Beach Boulevard Infrastructure Resiliency Project

Multi-Hazard Risk Assessment

May 2021

City of Pacifica, CA

Table of Contents

Figure Index

Table Index

Appendix Index

1. Executive Summary

The Multi-Hazard Risk Assessment (MHRA) provides a comprehensive understanding of risks from natural hazards to the Beach Boulevard Seawall and associated assets (i.e. infrastructure and resources) in the City of Pacifica. Risks of primary concern to the City include damage from coastal flooding, erosion, and earthquake hazards. The understanding of these risks will be used to inform the development and comparison of project alternatives being generated for the Beach Boulevard Infrastructure Resiliency Project (Project), which seeks to address frequent seawall failures and overtopping in order to ensure public health and safety in the vicinity of Beach Blvd and West Sharp Park neighborhood. Doing nothing or the No Action alternative is an area of focus in the MHRA as it provides a useful means to define what is at risk should the seawall fail.

Key findings from the MHRA in terms of the definition of natural hazards and what assets are at risk are summarized in this section.

1.1 Natural Hazards Summary

Coastal Flooding

- Extreme wave runup elevations and overtopping rates vary along the Beach Boulevard seawall and are greater north of the pier than south of the pier.
- Total Water Levels (TWL) are approximately **15 feet above the North Wall crest** during a 10-year return period event. TWL higher than the seawall crest results in significant wave overtopping and flood hazards along Beach Boulevard.
- During the same 10-year return period event, TWL elevations are about **5 feet above the South Wall crest**. This is due to the presence of a beach fronting the wall dissipating wave energy before approaching the wall.
- During a 60-year return period event (i.e. roughly equivalent to the 1983 El Niño storm), TWLs are significantly higher than the seawall crests and result in a **wave/flood hazard zone** that could extend up to **200 feet landward the North Wall** and about **75 feet landward of the South Wall**.
- **Coastal hazards are anticipated to worsen with sea-level rise** with wave runup and overtopping increasing at an amplified rate. A **2-foot sea-level rise scenario[1] will increase TWL elevations by 8-10 feet during extreme events**. The wave hazard zone would extend about 50 feet further landward along the North Wall and about 75 feet further landward along the South Wall under a 2-foot SLR scenario.

Coastal Erosion

[1] A 2-foot SLR scenario has 0.4% probability of exceedance by 2050 and 13% probability of exceedance by 2070 (OPC, 2018).

- The **Pacifica shoreline and bluffs are highly erodible** due to the narrow sandy beaches, high wave energy and the loosely consolidated nature of its bluffs. The long-term shoreline erosion rate was estimated to range from 0.7-2.2 ft/year and is one of the highest in the San Francisco Littoral Cell (Griggs 2020).

- In order to define potential coastal erosion hazards in the Project area, a hypothetical scenario of the seawall not being in place was assumed. The Coastal Storm Modeling System (CoSMoS) Version 3.1, was used to define future coastal erosion hazards with sea-level rise.

- The results indicate that **most of the Beach Boulevard corridor would be lost to erosion by 2030 should no shoreline protection be in place**. The coastal erosion hazard zone progresses landward with time and projected rates of sea-level rise **resulting in significant property loss of approximately 50 buildings by 2050, and 165 buildings by 2100**.

- Seasonal erosion of beach deposits (i.e., beach sand) expose the beach platform (hardpan) to scouring over time. Estimated potential future scour depths at the existing seawall alignment are -3 feet (NAVD88) for the south wall and -5.5 feet (NAVD88) along the north wall for the 2070 time horizon.

<u>Earthquake Hazards</u>

- The presence of active faults nearby the Project (i.e. San Andreas, San Gregorio-Hosgri, and Hayward) make the site susceptible to strong seismic shaking over the design life of the project.

- Given the proximity to active faults and the young alluvial soils encountered below Beach Boulevard, **severe shaking is likely to occur and will need to be accounted for in any new shoreline protection structure**.

- The interbedded young alluvial soils and beach sand that exists in the Project area make **the site vulnerable to liquefaction and potential ground settlement**.

1.2 Risk Assessment Key Findings

Over the next 50 years sea-level rise (SLR) has the potential to significantly compound existing consequences from flooding and erosion. In the absence of adaptation measures developed to mitigate these hazards, a No Action scenario, the vulnerabilities are overwhelming. **If the existing seawall and revetment were removed, the entire Beach Boulevard corridor could be lost to erosion within a decade.**

A qualitative assessment of risk was performed based on quantitative analysis of hazards and their impacts. High risk events, described in this section, have a high probability of occurrence and result in moderate to high consequence for resources, property, and infrastructure along the Beach Boulevard corridor. A high probability of occurrence was assigned to events with a 60-year return period or less, in combination with 0-2 feet of SLR.

Infrastructure

- Coastal erosion presents a high risk to the Beach Boulevard corridor. The corridor is highly sensitive to erosion damage because undermining of the pavement structure poses not only a safety risk, but also requires more extensive repairs after such an event. The duration of this repair work can last from several weeks to over a month in which access through the work area is restricted.
- Erosion hazard projections in 2030 for a "No Action" scenario indicate the entire Beach Boulevard corridor would be lost to erosion along with the variety of infrastructure and uses supported by the corridor.
- Coastal flooding currently presents a moderate risk to infrastructure along Beach Boulevard due to the temporary disruption in service (~2-3 hours during peak tides) that occurs during events with coincident high tides and large waves.
- With 2-feet of SLR, coastal flooding presents a high risk to Beach Boulevard during a 10-year return period event. Overtopping is expected to double for this event, which has the potential to cause more significant damage to the roadway, promenade, and property.
- Erosion hazard projections in 2030 for a "No Action" scenario present a high risk to the utility systems along Beach Boulevard. The sanitary sewer, potable water, gas, and other utilities would require a major investment (~$42.5M) to be relocated and equipped to function outside the 2030 erosion hazard zones.
- Coastal flooding presents a low risk for underground utilities that are closed systems (potable water & gas) or overhead utilities (electrical power & communications). These systems are less sensitive to temporary flooding events.
- Storm drain systems are at high risk from coastal flooding and SLR, especially at the low-lying areas long Clarendon Road where high ocean water levels could reduce the conveyance capacity of gravity systems and actively managed systems.
- Erosion hazards under a "No Action" scenario also pose a high risk to the Pacifica Municipal Fishing Pier because damage to the pier wall would prohibit safe access for pedestrians to enjoy the aesthetic and recreational benefits of the Pier.

Public Safety

- Coastal flooding poses a high risk to the safety of pedestrians and vehicles accessing the Promenade and Beach Boulevard during storm events. Overtopping observed during the January 2016 series of storms far exceeded the tolerable overtopping rate for safe pedestrian access. A 2-foot SLR scenario will nearly double the volume of water overtopping the seawall during a similar event.
- Coastal erosion also poses a high risk to public safety. Erosion behind the seawall has caused localized failures of the structure and undermined the Promenade. The most recent example of this occurred in December 2020 at the base of the Pier, resulting in temporary closure while emergency repairs are made.

- Under a "No Action" scenario, in which the existing seawall experienced widespread failure, or was removed, coastal erosion would become the primary safety hazard to pedestrian access along Beach Boulevard. The geology of the coastal bluff offers very little resistance to wave attack and the active erosion processes would pose a hazard to pedestrians along the top of bluff and along the beach at the base of the bluff under this scenario.

Environmental

- Marine resources in the project area includes beach and foredune areas south of the Pier and subtidal areas throughout. The beach and foredune resources are sensitive to long-term erosion due to the progressive loss of habitat areas in front of the seawall.
- Due to the presence of mostly developed and landscaped areas within the Project area, terrestrial resources are limited with low quality habitat for wildlife because it is predominantly hardscape and highly disturbed (ruderal) or maintained landscaped areas.
- Laguna Salada, the fresh-brackish lagoon wetland complex located just south and east of the Project area is the only sensitive natural community in the vicinity of the Project area and supports the highest concentration of special-status wetland wildlife species on the San Francisco Peninsula coast. Consideration of direct and indirect impacts to the Laguna Salada wetland complex should be considered as part of the development of alternatives.
- Recreation resources such as the Promenade and Pier are at risk of damage, or complete loss due to coastal erosion under a "No Action" scenario. Loss of these resources would significantly reduce public access opportunities along the Project area. Under this scenario, a narrow and seasonal beach may be accessible to the public, though active erosion of the unprotected bluffs would also pose a safety concern.
- Visual resources consist of several ocean view corridors along the Project area. Coastal views are considered resources of public importance under the California Coastal Act and will warrant consideration when developing and analyzing project alternatives.

Economic Risk Assessment

- Both primary and secondary risks of "Doing Nothing" in the study area were evaluated in this assessment.
- Monetized primary impacts include impacts to properties, infrastructure (e.g. roadway, seawall, pier) and utilities within a hazard zone. It was estimated that about $94.6M of primary economic impacts would occur within the 2020-2030 time horizon. A total of $299.6M of primary economic impacts would occur by the end of the century.
- Monetized secondary impacts include business interruptions, debris cleanup, emergency response and minor repairs, and disruption costs. It was estimated that about $970k in secondary economic impacts would occur in the 2020-2030 time horizon. A total of $5.6M of secondary economic impacts would occur by the end of the century.

- In total, approximately $95.6M of combined economic impacts would be expected within the 2020-2030 time horizon. Combined economic impacts would exceed $305M by the end of the century under a “No Action” scenario.

1.3 Next Steps

Based on the findings from this assessment, the GHD team will develop alternatives that aim to balance the range of coastal resources, public and private property and infrastructure systems which exist along the Beach Boulevard corridor. The development and analysis of project alternatives will occur in parallel with additional community engagement activities including online outreach and public workshops to incorporate public feedback into the development and analysis of alternatives. Some of the key upcoming tasks include:

- Development of three project alternatives to be compared against No Action alternative
- Feasibility study analyzing (comparison and ranking) project alternatives including benefit cost-analysis
- Development of Project features and amenities toolbox
- Refinement of top three project alternatives
- Selection of preferred alternative
- Public outreach and stakeholder engagement

2. Introduction

As part of the Beach Boulevard Infrastructure Resiliency Project (BBIRP, or the Project) the City of Pacifica (City) is in the process of completing a feasibility study to replace the existing Beach Boulevard Seawall. The current seawall infrastructure, built in the 1980s, has experienced failures in multiple locations and continues to be a public health and safety risk for the City. To protect the West Sharp Park neighborhood from future damaging coastal events, the City must be proactive and expedient in the approach to determining and implementing a solution.

The primary purpose of the Project is to:

- ensure public health and safety in the general vicinity of Beach Boulevard including the West Sharp Park neighborhood
- improve public access and use of the Beach Boulevard Promenade and the beach
- replace the current seawall and outdated infrastructure
- build climate resilience into one of the most vulnerable segments of the City's shoreline
- create a multi-benefit solution to protect public infrastructure, recreational activities, homes, businesses, and the community at large, from further coastal erosion impacts.

The Project is an example of how the City is taking proactive steps to adapt to current and projected future coastal hazards associated with sea level rise. These proactive steps will minimize impacts from coastal flooding and erosion to protect and preserve the community and its surroundings.

2.1 Project Location

The Project is located in northern Pacifica along a 0.5-mile stretch of coast along the western edge of the historic West Sharp Park neighborhood. This area runs parallel to Beach Boulevard just west of Highway 1 and the Palmetto Shopping District. The general project vicinity, and project boundary, is presented in Figure 2-1. The Project involves assessing the entire span of the current infrastructure and seawall which includes four different segments of shoreline, each with a different types of shoreline protection as described below:

1. **North wall:** Combination of armor stone revetment and concrete reinforced earth seawall.
2. **Pier abutment wall:** Steel sheet pile backed by a soil cement wall and repaired with an internal reinforced concrete wall.
3. **South wall:** Combination of armor stone revetment and concrete panel seawall.
4. **South gap:** A gap in structural shoreline protection centered at the western terminus of Clarendon Avenue between South Wall and Sharp Park Golf Course rock embankment/levee.

Figure 2-1 Project Location Map

2.2 Defining Vulnerability and Risk

Vulnerability and risk are fundamental topics of this study that are important to distinguish from one another. Vulnerability is the degree to which natural, built, and human systems are susceptible to harm as defined in the Adaptation Planning Guide[2] which was recently updated by the State of California Office of Planning and Research. Assessing vulnerability is one of the key steps in understanding existing and future hazards and their potential impacts and consequences. Vulnerability is typically evaluated based on three factors:

- **Exposure** is the degree to which a resource is exposed to sea level rise (SLR) and associated hazards. Exposure is often described in terms of the spatial extent, duration, and frequency of a specific hazard.

[2] https://resilientca.org/apg/

- **Sensitivity** is the degree an asset would be impaired by the impacts of SLR. Systems that are greatly impaired by small changes in SLR have a high sensitivity, while systems that are minimally impaired by the same small change in SLR have a low sensitivity.
- **Adaptive capacity** is the ability of an asset to respond to SLR, to moderate potential damages, to take advantage of opportunities, and to cope with the consequences. This does not mean that the system must look the same as before the impact, but it must provide comparable services and functions with minimum disruption or additional cost.

Identifying impact thresholds, or tipping points, at which the potential consequences associated with a given hazard scenario increase significantly are a key outcome of this assessment. The impact thresholds can be correlated to a SLR projection to quantify the probability of occurrence at a given time horizon. This provides valuable information for prioritizing adaptation strategies and understanding how these strategies may need to evolve over longer planning horizons.

Risk is a function of probability and consequence. SLR has the potential to increase both probability of exposure to coastal hazards and the consequence from these events. Probability of occurrence can be estimated by the joint probability of a hazard event (e.g. 10-year storm event) and specific sea level rise projection associated with a given impact threshold. Consequences are determined through both quantitative assessments of physical damage and qualitative assessments of environmental resources. Risk tolerance is an important factor to consider and will vary depending on the hazard or resource under consideration. For example, utilities beneath Beach Boulevard have a higher risk tolerance for temporary flooding than the road and promenade which experience significant disruption during temporary flooding events.

A qualitative assessment of risk was performed based on quantitative analysis of hazards and their impacts. Risk levels were assigned either a low, moderate, or high rating as defined below:

- **High risk** events have a high probability of occurrence and result in moderate to high consequence for resources, property, and infrastructure along the Beach Boulevard corridor. A high probability of occurrence was assigned to events with a 60-year return period or less, in combination with up to 2 feet of SLR. A 60-year storm event, comparable to the 1983 El Niño storm, has a reasonably high probability of occurrence over the project's 50-year design life. Likewise, 2 feet of sea level rise represent the upper end of the likely range of projections for the 2070 time horizon.
- **Moderate risk** was used to characterize events with a low probability of occurrence but moderate to high consequence. This rating was also used to describe events with a moderate to high probability of occurrence but only low consequences.
- **Low risk** events have a low probability of occurrence and result in a low to moderate consequence. A low probability of occurrence was assigned to events with a 2-year return period or greater, in combination with more than 3.5 feet of SLR.

2.3 Study Approach

Natural hazards, coastal erosion, and flooding in particular, pose a significant challenge to the uses and resources along the Beach Boulevard corridor. Although the topic has been studied in a variety of ways at the local and regional scale, a project-scale assessment was required to understand the baseline conditions and potential risks associated with these hazards over the Project's design life. The Multi-Hazard Risk Assessment (MHRA) provides a project-level assessment of hazards that will be used to evaluate the risk of impacts to resources along Beach Boulevard. The MHRA included the following general steps to identify potential risks.

1. **Identify primary hazards of concern for a range of sea level rise projections.** Hazards considered in this assessment are described in Section 3 and include:
    - Coastal flooding due to wave runup and overtopping along the existing seawall.
    - Coastal erosion in the event of widespread seawall failure or removal (see Section 2.3.1).
    - Earthquake hazards such as ground shaking and soil liquefaction.
2. **Assess vulnerability to determine impact thresholds.** Exposure to hazards is discussed in Section 3 with findings from the vulnerability assessment organized in subsequent sections:
    - Public Safety – this section describes the potential safety issues caused by natural hazards along the Beach Boulevard corridor.
    - Infrastructure – this section includes Beach Boulevard, the promenade, utilities, and the Pacifica Municipal Fishing Pier.
    - Environmental Resources – this section includes marine, terrestrial, recreation and visual resources.
3. **Describe potential consequences and risks associated with these impact thresholds**. The overall consequences are described in terms of economic impacts in Section 7. This section describes the potential costs of inaction in terms of potential damage to property, infrastructure, and resources along the project reach.

2.3.1 "No Action" Scenario

The MHRA will be performed under a hypothetical "No Action" or "Do Nothing" adaptation strategy. This represents a worst-case scenario in which the existing shoreline protection infrastructure is not maintained or upgraded and there are no other strategies implemented to mitigate current and future coastal hazards. The purpose of evaluating the "No Action" scenario is to describe and quantify the potential costs of inaction. These results will provide a useful point of comparison against costs and benefits of project alternatives. Some of the key assumptions regarding this scenario are described below:

- The existing seawall has limited remaining service life and requires frequent repair to maintain stability. In the hypothetical "No Action" scenario, without frequent repairs, we have assumed the existing seawall and revetment would soon experience widespread failure, necessitating removal of the damaged structure.

- Under a No Action scenario the existing structures would not be replaced by any other adaptation strategy to mitigate coastal hazards along Beach Boulevard. Coastal erosion would likely become the primary hazard of concern given historic erosion trends and the dynamic coastal environment. Coastal erosion hazard zones are described in Section 3.3.
- Although, this scenario assumes coastal erosion will progress unchecked along the project reach, it was assumed that adjacent property owners would continue to implement a protection strategy against coastal erosion and flooding. It was assumed that rock-lined embankments/levees would be constructed to protect adjacent properties (north and south) against flanking.

3. Hazards

3.1 Sea Level Rise

Sea level rise (SLR) is the primary issue of concern when considering how impacts from a changing climate could affect the Project. Global mean sea level is rising, with acceleration in recent decades due to increasing rates of ice loss from Greenland and Antarctic ice sheets, as well as continued glacier mass loss and ocean thermal expansion (IPCC, 2019). The rate of global SLR for 2006-2016 of 3.6 mm/yr is unprecedented over the last century and 2.5 times higher than the rate for 1901-1990 of 1.4 mm/yr (IPCC, 2019).

SLR projections along the west coast of California are provided in the 2018 State of California Sea Level Rise Guidance document (OPC, 2018) for 12 active tide gauges. The California Coastal Commission Sea Level Rise Policy Guidance, updated in 2018 to reflect the latest projections, refers to these as the “best available science” on SLR projections in California. SLR projections for San Francisco, the nearest tide gauge to Pacifica, are appropriate for reference on the Project. These projections are listed in Table 3-1 for a range of probabilistic scenarios and time horizons provided in the guidance.

Table 3-1 Sea Level Rise Projections for San Francisco (OPC, 2018)

Time Horizon	Likely Range, 66% probability SLR is between... (feet)		5% Probability Projection (feet)	0.5% Probability Projection (feet)	H++ Scenario Projection (feet)
2030	0.3	0.5	0.6	0.8	1.0
2050	0.6	1.1	1.4	1.9	2.7
2060	0.8	1.5	1.8	2.6	3.9
2070	1.0	1.9	2.4	3.5	5.2
2080	1.2	2.4	3.0	4.5	6.6
2100	1.6	3.4	4.4	6.9	10.2

Risk tolerance and design life are important factors to consider when evaluating SLR projections and their effect on coastal hazards. A design life of 50 years has long been a default value for civil infrastructure projects based largely on the durability of commonly used construction material and degradation in the marine environment. In practice, some assets remain in service beyond their original design life, especially if subject to regular maintenance and repair. However, if SLR follows projections for a high emissions climate scenario then environmental factors and coastal hazards could change significantly over the next 50 years. The Project design life is assumed to be 50 years although some adaptation strategies may have to be implemented before this time horizon (i.e. 2070) depending on the rate of SLR.

Specific risk tolerances vary for different resources, infrastructure and property along the Project area and will be determined during the design phase. For purposes of the MHRA, a range of SLR scenarios have been evaluated to capture the range of projections through 2100 for the 0.5% probability scenario. The state guidance document recommends evaluating the 0.5% probability SLR projections for “medium-high risk aversion” projects, which seems appropriate for the BBIRP. To clarify what is meant by the probability of these projections, there is a 0.5% chance these values will be exceeded at each time horizon based on the “best available science” at the time of this study.

The state guidance document does not specify how these projections should be combined with other hazards such as an extreme coastal storm event. A 60-year return period storm event has a 1.67% (1/60) chance of exceedance in any given year. If combined with a “medium-high risk aversion” projection the joint probability of this event occurring would be less than 0.01% at a given time horizon. The joint probability of this event is far lower than the typical design standard applied to civil works projects. The combination of SLR and storm events will be further evaluated with input from the City and stakeholders, so the Project design scenarios are in line with the Community’s risk tolerance.

The State SLR Guidance also includes a specific scenario, labeled H++, which is based on projections by Sweet et al., 2017 to estimate a maximum plausible sea-level rise scenario. The H++ projections incorporate findings of Pollard & Deconto, 2016 that are based on a theory of marine ice cliff instability which results in self-sustaining ice-cliff failure that would significantly increase global sea-level rise. The validity of the marine ice cliff instability theory, which underpins the H++ scenario, remains unproven and characterized by deep uncertainty according to the most recent IPCC report titled *The Ocean and Cryosphere in a Changing Climate* (IPCC, 2019). The H++ scenario projections are based on a series of assumptions, not probabilistic modeling, and therefore the likelihood of this scenario cannot be determined.

Under a maximum plausible SLR scenario, the coastal hazard results provided in this report would occur sooner than indicated by the 0.5% probability projections. For example, a 3.5 foot SLR projection has 0.5% chance of occurring in 2070, but under an H++ scenario this amount of SLR could occur before 2060.

3.2 Coastal Flood Hazards

Coastal flood hazards refer to wave runup and overtopping of the existing seawall along Beach Boulevard. Wave runup and overtopping are dynamic and sometimes violent processes that pose a danger to pedestrians, property, and infrastructure. Environmental Science Associates (ESA) performed a detailed assessment of wave runup and overtopping at the project site to document existing hazards and estimate how these hazards would change with SLR. Key findings from their BBIRP-specific assessment are summarized in this section and the complete report is provided in Appendix A.

The technical approach applied to this assessment was based on guidelines established by the USACE (1984; 2003) and FEMA (2005), and as recommended by the CCC (2018) for assessing the coastal hazards as part of the coastal development permit (CDP) application process. Estimating the extreme wave runup heights and landward extents at Beach Boulevard requires information on the water levels, offshore wave height and period and the shape of the shore, including the elevations through the nearshore, the surf zone, the beach, and the developed backshore.

3.2.1 Water Levels and Wave Climate

Water level data was collected from nearby stations operated by NOAA at San Francisco Bay and Pillar Point. Water levels were interpolated between these data points to provide local tidal datums shown in Table 3-2, relative to the North American Vertical Datum of 1988 (NAVD88). Note that the maximum still water level of 8.7 feet NAVD88 was observed during the El Niño winter of 1982-1983, which is the storm of record for much of the California coast.

Table 3-2 Project Tidal Datums (ESA, 2020)

Datum	Description	San Francisco, Sta. 9414290	Pillar Point Harbor, Sta. 9414131	Project Site, Sharp Park[a]
Max Tide	Highest Observed Tide	8.72	--	--
HAT	Highest Astronomical Tide	7.32	7.32	7.32
MHHW	Mean Higher-High Water	5.90	5.64	5.75
MHW	Mean High Water	5.29	4.99	5.12
MTL	Mean Tide Level	3.24	3.07	3.14
MSL	Mean Sea Level	3.18	3.03	3.09
MLW	Mean Low Water	1.19	1.15	1.17
MLLW	Mean Lower-Low Water	0.06	0.04	0.05
NAVD88	North American Vertical Datum of 1988	0.00	0.00	0.00
Min Tide	Lowest Observed Tide	-2.82	--	--
LAT	Lowest Astronomical Tide	-1.87	-2.07	-1.98

NOTES:

[a] Value interpolated between San Francisco and Pillar Point Harbor Datums

SOURCE: NOAA, 2020

Pacifica is exposed to large swells and storm waves generated in the Pacific Ocean. Winter conditions are characterized by very large swells (frequently exceeding 10 feet and occasionally exceeding 30 feet) with long wave lengths (wave periods typically greater than 12 seconds), resulting in very powerful breaking waves, currents, scour and dangerous conditions. Summer conditions are generally characterized by relatively smaller, locally generated seas or wind waves associated with predominately northwesterly winds; however, longer wavelength swell from the southern hemisphere also is persistent during this season.

The nearshore wave climate has been quantified via modeling by the Coastal Data Information Program (CDIP). This modeling was accomplished along the California coast for the Federal

Emergency Management Agency (FEMA) in order to inform coastal flood studies, and the data are now available to the public.

During large swell events, the wave energy reaching the shoreline are limited by the offshore water depths that force the waves to break. The resultant wave height depends on static and dynamic water levels, which control water depths in the surf zone. Greater water depths allow larger waves to reach the shoreline with more energy. Therefore, larger waves impinging on the shoreline with greater wave energy is anticipated with any SLR projection.

3.2.2 Nearshore Beach Profiles

Nearshore profiles were developed at four locations along the project reach for purposes of evaluating wave runup and overtopping. The profile shape and elevations were developed using NOAA bathymetry data for the offshore, ESA estimations for profile shape through the surf zone, and GHD Lidar topography for the backshore. NOAA Bathymetry data was not useful through the surf zone as it was simply interpreted as a straight line between elevation data on land and bathymetry data offshore. The estimated surf zone profile has a “S-shaped” profile defined by a shallower “bar” offshore and an ephemeral (seasonal) trough nearshore. An example of the composite data used to generate profile 1, located north of the Pier at Paloma Avenue, is provided in Figure 3-1.

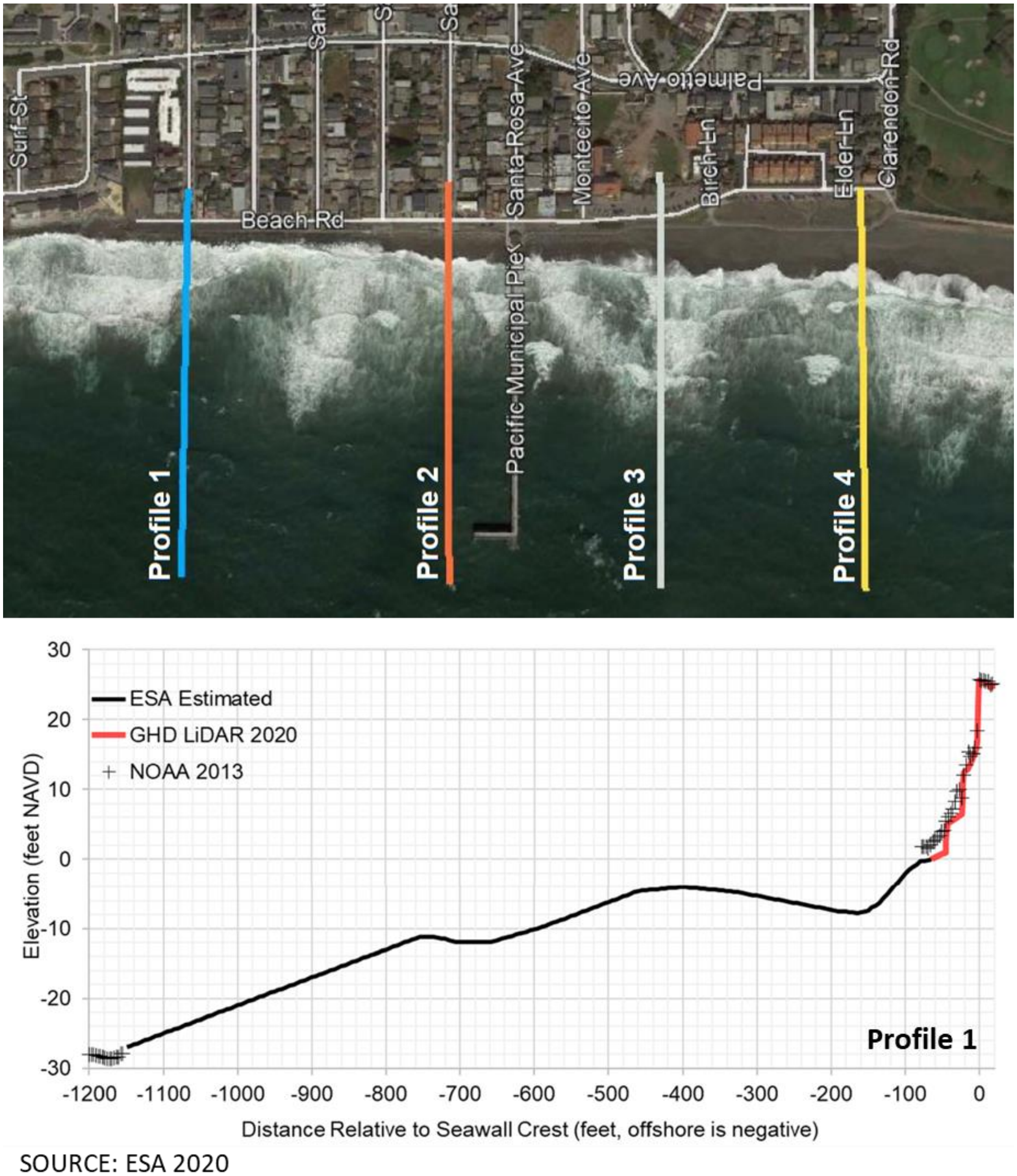
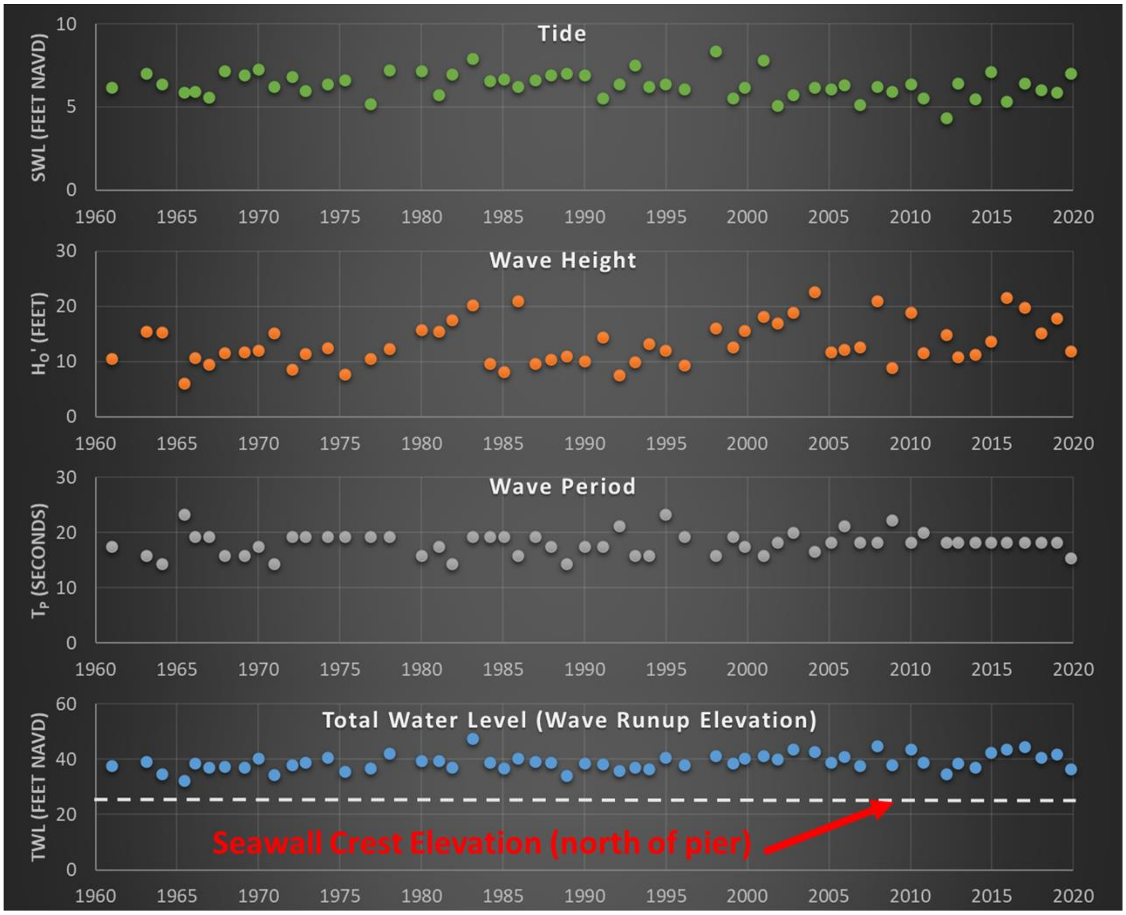


Figure 3-1 Location of Nearshore Profiles, Elevation of Profile 2 (ESA, 2020)

3.2.3 Wave Runup

Wave runup was evaluated to determine both the maximum runup elevation, referred to as total water level (TWL), and the approximate landward extent of this wave runup. TWL provides an indication of how much wave energy will be directed up and over the backshore. In this case, the existing seawall forms the backshore along the project reach. TWL higher than the seawall crest elevation will result in overtopping. The landward extent of the wave overtopping hazard zone provides an approximation of the coastal floodplain, consist with FEMA guidelines.



SOURCE: ESA 2020, FEMA 2020, Scripps 2020.

Figure 3-2 Annual Maximum Total Water Levels (ESA, 2020)

The seawall crest elevation immediately north of the Pier is shown as a dashed line along the bottom plot of Figure 3-2 to provide context. The existing seawall crest elevations vary from ~25.5 feet to ~31.5 feet (NAVD88) along the north wall. South of the Pier, the seawall crest elevation varies from ~25.5 feet near the Pier to ~23 feet (NAVD88) near Clarendon Road.

Results indicate all the annual maximum events have TWLs higher than the seawall crest, indicating wave runup exceeds the crest, which results in frequent wave overtopping and flooding of Beach Boulevard, consistent with observations. Note also that the maximum TWL elevations do not necessarily coincide with the maxima of any of the other parameters (tide and wave conditions). In other words, maximum runup elevations and flooding events do not necessarily occur during periods of peak high tides or waves. Combinations of lesser waves and tides can result in these extreme TWL events.

Recent structural damages in 2016 and 2020 occurred following a series of large overtopping events, each of which was not that extreme in terms of wave height or water level, but the combination of events resulted in significant seawall damage. Hence, there is an indication that a series of events, such as experienced during an extreme winter, is a better indicator of risk than a single swell or storm event.

The series of storms during the 2015-2016 winter were evaluated to compare calculated TWL to video and photos of significant runup and overtopping during the December 2015 and January 2016 events. The computed TWL elevations approach 40 feet, which is more than 10 feet above the nominal seawall crest elevation. Based on the observations of water exceeding 40 feet (Figure 3-3), the calculations may under-estimate the maximum TWL elevations. This is likely because the empirical equations used to estimate TWL are based on a simplified relationship between waves, beach profile geometry and runup. The formulas are intended to estimate runup that will only be exceeded by 2% of waves. Observed TWL higher than calculated values could be an indication the observed wave was among the largest 2% of waves in a given storm event, or that the simplified formulas don't capture the effects of unique seawall geometry and dynamic wave conditions.

Figure 3-3 Wave runup during January 22, 2016 event (ESA 2020)

An extreme value analysis of annual maximum TWL was performed to estimate the vertical extent of wave runup at each profile. The results, shown in Figure 3-4, indicate TWL is higher along the north seawall and could reach elevations of 40 feet (NAVD88) or more during a 10-year return period event, roughly 10-15 feet higher than the seawall crest. Along the south seawall, a 10-year return period event would result in TWL elevations of 30 feet (NAVD88), roughly 4-7 feet higher than the south seawall crest.

TWLs were computed for a sea-level rise of two feet above existing conditions, consistent with the policies for shoreline protection structures identified in the Local Coastal Land Use Plan (LCLUP) Certification Draft dated February 2020. A 2-foot SLR scenario represents the upper end of the likely range of projections in 2070 and an extremely low probability projection in 2050. Rather than rerun the Composite Slope program, the increase in TWL with sea-level rise was computed by proration. The proration methodology increases the TWL by a multiplication factor called the

Morphology Factor, ranging from 1 to 5 (ESA, 2016). The results indicate 2 feet of SLR will increase TWL elevations by 8-10 feet during extreme events.

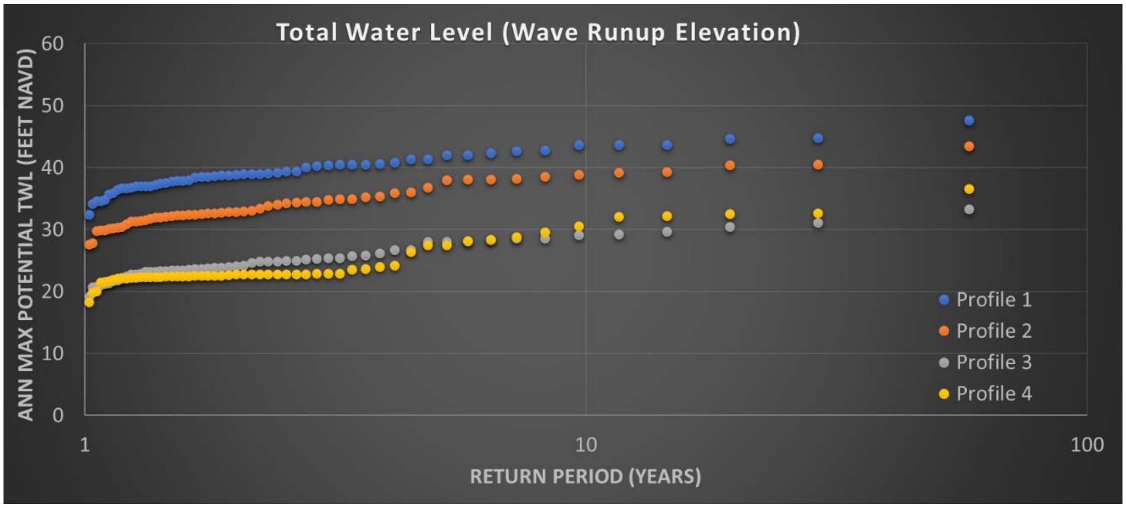


Figure 3-4 Extreme Value Analysis of Total Water Level (ESA, 2020)

3.2.4 Landward Extent of Wave Runup

The landward extent of wave runup overtopping was computed and plotted as an indication of the zone of potential property damages. This limit represents the landward extent of the FEMA "V-Zone," a special flood hazard zone that includes velocity and wave hazards, and which would require more stringent building requirements. This analysis represents an extension of the wave runup calculations summarized above and provides the approximate limits of wave hazards under existing conditions and a 2-foot SLR scenario. These water surface profiles were computed using the formulation of the Cox-Machemehl equation as presented in FEMA (2005).

The results are presented in Figure 3-5 for existing and future (with SLR) conditions for the four profiles. Note that the computed distances are potential hazard zones and more closely represent the extents along roadways where walls, structures and higher terrain obstructs water flow along the ground. The overtopping bore[3], which results from wave runup higher than the seawall, could extend up to 200 feet beyond the north seawall (Profiles 1 and 2) and about 75 beyond the south seawall (Profiles 3 and 4). Under a 2-foot SLR scenario this hazard zone would extend about 50 feet further landward north of the Pier and about 75 feet further landward south of the Pier.

[3] Overtopping bore refers to the waveform landward of the seawall which is typically a pulse of water that decreases in depth as it travels landward.

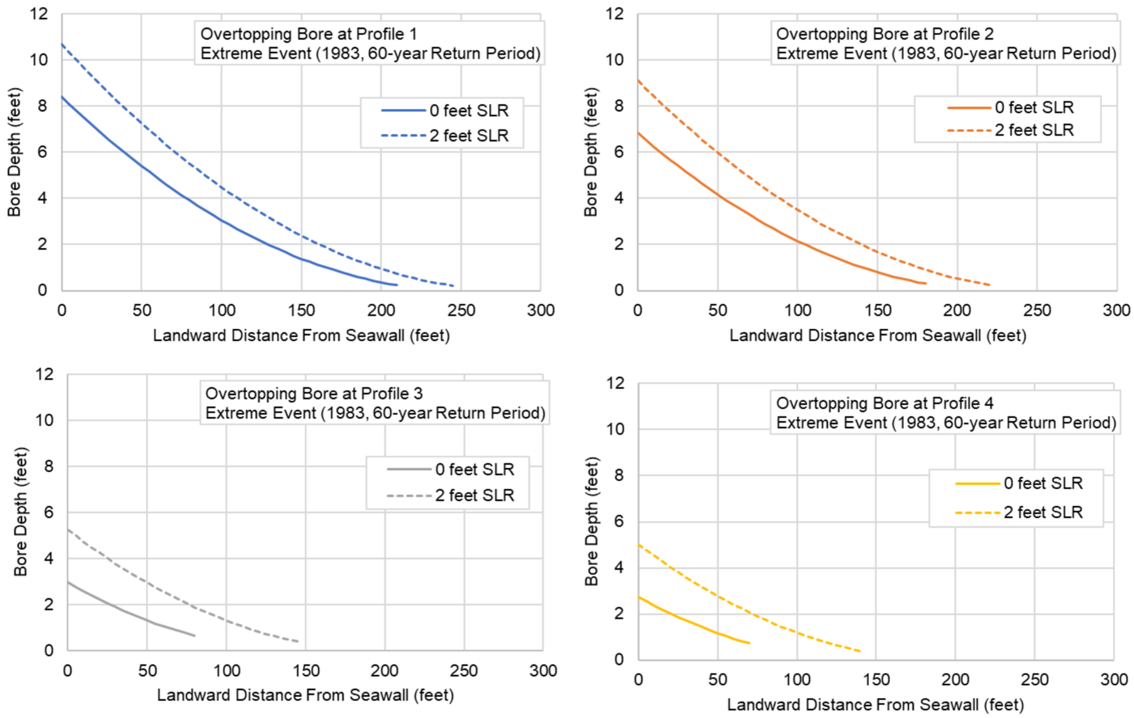


Figure 3-5 Landward Extent of Wave Hazard Zone (ESA, 2020)

3.2.5 Wave Overtopping

The wave overtopping discharge as a function of seawall crest height was computed following the EurOtop 2018 methods (EurOtop 2018). Primarily developed for analysis of coastal defense systems, the EurOtop methods are tailored for the design and assessment of coastal structures. The document provides useful procedures for determining design overtopping rates that account for method uncertainty and incorporate appropriate factors of safety.

EurOtop procedures were used to evaluate the three main types of existing shoreline geometries present along the study area. These geometries included: a composite vertical wall with fronting rock mound (found along the northern portion of the site), a simple vertical wall (present abutting the pier), and a vertical wall at the top of a smooth dike (in the southern portion of the site - sandy beach was assumed similar to a smooth dike).

For each geometry, seawall overtopping was assessed for a range of water levels and wave conditions associated with the 2-year, 10-year, and 60-year TWL events. Overtopping rates were calculated for a range of crest elevations to illustrate the influence of crest height on overtopping rate reduction. All cases were analyzed for zero through seven feet of sea-level rise as shown in Figure 3-6.

The overtopping rates are provided as time-averaged rates of flow (defined as cubic feet per second, or cfs) per linear foot (lf) of seawall. Each subplot contains three colored lines which correspond to the different TWL events. Under current conditions, the seawall north of the pier (crest at 25.5 ft NAVD88) will experience between 0.5 and 0.8 cfs/lf of mean overtopping discharge during large storm events. The mean overtopping discharge for a 2-year storm is near zero. However, the mean discharge is time averaged over the duration of the storm, and thus is much smaller than the instantaneous discharge observed when any particular wave breaks and overtops the wall. Increased wall elevations reduce the overtopping rate non-linearly. Increasing sea levels substantially increase the amount of overtopping for all storm events. At high sea-level rise amounts (7-foot SLR scenario) and low wall crest elevations (<26 feet NAVD88), major storms may experience direct overflow of the seawall.

The overtopping rates for the plain vertical wall are larger than those calculated for the vertical wall with a fronting mound. This is because the mound acts to dissipate some wave energy before impact with the vertical portion of the wall. Note that the wall at the pier abutment is at an angle to the incident waves, and hence runup is reduced at the abutment and deflected inland toward the north and south walls.

Overtopping along the Pacifica Seawall already occurs all along the project site on an annual basis, resulting in street closures and frequent damages. In order to provide a reference point for overtopping rates presented in Figure 3-6 ESA compared observed overtopping events at known dates and locations to the EurOtop rates calculated for the same wave and water level conditions.

Figure 3-7 presents screenshots from a YouTube video taken January 7, 2016[4]. Visual inspection of these images indicate that this storm had a maximum individual wave overtopping volume of 50 to 100 cubic feet. EurOtop reports that mean rates of overtopping discharge are typically between 100 and 1,000 times smaller than maximum overtopping volumes. Thus, the mean discharge of the January 2016 event was likely between 0.05 and 1.0 cfs/lf over the duration of the event. Note that the instantaneous overtopping (as exemplified by the images below) are much larger than the mean overtopping rate.

Calculations following the EurOtop method yield a mean discharge of 0.45 cfs/ft for an event on December 11th, 2015, which was similar to the January 2016 event shown in the YouTube video and other events from January 2016. The calculated value of 0.45 cfs/lf falls within the event’s observed estimated mean overtopping rate of 0.05 to 1.0 cfs/lf. Therefore, the EurOtop procedures described in this section appear to reasonably represent observed overtopping conditions. This means that our computed overtopping rate is also indicative of potential structural damage according to EurOtop damage thresholds and is consistent with reports of damage to nearby properties and structural damage to the seawall.

[4] Overtopping screenshots from online video: https://www.youtube.com/watch?v=7lg-SliupQ4v

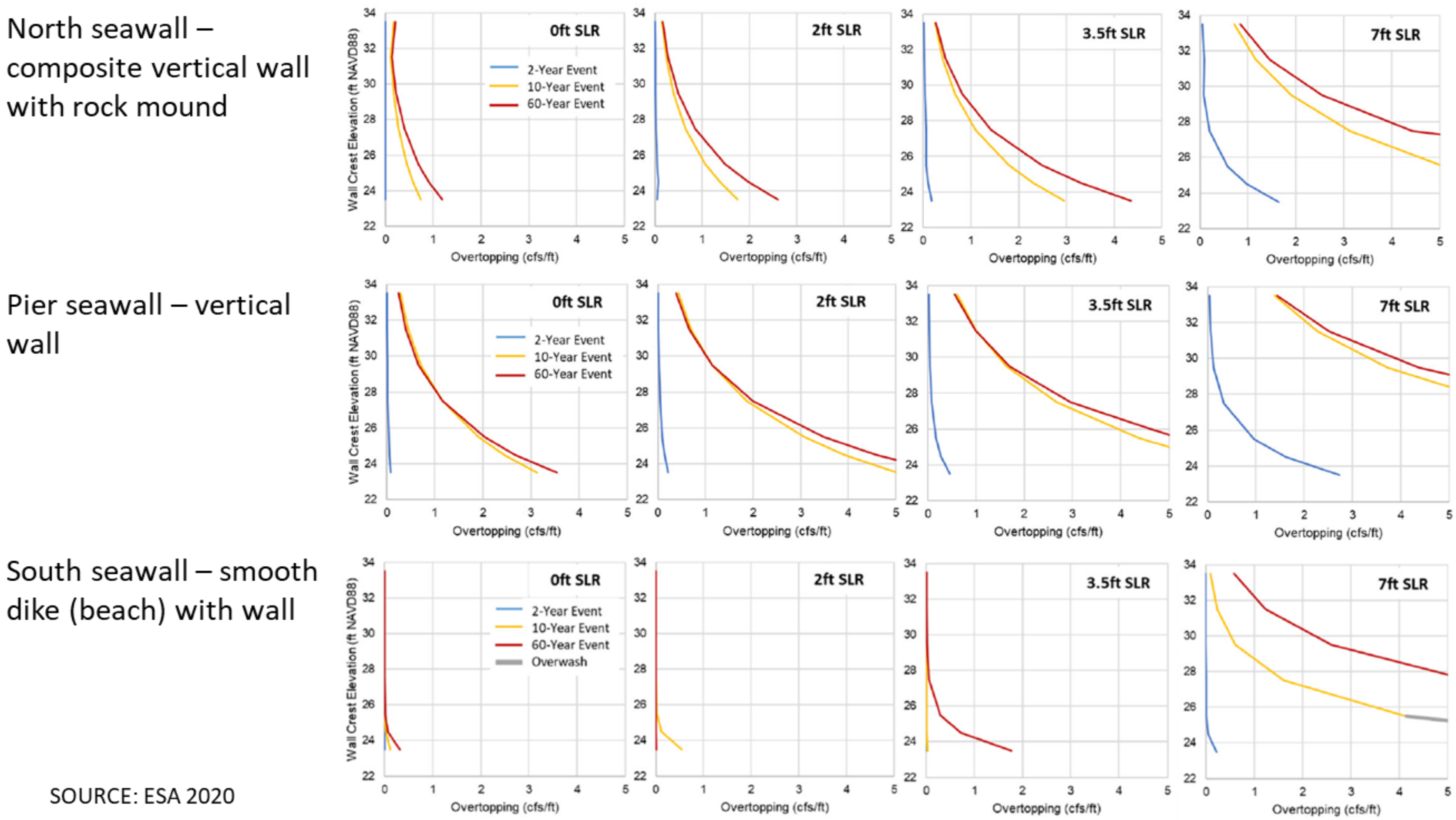


Figure 3-6 Mean Overtopping Rates along Beach Boulevard (ESA, 2020)

Figure 3-7 Individual Wave Overtopping, January 7, 2016

3.3 Coastal Erosion Hazards

This section provides a summary of the historic coastal erosion hazards and the performance of shoreline protection infrastructure in the project vicinity. Sea level rise is expected to accelerate these historic erosion trends. Future coastal erosion hazards are described in this section based on data published by the United State Geological Survey (USGS) as part of their Coastal Storm Modeling System (CoSMoS) program. These potential erosion hazards are consistent with prior studies (i.e. Sea Level Rise Vulnerability Assessment and Adaptation Plan – ESA 2018), except that the CoSMoS data allows for consideration of erosion hazards for a wider variety of SLR projections.

3.3.1 Historic Erosion Hazards

The geologic setting and littoral processes responsible for historic erosion trends and events are described in detail in the report titled "*Geological Evaluation for the Beach Boulevard Seawall Replacement Project, Pacifica, California*" prepared by Gary Griggs (2020) and summarized in the Existing Conditions Report (GHD, 2020). A few key findings related to local geology and coastal processes are described below.

- The northern Pacifica shoreline consists of a narrow sandy beach backed by vertical bluffs eroded into loosely consolidated sands and gravels.
- The bluffs decrease in elevation from 160 ft near Mussel Rock to 25 feet along Beach Boulevard, north of the Pier. South of the Pier, the backshore transitions to low lying topography adjacent to the Sharp Park Golf Course and Laguna Salada.
- Where beaches are narrow or non-existent, wave attack dominates, leading to undercutting and ongoing bluff collapse, and typically steep to near vertical bluffs.
- A long-term trend of erosion estimated to range from 0.7-2.2 ft/year (Griggs, 2020) resulted in a persistent erosion hazard that threatened development along Beach Boulevard and prompted the construction of the existing seawalls along the project reach in the 1980s.
- Most damage to the Beach Boulevard seawalls and upland development have occurred during strong El Niño Southern Oscillation (ENSO) events. Permit documents for existing seawall construction projects described episodic erosion of 40-50 ft of bluffs and dunes during the winter storms of 1983 (CDP 3-83-172A3).

Since construction of the seawalls in the 1980s, erosion hazards remain a concern, especially during periods of coincident high-water level and wave events. The north segment of wall is subject to significant overtopping during these events in addition to wave impact forces acting on the face of the wall. Documented seawall failures in 2002, 2016 and 2020 seem to be a direct result of these events. In each event, a segment of concrete tiles failed resulting in additional erosion and undermining of the Promenade. Photos of these locations indicate backfill material was not adequately retained behind the concrete tile wall and failure resulted after the formation of a void behind the wall. The void was likely caused by loss of backfill material either through the face of the wall, or under the footing of the wall during these events.

All the wall failures described above have occurred north of the Pier. As evident from Figure 3-8, the shoreline has retreated to a point where there is little or no dry sand beach along the northern segment of Beach Boulevard Seawall. Mori Point forms a natural barrier to southerly littoral sand transport (Griggs, 2020) and results in a wider and more stable beach area fronting the Sharp Park Golf Course, Laguna Salada, and the south segment of the Beach Boulevard Seawall (Figure 3-8).

The figure also illustrates how the orientation of the shoreline and Beach Boulevard are out of alignment. Beach Boulevard is oriented close to true north, whereas the shoreline orientation is east of north. Due to this misalignment and long-term erosion trend, the northern segment of seawall extends beyond the shoreline and is exposed to greater wave energy. The southern segment of seawall benefits from this misalignment because its fronted by a wider sandy beach that provides a natural buffer against seasonal erosion and storm waves.

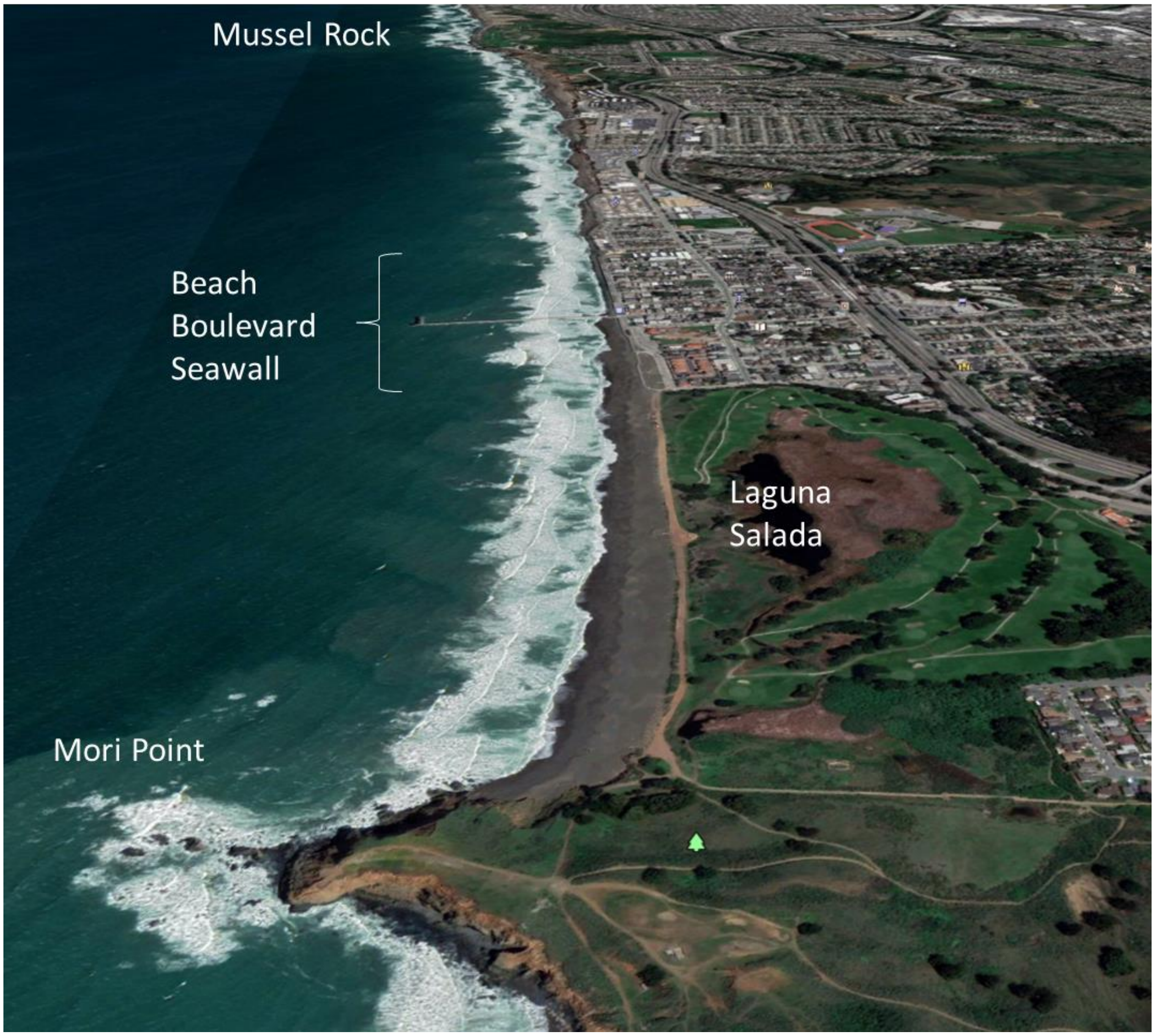


Figure 3-8 Shoreline Orientation from Mussel Rock to Mori Point

3.3.2 Future Erosion Hazards

The effects of SLR on coastal erosion hazards were evaluated using results of the Coastal Storm Modeling System (CoSMoS) Version 3.1, a multi-agency effort led by the United States Geological Survey (USGS) to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for California. CoSMoS modeling results provide predictions of shoreline erosion, bluff erosion, and coastal flooding under both average conditions and extreme events. For purposes of the MHRA, the predictions for bluff erosion are most relevant for the project reach. CoSMoS results for coastal flooding and shoreline erosion do not adequately resolve the site-specific features like the existing revetment and seawall structures.

The CoSMoS bluff erosion model is based on historic retreat rates with a suite of models applied to estimate the effect of SLR and wave impacts on future bluff erosion hazards. The hazard data available is available in 0.8 feet (25 cm) increments from 0 to 6.6 feet (200 cm) and an extreme scenario of 16.4 feet (500 cm). Since the CoSMoS results are only available in discrete increments the data used to estimate coastal hazards may not precisely correlate with the SLR projections and time horizons listed in Table 3-1. However, the differences between the nearest CoSMoS data increment and the SLR projections are insignificant when considering the uncertainties in predicting SLR and coastal hazards over the long-term.

CoSMoS bluff erosion projections are available for two management scenarios. One scenario, referred to as a “Hold-the-Line” scenario, assumes the existing bluff is maintained in its current position with coastal structures. The “No Hold-the-Line” scenario assumes no such armoring is in place and allows shoreline erosion projections to propagate inland based solely on physical processes of wave induced erosion. The No Hold-the-Line scenario is used in the MHRA to document the worst-case potential SLR hazards, assuming the existing structures are removed, consistent with assumptions for the “No Action” scenario. Along most of project reach the shoreline position would be constrained by the bluff position under a “No Action” scenario. In other words, long-term bluff erosion rates will be the controlling factor for long-term shoreline erosion. Given that beaches are narrow or non-existent along most of the project reach bluff erosion is used as a proxy for future coastal hazards.

The future coastal erosion hazards for a range of SLR values are depicted in Figure 3-9. The time horizons listed in the figure are approximate and based on the “medium-high risk aversion” projections which have a 0.5% probability of occurrence. The predicted shoreline positions for each time horizon are shown with solid lines. The erosion hazard zones extend 50 feet landward of the shoreline position to reflect uncertainties around these projections and the stochastic nature of bluff erosion in which tens of feet of erosion could occur during a severe winter season (i.e. 1983 El Niño season). For reference and comparison purposes, the 2100 erosion hazard zone from the Draft Sea Level Rise Vulnerability Assessment for Pacifica LCP Update (ESA, 2018a) is also shown in the background.

These future erosion hazard zones represent a worst-case scenario in which no adaptation strategies are developed and implemented in response to increasing coastal hazards associated with SLR. The Project team recognizes this is not a preferred or realistic strategy, but the impacts associated with these hazards are evaluated in the MHRA to illustrate the potential consequences of a “No Action” scenario. The consequences of a “No Action” scenario will provide a useful point of comparison against the project alternatives developed to mitigate these hazards and illustrate the potential damage costs avoided through implementation of the alternatives.

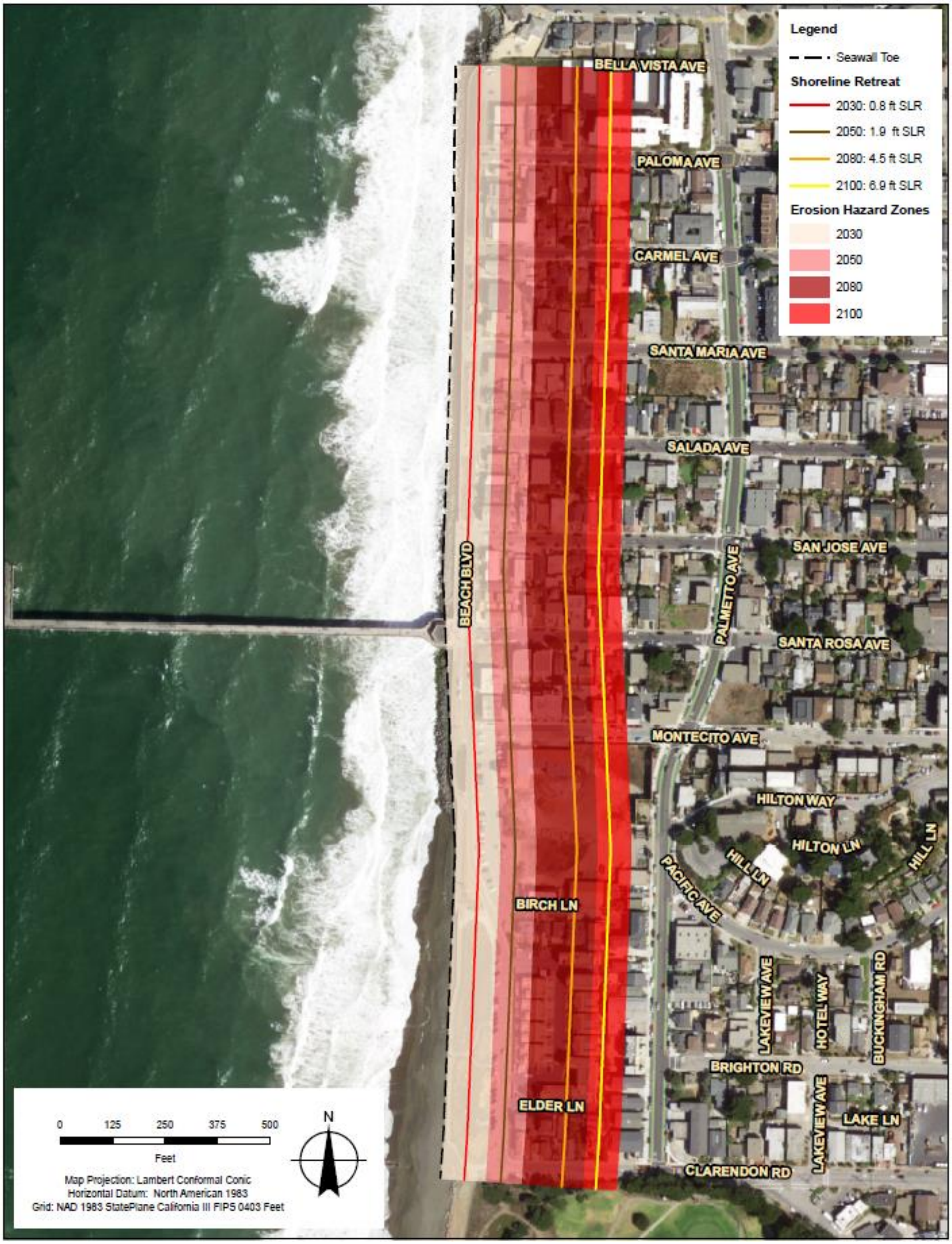


Figure 3-9 CoSMoS erosion hazards, "No Action" scenario

3.3.3 Scour Potential for Shoreline Protection Structures

The Feasibility Level Geotechnical Evaluation (HKA, 2020) included an assessment of potential scour in front of a seawall along Beach Boulevard with considerations for long-term shoreline erosion hazards. As described in previous sections the potential for scour of the beach deposits (i.e., beach sand) is very high and occurs seasonally. The beach platform (hardpan) below the seasonally scoured beach sand is comprised of alluvial deposits.

HKA developed four geotechnical transects along the project reach using existing geotechnical related data for the project site, additional geotechnical boring data, and probe data from field exploration in July 2020. The geotechnical transects indicate the elevation of the hardpan beach platform at the toe of the (North Wall) revetment was approximately at elevation 0 ft NAVD88 during construction in 1985. The hardpan beach platform at the toe of the revetment along the south wall is about elevation +2.6 ft NAVD88.

While the hardpan is more resistant to erosion than beach sand, the seasonal exposure of the hardpan along the North Wall does result in scouring (lowering) of the hardpan elevations over time. HKA estimated potential future scour depths at the existing seawall alignment based on long-term shoreline retreat rates and an assumed gradient of the hardpan. The estimated scour elevations for the 2070 time horizon are -3 feet (NAVD88) for the south wall and -5.5 feet (NAVD88) along the north wall. The scour estimates are suitable for SLR projections up to the medium-high risk aversion scenario.

3.4 Earthquake Hazards

An earthquake hazard risk assessment was completed by Haro, Kasunich and Associates (HKA) specifically for the Project in December 2020. Key information from HKA's earthquake risk assessment is presented in this section.

3.4.1 Geotechnical Subsurface Conditions

The Project site including the seawall footprint and Beach Boulevard is located upon a coastal terrace comprised of young and older alluvial deposits, greenstone volcanic rock, and greywacke sandstone. Based on historic and recent test boring data the project site is underlain by alluvial deposits with interbedded layers of beach sand to a depth of approximately 60 to 102 feet below Beach Boulevard (HKA, 2020b). These subsurface soils were predominately granular in nature with some clay and/or silt binders. Loose to medium dense coarse grain soil or firm to very stiff fine grain soil was encountered within the upper 9 to 37 feet below ground surface (bgs) (+17.9 to -9.2 feet NAVD88) to the north of the pier and 10 to 28 feet bgs (+16.0 to -3.6 feet NAVD 88) south of the pier. The material below these depths generally became dense or hard with an occasional lower density layer.

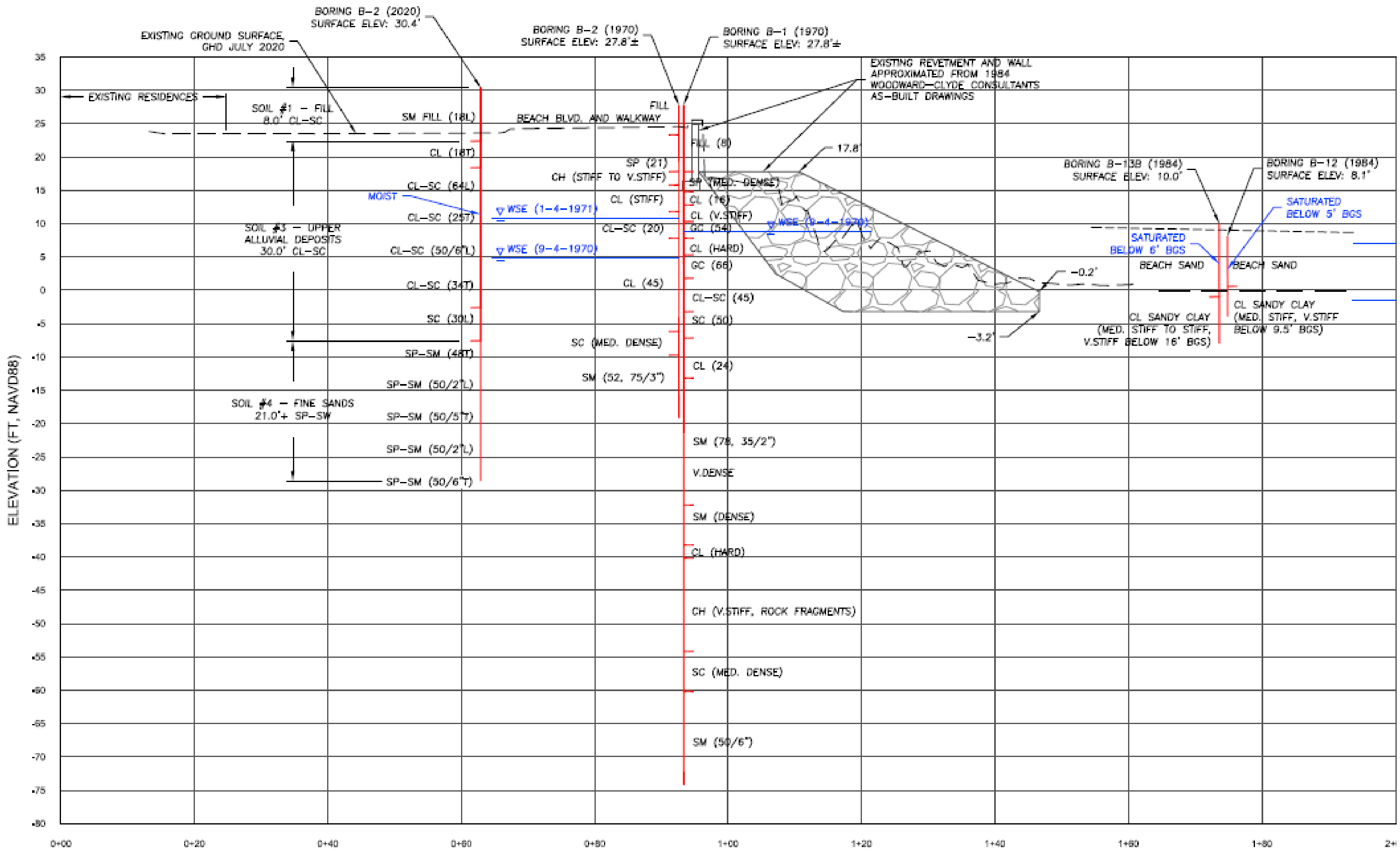


Figure 3-10 Geotechnical Transect #2, at San Jose Ave (HKA, 2020a)

3.4.2 Regional Faults

The Project site is situated between two active faults as illustrated in Figure 3-11. The San Andreas Fault located 1.6 miles to the northeast and the less active San Gregorio-Hosgri Fault located 2.0 miles due west. The Hayward fault is another active fault located 22 miles due east. The Working Group on California Earthquake Probabilities has estimated the probability of a magnitude 6.7 or larger earthquake on each of these faults between 2014 and 2043. Of the three active faults the Hayward Fault has the highest probability at 33 percent. The San Gregorio-Hosgri and San Andreas, nearest the Project, have respective probabilities of 6 percent and 22 percent. The presence of active faults nearby the project site make it susceptible to strong seismic shaking over the design life of the project.

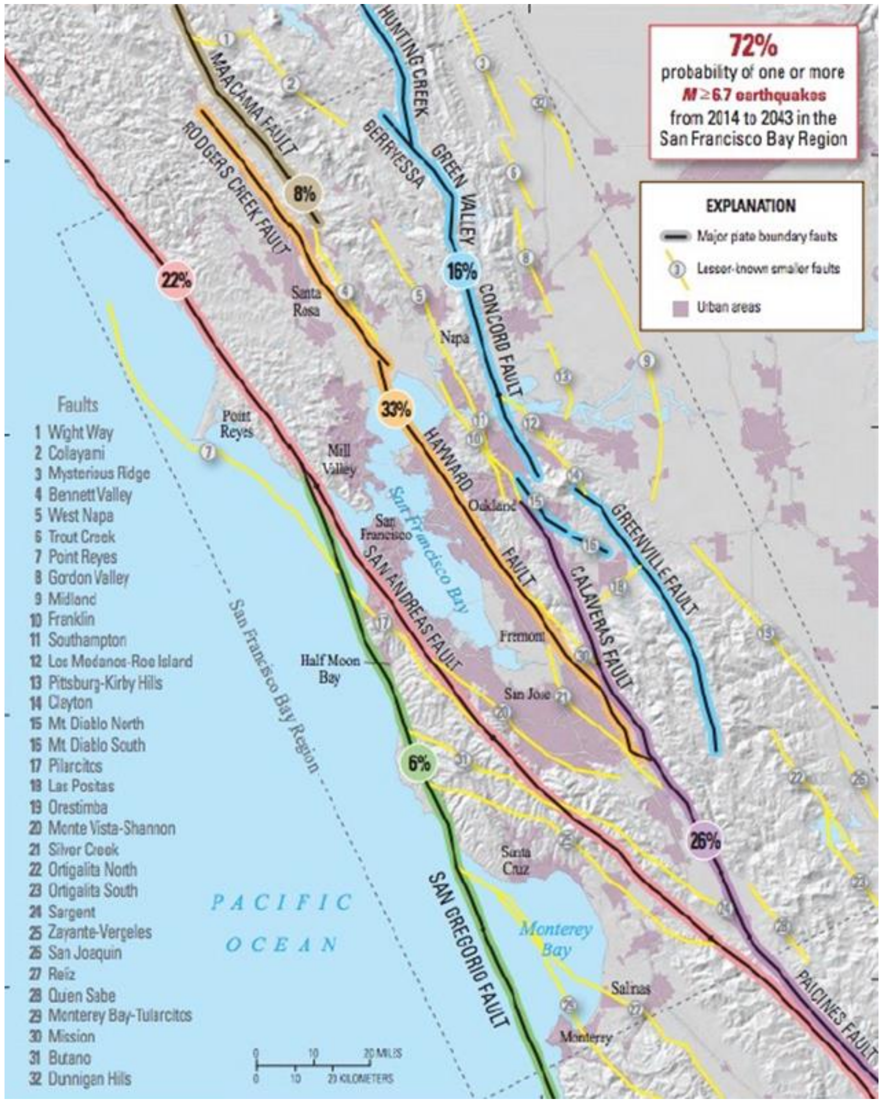


Figure 3-11 Earthquake Probabilities on Individual Faults (San Francisco Bay Region 2014-2043)

3.4.3 Shaking and Surface Rupture

The Project site is located within the influence of active faults that have generated strong ground shaking during earthquakes that occurred in the years 1906, 1957, and 1989. Ground shaking from one or more of these active faults should be expected during the design life of the project and presents a hazard to life, property, and infrastructure in Pacifica. The severity of the ground shaking will depend on the distance to the earthquake epicenter and the subsurface soil conditions at the project site. Given the proximity to active faults and the young alluvial soils encountered below Beach Boulevard severe shaking is likely to occur.

Although not reported in Sharp Park during the past earthquake events, ground rupture at the surface may occur during severe ground shaking. This phenomenon is when the ground cracks at the surface, sometimes several feet as seen in Hollister during the 1989 Loma Prieta earthquake. Reports of ground cracking occurred on Highway One near Pacifica during the 1906 earthquake.

Modern building codes require that seismic loading and lateral forces be developed and implemented in the design of new improvements that pose a life safety risk to the public. The ground shaking is measured as a function of gravity. Project design criteria will need to include seismic parameters, allowing for peak ground acceleration (PGA) of 1.5g based on direct readings (Griggs 2020, as cited in HKA, 2020b). The California Building Code has mapped peak ground accelerations based on a deterministic method for this site to be 1.1g.

3.4.4 Soil Liquefaction

Liquefaction of soils is a phenomenon occurring during earthquake induced ground shaking of predominately granular soil underneath the groundwater table and have low to medium density. The cyclic shaking motion causes water within the soil pores to build up pressure temporarily separating the particles causing the strength of the soil to be zero and the soil liquefies. Ground effects such as settlement, bearing failure, and sand boils have been documented from liquefaction events occurring within the upper 50 to 60 feet of soil below the ground surface.

The interbedded young alluvial soils and beach sand that were encountered during subsurface exploration phases are vulnerable to liquefaction. These soils were loose to dense in the upper 30 to 35 feet and became dense to very dense with depth. The groundwater was encountered at elevations -5.6 to +10.8 feet NAVD88 on the north side of the pier and -5.0 to +14 feet NAVD88 on the south side of the pier. On both the north and south sides the groundwater was encountered within the elevations the low to high tides occur. The low to medium density soils below the groundwater are subject to potential liquefaction during strong seismic shaking. A quantitative liquefaction analysis would need to be performed to determine the actual liquefaction potential and estimated ground settlement. Figure 3-12 is a map of liquefaction susceptibility of San Mateo County (Youd and Jeanne, 1987), which has Beach Boulevard in Sharp Park mapped as "Low to High" defined as "Generally low to moderate, locally high near active and abandoned streams". Historic photos show what appears to be a possible drainage course in the area of the Laguna Salada Golf Course so there could be a higher potential for liquefaction in the soils adjacent to this area.

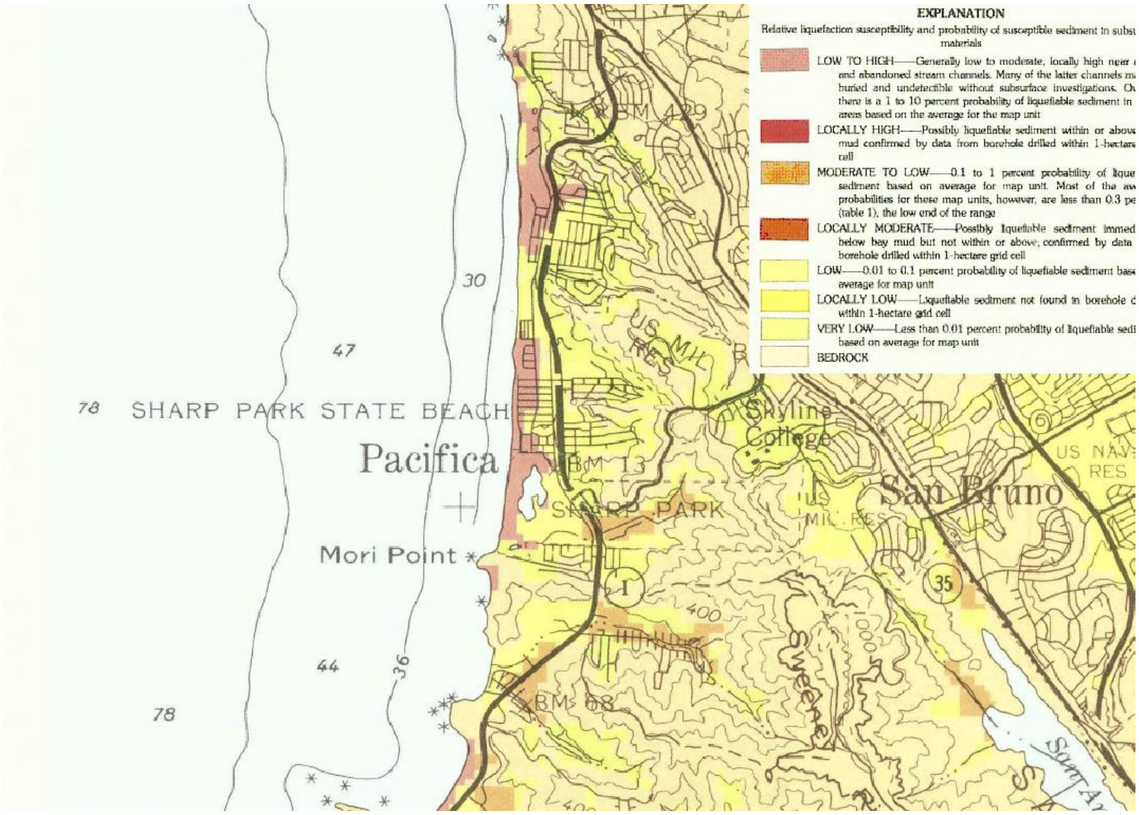


Figure 3-12 Liquefaction Susceptibility of San Mateo County, California

Since the groundwater coincided with the tidal waters there is potential for the groundwater to rise to a shallower depth as sea level continues to rise in the future. Sea level rise projections are discussed in Section 3.1 of this report. A fluctuation within the groundwater depth of +/- 5 vertical feet will have some but not significant impact on the liquefaction potential and related ground effects at the project site.

Replacement structure foundations should extend below liquefiable layers. The liquefiable layer(s) are located above the hardpan which varies in elevation along the project reach and under future conditions as described in Section 3.3.3. As a result, a new structure foundation will likely be embedded well below the potentially liquefiable soils, this should be confirmed during the design phase of the Project. Utilities within Beach Boulevard will be vulnerable to damages if a liquefaction event occurs in the future.

3.4.5 Coastal Bluff Slope Failure

Slope failures are commonly called landslides. They occur when the driving forces on the slope (i.e. water, gravity, seismic shaking, and surcharge) exceed the internal shear strength (resisting forces) of the soils on the slope. Once the resisting forces are overwhelmed the soil on the slope mobilizes in the form of a fluid debris flow. Rockslides and translational failures are also common along coastal bluffs. Slope failure is also a function of slope gradient and height of bluff. The steeper and taller the bluff the more susceptible it is to landslides.

The most common cause of bluff slope failures is rain events. Seismic shaking can also initiate bluff slope failures to occur. Coastal bluffs subject to wave attack at their base can experience landslides as the toe of the bluff is scoured away leaving behind overhangs that slump down onto the beach.

The bluffs along Beach Boulevard are much lower in height on the order of 20 to 30 feet tall relative to the ~80-100 feet tall bluffs to the north (e.g. along Esplanade Avenue and Palmetto Avenue). The lower height makes the bluffs at Beach Boulevard less susceptible to landsliding and mostly vulnerable to direct wave attack.

The presence of the seawall armoring the bluff along Beach Boulevard make the potential nil for seismic slope failures to occur. If coastal armoring is not present, there is potential for seismic bluff failure. However, potential for bluff failure due to coastal erosion hazards at the Project site is significantly higher than for earthquake hazards.

4. Public Safety

Opportunities for coastal access and recreation in the Project area are important resources for residents and visitors, as described in the Local Coastal Land Use Plan (LCLUP) Certification Draft (February 2020) and confirmed with online survey responses collected from the public to inform development of the Project. The key findings from the survey responses are summarized by Kearns & West (2020) below:

- Protection and safety of people, homes and businesses was the most commonly expressed concern.
- Respondents are active and social people. They enjoy spending their time along Beach Boulevard recreating, visiting with friends, taking in the ocean and wildlife, shopping, and participating in their local government.
- Respondents enjoy visiting Beach Boulevard all throughout the year and can typically find places to park and can access the activities they enjoy

The Beach Boulevard Promenade provides connectivity to resources such as the Municipal Pier, Pacifica Beach Park and Sharp Park Beach and a network of trails at Mori Point. Access stairways built into the existing seawall provide vertical beach access at two locations, San Jose Avenue and Birch Lane. Due to the narrow or non-existent beach area north of the Pier, most beach access occurs at the Birch Lane stairway and at Clarendon Avenue where a gap exists between the south seawall and Sharp Park Golf Course embankment.

4.1 Pedestrian Safety

Under existing conditions, coastal flooding is a primary hazard of concern for pedestrian access along the Beach Boulevard Promenade. During winter months, high tides combined with even moderate wave heights result in waves overtopping the seawall. In severe events (e.g. winter of 2015/2016 and December 2020) the overtopping from individual waves can be violent with the potential to knock a pedestrian off their feet in addition to launching small rocks or other debris over the seawall.

Physical model testing, described in the EurOtop Manual (2018), showed that a person was repeatedly swept off the crest of a dike for mean overtopping discharge of 0.1-0.2 cfs/lf (10-20 liters/second per meter or l/s/m). Based on this testing and other observations, the recommended tolerable overtopping discharge is in the 0.01-0.2 cfs/lf (1-20 l/s/m) range, depending on the wave heights breaking on or near the structure. For reference, the mean overtopping discharge observed during the January 2016 events was estimated to be in the 0.1-1 cfs/lf (10-100 l/s/m) range. Despite the hazards associated with wave overtopping, these type of events do attract pedestrians interested in observing the violent wave action and overtopping as shown in Figure 4-1.

Figure 4-1 January 2016 Wave Overtopping[5]

Alternatives developed for the BBIRP will consider a variety of methods for reducing the frequency and magnitude of wave overtopping to reduce the safety risk to pedestrians along the Promenade. Given the energetic wave environment and increasing hazards due to SLR it may not be practical or feasible to eliminate overtopping during extreme events. Other options for mitigating this safety risk include access restrictions during extreme events.

Coastal erosion also poses a hazard to pedestrian safety along the Promenade. Previous storm events have resulted in erosion behind the seawall causing partial failure of the eroded segment and undermining of the Promenade. The most recent example of this occurred in December 2020 at the base of the Pier in which wave energy propagated through a gap in the existing Pier wall and undermined a segment of Promenade between the Pier access point and Beach Boulevard (Figure 4-2). The City responded quickly to temporarily restrict access to the Pier, Promenade and Beach Boulevard to reduce the potential safety hazard to pedestrians and vehicles while emergency repairs are made.

In the event the existing seawall experienced widespread failure, or was removed in the future, coastal erosion would likely become the primary safety hazard to pedestrian access along Beach Boulevard. The geology of the coastal bluff offers very little resistance to wave attack and the active erosion processes would pose a hazard to pedestrians along the top of bluff and along the beach at the base of the bluff under this scenario.

[5] Photo is a screen capture from an online video: https://www.youtube.com/watch?v=7lg-SliupQ4 accessed December 2020

Figure 4-2 Undermining of Promenade at Pier Access (December 2020)

4.2 Vehicle Safety

Vehicles travelling along Beach Boulevard are exposed to similar hazards as pedestrians along the Promenade. Beach Boulevard provides storage and conveyance of flooding from wave overtopping and could pose a hazard to safe driving conditions during extreme events. As expected, vehicles have a higher tolerance for overtopping than pedestrians, in the range of 0.05-0.8 cfs/lf (5-75 l/s/m), depending on the wave heights breaking on or near the structure (EurOtop, 2018). The significant overtopping shown in Figure 4-1, provides an example of the hazardous driving conditions caused by wave action and flooding pose a risk to vehicles, their occupants, and adjacent pedestrians and property.

Erosion hazards and corresponding seawall failures in recent events have mostly impacted the Promenade. However, as the seawall approaches the end of its service life there is potential for erosion to undermine portions of Beach Boulevard in the event of a significant wall failure. Erosion hazards are a primary factor to consider when evaluating BBIRP alternatives, particularly for alternatives such as beach nourishment or sand retention which may not include an engineered shoreline protection structure.

5. Infrastructure

The following sections describe the resources and infrastructure at risk from damage due to coastal hazards and earthquakes in the absence of adaptation. Over the next 50 years SLR has the potential to significantly compound existing consequences from flooding and erosion. In the absence of adaptation measures developed to mitigate these hazards, a No Action scenario, the vulnerabilities are overwhelming. If the existing seawall and revetment were removed, the entire Beach Boulevard corridor could be lost to erosion within a decade.

Earthquake risks are present throughout the Project area and are not sensitive to sea-level rise. These risks are assumed to remain the same regardless of adaptation strategies and alternatives developed to mitigate other hazards.

Given the dynamic coastal environment along Pacifica, adaptation will not be easy or cheap, and there will be some difficult trade-offs to consider in balancing ecosystem benefits, public safety, property protection and coastal access. The purpose of this assessment is to document the potential consequences from a No Action scenario, in order to quantify the potential benefits (i.e. damage avoided) of each adaptation alternative. Adaptation, by definition, is not a singular action and will require ongoing monitoring and maintenance measures in addition to a significant capital investment. By comparing the costs and benefits of the No Action scenario to the adaptation alternatives, the City of Pacifica will be able to identify a path forward that is informed by a detailed risk assessment.

Section 5 describes the potential consequences and risk for a variety of key infrastructure assets within the Project area. Economic impacts associated with the infrastructure damage are described in Section 7.

5.1 Beach Boulevard Road & Promenade

The Beach Boulevard corridor, which refers to the roadway and adjacent promenade, supports a variety uses which provide benefits to the community. The Beach Boulevard corridor varies in width from north to south, measured from the edge of seawall to the landward edge of sidewalk (assumed public/private property line). Most of the northern reach (Paloma Avenue to San Jose Avenue) has a corridor width of approximately 45 ft. The corridor widens to about 50 ft in the vicinity of the Pier (between San Jose Avenue and Montecito Avenue). South of Montecito Avenue, Beach Boulevard curves landward to follow an alignment behind Pacifica Beach Park. The maximum width of the Beach Boulevard corridor at Pacifica Beach Park is approximately 150 ft.

Beach Boulevard supports one-way vehicular traffic moving from north to south. Annual average daily traffic (AADT) on Beach Boulevard is 1,300. The road is typically about 17 ft wide, measured from curb to curb, and provides vehicular access to over 100 housing units along Beach Boulevard including emergency service access. The corridor is frequently exposed to flooding and erosion hazards during severe coastal storm events (large waves and high water levels) as discussed in Sections 3.2 and 3.3. This exposure will increase significantly with sea level rise and will likely result in greater damage and disruption than currently experienced.

The Beach Boulevard corridor is sensitive to flooding from wave overtopping because pedestrian and vehicular access is inhibited temporarily (~2-3 hours during peak tides) during events with coincident high tides and large waves. The overtopping currently experienced during a 10-year return period storm event is assumed to be the impact threshold for tolerable flooding of Beach Boulevard and Promenade. The road and promenade damage from events in 2016, on the order of a 10-year return period, were localized to certain seawall segments resulting in temporary disruption and repairs costs on the order of $0.5M. SLR will increase both the damage and length of disruption from this type of event. Analysis of flood hazards (Section 3.2) indicates the overtopping rate for a 10-year event will double with 2 feet of SLR.

The corridor is highly sensitive to erosion damage because undermining of the pavement structure poses not only a safety risk, as described in Section 4, but also requires more extensive repairs after such an event. The duration of this repair work can last from several weeks to over a month in which access through the work area is restricted.

In the absence of a seawall, or other coastal protection structure, erosion hazards would become an immediate concern, especially north of the Pier. Erosion hazard projections in 2030 for a “No Action” scenario (Figure 3-9) indicate the entire Beach Boulevard corridor would be lost to erosion along with the variety of vehicular and pedestrian access uses supported by the corridor. Given the erosion projections increase significantly with SLR we assume there would be no public access path along the bluff under a No Action scenario. For purposes of estimating infrastructure costs associated with the No Action erosion scenarios we assume street ends which run perpendicular to Beach Boulevard would be re-configured into cul-de-sacs and marked with appropriate signage and barriers. In situations where cul-de-sacs are not feasible it’s assumed some other type of turnaround would be constructed for emergency vehicle access. To maintain coastal access, new beach stairs would be provided at each street end. These features would be removed and relocated as necessary in response to the erosion hazards.

5.2 Utilities

A number of existing utilities are located within the Beach Boulevard Corridor and protected by the existing seawall. One of the primary objectives of the original seawall was in fact to protect utilities, namely the large sewer main that runs parallel to the wall beneath the road pavement.

GHD contacted utility owners and operators known to have utility infrastructure in the West Sharp Park area. All organizations contacted responded either with utility maps showing approximate utility locations or informed GHD none of their utilities existed within the project boundary. Actual locations of manholes and utility accesses at ground surface level along Beach Boulevard were captured as part of GHD’s topographic survey. Utilities that have been located within the project boundary and general vicinity are listed in Table 5-1 with locations shown in Figure 5-1.

Existing utilities within the study area are exposed to all hazards described in Section 3. Coastal flooding extends across and beyond Beach Boulevard under existing conditions. With 2 feet of SLR the amount of flooding will significantly increase. The sensitivity to flooding varies for each utility. Potable water and gas distribution networks are closed and pressurized systems less sensitive to temporary surface flooding. On the other hand, storm drains are open systems which could be overwhelmed if a coastal flooding event coincided with a strong rainfall event. Sanitary sewer gravity mains could also be sensitive to prolonged surface flooding that would result in addition inflow and infiltration into the system.

Under a No Action scenario, erosion hazards would be a major concern with a very high risk that utilities along beach Boulevard would be exposed and undermined in a relatively short amount of time. Erosion projections for 2030 indicate the sanitary sewer, potable water main, gas main and storm drain systems along Beach Boulevard would be vulnerable to damage. Some portions of the existing utilities will need to be relocated, disconnected, or capped to maintain the integrity of the existing systems and continue service to surviving properties along the boundary of the study area. The following sections describe the utilities damaged and the additional work required to maintain service to the study area.

A severe earthquake could also result in damage to utilities due to ground displacement (settlement) and surface rupture. Historic seismic events have been reported to cause damage to property and infrastructure in the region, including utilities (HKA, 2020). Damages to underground pipelines systems could cause hazardous leaks and service disruptions. Potential breaks in water or sewer lines can result in damage to roadways limiting access in an emergency. Potential breaks in natural gas mains or electrical power lines could also pose a significant safety hazard.

Table 5-1 Summary of Existing Utilities

Owner or Operator	Utility	Dimension	Overhead (O/H) or Underground (U/G)	Notes
City of Pacifica	Stormwater drainage	Varies 12" – 72"	U/G	Inlets, pipes & ocean outfalls
City of Pacifica	Sewer (gravity & force main)	Varies: 6" gravity below Beach Blvd, 20" force main from Sharp Park PS	U/G	Incl. abandoned sewer main under Beach Blvd pavement
City of Pacifica	Street Lighting	Light poles along Beach Blvd and promenade	O/H & U/G	O/H lights supplied by U/G electrical
North Coast County Water District	Drinking Water	6"	U/G	Drinking Water Main
PG&E	Gas	2" steel & smaller service lines	U/G	Includes high pressure gas distribution main
PG&E	Electricity	12kV	O/H & U/G	
AT&T	Communications	Unknown	U/G & O/H	
Comcast	Communications	No utilities with project area		
MCI Worldcom	Communications			
Intermountain Infrastructure Group	Communications			

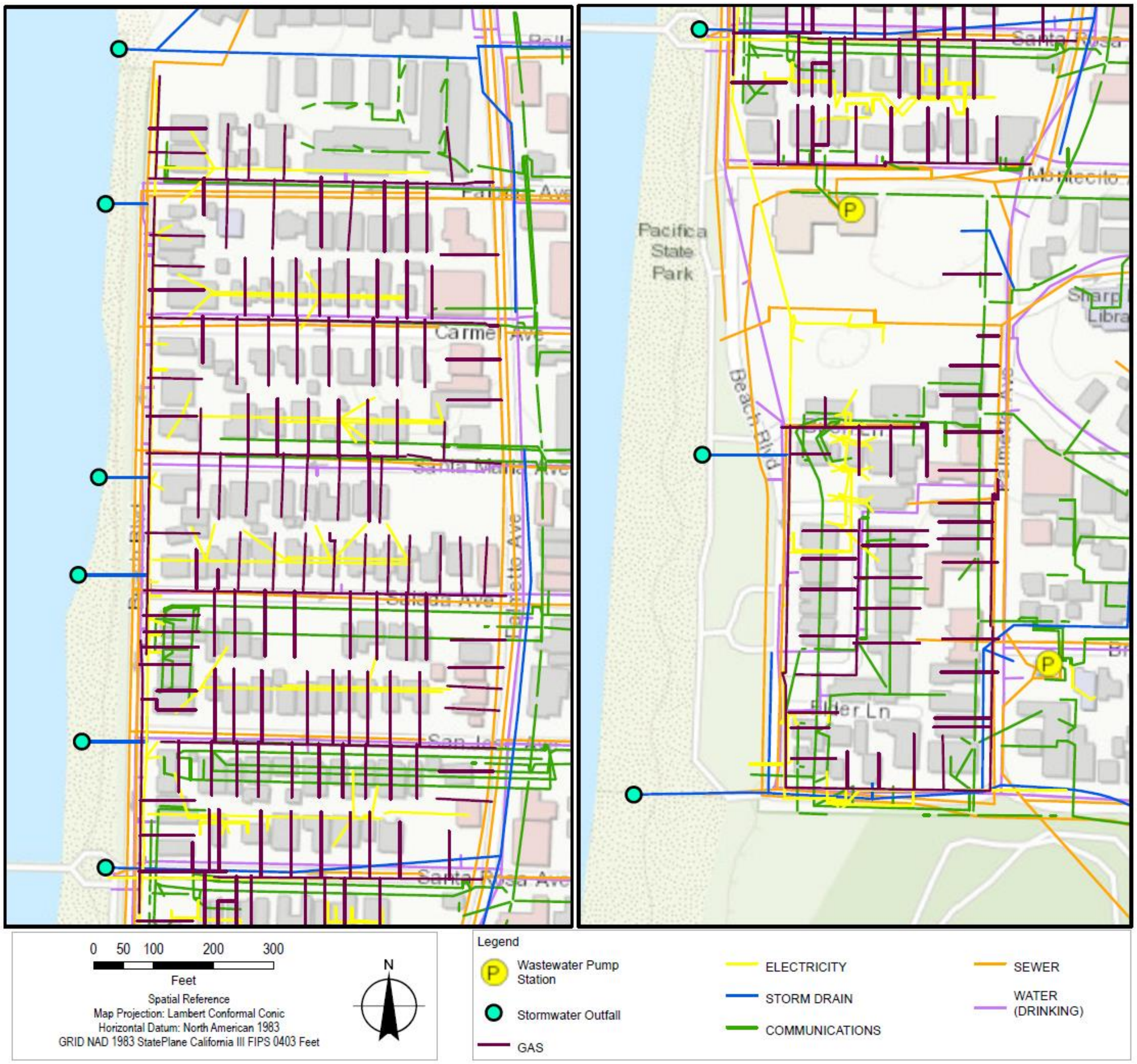


Figure 5-1 Existing Utilities North of Pier (Left) and South of Pier (Right)

5.2.1 Potable Water

North Coast County Water District (NCCWD) provides potable water to the area of study. NCCWD provided geographic information system (GIS) shape files of the agency's water system. The potable water system is looped through and around the study area as shown in Figure 5-1 with main distribution lines along Beach Boulevard, Palmetto Avenue and along each street oriented east-west.

Failure of the sea wall and resulting erosion of the study area will effectively break the loop. The potable water mains along the streets connecting Beach Boulevard and Palmetto Avenue will need to be capped in order to maintain a closed and pressurized system necessary for utility function.

The remaining water mains along the side streets between Palmetto Avenue and the ocean will be converted to dead ends but will likely be sufficient for serving the remaining properties. At each successive time horizon, the potable water mains would need to be removed and capped to remain outside of the erosion hazard zone. An example of where the water system would be capped outside of the 2100 erosion hazard zone is shown in Figure 5-2.

Liquefaction induced settlement due to strong ground shaking could result in rupture of potable water lines during a large earthquake. This would result in temporary service disruptions and potentially affect firefighting capabilities post-disaster.

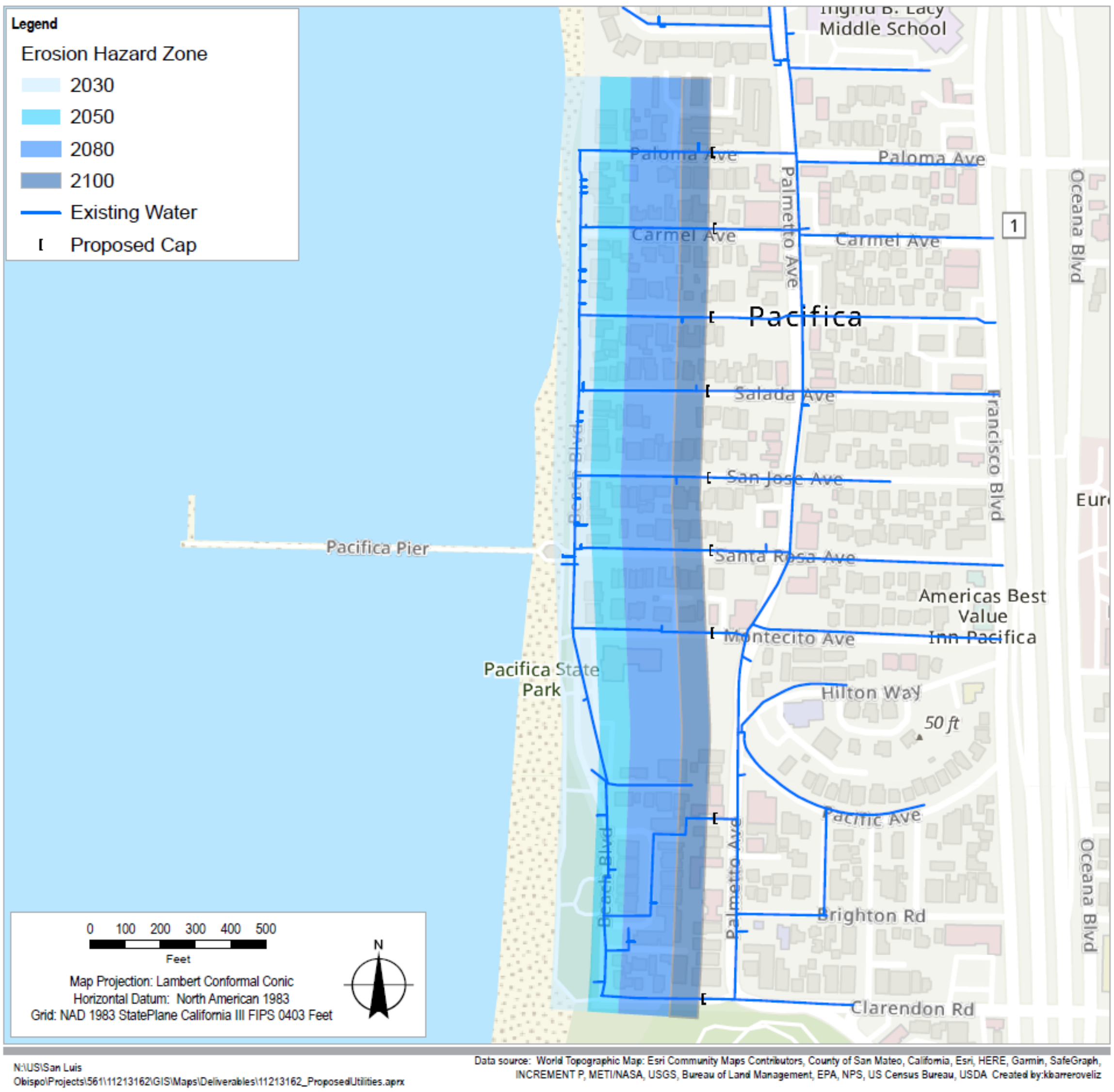


Figure 5-2 Potable Water System

5.2.2 Sanitary Sewer

The City of Pacifica (City) owns and maintains the sewer collection system within the area of study. Within the study area most of the sewer pipelines are 6-inch diameter gravity lines. There are 12- and 21-inch pipelines along Palmetto Avenue. The City's Sharp Park Sewer Pump Station sits on Montecito Avenue between Beach Avenue and Palmetto Avenue. This is the City's largest sewer pump station. A 20-inch sewer force main takes flows from the Sharp Park Sewer Pump Station to the Calera Creek Water Recycling Plant (CCWRP), which lies outside the study area.

Erosion within the study area will impact important sanitary sewer infrastructure along Beach Boulevard, including a 6-inch gravity sewer which collects wastewater from all properties west of Palmetto Avenue. This represents a key impact threshold with a high consequence due to the damage, disruption in service, environmental impact (spills) and costs of reconfiguring the sewer collection network. Given the history of coastal erosion hazards in Pacifica, the sanitary sewer system would be at high risk of damage under a No Action scenario in which the existing seawall fails without the implementation of other adaptation measures.

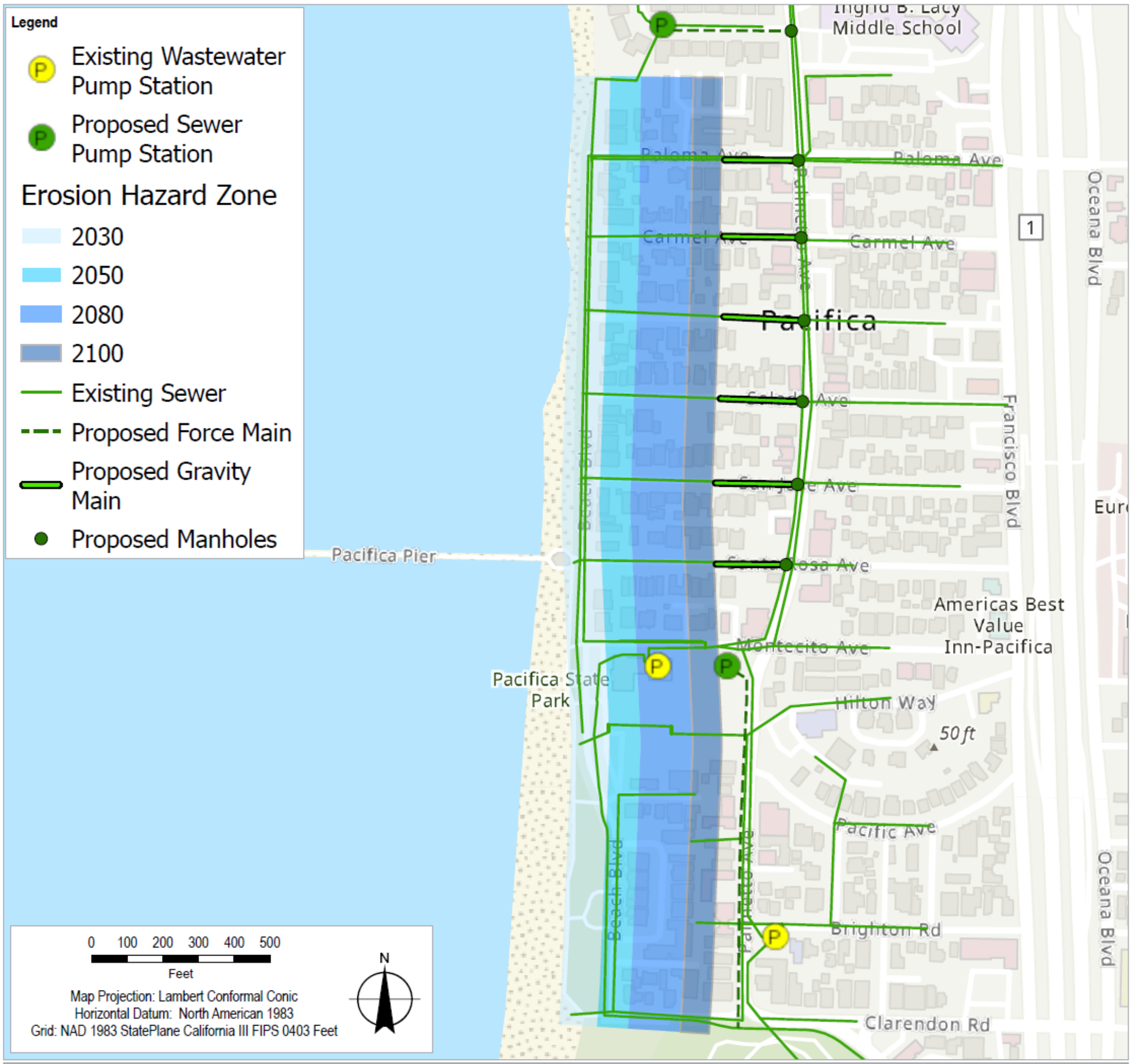
Loss of this sewer collection line, projected to occur in the 2030 time horizon in the No Action scenario, would result in service disruption to this entire community in addition to the potential environmental impacts from sewer spills if the system was not relocated prior to failure. A smaller sewershed lies to the north of the study area, along Shoreview Avenue which flows into the Beach Boulevard sewer. Flows from this small area will need to be redirected to Palmetto Avenue through the installation of a new pump station and force main.

Another significant vulnerability under a No Action scenario would be the exposure of the Sharp Park Sewer Pump Station. The pump station is projected to be vulnerable to coastal erosion in the 2050-2080 time frame. Gravity lines that feed the Beach Boulevard sewer would continue to be compromised by erosion hazards at each time horizon. In order to maintain service to the remaining properties several improvements to the existing sanitary sewer collection system will be required, including:

1. Approximately 3,850 linear feet (LF) of new 6" diameter HDPE sewer main. The existing lower laterals serving remaining properties will need to be reconfigured.
2. Six (6) new sanitary sewer manholes.
3. Approximately 1,025 LF of 26" diameter HDPE sanitary sewer force main.
4. New sewer pump station: 13-MGD pump station with three (3) pumps.
5. Approximately 1,400 LF of 18" diameter gravity sewer line along Palmetto Avenue

These sanitary sewer system improvements are illustrated in Figure 5-3 for the 2100 time horizon.

Liquefaction induced settlement due to strong ground shaking could result in rupture of sanitary sewer lines during a large earthquake. Damage to the sanitary sewer collection system could result in potential spills of untreated wastewater until emergency repairs could be made.



N:\US\San Luis Obispo\Projects\561\11213162\GIS\Maps\Deliverables\11213162_ProposedUtilities.aprx

Data source: World Topographic Map: Esri Community Maps Contributors, County of San Mateo, California, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA Created by:kbarreroveliz

Figure 5-3 Sanitary Sewer System

5.2.3 Storm Drain

The City of Pacifica (City) provides storm drainage within the area of study. The locations of the existing storm drain pipelines are shown in Figure 5-1. There are six stormwater outfalls along Beach Boulevard that consist of relatively short runs of 15-inch diameter storm drains that convey surface runoff through the seawall to the ocean. Each of these systems capture surface runoff from local drainage areas west of Palmetto Avenue with outfalls typically aligned with street ends.

Adjacent to the existing seawall, there are larger storm drain systems that service drainage areas east of Palmetto Avenue. There is a 72-inch reinforced concrete pipe (RCP) at the northern end of the study area, north of Paloma Avenue. South of the existing seawall there is also a storm drain along Clarendon which services a larger drainage area. The City's Vulnerability Assessment (ESA, 2018a) describes this system as undersized and subject to persistent flooding in which temporary pumps are often used to supplement the existing storm drain system.

Erosion hazards are a primary concern due to the potential for undermining, failure, and potential blockage of the stormwater outfalls. Flooding and elevated water levels due to SLR are also a concern, especially at the low-lying areas along Clarendon Road where high ocean water levels could reduce the conveyance capacity of gravity systems. Development of flood control solutions at Clarendon Road should include considerations for future coastal hazards and coordination with this Project regarding the configuration of a new or modified ocean outfall.

The topography within the study area generally slopes gently away from the ocean and surface runoff will continue to flow away from the blufftop into the storm drainage system and flows by pipe back through the seawall. Under a No Action scenario, uncontrolled drainage could exacerbate the rate of erosion at each street end. As the erosion hazards move east into the study area, storm drain pipelines will likely need to be supported with new headwalls to maintain operation, in addition to slope drains at each street end.

5.2.4 Natural Gas

Pacific Gas & Electric (PG&E) provides natural gas service within the area of study. The natural gas lines within the area mostly consist of 2-inch steel distribution mains and smaller lines servicing each property. The natural gas system is similar to the potable water system in that it is looped through and around the study area. In response to the erosion hazards, the existing steel gas lines will need to be capped outside of each hazard zone at each time horizon. Service will no longer be looped but the existing steel gas lines will likely be sufficient to serve the remaining properties.

Liquefaction induced settlement due to strong could result in rupture of natural gas lines during a large earthquake. These ruptures could pose a threat to life and safety in addition to service disruptions.

5.2.5 Electrical Power

PG&E provides electrical power within the area of study. Most power lines within the area are overhead with a few buried power drops. Since most of the electrical infrastructure is overhead, temporary flooding does not pose a major hazard to the power supply system. Under a No Action scenario, coastal erosion would begin to undermine some of the existing power poles. PG&E maps indicate the area can be served from Palmetto Avenue. Power poles threatened by erosion will need to be removed and power drops may need to be reconfigured in order to provide power to the surviving properties.

Downed power lines resulting from a strong ground shaking during a large earthquake also pose a life and safety risk to the public and emergency responders.

5.2.6 Communication

AT&T provides communication service within the area of study. The communication lines consist of both overhead and buried communication lines and conduits. Under a No Action scenario, coastal erosion would likely result in localized failures within the communication network. Local services will likely require reconfiguration, outside potential flooding, and erosion hazard zones to maintain service to remaining properties.

5.3 Pacifica Municipal Fishing Pier

The Pier is dependent on a stable backshore at Beach Boulevard to provide safe access for pedestrians to enjoy the aesthetic and recreational benefits of the Pier. Under a No Action scenario, coastal erosion would prohibit access from the Beach Boulevard Promenade. As the erosion hazards progress landward through each planning horizon the City would have to decide whether to extend the Pier landward and stabilize with a new foundation at the base of the Pier, or to demolish the Pier. For purposes of evaluating economic impacts from a No Action scenario it was assumed the Pier would be demolished because access to the Pier could not be maintained without some type of adaptation strategy to stabilize the shoreline at the base of the Pier. The estimated cost associated with demolition of the Pier was assumed to occur at the 2030 planning horizon. Loss of the Pier would result in significant adverse consequences to public access and recreation opportunities provided by the Pier.

Access to the Pier could feasibly be maintained, but would likely require additional protective structures at the base of the Pier along with adjacent shoreline protection to protect against flanking, similar to what was installed before the existing seawalls were constructed. Safe and reliable access to the Pier structure would require a routine monitoring plan and regular maintenance and modification of the structures at the base of the Pier to accommodate the progressive erosion occurring elsewhere along Beach Boulevard. In other words, an adaptive approach that is inconsistent with the hypothetical No Action scenario considered in the MHRA.

A more detailed assessment, beyond the scope of this Project, would be required to evaluate the additional structures required to maintain access to the Pier under a No Action scenario. The costs associated with these additional structures, along with modifications in response to an eroding shoreline would likely be far more than assumed for demolition of the Pier. In other words, our assumption for demolition of the Pier could under-estimate the economic impacts of managing Pier access under a No Action scenario.

6. Environmental

The MHRA assessed the condition of existing environmental resources of the Project site in order to: 1) identify opportunities and constraints, 2) support alternatives comparison and ranking and 3) support future phases of work (environmental review and permitting). The condition of the following environmental resources was characterized for the MHRA:

- Marine resources (i.e. beach and foredune, sub-tidal and developed),
- Terrestrial biological resources (i.e. biological resources landward of the beach), and
- Recreation and visual resources.

Key findings from the resource assessment are presented in this section. Detailed technical memos are provided in Appendix B.

6.1 Marine Resources

6.1.1 Beach and Foredune Areas

Within the Project area the beach and foredune community consists of the area west of the promenade and inland of the mean high tide line and includes the foredunes south of the intersection of Beach Boulevard and Clarendon Road. These areas, where present in the Project area, consist of barren sand with little vegetation due to regular disturbance by public access. Western gull (Larus occidentalis), California gull (L. californicus), common raven (Corvus corax) and American crow (C. brachyrhynchos), are often observed loafing or scavenging drift debris and litter on the sand within this community. Caspian terns (Hydroprogne caspia), a USFWS Bird of Conservation Concern, may forage for fish in Laguna Salada or roost on the beach within the Project area. Western snowy plover (Charadrius alexandrius nivosus), a federally Threatened species and California Species of Special Concern, may seasonally occupy the Project area between July and May, where they are observed resting in shallow depressions and among driftwood or foraging small invertebrates from wrack debris deposited at the high tide line. Caspian tern and western snowy plover are not known to nest on the beach within the Study Area.

6.1.2 Sub-tidal Areas

The subtidal zone consists of areas west of the mean high tide line. The offshore environment in the Project area includes critical habitat designation for three marine species: black abalone, leatherback sea turtle, and green sturgeon. Additionally, the offshore, pelagic environment is located within proposed critical habitat for populations of humpback whale and killer whale. The entirety of the coastal environment is designated as essential fish habitat under multiple Federal fisheries management plans. Northern California also supports a range of resident marine mammal species and serves as a migration corridor for a significant number of protected cetaceans. However, even with the large amounts of protected habitat and complex regulatory setting, the likelihood for the physical occurrence of any individual special-status species within the intertidal and subtidal environments off of the Project area is considered low to moderate. No special-status species are known to be permanent residents of the nearshore environment.

Any in-water or shoreline work conducted at the beach within the Project area would occur within these protected habitats, and as such, have the potential to negatively impact multiple special-status species. Consultation with state and federal agencies may be required depending on the alternative being considered anticipated impacts to these species.

Other general impacts and considerations associated with marine construction projects of this type are as follows:

- Water Quality: Marine construction can result in temporary impacts to water quality through increases in turbidity. Use of BMPs such as silt curtains may result in the exclusion of marine species from the affected area. **The potential for the Project to result in turbidity impacts should be considered.**

- Underwater noise: Driving of piles and other in-water construction work has the potential to increase underwater noise to levels that could result in injury or behavioral changes to fish and mammals within the Project area. **Consideration of the potential generation of in-water noise above ambient levels should be considered.**

- Risk of Spills: Construction in the marine environment requires diligence in the selection of contaminated materials storage and fueling areas. Risks vary contingent on the types of marine construction equipment needed and work in the surf zone. **Alternatives should consider the risk of hazardous materials spills.**

- Placement of fill in waters of the U.S.: The placement of fill or other permanent alterations to the marine environment may result in a net loss in critical habitat or essential fish habitat areas. Such alterations do not always result in negative impacts on marine species and habitat; especially if dilapidated infrastructure is removed and replaced with more ecologically-conscious alternatives. **Project alternatives should consider the temporary and permanent areas of "fill" within jurisdictional areas / Waters of the U.S. Potential impacts to critical habitat or essential fish habitat should also be considered.**

6.2 Terrestrial

6.2.1 Developed/Landscaped/Ruderal

Developed and landscaped areas within the Project area include roads, buildings, parking lots, paved surfaces, existing facilities, landscaping, and the Sharp Park Golf Course. These areas support a variety of ornamental trees and shrubs, non-native grasses, and ruderal (opportunistic, weedy) species that tolerate sandy soils. Monterey cypress (Hesperocyparis macrocarpa), a native tree that is not locally native, dominates the trees species in this habitat. Other trees that are less common in this habitat include native Monterey pine (Pinus radiata) and blackwood acacia (Acacia melanoxylon). The understory of this habitat consists of litter and sparse vegetation in dense canopy areas and in more open canopy areas and on edges, the vegetation is similar to dune mat (disturbed) vegetation but in some areas supports more non-native grasses.

Developed portions of the Study Area provide limited, low quality habitat for wildlife because it is predominantly hardscape and highly disturbed (ruderal) or maintained landscaped areas. Landscaped and ruderal areas can still provide cover, foraging, and nesting habitat for a variety of bird species as well as reptiles and small mammals, especially those that are tolerant of disturbance and human presence. Cooper's hawk (Accipiter cooperi), redtailed hawk (Buteo jamaicensis), American kestrel (Falco sparverius), white-tailed kite (Elanus leucurus), and great horned owl (Bubo virginianus) may nest or perch in the dense canopy of Monterey cypress in the Sharp Park Golf Course portion of the Study Area. Birds commonly found in such areas include non-native species such as house sparrow (Passer domesticus) and European starling (Sturnus vulgaris), as well as birds native to the area, including American robin, house finch, and western scrub jay (Aphelocoma californica). Other wildlife expected in urban landscaped areas of the study area include Norway rat (Rattus norvegicus), striped skunk (Mephitis mephitis), Virginia opossum (Didelphis virginiana), and raccoon (Procyon lotor).

6.2.2 Sensitive Natural Communities

A sensitive natural community is a biological community that is regionally rare, provides important habitat opportunities for wildlife, is structurally complex, or is in other ways of special concern to local, state, or federal agencies. Laguna Salada, the fresh-brackish lagoon wetland complex located just south and east of the Project area is the only sensitive natural community in the Project area. The area is considered sensitive due to the presence of extensive native wetland plant communities and for its function in supporting the highest concentration of special-status wetland wildlife species on the San Francisco Peninsula coast; most notably the California red-legged frog, San Francisco garter snake, western pond turtle, and saltmarsh common yellowthroat.

The isolated nature of the proposed shoreline work and distance away from habitat supporting special status species likely precludes project-related direct impacts on California red-legged frog, San Francisco garter snake, western pond turtle, and saltmarsh common yellowthroat individuals. However, vegetation removal and an increase in noise, vehicle traffic, and human presence could result in disturbance to these species in addition to nesting birds, including saltmarsh common yellowthroat, and roosting bats. **Consideration of direct and indirect impacts to wildlife within the nearby Laguna Salada wetland complex should be considered as part of the development of alternatives.**

6.3 Recreation Resources

The Beach Boulevard Promenade, together with the Municipal Pier and Sharp Park Beach, provide extensive access to free or low-cost public recreational opportunities. Activities observed or known to occur along the promenade include walking (with and without dogs), jogging, socializing and Pelican watching (in summer months).

The beach is accessed from trails from the south, at Clarendon Road, and also from two sets of stairs (one along the North Wall and one along the South Wall) that provide access from the Promenade to the beach. The beach is used for shore fishing, beachcombing, sunbathing, and surfing.

There is limited beach and promenade parking along the Project area. Parking is provided as protected on-street pockets on Beach Boulevard north of the Pier. More public parking is available on the southern-most section of the Project area where diagonal off-street parking exists. A total of approximately 64 parking spaces exist in the Project area. All spots are free, two-hour parking stalls.

A picnic area/trailhead exists along the South Wall for the Promenade to the north, as well as to the Coastal Trail. The Coastal Trail, which runs south along the berm in front of the Sharp Park Municipal Golf Course, is accessed from the picnic area/trailhead at the end of Clarendon Road.

The Municipal Pier is 1,140 feet long, and has lights, fish cleaning stations, benches, restrooms, and a coffee house/snack bar. Free parking is located on adjacent streets and in a nearby lot. Handicapped parking is also available, with pier accessibility via a ramp leading to the south side of the pier. The pier is open daily from 4AM to 10PM, unless closed due to inclement weather, high surf, or repairs. No admission is charged, and no fishing license is required at the Pier.

Adjacent to the southernmost boundary of the Project area is the Sharp Park Municipal Golf Course, which provides a unique recreational asset to the City and region. The golf course is part of a land bequest made to the City and County of San Francisco early in the 20th Century on the condition that the land be used for public park or recreation. Designed by the preeminent architect Alister MacKenzie, the golf course is often referred to as “The Poor Man’s Pebble Beach” and offers views of the Pacific Ocean and surrounding headlands and mountains (sfrecpark.org). Several holes wrap around Laguna Salada, a natural lake and marsh located on the western side of the golf course, that provides habitat for the San Francisco garter snake and California red-legged frog.

The Sharp Park neighborhood has one main bikeway that runs parallel to and east of Beach Boulevard: a class II bicycle lane along the length of Palmetto Avenue from Paloma Avenue to the north, to Clarendon Road to the south. This bicycle lane was installed as part of the Phase I Palmetto Avenue Streetscape Improvement Project, completed in 2018. At Clarendon Road, the Class II facility continues on the eastern side of the Sharp Park Golf Course as a Class III Bicycle Route, and on the western side as a Class I Shared Use Path. A new comprehensive Bicycle and Pedestrian Master Plan for the City of Pacifica was adopted in February 2020.

6.4 Visual Resources

The Promenade and the Municipal Pier themselves offer access to public views of, and along the coast. Coastal views are considered resources of public importance under the California Coastal Act, and Coastal Act Section 30251 recognizes that “[t]he scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas.” The Coastal Act generally considers view blockage to be a “substantial issue” when it pertains to public views, and not to views from private residences (Citizens Guide to the Coastal Act of 1976, PACE 1977). There are three designated public coastal view corridors in the Sharp Park Planning Area; looking west to the ocean from Paloma Avenue, from Salada Avenue, and from Clarendon Road (Figure 6-1).

Figure 6-1 Existing Views from Designated Coastal View Corridors (ESA, 2020b)

6.5 Regulatory Context

The Project area is within the jurisdictions of the following agencies:

- California Coastal Commission: The California Coastal Act of 1976 established the California Coastal Commission (CCC) to "protect, conserve, restore, and enhance environmental and human-based resources of the California coast and ocean for environmentally sustainable and prudent use by current and future generations." The CCC has authority to regulate development within California's coastal zone, according to the provisions of the California Coastal Act. The coastal zone is delineated by official maps available from the CCC and generally extends three miles seaward and in Pacifica, the coastal zone extends inland to Highway 1.

  The California Coastal Act's coastal resources planning, and management policies cover six areas: public access, recreation, the marine environment, land resources, development, and industry. The policies articulate requirements for public access and for protection of marine resources and environmentally sensitive habitat areas. They lay out priorities for preserving open space, protecting fishing and coastal-dependent industry, promoting recreational use of the coast, and giving priority to visitor-serving commercial uses over general commercial or residential development.

In order to carry out the policies of the Coastal Act, each of the 73 cities and counties in the coastal zone is able to prepare a local coastal program for the portion of its jurisdiction within the coastal zone and to submit the program to the commission for certification. Once the Commission certifies a local coastal program, the local government gains authority to issue most coastal development permits. However, the Commission generally retains permit authority over tidelands, submerged lands, and public trust lands. Only the Commission can grant a coastal development permit for development in areas of its retained jurisdiction.

The City of Pacifica's certified Local Coastal Land Use Plan is dated March 24, 1980 and is in the process of being updated. A Certification Draft Local Coastal Land Use Plan (LCLUP), dated February 2020, was submitted to the CCC for review and certification, in June 2020. The City's LCLUP ensures consistency with the goals and policies of the Coastal Act. These include the protection and enhancement of the coastal environment, the provision of public access to the shoreline and recreational opportunities.

- U.S. Army Corps of Engineers: For tidal waters, the Corps jurisdiction extends to the High Tide Line under Section 404 of the Clean Water Act. Areas below Mean Higher High Water fall under both Section 404 and under Section 10 of the Rivers and Harbors Act.
    - Under Section 404 of the Clean Water Act the Corps regulates the disposal of dredge or fill material into waters of the U.S. This includes all filling activities such as utility lines, outfall structures, road crossings, beach nourishment, riprap, jetties, and some excavation activities.
    - Under Section 10 of the Rivers and Harbors Act of 1899 the Corps regulates all structures and work within tidal waters and freshwaters that involve dredging, marinas, piers, wharves, floats, intake and outtake pipes, pilings, bulkheads, ramps, fills, overhead transmission lines, etc.
- Regional Water Quality Control Board: The Regional Water Quality Control Board has jurisdiction over waters of the U.S. and waters of the state which may not be subject to US Army Corps of Engineers (Corps) jurisdiction. Before the Corps can issue the 404 permit, the Regional Water Board must certify that the project also meets state water quality objectives under Section 401 of the Clean Water Act.
- California State Lands Commission: The State Lands Commission (SLC) has jurisdiction and management authority over all ungranted tidelands, submerged lands, and the beds of navigable lakes and waterways. The state holds these lands for the benefit of all people of the state for statewide Public Trust purposes, which include but are not limited to waterborne commerce, navigation, fisheries, water-related recreation, habitat preservation, and open space. A General Surface Lease (Right-of-Way Permit) is required for any project within the

SLC's jurisdiction (per Pub. Resources Code Section 6000 et seq.; 14 Cal. Code Regs. Section 1900 et seq.). Any work below the Mean High Tide Line in areas that are subject to tidal action would be within their jurisdiction.

- U.S. Fish and Wildlife Service and National Marine Fisheries Service: The federal Endangered Species Act (16 U.S. Code section 1531 et seq.) designates threatened[6] and endangered[7] animal and plant species and provides measures for their protection and recovery. Activities that damage (i.e., harm) the habitat of listed wildlife species require approval from the U.S. Fish and Wildlife Service or National Marine Fisheries Service; collectively, these entities administer the act. Take of listed species can be authorized through either the section 7 consultation process (for actions by federal agencies) or the section 10 permit process (for actions by non-federal agencies).

  The federal Endangered Species Act also generally requires determination of critical habitat for listed species. Critical habitat is defined as the specific areas that are essential to the conservation of a federally listed species and that may require special management consideration or protection.

  The Magnuson-Stevens Act (16 United States Code 1801–1884) of 1976, as amended in 1996 and reauthorized in 2007, applies to fisheries resources and fishing activities in federal waters. Federal waters extend to 200 miles offshore. The Act defines *essential fish habitat* as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The waters offshore Sharp Park Beach are designated as essential fish habitat for fish managed under four fisheries management plans (FMPs): the Pacific Coast Groundfish FMP, the Coastal Pelagic Species FMP, the Pacific Coast Salmon FMP, and the West Coast Highly Migratory Species FMP.

  The Marine Mammal Protection Act of 1972, as amended, establishes a federal responsibility for the protection and conservation of marine mammal species by prohibiting the harassment, hunting, capture, or killing of any marine mammal. The primary authority for implementing the act belongs to the U.S. Fish and Wildlife Service and National Marine Fisheries Service.

[6] The term threatened refers to species, subspecies, or distinct population segments that are likely to become endangered in the near future.

[7] The term endangered refers to species, subspecies, or distinct population segments that are in danger of extinction through all or a significant portion of their range.

7. Economic Risk Assessment (Cost of Inaction)

Similar to other sections, the economic risk assessment was based on the hypothetical “No Action” scenario in which the existing seawall experiences widespread failure due to increasing coastal hazards and is not replaced by any other adaptation strategy to mitigate these hazards. This represents a worst-case scenario which will be used to describe the potential costs of inaction.

Economic analyses are commonly used to compare long-term benefits and costs of a project or project alternatives. The economic analysis of the “No Action” scenario will provide a useful point of comparison against costs and benefits of project alternatives. Damages that would be incurred under the “No Action” scenario, described in previous sections, include loss of the Promenade, Beach Boulevard, and utilities within this corridor due to coastal erosion. Significant damage and loss of property and buildings would also be expected once erosion progresses beyond the Beach Boulevard corridor. These damages are quantified in this assessment and described as an economic indicator of the potential cost of inaction.

Subsequent Project tasks will develop alternatives to mitigate existing and future hazards to reduce the potential for significant economic impacts under these scenarios. Alternatives that are effective at mitigating erosion and flood hazards will reduce the potential costs described in this section. When compared to the “No Action” scenario the avoided costs associated with each alternative will be characterized as benefits.

7.1 Economic Analysis Methods

A variety of economic methods and guidelines can be applied in this type of assessment. Relevant guidelines considered for this analysis were developed by the Federal Emergency Management Agency, the National Oceanic and Atmospheric Administration (NOAA), and the United States Army Corps of Engineers. These guidelines follow the same general approach and the decision on which method to apply is often dictated by the potential funding mechanism targeted for a given project. Since this assessment is intended to inform a feasibility study for the Project, not a funding application, the decision on which method to apply was based on the best fit for the Project type and City needs.

Consideration for unique coastal challenges and trade-offs associated with adaptation to SLR, as well as consideration for non-market benefits, were key factors in selecting the NOAA methodology for this analysis. The NOAA framework is described in *What Will Adaptation Cost? An Economic Framework for Coastal Community Infrastructure* (NOAA 2013). The document provides guidelines for communities to assess options for making coastal infrastructure more resilient in the face of climate change impacts.

An overview of the framework is shown in Figure 7-1. The steps and tasks outlined in red are included in the economic analysis of the “No Action” scenario. The remaining steps and tasks will be completed once alternatives are developed.

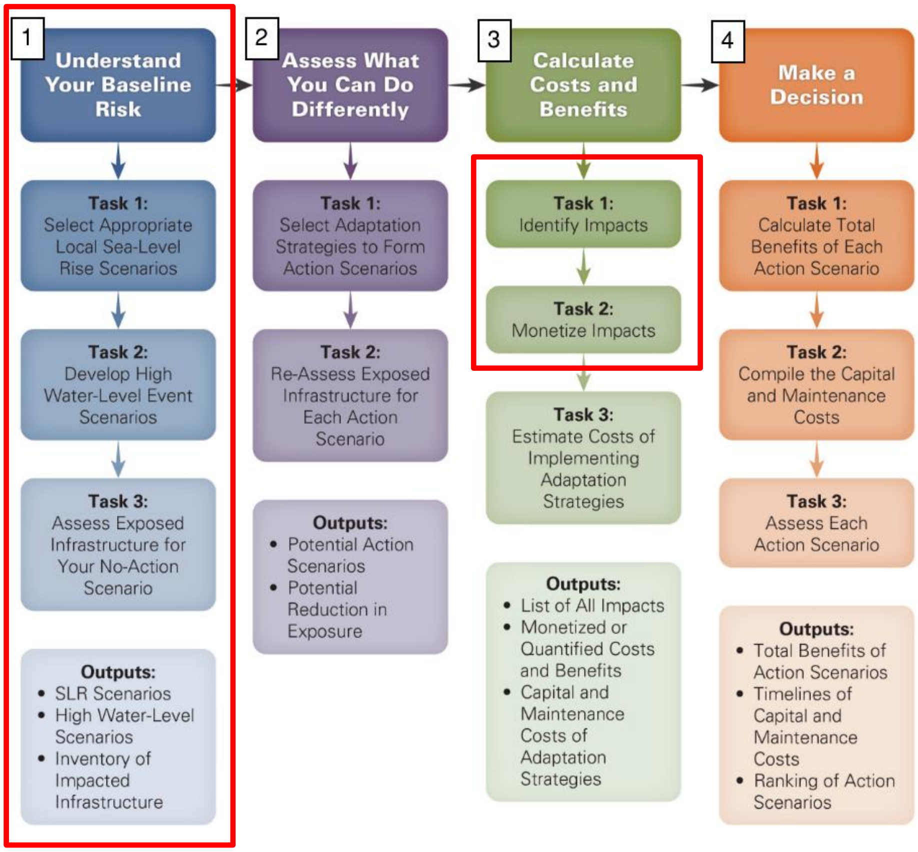


Figure 7-1 NOAA Framework Steps and Tasks.

The NOAA framework is organized into four steps with tasks associated with each one. Step 1 allows a community to understand current risks associated with a hazard (e.g., coastal erosion and flooding). In this step, the scenario in which no project is constructed, herein referred to as the "No Action Scenario", is evaluated. In Step 2, alternatives (or "Action Scenarios") are developed to determine what a community can do differently to minimize the impacts of the hazard. Step 3 includes identifying the positive and negative impacts of each alternative and, to the extent possible, monetizing those impacts. All property and infrastructure at risk of failure under a "No Action" scenario was assessed in this step. In Step 4, the impacts and alternative costs are combined to determine a benefit cost ratio (BCR) for each alternative. Note that the final BCR is intended to provide insight into identifying the alternative that is most suitable for a community from an economics standpoint. While this analysis is intended to take a holistic approach, there may be other factors to consider that are beyond the scope of an economic analysis.

7.2 Economic Impacts

Under the No Action Scenario, described in Section 2.3.1, potential economic impacts were assessed for several planning horizons based on the coastal erosion hazard zones shown in Figure 3-9. A summary of the scenario for each of the planning horizons and associated economic impacts are shown in Table 7-1. Economic impacts identified for the No Action Scenario are categorized as primary, secondary, and environmental. Primary impacts consist of damage associated with infrastructure. Secondary impacts include costs that would be incurred indirectly (e.g., loss in business productivity due to building damage or access disruptions). Environmental impacts encompass the ecological and recreational costs and benefits of a scenario. Table 7-2 provides an overview of the impacts considered, and how the impact will be included in the analysis (i.e., monetary, or non-monetary). Each of the impacts is discussed in more detail in the following sections.

Table 7-1 Erosion conditions for indicated planning horizons.

Planning Horizon	Physical Impacts	Economic Impact
2020-2030	• The existing seawall will experience widespread failure and removal • Beach Blvd Corridor (Promenade and road) will be lost to coastal erosion • Utilities removed and relocated as described in Section 5.2 • Pacifica Municipal Pier inaccessible due to seawall failure & removal • First row of development along Beach Blvd, north of Montecito Ave, would be extremely vulnerable to erosion	• Demolition costs associated with Beach Blvd Corridor, utilities, and Pier • Cost to relocate utilities, including Sharp Park Pump Station • Eight (8) side streets connected to Beach Blvd would become cul-de-sacs or “dead-end” streets with a turnaround. • Property: 27 structures will be lost to erosion • Rock-lined levees installed to protect properties north and south of Project reach • Loss of pedestrian access and recreation along promenade and Pier • Potential for increased seasonal beach access and recreation during summer months
2030-2050	• Erosion progresses further into development north and south of the Pier	• Property: 24 structures will be lost • Roadway modifications at each side street

Planning Horizon	Physical Impacts	Economic Impact
		• Utilities modified to accommodate increasing coastal erosion • Levees extended along development adjacent to Project reach • Potential for increased seasonal beach access and recreation during summer months
2050-2080	• Longer time horizon translates to greater coastal erosion due to higher SLR projection • Erosion progresses further into development north and south of the Pier	• Property: 71 structures will be lost • Roadways, utilities, and levees modified in response to erosion hazards • Potential for increased seasonal beach access and recreation during summer months
2080-2100	• Erosion progresses further, impacting the majority of development west of Palmetto Ave	• Property: 43 structures will be lost • Roadways, utilities, and levees modified in response to erosion hazards • Potential for increased seasonal beach access and recreation during summer months

GHD

Table 7-2 List of Economic Impacts

Impact	Data Source	Monetary Value	Non-Monetary Value
Primary Impacts			
Property damage	ParcelQuest, Zillow, Redfin	✓	
Road damage	GHD, based on prior projects	✓	
Utility damage		✓	
Pier damage		✓	
Promenade damage		✓	
Secondary Impacts			
Change in property value	N/A		✓
Loss in property tax revenue	N/A		✓
Business interruption cost	Department of Water Resources Flood Damage Analysis (SCDWR, 2012)	✓	
Debris cleanup	Department of Water Resources Flood Model (DWR, 2018)	✓	
Emergency response and minor repairs	Based on previous projects	✓	
Disruption costs	FEMA Benefit Cost Analysis Reference Guide (FEMA, 2011) and United States Census Bureau Pacifica Quick Facts (USCB, 2019)	✓	
Anxiety and discomfort	N/A		✓
Environmental Impacts			
Beach, Pier and Promenade Access Impacts	N/A		✓
Saltwater Intrusion into Laguna Salada	N/A		✓

7.3 Non-Monetized Impacts

Due to a lack of available data, some impacts will not be monetized in this analysis. This section provides a discussion of the complexities in monetizing these impacts. It is important to note that although quantification is not included in the analysis, these impacts need to be discussed and considered when evaluating project alternatives and the No Action scenario.

7.3.1 Change in Residential Property Values and Lost Tax Revenue

With an eroding shoreline, values of coastal properties will change. A Continuing Authorities Program, Federal Interest Determination (FID) Report of Beach Boulevard (USACE, 2017) suggests that an eroding bluff essentially creates new beachfront property, thereby increasing property value. Conversely, a property may be considered less valuable being located on an eroding bluff due to the future buyer having knowledge that homes in previous planning horizons have been lost and as erosion continues their properties will be at higher risk. Additionally, home values may decrease if local or state policy has been established that discourages or precludes construction of coastal protection structures to combat erosion and property loss. For these reasons, changes in property values as erosion occurs is difficult to associate with a monetary value but would indicate that economic impacts to property may result before they are exposed to hazards. In addition to changes in property values, property taxes fluctuate and cannot be predicted. The loss in revenue generated by property taxes is therefore not quantified as part of the analysis.

7.3.2 Anxiety and Discomfort

Should No Action be taken, mental stresses for local homeowners, business owners, and City staff will be heightened. The anxiety and uncertainties associated with persistent erosion hazards could reduce the opportunities for economic development and investment in the identified hazard zones. The indirect economic impacts resulting from this anxiety and discomfort can have lasting impacts on the community as a whole but is difficult to monetize.

7.3.3 Beach, Pier and Promenade Access

Sharp Park Beach, the Pier, and the Promenade along the existing seawall provide valuable recreation areas that are integral to the community. The features not only provide the local community with recreation activities, but also draw tourists, increasing local business revenue. Under the No Action Scenario, the Pier and Promenade would fail, limiting coastal recreation activities for Pacifica. As the existing seawall is demolished due to damage and the shoreline naturally erodes, this process will introduce sediment to the littoral zone and potentially result in a seasonal sandy beach at the toe of the bluff. Although it will likely be narrow and seasonal, like beaches north of the Project area, it may provide seasonal beach access for recreational purposes and improve the chances that beach can adapt to SLR. The increased beach access provided by a larger beach may be offset by shoreline protection measures installed by private property owners. The construction of individual seawalls or revetments at the parcel scale could potentially reduce the available public beach area and create interrupted lateral access along the Project reach. Given the potential impacts from these individual structures, they would likely be subject to the requirements of the certified LCP and Coastal Act. While previous research (e.g., by the California Coastal Commission) has been completed to estimate the value of a beach day, the literature was generated for areas that draw more tourists in comparison to Pacifica. In addition, attempting to distinguish between tourists that use the Promenade versus Sharp Park Beach versus the Pier would not be possible without data to support these estimates and subsequent valuation attributed to the beach area versus the promenade.

7.3.4 Laguna Salada, Sharp Park Golf Course and Shoreview Neighborhood

Laguna Salada and Sharp Park Golf Course are located outside of the Project area but are recognized as important resources for the community. Laguna Salada supports the highest concentration of special-status wetland wildlife species on the San Francisco Peninsula coast in addition to extensive native wetland plant communities. Sharp Park Golf Course, owned by the San Francisco Recreation and Parks Department, is an historic 18-hole golf course along with a variety of other facilities that provide recreational and cultural value to the community.

Laguna Salada and Sharp Park Golf Course are outside the limits of the BBIRP area but are subject to similar coastal erosion and flooding hazards as described in Section 3. Similarly, the Shoreview neighborhood to the north of the Project is subject to similar costal hazards. The market and non-market values of adjacent resources such as Laguna Salada, Sharp Park Golf Course and Shoreview neighborhood were not included in this assessment because those impacts would depend on the adaptation strategies implemented by those property owners.

For purposes of this economic assessment, it was assumed that any adaptation strategy implemented along the Project reach would include provisions to mitigate potential coastal flooding of adjacent areas. Under the “No Action” scenario it was assumed that rock lined embankments or levees would be constructed along adjacent properties, to the north and south, to prevent coastal erosion and flooding from flanking their existing shoreline protection infrastructure. These features would theoretically be aligned perpendicular to the shoreline and extended landward as needed in response to future coastal hazards. The estimated cost of the embankments/levees for adjacent property protection were included in this assessment.

7.4 Monetized Primary Impacts

Buildings were assumed to fail once a portion of the parcel was within a coastal hazard zone (Figure 3-9). A one-time cost of the property’s value was included in the analysis. Monetary values for each property were collected from Redfin, Zillow, and ParcelQuest. Though several properties lack information through these sources, the majority were assigned a monetary value. Zillow estimates each property’s value based on any data the homeowner has submitted, facts for each home, the housing market, as well as the location (Zillow, 2020). Property value estimates on Redfin are calculated using multiple listing service databases of properties recently sold in the nearby area (Redfin, 2020). ParcelQuest receives property data directly from assessors with the estimated value of the land and property listed and used for property tax purposes (ParcelQuest, 2020). All properties with structures within the coastal hazard zones ranged from approximately $700,000 up to $19M, with an average value of about $1.34M. For the current analysis, an average of the property values from Redfin and Zillow were used and supplemented with ParcelQuest data as needed. Please refer to Appendix C for a list of the assumptions and methods used in the economic assessment.

The utilities listed in Table 7-3 will require relocation and new connection points and supporting infrastructure as described in Section 5. Beach Boulevard will need to be demolished, requiring roads such as Paloma Ave to be converted to cul-de-sacs with appropriate signage and barriers. To allow for direct comparison, all costs for damages were calculated in present value for the year 2020. Note, the subtotals at the bottom of the following tables are calculated for each planning horizon and are not cumulative. Cumulative totals for each item are provided in the right column for the 2100 planning horizon.

Table 7-3 Monetized Primary Impacts (all values in 2020 dollars)[8]

Item Description	2020-2030	2030-2050	2050-2080	2080-2100	Totals
Roadway	$6,600,000	$3,300,000	$4,600,000	$3,300,000	**$17,800,000**
Sanitary Sewer	$38,600,000	$500,000	$500,000	$500,000	**$40,100,000**
Water	$1,200,000	$800,000	$800,000	$800,000	**$3,600,000**
Gas	$1,100,000	$700,000	$700,000	$700,000	**$3,200,000**
Electricity	$1,000,000	$500,000	$500,000	$500,000	**$2,500,000**
Communications	$600,000	$400,000	$400,000	$400,000	**$1,800,000**
Pier	$4,700,000	-	-	-	**$4,700,000**
Shore protection (adjacent)	$1,100,000	$900,000	$1,500,000	$900,000	**$4,400,000**
Property Value	$39,700,000	$29,500,000	$99,500,000	$52,800,000	**$221,500,000**
Subtotals	**$94,600,000**	**$36,600,000**	**$108,500,000**	**$59,900,000**	**$299,600,000**

7.5 Monetized Secondary Impacts

Monetized secondary impacts include business interruptions, emergency cleanup, emergency response and minor repairs, and disruption costs. These impacts are tabulated in Table 7-4.

Business interruption costs have been applied to four small businesses located within the Project site. One business is located on the Pier and was assumed to be closed and relocated when the pier was demolished in the 2020-2030 planning horizon. The other three businesses are located in the 2080-2100 erosion hazard zone. Consistent with typical flood damage analyses (SCDWR, 2018), the method assigns a dollar value to business revenue generation per day based on the building footprint (estimated using Google Earth) and business type. It was assumed that it would take each business one month to relocate and reopen.

The cost of debris is dependent upon whether a property is residential or commercial. The value stated for debris cleanup comes from DWR's Flood Rapid Assessment Model (DWR, 2008) which

[8] All monetary values listed in Table 7-3 have been rounded to the nearest $100,000.

states that clean-up costs for residential properties is $3,000 and 30% of structural damages for commercial and industrial buildings. Of the 165 properties identified, three properties have structures that are considered commercial businesses. It was assumed the business on the pier would not incur cleanup costs because the business would be demolished with the pier. The remaining properties were assumed to be residential.

Emergency response costs were calculated based on the wave events that took place on January 17th, 2016 along Beach Boulevard during which extensive damage was incurred on the existing shoreline system. The costs sustained included the emergency deployment of workers to assess the damage, the development of engineering design plans, and the construction repairs for the seawall, street and promenade, guardrails, and streetlight pillars. This same budget amount was included at each time horizon although the type of emergency work may vary in response to the erosion hazards expected under the No Action scenario.

Disruption costs consist of lodging and meal expenses per resident using FEMA's Wildland Fire BCA Module with per diem federal rates of $91 and $51 for lodging and meals, respectively. The average number of persons per household for the City of Pacifica was 2.77 from 2013-2017 and was used to determine the number of people displaced and therefore disrupted. It was conservatively assumed that it would require a one month for residents to relocate to a new property.

Table 7-4 Monetized Secondary Impacts

Item Description	2020-2030	2030-2050	2050-2080	2080-2100	Totals
Business interruption	$10,000	$0	$0	$40,000	**$50,000**
Debris cleanup	$80,000	$70,000	$210,000	$870,000	**$1,230,000**
Emergency response and minor repairs	$580,000	$580,000	$580,000	$580,000	**$2,320,000**
Disruption costs	$310,000	$280,000	$840,000	$480,000	**$1,910,000**
Subtotals	**$970,000**	**$940,000**	**$1,630,000**	**$2,050,000**	**$5,590,000**

7.6 Summary of Monetized Economic Impacts

The damage costs of all primary and secondary impacts (in present day value) for each planning horizon are summarized in Table 7-5. The results indicate erosion hazards under a "No Action Scenario" could potentially cause over $95 million in direct economic impacts in the first ten years. Damage to property represents the majority of direct impacts overall, but the economic impacts due to infrastructure damage are also significant. The greatest economic impact due to infrastructure damage occurs in the 2020-2030 planning horizon at nearly $55 million since the majority of utility systems will require relocation once coastal erosion hazards undermine Beach Boulevard under a "No Action" scenario.

Table 7-5 Summary of Monetized Economic Impacts

Monetary Impacts	2020-2030	2030-2050	2050-2080	2080-2100	Totals
Primary Impacts	$94,600,000	$36,600,000	$108,500,000	$59,900,000	**$299,600,000**
Property	$39,700,000	$29,500,000	$99,500,000	$52,800,000	**$221,500,000**
Infrastructure	$54,900,000	$7,100,000	$9,000,000	$7,100,000	**$78,100,000**
Secondary Impacts	$970,000	$940,000	$1,630,000	$2,050,000	**$5,590,000**
Subtotals	**$95,570,000**	**$37,540,000**	**$110,130,000**	**$61,950,000**	**$305,190,000**

8. Key Findings and Next Steps

Natural hazards, coastal erosion, and flooding in particular, pose a significant challenge to the uses and resources along the Beach Boulevard corridor. The Multi-Hazard Risk Assessment (MHRA) provides a project-level assessment of hazards that will be used to evaluate the risk of impacts to the Beach Boulevard seawall and associated infrastructure to inform the development of project alternatives. Key findings from the MHRA are summarized in this section.

8.1 Hazards Summary

Coastal Flooding

The extreme wave runup elevations and overtopping rates vary along Beach Boulevard, generally greater in the north of the pier with Total Water Level (TWL) elevations of 40 feet, NAVD88 during a 10-year return period event. The south wall also experiences wave runup and overtopping, but at a lesser frequency and intensity because the beach is more effective in dissipating wave energy south of the Pier. Along the south seawall, a 10-year return period event would result in TWL elevations of about 30 feet, NAVD88.

Extreme TWL elevations are significantly higher than the existing seawall crest and result in a wave hazard zone that could extend up to 200 feet beyond the north seawall and about 75 beyond the south seawall during a 60-year return period event (i.e. 1983 El Niño storm).

With sea-level rise (SLR), we expect these challenges from coastal hazards to worsen from both increased magnitude and frequency of events. Calculations show that wave runup and overtopping will increase at an amplified rate. A 2-foot SLR scenario will increase TWL elevations by 8-10 feet during extreme events. The wave hazard zone would extend about 50 feet further landward north of the Pier and about 75 feet further landward south of the Pier under a 2-foot SLR scenario. There is a 0.4% chance that 2 feet of SLR is exceeded by 2050 and a 13% chance this amount of SLR is exceeded by 2070.

Coastal Erosion

The Pacifica shoreline consists of a narrow sandy beach backed by vertical bluffs eroded into loosely consolidated sands and gravels. A long-term trend of erosion estimated to range from 0.7-2.2 ft/year resulted in a persistent erosion hazard that threatened development along Beach Boulevard and prompted the construction of the existing seawalls along the project reach in the 1980s (Griggs, 2020). Sea level rise is expected to accelerate these historic erosion trends.

The effects of SLR on coastal erosion hazards were evaluated using results of the Coastal Storm Modeling System (CoSMoS) Version 3.1, a multi-agency effort led by the United States Geological Survey (USGS) to make detailed predictions of coastal flooding and erosion based on existing and future climate scenarios for California. CoSMoS bluff erosion projections assume a hypothetical scenario of no shoreline armoring being in place as a conservative measure. Thus, estimates of shoreline erosion are based solely on physical processes of wave induced erosion on the unprotected bluff. The results indicate that most of the Beach Boulevard corridor would be lost to erosion by 2030 in this scenario (i.e.- no shoreline protection in place). These hazards continue to progress landward with time resulting in significant property loss of approximately 50 buildings by 2050, and 165 buildings by 2100.

These future erosion hazard zones represent a worst-case scenario in which no adaptation strategies are developed and implemented in response to increasing coastal hazards associated with SLR. The Project team recognizes this is not a preferred or realistic strategy, but the impacts associated with these hazards are evaluated in the MHRA to illustrate the potential consequences of a “No-Action” scenario. The consequences of a “No-Action” scenario will provide a useful point of comparison against the project alternatives developed to mitigate these hazards and illustrate the potential damage and costs avoided through implementation of the alternatives.

Earthquake Hazards

An earthquake hazard risk assessment was completed by Haro, Kasunich and Associates (HKA) as part of this Project. The Project site is situated between two active faults, the San Andreas Fault located 1.6 miles to the northeast and the less active San Gregorio-Hosgri Fault located 2.0 miles due west. The Hayward fault is another active fault located 22 miles due east. The Working Group on California Earthquake Probabilities has estimated the probability of a magnitude 6.7 or larger earthquake on each of these faults between 2014 and 2043. Of the three active faults the Hayward Fault has the highest probability at 33 percent. The San Gregorio-Hosgri and San Andreas, nearest the Project, have respective probabilities of 6 percent and 22 percent.

The presence of active faults nearby the project site make it susceptible to strong seismic shaking over the design life of the project. The severity of the ground shaking will depend on the distance to the earthquake epicenter and the subsurface soil conditions at the project site. Given the proximity to active faults and the young alluvial soils encountered below Beach Boulevard severe shaking is likely to occur and will need to be accounted for in any new shoreline protection structure.

Liquefaction of soils is a phenomenon occurring during earthquake induced ground shaking of predominately granular soil underneath the groundwater table and have low to medium density. The cyclic shaking motion causes water within the soil pores to build up pressure temporarily separating the particles causing the strength of the soil to go to zero and the soil liquefies. The interbedded young alluvial soils and beach sand that were encountered during subsurface exploration phases are vulnerable to liquefaction and potential ground settlement.

8.2 Risk Assessment Key Findings

Over the next 50 years SLR has the potential to significantly compound existing consequences from flooding and erosion. In the absence of adaptation measures developed to mitigate these hazards, a No Action scenario, the vulnerabilities are overwhelming. If the existing seawall and revetment were removed, the entire Beach Boulevard corridor could be lost to erosion within a decade.

A qualitative assessment of risk was performed based on quantitative analysis of hazards and their impacts. High risk events, described in this section, have a high probability of occurrence and result in moderate to high consequence for resources, property, and infrastructure along the Beach

Boulevard corridor. A high probability of occurrence was assigned to events with a 60-year return period or less, in combination with up to 2 feet of SLR.

Public Safety

- Coastal flooding poses a high risk to the safety of pedestrians and vehicles accessing the Promenade and Beach Boulevard during storm events. Overtopping observed during the January 2016 series of storms far exceeded the tolerable overtopping rate for safe pedestrian access. A 2-foot SLR scenario will nearly double the volume of water overtopping the seawall during a similar event.
- Coastal erosion also poses a high risk to public safety. Erosion behind the seawall has caused localized failures of the structure and undermined the Promenade. The most recent example of this occurred in December 2020 at the base of the Pier, resulting in temporary closure of the road and promenade while emergency repairs are made.
- Under a “No Action” scenario, in which the existing seawall experienced widespread failure, or was removed, coastal erosion would become the primary safety hazard to pedestrian access along Beach Boulevard. The geology of the coastal bluff offers very little resistance to wave attack and the active erosion processes would pose a hazard to pedestrians along the top of bluff and along the beach at the base of the bluff under this scenario.

Infrastructure

- Coastal erosion presents a high risk to the Beach Boulevard corridor. The corridor is highly sensitive to erosion damage because undermining of the pavement structure poses not only a safety risk, but also requires more extensive repairs after such an event. The duration of this repair work can last from several weeks to over a month in which access through the work area is restricted.
- Erosion hazard projections in 2030 for a “No Action” scenario (Figure 3-9) indicate the entire Beach Boulevard corridor would be lost to erosion along with the variety of infrastructure and uses supported by the corridor.
- Today, coastal flooding presents a moderate risk to infrastructure along Beach Boulevard due to the temporary disruption in service caused by flooding during the peak of the tide cycle (~2-3 hours).
- Coastal flooding presents a high risk for a 10-year return period event in combination 2-feet of SLR. Overtopping is expected to double for this event, which has the potential to cause more significant damage to the roadway and promenade.
- Erosion hazard projections in 2030 for a “No Action” scenario present a high risk to the utility systems along Beach Boulevard. The potable water, sanitary sewer, gas and other utilities would require a major investment (~$42.5M) to be relocated and equipped to function outside the 2030 erosion hazard zones as described in Section 5.2.

- Coastal flooding presents a low risk for underground utilities that are closed systems (potable water & gas) or overhead utilities (electrical power & communications). These systems are less sensitive to temporary flooding events.
- Storm drain systems are at high risk from coastal flooding and SLR, especially at the low-lying areas long Clarendon Road where high ocean water levels could reduce the conveyance capacity of gravity systems and actively managed systems.
- Erosion hazards under a “No Action” scenario also pose a high risk to the Pacifica Municipal Fishing Pier because damage to the pier wall would prohibit safe access for pedestrians to enjoy the aesthetic and recreational benefits of the Pier.

Environmental

- Marine resources in the project area includes beach and foredune areas south of the Pier and subtidal areas throughout. The beach and foredune resources are sensitive to long-term erosion due to the progressive loss of habitat areas in front of the seawall.
- Due to the presence of mostly developed and landscaped areas within the Project area, terrestrial resources are limited with low quality habitat for wildlife because it is predominantly hardscape and highly disturbed (ruderal) or maintained landscaped areas.
- Laguna Salada, the fresh-brackish lagoon wetland complex located just south and east of the Project area is the only sensitive natural community in the vicinity of the Project area. Consideration of direct and indirect impacts to the Laguna Salada wetland complex should be considered as part of the development of alternatives.
- Recreation resources such as the Promenade and Pier are at risk of damage, or complete loss due to coastal erosion under a “No Action” scenario. Loss of these resources would significantly reduce public access opportunities along the Project area. Under this scenario, a narrow and seasonal beach may be accessible to the public, though active erosion of the unprotected bluffs would also pose a safety concern.
- Visual resources consist of several ocean view corridors along the Project area. Coastal views are considered resources of public importance under the California Coastal Act and will warrant consideration when developing and analyzing project alternatives.

Economic Risk Assessment

- Both primary and secondary risks of “Doing Nothing” in the study area were evaluated in this assessment.
- Monetized primary impacts include impacts to properties, infrastructure (e.g. roadway, seawall, pier) and utilities within a hazard zone. It was estimated that about $94.6M of primary economic impacts would occur within the 2020-2030 time horizon. A total of $299.6M of primary economic impacts would occur by the end of the century.
- Monetized secondary impacts include business interruptions, debris cleanup, emergency response and minor repairs, and disruption costs. It was estimated that about $970k in

secondary economic impacts would occur in the 2020-2030 time horizon. A total of $5.6M of secondary economic impacts would occur by the end of the century.

- In total, approximately $95.6M of combined economic impacts would be expected within the 2020-2030 time horizon. Combined economic impacts would exceed $305M by the end of the century under a "No Action" scenario.

8.3 Next Steps

With a solid understanding of the existing conditions, hazards and potential risks over the project lifespan, the GHD team will develop alternatives that aim to balance the range of coastal resources, public and private property and infrastructure systems which exist along the Beach Boulevard corridor. The development and analysis of project alternatives will occur in parallel with additional community engagement activities including online outreach and public workshops to incorporate public feedback into the development and analysis of alternatives. Some of the key upcoming tasks include:

- Development of three project alternatives to be compared against No Action alternative
- Feasibility study analyzing (comparison and ranking) project alternatives including benefit cost-analysis
- Development of Project features and amenities toolbox
- Refinement of top three project alternatives
- Selection of preferred alternative
- Public outreach and stakeholder engagement

9. References

Barnard, P.L., Erikson, L.H., Foxgrover, A.C., Limber, P.W., O'Neill, A.C., and Vitousek, S., 2018, Coastal Storm Modeling System (CoSMoS) for Southern California, v3.0, Phase 2 (ver. 1g, May 2018): U.S. Geological Survey data release, https://doi.org/10.5066/F7T151Q4.

California Coastal Commission. 2018. California Coastal Commission Sea Level Rise Policy Guidance. Retrieved from: documents.coastal.ca.gov/assets/slr/guidance/2018/0_Full_2018AdoptedSLRGuidanceUpdate.pdf

California Ocean Protection Council (OPC). 2018. State of California Sea Level Rise Guidance 2018 Update. Retrieved from: opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

California Ocean Protection Council (OPC). 2020. Strategic Plan to Protect California's Coast and Oceans 2020-2025 to "Build Resiliency to Sea-Level Rise, Coastal Storms, Erosion and Flooding". Retrieved from: http://www.opc.ca.gov/webmaster/ftp/pdf/2020-2025-strategic-plan/OPC-2020-2025-Strategic-Plan-FINAL-20200228.pdf

Department of Water Resources (DWR), 2008. Flood Rapid Assessment Model.

Environmental Science Associates (ESA) (2016). Relating Future Coastal Conditions to Existing FEMA Flood Hazard Maps: Technical Methods Manual, Prepared for California Department of Water Resources and California Ocean Science Trust.

ESA (2018a). Sea Level Rise Vulnerability Assessment. Pacifica, CA. Draft January 2018.

ESA (2018b). Sea Level Rise Adaptation Plan. Pacifica, CA. Final Draft July 2018.

ESA (2020). City of Pacifica Beach Boulevard Infrastructure Resiliency Project, Wave Runup and Overtopping Risk Assessment. Progress Draft, December 2020.

ESA (2020b). Beach Boulevard Infrastructure Resiliency Project, Ecological Characterization: Recreation and Visual Resources. Memorandum October 9, 2020.

EurOtop (2018). Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., www.overtopping-manual.com.

Federal Emergency Management Agency (FEMA). 2011. Supplement to the Benefit Cost Analysis Reference Guide.

Griggs, Gary (2020). Geological Evaluation for the Beach Boulevard Seawall Replacement Project, Pacifica, California.

Haro, Kasunich and Associates, Inc (HKA), (2020a). Feasibility Level Geotechnical Engineering Investigation, Beach Boulevard Infrastructure Resiliency Project (BBIRP), Pacifica, CA. Draft October 2020.

HKA (2020b). BBIRP Earthquake Risk Assessment Technical Report. Final Draft December 2020.

IPCC. (2019). *The Ocean and Cryosphere in a Changing Climate.* Intergovernmental Panel on Climate Change.

\\ghdnet\ghd\US\San Luis Obispo\Projects\561\11213162\Tech\Task 1-4 - Multi Hazard Risk Assessment\Report\Public Review Rev 0 - 2021-05-17\BBIRP_MHRA_Public Review Draft_3-09-21.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	A. Holloway	B. Leslie		P. Henderson		01/15/2021
B	A. Holloway	B. Leslie		P. Henderson		03/09/2021
0	A. Holloway	P. Henderson		P. Henderson		05/17/2021

Appendix A

Wave Runup and Overtopping Risk Assessment (ESA 2020)

Final

CITY OF PACIFICA BEACH BOULEVARD INFRASTRUCTURE RESILIENCY PROJECT

Wave Runup and Overtopping Risk Assessment

Prepared for
City of Pacifica,
Under Contract to GHD Inc.

February 2021

Final

CITY OF PACIFICA BEACH BOULEVARD INFRASTRUCTURE RESILIENCY PROJECT

Wave Runup and Overtopping Risk Assessment

Prepared for
City of Pacifica,
Under Contract to GHD Inc.

February 2021

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900
esassoc.com

D202000164.00

TABLE OF CONTENTS

Wave Runup and Overtopping Risk Assessment for the City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Page

Appendices

List of Figures

Page

List of Tables

1 INTRODUCTION

The City of Pacifica (City) is undertaking the Beach Boulevard Infrastructure Resiliency Project (BBIRP or Project) in order to develop reasonable and feasible alternatives that will address significant deficiencies in the existing system. This report presents calculations of wave runup and overtopping along Beach Boulevard at a preliminary level to support an assessment of hazards and formulation of measures to mitigate the hazards. This report is a component of a larger multi-hazard risk assessment (MHRA) that is being prepared for the project by GHD Inc.

1.1 Background

This section describes the historical context of the wall system, the current flood and erosion management challenges facing the City and community, a summary of prior relevant work and studies that have been completed in the area, and the major technical data gaps that drive ongoing studies.

1.1.1 Problem Statement

The study area and existing shore armoring are shown in Figure 2-1. The Beach Boulevard Seawall (seawall) was constructed in two phases: the north seawall (north of the pier, constructed in 1984) and the south seawall (south of the pier, constructed in 1987). The pier includes an abutment with a seawall that protrudes toward the ocean: The pier abutment was constructed in the 1970s and by 1990 was structurally compromised by wave action. A new reinforced concrete wall was constructed immediately inboard of the original abutment wall in 1993, with remnants of the old wall left in place. The north seawall has experienced failures in multiple locations and is routinely overtopped by waves, posing a public health and safety risk for the City. Recently, the south seawall has been overtopped by wave runup more frequently. South of these seawalls is a “gap” in shore armoring approximately aligned with the seaward end of Clarendon Boulevard, near its intersection with the end of Beach Boulevard. The City of Pacifica moves beach sand to form a barrier to wave runup overtopping in this location. Storm drainage is then pumped across the sand barrier to the ocean. Immediately south is an earth berm that extends to Mori Point: This earth berm is owned by the City of San Francisco and is part of the Sharp Park Recreation Area.

In summary, the existing shore armoring is not reliable in terms of its structural integrity and is not functional in terms of the frequent overtopping by wave runup, while requiring ongoing maintenance to prevent structural failures from progressing. This exposure results in vulnerability to City assets, in particular, Beach Boulevard and a wastewater pipeline, as well as risks to private residential property and public safety. Beach Boulevard is frequently closed, restricting public access to the otherwise highly-used promenade and recreational pier. Long-term erosion and the presence of coastal armoring has also resulted in the progressive loss of beach and increased overtopping and wave loadings.

1.1.2 Summary of Existing Studies

Several prior studies with information pertinent to this Project have been completed. Appendix A presents a summary of relevant studies that address coastal hazards, vulnerabilities, and adaptation measures along Beach Boulevard and the San Mateo County coastline.

The recently completed Sea-Level Rise Adaptation Plan for the Local Coastal Program (LCP) Update describes the vulnerability of the system to sea-level rise and presents several adaptation options that were used to update policies in the LCP (City of Pacifica and ESA 2018). A vulnerability assessment was developed, followed by the development of a plan to adapt to sea-level rise.

A Regional Sediment Management Plan was completed in 2012 (Coastal Sediment Management Workgroup and ESA et al. 2015 that considered adaptation options to address chronic erosion issues along the shore.

As part of the above studies, alternatives to mitigate coastal hazards were analyzed with an economic analysis of costs and benefits. The analyses considered future sea levels, improved structural armoring, and beach nourishment, pertinent to this Project.

1.1.3 Primary Data Gaps

Although hazard mapping products developed by ESA (e.g., Coastal Resilience), USGS (e.g., CoSMoS), and others represent the geographic areas that are vulnerable to existing and future flooding and erosion, they are informed by modeling that is conducted at a regional scale, and therefore these maps are limited in their applications to planning-level assessments.

Appendix A presents a discussion on the primary data gaps that we identified after completing a review of the existing relevant studies. These data gaps include the following:

- Runup and overtopping
- Nearshore bathymetry
- Hardpan / Subsurface Conditions / Beach Thickness
- Sand Transport Rates/Sand Budget
- Sand Sources for Beach Nourishment
- Storm Drain System Capacities

1.2 Purpose and Scope of Study

As described on the City's website for the project, the BBIRP is being designed as a multi-objective (i.e., multi-benefit) solution to protect public infrastructure, recreational activities, numerous homes, businesses, and the community at large, from further impacts due to continued coastal erosion. The Project aims to replace the current seawall and outdated infrastructure while building climate resilience into the most vulnerable segment of the City's shore.[1]

The City considers the project critical to the public health and safety of the citizens and visitors in and around the historic West Sharp Park neighborhood.

The City's objectives for the project include the following:

- Protect the West Sharp Park homes and businesses from overtopping, coastal erosion, and future sea level rise
- Secure public infrastructure of roads and underlying sewer mains, storm drains, and gas and electrical conduit
- Improve public access to the beach
- Protect recreational use on the Promenade for walkers, joggers, cyclists, and others

The above objectives frame the range of solutions, which include balancing recreational needs with flood and erosion protection of public and private property assets. In consideration of projected sea-level rise, these objectives become even more important and challenging to balance. Although a range of factors need to be considered in the overall MHRA and development of alternatives, this report is focused on the issues of flooding for existing and future conditions with sea-level rise. The scope of the study presented by this report includes the following:

- Quantify the wave runup and overtopping,
- Estimate how hazards would change with sea-level rise, and
- Summarize prior studies pertinent to coastal hazards and identify data gaps.

1.3 Structure of Report

The report is structured as follows:

- **Section 2 – Project Setting:** An overview of the physical context of the project site, including its history and landscape. This section begins with a brief discussion of the project site, including elevations and site features, followed by a summary of the coastal hydrology and geomorphology, and finally a description of relevant climate change issues and sea-level rise scenarios used in the study.

[1] City of Pacifica, Beach Boulevard Infrastructure Resiliency Project website: https://www.cityofpacifica.org/depts/pw/engr/current_projects/beach_boulevard_infrastructure_resiliency_project/default.asp#Background

- **Section 3 – Wave Runup & Overtopping for Baseline Conditions:** The technical analysis methods and results for the coastal hazards assessment are described, including:
  - An overview of the technical approach that provides context of the parameters and methods.
  - A brief description of the still water level analysis used to estimate extreme still water level as a function of recurrence.
  - The approach to constructing a composite series of annual maximum wave and water level events to be applied to the wave runup analysis, including wave transformation and compilation of multiple data sources.
  - The analysis used to construct the nearshore profiles for existing and future conditions with sea-level rise.
  - The wave runup analysis, including a summary of method used and the results of the potential maximum wave runup and the landward extents calculations for existing and future conditions with sea-level rise.
- **Section 4** – Conclusions & Recommendations: This section summarizes the primary findings and conclusion of the study.
- **Appendix A** – Summary of prior work and list of apparent data gaps.
- **Appendix B** – Estimated surf zone elevation used for wave runup and overtopping calculations.

2 PROJECT SETTING

This section presents information on the physical context of the project site, including its history and landscape. This section begins with a brief discussion of the project site, including elevations and site features, followed by a summary of the coastal hydrology and geomorphology, and finally a description of relevant climate change issues and sea-level rise scenarios used in the study.

2.1 Project Study Area

The Study Area is shown in **Figure 2-1**. The Study Area is described in the Vulnerability and Adaptation reports (City of Pacifica and ESA, 2018) within the Sharp Park, West Fairway Park and Mori Point planning subarea. The study area is also described in the Coastal Regional Sediment Management Plan, San Francisco Littoral Cell (CSMW and ESA 2015) within the Beach Blvd subarea, which extended 5,200 feet north of Paloma to the Milagra Drain, just south of the RV Park. These and other pertinent documents are summarized in Appendix A.

SOURCE: City of Pacifica

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-1
Site Location and Project Study Area

2.1.1 North Wall

The North Wall seawall system is a reinforced-earth retaining wall above a large rock revetment that extends approximately 0.25 miles from the Shoreview Neighborhood (generally aligned with Bella Vista Avenue, one block north of Paloma Avenue) south to the Pier (near Santa Rosa Avenue). Landward of the wall is hardscape consisting of a walkway (aka The Promenade), followed by Beach Boulevard, which is one-way southbound, with another narrow sidewalk fronting residential properties (single family homes, apartments and condominiums). The distance from the seawall to the land side of Beach Boulevard is about 40 feet.

Signs warn of wave overtopping and Beach Boulevard is cordoned off during most spring tides in the winter owing to unsafe conditions resulting from extensive wave overtopping. The hardscape includes low walls to mitigate wave runup, integrated in to benches (**Figure 2-2**). Most residents have walls in their front yards and place barriers (boards or sand bags) at walkways and driveways to reduce direct impact of wave overtopping to the homes. There is little to no beach during the winter and the one stairway to the shore is degraded and blocked by large boulders and waves.

The reinforced earth portion (the upper wall) has failed twice (2001 and 2016), requiring construction of cast-in-place reinforced concrete repairs. Voids below the promenade form frequently, presumably resulting from piping of soils through the wall by direct wave action and return flow from wave runup overtopping: Repairs consist of filling the voids and repaving the walkway. The rock revetment has experienced settling and displacement over the years requiring maintenance and repairs in the form of additional rock placement and the use of concrete grout along the backside of the revetment.

SOURCE: City of Pacifica

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-2
North Wall, Looking South

2.1.2 Pier Wall System

The pier includes an abutment with 4 straight segments that extend seaward: two are perpendicular to Beach Boulevard and two form a point, like a ship's bow, under the pier deck (**Figure 2-3**). Constructed in the 1970s, the wall was penetrated by waves, forming a cave and a beach under the abutment deck. A new reinforced concrete wall, extending vertically from the deck to the underlying clay hardpan was constructed in 1993. The new wall was constructed inboard of the original wall, and the remnants of the original wall are visible and continue to degrade.

SOURCE: ESA Dec 18 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-3
Pier Abutment, Looking South

The pier abutment does not connect to the north seawall, and the scour of underlying soils has resulted in repeated sinkhole formation and pavement failure and repair. An erosion cavity has formed, and the pier and Beach Boulevard are presently closed (**Figure 2-4**. December 18, 2020).

SOURCE: ESA, December 18 2020

NOTES: Closure of the Pacifica Pier and Beach Boulevard at Santa Rosa Street due to undermining of Promenade by Wave action

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-4
Closure of the Pacifica Pier

2.1.3 South Wall

The south seawall is a reinforced concrete gravity structure, constructed in 1987 (**Figure 2-5**). It also includes a rock revetment which was "cut into" the underlying clay "hardpan" (**Figure 2-6**). A public park with parking and open space exists landward of the south seawall. The open space was a grassy picnic area, but has been converted to sand by extensive wave overtopping and sand transport (**Figure 2-7**). In this location, Beach Boulevard jogs landward with residential properties set farther inland. However, this area was part of Laguna Salada (a coastal lagoon now limited to the vicinity of the Sharp Park Golf Course, to the south) and the land elevation is below beach level and hence subject to flooding. The City pumps rainfall runoff from this area to the ocean, and other runoff drains to the Golf Course, where it is also pumped to the ocean.

SOURCE: City of Pacifica

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-5
Photograph Showing Construction of the South Wall

SOURCE: ESA, October 2020

NOTES: Rock Revetment and exposed hardpan at south seawall. The hardpan is located at the shoreline, and is the dark mass in the foreground and marked by tan water in the middle of the picture, where eroded sediment is in suspension.

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-6
South Wall

SOURCE: ESA, December 17 2018

NOTES: The grassy park has become sandy owing to wave overtopping and deposition of course sands and gravels.

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-7
Park Behind South Wall

2.1.4 South Gap

The south gap is a short length between the end of the southern seawall and the earth berm (aka levee), located at the end of Clarendon Road (**Figures 2-8** and **2-9**). The gap is similar in width to Clarendon Road and includes an access ramp to the beach presently buried by sand. The sand was placed by wave runup and by the City to form a wave barrier. Without the mounded sand, wave runup would reach Beach Boulevard at the Clarendon Road intersection, which has a lower elevation than the beach. Rainfall runoff is pumped to the ocean past the sand barrier.

SOURCE: ESA Jan 11 2017

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

NOTES: The rocks in the foreground are part of the Sharp Park Levee. The blue hose is for pumping rainfall runoff to the ocean. The shore-perpendicular railing is the southern end of the south wall, and part of a beach access ramp structure. The railing has been removed and the access structure is buried in sand.

Figure 2-8
South Gap Looking North

SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-9
South Gap Looking South

2.2 Coastal Hydrology

This section summarizes the relevant information for the coastal water levels and waves of the project site.

2.2.1 Water Levels, Tides, and Datums

The tides at San Francisco Bay and Pillar Point were used to interpolate and estimate the tide datum at the project location.

Table 2-1 presents the published tidal datums for San Francisco Station (NOAA Sta. 9414290) and Pillar Point Harbor Station (NOAA Sta. 9414131). The tidal datums for the project site were linearly interpolated between these two stations. Note that the maximum still water level of 8.7 feet NAVD was observed during the El Niño winter of 1982-1983, which is the storm of record for much of the California coast.

TABLE 2-1
PROJECT TIDAL DATUM BASED ON SAN FRANCISCO AND PILLAR POINT HARBOR STATIONS

Datum	Description	San Francisco, Sta. 9414290	Pillar Point Harbor, Sta. 9414131	Project Site, Sharp Park[a]
Max Tide	Highest Observed Tide	8.72	--	--
HAT	Highest Astronomical Tide	7.32	7.32	7.32
MHHW	Mean Higher-High Water	5.90	5.64	5.75
MHW	Mean High Water	5.29	4.99	5.12
MTL	Mean Tide Level	3.24	3.07	3.14
MSL	Mean Sea Level	3.18	3.03	3.09
MLW	Mean Low Water	1.19	1.15	1.17
MLLW	Mean Lower-Low Water	0.06	0.04	0.05
NAVD88	North American Vertical Datum of 1988	0.00	0.00	0.00
Min Tide	Lowest Observed Tide	-2.82	--	--
LAT	Lowest Astronomical Tide	-1.87	-2.07	-1.98

NOTES:
[a] Value interpolated between San Francisco and Pillar Point Harbor Datums
SOURCE: NOAA, 2020

2.2.2 Wave Climate

Pacifica is exposed to large swells and storm waves generated in the Pacific Oceans. Winter conditions are characterized by very large swells (frequently exceeding 10 feet and occasionally exceeding 30 feet) with long wave lengths (wave periods typically greater than 12 seconds), resulting in very powerful breaking waves, currents, scour and dangerous conditions. Summer conditions are generally characterized by relatively smaller wind waves associated with predominate northwesterly winds with long-wavelength swell from the southern hemisphere. In general, the Project area is considered to have a strong wave exposure, as evidenced by the pier deck elevation, designed to be just above the crests of breaking waves and sloping upward with distance offshore. The waves reaching the shoreline are therefore limited by the offshore depths. Larger waves reach the shoreline during high tides. The wave heights at the shoreline are therefore expected to increase with sea-level rise.

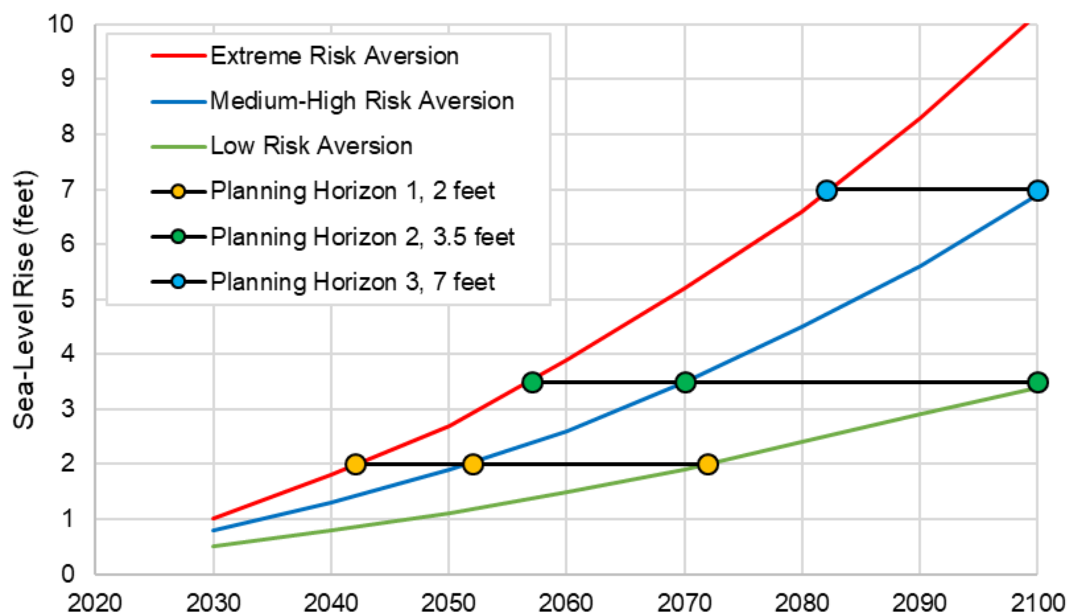
The nearshore wave climate has been quantified via modeling by the Coastal Data Information Program (CDIP). This modeling was accomplished along the California coast for the Federal Emergency Management Agency (FEMA) in order to inform coastal flood studies, and the data are now available to the public. ESA used these data to drive the wave runup and overtopping calculations, described below.

2.3 Sea-Level Rise and Selected Scenarios

To address the expected requirements of the California Coastal Commission (CCC), we initially considered a range of sea-level rise amounts over time, consistent with current state sea-level rise guidance (e.g., OPC 2018, CCC 2018). However, the analysis to date has been focused on up to three feet of sea-level rise, which is the approximate maximum practicable amount that the existing seawall system is expected to accommodate, pending further analysis to assess the performance of a preferred alternative. This assessment is consistent with the Adaptation Plan (City and ESA 2018) which indicates structural renovation of the Beach Boulevard shore armoring alone is not likely to be sustainable beyond 2 to 3 feet of sea-level rise. Therefore, additional adaptive actions beyond the scope of this wave runup overtopping analysis are anticipated.

The state guidance includes three projections associated with low, medium-high, and extreme risk aversion projections to be used accordingly for projects that have high to low levels of adaptive capacity, respectively. The low risk aversion projection is considered the “likely” range of sea-level rise and is associated with a 17% chance of occurrence. The medium-high risk aversion projection is associated with a 0.5% chance of occurrence and is considered a conservative approach for projects with relatively low adaptive capacity. The extreme risk aversion is a worst-case scenario without an assigned probability and is based on the maximum physically plausible sea level rise increase due to rapid ice sheet loss on Antarctica.

Figure 2-10 presents the state’s sea-level rise projections for each risk aversion scenario.



SOURCE: OPC 2018, CCC 2018

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 2-10
Sea-Level Rise Projections and Selected Scenarios

3 WAVE RUNUP & OVERTOPPING FOR BASELINE CONDITIONS

The purpose of this study is to assess the vertical and horizontal extents of wave runup and coastal hazards at the project site for existing and future conditions with sea-level rise over the expected life of the development. The results are preliminary and provided to develop measures and alternatives to mitigate the wave hazards.

3.1 Nearshore Profiles and Seawall Geometry

3.1.1 Existing Seawall Geometries

The seawall is configured in three primary geometries within the study area. The northernmost portion of the seawall, labeled the North Wall in this report, stretches between Paloma Ave and Santa Rosa Ave. In this section, the wall is fronted by riprap toe armoring that begins at approximately 0 feet NAVD88 and extends up the wall to an elevation of approximately 17 feet NAVD88. Lower portions of the toe armoring are periodically covered by sand and water, depending on the season and wave conditions. The North Wall extends above the rock revetment to a crest elevation that varies from 25.5 to 31.5 feet NAVD88. The wall is backed by a wide sidewalk called the Promenade, adjacent to Beach Boulevard. The wall elevation varies and is lower and close to street level at the northern end.

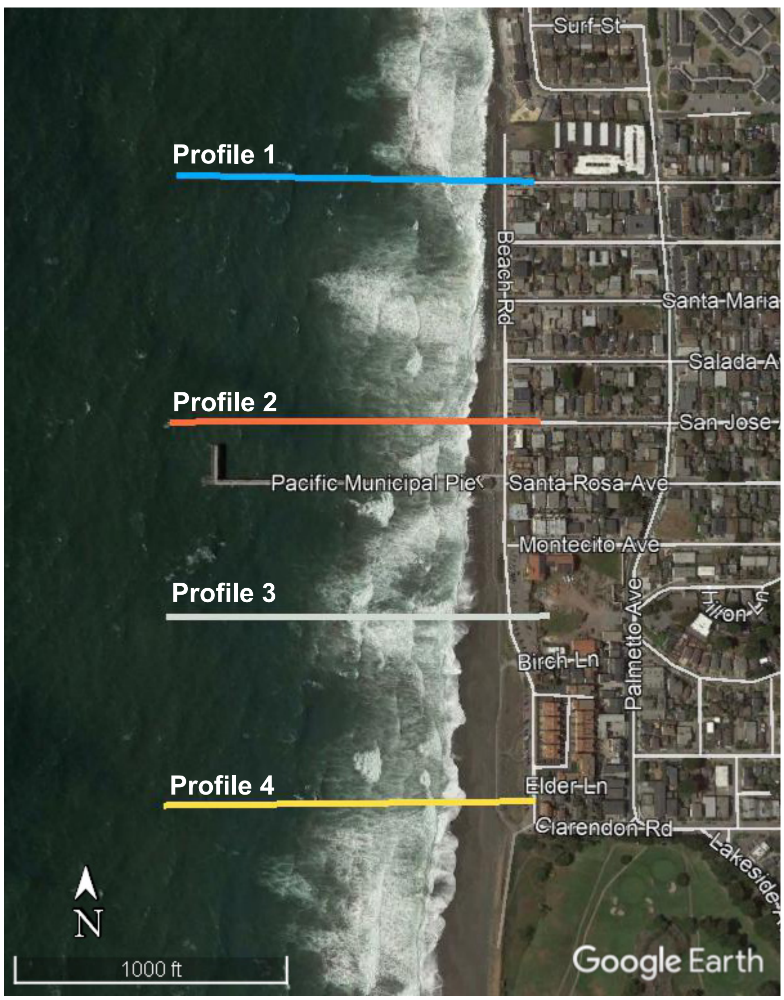
The Pacifica Pier abutment at the intersection of Beach Boulevard and Santa Rosa Ave consists of the vertical reinforced concrete wall without toe armoring. Remnants of the original steel sheet pile wall and soil cement backfill (constructed in the 1970s) can be seen, whereas the reinforced concrete wall (1993 repair) is not visible.

South of Montecito Ave, the beach widens from narrow (or non-existent) to approximately 30 feet wide. A rock revetment was installed in front of the seawall and is exposed in the winter. The South Wall has similar crest elevations as the North and Pier sections of the seawall.

3.1.2 Estimation of Existing Nearshore Profiles

Figure 3-1 presents the locations of four transects used in this study to conduct wave runup modeling across the surf zone and over the seawall. **Figure 3-2** shows how a composite of data sets were used to construct the profiles (Profile 1 shown): NOAA bathymetry data for the offshore, ESA estimated bathymetry through the surf zone, and GHD LiDAR for the beach, coastal structure (e.g. seawall), and the backshore. A detailed description of the assumptions and methods to estimate the shore profile through the surf zone is provided in Appendix B.

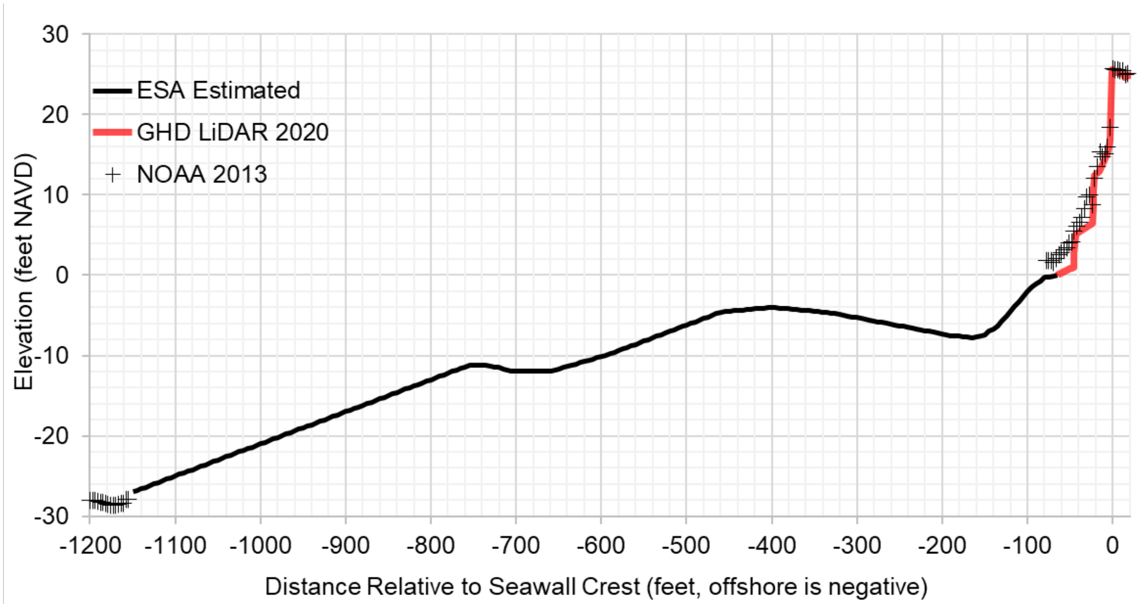
The nearshore surf zone at the project site is spatially and temporally dynamic, undergoing long-term changes, seasonal changes, and event changes. Although seasonal and event changes are reversible as sand moves along and on/off shore, the long-term changes are generally net-erosive because the seawall prevents erosion of the backshore, inducing profile changes. Shallow hardpan observed at the site, and excavated in some areas, affects the limits of the changes to some degree. Because the area is exposed so much wave energy, persistent rip currents develop in the area and scour through the sand, which provides a locally deeper area where larger waves can traverse offshore bars and impact the seawall. The rip current channels become larger and more distinct through the winter and into the spring due to the cumulative effects of elevated wave exposure. There is a tendency for development of persistent rip currents in the vicinity of the pier, in the vicinity of the 2016 seawall failure, and in the vicinity of the discontinuity of the shore protection at north end. South of the pier are typically two rip current channels that are not as location-specific, but which occur regularly (based on observations). A shore parallel trough deepens as the beach recedes during the winter and feeds into the rip currents (Figure 7 of Appendix B shows the rip current and channel patterns). Moving into the summer, these features become less distinct as sand settles and fills in the channels.



SOURCE: ESA 2020, Google Earth

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-1
Beach Profiles Along the Shore Used in this Study



SOURCE: ESA 2020, GHD 2020, NOAA 2013

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-2
Composite Beach Profile

3.2 Description of Methods

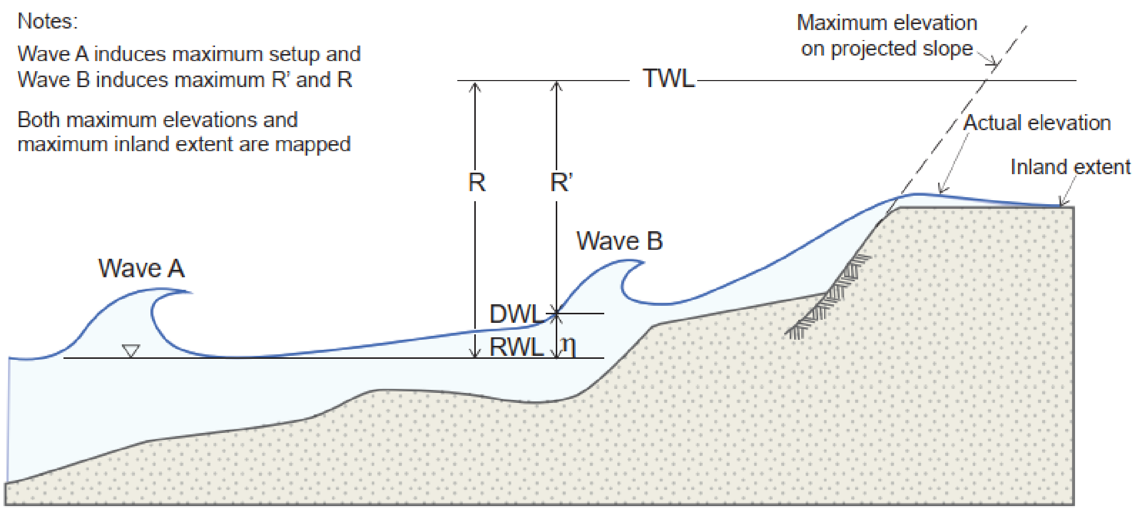
The technical approach applied to this study is based on guidelines established by the USACE (1984; 2003) and FEMA (2005), and as recommended by the CCC (2018) for assessing the coastal hazards as part of the CDP application process. Estimating the extreme wave runup heights and landward extents at a specific site requires information on the tidal water elevations and storm surge, wave height and period offshore of the project site, and the shape of the shore, including the elevations through the nearshore, the surf zone, the beach, and the developed backshore.

Figure 3-3 presents a definition sketch of the wave runup parameters from the *Technical Methods Manual (TMM) for Relating Future Coastal Conditions to Existing FEMA Flood Hazard Maps* prepared for the California Department of Water Resources and the California Ocean Science Trust (Battalio et al. 2016). The sketch illustrates the concepts that are used to determine the greatest wave runup hazards at a project site, consistent with the FEMA (2005) guidance:

1. "Wave A" represents the offshore wave conditions, which induces the maximum wave setup (i.e., a super-elevation of the water surface across the surf zone) that increases the depths above the reference water level (RWL). The RWL is similar to the still water level (SWL) that is often used in the literature to refer to the water level not affected by the incoming waves.
2. The relatively deeper water in the surf zone, referred to as the dynamic water level (DWL), allows depth-limited waves ("Wave B") to propagate closer to shore.
3. Wave B breaks in the surf zone and induces the maximum runup on a projected backshore slope, shown as the dashed line. The potential maximum runup elevation also called the total

water level (TWL), is used to define the FEMA 100-year base Flood Elevation (BFE). In subsequent discussion and figures, this potential elevation is also called *potential TWL*.

4. The actual wave runup (if greater than the backshore elevations) will overtop the barrier and rush landward to a location of maximum inland extent. This is another parameter that is mapped as a hazard zone by FEMA. In subsequent discussion and figures, this is called the *inland extent*.



TWL = Total water level = RWL + R

RWL = Reference water level ~ still water level

DWL = Dynamic water level, typicallly 2% exceedence ~ mean setup (aka "static") + 2x standard deviation

η = 2% setup at RWL shoreline, wave A

R = runup, including setup, above RWL, wave B typically on projected slope above back shore

R' = runup, not including setup, above RWL, wave B typically on projected slope above back shore

SOURCE: Battalio et al. (2016)

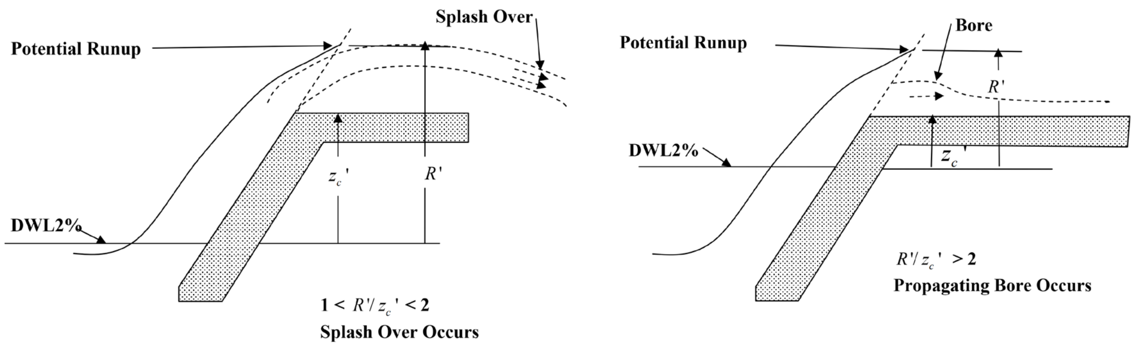
NOTES: Maximum elevation on the projected slope is described as the potential maximum runup in this analysis

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-3
Definition Sketch of Wave Runup Parameters

The use of the two wave runup extent measures called here *potential TWL* and *inland extent* is beneficial to inform flood plain management, planning, and design. The potential TWL is a theoretical maximum wave runup that could be achieved if the area was filled. FEMA uses the potential TWL to define the FEMA base flood elevation for a V-zone (i.e., high-velocity hazard zone used by FEMA), which indicates how high a living or working space would need to be in order to avoid damages, presuming that fill or another obstruction may be located in the vicinity and cause the runup to extend higher (FEMA 2005). The inland extent is the landward limit of wave runup, thus defining the coastal flood plain. The height and extent of runup depends on the shore profile, which often changes with development. Providing the potential TWL and inland extent provide the potential vertical and horizontal dimensions of the wave runup hazard, where anything located within the space defined by these two dimensions may be subject to damage or injury during the flood event.

Figure 3-4 presents a sketch of wave overtopping parameters at a barrier from FEMA (2005), which are used in the computation of the landward extents of the wave runup. The schematic illustrates how splash and bore water surfaces relates to the potential maximum wave runup. Note that the computed TWL is the potential maximum wave runup and may exceed water's actual elevation.



a) Conditions for Splash Overtopping

b) Conditions for Bore Propagation Overtopping

SOURCE: FEMA (2005)

NOTES: Potential runup is described as the potential maximum runup in this analysis. Potential runup is typically defined as the height above the reference water level, and corresponds to the potential TWL when the elevation of the reference water level is added

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-4
Definition Sketch of Wave Runup and Overtopping Parameters at Barrier

3.2.1 Selection of Hindcast Data

Hindcast data for waves (e.g., height, period, etc.) and tides were collected from two primary sources, as described below.

1960 -2009

As part of FEMA's *Open Pacific Coast Flood Study*, a 50-year hourly offshore wave hindcast was developed for the period from 1960 to 2009 (FEMA 2015). The offshore wave hindcast was completed by modeling deepwater wave generation resulting from historic storms and wind fields over the Pacific Ocean. The deepwater wave conditions were transformed to nearshore using the SIO CDIP transformation coefficients described in Section 3.3.2. FEMA (2015) presents the annual maximum wave events at each location where wave runup is computed. Although runup was computed along a transect at the project site, the annual maximum wave event data are not provided.

2000 – 2020

Nearshore wave characteristics, including the significant wave height, H_S, and peak wave period, T_P, were furnished by the Coastal Data Information Program (CDIP), Integrative Oceanography Division, operated by the Scripps Institution of Oceanography (SIO). Hourly wave height and period data were downloaded from the CDIP Monitoring and Prediction (MOP) System for a location immediately offshore of the project site at a water depth of 15 meters. The MOP data are based on detailed spectral wave modeling and field data collection programs that have been developed into an efficient real-time conversion of offshore conditions to nearshore at virtual

MOPs located up and down the coast (O'Reilly et al. 2016). The data span the time period 2000 to 2020.

3.2.2 Compilation of Annual Maximum Data

Annual maximum event data were compiled and normalized so that all wave height and period data used in calculations were in the form of the unrefracted deepwater wave height and period. To accomplish this, the wave height-period events were deshoaled using a two-step process. The first step is completed by computing the wave length of each wave event at the 15 meter (49 feet) depth contour using the dispersion relation, shown by the equation

$$L = \frac{gT^2}{2\pi}\tanh\left(\frac{2\pi h}{L}\right) \tag{1}$$

where L is the wave length in feet, T is the wave period in seconds, h is the water depth in feet, and g is the acceleration of gravity assumed to be 32.2 feet per second squared. The second step is to deshoal the waves and obtain the unrefracted deepwater wave height, H_0', using the equation

$$H_0' = H\sqrt{\left[1 + \frac{4\pi h/L}{\sinh(4\pi h/L)}\right]\tanh\left(\frac{2\pi h}{L}\right)} \tag{2}$$

where H is the shoaled wave height in feet. The ratio H/H_0' is known as the shoaling coefficient, K_S (Goda 1985).

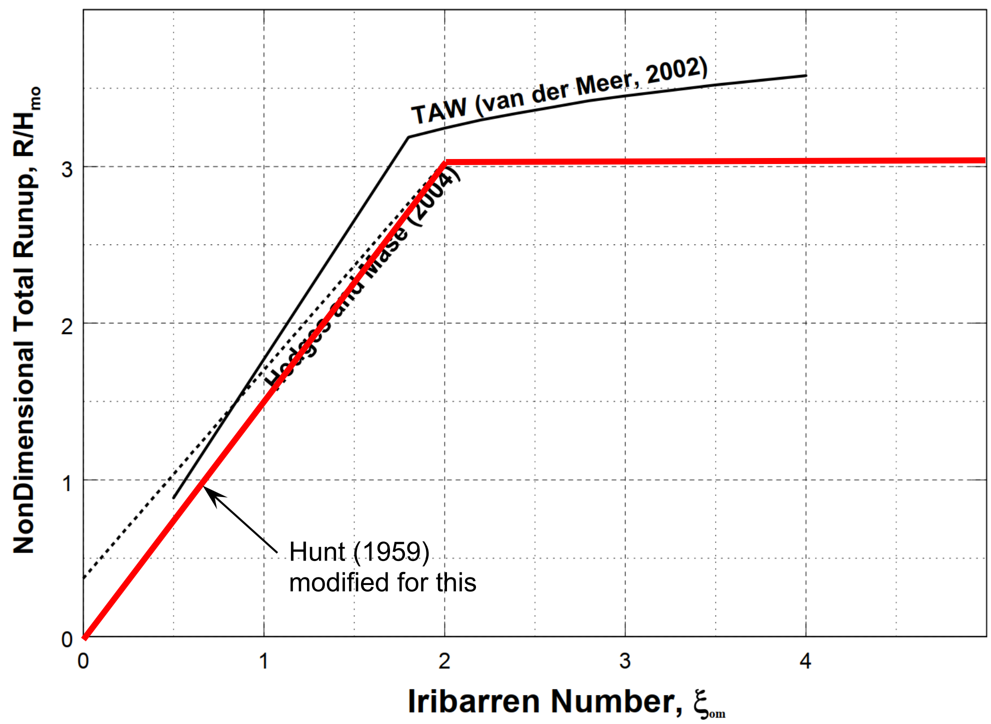
These steps are critical to the analysis because the wave runup methods and their components require using the unrefracted deepwater wave height to correct for potential overestimated wave heights for extreme events at the 15-meter depth contour using CDIP's transformation coefficients.

3.3 Wave Runup

This section presents the wave runup analysis, including a brief overview of the methods used to compute the runup, followed by results of the maximum potential wave runup at the seaward edge of the project site, and finally, a description of the landward extents of the wave runup.

3.3.1 Wave Runup Method Used

The annual maximum wave event parameters (e.g., significant wave height, wave period, and coincident still water level) were used as inputs to a runup program that is valid for a wide range of profile configurations. This runup program used the Composite Slope Methodology and was developed by ESA (previously Philip Williams and Associates, or PWA) and consistent with FEMA guidelines, was used to iteratively calculate the dynamic water surface profile along with each representative shore profile, the nearshore depth-limited wave, and the runup elevation at the end of the profile. The dynamic water surface is the water level at the coast that is driven by sets of waves (or wave groups) that cause super-elevation of these water levels. Wave runup is computed using the method of Hunt (1959), which is based on the Iribarren number (also called the surf similarity parameter), a non-dimensional ratio of shore steepness to wave steepness. The runup is limited to a maximum of about three times the incident wave height, which is generally consistent with other methods that rely on the Iribarren number, as depicted in **Figure 3-5**. While there are a variety of runup equations (including TAW, which is used in EurOtop 2018), they provide a range of results, and hence the Hunt (1959) method was selected because it is the simplest and most direct.



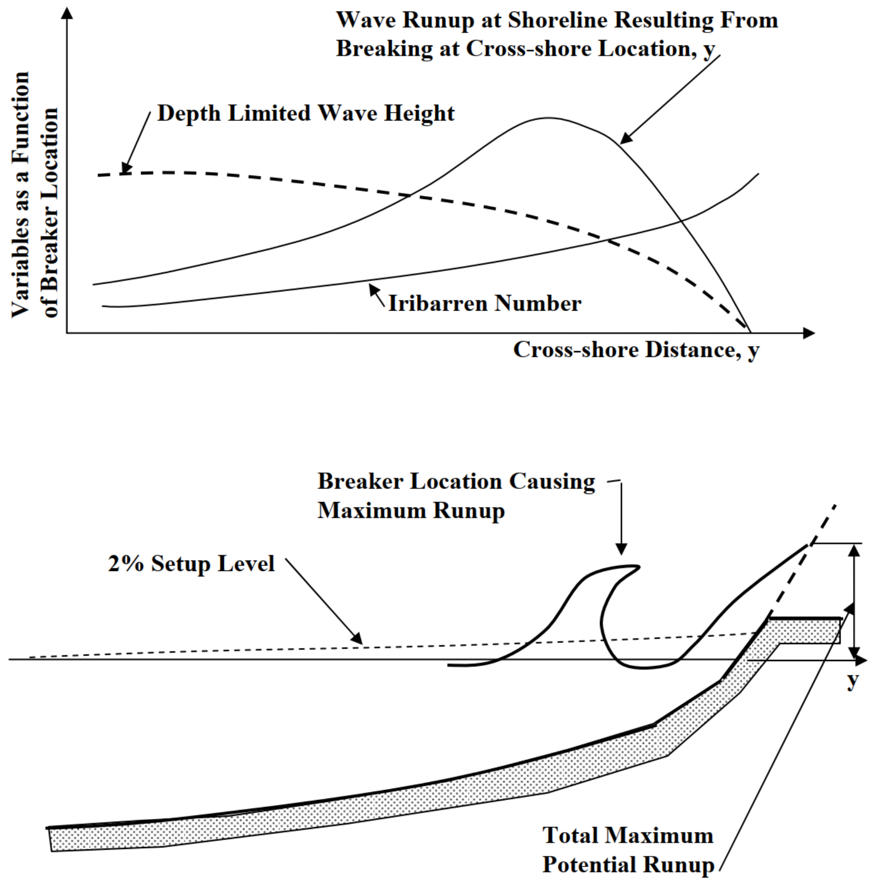
SOURCE: Modified from FEMA (2005)

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-5
Non-dimensional Wave Runup as a Function of Iribarren Number for Different Wave Runup Models (Hunt 1959 Used in this Study)

The program also uses the Direct Integration Method (DIM) to estimate the static and dynamic wave setup and resulting high dynamic water surface profile (FEMA 2005; Dean and Bender 2006; Stockdon et al. 2006). The methodology is consistent with the FEMA Guidelines for Pacific Coastal Flood Studies for barrier shores, where wave setup from larger waves breaking farther offshore and wave runup directly on barriers combine to generate the highest total water level and define the flood risk (FEMA 2005). This program also incorporates overland and structure surface roughness, which act as friction on the uprush of the waves, thus reducing the extent of wave runup. This method also uses a composite slope technique as described by Saville (1958), and outlined in the *Shore Protection Manual* (USACE 1984) and *Coastal Engineering Manual* (USACE 2003).

Figure 3-6 presents a schematic of the composite slope methodology and parameters. The largest waves incident to the site will set up the dynamic water level (shown as 2% water level), which then allows for smaller depth-limited waves to propagate further toward shore and result in the maximum wave runup at the shoreline. As described above, the process is iterative and requires stepping through the profile across the entire surf zone to the shoreline to find the maximum wave runup.



SOURCE: FEMA (2005)

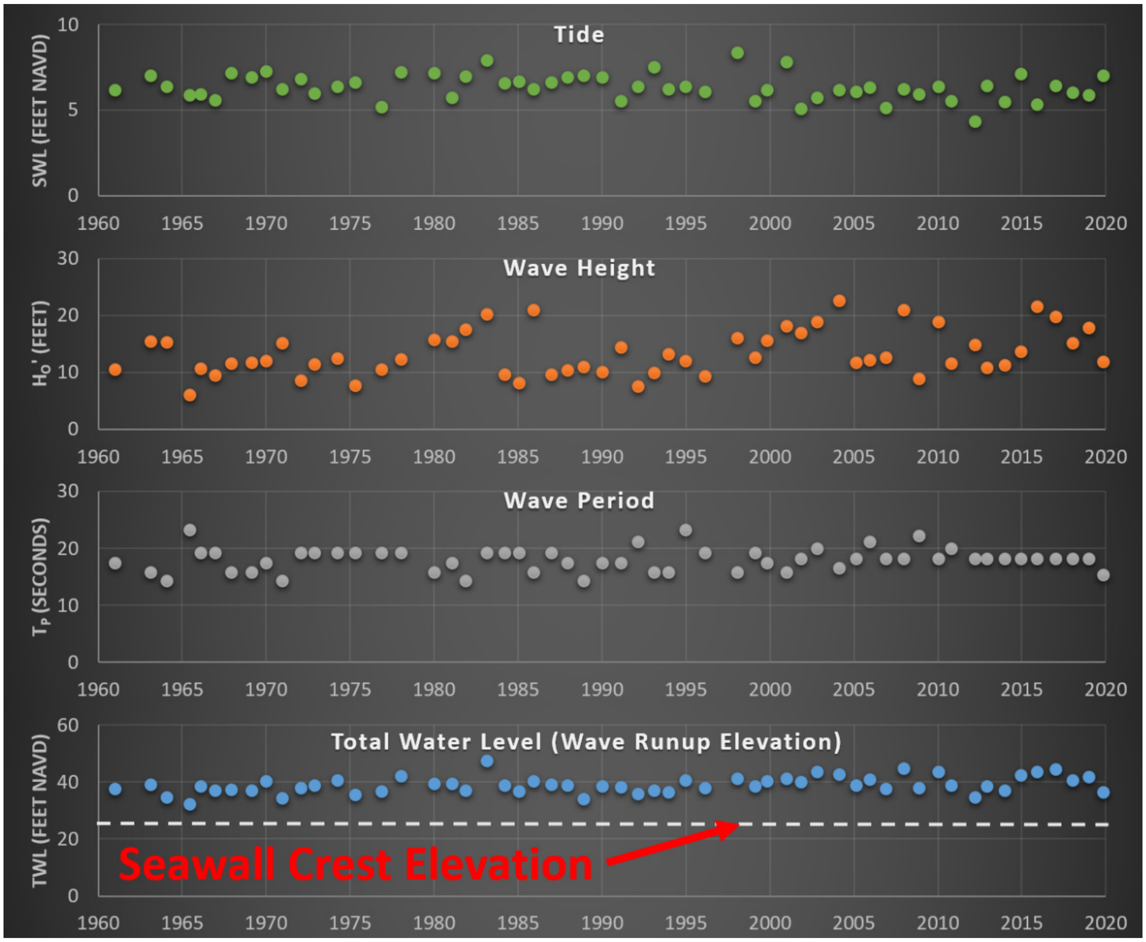
City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-6
Example of Composite Slope Parameters and Methodology:
Maximum Runup Caused by Intermediate Depth-Limited Wave

3.3.2 Potential Wave Runup Elevations

The potential maximum runup elevation, also referred to as the total water level (TWL), was computed using the methods described above for 57 annual maximum events over 61 years of data from 1960 to 2020.

Figure 3-7 plots these annual events in time, along with the computed wave runup elevation, called the Total Water Level, because the wave runup height is added to the tide level. The nominal seawall crest elevation is shown as a dashed line to provide context: All the annual maximum events have total water levels higher than the seawall crest, indicating wave runup exceeds the crest, which is called wave overtopping. Hence, the calculations predict that wave overtopping is a frequent (at least annual) occurrence. Note also that the maximum TWL elevations do not necessarily coincide with the maxima of any of the other parameters (tide and wave conditions). Hence the TWL "response" extreme values are distributed differently than these "forcing" parameters, and therefore the "100-year" wave or tide does not necessarily produce the "100-year" wave runup or TWL (FEMA 2005, Garrity et al. 2007).



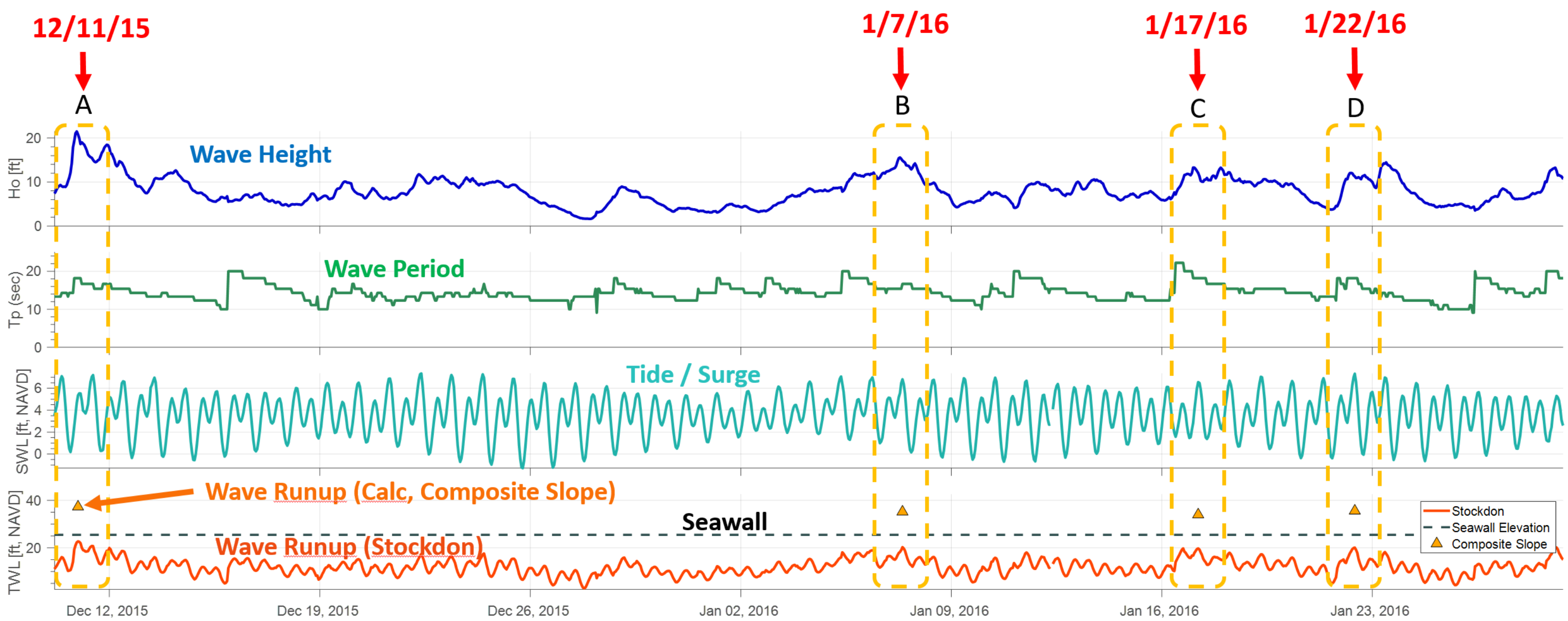
SOURCE: FEMA 2020, Scrips 2020.

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-7
Composite Time Series of Annual Max and Total Water Level

Figure 3-8 compares the data for December 2015 and January 2016 when the north wall was damaged and extensive wave overtopping is documented. The bottom strip chart shows TWL computed two ways: with the Stockdon Equation and with the Composite Slope Methodology (FEMA 2005). The Stockdon Equation computes wave runup on beaches and is often used as an "index" for wave runup on armored and other shores because of its ease of use and its inclusion of important parameters. The Composite Slope Methodology (Section 3.3.1) is computationally more intensive but also more accurate, especially for steep, armored shores. TWL was computed with the Composite Slope Method for four periods of high TWL associate with the high overtopping and seawall damage during the 2105-2016 winter. The computed elevations approached 40 feet NAVD, which is more than 10 feet above the nominal seawall crest. Based on the observations of water exceeding 40 feet NAVD, the calculations may under-estimate the maximum TWL. Note that the TWL using Stockdon, which is used in previous studies, never exceeds the seawall crest elevation; the composite slope method shows TWL exceeding the seawall crest elevation during observed events where the seawall was overtopped.

This page intentionally left blank



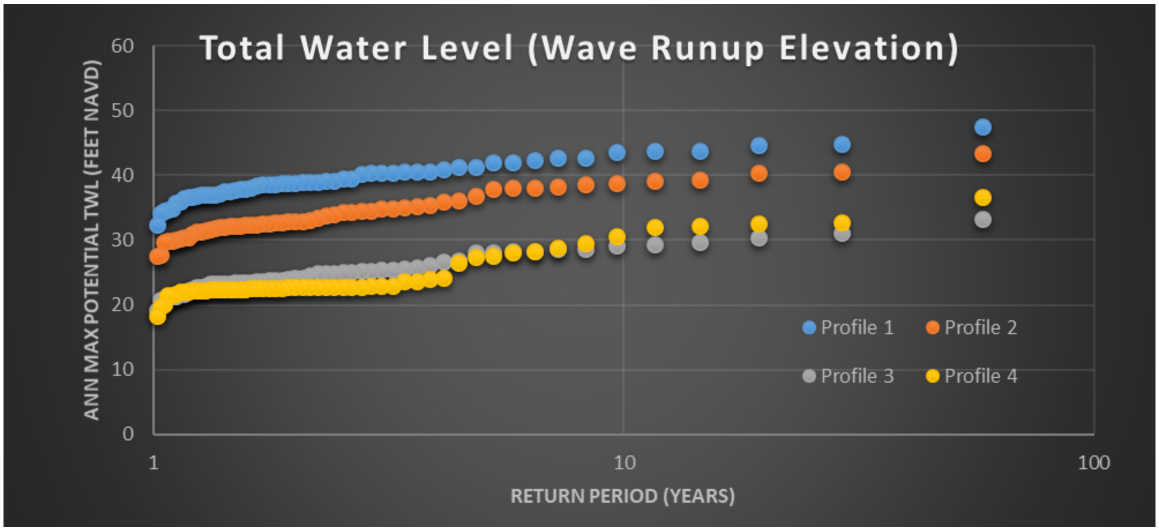
SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-8
Timeline of Runup Events from December 2015 to January 2016 Leading to Seawall Damages: Waves, Water Levels and Runup

This page intentionally left blank

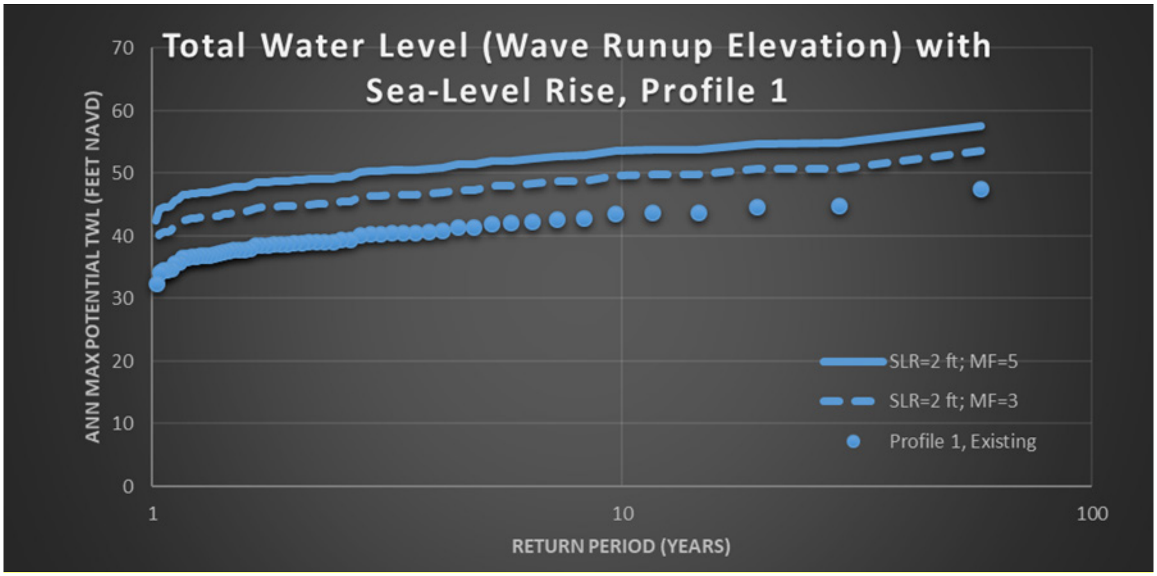
Figure 3-9 plots the computed annual extreme TWLs for each of the four seawall profiles. The north seawall (profiles 1 and 2) are computed to have higher TWLs than the south seawall (profiles 3 and 4).



SOURCE: City of Pacifica Beach Boulevard Infrastructure Resiliency Project

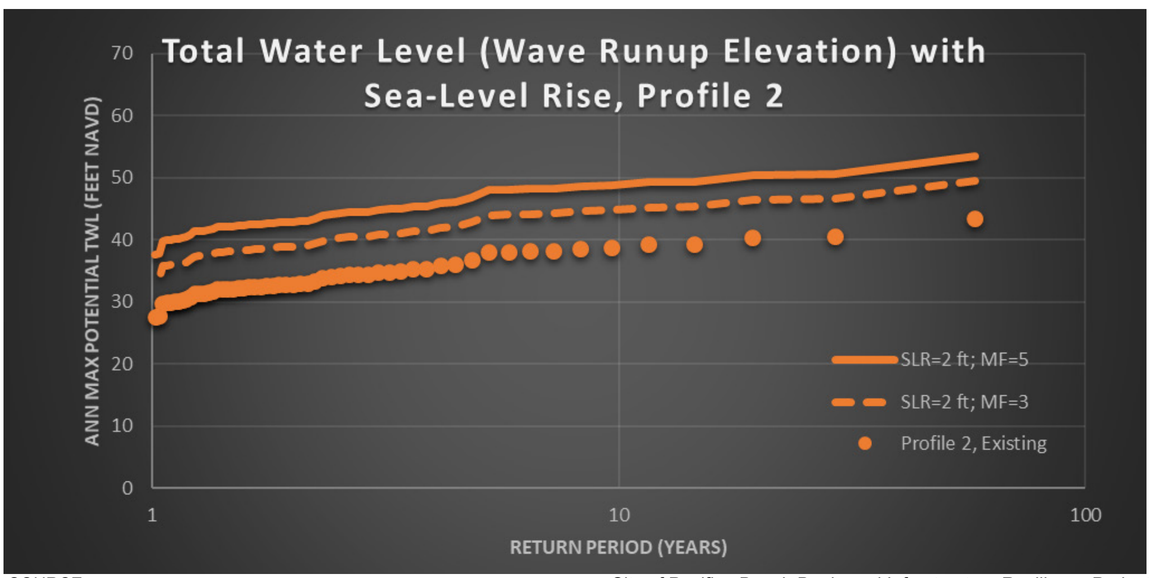
Figure 3-9
Annual Maximum Potential Total Water Level as a Function of Return Period for all Beach Profiles

TWLs were computed for a sea-level rise of two feet above existing conditions. Rather than re-run the Composite Slope program, the increase in TWL with sea-level rise was computed by proration. The proration methodology increases the TWL by a multiplication factor called the Morphology Factor, ranging from 1 to 5 (Battalio and others 2016). Morphology Factors of 3 and 5 were selected to represent the Beach Boulevard location. The results are plotted for each of the four profiles in **Figures 3-10 through 3-13**.



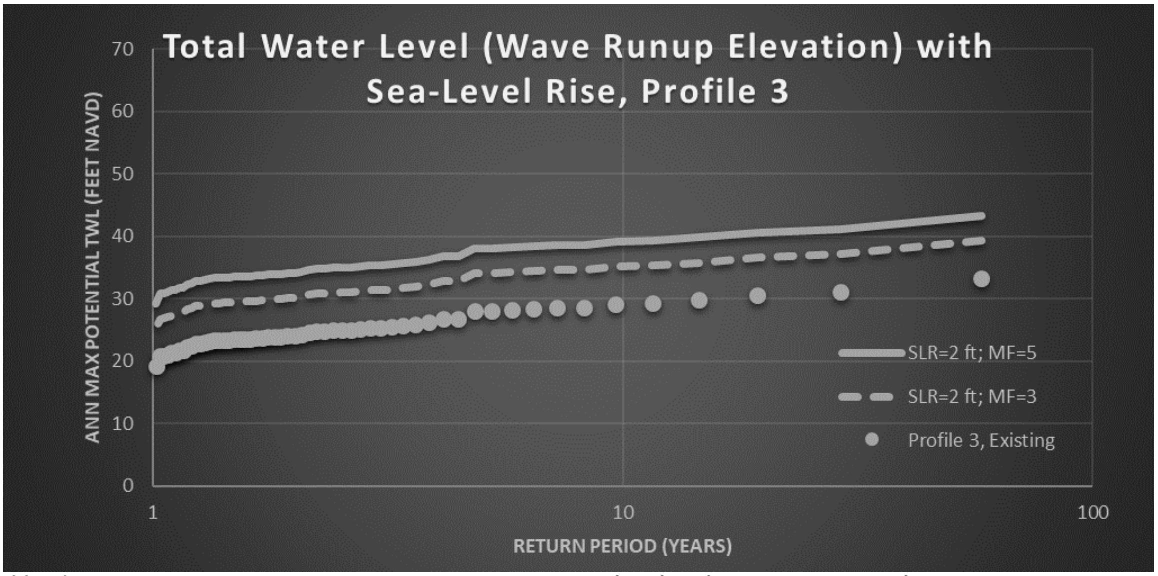
SOURCE: City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-10
Annual Maximum Potential TWL as a Function of Return Period for Existing and Future Conditions (2 feet SLR) at Profile 1



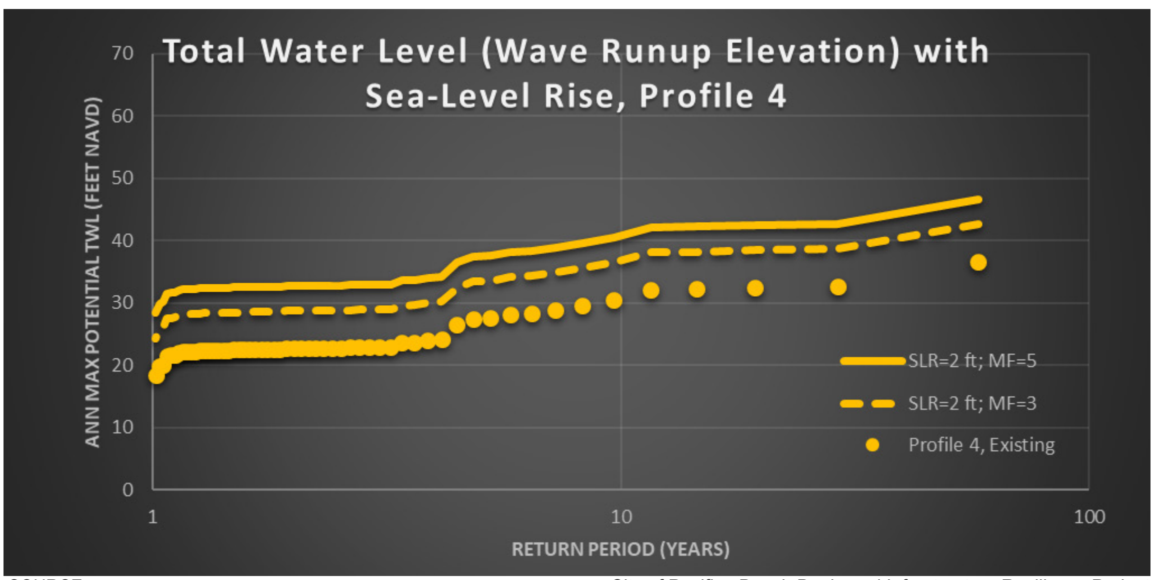
SOURCE: City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-11
Annual Maximum Potential TWL as a Function of Return Period for Existing and Future Conditions (2 feet SLR) at Profile 2



SOURCE: City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-12
Annual Maximum Potential TWL as a Function of Return Period for Existing and Future Conditions (2 feet SLR) at Profile 3



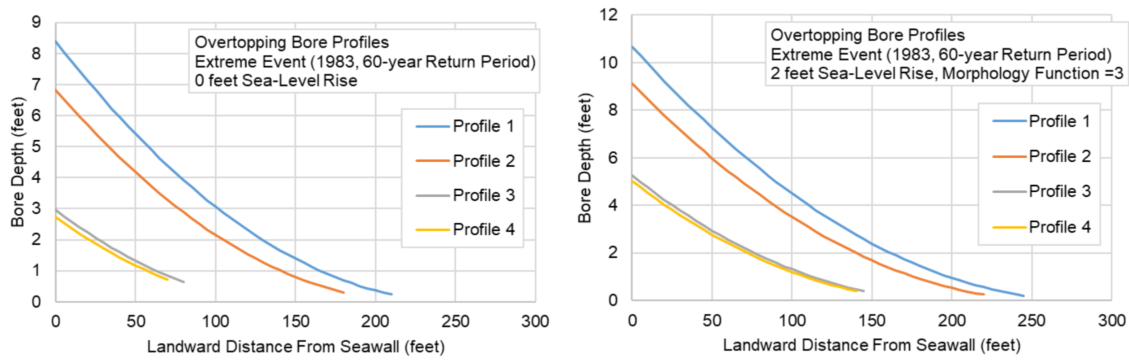
SOURCE: City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-13
Annual Maximum Potential TWL as a Function of Return Period for Existing and Future Conditions (2 feet SLR) at Profile 4

3.3.3 Landward Extents of Wave Runup

The landward extent of wave runup overtopping was computed and plotted as an indication of the zone of potential damages. The inland extent corresponds to the FEMA high velocity "V-Zone" where it is recommended that buildings be founded on piles with finished floors (habituated areas) above the dynamic water line. This limit represents the landward extent of the "V-Zone," a special flood hazard zone that includes velocity and wave hazards, and which would require more stringent building requirements. For example, structures located within this zone would be required to be constructed on piles, with the lowest horizontal member elevated above the selected water profile presented in Figure 30. Elevating structures in a V-Zone should comply with FEMA building codes, and should use design approaches such as elevating critical infrastructure on piles with "break-away" walls that would allow flood waters to disperse in the event that the site floods. Constructing on fill is not an acceptable technique to elevate structures in a V-Zone because of the high erosion potential (FEMA 2005).

The results are presented in **Figures 3-14** and **3-15**, and tabulated in **Table 3-1**. Figure 3-14 shows the results for existing conditions, and with sea-level rise for the four profiles. Note that the computed distances are potential, more closely representing the extents along roadways where walls, structures and higher terrain obstructs water flow along the ground. Figure 3-15 shows the same projections organized by seawall reach.



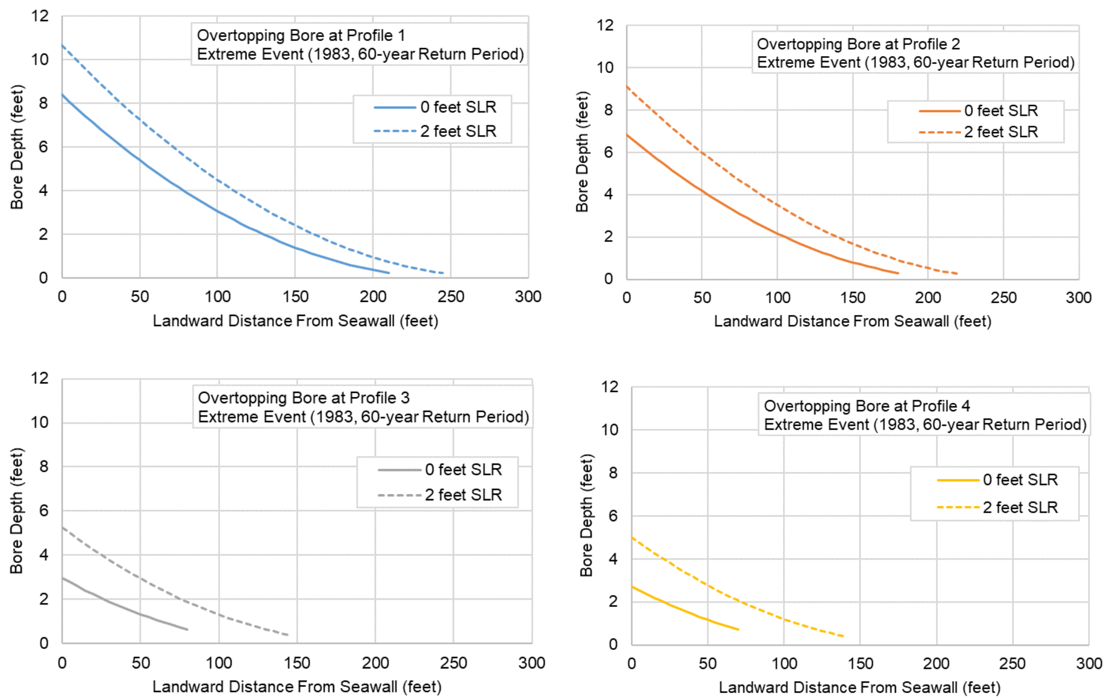
SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-14
Potential Inland Extent of Wave Overtopping for Existing and Future Conditions

TABLE 3-1
LANDWARD EXTENTS OF V-ZONE AT FOUR PROFILES FOR EXISTING AND FUTURE CONDITIONS WITH VAR. A=4 AND MORPHOLOGY FUNCTION MF=3; EL NIÑO WINTER, 1983, APPROX. 60-YEAR+ EVENT

Profile	Existing, SLR=0 ft	Future, SLR = 2 ft
		MF=3
	A=4	A=4
1	211	247.6
2	181	222.9
3	79	146.4
4	71	140.8



SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-15
Potential Inland Extent of Wave Overtopping for Each Seawall Reach

Note that the project site is not currently mapped in a 100-year flood hazard zone by FEMA. The FEMA maps appear to under-represent the flood risk at the site, which is likely attributed to method uncertainty that is known to occur with regional studies: FEMA allows for map revisions based on more detailed and location-specific analysis, such as accomplished herein.

This analysis represents an extension of the wave runup calculations presented above, and provides the approximate limits of wave hazards in the future with sea-level rise. These water surface profiles were computed using the formulation of the Cox-Machemehl equation as presented in FEMA (2005). Unique values of the scaling parameter “A” were selected so that the landward extents would match those observed in photographs and videos. An “A” value of four (4) was selected to best match observations. For future conditions, we used two (2) feet of sea-level rise and increased the TWL using a morphology function (MF) of three (3) per the Technical Methods Manual (Battalio et al. 2016). The selected MF of three is on the lower end of the appropriate range of 3 to 5 for this location: A higher MF would increase the landward distance relative to that presented here. Our judgment is that irregularities in the pavement, including automobiles and drain inlets, would dissipate the water flow somewhat. Also, a lesser extent is more consistent with the developed lots where obstructions have been constructed.

The velocity was calculated using a method presented in FEMA (2005) that is based on the relative height of the potential wave runup and the elevation of the seawall The FEMA (2005) guidelines recommend using this velocity for determining the limits of the wave momentum threshold of V^2h = 200 feet^3/second^2. Note that recent research suggests that a more appropriate limit is a value of $V^2h = 100$ feet^3/second^2 owing to the force exerted by the collapse of runup deflected upward by the obstruction, presuming a rigid body (no failure or deflection), resulting in instantaneous transfer of momentum to force.

3.4 Wave Overtopping

3.4.1 EurOtop 2018 Overtopping

The wave overtopping discharge as a function of seawall crest height was computed following the EurOtop 2018 methods (EurOtop 2018). Primarily developed for European coastal defense systems, the EurOtop methods are tailored for the design and assessment of coastal structures. The document provides useful procedures for determining design overtopping rates that account for method uncertainty and incorporate appropriate factors of safety. Tolerable discharge rates and discharge volumes for safe pedestrian and vehicle access are provided to inform design, along with thresholds for potential damage of paving surfaces, nearshore structures, moored vessels, and other features impacted by wave overtopping. Tolerable discharge for pedestrian access near the seawall (0.01 cfs/lf) was identified as the limiting discharge threshold for this assessment. However, the tolerable discharge for pedestrians depends on a variety of factors such as the pedestrians' preparedness, willingness to get wet, and awareness of oncoming waves (EurOtop 2018).

The EurOtop approach has several limitations when assessing overtopping at the project site. Defining absolute extreme hazards, such as those represented by FEMA V-Zones, is difficult using the EurOtop approach. Use of the EurOtop equations requires the application within a methodology similar to that used here to account for large, dynamic water level fluctuations and large, long-period waves.

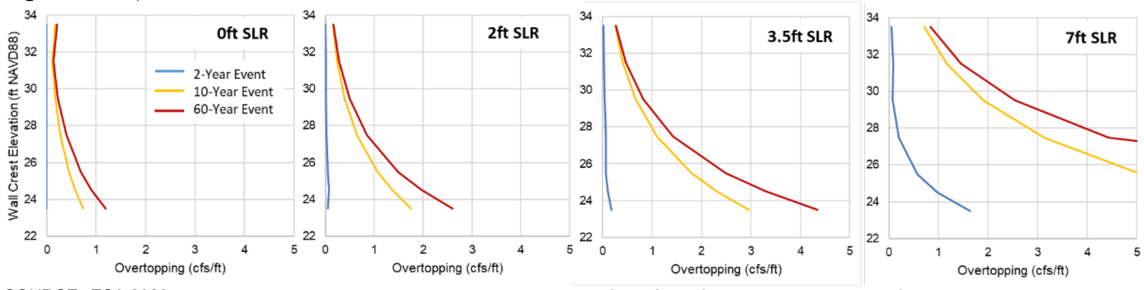
We followed EurOtop procedures for the three main types of existing shoreline geometries present along the study area. These geometries included: a composite vertical wall with fronting rock mound (found along the northern portion of the site), a simple vertical wall (present abutting the pier), and a vertical wall at the top of a smooth dike (in the southern portion of the site, we considered the sand beach to be similar to a smooth dike).

For each geometry, we assessed seawall overtopping for a range of water levels and wave conditions associated with the 2-year, 10-year, and 60-year TWL events. Overtopping rates were calculated for the existing wall crest height of approximately 25.5 feet NAVD88, as well as a range of potential higher crest height to illustrate the influence of crest height on overtopping rate reduction. All cases were analyzed for zero through seven feet of sea-level rise.

We gauge our analysis using the EurOtop overtopping equations as well as an overtopping model presented by Laudier et al. (2011), which yielded higher overtopping rates because it is directly a function of the 2%-exceedance wave runup, $R_{2\%}$, or potential TWL. These two methods provide a reasonable estimate for alternatives analysis but we recommend more sophisticated methods for design.

3.4.2 Computed Overtopping Rates

Mean overtopping rates relative to wall crest elevation for the vertical wall with fronting mound (present in the northern portion of the site) are shown in **Figure 3-16**. The overtopping rates are provided as time-averaged rates of flow (defined as cubic feet per second, or cfs) per linear foot (lf) of seawall. Each subplot contains three colored lines which correspond to the different TWL events. Figure 3-16 indicates that under current conditions, the 25.5 ft NAVD88 seawall will experience between 0.5 and 0.8 cfs/lf of mean overtopping discharge during large storm events. The mean overtopping discharge for a 2-year storm is near zero. However, the mean discharge is time averaged over the duration of the storm, and thus is much smaller than the instantaneous discharge observed when any particular wave breaks and overtops the wall (See Section 3.4.3 Comparison to Recent and Historic Flood Events). Increased wall elevations reduce the overtopping rate non-linearly. Increasing sea levels substantially increase the amount of overtopping for all storm events. At high sea-level rise amounts and low wall crest elevations, major storms may experience direct overflow of the seawall (not shown within axes bounds in Figure 3-16).

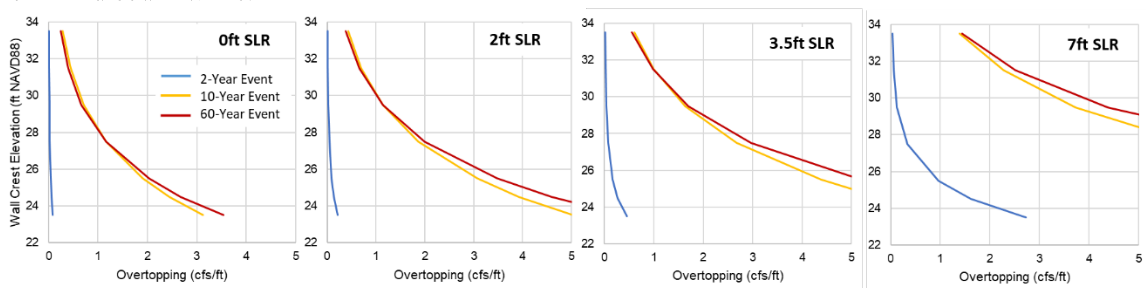


SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-16
Mean Overtopping Rates with Sea-Level Rise for a Composite Vertical Wall with Mound

Figure 3-17 provides overtopping rates for a plain vertical wall, which is present adjacent to the pier. As with the vertical wall with a mound, overtopping rates increase with increase sea-level and with storm severity and decrease with increasing wall crest elevation. The overtopping rates for the plain vertical wall are larger than those calculated for the vertical wall with a fronting mound. This is because the mound acts to dissipate some wave energy before impact with the vertical portion of the wall. Note that the wall at the pier abutment is at an angle to the incident waves, and hence runup is reduced at the abutment, and the runup is deflected inland toward the north and south walls.

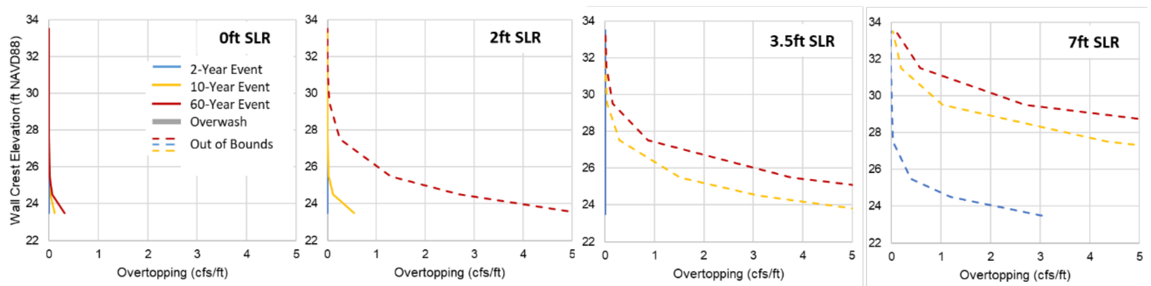


SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-17
Mean Overtopping Rates with Sea Level Rise for a Vertical Wall, No Mound

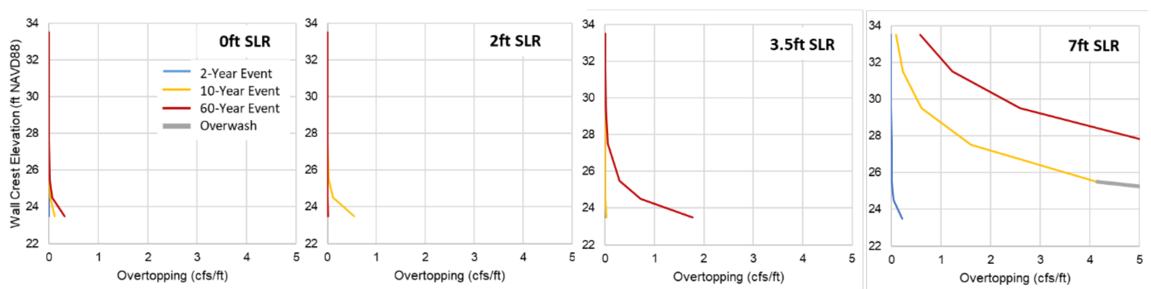
Figure 3-18 presents the same information as Figure 3-16 and 3-17 for the southern portion of the site, which is represented as a smooth dike (i.e., beach) with a wall at the top of the slope. The dashed lines represent conditions where the equations are out of range, where the reference water level is intercepting the backshore wall. In order to account for this, **Figure 3-19** presents a modification of the smooth dike procedure, where the plain vertical wall equations are used when the dynamic water level exceeds the toe of the wall. This results in lower, more realistic overtopping rates.



SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-18
Mean Overtopping Rates with Sea Level Rise for a Smooth Beach With Wall

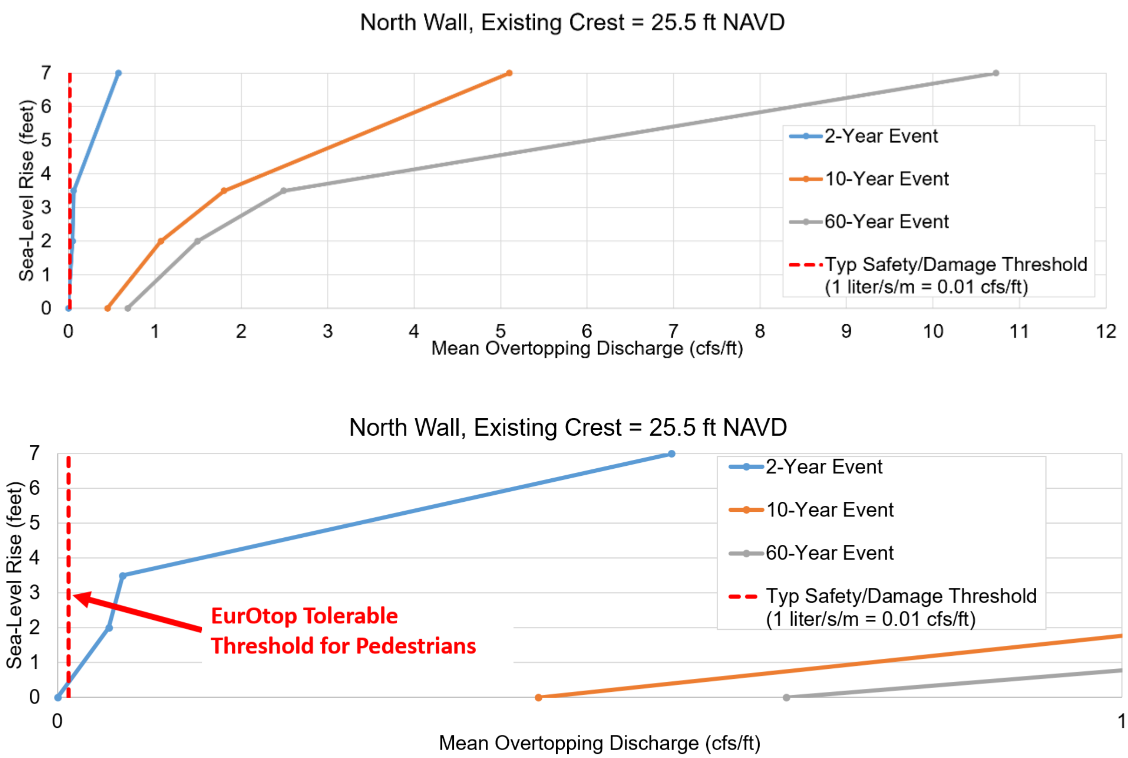


SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-19
Mean Overtopping Rates with Sea Level Rise for a Smooth Beach With Wall and Vertical Wall, No Mound Equations

An alternative way to view the results is presented in **Figure 3-20**. Figure 3-20 plots the overtopping rate as a function of sea-level for the existing crest height of 25.5 feet NAVD88 for the composite vertical wall with mound case (northern seawall). The bottom panel of Figure 3-20 zooms into small discharge rates (<1 cfs/lf) to illustrate the typical threshold for safety and damage. Under existing conditions (0 feet sea-level rise), the two-year storm does not exceed the threshold. However, with 6 inches of sea-level rise, the threshold would be exceeded. The 10-year and 60-year event already exceed safety and damage thresholds under existing conditions (See Section 3.3.3 Comparison to Recent and Historic Flood Events).



SOURCE: ESA 2020

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-20
Overtopping Rate as a Function of Sea-Level Rise - North Wall Example
Full Range of Discharges (Top Panel)
Zoomed into <1 cfs/lf Discharge (Bottom Panel)

3.4.3 Comparison to Recent and Historic Flood Events

Overtopping along the Pacifica Seawall already occurs all along the project site on an annual basis, resulting in street closures and occasional damages. We compared observed overtopping events at known dates and locations to the EurOtop rates calculated for the same wave and water level conditions.

Figure 3-21 presents screenshots from a YouTube video taken January 7, 2016[2]. Visual inspection of these images indicate that this storm had a maximum individual wave overtopping volume of 50 to 100 cubic feet per linear foot of seawall. EurOtop reports that mean rates of overtopping discharge are typically between 100 and 1,000 times smaller than maximum overtopping volumes. Thus, the mean discharge of the January 2016 event was likely between 0.05 and 1.0 cfs/lf over the duration of the event. Note that the instantaneous overtopping (exemplified by the images in Figure 3-21) are much larger than the mean overtopping rate.

Calculations following the EurOtop method yield a mean discharge of 0.45 cfs/ft for an event on December 11th, 2015, which was similar to the January 2016 event shown in the YouTube video and other events from January 2016. The calculated value of 0.45 cfs/lf falls within the event's

[2] https://www.youtube.com/watch?v=7lg-SliupQ4 last visited December 2020

observed estimated rate of 0.05 to 1.0 cfs/lf. Therefore, the EurOtop procedures described in this section appear to reasonably represent observed overtopping conditions. This mean that our computed overtopping rate is also indicative of potential structural damage according to EurOtop damage thresholds, and is consistent with residents' reports of damage to nearby properties and structural damage to the seawall.

SOURCE: https://www.you
tube.com/watch?v=7lg-SliupQ4

City of Pacifica Beach Boulevard Infrastructure Resiliency Project

Figure 3-21
Overtopping Along North Wall: Screenshots from YouTube Video Dated January 2016

3.5 Summary

The wave runup (TWL Composite Slope Method) and wave overtopping (EurOtop) procedures described in Section 3 are suitable for evaluating relative performance of different seawall alternatives and provide useful information about the tradeoff of reduction in overtopping with seawall crest elevation. Calculated TWLs are consistent with observations. Calculated rates of mean overtopping discharge are consistent with observed overtopping events along the Pacifica Seawall. There remains a need to distinguish the difference and utility of performing a FEMA-type hazard analysis in the study area versus the EurOtop-type approach for evaluating design overtopping rates. The FEMA approach, which is based on the 2%-exceedance probability, and which may not happen everywhere simultaneously but may occur during an extreme event, helps define the hazard areas and the vertical and landward extents of high-velocity wave action, while the EurOtop methods, which yield an average overtopping rate, are best applied to designing the structure to manage overtopping, but which are less useful for defining the hazards. Note that the peak overtopping rates are approximately 100 to 1,000 times greater than the mean overtopping discharge (EurOtop 2018).

The existing seawall and defense system is in marginal condition and exposes the public and the City to severe overtopping hazards. As sea-levels rise, these hazards will increase as will the frequency of overtopping events. Further detailed coastal analysis would be appropriate during design of seawall improvements to determine anticipated hazards and optimal design crest elevations.

This page intentionally left blank

4 SUMMARY OF FINDINGS

A summary of our findings are as follows:

1. Functions of Beach Boulevard for transportation and recreation, and as an infrastructure corridor, are currently at significant risk from wave runup and overtopping-induced flooding and erosion.

2. The extreme wave runup elevations and overtopping rates vary along Beach Boulevard, generally greater in the north, also large in the vicinity of the Pier due to the unique interactions of waves with the pier abutment. The south wall also experiences wave runup overtopping, but at a lesser frequency and intensity.

3. A beach fronting the wall dissipates waves somewhat before reaching the seawalls, thereby reducing wave runup and overtopping. We believe this is the reason the south wall has experienced less overtopping. Also, the progressive loss of beach since seawall construction is likely the cause of increased overtopping in recent years. The additional loss of beach will likely amplify the effect of higher sea-levels on wave runup and overtopping.

4. The wave runup and overtopping methods used in this analysis are adequate to support formulation of measures to mitigate hazards, and evaluate alternatives at a conceptual to preliminary level or design. Calculations were approximately verified by a comparison with observations. We recommend additional analysis with more sophisticated methodologies for engineering design to result in construction.

5. The computed runup heights and total water level elevations are generally consistent with observations, but may under-estimate short-term and localized extremes while over-predicting average conditions. The calculations are based on parametric equations with methodologies consistent with standard practice such as described in engineering manuals (USACE 2003; FEMA 2005). These calculations are intended to represent the extreme peak loadings conditions, generally referred to as those exceeded only by about 2% of the incident waves.

6. The computed overtopping rates using methods based on the European Overtopping Manual (2018) exceed the typical damage and safety thresholds, consistent with observations and performance. The European methods were developed for conditions less extreme than those at Beach Boulevard, and hence should be used with caution and professional judgment. Consequently, we tested and modified application of the European guidance. Note that these methods present the average overtopping rate, in volume of water per time per unit length of seawall. This type of calculation is useful for management of the volume of overtopped water during a particular event. However, the average overtopping rate is 100 to 1000 times lower than the extremes: Conceptually, while the runup calculation (finding 5, above) is exceeded

by about 2% of the waves during an event, the average overtopping rate is exceeded by about 50% of the waves.

7. With sea-level rise, we expect these challenges from coastal hazards to worsen from both increased magnitude and frequency of events. Calculations show that wave runup and overtopping will increase at an amplified rate; that is, one foot of sea-level rise will result in a greater rise in TWL and amplified overtopping.

8. Increasing the sea wall crest could reduce risk and accommodate a limited amount of sea-level rise before the current level of risk is exceeded. For example, as illustrated by Figure 3-16, raising the lowest areas along the North Wall (currently about 25 feet NAVD) by approximately 4 feet above the flush curb could accommodate up to about 2 feet of sea-level rise for the 10-year overtopping event. This finding is consistent with the Adaptation Plan (City and ESA, 2018) which indicated additional adaptation measures will be needed with higher amounts of sea-level rise.

9. Other adaptation measures, including beach nourishment and stormwater management, should be considered further, and may help extend the project beyond 2 feet of sea-level rise.

10. We note that recent structural damages in 2016 and 2020 occurred following a series of large overtopping events, each of which was not that extreme in terms of wave height or water level. Hence, there is an indication that a series of events, such as experienced during an extreme winter, is a better indicator of risk than a single swell or storm event. Also, the wave runup and overtopping depend on a combination of parameters (wave conditions, tides, seawall and beach geometry) in combination.

11. Prior hazard mapping by others (e.g., FEMA) appears to underestimate the flood risk along Beach Boulevard, thereby under-representing the risks to safety and property, and the amount of potential damages. See Appendix A *Review of Existing Modeling, Assessments, and Studies Conducted at the Beach Boulevard Seawall, ESA Draft Memo updated December 14, 2020* for additional information.

12. There are several data gaps that need to be addressed, including:

    a. Wave runup and overtopping data;

    b. Nearshore bathymetry - surf zone elevation profiles;

    c. Elevation horizon of erosion-resistant “hardpan” underlying the nearshore;

    d. Sand transport rate / sand budget for Pacifica;

    e. Sand sources for beach nourishment; and,

    f. Storm drain system capacities.

See Appendix A *Review of Existing Modeling, Assessments, and Studies Conducted at the Beach Boulevard Seawall, ESA Draft Memo updated December 14, 2020* for additional information.

5 REFERENCES

Battalio, R.T., Bromirski, P.D., Cayan, D.R., and White, L.A., 2016, *Relating Future Coastal Conditions to Existing FEMA Flood Hazard Maps: Technical Methods Manual*, Prepared for California Department of Water Resources and California Ocean Science Trust, Prepared by Environmental Science Associates (ESA), pp. 114.

California Coastal Commission (CCC), 2018, California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits, Original Guidance Adopted August 12, 2015, Update Adopted November 7, 2018.

Dean, R.G., and Bender, C.J., 2006, Static wave setup with emphasis on damping effects by vegetation and bottom friction, *J. Coastal Engineering*, 53, 149-156.

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

ESA and others, 2018a, Sea-Level Rise Adaptation Plan, Prepared for the City of Pacifica by Environmental Science Associates (ESA), September 2018. https://www.cityofpacifica.org/civicax/filebank/blobdload.aspx?t=58348.79&BlobID=14632.

EurOtop, 2018. Manual on wave overtopping of sea defenses and related structures. An overtopping manual largely based on European research, but for worldwide application. Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., www.overtopping-manual.com.

Federal Emergency Management Agency (FEMA), 2005, Final Draft Guidelines for Coastal Flood Hazard Analysis and Mapping for the Pacific Coast of the United States, January 2005.

Federal Emergency Management Agency (FEMA), 2015, Intermediate Data Submittal #3, Nearshore Hydraulics, Los Angeles County, California, FEMA Region IX, California Coastal Analysis and Mapping Project / Open Pacific Coast Study, Prepared by BakerAECOM, October 12, 2015.

Garrity, N.J., Battalio, R., Hawkes, P.J., and Roupe, D., 2007, Evaluation of Event and Response Approaches to Estimate the 100-year Coastal Flood for the Pacific Coast Sheltered Waters, Proceedings of the 30th International Conference on Coastal Engineering, 2006, pp. 1651-1663.

Goda, Y., 1985, *Random Seas and Design of Maritime Structures*, University of Tokyo Press, Tokyo, Japan.

Hunt, I.A., 1959, Design of Seawalls and Breakwaters, *Proc. J. Waterways and Harbors Div.*, ASCE, Vol. 85, No. WW3, pp. 123-152, September 1959, New York, NY.

Laudier, N.A., Thornton, E.B., and MacMahan, J., 2011, Measured and modeled wave overtopping on a natural beach, *Coastal Engineering*, 58, 815-825.

Ocean Protection Council (OPC), 2018, State of California Sea-Level Rise Guidance 2018 Update, Prepared by the California Natural Resources Agency and the California Ocean Protection Council, March 2018.

O'Reilly, W.C., Olfe, C.B., Thomas, J., Seymour R.J., Guza, R.T. 2016. The California Coastal Wave Monitoring and Prediction System. *Coastal Engineering,* 116, 118-132.

Stockdon, H.F., Holman, R.D., Howd, P.A., and Sallenger, A.H., 2006, Empirical parameterization of setup, swash and run-up, *Coastal Engineering*, 53(7), 573-588.

U.S. Army Corps of Engineers (USACE), 1984, *Shore Protection Manual*, 4th ed., 2 Vol., U.S. Army Engineer Waterways Experiment Station, U.S. Government Printing Office, Washington D.C., pp. 1,088.

U.S. Army Corps of Engineers (USACE), 2003, *Coastal Engineering Manual*, Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington D.C. (in 6 volumes).

6 ACKNOWLEDGEMENTS

The following ESA staff contributed to this report:

Louis White, PE (Project Engineer, Coastal Task Lead)

Hannah Snow, PE

Pablo Quiroga

Robert (Bob) Battalio, PE

Eric Zigas (Project Manager)

We would like to acknowledge the GHD team for their review and comments on this document, as well as technical contributions during the analysis period, including Brian Leslie, Aaron Holloway, Gillian Millar, and Paul Henderson.

We also appreciate the opportunity to work with and support the City of Pacifica.

This page intentionally left blank

Appendix A

Review of Existing Modeling, Assessments, and Studies Conducted at the Beach Boulevard Seawall, ESA Memo updated December 14, 2020

ESA

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

esassoc.com

memorandum

date	October 14, 2020 (updated December 14, 2020)
to	Brian Leslie (GHD)
cc	Paul Henderson (GHD)
from	Louis White, PE
subject	Review of Existing Studies, Identification of Data Gaps, and Recommended Sea-Level Rise Scenarios for City of Pacifica Beach Boulevard Infrastructure Resiliency Project, ESA Ref. #D202000164.00

Introduction

To inform the planning and design of the City of Pacifica Beach Boulevard Infrastructure Resiliency Project, we reviewed and summarized the relevant existing modeling, assessments, and studies as a first step in identifying the primary data gaps. The data gaps were used to recommend areas for further assessment. We also present a brief description of the recommended sea-level rise scenarios for the project, which will be confirmed by the City. This memorandum was prepared by Louis White, PE and Bob Battalio, PE of ESA.

Review of Existing Modeling, Assessments, and Studies

This summary of existing studies is focused on the physical conditions in the study area, including in particular coastal flood and erosion hazards, vulnerabilities, and adaptation measures. An annotated bibliography format is used, with each reference briefly summarized and key points pertinent to the Beach Boulevard Infrastructure Resiliency Project summarized succinctly. Two studies, *Sea-level Rise Adaptation Plan* (2018) and *Regional Sediment Management Plan* (2012), require longer descriptions owing to their pertinence and utility. Otherwise, there is not a specific order or hierarchy in the sequence.

A. Sea-level Rise Adaptation Plan (2018), City of Pacifica

A sea-level rise adaptation plan was funded by the City of Pacifica and the California Coastal Commission (CCC) to provide draft land use policies addressing adaptation to sea-level rise for an updated Local Coastal Program (LCP) (ESA and others 2018a[1]). The study consisted of a vulnerability analysis and an analysis of alternative adaptation scenarios to inform an LCP update. The Adaptation Plan and draft policies were modified and then

[1] ESA and others, 2018a, Sea-Level Rise Adaptation Plan, Prepared for the City of Pacifica by Environmental Science Associates (ESA), September 2018. https://www.cityofpacifica.org/civicax/filebank/blobdload.aspx?t=58348.79&BlobID=14632

adopted by the City Council, and are presently under review by the CCC. [This project is separate from other LCP updates and Sharp Park planning].

Exposure

Readily available hazard maps related to coastal erosion and flooding were gathered, georeferenced and are available for public review with links on the City's Sea-Level Rise page.[2] Maps of coastal flooding by the USGS (CoSMoS, OCOF) and erosion maps from the Pacific Institute were used to define the potential flood plain under existing and future conditions. Flood and erosion hazard maps were selected to correspond with California's 2018 sea-level rise guidance (e.g., OPC 2018 and CCC 2018) at future years 2050 and 2100, as summarized in Table 1.

TABLE 1
SUMMARY OF SEA-LEVEL RISE SCENARIOS USED IN 2018 CITY OF PACIFICA SEA-LEVEL RISE ADAPTATION PLAN

Sea-Level Rise Scenario	2050	2100
Extreme (n/a)[a]	2.7 feet	10 feet
Med-High (0.5% chance)	2 feet	6 feet
Low (17% chance)	1 foot	3 feet

a The 2050 Extreme sea-level rise scenario was not examined and was provided for consistency. SLR of 6 feet at 2075 was considered in place of 10 feet at 2100 to assess potential impacts under the Extreme scenario, which was required because of the lack of erosion and flooding data for 10 feet of sea-level rise.

Vulnerability

A Vulnerability Assessment (ESA 2018b[3]) was completed as a first phase of the Sea-Level Rise Adaptation Plan, and is located as *Appendix A* to the 2018 Plan. Assets were inventoried and georeferenced within a GIS framework. Hazards were overlaid onto the asset maps and assets within the mapped hazards were identified as potentially vulnerable at each time horizon and sea-level rise amount. Plate 1 presents three figures, excerpted from the Vulnerability Assessment, that show how the Beach Boulevard reach is subject to wave overtopping and seawall structural damages.

Adaptation

Adaptation scenarios that used armor, beach nourishment, retreat and hybrid strategies were identified for each subarea. The resulting beach width was modeled and hazard maps adjusted, and vulnerability recalculated for each scenario. A multi-benefit economic analysis was conducted to identify costs, benefits, net benefits and revenues for comparison, for each subarea. The City then identified its preferred alternative.

Beach Boulevard Adaptation

Beach Boulevard (Paloma to Clarendon) was included in the Sharp Park, West Fairway Park and Mori Point planning subarea. The Adaptation Plan for this area is described in Plate 2. The analysis of alternative adaptation scenarios is summarized in Plate 3. The Adaptation Plan includes the following measures and strategies:

---

2 https://www.cityofpacifica.org/depts/planning/sea_level_rise.asp

3 ESA, 2018b, Sea-Level Rise Vulnerability Assessment, Prepared for the City of Pacifica, Revised June 2018. https://www.cityofpacifica.org/civicax/filebank/blobdload.aspx?BlobID=14283

- Seawalls: Upgrading the existing seawalls and extending across the end of Clarendon to the CCSF earth berm;
  - Reconstruct Beach Blvd. seawall north of Pier and address wave overtopping by considering a higher crest and storm water runoff management – estimated cost $20,000 per linear foot. $31 million.
  - Upgrade Beach Blvd. seawall south of pier to address overtopping – estimated cost $10,000 per linear foot. $12 million.
  - Extend southern wall across Clarendon. $1.4 million.
- Place sand to widen the beaches seaward of the armoring;
  - Investigate sand sources and feasibility of beach nourishment with and without structures to limit sand transport and amount of required sand
  - Widen beach 100 feet and repeat when beach gets too narrow. Estimated nearly 700,000 cubic yards needed for the 2,600 long Beach Blvd. at a cost of $22 / cubic yard or about $15 million. Three to four placements by 2050, and about eight by 2100, presuming high sea-level rise.
  - With sand retention structures, the sand placements would be reduced to two to three by 2050 and six by 2100, presuming high sea-level rise. The cost of the sand retention structures was estimated to be about $37 million for Beach Boulevard, or equivalent to about 2.5 sand placements.
- Improve storm water management, including a detention basin and pump station for the low area around Clarendon Road;
  - Low earth “setback” levee to prevent flooding from a flooded Laguna Salada – SF Golf Course
  - Excavate a detention basin (pond) to collect rainfall runoff from inland
  - Construct a pump station to pump-out the pond
  - Construct a storm drain (pipe) to convey the pumped water down Clarendon and under the beach to the ocean.
  - Estimated about $2.4 Million to construct.
  - Wave overtopping along Beach Blvd. included in seawall upgrades (see above).
- Consider additional actions which may be needed in the future with sea-level rise of 2 to 3 feet, which may occur as early as 2050. Several actions were identified for future consideration:
  - Additional seawall and storm water management upgrades;
  - Relocate vulnerable utilities inland (e.g. wastewater line in Beach Blvd.);
  - Allow residents to elevate houses on pilings;
  - Voluntary retreat, preferably subsidized with buy-out using “outside” funding.

Beach Boulevard Coastal Hazards

Existing and future coastal hazards were developed from available information. A comparison of the recently updated FEMA flood hazard maps indicates that these maps are not reliable because they do not indicate an existing hazard along Beach Boulevard in contrast to the overtopping and structural damages experienced in 2016. However, the CoSMoS modeling does indicate flood hazards under existing conditions.

Historic Erosion Rates

Long-term erosion rates for the Beach Boulevard shore computed by others are 1.7 feet per year (fpy) at the high tide elevation and 2.4 fpy at the bluff edge. Shore erosion rates have reduced due to armoring (e.g., seawall and rock revetments) with minimal beach widths on the order of about 30 to 50 feet, occasionally wider especially toward the south and often non-existent, especially north of the pier during the winter and spring. A potential average annual high tide erosion rate of 2 fpy was associated with a 50-foot wide beach used in modeling of beach widths (Figure 1). The maximum shore erosion rate was estimated to be 6 fpy for a beach width of 100 feet or greater: This value was selected presuming a localized beach-widening, which increases sand transport away from the wide beach to other areas, with the maximum transport limited by available wave power. As the beach width narrows, the backshore takes the brunt of the wave power, the high tide shore erosion slows and the backshore erosion increases, in this case to a maximum average annual rate of 4 fpy. These potential erosion rates are not realized if the shore armoring prevents erosion, as is the case at Beach Boulevard. The dashed lines indicate the estimated (and modeled) shore erosion rates with sand retention structures, with the erosion rate reduced to 1 fpy at a beach width of 70 feet. This quantified conceptual model of shore response was used to compute the required sand placement to maintain a beach and reduce coastal erosion potential at Beach Boulevard (see *Beach Boulevard Adaptation*, above). The model results are also summarized in Plate 2, for the combined Sharp Park and West Fairway Park planning area.

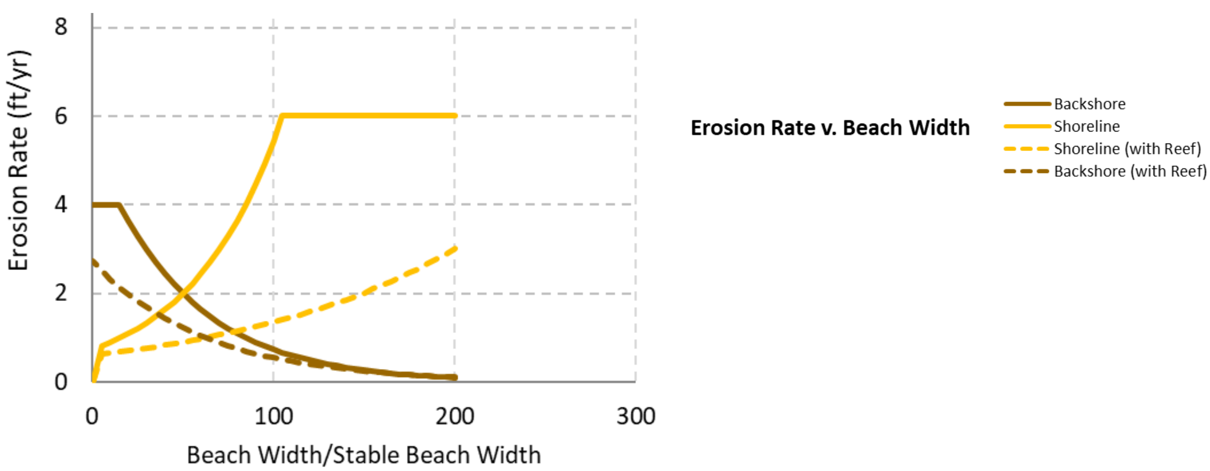


Figure 1
Estimated shore erosion rates at Beach Boulevard as a function of beach width, without and with retention structures (reef headlands) to reduce sand transport

Assets

Infrastructure assets were mapped to support vulnerability assessments and the economic analysis of adaptation alternatives. Plate 4 shows infrastructure and FEMA flood map zones. Note, natural gas and electrical utilities are not shown owing to restrictions associated with public safety.

B. San Francisco Littoral Cell Coastal Regional Sediment Management Plan

The San Francisco Littoral Cell Coastal Regional Sediment Management Plan was a study funded by the Coastal Sediment Work Group, which is a partnership of the State of California with the US Army Corps of Engineers, to investigate sediment management actions to mitigate coastal erosion (ESA 2015[4]). One of multiple studies for each littoral cell[5] along the California coast, the San Francisco Littoral Cell was defined as the shores of San Francisco, Daly City and Pacifica. Based largely on existing information, the study projected future shore erosion, quantified vulnerability to erosion, and evaluated several alternative approaches to mitigate erosion, including a comparison of economic costs, benefits and revenues. Plate 5 shows the study subarea that includes Beach Boulevard: This study area was called Beach Boulevard but also includes the Shoreview neighborhood and additional shore to the north for a total shore length of 5,200 feet. The Regional Sediment Management (RSM) study used methods consistent with economics analysis of alternatives used by the U.S. Army Corps of Engineers. The methods used were similar to those employed subsequently for the City of Pacifica Sea-Level Rise Adaptation Plan (2018) and described above. However, different sea-level rise amounts were used. Also, the focus of the study was coastal erosion, and therefore coastal flooding was not addressed in any detail. The CoSMoS and updated FEMA hazard mapping resources were not yet available.

Exposure

The focus was on coastal erosion and coastal flooding was not addressed in detail. Historic erosion rates were increased based on projected future sea-level rise. A recent historic erosion rate of two feet per year (fpy) was used for Beach Boulevard, recognizing the effect of existing shore armor to slow erosion. The sea-level rise curve was based on the "High" sea level rise scenario described in USACE (2011). This curve predicts 1.6 feet of sea level rise by 2050 and 5.0 feet by 2100 (relative to 2000).

Vulnerability

Assets were inventoried and georeferenced within a GIS framework. Hazards were overlaid onto the asset maps and assets within the mapped hazards were identified as potentially vulnerable at each time horizon and sea-level rise amount.

Adaptation

Erosion Mitigation Options were developed and evaluated for each subarea with erosion vulnerability within the littoral cell. Options included beach nourishment, beach nourishment with retention and shore protection structures, shore protection structures alone, and "allow erosion / retreat" were considered, primarily as a baseline from which to evaluate alternatives. The resulting beach width was modeled and hazard maps adjusted, and vulnerability recalculated for each scenario. A multi-benefit economic analysis was conducted to identify costs, benefits, net benefits and revenues for comparison, for each subarea. No preferred option(s) were selected.

---

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

[5] Littoral cell is an area of contiguous sand transport along its shore(s), where actions affecting sand supply in one location may affect other locations within the cell.

Beach Boulevard Adaptation

The Beach Blvd subarea extended 5,200 feet north of Paloma and included Beach Boulevard, Shore View, the mobile home park, the mixed-use area to the north and ended at the Milagra Drain, just south of the RV Park (Plate 5). The results of the erosion control options evaluation are summarized in Plate 6. Shore Armor (aka "hold the line") alternative had the highest net benefits (-$56M, still a negative, or net cost), vs. other alternatives (-$70 to -$95M net benefits). The shore armor option also had the lowest economic impact ($18M vs about $60M for other alternatives) because the beach and associated recreation would diminish over time. However, the economic impact of maintaining the Beach Boulevard promenade may be under-estimated at only 40,000 annual visitors while 120,000 annual visitors were estimated for the Sharp Park subarea, directly south.

Beach Nourishment

Placement of sand to widen beaches (i.e., beach nourishment) was investigated as a shore erosion mitigation option. The longevity of a widened beach was investigated in terms of the rates at which waves would transport sand away from the widened beach to adjacent narrow beaches. An analytical model using the concept of diffusion[6] (migration away from a location of high concentration, in this case a large mass of sand represented by a wider beach) was applied. The analysis indicated that a constructed beach width of 70 feet would be reduced by half in less than 5 years, and reduced to 25% within 10 years. The rate of sand transport predicted by this method depends primarily on the wave exposure and sand grain size, with coarser sands performing better (less rapid transport and beach width loss). Consequently, offshore reef breakwaters were considered to limit sand transport and increase the effectiveness of the sand placement.

Geology

The RSM identified several data gaps related to coastal geology:

- Beach Thickness: Sedimentary rock outcrops are observed along the Pacifica shore and have been encountered in coastal construction. The encountered rock is often relatively soft and hence is often called "hardpan." The erosion resistance and elevation of the hardpan, the thickness of sand above it have not been mapped but are thought to vary along the shore. The hardpan may affect waves, sand movement, and wall design and construction.

- Sand Sources: Geologic maps indicate that sand deposits in the vicinity of Pacifica are thin and hence there may not be sufficient sand volumes nearby to support economical beach nourishment.

- Sand Transport: Sand transport rates and the driver(s) for erosion in north Pacifica are not defined sufficiently to have confidence in future projections and the performance of beach nourishment. Prior studies have been limited to the use of previously developed information and a sand budget and transport study has not been completed for Pacifica and Daly City.

C. San Mateo County Sea Change: Sea-level Rise Vulnerability Assessment

This Sea Change San Mateo County study established and executed a risk-informed methodology to assess sea-level rise vulnerability and flood risk in San Mateo County (SMC 2017[7]). The assessment used data from all three

[6] Robert Dean, 2002, *Beach nourishment: Theory and practice*, World Scientific, 399p.

[7] San Mateo County, 2018, Sea Change County of San Mateo Sea-level Rise Vulnerability Assessment, Accessed online: http://seachangesmc.com/wp-content/uploads/2018/03/2018-03-12_SLR_VA_Report_2.2018_WEB_FINAL.pdf

sources mentioned below for evaluating the vulnerability of the County and its assets to coastal hazards. The study used the OCOF / CoSMoS and Pacific Institute coastal hazard maps.

D. Various Flood Hazard Maps

There are multiple flood hazard maps for Pacifica, listed below. These hazard maps can be viewed on the web-mapper developed for the Pacifica Adaptation Plan, accessible via the Pacifica Sea Level Rise webpage.[8]

FEMA Flood Hazard Maps

Maps show the computed extents of the "100-year" flood from coastal and creek flood sources.

- 1980s version: Published as paper maps in 1987[9] and republished in digital form in 2008[10], the coastal flood limits are out of date due to coastal erosion and other changes. These maps include the most recent creek flood projections however.
- 2017 version: Recently updated flood hazard maps include updated projections of coastal flooding[11]. The study includes wave and water level data sets which can be used to compute wave runup, overtopping and wave loads. [*Note: The flood projections for Beach Boulevard indicate now wave overtopping of the seawall for the 100-year event, despite wave overtopping occurring every winter and with severe overtopping observed in 2016. Hence the FEMA mapping of coastal hazards are considered erroneous and not reliable.]*

Pacific Institute

Funded by the State of California, the Pacific Institute develop existing and future flood and erosion maps for most of California, including Pacifica, to support an assessment of the potential socio-economic impacts of sea-level rise (Pacific Institute 2009[12]; PWA 2009[13]). The flood maps are based on FEMA maps available at the time and estimates where no mapping existed. Flood elevations were raised with sea-level rise and projected landward: This simple projection over-predicts flooding in low-lying areas and under-predicts flooding on steep shores. Coastal erosion was computed using a new approach that has subsequently been improved upon: The erosion projections are greater than the more recent versions, as intended to project erosion extents not likely to be exceeded during the forecasting period. The hazard maps do not account for shore protection structures.

---

[8] Pacifica Sea Level Rise webpage: https://www.cityofpacifica.org/depts/planning/sea_level_rise.asp

[9] FEMA. 1987a. Flood Insurance Study. City of Pacifica, CA, San Mateo County. February 19, 1987. Community Number 060323. And FEMA. 1987b. Flood Insurance Rate Map. City of Pacifica, CA, San Mateo County. Panel 2 of 7. Community Panel Number 060323 0002 D. February 19, 1987.

[10] FEMA. 2008. Revised Preliminary Flood Insurance Rate Map. San Mateo County, CA. Panel 38 of 510. Map Number 06081C0038E.

[11] FEMA, 2017, Flood Insurance Rate Map 06081C0038F, City of Pacifica, Effective August 2, 2017. Accessed online: https://www.cityofpacifica.org/civicax/filebank/blobdload.aspx?t=68853.43&BlobID=15138

[12] Pacific Institute, 2009. "The Impacts of Sea-Level Rise on the California Coast." A paper from the California Climate Change Center, May 2009.

[13] Philip Williams and Associates (PWA), 2009. "California Coastal Erosion Response to Sea-level Rise - Analysis and Mapping." Prepared for the Pacific Institute.

Our Coast Our Future / CoSMoS

Our Coast Our Future (Ballard et al. 2016[14]) is a collaborative project that provides online maps of 40 different sea-level rise and storm scenarios that were developed by the United States Geological Survey (USGS) using their Coastal Storm Modeling System (CoSMoS 2.0, North-central California, outer coast, Barnard et al 2009[15]). OCOF/CoSMoS modeling for Pacifica does not incorporate the long-term erosion of shorelines and bluffs.

Regional Sediment Management (RSM) Plan, San Francisco Littoral Cell

See item B discussion above.

Pacifica Sea-Level Rise Adaptation Plan

See item A discussion above

E. Coastal Hazards Study for 2212 Beach Boulevard, Pacifica

The report assessed the potential for flooding at old wastewater treatment facility as a precursor to commercial redevelopment (Moffatt and Nichol 2016[16]). The study concluded that the site was not subject to flooding under present conditions or with sea-level rise. [*Note: The findings are predicated on dubious assumptions (1) that the FEMA maps are accurate in terms of predicting overtopping during the 100-year event (the FEMA maps are not accurate), (2) that the City of Pacifica will maintain the beach and seawall and thereby limit wave runup, overtopping and erosion (the feasibility of maintaining a beach with or without sea-level rise is not confirmed). Consequently, this study is not considered reliable.*]

F. Coastal Hazard Discussion for 1567 Beach Boulevard and Inspection of City of Pacifica Shore Protection Fronting 1567 Beach Boulevard, Pacifica

GeoSoils, Inc. prepared a study that discusses coastal hazards at a proposed development site on Beach Boulevard (GeoSoils 2017[17]). The study calculated wave overtopping extending about 40 inland of the seawall for a future condition consisting of 3 feet of sea-level rise, an ocean level of 11.7 feet NAVD (100-year water level plus sea-level rise), incident wave 11.5 feet and 17 seconds, resulting in wave runup of 31 feet NAVD, and an overtopping rate of 1.18 cubic feet per second per foot of wall. The proposed project located 70 feet inland from the seawall were estimated to be exposed to about 1 foot of tsunami inundation during a 200 to 240-year recurrence tsunami. A 3-foot-tall cement block wall was considered sufficient to mitigate the tsunami. Also, the report concluded that no additional erosion or flood protection would be needed for 75 years. [*Note: The study conclusions are dubious because: (1) the OCOF-CoSMoS flood limits (Figure 4 in the report) show the 5-minute average water extents which does not include wave runup and overtopping; the blue dots to the north and south indicate the extent of wave runup and show overtopping onto Beach Boulevard farther south; (2) the finding that the overtopping only extends 40 feet inland during an 100-year event with 3 feet of sea-level rise is incongruent with observed extents*

[14] Ballard, G., Barnard, P.L., Erikson, L., Fitzgibbon, M., Moody, D., Higgason, K., Psaros, M., Veloz, S., Wood, J. 2016. Our Coast Our Future (OCOF). [web application]. Petaluma, California. www.ourcoastourfuture.org. (Accessed: Date [e.g., August, 2016]).

[15] Barnard, P.L., M. van Ormondt, L. H. Erikson, J. Eshleman, C. Hapke, P. Ruggiero, P. N. Adams, A. C. Foxgrover, 2014. Development of the Coastal Storm Modeling System (CoSMoS) for predicting the impact of storms on high-energy, active-margin coasts. Natural Hazards 74(2): 1095-1125. doi:10.1007/s11069-014-1236-y.

[16] Moffatt & Nichol, 2016, Coastal Hazards Study for 2212 Beach Boulevard, Pacifica, Prepared for City of Pacifica, June, 2016.

[17] GeoSoils, Inc., Coastal Hazard Discussion for 1567 Beach Boulevard and Inspection of City of Pacifica Shore Protection Fronting 1567 Beach Boulevard, Pacifica, San Mateo County, California, Prepared for Pacifica States Capital Corp., November 27, 2017.

about the same distance during events which happen more frequently. Consequently, this study is not considered reliable.]

G. Tsunami Hazards Estimates

A study by Elwani et al. (2011)[18] reviewed historic tsunami records and estimated wave runup heights and recurrence probabilities. For Pacifica, a 100-year tsunami runup was computed to be about 3 feet (Figure 2). This study is based on a prior development proposal for 1567 Beach Boulevard, but we were not able to located the study.

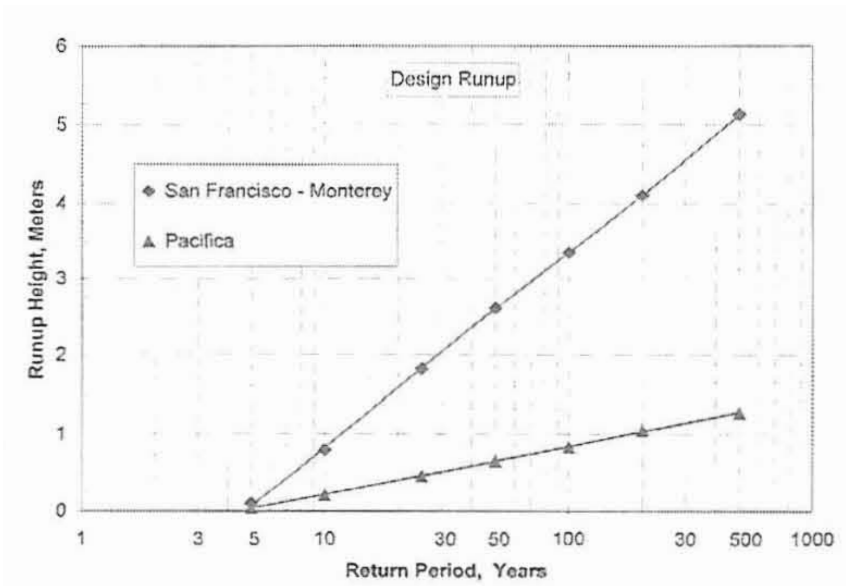


Figure 2
Tsunami runup height at Pacifica for a range of return periods (source: Elwani et al. 2011)

H. California Coastal Commission Staff Report and Exhibits for Item W10a A-2-PAC-19-0160 (Phoenix Capital Condos), June 10, 2020

A CCC staff report[19] for an appeal included photographs, observations and testimony documenting wave runup and overtopping of the Beach Boulevard Seawall focused on the northern end at 1567 Beach Boulevard (reference F above) but including information documenting overtopping at other locations and including comments on 2212 Beach Boulevard (reference E above).

[18] Elwani et al. 2011, Tsunami Hazard Estimates in Central California Using a Probabilistic Approach, Solutions to Coastal Disasters 2010, ASCE, pp 364-375.

[19] CCC 2020, California Coastal Commission, June 2020 Hearing Agenda, Exhibits for Item W10a A-2-PAC-19-0160 (Phoenix Capital Condos) June 10, 2020.

I. U.S. Army Corps of Engineers San Francisco District, CONTINUING AUTHORITIES PROGRAM FEDERAL INTEREST DETERMINATION (FID) REPORT, Beach Boulevard 103, Pacifica, CA

The US Army Corps of Engineers (USACE) investigated Federal interest in reducing storm damages along Beach Boulevard.[20] The study estimated the annual maintenance cost of the Beach Boulevard Seawall to be about $50,000, based on maintenance costs incurred of about $1.75 Million since initial construction about 30 years ago, not including the repairs following the 2016 structural failure. The cost to replace the seawall was preliminarily estimated to be between $5,400 and $19,000 per linear foot, for a total cost of $14 to $45 Million (2017). The report concluded that there was likely not a Federal interest because the potential damages were much less than the cost of seawall construction. [*Note: The assessment of damages relied on the D. FEMA flood hazard mapping and the E. Moffatt & Nichol study, both of which under-estimate the wave overtopping and potential damages. Hence, with accurate wave overtopping projections it is possible that a different conclusion regarding Federal interest could result.*].

J. Structural and Geotechnical Engineering Reports

There are engineering reports associated with each of the coastal structures in the study area. These reports include information pertinent to the project, including subsurface (soils) data, design of coastal structures, and engineering design criteria. These studies will be reviewed by the project civil-structural and civil-geotechnical consultants.

K. Rainfall Hydrology and Runoff

There are several studies relating to the Laguna Salada area just south of Clarendon with relevance to the contiguous flood basin extending north of Clarendon and into the project area:

Hydrologic assessment and ecological enhancement feasibility study: Laguna Salada wetland system

Kamman Hydrology[21] quantified extreme runoff from Sanchez Creek which flows into Laguna Salada and estimated required pump capacity to prevent flooding.

Laguna Salada Resource Enhancement Plan, June 1992.

PWA and others[22] investigated rainfall runoff and lagoon hydrology affecting management of the Sharp Park Golf Course (Laguna Salada).

[20] U.S. Army Corps of Engineers San Francisco District, CONTINUING AUTHORITIES PROGRAM FEDERAL INTEREST DETERMINATION (FID) REPORT, Beach Boulevard 103, Pacifica, CA, P2#: 457824, California's 14th Congressional District Federal Investigation Study of, draft, 2018, 5 July 2017.

[21] Kamman Hydrology & Engineering, Inc. 2009. Report for the hydrologic assessment and ecological enhancement feasibility study: Laguna Salada wetland system, Pacifica CA. Prepared for Tetra Tech, Inc., San Francisco, CA. March 30, 2009.

[22] PWA, Wetlands Research Associates, Inc., and Associated Consultants: Todd Steiner and John Hafernik. 1992. Laguna Salada Resource Enhancement Plan. Prepared for the City of San Francisco and the State of California Coastal Conservancy. June 1992.

Conceptual Ecosystem Restoration Plan and Feasibility Assessment: Laguna Salada, Pacifica, California

ESA PWA and others[23] estimated flood levels in Laguna Salada with future sea level rise based on prior studies with wetland restoration. Developed conceptual design of flood protection for West Fairway Park and Clarendon Road vicinity comprised of low-height setback levees, rainfall runoff detention basins, and pump stations with wetland or ocean discharge.

L. Street, J., 2020 Geotechnical Review Memorandum for 1567 Beach Boulevard, Pacifica, Appeal No. A-2-PAC-19-0160. California Coastal Commission, 14pp.

CCC Geologist Joseph Street provided potential bluff erosion projections at the parcel at the very north end of the seawall study area. The values are:

- Bluff erosion event setback: About 30 feet of bluff erosion may occur within an extreme winter based on historical erosion during el nino winters in north Pacifica.
- Future bluff erosion: for medium-high risk aversion based on CA guidance (OPC and CCC 2018) and a 50 to 75 year life, 200 to 300 feet of bluff erosion.
- Future bluff erosion with seawall removed at 2060: For 45 years after presumed end of seawall life (2060), estimated a potential for 166 to 264 feet of bluff erosion for medium-high risk aversion slr scenario.
- Historical bluff erosion rate if not armored: Estimated 1.5 feet/year of bluff erosion based on historical erosion rates for unarmored bluffs to the north and over longer term, pre-armor at beach Blvd..

Y. Ewing, L., 2020 Flood and Overtopping Risks for New Development at 1567 Beach Blvd. Pacifica, Appeal No. A-2-PAC-19-0160. California Coastal Commission, 14pp.

CCC Coastal Engineer Lesley Ewing addressed overtopping and flooding potential at the project site for seawall in place, seawall removed at 2060 and tsunami with seawall in place. The findings were:

- Seawall in place, existing conditions, in general: Based on historical observations:
  - The City of Pacifica closes Beach Blvd. to traffic during wave overtopping conditions.
  - "*.... some of the homes inland of the road have experienced wave overtopping, resulting in some flooding of garages, debris being washed onto the road and, in one instance, debris broke a sliding glass door. For current conditions, the overtopping occurs only for an hour or two for high tide and storm conditions and most property owners are protecting their homes with sandbags.*"
- Seawall in place: Based on applicant submittals, Ewing takes no exceptions, although suggest guidance recommends higher sea-level rise:

[23] ESA PWA, Peter Baye, and Dawn Reis Ecological Services, 2011. Conceptual Ecosystem Restoration Plan and Feasibility Assessment: Laguna Salada, Pacifica, California. Prepared for the Wild Equity Institute. February 9, 2011.

  - The property has not experienced flooding because the seawall has not overtopped in this location [ESA notes: this is not accurate based on photographs submitted by residents showing overtopping at the site and flooding extending into the lot: See appeal]
  - With 3 feet of SLR, overtopping will result in 1.18 cfs/lft with flooding about 0.5 feet deep extending 40 feet inland of seawall.
  - With greater SLR, the site would not be flooded.
- Seawall NOT in place: Computed for higher sea-levels associated with medium high risk aversion CA guidance scenario:
  - 2060 - with 2.6 feet of SLR: 0.3 to 0.56 cfs/lft- indicating a FEMA AO flood zone
  - 2095 – with 6.25 feet of SLR 2 to 3.76 cfs/lft – indicating a FEMA VE flood zone of 30 feet.
- Tsunami: Overtopping and flooding due to a moderate to severe tsunami is possible.

Z. 1567 Beach Blvd- Required Hazard Setback for 1567 Beach Boulevard, Pacifica, Appeal No. A-2-PAC-19-0160. California Coastal Commission, 2pp.

Recommended 105-foot setback based on end of seawall life in 2060 and project life of 75 years to 2095, with medium-high risk aversion SLR scenario. The setback components were:

- 1.5 fpy historical bluff erosion rate estimate
- SCAPE-type acceleration of erosion in response to sea-level rise
- 30-foot allowance for event erosion.

Data Gaps and Recommendations for Further Assessment

Based on the review of prior studies, the following data gaps and recommendations for further assessment are identified.

Runup and Overtopping

Prior studies, including the effective FEMA flood hazard maps, do not accurately quantify the extent of wave overtopping along Beach Boulevard.

As part of this study, our scope includes re-assessing the wave runup and overtopping hazards along Beach Boulevard for existing and future conditions with sea-level rise for several alternatives, including no project alternative.

Nearshore Bathymetry

No survey data of the surf zone bed elevations is available. While there are digital elevation models comprised of grids of elevation data, the surf zone values are interpolated between the LIDAR-based surveys above water and the sonar-based surveys offshore beyond wave breaking. The interpolation is a straight plane which is not at all representative of the existing bottom elevation, and can result in inaccurate projections of wave runup, overtopping and wave loads.

For this study, we propose using engineering judgment and observations to estimate the likely profile through the surf zone, and to consider collecting limited surf zone elevation transects to inform subsequent work.

Hardpan / Subsurface Conditions / Beach Thickness

It is generally understood that an irregular “hardpan” comprised of weak sedimentary rock has a surface that is very close to beach elevations. This hardpan has been encountered in prior coastal construction, but its surface horizon is not mapped. The presence of hard, erosion resistant material has implications to structure foundations and coastal processes including wave breaking (and runup, overtopping, and structural loads) as well as beach nourishment and response to sea-level rise.

As part of this study, Haro-Kasunich and Associates (HKA) and ESA conducted observations of exposed hardpan along the shore, and HKA surveyed the location and elevation of exposed hardpan. If possible, future surf zone data collection could include limited sediment characterization and investigations to assess the presence of hardpan at subtidal elevations through the surf zone.

Sand Transport Rates/Sand Budget

Comprehensive study of sand transport and sand budget (tracks and projects sand volume changes and beach widths) has not been completed. This data gap makes uncertain:

- Reason(s) / cause(s) of coastal erosion, and
- Feasibility of beach nourishment with and without sand retention structures (reefs, headlands, etc.)

As part of this study, we propose collecting and summarizing existing information, and using simple methods to refine potential implications of beach nourishment for this location at a planning level. Additional study and analysis is recommended at later stages of planning and design of a beach nourishment project.

Sand Sources for Beach Nourishment

Geological investigation demonstrates that the thickness of sand deposits offshore of Pacifica are thin. This implies that the offshore is not a viable source of sand for beach nourishment, and that sand will need to be transported from sources farther away. While there are large sand deposits in the vicinity of the Golden Gate, it is not known whether these sources would be available for use in Pacifica. Therefore, the cost of beach nourishment at Pacifica is difficult to assess.

As part of this study, we recommend considering a range of possible sand sources, and conducting more detailed of sediment availability for subsequent stages of the project.

Storm Drain System Capacities

The capacities of the storm drain system to store and convey wave overtopping waters is not known.

As part of this study, wave overtopping rates will be provided to engineering team members who will assess the storm drain capacities and needed upgrades for existing and future conditions.

Recommended Sea-Level Rise Scenarios

To address expected requirements of the CCC, we recommend considering a range of sea-level rise amounts over time, consistent with current state sea-level rise guidance (e.g., OPC 2018[24], CCC 2018[25]). The state guidance includes three projections associated with low, medium-high, and extreme risk aversion projections, to be used accordingly for projects that have high to low levels of adaptive capacity, respectively. The low risk aversion projection is considered the "likely" range of sea-level rise, and is associated with a 17% chance of occurrence. The medium-high risk aversion projection is associated with a 0.5% chance of occurrence, and is considered a conservative approach for projects with relatively low adaptive capacity, such as the BBIRP. The extreme risk aversion is a worst-case scenario without an assigned probability, and based on catastrophic polar ice melt.

Figure 3 presents the state's sea-level rise projections with recommended planning amounts/horizons for the project: 2 feet by mid-century, 3.5 feet by 2070, and 7 feet by 2100. Based on a 50-year design life of the BBIRP, a sea-level rise amount of 3.5 feet is projected to occur by 2070 under the medium-high risk aversion projection, and was selected as the basis for sea-level rise. Note that sea-level rise amounts of 2 and 3.5 feet are projected to occur at approximately 2070 and 2100, respectively, under the low risk aversion projection. We also recommend considering a sea-level rise of 7 feet occurring at 2100 under the medium-high risk aversion projection as an additional assessment to consider for planning beyond the 50-year design life.

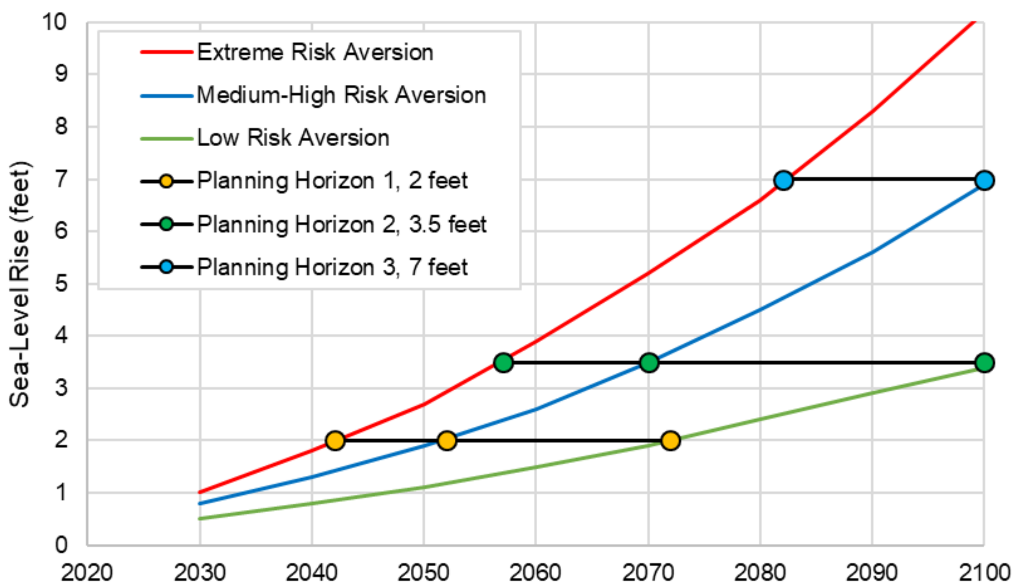


Figure 3
Sea-Level Rise Projections and Recommended Scenarios for the Project

[24] OPC, 2018, State of California Sea Level Rise Guidance, 2018 Update. Accessed online: https://opc.ca.gov/webmaster/ftp/pdf/agenda_items/20180314/Item3_Exhibit-A_OPC_SLR_Guidance-rd3.pdf

[25] CCC, 2018, Sea-Level Rise Policy Guidance, Interpretive Guidelines for Addressing Sea-Level Rise in Local Coastal Programs and Coastal Development Permits, Adopted November 7, 2018. Accessed online: https://documents.coastal.ca.gov/assets/slr/guidance/2018/0_Full_2018AdoptedSLRGuidanceUpdate.pdf

Attachments

Plate 1: Documented wave overtopping and structural damage, Beach Boulevard (source: ESA 2018a,b)

Plate 2: Adaptation Plan: Sharp Park, West Fairway and Mori Point Excerpt from 2018 Sea-Level Rise Adaptation Plan (ESA 2018a,b)

Plate 3: Adaptation Alternatives for Sharp Park, West Fairway Park and Mori Point, from Appendix C of 2018 Sea-Level Rise Adaptation Plan (source: ESA 2018a)

Plate 4: Existing Conditions Map for Sharp Park, West Fairway Park and Mori Point, Figure A-4 from Appendix A of 2018 Sea-Level Rise Adaptation Plan (source: ESA 2018a)

Plate 5: Coastal Erosion Hazard Zones for Beach Boulevard, Figure A-2.6 from San Francisco Littoral Cell Regional Sediment Management Plan (source: ESA 2015)

Plate 6: Summary of Adaptation Alternatives and Results for Beach Boulevard, from San Francisco Littoral Cell Regional Sediment Management Plan (source: ESA 2015)

SOURCE: B. Battalio

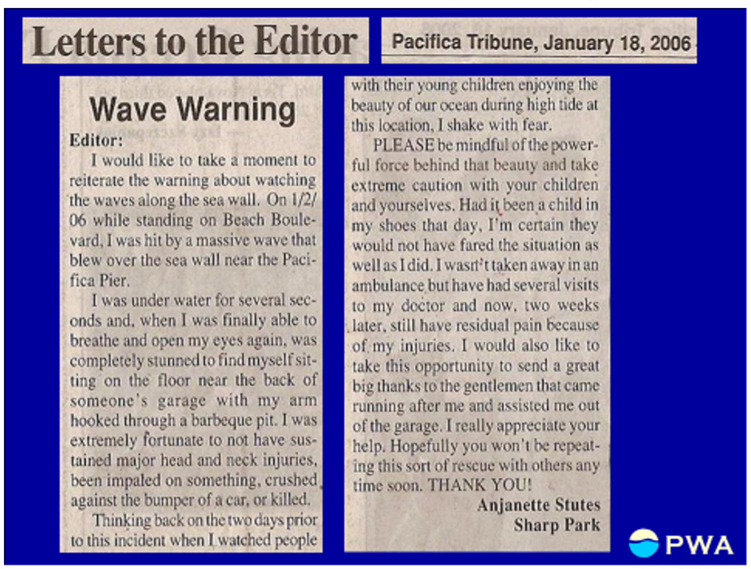
Pacifica LCP 170663

Figure 2
Observed flooding and erosion along Beach Blvd on January 11, 2001

SOURCE: B. Battalio

Pacifica LCP 170663

Figure 3
Observed flooding and erosion events at Pacifica on January 22, 2016



Letters to the Editor

Pacifica Tribune, January 18, 2006

Wave Warning

Editor:

I would like to take a moment to reiterate the warning about watching the waves along the sea wall. On 1/2/06 while standing on Beach Boulevard, I was hit by a massive wave that blew over the sea wall near the Pacifica Pier.

I was under water for several seconds and, when I was finally able to breathe and open my eyes again, was completely stunned to find myself sitting on the floor near the back of someone's garage with my arm hooked through a barbeque pit. I was extremely fortunate to not have sustained major head and neck injuries, been impaled on something, crushed against the bumper of a car, or killed.

Thinking back on the two days prior to this incident when I watched people with their young children enjoying the beauty of our ocean during high tide at this location, I shake with fear.

PLEASE be mindful of the powerful force behind that beauty and take extreme caution with your children and yourselves. Had it been a child in my shoes that day, I'm certain they would not have fared the situation as well as I did. I wasn't taken away in an ambulance but have had several visits to my doctor and now, two weeks later, still have residual pain because of my injuries. I would also like to take this opportunity to send a great big thanks to the gentlemen that came running after me and assisted me out of the garage. I really appreciate your help. Hopefully you won't be repeating this sort of rescue with others any time soon. THANK YOU!

Anjanette Stutes
Sharp Park

PWA

SOURCE: Pacifica Tribune

Pacifica LCP 170663

Figure 4
Reported wave overtopping at Pacifica on Jan 2, 2006

PLATE 1
Documented wave overtopping and structural damage, Beach Boulevard (source: ESA 2018a,b)

PLATE 2 (Page 1 of 3)
Adaptation Plan: Sharp Park, West Fairway and Mori Point
Excerpt from 2018 Sea-Level Rise Adaptation Plan (ESA 2018a,b)

Adaptation Plan: Sharp Park, West Fairway Park and Mori Point

Most of the area is armored. The northern section between the pier and Paloma is subject to frequent wave overtopping and damages to homes have occurred: Therefore, we believe this area is on the threshold of further damages and establish threshold of one foot of sea-level rise. Beaches are narrow and ephemeral, with armoring impeding lateral access from the degraded vertical access ways.

South of the pier, the beach tends to be more persistent and wider, and there is usually an accessible beach in the vicinity of the end of Clarendon, with reliable vertical and lateral beach access. The sea-level rise threshold for this area is estimated to be 1 to 2 feet. South of Clarendon to Mori Point, the beach persists although wave run-up can reach the levee and there is some armoring. The sea-level rise threshold for this area is estimated to be about 2 to 3 feet.

This sub-area is exposed to flooding due to rainfall runoff which cannot flow directly to the ocean. The Clarendon area is exposed to flooding now, and the West Fairway development may be exposed to flooding if sea-level and ground water levels rise over 3 feet.

Armoring

Existing property and infrastructure is at risk to coastal erosion so actions should be taken soon. San Francisco will maintain the SPGC berm and armoring in accordance with Coastal Development Permit (CDP 2-17-0702) to prevent ocean-driven flooding in the sub-area. Adaptation planning undertaken for the SPGC, which is under the authority of San Francisco, should be coordinated with the City of Pacifica to ensure the consistency with Pacifica's adopted policies and community values. A public access improvement plan should be included as part of any erosion-specific adaptation strategy.

2020-2030 (immediately) – Maintain and expand armoring structures to protect public infrastructure. Includes expanding the south Beach Boulevard seawall to the SPGC berm. The City is currently planning to update the Beach Boulevard retaining wall north of the pier to a seawall. Wave overtopping of both north and south Beach Boulevard structures is currently an issue.

2030-2040 (~1 ft SLR) – Armor upgrades to limit wave overtopping will be needed without beach nourishment.

2050 (~2 feet SLR) – Wave overtopping may become unmanageable with 2-3 feet of SLR and further actions such as elevating structures may be needed. If seawalls are not raised and/or SLR exceeds 2-3 feet, further actions may be needed such as utility relocation and further reducing the usage of Beach Boulevard and closing it during storm events.

Beach nourishment

Due to the potential lead time of establishing a sand source, beach nourishment planning should begin immediately. Coarse sand and/or gravel sources are also preferable and would be more cost effective than finer sands due to sediment transport regimes in this sub-area. By constructing sand retention structures along north Pacifica, the efficacy of beach nourishments can be increased.

PLATE 2 (Page 2 of 3)
Adaptation Plan: Sharp Park, West Fairway and Mori Point
Excerpt from 2018 Sea-Level Rise Adaptation Plan (ESA 2018a,b)

2020-2050 (immediately) – Nourish beach to reduce armoring maintenance requirements and provide recreation and ecology benefits. Sand retention structures will increase the efficacy of beach nourishment (at an additional cost).

Ongoing – San Francisco should nourish the beach in front of the SPGC berm as needed to maintain the current beach width.

Flood Protection

Flood protection is already needed for homes and businesses along Clarendon Avenue during rain events and will need to be improved around the SPGC to manage flooding of Laguna Salada regardless of the condition of the SPGC berm. San Francisco is expected to maintain the SPGC berm which protects the Sharp Park neighborhood from the coastal flooding source, but existing pumping facilities in SPGC are not designed to mitigate flooding in and around the course during significant rainfall events (i.e., a portable pump station is currently used to manage rainfall-runoff flooding along Clarendon Avenue). The priority recommendations for flood protection surrounding SPGC are therefore based on the rainfall (fluvial) flood source, but would also be effective during a major coastal storm if the SPGC berm is overtopped or breached. Flooding due to wave run-up landward of Beach Boulevard seawalls is already an issue. If the seawalls are not properly maintained and upgraded in the future to accommodate higher sea-levels, private landowners will need other mechanisms to adapt to flood risks such as raising homes.

2020-2030 (immediately) – Construct Clarendon Ave stormwater basin, pump station, and interior SPGC levee to protect homes and businesses from existing fluvial storm flood hazard zone.

2060-2070 (~3 ft SLR) – Construct West Fairway Park stormwater basin, pump station, and interior SPGC levee to protect western homes from future coastal/fluvial flood hazard zone.

Managed Retreat/Realignment

In absence of any armoring or beach nourishment, managed relocation of private property by private property owners (optional) and realignment of public infrastructure will be needed by 2050.

Timing is dependent on presence and condition of coastal armoring structures, location of built assets relative to the bluff edge and or flood hazard zone, willingness of property owners to engage in managed retreat, and availability of public funding for relocation of public infrastructure. A managed retreat alternative will require significant lead time for both public and private property, so planning and feasibility should be pursued as soon as possible.

PLATE 2 (Page 3 of 3)
Adaptation Plan: Sharp Park, West Fairway and Mori Point
Excerpt from 2018 Sea-Level Rise Adaptation Plan (ESA 2018a,b)

Pacifica LCP 170663

SOURCE: ESA, Pacifica, San Mateo County

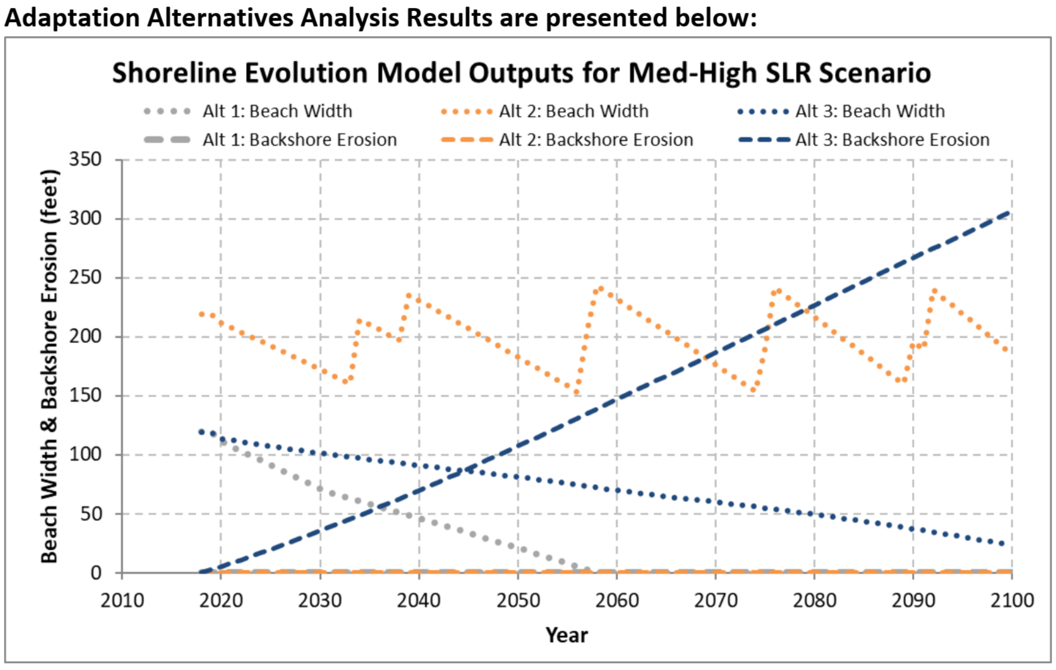
Figure 12
Sharp Park, West Fairway Park and Mori Point Sub-area and existing coastal armor

Table 9. Sharp Park, West Fairway Park and Mori Point Sub-area Adaptation Alternatives

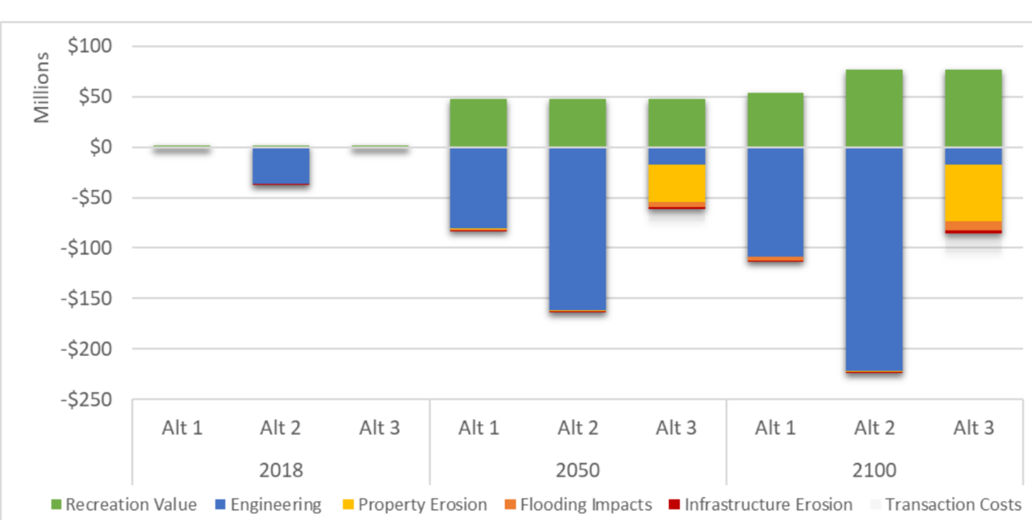
Adaptation Alternative	Adaptation Measures	Description
1 Protect	Armor, levees	**Now:** Maintain existing armor, extend seawall to close Clarendon gap to SPGC levee. Assumes SF will armor and maintain SPGC levee. Build stormwater detention basins with setback levees and stormwater pump stations at Clarendon/Lakeside Ave and end of Fairway Drive. **Future:** Maintain armoring structures.
2 Protect	Armor, Beach nourishment, Sand retention structures, Levees	**Now:** Maintain existing armor, extend seawall to close Clarendon gap to SPGC levee. Nourish beach by 100 feet. Build stormwater detention basins with setback levees and stormwater pump stations at Clarendon/Lakeside Ave and end of Fairway Drive to prevent flooding from Laguna Salada during rain events. Build sand retention structures (part of overall artificial headlands strategy for north Pacifica). **Future:** Maintain armoring and sand retention structures. Place sand: repeat 100-foot beach nourishment every time beach width falls below minimum threshold, increasing frequency as SLR accelerates.
3 Retreat	Managed removal/ relocation of assets	**Now:** Option to private property owners to remove or abandon existing armoring structures protecting property once it is damaged or no longer effective and to allow erosion. **Future:** Purchase property when buildings at risk, Remove or relocate public structures and infrastructure when at risk as erosion progresses.

Adaptation Alternative	Adaptation Measures	Description
1 Protect	Armor, levees	**Now:** Maintain existing armor, extend seawall to close Clarendon gap to SPGC levee. Assumes SF will armor and maintain SPGC levee. Build stormwater detention basins with setback levees and stormwater pump stations at Clarendon/Lakeside Ave and end of Fairway Drive. **Future:** Maintain armoring structures.
2 Protect	Armor, Beach nourishment, Sand retention structures, Levees	**Now:** Maintain existing armor, extend seawall to close Clarendon gap to SPGC levee. Nourish beach by 100 feet. Build stormwater detention basins with setback levees and stormwater pump stations at Clarendon/Lakeside Ave and end of Fairway Drive to prevent flooding from Laguna Salada during rain events. Build sand retention structures (part of overall artificial headlands strategy for north Pacifica). **Future:** Maintain armoring and sand retention structures. Place sand: repeat 100-foot beach nourishment every time beach width falls below minimum threshold, increasing frequency as SLR accelerates.
3 Retreat	Managed removal/ relocation of assets	**Now:** Option to private property owners to remove or abandon existing armoring structures protecting property once it is damaged or no longer effective and to allow erosion. **Future:** Purchase property when buildings at risk, Remove or relocate public structures and infrastructure when at risk as erosion progresses.

Adaptation Alternatives Analysis Results are presented below:



Shore evolution modeling results along Beach Boulevard and Sharp Park Golf Course berm (length-weighted average erosion distances and beach widths combining the two reaches in this sub-area), which inform adaptation strategy implementation and provide outputs for recreational and ecological benefits.



Economic Costs and Benefits for each adaptation strategy
Costs include: Engineering costs of adaptation, cost of damaged infrastructure/property to erosion or flooding, cost of asset removal (where applicable) and property transaction costs (shown as a range of 0-50% of property values affected).
Benefits shown consist of Recreational value. Additional benefits for Alternatives 1 and 2 can be considered to equal avoided cost of erosion and flooding damages under Alternative 3.

Sub-area Asset Exposure Table Sharp Park, West Fairway Park, and Mori Point				Existing Conditions (% of Sub-area)	2100 Exposure Count (Percent of sub-area total) *Exposure Range for inundation and flooding is for Low to Medium-High SLR*		
Category	**Asset**	**Units**	**Total in Sub-area (% of Pacifica)**	**Storm Flooding**	**Coastal Erosion**	**Regular Tidal Inundation**	**Storm Flooding**
Coastal Structures	Armor Structures	feet	5745.243 (35.4%)	5303.68 (92.3%)	5705.658 (99.3%)	-	5459.00-5459.00 (95.0% - 95.0%)
Coastal Structures	Levee	feet	3149.267 (100%)	1707.391 (54.2%)	3149.267 (100%)	-	2028.50-2115.12 (64.4% - 67.2%)
Communication	Comcast Underground Conduit	feet	12976.887 (8.8%)	1848.454 (14.2%)	3920.002 (30.2%)	-	5545.68-5694.46 (42.7% - 43.9%)
Communication	Towers Private	count	5 (19.2%)	-	-	-	-
Community	Affordable Rentals	count	1 (20.0%)	-	-	-	-
Community	Communities At Risk	acres	0 (0.0%)	-	-	-	-
Community	Healthcare Facility	count	0 (0.0%)	-	-	-	-
Community	Landmarks	count	4 (44.4%)	-	-	-	-
Community	Mobile Home Parks	count	0 (0.0%)	-	-	-	-
Community	Schools	acres	0.093 (0.0%)	-	-	-	-
Community	Senior Centers	count	0 (0.0%)	-	-	-	-
Ecosystem	Beaches	acres	20.531 (35.2%)	20.353 (99.1%)	20.378 (99.3%)	4.88-7.61 (23.8% - 37.1%)	20.51-20.51 (99.9% - 99.9%)
Ecosystem	CA Red Leg Frog Habitat	acres	0 (0.0%)	-	-	-	-
Ecosystem	Steelhead Habitat	feet	0 (0.0%)	-	-	-	-
Ecosystem	Streams	feet	1700.067 (1.5%)	-	-	-	-
Ecosystem	Surfgrass	feet	329.821 (2.0%)	329.821 (100%)	2.406 (0.7%)	329.82-329.82 (100% - 100%)	329.82-329.82 (100% - 100%)
Ecosystem	Wetlands	acres	31.712 (14.8%)	30.459 (96.0%)	14.349 (45.2%)	20.10-28.76 (63.4% - 90.7%)	30.68-30.70 (96.7% - 96.8%)
Emergency Response	Fire	acres	0 (0.0%)	-	-	-	-
Emergency Response	Police	acres	0 (0.0%)	-	-	-	-
Hazardous Waste	Cleanup Sites	count	1 (12.5%)	-	-	-	-
Hazardous Waste	Solid Waste Facility	count	0 (0.0%)	-	-	-	-
Hazardous Waste	Underground Storage Tanks	count	1 (20.0%)	-	-	-	-
Land Use	Auto Services	acres	0.586 (12.2%)	-	-	-	-
Land Use	Beach	acres	2.245 (4.9%)	2.236 (99.6%)	-	0.28-0.61 (12.6% - 27.1%)	2.24-2.24 (100% - 100%)
Land Use	Commercial	acres	2.204 (2.5%)	0.234 (10.6%)	-	-	0.30-0.35 (13.5% - 15.9%)
Land Use	Hotels	acres	0 (0.0%)	-	-	-	-
Land Use	Industrial	acres	0.296 (1.6%)	-	-	-	-
Land Use	Mixed Use	acres	1.672 (47.5%)	0.221 (13.2%)	-	-	0.76-0.76 (45.3% - 45.3%)
Land Use	Mobile Homes	acres	0 (0.0%)	-	-	-	-
Land Use	Multi-Family	acres	17.381 (9.4%)	3.457 (19.9%)	-	-	8.62-9.05 (49.6% - 52.1%)
Land Use	Office	acres	0.934 (21.5%)	-	-	-	-
Land Use	Other Open Space	acres	0.088 (0.0%)	0.088 (100%)	-	-	0.09-0.09 (100% - 100%)
Land Use	Other Public or Community Uses	acres	7.332 (9.6%)	0.011 (0.1%)	3.728 (50.8%)	-	4.20-4.31 (57.2% - 58.7%)
Land Use	Parks & Accessible Open Space	acres	266.781 (9.6%)	114.524 (42.9%)	92.665 (34.7%)	43.15-71.84 (16.2% - 26.9%)	120.73-128.38 (45.3% - 48.1%)
Land Use	ROW	acres	0.64 (7.7%)	0.007 (1.1%)	0.64 (100%)	-	0.64-0.64 (100% - 100%)
Land Use	Schools	acres	0 (0.0%)	-	-	-	-
Land Use	Single Family Residential	acres	43.819 (2.5%)	1.174 (2.7%)	5.211 (11.9%)	-	5.51-6.79 (12.6% - 15.5%)
Land Use	Vacant/Undeveloped	acres	3.24 (0.3%)	0.234 (7.2%)	1.44 (44.5%)	-	0.87-1.03 (26.9% - 31.9%)
Lands	Pacifica City Limits	acres	410.471 (5.1%)	129.269 (31.5%)	120.09 (29.3%)	42.74-72.72 (10.4% - 17.7%)	157.40-168.37 (38.3% - 41.0%)
Lands	Parks Conservation	acres	269.053 (7.4%)	116.787 (43.4%)	94.91 (35.3%)	43.43-72.45 (16.1% - 26.9%)	123.00-130.65 (45.7% - 48.6%)
Lands	Parcels	count	683 (5.2%)	111 (16.3%)	207 (30.3%)	9.00-15.00 (1.3% - 2.2%)	241.00-263.00 (35.3% - 38.5%)
Recreation	Access Lateral	feet	4967.416 (44.6%)	4799.061 (96.6%)	4967.416 (100%)	-	4965.54-4967.42 (100% - 100%)
Recreation	Access Vertical	feet	739.208 (29.2%)	393.876 (53.3%)	739.208 (100%)	-	617.47-617.53 (83.5% - 83.5%)
Recreation	Fishing Pier	count	12 (1200.0%)	1 (8.3%)	1 (8.3%)	-	1.00-1.00 (8.3% - 8.3%)
Recreation	Parks	acres	131.383 (4.5%)	83.299 (63.4%)	48.591 (37.0%)	26.18-52.28 (19.9% - 39.8%)	86.11-93.54 (65.5% - 71.2%)
Recreation	Trails	feet	25646.832 (13.8%)	3041.175 (11.9%)	10838.471 (42.3%)	-	4493.83-5049.88 (17.5% - 19.7%)
Stormwater	Pipes	feet	23201.914 (7.9%)	5461.811 (23.5%)	4652.522 (20.1%)	473.54-1851.89 (2.0% - 8.0%)	7576.66-8060.68 (32.7% - 34.7%)
Stormwater	Pump Stations	count	3 (33.3%)	1 (33.3%)	3 (100%)	-	3.00-3.00 (100% - 100%)
Stormwater	Stormwater Outfalls	count	12 (11.0%)	9 (75.0%)	8 (66.7%)	3.00-6.00 (25.0% - 50.0%)	10.00-10.00 (83.3% - 83.3%)
Transportation	Bridge Local	count	0 (0.0%)	-	-	-	-
Transportation	Bridge State	count	4 (44.4%)	-	-	-	-
Transportation	Highway	feet	9263.799 (0.0%)	-	-	-	59.19-69.87 (0.6% - 0.8%)
Transportation	Streets City	feet	36633.25 (6.5%)	5342.075 (14.6%)	7491.986 (20.5%)	31.69-439.18 (0.1% - 1.2%)	11250.25-12410.01 (30.7% - 33.9%)
Wastewater	Pipeline	feet	44760.047 (8.1%)	10253.233 (22.9%)	12827.066 (28.7%)	-	17534.30-19141.75 (39.2% - 42.8%)
Wastewater	Pump Stations	count	2 (33.3%)	1 (50.0%)	1 (50.0%)	-	2.00-2.00 (100% - 100%)
Water	NCCWD Pipelines	feet	35373.134 (5.1%)	4364.073 (12.3%)	8235.167 (23.3%)	-	10918.07-12148.84 (30.9% - 34.3%)

Summary of recommended near-term adaptation priorities (years correspond to medium-high SLR scenario, see specific triggers in Adaptation Plan):

Armoring

2020-2030 (immediately) – Maintain and expand armoring structures to protect public infrastructure.
2030-2040 (~1 ft SLR) – Armor upgrades to limit wave overtopping will be needed without beach nourishment.
2050 (~2 feet SLR) – Wave overtopping may become unmanageable with 2-3 feet of SLR and further actions such as elevating structures may be needed.

Beach nourishment

2020-2050 (immediately) – nourish beach to reduce armoring maintenance requirements and provide recreation and ecology benefits. San Francisco should nourish the beach in front of the SPGC berm as needed to maintain the current beach width. By constructing sand retention structures along north Pacifica, the efficacy of beach nourishments can be increased.

Flood Protection

2020-2030 (immediately) – construct Clarendon Ave stormwater basin, pump station, and interior SPGC levee to protect homes and businesses from existing fluvial storm flood hazard zone.
2060-2070 (~3 ft SLR) – construct West Fairway Park stormwater basin, pump station, and interior SPGC levee to protect western homes from future coastal/fluvial flood hazard zone.

Managed Retreat/Realignment

Timing is dependent on presence and condition of coastal armoring structures, location of built assets relative to the bluff edge and or flood hazard zone, willingness of property owners to engage in managed retreat, and availability of public funding for relocation of public infrastructure.

PLATE 3
Adaptation Alternatives for Sharp Park, West Fairway Park and Mori Point, from Appendix C of 2018 Sea-Level Rise Adaptation Plan (source: ESA 2018a)

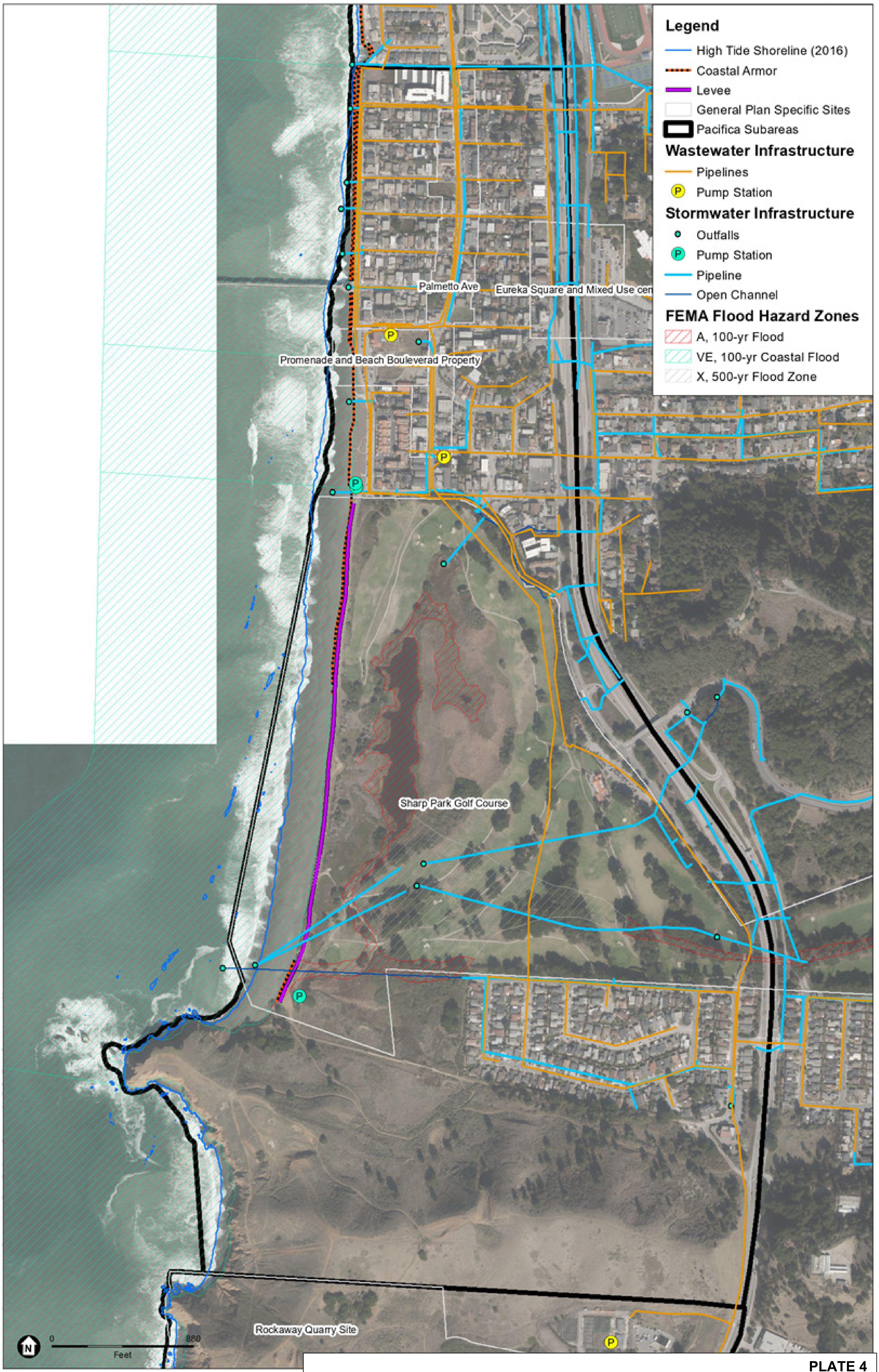


PLATE 4
Existing Conditions Map for Sharp Park, West Fairway Park and Mori Point, Figure A-4 from Appendix A of 2018 Sea-Level Rise Adaptation Plan (source: ESA 2018a)

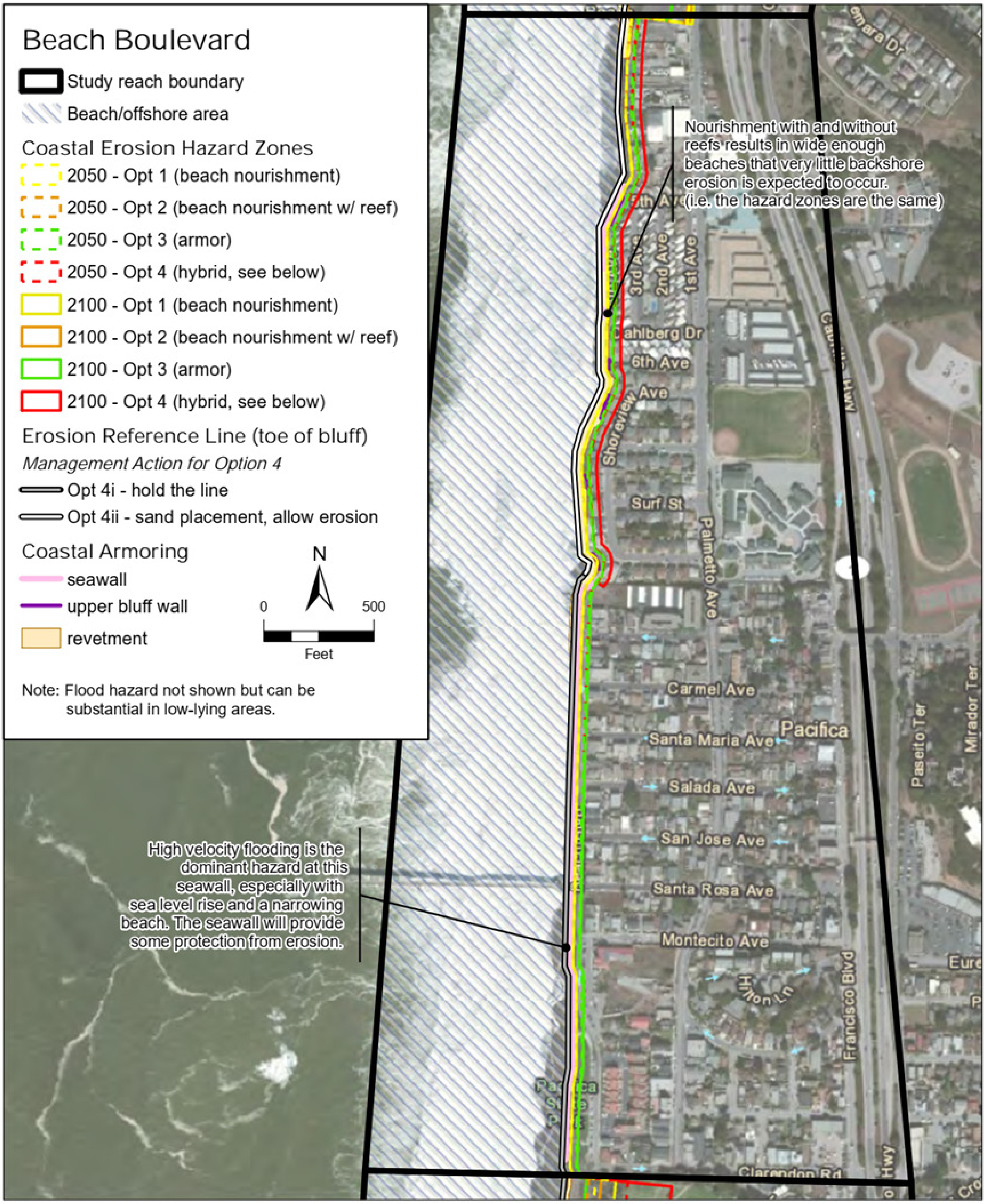


PLATE 5

Coastal Erosion Hazard Zones for Beach Boulevard, Figure A-2.6 from San Francisco Littoral Cell Regional Sediment Management Plan (source: ESA 2015)

Option	Measure	Description	Length	Sand Placements	
			mile	*# by 2100*	*years*
1	Sand Placement	100' sand placement the first year, and then every time the beach width falls below the minimum beach width. Hold the line at backshore.	0.99	8	2010, 2024, 2039, 2052, 2065, 2077, 2088, 2099
2	Sand Placement with Artificial Reef	100' sand placement the first year, and then every time the beach width falls below the minimum beach width. Hold the line at backshore. Offshore reef added.	0.99 (sand), 0.66 (reef)	4	2010, 2039, 2063, 2083
3	Hold the Line	At the seawall, including addition of armor where it currently does not exist.	0.99	N/A	N/A
4(i)	Hold the Line	At selected seawall locations through maintenance.	0.52	N/A	N/A
4(ii)	Sand Placement	100' sand placement the first year, and then every time the beach width falls below the minimum beach width. Backshore allowed to erode.	0.49	8	2010, 2024, 2039, 2052, 2065, 2077, 2088, 2099

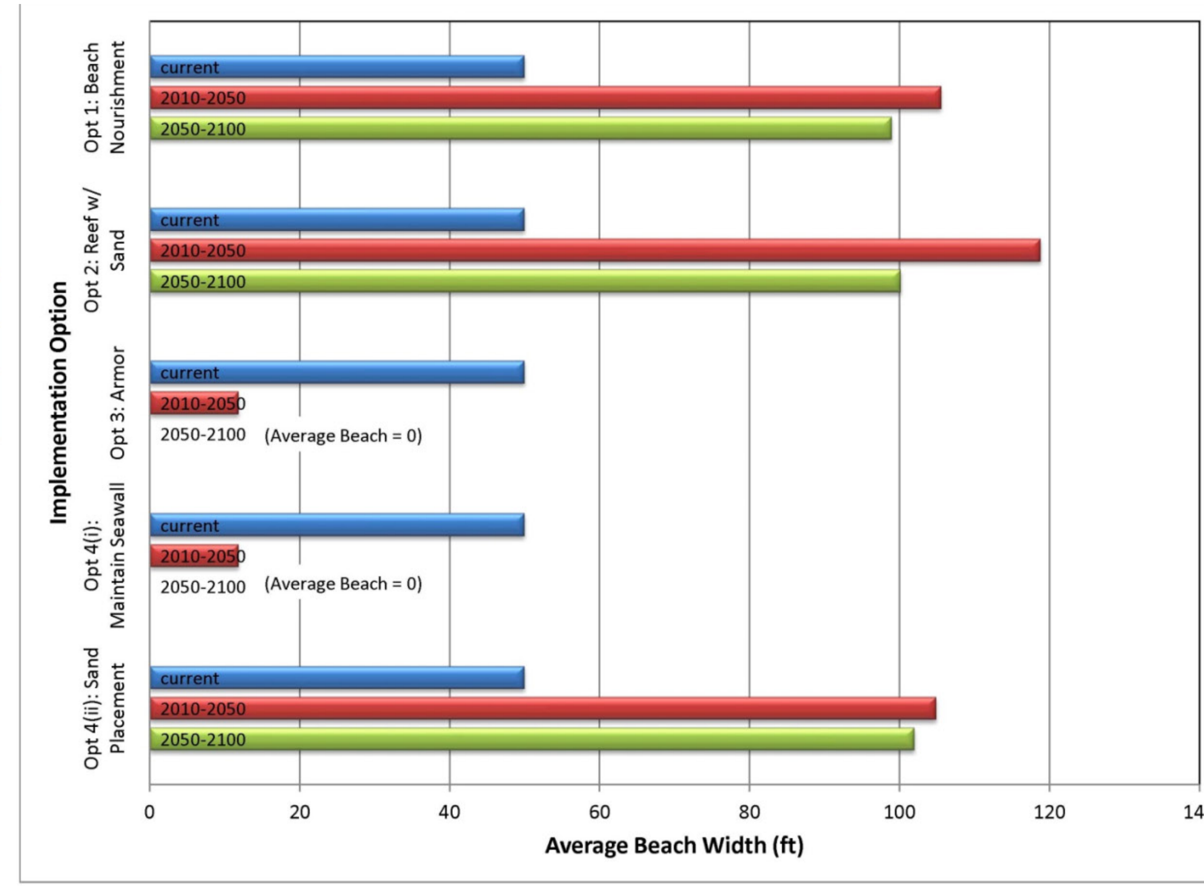
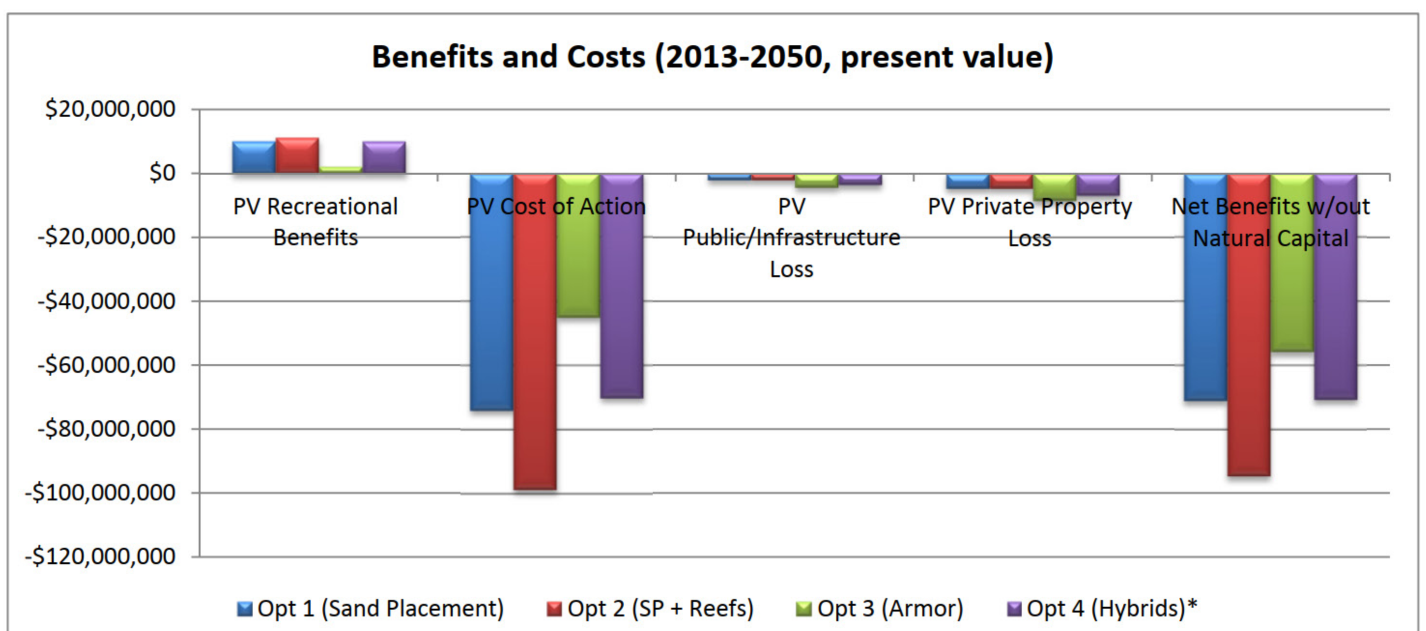


Photo Credits: (left) Elena Vandebroek, (right) Elena Vandebroek



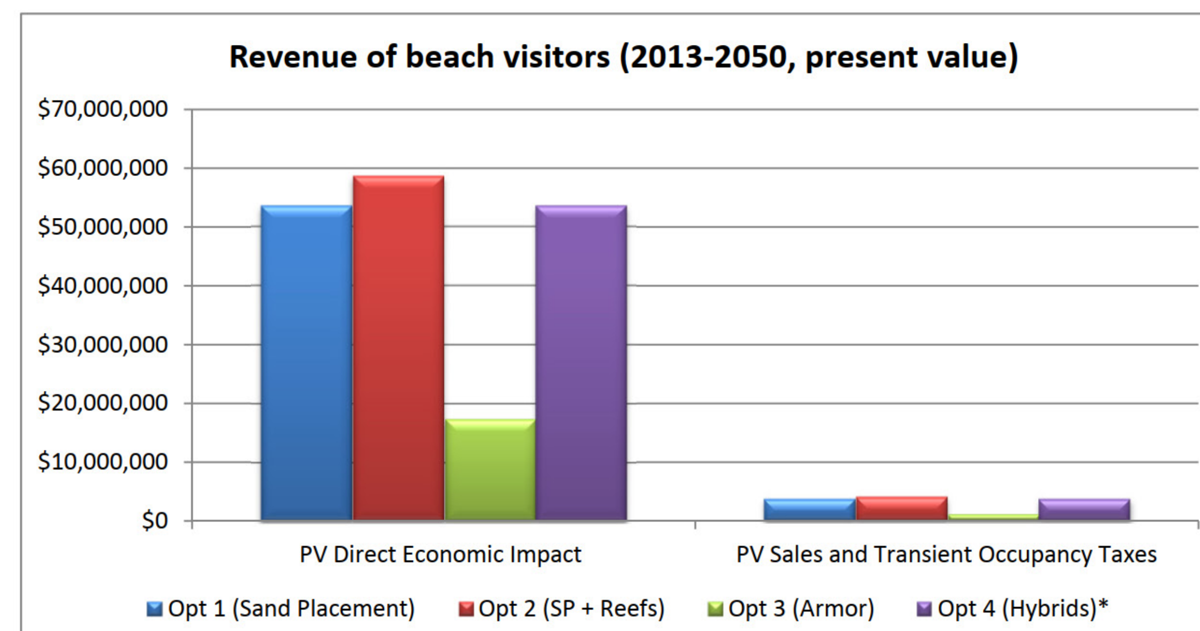


PLATE 6

Summary of Adaptation Alternatives and Results for Beach Boulevard, from San Francisco Littoral Cell Regional Sediment Management Plan (source: ESA 2015)

Appendix B

Proposed Adjustments to Pacifica Surf-Zone Profiles, ESA Memo October 7, 2020

ESA

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

www.esassoc.com

memorandum

date	October 7, 2020 (Updated February 22, 2021)
to	Brian Leslie (GHD), Brian Shedden (HKA), Moses Cuprill (HKA)
cc	Paul Henderson (GHD), John Kasunich (HKA), Louis White (ESA)
from	Bob Battalio, PE (ESA)
subject	Proposed Adjustments to Pacifica Surf-Zone Profiles for City of Pacifica Beach Boulevard Seawall Replacement Project, ESA Ref. #D202000164

Introduction

Per our recent discussions, I've sketched an approximate surf zone profile near the Pacifica Municipal Pier (pier) based on observations taken yesterday and general familiarity with the area. Louis White, PE, contributed to this memorandum. We compared the approximate profile sketch with available surveyed profiles and a final approximate surf zone profile is provided at the end of this memo.

Purpose

The purpose of this exercise is to inform development of a profile for wave runup and overtopping calculations. The best available data consist of the 2017 merged topography (LIDAR) and bathymetry (sonar) which includes interpolation of elevations through the surf zone, resulting in an unrealistic plain, uniform slope through the surf zone (Figure 1). Note in Figure 1 the scale is not correct. We are currently developing a series of digital profiles to use for the wave runup modeling that includes the approximate sand bar and geologic formations to better represent variations of the elevations throughout the surf zone.

Observations of Shore and Surf Zone Conditions

On October 5, 2020, I visited the site and took pictures and notes of conditions with the intent of estimating the elevation of surf zone sand bars based on the breaking waves and tide. The predicted tide for Ocean Beach, San Francisco was +1.7 dropping to about +1.3 feet MLLW between about 5:45 and 6:30 PM. Breaking waves were about 4 to 6 feet face height at breaking, with some larger sets reaching 8 feet, and lulls with only smaller waves. Waves were first breaking about even with pile bent #6 (counted from the shore), which is about 120 feet seaward of the landward-most 4-pile bent (pile bents are a nominal 60 feet apart, and the first and second 4-pile bents are 360 feet apart).

Estimated Profile Through Surf Zone

The estimated profile is shown in Figure 2: Note that this is very approximate. Selected profile elevation points from Figure 2 were transferred to the topo-bathy (Figure 1) and plotted as red circles on Figure 3.

As expected, the estimated surf zone profile has a "S-shaped" profile defined by a shallower "bar" offshore and an ephemeral (seasonal) trough nearshore. It is possible, but not investigated, that the offshore "bar" may relate to shallow hardpan, per sea-floor mapping by the USGS (Figure 4). Hardpan was also recently observed along the shore south of the pier (Figure 5), and surveyed by Haro-Kasunich and Associates (HKA) on August 6, 2020.

Selected pictures of the site during the October 5 2020 observations are provided in Figure 6. Note the distinct wave breaking zone offshore with limited wave breaking at the shore.

A schematic of surf zone morphology interpreted from aerial photograph is provided in Figure 7. Note bar-trough system apparent from the white water associated with wave breaking.

Next Steps

We plan on digitizing the estimated profile at the identified transect locations along the study area for which we will be doing wave runup analysis. We would like to include additional information on the hardpan, which we understand was observed and measured (elevation and location) by HKA. The estimated profile through the surf zone will be modified for future conditions with higher sea-levels using a combination of available geometric modeling and our engineering judgment.

February 2021 Update – Final Approximate "Composite" Profile

The only readily available surf zone surveys were found in the construction drawings for the pier (Ferver 1972), which also included simplified profiles used in the pier design. One profile was not used as it appeared to be a higher, summer-fall profile and it was not complete across the surf zone. These profiles are plotted in Figure 8 along with the estimated profiles derived separately by ESA (described above).

The ESA profiles show good agreement with the range of other profile data. A "composite" profile was drawn to reflect an estimated typical-extreme winter profile for wave runup analysis. The composite profile follows, from shore to offshore:

- The GHD 2020 LiDAR,
- The ESA 2020 Estimated Low,
- Lowest Recorded (Ferver 1975) and September 1965 (attributed to the USACE in Ferver 1975), and
- NOAA 2013 bathymetric survey.

Estimates of the hardpan elevations including field observations were considered. In general, the seaward sloping hardpan observed in the nearshore in 2020, reported in soil borings and construction documents, as generally interpreted in the BBIRP geotechnical engineering report (HKA 2020), are consistent with a nearshore trough as depicted in the estimated composite profile. The expression of hardpan through the surf zone is otherwise not well documented and apparently unknown. Additional review of the pier and seawall project documents, if available, may provide additional information. Field data collection is recommended for engineering design.

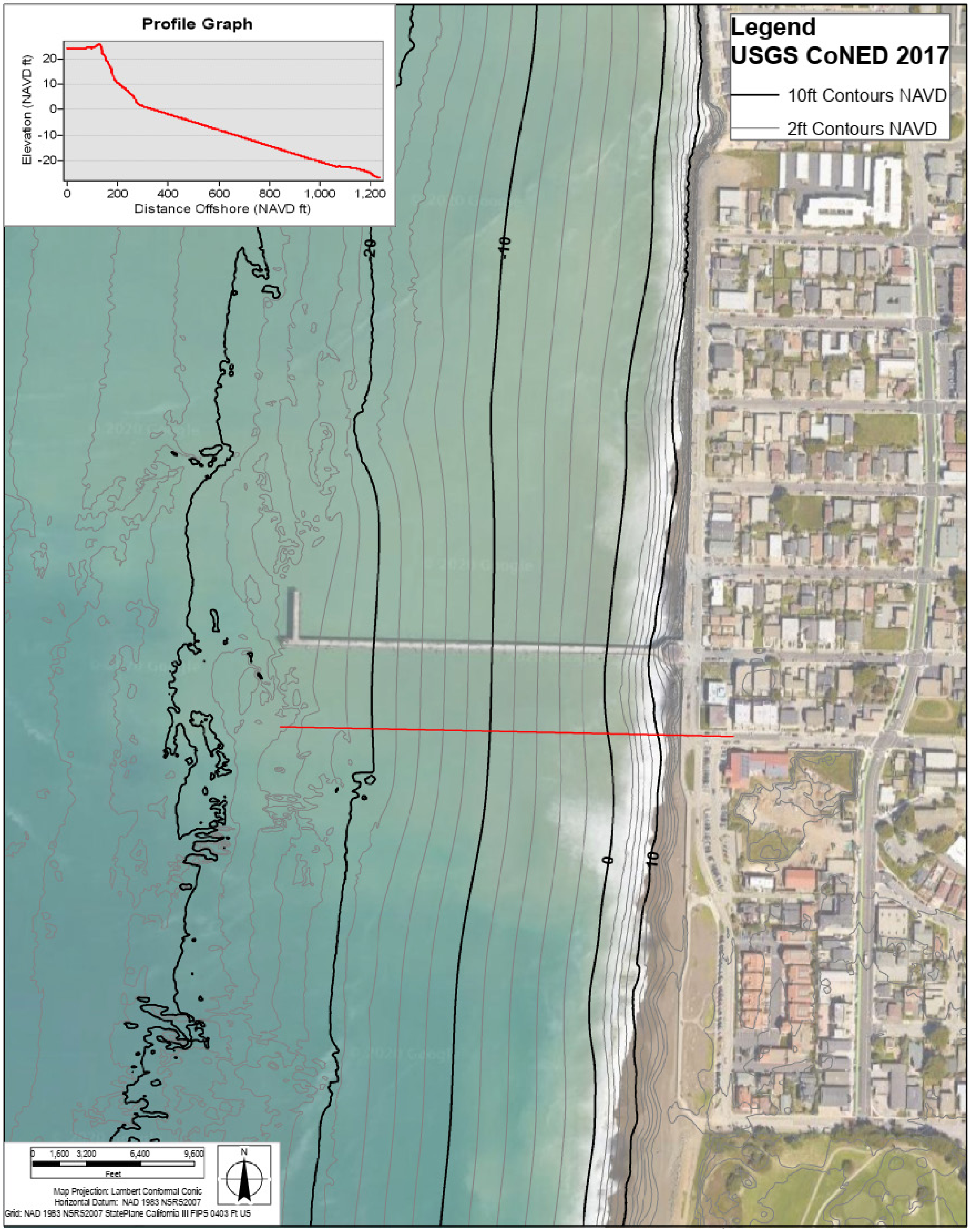
References

Ferver 1972. City of Pacifica Ocean Fishing Pier, Construction drawings by Ferver Engineering Company,

GHD 2020. Elevation survey of nearshore upland for the BBIRP project.

HKA 2020. Feasibility Level Geotechnical Engineering Investigation Beach Boulevard Infrastructure Resiliency Project (BBIRP) Beach Boulevard Pacifica, CA. Prepared for GHD. Draft, October 2020.

NOAA 2013. Digital Elevation Model compiled from data collected in 2013. https://coast.noaa.gov/digitalcoast/data/home.html last visited October 2020.



Source: USGS, NOAA, California State Coastal Conservancy

FIGURE 1
2017 merged topography and bathymetry by others shows interpolation through surf zone

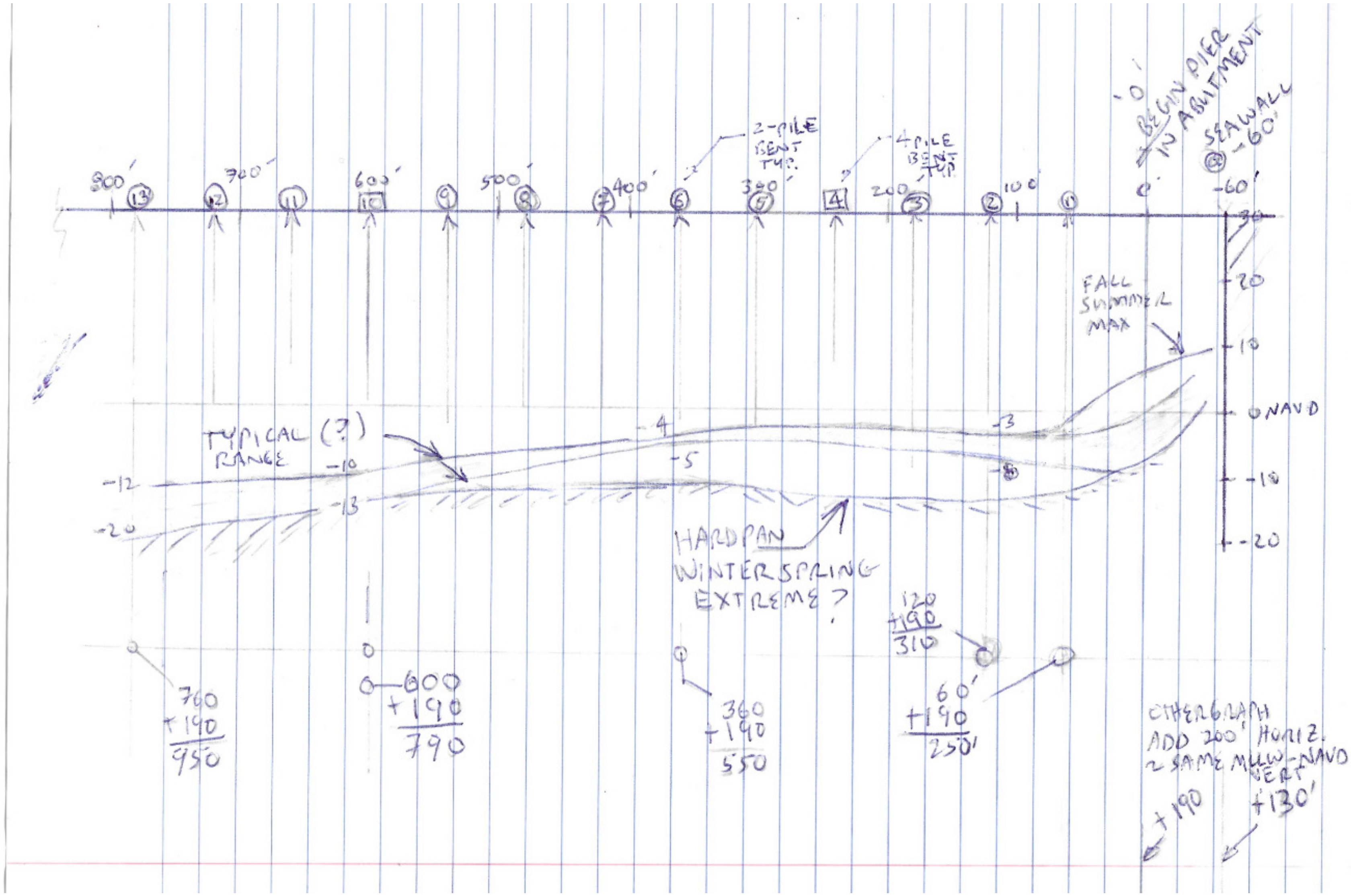


FIGURE 2

Estimated surf zone profile representative of vicinity of Beach Boulevard near the Pacifica Pier, based on visual observations from land on October 5 2020. The calculations on the bottom of the page are coordinate transfer to overlay on the digital profile (see Figure 3).

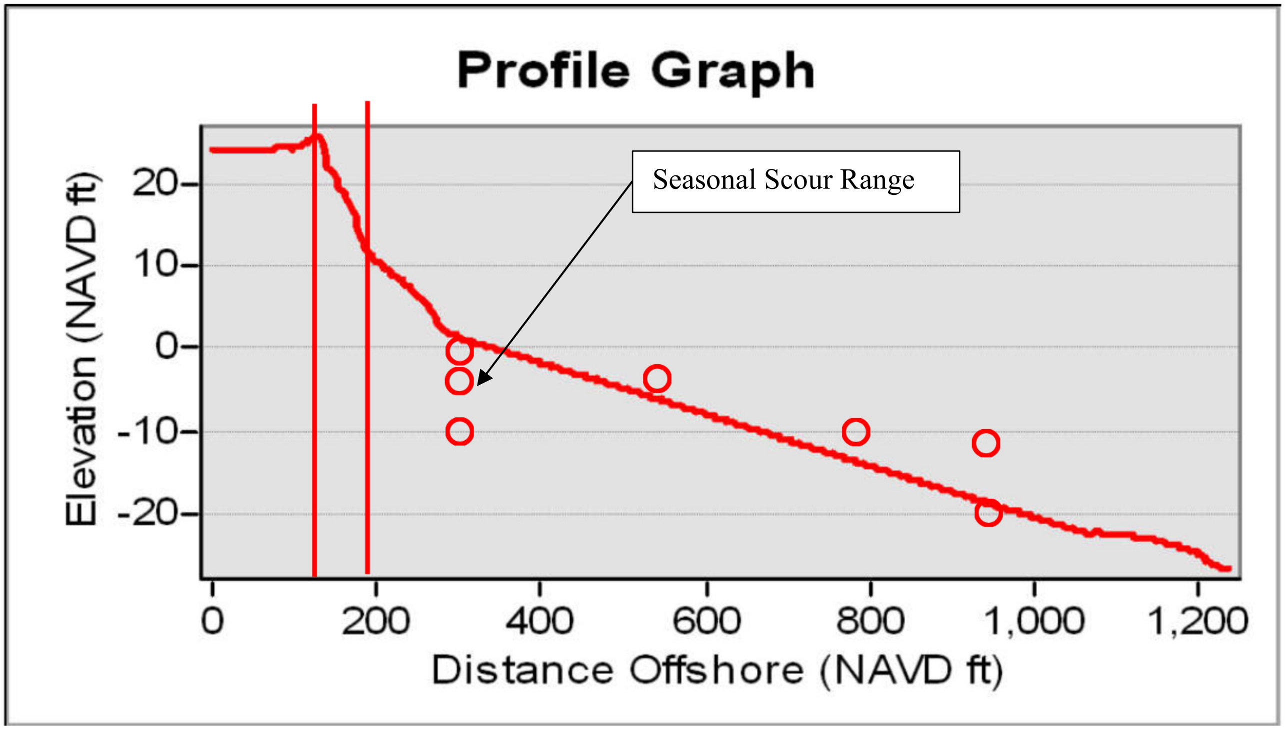


Figure 3
Estimated elevation points from Figure 2 superimposed on profile from Figure 1. Red circles are elevation locations The three circles on the left nearshore indicate the range of elevations observed in this highly-dynamic nearshore: On October 5 2020, the elevations ranged within the upper two circles approximately -1 to -4' MLLW / NAVD. The lower circle is an estimated minimum elevation limited by hardpan south of the pier and quarry stone boulders north of the pier. The two circles on the far right indicate the uncertainty of depths farther offshore where waves were not breaking at the time of recent observations. See Figure 2.

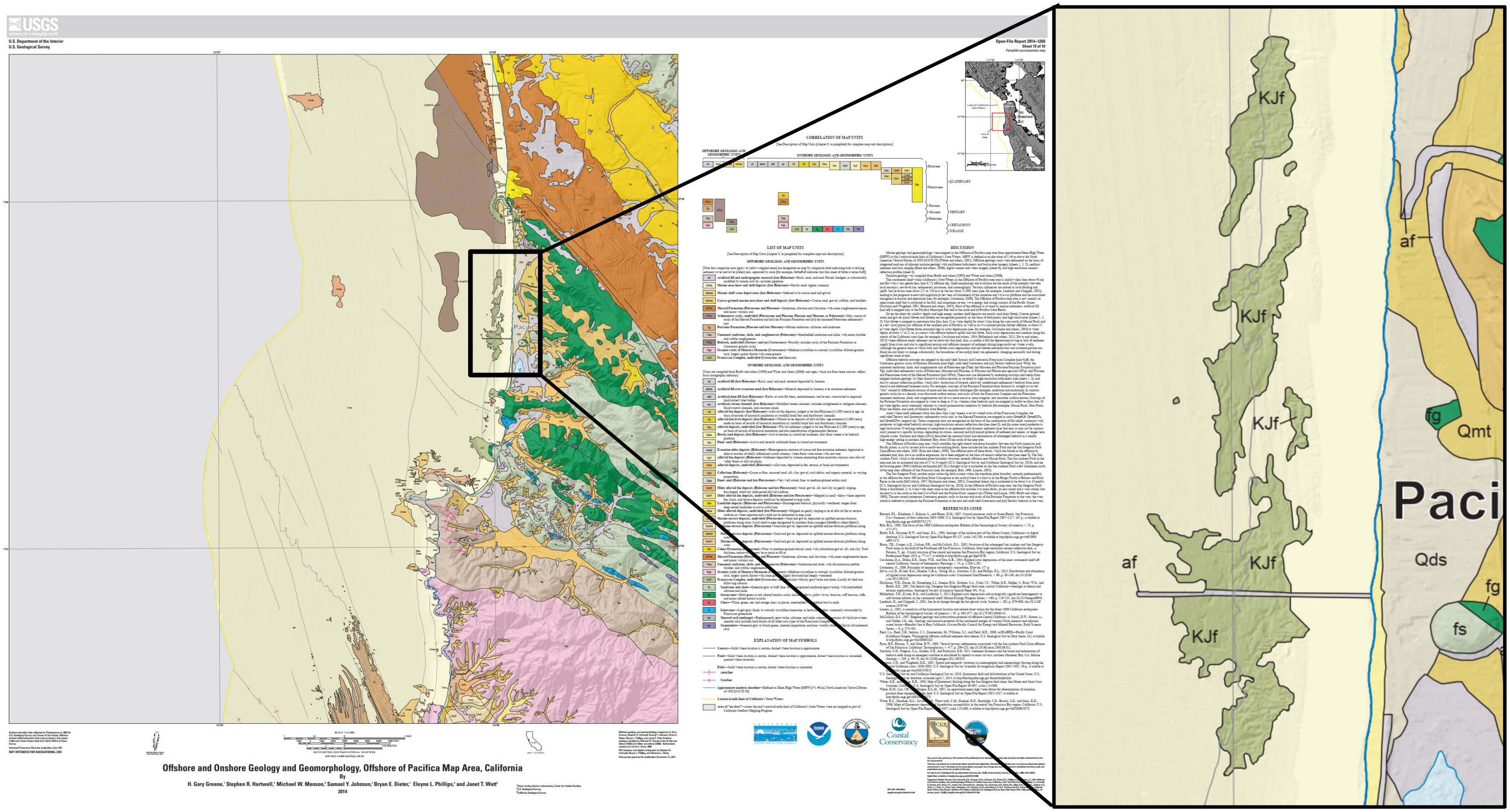


Figure 4
USGS geologic map of the seafloor and nearshore of Pacifica (left) and expanded excerpt vicinity of the Pacifica Pier and Beach Boulevard (right).

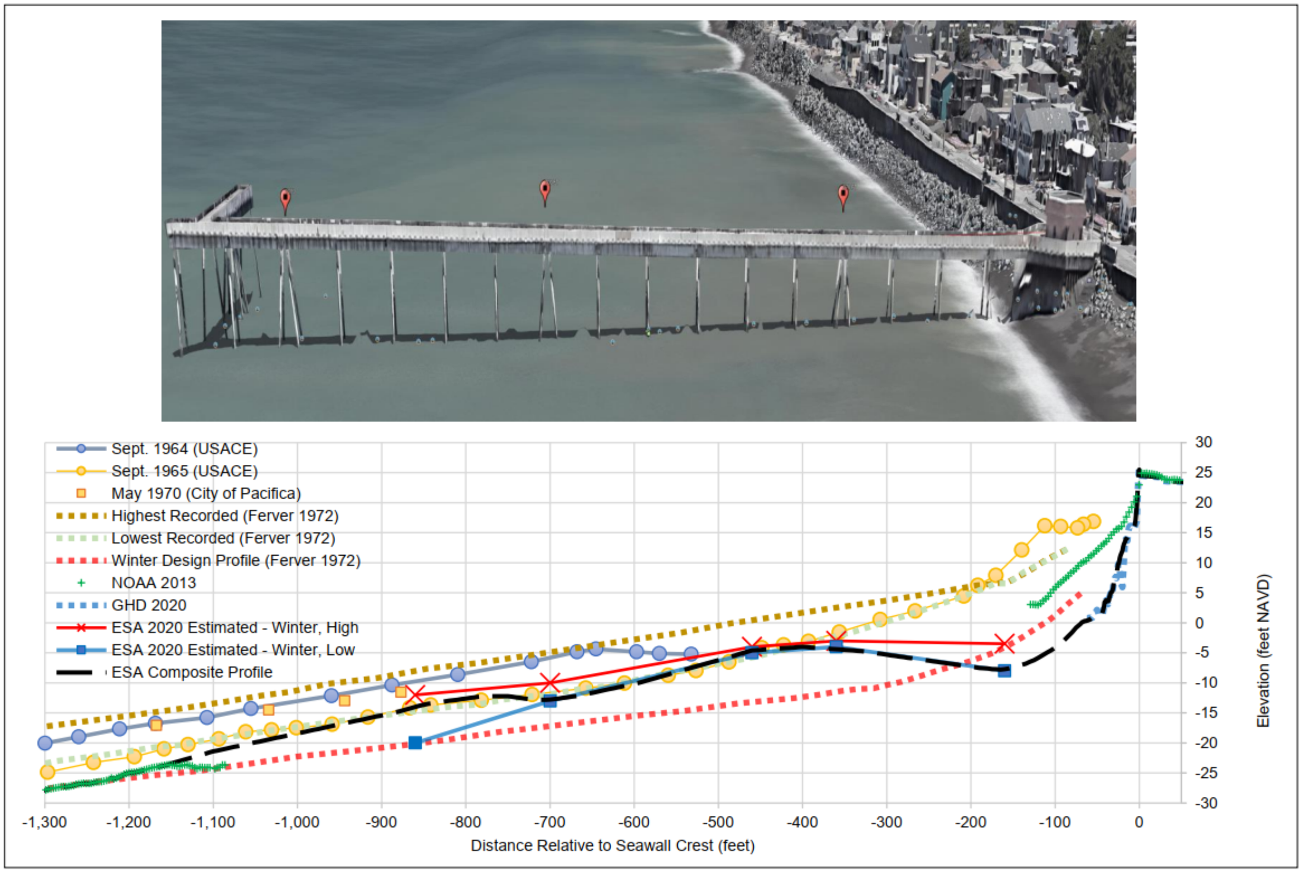
Figure 5
(Top) Hardpan exposed on beach south of Pier on August 3, 2020, 5:30 pm, Tide about +2.5' MLLW and hardpan sloped down and to at least -3.5' MLLW (maximum depth of swimming with wetsuit). (Bottom) Hardpan pictures taken August 5, 2020.

Figure 6
Photographs of conditions on October 5 2020

Source: Google

Figure 7
Surf zone morphology at Beach Boulevard, Pacifica: interpretation of aerial photograph and local knowledge, representative of winter-spring conditions with narrow beach and nearshore trough.

INSERT FIGURE 8 PDF



City of Pacifica BBIRP . D202000164.00

SOURCE:
Imagery from Google Earth
Bathy Data as noted in Legend and Memorandum Text

Figure 8
Comparison of surf-zone profiles in the vicinity of Beach Boulevard and the Pacifica Pier.
"ESA Composite Profile was selected for use in the BBIRP pending better information."

Appendix B

Environmental Conditions Assessment Memorandums (ESA 2020)

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

esassoc.com

memorandum

date October 12, 2020

to Paul Henderson, GHD

from Garrett Leidy, Environmental Science Associates (ESA)

subject City of Pacifica, CA.
Beach Boulevard Infrastructure Resiliency Project – Marine Biological Resources

Introduction

The purpose of this memorandum is to document marine biological resources at Sharp Park Beach, located within the City of Pacifica, California, as they relate to the City's proposed Beach Boulevard Infrastructure Resiliency Project (BBIRP). Specifically, this memorandum summarizes the existing conditions and regulatory setting of the marine environment, discusses the presence of special-status marine species and habitat, and identifies potential benefits of the proposed BBIRP on the marine community. The marine resources described below are based on best available scientific literature, regulatory requirements, and a site assessment conducted by ESA biologist Garrett Leidy on July 14, 2020. Photos from this site assessment can be found in **Appendix A**.

Sharp Park Beach

The proposed project site includes the portions of Sharp Park beach along the existing seawall, which spans approximately 0.5 miles of the waterfront adjacent to Beach Boulevard in the city of Pacifica. Adjacent sandy beach habitat extends approximately 0.7 miles to the south beyond the terminus of the south seawall. Interior to this section of beach lies the Sharp Park Golf Course. On the marine side of the seawall the intertidal environment is comprised of a mix of sandy, beach habitat and large rip-rap armoring. Approximately 400 feet of the seawall adjacent habitat is comprised solely of sandy substrates, all the remaining shoreline contains some amount of rip-rap armoring. The Pacifica Municipal Pier extends approximately 1,100 feet into the Pacific Ocean at the midpoint of the existing seawall. The pier has a continuous width of approximately 16 feet and is supported by a series of concrete piles. North of the pier the rip-rap armoring is larger and occurs in greater quantities relative to the southern portions of the seawall.

Regulatory Setting

Marine biological resources offshore of Sharp Park Beach fall under the jurisdiction of various regulatory agencies. In general, the greatest legal protections are provided for marine species that are formally listed by federal or State agencies. The following regulations are commonly associated with projects that have the potential to affect marine biological resources.

Federal Endangered Species Act

The federal Endangered Species Act (16 U.S. Code section 1531 et seq.) designates threatened and endangered animal and plant species and provides measures for their protection and recovery. The term endangered refers to species, subspecies, or distinct population segments that are in danger of extinction through all or a significant portion of their range. The term threatened refers to species, subspecies, or distinct population segments that are likely to become endangered in the near future.

Activities that damage (i.e., harm) the habitat of listed wildlife species require approval from the U.S. Fish and Wildlife Service or National Marine Fisheries Service; collectively, these entities administer the act. Take of listed species can be authorized through either the section 7 consultation process (for actions by federal agencies) or the section 10 permit process (for actions by non-federal agencies). Federal agency actions include activities on federal land or that are conducted by, funded by, or authorized by a federal agency (including issuance of federal permits and licenses).

The federal Endangered Species Act also generally requires determination of critical habitat for listed species. The Secretary of the Interior (or the Secretary of Commerce, as appropriate) formally designates critical habitat for certain federally listed species and publishes these designations in the Federal Register. Critical habitat is defined as the specific areas that are essential to the conservation of a federally listed species and that may require special management consideration or protection. Designated and proposed critical habitat is present within the Pacific Ocean and is discussed below.

Marine Mammal Protection Act

The Marine Mammal Protection Act of 1972, as amended, establishes a federal responsibility for the protection and conservation of marine mammal species by prohibiting the harassment, hunting, capture, or killing of any marine mammal. The primary authority for implementing the act belongs to the U.S. Fish and Wildlife Service and National Marine Fisheries Service.

Federal Regulation of Wetlands and Other Waters

Federal jurisdictional waters include wetlands and other waters. Wetlands are ecologically complex habitats that support a variety of both plant and animal life. Under normal circumstances, the federal definition of wetlands requires the presence of three identification parameters: wetland hydrology, hydric soils, and hydrophytic vegetation. Other waters of the United States are seasonal or perennial water bodies, including lakes, stream channels, drainages, ponds, and other surface water features, that exhibit an ordinary high-water mark but lack positive indicators for the three wetland parameters.

Section 404 of the Federal Clean Water Act (33 United States Code 1251–1376) prohibits the discharge of any pollutant, including dredged or fill material, into waters of the U.S. without a permit from the Corps. The jurisdiction of the Corps in tidal waters under section 404 extends to the high tide line or high tide mark, simply indicating a point on the shore where water reaches a peak height at some point each year. Implicit in the definition of *pollutant* is the inclusion of dredged or fill material regulated by section 404 (22 United States Code 1362). The discharge of dredged or fill material typically means adding into waters of the U.S. materials such as concrete, dirt, rock, pilings, or side-cast material for the purpose of replacing an aquatic area with dry land or raising the elevation of an aquatic area. Activities typically regulated under section 404 include the use of construction equipment such as bulldozers, and the leveling or grading of sites where jurisdictional waters occur.

Pursuant to Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 United States Code section 403), the Corps regulates the construction of structures in, over, or under, excavation of material from, or deposition of material into *navigable waters*. Navigable waters under the act are those "subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce" (33 Code of Federal Regulations section 3294). In tidal areas, the limit of navigable water under section 10 is the elevation of mean high water mark. Larger streams, rivers, lakes, bays, and oceans are examples of navigable waters regulated. The act prohibits the unauthorized obstruction or alteration of any navigable water (33 United States Code section 403).

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Act (16 United States Code 1801–1884) of 1976, as amended in 1996 and reauthorized in 2007, applies to fisheries resources and fishing activities in federal waters. Federal waters extend to 200 miles offshore. Conservation and management of U.S. fisheries, development of domestic fisheries, and phasing out of foreign fishing activities are the main objectives of the legislation.

The Magnuson-Stevens Act defines *essential fish habitat* as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The act, as amended through 2007, sets forth a number of new mandates for the National Marine Fisheries Service, regional fishery management councils, and federal action agencies to identify essential fish habitat and to protect important marine and anadromous fish habitat. The Magnuson-Stevens Act provided the National Marine Fisheries Service with legislative authority to regulate fisheries in the United States in the area between 3 miles and 200 miles offshore and established eight regional fishery management councils that manage the harvest of the fish and shellfish resources in these waters. The councils, with assistance from the National Marine Fisheries Service, are required to develop and implement fishery management plans, which include the delineation of essential fish habitat for all managed species.

A fisheries management plan is a plan to achieve specified management goals for a fishery and is comprised of data, analyses, and management measures. Essential fish habitat that is identified in a management plan applies to all fish species managed by that plan, regardless of whether the species is a protected species or not. Federal agency actions that fund, permit, or carry out activities that may adversely affect essential fish habitat are required under section 305(b), in conjunction with required section 7 consultation under the federal Endangered Species Act, to consult with the National Marine Fisheries Service regarding potential adverse effects of their actions on essential fish habitat and to respond in writing to the National Marine Fisheries Service's recommendations.

The waters offshore Sharp Park Beach are designated as essential fish habitat for fish managed under four fisheries management plans (FMPs): the Pacific Coast Groundfish FMP, the Coastal Pelagic Species FMP, the Pacific Coast Salmon FMP, and the West Coast Highly Migratory Species FMP.

Coastal Zone Management Act

The Coastal Zone Management Act, Section 307 (16 USC §1456(c)) mandates that federal agency activities be "consistent to the maximum extent practicable with the enforceable policies of approved state management programs," and that this consistency be documented and coordinated with the state. A federal agency ensures consistency of its proposed actions with state management programs by submitting a consistency determination to the relevant state agency. After receipt of the consistency determination, the state agency informs the federal agency of its concurrence with, or objection to, the federal agency's consistency determination.

The California Coastal Commission is the state agency charged with administering the federal act within the California coastal zone (see California Coastal Zone, below). The coastal zone defines the Commission's jurisdiction and area of concern. Any federal activity that affects any natural resources (including wetlands and other water bodies), land uses, or water uses within the Commission's area of concern will be subject to the consistency requirement. Obligations under the act must be met through the federal consistency determination process that is outlined in the act's Federal Consistency Regulations, 71 Federal Regulation 787-831 at 15 CFR 930. The Commission and the California Coastal Act are discussed below under *California Coastal Zone*.

California Endangered Species Act

Under the California Endangered Species Act, the California Department of Fish and Wildlife has the responsibility for maintaining a list of threatened and endangered species (California Fish and Game Code section 2070). The department also maintains a list of candidate species, which are species formally under review for addition to either the list of endangered species or the list of threatened species. In accordance with the requirements of the California Endangered Species Act, an agency reviewing a project within its jurisdiction must determine if any state-listed endangered or threatened species could be present in the project area. The agency also must determine if the project could have a potentially significant impact on such species. In addition, the department encourages informal consultation on any project that could affect a candidate species.

California Fish and Game Code

Fully Protected Species

Certain species are considered fully protected, meaning that the California Fish and Game Code explicitly prohibits all take of individuals of these species except for take permitted for scientific research. Fully protected amphibians and reptiles, fish, birds, and mammals are listed in sections 5050, 5515, 3511, and 4700, respectively.

Marine Life Management Act

Within California, most of the legislative authority over fisheries management is enacted within the Marine Life Management Act. This law directs the California Department of Fish and Wildlife and the Fish and Game Commission to issue sport and commercial harvesting licenses, as well as license aquaculture operations. The department, through the commission, is the state's lead biological resource agency and is responsible for enforcement of the state's endangered species regulations and the protection and management of all state biological resources.

Nearshore Fishery Management Plan

The California Department of Fish and Wildlife prepared the Nearshore Fishery Management Plan in 2002. The management plan establishes a hierarchical framework within which adjustments to the management of the nearshore fishery can be made in a responsible and timely manner in order to meet the 1999 Marine Life Management Act mandate for adaptive management. Of the 19 species addressed in the management plan, six have a life stage with some potential to occur in waters offshore of Sharp Park Beach: Black-and-yellow rockfish (*Sebastes chrysomelas*), Blue rockfish (*S. mystinus*), Gopher rockfish (*S. carinatus*), Grass rockfish (*S. rastrelliger*), Kelp rockfish (*S. atrovirens*) and kelp greenling (*Hexagrammos decagrammus*).

State Regulation of Wetlands and Other Waters

The state's authority in regulating activities in wetlands and waters in the project area resides primarily with the State Water Resources Control Board. The state board, acting through the San Francisco Regional Water Quality Control Board under Clean Water Act section 401, must certify that a U.S. Army Corps of Engineers Clean Water Act Section 404 and Rivers and Harbors Act section 10 permit action meets state water quality objectives. Any condition of water quality certification is then incorporated into the Corps' section 404/10 permit authorized for the project.

The state and regional boards also have jurisdiction over waters of the state under the Porter-Cologne Water Quality Control Act. The state and regional boards evaluate proposed actions for consistency with the regional board's Basin Plan, and authorize the discharges of dredged or fill material to waters of the state by issuing waste discharge requirements or, in some cases, a waiver of discharge requirements. Dredging, filling, or excavation of isolated waters constitutes a discharge of waste to waters of the state, and prospective dischargers are required to submit a report of waste discharge to the regional board.

California Coastal Zone

Within California's coastal zone, the California Coastal Commission has authority to regulate development according to the provisions of the California Coastal Act. The coastal zone generally extends three miles seaward and about 1,000 yards inland from the mean high tide line of the sea. In order to carry out the policies of the Coastal Act, each of the 73 cities and counties in the coastal zone is required to prepare a local coastal program for the portion of its jurisdiction within the coastal zone and to submit the program to the commission for certification. The Commission manages protection of biological resources through a permitting process for all projects in the coastal zone. Once the Commission certifies a local coastal program, the local government gains authority to issue most coastal development permits. The Commission generally retains permit authority over tidelands, submerged lands and public trust lands. Only the Commission can grant a coastal development permit for development in areas of its retained jurisdiction. Coastal Act policies of primary relevance to biological resources are:

- Section 30230 Marine resources; maintenance
- Section 30231 Biological productivity; water quality
- Section 30233 Diking, filling or dredging; continued movement of sediment and nutrients
- Section 30240 Environmentally sensitive habitat areas; adjacent developments

Protected Marine Species and Habitat

Table 1 below identifies special-status marine species that are known to occur along the central California coast and may be present within the waters offshore of Sharp Park Beach. Most of these species are primarily confined to deeper, subtidal waters offshore of the project site but may occasionally stray into the shallow subtidal and intertidal beach environment.

TABLE 1
SPECIAL-STATUS MARINE SPECIES THAT MAY OCCUR IN THE PACIFIC OCEAN WITHIN THE STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**	**Time Period Present in Study Area Waters**
Invertebrates					
Black abalone *Haliotis cracherodii*	FE/-	-	Coastal and offshore island intertidal habitats on exposed rocky shores where bedrock provides deep, protective crevices for shelter.	**Low.** Could be present on hard substrate areas in the nearshore, intertidal portions of the Action Area.	Year-round
Fish					
Sacramento River winter-run ESU Chinook salmon *Oncorhynchus tshawytscha*	FE/-	CE	Anadromous and semelparous. As adults they migrate from a marine environment into the fresh water streams and rivers of their birth (anadromous) where they spawn and die (semelparous).	**Low.** Chinook salmon typically enter the Sacramento River from November to June and spawn from late-April to mid-August, with a peak from May to June. They inhabit nearshore coastal waters of Central California throughout the year, but especially during migration periods.	Adults - November and December Juveniles – fall and winter
Central Valley spring-run ESU Chinook salmon *O. tshawytscha*	FT/-	CT	Ocean waters, Sacramento and San Joaquin Rivers; Migrates from ocean through San Francisco Bay-Delta to freshwater spawning grounds	**Low.** Chinook salmon typically enter the Sacramento River from November to June and spawn December to April. They inhabit nearshore coastal waters of Central California throughout the year, but especially during migration periods.	Adults - late winter to spring Juveniles - fall though spring
Central Valley fall-run/late fall-run ESU Chinook salmon *O. tshawytscha*.	FSC/-	-	Ocean waters, Sacramento and San Joaquin Rivers; Migrates from Ocean through San Francisco Bay-Delta to freshwater spawning grounds	**Low.** No foraging of spawning habitat for this species is present. No streams supporting spawning runs are present within or in the vicinity of the project site. There is a low potential for incidental occurrence of this species if individuals stray from migration routes.	Adults - June through September Juveniles - winter through summer
Central Valley DPS steelhead *O. Mykiss*	FT/-	-	Steelhead are anadromous and can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning.	**Low.** No foraging or spawning habitat for this species is present. No streams supporting spawning runs are present within or in the vicinity of the marine environment. There is a low potential for incidental occurrence of this species if individuals stray from migration routes.	Adults - winter and spring Juveniles - year-round
Central California coast DPS steelhead *O. mykiss*	FT/-	CSC	Steelhead are anadromous and can spend up to 7 years in fresh water prior to smoltification, and then spend up to 3 years in salt water prior to first spawning.	**Low.** No foraging or spawning habitat for this species is present. No streams supporting spawning runs are present within or in the vicinity of the marine environment.	Adults - winter Juveniles – year-round

TABLE 1 (CONT.)
SPECIAL-STATUS MARINE SPECIES THAT MAY OCCUR IN THE PACIFIC OCEAN WITHIN THE STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**	**Time Period Present in Study Area Waters**
Fish (cont.)					
Central California ESU *O. kisutch*	FE		Spend approximately the first half of their life cycle rearing and feeding in streams and small freshwater tributaries with stable gravel substrates. The remainder of the life cycle is spent foraging in estuarine and marine waters of the Pacific Ocean.	**Low.** Historically, runs were common in San Francisco Bay tributaries. Current runs in the Russian River to the north and in Waddell Creek, Scott Creek, San Lorenzo River, Soquel Creek, and Aptos Cree to the south.	May potentially occur in the waters adjacent to the marine study area during migration.
Green Sturgeon (Southern DPS) *Acipenser medirostris*	FT/-	CSC	Marine and estuarine environments and Sacramento River; All of San Francisco Bay-Delta	**Low.** There is little data on green sturgeon presence in coastal waters. This species may forage in or near the study area but its distribution in ocean waters is essentially unknown. Spawning only occurs in the upper Sacramento River watershed for the southern DPS, but fish are known to frequent coastal waters of < 110 meters along the Pacific Coast.	Year-round
Longfin smelt *Spirinchus thaleichthys*	FC/-	CT	Anadromous estuarine species occupying the middle or bottom of water column in salinities between 15-30 ppt.	**Low.** This species is documented to inhabit the deep channels of Central San Francisco Bay for most of the year. Seasonally observed within the offshore environment including potentially in the waters adjacent to the project site.	Year-round
Marine Mammals					
California Sea Lion *Zalophus californianus*	FP	--	Coastal waters off California, ranges from the Farallon Islands off San Francisco to the San Benito Islands off Baja California.	**Moderate**. Common within San Francisco Bay and nearshore coastal environment.	Seasonal
Steller Sea Lion *Eumetopias jubatus*	FT, FP	--	Ranges from Alaska to southern California, and occasionally breeds along the California coast.	**Low.** Occasionally observed on Seal Rocks opposite the Cliff House in San Francisco rare along California coast.	Seasonal
Harbor Seal *Phoca vitulina richardii*	FP	--	Common along the California coast and within San Francisco Bay.	**Moderate**. Common within San Francisco Bay and nearshore coastal environment.	Year-round
Northern Fur Seal *Callorhinus ursinus*	FD	--	Usually come ashore in California only when debilitated, however, few individuals observed on Año Nuevo Island.	**Low**. Occur off of central California during winter following migration from northern breeding grounds.	Seasonal
Northern Elephant Seal *Mirounga angustirostris*	FP	--	Usually observed offshore swimming and foraging and only come ashore when debilitated or at one of the established rookeries.	**Low.** Nearby rookeries are on beaches at Año Nuevo State Park and Southeast Farallon Islands.	Year-round

TABLE 1 (CONT.)
SPECIAL-STATUS MARINE SPECIES THAT MAY OCCUR IN THE PACIFIC OCEAN WITHIN THE STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**	**Time Period Present in Study Area Waters**
Marine Mammals (cont,)					
Guadalupe Fur Seal *Arctocephalus townsendi*	FT, FD	CT	Breed along the eastern coast of Guadalupe Island, approximately 200 Kilometers west of Baja California. In addition, individuals have been sighted in the southern California Channel Islands, including two males who established territories on San Nicolas Island.	**Low.** Guadalupe fur seals have been reported on other southern California islands, and the Farallon Islands off northern California with increasing regularity since the 1980s.	Seasonal
Harbor Porpoise *Phocoena phocoena*	FP	--	Common along the California coast and occasionally observed within San Francisco Bay.	**Moderate**. Common within San Francisco Bay and nearshore coastal environment.	Year-round
Risso's Dolphin *Grampus griseus*	FP	--	Generally found in waters greater than 1,000m in depth and seaward of the continental shelf and slopes, occasionally sighted along the central California coast.	**Low.** Typically found within waters deeper than found within the marine environment.	Year-round
Common Dolphin – Short-beaked *Delphinus delphis*	FP	--	A more pelagic species than the long-beaked common dolphin, ranges from British Columbia to Ecuador.	**Low**. Abundant off the coast of southern California and the Baja peninsula, rare in northern California.	Year-round
Dall's Porpoise *Phocoenoides dalli*	FP	--	Year-round residents of the north Pacific waters of Alaska, but have been observed as far south as Baja California.	**Low**. Uncommon in coastal California waters.	Year-round
Bottlenose Dolphin *Tursiops truncatus*	FD	--	Includes coastal and offshore populations along the Pacific coast of North America.	**Low**. Rare within the coastal waters of northern California.	Year-round
Pacific White-sided Dolphin *Lagenorhynchus obliquidens*	FP	--	Occurs in the Pacific from Alaska to Baja California. In southern California observed in schools up to 1,000 individuals.	**Low**. More common in Pacific waters north of California.	Year-round
Northern Right Whale Dolphin *Lissodelphis borealis*	FP	--	Deep, cold temperate waters over the continental shelf and slope from the Bering Sea to southern California along the Pacific Coast. Groups of 200 individuals are common along the southern California coast.	**Low**. More common in southern California, typically found in waters deeper than present within the study area.	Year-round
Minke Whale *Balaenoptera acutorostrata*	FP	--	Occur from Alaska to Baja California.	**Low**. Primarily confined to northern Pacific waters.	Year-round
Blue Whale *Balaenoptera musculus*	FE, FD	--	Blue whales feed only on krill and occur along the California coast between June and October, during times of high krill abundance. Blue whales begin to migrate south during November.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Seasonal

TABLE 1 (CONT.)
SPECIAL-STATUS MARINE SPECIES THAT MAY OCCUR IN THE PACIFIC OCEAN WITHIN THE STUDY AREA

Common Name *Scientific Name*	Federal Status	State Status	Habitat Description	Potential to Occur in the Study Area	Time Period Present in Study Area Waters
Marine Mammals (cont,)					
Humpback Whale *Megaptera novaeangeliae*	FE, FD	--	Central California population of humpback whales migrates from their winter calving and mating areas off Mexico to their summer and fall feeding areas off coastal California.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Seasonal
Fin Whale *Balaenoptera physalus*	FE, FD	--	More common farther from shore; occasionally encountered during the summer months in close proximity to the California coast.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Seasonal
Sperm Whale *Physeter macrocephalus*	FE, FD	--	Occur in many open oceans; live at the surface of the ocean but dive deeply to catch giant squid.	**Low**. Rarely encountered along the California coast.	Seasonal
Gray Whale *Eschrichtus robustus*	FDL, FP	--	Most commonly encountered great whale along the California coast. In winter, December through February, they are commonly seen traveling south along the California coast.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Seasonal
Killer Whale *Orcinus orca*	FP	--	Transient species observed throughout coastal California waters, ranging from Alaska to Costa Rica.	**Low**. Presence and occurrence can be common but unpredictable.	Seasonal
North Pacific Right Whale *Eubalaena glacialis*	FE, FD	--	Seasonally migratory; inhabit colder waters for feeding, and then migrate to warmer waters for breeding and calving. Found from Alaska to California, herds containing 2,000 individuals have been observed off the southern California coast.	**Low**. Typically confined to ocean waters deeper than found within the marine study area.	Seasonal
Sei Whale *Balaenoptera borealis*	FE, FD	--	Observed generally in deep water habitats including along the edge of the continental shelf, over the continental slope, and in the open ocean.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Seasonal
Short-finned Pilot Whale *Globicephala macrorhynchus*	FP	--	Found primarily in deep waters in warmer tropical and temperate waters, from Alaska to Peru. Forage in areas with high densities of squid, fairly common in southern California waters.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Year-round
Baird's Beaked Whale *Berardius bairdii*	FD	--	Inhabit deep offshore waters in the North Pacific, from Alaska to Monterey, California.	**Low**. Fairly abundant off central California from June to October. However, typically confined to ocean waters deeper than found within the marine environment.	Seasonal

TABLE 1 (CONT.)
SPECIAL-STATUS MARINE SPECIES THAT MAY OCCUR IN THE PACIFIC OCEAN WITHIN THE STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**	**Time Period Present in Study Area Waters**
Cuvier's Beaked Whale *Ziphius cavirostris*	FP	--	Deep pelagic waters (usually greater than 1,000m deep) of the continental shelf and slope, from Alaska to Baja California. Seasonality and migration patterns are unknown.	**Low**. Typically confined to ocean waters deeper than found within the marine environment.	Seasonality unknown

NOTES:
The "Potential for Occurrence within the Project Area" category is defined as follows:
High = Suitable foraging or spawning/rookeries/birthing habitat is present and/or the species has been documented to be present throughout the year and/or in substantial numbers.
Moderate = Suitable foraging or spawning//rookeries/birthing habitat is present and/or the species has been documented to be present for part of the year
Low = Suitable foraging or spawning/rookeries/birthing habitat is present, but the species has either not been documented to be present or if present, the presence is infrequent.
No Potential = Suitable foraging or spawning/rookeries/birthing habitat is not known to be present and the species has not been documented to occur.

FESA = Federal Endangered Species Act, MMPA = Marine Mammal Protection Act, CESA = California Endangered Species Act

Critical Habitat

Critical habitat for green sturgeon, leatherback sea turtle, and black abalone is designated along the California coastline waters of the Pacific Ocean within the marine study area. Additionally, critical habitat for humpback whale and southern resident killer whale is proposed for designation along the Pacific coastline.

Green sturgeon

Critical habitat is designated for green sturgeon along the California Pacific coastline. This designation includes the coastal marine habitat off California from Monterey Bay, north and east to include waters in the Strait of Juan de Fuca, Washington, and extends from mean higher high water to a depth of 358 feet (109 meters) (74 FR 52300). This designation includes all portions the marine environment between these depths. The specific primary constituent elements essential for the conservation of the southern population in coastal marine areas includes:

1. Migratory corridor: A migratory pathway necessary for the safe and timely passage of southern distinct population segment fish within marine and between estuarine and marine habitats

2. Water quality: Coastal marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants (e.g., pesticides, polycyclic aromatic hydrocarbons, heavy metals that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon)

3. Food resources: Abundant prey items for subadults and adults, which may include benthic invertebrates and fish

Leatherback sea turtle

Critical habitat is also designated along the California Pacific coastline for leatherback sea turtles. This critical habitat was designated for this species on January 26, 2012 (77 FR 4170) and includes the portions of the marine study area. Within central California, critical habitat includes the area bounded by Point Sur north along the shoreline following the line of extreme low water to Point Arena extending outward to the 200 meter isobaths.[1] This designation includes all portions the marine environment between these depths.

The occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia, Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks are the primary constituent elements essential for the conservation of leatherbacks in marine waters.

Black abalone

Critical habitat includes areas of rocky intertidal and subtidal habitats with rocky substrate, including rocky benches that contain channels with crevices or large boulders, abundant food resources and suitable water quality. Additional elements of critical habitat include juvenile settlement habitat and nearshore circulation patterns that retain eggs, sperm, fertilized eggs, and late-stage larvae within 100 km from shore so that fertilization and settlement to the rocky intertidal can occur.[2] The marine study area overlaps with black abalone critical habitat. Critical habitat for black abalone within the study area includes rocky intertidal subtidal habitats from the mean higher high water line to a depth of -6 meters, as well as the coastal marine waters encompassed by these areas.[3] The following Primary Constituent Elements are essential for the conservation of black abalone:

(1) **Rocky substrate.** Suitable rocky substrate includes rocky benches formed from consolidated rock of various geological origins (e.g., igneous, metamorphic, and sedimentary) that contain channels with macro- and micro- crevices or large boulders (greater than or equal to 1 meter in diameter) and occur from mean higher high water to a depth of −6 meters relative to mean lower low water.

(2) **Food resources.** Abundant food resources including bacterial and diatom films, crustose coralline algae, and a source of detrital macroalgae, are required for growth and survival of all stages of black abalone. The primary macroalgae consumed by juvenile and adult black abalone are giant kelp (*Macrocystis pyrifera*) and feather boa kelp (*Egregia menziesii*) and to a lesser extent in the Action Area, bull kelp (*Nereocystis leutkeana*).

(3) **Juvenile settlement habitat.** Rocky intertidal and subtidal habitat containing crustose coralline algae and crevices or cryptic biogenic structures (e.g., urchins, mussels, chiton holes, conspecifics, anemones) is important for successful larval recruitment and juvenile growth and survival of black abalone less than approximately 25 mm shell length.

---

1 National Marine Fisheries Service, 2012. Final Biological Report. Final Rule to Revise the Critical Habitat Designation for Leatherback Sea Turtles. Prepared by NOAA's National Marine Fisheries Service. January. Available: http://www.nmfs.noaa.gov/pr/pdfs/species/leatherback_criticalhabitat_biological.pdf.

2 National Oceanic and Atmospheric Administration. 2011. Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for Black Abalone. *Federal Register* 76(208):66805–66844. October 27, 2011.

3 National Oceanic and Atmospheric Administration. 2011. Endangered and Threatened Wildlife and Plants: Final Rulemaking to Designate Critical Habitat for Black Abalone. *Federal Register* 76(208):66805–66844. October 27, 2011.

(4) **Suitable water quality.** Suitable water quality includes temperature, salinity, pH, and other chemical characteristics necessary for normal settlement, growth, behavior, and viability of black abalone.

(5) **Suitable nearshore circulation patterns.** Suitable circulation patterns are those that retain eggs, sperm, fertilized eggs, and ready-to-settle larvae enough so that successful fertilization and settlement to suitable habitat can take place.

Proposed Critical Habitat for Humpback Whale

Both the Central America and Mexico distinct population segments of humpback whale feed off the Pacific Coast of the United States from California to Alaska. Proposed critical habitat for these populations include the waters of all Pacific Coast shorelines. Currently, the National Marine Fisheries Service lists the biggest threats to these populations as entanglement in fishing gear, ship strike, and environmental pollutants.

Essential habitat features for these populations include the maintenance of migratory corridors and ambient soundscape conditions that do not hinder access to prey. Prey availability is specifically defined as, primarily euphausiids and small pelagic schooling fishes of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. The proposed critical habitat ruling does not list migratory corridor access or soundscape conditions as essential habitat features in their own right. However, ocean noise as well as climate change, direct harvest of the prey by fisheries, and marine pollution were identified as having the potential to negatively impact the essential prey feature and the ability of feeding areas to support the conservation of listed humpback whales in the North Pacific.

Proposed Critical Habitat for Southern Resident Killer Whale

Although they are primarily found in northern Washington State, southern resident killer whales are known to travel as far south as central California. Less is known about the whales' movements in coastal waters; however, satellite tagging, opportunistic sighting, and acoustic recording data suggest that killer whales spend nearly all of their time on the continental shelf, within 21.1 miles of shore in water less than 656.2 feet deep. The proposed designated critical habitat includes marine waters between the depth contours of 20 feet and 656 feet.

There is considerable uncertainty about which threats may be responsible for the decline in the southern resident killer whale population, or which is the most important to address for recovery. The National Marine Fisheries Service described the limiting factors to recovery as reduced prey availability and quality, high levels of contaminants from pollution, and disturbance from vessels and other sources of anthropogenic sound (e.g., dredging, drilling, construction, seismic testing, sonar). Essential habitat features include water quality to support growth and development; prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and passage conditions to allow for migration, resting, and foraging.

Essential Fish Habitat

Fish species present along the central California coast, including the marine study area, that are included in Fishery Management Plans prepared by regional Fishery Management Councils under the Magnuson-Stevens Act are listed in **Table 2**. Of the EFH-protected species shown below, those covered under the Pacific Groundfish FMP have the greatest potential to occur within the intertidal and shallow subtidal habitat of Sharp Park Beach. The remaining species are most commonly encountered in deeper, offshore pelagic waters but may occasionally stray into the intertidal environment.

TABLE 2
CALIFORNIA COAST FISH SPECIES MANAGED UNDER THE MAGNUSON-STEVENS ACT

Fisheries Management Plan	Common Name	Scientific Name	Life Stages Present	Potential to Occur in Study Area
Coastal Pelagic	Northern anchovy	*Engraulis mordax*	L, J, A[1]	Moderate
	Pacific sardine	*Sardinops sagax*	L, J, A[1]	Moderate
	Jack mackerel	*Trachurus symmetricus*	J, A[1]	Low
	Pacific mackerel	*Scomber japonicus*	L, J, A[1]	Low
	Pacific herring	*Clupea pallasi*	L, J, A	Low
	Market squid	*Doryteuthis (Loligo) opalescens*	L, J, A[1]	Low
Pacific Groundfish	English sole	*Parophrys vetulus*	L, J, A[2]	Moderate
	Sand sole	*Psettichthys melanostictus*	L, J, A[1]	Moderate
	Rock sole	*Pleruonectes bilineatus*	J, A	Moderate
	Butter sole	*Pleuronectes isolepsis*	J, A	Moderate
	Pacific sanddab	*Citharichthys sordidus*	L, J, A[1]	Moderate
	Starry flounder	*Platichthys stellatus*	L, J, A[3]	Moderate
	Diamond turbot	*Hypsopsetta guttulata*	A	Moderate
	Ratfish	*Hydrolagus colliei*	J, A	Moderate
	Lingcod	*Ophiodon elongatus*	L, J, A[4]	Low
	Brown rockfish	*Sebastes auriculatus*	L, J, A[5]	Low
	Kelp rockfish	*Sebastes atrovirens*	L, J, A	Low
	Aurora rockfish	*Sebastes aurora*	L	Low
	Gopher rockfish	*Sebastes carnatus*	L, J, A	Low
	Splitnose rockfish	*Sebastes diploproa*	L, J[6]	Low
	Yellowtail rockfish	*Sebastes flavidus*	A	Low
	Shortbelly rockfish	*Sebastes jordani*	L, J[7]	Low
	Black rockfish	*Sebastes melanops*	L, J, A[8]	Low
	Black and yellow rockfish	*Sebastes chrysomelas*	L, J, A[9]	Very Low
	Blue rockfish	*Sebastes mystinus*	L, J, A[10]	Low
	Boccacio	*Sebastes paucispinis*	L, J, A	Low
	Grass rockfish	*Sebastes rastrelliger*	L, J, A[11]	Low
	Stripetail rockfish	*Sebastes saxicola*	L, J	Low
	Juvenile & larval rockfish	*Sebastes spp.*	J, L	Low
	Leopard shark	*Triakis semifasciata*	J, A[1]	Low-Moderate
	Spiny dogfish	*Squalus acanthias*	A, J,	Low-Moderate
	Soupfin shark	*Galeorhinus zyopterus*	J, A	Low-Moderate
	Big skate	*Raja binoculata*	J, A	Low-Moderate
	California skate	*Raja inornata*	J, A	Low-Moderate
	Longnose skate	*Raja rhina*	J, A	Low-Moderate
	Cabezon	*Scorpaenichthys marmoratus*	L, J, A	Low-Moderate
Pacific Coast Salmon	Chinook salmon	*Oncorhynchus tshawytscha*	J, A	Low, during migration
	Coho salmon	*Oncorhynchus kisutch*	J, A	Low, during migration
Highly Migratory Species	Common thresher shark	*Alopias vulpinus*	J, A	Low
	Shortfin mako shark	*Isurus oxyrinchus*	J, A	Low, Present in waters deeper than 600 feet
	Albacore tuna	*Thunnus alalunga*	J, A	Low
	Northern bluefin tuna	*Thunnus orientalis*	J	Low, Present in waters deeper than 600 feet

NOTES: Life Stages- A = Adult, J = Juvenile, L = Larvae

SOURCES: [1]Tenera, 2014; [2]Boehlert & Mundy, 1987; [3]PFMC, 2005; [4]Allen, 2014; [5]NOAA, 2014a; [6]NOAA, 2016b; [7]Lenarz, 1980; [8]Miller and Shanks, 2004; [9]SIMoN, 2016c; [10]CDFG, 2001; [11]CDFW, 2016; [12]Driscoll, 2014.

Regional Setting

Intertidal Beach Environment

The intertidal and beach habitat of Sharp Park Beach likely support communities of *benthic* (bottom-dwelling) invertebrates and *plankton* (drifting organisms in the water column).[4] In the shallower sand and mud bottom, the benthic fauna includes various assemblages of polychaete worms, crustaceans (amphipods, crabs, and ostracods), mollusks (pelecypods, gastropods, and scaphopods); echinoderms (starfish, brittle stars, heart urchins, sea cucumber, and sea pens). Other phyla that may be present include nematodes, coelenterates, echiuridans, and rhychocoels.[5] The amphipods, polychaetes, and flies of the intertidal zone provide food for fish and shorebirds.

Seasonal epibenthic surveys conducted along the San Francisco Pacific coastline north of the project site in late winter and fall showed arthropods, such as crabs, dominated the intertidal and subtidal habitat, while echinoderms, mainly sand dollar (*Dendraster exentricus*), were the dominant species in the benthic surveys.[6] The surveys found the most characteristic infaunal species of the beach and intertidal habitat are great beach hopper (*Orchistoidea corniculata*), mole crab (*Emerita analoga*), Pismo clam (*Tivela stultorum*), razor clam (*Siliqua patula*), short-spined starfish, a nephtyid polychaete worm (*Nephtys californensis*), and various species of jellyfish.[7]

Shoreline vegetation observed during the site assessment on the hard surface, rip-rap habitat includes two algae species: rock weed (*Fucus distichus* ssp. *dentates*) and sea lettuce (*Ulva californica*) in the middle and lower intertidal zones, respectively. Several species of crabs, and numerous amphipods and marine worms are common in the rocky intertidal areas and evident under loose rocks and debris. Crabs that are commonly found in similar lower intertidal areas include red rock crab (*Cancer productus*), Pacific rock crab (*Romaleon antennarium*), and yellow shore crab (*Hemigrapsus oregonensis*).

Subtidal / Open Water Environment

The marine environment offshore of Sharp Park Beach is an important migration corridor for many anadromous fish and marine mammals. Three Chinook salmon and two steelhead runs spawn in freshwater tributaries along the California coastline, San Francisco Bay, and within the Sacramento and San Joaquin River watersheds. Other salmonids, including Coho salmon, with no spawning habitat in the San-Francisco Bay-Delta may still utilize the offshore marine waters as a migration corridor. Non-salmonid anadromous fish species including green sturgeon and Pacific lamprey also spawn in freshwater tributaries to the San Francisco Bay-Delta before migrating to the Pacific Ocean and may temporarily occur within the offshore marine environment during migration periods. Other migratory fish species including longfin smelt and Pacific herring are known to seasonally move between San Francisco Bay and the waters of the California coast. In addition to special-status fish species, many species of marine mammals utilize the waters of coastal California as a migration corridor between Mexico and Canada. The migratory patterns of individual special-stratus species and marine mammals are discussed in more detail below.

---

4 U.S. Army Corps of Engineers and the Regional Water Quality Control Board, *Final Environmental Assessment/Environmental Impact Report for Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay, Fiscal Years 2015 – 2024,* April 2015.

5 Ibid.

6 U.S. Army Corps of Engineers, Five-*Year Programmatic Environmental Assessment and 404(b)(1) Analysis for San Francisco Main Ship Channel Operations and Maintenance Dredging Fiscal Year 2012-2016*, January 2013.

7 Ibid.

Numerous species of waterbird occur in the open water marine habitat offshore of Sharp Park Beach. These species include a mix of migrant, wintering, and breeding species, such as, brown pelican (*Pelecanus occidentalis*), fork-tailed storm-petrel (*Oceanodroma furcata*), Brandt's cormorant (*Phalacrocorax penicillatus*), sooty shearwater (*Ardenna grisea*), western grebe (*Aechmophorus occidentalis*) and Clark's grebes (*A. clarkii*), and a variety of gulls and terns.[8]

Sea Turtles

As described above, Sharp Park Beach also falls within areas designated as critical habitat for the leatherback sea turtle (*Dermochelys coriacea*). Leatherbacks migrate across the Pacific Ocean, between the Asian and American continents, typically residing along the west coast of California in late summer and early fall months.[9] Leatherbacks are infrequently observed along the California coastline, with peak observations observed between July and October, but have the potential occur year round.[10] Other sea turtle species including the green sea turtle (*Chelonia mydas*), loggerhead sea turtle (*Caretta caretta*), and Olive Ridley sea turtle (*Lepidochelys olivacea*) are infrequent visitors the open water habitat offshore central California. While these species are unlikely to maintain a sustained presence within the waters offshore of Sharp Park Beach they may temporarily inhabit this habitat during migratory periods.

Special-Status Fish

The intertidal waters of Sharp Park Beach fall within areas designated as critical habitat for green sturgeon, which extends from the Mean Higher High Water (MHHW) line to a depth of 110 meters.[11] As an anadromous species, green sturgeon migrate from freshwater spawning habitat to the Pacific Ocean, the timing of which places sturgeon in coastal waters primarily during summer and fall months.[12] However, the overall timing of sturgeon migration is somewhat variable, so there is a low potential for occurrence year round within the study area.

In addition to green sturgeon, special-status salmonids including the central California coast Coho salmon ESU (*Oncorhynchus kisutch*), California coastal Chinook salmon ESU (*Oncorhynchus tshawytscha*), Sacramento River winter-run Chinook salmon ESU (*O. tshawytscha*), Central Valley spring-run Chinook salmon ESU (*O. tshawytscha*), central California coast steelhead DPS (*Oncorhynchus mykiss*), and California central valley steelhead DPS (*O. mykiss*) are all known to occur within the coastal waters of central California when migrating between freshwater spawning habitat and the Pacific Ocean. Of those races, central California coast steelhead has the nearest natal spawning streams and is the most likely to occur in the waters adjacent to the study area during migratory periods. The presence of any special-status salmonids within the marine waters offshore of Sharp Park Beach would only be temporary and occur during migratory periods.

---

8 eBird: Sharp Park beach. Hotspot, https://ebird.org/hotspot/L1022599, accessed October 9, 2020.

9 Benson, S. R., T. Eguchi, D. G. Foley, K. A. Forney, H. Bailey, C. Hitipeuw, B. P. Samber, R. F. Tapilatu, V. Rei, P. Ramohia, J. Pita, and P. H. Dutton. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7): art84.

10 Benson, S. R., K. A. Forney, J. T. Harvey, J. V. Caretta, and P.H. Dutton. 2007. Abundance distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California 1990-2003. Fish. Bull. 105:337-347.

11 National Marine Fisheries Service (NMFS). 2009. Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Vol. 74, No. 195. Friday, October 9, 2009.

12 NMFS. 2015. Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*) – 5-year Review: Summary and Evaluation. 2015.

Marine Mammals

A significant number of cetacean species utilize the open waters of the coast of central California as a migration corridor, including: blue whale (*Balaenoptera musculus*), eastern North Pacific gray whale (*Eschrichtius robustus*), North Pacific humpback whale (*Megaptera novaeangliae*), killer whale (*Orcinus orca*), minke whale (*Balaenoptera acutorostrata*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Risso's dolphin (*Grampus griseus*), long-beaked common dolphin (*Delphinus capensis*), bottlenose dolphin (*Tursiops truncatus*), and Dall's porpoise (*Phocoenoides dalli*).[13] Of these, gray whale is the most commonly encountered cetacean, as migrating populations often pass within 3 km of the coastline.[14]

Other marine mammals including the California sea lion (*Zalophus californianus*), harbor porpoise (*Phocoena phocoena*), and Pacific harbor seal (*Phoca vitulina richardsi*) are more frequent visitors of the nearshore environment off the Pacifica coastline. The northern elephant seal (*Mirounga* angustirostris) maintains a breeding colony to the south at Año Nuevo State Park and thus may temporarily occur in the offshore environment.

Conclusion

The intertidal, subtidal, and open water environments adjacent to the Sharp Park Beach support a diverse marine community, including several protected species and habitats. The offshore environment includes critical habitat designation for three marine species: black abalone, leatherback sea turtle, and green sturgeon. Additionally, the offshore, pelagic environment is located within proposed critical habitat for populations of humpback whale and killer whale. The entirety of the coastal environment is designated as EFH under multiple Federal fisheries management plans. Central California also supports a range of resident marine mammal species and serves as a migration corridor for a significant number of protected cetaceans. However, even with the large amounts of protected habitat and complex regulatory setting, the likelihood for the physical occurrence of any individual special-status species within the intertidal and subtidal environments off Sharp Park Beach ranges from low to moderate. No special-status species are known to be permanent residents of the nearshore environment.

Any in-water or shoreline work conducted at Sharp Park Beach would occur within these protected habitats, and as such, have the potential to negatively impact multiple special-status species. Marine construction work typically causes temporary impacts to water quality through increases in turbidity and may result in the exclusion of marine species from the affected area. Other marine impacts from construction include elevated underwater noise levels, increased vessel traffic, and the increased risk of spill or contamination from construction equipment. With the implementation of mitigation measures, including the use of silt curtains and floating booms, hydroacoustic monitoring, and standard construction best management practices, any impacts on marine species or habitat would likely occur at a negligible level. The placement of fill or other permanent alterations to the marine environment may result in a net loss in critical habitat or EFH. Such alterations do not always result in negative impacts on marine species and habitat; especially if dilapidated infrastructure is removed and replaced with more ecologically-conscious alternatives.

---

[13] U.S. Army Corps of Engineers. 2015. Coastal Regional Sediment Management Plan for the Santa Cruz Littoral Cell, Pillar Point to Moss Landing. Prepared for The California Coastal Sediment Management Workgroup. September 2015.

[14] National Oceanic and Atmospheric Administration. 2017. Monterey Bay National Marine Sanctuary – Marine Mammals. Accessed November 22, 2017. https://montereybay.noaa.gov/sitechar/mamm3.html#3a.

APPENDIX A

Site Photos

Photo 1: Southern extent of seawall (looking south)

Photo 2: Southern extent of seawall (looking north)

Photo 3: Boulder rip-rap and pier (looking northwest)

Photo 4: Boulder rip-rap and pier café (looking northwest)

Photo 5: Boulder rip-rap with pier (looking west)

Photo 6: North of pier, boulder rip-rap (looking north)

ESA 50 YEARS 1969-2019

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

esassoc.com

memorandum

date	October 9, 2020
to	Paul Henderson, GHD
cc	Project File
from	Eric Zigas, ESA
subject	Beach Boulevard Infrastructure Resiliency Project Ecological Characterization: Recreation and Visual Resources

Section 1. Introduction

1.1 Background and Purpose

This memorandum presents the findings of reconnaissance-level surveys of recreation and visual resources along the existing Pacifica Seawall Promenade in the Sharp Park neighborhood of Pacifica, California. The scope of this document is to characterize these resources, and to identify potential opportunities for the proposed seawall replacement to improve them.

1.2 Project Location

Beach Boulevard is a southbound, one-lane street in the West Sharp Park neighborhood and is oriented along, and parallel to, the Pacific Ocean. It is bordered primarily with residential properties on the eastern side, and the seawall/beach promenade on the west. See Figure 1. Beach Boulevard provides approximately 0.5 mile of access to the coastline and connects the Pacifica Beach Park, the Coastal Trail, and the Pacifica Municipal Pier.

Section 2. Characterization

2.1 Methods

ESA staff reviewed available documentation on the recreational site conditions along the North Seawall, the South Seawall, and the Municipal Pier/Promenade. Likewise, Pacifica's scenic views of the coast and visual resource protection policies, as well as views from, and of the coast, have been reviewed and key viewpoints have been identified. ESA staff conducted reconnaissance-level site visits on July 13 and 14, 2020. No formal recreation user counts were conducted.

The following documents were reviewed prior to the site visit:

- Plan Pacifica Neighborhood Visioning Meetings, Summary Report, July 2019
- Sharp Park Existing Conditions Report, December 2019
- Existing Conditions Report -- Survey Analysis, December 2019
- Draft Local Coastal Land Use Plan (for CCC Review), February 2020
- City of Pacifica, Bicycle & Pedestrian Master Plan, February 2020

2.2 Setting

The Beach Boulevard Promenade, together with the Municipal Pier and Sharp Park Beach, provide extensive access to recreation opportunities. Activities observed along the North Wall included walking (with and without dogs) and jogging.

The Municipal Pier is 1,140 feet long, and has lights, fish cleaning stations, benches, restrooms and a coffee house/snack bar. Free parking is located on adjacent streets and in a nearby lot. Handicapped parking is also available, with pier accessibility via a ramp leading to the south side of the pier. The pier is open daily from 4AM to 10PM, unless closed due to inclement weather, high surf, or repairs. No admission is charged and no fishing license is required at the Pier[1].

Activities along the South Wall included walking, jogging, socializing, shore fishing and beachcombing. Pelican watching is a favorite activity in the summer months[1]. The beach, part of Pacifica State Beach is open to the public, is accessed from trails from the south, at Clarendon Road, and also from stairs along the South Wall of the Beach Boulevard Promenade. See Figures 2 and 3. Stairs are also available along the North Wall, but on the days of the site visit there was no beach observed north of the Pier; the shoreline along the base of the North Wall is composed of large rocks to protect the wall from the surf. See Figure 4. There is limited parking, provided as pockets on Beach Boulevard north of the Pier. Public parking is available on the southern-most section of Beach Boulevard and provides access to a picnic area/trailhead for the Promenade to the north, as well as to the Coastal Trail. The Coastal Trail, which runs south along the berm in front of the Sharp Park Municipal Golf Course, is accessed from the picnic area/trailhead at the end of Clarendon Road. See Figures 5 and 6.

The Sharp Park Municipal Golf Course is located south of Clarendon Road, borders the Coastal Trail and provides a unique recreational asset. The golf course is part of a land bequest made to the City and County of San Francisco early in the 20th Century on the condition that the land be used for public park or recreation. Designed by the preeminent architect Alister MacKenzie, the golf course is often referred to as “The Poor Man’s Pebble Beach”[2], and offers views of the Pacific Ocean and surrounding headlands and mountains. Several holes wrap around Laguna Salada, a natural lake and marsh located on the western side of the golf course, that provides habitat for the San Francisco garter snake and California red-legged frog.

The Sharp Park neighborhood has one main bikeway that runs parallel to and east of Beach Boulevard; a class II bicycle lane along the length of Palmetto Avenue from Paloma Avenue to the north, to Clarendon Road to the south. This bicycle lane was installed as part of the Phase I Palmetto Avenue Streetscape Improvement Project,

[1] https://www.cityofpacifica.org/depts/rec_department/parksbeaches/beach_and_park_info_and_rules/sharpbeach.asp
[2] https://sfrecpark.org/Facilities/Facility/Details/Sharp-Park-Golf-Course-42

completed in 2018. At Clarendon Road, the Class II facility continues on the eastern side of the Sharp Park Golf Course as a Class III Bicycle Route, and on the western side as a Class I Shared Use Path. A new comprehensive Bicycle and Pedestrian Master Plan for the City of Pacifica was adopted in February 2020.

The amenities along the promenade -- including the pavement, handrails, benches, trash receptacles and lighting standards – show signs of weathering as a result of prolonged exposure to the harsh sea air and seawater. See Figures 7 and 8.

The Municipal Pier is a visible feature from upper elevation public viewpoints such as along Sharp Park Boulevard, and specifically from the Grace McCarthy Vista Point/Overlook, although it is difficult to discern the Promenade itself from this distance. Public views of the Municipal Pier from lower elevation viewpoints such as the Pacifica Sharp Park Library just east of and above Paloma Avenue, are generally blocked by the intervening residences and other buildings. The Promenade and the Municipal Pier themselves offer access to public views of, and along the coast. Coastal views are considered resources of public importance under the California Coastal Act, and Coastal Act Section 30251 recognizes that "[t]he scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas." The Coastal Act generally considers view blockage to be a "substantial issue" when it pertains to public views, and not to views from private residences[3]. There are three designated public coastal view corridors in the Sharp Park Planning Area; looking west to the ocean from Paloma Avenue, from Salada Avenue, and from Clarendon Road (Dyett and Bhatia, November 2019). See Figures 9, 10, and 11.

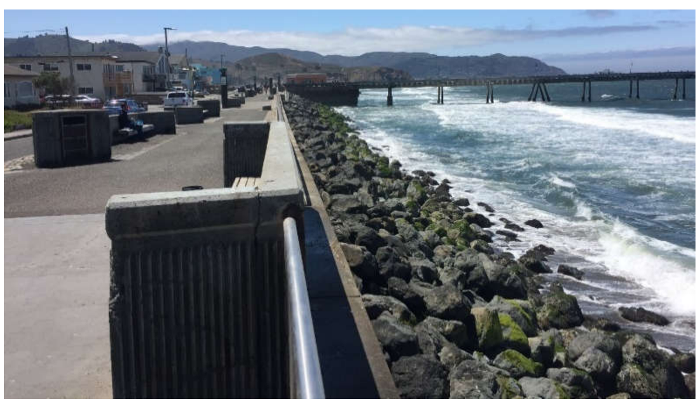


Figure 1: View of Beach Boulevard looking SOUTH. Residential properties are located on the left side and the beach promenade is visible on the right. The Pacifica Municipal Pier can be seen in the distance.

[3] A Citizen's Guide to the California Coastal Act of 1976, PACE (People, Access, Coastal Environment), October 1977.

Figure 2: Looking NORTH along South Wall

Figure 3: Looking SOUTH along South Wall

Figure 4: Looking NORTH along North Wall from Northern steps

Figure 5: Looking NORTH from Coastal Trail

Figure 6: Looking SOUTH at the Coastal Trail from the South Wall. The end of Clarendon Road is on the left.

Figure 7: Trash Receptacle, typical

Figure 8: Bench, typical

Figure 9: View looking WEST from Paloma Ave

Figure 10: View looking WEST from Salada Ave

Figure 11: View looking WEST from Clarendon Road

2.3 Regulatory Framework and Opportunities

The California Coastal Act's coastal resources planning and management policies cover six areas: public access, recreation, the marine environment, land resources, development, and industry. The policies articulate requirements for public access and for protection of marine resources and environmentally sensitive habitat areas. They lay out priorities for preserving open space, protecting fishing and coastal-dependent industry, promoting recreational use of the coast, and giving priority to visitor-serving commercial uses over general commercial or residential development.

The City's Coastal Zone Combining District ensures consistency with the goals and policies of the Coastal Act. These include the protection and enhancement of the coastal environment, the provision of public access to the shoreline and recreational opportunities. Specifically, the City's Local Coastal Land Use Plan (February 2020) identifies a series of public access and recreation (PR) guiding (G) and implementing (I) policies relevant to Beach Boulevard, and provide insight into opportunities for success in permitting a seawall replacement project:

- Guiding Policy PR-G-1: Provide maximum coastal access and recreational opportunities for all people consistent with public safety needs and the need to protect public rights, rights of property owners, and natural resource areas from overuse.
- Guiding Policy PR-G-27**:** Facilitate beach and recreational use by providing safe and well-located public parking. Distribute parking areas throughout the Coastal Zone to mitigate against the impacts of overcrowding or overuse by the public of any single area.
- Implementing Policy PR-I-13: Ensure that public access to the coast at the Promenade and Pier is maintained and enhanced by redevelopment at the City-owned 2212 Beach Boulevard site, including continuation of public parking.
- Implementing Policy PR-I-40: Develop a direct pedestrian route between the Sharp Park Beach Promenade and upper Sharp Park Road, also connecting the West and East Sharp Park neighborhoods.
- Implementing Policy PR-I-47: Create and upgrade bicycle facilities that provide an alternative for north-south bicycle travel west of Highway 1. Improvements should include the following …
  - A Class III route along Beach Boulevard between Paloma Avenue and Clarendon Road;
- Implementing Policy PR-I-78: Ensure that adequate and well-located public parking is preserved for Sharp Park Beach, the Promenade and Pier as part of any redevelopment of the City-owned Beach Boulevard property.

550 Kearny Street
Suite 800
San Francisco, CA 94108
415.896.5900 phone
415.896.0332 fax

esassoc.com

memorandum

date	October 9, 2020
to	Paul Henderson, GHD
cc	Project Files
from	Elizabeth Hill, ESA
subject	City of Pacifica, CA. Beach Boulevard Infrastructure Resiliency Project, Terrestrial Biological Resources Existing Conditions

Section 1. Introduction

1.1 Background and Purpose

This report presents the findings of reconnaissance-level vegetation, wildlife, and wetland surveys to identify potential presence and distribution of common and special-status plant and wildlife species, sensitive natural communities, and State- and federally-regulated waters and wetlands within the vicinity of the Beach Boulevard seawall and promenade in the Sharp Park neighborhood of Pacifica, California. The intent and scope of this document is to characterize these biological resources in the area where the proposed Beach Boulevard Infrastructure Resiliency Project (BBIRP, or the Project) will be implemented, and identify potential benefits or opportunities of the proposed project improvements on the terrestrial biological community. The terrestrial biological "Study Area" described in this report therefore, includes the immediate footprint of the proposed project ("Project Area"), and adjacent areas to characterize sensitive resources that may support special status species habitat in the vicinity. **Figure 1** displays the limits of the Project Area and the biological resources Study Area.

1.2 Project Location

The Project Area is a north-south corridor along the Pacific Ocean on the western side of the Sharp Park neighborhood. The recreational promenade is located parallel to the seawall, with the Pacifica Municipal Pier bisecting the promenade at Santa Rosa Avenue. Beach Boulevard is a one-lane street with residential properties east of the promenade. Sharp Park Golf Course is located southeast of the Project Site, a portion of which is considered within the Study Area.

1.3 Regulatory Context

Biological resources in the Study Area may fall under the jurisdiction of various regulatory agencies and be subject to their regulations. In general, the greatest legal protections are provided for plant and wildlife species that are formally listed by the federal or State government. The following regulations and agencies are commonly associated with projects that have the potential to affect biological resources:

- Federal Endangered Species Act
- Migratory Bird Treaty Act
- Bald and Golden Eagle Protection Act
- Clean Water Act, Section 404
- California Coastal Act
- California Endangered Species Act
- Fish and Game Code Section 3503
- Native Plant Protection Act
- Lake or Streambed Alteration Program
- Porter Cologne Water Quality Act
- CEQA Guidelines Section 15380

Section 2. Methods

2.1 Study Area

The footprint of proposed project activities is generally the starting point to define the biological resources survey area. However, in practical terms, biological resources have varied sensitivity to disturbance and a somewhat larger Study Area is needed for many species. The Study Area as it pertains to terrestrial biological resources therefore, includes the footprint of a proposed seawall and promenade (the Project Area), and approximately 65 acres of western limits of the Sharp Park Golf Course. The portion of the Sharp Park Golf Course located in the Study Area contains sensitive resources that may be impacted with the implementation of the project, discussed in further detail below.

2.2 Survey Methodology

ESA biologist Liz Hill, conducted a reconnaissance terrestrial biological survey of accessible portions of the Study Area on July 14, 2020. The survey was conducted to observe and characterize upland vegetation communities in the Study Area and to assess habitat quality and potential for common and special-status terrestrial wildlife species. The survey was performed on foot over the entire Project Site, focusing on habitat features that support terrestrial wildlife. The Sharp Park Golf Course portion of the Study Area was not accessed during the survey due to a fence restricting access from the Coastal Trail, a paved multi-use recreational trail along the western boundary of the golf course, and the chain-linked fence along the northern boundary of the golf course, adjacent to Clarendon Road.

Project name: the Pacifica Beach Boulevard Seawall Replacement Project

Figure 1
Project Location

ESA

2.3 Review of Background Information

Prior to performing the reconnaissance-level survey, ESA reviewed publicly available data and subscription-based biological resource data. In part, field surveys provided confirmation of the general accuracy of publicly available data.

Data sources that assisted in this analysis include:

- Historic and current aerial imagery
- California Department of Fish and Wildlife (CDFW) California Natural Diversity Database (CNDDB)
- California Native Plant Society (CNPS) online database
- U.S. Fish and Wildlife Service (USFWS) species list
- USFWS National Wetlands Inventory
- Sharp Park Existing Conditions Report[1]
- Significant Natural Resources Areas Management Plan[2]

Section 3. Environmental Setting

This section provides the environmental baseline for natural communities, habitats, wetlands, and special-status plant and wildlife species in the Study Area.

3.1 Terrestrial Vegetation Communities and Wildlife Habitats

Disturbed Dune Mat and Dune Scrub

This community features a combination of native and non-native species occupying dune or areas with sandy soils. In the Project Area, this community is located south of the pier, between the promenade and Beach Boulevard; in the larger Study Area, this habitat is also located in the narrow strip east of the paved Coastal Trail and west of the golf course greens. Dense mats of ice plant are present among native dune flora in a complex mosaic and is interspersed with bare sandy areas and non-native grasses. Intensive trampling and beach erosion appear to limit vegetation establishment west of the Coastal Trail within the Study Area. Disturbed dune mat and scrub includes a moderate cover of native shrubs, including silver beachweed (*Ambrosia chamissonis*), beach sagewort (*Artemisia pycnocephala*), and coyote brush (*Baccharis pilularis*). Dominant non-native species include, non-native highway ice plant (*Carpobrotus edulis*), sea rocket (*Cakile maritima*), cheeseweed mallow (*Malva parviflora*), and some European beachgrass (*Ammophila arenaria*).

Vegetated dune communities within the Study Area support northern alligator lizard (*Elgaria coerulea*), southern alligator lizard (*Elgaria multicarinata*), western fence lizard (*Sceloporus occidentalis*), and gopher snakes (*Pituophis catenifer*); small rodents such as deer mouse (*Peromyscus maniculatus*), vagrant shrew (*Sorex vagrans*), and California vole (*Microtus californicus*); and a variety of birds including white-crowned sparrow

1 Dyett & Bhatia, 2019. Sharp Park Specific Plan Existing Conditions Report. November 2019.

2 City and County of San Francisco, 2016. Significant Natural Resources Area Management Plan. Case No. 2005.0912E. December 2016.

(*Zonotrichia leucophrys*), Bewick's wren (*Thryomanes bewickii*), American robin (*Turdus migratorius*), common bushtit (*Psaltriparus minimus*), house finch (*Haemorhous mexicanus*), and mourning dove (*Zenaida macroura*).[3]

Brackish and Freshwater Emergent Wetland, and Freshwater Pond

The lagoon wetland complex known as Laguna Salada was formed by impoundment of freshwater runoff from the local watershed, and intermittent marine overwash, establishing a fresh-brackish nontidal wetland gradient in the Sharp Park Golf Course portion of the Study Area.[4] This feature is surrounded by the Sharp Park Golf Course greens to the north, south, and east. Laguna Salada is the only one of the three historic lagoon ecosystems of the San Francisco Peninsula that retains both extensive native wetland plant communities and hydrologic connections to the Pacific Ocean through its barrier beach.

The Laguna Salada freshwater marsh complex lies at the terminus of the 844-acre Sanchez Creek watershed. Historically a small channel connected the brackish lagoon with the ocean; however, this connection was eliminated with the construction of the golf course and adjacent earthern/rock berm/levee. Runoff from the watershed has been pumped from the lagoon to the ocean since 1941. The complex includes the 27-acre open water Laguna Salada lagoon, neighboring vegetated wetlands, a 1,000 foot connecting canal, and a small inland pond (Horse Stable Pond).

Fresh-brackish emergent nontidal fringing marsh of the lagoon is mostly dominated by native tules (*Schoenoplectus californicus*, with local stands of *S. acutus*) and cattails (native *Typha latifolia*, European *T. angustifolia*), bordered by bulrush and rush (*Schoenoplectus pungens, Juncus lescurii*) and marsh silverweed (*Potentilla anserina*). The seaward marsh edge grades into marginal coastal scrub and iceplant-dominated vegetation.

The eastern fringing marsh, Horse Stable Pond, and lower Sanchez Creek and riparian wetlands of Laguna Salada support a substantial breeding population of California red-legged frog (*Rana draytonii*), a federal Threatened and California Species of Special Concern, as well as Sierra chorus/Pacific tree frog (*Pseudacris sierra*). The San Francisco garter snake (*Thamnophis sirtalis tetrataenia*), a federal and state Endangered species, inhabits the fringing marsh and adjacent upland and riparian habitats of Laguna Salada. The California red-legged frog and San Francisco garter snake populations extend to a series of artificially constructed freshwater ponds (fringing freshwater marsh and submerged aquatic vegetation) bordering Laguna Salada at the toe of Mori Point slopes, on GGNRA, some of which are south of the Study Area. In addition to the California red-legged frog and San Francisco garter snake, the Laguna Salada wetland complex supports other special-status species and species of conservation concern, including the western pond turtle (*Emys marmorata*) and salt marsh common yellowthroat (*Geothlypus trichas sinuosa*).

Beach and Foredunes

The beach and foredune community consists of the Sharp Park Beach, a sub-area of Pacifica State Beach, west of the promenade and inland of the mean high tide line, including the foredunes south of the intersection of Beach Blvd. and Clarendon Rd. These areas consist of barren sand, with little vegetation due to regular disturbance by

---

3 Russell, Will, Jennifer Shulzitski, and Asha Setty, 2009. Evaluating Wildlife Response to Coastal Dune Habitat Restoration in San Francisco, California. Ecological Restoration, Vol. 27, No. 4, pp. 439-448, December.

4 ESA PWA. 2013. San Francisco Littoral Cell Coastal Regional Sediment Management Plan, Appendix C Biological Assessment.

public access. Western gull (*Larus occidentalis*), California gull (*L. californicus*), common raven (*Corvus corax*) and American crow (*C. brachyrhynchos*), are often observed loafing or scavenging drift debris and litter on the sand within this community. Caspian terns (*Hydroprogne caspia*), a USFWS Bird of Conservation Concern, may forage for fish in the lagoon or roost on the beach within the Study Area. Western snowy plover (*Charadrius alexandrius nivosus*), a federally Threatened species and California Species of Special Concern, may seasonally occupy this community within the Study Area between July and May, where they are observed resting in shallow depressions and among driftwood or foraging small invertebrates from wrack debris deposited at the high tide line.[5] Caspian tern and western snowy plover are not known to nest on the beach within the Study Area.

Developed/Landscaped/Ruderal

Developed and landscaped areas within the Study Area include roads, buildings, parking lots, paved surfaces, existing facilities, landscaping, and the Sharp Park Golf Course. These areas support a variety of ornamental trees and shrubs, non-native grasses and *ruderal* (opportunistic, weedy) species that tolerate sandy soils. Monterey cypress (*Hesperocyparis macrocarpa*), a native tree that is not locally native, dominates the trees species in this habitat. Other trees that are less common in this habitat include native Monterey pine (*Pinus radiata*) and blackwood acacia (*Acacia melanoxylon*). The understory of this habitat consists of litter and sparse vegetation in dense canopy areas and in more open canopy areas and on edges, the vegetation is similar to dune mat (disturbed) vegetation but in some areas supports more non-native grasses.

Developed portions of the Study Area provide limited, low quality habitat for wildlife because it is predominantly hardscape and highly disturbed (ruderal) or maintained landscaped areas. Landscaped and ruderal areas can still provide cover, foraging, and nesting habitat for a variety of bird species as well as reptiles and small mammals, especially those that are tolerant of disturbance and human presence. Cooper's hawk (*Accipiter cooperi*), red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), white-tailed kite (*Elanus leucurus*), and great horned owl (*Bubo virginianus*) may nest or perch in the dense canopy of Monterey cypress in the Sharp Park Golf Course portion of the Study Area. Birds commonly found in such areas include non-native species such as house sparrow (*Passer domesticus*) and European starling (*Sturnus vulgaris*), as well as birds native to the area, including American robin, house finch, and western scrub jay (*Aphelocoma californica*). Other wildlife expected in urban landscaped areas of the study area include Norway rat (*Rattus norvegicus*), striped skunk (*Mephitis mephitis*), Virginia opossum (*Didelphis virginiana*), and raccoon (*Procyon lotor*).

3.2 Sensitive Natural Communities

A sensitive natural community is a biological community that is regionally rare, provides important habitat opportunities for wildlife, is structurally complex, or is in other ways of special concern to local, state, or federal agencies. Most sensitive natural communities are given special consideration because they perform important ecological functions, such as maintaining water quality and providing essential habitat for plants and wildlife. Some plant communities support a unique or diverse assemblage of plant species and therefore are considered sensitive from a botanical standpoint.

The majority of the habitat in the Project Area is disturbed. No upland-based sensitive natural communities are within the immediate vicinity of the Project Area. Laguna Salada, the fresh-brackish lagoon wetland complex located in the

5 National Park Service, 2006. Protecting the Snowy Plover. U.S. Department of the Interior, Golden Gate National Recreation Area. Revised October.

southern portion of the Study Area, partially surrounded by the Sharp Park Golf Course is considered a sensitive natural community due to the presence of extensive native wetland plant communities and hydrologic connections to the Pacific Ocean.

3.3 Jurisdictional Waters and Wetlands

Federal and state jurisdictional waters include wetlands and other waters. The U.S. Army Corps of Engineers (Corps), Regional Water Quality Control Board (regional board), California Department of Fish and Wildlife, and/or California Coastal Commission may regulate wetlands and other waters.

The Pacific Ocean is a traditional navigable water and therefore a water of the United States under Section 404 of the federal Clean Water Act and Section 10 of the River and Harbors Act, and is also a water of the state under the Porter-Cologne Water Quality Control Act.

Three definitions of "wetland" are considered for purposes of this project, one administered by the Corps under the federal Clean Water Act (federal wetlands and other waters), one administered by the State Water Resources Control Board and San Francisco Bay regional board under the Porter-Cologne Water Quality Control Act (state wetlands), and one administered by the California Coastal Commission under the California Coastal Act (wetlands in the coastal zone). These definitions are presented below.

Federal Wetlands and Other Waters Definition

Waters of the United States are areas subject to federal jurisdiction pursuant to section 404 of the act. Waters of the United States are typically divided into two types: (1) wetlands and (2) other waters of the United States. Wetlands are a subset of waters of the United States and receive protection under Section 404 of the Clean Water Act. The term "waters of the United States," as defined in the Code of Federal Regulations under the Navigable Waters Protection Rule (33 CFR Part 328), includes:

1. Territorial seas and navigable waters;
2. Perennial and intermittent tributaries that, in a typical year, contribute surface water flow to such [territorial seas and navigable] waters;
3. Certain lakes, ponds, and impoundments of jurisdictional waters; and
4. Wetlands adjacent (hydrologically connected in a typical year through surface water [includes connections resulting from normal flooding]) to other jurisdictional waters.

Federal wetlands are defined in Title 33, Chapter II, Part 328.4 of the Code of Federal Regulations:

> *"Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."*

For the purposes of identifying or delineating a wetland under federal jurisdiction, an area must meet three diagnostic environmental characteristics in order to be considered a wetland. These three characteristics include the presence of 1) wetland hydrology, 2) hydrophytic vegetation, and 3) hydric soils in order to meet the federal definition.

Other waters of the United States are seasonal or perennial water bodies, including lakes, stream channels, drainages, ponds, and other surface water features, that exhibit an ordinary high-water mark but lack positive indicators for the three wetland parameters.

California Wetland Definition

The State Water Resources Control Board adopted the following definition of state wetlands on April 2, 2019, which became effective May 28, 2020.

> *An area is wetland if, under normal circumstances, (1) the area has continuous or recurrent saturation of the upper substrate caused by groundwater, or shallow surface water, or both; (2) the duration of such saturation is sufficient to cause anaerobic conditions in the upper substrate; and (3) the area's vegetation is dominated by hydrophytes or the area lacks vegetation.*

The Water Code defines "Water of the state" broadly to include "any surface water or groundwater, including saline waters, within the boundaries of the state." "Waters of the state" includes all "water of the U.S."

Wetlands in the Coastal Zone

Wetlands and other environmentally sensitive habitats in California's coastal zone are regulated by the California Coastal Commission (Coastal Commission) under the California Coastal Act of 1976. The Coastal Commission broadly defines wetlands under the Coastal Act (Cal. Pub. Res. Code §30121) as follows:

> *Wetland means lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, or fens.*

The Coastal Act requires that most development avoid and buffer wetland resources. The project lies within the coastal zone and is subject to the regulations of the City of Pacifica's Local Coastal Program, the city's certified local coastal program.

Whereas both the federal and state water board definitions require the presence of all three wetland identification parameters to be met (hydrophytic vegetation, hydric soils, and hydrology), the Coastal Commission regulations (California Code of Regulations Title 14 (14 CCR)) establish a "one parameter definition" that only requires evidence of a single parameter to establish wetland conditions:

> *"Wetland shall be defined as land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes, and shall also include those types of wetlands where vegetation is lacking and soil is poorly developed or absent as a result of frequent and drastic fluctuations of surface water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, adjacent to, vegetated wetlands or deep-water habitats. (14 CCR Section 13577)."*

Thus, the Coastal Commission's area of jurisdiction over wetlands is broader than that of the agency's federal and state counterparts, as areas presenting any one of the three parameters within the coastal zone would be jurisdictional to the Coastal Commission.

The commission regulations do not provide definitions of hydric soils or hydrophytic vegetation, but rely on the 1987 Army Corps of Engineers Wetland Delineation Manual[6], the National Wetland Plant List[7] and the Field Indicators of Hydric Soils in the United States[8] as appropriate documents to use when determining the presence of wetlands.

Potential Wetlands and Other Waters of the Study Area

A formal wetland delineation of the Study Area has not been performed; however, the National Wetlands Inventory documents features within the Study Area[9] exhibiting wetland characteristics based on vegetation mapping observations and superficial observations of topography and hydrology. The different types of wetlands within the terrestrial Study Area are brackish and freshwater emergent wetland, and freshwater pond, none of which occur within the immediate vicinity of the Project Site.

3.4 Special-Status and Otherwise Protected Species

Several species known to occur on or in the vicinity of Study Area are protected pursuant to federal and/or State endangered species laws, or have been designated as Bird of Conservation Concern by USFWS or Species of Special Concern by CDFW. In addition, Section 15380(b) of the *CEQA Guidelines* provides a definition of rare, endangered, or threatened species that are not included in any listing.[10] Species recognized under these terms are collectively referred to as "special-status species."

A list of special-status species with potential to occur in the vicinity of Study Area was compiled from a search of CDFW's CNDDB,[11] CNPS's Rare Plant Inventory,[12] USFWS's IPaC planning tool search of the Study Area,[13] and biological literature of the region for the San Francisco South and Montara Mountain 7.5-minute USGS topographic quadrangles.

From the full list of species, each was then individually assessed based on habitat requirements and distribution relative to vegetation communities that occur in the Study Area. A comprehensive list of special-status plant and wildlife species that were considered in the analysis is provided in **Attachment A**. Those species with a moderate or high potential to occur in the Study Area are described below in greater detail.

---

6 U.S. Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y 87 1, U.S. Army Engineer Waterways Experiment Station. Vicksburg, Miss.

7 Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. The National Wetland Plant List: 2016 wetland ratings. Phytoneuron 2016-30: 1-17. Published 28 April 2016. ISSN 2153 733X. Available at: http://wetland-plants.usace.army.mil/

8 United States Department of Agriculture, Natural Resources Conservation Service. 2018. Field Indicators of Hydric Soils in the United States, Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053171.pdf

9 USFWS, 2020b. National Wetlands Inventory Beach Boulevard Infrasturucture Resiliency Project. August 12, 2020.

10 For example, vascular plants listed as rare or endangered or as List 1 or 2 by the California Native Plant Society (CNPS) are considered to meet Section 15380(b) requirements.

11 California Department of Fish and Wildlife, California Natural Diversity Database (CNDDB) Rarefind version 5 query of the San Francisco South and Montara Mountain USGS 7.5-minute topographic quadrangles, Commercial Version, accessed July 13, 2020.

12 California Native Plant Society (CNPS), Inventory of Rare and Endangered Plants for San Francisco South and Montara Mountain USGS 7.5-minute topographic quadrangles, accessed July 13, 2020.

13 U.S. Fish and Wildlife Service (USFWS), My Project, IPaC Trust Resource Report and Official Species List of Federally Endangered and Threatened Species that may occur in the Pacifica Seawall Replacement Project location, and/or may be affected by the proposed project, July 13, 2020.

Special-Status and Otherwise Protected Plants

Based on the Project Area's high degree of exposure to human disturbance and limited available habitat, special-status plants are not expected in the Project Area. Dune scrub within the larger Study Area is not known to support San Francisco spineflower (*Chorizanthe cuspidata cuspidata*), a California Rare Plant Rank 1B.2 species. The San Francisco Recreation and Parks Department (SFRPD) maintains a GIS database with all recorded locations of protected and special status plants within natural areas under their jurisdiction, including Laguna Salada, known to only historically support protected plant species.[14]

Special-Status and Otherwise Protected Terrestrial Animals

Special-Status Birds

Saltmarsh Common Yellowthroat

San Francisco common yellowthroat is a California Species of Special Concern and a USFWS Bird of Conservation Concern. The current species range includes four main areas: coastal riparian and wetland areas of western Marin County, the tidal marsh system of San Pablo Bay, the tidal marsh system of southern San Francisco Bay, and coastal riparian and wetland areas in San Mateo County. Suitable breeding habitat exists in the emergent marsh vegetation found along the edges of Laguna Salada and Horse Stable Pond.

Cooper's Hawk

Cooper's hawk is a CDFW Watch List species. This species nests in large trees and dense, wooded areas but is increasingly found nesting in urban areas.[15] The Cooper's hawk breeds in extensive forests and smaller woodlands of deciduous, coniferous, and mixed pine-hardwoods, as well as in pine plantations, in both suburban and urban environments. This species captures a variety of prey, mainly medium-sized birds and mammals such as doves, jays, robins, chipmunks, and other rodents.[16] Stands of mature and tall trees in the Sharp Park Golf Course portion of the Study Area may provide suitable breeding (and foraging) habitat for Cooper's hawk.

Other Resident and Migratory Birds

Although many native birds are not considered to be special-status species, their nests are protected by the Migratory Bird Treaty Act and the California Fish and Game Code. Several migratory birds that do not have special-species status could nest in trees and shrubs within the Study Area along Clarendon Road and in the Sharp Park Golf Course. Shorebirds common to the San Mateo County coast including, whimbrel (*Numenius phaeopus*), sanderling (*Calidris alba*), willet (*Tringa semipalmata*), western snowy plover, and marbled godwit (*Limosa fedoa*) likely frequent beach habitat within the Study Area for foraging during migration or overwintering within the Study Area; however, are not known to nest there. The Migratory Bird Treaty Act and California Fish and Game Code protect raptors, most native migratory birds, and resident breeding birds that would occur and/or nest in the Study Area.

[14] SFPUC, 2017. Significant Natural Resource Areas Management Plan Final EIR. Case No. 2005.0912E. June 2017.

[15] Peeters, H. and P. Peeters. 2005. California Natural History Guides: Raptors of California. University of California Press.

[16] O. E., R. N. Rosenfield, and J. Bielefeldt (2006). Cooper's hawk (*Accipiter cooperii*), version 2.0. In The Birds of North America (A. F. Poole, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA. https://doi.org/10.2173/bna.75

Special-Status Bats

Several bat species without special federal or state protective status have potential to forage and roost within suitable habitat of the Study Area, including silver-haired bat (*Lasionycteris noctivagans*), hoary bat (*Lasiurus cinereus*), little brown bat (*Myotis lucifugus*), and fringed myotis (*Myotis thysanodes*), each detected during acoustic monitoring performed at Fort Funston between 2004 and 2005, south of the Study Area.[17] While these individuals are not considered a sensitive resource afforded protection under the federal or California endangered species acts, their maternity roosts are protected under California Fish and Game Code and CEQA as wildlife nursery sites. Silver-haired bats establish maternity roosts almost exclusively in trees, utilizing hollows, cavities excavated by birds or under loose bark. Hoary bat is the most widespread bat in North America and can be found throughout California where suitable foraging and roosting habitat is present. Hoary bats generally roost in dense foliage of medium to large trees. Little brown bat is also common in North America and California and breeding females establish communal maternity roosts or colonies. This species may also establish roosts in tree cavities but will use caves and even human-occupied structures. Fringed myotis is widespread throughout western North America and establishes roosts in crevices in buildings, underground mines, rocks, cliff faces, bridges, and large trees and snags. Although big free-tailed bat (*Nyctinomops macrotis*), a California Species of Special Concern, is known to historically roost in Pacifica, the species requires high cliffs or rocky outcrops, not located within the Study Area.

Special-Status Amphibians and Reptiles

California Red-Legged Frog

California red-legged frog is a federally listed threatened species and California Species of Special Concern. The Study Area is not within designated critical habitat for this species; however critical habitat is located approximately 0.60 miles east of the Study Area.

This largely aquatic frog is found at ponds and slow-moving streams with permanent or semipermanent water. California red-legged frogs opportunistically migrate into upland habitats during normal dispersal and may aestivate in upland environments when aquatic sites are unavailable or environmental conditions are inhospitable. If aquatic sites are unavailable, they shelter from dehydration within a variety of refuges, including under boulders and downed wood, and in moist leaf litter or small mammal burrows.

During winter months, California red-legged frogs generally lay their eggs on emergent vegetation in standing or slow-moving water.[18] Upon hatching, the herbivorous larvae take 11 to 20 weeks to mature, depending on water temperatures. Adults will consume essentially any invertebrate or vertebrate prey they can capture.[19] [20] [21]

The Sharp Park Golf Course (SPGC) supports a robust California red-legged frog population that includes several notable breeding sites and non-breeding foraging and basking habitat. Focused California red-legged frog surveys

---

17 Fellers, Gary M. 2005. Acoustic Inventory and Monitoring of Bats at Golden Gate National Recreation Area. USGS.

18 USFWS. 2002. Recovery Plan for the California Red-legged Frog (Rana aurora draytonii). U.S. Fish and Wildlife Service, Portland, Oregon.

19 Jennings, M. R. and M. P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California, Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California.

20 USFWS. 2005. Revised Guidance on Site Assessment and Field Surveys for California Red-legged Frogs, Sacramento, California, August 2005.

21 Zeiner, D. C., W. F. Laudenslayer, Jr., and K. E. Mayer (compiling editors). 1988. California's wildlife. Volume I. Amphibians and reptiles. California Statewide Wildlife Habitat Relationships System, California Department of Fish and Game, Sacramento, California.

by K. Swaim in 2008 documented 85 egg masses at SPGC, with 57 egg masses in Horse Stable Pond, 20 in Laguna Salada, and 4 in the canal.[22] Areas that provide California red-legged frog foraging and basking habitat, but offer relatively limited breeding opportunities included Sanchez Creek and the northern portion of Laguna Salada. In 2007, the Golden Gate National Recreation Area (GGNRA) constructed two ponds at Mori Point, south of the Study Area, to expand local California red-legged frog breeding opportunities and enhance local conditions and forage availability for the San Francisco garter snake.

Embryonic stages of California red-legged frog have a low salinity tolerance, with significant (>40 percent) developmental abnormalities or mortality observed from salinities between 5 and 6.5 parts per thousand (ppt).[23] The presence of viable California red-legged frog breeding populations at Laguna Salada and Horse Stable Pond indicates normal salinity levels that are generally below 5 ppt. Jennings and Hayes (1990) noted that adult California red-legged frog at Pescadero Marsh vacated areas where salinities increased above 6.5 ppt.

To the west of Laguna Salada, a sparsely vegetated 25-foot tall levee protect the marsh complex from tidal inundation. High storm surges such as those in 1956 and 1983 caused levee overtopping and temporarily introduced seawater into the complex; however, levee reinforcement in 1989 has prevented additional occurrences.[24] The USFWS perceives that snake populations at Laguna Salada decreased following the two salt water inundation events in the 1980s, which reduced amphibian breeding capacity and reduced prey availability for garter snakes. Salinity levels in the lagoon are normally somewhat elevated, though are generally below the threshold at which they would harm amphibians or other wildlife.[25]

San Francisco Garter Snake

The San Francisco garter snake is a federal and state-listed endangered species and California Fully Protected species. Critical habitat is not designated for this species. A single population of San Francisco garter snake occurs in the Study Area in the Laguna Salada/Mori Point area. Habitat for this species is also present in upper San Pedro Creek, outside of the Study Area; although, San Francisco garter snake are absent from the recently restored lagoon mouth. The USFWS considers the Laguna Salada/Mori Point San Francisco garter snake population as one of six that is significant to species recovery.[26]

San Francisco garter snake habitat needs vary during the year, and include aquatic foraging habitat and nearby upland retreats located in underground burrows and soil crevices, typically located in grassland or shrub habitats.[27] Adult San Francisco garter snake feed primarily on California red-legged frog. A deficiency in suitable upland habitat next to Laguna Salada is the limiting factor for this species at SPGC. However, San Francisco garter snake presumably use the entire 27-acre Laguna Salada freshwater marsh complex and are documented from the lagoon, Horse Stable Pond, and in the canal that connects the two water bodies. To the south of Mori Point, the Calera Creek

[22] Tetra Tech, Inc., Swaim Biological, and Nickels Golf Group. 2009. Sharp Park Conceptual Restoration Alternatives Report. Prepared for the San Francisco Recreation and Parks Department, November 2009.

[23] Jennings, M. R. and M. P. Hayes. 1994. Amphibian and Reptile Species of Special Concern in California, Final Report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California.

[24] ESA PWA. 2013. San Francisco Littoral Cell Coastal Regional Sediment Management Plan, Appendix C Biological Assessment.

[25] Tetra Tech, Inc., Swaim Biological, and Nickels Golf Group. 2009. Sharp Park Conceptual Restoration Alternatives Report. Prepared for the San Francisco Recreation and Parks Department, November 2009.

[26] U.S. Fish and Wildlife Service (USFWS). 2006. San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*): 5-Year Review: Summary and Evaluation, U.S. Fish and Wildlife Service, Sacramento Field Office, Sacramento, California, September 2006.

[27] Tetra Tech, Inc., Swaim Biological, and Nickels Golf Group. 2009. Sharp Park Conceptual Restoration Alternatives Report. Prepared for the San Francisco Recreation and Parks Department, November 2009.

watershed also supports California red-legged frog and provides potential habitat for San Francisco garter snake. Both species may move between some or all of these sites.

Western Pond Turtle

Western pond turtle is a California Species of Special Concern. It inhabits rivers, streams, natural and artificial ponds, and lakes. Adjacent terrestrial habitat is also critical for egg laying, winter refuge, and dispersal. The lagoon wetland complex of Laguna Salada provides suitable habitat in the Study Area, approximately 0.15 miles south of the Project Area, where western pond turtle individuals have been identified.[28] The upland dune scrub community closer to the Project Area may provide egg laying, winter refuge, and dispersal habitat.

3.5 Critical Habitat

No USFWS designated critical habitat is located in the Study Area. The nearest critical habitat is located approximately 0.60 miles east of the Study Area and is designated as California red legged frog habitat.

Section 4. Conclusions

Laguna Salada wetland complex supports the highest concentration of special-status wetland wildlife species on the San Francisco Peninsula coast.[29] Minimizing saltwater intrusion is key to maintaining freshwater habitat for continued California red-legged frog breeding at the Laguna Salada wetland complex. Protecting the wetland complex from shoreline retreat and saltwater intrusion would ensure the barrier beach and lagoon ecosystem continue to support California red-legged frog, San Francisco garter snake, western pond turtle, and saltmarsh common yellowthroat.

The isolated nature of the proposed shoreline work and distance away from habitat supporting special status species likely precludes project-related direct impacts on California red-legged frog, San Francisco garter snake, western pond turtle, and saltmarsh common yellowthroat individuals during the construction phase of the Project. However, the use of project-related heavy equipment could still potentially result in the crushing of sensitive amphibian and reptile species. Further, vegetation removal and an increase in noise, vehicle traffic, and human presence could result in disturbance to these species in addition to nesting birds, including saltmarsh common yellowthroat, and roosting bats. Preconstruction surveys, worker environmental awareness training, and installation of wildlife exclusion fence would help avoid such potential impacts during the construction phase of the project.

28 SFPUC, 2017. Significant Natural Resource Areas Management Plan Final EIR. Case No. 2005.0912E. June 2017.

29 ESA PWA. 2013. San Francisco Littoral Cell Coastal Regional Sediment Management Plan, Appendix C Biological Assessment.

ATTACHMENT A

Biological Resources Supporting Information

Table BIO-1: Special-Status or Otherwise Protected Plant Species that May Occur in the Terrestrial Study Area

Table BIO-2: Special-Status or Otherwise Protected Animal Species that May Occur in the Terrestrial Study Area

TABLE BIO-1
SPECIAL-STATUS OR OTHERWISE PROTECTED PLANT SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**CRPR Ranking**	**Habitat Description / Blooming Period**	**Potential to Occur in the Study Area**
Plant Species Listed or Proposed for Listing					
Franciscan manzanita *Arctostaphylos franciscana*	FE	--	1B.1	Open, rocky, serpentine outcrops in chaparral. February – April	**No Potential.** No suitable habitat present, no serpentine areas.
San Bruno Mountain manzanita *Arctostaphylos imbricata*	--	CE	1B.1	Chaparral and coastal scrub, usually on sandstone outcrops. February – May	**Low Potential**. Regional occurrences are restricted to San Bruno Mountain and the Santa Cruz Mountains.
Presidio manzanita *Arctostaphylos montana (=hookeri)* ssp. *ravenii*	FE	CE	1B.1	Open, rocky, serpentine slopes in chaparral, coastal scrub, and coastal prairie. February – March	**Low Potential.** Low quality suitable habitat present along Coastal Trail.
Pacific manzanita *Arctostaphylos pacifica*	--	CE	1B.2	Coastal scrub and chaparral. February – April	**Low Potential**. Suitable habitat potentially present. There is only one CNDDB record of this species in northeastern San Mateo County.
Robust spineflower *Chorizanthe robusta var. robusta*	FE	--	1B.1	Sandy or gravelly coastal dunes, coastal scrub, cismontane woodland and maritime chaparral. April – September	**Low Potential**. Suitable habitat potentially present. Two CNDDB regional occurrences are historic and possibly extirpated.
Beach layia *Layia carnosa*	FE	CE	1B.1	Sand dunes and coastal strand. March – July	**Low Potential.** Suitable habitat potentially present. There is only one broadly mapped CNDDB record in San Francisco and it is believed to be extirpated.
San Francisco lessingia *Lessingia germanorum*	FE	CE	1B.1	Coastal scrub, sandy soils free of competing species. July – November	**Low Potential.** Low quality suitable habitat potentially present. Occurs in the vicinity of Fort Funston[1].
White-rayed pentachaeta *Pentachaeta bellidiflora*	FE	CE	1B.1	Open, dry, rocky slopes and grassy areas, usually on serpentine. March – May	**No Potential.** Suitable habitat not potentially present.
Adobe sanicle *Sanicula maritima*	--	Rare	1B.1	Moist clay or ultramafic soil in chaparral, coastal prairie, meadows, seeps, and valley and foothill grassland. February – May	**No Potential.** No suitable habitat present. No serpentine soils present in the project study area. Only CNDDB occurrence is considered extirpated.
California seablite *Suaeda californica*	FE	--	1B.1	Coastal salt marshes and swamps. July – October	**No Potential.** Known occurrences in region are restored plantings along eastern San Francisco shoreline.
Showy Indian (=two-fork) clover *Trifolium amoenum*	FE	--	1B.1	Valley grassland and wetland and riparian areas. Affinity to serpentine soils. April – June	**Low Potential.** Low quality suitable habitat potentially present.

1 NPS unpublished data

TABLE BIO-1 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED PLANT SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name *Scientific Name*	Federal Status	State Status	CRPR Ranking	Habitat Description / Blooming Period	Potential to Occur in the Study Area
California Rare Plant Ranked Species					
Franciscan onion *Allium peninsulare var. franciscanum*	--	--	1B.2	Clay, volcanic, or serpentine substrate in valley and foothill grassland and cismontane woodland. May – June	**No Potential.** Serpentine rock outcrops or soils are not present in the project study area. This species is not expected as there is no suitable habitat on site.
Bent-flowered fiddleneck *Amsinckia lunaris*	--	--	1B.2	Coastal bluff scrub, cismontane woodland, and valley and foothill grassland. March – June	**No Potential.** This species is not expected as there is no suitable habitat on site.
Montara manzanita *Arctostaphylos montaraensis*	--	--	1B.2	Slopes and ridges in chaparral and coastal scrub. January – March	**No Potential.** This species is not expected as there is no suitable habitat on site due to sea-level elevation of project.
Nuttall's (=ocean bluff) milkvetch *Astragalus nuttallii var. nuttallii*	--	--	4.2	Coastal bluff scrub and coastal dunes, January – November	**Low Potential.** Low quality suitable habitat potentially present along Coastal Trail. The coastal bluff grassland at Mori Point supports the largest populations of this species.
Alkali milk-vetch *Astragalus tener var. tener*	--	--	1B.2	Alkali flats, flooded grassland, playas and vernal pools. March – June	**No Potential.** No suitable habitat present; species presumed extirpated in San Francisco.
Bristly sedge *Carex comosa*	--	--	2B.1	Lake margins, marshes, swamps, coastal prairie, and valley and foothill grasslands. May – September	**Low Potential.** Only CNDDB occurrence is located in San Francisco and considered extirpated. Suitable habitat present in Laguna Salada.
Johnny-nip *Castilleja ambigua var. ambigua*	--	--	4.2	Wet sites in coastal bluff scrub, coastal prairie, marshes and swamps, valley and foothill grassland, and at the margins of vernal pools. March – August	**Low Potential.** Suitable habitat present in Laguna Salada; however, not known to occur in region.
Pappose tarplant *Centromadia parryi ssp. parryi*	--	--	1B.2	Chaparral, coastal prairie, meadows, seeps, coastal salt marshes and swamps, and vernally mesic, often alkaline, valley and foothill grasslands. May – November	**Low Potential.** Suitable habitat potentially present. Historically known to occur in vicinity of Laguna Salada. 2006 occurrence near Rockaway Beach near quarry.
San Francisco spineflower *Chorizanthe cuspidata var. cuspidata*	--	--	1B.2	Sandy terraces and slopes of coastal bluff scrub, coastal dunes, coastal prairie and coastal scrub. April – July	**Low Potential.** Historically known to occur in vicinity of Laguna Salada. Occurs north of the project study area within Fort Funston.
Franciscan thistle *Cirsium andrewsii*	--	--	1B.2	Coastal bluff scrub, coastal prairie, coastal mesic scrub, and broadleaf upland forest; sometimes on serpentine soils; often associated with seeps. March – July	**Low Potential.** Serpentine soils are not present in the project study area.
Compact cobwebby thistle *Cirsium occidentale var. compactum*	--	--	1B.2	Coastal scrub, grassland, and dunes; often associated with seeps. April – June	**Low Potential.** Suitable habitat potentially present. Regional occurrence is historic and considered possibly extirpated.

TABLE BIO-1 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED PLANT SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**CRPR Ranking**	**Habitat Description / Blooming Period**	**Potential to Occur in the Study Area**
California Rare Plant Ranked Species (continued)					
Round-headed Chinese-houses *Collinsia corymbosa*	--	--	1B.2	Coastal dunes and coastal prairie. April – June	**Low Potential.** Suitable habitat potentially present. Has not been documented in region for more than 100 years.
San Francisco collinsia *Collinsia multicolor*	--	--	1B.2	On humus-covered soil derived from mudstone in closed-cone coniferous forest and coastal scrub. March – May	**No Potential.** This species is not expected as there is no suitable habitat in the project study area.
Marsh horsetail *Equisetum palustre*	--	--	3	Freshwater marshes and swamps.	**Low Potential.** Suitable habitat potentially present in vicinity of Laguna Salada; however, not documented in region.
San Francisco wallflower *Erysimum franciscanum*	--	--	4.2, LS	Coastal scrub and grassland, often on serpentine soils. March – June	**No Potential.** This species is not expected as there is no suitable habitat in the project study area. Occurs north of the project study area within Fort Funston.
Fragrant fritillary *Fritillaria liliacea*	--	--	1B.2	On clay, often serpentine derived soils in coastal scrub, grassland, and coastal prairie. February – April	**No Potential.** This species is not expected as there is no suitable habitat in the project study area. Nearest occurrence over 5 miles southeast of study area.
Blue coast gilia *Gilia capitata ssp. chamissonis*	--	--	1B.1	Coastal dunes and scrub. April – July	**Low Potential.** Suitable habitat potentially present. Occurs north of the project study area within Fort Funston.
Dark-eyed gilia *Gilia millefoliata*	--	--	1B.2	Coastal dunes. April – July	**Low Potential.** Suitable habitat potentially present. Occurs north of the project study area near San Bruno Hills.
San Francisco gumplant *Grindelia hirsutula var. maritima*	--	--	3.2	Coastal scrub and grasslands. June – September	**No Potential.** This species is not expected as there is no suitable habitat in the project study area. Occurs north of the project study area within Fort Funston.
Diablo helianthella *Helianthella castanea*	--	--	1B.2	On rocky soils in broadleaf upland forest, cismontane woodland, coastal scrub, riparian woodland, and valley and foothill grassland. March – June	**No Potential.** This species is not expected as there is no suitable habitat in the project study area.
White seaside (=congested- headed hayfield) tarplant *Hemizonia congesta ssp. congesta*	--	--	1B.2	Grassy valleys and hills, often on fallow fields in coastal scrub. April – November	**No Potential.** This species is not expected as there is no suitable habitat in the project study area.
Short-leaved evax *Hesperevax sparsiflora var. brevifolia*	--	--	1B.2	Sandy bluffs and flats in coastal scrub and coastal dunes. March – June	**Low Potential.** Suitable low-quality habitat potentially present. Regional occurrence considered historic and extirpated.
Water star-grass *Heteranthera dubia*	--	--	2B.2	Marshes and swamps (alkaline, still or slow-moving water) July – October	**Low Potential.** Suitable low-quality habitat potentially present. Regional occurrence considered historic and extirpated.

TABLE BIO-1 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED PLANT SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**CRPR Ranking**	**Habitat Description / Blooming Period**	**Potential to Occur in the Study Area**
California Rare Plant Ranked Species (continued)					
Kellogg's horkelia *Horkelia cuneata ssp. sericea*	--	--	1B.1	Coastal scrub, dunes, and openings of closed-cone coniferous forests. February – July	**Low Potential.** Suitable habitat potentially present. Nearest regional occurrence approximately 4 miles south of study area.
Point Reyes Horkelia *Horkelia marinensis*	--	--	1B.2	Coastal dunes, prairie, and scrub. May – September	**Low Potential.** Suitable habitat potentially present. Nearest regional occurrence over 3.5 miles east of study area.
Island tube lichen *Hypogymnia schizidiata*	--	--	1B.3	Coastal scrub on or near old-growth shrubs in few locations throughout California and Mexico.	**Low Potential.** This species is not expected as there is no suitable habitat within the project area as currently understood for this species.
Coast iris *Iris longipetala*	--	--	4.2	Coastal prairie, lower montane coniferous forest, meadows and seeps, mesic sites. March – May	**No Potential.** This species is not expected as there is no suitable habitat within the project study area.
Rose leptosiphon *Leptosiphon rosaceus*	--	--	1B.1	Coastal bluff scrub. April – July	**Low Potential.** Suitable habitat potentially present. Nearest documented occurrence at Mori Point; however, this species is not expected as there is no suitable habitat within the project study area.
Arcuate bush mallow *Malacothamnus arcuatus*	--	--	1B.2	Gravelly alluvium in chaparral and cismontane woodland. April – September	**No Potential.** This species is not expected as there is no suitable habitat within the project study area.
Northern curly-leaved Monardella *Monardella sinuata ssp. nigrescens*	--	--	1B.2	Coastal dunes and scrub, chaparral, lower montane coniferous forest. (Apr) May – July (Aug-Sept)	**Low Potential.** Suitable habitat potentially present. Only one CNDDB documented occurrence in region considered extirpated.
Choris's popcorn-flower *Plagiobothrys chorisianus* var. *chorisianus*	--	--	1B.2	Mesic sites in chaparral, coastal scrub, and coastal prairie. March – June	**No Potential.** This species is not expected as there is no suitable habitat within the project study area. Nearest occurrence along Sweeney Ridge.
Oregon polemonium *Polemonium carneum*	--	--	2B.2	Coastal prairie, coastal scrub, lower montane coniferous forest. April – September	**No Potential.** This species is not expected as there is no suitable habitat within the study area.
Chaparral ragwort *Senecio aphanactis*	--	--	2B.2	Chaparral, cismontane woodland and coastal scrub, sometimes in alkaline soil. January – April (May)	**No Potential.** This species is not expected as there is no suitable habitat within the study area.
Scouler's catchfly *Silene scouleri* ssp. *scouleri*	--	--	2B.2	Coastal bluff scrub, coastal prairie, and valley and foothill grassland. (Mar-May) June – August (Sept)	**No Potential.** This species is not expected as there is no suitable habitat within the study area. Regional occurrences located on bluffs, habitat not found in study area.
San Francisco campion *Silene verecunda ssp. verecunda*	--	--	1B.2	Mudstone, shale, or serpentine substrates in coastal scrub, coastal prairie, chaparral and valley and foothill grassland. March – June	**No Potential.** This species is not expected as there is no suitable habitat within the study area.

TABLE BIO-1 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED PLANT SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**CRPR Ranking**	**Habitat Description / Blooming Period**	**Potential to Occur in the Study Area**
California Rare Plant Ranked Species (continued)					
Santa Cruz microseris *Stebbinsoseris decipiens*	--	--	1B.2	On sandstone, shale or serpentine derived seaward facing slopes in broadleaf upland forest, closed-cone coniferous forest, chaparral, coastal prairie, and coastal scrub. April – May	**No Potential.** This species is not expected as there is no suitable habitat within the study area.
San Francisco owl's clover *Triphysaria floribunda*	--	--	1B.2	Usually serpentinite coastal prairie, valley grasslands, and coastal scrub. April – June	**No Potential.** This species is not expected as there is no suitable habitat within the study area.
Coastal triquetrella *Triquetrella californica*	--	--	1B.2	This moss grows on coastal bluffs and in coastal scrub habitats.	**No Potential.** This species is not expected as there is no suitable habitat within the study area.

NOTES:

* Please refer to Figure 1 for reference to the project study area for terrestrial biological resources.

The "Potential for Effect" category is defined as follows:

Present = Species was observed during reconnaissance or focused surveys of the project area.

High = Species is expected to occur, habitat meets species requirements and is of moderate or high quality, and the study area is within the known species range.

Moderate = Habitat is marginally suitable (i.e. of low or moderate quality) or the study area is within the known range of the species, even though the species was not observed during biological surveys.

Low = Habitat does not meet species requirements as currently understood in the scientific community or the site is not within a species' geographic range.

No Potential = Habitat does not meet species requirements or the species is presumed to be extirpated from the project area or region based on the best scientific information available.

FESA = Federal Endangered Species Act, CESA = California Endangered Species Act,
CNDDB = California Natural Diversity Database

STATUS CODES:

Federal: U.S. Fish and Wildlife Service (USFWS)

FE = Listed as "endangered" under the FESA

FT = Listed as "threatened" under the FESA

FPD = Proposed delisted

FD = Delisted

State: California Department of Fish and Wildlife (CDFW)

CE = Listed as "endangered" under the CESA

CT = Listed as "threatened" under the CESA

CSC = CDFW designated "species of special concern"

CFP = CDFW designated "fully protected"

SC = CDFW designated "candidate threatened"

WL = CDFW designated "watch list"

California Rare Plant Rank (CRPR):

Rank 1A = Plants presumed extirpated in California and either rare or extinct elsewhere.

Rank 1B = Plants rare, threatened, or endangered in California and elsewhere.

Rank 2A = Plants presumed extirpated in California, but more common elsewhere.

Rank 2B = Plants rare, threatened, or endangered in California, but more common elsewhere.

Rank 3 = Plants about which we need more information – a review list

Rank 4 = Plants of limited distribution – a watch list

An extension reflecting the level of threat to each species is appended to each rarity category as follows:

.1 – Seriously endangered in California.

.2 – Fairly endangered in California.

.3 – Not very endangered in California.

LS = Locally Significant Plant Species for San Francisco County as designated by the CNPS Yerba Buena Chapter

SOURCE:

CDFW, 2020. California Natural Diversity Database (CNDDB) Rarefind version 5 query of the San Francisco South and Montara Mountain USGS 7.5-minute topographic quadrangles, Commercial Version. Accessed July 13, 2020.

California Native Plant Society (CNPS), Inventory of Rare and Endangered Plants for San Francisco South and Montara Mountain USGS 7.5-minute topographic quadrangles, accessed July 13, 2020.

U.S. Fish and Wildlife Service (USFWS), 2020. My Project, IPaC Trust Resource Report and Official Species List of Federally Endangered and Threatened Species that may occur in the Pacifica Seawall Replacement Project location, and/or may be affected by the proposed project, July 13, 2020.

TABLE BIO-2
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name *Scientific Name*	Federal Status	State Status	Habitat Description	Potential to Occur in the Study Area
Species Listed or Proposed for Listing				
Invertebrates				
San Bruno elfin butterfly *Callophrys mossii bayensis*	FE	*	Coastal scrub or grassland on rocky outcrops with broadleaf stonecrop (*Sedum spathulifolium*).	**Low Potential.** Three known populations occur at San Bruno Mountain, Montara, and Pacifica. Typical habitat does not occur within the study area.
Bay checkerspot butterfly *Euphydryas editha bayensis*	FT	*	Serpentine grasslands with larval host plants dwarf plantain (*Plantago erectis*) and purple owl's clover (*Castilleja exserta spp. exerta*).	**Low Potential.** Serpentine grassland habitat for host plants does not occur within the study area; therefore this species is not expected.
Mission blue butterfly *Plebejus icarioides missionensis*	FE	*	Grassland with *Lupinus albifrons*, *L. Formosa*, and *L. varicolor*.	**Low Potential.** Typical grassland habitat for host plants does not occur within the study area; therefore this species is not expected.
Callippe silverspot butterfly *Speyeria callippe callippe*	FE	*	Found in native grasslands with *Viola pedunculata* as larval food plant.	**Low Potential.** Typical grassland habitat for host plants does not occur within the study area and host plant not observed during 2019 field surveys; therefore this species is not expected.
Myrtle's silverspot butterfly *Speyeria zerene myrtleae*	FE	*	Coastal dune habitat with host plants *Grindelia hirsutula, Abronia latifolia, Mondardella, Cirsium vulgare, and Erigeron glaucus* on the San Francisco and Marin peninsulas.	**Low Potential.** Although species historically known in Pacifica; species is considered extirpated.
Reptiles				
San Francisco garter snake *Thamnophis sirtalis tetrataenia*	FE	CE, CFP	Densely vegetated ponds near open hillsides with abundant small mammal burrows.	**Present.** Species known to occur in the Laguna Salada area of the Sharp Park Golf Course within the study area.
Amphibians				
California red-legged frog *Rana draytonii*	FT	CSC	Freshwater ponds and slow streams with emergent vegetation for egg attachment.	**Present.** Species known to occur in the Laguna Salada area of the Sharp Park Golf Course within the study area.
Birds				
Golden eagle *Aquila chrysaetos*	--	CFP, WL	Rolling foothills, mountain areas, sage-juniper flats and deserts. Cliff-walled canyons provide nesting habitat in most parts of range; also large trees in open areas.	**Low Potential.** Suitable foraging habitat for this species is in the project study area; however, unlikely to nest in study area.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**
Species Listed or Proposed for Listing (continued)				
Birds (cont.)				
Marbled murrelet *Brachyramphus marmoratus*	FT	CE	Breeds in coniferous forests near the coast and prefers old growth, mature stands. Nests on large horizontal branches high in the trees. Winters at sea.	**Low Potential.** Suitable nesting habitat in wooded areas of the Pacifica hills, east of the study area. Foraging habitat for this species is in the project study area.
Western snowy plover *Charadrius alexandrinus nivosus*	FT	CSC	Sandy beaches, salt pond levels and shores of alkali lakes. Needs sandy, gravelly or friable soils for nesting.	**Present (No nesting potential).** Northern section of Linda Mar State Beach (Pacifica State Beach), south of the Study Area, contains an environmentally sensitive habitat area for wintering western snowy plovers in an area of backbeach sand dunes. May forage in study area; however, not known to nest in study area.
American peregrine falcon *Falco peregrines anatum*	FD	CD, CFP	Woodlands, coastal habitats, riparian areas, coastal and inland waters, human made structures that may be used as nest or temporary perch sites.	**Low Potential (Unlikely to nest).** May hunt birds on beach within the project study area. No known nest sites within the study area; typical cliff features for nesting are not present within the study area.
Bald eagle *Haliaeetus leucocephalus* (nesting and wintering)	FD	CE, CFP	Nests and forages on inland lakes, reservoirs, and rivers.	**Low Potential (Unlikely to nest).** Marginal nesting habitat is present within the large trees within Sharp Park Golf Course; however, no existing nest site is known.
California black rail *Laterallus jamaicensis coturniculus*	--	CT, CFP	Salt and brackish marshes; also in freshwater marshes at low elevations.	**Low Potential (Unlikely to nest).** Suitable habitat for this species is not found in the project study area; however, not known to occur in Laguna Salada.
Brown pelican *Pelecanus occidentalis californicus* (nesting colony and communal roosts)	FD	CD, CFP	Pelagic forager along ocean and bay shorelines whose breeding range extends from the Channel Islands south to Mexico.	**Present (No nesting potential).** Forages in the Pacific Ocean offshore of the study area.
Short-tailed albatross *Phoebastria (=Diomedea) albatrus*	FE	CSC	A pelagic species that spends most of its time at sea and returns to land only for breeding purposes.	**Low Potential (No nesting potential).** Breeds only at one or two sites off the coast of Japan, occasional visitor to California coast and could appear on a transient basis offshore of the study area.
Ridgway's rail *Rallus obsoletus obsoletus*	FE	CE, CFP	Salt marsh wetlands with dense vegetation along the San Francisco Bay.	**No Potential.** Suitable habitat for this species is not found in the project study area.
Bank swallow *Riparia riparia (nesting)*	--	CT	Vertical banks and cliffs with sandy soil, near water. Nests in holes dug in cliffs and river banks.	**Low Potential.** Cliffs nearby study area provide suitable breeding habitat. Could appear on a transient basis through study area.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**
Species Listed or Proposed for Listing (continued)				
Birds (cont.)				
California least tern *Sternula antillarum browni*	FE	CE, CFP	Open beaches free of vegetation along the California coast.	**Low Potential (No nesting potential).** May occasionally be sighted offshore of the study area while foraging. Closest nesting site is located on Alameda NAS.
Other Special-Status Species				
Invertebrates				
Western bumble bee *Bombus occidentalis*	--	SCE	Largely restricted to high elevation sites in the Sierra Nevada, with few observations of this species near the coast. Favors plant families *Melilotus, Cirsium, Trifolium, Centaurea, Chrysothamnus* and *Eriogonum.*	**Low Potential.** Suitable foraging and burrow habitat are present in the study area; however, given the rarity of this species in California and range declines throughout the state, this species is not expected.
Crotch bumble bee	--	SCE	Nearly endemic to California, historically ranging across southern California, from the coast and coastal ranges, through the Central Valley, and to the adjacent foothills. Favors plant families *Fabaceae, Apocynaceae, Asteraceae, Lamiaceae, Hydrophyllacae, Asclepiadaceae* and *Boraginaceae*.	**Low Potential.** Suitable foraging and burrow habitat are present in the study area; however, given the rarity of this species in California and range declines throughout the state, this species is not expected.
Monarch butterfly *Danaus plexippus* (overwintering sites)	--	*	Eucalyptus groves (wintering sites).	**Low Potential**. Species recorded in Montara but no wintering sites have been identified within the study area.
Amphibians				
California giant salamander *Dicamptodon ensatus*	--	CSC	Wet coastal forests in or near cold, permanent and semi-permanent streams and seepages.	**Low Potential.** Minimal low quality suitable habitat in the study area.
Reptiles				
Western pond turtle *Actinemys marmorata*	--	CSC	Ponds, marshes, rivers, streams, and irrigation ditches with aquatic vegetation. Requires basking sites and suitable upland habitat for egg-laying. Nest sites most often characterized as having gentle slopes (<15%) with little vegetation or sandy banks.	**Present.** Documented in Laguna Salada. Dune scrub in study area could serve as egg laying, winter refuge, and dispersal habitat.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**
Other Special-Status Species (continued)				
Birds				
Clark's grebe *Aechmophorus clarkii*	BCC	--	Freshwater lakes and marshes with extensive open water bordered by vegetation. Nest is typically built on floating vegetation hidden among emergent plants. Typically found in saltwater or brackish water environments like San Francisco Bay during winter.	**Moderate (Low nesting potential).** Regularly observed in open water off-shore of the study area while foraging.
Black turnstone *Arenaria melanocephala*	BCC	--	Winters in coastal areas with rocky shorelines, jetties, and piers. Breeds in sparsely vegetated coastal meadows of the arctic tundra.	**Moderate (No nesting potential).** May be observed offshore of the study area while wintering in the San Francisco Bay Area.
Tricolored blackbird *Agelaius tricolor* (nesting colony)	BCC	SCE, CSC	Nests in dense colonies within sloughs, swamps, and marshes where tall aquatic vegetation is present. Nests can extend into upland scrub habitat on colony fringes.	**Low (No nesting potential).** Low quality foraging habitat is present in the study area.
Oak titmouse *Baeolophus inornatus*	BCC	§3503	Open, dry oak woodlands.	**Low (No nesting potential).** Few oak trees may be present within the Sharp Park Golf Course portion study area to support this species foraging and nesting.
Wrentit *Chamaea fasciata*	BCC	§3503	Dense coastal scrub and chaparral of the west coast. Inland habitat is dense shrubland and thickets.	**Low (Unlikely to nest).** Suitable dense coastal scrub nesting and foraging habitat is adjacent to study area; may forage over study area.
Bonaparte's gull *Chroicocephalus philadelphia*	--	--	Migrate in flocks across North America. Nest in trees of the boreal forest.	**Low (No nesting potential).** May be present on beach or off shore of the study area during migration or periods of non-breeding.
Black swift *Cypseloides niger* (nesting)	BCC	CSC	Breeds in areas with cliff faces, on coasts or inland canyons. Nests are in sheltered crevices or ledges under overhangs near water, such as a seep or waterfall.	**Low (Unlikely to nest).** May occur over the project study area while foraging. Breeding habitat for this species is not present in the study area.
Northern fulmar *Fulmarus glacialis*	--	§3503	Nest in colonies on cliffs in the North Pacific, North Atlantic, and Arctic Oceans. Spend non-breeding periods at sea.	**Low (No nesting potential).** May be present while wintering offshore of the project area.
Common loon *Gavia immer*	--	CSC	From September to May, fairly common in estuarine and subtidal marine habitats along entire coast, and uncommon on large, deep lakes in valleys and foothills throughout state.	**Low (No nesting potential).** May be present off shore of the study area while foraging during non-breeding periods.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**
Other Special-Status Species (continued)				
Birds (continued)				
Red-throated loon *Gavia stellata*	BCC	§3503	Breeds in lakes and coastal areas of the alpine tundra. Winters in shallow coastal estuaries.	**Low (No nesting potential).** May be present off shore of the study area while foraging during non-breeding periods.
saltmarsh common yellowthroat *Geothlypis trichas sinuous*	BCC	CSC	Forages in various marsh, riparian and upland habitats. Nests on or near the ground in concealed locations.	**Present.** Suitable dense wetland habitat for nesting present in vicinity of Laguna Salada.
Black oystercatcher *Haematopus bachmani*	--	§3503	Rocky shoes along the Pacific coast from the Aleutian Islands to Baja California.	**Low (Unlikely to nest).** Suitable breeding habitat is not present on beach within the study area. This species may be present in the study area when moving between suitable rocky outcrops along the San Francisco Peninsula coastline which do provide foraging and breeding opportunity.
Herring gull *Larus argentatus*	--	§3503	Open water, tidepools, beaches, and human-influenced areas like plowed fields, landfills and picnic areas. Breed near lakes in Alaska, Canada, and parts of the Arctic.	**Moderate (No nesting potential).** Commonly observed on beach in study area while wintering.
Ring-billed gull *Larus delawarensis*	--	§3503	Coastal waters, beaches, and estuaries though commonly observed inland at reservoirs, lakes, landfills and parking lots. Breed across North America above the 40 degree latitude line and below the Arctic.	**High (No nesting potential).** Commonly observed on beach while wintering.
Short-billed dowitcher *Limnodromus griseus*	--	§3503	Saltwater tidal flats, beaches, and salt marshes during migration.	**Low (No nesting potential).** Common winter migrant that could occur along the coastline within the study area during low tide events.
Marbled godwit *Limosa fedoa*	--	§3503	Shoreline mudflats and beaches.	**Low (No nesting potential).** Common winter migrant that could occur along the coastline within the study area during low tide events.
White-winged scoter *Melanitta fusca*	--	§3503	Shallow intertidal and subtidal areas along the Pacific and Atlantic coasts while wintering. Breeds in boreal forests near lakes.	**Moderate (No nesting potential).** Commonly observed off shore of study area while wintering.
Black scoter *Melanitta nigra*	--	§3503	Shallow intertidal and subtidal areas along the Pacific and Atlantic coasts while wintering. Breeds in the boreal forests of Alaska and the North East near lakes.	**High (No nesting potential).** Commonly observed off shore of study area while wintering.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name ***Scientific Name***	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**
Other Special-Status Species (continued)				
Birds (continued)				
Surf scoter *Melanitta perspicillata*	--	§3503	Shallow intertidal and subtidal areas along the Pacific and Atlantic coasts while wintering. Breeds in the boreal forest and tundra of northern Canada and Alaska.	**High (No nesting potential).** Commonly observed off shore of study area while wintering.
Song sparrow *Melospiza melodia*	--	--	Open woodlands, tidal marshes, freshwater lakes, wetlands, agricultural areas and suburbs.	**High (Potential to nest).** Common to Pacifica. Could occur within dense shrub habitat within the Sharp Park Golf Course.
Alameda song sparrow *Melospiza melodia pusillula*	--	CSC	Salt marshes of eastern and south San Francisco Bay.	**Low (No nesting potential).** Not known to occur in coastal marshes of northern San Mateo; therefore this species is not expected.
Red-breasted merganser *Mergus serrator*	--	§3503	Common to coastal areas and interior lakes of North America while wintering or during migration. Breed in northern Canada, Alaska, and the Arctic.	**Moderate (No nesting potential).** May be observed offshore of study area while wintering.
Long-billed curlew *Numenius americanus* (nesting)	BCC	WL, §3503	Breeds in upland shortgrass prairies and wet meadows in northeastern California in gravelly soils. Winter visitor to the San Francisco Bay Area.	**Moderate (No nesting potential).** Common winter migrant to beach in study area. Likely to be present while foraging during low tide events within the study area.
Whimbrel *Numenius phaeopus*	--	§3503	Saltwater tidal flats, beaches, and salt marshes during migration.	**Moderate (No nesting potential).** Common winter migrant to beach in study area. Likely to be present while foraging during low tide events within the study area.
Double-crested cormorant *Phalacrocorax auritus*	--	WL, §3503	Rookery breeder in coastal areas and inland lakes in fresh, saline, and estuarine waters.	**Moderate (No nesting potential).** Common forager in waters offshore of the study area.
Red phalarope *Phalaropus fulicarius*	--	§3503	Winter at sea within the Pacific Ocean off the California coast. Breed in the Arctic.	**Moderate (No nesting potential).** May be observed offshore of the study area.
Red-necked phalarope *Phalaropus lobatus*	--	§3503	Winter at sea within the Pacific Ocean off the California coast. Breed in the Arctic.	**Moderate (No nesting potential).** May occur on a transient basis during migration.
Nuttall's woodpecker *Picoides nuttallii*	--	§3503	Oak and riparian woodlands.	**Low (No nesting potential).** Low quality suitable nesting or foraging habitat is present in the study area.
Spotted towhee *Pipilo maculatus clementae*	--	§3503	Dense, dry thickets and shrubby areas, forest edges, and chaparral. Nests on or near the ground.	**Low (Unlikely to nest).** Suitable dense coastal scrub nesting adjacent to study area; foraging habitat is limited to shrubby areas on fringes of golf course.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name *Scientific Name*	Federal Status	State Status	Habitat Description	Potential to Occur in the Study Area
Other Special-Status Species (continued)				
Birds (continued)				
Allen's hummingbird *Selasphorus sasin*	BCC	§3503	Brush and woodlands along the California coast.	**Moderate (Potential to nest).** May forage and nest within the landscaped trees and shrubs of the San Francisco Zoo or east of the study area at Lake Merced.
Parasitic jaeger *Stercorarius parasiticus*	--	§3503	Offshore waters of the Pacific Ocean or coastal bays during migration or while wintering. Breeds in the Arctic.	**Low (No nesting potential).** May occur during migration or wintering offshore of the study area while foraging.
Pomarine jaeger *Stercorarius pomarinus*	--	§3503	Offshore waters of the Pacific Ocean during migration or while wintering. Breeds in the Arctic.	**Low (No nesting potential).** May occur during migration or wintering offshore of the study area while foraging.
Common tern *Sterna hirundo*	--	§3503	Ocean waters, lakes, bays and beaches along the Pacific coast during migration to breeding areas in central Canada.	**Low (No nesting potential).** May occur during migration offshore of the study area while foraging.
Willet *Tringa semipalmata*	BCC	§3503	Common to open beaches, bay shorelines, marshes, mudflats, and rocky coasts. Nest at inland marshes, prairies with ponded water and fields.	**Moderate (No nesting potential).** Does not nest locally. Likely to be present while foraging during low tide events within the study area.
Common murre *Uria aalge*	--	§3503	Nest in colonies on steep rocky cliffs in few areas along the coast of California, Oregon, Washington and Alaska. One breeding colony is located offshore of the San Francisco peninsula.	**Moderate (No nesting potential).** Suitable rocky habitat for this species is not found within the study area; however, this species is common offshore of beach within study area.
Mammals				
Townsend's big-eared bat *Corynorhinus townsendii*	--	CSC, WBWG: High	Throughout California in a wide variety of habitats. Most common in mesic sites. Roosts in the open, hanging from walls and ceilings of rocky areas with caves or tunnels. Roosting sites limited. Extremely sensitive to human disturbance.	**Low.** Suitable roosting habitat for this species is not available within the study area. May be present intermittently while foraging.
Silver-haired bat *Lasionycteris*	--	WBWG: Medium	Roosts in hollow trees, snags, buildings, rock crevices, caves, and under bark. Primarily a forest dweller, feeding over streams, ponds, and open brushy areas.	**Moderate.** Suitable roosting habitat for this species is available in the matures trees around the Sharp Park Golf Course. May forage over the dune vegetation communities of the study area. Detected north of the study area at Fort Funston during acoustic monitoring between 2004 and 2005.[2]

2 Fellers, Gary M. 2005. Acoustic Inventory and Monitoring of Bats at Golden Gate National Recreation Area. USGS.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAY OCCUR IN THE TERRESTRIAL STUDY AREA

Common Name *Scientific Name*	**Federal Status**	**State Status**	**Habitat Description**	**Potential to Occur in the Study Area**
Other Special-Status Species (continued)				
Mammals (continued)				
Western red bat *Lasiurus blossevillii*	--	CSC, WBWG: High	Roosts primarily in trees, 2-40 feet above ground, from sea level up through mixed conifer forests. Prefers habitat edges and mosaics with trees that are protected from above and open below with open areas for foraging.	**Low.** Low quality roosting habitat for this species is available in the matures trees around Sharp Park Golf Course. May forage over the dune vegetation communities of the project area. Detected north of the study area at Fort Funston during acoustic monitoring between 2004 and 2005.[3]
Hoary bat *Lasiurus cinereus*	--	WBWG: Medium	Prefers open habitats or habitat mosaics, with access to trees for cover and open areas or habitat edges for feeding. Roosts in dense foliage of medium to large trees. Feeds primarily on moths; requires water.	**Moderate.** Suitable roosting habitat for this species is available in the matures trees around the Sharp Park Golf Course. May forage over the dune vegetation communities of the project area. Detected north of the study area at Fort Funston during acoustic monitoring between 2004 and 2005.[4]
San Francisco dusky-footed woodrat *Neotoma fuscipes annectens*	--	CSC	Forest habitats of moderate canopy and moderate to dense understory. May prefer chaparral and redwood habitats. Constructs nests of shredded grass, leaves, and other material. May be limited by availability of nest-building materials.	**Low.** Low quality suitable habitat found in southern portion of study area, unlikely affected by proposed activities.
Little brown bat *Myotis lucifugus*	--	WBWG: Medium	Day roosts located in buildings, trees, under rocks or wood, or occasionally in caves. Nursery roosts typically established in buildings, but also in other locations with suitable temperatures.	**Moderate.** Suitable day and nursery roost habitat located around the Sharp Park Golf Course. May forage over the dune vegetation communities of the project area. Detected north of the study area at Fort Funston during acoustic monitoring between 2004 and 2005.[5]
Fringed myotis *Myotis thysanodes*	--	WBWG: High	Most common in drier woodlands, they may roost in caves, mines, buildings, and crevices.	**Moderate.** Suitable roosting habitat for this species is available in the matures trees in the Sharp Park Golf Course. May forage over the dune vegetation communities of the project area. Detected north of the study area at Fort Funston during acoustic monitoring between 2004 and 2005.[6]
American badger *Taxidea taxus*	--	CSC	Open grasslands with loose, friable soils.	**No Potential.** No suitable habitat present on site.

NOTES:
* Please refer to Figure 1 for reference to the project study area for terrestrial biological resources.
The "Potential for Effect" category is defined as follows:
Present = Species was observed during reconnaissance or focused surveys of the project area.
High = Species is expected to occur, habitat meets species requirements and is of moderate or high quality, and the study area is within the known species range.
Moderate = Habitat is marginally suitable (i.e. of low or moderate quality) or the study area is within the known range of the species, even though the species was not observed during biological surveys.
Low = Habitat does not meet species requirements as currently understood in the scientific community or the site is not within a species' geographic range.
No Potential = Habitat does not meet species requirements or the species is presumed to be extirpated from the project area or region based on the best scientific information available.

3 Fellers, Gary M. 2005. Acoustic Inventory and Monitoring of Bats at Golden Gate National Recreation Area. USGS.
4 Fellers, Gary M. 2005. Acoustic Inventory and Monitoring of Bats at Golden Gate National Recreation Area. USGS.
5 Fellers, Gary M. 2005. Acoustic Inventory and Monitoring of Bats at Golden Gate National Recreation Area. USGS.
6 Fellers, Gary M. 2005. Acoustic Inventory and Monitoring of Bats at Golden Gate National Recreation Area. USGS.

TABLE BIO-2 (CONTINUED)
SPECIAL-STATUS OR OTHERWISE PROTECTED ANIMAL SPECIES THAT MAYOCCUR IN THE TERRESTRIAL STUDY AREA

FESA = Federal Endangered Species Act, CESA = California Endangered Species Act,
CNDDB = California Natural Diversity Database

Federal: U.S. Fish and Wildlife Service (USFWS)
FE = Listed as "endangered" under the FESA
FT = Listed as "threatened" under the FESA
FPD = Proposed delisted
FD = Delisted
BCC = Bird of Conservation Concern

State: California Department of Fish and Wildlife (CDFW)
CE = Listed as "endangered" under the CESA
CT = Listed as "threatened" under the CESA
CD = Delisted
CSC = CDFW designated "species of special concern"
CFP = CDFW designated "fully protected"
SCE = CDFW designated "candidate endangered"
SCT = CDFW designated "candidate threatened"
WL = CDFW designated "watch list"
§3503 = Eggs, Nests, and Nestlings Protected under Section 3503 of the California Fish and Game Code
§3503.5 = Eggs, Nests, and Nestlings of Falconiformes and Strigiformes Protected under Section 3503.5 of the California Fish and Game Code

Other: Western Bat Working Group (WBWG)
Low = Stable population
Medium = Need more information about the species, possible threats, and protective actions to implement.
High = Imperiled or at high risk of imperilment.

SOURCES:

CDFW, 2020. California Natural Diversity Database (CNDDB) Rarefind version 5 query of the San Francisco South and Montara Mountain USGS 7.5-minute topographic quadrangles, Commercial Version. Accessed July 13, 2020.

U.S. Fish and Wildlife Service (USFWS), 2020. My Project, IPaC Trust Resource Report and Official Species List of Federally Endangered and Threatened Species that may occur in the Pacifica Seawall Replacement Project location, and/or may be affected by the proposed project, July 13, 2020.

Appendix C

Economic Impacts Assessment

Key Assumptions and Infrastructure Cost Estimates

MHRA Economic Assessment – List of Assumptions

This appendix is intended to provide a summary of the key assumptions made in estimating the costs associated with a No Project scenario. Tables with estimated costs for each item are also provided. These values are considered pre-planning level estimates and should not be used for any purpose other than intended, which is to inform the feasibility study for the BBIRP Project. All estimated costs, including those at future time horizons, are provided in 2020 dollars. Infrastructure costs used in this assessment include a 30% contingency sum which allows for uncertainties and unknowns present at the time of the assessment.

Accuracy of Infrastructure Cost Estimates

The opinions of infrastructure costs included in this MHRA have been developed to a level of accuracy in line with the Association for the Advancement of Cost Engineering (AACE) International Recommended Practices. At the time of this MHRA report the project status is at the feasibility level, which uses a Class 4 Estimate Class (-30% to +50%). AACE's Cost Estimate Classification System is Widely used to communicate the expected accuracy of an estimate at various stages of a project. Figure 1 is a table developed from AACE International Recommended Practice No. 17R-97 COST ESTIMATE CLASSIFICATION SYSTEM.

Estimate Class	Maturity Level of Project Deliverables	Typically Expected Accuracy Range	Preparation Effort
Class 5	0% to 2%	-50% to +100%	1
Class 4	1% to 15%	-30% to +50%	2 to 4
Class 3	10% to 40%	-20% to +30%	3 to 10
Class 2	30% to 75%	-15% to +20%	5 to 20
Class 1	65% to 100%	-10% to +15%	10 to 100

Figure 1 – The Five Classes of Cost Estimates Presented by AACE

The values shown in Figure 1 related to 17R-97 provides a range for low end accuracy and a range the high end accuracy for each class. The range reported herein corresponds to the lowest low value and the highest high value for each class and is therefore conservative.

Monetized Primary Economic Impacts - Infrastructure

As the pre-planning level estimates for infrastructure costs of the 'no project' scenario have been developed the costs for City administration have not been included. Some agencies, such as FEMA, allow for a 10% administration sum to be included in projects. A 10% City administration cost has not been included to avoid the perception that the City may benefit in any way from a 'no action scenario'.

<u>Beach Blvd Promenade and Roadway Infrastructure – Key Assumptions</u>

Under a No Project scenario, the costs associated with demolition and removal of the following items have been included in the 2020-2030 planning horizon.

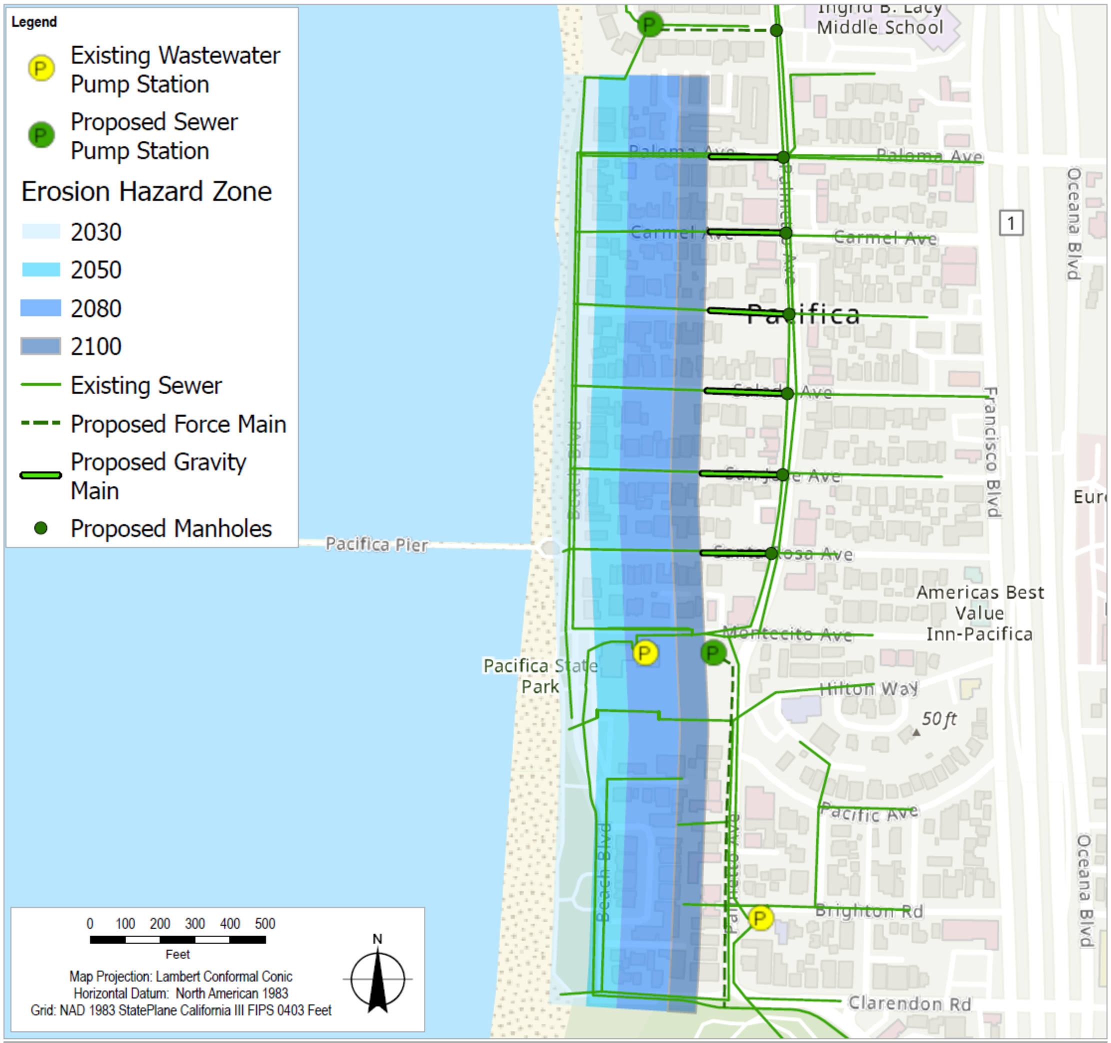
- Closure, demolition and removal of the Promenade and Beach Blvd pavement, subgrade and associated landscape and hardscape improvements.
- Demolition and removal of failed seawall and revetment structures along Project reach
- Turnaround areas will be constructed at each street to allow for fire department requirements, with 'No Exit' signs installed. In some cases a cul-de-sac may be a feasible option but in other cases adjacent properties or other constraints may prohibit this option. Other turnaround options include a hammer-head type of configuration, or a temporary gravel access road.

- It was assumed that purchase or acquisition of property for the sole purpose of constructing a turnaround would be unlikely and other options for vehicular and emergency service access would be evaluated.
- These street end areas will require planning and design based on opportunities and constraints as the situation presents itself at the time, including the regulations of the fire department and other future community needs.
- It is assumed that street ends will be reconstructed an average of 3 times per planning horizon, as the shoreline erodes landward.
- To provide coastal access, it is assumed stairways would be constructed at each street end.

Sanitary Sewer Infrastructure – Key assumptions

Improvements listed below will need to be implemented in the 2020-2030 planning horizon under a No Project scenario to maintain wastewater service to the community:

- 6" gravity collection line and abandoned line within Beach Blvd R/W removed
- Neighborhood will be serviced via new 18" gravity collection line within Palmetto Ave R/W.
- New 6" HDPE wastewater collection lines and new lateral connections required within each street running perpendicular to Beach Blvd. A preliminary review of grades, and discussions with City wastewater operators, provides confidence the new 6" wastewater collection lines can be replaced and reversed to gravity feed to the new 18" sewer collection line along Palmetto Avenue.
- Replacement laterals on the new 6" lines may simply be short connections or may need full replacement from the 6" line to the dwelling connection. Further investigation will be needed to determine the extent of lateral replacement. Full replacement of approximately half of lateral has been allowed for (approx. 10/20 per street).
- New pump station and force main required for service area immediately north of Project and west of Palmetto Ave, along Shoreview Ave.
- Sharp Park Pump Station (SPPS) will also require relocation with an assumed design capacity of 13 MGD. New 26" HDPE forcemain will be required to connect relocated PS to existing forcemain.
- SPPS is projected to become exposed in the ~2050 time horizon but there is a long lead time associated with relocating this type of facility. For purposes of estimating the economics impacts, the SPPS relocation costs were assumed to be incurred in the 2030 time horizon, such that the new facility is sited, designed, permitted and constructed before the existing PS is vulnerable to erosion damage.
- The SPPS is the most important and expensive infrastructure asset within the No Action erosion hazard zone. The replacement cost estimate for this facility has been estimated at $15M but could vary significantly based on a number of site and facility details which are not available.
- A lump sum value of $2.5M was included to cover property acquisition costs for the relocated SPPS.
- Subsequent planning horizons will involve incremental removal and capping of the collection lines and laterals on each street to remove facilities in the hazard zones.



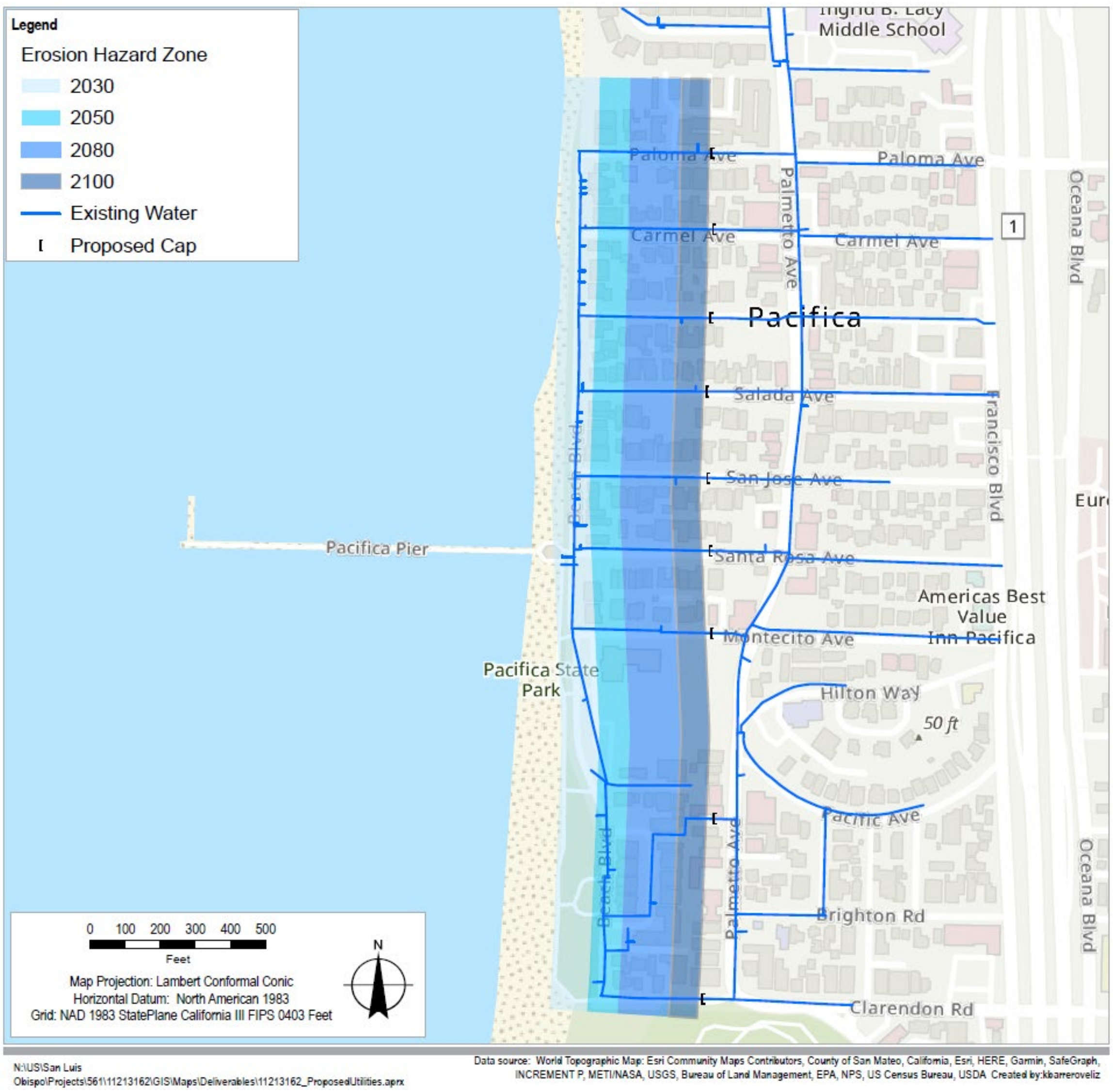
N:\US\San Luis Obispo\Projects\561\11213162\GIS\Maps\Deliverables\11213162_ProposedUtilities.aprx

Data source: World Topographic Map: Esri Community Maps Contributors, County of San Mateo, California, Esri, HERE, Garmin, SafeGraph, INCREMENT P, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA Created by:kbarreroveliz

Sanitary Sewer System

Potable Water Infrastructure – Key Assumptions

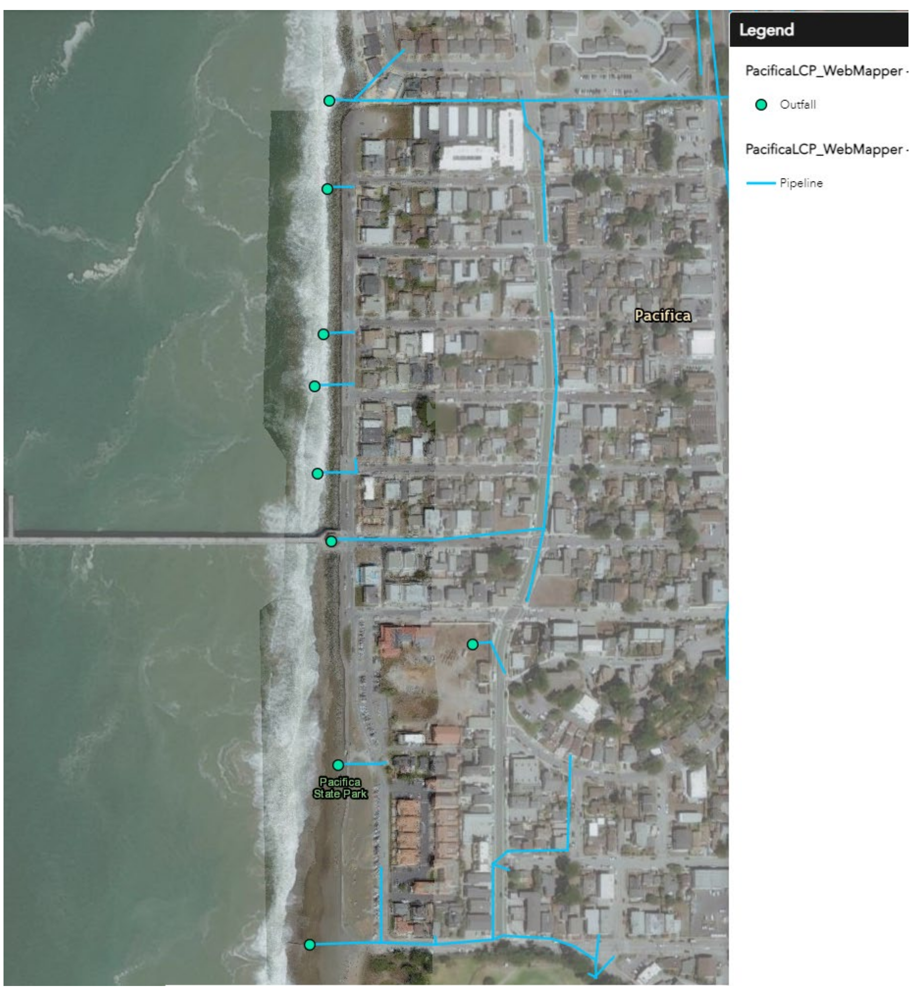
- Water supply lines along Beach Blvd R/W will be removed in the 2020-2030 planning horizon
- Water supply line currently looped through each street running perpendicular to Beach Blvd and will continue to be serviced from the Palmetto Ave supply line for subsequent planning horizons.
- Water line at each street end will be capped outside of erosion hazard zone. As erosion progresses landward in each planning horizon, the water line will be demolished and capped as needed



Potable Water System

Storm Drainage Infrastructure – Key Assumptions

- Under a No Project scenario, in the 2020-2030 planning horizon, the costs associated with demolition and removal storm drainage infrastructure is included in the Pier and roadway demolition estimates, noting as the storm drainage beach outfalls are all built into and connected to these other infrastructure items, with the exception of the 72” reinforced concrete pipe (RCP) at the northern terminus of the North Wall.
- The 72” pipe at the northern terminus of the North Wall will be protected by the rock lined embankment levee assumed to be constructed to protect the properties on Shoreview Avenue.
- The Santa Rosa Avenue storm drain outlet will require modifications in response to progressing erosion hazards. It’s assumed the outlet would be reconstructed every 10 years in response to future erosion hazards.
- Costs associated with removal of dislodged outlet pipe sections is deemed to be a relatively low cost item and included in the roadway infrastructure demolition items.
- Occasional cleanup will be required as sections of RCP are exposed and dislodge to the beach, as occurs with other storm drainage infrastructure along this coastline.



Storm Drainage System

Gas, Electrical & Communications Infrastructure – Key Assumptions

- Service lines along Beach Blvd R/W will be removed in the 2020-2030 planning horizon
- Neighborhood will continue to be serviced from the lines along Palmetto Ave for subsequent planning horizons.
- As erosion progresses landward in each planning horizon, the service lines along each side street will be demolished and removed as needed.

Pier Demolition and Removal – Key Assumptions

- Based on assumptions laid out under the No Project scenario, Pier would be closed and demolition would commence upon removal of the existing seawall.
- Cost to demolish and remove the Pier are assumed to be a one-time expense in the 2020-2030 planning horizon.
- Assume concrete piles are cut below the mud line, rather than entirely removed.

Shoreline Protection of Adjacent Properties (Levees) – Key Assumptions

- It was assumed adjacent property owners would continue to implement an adaptive strategy that includes a shoreline protection element designed to maintain present uses.
- Given assumptions under the No Project scenario, erosion would progress landward within the Project area, posing a risk of damage from flank erosion at adjacent properties, if left unprotected.
- It was assumed rock lined embankments or levees would be installed in a shore perpendicular alignment in response coastal erosion hazards within the Project reach.
- The distance of levee protection needed was based on the erosion hazard zones identified for each planning horizon.

Monetized Primary Economic Impacts – Property

Under a No Project scenario, the erosion hazards projected along the Project reach pose a major risk to existing property. Most parcels within the hazard zones are developed with single unit and multi-unit residential housing. The following list includes assumptions made in estimating the loss of property value in this assessment.

- Erosion hazards were deemed to be the most significant threat to property under a No Project scenario. Erosion and undermining of buildings were assumed to result in complete loss of property value.
- Monetary values for each property were collected from Redfin, Zillow, and ParcelQuest.
- The average value from Zillow and Redfin was used in the assessment if both sources were available. In the cases where a property only had a value on Zillow or Redfin, the individual value was used in the assessment.

- The properties without Zillow or Redfin values were assigned property values based on the ParcelQuest data. Due to the values on ParcelQuest reflecting the assessors value and not market value, a correction factor was used.
    - Zillow estimates each property's value based on any data the homeowner has submitted, facts for each home, the housing market, as well as the location (Zillow, 2020).
    - Redfin estimates are calculated using multiple listing service databases of properties recently sold in the nearby area (Redfin, 2020).
    - ParcelQuest receives property data directly from assessors with the estimated value of the land and property listed and used for property tax purposes (ParcelQuest, 2020).
- Improved properties with an average value below $700k were assigned a value of $700k based on a comparison of similar properties in the area.
- Properties without a structure (empty lot) were not assigned a value of $700k but retained the originally calculated average value using Redfin and Zillow or ParcelQuest with a correction factor.
- Summary of the number of buildings and average value loss/building at each time horizon is provided below:

Time Horizon	Number of buildings	Average Value loss/building
2030	27	$1.47M
2050	24	$1.23M
2080	71	$1.40M
2100	43	$1.23M
Cumulative total	165	$1.34M

- The timing of property value loss was assumed to coincide with the erosion hazard zones. In reality, property value loss may occur sooner than indicated and before a building is directly exposed to erosion, depending on the rate of erosion and a properties distance from the hazard zones. This assumption does not affect the overall property value loss estimates listed in the assessment, only that a portion of this value loss may occur sooner than indicated at each planning horizon.
- We assumed removal of the buildings only and did not account for the potential construction of temporary or permanent shoreline protection structures at individual parcels. An average demolition cost of $30,000 was added to the estimated value of each property.

Monetized Secondary Economic Impacts – Property

Secondary monetized impacts for properties included the following:

- Disruption costs
- Debris cleanup

Disruption costs were calculated by using the average residents per dwelling of 2.77 and using a multiplier for lodging and meals. Debris cleanup for each property was calculated by multiplying the estimated property value with a debris cleanup multiplier of $3,000.

Monetized Secondary Economic Impacts – Businesses

Under a No Project scenario, the erosion hazards projected along the Project reach will impact a total of four businesses. One in the 2020-2030 Erosion Horizon and three in the 2080-2100 Erosion Horizon. Secondary impacts for each business were calculated and included the following calculations:

- Business interruption
- Debris cleanup

Business interruptions were calculated by estimating the square footage of the business using Google Earth. Each identified business was assigned a non-residential category with its corresponding square feet per employee (EIA) and daily output per employee (IMPLAN). An assumption was made that each business would be interrupted for one month. The business interruption cost value was obtained by dividing the estimated square footage by the EIA and multiplying the value with the IMPLAN and 30 days.
Debris cleanup for each business was calculated by multiplying the estimated property value with a debris cleanup multiplier of 30%.

Monetized Secondary Economic Impacts – Emergency Response

An Emergency response and minor repair value was included in the monetized secondary impacts. This value reflects the costs accrued during the January 2016 storm events and applies to all properties. This same budget amount was included at each erosion horizon although the type of emergency work may vary in response to the erosion hazards expected under the No Action scenario.

City of Pacifica

Beach Boulevard Infrastructure Resiliency Project (BBIRP)

Opinion of Probable Cost for "No Action" Scenario

Summary of Infrastructure Costs

Date: 3/9/2021

Item	Item Description	Planning Horizon 1 (2020 - 2030)	Planning Horizon 2 (2030 - 2050)	Planning Horizon 3 (2050 - 2080)	Planning Horizon 4 (2080 - 2100)	Total
1	Infrastructure Costs - Roadway	$ 6,600,000	$ 3,300,000	$ 4,600,000	$ 3,300,000	**$ 17,800,000**
2	Infrastructure Costs - Sanitary Sewer	$ 38,600,000	$ 500,000	$ 500,000	$ 500,000	**$ 40,100,000**
3	Infrastructure Costs - Water	$ 1,200,000	$ 800,000	$ 800,000	$ 800,000	**$ 3,600,000**
4	Infrastructure Costs - Gas	$ 1,100,000	$ 700,000	$ 700,000	$ 700,000	**$ 3,200,000**
5	Infrastructure Costs - Electricity	$ 1,000,000	$ 500,000	$ 500,000	$ 500,000	**$ 2,500,000**
6	Infrastructure Costs - Communications	$ 600,000	$ 400,000	$ 400,000	$ 400,000	**$ 1,800,000**
7	Infrastructure Costs - Pier Demo	$ 4,700,000	$ -	$ -	$ -	**$ 4,700,000**
8	Infrastructure Costs - Levees	$ 1,100,000	$ 900,000	$ 1,500,000	$ 900,000	**$ 4,400,000**
	Rounded Cost	**$ 54,900,000**	**$ 7,100,000**	**$ 9,000,000**	**$ 7,100,000**	**$ 78,100,000**

Notes:
1. The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
2. All values shown in this table are based on 2020 costs.
3. A 30% contingency amount is included in the above sums.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Roadway

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	Item Description	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount
Construction & Property Acquisition Items																	
1	Mobilization (% of all other Items)	5%	%	$ 3,790,000	$ 189,500	5%	%	$ 1,910,000	$ 95,500	5%	%	$ 2,830,000	$ 141,500	5%	%	$ 1,910,000	$ 95,500
2	Traffic Control	1	LS	$ 100,000	$ 100,000	1	LS	$ 50,000	$ 50,000	1	LS	$ 50,000	$ 50,000	1	LS	$ 50,000	$ 50,000
3	Stormwater Pollution Prevention	1	LS	$ 50,000	$ 50,000	1	LS	$ 20,000	$ 20,000	1	LS	$ 20,000	$ 20,000	1	LS	$ 20,000	$ 20,000
4	Sheeting, Shoring & Bracing	1	LS	$ 50,000	$ 50,000	0	LS	$ 50,000	$ -	0	LS	$ 50,000	$ -	0	LS	$ 50,000	$ -
5	Demolition of failed wall	1	LS	$ 1,000,000	$ 1,000,000	0	LS	$ 1,000,000	$ -	0	LS	$ 1,000,000	$ -	0	LS	$ 1,000,000	$ -
6	Demolition of road corridor	1	LS	$ 500,000	$ 500,000	0	LS	$ 500,000	$ -	0	LS	$ 500,000	$ -	0	LS	$ 500,000	$ -
7	Close Street Ends	8	Ea	$ 150,000	$ 1,200,000	8	Ea	$ 150,000	$ 1,200,000	8	Ea	$ 225,000	$ 1,800,000	8	Ea	$ 150,000	$ 1,200,000
8	Beach Access Stairs at street ends	8	Ea	$ 30,000	$ 240,000	8	Ea	$ 30,000	$ 240,000	8	Ea	$ 45,000	$ 360,000	8	Ea	$ 30,000	$ 240,000
9	Storm drain outlets	2	LS	$ 200,000	$ 400,000	2	LS	$ 200,000	$ 400,000	2	LS	$ 300,000	$ 600,000	2	LS	$ 200,000	$ 400,000
10	72" storm drain outlet structure	1	Ea	$ 250,000	$ 250,000	0	Ea	$ -	$ -	0	Ea	$ -	$ -	0	Ea	$ -	$ -
Construction & Property Acquisition Items Total					**$ 3,979,500**				**$ 2,005,500**				**$ 2,971,500**				**$ 2,005,500**
Professional Services Items																	
1	Geotechnical Investigations	1	LS	$ 50,000	$ 50,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
2	Survey	1	LS	$ 25,000	$ 25,000	1	LS	$ 20,000	$ 20,000	1	LS	$ 20,000	$ 20,000	1	LS	$ 20,000	$ 20,000
3	Design	8%	%	$ 3,979,500	$ 318,360	8%	%	$ 2,005,500	$ 160,440	8%	%	$ 2,971,500	$ 160,440	8%	%	$ 2,005,500	$ 160,440
4	Permits	8%	%	$ 3,979,500	$ 318,360	8%	%	$ 2,005,500	$ 160,440	8%	%	$ 2,971,500	$ 160,440	8%	%	$ 2,005,500	$ 160,440
5	Construction Management	10%	%	$ 3,979,500	$ 397,950	10%	%	$ 2,005,500	$ 200,550	10%	%	$ 2,005,500	$ 200,550	10%	%	$ 2,005,500	$ 200,550
	Professional Services Total				**$ 1,109,670**				**$ 566,430**				**$ 566,430**				**$ 566,430**
	Contingency	**30%**	**%**	**$ 5,089,170**	**$ 1,526,751**	**30%**	**%**	**$ 2,571,930**	**$ 771,579**	**30%**	**%**	**$ 3,537,930**	**$ 1,061,379**	**30%**	**%**	**$ 2,571,930**	**$ 771,579**
	Project Total				**$ 6,615,921**				**$ 3,343,509**				**$ 4,599,309**				**$ 3,343,509**
	Project Total Rounded				**$ 6,600,000**				**$ 3,300,000**				**$ 4,600,000**				**$ 3,300,000**

Notes:

1 Demolition of failed wall includes removal of the failed wall structure and rock revetment
2 Demolition of road corridor includes removal of concrete curb, sidewalk/path, road pavement, lighting, walls and benches - utilities demolition included elsewhere
3 Permits includes professional services for CDP to remove the wall and roadway
4 The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
5 All values shown in this table are based on 2020 costs.
6 Storm drain costs include demolition of pipes as they are dislodge form the eroded bluff and reconstruction of outlet rip rap and end walls. Planning Horizon 1 has storm drain demolition included in the seawall demolition
7 After initial demolition in Planning Horizon 1 only 3 storm drain outlets will remain, 2 of which will require maintenance as the bluffs are eroded. The 3rd outlet (72" pipe at northern terminus of the seawall) will be
8 protected by the rock lined embankment levee assumed to be constructed to protect the properties on Shoreview Avenue.
9 Storm drain outlets assumed to require maintenance every 5 years.
10 Closing of street ends will require turnaround area for Fire Dept. Nominal amount included for either cul de sac or "hammer head", final solution will depend on available area and other factors.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Sanitary Sewer

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	**Item Description**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**
Construction & Property Acquisition Items																	
1	Mobilization (% of all other Items)	5%	%	$ 22,021,250	$ 1,101,063	5%	%	$ 245,000	$ 12,250	5%	%	$ 245,000	$ 12,250	5%	%	$ 245,000	$ 12,250
2	Traffic Control	1	LS	$ 50,000	$ 50,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Stormwater Pollution Prevention	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000
4	Sheeting, Shoring & Bracing	1	LS	$ 50,000	$ 50,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000
5	Demolition, incl. pump station	1	LS	$ 600,000	$ 600,000	1	LS	$ 200,000	$ 200,000	1	LS	$ 200,000	$ 200,000	1	LS	$ 200,000	$ 200,000
6	6" gravity HDPE Pipe	3850	ft	$ 250	$ 962,500	0	ft		$ -	0	ft		$ -	0	ft		$ -
7	Lateral connections to 6" HDPE Pipe	70	Ea	$ 10,000	$ 700,000	0	Ea		$ -	0	Ea		$ -	0	Ea		$ -
8	18" Upgraded Palmetto Sewer Main	1400	ft	$ 700	$ 980,000	0	ft		$ -	0	ft		$ -	0	ft		$ -
9	26" force main HDPE pipe	1025	ft	$ 950	$ 973,750	0	ft		$ -	0	ft		$ -	0	ft		$ -
10	Pump station 13-MGD (3 pumps)	1	LS	$ 15,000,000	$ 15,000,000	0	LS		$ -	0	LS		$ -	0	LS		$ -
11	Shoreview pump and forcemain	1	LS	$ 195,000	$ 195,000	0	LS		$ -	0	LS		$ -	0	LS		$ -
12	Property Acquisition	1	LS	$ 2,500,000	$ 2,500,000	0	LS		$ -	0	LS		$ -	0	LS		$ -
Construction & Property Acquisition Items Total					**$ 23,122,313**				**$ 257,250**				**$ 257,250**				**$ 257,250**
Professional Services Items																	
1	Geotechnical Investigations	1	LS	$ 50,000	$ 50,000	0	LS	$ 50,000	$ -	0	LS	$ 50,000	$ -	0	LS	$ 50,000	$ -
2	Survey	1	LS	$ 50,000	$ 50,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Design	10%	%	$ 23,122,313	$ 2,312,231	10%	%	$ 257,250	$ 25,725	10%	%	$ 257,250	$ 25,725	10%	%	$ 257,250	$ 25,725
4	Permits & Environmental	8%	%	$ 23,122,313	$ 1,849,785	8%	%	$ 257,250	$ 20,580	8%	%	$ 257,250	$ 20,580	8%	%	$ 257,250	$ 20,580
5	Construction Management	10%	%	$ 23,122,313	$ 2,312,231	10%	%	$ 257,250	$ 25,725	10%	%	$ 257,250	$ 25,725	10%	%	$ 257,250	$ 25,725
	Professional Services Total				**$ 6,574,248**				**$ 97,030**				**$ 97,030**				**$ 97,030**
	Contingency	**30%**	**%**	**$ 29,696,560**	**$ 8,908,968**	**30%**	**%**	**$ 354,280**	**$ 106,284**	**30%**	**%**	**$ 354,280**	**$ 106,284**	**30%**	**%**	**$ 354,280**	**$ 106,284**
	Project Total				**$ 38,605,528**				**$ 460,564**				**$ 460,564**				**$ 460,564**
	Project Total Rounded				**$ 38,600,000**				**$ 500,000**				**$ 500,000**				**$ 500,000**

Notes:

1. Demolition in Horizon 1 includes demolition of the Sharp Park pump station sewer lines along Beach Boulevard and side streets, side streets need to be removed for new gravity lines are installed to drain opposite way to existing lines
2. Demolition in Horizons 2-4 includes removing new 6" lines and capping as the shoreline moves landward
3. Although exisiting Sharp Park Pump station is not physically affected in Planning Horizon 1 it is assumed relocation would be in this period, in conjunction with other major sewer relocation efforts to reroute the collection systems along Palmetto Avenue. This also accounts for the long lead time associated with planning, permitting, designing and funding a new sewer pump station. This is a highly important infrastructure asset, which should be relocated and brought online well before erosion hazards threaten the existing facility.
4. The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
5. All values shown in this table are based on 2020 costs.
6. Property acquisition assumes potential eminent domain process.
7. Manholes, valves etc. are deemed to be included in the sewer pipe items

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Water

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	**Item Description**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**
Construction Items																	
1	Mobilization (% of all other Items)	5%	%	$ 695,000	$ 34,750	5%	%	$ 485,000	$ 24,250	5%	%	$ 485,000	$ 24,250	5%	%	$ 485,000	$ 24,250
2	Traffic Control	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Stormwater Pollution Prevention	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000
4	Sheeting, Shoring & Bracing	1	LS	$ 10,000	$ 10,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
5	Demolition of Main on Beach Blvd	1	LS	$ 200,000	$ 200,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
6	Demo and Cap of Side Street Mains	9	Ea	$ 50,000	$ 450,000	9	Ea	$ 50,000	$ 450,000	9	Ea	$ 50,000	$ 450,000	9	Ea	$ 50,000	$ 450,000
	Construction Total				**$ 729,750**				**$ 509,250**				**$ 509,250**				**$ 509,250**
Professional Services Items																	
1	Geotechnical Investigations	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
2	Survey	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
3	Design	8%	%	$ 729,750	$ 58,380	8%	%	$ 509,250	$ 40,740	8%	%	$ 509,250	$ 40,740	8%	%	$ 509,250	$ 40,740
4	Permits	8%	%	$ 729,750	$ 58,380	8%	%	$ 509,250	$ 40,740	8%	%	$ 509,250	$ 40,740	8%	%	$ 509,250	$ 40,740
5	Construction Management	10%	%	$ 729,750	$ 72,975	10%	%	$ 509,250	$ 50,925	10%	%	$ 509,250	$ 50,925	10%	%	$ 509,250	$ 50,925
	Professional Services Total				**$ 189,735**				**$ 132,405**				**$ 132,405**				**$ 132,405**
	Contingency	**30%**	**%**	**$ 919,485**	**$ 275,846**	**30%**	**%**	**$ 641,655**	**$ 192,497**	**30%**	**%**	**$ 641,655**	**$ 192,497**	**30%**	**%**	**$ 641,655**	**$ 192,497**
	Project Total				**$ 1,195,331**				**$ 834,152**				**$ 834,152**				**$ 834,152**
	Project Total Rounded				**$ 1,200,000**				**$ 800,000**				**$ 800,000**				**$ 800,000**

Notes:

1 The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project

2 All values shown in this table are based on 2020 costs.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Gas

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	Item Description	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount
Construction Items																	
1	Mobilization (% of all other Items)	5%	%	$ 645,000	$ 32,250	5%	%	$ 395,000	$ 19,750	5%	%	$ 395,000	$ 19,750	5%	%	$ 395,000	$ 19,750
2	Traffic Control	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Stormwater Pollution Prevention	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000	1	LS	$ 10,000	$ 10,000
4	Sheeting, Shoring & Bracing	1	LS	$ 10,000	$ 10,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
5	Demolition of Main on Beach Blvd	1	LS	$ 150,000	$ 150,000	1	LS	$ -	$ -	1	LS	$ -	$ -	1	LS	$ -	$ -
6	Demo and Cap of Side Street Mains	9	Ea	$ 50,000	$ 450,000	9	Ea	$ 40,000	$ 360,000	9	Ea	$ 40,000	$ 360,000	9	Ea	$ 40,000	$ 360,000
	Construction Total				**$ 677,250**				**$ 414,750**				**$ 414,750**				**$ 414,750**
Professional Services Items																	
1	Geotechnical Investigations	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
2	Survey	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
3	Design	8%	%	$ 677,250	$ 54,180	8%	%	$ 414,750	$ 33,180	8%	%	$ 414,750	$ 33,180	8%	%	$ 414,750	$ 33,180
4	Permits	8%	%	$ 677,250	$ 54,180	8%	%	$ 414,750	$ 33,180	8%	%	$ 414,750	$ 33,180	8%	%	$ 414,750	$ 33,180
5	Construction Management	10%	%	$ 677,250	$ 67,725	10%	%	$ 414,750	$ 41,475	10%	%	$ 414,750	$ 41,475	10%	%	$ 414,750	$ 41,475
	Professional Services Total				**$ 176,085**				**$ 107,835**				**$ 107,835**				**$ 107,835**
	Contingency	**30%**	**%**	**$ 853,335**	**$ 256,001**	**30%**	**%**	**$ 522,585**	**$ 156,776**	**30%**	**%**	**$ 522,585**	**$ 156,776**	**30%**	**%**	**$ 522,585**	**$ 156,776**
	Project Total				**$ 1,109,336**				**$ 679,361**				**$ 679,361**				**$ 679,361**
	Project Total Rounded				**$ 1,100,000**				**$ 700,000**				**$ 700,000**				**$ 700,000**

Notes:
1 The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
2 All values shown in this table are based on 2020 costs.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Electricity

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	**Item Description**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**
Construction Items																	
1	Mobilization (% of all other Items)	5%	%	$ 595,000	$ 29,750	5%	%	$ 295,000	$ 14,750	5%	%	$ 295,000	$ 14,750	5%	%	$ 295,000	$ 14,750
2	Traffic Control	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Stormwater Pollution Prevention	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
4	Sheeting, Shoring & Bracing	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
5	Demolition of Main on Beach Blvd	1	LS	$ 200,000	$ 200,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
6	Demo & Terminate Side Street Lines	9	Ea	$ 30,000	$ 270,000	9	Ea	$ 30,000	$ 270,000	9	Ea	$ 30,000	$ 270,000	9	Ea	$ 30,000	$ 270,000
7	Demo City Lighting	1	LS	$ 100,000	$ 100,000	0	LS	$ -	$ -	0	LS	$ -	$ -		LS	$ -	$ -
	Construction Total				**$ 624,750**				**$ 309,750**				**$ 309,750**				**$ 309,750**
Professional Services Items																	
1	Geotechnical Investigations	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
2	Survey	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
3	Design	8%	%	$ 624,750	$ 49,980	8%	%	$ 309,750	$ 24,780	8%	%	$ 309,750	$ 24,780	8%	%	$ 309,750	$ 24,780
4	Permits	8%	%	$ 624,750	$ 49,980	8%	%	$ 309,750	$ 24,780	8%	%	$ 309,750	$ 24,780	8%	%	$ 309,750	$ 24,780
5	Construction Management	10%	%	$ 624,750	$ 62,475	10%	%	$ 309,750	$ 30,975	10%	%	$ 309,750	$ 30,975	10%	%	$ 309,750	$ 30,975
	Professional Services Total				**$ 162,435**				**$ 80,535**				**$ 80,535**				**$ 80,535**
	Contingency	**30%**	**%**	**$ 787,185**	**$ 236,156**	**30%**	**%**	**$ 390,285**	**$ 117,086**	**30%**	**%**	**$ 390,285**	**$ 117,086**	**30%**	**%**	**$ 390,285**	**$ 117,086**
	Project Total				**$ 1,023,341**				**$ 507,371**				**$ 507,371**				**$ 507,371**
	Project Total Rounded				**$ 1,000,000**				**$ 500,000**				**$ 500,000**				**$ 500,000**

Notes:
1 The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
2 All values shown in this table are based on 2020 costs.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Communications

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	**Item Description**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**
Construction Items																	
1	Mobilization (% of all other Items)	5%	%	$ 355,000	$ 17,750	5%	%	$ 205,000	$ 10,250	5%	%	$ 205,000	$ 10,250	5%	%	$ 205,000	$ 10,250
2	Traffic Control	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Stormwater Pollution Prevention	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
4	Sheeting, Shoring & Bracing	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
5	Demolition of Main on Beach Blvd	1	LS	$ 150,000	$ 150,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
6	Demo & Terminate Side Street Lines	9	Ea	$ 20,000	$ 180,000	9	Ea	$ 20,000	$ 180,000	9	Ea	$ 20,000	$ 180,000	9	Ea	$ 20,000	$ 180,000
											$ -						
	Construction Total				**$ 372,750**				**$ 215,250**				**$ 215,250**				**$ 215,250**
Professional Services Items																	
1	Geotechnical Investigations	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
2	Survey	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
3	Design	8%	%	$ 372,750	$ 29,820	8%	%	$ 215,250	$ 17,220	8%	%	$ 215,250	$ 17,220	8%	%	$ 215,250	$ 17,220
4	Permits	8%	%	$ 372,750	$ 29,820	8%	%	$ 215,250	$ 17,220	8%	%	$ 215,250	$ 17,220	8%	%	$ 215,250	$ 17,220
5	Construction Management	10%	%	$ 372,750	$ 37,275	10%	%	$ 215,250	$ 21,525	10%	%	$ 215,250	$ 21,525	10%	%	$ 215,250	$ 21,525
	Professional Services Total				**$ 96,915**				**$ 55,965**				**$ 55,965**				**$ 55,965**
	Contingency	**30%**	**%**	**$ 469,665**	**$ 140,900**	**30%**	**%**	**$ 271,215**	**$ 81,365**	**30%**	**%**	**$ 271,215**	**$ 81,365**	**30%**	**%**	**$ 271,215**	**$ 81,365**
	Project Total				**$ 610,565**				**$ 352,580**				**$ 352,580**				**$ 352,580**
	Project Total Rounded				**$ 600,000**				**$ 400,000**				**$ 400,000**				**$ 400,000**

Notes:
1 The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
2 All values shown in this table are based on 2020 costs.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Pier Demo

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	**Item Description**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**	**Qty**	**Unit**	**Rate**	**Amount**
Construction Items																	
1	Mobilization (% of all other Items)	5%	%	$ 2,760,000	$ 138,000	5%	%	$ -	$ -	5%	%	$ -	$ -	5%	%	$ -	$ -
2	Traffic Control	1	LS	$ 100,000	$ 100,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
3	Stormwater Pollution Prevention	1	LS	$ 100,000	$ 100,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
4	Sheeting, Shoring & Bracing	1	LS	$ 50,000	$ 50,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
5	Demolition of Café	1	LS	$ 100,000	$ 100,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
6	Demolition of Pier Superstructure	1	LS	$ 1,200,000	$ 1,200,000	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
7	Demolition of Pier Foundations	48	Ea	$ 20,000	$ 960,000	0	Ea	$ -	$ -	0	Ea	$ -	$ -	0	Ea	$ -	$ -
8	Demolition of Pier Abutment	1	Ea	$ 250,000	$ 250,000	0	Ea	$ -	$ -	0	Ea	$ -	$ -	0	Ea	$ -	$ -
	Construction Total				**$ 2,898,000**				**$ -**				**$ -**				**$ -**
Professional Services Items																	
1	Geotechnical Investigations	1	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
2	Survey	1	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -	0	LS	$ -	$ -
3	Design	8%	%	$ 2,898,000	$ 231,840	8%	%	$ -	$ -	8%	%	$ -	$ -	8%	%	$ -	$ -
4	Permits	8%	%	$ 2,898,000	$ 231,840	8%	%	$ -	$ -	8%	%	$ -	$ -	8%	%	$ -	$ -
5	Construction Management	10%	%	$ 2,898,000	$ 289,800	10%	%	$ -	$ -	10%	%	$ -	$ -	10%	%	$ -	$ -
	Professional Services Total				**$ 753,480**				**$ -**				**$ -**				**$ -**
	Contingency	**30%**	**%**	**$ 3,651,480**	**$ 1,095,444**	**30%**	**%**	**$ -**	**$ -**	**30%**	**%**	**$ -**	**$ -**	**30%**	**%**	**$ -**	**$ -**
	Project Total				**$ 4,746,924**				**$ -**				**$ -**				**$ -**
	Project Total Rounded				**$ 4,700,000**				**$ -**				**$ -**				**$ -**

Notes:

1. Assumes pier abutment failure and therefore complete removal of Pier
2. Assumes piles to be cut off at mud line
3. The values provided in this table are considered pre-planning level estimates, and should not be used for any purpose other than intended, which is the feasibility study for the BBIRP Project
4. All values shown in this table are based on 2020 costs.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)
Opinion of Probable Cost for "No Action" Scenario

Infrastructure Costs - Levees

Date: 3/9/2021

		Planning Horizon 1 (2020 - 2030)				Planning Horizon 2 (2030 - 2050)				Planning Horizon 3 (2050 - 2080)				Planning Horizon 4 (2080 - 2100)			
Item	Item Description	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount	Qty	Unit	Rate	Amount
Construction Items																	
1	Mobilization (% of all other Items)	5%	%	$ 575,000	$ 28,750	5%	%	$ 475,000	$ 23,750	5%	%	$ 825,000	$ 41,250	5%	%	$ 475,000	$ 23,750
2	Traffic Control	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Stormwater Pollution Prevention	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
4	Clearing and Grubbing	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
5	South Levee/embankment	100	FT	$ 2,500	$ 250,000	80	FT	$ 2,500	$ 200,000	150	FT	$ 2,500	$ 375,000	80	FT	$ 2,500	$ 200,000
6	North Levee/embankment	100	FT	$ 2,500	$ 250,000	80	FT	$ 2,500	$ 200,000	150	FT	$ 2,500	$ 375,000	80	FT	$ 2,500	$ 200,000
	Construction Total				**$ 603,750**				**$ 498,750**				**$ 866,250**				**$ 498,750**
Professional Services Items																	
1	Geotechnical Investigations	1	LS	$ 50,000	$ 50,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
2	Survey	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000	1	LS	$ 25,000	$ 25,000
3	Design	8%	%	$ 603,750	$ 48,300	8%	%	$ 498,750	$ 39,900	8%	%	$ 866,250	$ 69,300	8%	%	$ 498,750	$ 39,900
4	Permits	8%	%	$ 603,750	$ 48,300	8%	%	$ 498,750	$ 39,900	8%	%	$ 866,250	$ 69,300	8%	%	$ 498,750	$ 39,900
5	Construction Management	10%	%	$ 603,750	$ 60,375	10%	%	$ 498,750	$ 49,875	10%	%	$ 866,250	$ 86,625	10%	%	$ 498,750	$ 49,875
	Professional Services Total				**$ 231,975**				**$ 179,675**				**$ 275,225**				**$ 179,675**
	Contingency	**30%**	**%**	**$ 835,725**	**$ 250,718**	**30%**	**%**	**$ 678,425**	**$ 203,528**	**30%**	**%**	**$ 1,141,475**	**$ 342,443**	**30%**	**%**	**$ 678,425**	**$ 203,528**
	Project Total				**$ 1,086,443**				**$ 881,953**				**$ 1,483,918**				**$ 881,953**
	Project Total Rounded				**$ 1,100,000**				**$ 900,000**				**$ 1,500,000**				**$ 900,000**

Notes:

1 South Levee is the Sharp Park Golf Course Levee and assumed to be constructed between Clarendon Rd pavement and golf course
2 North Levee is the levee protecting Shoreview assumed to be constructed along nothern side of current SeaPointe Apartments, these apartments would be demolished as coastal erosion moves the shoreline eastward
3 Levee assumed to be a rock lined embankment, similar to the existing levee protection the golf course along the beach south of the project
4 The values provided in this table are considered pre-planning level estimates, and should not be used for any pursponse other than intended, which is the feasibility study for the BBIRP Project
5 All values shown in this table are based on 2020 costs.

City of Pacifica
Beach Boulevard Infrastructure Resiliency Project (BBIRP)

Summary of Primary Economic Impacts

Date: 3/9/2021

Table 7-3[1]

Item Description	Planning Horizon 1 (2020 - 2030)	Planning Horizon 2 (2030 - 2050)	Planning Horizon 3 (2050 - 2080)	Planning Horizon 4 (2080 - 2100)	Total
Infrastructure Costs - Roadway	$ 6,600,000	$ 3,300,000	$ 4,600,000	$ 3,300,000	**$ 17,800,000**
Infrastructure Costs - Sanitary Sewer	$ 38,600,000	$ 500,000	$ 500,000	$ 500,000	**$ 40,100,000**
Infrastructure Costs - Water	$ 1,200,000	$ 800,000	$ 800,000	$ 800,000	**$ 3,600,000**
Infrastructure Costs - Gas	$ 1,100,000	$ 700,000	$ 700,000	$ 700,000	**$ 3,200,000**
Infrastructure Costs - Electricity	$ 1,000,000	$ 500,000	$ 500,000	$ 500,000	**$ 2,500,000**
Infrastructure Costs - Communications	$ 600,000	$ 400,000	$ 400,000	$ 400,000	**$ 1,800,000**
Infrastructure Costs - Pier Demo	$ 4,700,000	$ -	$ -	$ -	**$ 4,700,000**
Infrastructure Costs - Levees	$ 1,100,000	$ 900,000	$ 1,500,000	$ 900,000	**$ 4,400,000**
Subtotals - Infrastructure [2]	***$ 54,900,000***	***$ 7,100,000***	***$ 9,000,000***	***$ 7,100,000***	***$ 78,100,000***
Property Costs	$ 39,700,000	$ 29,500,000	$ 99,500,000	$ 52,800,000	**$ 221,500,000**
Subtotals	**$ 94,600,000**	**$ 36,600,000**	**$ 108,500,000**	**$ 59,900,000**	**$ 299,600,000**

1. Rounded to the 100,000
2. Line item not in Table 7-3, but used in Table 7-5