdoor), Handball Courts (Unlighted), Gymnastics Area, Children's Play Area - 2, Sand Volleyball Court, Fishing Pier, Skate Park, Muscle Beach Venice, Outdoor Stage (Unlighted)

## Analysis

- Northern reaches of complex at risk to flooding at 3.3 ft SLR during extreme storm event
- Exposure could be increased with beach erosion leading to scouring of structures, dependent on sand nourishment and protective measures
- Skate park at risk to flooding or decreased capacity in drainage
- Larger flooding exposure at 6.6 ft SLR
- Highly sensitive as central tourism, recreation, cultural hub
- Potential for reconstruction, protection, relocation
- Beach area seaward is narrowest within the CZ.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

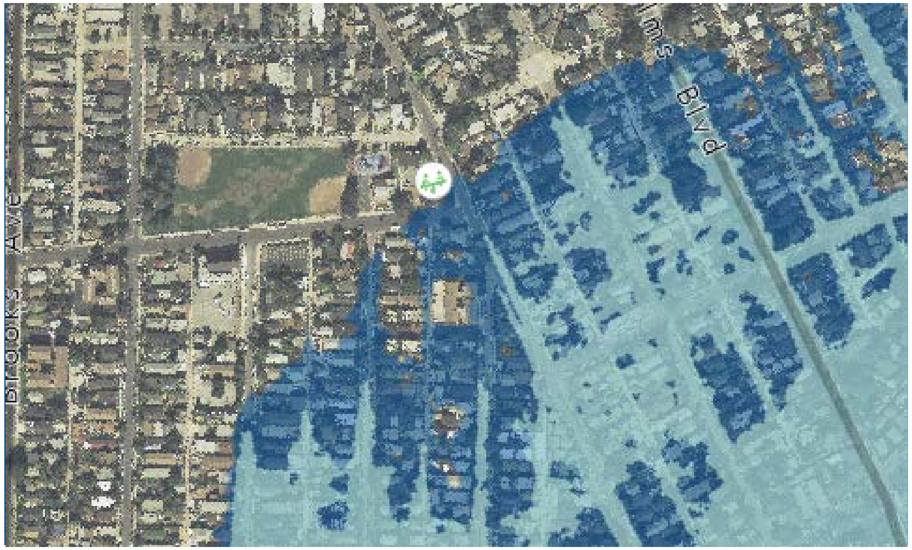
Non-storm: (Long-term Threshold)
Potentially at risk to beach erosion, reducing access and resulting in possible damage

Storm: (3.3 ft +)
CoSMoS model results show potential for flooding during a 100-year storm. Potential for damage from direct wave action. Initial areas at risk are in northern portion such as skate park.

# Oakwood Recreation Center

## Description

Recreation Center with after school programs, teen club, senior programs with community room, indoor gym, multipurpose fields and courts, and computer lab




## Analysis

- No direct physical exposure with SLR < 6.6 ft
- Sensitive resource for community
- Limited space to relocate

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Long-term Threshold)
Limited access due to flooding in the case of tide gate failure.

Storm: (Long-term Threshold)
CoSMoS model results show potential for limited flooding  near facility during a 100-year storm.

# Venice Beach Boardwalk

## Description

1.5 mile ocean front pedestrian promenade and bikeway. Center for tourism, commercial activity and cultural activities.


## Analysis

- Low lying areas at Rose Ave and Thornton Ave result in potential flooding from large storm events around 3.3 ft SLR (High uncertainty in CoSMoS results)
- Exposure increases with 6.6 ft SLR
- Sensitive pedestrian mobility corridor and tourism center for economy
- Beach width and profile impact exposure
- Drainage capacity can improve adaptive capacity
- Storm preparation and warning can limit exposure of more sensitive resources for shops and vendors

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Long-term Threshold)
Potentially at risk to beach erosion, reducing access and resulting in possible damage

Storm: (3.3 ft +)
CoSMoS model results show potential for flooding during a 100-year storm. Potential for damage from direct wave action.

# Venice Fishing Pier

## Description

Venice Fishing Pier part of larger Venice Beach Recreation Center


Victor Decolongon/Getty Images

## Analysis

- Further analysis needed to determine vulnerability from extreme wave events
- Highly dependent on storm activity and beach erosion
- Historically damaged by large storm events

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Short-term Threshold)
Potentially at risk to beach erosion, reducing access at base of pier and resulting in possible damage

Storm: (Unknown Threshold)
Further review of design and structural components needed to estimate critical SLR. Historic storms have resulted in significant damage.

# Beach Recreation

## Description

Use of beach for leisure and recreation considered to be important culturally and economically to the region

Venice Beach Eco Cottages

## Analysis

- Narrowest width of beach is also center for tourism in Venice (recreation center)
- Historical nourishment has maintained relatively wide beach for Southern California, SLR will push beach back and up and exacerbate storm related erosion
- Economically important resource on magnitude of $100s of millions of dollars (King, 2011)
- Hazards include beach erosion (semi-permanent loss) and coastal flooding (periodic loss)

## SLR Exposure

Non-storm: (continuous threat)
Potentially at risk to beach erosion, reducing access and resulting in permanent economic loss

Storm: (Unknown Threshold)
Large storm events will have greater impact with higher SLR resulting in more severe flooding and damage to beach and associated economic activities

Assets evaluated:

- Sandy Beach Habitat
- Ballona Lagoon Marsh Preserve
- Canals Habitat Area
- Coastal Rocky Nesting Habitat

# Ecological

## Sandy Beach Habitat

Beach erosion could range from 0 - 100 ft with +1.6ft and 100-350 ft with +6.6 ft.

Includes protected species ( Snowy Plover, Least Tern, Grunion)

## Ballona Lagoon Marsh Preserve

Sensitive to changes in salinity from tide gate operations

Vulnerable to “coastal squeeze”

Loss of vital intertidal habitat

## Canals Ecological Sensitive Habitat

Less intertidal habitat than Ballona Lagoon, relatively more mudflat

Potential effects on Water Quality from reduced flushing

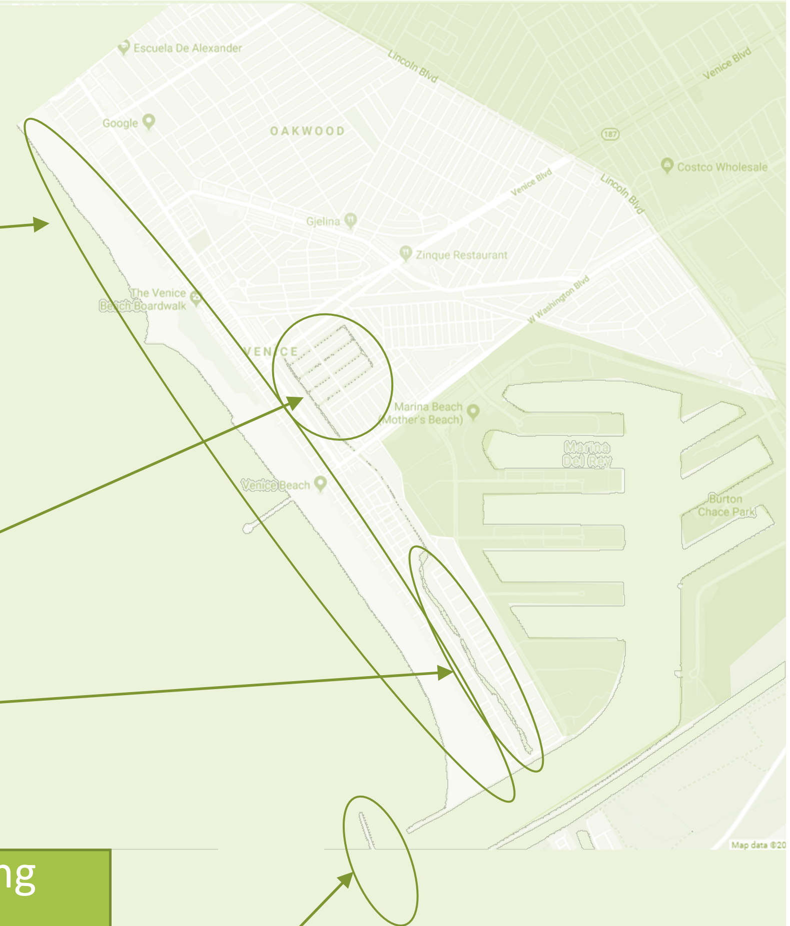
Increase in subtidal habitat

## Coastal Rocky Nesting Habitat

Recovering CA Brown Pelican Nesting Area (CNDBB)

Loss of habitat with SLR

Potential for relocation to Marina jetties



Exposure

- Erosion of 50 feet (short term) to 300 feet (long term) of beach
- Water quality and tidal flow of canals likely affected by tide gates

Sensitivity

- Endangered Species such CA Snowy Plover at critically low habitat for nesting
- Plant species within canals area limited migration area causing loss of habitat (Coastal Squeeze)

Adaptive capacity

- Habitat can be restored
- Large beach allows for increase in future restored/protected habitat

# Ecological

# Sandy Beach Habitat

## Description

Includes migratory birds Snowy Plover, Threatened status under ESA (1973), and Least Tern, Endangered (recovering) status, nesting areas in sandy beach/ dune habitat in addition to Grunion spawning areas on intertidal portion of beach.


## Analysis

- Non-protected beach habitat sensitive to sand raking and pedestrian use, erosion of sandy beach
- Well protected at southern reach of beach in terms of erosion but this could limit taking of sand to be used for nourishment in other areas
- Protected nesting areas can be re-configured & expanded to other portions of beach

## SLR Exposure

Non-storm: (Continuous threat)
At risk to loss of habitat due to erosion of sandy beach along

Storm: (Unknown Threshold)
Large storm events have potential greater risk to erode sandy beach with increasing SLR

# Ballona Lagoon Marsh Preserve

## Description

Coastal, Intertidal, and subtidal habitat including rare, threatened, or endangered species of plant known as "Ballona Flower."


## Analysis

- Sensitive to coastal squeeze from SLR, increased salinity due to decreased flushing of tide gates, runoff, chronic flooding
- Limited habitat or potential restoration areas.
- Near tidal ecosystems are typically resilient to temporary flooding or salinity but chronic conditions or changes in groundwater may cause permanent ecological changes.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (1.6 ft +)
Changes in salinity from adjusted tide control, reduced wildlife access to ocean, tied to tide gate management system

Storm: (Long-term Threshold)
Reduced capacity for stormwater management may result in periodic flooding at higher elevations

# Canals Area ESHA

## Description

Mainly subtidal habitat and lower-intertidal habitat due to reinforced canal banks considered environmentally sensitive habitat area by city


## Analysis

- More restricted tide schedule than Ballona Lagoon system with larger drainage area resulting in higher exposure to runoff and flooding.
- Environmental quality important to recreational use and surrounding community
- Sensitive to coastal squeeze from SLR, increased salinity due to decreased flushing of tide gates, runoff, chronic flooding
- Near tidal ecosystems are typically resilient to temporary flooding or salinity but chronic conditions or changes in groundwater may cause permanent ecological changes.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

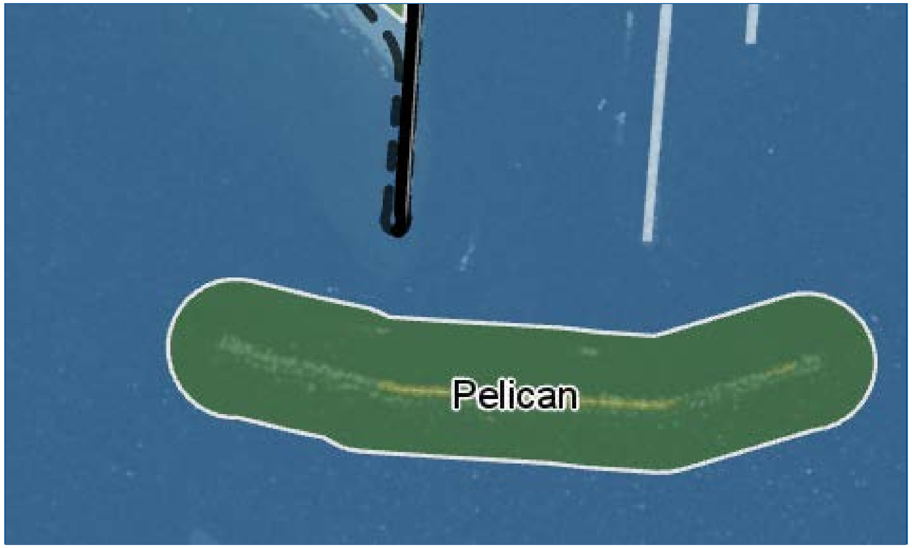
Non-storm: (1.6 ft +)
Changes in salinity from adjusted tide control, reduced wildlife access to ocean, tied to tide gate management system

Storm: (Long-term Threshold)
Reduced capacity for stormwater management may result in periodic flooding at higher elevations

# Coastal Rocky Nesting Habitat

## Description

California Brown Pelican, a recently de-listed species, of pelican known to nest and feed off of Marina breakwater.




## Analysis

- Sensitive to habitat loss via coastal squeeze
- Breakwater can be elevated or reinforced to re-establish existing habitat
- Potentially high adaptive capacity to storms due to ability to migrate inland.

## SLR Exposure

| Current | 50 cm/ 1.6 ft | 100 cm/ 3.3 ft | 150 cm/ 4.9 ft | 200cm/ 6.6 ft |
|---|---|---|---|---|

Non-storm: (Long-term Threshold)
Higher water levels will reduce potential habitat

Storm: (Long-term Threshold)
Higher SLR will increase damage from storms

# Appendix B
# DRAFT SEA LEVEL RISE MEMO
# (M&N NOV. 2017)

# VENICE VULNERABILITY ASSESSMENT

# COASTAL HAZARD MODEL AND SEA LEVEL RISE SCENARIO SELECTION REPORT

## DRAFT

November 2017


Submitted By

moffatt & nichol

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Prepared for
City of Los Angeles
Department of City Planning


Funded in part by
California Coastal Commission
Grant LCP-14-09


CALIFORNIA COASTAL COMMISSION

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# 1. Introduction

A number of prior sea level rise (SLR) vulnerability studies and supporting studies have been completed in the Venice coastal zone of the City of Los Angeles, California. These studies were conducted mostly under regional efforts, which can sometimes miss small-scale details affecting local hazards in communities like Venice. As a first step toward completing a Venice Vulnerability Assessment (VA) to inform the preparation of the Land Use Plan (LUP) Coastal Hazards policies and Implementation Plan (IP) standards, Moffatt & Nichol (M&N) conducted a review and summary of these available studies with the goal of leveraging these existing work products as much as possible. This report provides a description of the limitations of prior efforts and the numerical modeling used to drive the hazard mapping. Recommendations on which model to use to map coastal hazards, as well as which SLR scenarios to use for the Venice VA are provided in this study.

This study also identifies assets and resources to be analyzed within Venice VA. These assets are shown in preliminary coastal hazard base maps, which will be further developed with additional input from the project team, stakeholders, and the public during the outreach process.

## 1.1. Scope of Work

M&N's scope of work for the Venice VA is provided below:

1.1. Develop SLR Scenarios: Five (5) SLR scenarios (covering increments of SLR between 1 and 6 feet) will be evaluated. The exact SLR scenarios will be developed with the City and based upon information available in the regional studies. These scenarios will be selected to provide a basis for understanding how hazards and vulnerabilities change with each increment of SLR. Given the low lying topography of the Venice coastal zone, additional focus on the lower SLR increments may be warranted.

1.2. Discussion of model limitations: M&N will prepare a memorandum that will include a discussion of the assumptions and limitations of the data, model(s), or method used and whether said limitations or assumptions lead to over-estimation, under estimation, or unknown impacts on the mapped hazard zones.

1.3. Spatial data and base map: M&N will compile spatial data on City assets and resources to create a GIS basemap from which the various coastal hazards will be overlain. These maps will provide the basis for a Venice VA and provide a valuable resource for City staff to communicate the potential coastal hazards to stakeholders, resource agencies, and the public. SLR hazard maps will also show storm and non-storm conditions at each SLR increment.

1.4. Memorandum of previous SLR and Climate Change Studies: M&N will prepare a memorandum to summarize the previous studies and identify how the information available can be applied in the draft and final Venice VA. This memorandum will discuss the assumptions and limitations of the data, model, or method and whether said limitations or assumptions lead to over-estimation, under estimation, or unknown impacts on the mapped vulnerabilities.

1.5. Coastal Resources Assessment: M&N will create a qualitative and quantitative assessment of consequences/risks/impacts on coastal resources.

1.6. Prepare Vulnerability Assessment:

A. Prepare Venice VA: M&N will prepare a Venice VA that will build from the existing regional SLR. Results of the Venice VA will inform preparation of the LUP Coastal Hazards policies and IP standards by identifying "triggers" at which significant planning areas, assets, or coastal resources could be impacted by SLR. The consequence of the identified impacts will also inform the policies and programs to minimize risk to important infrastructure, basic services, and valuable resources. The vulnerabilities and consequences identified in this assessment will help prioritize planning efforts to account for the urgency (time horizon) of each impact, and the importance of each impact on the community and resources.

B. Risk Assessment Matrix: M&N will prepare a matrix that evaluates potential risks and impacts of SLR to asset categories by rating and describing the exposure, sensitivity, and adaptive capacity.

1.7. Draft Presentation Materials: M&N will develop draft presentation materials in coordination with City staff for their presentation on the VA findings for the public, the City's Technical Advisory Group (TAG), regional collaborators, and community stakeholders.

This study presents the results of Tasks 1.1 through 1.4 of our scope of work and provides the foundation for tasks 1.5 and 1.6.

# 2. Available Studies and Models

Available SLR VAs and supporting studies for the Venice area were reviewed to understand what work could be leveraged for this study. Prior studies were based on results from regional SLR models along with some site-specific analyses. These efforts include:

- AdaptLA (USC Sea Grant 2016)
- Los Angeles County Public Beach Facilities SLR VA (Noble 2016)
- Coastal Storm Modeling System (CoSMoS) 3.0, Phase 2 (USGS 2017)
- Federal Emergency Management Agency (FEMA) Open Pacific Coast Study of California Coastal Analysis and Mapping Project (CCAMP) (FEMA 2017)

These studies, and the corresponding SLR models and analyses are summarized below with a focus on their applicability and limitations to this Venice effort. The latest regional SLR coastal hazard model available for the Venice area is CoSMoS Version 3.0, Phase 2. Although previous versions of this model have been used in prior studies, the latest version has not yet been incorporated in any studies and its applicability and limitations are included in this document. Discussion of the recent FEMA Open Pacific Coast Study of California Coastal Analysis and Mapping Project (CCAMP) is included as an additional reference for baseline conditions. The CCAMP Study does not account for or map sea level rise related coastal hazards.

## 2.1. AdaptLA: Coastal Impacts Planning for the Los Angeles Region (USC SeaGrant 2017)

The study summarizes the methodologies, findings, and recommendations of two technical studies developed by TerraCosta Consulting Group (TCG) and Environmental Science Associates (ESA) for the Los Angeles County coast. The TCG study provides short-term seasonal shoreline position change driven by waves and long-term shoreline position change driven by SLR. The TCG results only include shoreline position change estimates and did not analyze the potential for coastal flooding. The ESA study assesses coastal hazards and vulnerabilities associated with long-term, wave-driven shoreline erosion and flooding. Therefore, the ESA study provides a more comprehensive assessment of coastal hazards due to SLR.

### 2.1.1. Sea Level Rise Scenarios

Table 2.1 lists the SLR scenarios used in the AdaptLA Study. SLR projections used ranged from 0.4 to 5.5 feet. Each of these scenarios included an armored and non-armored shoreline condition scenario to evaluate potential future management actions. The armored condition assumes that the existing coastal structures will protect against flooding and erosion in future SLR scenarios. The unarmored condition scenario assumes that existing coastal structures do not exist and the shoreline is allowed to erode landward unimpeded.

**Table 2.1: AdaptLA Sea Level Rise Scenarios**

| Planning Horizon, Year | Description | Sea Level Rise, ft (m) |
|---|---|---|
| 2010 | Existing Conditions | - |
| 2030 | Medium SLR | 0.4 ft (0.14 m) |
| 2050 | Medium SLR | 1.0 ft (0.29 m) |
| 2100 | Medium SLR | 3.0 ft (0.93 m) |
| 2030 | High SLR | 1.0 ft (0.31 m) |
| 2050 | High SLR | 2.0 ft ( 0.61 m) |
| 2100 | High SLR | 5.5 ft (1.68 m) |
| 2080* | Extreme SLR | 5.5 ft (1.68 m) |

**Extreme SLR scenario with a trajectory that reaches 9.4 ft (2.88 m) by 2100.*

### 2.1.2. Storm Scenarios

A 100-year (1% annual chance) coastal storm event was calculated from the results of ESA's coastal flooding and erosion modeling. ESA and TCG used CoSMoS 3.0 modeled hindcast (1980-2011) and forecast (2012-2100) wave and water level predictions at nearshore locations (USGS model output points) at 3-hour time intervals as forcing for their modeling.

### 2.1.3. Flooding

ESA coastal flood hazard zones include the effects of coastal processes and future SLR. Flooding extents were mapped based on a total water level (TWL) exceedance curve, which is used to determine a threshold for the relative amount of time that flood water from wave run-up reaches a certain elevation. The TWL is based on coastal processes that include: elevated ocean levels due to anomalies (e.g., elevated water levels during El Niño phases), storm surge (a rise in the ocean water level caused by winds and pressure changes during a storm), and wave runup and wave setup (water levels from waves, including water levels resulting from waves running up over the beach and coastal structures).

The combination of these coastal processes yields the TWL for existing conditions. Coastal flooding was assessed along each coastal reach, comprising elevation data shoreline transects, representative beach slopes and wave parameters to calculate TWLs and resulting flooding extents for a given reach. This methodology was adapted for the SLR scenarios by applying projected sea levels in the TWL calculations.

ESA also mapped extreme monthly tidal flooding hazard zones that only include water levels resulting from the monthly high astronomic tide (not considering waves, storms, erosion, or river discharge).

### 2.1.4. Erosion

Three erosion hazard zones were mapped by ESA and TCG. ESA modeled two erosion scenarios: (1) long term-coastal erosion with SLR and (2) 100-year (1% annual chance) coastal storm erosion with SLR. The ESA scenarios include both armored and non-armored conditions. The armored scenario assumes any existing armor structures would remain intact during future SLR conditions. TCG modeled one scenario that included future seasonal erosion and long-term coastal erosion with SLR.

The ESA long-term erosion hazard zone represents the potential maximum extents of erosion that could occur based on historic erosion trends and the additional effects of SLR. This includes applying historic erosion rates over the planning horizon along with beach recession resulting from increased wave runup elevations due to higher sea levels. The initial beach condition is based on a 2010 fall shoreline; thus, the long-term eroded shoreline positions represent future fall shoreline positions when beaches are generally their widest. This erosion methodology is based on the 2009, Philip William and Associates, Ltd. (PWA, now ESA) Pacific Institute Study "Impacts of Sea Level Rise to the California Coast."

The ESA 100-year coastal storm erosion hazard zone includes long-term erosion and additional erosion that could result from a 100-year wave event. The 100-year storm erosion approach models beach erosion due to wave action with adjustments to beach slopes and inclusion of long-term erosion to include the effects of SLR.

The TCG erosion hazard zone includes short-term seasonal changes (erosion and accretion) resulting from waves and long-term beach erosion considering SLR. The short-term seasonal change model utilizes USGS wave data and USGS beach change coefficients. The long-term beach erosion model utilizes a sand balance approach based on the Bruun rule, which assumes a beach profile will rise at the same rate as sea levels by eroding landward to provide sand to the shifting profile. This long-term erosion approach is independent of historic erosion rates. The TCG erosion approach does not consider beach nourishment, coastal structures (i.e., breakwater, groins), or coastal armoring (i.e., revetments and seawalls).

### 2.1.5. Inland Flooding

ESA mapped areas of potential inland flooding to address low-lying areas such as the Venice Canals Historic District. Areas such as this may be susceptible to flooding as higher sea levels diminish their effectiveness to drain stormwater to the ocean during low tides. This also includes areas that may potentially connect to other flooded areas through conduits or seepage like pools (greater than 3 square meters) within 5 meters of areas connected to the ocean, patches of dry land that are smaller than 1 acre and completely surrounded by inundated area, and areas with uncertain connectivity to coastal waters that could be susceptible to flooding. The flood extents shown in this study are low-lying areas relative to the projected tide elevation and do not account for effectiveness of the tide gates that are used to manage water levels in the Grand Canal and Venice Canals.

### 2.1.6. Applicability and Limitations

The AdaptLA study provides projected flooding and erosion data for six SLR scenarios ranging from 0.5 ft to 5.5 ft, which are a useful point of comparison for other studies that assess the same levels of SLR. The following should be considered:

- The ESA and TCG models both use the USGS CoSMoS wave hindcast and forecast data, providing a consistent wave dataset across these models and CoSMoS.
- ESA mapped flood areas are based on an exceedance curve, and the threshold for elevation and duration is not clear.
- ESA inland flood hazard zones do not explicitly consider stormwater flooding, which will likely impact low-lying coastal areas like Venice as sea levels rise. The inland flood hazard zones reflect a tidal elevation and do not account for the tide gates that currently manage water levels in the canals. Therefore, the inland flood extents can be interpreted as an approximation of flood limits if the tide gates were removed or if they malfunctioned and remained in the open position during a high-water level event.

- ESA erosion hazards are mapped for an armored (existing structures) and non-armored condition.
- ESA erosion rates are based on the projected time horizon.
- TCG erosion hazards do not consider armoring, beach nourishment, coastal structures, or historic erosion rates.
- TCG erosion hazards apply the Bruun rule to a shoreline with sediment transport patterns that have been historically altered and continue to be shaped by coastal structures, including the Santa Monica Breakwater, Venice Breakwater, and the Marina Del Rey Jetty and Breakwater. The Bruun rule may not be appropriate in this location to account for these site-specific conditions.

## 2.2. Los Angeles County Public Beach Facilities Sea Level Rise Vulnerability Assessment (Noble April 2016)

This study assessed the vulnerability of beach facilities along the Los Angeles coastline due to the effects of SLR, flooding, and erosion. The study includes an assessment based on CoSMoS Version 3.0 results along with a "Traditional Beach Erosion and Wave Runup Hazard Analysis," described in the study as a simplified assessment of shoreline erosion and wave runup. This study includes an assessment of the effectiveness of the use of beach berms to control localized coastal flooding. Analysis of this study is limited to the "Traditional Beach Erosion and Wave Runup Hazard Analysis" as the version of CoSMoS used in this study has been superseded by CoSMoS Version 3.0 Phase 2, which is described in Section 2.3.

### 2.2.1. Sea Level Rise Scenarios

Table 2.2 lists the SLR scenarios used in this study. SLR estimates from 1.5 to 6.6 feet were analyzed.

***Table 2.2: Los Angeles County Public Beach Facilities Sea Level Rise Scenarios***

| Planning Horizon, Year | Description | Sea Level Rise, ft (m) |
|---|---|---|
| N/A | CoSMoS 100 cm SLR Scenario | 3.3 ft (1.00 m) |
| N/A | CoSMoS 200 cm SLR Scenario | 6.6 ft (2.00 m) |
| 2040 | NRC Upper Curve Projection | 1.5 ft (0.45 m) |
| 2100 | NRC Upper Curve Projection | 5.5 ft (1.68 m) |

### 2.2.2. Storm Scenarios

A 100-year (1% annual chance) coastal storm event was calculated from the results of wave runup modeling. Water levels used in runup calculations were obtained from 36 years of historic water level data from the Los Angeles Outer Harbor tide gauge (NOAA ID: 9410660).

### 2.2.3. Flooding

Coastal flood extents were assessed based on wave runup elevations and wave overtopping calculations. Wave runup was calculated using historic water level data, and representative wave and beach parameters from the Los Angeles Coast of California Storm and Tidal Waves Study (USACE 2010). A statistical analysis was performed on the overtopping results to determine the 100-year (1% annual chance) event. Wave overtopping was calculated in areas where wave runup elevations exceeded that of the beach berm. The berm elevations, runup elevations and inland propagation distance of flood waters area reported for Venice in the report.

#### 2.2.4. Erosion

Beach erosion was assessed considering seasonal variation, storm erosion, and the effects of SLR. A statistical analysis was conducted on surveyed beach profiles to determine a seasonal beach erosion distance. Storm erosion was determined from the beach widths following the January 18-25, 2010 El Niňo storm. Beach erosion due to SLR was calculated using the Bruun rule, which assumes a beach profile will rise at the same rate as sea levels by eroding landward to provide sand to the shifting profile. The 2010 beach width and erosion distance associated with a seasonal shifts, storm response, and SLR are reported for Venice in the report.

#### 2.2.5. Inland Flooding

Inland flooding was not assessed in this study. The focus was on the coastal zone.

#### 2.2.6. Applicability and Limitations

The study analyzes four separate SLR scenarios for the beachfront area. Two of the scenarios are based on an outdated version of CoSMoS and should not be carried forward. The most recent version of CoSMoS should be used in any future study. The “Traditional Beach Erosion and Wave Runup Hazard Analysis” SLR scenarios provide an additional reference for other studies that consider 1.5 ft and 5.5 ft of SLR. The following aspects of the “Traditional Beach Erosion and Wave Runup Hazard Analysis” should be considered:

- This study is based on historic wave and water level data that may not accurately reflect future conditions.
- Venice is characterized by a single set of results that may not fully capture shoreline dynamics influenced by the Venice Breakwater, groin, and the Marina Del Rey Jetty and Breakwater.
- Results are not mapped, making comparison to other studies difficult.
- Findings of the beach berm study can be applied in the Venice VA as an evaluation of beach berms as a potential future adaptation strategy.
- Beach erosion did not consider beach nourishment or historic erosion rates.
- SLR erosion applied the Bruun rule to a shoreline with sediment transport patterns that have been historically altered and continue to be shaped by coastal structures, including the Santa Monica Breakwater, Venice Breakwater, and the Marina Del Rey Jetty and Breakwater. The Bruun rule may not be applicable for use at this location.
- Flooding was assumed not to pass any “hard structure” barriers.

### 2.3. Coastal Storm Modeling System (CoSMoS) Version 3.0 Phase 2

CoSMoS Version 3.0 Phase 2 is the latest version of the USGS Coastal Storm Modeling System that utilizes global, regional, and local models to assess coastal flooding and erosion. CoSMoS includes 40 combinations of SLR and storm scenarios that apply wave projections, storm surge, sea level anomalies, river discharge, tides, and SLR.

### 2.3.1. Sea Level Rise Scenarios

A total of 10 SLR scenarios are available, these include 0.8 ft (0.25 m) increments from 0 to 6.6 feet (0 to 2 m) and an extreme sea level rise scenario of 16.4 feet (5 m). Table 2.3 summarizes the SLR scenarios that are available from CoSMoS Version 3.0 Phase 2. Shoreline erosion projections are available for each SLR scenario and four management scenarios. Management scenarios include with and without beach nourishment and coastal armoring (Hold-the-Line or not). Flood hazards are only available for the "Hold-the-Line and No Beach Nourishment" management scenario.

***Table 2.3: Summary of CoSMoS Version 3.0 Phase 2 Scenarios***

| Planning Horizon, Year | Management Scenario Description | Sea Level Rise, ft (m) | Available Data |
|---|---|---|---|
| Current – 2100 | Hold-the-Line, Beach Nourishment | 0 – 16.4 ft (0 – 5.0 m) | Shoreline erosion |
| Current – 2100 | Hold-the-Line, No Beach Nourishment | 0 – 16.4 ft (0 – 5.0 m) | Flood hazards and shoreline erosion |
| Current – 2100 | No Hold-the-Line, Beach Nourishment | 0 – 16.4 ft (0 – 5.0 m) | Shoreline erosion |
| Current – 2100 | No Hold-the-Line, No Beach Nourishment | 0 – 16.4 ft (0 – 5.0 m) | Shoreline erosion |

### 2.3.2. Storm Scenarios

Future storm scenarios for typical conditions, 1-year (100% annual chance), 20-year (5% annual chance), and 100-year (1% annual chance) are available for each SLR scenario. The coastal storm is largely characterized by waves but also includes limited fluvial (river) inputs resulting from projected atmospheric conditions; however, there is no fluvial source modeled for Venice. Future wave conditions are based on hindcast and future-cast data and tides were derived from the Oregon State University TOPEX/Poseidon global tide database. Sea level anomalies were also applied in the modeling.

### 2.3.3. Flooding

CoSMoS coastal flooding includes the effects of waves during storm events. Flooding extents are mapped at the intersection of the maximum 2-minute sustained water level and landward position of the eroded beach profile. Wave runup was calculated along each coastal reach, comprising elevation data, shoreline transects, representative beach slopes, forecasted wave parameters and water levels to calculate resulting flooding extents. The projected water levels used in runup calculations consider shoreline change, tides, sea level anomalies like El Niňo, storm surge, and SLR. The flooding results are only available for the "Hold-the-line, No Beach Nourishment" management scenario, which assumes future shoreline retreat will be halted at the existing development line and protected by coastal structures. The Hold-the-Line assumption is applied to future shoreline position but not flooding. Wave runup and flooding landward of the development line was mapped as predicted.

Maximum runup is also mapped as part of the CoSMoS results as single points at each coastal transect. This is because maximum runup levels are short in duration and, depending on beach geometry, may only result in a few inches of flood depth.

### 2.3.4. Erosion

CoSMoS results include long-term erosion resulting from SLR and projected wave conditions. Beach erosion was modeled with the CoSMoS Coastal One-line Assimilated Simulation Tool (CoSMoS-COAST), which comprises a suite of models that consider historic erosion trends, long-shore and cross-shore sediment transport, and changes due to SLR; these models were tuned with historic data to account for unresolved sediment transport processes and inputs, such as sediment loading from rivers and streams, regional sediment supply (beach nourishment and bypassing), and long-term erosion. Model tuning is a valuable feature because it considers site-specific sediment erosion and accretion trends, which may be under predicted or over predicted by erosion models that are based on idealized shoreline conditions.

Any accretion trends, regardless of their source, were included in the beach nourishment scenario. The differences between with and without beach nourishment scenarios is relatively small, with a maximum fluctuation of approximately 60 ft. This is a relatively small difference considering existing beach width ranges from 400 to 700 ft.

The erosion results are based on long-term trends, which may not account for erosion that could result from a large-scale wave event. Large-scale wave events can result in significant beach width losses over a short period of time, and this type of event-based erosion may be suppressed when considering long-term trends. Additionally, a large-scale event may not have occurred over the timespan covered by available historical erosion data.

Beach erosion results include four management scenarios:

- Hold-the-Line, Beach Nourishment
- Hold-the-Line, No Beach Nourishment
- No Hold-the-Line, Beach Nourishment
- No Hold-the-Line, No Beach Nourishment

Hold-the-Line assumes that the existing division of beach and urban infrastructure is maintained with coastal structures. No Hold-the-Line would allow erosion to propagate inland to the maximum potential erosion extents. Beach Nourishment assumes historical beach nourishment rates are carried forward. No Beach Nourishment assumes the beach is left in its existing state.

### 2.3.5. Inland Flooding

Inland flooding potential was mapped as part of the CoSMoS results. This includes low-lying, flood-prone areas below the surrounding coastal flood elevation, but not directly connected. The Venice Canal District was modeled without a connection to Marina Del Rey Harbor. The extents of flooding mapped in the Venice Canal District and surrounding low-lying areas are based on the coastal flood elevation of the selected SLR and storm scenario.

### 2.3.6. Applicability and Limitations

CoSMoS Version 3.0 Phase 2, is the latest SLR model for Venice, California and is a useful tool for identifying coastal erosion and flooding hazards for a wide range of sea level rise scenarios and shoreline management conditions. The following should be considered:

- A wide range of SLR scenarios and shoreline management options can be considered from this model in the Venice VA.

- CoSMoS-COAST provides long-term beach erosion projections that account for SLR and erosion trends, the model is tuned from historical data to account for site-specific erosion and accretion patterns.
- CoSMoS-COAST looks at long-term changes and does not detail short-term, event-based storm erosion. This may under predict significant beach recession resulting from successive coastal storm events.
- Coastal flooding extents for 2-minute duration flooding and potential maximum flooding extents from runup are mapped separately, providing a more representative depiction of hazards.
- Flooding resulting from stormwater is not considered.
- Inland flooding extents do not follow existing topography so it’s difficult to understand what is controlling the potential flooding limits.

## 2.4. FEMA Open Pacific Coast Study of California Coastal Analysis and Mapping Project (CCAMP)

FEMA distributed Preliminary Flood Insurance Rate Maps (PFIRMs) to map results of the Open Pacific CCAMP. The PFIRMs are intended to supersede the current effective FIRMs. These maps include updated coastal flooding hazards that are based on current conditions and do not consider future SLR or erosion. Coastal flooding hazards for Venice, California are mapped on PFIRM panels 1751, 1752, and 1754. These panels are combined into a single map, which is available on the FEMA GIS Webmap viewer, this composite map is provided in Figure 2.1.

### 2.4.1. Sea Level Rise Scenarios

The study does not include the potential impacts of SLR.

### 2.4.2. Storm Scenarios

The PFIRMs delineate flood zones that show the extents of 100-year (1% annual chance) coastal flooding and note the flood elevation (Zone VE). The 500-year (0.2% annual chance) is delineated by a separate zone and the flood elevation is not provided (Zone X). Ocean wave, wind, and water level data is based on a hindcast for the period of January 1, 1960 to December 31, 2009 at various points along the California coastline.

### 2.4.3. Flooding

Flooding mapped along the beachfront comprises Zone VE, which is based on the extents and elevation of the resulting 100-year (1% annual chance) base flood elevation (BFE) resulting from wave runup. The PFIRM maps the full extents that wave runup could travel up the beach on an infinite slope, this differs from ESA’s approach, which uses an exceedance curve to determine flooding extents, and CoSMoS, which uses a 2-minute sustained water level criteria. The extents of this flooding appear to be truncated in some locations where the beach ends and urban development begins.

Wave runup was modeled along representative coastal reaches using nearshore wave parameters from the wave hindcast and transect parameters, including beach slopes and other shoreline characteristics. The results of the wave runup calculations yielded the TWLs. A statistical analysis was performed on the TWLs of the highest 100+ selected storm events, yielding the 100-year (1% annual chance) BFE.

### 2.4.4. Erosion

The FEMA maps do not include the potential for shoreline erosion. This study is based on current conditions.

### 2.4.5. Inland Flooding

Inland flooding mapped on the PFIRMs (Zone AE) for Venice includes the Canal District and low-lying land that surrounds this area. These flooding extents assume that all tide gates are open, allowing tidal waters to flow freely from the Grand Canal entrance at the Marina Del Rey Harbor entrance inland to the canal district and surrounding areas. Based on this assumption, the inland flooding elevation is consistent with the water surface elevation in Marina Del Rey Harbor.

### 2.4.6. Applicability and Limitations

The PFIRMs provide a baseline for existing coastal flood hazards and do not consider future sea level rise flooding or erosion. The following should be considered:

- Coastal flooding (Zone VE) BFEs assume wave runup on an infinite beach slope and extend the entire beach width, which may be an overly conservative assumption.
- Tide gates were modeled “open,” allowing tidal waters to propagate inland to the Venice Canal District and surrounding low-lying areas.
- Flooding resulting from stormwater is not considered.

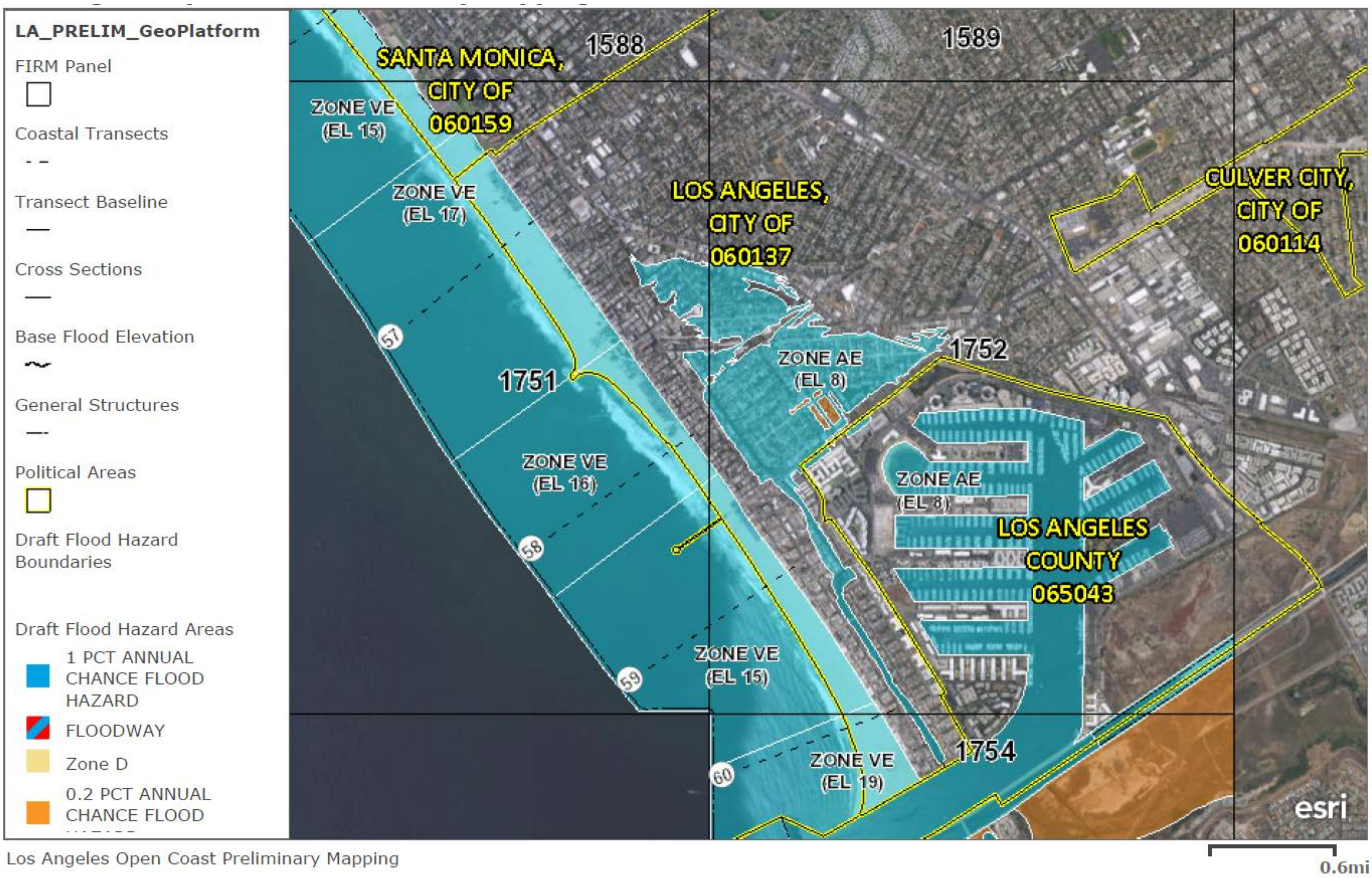


***Figure 2.1: Los Angeles Open Coast Preliminary Mapping (FEMA 2017)***

# 3. Sea Level Rise Hazard Model Selection

## 3.1. Coastal Flooding and Erosion

CoSMoS 3.0 Phase 2 model results have been selected to map coastal flooding hazards for the Venice VA. A summary table comparing the available models and the justification for selecting CoSMoS is provided in Table 3.1.

CoSMoS 3.0 Phase 2 model results are recommended for use in this study since these data are the most recent and comprehensive SLR hazard maps developed for the study area. Use of AdaptLA data for this effort would result in data gaps (e.g., SLR scenarios) that would require additional effort to fill. Advantages of using CoSMoS 3.0 Phase 2 are summarized below:

- A wide range of SLR scenarios.
- Flooding modeled with forecasted wave conditions and shoreline change for the 1-year, 20-year, and 100-year coastal storm with layers for 2-minute sustained water level flooding and maximum wave runup extents.
- Includes shoreline management scenarios that consider Beach Nourishment and Hold-the-Line at the urban/beach interface.
- Erosion modeling comprises multiple methods that consider future erosion resulting from historic trends, long-shore and cross-shore sediment transport, and changes due to SLR; additionally, historic data was used to tune these models to account for site specific erosion and accretion trends driven by natural and anthropogenic causes.

The differences between the AdaptLA and CoSMoS model are shown graphically for an approximately 3-foot SLR scenario for comparative purposes (Figure 3.1 and Figure 3.2). In general, CoSMoS depicts more coastal flooding and less beach erosion than AdaptLA results. Although the use of the CoSMoS results for this study are recommended, the following limitations should be considered when using these data:

- CoSMoS-COAST does not include event-based storm erosion, which may under predict significant short-term beach recession resulting from one or more large coastal storm events. The CoSMoS XBeach modeling includes storm related erosion but the landward extent of flooding is less than predicted by ESA and TCG.
- The shoreline erosion (retreat) predicted by CoSMoS-COAST is significantly less than that predicted by ESA and TCG, as illustrated in Figure 3.3 and Figure 3.4. Different assumptions were applied in each analysis leading to the disparity in predictions. Due to the many unknowns associated with future beach profile evolution, a definitive judgement as to which method is more appropriate or accurate cannot be made.
- Flood mapping and analyses are based on aerial LiDAR derived Digital Elevation Models (DEM), which may not capture narrow topographical features like seawalls or other structures that are less than the dataset 3 feet (1 m) resolution, which can result in over prediction of flooding in some areas. This is common to other regional SLR models that rely on LiDAR derived DEMs and can only be corrected by incorporating local survey data that identifies these features.

## 3.2. Inland Flooding

The existing studies identify inland flooding potential in the low lying areas around the Venice Canals. Although these areas are setback from the active shoreline the low topography requires a system of tide gates to control water levels and prevent flooding from the Canals. Canal water levels are controlled by two sets of tide gates that are operated to keep high tides out but also provide storage and release of stormwater during low tides. These gates may not provide the same functionality as sea levels rise since higher water levels could prohibit drainage and circulation that is currently achieved during low tides. SLR will reduce and eventually eliminate the potential for release of stormwater during low tides. A rising groundwater table will also pose challenges to managing water levels in the Canal District.

The detail contained in existing studies does not accurately capture the potential for inland flooding in the Canal District because they do not account for the tide gate operation, the stormwater storage and drainage capacity and the influence of groundwater. The complexity of the existing system requires a focused study that accounts for the different functions of the tide gates and potential hazards associated with rising sea levels. This type of study was beyond the scope of previous studies and is also beyond the scope of this memo and the Venice Vulnerability Assessment.

In order to capture this potential for inland flooding during a scenario in which the tidal gates are opened or damaged during a high tide event, a "bathtub" model was used to map flood hazards for the 1.65 feet (0.5 m) increment scenarios. We applied the same water level assumptions (extreme monthly high water level) used by ESA in the AdaptLA study to model flood risk for the Canals District but have modified the hazard maps based on the SLR scenarios selected for the Venice Vulnerability Assessment.

Without further study into the capacity, design, and operation of the tide gates, this is our preferred method for depicting the potential for inland flooding from high water levels in the Canals. When CoSMoS is compared to the type of analysis performed by ESA, as seen in Figure 3.5, the resulting low-lying area does not follow existing topography. The CoSMoS modeling effort was more complicated than a simple "bathtub" assessment but since we are not familiar with the input parameters, assumptions and resulting water levels in the Venice Canals it is difficult to understand what factors are responsible for the mapped low-lying flood limits. For this reason, we propose using the modified "bathtub" approach that is consistent with the method ESA applied for the AdaptLA study.

### *Table 3.1: Comparison of AdaptLA and CoSMoS Sea Level Rise Models and Coastal Hazard Model Selection*

| Parameter | AdaptLA | CoSMoS Version 3.0 Phase 2 | Selected Model or Method for this Study | Justification |
|---|---|---|---|---|
| Coastal Management | ESA:<br>• Armored (existing structures)<br>• Non-Armored<br>TCG:<br>• Non-Armored | • Hold-The-Line (urban development line)<br>• No Hold-The-Line<br>• Beach Nourishment<br>• No Beach Nourishment | CoSMoS V3.0 Phase 2, No Hold-The-Line | • Identifies all areas of potential vulnerability. May underscore the value of coastal protection in areas |
| Coastal Flooding | Storm:<br>• Forecasted 100-year storm wave conditions<br>Extents:<br>• Determined from exceedance curve<br>• Maximum runup not mapped | Storm:<br>• Forecasted 100-year coastal storm<br>Extents:<br>• 2-minute sustained water level/land position<br>• Maximum runup mapped with a marker at each transect | CoSMoS V3.0 Phase 2 | • Clear definition of flood mapping criteria<br>• Wave runup points provide valuable depiction of maximum runup hazards |
| Erosion | ESA:<br>• Long-term erosion based on historic rates and projected time horizon<br>• Shoreline retreat due to increased wave runup elevation<br>• Erosion resulting from 100-year event wave conditions<br>TCG:<br>• Seasonal variation<br>• Long-term SLR erosion (Bruun Rule) | • Long-term erosion trends<br>• Long- and cross-shore erosion<br>• Erosion due to SLR<br>• Historic data used for model tuning to account for site-specific erosion and accretion trends driven by natural and anthropogenic causes<br>• Results show much less long-term erosion than both ESA and TCG<br>• CoSMoS-COAST does not include event-based storm erosion, which may under predict significant beach recession resulting from one or more large wave events | CoSMoS V3.0 Phase 2 | • Applies multiple erosion models that are tuned with historical data to account for natural and anthropogenic conditions |
| Inland Flooding | • Low-lying areas, flood-prone areas vulnerable due to groundwater levels/seepage or indirect connections, extents are mapped based on projected tide elevation. | • Low-lying, flood-prone areas below the surrounding coastal flood elevation but not directly connected, extents based on the 2D modeling performed for harbors, embayments and estuaries | AdaptLA (modified for selected SLR scenarios) | • Mapping potential inland flooding based on existing topography provides a simple way to understand potential vulnerabilities in and around the Canal District |

# Venice (North)


***Figure 3.1: Comparison of CoSMoS 3.0 and Adapt LA Flooding Results in Venice (North) (TPL 2017)***

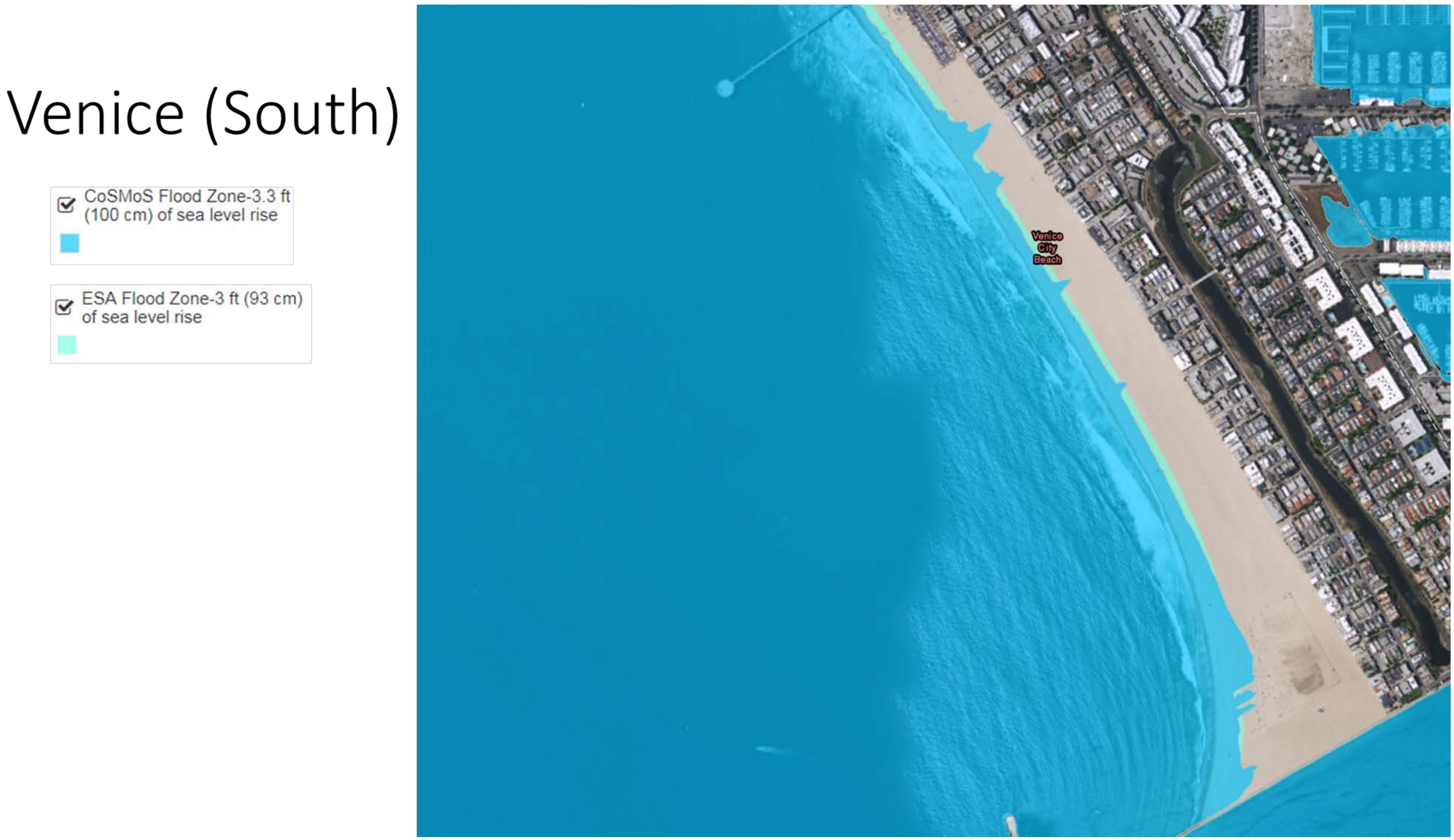


***Figure 3.2: Comparison of CoSMoS 3.0 and Adapt LA Flooding Results in Venice (South) (TPL 2017)***

# Venice (North)

CoSMoS Coastal Erosion-3.3 ft (100 cm) of sea level rise

TerraCosta Coastal Erosion-3 ft (93 cm) of sea level rise

ESA Coastal Erosion-3 ft (93 cm) of sea level rise

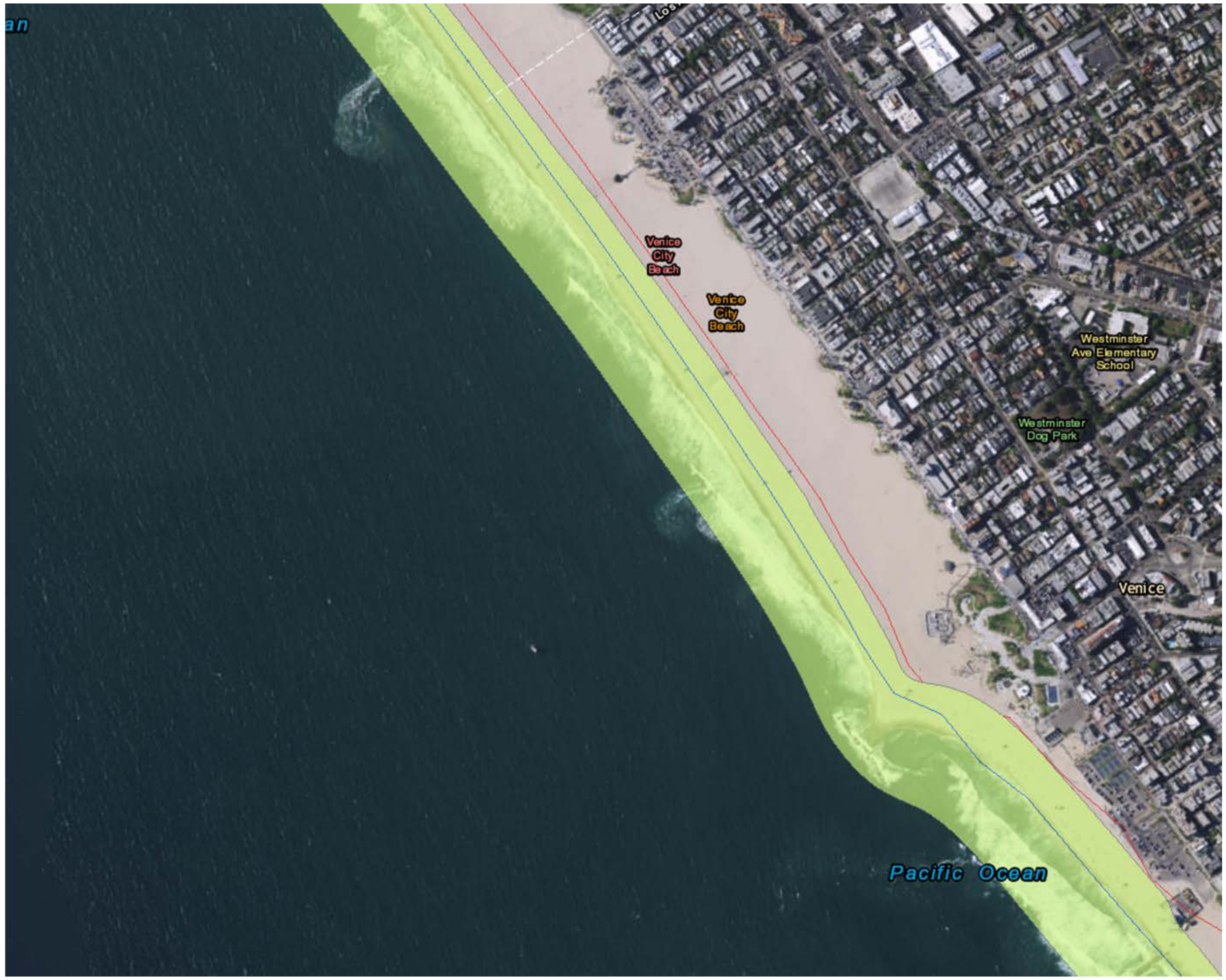


***Figure 3.3: Comparison of CoSMoS 3.0 and Adapt LA Shoreline Erosion Results in Venice (North) (TPL 2017)***


***Figure 3.4: Comparison of CoSMoS 3.0 and Adapt LA Shoreline Erosion Results in Venice (South) (TPL 2017)***

Venice Beach – Canals District & Surrounding Areas

ESA Coastal Erosion and inland flooding for 3.0ft (93cm)

CoSMoS 3.0 Phase 2 Erosion and low lying areas for 100cm (3.3ft)

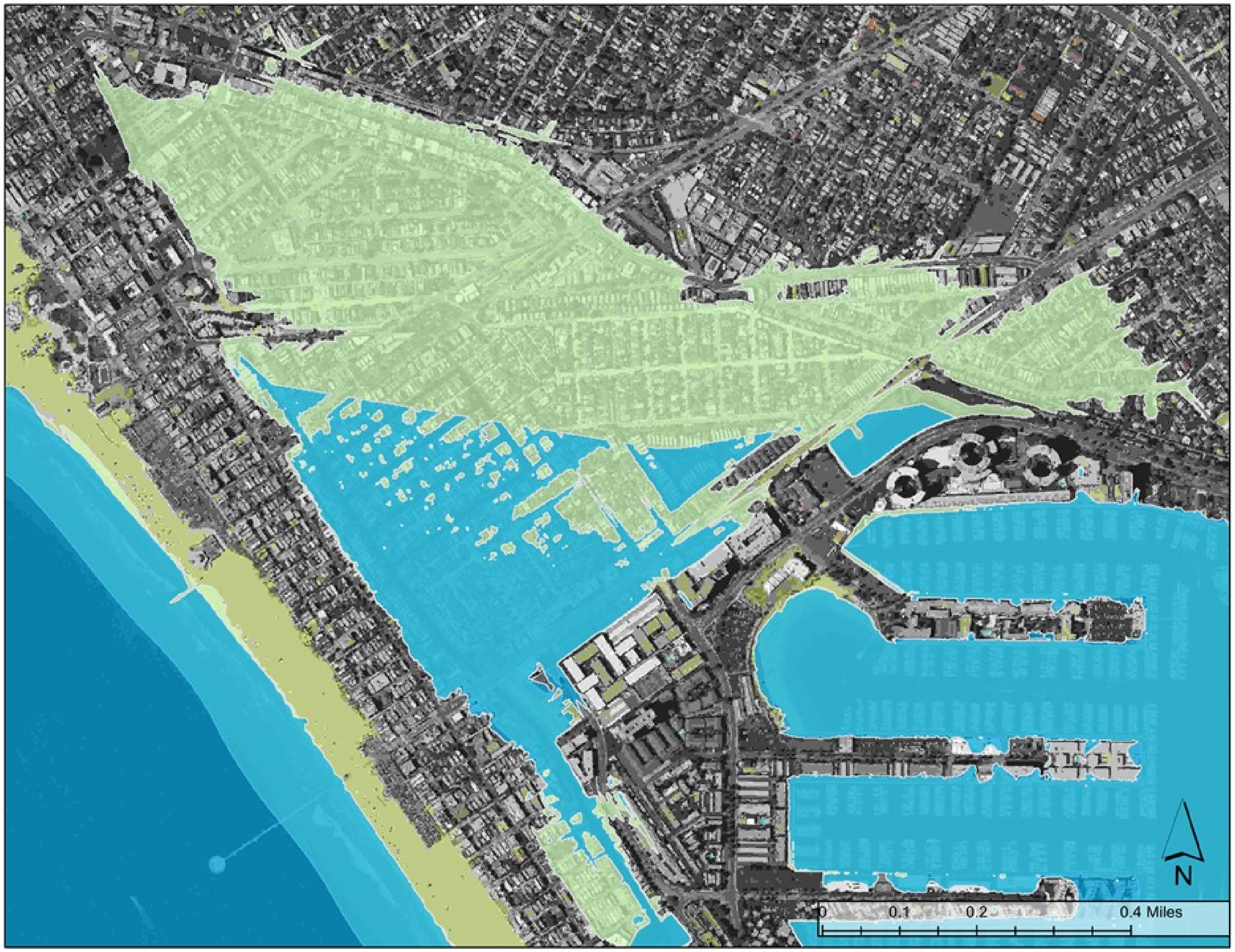


***Figure 3.5: Comparison of CoSMoS 3.0 and Adapt LA - Potential Inland Flooding Areas***

# 4. Selected Sea Level Rise Scenarios

Five scenarios have been selected for this study that consider increments of SLR between 0 and 6.6 feet (0 – 2 m). This range of scenarios is based on available data for the region. Best available science currently projects sea levels to rise by 1.5 to 5.5 feet in the study area by year 2100 (NRC 2012).

The five sea level rise scenarios were selected based upon review of existing data and observed vulnerability thresholds (i.e., tipping points of where coastal hazard exposure changes substantially). The recommended SLR scenarios for the study area are provided in Table 4.1 below.

***Table 4.1: Venice Vulnerability Assessment Sea Level Rise Scenarios***

| Scenario | Sea Level Rise, ft | Sea Level Rise, m | Approximate Time Horizon for Sea Level Rise Projection* | Justification |
|---|---|---|---|---|
| 1 | 0 | 0 | Current | Establish existing (baseline) conditions |
| 2 | 1.7 | 0.5 | 2050 to 2080 | Identify vulnerabilities within LCP planning horizon |
| 3 | 3.3 | 1.0 | 2060 to 2100+ | Potential threshold for inland flooding & coastal recreation |
| 4 | 4.9 | 1.5 | 2080 to 2100+ | Consistent with upper range of projections in 2100 |
| 5 | 6.6 | 2.0 | Beyond 2100 | Characterize vulnerabilities from extreme SLR |

**Time horizon from ourcoastourfuture.org using CA SCI UPDT (Griggs, et al. 2017) RCP 8.5 projections*

# 5. Preliminary Sea Level Rise Hazard Maps

Based on the selected models and scenarios described we have generated preliminary sea level rise hazard maps depicting both storm and non-storm conditions. A map for each sea level rise scenario is shown in the following figures (Figure 5.1 through Figure 5.5). The preliminary maps also include an inventory of the coastal resources based on information collected from City and County GIS data. The coastal resource database is shown in Figure 5.6 with more information provided on each feature in Figure 5.7 and Figure 5.8. The sea level rise hazard maps and coastal resource inventory will provide the basis for the Venice Vulnerability Assessment. These should be circulated to the project team, City staff and other stakeholders for additional input to expand on this inventory if necessary.


***Figure 5.1:*** ***Coastal Hazard Map for Existing Conditions (current sea level)***


*Figure 5.2: Coastal Hazard Map for 1.64ft (0.5m) of Sea Level Rise*


*Figure 5.3: Coastal Hazard Map for 3.28ft (1.0m) of Sea Level Rise*


***Figure 5.4: Coastal Hazard Map for 4.92ft (+1.5m) of Sea Level Rise***


***Figure 5.5:*** ***Coastal Hazard Map for 6.56ft (+2.0m) of Sea Level Rise***


*Figure 5.6: Coastal Resources Base Map for Venice, CA*

## Coastal Resources List / Legend

| | | Data source: | Comments: |
|---|---|---|---|
| **Infrastructure:** | Tide Gates<br>-- Marina Del Rey owned by county and operated by city<br>-- Washington Blvd. unknown owner and operated by Mariposa Landscaping | LA City geohub | • Additional water infrastructure such as stormwater pipes was not shown in this map |
| | Stormwater Pumping Stations<br>-- Windward Circle | LA County GIS Portal | |
| | Wastewate Pumping Stations<br>-- Venice Pumping Plant (VPP)<br>-- Venice Auxillary Pumping Plant (VAPP) | LA County GIS Portal | |
| | Outfalls | LA County GIS Portal | |
| | Canals | LA County GIS Portal | |
| | Armoring | LA County GIS Portal | |
| | Major Sewer Pipes<br>-- Force main from VPP to Hyperion<br>-- Gravity main along canal | LA City geohub | |
| **Access:** | Metro bus line<br>-- 108<br>-- 33 & 733 | LA City geohub | |
| | Parking<br>-- City owned lots<br>-- County owned lots at Venice City Beach | LA City geohub<br>LA County GIS Portal | |
| | Coastal Path/Bike Path | LA County GIS Portal | |
| **Cultural Resources:** | Historic Monuments<br>-- Venice Canal District<br>-- Others including: Kinney-Tabor House, Lincoln Place Apartments, Sturdevant Bungalow, Venice Arcades, Venice Branch Library, Venice City Hall, Venice Division Police Station, Venice of America House, Venice West Cafe, and Warren Wilson Beach House | LA City geohub | • Historic-Cultural Monument Areas as listed by City of Los Angeles, does not include recent Venice Pride Lifeguard Tower |

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***Figure 5.7: Coastal Resources Inventory (1 of 2)***

## Coastal Resources List / Legend (cont.)

| | | Data source: | Comments: |
|---|---|---|---|
| **Civic Facilities:** | | | |
| | Lifeguard HQ | LA County Fire | • Marina Del Rey Hospital, LAC Fire Station 110 are not within City of Los Angeles, but included for functional proximity |
| | Lifeguard towers (22 in total) | LA City geohub | |
| | Schools -LAUSD<br>-- Broadway Elementary<br>-- Coeur d'Alene Elementary<br>-- Venice Skills Center<br>-- Westminster Elementary<br>-- Westside Global Awareness Magnet | LA City geohub | |
| | Schools - Private/Charter<br>-- Acton Academy Venice Beach<br>-- Animo Venice Charter High School<br>-- St. Mark School<br>-- Venice Lutheran School | LA City geohub | |
| | LAPD Venice Substation | | |
| | Marina Del Rey Hospital | LA City geohub | |
| | LAFD Stations<br>-- Los Angeles Fire Station 63<br>-- LA County Fire Station 110 (Marina Del Rey) | LA City geohub | |
| **Coastal Amenities** | | | |
| | Recreation Centers<br>-- Venice Beach Recreation Center<br>-- Oakwood Recreation Center | LA City geohub | |
| | Other Amenities<br>-- Venice Beach Boardwalk<br>-- Venice Fishing Pier | | |
| **Ecological Resources:** | | | |
| | Rare plants and animals habitat<br>-- Snowy Plover<br>-- Least Tern<br>-- Orcutt's Pincushion<br>-- California Brown Pelican | California Natural Diversity Database (CNDDB) | |

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***Figure 5.8: Coastal Resources Inventory (2 of 2)***

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# Appendix C
# OPC RISK DECISION FRAMEWORK

## APPENDIX 4:

# Risk Decision Framework

*(Adapted from the Governor's Office of Planning and Research's "Planning and Investing for a Resilient California: A Guidebook for State Agencies")*

This framework serves to help planners and decision makers evaluate sea-level rise impacts across a range of projections to inform appropriate design, adaptation pathways, and contingency plans that build resilience.

| | | | | |
|---|---|---|---|---|
| **RISK CONSIDERATIONS & EVALUATION** | **Consequences of Impact or Disruption** | **LOW** *Minimum Disruption, Limited Scale and Scope* | **MEDIUM TO HIGH** *Inconvenience, but Limited in Scope and Scale* | **EXTREME** *Unacceptable Risk and/or Extensive Scale and Scope* |
| | **Adaptive Capacity** | • Future flexibility maintained<br>• People or systems readily able to respond or adapt | • Limited future flexibility | • Irreversible<br>• Threat to public health and safety |
| | **Who or What is Affected?** | • Low impact on communities, infrastructure, or natural systems | • Communities, systems, or infrastructure readily able to adapt or respond to change | • Vulnerable populations<br>• Critical infrastructure<br>• Critical natural systems<br>• Areas of economic, historic, or cultural significance |
| | **Economic Impacts** | **LOW** | **MEDIUM** | **HIGH** |
| **EMISSIONS SCENARIO EVALUATION** | **Pre-2050** | **RCP 8.5** *(high emissions)* | **RCP 8.5** *(high emissions)* | **RCP 8.5** *(high emissions)* |
| | **Post-2050** | ← **EVALUATE RCP 2.6 AND RCP 8.5** *(low emissions and high emissions)* → | | |
| **SLR PROJECTIONS SELECTION** | | **LOW RISK AVERSION** | **MEDIUM-HIGH RISK AVERSION** | **EXTREME RISK AVERSION** |