MEMORANDUM

COUNTY OF SAN MATEO
PLANNING AND BUILDING DEPARTMENT

DATE:	**August 30, 2019**
TO:	**Erik Martinez, Coastal Analyst, California Coastal Commission**
FROM:	**Summer Burlison, Project Planner, County of San Mateo Planning and Building Department**
SUBJECT:	**Water Level Considerations for Plan Princeton**

Purpose:

To summarize the County's proposed sea level rise (SLR) scenarios and resulting erosion rates to be used for the vulnerability assessment of the shoreline management plan for Plan Princeton and the water level considerations underpinning them, and to get feedback on the County's policy approach for addressing identified vulnerabilities.

Desired Outcome:

To receive feedback from California Coastal Commission (CCC) staff on the County's proposed approach for characterizing SLR vulnerability for Plan Princeton and its proposed policy approach.

Goals:

a. Verify the appropriate water levels and shoreline erosion rates for Plan Princeton.
b. Agree on a policy framework for managing shoreline development and shoreline management based on projected SLR and shoreline erosion.

Introduction

Plan Princeton is an effort by the Planning and Building Department to provide policy and zoning updates for the unincorporated Princeton area that will guide future development in a manner that prioritizes coastal-dependent and coastal-related development, enhances coastal access and recreation, and protects natural coastal resources. Plan Princeton will include a Shoreline Management Plan to ensure that management interventions to improve coastal and beach habitats, public recreation, and coastal access and development will be resilient to coastal erosion and flooding from SLR and storms and will be managed over time to ensure continued resilience.

The Shoreline Management Plan will provide clear policies and a public process for the development and design of a shoreline management strategy that protects habitat resources, increases recreational values, protects property, and addresses SLR in a sustainable, adaptable, environmentally acceptable, and economically viable manner. The Shoreline Management Plan will also include implementation options for funding improvements. In order to develop a feasible and locally relevant Shoreline Management Plan for Plan Princeton, a vulnerability assessment will be necessary to identify the vulnerable resources within the study area and assess the risks from projected SLR and shoreline erosion to these identified resources.

Water Level Considerations

As recognized in San Mateo County's (SMC) Sea Change Sea Level Rise Vulnerability Assessment (SMC, 2018), a total water level approach is necessary to assess the impacts of future flooding within the Princeton area from SLR and storms.

In accordance with the California Coastal Commission's (CCC) 2018 Sea Level Rise Guidance, based on the Ocean Protection Council's (OPC's) 2018 State of California Sea-Level Rise Guidance Update, the variables necessary to determine future flooding levels are as follows:

Future Flooding Level = *Higher High Tide* + *Sea Level Rise* + *Surge* + *Forcing* + *Wave Runup*

Other recommended parameters for determining locally relevant SLR projections from the CCC's 2018 SLR Guidance document include the use of best available science. The values that are proposed for Plan Princeton include the above Future Flooding Level factors, and consider these other recommended parameters, as discussed below.

Higher High Tide

The higher high tide value is derived from the value from the nearest NOAA tidal gauge. In the case of the project area for Plan Princeton, the nearest monitored NOAA tidal gauge is the San Francisco tide gauge (NOAA ID: 9414290), referenced below.

Tidal Characteristics at San Francisco Bay
(Tidal Epoch: 1983-2001)

Datum	*Elevation (ft., MLLW)*	*Elevation (ft., NAVD88)*
Highest Measured Water Level (27 Jan 1983)	8.66	8.72
Mean Higher High Water (MHHW)	5.84	5.90
Mean High Water (MHWS)	5.23	5.29
Mean Tide Level (MTL)	3.18	3.24
Mean Sea Level (MSL)	3.12	3.18
Mean Low Water (MLW)	1.13	1.19
Mean Lower Low Water (MLLW)	0.00	0.06
North America Vertical Datum- 1988 (NAVD88)*	-0.06	0.00

Lowest Measured Water Level (20 Jan 1988)	-2.88	-2.84

Source: NOAA Tidal Bench Mark

Sea Level Rise (SLR)

The selected SLR scenarios of 1.6 ft., 3.3 ft., and 6.6 ft. (each with and without a 100-year storm) are proposed for Plan Princeton, based on our review of state agency guidance and the best available modeled water levels from United States Geologic Survey and its Coastal Storm Modeling System (CoSMoS) model, made accessible through Point Blue's Our Coast, Our Future (OCOF)[1]. OCOF's modeling of these scenarios are provided in Attachments 1 – 6.

Best Science Available for Projecting SLR

California Coastal Commission (CCC), Sea Level Rise Guidance, 2018

The CCC's adopted 2018 SLR Policy Guidance provides step-by-step guidelines for addressing sea level rise and adaptation planning in Local Coastal Programs. The Policy Guidance recognizes that while SLR science continues to evolve, best available science should be used to determine locally relevant SLR projections under a scenario-based analysis in order to identify local impacts from SLR. The 2018 Policy Guidance relies on the best available science on SLR in California, which is currently the 2018 Ocean Protection Council's *State of California Sea-Level Rise Guidance: 2018 Update*.

Use of scenario-based analysis[2] is recommended for SLR projections as it addresses the uncertainty in SLR projections by providing a full range of possible flooding from SLR that can be reasonably expected for a particular location; builds an understanding of the overall risks posed by projected SLR, based on best available science; and helps to identify the "tipping points" when SLR will become a serious issue in a particular location (CCC, 2018).

The Guidance suggests evaluating the impacts of multiple SLR scenarios based on a range of SLR projections that includes the "medium-high risk aversion" and "extreme risk aversion" scenarios from the OPC's 2018 probabilistic projections. The Guidance also suggests evaluating the minimum amount of SLR that will cause impacts to the community, and tipping points where SLR impacts become more severe.

Ocean Protection Council (OPC), State of California Sea-Level Rise Guidance: 2018 Update

The OPC's *State of California Sea-Level Rise Guidance: 2018 Update* is scientifically accepted as the State's best available science for SLR projections and rates for California. A key shift in the OPC's 2018 Guidance includes a change from scenario-based SLR projections to probabilistic projections. Probabilistic SLR projections associate the

[1] The Our Coast, Our Future (OCOF) tool is an interactive online mapping tool that provides a number of SLR and storm scenarios using the USGS Coastal Storm Modeling System (CoSMoS). The OCOF tool is currently considered to be the best available SLR modeling data.
[2] Scenario-based analysis refers to the idea of developing multiple scenarios from which to analyze vulnerabilities, generate new ideas and adaptation options and/or test strategies (CCC, 2018).

probability of occurrence with SLR heights and rates that are directly connected to future greenhouse gas (GHG) emission scenarios. There are four scientifically accepted GHG emission scenarios, called Representative Concentration Pathways (RCPs), each representing a different emissions trajectory, RCP 2.6 (low-emissions scenario), RCP 4.5, RCP 6.0, and RCP 8.5 (high-emissions scenario). Additionally, there is an H++ scenario for extreme SLR that could result from a rapid loss of West Antarctic ice sheet under high GHG emission scenarios. The OPC's 2018 Guidance update relies on the comprehensive probabilistic approach used by Kopp et al. 2014 that provides SLR projections in 10 year increments at least through 2100 based on low and high emissions (RCP 2.6 and RCP 8.5, respectively) that are tied to the likelihood of occurrence (referred to as low, medium-high and extreme risk aversion). For purposes of Plan Princeton, we will refer to the high emissions scenarios from the OPC's guidance for a conservative approach to determining SLR projections. These scenarios appear to be the most accurate, based on recent observations of atmospheric carbon concentrations, and emerging understanding of methane emissions and impacts.

2018 OPC Probabilistic Projections (based on Kopp et al. 2014)				
Scenario	**Time Period**	**Likely Range (low-risk aversion, 66% probability for occurrence)**	**1-in-200 chance (medium-high risk aversion, 0.5% probability for occurrence)**	**H++ (extreme risk aversion, unknown probability of occurrence)**
High Emissions	2030	0.5'	0.8'	1.0'
	2040	0.8'	1.3'	1.8'
	2050	1.1'	1.9'	2.7'
	2060	1.5'	2.6'	3.9'
	2070	1.9'	3.5'	5.2'
	2080	2.4'	4.5'	6.6'
	2090	2.9'	5.6'	8.3'
	2100	3.4'	6.9'	10.2'
Probabilistic projects do not account for impacts of El Niño or storms. Most of the available climate model experiments do not extend beyond 2100.				

Sea Change San Mateo County

In March 2018, the County of San Mateo Board of Supervisors accepted a final Sea Level Rise Vulnerability Assessment (SMC, 2018) that takes a risk-based approach, using best SLR guidance available at the time of the report, to analyze SLR vulnerability and flood risk in San Mateo County (SMC) under two SLR scenarios and one coastal erosion scenario.

The assessment relies on the best available SLR inundation modeling data from the USGS and from the OCOF modeling tool. The advantage of the OCOF tool is that it is a fine scale model that extends beyond a traditional bathtub model and incorporates storms, atmospheric forcing, wave height, current velocity and flood depth. In following the CCC's 2015 SLR Policy Guidance (appropriate at the time that the Assessment was developed), Sea Change uses a scenario-based analysis that includes a baseline scenario (present-day extreme flood), a mid-level SLR scenario, and a high-end SLR scenario; along with a coastal erosion scenario with SLR. However, as a broad risk-based study, Sea Change does not link its SLR and erosion scenarios to any specific planning horizons.

County of San Mateo Sea Change SLR Scenarios (2018)	
Baseline Scenario	1% annual chance flood (present-day extreme flood also known as 100-year flood)
Mid-level Scenario	1% annual chance flood + 3.3 feet of SLR
High-end Scenario	1% annual chance flood + 6.6 feet of SLR
Coastal Erosion	The projected extent of coastal erosion expected with 4.6 feet of SLR

As the County moves forward on SLR efforts under its Sea Change program, the County intends to rely on the probabilistic projections in the OPC's 2018 SLR Guidance.

Plan Princeton Approach to SLR Projections

Plan Princeton considers the above State and local guidance for determining appropriate local SLR projections for the Plan Princeton Study Area. Consistent with the County of San Mateo's Sea Change work, Plan Princeton relies on the OCOF tool as the best available SLR inundation modeling data for the local study area. Given OCOF's modeling tool is based on a suite of preset SLR values from the USGS CoSMoS model, staff has reviewed OCOF's numerous flood scenarios for the Plan Princeton study area and has identified a range of SLR scenarios from low to high-end that we've determined represent likely noticeable changes in local flood impacts on the Princeton area. Staff has related these selected scenarios to a potential bracket of time consistent with the planning horizons from OPC (2018).

Plan Princeton SLR Projections		
Time Period	**Sea Level Rise**	**Storms**
2030 - 2045	19.2 inches (1.6 feet)	1% Flood (100-year)
2045 - 2070	39.6 inches (3.3 feet)	

2070 - 2100	79.2 inches (6.6 feet)	

The above selected SLR scenarios will incorporate storm scenarios provided in the OCOF tool. Staff believes the above local projections are consistent with the County's accepted and future Sea Change work. Additionally, the selected Plan Princeton SLR projections are within a comparatively reasonable range relative to the probabilistic projections from the OPC, and adopted by the CCC, when considering the fact that the Plan Princeton scenarios will account for storm events, where the probabilistic SLR projections from the OPC do not account for storms.

<table>
<tr><th rowspan="2">Planning Horizon</th><th rowspan="2" colspan="2">Plan Princeton</th><th rowspan="2">SMC Sea Change 2018</th><th colspan="3">OPC 2018 Guidance Update (High Emissions Scenarios)</th></tr>
<tr><th>Low risk aversion (66% probability)</th><th>Med-High risk aversion (0.5% probability)</th><th>H++ Extreme risk (unknown probability)</th></tr>
<tr><td>2030 – 2045 (low)</td><td>1.6'</td><td rowspan="3">1% Flood (100-year)</td><td>--</td><td>0.8' *</td><td>1.3' *</td><td>1.8' *</td></tr>
<tr><td>2045 – 2070 (mid)</td><td>3.3'</td><td>3.3'</td><td>1.9'</td><td>3.5'</td><td>5.2'</td></tr>
<tr><td>2070 -2100 (high)</td><td>6.6'</td><td>6.6'</td><td>3.4'</td><td>6.9'</td><td>10.2' **</td></tr>
<tr><td colspan="7">* 2040 projections from the OPC 2018 Guidance.
** Based on Table 2 of the OPC 2018 Guidance, there is a 0.1% probability that SLR will meet or exceed 10 ft. by 2100 under a high emissions scenario (RCP 8.5).</td></tr>
</table>

A lack of available OCOF modeling data (or other science-based data) for a 10-ft. SLR projection along the ocean coast limits the Plan Princeton assessment of a H++ scenario (per the OPC Guidance) to the nearest available modeling data of 6.6 ft. SLR + 100-year storm. The National Oceanic and Atmospheric Administration (NOAA) Sea Level Rise Viewer has recently added a 10-ft. SLR projection to their modeling tool, and when compared to OCOF's modeling for 6.6 ft. SLR + 100-year storm, the flooding impacts are very similar, see Attachment 7. Therefore, to maintain consistency in the modeling system being relied on by Plan Princeton, an H++ scenario will be considered in the Plan by using OCOF's 6.6 ft. SLR + 100-year storm to understand the extreme potential impacts of SLR to the Princeton Study Area through 2100. It is intended for Plan Princeton to focus primarily on the low-end scenario of 1.6 ft. SLR to align with the Plan's intended 25-year Planning horizon. However, the Plan will consider infrastructure lifetime and pre-identified triggers for flooding and erosion as indicators for evaluating the higher SLR scenarios under a Plan amendment.

Surge, Forcing, Wave Runup

Storm surge is a temporary increase in water level driven by wind stress and reduced atmospheric pressure. While storm surge is more of a significant factor in rising sea levels along the Gulf and Atlantic coasts due to tropical storms and hurricanes that frequent that region, storm surge along the California coast during major winter storm events can result in elevated water levels by up to 3 ft. above predicted sea level (OPC, 2017). Pursuant to the CCC's 2018 SLR Guidance, Table B-5 (Factors that Influence Local Water Level Conditions), the typical storm surge range for the California Coast is between 2 – 3 feet.

The most prominent atmospheric forces that affect water temperatures and levels relevant to the California coast and more specifically, to the Princeton shoreline, include the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO).

El Niño events can last for months or years at a time and occur approximately every 2 to 7 years. Major El Niño events within the past half century include 1972-73, 1982-83, 1997-98, and 2015-16, where sea level has risen by up to 12 inches for several months at a time (OPC, 2017). The damaging 1983 El Niño event, accompanied by high astronomical tides and large waves, elevated water levels along the California coast by approximately 0.4 to 0.7 ft. (CCC, 2018).

The PDO, which affects SLR due to its correlation between wind forces and sea surface temperature patterns, has shifted towards a cooling phase where warmer surface water can be a contributing factor to rising sea level.

According to the OPC's 2017 Rising Seas in California Update, wave runup along the California coast can be up to 6 ft. The breakwaters that protect Pillar Point Harbor and the Princeton shoreline have changed the typical wave pattern within the harbor such that fetch-limited waves have become dominant (i.e. wave height is limited by the size of the wave generation area) resulting in the Princeton shoreline being primarily exposed to small period waves. Nonetheless, anecdotal observation of wave runup around the midsection of the Princeton shoreline describes winter storm event wave runup reaching up to 4 - 5 ft.

The OCOF modeling tool incorporates storm surge, sea level anomalies (such as El Niño), and wave runup in its total water level models. Therefore, Plan Princeton proposes to use the range of values for surge, forcing, and wave runup that are factored into the OCOF modeling tool for the particular specified SLR scenarios and storm conditions that the Plan will consider.

As a result, Plan Princeton's total water level approach for assessing the impacts of future flooding within the Princeton area from SLR and storms will be based on the proposed values in the table below. Additionally, Attachment 8 provides a numeric illustration of these future flooding levels that will be considered in Plan Princeton.

Future Flooding Levels for Plan Princeton	
Variable	**Value**
Mean Higher High Water	5.90’
Sea Level Rise	1.6’, 3.3’, and 6.6’; + 100-year storm*
Surge, Forcing, Wave Runup	Varied (0.59’ to 3.44’)
*The increase in water level under a 100-year storm ranges from 2.01’ to 2.85’ above the SLR scenario, as illustrated in Attachment 8.	

Watershed and Groundwater Induced Flooding

The impacts of sea level rise can be exacerbated by upland watershed flooding and rising groundwater levels. On the other hand, downstream sediment transport can allow marshes and shorelines to maintain elevation in light of rising sea levels. The County could consider the impacts of groundwater tables and impacts of watershed flooding on the resilience of properties in Princeton to rising sea levels. By Fall 2019, the County will have access to data showing changes in shallow groundwater elevation under 12 sea level rise scenarios. The County is also finalizing watershed level models to show where creeks will flood based on projections of future precipitation for 2030 and 2070 combined with CoSMoS data.

Coastal Erosion

Flooding is not the only implication of SLR. SLR and storms will increase the rate of coastal erosion along the Princeton shoreline modifying sediment supply and movement, resulting in a loss of beach, impacts to habitat, public access and recreation, and development.

Decadal-scale coastal erosion for southern and central California using airborne LIDar data from 1998 and 2009-2010 to measure coastal cliff retreat between the California/Mexico border and Bodega Head, California, indicates that bluffs along the California coast are retreating at an average bluff top retreat rate of 0.4 feet per year (ft./yr.) with maximum retreat of about 13 ft./yr., as reported in a 2017 article “Decadal-scale coastal cliff retreat in southern and central California”, by Adam P. Young. The process by which sediment is removed from the coastal shoreline through natural processes, such as waves, tides, and changing sea levels, is referred to as shoreline erosion. Shoreline erosion will increase with rising sea level as wave impacts, including frequency and movement inland, increase. As cited in the CCC’s 2018 SLR Guidance, the Pacific Institute estimated that 41 sq. miles of coastal land from the California-Oregon border through Santa Barbara County could be lost due to increased erosion with 4.6 ft. of SLR by the year 2100, equating to an average bluff erosion/retreat distance of 102 ft. along the San Mateo County coast (USACE, et al., 2017). This is a generalized estimate across the entire coast of San Mateo County and does not consider the specific influencing characteristics of different segments of the coast, such as geological conditions or wave exposure factors.

As described in the 2015 Coastal Regional Sediment Management Plan (CRSMP) for the Santa Cruz Littoral Cell, prepared by the United States Army Core of Engineers (USACE), Monterey Bay National Marine Sanctuary, and Noble Consultants, Inc., the Princeton shoreline (located within the breakwaters of Pillar Point Harbor) lies at the north end of Reach 1 (Pillar Point to Surfer's Beach) of the 75-mile long Santa Cruz Littoral Cell (USACE, et al., 2015) which extends from the Point San Pedro headland, north of Pillar Point, to Moss Landing in Monterey County. The CRSMP estimates that the regional wave climate within the Santa Cruz littoral cell generates a net direction of sand transport from north to south of as much as 300,000 cubic yards per year (USACE, et al., 2015). Changes to the sediment budget of a littoral cell can alter the dynamic equilibrium at a beach and cause either erosion or accretion of sand (USACE, et al., 2015), as is evidenced along the Princeton Shoreline.

Based on review of historical aerial photography, the shoreline of the harbor area prior to construction of the breakwaters had a smooth curved shape with a continuous sandy beach backed by the adjoining low bluff terrace that makes up the community of Princeton, as shown in Attachment 9. According to the USACE, this smooth arcuate-shaped shoreline was a result of prevailing northwest swell refraction around the Pillar Point headland that evenly distributed wave energy, and its resulting effect on sediment supply to the Princeton shoreline (USACE, 2017). The Pillar Point Harbor breakwaters disrupted the natural littoral cell sand transport process by isolating the harbor, and Princeton shoreline, from the larger Santa Cruz Littoral Cell, thereby changing the hydrodynamic system and wave patterns within the harbor that affect the Princeton Shoreline with respect to sediment supply and shoreline erosion as the breakwaters became a barrier for littoral and offshore sediment material that once supplied sand to the Princeton shoreline. Large ocean swells that affected the Princeton shoreline prior to the breakwaters have become small period waves that erode the shoreline. As a result, erosion of the Princeton shoreline has increased since the construction of the outer breakwaters as concluded by the USACE (USACE, 2006).

The SMC Sea Change assessment relies on the Pacific Institute's erosion data for the San Mateo coastline to assess the erosion risk on the coast; however, the Pacific Institute's modeling data does not extend into the protected Pillar Point Harbor area where the Princeton shoreline study area lies. Furthermore, the USGS' currently published CoSMoS data for SLR projections does not take erosion into account. While there has been no known erosion modeling performed inside the harbor, various studies have recognized the erosion concerns along the Princeton shoreline due to the breakwaters, constructed by the USACE in 1959 – 1961, which have modified the shoreline sufficiently to require a particularized approach to characterizing shoreline erosion.

Projected Shoreline Erosion

A projected shoreline erosion rate of 6 in./yr. (-0.5 ft./yr.) is proposed for Plan Princeton. This erosion rate is derived from doubling the average projected erosion rate of 3 in./yr., estimated by Noble Consultants, to account for SLR. This also includes an analysis, conducted by staff, of historic erosion rates along the shorelines using high resolution aerial imagery. We believe the projected shoreline erosion rate of 6 in./yr. is an appropriate rate for erosion along the Princeton shoreline based on our review of best available science on historical erosion rates and shoreline changes, project specific shoreline erosion studies, and historical aerial photography, accompanied by the understanding that SLR will accelerate shoreline erosion by changing the frequency and location of wave impacts along the Princeton shoreline.

Past Erosion Studies

According to a SLR and erosion study by GHD for the San Mateo County Harbor District's Phase I West Trail repair, average bluff retreat along the West Trail (interior harbor side of Pillar Point bluffs and headland), was 0.6 ft./yr. (or 7.2 in./yr.) from 1986 – 2016. Other past project specific studies along the Princeton shoreline support the conclusion that the breakwaters in the harbor have disrupted the natural littoral cell which has resulted in accelerated erosion along the Princeton shoreline. For example, a project specific study in 1998 for the shoreline between Columbia Avenue and Broadway identified the natural average erosion rate prior to the breakwaters (between 1940 – 1960) was 3.6 in./yr. and between 1960 -1983, after the inner breakwaters were constructed, average retreat had accelerated to 26.4 in./yr. In general, coastal bluff retreat is an episodic process where most of the major incidents of retreat occurs during short periods of high tides or significant storm events such as El Niños, when cliff stability is compromised and, over the course of a few years, several feet may be lost as the cliff progressively retreats back to a more stable inclination.

Pillar Point Harbor Basin

Given the unnatural conditions of Pillar Point Harbor, particularly as a result of the construction of the breakwaters, it is critical in the development of a shoreline management plan for Plan Princeton, which focuses on the Princeton shoreline (between West Point Avenue and Broadway) and Pillar Point Marsh, to understand other characteristics and influences of this significantly altered, closed harbor environment as shoreline management policies are developed for the Plan. This section identifies three shoreline segments within the harbor, starting at the west breakwater, as depicted in Attachment 10, and describes the key features and characteristics within each segment.

Western Shoreline Segment

The western shoreline segment extends from the west breakwater to West Point Avenue and includes Pillar Point Bluff and the West Trail, and Pillar Point Marsh.

Pillar Point Bluff and West Trail

The prominent Pillar Point Bluff lies on the west side of Pillar Point Harbor and supports the West Trail, a public access path owned and managed by the San Mateo County Harbor District (Harbor District) that follows the edge of the bluff to an outer harbor beach where the west arm of the breakwater connects to land. The trail and bluff have been subject to erosion due to tidal and wave action and drainage issues from the adjacent hillside. The Harbor District is currently in the process of design/engineering and permitting for the West Trail Erosion Protection Project which seeks to address trail/bluff erosion through the development of a living shoreline alternative that would minimize the use of hard armoring.

Pillar Point Marsh

Pillar Point Marsh is located between Pillar Point headland on the west and the developed Princeton waterfront area to the east, and is owned by the County of San Mateo. The marsh lies within the Pillar Point Marsh Watershed and is influenced by tidal action (i.e., lower, southern saltwater marsh) and stormwater runoff (i.e., upper, northern freshwater marsh), with the marsh reportedly comprising 41 acres, including 23.5 acres of freshwater marsh and 17.5 acres of saltwater marsh (Christopher A. Joseph & Associates, 2010). In addition to supporting a wide variety of plant and animal species, the Marsh serves as a water purifier and sediment basin.

The marsh is underlain by relatively young, fine-grained, organic-rich basin deposits and fine-grained alluvial deposits carried by flood waters from Denniston Creek, the Half Moon Bay airport, and neighboring uplands (Christopher A. Joseph & Associates, 2010). Geotechnical borings and water wells near the marsh indicate that flood flows and alluvial sediments from Denniston Creek have periodically been transported to the marsh area; however, increased development in the core area of Princeton now limits surface connections between the creek and the marsh (Christopher A. Joseph & Associates, 2010). Additionally, the San Gregorio Fault cuts through the middle of the marsh, playing an important role in marsh hydrology as it displaces and deforms the underlying Half Moon Bay Terrace (Christopher A. Joseph & Associates, 2010).

Based on our review and mapping of historical aerial imagery, the marsh was much larger in the 1930's when the area was dominated by farmland. Since the 1930's, three significant anthropogenic alterations in the Princeton area have impacted the drainage pattern and tidal action influencing the marsh, including construction of West Point Avenue and the street grid between Denniston Creek and the marsh; construction of the Half Moon Bay Airport in 1942-43; and construction of the harbor breakwaters in 1959-61.

The earliest detailed map illustrating the marsh is an 1861 topographic map by the U.S. Coast Survey depicting the marsh as a lagoon connected to the bay with all land to the east identified as grain fields. The marsh was reportedly dammed in the early 1900's by farmers to protect the surrounding predominant farmlands from saltwater (Christopher A. Joseph & Associates, 2010). The earliest available photos of the marsh in 1931 show the marsh area inundated to the same extent as the 1861 topo map, with some form of access crossing the marsh in an east-west direction, see Attachment 16.

The Half Moon Bay Airport was constructed in 1942-43, resulting in significant alteration in upland drainage patterns to the area. Airport construction created the surface drainage network that exists today; it collects and conveys surface water from the watershed, including the airport runways and agricultural fields, into a drainage ditch that culverts under Airport Street and discharges into the upper freshwater marsh area on the west side of Airport Street.

The outer harbor breakwaters, constructed in 1959-61, have also had a significant tidal influence on the marsh as its construction substantially reduced wave and tidal action at the mouth of the salt marsh (Christopher A. Joseph & Associates, 2010). As mentioned in earlier discussion, these breakwaters have also contributed to accelerated erosion along the eastern extending Princeton shoreline and have affected erosion along the West Trail, west of the marsh.

The air force tracking station was established at Pillar Point around 1968 with the current horseshoe access road, currently known as West Point Avenue, being formed at this time. West Point Avenue divides the marsh into the upper 23.5-acre freshwater marsh and lower 17.5-acre salt marsh. A culvert, running in a north-south direction under West Point Avenue, provides connection between these otherwise separated areas. The road and culvert have had a significant impact on the tidal influence of the marsh by constraining tidal inflow to the northern freshwater area and trapping sediment which has caused an aggradation of freshwater habitat (Flint, 1977; Christopher A. Joseph & Associates, 2010).

Princeton Shoreline Segment

Individual segments of unauthorized rip-rap and other protective measures started to appear along the Princeton shoreline around the late 1970’s to early 1980’s to protect private properties from erosion. However, it is apparent from visual observation and examination of high resolution aerial imagery of the shoreline that the piece-meal placement of such unpermitted protection devices may have exacerbated bluff and beach erosion adjacent to these areas as the degree of erosion is inconsistent along the Princeton shoreline. Plan Princeton’s shoreline management plan will focus on addressing this segment of shoreline, therefore, it is important to understand the particular characteristics of the shoreline as a result of erosion in order to formulate an effective strategy that will address the issues in a manner consistent with project goals. Our method for characterizing the shoreline includes field observation, and aerial and surveyed data comparisons. Based on this methodology, we’ve determined that the shoreline between West Point Avenue and Broadway can be divided into three (3) segments of shoreline that each generally encompass a block of shoreline parcels differing in characteristics.

Princeton Shoreline Segment 1: West Point Avenue to APN 047-037-300

Segment 1 includes the western portion of the Princeton shoreline, as shown in Attachment 12. This segment consists of a number of developed shoreline fronting parcels that were all developed by the early 2000’s. Based on a comparison of the 1959 surveyed MHW line and aerial LIDar from 2015, this segment of shoreline has been altered over time by seaward fill of approximately 24 ft. to support development.

Segment 1 is predominantly armored with engineered and non-engineered structures, including concrete rubble, rip-rap, sand bags, and a concrete seawall. Minimal bluff area along this segment has been left unprotected and the areas adjacent to the fill, still within this segment, have experienced the most erosion. A beach, which narrows at high tides, exists along this segment of the shoreline. Continued observation will be necessary to determine shoreline impacts from the San Mateo County Harbor District’s recent removal of Romeo Pier along this segment.

Princeton Shoreline Segment 2: APN 047-037-300 to APN 047-037-510

Segment 2 includes the middle portion of the Princeton shoreline, as shown in Attachment 13. This segment supports the least amount of development. The most prominent feature is the former boat haul-out facility with a concrete seawall and shipways built in the mid 1970’s. Based on a comparison of the 1959 surveyed MHW line and aerial LIDar from 2015, this segment of shoreline has experienced minimal change, averaging to about -0.05 ft./yr. (0.6 in./yr.) of erosion over this time period comparison.

Segment 2 of the shoreline consists of a mix of unprotected scarp, non-engineered concrete rubble, and engineered concrete seawall at a former boat haul-out site. A beach extends along this segment of the shoreline, which narrows at high tides.

Princeton Shoreline Segment 3: APN 047-037-510 to Broadway

Segment 3 extends along the eastern portion of the Princeton shoreline, as shown in Attachment 14. This segment consists of a few developed shoreline parcels that were predominately constructed in the mid 1990's. Based on a comparison of the 1959 surveyed MHW line and aerial LIDar from 2015, this segment of shoreline has experienced significant erosion of up to approximately -0.51 ft./yr. (6.12 in./yr.). Based on historical aerial imagery, the erosion appears to have accelerated after construction of the breakwaters.

Segment 3 of the shoreline consist of a mix of unprotected and protected scarp with armoring along the developed portions that consists of both engineered rip-rap and non-engineered rubble. The bluffs along this segment are the highest of the three shoreline segments forming a vertical scarp as tall as 15-20 feet in some locations and the physical effects of erosion are the greatest. Except at low tide, little to no beach is visible along the majority of this segment of shoreline.

While there is no known erosion modeling data available for the shoreline within the Pillar Point Harbor breakwaters which includes the Princeton shoreline; the USGS is in the process of updating their CoSMoS model to include erosion projections that will cover the area within the harbor breakwaters. Plan Princeton will rely on any updated erosion modeling projections from the USGS as it becomes available within the timeframe of completing the shoreline component of the Plan. The County and San Mateo County Harbor District are seeking grant funds to use the USGS model to project tidal currents and sediment transport within the harbor basin.

Eastern Shoreline Segment

The eastern shoreline segment of the harbor extends from Broadway to the east breakwater and includes Denniston Creek, Capistrano Beach, and the Harbor and Boat Launch area.

Denniston Creek, Capistrano Beach

Denniston Creek discharges into the harbor east of Broadway. A delta at the mouth of Denniston Creek is visible during low-to-mid-tides resulted from a significant storm event in January 1982. The shoreline bluff along the privately-owned parcel east of Denniston Creek, which historically was the Princeton Packers Cannery site in the 1940's but sits vacant today, is lined with rip-rap extending eastward to a seawall supporting a segment of Capistrano Road. The fronting beach area along this mixed seawall and rip-rapped bluff is Capistrano Beach, accessible by informal paths over riprap and walkable except at the highest tides. The beach material at Capistrano Beach is predominantly fine sands, with an average grain size between 0.10 mm and 0.15 mm (Dyett & Bhatia, 2017). Grain size is an important characteristic for understanding sediment mobility and deposition, which are considering factors to implementing soft shoreline protection measures.

Harbor and Boat Launch Area

The public harbor and boat launch shoreline area, owned and managed by the Harbor District, is predominantly protected with rip-rap or seawalls. Based on historical imagery, between June 1961 and February 1963, a significant quantity of fill supported by seawall was placed seaward of the natural shoreline to develop the original parking lot that supports Johnson Pier. When the Harbor District constructed the inner breakwaters in 1982, additional fill supported by rip-rap revetment was placed seaward of Capistrano Road to extend the parking lot northward around a portion of the previously rip-rap protected roadway.

Southeast of the Harbor District's parking lots is Perched Beach, an area created through permit condition by the California Coastal Commission's 1984 Coastal Development Permit (CDP) Amendment to the Harbor District's original 1976 CDP (No. 133-76) for expansion of the harbor facilities that included construction of the inner breakwaters. Past use of Perched Beach as a dredge disposal site by the Harbor District in 1998, 2006, and 2013, has cumulatively resulted in the conversion of beach to what is now an upland grassy area above a sandy shoreline. Southeast of Perched Beach and extending to the southeast inner breakwater and adjacent boat launch ramp, is an area of shoreline that was created in 1991 as new intertidal and mudflat habitat as a mitigation for the Harbor District's construction of the boat launch ramp in 1992.

Additionally, a vegetated sandy dune area east of the boat launch ramp is found inside the east breakwater, where the shoreline and east breakwater join, just outside of the Plan Princeton Study Area. Aerial photos from construction of the outer breakwaters in 1959 support the conclusion that this dune area was created as a construction staging area for the breakwater construction.

Future Shoreline Implications

Plan Princeton's shoreline management plan will focus on addressing Pillar Point Marsh, owned and managed by the County of San Mateo, and the Princeton Shoreline (segments 1 – 3), to ensure their resilience from coastal erosion and flooding from SLR and storms.

Implications to the marsh over time include a migration of the tidal marsh northward into the upper freshwater marsh area, causing an increase in saltwater intrusion as the extent of the marsh area becomes more connected to the ocean, and both permanent and more frequent inundation of the lower marsh. This inland migration of tidal marsh will affect plant and wildlife species in the marsh as freshwater areas become more brackish to saline. Additionally, as the marsh becomes more inundated by SLR, there will be an increased risk for more frequent nuisance flooding into the eastern edge of the adjacent developed Princeton area.

Additionally, implications to the Princeton shoreline over time would increase the risk of public and private property damage from flooding and erosion, including public access and sustainability of natural resources. As water level rises, flooding and erosion will pose a greater risk to shoreline development and to public infrastructure such as roads and utilities. Based on OCOF modeling, the Princeton beach would become more inundated, resulting in a loss of recreational beach area. Vertical and lateral access to and along the shoreline would be adversely affected as well. Nuisance flooding and inundation to the eastern portion of Princeton would also become increasingly problematic. Additionally, an increased area of inundation and erosion from SLR would drive nearshore habitat and intertidal habitat to migrate inward as water level rises. As the physical conditions of the shoreline change, nearshore habitat would convert to intertidal habitat and intertidal habitat would convert to subtidal habitat.

Fluvial and Tidal Sediment Sources

Fluvial Sediment

Understanding sediment sources and quantities in the harbor are essential in determining the feasibility of soft protection measures for shoreline management, including beach restoration and replenishment. This is true for a number of reasons, including the ability of the marsh to accrete; the likelihood of structures or living shorelines to remain in place; etc.

Pillar Point Harbor receives sediment-laden stormwater runoff from three watersheds, including the Deer Creek, Denniston Creek, and Pillar Point Marsh watersheds, see Attachment 23.

Deer Creek Watershed

The Deer Creek watershed is approximately 1.05 square miles in size and feeds Deer Creek, a perennial stream that discharges directly into the harbor near the small boat launch ramp at the eastern end of the harbor. The watershed predominantly consists of the rural coastal hills above El Granada, with Deer Creek flowing from these upper rural hills through the highly developed lower portion of El Granada, mostly through culverts, before culverting under Highway 1 and discharging into the harbor. The upper watershed area is comprised of highly erodible soils, with landslides in the hillslopes being the primary sediment source for Deer Creek. The lack of maintenance of the creek's upstream reservoir and creek channel (upstream of the reservoir) over the years has reduced the amount of sediment that enters the harbor from this creek due to sediment build-up that prevents its transport downstream. According to a sediment retention study for Deer Creek in 1999, for the period from November 1943 to May 1956 the annual average sediment yield for Deer Creek at its Pillar Point Harbor outfall was 3,052 tons/year. By March 1973, upstream sediment build-up had reduced this yield to 2,176 tons/year. Sample test results reported at that time characterized the sediment yield in the watershed being primarily composed of sand (primarily fine to medium) and silt, with small amounts of gravel and clay (Philip Williams & Associates, 1999).

Denniston Creek Watershed

The Denniston Creek watershed covers 3.83 square miles below Montara Mountain and feeds Denniston Creek, which originates in the steep coastal hills and flows through a lower rural valley and suburban area of the watershed before discharging directly into the harbor east of Broadway. Approximately 75% of the flow is from stormwater runoff (AES, 2015). The headwater area of Denniston Creek consists of erodible granitic rock and Miramar coarse sandy loam (highly erosive) with the lower valley area being Farallone coarse sandy loam. Denniston Creek is the only significant source of littoral material in the harbor, with an estimated contribution of 1,600 cubic yards per year (USACE, 1981; 1996). Similar to Deer Creek, a lack of maintenance of the upstream reservoir for Denniston Creek limits sediment transport to the harbor. Additionally, farmers and the Coastside County Water District (CCWD) pump water out of the Denniston reservoir, which significantly reduces the stream flow between the reservoir and the harbor, further reducing downstream sediment transport. The delta at the mouth of Denniston Creek that is visible today during low-to-mid-tides resulted from a significant storm event in January 1982. The storm caused a sediment event that overwhelmed the upstream reservoir and consequently discharged a relatively large plume of sediment into the harbor (Christopher A. Joseph & Associates, 2010). Historically, CCWD has performed maintenance dredging within and around the reservoir. In 1982, CCWD dredged approximately 20,000 cubic yards (c.y.) of sediment and removed vegetation in the reservoir. Later CCWD obtained permits for annual dredging from 2009 to 2014 in the immediate vicinity of the reservoir. During this period, the district removed 800 c.y. of sediment in the first year and 400 c.y. annually until their permit expired in 2014; all of the dredge material was transported approximately ½ mile uphill from the reservoir to a dredge spoil site. However, maintenance dredging has not been completed since 2014.

Pillar Point Marsh Watershed

The Pillar Point Marsh watershed covers the eastern half of Princeton extending north and east across Highway 1 into the southeast portion of Moss Beach, including the northern half of the Half Moon Bay Airport. Drainage through the watershed consists primarily of surface water runoff from the Half Moon Bay Airport and limited urban development in Moss Beach that discharges into the northeastern portion of Pillar Point Marsh. A significant sized delta can be observed at the mouth of Pillar Point Creek, the discharge outlet of the marsh, acting as somewhat of a protection barrier from wave action.

While the watersheds feeding Pillar Point Harbor prove to be sources of fluvial sediment, a lack of upstream maintenance and low water flow may hinder the transport of sediment to the harbor and the downstream beaches.

Other Sediment Sources

Prior to the breakwaters, the primary sediment source along the Princeton shoreline was bluff erosion due to wave action and transported sediment from creeks and offshore waves. The Coastal Storm Modeling System (CoSMos) confirms that prior to construction of the harbor, sediment moved from a northwest to southeast direction along the shoreline (i.e., littoral drift) due to longshore currents induced by waves approaching from the northwest. The breakwaters disrupted this process as the western breakwater became a barrier for these southeast trending longshore currents, resulting in sand deficit on the beaches within the harbor (Dyett & Bhatia, 2017).

A 1996 shoaling analysis by the USACE concluded that wave surge through the eastern (outer) breakwater accounts for a significant amount of sand accumulation in the harbor, with at least 1,200 linear ft. of the east breakwater subject to significant surging. The reversal in wave direction to the northwest is believed to be caused by occasional strong storm events from the south and southwest. There is estimated to be approximately 260,000 cubic yards of sediment deposit along the inside of the eastern breakwater due to surge through the east breakwater. A lack of wave action inside the harbor breakwaters prevents this sediment from moving back into the littoral cell (outside of the harbor breakwaters). Overall, the USACE estimates that 85% of the sediment comes from outside the harbor with the remaining coming from bluff and shoreline erosion and creek discharges inside the harbor.

Sediment and Water Quality

Pillar Point Harbor water quality is chronically so poor that the location has been listed on the State Water Resources Control Board 303(d) list for elevated levels of indicator bacteria since 2002. Pollutant results from the San Mateo County Resource Conservation District's 2018 First Flush program show that fecal contamination and bacteria from residential stormwater systems are primary contributors for the impaired water quality in the harbor. The State Water Resources Control Board is currently in the process of developing a Total Maximum Daily Load (TMDL) for Pillar Point Harbor to improve water quality in the harbor and at the beaches.

Past sampling and testing of dredge material within the western inner harbor breakwater and outside the eastern inner harbor breakwater, around the boat launch ramp, have consistently concluded the harbor material to be predominantly composed of fine to course grained sand, free of contaminants, with a high potential for beneficial reuse for beach replenishment elsewhere within the harbor (CCC, 2013; 2014; Soil Control Lab, 2017), as supported in the approval of the Surfer's Beach nourishment project which entails removing sand from the harbor basin and placing it at adjacent Surfer's Beach. Test results show the sand material having low values of organic carbon, which helps prevent contaminants from bonding to the dredge material, giving it a high potential for reuse.

Biological Resources

Shoreline management policies will be sensitive to biological resources, including saltmarsh common yellowthroat (G*eothlypis trichas sinuosa),* California red-legged frog *(Rana draytonii),* coastal marsh milk-vetch *(Astragalus pycnostachyus var. pycnostachyus),* and northern coastal salt marsh that are identified in the Pillar Point Marsh area, according to the California Natural Diversity Database (CNDDB). Additionally, an eel grass survey was commissioned by the Harbor District for their current boat launch ramp dredging project. The April 2019 survey found 419 square meters of eel grass within the focused boat launch ramp study area, mostly located near the eastern outer breakwater in low intertidal and shallow subtidal depths. Additional surveying for eel grass, as well as surveying for nearshore, intertidal and subtidal zone resources would be required for any proposed work associated with the implementation of any shoreline management strategies recommended in Plan Princeton.

Preliminary Shoreline Management Policy Direction

Given the current highly altered condition of the shoreline and tidal basin at Pillar Point Harbor, management actions are limited. The development of shoreline management policies for Plan Princeton will be based on the following shoreline management goals:

- Preserve and/or enhance the quality of Princeton's shoreline for recreation, access, and resource conservation;
- Protect people and human health from risks associated with flooding and erosion, especially socially vulnerable community members;
- Provide reasonable protection of property, infrastructure and uplands in a manner consistent with the area's aesthetic qualities, public access needs, and other community goals and objectives;

- Based on best available science, incorporate sea level rise into the County's long-term planning and include a phased approach in actions to address uncertainty and build flexibility into adaptation planning and policies;
- Provide clear direction for developers, property owners, and County staff for designing and approving future development along the Princeton shoreline.

Ecosystem Protection and Management

The County intends to develop policies to ensure sensitive coastal habitats that are identified at Pillar Point Marsh, including saltmarsh common yellowthroat (G*eothlypis trichas sinuosa),* California red-legged frog *(Rana draytonii),* coastal marsh milk-vetch *(Astragalus pycnostachyus var. pycnostachyus),* and northern coastal salt marsh, along with eel grass beds, dunes, sand flats, beaches and other marine and terrestrial habitats, are protected and managed in consideration of SLR and coastal erosion, and to avoid human disturbance and damage. Protecting and enhancing the coastal ecosystem will not only benefit the sensitive habitats but can also increase resilience of the shoreline to SLR and waves. Ecosystem protection and management policies will provide direction to:

- Protect and enhance the existing ecosystems;
- Incorporate stormwater management, including green infrastructure where feasible, into public and private projects to prevent pollutants from entering the Pacific Ocean, or from eroding the shoreline;
- Support and understand watershed sediment inputs that could support SLR resilience;
- Ensure sensitive habitats are maintained and conserved;
- Facilitate inland habitat migration, where appropriate and feasible, including for Pillar Point Marsh.

Shoreline Protection

The County envisions installing a shoreline protection system along the Princeton shoreline that combines nature-based and engineered structural solutions to respond to past alterations of harbor conditions and to avoid continued unnatural shoreline erosion. The installation of the breakwaters in 1959-61 destroyed the sand replenishment system at work along the Princeton Shoreline for millennia. Instead of a natural pattern of erosive winter storm waves followed by summer replenishment waves, the inner harbor is subject to only low period waves and occasional large winter storm waves, all of which are erosional, and none are replenishing. The eroded shoreline sand ends up in the harbor. The shoreline protection system may entail armoring to stabilize the current shoreline with an ongoing sand nourishment program to restore and maintain the beach and coastal access and improve habitat.

Shoreline Armoring

Shoreline armoring may be installed to provide direct erosion protection to the shoreline and the properties along the shoreline. The Plan will consider an engineered revetment or retaining wall as options for hard shoreline protective devices along the Princeton shoreline and will provide guidance on the determining factors for design parameters, such as the design extreme stillwater level, wave action, geotechnical condition, and future SLR. Shoreline armoring would be integrated with soft protection measures, such as beach fill.

Beach Restoration and Nourishment

Beach fill not only provides protection to the shoreline during times of extreme water levels and waves, but also provides a widened recreational beach. The Plan will include guidance for determining beach fill parameters that prioritize access, recreation, community and ecosystem benefits, and includes the need for hydrodynamic and sediment transport models for the harbor basin that will inform the placement and shape of replenishment beach sand, and the pace of ongoing maintenance to preserve the beach.

Additional soft measures will be encouraged as appropriate to continue to support the recreation and fisheries conditions. These could include, but are not limited to, eel grass restoration, dune restoration and/or marsh restoration.

Managing Shoreline Development

The siting and design of development on or near the shoreline must take into account coastal hazards and the extent of shoreline migration and groundwater changes that can be anticipated over the expected life of the existing and/or future development. In an effort to prevent the seaward encroachment of development, in light of SLR and coastal erosion, project design policies will be developed to provide siting and design parameters for development along the shoreline that would establish vertical and horizontal stringlines for development; establish requirements for limiting the value of authorized development to realistic amortization periods as the Plan is implemented in concert with ongoing rates of SLR and erosion; and provide guidance for the expansion or redevelopment of non-conforming development.

- The Plan will establish a vertical stringline that sets a minimum finished floor elevation, NAVD 88, for new development, or criteria for determining an appropriate vertical stringline on a project specific basis. The stringline will be based on projected water levels associated with SLR and coastal storms for the life of the Plan. No areas within a new building below this vertical stringline would be allowed for occupancy. However, other uses such as boat storage, parking, etc. could be considered.

- The Plan will establish a horizontal stringline for new shoreline development as a minimum setback from the existing shoreline top of bluff for new development. The determined stringline will be based on SLR and erosion projections for the life of the Plan. No portion of new construction would be allowed to encroach seaward of the delineated horizontal stringline.

- The Plan will include policies to encourage or potentially require alternative design approaches, such as foundation designs, modular construction or other building techniques, be considered in areas identified in the Plan that are within high flood or erosion risk locations in order to allow incremental or complete removal or relocation based on pre-identified water level or flooding event thresholds.

- The Plan will include procedural policies establishing expected water-level timeframes and observed thresholds to guide decisions about amortization requirements for authorized development, including the removal or relocation of shoreline protection.

- The Plan will provide policy guidance on siting and design parameters specific to the expansion or redevelopment of nonconforming structures, or the perpetuation of existing non-conforming structures.

Managed Shoreline Realignment

The County intends to establish SLR thresholds in the Plan that, when crossed, would require that the County consider alternative measures to implementing Plan Princeton while a revised Plan is developed based on the most current best available science. Alternative measures may include a construction moratorium within the portion of the Plan Area identified as vulnerable to coastal flooding and shoreline erosion based on the Plan thresholds, and the need for removal and/or realignment of all shoreline protection devices, streets and subterranean infrastructure, buildings, including foundations, and other improvements along the shoreline that are unsuitable for habitat and safe coastal recreation. Pre-defined thresholds will be based on the consideration of changing site conditions that would result in increased risk for development, such as:

- A rise in Mean High Water elevation that could increase flood risk to finished floor (i.e., occupied) elevations of development.
- Increased frequency of nuisance flooding that would be considered disruptive to the community, based on the National Weather Service's (NWS) definition[3].
- Inability for the County to maintain a beach nourishment component of the shoreline protection system established by Plan Princeton over a predetermined period of time and any authorized shoreline armoring has become completely exposed.
- Inadequacy of the shoreline management system to protect the shoreline evidenced by a significant landward erosion of the top of bank or significant undermining and slope failure of any authorized shoreline armoring.

A post-threshold, revised Plan Princeton would need to include a strategy designed to protect people and coastal habitats, preserve shoreline access and provide for reasonable coastal development, consistent with the Coastal Act then in effect.

[3] The National Weather Service defines "nuisance flooding" as the water level at which minor impacts begin to occur in coastal communities.

Shoreline Monitoring and Evaluation

Monitoring and evaluation is a critical component of shoreline management. The Plan will provide policies to ensure a thorough monitoring program is developed as part of a shoreline management strategy. Monitoring efforts would need to track conditions through consistent data collection and reporting to guide timely decision making, approaching or crossed thresholds, ensure accountability, and provide the basis for evaluation and learning. The County will encourage methods for monitoring sea-level rise, erosion and flooding by using existing tidal gage data, observations during king tides events and observations of impacts to public access. Monitoring information and/or new science on sea level rise, erosion or storms would be incorporated into planning, as necessary.

Design and Implementation

Governance

Pillar Point Harbor below MHT is within the jurisdiction of the San Mateo County Harbor District and the California Coastal Commission. Any beach nourishment or shoreline armoring along the Princeton shoreline that may be below MHT would require partnership with the Harbor District and authorization by the Coastal Commission. The Plan will provide policy guidance that clarifies the participating regulatory agencies, permitting processes, and potential partnership opportunities for pursuing the design and implementation of a shoreline management system. Additionally, San Mateo County and Cities have recently formed the Flood and Sea Level Rise Resiliency Agency to plan, fund and implement shoreline resiliency strategies, including the shoreline management plan for Plan Princeton.

Funding

The County recognizes that there are two critical parts to funding a shoreline management system, including initial design and implementation, and ongoing maintenance. It is expected that the capital cost of an initial shoreline management system (i.e., design and implementation) would be borne by the County, in part using grant funds. It is possible that ongoing maintenance of the system, including beach replenishment, could be funded by an alternative source, or combination of sources. The Plan will explore the feasibility of funding options that may include an assessment district, joint power authority, developer fees, and/or grant opportunities for funding ongoing maintenance of a shoreline management system.

Post-Threshold Strategies

As pre-defined thresholds are crossed, the County would need to reevaluate and revise Plan Princeton based on changed conditions and current science on SLR and coastal erosion. Strategies that may be considered under a revised Plan would include:

- Implementing a development moratorium that limits new development, or major remodels, upgrades, or expansions of non-conforming buildings, until a revised Plan is developed that sets forth new shoreline management policies based on an understanding of the increased risks of SLR and erosion.

- Managed shoreline realignment which would require the removal or relocation of development and infrastructure to avoid hazardous or compromised facilities and allow the shoreline to migrate inward unimpeded.

The implications of any post-threshold management strategy alternatives for reducing hazards posed by SLR and coastal erosion would need to be fully assessed before implemented. Additionally, any alternative strategy should be a joint endeavor between the County and stakeholders, including property owners. Plan Princeton will provide a starting point to this future planning effort by considering the methods for implementing adaptive post-threshold alternatives, such as a transfer of development rights program or property buyout program. Additionally, the Plan will identify the advantages and obstacles for each option, including the process, costs, and funding sources relative to local socio-economic and political contexts, to help inform future planning efforts.

ATTACHMENTS

1. OCOF SLR (Low) Scenario Map for 1.6 ft. SLR
2. OCOF SLR (Low) Scenario Map for 1.6 ft. SLR plus 1% Storm
3. OCOF SLR (Mid) Scenario Map for 3.3 ft. SLR
4. OCOF SLR (Mid) Scenario Map for 3.3 ft. SLR plus 1% Storm
5. OCOF SLR (High) Scenario Map for 6.6 ft. SLR
6. OCOF SLR (High) Scenario Map for 6.6 ft. SLR plus 1% Storm
7. Extreme Scenario Map Comparison, OCOF 6.6 ft. SLR plus 1% Storm versus NOAA 10 ft. SLR
8. Water Level Bar Graph for OCOF SLR Scenarios
9. Historical Princeton Shoreline
10. Princeton Shoreline Segments 1 - 3
11. Historical Princeton Shoreline Erosion
12. Princeton Shoreline Segment 1
13. Princeton Shoreline Segment 2
14. Princeton Shoreline Segment 3
15. Pillar Point Harbor Vicinity Map
16. Historical Pillar Point Marsh Surveys, 1861 and 1866
17. Historical Pillar Point Marsh Imagery, March 30, 1931
18. Historical Pillar Point Marsh Imagery, April 12, 1941
19. Historical Pillar Point Marsh Imagery, 1956
20. Historical Pillar Point Marsh Imagery, May 1, 1965
21. Historical Pillar Point Marsh Imagery, June 7, 1974
22. Historical Pillar Point Marsh Imagery, October 10, 1983
23. Watersheds Map

REFERENCES

Analytical Environmental Services (AES), 2014. Draft Environmental Impact Report, Denniston/San Vicente Water Supply Project, Coastside County Water District. August 2014.

Analytical Environmental Services (AES), 2015. Final Environmental Impact Report, Denniston/San Vicente Water Supply Project, Coastside County Water District. February 2015.

Applied Earth Sciences Consultants, 1998. Geotechnical investigation and repair recommendations to mitigate on-going wave erosion at Lots 20 through 31, Block 1, Volume 6, Page 33 San Mateo County records, Princeton by the Sea, California 94019. December 14, 1998.

Brady/LSA, 2002. Fitzgerald Marine Reserve Master Plan, Final Draft. May 2002.

California Coastal Commission, 2018. California Coastal Commission Sea-Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea-Level rise in Local Coastal Programs and Coastal Development Permits. Last adopted November 7, 2018.

California Ocean Protection Council Science Advisory Team (OPC-SAT), California Natural Resources Agency, 2018. State of California Sea-Level Rise Guidance 2018 Update. Adopted on March 14, 2018.

California Ocean Protection Council Science Advisory Team (OPC-SAT), California Ocean Science Trust, 2017. Rising Seas in California: An Update on Sea-Level Rise Science. April 2017.

Christopher A. Joseph & Associates, 2009. Big Wave Wellness Center and Office Park Draft Environmental Impact Report. October 2009.

Cotton, Shires and Associates, Inc., 2016. Geotechnical Hazard Assessment RE: Pillar Point Bluffs and California Coastal Trail, County of San Mateo, California. June 23, 2016.

Dyett & Bhatia, 2017. Administrative Draft Coastal Access and Shoreline Management Chapter for Plan Princeton. 2017.

Flint, Philip S., 1977. Environmental Study of the Pillar Pt. Marsh, Part I. Baseline Data. February 1977.

GHD, 2016. West Trail Repair – Phase 1, Sea Level Rise and Erosion Study. August 2016.

Moffatt & Nichol Engineers, 2001. Shoreline Protection Feasibility Study for Princeton, Pillar Point, Half Moon Bay, California. September 2001.

Morello, Lauren, 2011. Climate Shift May Accelerate West Coast Sea-Level Rise. ClimateWire, May 3, 2011.

Our Coast our Future (OCOF), 2016. Web application.

Philip Williams & Associates, 1999. A Feasibility Study of Sediment Retention Basins for Deer Creek, El Granada, California. June 30, 1999.

San Mateo County, 2018. County of San Mateo Sea-Level Rise Vulnerability Assessment Final Report. Published in March 2018.

U.S. Army Core of Engineers, 2017. Continuing Authorities Program Section 111 Detailed Project Report and Draft Environmental Assessment, North Half Moon Bay, Pillar Point Harbor, San Mateo County, CA. January 2017.

U.S. Army Core of Engineers, 2006. Draft Princeton Shoreline Improvement Project Section 216 Initial Appraisal. January 2006.

U.S. Army Core of Engineers, Monterey Bay National Marine Sanctuary, Noble Consultants, Inc., 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing. September 2015.

U.S. Army Core of Engineers, Craig Vogt, Inc., CSRA, Eastern Research Group, 2017. Draft Final California Regional Assessment National Shoreline Management Study. August 7, 2017.

Young, Adam P., 2017. “Decadal-scale coastal cliff retreat in southern and central California”. Published online on October 19, 2017.