

Appendix J

Coastal Hazards Assessment



Shelter Island Commercial Fishing Wharf Redevelopment Project

Coastal Hazards Assessment

Prepared for: Ascent Environmental and the Port of San Diego

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→ The Power of Commitment

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1. Introduction

The Shelter Island Commercial Fishing Wharf leasehold is located within Port tidelands in San Diego Bay (Bay) at 4918 North Harbor Drive (Figure 1). The site is within the Port's Shelter Island Planning District.

The Shelter Island Commercial Fishing Wharf Redevelopment Project (Project) proposes the removal of the existing fish offloading pier, four floating docks, and four accessways to accommodate the development of a new pier and dock configuration. The new configuration includes four floating docks and gangway access points, construction of a new pile-supported pier, and construction of a floating wave attenuator (Figure 2). The proposed Project features were grouped into fixed and floating categories for this assessment due to having similar vulnerabilities and adaptation options. These Project features are further described below:

- Fixed Structures
 - Construction of new, pile-supported pier (2,800 sq. ft.) on 14 concrete piles. The deck elevation of Pier 4 is yet to be determined per the plans, but was assumed to be 10.07 ft (NAVD88) as directed by the project engineer. This structure will feature a jib crane and lighting.
 - Construction of four new concrete accessway platforms with a top elevation of 10.07 ft (NAVD88) and 15 new piles. These platforms connect the proposed gangways and loading ramp to Regatta Walk.
- Floating Structures
 - Installation of four new floating docks connected by a main walk with seventy-four new guide piles. Floating docks were designed to have 1.5 ft of freeboard and will feature lighting powered by cables fed through conduit in a pull box under the decks.
 - Installation of three new gangways and one loading ramp to access floating docks.
 - Installation of one 270 foot-long floating wave attenuator with 30 guide piles. The wave attenuator is roughly intended to provide approximately 30 percent attenuation on a design wave height and was designed to have 1.75 ft of freeboard. This structure will also feature lighting powered by cables fed through conduit in a pull box under the deck.

Though the Project does not propose any improvements to the adjacent Regatta Walk, it was included in the assessment due to the importance of its connection with the improvements. No topographic survey has been performed yet as part of the engineering design. Landside buildings and a surface parking lot exist north of Regatta Walk, but no improvements are proposed for these structures so they were not included in this assessment.

The goal of this study is to assess the potential current and future coastal hazard vulnerabilities, specifically associated with sea level rise (SLR), across all the Project structures' projected lifespans (i.e. 50 years). Our understanding is that the Project requires this assessment for its CEQA review to determine if the Project may exacerbate SLR impacts in the area and whether adaptation measures are necessary to mitigate any potential impacts. This analysis was performed consistent with the California Coastal Commission's (CCC) Update to the Sea Level Rise Policy Guidance (CCC 2024) as well as the recently adopted State of California Sea Level Rise Guidance: 2024 Science and Policy Update (OPC 2024).



Figure 1. Project Location

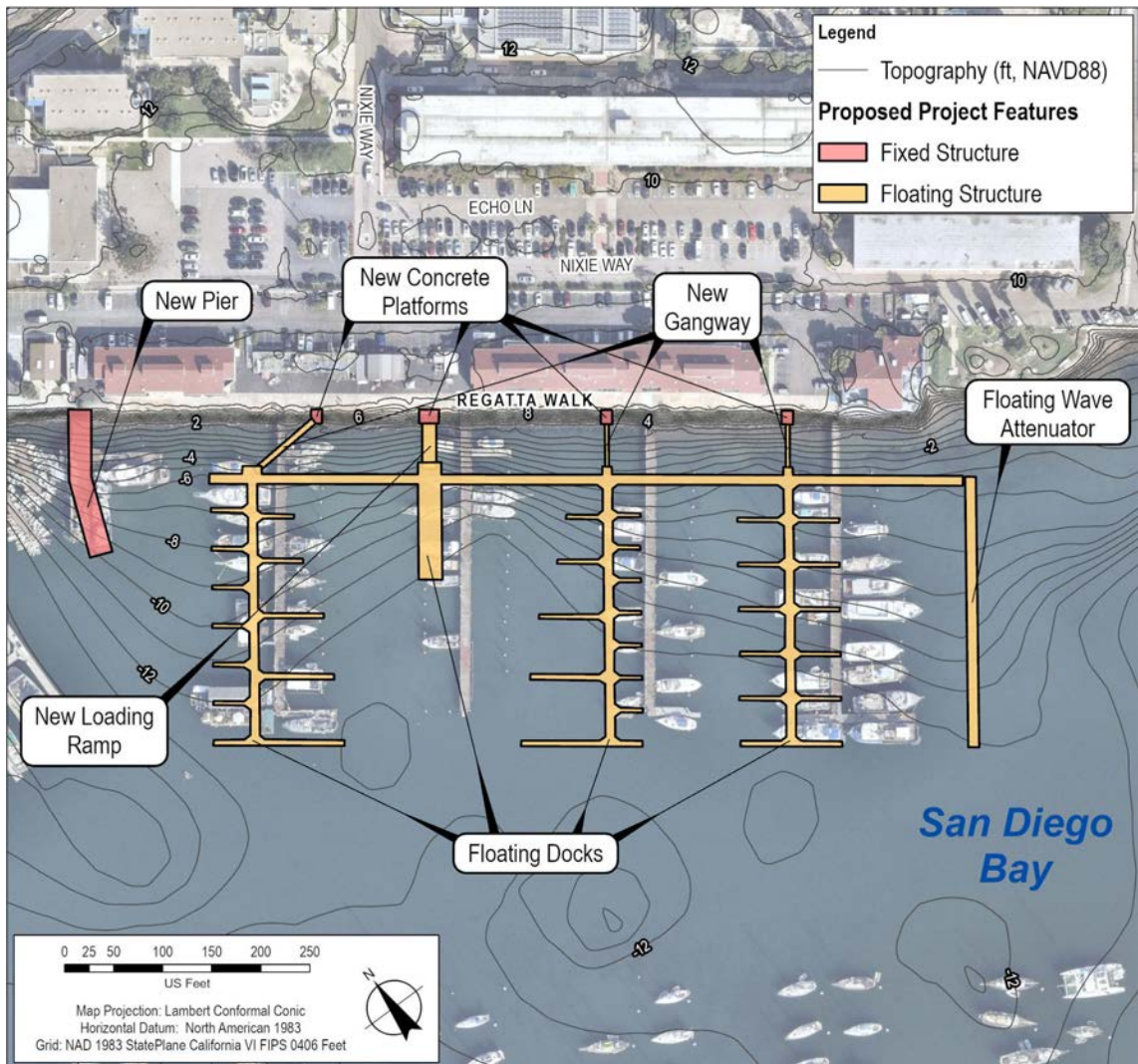


Figure 2. Proposed Project Features

1.1 Scope of Work

The scope of this assessment is as follows:

1. Prepare the Coastal Hazards Assessment in accordance with the California Coastal Commission (CCC) Sea-Level Rise (SLR) Policy Guidance, as well as the recently adopted State of California Sea Level Rise Guidance: 2024 Science and Policy Update from the Ocean Protection Council (OPC).
2. Coastal hazards, such as flooding, will be evaluated for each of the selected SLR scenarios using existing regional and local studies.
3. Coastal hazard limits may be mapped and described for existing and projected future conditions which will include both day-to-day conditions (i.e., current and future tidal inundation) as well as extreme conditions (e.g., flooding associated with extreme tides and storm events).
4. Adaptation strategies or an adaptive pathway may be suggested based on the Project's sensitivity to coastal hazards and SLR to avoid or minimize impacts.

2. Background

2.1 Sea Level Rise

In November 2024, the California Coastal Commission (CCC) adopted the Sea Level Rise Policy Guidance 2024 Update that formally replaced the 2018 Sea Level Rise Policy Guidance. This 2024 update refers to the Ocean Protection Council's (OPC) recently adopted California Sea Level Rise Guidance: 2024 Science and Policy Update as the "best available science" on SLR projections in California. These projections are recommended by the CCC for planning, permitting, and other coastal management decisions.

Within this revised policy guidance, SLR projections are provided for 14 active tide gauges along the coast of California. This document formally replaced the pre-existing 2018 California Sea-Level Rise Guidance to reflect the previous five years of scientific research on SLR projections, including the IPCC's Sixth Assessment Report (2021) and NOAA's national report, Global and National Sea Level Rise Scenarios for the United States (Sweet et al. 2022). NOAA's 2022 report (Sweet et al. 2022) developed a set of five sea level scenarios for the U.S. with a range of plausible changes through 2150 based on the modelled projections in the IPCC AR6 (OPC 2024). The framework and approach for these five scenarios (Low, Intermediate-Low, Intermediate, Intermediate-High, and High) were adopted and regionalized to apply to California-specific scenarios. Unlike the OPC (2018) guidance that provided probabilistic projections corresponding with risk aversion scenarios, the scenarios under the 2024 Update span the plausible range of future SLR in consideration of emissions and global development futures and eliminate the need to select single emission futures for sea level planning (OPC 2024).

A notable advance in the update is the increased understanding of how low confidence processes (e.g., ice-shelf disintegration, marine ice-sheet-ice-cliff instability, and faster-than-projected changes in surface-mass balance) are anticipated to affect sea levels near the end of the century (OPC 2024). While this has allowed the H++ scenario to be determined as no longer physically realistic this Century, the other 2018 risk aversion scenarios are consistent with the OPC (2024) scenarios.

It is important to consider risk tolerance, risk aversion, and design life when evaluating SLR scenarios and the effects of SLR on various coastal hazards. The OPC defines risk tolerance as the level of comfort associated with the consequences of SLR and associated hazards in project planning and design whereas risk aversion is defined as the strong inclination to avoid taking risks in the face of uncertainty (OPC 2024). The OPC (2024) guidance recommends a precautionary approach, when feasible, through an evaluation of the Intermediate, Intermediate-High, and High scenarios to inform appropriate SLR planning and project decisions. These scenarios are defined below:

Intermediate Scenario: The Intermediate scenario should be included in technical analyses for development with low risk aversion, i.e., development that would have limited consequences or a higher ability to adapt, such as some ancillary development or public access amenities. This scenario represents a reasonable estimate for the upper bound of the most likely sea level rise in 2100 (OPC 2024).

Intermediate-High Scenario: The Intermediate-High scenario should be included in technical analyses for development with medium-high risk aversion, i.e., development that would experience greater consequences and/or have a lower ability to adapt, such as most residential and commercial structures. This scenario is representative of a world where rapid ice sheet loss processes contribute to SLR, associated with intermediate to high future emissions, and high warming (OPC 2024). This corresponds to scientific estimates for plausible high-end SLR projections by 2100.

High Scenario: The High scenario should be included in technical analyses for development with extreme risk aversion, i.e., development with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur, such as most critical infrastructure. This scenario is representative of rapid ice sheet loss processes due to high future emissions and high warming, and should be utilized with careful caution and consideration (OPC 2024). The large uncertainties and ambiguity associated with this scenario reflect a worst case toward 2100 and beyond. The likelihood of this occurrence is not possible to state, but it is based on a combination of high emissions and low confidence processes.

The appropriate SLR planning scenario for this Project is the Intermediate-High because it is a commercial structure that has a lower ability to adapt. The three scenarios selected for analysis within this study considered SLR projections for 2050, 2070, and 2100. These SLR projections for the San Diego Bay tide gauge are presented below in Table 1. Based on this 2100 planning horizon being utilized, approximately 95% of OPC's SLR projections across all planning scenarios are accounted for in this assessment, as shown in Figure 3. This would indicate that this assessment provides a thorough analysis of the most plausible SLR scenarios.

Table 1 Sea Level Rise Projections for San Diego Bay (OPC 2024)

	Sea Level Rise Planning Scenarios (ft)		
	Intermediate	Intermediate-High*	High
2030	0.4	0.5	0.5
2050	0.8	1.1	1.3
2070	1.4	2.3	3.0
2100	3.2	4.9	6.7

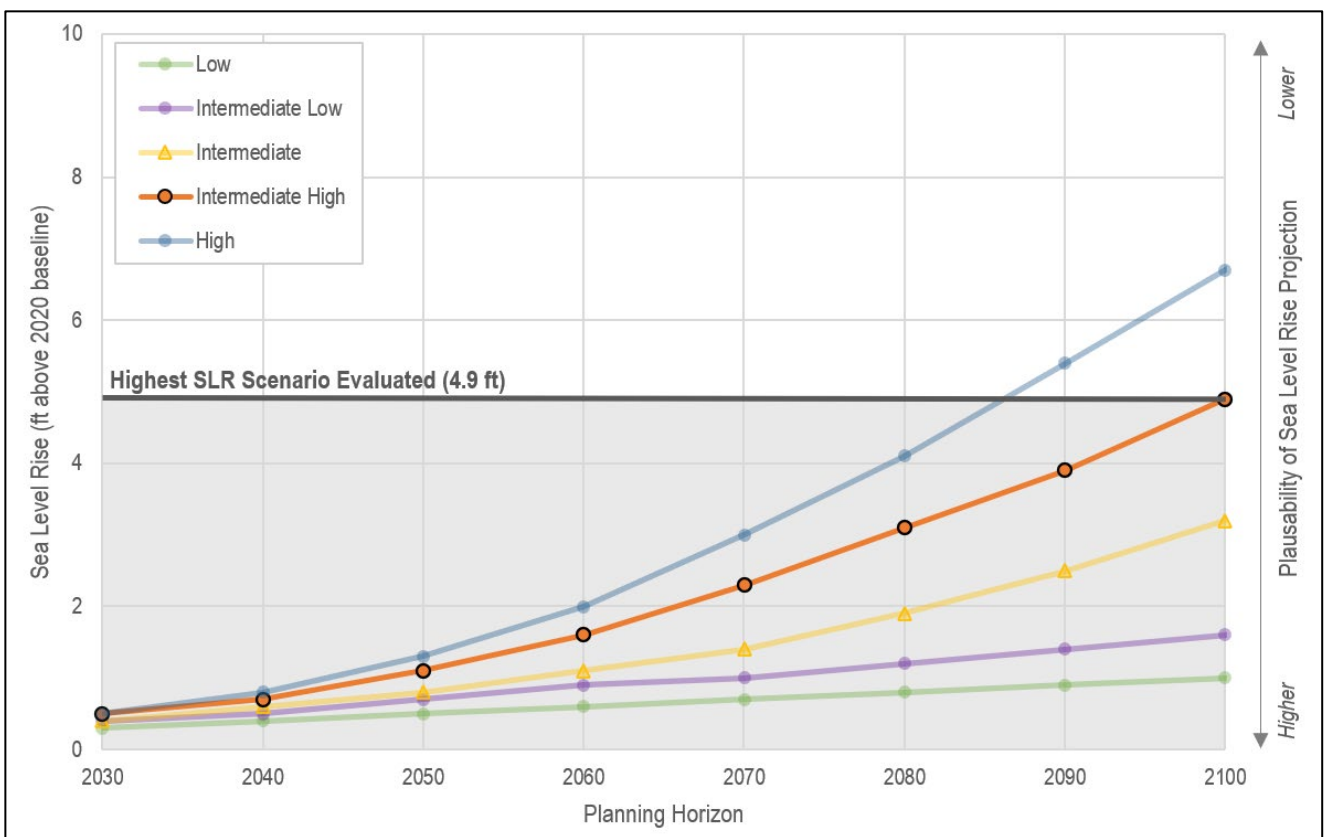


Figure 3. Sea Level Rise Projections, San Diego (OPC 2024)

2.2 Port of San Diego Sea Level Rise Vulnerability Assessment Review (2019)

Coastal flood hazards for the Project site were previously examined in the Port of San Diego Sea Level Rise Vulnerability Assessment and Coastal Resiliency Report (Port of San Diego 2019). This assessment was initially based on the 2018 SLR projections adopted by OPC, which have since been updated according to new science. This assessment did not specifically evaluate SLR impacts to marine structures such as the existing gangways, fish offloading pier, and floating docks at the Project site. However, the assessment determined that walkways and landside buildings are considered likely to be impacted by potential projected SLR inundation under normal tidal conditions at 4.9 ft of SLR (Port of San Diego 2019). The assessment had also evaluated the vulnerabilities of walkways and landside buildings to temporary coastal flooding from a 100-year storm event. These structures

were projected to experience severe coastal flooding under this scenario with 4.9 ft of SLR in this assessment (Port of San Diego 2019).

This assessment provides a site-specific analysis that supersedes this prior Port-wide assessment as it analyses the area in greater detail and is based on the best-available SLR science.

2.3 USGS Coastal Storm Modeling System

A screening-level assessment of coastal hazards was also conducted of the Project site using the U.S. Geological Survey's (USGS) Coastal Storm Modeling System (CoSMoS). CoSMoS provides regional scale predictions of coastal hazards via an online mapping tool. The CoSMoS flood projections include various SLR scenarios as well as SLR coupled still water levels and storms, the intensity of which is designated by storm frequency (e.g., no storm, 100-yr storm). The estimated flood extents are based upon a minimum duration of flooding specified in the model simulations. Actual flooding may vary depending on the site topography, hydraulic connectivity and ecology (e.g., soil characteristics/permeability, vegetation, precipitation, fluvial forces, etc.).

CoSMoS results are provided for increments of 0.25 meters from 0 to 3 meters (9.8 ft), and an extreme scenario of 5 meters (16.4 ft). These scenarios allow the tool to be used independent of SLR science as it continues to evolve. The CoSMoS SLR scenarios most similar to the selected OPC projections for the Project are compared below in Table 2.

The CoSMoS flood potential extents for each of these scenarios for both daily tidal and 100-year storm events are provided in Figure 4 and Figure 5, respectively. These flood projections are typically utilized as a first order of analysis due to the regional scale of the model, which makes it difficult for it to resolve site-specific details. Based on the model outputs, the Regatta Walk would expect to experience flooding under a 100-year storm event with 2.5 ft of SLR. Since the Project entirely consists of overwater features, these flood projections do not contribute to the understanding of how the proposed structures may be exposed to flood hazards. However, CoSMoS was utilized to inform how access to these features could be impaired under this vulnerability assessment.

Table 2 OPC (2024) SLR Projections for San Diego Bay relative to CoSMoS

	OPC 2024 SLR Scenario (Intermediate-High)	Relevant CoSMoS Scenarios
2050	1.1	0.8
2070	2.3	2.5
2100	4.9	4.9

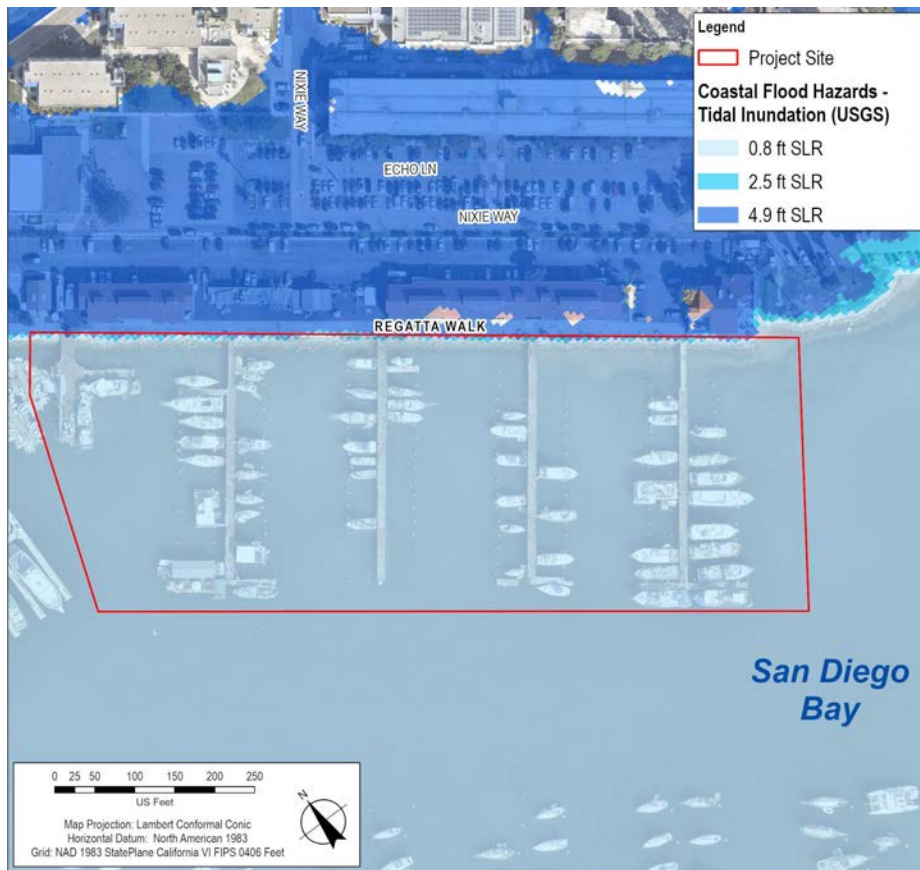


Figure 4. USGS CoSMoS flood projections under daily tidal conditions with SLR

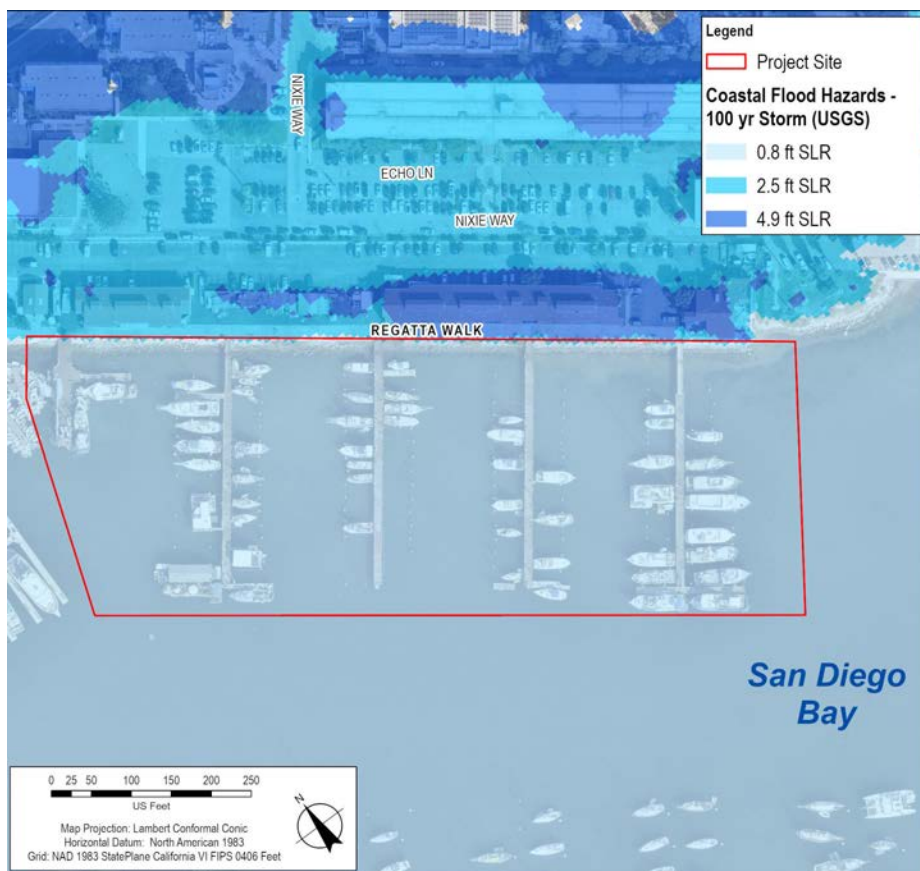


Figure 5. USGS CoSMoS flood projections under 100-year storm conditions with SLR

3. Coastal Hazards

3.1 Tides

The tides in southern California are mixed semi-diurnal, meaning there are two unequal low and high tides each lunar day, which is approximately 25-hours. The National Oceanic and Atmospheric Administration (NOAA) operates tide stations globally and the nearest station to the Project site is located at the end of Broadway Pier, approximately 1,800 ft south of the Project site. This station has a data repository as far back as 1906 and is representative of high-water levels at the Project site. The tidal datums for the San Diego Bay relative to NAVD88 (the datum used for this study) is shown in Table 3.

Table 3 Tidal Datums for the San Diego Bay (NOAA Station 9410170)

Datum	Elevation (ft, NAVD88)
Highest Observed Tide (11/25/2015)	7.81
Highest Astronomical Tide (HAT)	7.19
Mean Higher High Water (MHHW)	5.29
Mean High Water (MHW)	4.56
Mean Sea Level (MSL)	2.51
NAVD88	0.00
Mean Low Water (MLW)	0.51
Mean Lower Low Water (MLLW)	-0.43
Lowest Astronomical Tide (LAT)	-2.49
Lowest Observed Tide (12/17/1937)	-3.52

3.2 Extreme Water Levels

Water levels have the potential to increase under normal astronomical tide ranges, water level anomalies, and the influence of waves. The combination of these events can lead to abnormally high water levels, referred to as extreme water levels in this assessment. These water levels can be divided into two categories, static and dynamic. Static water levels include still water levels (SWL) under normal astronomical tide ranges and tidal anomalies. Dynamic water levels are those which include wave components (wave setup and runup). These extreme water levels are further described in this section.

3.3 Still Water Levels

Still water levels are the water surface elevations resulting from astronomical tides and storm surge but do not include wave heights and runup (FEMA 2016). Ocean water levels typically vary within predictable astronomical tide ranges. However, sea level anomalies may occur that increase water levels above the predicted tides. These anomalies may occur during low atmospheric pressure, abnormally warm water temperatures and meteorological conditions that can lead to storm surge (piling up of water along a coastline).

Extreme water levels are provided by NOAA's Center for Oceanographic Products (NOAA CO-OPS) for annual occurrence probabilities of 1%, 10%, 50%, and 99% for tidal stations with adequate data records. These probabilities correspond to an annual return period of 100-years, 10-years, 2-years, and 1-year; respectively. The extreme water levels at the San Diego Bay stations are shown in Table 4 and are representative of extreme still water levels (ESWLs) for the Project site.

Table 4 Extreme Still Water Levels for San Diego Bay (NOAA Station 9410170)

Annual Exceedance Probability	Return Period (years)	Elevation (ft, NAVD88)
1%	100	7.9

Annual Exceedance Probability	Return Period (years)	Elevation (ft, NAVD88)
10%	10	7.7
50%	2	7.4
99%	1	7.0

3.4 Dynamic Water Levels

Dynamic water levels are the water surface elevations including still water levels plus static and dynamic wave setup (FEMA 2016). Static wave setup is the increase in water level due to wave breaking, or when a wave becomes unstable and collapses. Whereas, dynamic wave setup accounts for wave action, which involves the overall movement and behavior of waves. Within the Bay, two sources are identified as the primary origin of waves around the Project site. Boat wakes are produced from the movement of boats that propagate outward from the boat's path. Wind generated waves are created as wind blows across the surface of the water, and dependent upon the available fetch, result in waves.

3.4.1 Boat Wakes

The North San Diego Bay supports a variety of boating activities which would potentially expose the Project site to boat wakes from passing vessels. As vessels travel through the water, diverging and traversing waves are produced from the stern and bow of the vessel, respectively (Figure 6). The wave height and period produced from a passing vessel is complex and highly dependent on the shape of the hull and speed of the vessel. Thus, the waves produced will vary widely based on the specific ships and predicting such waves would require a comprehensive assessment of the vessel traffic and modeling of wake waves.

The Project site is located approximately 2,700 ft from the federal navigation channel within the America's Cup Harbor Moorage area along the north end of the Bay. However, waves generated by passing vessels are not considered in this study as the assumed magnitude of wake waves are less than that of wind waves. A study completed by GHD (2023) examined recreational and commercial fishing vessel wakes at various locations within the Bay, finding that a 63 ft long fishing vessel drafting at 10.2 ft and traveling a speed of 10.6 knots produced a 0.8 ft wave height. This 0.8 ft wave height also assumed the vessel was 2,650 ft from the shoreline, which is a comparable distance from the federal navigation channel to the Project site. Based on a wind wave analysis completed herein, the maximum wind wave height under extreme conditions was 0.8 ft. Therefore, the dynamic water level that includes wind waves captures the potential boat wakes which may impact the site. Additionally, the moorage area is considered to have a speed limit of 5 mph according to the San Diego Unified Port District Code 4.30, at which speed it is unlikely that a sizable wake wave will be produced within the marina behind the wave attenuator. For this reason, boat wakes were not specifically studied in this coastal hazard assessment.

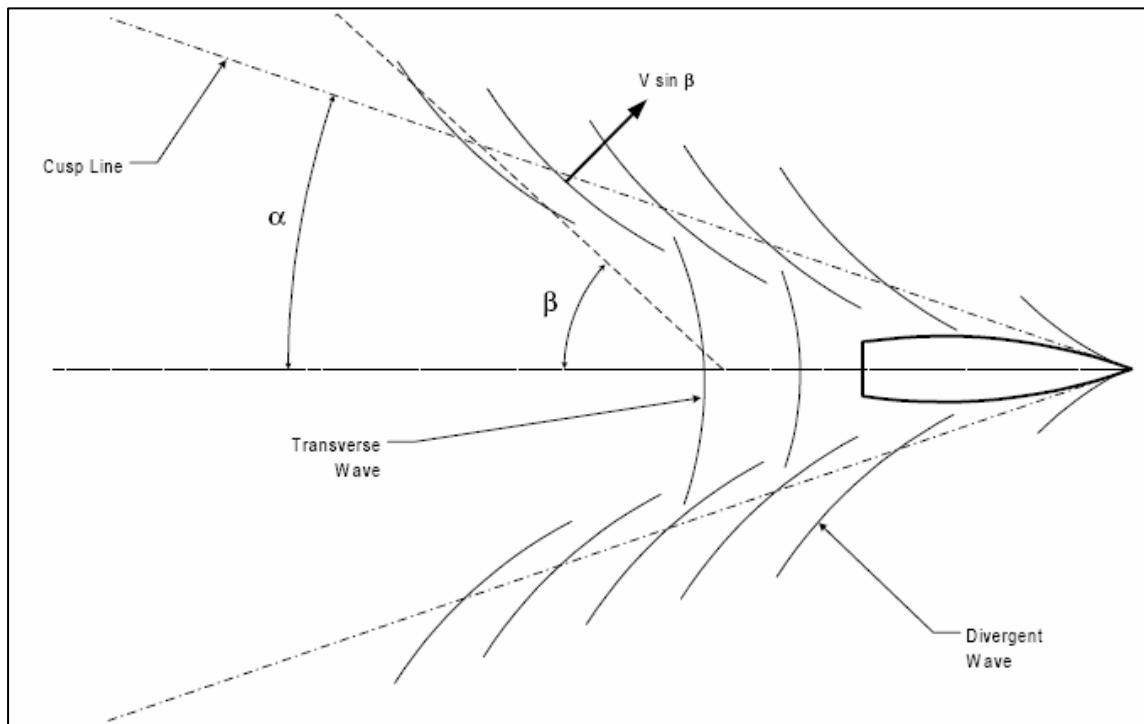


Figure 6. Vessel generated wave schematic (Ghani, Pauzi & Rahim, M. 2008)

3.4.2 Wind Waves

Given the Project site's exposure to wind generated waves, there is potential for the wave components to result in dynamic water levels higher than those listed in Table 4. Because of this, a wind wave analysis was performed to calculate the expected dynamic water levels at the site. The wind wave analysis was conducted for the primary directional bin approaching the site with the longest fetch, which was directly from the East (at 105 degrees north). This analysis examined the potential significant wave heights and periods from this primary dominant wind direction (Figure 7). This analysis considered two scenarios: the extreme wind events (100-year winds) and the typical (average) wind conditions. To accomplish this, an extreme value analysis was performed using the peak over threshold method from a wind data record collected from the San Diego Airport from 1999 to 2025. This method allowed for the extraction of extreme wind speeds from the West that were associated with 1-, 10-, 25-, 50-, and 100-year return periods (Table 5). It should be noted that the 100-year return periods have a higher uncertainty than the return periods of 50 years and below due to the extrapolation of the 26-year wind data record. More detailed methodology for the extreme value analysis may be found in Appendix A.

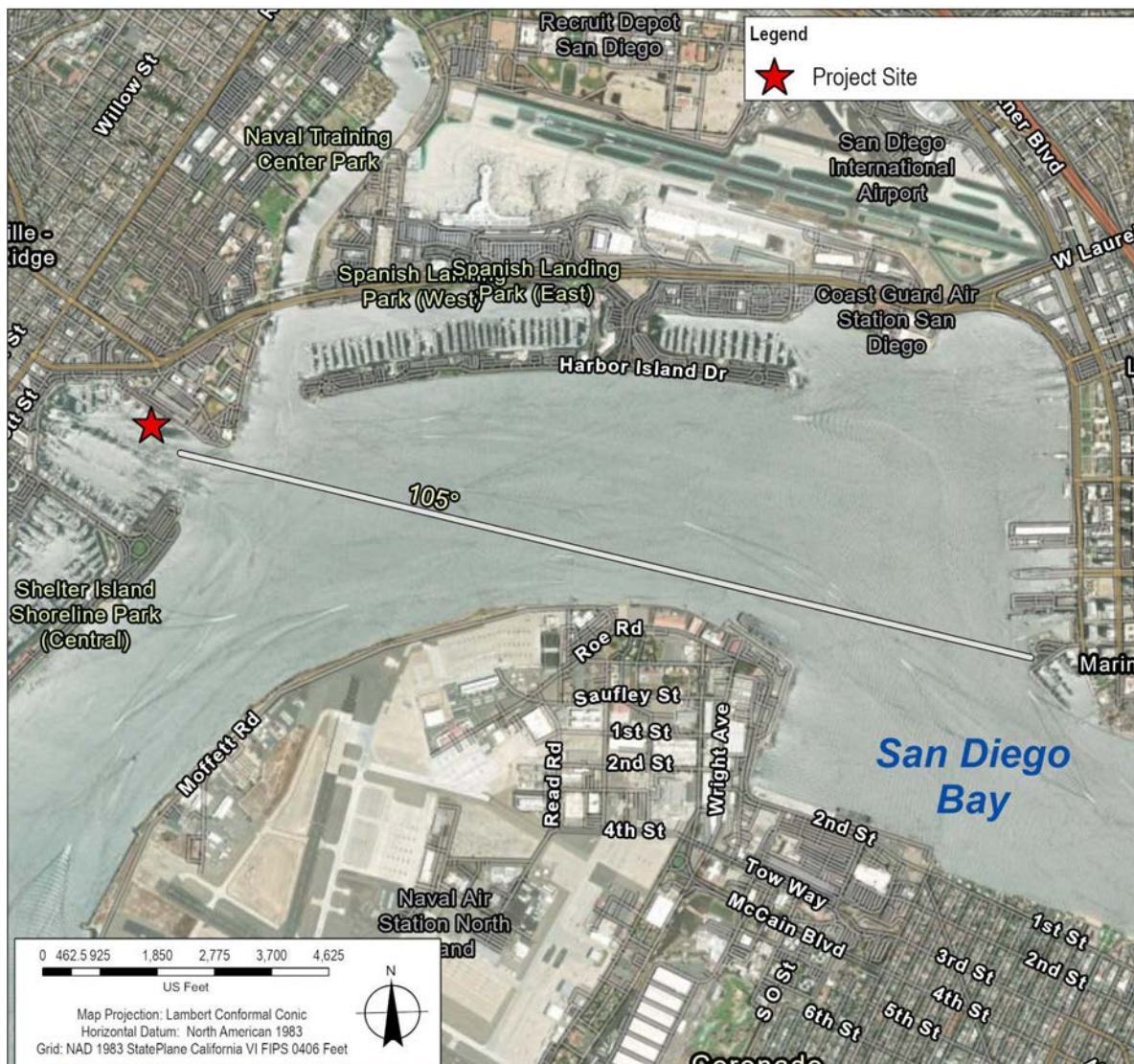


Figure 7. Fetch Radial Used for the Wind Wave Calculations

Wave heights from the West were calculated using the equations for fetch limited wave growth detailed in the Coastal Engineering Manual (CEM). The calculated wave heights and periods from this analysis is shown in Table 5.

Table 5 Calculated Wave Heights for Average Conditions and a 100-year Return Period Wind Event

Fetch Length (ft)	Average Water Depth (ft)	Offshore Wave Height, Hs (ft)		Wave Period, Tp (s)	
		Average Conditions	100-Year	Average Conditions	100-Year
14,146	-39.39	0.3	1.1	1.2	1.9

The results of this analysis allow for the calculation of the dynamic water level elevation by assuming that only 70% of the offshore wave height lies above the SWL (FEMA 2023). This would indicate that the maximum significant wave height above the SWL would be expected to reach approximately 0.8 ft. However, it is important to note the low probability occurrence of a 100-year wind event and its simultaneous occurrence with an extreme water level is unlikely. Therefore, the dynamic water levels being assessed under this analysis will be calculated based on the occurrence of a 100-year wind event under average daily tidal conditions (i.e., MHHW).

The Project involves the installation of a floating wave attenuator, designed to provide approximately 30 percent attenuation of wave heights. To incorporate the attenuation in this SLR assessment, the 100-year offshore wave

heights have been further reduced by 30 percent (to 0.6 ft) and are applied to the dynamic water levels assessed in this analysis.

3.5 Coastal Hazards Scenarios

For this analysis, four water level scenarios were investigated across the three selected SLR time horizons (i.e. 2050, 2070, and 2100). The four water level scenarios include: Scenario 1: SLR + average daily tide (i.e. MHHW), Scenario 2: SLR + average daily tide (i.e. MHHW) + 100-yr Wind Waves (dynamic water level) (according to wave attenuation), Scenario 3: SLR + 1-yr ESWL, and Scenario 4: SLR + 100-yr ESWL. These coastal hazard scenarios are shown below in Table 6. Scenario 1 (SLR + average daily tide) is intended to represent the expected frequent, daily inundation around the Project site. Scenario 2 (dynamic water level) is the unlikely coincidence of a frequent high tide with a 100-yr wind wave event from the East after being reduced by the proposed wave attenuator. This scenario involves waves reaching heights of 0.6 ft, which represent infrequent wetting of the asset rather than full submergence or inundation. Scenario 3 (SLR + 1-yr ESWL) is representative of the infrequent occurrence of an extreme still water level with a 99% annual occurrence probability. This scenario is likely to occur at least three to four times within a given year although it would be short in duration (about 1 hour). Scenario 4 (SLR+100-yr ESWL) is representative of the unlikely occurrence of an extreme still water level with a 1% annual occurrence probability. This extreme still water level would be short in duration (about 1 hour).

Table 6 Coastal Hazard Water Level Scenarios

Year	OPC 2024 SLR Scenario (Intermediate-High)	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		Tides (MHHW) + SLR*	Dynamic Water Level (MHHW) + 100-yr Waves + SLR*	1-yr ESWL + SLR*	100-yr ESWL + SLR*
2025	0.0	5.3	5.9	7.0	7.9
2050	1.1	6.4	7	8.1	9.0
2070	2.3	7.6	8.2	9.3	10.2
2100	4.9	10.2	10.8	11.9	12.8

*Elevations provided relative to ft, NAVD88

4. Vulnerability Assessment

Vulnerability is evaluated based on the proposed Project’s exposure, sensitivity, and adaptive capacity in response to coastal hazards. The vulnerability of a feature increases with both exposure and sensitivity, while it decreases based on its adaptive capacity. To identify when the proposed Project’s features are expected to be vulnerable to SLR, water level build-up calculations are used to provide an asset-specific analysis. This involves the development of cross sections that show the water level scenarios relative to the proposed Project features.

The vulnerability assessment was separated into an evaluation of fixed and floating Project features and is presented in this section.

4.1 Fixed Structures

4.1.1 Pier

According to the most recent plans for the Project, the proposed pier’s deck elevation and thickness are yet to be determined (Figure 8). However, as advised by the Project’s Engineer of Record for this assessment, the deck elevation was assumed to be 10.07 ft (NAVD88) with a thickness of approximately 1.67 ft, placing the soffit at 8.40 ft (NAVD88). These pier deck elevations were used as thresholds to identify when the structure may be exposed to flooding (Table 7). Based on these assumed elevations, there is potential for the pier deck to be exposed to extreme water levels during its projected 50 year lifespan. It is likely to experience infrequent partial submergence

near the end of its design life around 2070 under a 1-year ESWL. Under the unlikely 100-year extreme conditions in combination with an Intermediate-High SLR scenario, the pier deck could experience partial submergence before 2050 and inundation by 2070. Any hanging utilities serving lighting and a jib crane underneath the pier deck would become directly exposed to these elevated water levels. This exposure would subject the pier to increased hydrodynamic forces and buoyancy effects, but these low probability occurrences would be limited to a few hours at the peak of the tidal cycle. Also, assuming that the Regatta Walk remains in its current condition, it is likely that these backlands could experience temporary flooding near 2070 based on CoSMoS 100-year storm projections, thereby limiting access and use of the Pier (Figure 5). However, beyond the structures' design life near 2100, the deck is projected to experience daily tidal inundation that becomes exacerbated under dynamic water level and extreme conditions.

If the Pier is anticipated to remain in service for a 50-year design life, it is recommended that it be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario. To accommodate this elevation change, a ramp will likely be needed to transition into the existing Regatta Walk.

Table 7 Water Level Scenarios compared to the Proposed Pier Structure

Water Level Scenario	Time Horizon	Sea Level Rise Projection (ft)	Coastal Hazards Scenario*	Pier Freeboard (ft) (Deck Elevation Minus Coastal Hazard Scenario)	
				Top of Deck (10.07 ft)	Soffit of Deck (8.40 ft)
Tides (MHHW) + SLR	Existing	0	5.3	4.8	3.1
	2050	1.1	6.4	3.7	2.0
	2070	2.3	7.6	2.5	0.8
	2100**	4.9	10.2	-0.1	-1.8
Dynamic Water Level (MHHW) + 100-yr Waves + SLR	Existing	0	5.9	4.2	2.5
	2050	1.1	7.0	3.1	1.4
	2070	2.3	8.2	1.9	0.2
	2100**	4.9	10.8	-0.7	-2.4
1-yr ESWL + SLR	Existing	0	7.0	3.1	1.4
	2050	1.1	8.1	2.0	0.3
	2070	2.3	9.3	0.8	-0.9
	2100**	4.9	11.9	-1.8	-3.5
100-yr ESWL + SLR	Existing	0	7.9	2.2	0.5
	2050	1.1	9.0	1.1	-0.6
	2070	2.3	10.2	-0.1	-1.8
	2100**	4.9	12.8	-2.7	-4.4

*Elevations provided relative to ft, NAVD88

**Time horizon beyond design life of structure

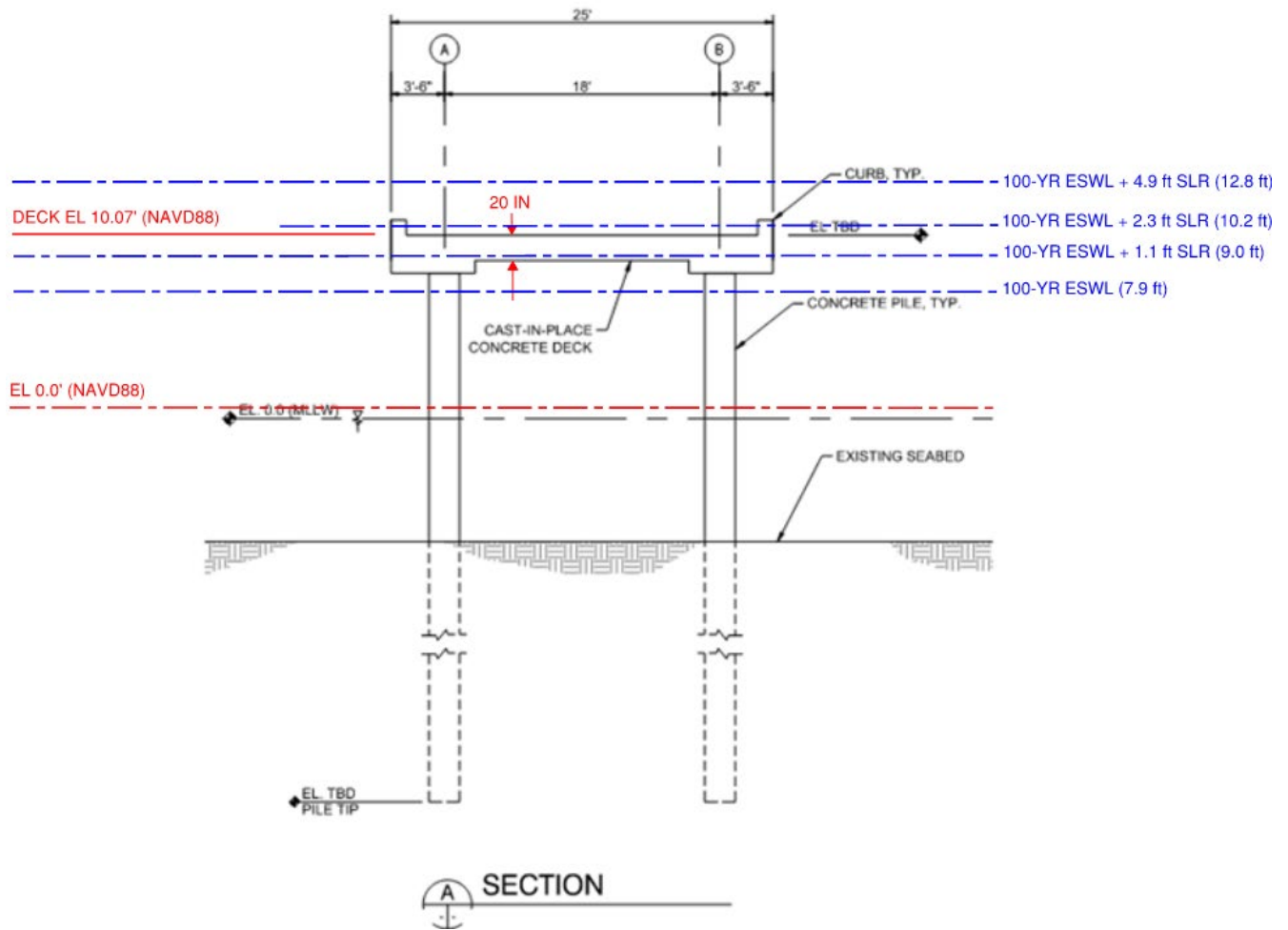


Figure 8. Pier 4 Project Flood hazards cross section for 100-yr ESWL for SLR scenarios

4.1.2 Concrete Platforms

While the finish grade elevations (FG) for each of the four individual concrete platforms are not specifically identified on the Project plans provided by the Port, a typical section identifies the FG as 10.07 ft (NAVD88) with a thickness of approximately 0.83 ft, placing the soffit at 9.24 ft (Figure 9). Based on these thresholds, the concrete platforms could be exposed to flooding before 2070 when in combination with an extreme water level and Intermediate-High SLR scenario (Table 8). Any hanging utilities serving lighting underneath the platforms would become directly exposed to these elevated water levels. While this would subject the platform to increased hydrodynamic forces and buoyancy effects, this low probability occurrence would be limited to a few hours at the peak of the tidal cycle. This would limit the effect of these elevated water level interactions with the concrete pier deck, thereby reducing its vulnerability to SLR over its design life. Also, assuming that the Regatta Walk remains in its current condition, it is likely that these backlands could experience temporary flooding near 2070 based on CoSMoS 100-year storm projections, thereby limiting access and use of the Pier (Figure 5). However, beyond the structures' design life near 2100, the platforms are projected to experience daily tidal inundation that becomes exacerbated under dynamic water level and extreme conditions.

If the concrete platforms are anticipated to remain in service for a 50-year design life, it is recommended that they be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario. To accommodate this elevation change, a ramp will likely be needed to transition into the existing Regatta Walk.

Table 8 Water Level Scenarios compared to the Proposed Concrete Platforms

Water Level Scenario	Time Horizon	Sea Level Rise Projection (ft)	Coastal Hazards Scenario*	Pier Freeboard (ft) (Deck Elevation Minus Coastal Hazard Scenario)	
				Top of Platform (10.07 ft)	Soffit of Platform (9.24 ft)
Tides (MHHW) + SLR	Existing	0	5.3	4.8	3.9
	2050	1.1	6.4	3.7	2.8
	2070	2.3	7.6	2.7	1.6
	2100**	4.9	10.2	-0.1	-1.0
Dynamic Water Level (MHHW) + 100-yr Waves + SLR	Existing	0	5.9	4.2	3.3
	2050	1.1	7.0	3.1	2.2
	2070	2.3	8.2	1.9	1.0
	2100**	4.9	10.8	-0.7	-1.6
1-yr ESWL + SLR	Existing	0	7.0	3.1	2.2
	2050	1.1	8.1	2.0	1.1
	2070	2.3	9.3	0.8	-0.1
	2100**	4.9	11.9	-1.8	-2.7
100-yr ESWL + SLR	Existing	0	7.9	2.2	1.3
	2050	1.1	9.0	1.1	0.2
	2070	2.3	10.2	-0.1	-1.0
	2100**	4.9	12.8	-2.7	-3.6

*Elevations provided relative to ft, NAVD88

** Time horizon beyond design life of structure

4.1.3 Regatta Walk

Though no changes are proposed to the existing Regatta Walk promenade, vulnerability was assessed due to the Project's critical connections with the feature. This promenade varies in elevation from about 8.5 ft to 11 ft (NAVD88) and is armored with a revetment shoreline (Photo 1). This configuration is intended to limit undermining and erosion of the path, however, landside runoff from adjacent buildings and surface drainage are observed to be causing scouring underneath the concrete walkway (Kleinfelder 2022). Based on CoSMoS projections, Regatta Walk could begin to experience temporary flooding near 2070 under 100-year storm conditions and regular tidal inundation by the end of the century (Figure 4; Figure 5). However, the probability of this temporary flooding occurrence is low and would be limited to a few hours at the peak of the tidal cycle, resulting in minimal flooding at this time horizon. Therefore, temporary access and use of the proposed Project may be affected during these rare events towards the end of the Project's 50-year lifespan.

If the Regatta Walk is anticipated to remain in service for the Project's 50-year design life, it is recommended that it be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario. This could involve increasing the crest of the revetment with an enhanced core or the addition of a floodwall along the seaward side of the promenade to add flood protection and resilience. However, we understand that no improvements are proposed to the Regatta Walk as part of this Project.



Photo 1. Existing Regatta Walk promenade

4.2 Floating Structures

4.2.1 Floating Wave Attenuator

The proposed floating wave attenuator, with a 1.75 ft freeboard, is designed to provide approximately 30 percent wave attenuation, moving vertically with water level changes along 30 new guide piles. These guide piles are designed with a pile cap elevation of 13.57 ft (NAVD88), with their pile guides flush with the deck of the attenuator. Based on these elevations, it is very unlikely the floating wave attenuator would reach the vertical limit of the piles over the next 50 years given the projected exposed pile length above the guide under 2070 water levels (Table 9). Only under extreme conditions in combination with an Intermediate-High SLR scenario in 2100, beyond this structure's design life, would the attenuator be expected to exceed this pile cap elevation.

No design changes or adaptation options are recommended for the floating wave attenuator based on the proposed structure's projected lifespan of 50 years.

Table 9 Water Level Scenarios compared to the Proposed Floating Wave Attenuator

Water Level Scenario	Time Horizon	Sea Level Rise Projection (ft)	Coastal Hazards Scenario*	Projected Exposed Pile Length Above Guide (ft)
				Pile Cap Elevation (13.57 ft) Minus Projected Deck Elevation
Tides (MHHW) + SLR	Existing	0	5.3	6.5
	2050	1.1	6.4	5.4
	2070	2.3	7.6	4.2
	2100**	4.9	10.2	1.6
Dynamic Water Level (MHHW) + 100-yr Waves + SLR	Existing	0	6.1	5.9
	2050	1.1	7.2	4.8
	2070	2.3	8.4	3.6
	2100**	4.9	11.0	1.0
1-yr ESWL + SLR	Existing	0	7.0	4.8
	2050	1.1	8.1	3.7
	2070	2.3	9.3	2.5
	2100**	4.9	11.9	-0.1
100-yr ESWL + SLR	Existing	0	7.9	3.9
	2050	1.1	9.0	2.8
	2070	2.3	10.2	1.6
	2100**	4.9	12.8	-1.0

*Elevations provided relative to ft, NAVD88

** Time horizon beyond design life of structure

4.2.2 Floating Docks

The proposed floating docks are designed with a 1.5 ft freeboard and can move vertically with water level changes aided by the installed guide piles. The proposed guide piles are designed with a pile cap elevation of 13.57 ft (NAVD88), and pile guides flush with the deck of the docks. Based on these elevations, it is unlikely that the floating docks would reach the vertical limit of the piles over its projected 50 year lifespan given the projected exposed pile length above the guide under 2070 water levels (Table 10). The floating docks would only be expected to become dislodged or damaged under extreme conditions in combination with an Intermediate-High SLR scenario by 2100 as the vertical limit of the guide pile would be exceeded by 0.7 ft. The dock’s guide pile elevation of 13.57 ft (NAVD88) would not be exceeded in any of the other coastal hazard scenarios evaluated, thereby supporting the floating docks through the Project’s lifespan.

No design changes or adaptation options are recommended for the floating docks based on the proposed structure’s projected lifespan of 50 years.

Table 10 Water Level Scenarios compared to the Proposed Floating Dock

Water Level Scenario	Time Horizon	Sea Level Rise Projection (ft)	Coastal Hazards Scenario*	Projected Exposed Pile Length Above Guide (ft)
				Pile Cap Elevation (13.57 ft) Minus Projected Deck Elevation
Tides (MHHW) + SLR	Existing	0	5.3	6.8
	2050	1.1	6.4	5.7
	2070	2.3	7.6	4.5

Water Level Scenario	Time Horizon	Sea Level Rise Projection (ft)	Coastal Hazards Scenario*	Projected Exposed Pile Length Above Guide (ft)
				Pile Cap Elevation (13.57 ft) Minus Projected Deck Elevation
	2100**	4.9	10.2	1.9
Dynamic Water Level (MHHW) + 100-yr Waves + SLR	Existing	0	6.1	6.2
	2050	1.1	7.2	5.1
	2070	2.3	8.4	3.9
	2100**	4.9	11.0	1.3
1-yr ESWL + SLR	Existing	0	7.0	5.1
	2050	1.1	8.1	4.0
	2070	2.3	9.3	2.8
	2100**	4.9	11.9	0.2
100-yr ESWL + SLR	Existing	0	7.9	4.2
	2050	1.1	9.0	3.1
	2070	2.3	10.2	1.9
	2100**	4.9	12.8	-0.7

*Elevations provided relative to ft, NAVD88

** Time horizon beyond design life of structure

4.2.3 Gangways and Loading Ramp

Due to the substantial increase in water levels and floating structure deck elevations anticipated under the 2050, 2070, and 2100 water level scenarios, the gangways' and loading ramp's appropriate tidal operating windows could be exceeded during the Project's 50 year lifespan. These elevated water levels would place the connection points for these features attached to the concrete platforms and floating docks under increased stress, potentially resulting in their damage. Based on the coastal hazard scenarios evaluated, the gangways and loading ramp could experience inversion before 2050 under extreme conditions combined with an Intermediate-High SLR scenario, requiring improvements to the features at that time. It should be noted that this projected inversion is based on the assumed FG of the concrete platforms at 10.07 ft (NAVD88) that the gangways and loading ramp are attached to. If these platforms are raised higher to accommodate 2.3 ft of SLR as recommended, this could mitigate the expected inversion.

If the gangways and loading ramp are anticipated to remain in service for a 50-year design life, it is recommended that they be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario.

5. Conclusions

This SLR analysis examined the proposed Project's vulnerability to SLR scenarios across three-time horizons, consistent with OPC 2024 guidance, resulting in the assessment of 1.1 ft, 2.3 ft, and 4.9 ft of SLR. These SLR scenarios were evaluated under projected daily tidal, dynamic water level, and 100-year ESWL conditions. Dynamic water levels were representative of the unlikely concurrence of a 100-year wind event alongside a high average tide (MHHW). The 1-year ESWL conditions are representative of the infrequent occurrence of a 1-year extreme water level during the short duration of a high tide about three to four times per year. The 100-year ESWL conditions are representative of the very unlikely occurrence of a 100-year extreme water level during the short duration of a high tide. Based on these coastal hazard scenarios, the results of the vulnerability assessment are provided below for the fixed and floating Project features. The following recommendations for the Project features are based on a 50-year design life, anticipating 2.3 ft of SLR under the Intermediate-High scenario by 2070. This

projection accounts for the Intermediate scenario estimates for the period between 2080 and 2090. No adaptation strategies are proposed given the limit vulnerabilities over the Project's lifespan. It is recommended that beyond the design life of the Project's features, the Port can evaluate the state of SLR science along with empirical evidence to determine if they are at risk of flooding.

Fixed Structures

- **Pier:** If the Pier is anticipated to remain in service for a 50-year design life, it is recommended that it be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario. To accommodate this elevation change, a ramp will likely be needed to transition into the existing Regatta Walk.
- **Concrete Platforms:** If the platforms are anticipated to remain in service for a 50-year design life, it is recommended that it be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario. To accommodate this elevation change, a ramp will likely be needed to transition into the existing Regatta Walk.
- **Regatta Walk:** If the Regatta Walk is anticipated to remain in service for the Project's 50-year design life, it is recommended that it be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario. This could involve increasing the crest of the revetment with an enhanced core or the addition of a floodwall along the seaward side of the promenade to add flood protection and resilience. However, we understand that no improvements are proposed to the Regatta Walk as part of this Project.

Floating Structures

- **Floating Wave Attenuator and Floating Docks:** No design changes or adaptation options are recommended for the floating wave attenuator and floating docks, given the minimal risk anticipated across its projected lifespan of 50 years.
- **Gangways and Loading Ramp:** If the gangways and loading ramp are anticipated to remain in service for a 50-year design life, it is recommended that they be designed to accommodate 2.3 ft of SLR, in accordance with OPC 2024 guidance projections for the 2070 Intermediate-High planning scenario.

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Appendix A

**Extreme Value Analysis Calculations –
Wind Data**

Extreme Value Analysis Calculations – Winds

Extreme Value Analysis (EVA) is a statistical method used to assess and quantify the risk of extreme, rare events. In the context of wind wave analysis, EVA is particularly useful for several reasons. This is necessary for the coastal zone, where the strongest events occur during intense single events. EVA is based on the Generalized Extreme Value (GEV) theory, which is designed to deal with rare events. This makes it suitable for studying phenomena like extreme wind speeds, which do not occur frequently but can have significant impacts.

A sufficiently long time series of data is necessary to accurately extrapolate the data to longer return periods. It is not recommended that the data be extrapolated more than 2-3 times its length, as the uncertainty increases significantly. The wind data used for this analysis was taken from the San Diego International Airport, which has been collecting data since 1997 and is located about 2 miles east of the Project site. A wind rose for this station is shown in Figure 1.

San Diego Airport Wind Rose 1999–2025

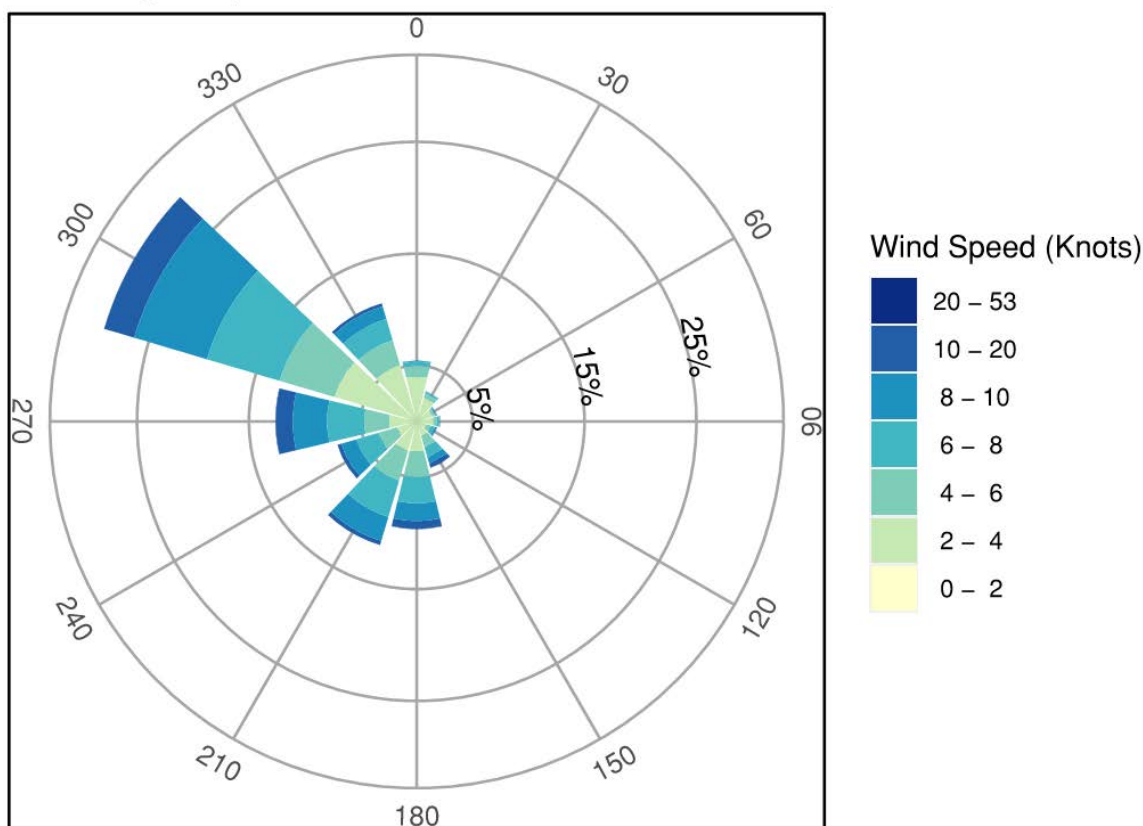


Figure 1. San Diego Airport Wind Station Wind Data from 1999-2025

The San Diego International Airport dataset was inspected for completeness and the outliers were checked for plausibility. The data from 1997 to 1998 contained large gaps of data for multiple months, so these data were not included in the EVA. The few outliers were evaluated by assessing their continuity with the timeseries. From 1999 to 2016, the data was recorded hourly, and from 2016 to 2025, data is 5-minute averaged recorded every hour. For the analysis to appropriately assess the wind dataset, only hourly recorded data was used to perform the EVA.

The peak over threshold method was used, which uses a threshold to seclude values considered extreme from the rest of the data and create a model for the extreme values by modeling the tail of all the values that exceed this threshold. Since wave conditions were only needed from the East (at 105 degrees north) direction, the EVAs were conducted in a 30-degree directional sector where waves could approach the Project site from 90-120 degrees north. The data was declustered by storm duration to capture the peak value of each storm and not sample the same event. A duration of 24 hours was iterated to inspect the time series and make sure that multiple values did not come from the same storm, which was noted by the peaks in the data. Then a threshold was chosen by iterating to a value that resulted in the average number of storms per year being around 2-4, per CEM guidelines.

Figure 2 and Figure 3 show the peak over threshold (POT) method graphically for the East directional sector and a threshold of 7 knots.

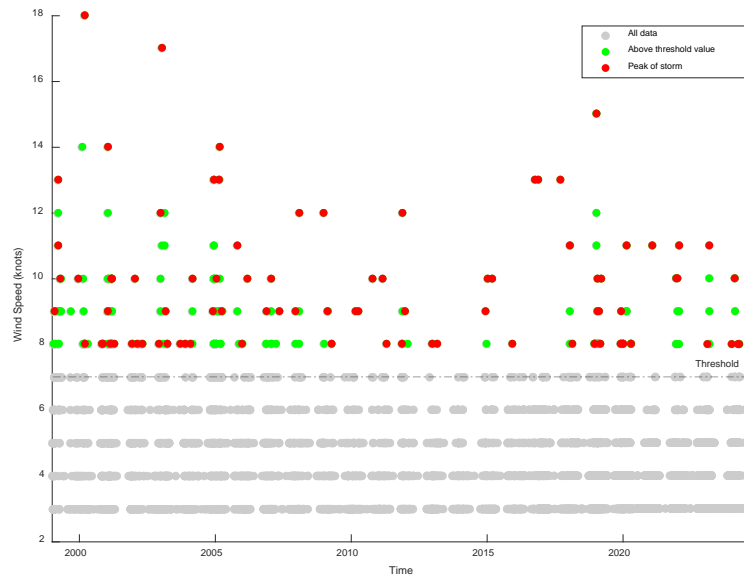


Figure 2. POT Method for the West Direction (All wind speed data shown in grey, directionally filtered values shown in green, and POT values for the directional sector shown in red.)

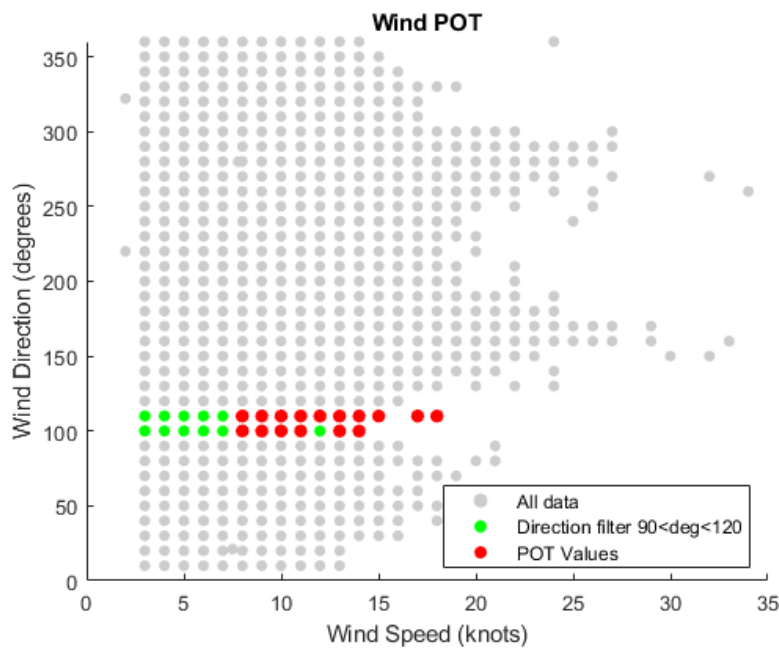


Figure 3. POT Method for the West Direction (All wind speed data shown in grey, directionally filtered values shown in green, and POT values for the directional sector shown in red.)

Once peak values were selected, the return period of the data are given by:

$$R = \frac{n + 1}{m}$$

When n is the number of years on record and m is the rank of the observed occurrence when arranged in descending order. To extrapolate to return periods past the length of the data record, the data must be fit to a distribution. MATLAB's distribution fitter was used to find the best fit, which iterates to a best fit using maximum likelihood estimators. Multiple distributions were fit to the data, but the Generalized Pareto Distribution (GPD)

showed the best fit for the data in the relevant directional sector. The probability density function (PDF) of the GPD is defined by:

$$F_{\xi}(x) = 1 - \left(1 + \frac{k(x - \mu)}{\sigma}\right)^{-\frac{1}{k}}$$

Where σ is the scale parameter, μ is the location parameter (or threshold), and k is the shape parameter. Table 1 presents the parameters for the best fit GPDs in the relevant directional sector. Figure 4 shows the peak over threshold data for the West direction fitted to a GPD for return periods up to 100 years. From this directional sector, the return periods were extracted at 1, 10, 25, 50, and 100 years. The return periods are presented in Table 2. It should be noted that the 100-year return periods have a higher uncertainty than the return periods of 50 years and below due to the longer extrapolation of the wind data.

Table 1 GPD Parameters for Relevant Directional Sector

Wind Direction (degrees)	Shape, k	Scale, σ	Threshold, μ
105	-0.23	3.38	7

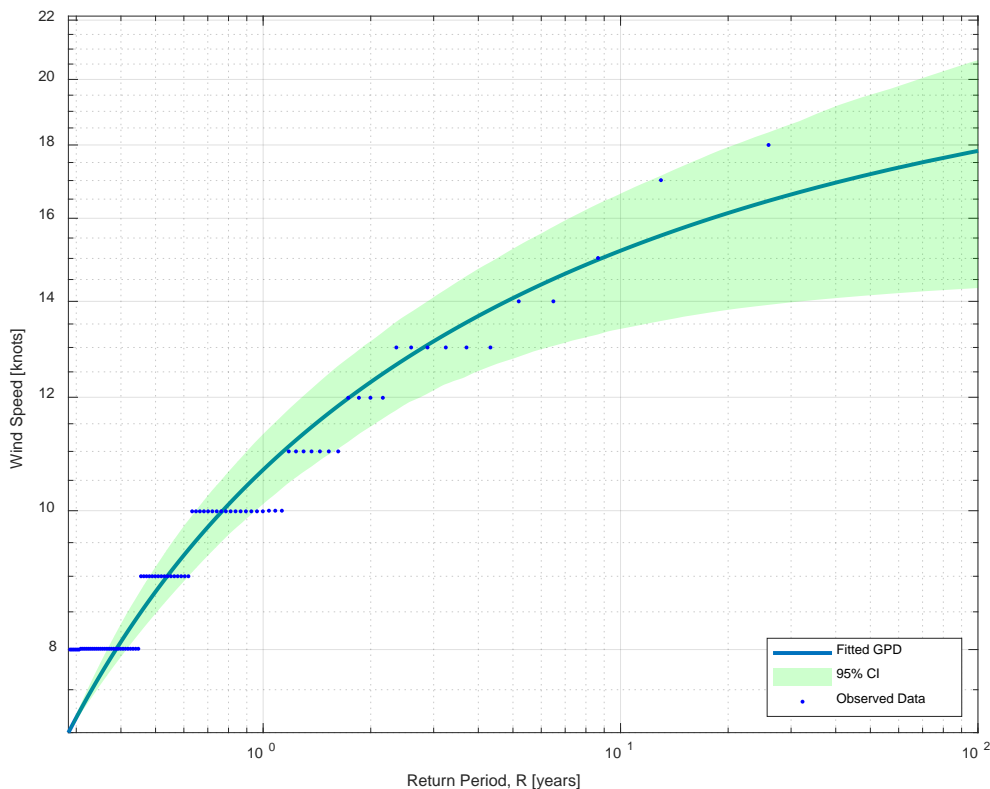


Figure 4. Best Fit GPD vs the POT Data for the West Direction

Table 2 Return Period Wind Speeds for the West Direction

Return Period (years)	Wind Speed (knots)
1	10.68
10	15.19
25	16.40
50	17.17
100	17.82



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