PORT OF OAKLAND

Port of Oakland

Sea Level Rise Assessment

July 1, 2019

Disclaimer

This AB 691 Sea-level rise analysis, and the associated maps, are intended to prepare for impacts from sea level rise. This analysis, and the associated maps, are not detailed to the parcel-scale and do not account for flooding from other sources, erosion, subsidence, future construction or shoreline protection upgrades, or other changes to the region that may occur in response to sea level rise. The maps also may not fully take into account the Port of Oakland's existing pumps and drainage system that may reduce impacts from sea level rise. Flooding due to sea level rise and storm surges is possible in areas outside of those predicted in these maps, and the maps do not guarantee the safety of an individual or structure.

This analysis and the associated maps are provided "as is" and should be used strictly as a reference tool and not for navigation, permitting, regulatory, construction, or other legal uses. Neither the Port of Oakland nor its contractors make any warranty whatsoever, whether expressed or implied, as to the accuracy, thoroughness, value, quality, validity, merchantability, suitability, condition, or fitness for a particular purpose of the maps and associated analyses, nor as to whether they are error-free, up-to-date, complete, or based upon accurate or meaningful facts.

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Introduction

The Port of Oakland (Port) is an international gateway and economic engine for the San Francisco Bay Area, encompassing a vibrant seaport, a thriving airport, and an array of commercial buildings and waterfront parks. Together, the Port supports more than 73,000 jobs in the region, and nearly 827,000 jobs across the United States.

The Port has developed a Sea Level Rise Assessment (Assessment) to comply with Assembly Bill 691 (AB 691), which requires that a sea level rise (SLR) assessment be completed for areas under the jurisdiction of the State Lands Commission. The study includes 1) an assessment of impacts, 2) maps showing the areas that may be affected for years 2030, 2050, and 2100, 3) an estimate of financial costs of the impacts, and 4) a description of how the Port proposes to protect and preserve resources as required by AB 691. It should be noted that this Assessment includes all Port-owned property, and not just the areas under State Lands jurisdiction (Refer to Figure 1).

This document is a summary of several technical memorandums that were developed to evaluate the following: port assets, SLR mapping, vulnerability, potential strategies, and financial cost analysis.

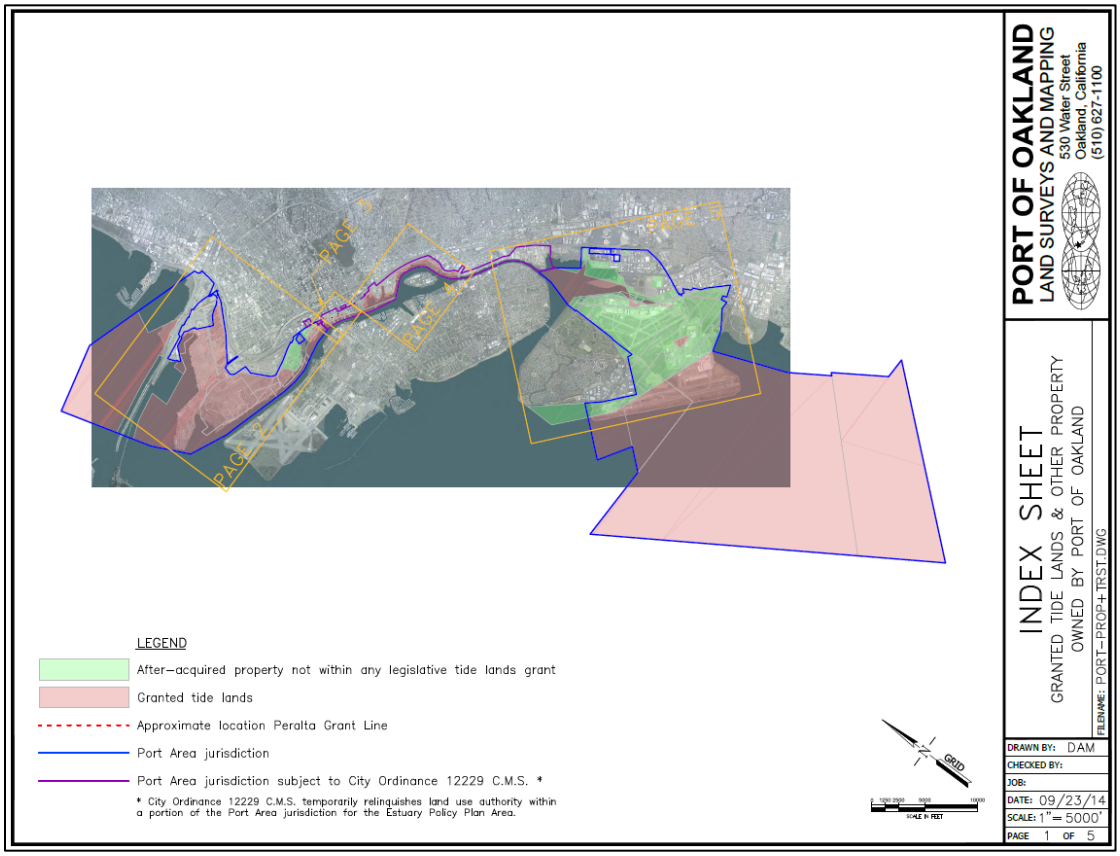


Figure 1: Port of Oakland State Lands Map

Methodology to Develop the Assessment

The following describes the Port's methodology in developing the Assessment to comply with AB 691, which closely aligns with the process identified in the California Coastal Commission Sea Level Rise Policy Guidance document[1].

Step 1: Sea Level Rise Science Overview

Over the last century, sea levels have risen nearly 8 inches in the San Francisco Bay[2]. Based on the latest science documented in the Ocean Protection Council's State of California Sea Level Rise Guidance, 2018 Update[3] (Guidance), local sea levels are likely (66 percent probability) to increase by an additional 0.6 to 1.1 feet by mid-century; and between 1.0 to 3.4 feet by end-of-century.

Because there is uncertainty in future greenhouse gas emissions, additional SLR projections with a lower probability of exceedance are recommended for infrastructure planning purposes.

In the San Francisco Bay Area, there is a 1-in-200 chance (0.5 percent probability) of SLR reaching or exceeding 1.9 feet by mid-century, and 6.9 feet by end-of-century under a high-emissions scenario.

In addition to the probabilistic projections, the Guidance also describes an extreme scenario (H++) caused by rapid loss of the West Antarctic ice sheet. The Port will continue to monitor the latest climate science associated with this scenario, but it was not evaluated for the Assessment.

Step 2: Maps of SLR Impacts for Years 2030, 2050, and 2100

SLR inundation maps were created to consider potential flood exposure of Port property and assets. Four representative SLR scenarios (1, 2, 3, and 5.5 feet) were evaluated under two tide conditions: (1) daily tidal inundation; and (2) extreme storm flooding. Daily tidal inundation, mapped as the mean higher high-water (MHHW) tidal datum, represents the permanent inundation that occurs during normal tide cycles. Extreme storm flooding, represented by the 100-year storm tide, refers to temporary flood conditions that only occur with elevated water levels during storm events.

[1] California Coastal Commission Sea Level Rise Policy Guidance, 2018 Update. Adopted November 7. Available at: https://documents.coastal.ca.gov/assets/slr/guidance/2018/0_Full_2018AdoptedSLRGuidanceUpdate.pdf

[2] National Oceanic and Atmospheric Administration (NOAA) Mean Sea Level Trend:9414290 San Francisco, California. Accessed May 30, 2019.

[3] Ocean Protection Council (OPC). 2018. State of California Sea-Level Rise Guidance, 2018 Update. Adopted March 14, 2018.

The selected SLR scenarios correspond to planning time horizons of 2030, 2050, and 2100 in the Guidance to capture near- and long-term vulnerabilities and potential protection and preservation needs (Table 1). For the Maritime and CRE areas, the coastal flood exposure mapping for the Assessment leveraged existing SLR inundation layers that were prepared as part of the Bay Conservation and Development Commission (BCDC) Adapting to Rising Tides (ART) program. For Aviation, the Assessment leveraged existing SLR inundation layers that were prepared as part of the Federal Emergency Management Agency (FEMA) Preliminary National Flood Insurance Rate Map Appeal,[4] providing a more detailed look at SLR exposure, using a sophisticated 2-dimensional stormwater flood model developed for the Airport.

Table 1: SLR Scenarios

Planning Time Horizon	Guidance Sea Level Rise Projections1	Port Assessment Mapping Scenario (closest match to existing ART SLR maps)
2030	0.8 feet Med-High Risk Aversion 0.5% Probability	1 foot
2050	1.9 feet Med-High Risk Aversion 0.5% Probability	2 feet
2100	3.4 to 6.9 feet Low to Med-High Risk Aversion 66% to 0.5% Probability	3 and 5.5 feet

Step 3: Asset Inventory

A comprehensive inventory to identify and organize assets and operations that are important for maintaining business continuity at the Port was developed. The inventory catalogs the assets by the following primary and secondary categories:

Business line:

- Maritime
- Commercial Real Estate (CRE)
- Aviation

Asset Type:

- Utilities
- Facilities
- Transportation (rail/roads and airfields)
- Natural Habitats
- Community Assets

[4] Port of Oakland, 2016. Appeal of 4.16.15 Preliminary FEMA Flood Insurance Rate Maps (FIRMs) for the Oakland Airport. Prepared by Wood Rogers, February 6.

Step 4: Vulnerability and Risk

Assets were evaluated for vulnerability based on exposure, sensitivity, and adaptive capacity. Based on vulnerability, potential risks were identified.

Exposure refers to the degree or extent that a particular asset is impacted by extreme storm flooding and daily tidal inundation. For example, a building may be exposed to daily tidal inundation by the 3-foot SLR scenario, but temporarily flooded during extreme storms during the 1-foot SLR scenario.

Sensitivity describes the degree to which the physical condition and functionality of an asset is affected by flooding and/or inundation. An asset is considered sensitive to flood waters if its function or construction material is impaired or damaged from being wet. For example, electrical structures are damaged more readily from water contact than roadways and are therefore more sensitive.

Adaptive Capacity is the ability of an asset or system to be modified in response to—or to cope with—the impacts of flooding to maintain its primary function. For example, cargo containers could be moved to a higher terminal prior to a storm event; electrical panels could be elevated without much additional cost; or vehicles using a roadway could take an alternative route.

Risk: for assets identified as vulnerable, a high-level risk assessment was completed by analyzing the potential consequences that could occur. Assets were evaluated qualitatively for the magnitude of social, environmental, and economic impacts of flooding and/or inundation based on a defined set of characteristics for each asset type.

Step 5: Protect and Preserve

Based on the vulnerability assessment, potential strategies were developed for each business line to protect and preserve natural and manmade resource and facilities (Figure 2).

The strategies focus primarily on physical (or structural) strategies, such as raising infrastructures or increasing shoreline elevations, to provide long-term flood protection. These strategies are supplemented by non-physical strategies, such as collaboration with neighboring stakeholders or completing additional studies to address data gaps, where applicable, to be considered as potential next steps to address SLR.

The strategies are high-level, preliminary concepts that will require additional analysis to ensure their site-specific applicability, and any modifications in Port operations necessary for their application.

When developing physical strategies, the following factors were considered:

- **Scale of protection:** Strategies were designed to provide flood protection at an asset-specific or area-wide scale.

- **Useful life:** Strategies developed considered SLR projections at the end of an asset's useful life when an asset is planned for replacement or significant retrofit.
- **Regional coordination and co-benefits:** Consideration was given to emphasize efforts among stakeholders adjacent to the Port to coordinate across jurisdictional lines, and to ensure that protection of one area does not negatively impact another.
- **Adaptive capacity:** Where applicable, strategies were designed to be incrementally protected or preserved to rising sea levels, providing a consistent level of flood protection through time.
- **Future land use:** Ports are dynamic environments that frequently reconfigure on-site land use, change tenants, and update facilities to suit evolving needs. Whenever possible, opportunities were prioritized to incorporate future sea level conditions into future Port modifications that are already planned.

The strategies address the flood hazards for high-risk and highly vulnerable assets identified in the risk evaluation and vulnerability assessment. In some cases, relatively small investments can provide protection against coastal storm events or increase the adaptive capacity of the Port's assets to maintain their functionality. However, in many cases, protection and preservation will require a broader, area-wide approach that will necessitate coordination with many neighboring stakeholders.

Figure 2: Location of Proposed SLR Protection and Preservation Strategies

Step 6: Financial Cost Analysis

The financial cost analysis compares the costs of inaction to the cost and benefits of potential strategies designed to mitigate impacts from SLR and storm tide flooding.

The analysis accounts for a suite of financial outcomes, including direct impacts (e.g., property) and indirect impacts (e.g., businesses and employment) caused by flood exposure of Port property. Financial consequences were evaluated for daily tidal inundation and extreme storm flooding for the Port's three business lines (Maritime, CRE, and Aviation). Table 2 summarizes the asset types evaluated in each financial cost category, as well as the financial cost types considered for daily tidal inundation and extreme storm flooding.

Table 2: Summary of asset types evaluated for each financial cost category

Financial Cost category	**Asset type**	**Financial cost type**	
		Daily tidal inundation	**Extreme storm flooding**
Property	Facilities	Market value loss/ Loss of insured value	Structure repair cost, content losses & cleanup costs
Business and Employment	Facilities	Sales loss Wage loss	Sales loss Wage loss
Infrastructure	Road, Rail, Utilities, Other Specialized Infrastructure	Cost to replace	Cost to replace
Non-Market	Natural Habitats, Community Assets	Recreation value Other Ecosystem service value	Not Applicable

Financial costs were evaluated with a qualitative rating scale of Low to Very High, based on a combination of qualitative and quantitative economic thresholds to indicate the relative magnitude of impact. Protection and preservation strategy costs were also translated to the same rating scale to allow for a comparison.

Table 3: Thresholds for financial impact ratings

Impact Rating	Financial Cost Impacts	Protection Strategy Costs
No Risk	No cost	Not applicable
Low	Limited cost of damages	Slight modification to maintain operations
Medium	Moderate cost of damages	Modification required to maintain operations
High	Significant cost of damages or impediments to port operations	Capital construction project required to maintain operations
Very High	Very significant cost of damages or impediments to port operations	Multiple capital construction projects required to maintain operations

Once the costs of inaction and protection and preservation were converted to the same rating scale, a comparison was made to evaluate the cost-effectiveness of protecting and preserving assets for future sea level conditions (Table 4). Results of the cost-effectiveness comparison are intended to assist Port decisionmakers with understanding whether the benefits of strategies outweigh their costs.

Table 4: Definitions of cost-effectiveness ratings

Cost-Effective Rating	Definition
Not Cost-Effective	The cost of protecting and preserving the asset is expected to be greater than the damages avoided or benefits conveyed by identified protection and preservation strategies
Cost-Effective	The cost of protecting and preserving the asset is expected to be less than the damages avoided or benefits conveyed by identified protection and preservation strategies
Highly Cost-Effective	The cost of protection and preservation is expected to be significantly less (more than a factor of two) than the damages avoided or benefits conveyed by identified protection and preservation strategies

Maritime Sea Level Rise Assessment

Overview

The Maritime business line supports the fifth-busiest container port in the United States. The Port consists of six port terminals (Ben E. Nutter, TraPac, Matson, Outer Harbor, Charles P. Howard, and the Oakland International Container Terminal) and a non-terminal tenant facility area. The Maritime business line oversees 1,300 acres of seaport facilities, including shipping berths and container storage areas. Intermodal rail (Union Pacific Railroad and BNSF) and road networks link the marine terminals and Port facilities to the surrounding region. The Oakland Middle Harbor shoreline of the Maritime area is also the location of two Port-operated community parks and a subtidal restoration site.

The Port's parks and restoration areas provide social and cultural value to the region, while also serving as an ecological reserve for many shallow bay species. The Maritime area also includes a variety of Port-owned/maintained utilities and network infrastructure, including stormwater, sewer, and electrical substations.

Figure 3: Picture of Maritime

Inundation Maps

The SLR maps help illustrate the extent of flooding based on 1, 2, 3, and 5.5 feet of SLR with extreme storm flooding (Figures 4 through 7). In summary, the northeastern and southeastern corners of the Maritime area are the most exposed to extreme storm flooding. With 1 foot of SLR (Year 2030), extreme storm flooding overtops low-lying stretches of shoreline along the Bay Bridge touchdown and Jack London Square area, providing a flood pathway to low-lying areas of the Port. Daily tidal inundation is not of concern until 5.5 feet of SLR (Year 2100), when the same areas of the shoreline are overtopped by high tides.

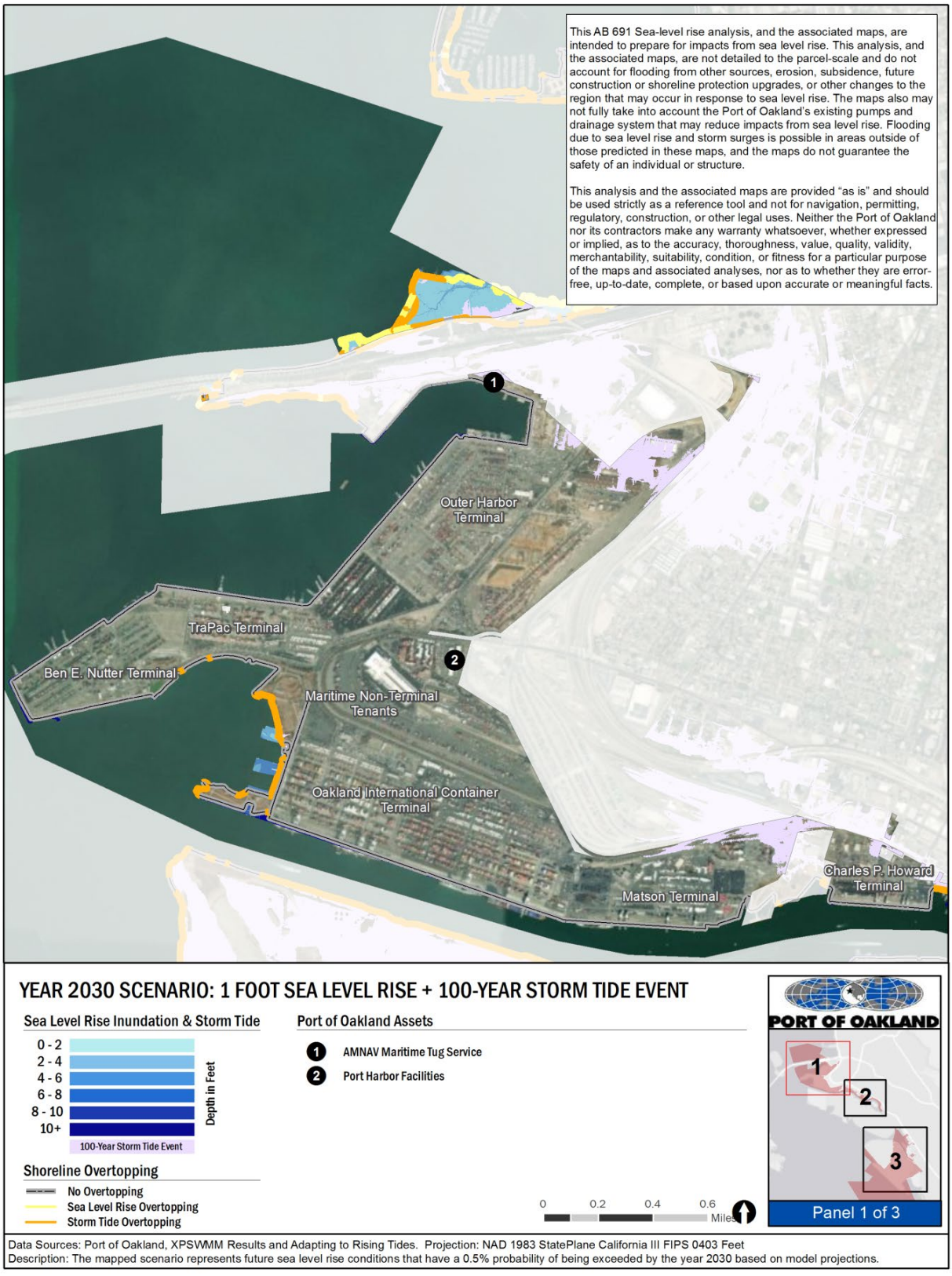


Figure 4. Year 2030 SLR scenario: 1 foot SLR + 100-year storm tide event

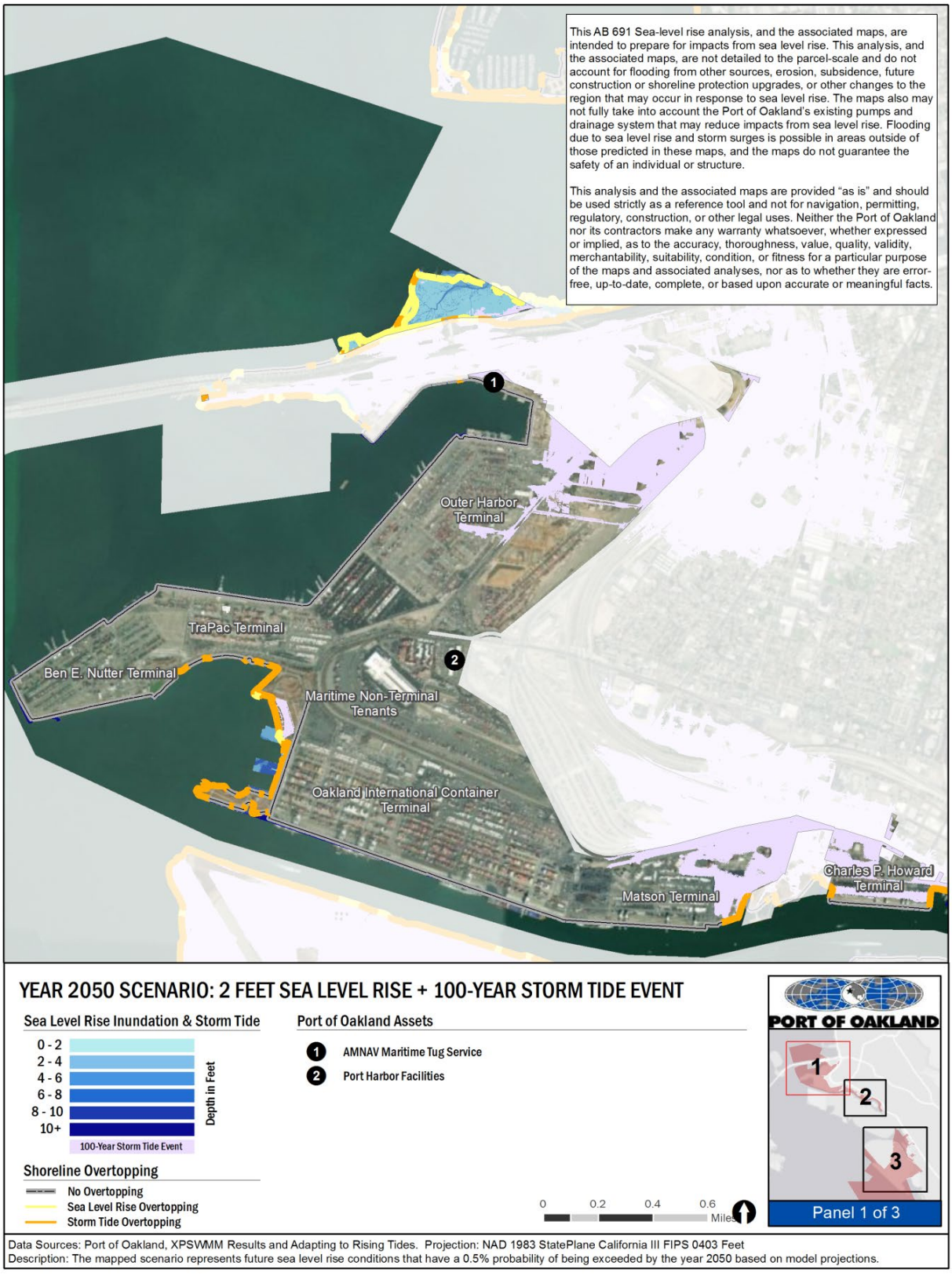


Figure 5. Year 2050 SLR scenario: 2 feet SLR + 100-year storm tide

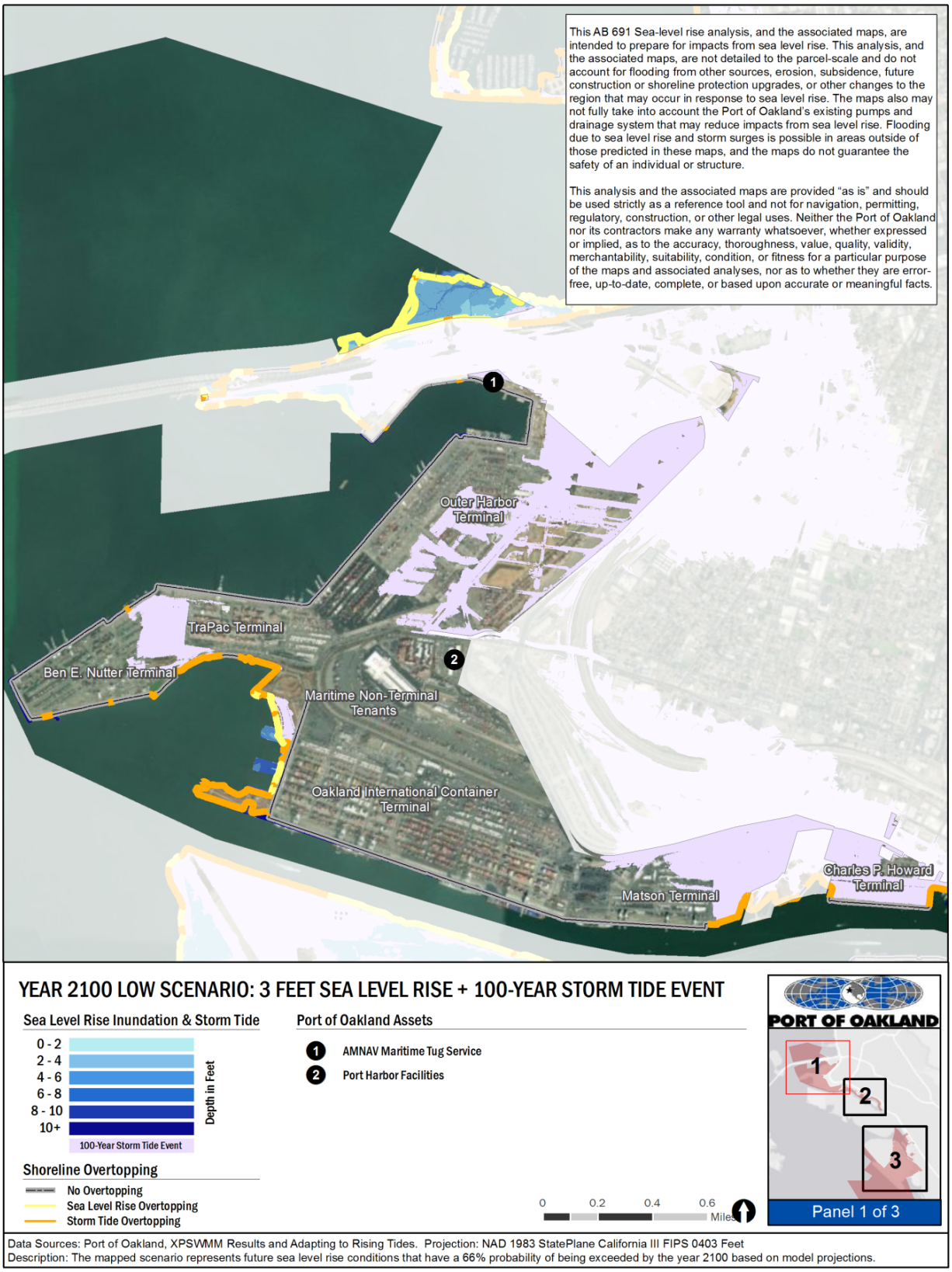


Figure 6. Year 2100 low SLR scenario: 3 feet SLR + 100-year storm tide

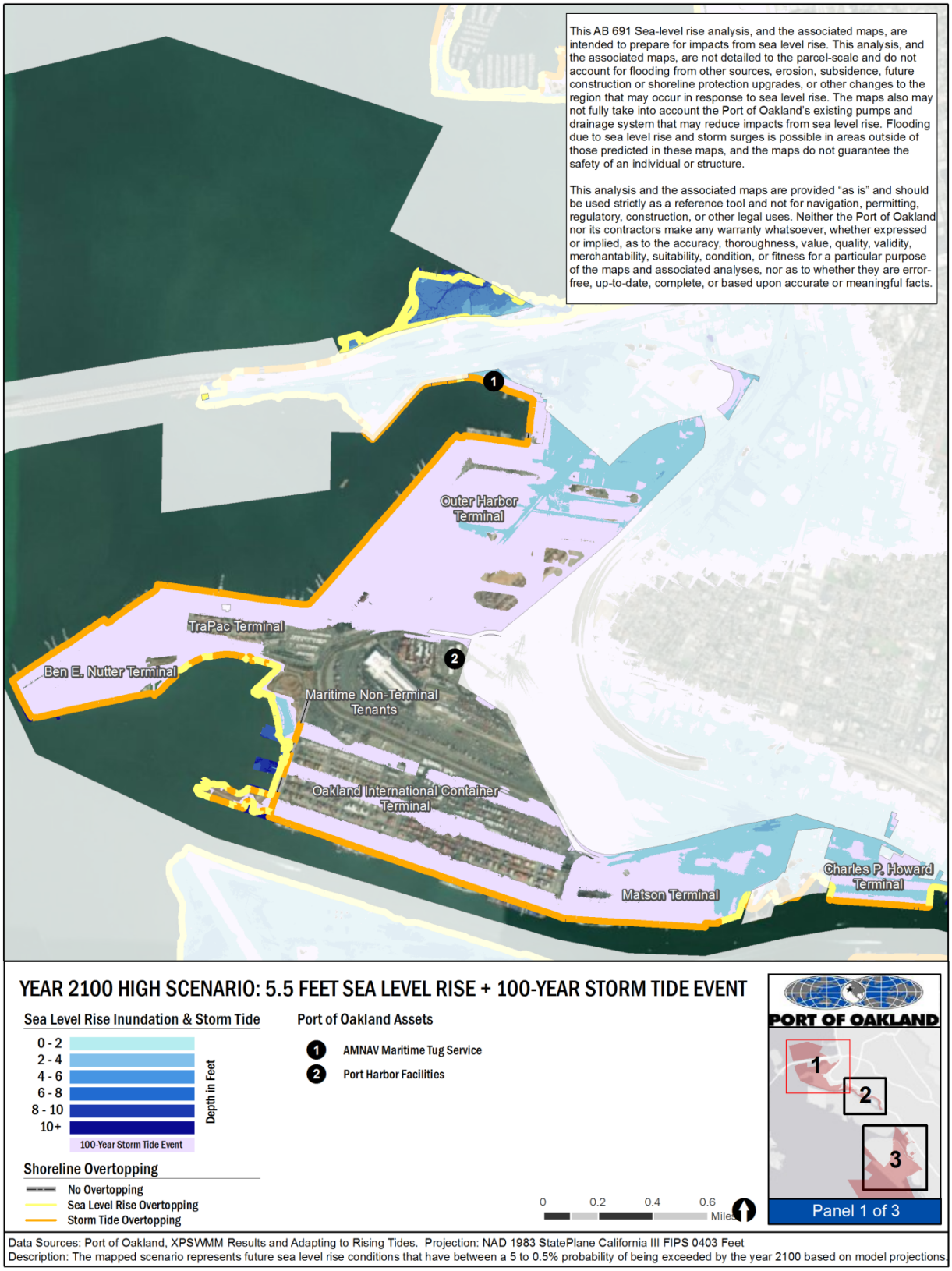


Figure 7. Year 2100 high SLR scenario: 5.5 feet SLR + 100-year storm tide

Key Vulnerabilities

Key vulnerabilities for assets in the Maritime Area are listed below by timeframe.

By Year 2030 (1 foot of SLR):

- The northern portion of the **Maritime Non-Terminal Tenant area** is one of the first regions of the Port to experience extreme storm flood exposure. In addition to tenant buildings, utilities and access roads in this area are also exposed. Flooding of the terminal will affect tenant operations, and tenant facilities may sustain damages.
- Portions of the **north- and east-bound rail lines** are exposed to extreme storm flood conditions, which may have a large effect on rail and intermodal operations during storm events.
- The **SS-E-2 substation** is the first substation exposed to extreme storm flooding. If sensitive electrical components are exposed, the Port will experience widespread impacts, because many facilities rely on an uninterrupted power supply.
- One **Sanitary Sewer Lift Station near the northeastern border of Outer Harbor Terminal** is exposed to extreme storm flooding. Extreme storm flooding of lift stations may prevent the conveyance of untreated sewage, causing potential backups and overflows to the adjacent areas.
- **Storm drainage discharge points** may be vulnerable to extreme storm flooding and/or daily tidal inundation. Exposure may decrease the system's ability to convey excess stormwater away from low-lying areas of the Port.

By Year 2050 (2 feet of SLR):

- The **Matson Terminal** and **Charles P. Howard Terminal** are the most exposed Maritime terminals. Both shorelines are overtopped by extreme storm flooding, exposing most of the terminal area, including utilities and access roads.
- Extreme storm flooding expands in the Maritime **Non-Terminal Tenant area**. Exposure may cause structural and property damage.
- Extreme storm flooding expands to include **3 substations** on the Charles P. Howard Terminal. If sensitive electrical components are exposed, the Port will have widespread impacts, because many facilities rely on an uninterrupted power supply.
- An additional **Sanitary Sewer Lift Station** east of the Matson Terminal is exposed to extreme storm flooding. Extreme storm flooding of lift stations may prevent the conveyance of untreated sewage, causing potential backups and overflows to the adjacent areas.

By Year 2100 (3 and 5.5 feet of SLR):

- **4 substations** (1 on TraPac Terminal, 3 on Outer Harbor Terminal, 1 near Matson Terminal) are exposed to extreme storm flooding by 3 feet of SLR. Nearly all substations are exposed to extreme storm flooding by 5.5 feet of SLR.

- By 3 feet of SLR, an additional **Sanitary Sewer Lift Station** near the Ben E. Nutter Terminal and West 10th Street is vulnerable to extreme storm flooding.
- Extreme storm flooding expands to expose nearly all of **Ben E. Nutter Terminal** and **TraPac Terminal** by 5.5 feet of SLR.
- Daily tidal inundation is not expected to impact the Maritime area until 5.5 feet of SLR, with the first exposure occurring at the **Matson Terminal, Charles P. Howard Terminal**, a small portion along the eastern border of the **Outer Harbor Terminal**, the northern portion of the Maritime **Non-Terminal Tenant area**, and the **north- and southeast-bound rail lines** that pass through these areas.
- By 5.5 feet of SLR, large portions of the **rail lines** are exposed to daily tidal inundation near the Matson Terminal and the Maritime **Non-Terminal Tenant area**, which will have large impacts on the Port's ability to transfer cargo.
- **4 substations** on the Charles P. Howard Terminal and near the Matson Terminal are exposed to daily tidal inundation by 5.5 feet of SLR. If sensitive electrical components are exposed, the Port will experience widespread impacts, because many facilities rely on an uninterrupted power supply.
- **Middle Harbor Shoreline** is exposed to daily tidal inundation by 5.5 feet of SLR, which will affect local recreational opportunities, cultural activities, and wildlife habitat.
- By 5.5 feet of SLR, nearly all **sanitary sewer lift stations** are exposed to daily tidal inundation. Once lift stations are permanently inundated, protection and preservation strategies will need to be developed to elevate or relocate sensitive components to maintain functionality.
- **Storm drain discharge points** are vulnerable to daily tidal inundation by 5.5 feet of SLR, which may cause flooding throughout the Port due to decreased drainage efficiency and conveyance of Bay water through the stormwater network.

Potential Strategies for Consideration and Further Evaluation

Five Maritime high level potential strategies (including one that is outside of Port jurisdiction) were developed for the Port's consideration and further evaluation (Figure 8) and are listed below in Tables M.1 through M.5.

In general, the strategies focus on addressing low-lying stretches of the shoreline up to 3 feet of SLR. Beyond 3 feet of SLR, or for major terminal redevelopments that include a lifespan beyond 2100, it is possible that the entire terminal may need to be raised.

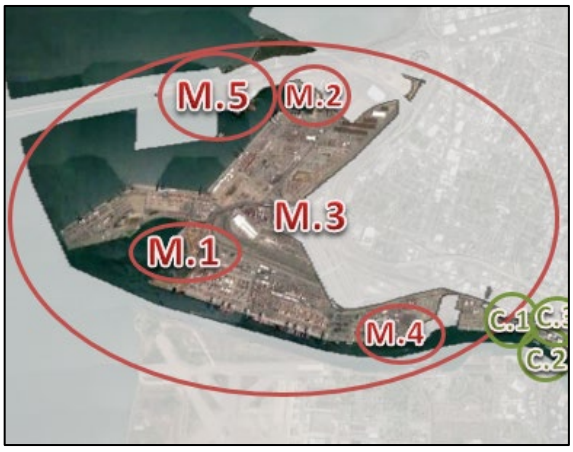
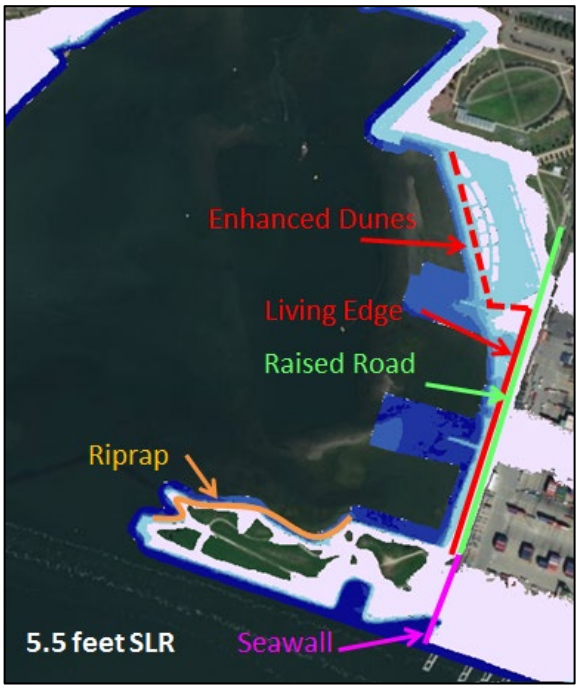


Figure 8: Approximate locations of Maritime strategies

M.1 Middle Harbor Shoreline

Strategy Types

Enhance existing dunes area; add a living shoreline south of Middle Harbor Shoreline Park; elevate street; and construct seawall to protect the park area, International Container Terminal and maintain roadway access. Also add armoring, such as riprap, to stabilize shoreline along peninsula of Middle Harbor Shoreline Park.



Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 2 feet (Year 2050)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected

- Middle Harbor Shoreline Park
- Oakland International Container Terminal

Strategy Cost

- Protect to 3 feet of SLR = Med
- Protect to 5.5 feet of SLR = Med

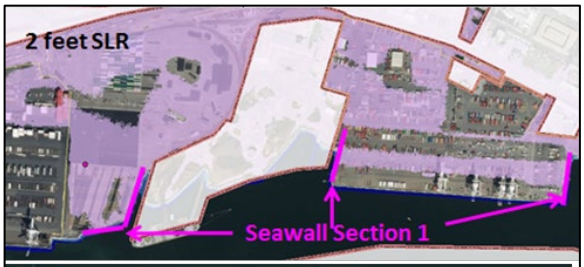
Potential Collaborators

- City of Oakland

M.2 Maritime Terminal Shorelines

Strategy Types

Raise seawall along low-lying areas of Maritime area and elevate footpath between the south side of Ben E. Nutter Terminal and TraPac Terminal.



Initial Exposure
- Extreme Storm Flooding: 100-year storm tide + 2 feet (Year 2050)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected
- Rail Lines
- Substations
- Sanitary sewer lift station

Strategy Cost
- Protect to 3 feet of SLR = Med
- Protect to 5.5 feet of SLR = See M.3 for longer-term flood protection

Potential Collaborators
- Schnitzer Steel

M.3 Maritime Terminals

Strategy Type

Raise grade of the shipping berths as a long-term solution when the terminals reach the end of their useful life to provide long-term flood protection once SLR exceeds 3 feet (Year 2100).

Initial Exposure
- Extreme Storm Flooding: Widespread flooding occurs during 100-year storm tide + 2 feet (Year 2100)
- Daily Tidal Inundation: Mean Higher High Water (MHHW) + 5.5 feet (Year 2100)

Assets Protected
- All terminals
- Non-terminal Maritime area
- Rail lines
- Substations
- Sanitary sewer lift station

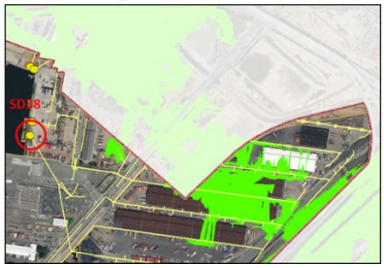
Strategy Cost
- Cost assumed part of ongoing upgrades to terminals. No cost estimated.

Potential Collaborators
- Port tenants

M.4 Stormwater discharge points

Strategy Type

Inventory all stormwater drainage points for condition and presence of backflow prevention.



Note: Green areas indicate low-lying areas that have an elevation lower than the MHHW projected between 3 and 5.5 feet of SLR.

Initial Exposure

To be determined – requires additional analysis, such as inventory of invert elevations and existing backflow prevention to understand the exposure timing.

Assets Protected

- Matson Terminal
- Maritime Non-Terminal Tenant Area

Strategy Cost

- No cost estimated

Potential Collaborators

None

M.5 Shoreline located on south side of Bay Bridge touchdown (South of I-80)

Strategy Types

Raise shoreline elevation to address a narrow flood pathway along Burma Road that provides access for Bay floodwaters to reach low-lying, inland areas of the Port.

Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Extreme Storm Flooding: MHHW + 5.5 feet (Year 2100)

Assets Protected

- Northbound rail
- Maritime Non-Terminal Tenant Area
- Sanitary sewer lift station

Strategy Cost

- Not estimated for this strategy—outside of Port jurisdiction.

Potential Collaborators

- City of Oakland
- Caltrans
- Metropolitan Transportation Commission

Financial Cost Analysis

Table 5 summarizes the findings of the cost of inaction for Maritime exposure to daily tidal inundation and extreme storm flooding. Maritime property is not exposed to daily tidal inundation until 5.5 feet of SLR (Year 2100) but has a medium financial impact by 2 feet of SLR (Year 2050) due to extreme storm flooding. By 1 foot of SLR (Year 2030), infrastructure assets are expected to have a medium financial impact due to daily tidal inundation, and a very high financial impact from extreme storm flooding. No net impacts to business and employment for Maritime operations are anticipated due to the ability for Maritime operations to increase their output overtime to compensate for any short-term impediment to their operations.

Table 5: Maritime summary findings for cost of inaction

Financial Cost Category	Daily Tidal Inundation					Extreme Storm Flooding				
	Assessment	+1 foot SLR (2030)	+2 feet SLR (2050)	+3 feet SLR (2100 Low)	+5.5 feet SLR (2100 High)	Assessment	+1 foot SLR (2030)	+2 feet SLR (2050)	+3 feet SLR (2100 Low)	+5.5 feet SLR (2100 High)
Direct Property	Market or insured value loss	No Risk	No Risk	No Risk	High	Structure repair, content & cleanup costs	Low	Medium	Medium	Medium
Business*	Sales loss	No Risk	No Risk	No Risk	No Risk	Sales loss	No Risk	No Risk	No Risk	No Risk
Employment*	Wage loss	No Risk	No Risk	No Risk	No Risk	Wage loss	No Risk	No Risk	No Risk	No Risk
Infrastructure	Replacement costs	Medium	Medium	Medium	Very High	Replacement costs	Very High	Very High	Very High	Very High
Non-Market	*Assessed Qualitatively based on Recreational Value and Other Ecosystem Service Values; Refer to Technical Memo*									

*for business and employment 'no risk' = no net impacts due to the ability for Maritime operations to increase their output overtime to compensate for any short-term impediment to their operations.

Potential strategies to protect Maritime assets from extreme storm flooding with 3 and 5.5 feet of SLR (Year 2100) were estimated to have medium costs. When compared with the cost of inaction, protection to 3 feet of SLR was categorized as cost effective; while the additional costs to provide protection to 5.5 feet of SLR were categorized as highly cost-effective (Table 6).

Table 6: Maritime potential strategy cost-effectiveness comparison

Potential Strategies	3 Feet of Sea Level Rise + 100-year Storm Tide			5.5 Feet of Sea Level Rise + 100-year Storm Tide		
	Cost of Inaction	Protection and preservation Costs	Cost-Effectiveness Rating	Cost of Inaction	Protection and Preservation Costs	Cost-Effectiveness Rating
M1. Middle Harbor Shoreline M2. Maritime Terminal Shorelines M3. Maritime Terminals M4. Stormwater Discharge Points M5. Shoreline located on south side of Bay Bridge touchdown	Medium	Medium	Cost-Effective	Very High	Medium	Highly Cost-Effective

Commercial Real Estate Sea Level Rise Assessment

Overview

The Port CRE division manages almost 20 miles of waterfront property along the San Francisco Bay and the Oakland estuary, grouped into three areas: Jack London Square, Embarcadero, and Airport Business Park. Over time, CRE has continued to transform formerly used industrial lots (warehouses, parking, vacant land) into dynamic new developments (hotels, offices, shops, restaurants, parks, food courts, and industrial flex/research centers) through private investment dollars (Figure 9).

Figure 9: Picture of Jack London Square

Inundation Maps

The SLR maps help visualize the extent of flooding based on 1, 2, 3, and 5.5 feet of SLR with extreme storm flooding (Figures 10 through 13). Due to its proximity to the Aviation area, maps of the Oakland Airport Business Park are shown on Panel 3 of the inundation maps. In summary, waterfront properties along Jack London Square and the Embarcadero are exposed to extreme storm flooding by 1 foot of SLR (Year 2030), because nearly the full shoreline is overtopped. Several buildings in the Oakland Airport Business Park in low-lying areas between Elmhurst Creek and San Leandro Creek are also exposed to extreme storm flooding with 1 foot of SLR. By 2 feet of SLR (Year 2050), extreme storm flooding expands to expose nearly all of the Jack London Square and Embarcadero areas, including facilities and infrastructure. By 5.5 feet of SLR (Year 2100), nearly all of the CRE areas are exposed to daily tidal inundation due to local shoreline overtopping of high tides.

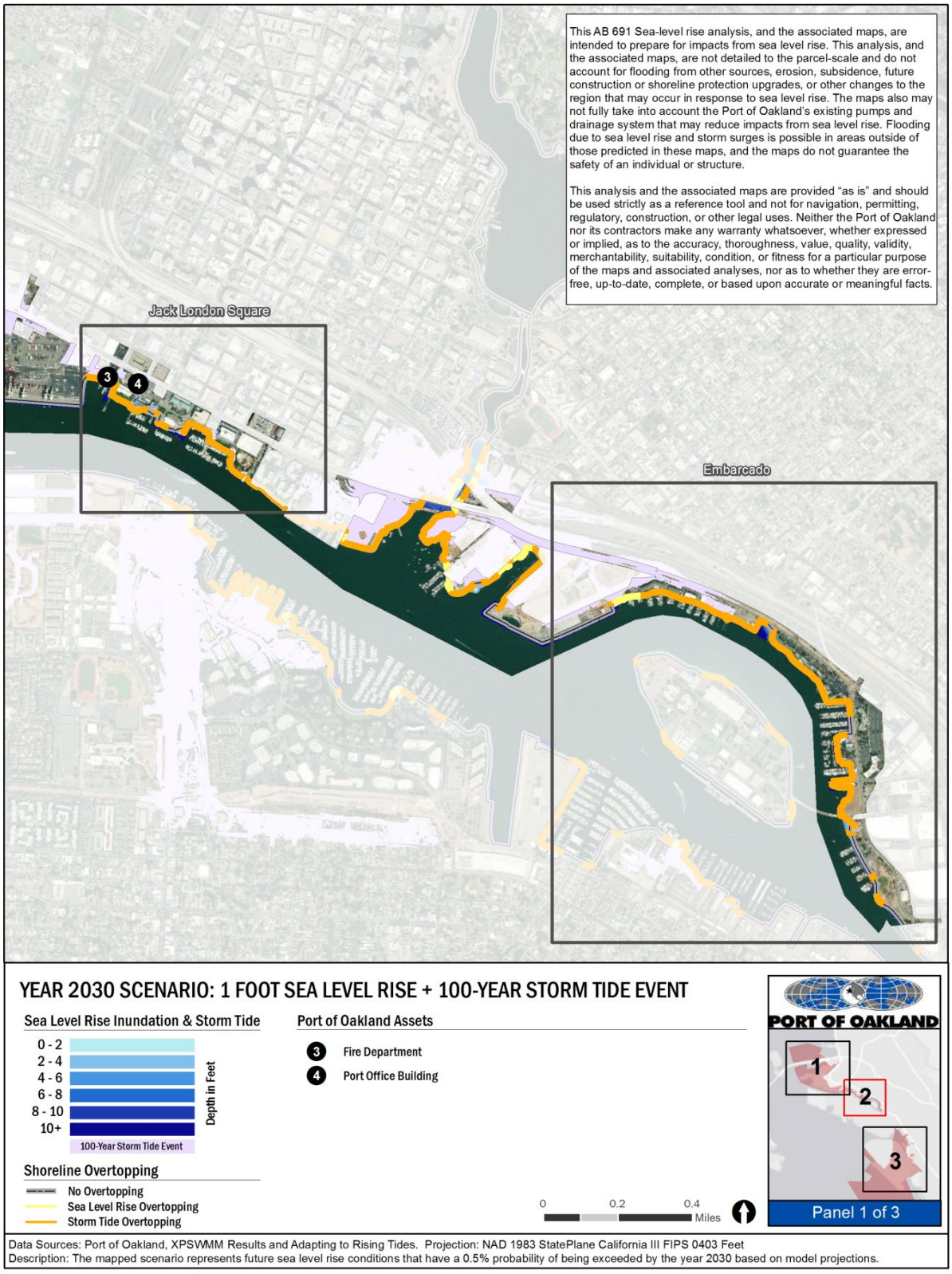


Figure 10. Year 2030 SLR scenario: 1 foot SLR + 100-year storm tide

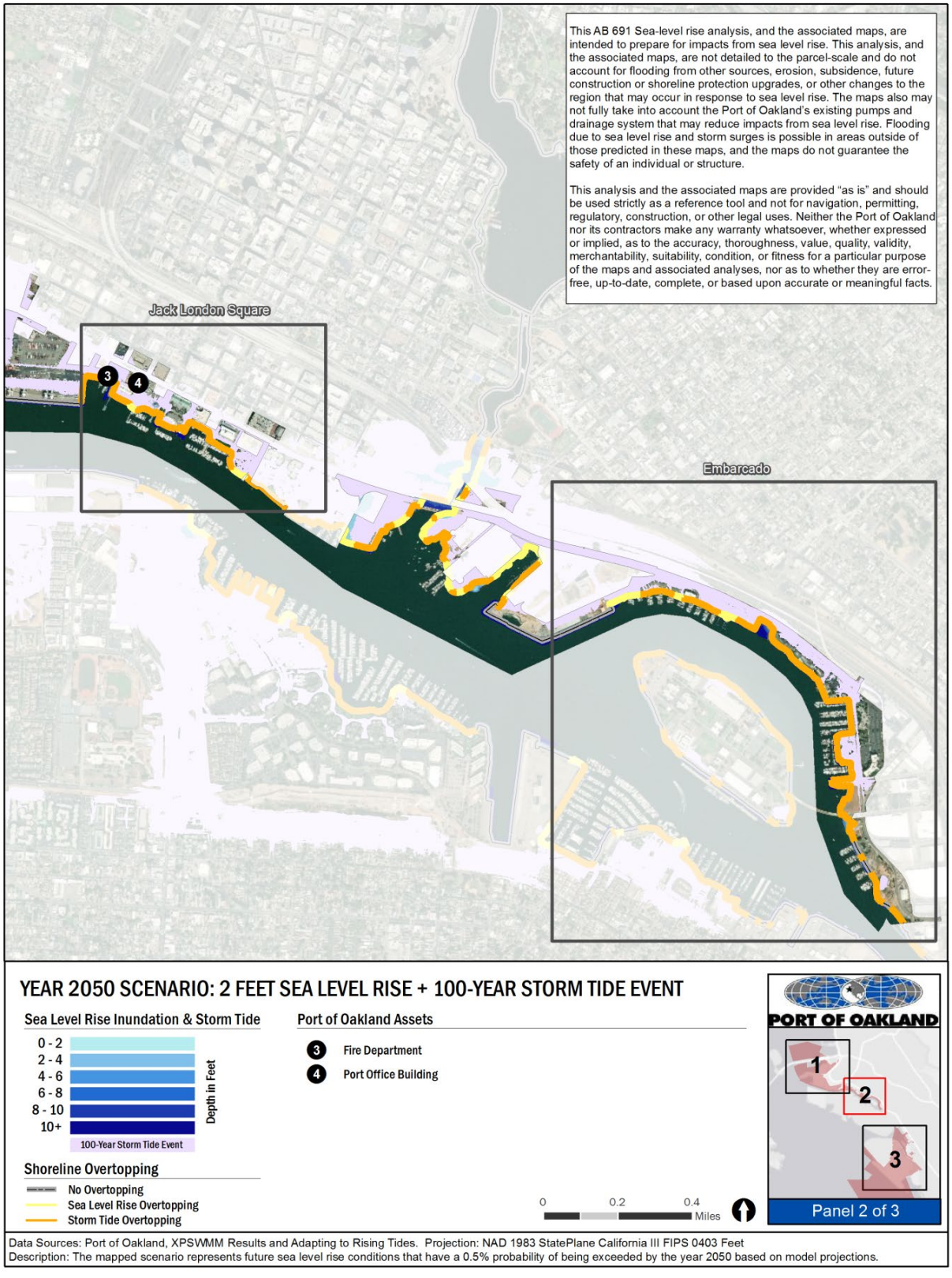


Figure 11. Year 2050 SLR scenario: 2 feet SLR + 100-year storm tide

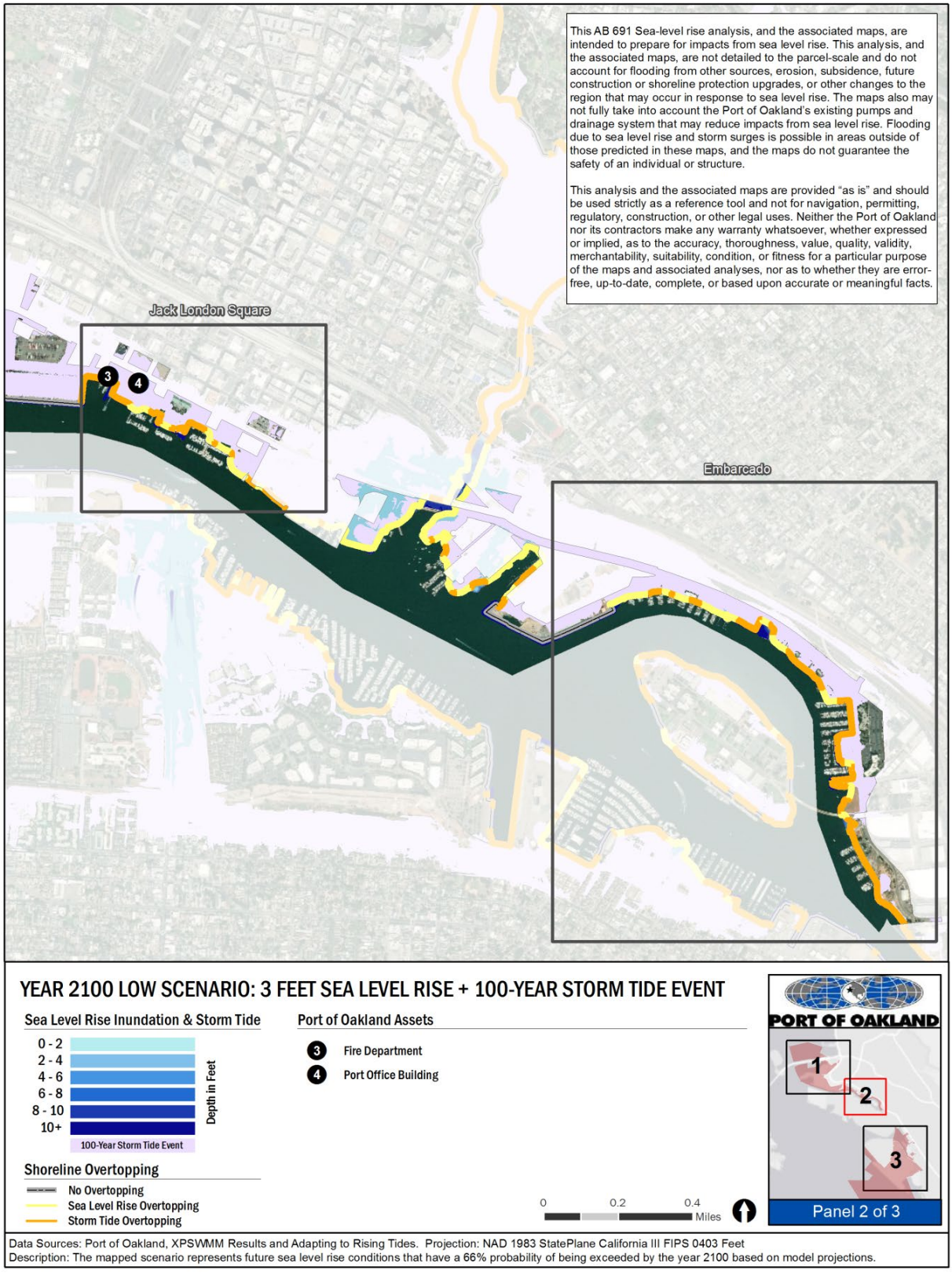


Figure 12. Year 2100 low SLR scenario: 3 feet SLR + 100-year storm tide

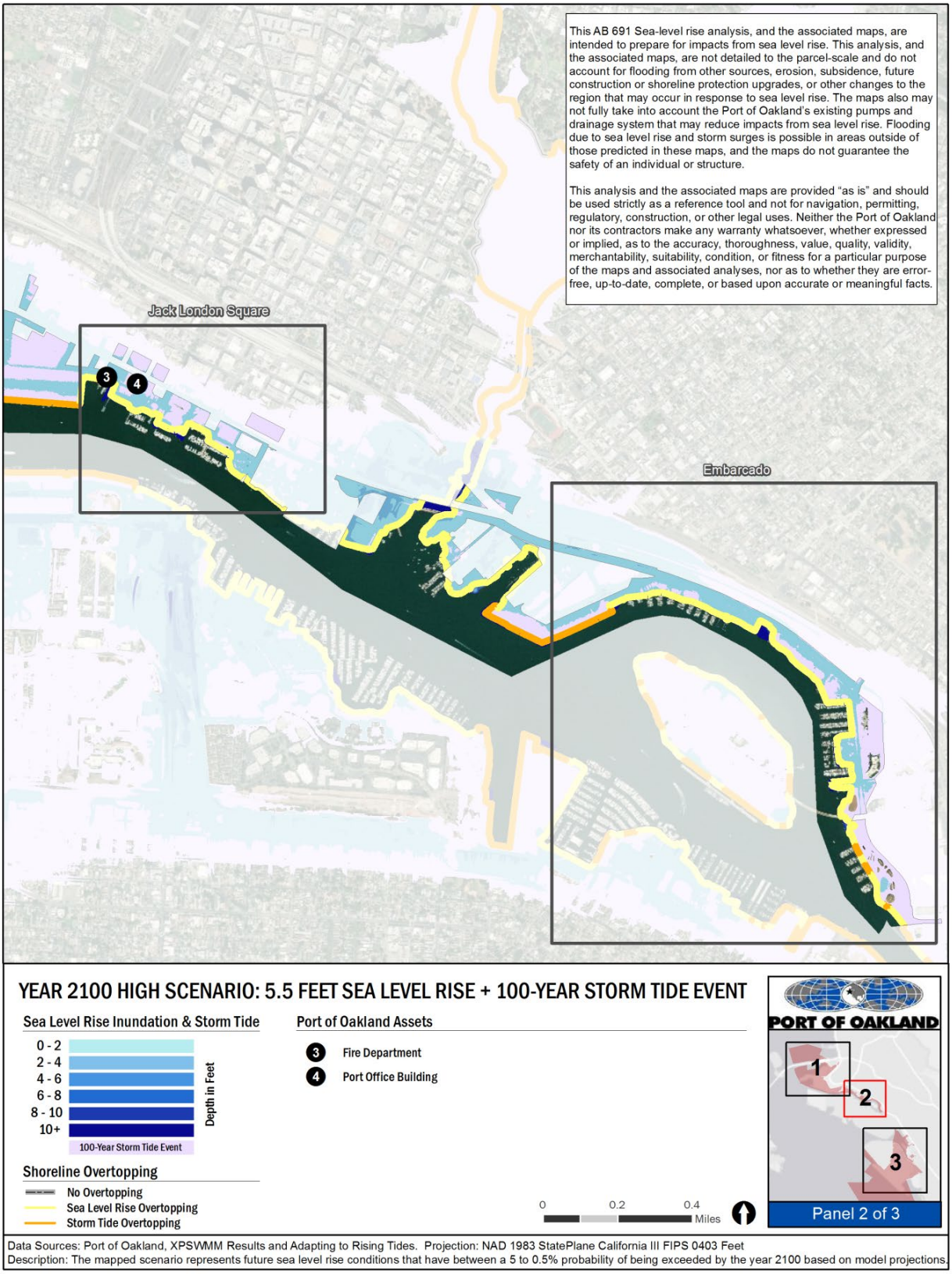


Figure 13. Year 2100 high SLR scenario: 5.5 feet SLR + 100-year storm tide

Key Vulnerabilities

Key vulnerabilities for the CRE area are listed below by timeframe.

By Year 2030 (1 foot of SLR):

- Most of **Jack London Square**, including the **Fire Department on Clay Street,** is vulnerable to extreme storm flood conditions. Flooding originates from local shoreline overtopping. Loss of the Fire Department will affect the local community's safety during emergency events. Jack London Square Facilities may also experience flood damage to building structures and property.
- **Oakland Airport Business Park** facilities near Elmhurst Creek are exposed to extreme storm flooding. Once exposed, these facilities may have structural and property damages.
- **Arrowhead Marsh** is vulnerable to submergence by daily tides if natural sedimentation cannot keep pace with SLR, impacting protected species habitat and local recreational opportunities.
- **Roadways** experience extreme storm flooding, affecting access and life safety operations throughout Jack London Square, Embarcadero, and Oakland Airport Business Park.
- Two **Sanitary Sewer Lift Stations** on the Jack London Square Harbor Pier and Dock are exposed to extreme storm flooding. Extreme storm flooding of lift stations may prevent the conveyance of untreated sewage, causing potential backups and overflows to the adjacent areas.
- **Storm drainage discharge points** become vulnerable to extreme storm flooding and/or daily tidal inundation. Exposure may decrease the efficiency of the system to convey excess stormwater away from low-lying areas of Jack London Square and Oakland Airport Business Park, increasing the potential for flooding.

By Year 2050 (2 feet of SLR):

- **Jack London Square** Facilities along the waterfront are vulnerable to daily tidal inundation due to shoreline overtopping along much of the local waterfront area.
- Most of the **Oakland Airport Business Park** is vulnerable to extreme storm flood conditions due to a combination of local shoreline overtopping, and flooding around the Oakland Coliseum originating from Elmhurst Creek and the San Leandro Creek. Oakland Airport Business Park facilities may experience flood damage to building structures and property.
- Most of the **Embarcadero** area and assets are vulnerable to extreme storm flood conditions, particularly the northern area abutting I-880. Flooding originates from local shoreline overtopping. Embarcadero facilities may experience flood damage to building structures and property.

By Year 2100 (3 and 5.5 feet of SLR):

- **Most of the Commercial Real Estate area** is vulnerable to daily tidal inundation by 5.5-foot SLR due to shoreline overtopping along much of the local waterfront area.

Potential Strategies for Consideration and Further Evaluation

Eight CRE high level potential strategies (including 2 that are outside of Port jurisdiction) for the Port's consideration or further evaluation were developed (Figure 14) and are listed below in Tables C.1 through C.8.

In general, the strategies along the Jack London Square and Embarcadero areas focus on incrementally elevating the local shoreline to prevent overtopping. Strategies for the Oakland Airport Business Park emphasize asset-specific temporary flood protection (such as sandbags) during extreme storm events because the Port does not have jurisdiction over the shoreline. Watershed restoration projects for the San Leandro and Elmhurst Creeks may be required to alleviate long-term flooding in the Oakland Airport Business Park, but will require collaboration with many local stakeholders. A potential strategy to provide incremental sediment augmentation of Arrowhead Marsh was also identified to allow the marsh to maintain its existing habitat.

Figure 14: Approximate locations of CRE strategies

C.1 Shoreline between Clay Street and Jefferson Street

Strategy Type

Construct seawall between Clay and Jefferson Streets to prevent flood pathway for large areas of the Maritime and Jack London Square.

Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: MHHW + 5.5 foot (Year 2100)

Assets Protected

- Fire Department on Clay Street
- Eastbound rail lines
- Charles P. Howard Terminal, Matson Terminal
- Maritime substations
- Jack London Square and Maritime roadways and facilities

Strategy Cost

- Protect to 3 feet of SLR = Med
- Protect to 5.5 feet of SLR =Med

Potential Collaborators

- Association of Bay Area Governments
- City of Oakland

C.2 Shoreline along Jack London Square

Strategy Type

Elevate San Francisco Bay Trail to prevent overtopping and flooding in the Jack London Square Area.

Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected

- Jack London Square facilities
- Fire Department on Clay Street
- Sanitary sewer lift stations
- Jack London Square roadways

Strategy Cost

- Protect to 3 feet of SLR = Med
- Protect to 5.5 feet of SLR= High

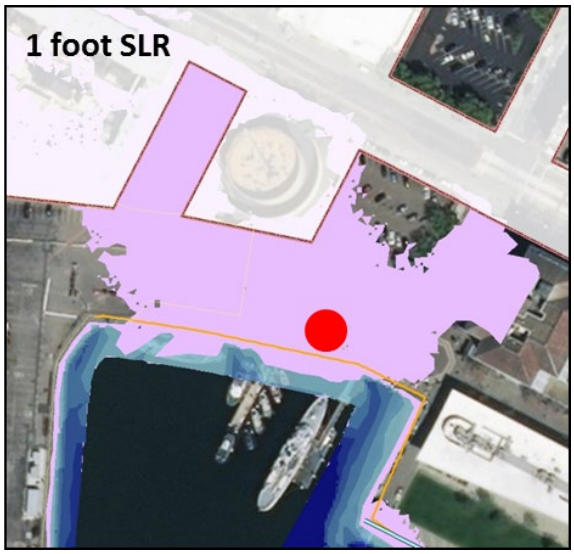
Potential Collaborators

- Association of Bay Area Governments, City of Oakland

C.3 Area around Fire Department

Strategy Type

Provide temporary flood protection during storm events that may occur prior to building replacement (at end of lifespan). *Note: Fire Department = red dot.*



Initial Exposure
- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected
- Fire Department on Clay Street

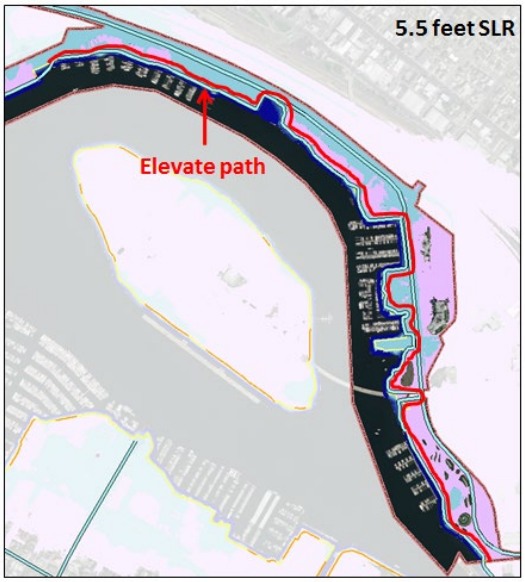
Strategy Cost
- Not estimated for this strategy; assumed negligible cost associated with deployment of sandbags around facility entryways

Potential Collaborators
- City of Oakland

C.4 Shoreline along the Embarcadero

Strategy Type

Elevate San Francisco Bay Trail to prevent overtopping and flooding within the Embarcadero Area.



Initial Exposure
- Extreme Storm Flooding: 100-year storm tide + 2 feet (Year 2050)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected
- Embarcadero facilities
- Embarcadero roadways

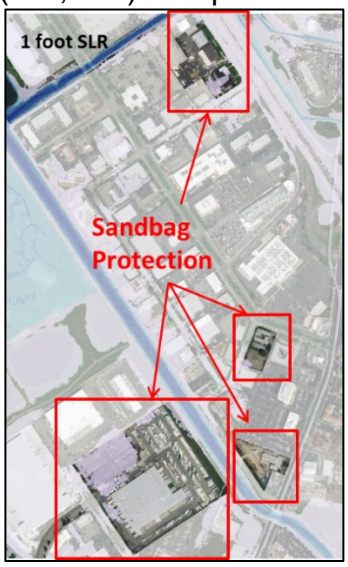
Strategy Cost
- Protect to 3 feet of SLR= Med to High
- Protect to 5.5 feet of SLR = High

Potential Collaborators
- Association of Bay Area Governments
- City of Oakland

C.5 Area around facilities located near San Leandro Creek

Strategy Type

Provide temporary flood protection during storm events to provide a short-term option until an area shoreline protection solution (C.7, C.8) is implemented.



Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected

- Facilities in Oakland Airport Business Park

Strategy Cost

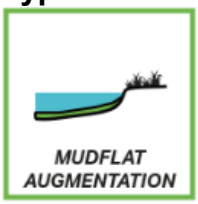
- Not estimated for this strategy; assumed negligible cost associated with deployment of sandbags around facility entryways

Potential Collaborators

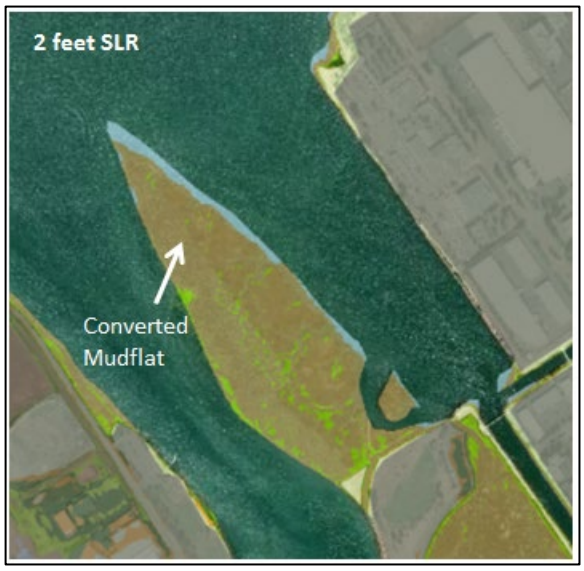
- City of Oakland
- City of San Leandro
- Alameda County Flood Control and Water Conservation District

C.6 Arrowhead Marsh

Strategy Type



Use dredge spoils to artificially increase the marsh elevation at a similar rate as SLR.



Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: 100-year storm tide + 1 foot (Year 2030); however, marsh conversion starts at 2 feet

Assets Protected

- Arrowhead Marsh

Strategy Cost

- Protect to 3 feet of SLR = Med
- Protect to 5.5 feet of SLR= High

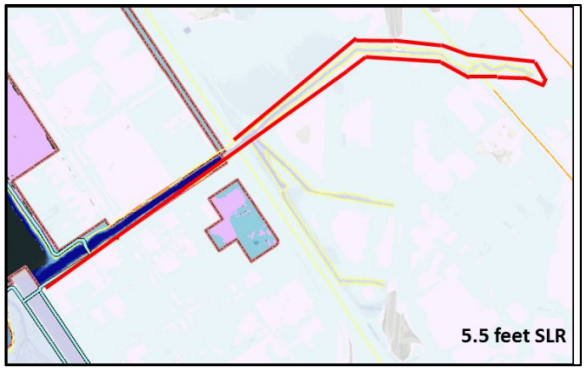
Potential Collaborators

- City of Oakland
- East Bay Regional Parks District

C.7 Elmhurst Creek

Strategy Types

Implement watershed restoration (outside of strategy detail image) and elevate existing levee (red line) along channel to reduce stormwater volume and increase shoreline protection.



Initial Exposure
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected
- Facilities in Oakland Airport Business Park
- Oakland Airport Business Park Roadways

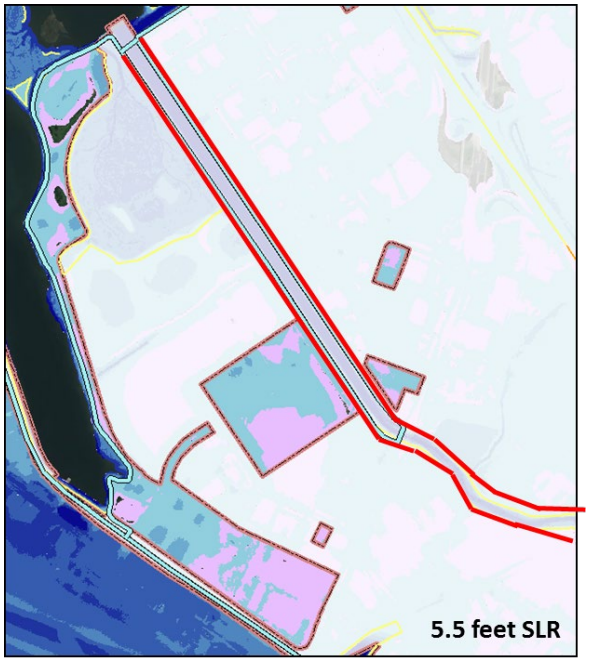
Strategy Cost
- Not estimated for this strategy—outside of Port jurisdiction.

Potential Collaborators
- City of Oakland
- Alameda County Flood Control and Water Conservation District

C.8 San Leandro Creek

Strategy Types

Implement watershed restoration (outside of strategy detail image) and elevate pathway (red line) along creek to reduce stormwater volume and prevent overtopping along shoreline.



Initial Exposure
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected
- Facilities in Oakland Airport Business Park
- Oakland Airport Business Park Roadways

Strategy Cost
- Not estimated for this strategy—outside of Port jurisdiction.

Potential Collaborators
- City of Oakland
- City of San Leandro (including San Leandro Creek Master Plan efforts)
- Alameda County Flood Control and Water Conservation District

Financial Cost Analysis

Table 7 summarizes the findings of the cost of inaction for CRE exposure to daily tidal inundation and extreme storm flooding. CRE property is not exposed to daily tidal inundation until 5.5 feet of SLR (Year 2100); however, it has a medium financial impact from 2 feet of SLR (Year 2050) due to extreme storm flooding. By 1 foot of SLR (Year 2030), infrastructure assets are expected to have a medium financial impact due to daily tidal inundation, and a high financial impact from extreme storm flooding. Businesses in the CRE area may have very high financial impacts for daily tidal inundation from 5.5 feet of SLR (Year 2100).

Table 7: CRE summary of findings for cost of inaction

Financial Cost Category	Daily Tidal Inundation					Extreme Storm Flooding				
	Assessment	+1 foot SLR (2030)	+2 feet SLR (2050)	+3 feet SLR (2100 Low)	+5.5 feet SLR (2100 High)	Assessment	+1 foot SLR (2030)	+2 feet SLR (2050)	+3 feet SLR (2100 Low)	+5.5 feet SLR (2100 High)
Direct Property	Market or insured value loss	No Risk	Medium	Medium	Very High	Structure repair, content & cleanup costs	Low	Medium	Medium	Very High
Business	Sales loss	No Risk	Medium	Medium	Very High	Sales loss	Medium	Medium	Medium	Very High
Employment	Wage loss	No Risk	Low	Low	Very High	Wage loss	Low	Low	Medium	High
Infrastructure	Replacement costs	Medium	Medium	Medium	High	Replacement costs	High	High	Very High	High
Non-Market	*Assessed Qualitatively based on Recreational Value and Other Ecosystem Service Values; Refer to Technical Memo*									

Potential strategies to protect CRE assets from extreme storm flooding with 3 and 5.5 feet of SLR (Year 2100) were estimated to have high costs. When compared to the cost of inaction, protecting and preserving to 3 feet of SLR was categorized as cost effective, while the additional costs to provide protection to 5.5 feet of SLR were categorized as highly cost effective (Table 8).

Table 8: CRE strategy cost of effectiveness comparison

Potential Strategies	3 Feet of Sea Level Rise + 100-year Storm Surge			5.5 Feet of Sea Level Rise + 100-year Storm Surge		
	Cost of Inaction	Protection and Preservation Costs	Cost-Effectiveness Rating	Cost of Inaction	Protection and Preservation Costs	Cost-Effectiveness Rating
C1. Shoreline between Clay Street and Jefferson Street C2. Shoreline along Jack London Square C3. Area around Fire Department C4. Shoreline along the Embarcadero C5. Area around facilities located near San Leandro Creek C6. Arrowhead Marsh C7. Elmhurst Creek C8. San Leandro Creek	**High**	**High**	**Cost-Effective**	**Very High**	**High**	**Highly Cost-Effective**

Aviation Sea Level Rise Assessment

Overview

Oakland International Airport (Figure 15) is the fourth-busiest airport in California. It provides commercial airline and general aviation services for passengers, handles over half of the Bay region's domestic freight and airmail, and serves a critical role in the region during emergency response. Airport facilities include commercial and general aviation runways, passenger and air cargo facilities, aircraft hangars, a fuel tank farm, a control tower, and a perimeter dike that provides flood protection for the site.

As with the other Port business lines, the Airport area includes a variety of Port-owned and maintained utilities and airport access roads.

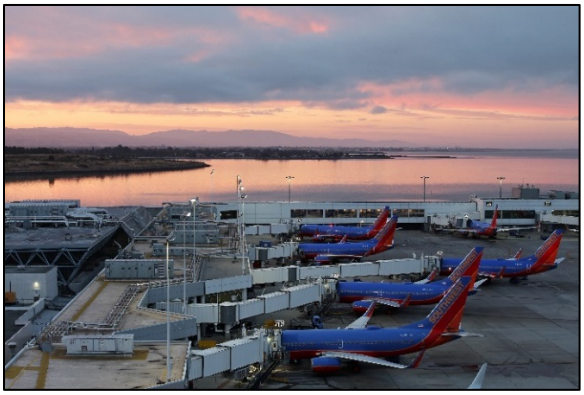


Figure 15: Picture of Oakland International Airport

Inundation Maps

The SLR maps help visualize the extent of flooding based on 1, 2, 3, and 5.5 feet of SLR with extreme storm flooding (Figure 16 through 19). In summary, two stormwater discharge points (north side of North Field under Doolittle Drive [outfall #384] and north side of South Field Runway [outfall #4166]), which are not currently equipped with backflow prevention features, provide the initial flood pathway for tidal water to enter the Airport property. Much of Doolittle Drive is also overtopped by extreme storm flooding with 1 foot of SLR (Year 2030) and daily tidal inundation by 3 feet of SLR (Year 2100), exposing the North Field. By 5.5 feet of SLR (Year 2100), the full length of the perimeter dike is overtopped during extreme storm events, with several low-lying stretches of the dike exceeded by daily tidal inundation, exposing the South Field.

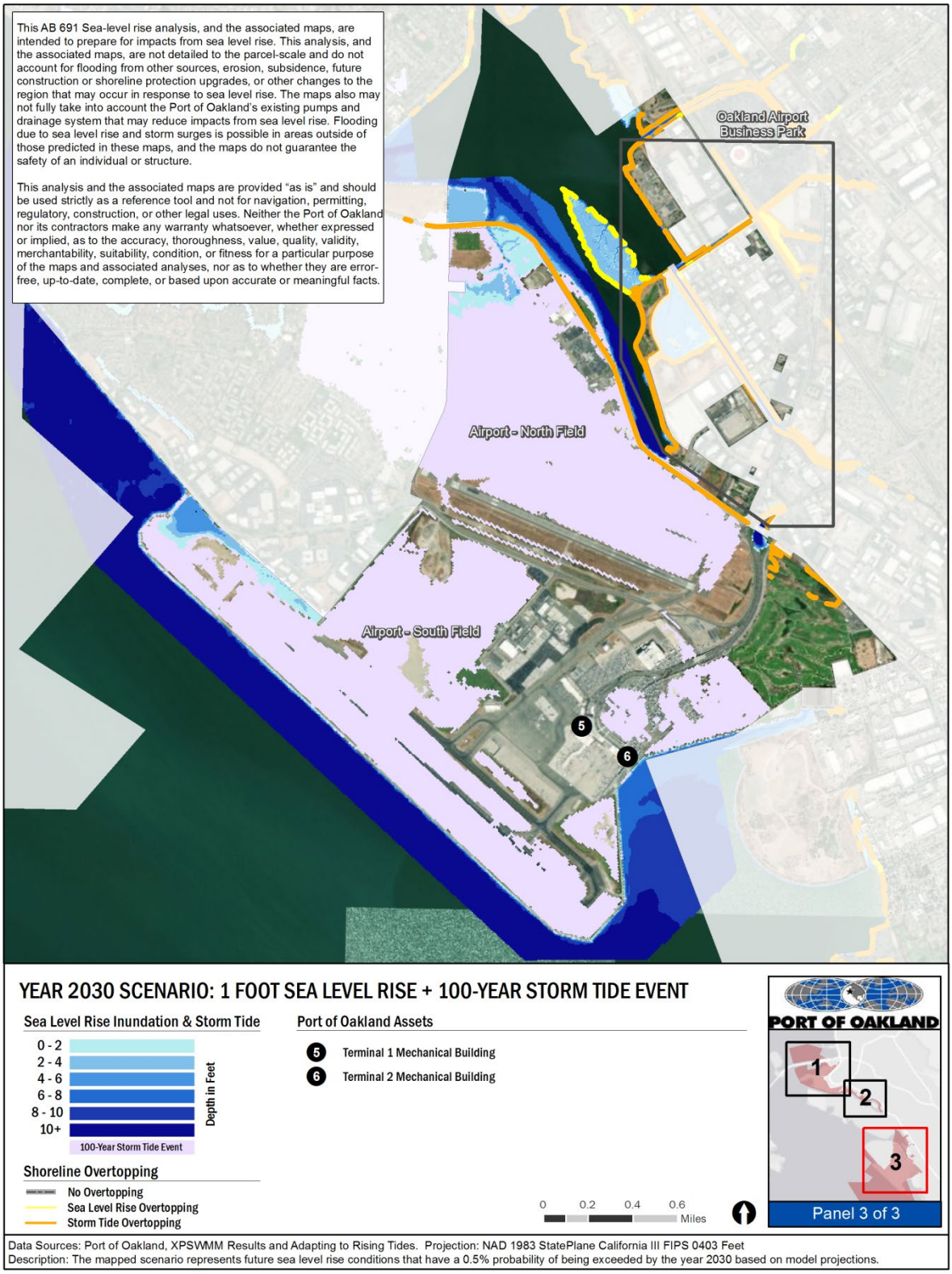


Figure 16. Year 2030 SLR scenario: 1 foot SLR + 100-year storm tide

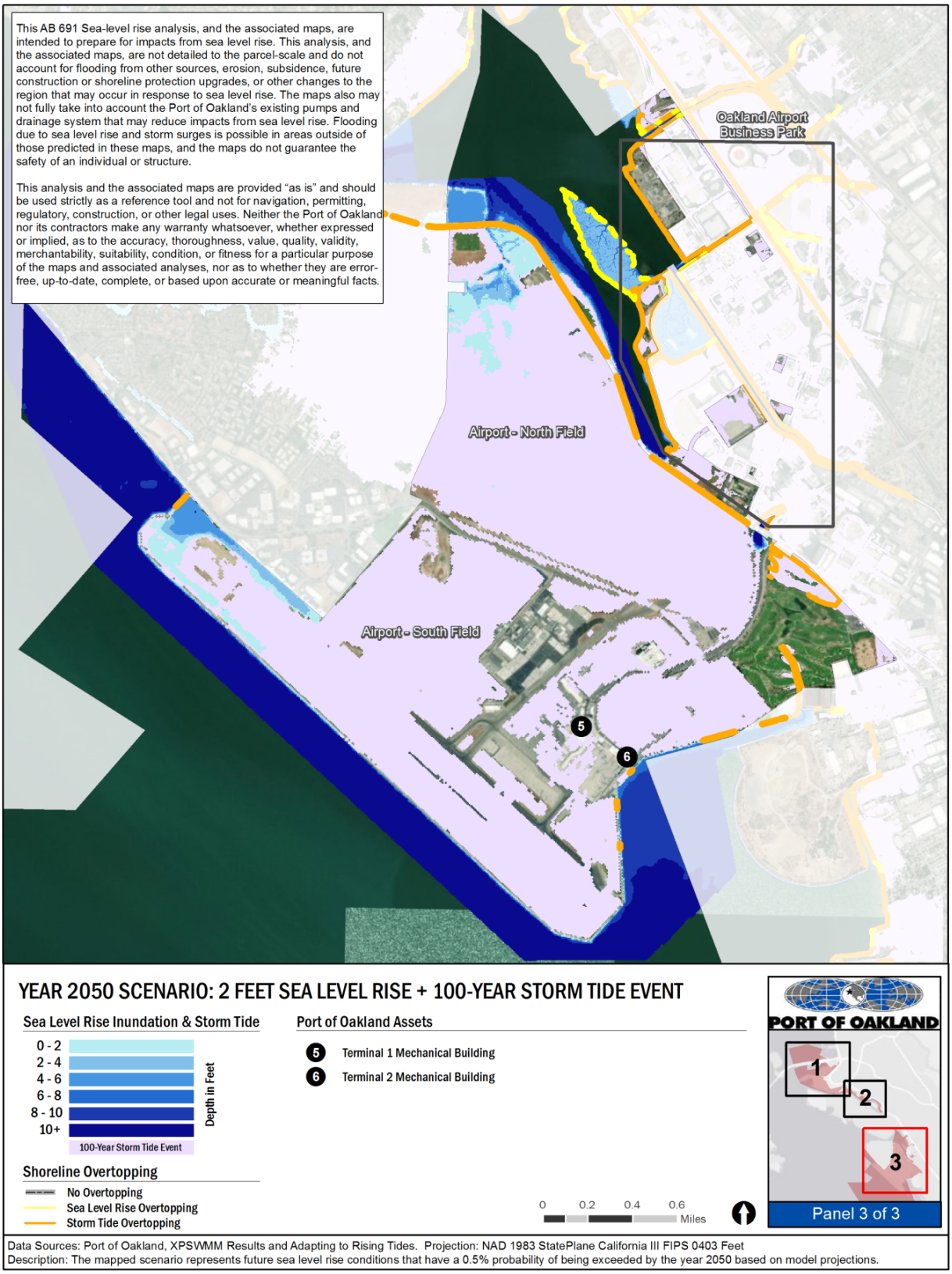


Figure 17. Year 2050 SLR scenario: 2 feet SLR + 100-year storm tide

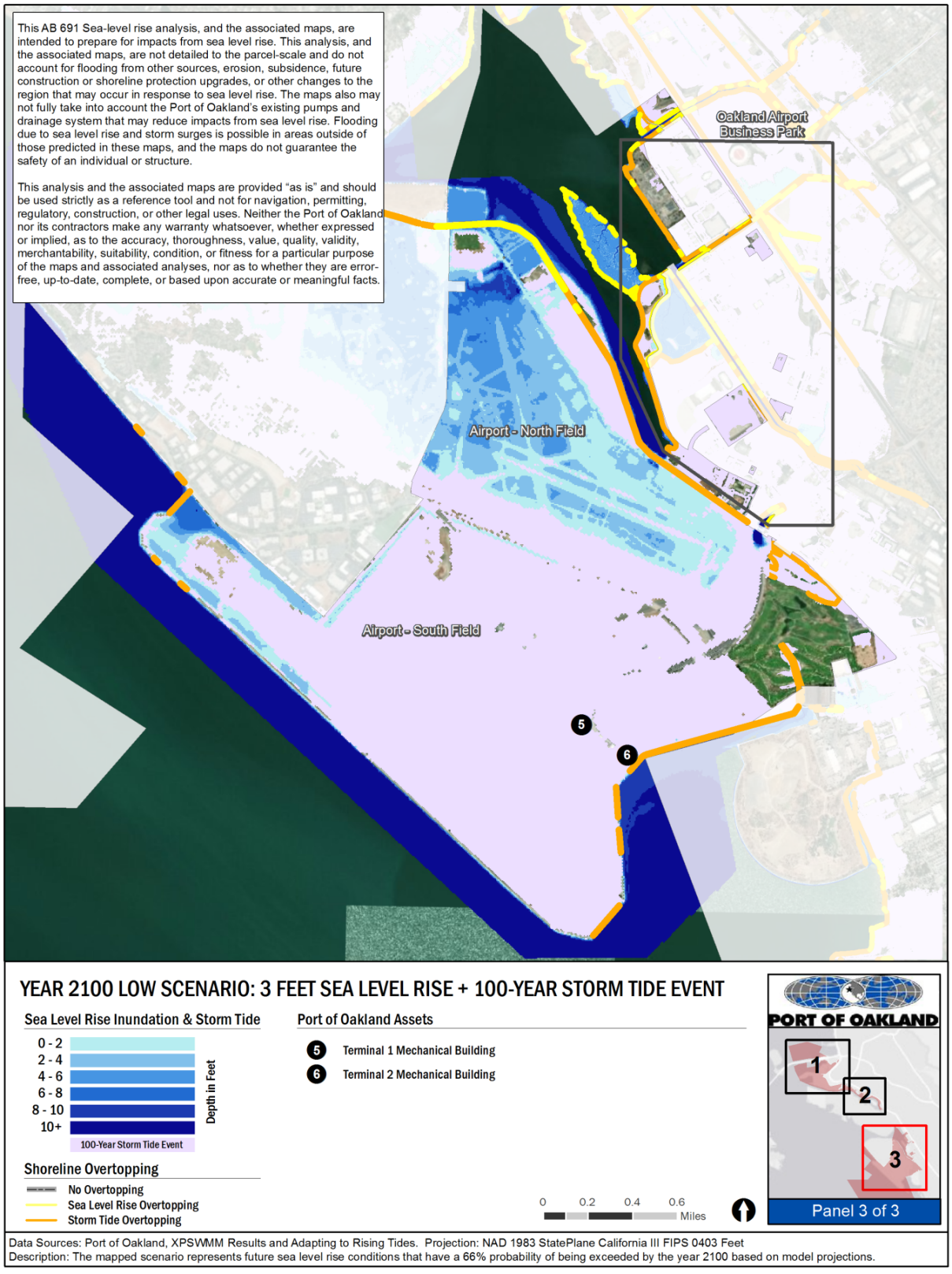


Figure 18. Year 2100 low SLR scenario: 3 feet SLR + 100-year storm tide

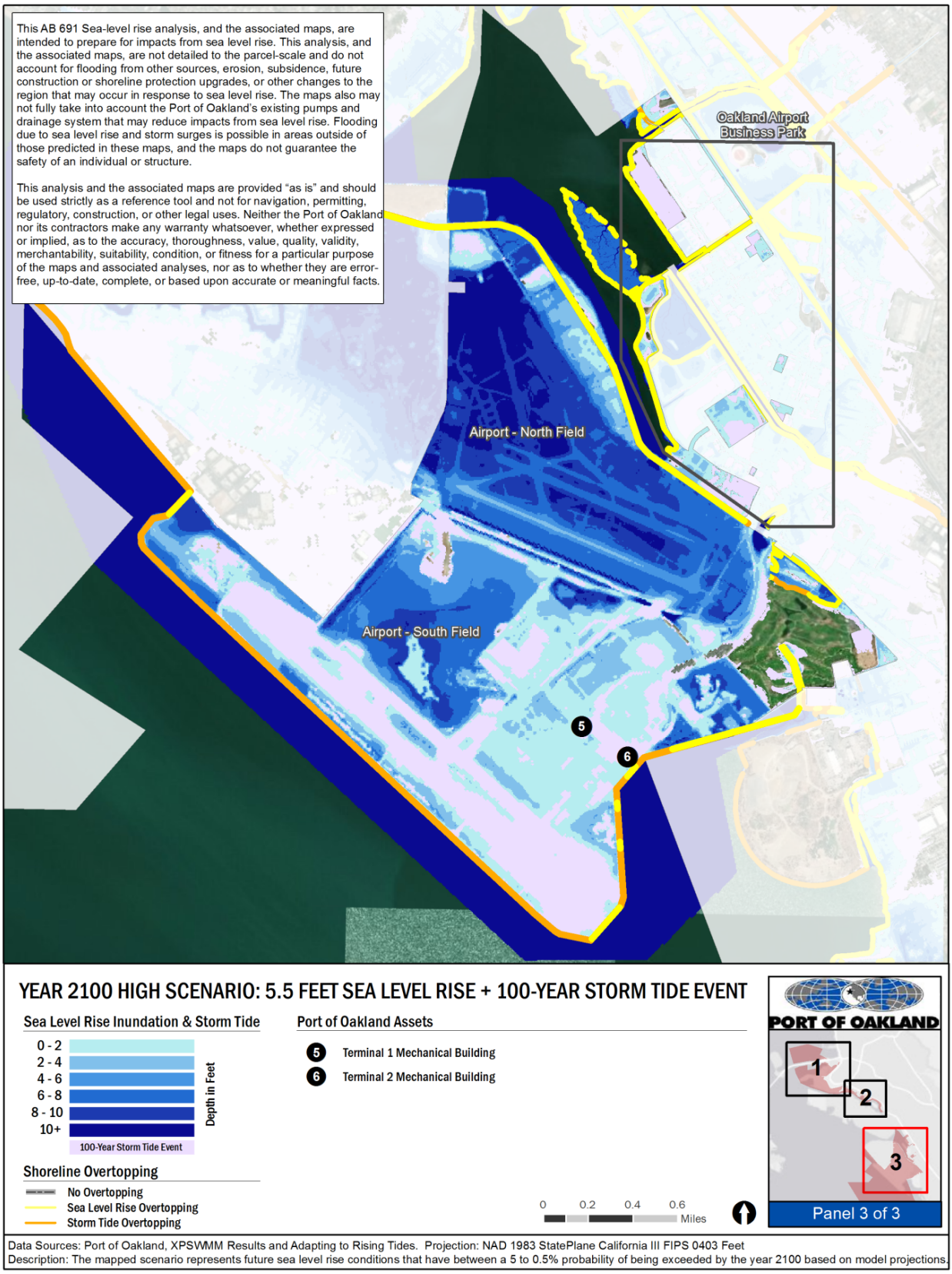


Figure 19. Year 2100 high SLR scenario: 5.5 feet SLR + 100-year storm tide

Key Vulnerabilities

Key vulnerabilities for the Airport are listed below by timeframe.

By Year 2030 (1 foot of SLR):

- The shoreline along **Doolittle Drive** is overtopped during the extreme storm event, exposing most of the North Field to flooding. Once exposed to extreme storm flood conditions, the Airport may experience operational delays, temporary closures, and/or damage to sensitive assets and facilities throughout the North Field.
- Backflow through an outfall (#384) along Doolittle Drive provides a flood pathway for daily tidal inundation for a small area on the northern side of the North Field. Several **hangar buildings** and **stormwater pump house #2** are exposed to daily tides.
- Backflow through the outfall (#4166) north of Runway 12 on the South Field provides a flood pathway for extreme storm flooding. The **runway** and **several buildings** become exposed to flooding, which may temporarily affect operations and/or damage sensitive assets and facilities.
- **Stormwater pump houses (#1, 2, 7)** on the North Field and **(#4, 6, 8)** on the South Field are exposed to extreme storm flooding, which may affect the ability to convey excess stormwater due to damaged electrical components in the pump houses.
- **Four sanitary sewer lift stations** (two on the North Field and two on the South Field) are exposed to extreme storm flooding, which may cause backups or overflows of untreated sewage.
- **Roadways** begin to experience extreme storm flooding, affecting access and life safety operations throughout the Airport.

By Year 2050 (2 feet of SLR):

- Extreme storm flooding expands to include the entire North Field, affecting all North Field facilities, assets, and roadways.
- Daily tidal inundation expands along the northern side of the North Field, exposing **stormwater pump house #1** to daily tides.
- Overtopping from extreme storm flooding begins to occur along several low areas of the **perimeter dike** surrounding the South Field. Extreme storm flooding expands to include an additional **7 sanitary sewer lift stations**, **roadways**, and **buildings** on the South Field.

By Year 2100 (3 and 5.5 feet of SLR):

- By 3 feet of SLR, daily tides begin to overtop **Doolittle Drive**, exposing much of the North Field, including **runways**, **many buildings**, **stormwater pump house #7**, and two additional **sanitary sewer force mains** to daily tidal inundation.
- On the South Field, 3 feet of SLR causes extreme storm flooding to affect the entire area, exposing all assets, roadways, and facilities, including the three identified critical facilities: **the T1 and T2 Mechanical Buildings**.

- Areas of the South Field affected by daily tidal inundation during 3 feet of SLR expand to expose **stormwater pump house #6**.
- By 5.5 feet of SLR, the entire North Field is exposed to daily tidal inundation, as daily tides overtop the full length of **Doolittle Drive**.
- By 5.5 feet of SLR, portions of the **perimeter dike** are overtopped by daily tides. Nearly all of the South Field is exposed to daily tidal inundation, including **10 sanitary sewer lift stations**, **stormwater pump houses (#4 and 8)**, **most buildings**, **T1 Mechanical Building**, and **roadways.**

Potential Strategies for Consideration and Further Evaluation

There are two projects currently underway at the Airport that will further assist with addressing impacts from SLR:

- South Field Perimeter Dike Improvement Project: the South Field Perimeter Dike Improvement Project will raise the dike crest and add 1 foot of freeboard for flood protection.
- Stormwater Management and Tidal Flooding Vulnerability at the North Field: will assess the existing storm water system at the Airport and propose improvements to the infrastructure that will also factor in impacts from SLR.

Four additional Aviation high level potential strategies were developed for further evaluation (Figure 20) as listed below in Tables A.1 through A.4.

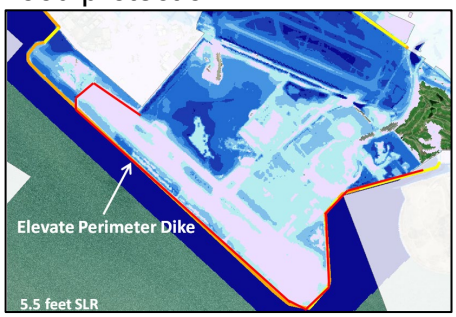
The strategies for the Airport focus on elevating low-lying areas of the shoreline—Doolittle Drive to the north, and the perimeter dike to the south—and enhancing on-site stormwater drainage. Asset-specific strategies for critical facilities were also included to provide redundant flood protection for the utility and mechanical buildings on the South Field.

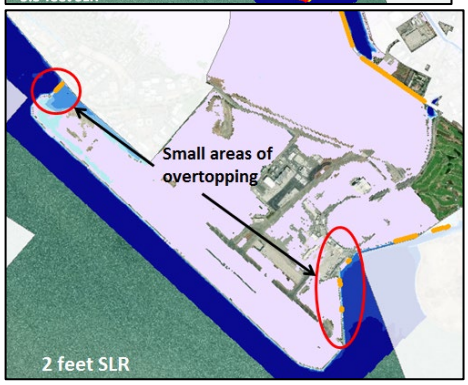
Figure 20: Approximate locations of Aviation strategies

A.1 Shoreline along the southwest side of the Oakland Airport South Field

Strategy Type

Following the South Field Perimeter Dike Improvement Project, raise the crest of dike design *incrementally over time* to maintain FEMA + 1 foot of freeboard flood protection.





Initial Exposure

- Extreme Storm Flooding: 100-year storm tide +2 feet (Year 2050); however, the full length of the dike is not overtopped until 5.5 feet of SLR.
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected

- South Field facilities
- South Field Runway
- T1 and T2 Mechanical Buildings
- South Field access roads

Strategy Cost

- Protect to 5.5 feet of SLR = Very High

Potential Collaborators

- Federal Aviation Administration

A.2 Flap Gate Additions to Culverts

Strategy Types

Add backflow prevention, such as flap gates, to two discharge points on the North Field to prevent negative flow from daily high tides.

This strategy does not provide flood protection from shoreline overtopping that may occur when extreme storm tides and daily tides exceed the elevations of Doolittle Drive. In order to provide long-term flood protection of the North Field, it will be necessary to raise Doolittle Drive, requiring collaboration with Caltrans.

Initial Exposure

- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: MHHW + 2 feet (Year 2050)

Assets Protected

- North Field facilities
- North Field Runway
- North Field access roads

Strategy Cost

- No cost estimated

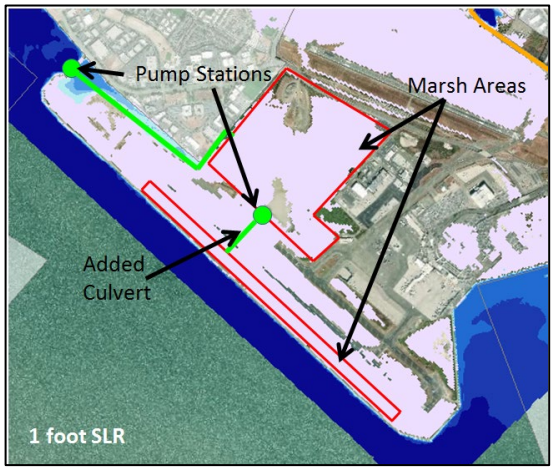
Potential Collaborators

- None

A.3 Marsh areas on South Field

Strategy Types

Add culvert and two pump stations to provide more efficient drainage connections between flood storage areas.



Initial Exposure
- Extreme Storm Flooding: 100-year storm tide + 1 foot (Year 2030)
- Daily Tidal Inundation: MHHW + 1 foot (Year 2030)

Assets Protected
- South Field Facilities
- South Field Runway
- T1 and T2 Mechanical Buildings

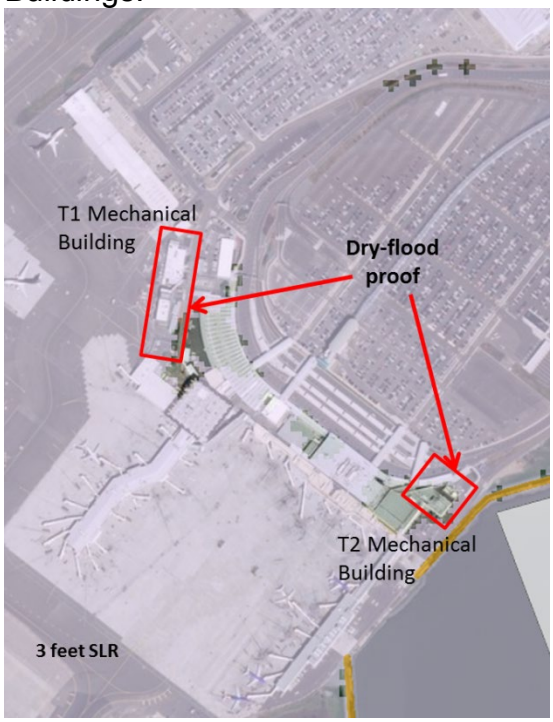
Strategy Cost
- Protect to 3 feet of SLR = High
- Protect to 5.5 feet of SLR = Not estimated for this strategy

Potential Collaborators
- None

A.4 Critical facilities in airport terminal area

Strategy Type

Provide redundant protection (dry-floodproofing techniques (such as a spray-on waterproof membrane and flood shield for entryways) around critical facilities: T1 and T2 Mechanical Buildings.



Initial Exposure
- Extreme Storm Flooding: 100-year storm tide + 3 feet (year 2100)
- Daily Tidal Inundation: MHHW + 5.5 feet (Year 2100)

Assets Protected
- T1 and T2 Mechanical Buildings

Strategy Cost
- Protect to 3 feet of SLR = Low
- Protect to 5.5 feet of SLR = Low

Potential Collaborators
- None

Financial Cost Analysis

Table 9 summarizes the findings of the cost of inaction for Airport exposure to daily tidal inundation and extreme storm flooding. All financial cost categories for the Aviation area are characterized as having varying degrees of financial impacts by 1 foot of SLR (Year 2030) from daily tidal inundation; however, 3 feet of SLR (Year 2100) represents a tipping point when ratings for all categories become very high, as most of the North and South Fields become exposed. Aviation property, businesses, and infrastructure are characterized as having very high financial impacts by 1 foot of SLR (Year 2030) from extreme storm flooding.

Table 9: Aviation summary findings for cost of inaction

Financial Cost Category	Daily Tidal Inundation					Extreme Storm Flooding				
	Assessment	+1 foot SLR (2030)	+2 feet SLR (2050)	+3 feet SLR (2100 Low)	+5.5 feet SLR (2100 High)	Assessment	+1 foot SLR (2030)	+2 feet SLR (2050)	+3 feet SLR (2100 Low)	+5.5 feet SLR (2100 High)
Direct Property	Market or insured value loss	Medium	Medium	Very High	Very High	Structure repair, content & cleanup costs	Very High	Very High	Very High	No Additional Risk*
Business	Sales loss	Very High	Very High	Very High	Very High	Sales loss	Very High	Very High	Very High	No Additional Risk*
Employment	Wage loss	Medium	Medium	Very High	Very High	Wage loss	Medium	High	High	No Additional Risk*
Infrastructure	Replacement costs	Low	Low	Very High	Very High	Replacement costs	Very High	Very High	Very High	Very High
Non-Market	*Assessed Qualitatively based on Recreational Value and Other Ecosystem Service Values; Refer to Technical Memo*									

* "No Additional Risk" is assigned when the daily tidal inundation risks overlap with potential extreme storm flooding risks. This prevents the double counting of impacts, and informs what methodology is used to estimate risk, although does not imply that these assets would not be exposed to extreme storm flooding in addition to tidal inundation.

Proposed protection and preservation strategies to protect Aviation assets from extreme storm flooding with 3 and 5.5 feet of SLR (Year 2100) were estimated to have very high costs. When compared with the cost of inaction, protecting to 3 and 5.5 feet of SLR was categorized as highly cost effective (Table 10).

Table 10: Aviation potential strategy cost effectiveness comparison

Potential Strategies	3 Feet of Sea Level Rise + 100-year Storm Surge			5.5 Feet of Sea Level Rise + 100-year Storm Surge		
	Cost of Inaction	Protection and Preservation Costs	Cost-Effectiveness Rating	Cost of Inaction	Protection and Preservation Costs	Cost-Effectiveness Rating
A1. Shoreline along the southwest side of the Oakland Airport South Field A2. Flap Gate additions to culverts A3. Marsh areas on South Field A4. Critical facilities in airport terminal area	**Very High**	**Very High**	**Highly Cost-Effective**	**Very High**	**Very High**	**Highly Cost-Effective**

Conclusion

This Assessment was prepared in compliance with AB 691, which includes 1) an assessment of impacts, 2) maps showing the areas that may be affected for years 2030, 2050, and 2100, 3) an estimate of financial costs of the impacts, and 4) a description of how the Port proposes to protect and preserve resources.

All potential strategies require significant approvals or participation from local and regional stakeholders as collaborators. Planning will need to be an iterative and ongoing process to protect assets and maintain business continuity as conditions change over the long-term.

And finally, it is important to revisit climate vulnerabilities and protection and preservation strategies as climate science is updated over time and new models and assessments are completed.