Subarea Profile

Northeast Waterfront

Subarea 2-1

SHORELINE TYPE:	SEISMIC RISK[1]:	FLOOD RISK[2]:	
Engineered: Filled land retained by rock dike with pile supported concrete bulkhead wall and wharves. Second generation piers and wharves, some with major investment in the last 10 years.	**Shoreline Instability:** Very High	**Tipping Point Elevation:**	65" above high tide
	Liquefaction Risk: High in Fill and Marine Sand Layers	**Coastal Flood Events**	**Timing**
	Shoreline Structure Vulnerability: High		
Subsurface Profile: Non-engineered fill, transition zone from deep bay mud to shallow rock at Telegraph Hill, liquefiable sand layers	**Unique Conditions:** Subsurface transition from shallow rock to deep Young Bay Mud	100-yr Flood + 25" SLR	2043 - 2058
		High tide + 66" SLR	2081 - 2132

SUBAREA DESCRIPTION

The Northeast Waterfront subarea is home to historic buildings and popular attractions, from the Exploratorium and a range of restaurants to the Embarcadero Historic District and a significant length of the Embarcadero Promenade. It also provides important maritime and disaster response, with large staging areas and the Water Emergency Transportation Authority (WETA) berths at Pier 9 that can support regional response efforts. The combination of recreational sites, maritime activity, and ability to provide disaster response make the subarea part of creating a thriving waterfront for generations to come.

The shoreline in this subarea is entirely hardened and engineered, including piers, seawalls, and wharves. Originally, the North Beach neighborhood was directly adjacent to the shoreline, but the beach, wetlands, and shallow Bay waters were filled to create additional developable land in the late 19th century.

[1] Shoreline Instability ratings within Embarcadero Seawall Program area based on advanced shoreline stability analysis and averaged over each subarea. Shoreline Structure Vulnerability based on Mean Damage Ratio calculated for the 225 year seismic event averaged across subarea.

[2] The timing of coastal flood events that will cause significant flooding in this subarea is provided as a range of dates based on the sea level rise projection scenarios provided by the California Ocean Protection Council (OPC) per the Likely and 1-in-200 chance of occurrence projections.

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The primary flood pathways are from overtopping along the engineered shoreline. Flooding first occurs in this subarea due to floodwaters conveyed along the Embarcadero roadway that overtops the shoreline in Subarea 2-2. Higher Bay water levels eventually overtop the shoreline in this subarea, and floodwaters extend several streets inland.

COMMUNITY IDENTIFIED PRIORITIES:	
Places • Pier 7 • Coit Tower • Exploratorium • Pier 27	Since 2017, the Port has connected with tens of thousands of community members through the Waterfront Resilience Program. Public feedback collected about the Northeast Waterfront underscores the importance of preserving natural habitats and ecology, maintaining recreation - from parks and bike paths to fishing, historic sites, and tourism - and staying connected to the rest of the city with transportation. Further feedback highlights additional community priorities, including opportunities to protect and enhance public space and amenities at Pier 27 and improvements to walkability and pedestrian safety.

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FIRST FLOODING OF ASSETS

The chart below describes the vulnerability of specific assets within the Northeast Waterfront subarea to flooding. These assets will be exposed to coastal flooding when the water level in the Bay reaches a certain height above the current high tide. The heights at which each asset is exposed to flooding is indicated with the shaded cells in the table. Over time and due to sea level rise these water levels can occur due to large storm events such as a 100 year flood of daily high tides. For example, the Embarcadero Roadway is exposed to flooding when the water rises 48 inches above current high tide, which could occur due to a 100 year flood with 3 ft. of sea level rise or as during daily high tide with 5.5 ft. of sea level rise.

● High Tide ○ 100 Year Flood ▭ Shaded cells indicate the water levels at which assets are exposed to flood

		WATER LEVEL ABOVE CURRENT HIGH TIDE										
SEA LEVEL RISE		**0”**	**12”**	**24”**	**36”**	**48”**	**52”**	**66”**	**77”**	**84”**	**96”**	**108”**
Today		●				○						
1 ft. SLR			●				○					
3 ft. SLR					●				○			
5.5 ft. SLR								●				○
Historic and Cultural												
	Exploratorium								▭	▭	▭	▭
	Historic piers 9, 15, 17, 19, 23, 29								▭	▭	▭	▭
	Pier 23 Café							▭	▭	▭	▭	▭
Disaster Response												
	Pier 9								▭	▭	▭	▭
	Pier 15/17 Bay-Delta Maritime Tugboat Dock								▭	▭	▭	▭
	Pier 15 Water Taxi Dock								▭	▭	▭	▭
	Large Vessel Berths	N/A (Flooding not quantified for floating overwater or in-water assets)										
Open Space and Ecology												
	Bay Trail					▭	▭	▭	▭	▭	▭	▭
	Promenade					▭	▭	▭	▭	▭	▭	▭
	Northeast Wharf							▭	▭	▭	▭	▭
	Pier 7							▭	▭	▭	▭	▭

Subarea Profile

Northeast Waterfront

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Maritime												
	Beltline Railroad Complex											
	Cruise Terminal											
	Pier 19											
	Pier 7.5											
	Pier 9											
Transportation												
	Embarcadero Roadway											
	Muni E-Line											
Utilities												
	Embarcadero Transport / Storage Box	N/A (Buried assets are not directly impacted by flooding)										
	Jackson Transport / Storage Box											
Critical Facilities												
	Broadway Family Apts.											>
	Garfield Elem. And Early Education School											>
	John Yehall Chin Elem.											>

EARTHQUAKE AND FLOODING RISK: MULTI-HAZARD RISK ASSESSMENT KEY FINDINGS FOR THIS SUBAREA

As detailed in the Seawall Earthquake Safety General Obligation Bond Report prepared when Proposition A was considered for the November 2018 ballot, the Port has spent the past two years assessing what is at risk on the Embarcadero waterfront when considering an earthquake or flood event to establish a basis for the development of Proposition A projects. This study is called the Multi-Hazard Risk Assessment, or MHRA.

We knew the Port's aging Embarcadero Seawall was at grave risk from earthquakes. MHRA findings tell us there are areas more at risk of earthquake damage due to different soil conditions - and some less so.

Specifically, the historic bulkhead wharves and historic buildings at Piers 9, 15, 17, 19, 23 and 29 are at high risk for seismic damage and increasing flood risk as sea level rises. The density of people along the Promenade and wharves with high seismic risk is a concern for both public safety and disaster response. The entire length of the Embarcadero roadway, including the segment within this subarea is at significant risk from an earthquake and the Embarcadero roadway is also one of the lowest elevations along the waterfront making it important to address as sea levels rise.

Northeast Waterfront

Subarea 2-1

Here are some specific key findings that relate to this subarea:

- Up to 40,000 people could be at risk on Port property if an earthquake occurs during the day.
- Many historic buildings and bulkhead wharves are at high risk. The bulkhead wharves are the structures located where the pile supported piers over the Bay meet the land. These structures are interconnected with the seawall and support the ornate, historic bulkhead buildings that line the Embarcadero. These structures are at high risk of earthquake damage and will flood with increasing sea levels.
- The Embarcadero roadway has significant seismic risk, which could impact disaster response and local and regional transportation. Due to the presence of weak soil, the Embarcadero transportation and utility corridor is at significant seismic risk. In a 1906-size earthquake, damage to the seawall and Embarcadero may be severe enough to significantly hamper disaster response efforts along the waterfront. A more likely earthquake like the 1989 Loma Prieta earthquake – but centered close to San Francisco – is expected to lead to loss of the Embarcadero as a transportation route for up to 1 year.
- At just over 2 feet of sea-level rise, expected to occur between 2050 and 2075, the Embarcadero roadway and promenade will reach a tipping point where the 100-year flood causes widespread overtopping of the shoreline, resulting in significant disruption to multi-modal movement, cutting off landside access to all Port facilities and flooding the Financial District nearly to Beale Street. Such widespread flooding results in severe disruption and damage to the entire Embarcadero corridor and historic district, along with hundreds of other small businesses, residential and commercial uses, jobs and critical services, impacting not only the City but the greater Bay Area region. Additionally, access to Port infrastructure via the Embarcadero is cut off which is expected to eliminate the ability for the Port to carry out its public trust responsibilities and maintain and operate critical City, State, and Port assets and services.

Life Safety

Piers 15 and 27:

- Northeast Waterfront Subarea includes key locations like the Exploratorium, and the cruise terminal, which are highly populated. These occupancy hotspots sit alongside numerous smaller venues and offices, which contribute to the relatively high occupant estimate throughout the Port's property in this subarea.

Piers 9, 15, 19, 23 and 29:

- Wharves and buildings adjacent to the seawall are high risk due to seawall-related earthquake damage and consequences for promenade and pier access. These facilities are much more likely to be damaged and have a higher potential for collapse and ignitions in very large earthquakes. In addition to the wharves and buildings, the adjacent promenade is highly occupied and damage to the seawall and wharves will limit landside access to the piers, complicating evacuation for thousands of people. The potential for damaging aftershocks can also cause life safety issues as people move to the waterfront for the purposes of evacuation and onto these structures before inspections and closures take place.

Disaster Response

Embarcadero Roadway:

- The Embarcadero roadway, a critical lifeline for every mission during disaster response and recovery, is expected to sustain damage along its entire length due to lateral spreading and settlement, especially at the 225-year and 975-year earthquake scenarios. The high damage predicted to the wharves and piers adjacent to the Embarcadero in the 225-year earthquake will also significantly impact all missions as these structures connect maritime facilities to the Embarcadero.

Pier 27:

- Of the six deep draft berths along the northern waterfront, the Pier 27 and Pier 35 cruise ship terminals are the only facilities expected to be at least partially operational after a 225-year earthquake scenario, though access to both facilities may be impaired from the Embarcadero and wharf damage. At the 975-year earthquake, Pier 35 is expected to be unusable and access is further complicated at Pier 27. When functional and accessible, these two facilities can efficiently receive, store, and manage large volumes of emergency supplies during the recovery phase. Earthquake damage that reduces or eliminates deep draft berthing capacity and staging along the northern waterfront could restrict the flow of supplies required for short-term recovery efforts.

Maritime

Piers 9 and 27:

- Critical disaster response and recovery services are provided by all maritime infrastructure assets and functions, including for embarkation and debarkation; assembly and staging; berthing for deep-draft vessels; and centers for emergency response and operations.

Pier 27:

- Regional enjoyment of the Bay is facilitated by water recreation, excursion, ferry, cruise, and ceremonial berth functions that are not replicated, or are scarce, within the region.

Utilities and Mobility

Pier 27:

- Ground displacement (lateral spreading and liquefaction-induced settlement), rather than ground shaking, is expected to drive utility damage, with significant damage occurring by the 100-year earthquake level. Damage is anticipated to be widespread with likely hotspots in the vicinity of the Embarcadero including near Pier 27, primarily caused by local ground displacement differentials where pipes cross a transport storage box or other large underground structure.
- Co-location of utility and transportation systems. Utility pipelines run below the roadway, light rail, and promenade. Damaged utilities may impact the ability to use the road, and utility repairs or replacements will have major impacts on use during the work. In the event of a large earthquake, the severity of damages predicted to utility and transportation infrastructure suggests that full reconstruction of the Embarcadero may be needed.
- Overtopping and inland flooding will allow significant amounts of saltwater to enter the wastewater system, greatly increasing the volume of water that needs to be stored, conveyed, and treated. Under 2.2 feet of sea-level rise, a 100-year extreme tide will allow significant floodwater to enter through catch basins and manholes and mix with both sewer and stormwater. Coupled with wet weather, this could overwhelm the collection system and cause inland flooding and flooding in buildings with fixtures below the flood elevation, which will then be conveyed to the lowest elevation via the city's roadways. In addition, the increased salinity in the wastewater system may impact treatment plant operations and increase corrosion rates of wastewater infrastructure.

Transportation

- Major repairs to the Embarcadero could take 6 months to 1 year following a 100-year earthquake, and severe damage following a 225-year earthquake would likely require complete reconstruction of some sections resulting in 1 to 2 years of construction and disruption. The Embarcadero roadway repair time from a 43-year earthquake will likely be a few days for minor repairs, but no functional disruption is expected as local roads provide redundancy. After the 100-year earthquake or larger event, damage will be significant, with temporary repairs needed to support moderate recovery and permanent repairs (and partial closures) ongoing for 6 months to 1 year or more as repairs are coordinated with underground utility repairs and multiple public and private agencies.

- The cascading impacts of severe and frequent mobility disruption, particularly to transbay trips, may result in regional transfer or loss of jobs and local businesses and threaten regional economic activity. While regional transfers may result in economic benefit somewhere else, San Francisco's local economy, businesses, and services, and role in the region will be impacted.

Historic Resources

- After a 100-year earthquake, a small number of bulkhead wharves and buildings could need full replacement due to complete damage. The U.S. Secretary of Interior's Standards for Reconstruction10 provide guidance to determine whether reconstruction is an appropriate action based on: (1) a contemporary depiction is required to understand/interpret a property's historic value, (2) no other property with the same associative value has survived, and (3) when sufficient historical documentation exists to ensure an accurate reproduction.
- Under 3.3 feet of sea-level rise, the impact to the district is anticipated to be high, given daily flooding of key assets, assuming no preventative action is taken. Adaptation efforts as well as preservation, rehabilitation, restoration or reconstruction work after a flooding event should involve historic preservation stakeholders and be consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties.

Buildings and Structures

- Extensive damage is expected where historic finger piers are rigidly connected to the wharves. The finger piers and wharves were built together and will likely move differently during an earthquake (wharves shake quick and piers shake slow), resulting in a hotspot for damage to the marine structures and buildings.

Open Space and Public Realm

- The 100-year earthquake is predicted to severely reduce the promenade function. It may be generally accessible, but many waterside destinations would be disrupted for a few months. In particular, areas near the Ferry Building, Fisherman's Wharf, and Oracle Park are likely to be significantly impacted, with the potential to affect access and use for approximately 570,000 users per month for a duration of 3 to 9 months.
- Under 2.2 feet of sea-level rise, a 100-year flood will make the entire waterfront unusable and inaccessible due to widespread flooded areas. This same widespread inaccessibility would occur an average every 10 years under 3.3 feet of sea-level rise, and on a daily basis under 5.3 feet of sea-level rise.

Economic Cost of Inaction

- The job sectors with the highest earthquake risk include restaurants (37 percent), and entertainment and media industries (within the seawall area these include Oracle Park, the Exploratorium, and television stations) (23 percent). These industries are most prevalent along the Embarcadero, a place of high public use, and represent sectors that depend on tourism and waterfront access to function at current capacity. Jobs within the program area and throughout California are expected to be impacted by earthquake activity within the program area.

WHAT'S AT STAKE?

Given the specific impacts of earthquakes, flooding, and future sea level rise, what is at stake in the Northeast Waterfront?

In the Northeast Waterfront, access to recreation and historic resources are likely to be impacted by a seismic or flood event. Residents and visitors move through this subarea to get to work, nearby attractions, or as part of recreational use along the waterfront. Access to and use of popular sites such as the Exploratorium will be disrupted and damage to the piers and bulkhead buildings will disrupt access to and use of the waterfront.

Damage to the historic bulkhead buildings and piers will also affect the integrity of the Embarcadero Historic District. Flooding and earthquakes will also damage and disrupt the Embarcadero Roadway, the Embarcadero Promenade, and the utilities within the Embarcadero corridor. As sea level rises, residents who live in the Northeast Waterfront subarea will be

affected by the rising bay. Earthquakes, flooding, and future sea level rise could cause disruptions in public access along this part of the waterfront.

Subarea Profile

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Subarea 2-1

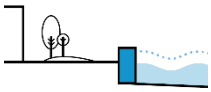
FUTURE POTENTIAL MEASURES UNDER CONSIDERATION IN THIS SUBAREA:

FLOOD MEASURES:

Physical Infrastructure

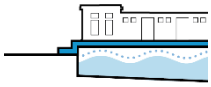
Floodwalls

Levees

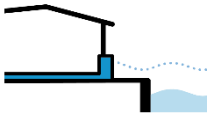


Seawalls

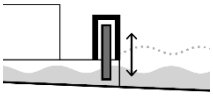
~~Breakwaters~~



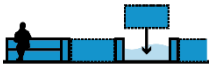
Raised Marine Structures



Building Adaptations



~~Tide Gates~~



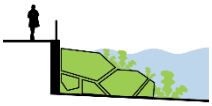
Deployables

Ecological Infrastructure

Ecological Marine Structures

Ecological Features

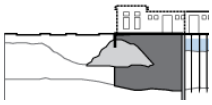
Aquatic Habitat



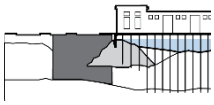
Ecological Shorelines

SEISMIC MEASURES:

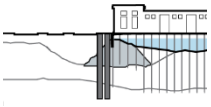
Shoreline Stabilization



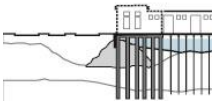
Nearshore Buttress



Landside Buttress



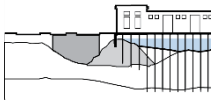
Drilled Shafts



Super Bulkhead Wharf

Targeted Measures

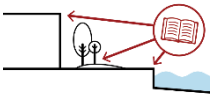
Bulkhead Wharf Retrofit



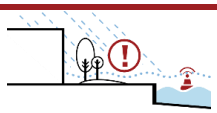
Liquefaction Mitigation

FLOOD AND SEISMIC MEASURES:

Policy and Emergency Preparedness



Policies and Zoning



Emergency Preparedness