Adaptation Pathways:
San Leandro Operational Landscape Unit

PREPARED BY
San Francisco Estuary Institute

FUNDED BY
San Francisco Bay Regional Water Quality Control Board

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Arrowhead Marsh, photo by Ellen Plane (SFEI).

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1. Introduction

PLANNING AT THE OPERATIONAL LANDSCAPE UNIT SCALE

Given the diverse uses and conditions of San Francisco Bay's 400-mile shoreline, a framework is needed to guide development of adaptation strategies appropriate to local conditions. Operational Landscape Units (OLUs), outlined for the San Francisco Bay in the San Francisco Bay Shoreline Adaptation Atlas (SFEI and SPUR 2019), share common physical characteristics and therefore can benefit from being managed as individual units. OLUs cross traditional jurisdictional boundaries (cities, counties), and instead follow the boundaries of natural processes like tides, waves, and sediment movement. By planning at the OLU scale, it is possible to prioritize adaptation strategies that work synergistically. Coordinated OLU planning can help avoid unintended impacts on neighboring locales and identify synergies to make use of limited resources in a more efficient manner.

OLU-scale planning is a regional goal for sea-level rise (SLR) adaptation in San Francisco Bay. Bay Adapt Draft Implementation Framework Task 8.2 is to "encourage collaboration among people doing projects in the same area." The task suggests formalizing organizations at the OLU scale to accelerate funding, development, and construction in places spanning jurisdictions. According to the Bay Adapt framework, planning at the OLU scale allows for coordinated action to achieve better project outcomes, inclusion of community-based organizations from the outset, and regional coordination linking together efforts at the OLU scale.

Some successful cross-jurisdictional collaborations for SLR adaptation planning in San Francisco Bay to date include the Hayward Area Shoreline Planning Agency Joint Powers Authority, the Sunnyvale Shoreline Resilience Vision, the San Mateo Flood and Sea Level Rise Resiliency District, Resilient SR37, and the San Francisquito Creek Joint Powers Authority. The San Leandro Bay/Oakland-Alameda Estuary Working Group has formed a stakeholder group for the San Leandro OLU and is now actively developing a strategy for coordinated planning.

SAN LEANDRO BAY/OAKLAND-ALAMEDA ESTUARY ADAPTATION WORKING GROUP

The purpose of the San Leandro Bay/Oakland-Alameda Estuary Adaptation Working Group (Working Group) is to "coordinate San Leandro Bay/Oakland-Alameda Estuary flood and adaptation projects to protect and restore water quality, habitat, and adjacent community vitality." The group aims to coordinate efforts, maximize opportunity, achieve better outcomes for the Bay and adjacent communities, and be a leader in coordinated adaptation planning and implementation.

The Working Group's planning area is the San Leandro Bay OLU, which extends from the Bay Bridge to Oyster Bay Regional Shoreline (Figure 1). To date, the Working Group includes over 25 stakeholders with an interest in the San Leandro Bay shoreline, including cities, special districts, community-based organizations, regional, state, and federal agencies, and others. Major assets in this OLU vulnerable to SLR include (but are not limited to): residential communities, the Port of Oakland (including the Oakland International Airport), recreational facilities including the Bay Trail and Martin Luther King Jr. Regional Shoreline (MLK Shoreline), essential habitat such as Arrowhead Marsh for the endangered Ridgway's rail and other marsh species, and transportation corridors including Interstate 880 (I-880) and State Route (SR) 61/Doolittle Drive.

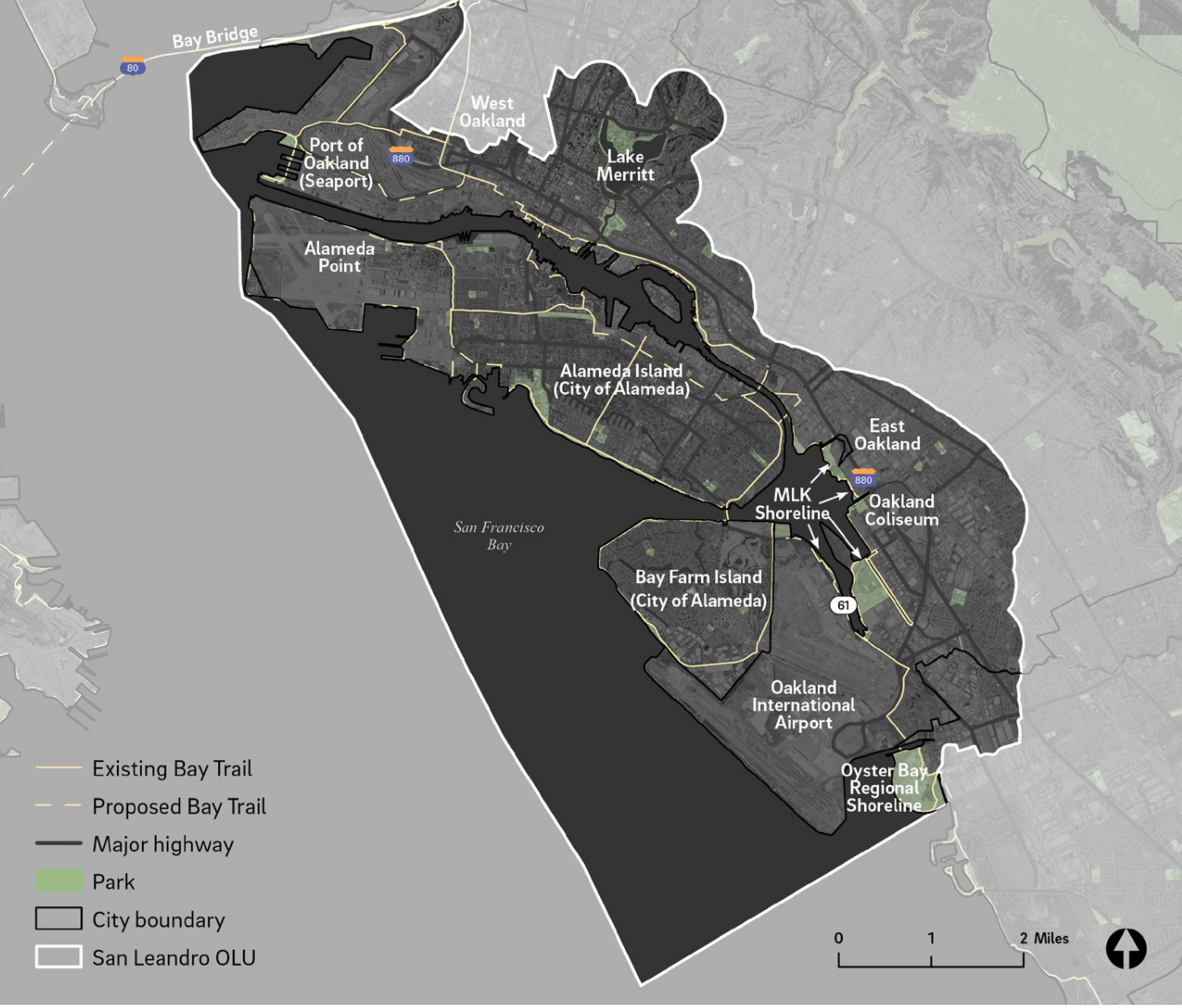


Figure 1. Key features of the San Leandro OLU.

PURPOSE OF THIS DOCUMENT

The present document is not a vulnerability assessment nor an adaptation plan. Instead, it demonstrates the application of Adaptation Atlas principles at the OLU scale. The San Leandro OLU is a highly urbanized and dynamic area, and correspondingly there are a range of ongoing projects, plans, and visions for the future of the shoreline from the many stakeholders in the area. Chapter 2 summarizes some of the vulnerability studies, habitat goals, and adaptation plans that have been developed for the area. Given the wide range of shoreline conditions and complex planning considerations for this OLU, there is a need to divide the OLU into subunits to allow more efficient collaboration on a project level. Chapter 3 lists suggested subunits for the OLU and explains the characteristics of each subunit, including physical and ecological conditions as well as stakeholders and jurisdictions. Chapter 4 of this document lays out example adaptation pathways for the San Leandro Bay subunit, including triggers and thresholds, to show how adaptation strategies can be woven together into a long-term plan for SLR adaptation that achieves multiple goals. Chapter 5 presents a limited version of the same type of analysis for the Oakland-Alameda Estuary subunit. The pathways build upon the lessons of the Adaptation Atlas by weaving suitable nature-based adaptation measures and physical SLR thresholds together with community priorities and existing plans. These pathways provide a first example for the Working Group as well as future OLUs as they engage in near-term and long-term adaptation planning. Suggested next steps are included in Chapter 6.

This document is not a plan, but rather is meant to catalyze discussion and inform future planning and coordination efforts of the Working Group. The adaptation pathways presented here are an initial set of conceptual ideas and will require review and careful consideration by Working Group partners to refine.

2. Existing plans

VULNERABILITY STUDIES AND LOCAL GOVERNMENT PLANS

Several existing SLR vulnerability studies cover the San Leandro OLU. Three studies have been conducted by the Bay Conservation and Development Commission (BCDC)'s Adapting to Rising Tides (ART) program: the Alameda County Shoreline Vulnerability Assessment (BCDC 2015), the Oakland-Alameda Resilience Study (BCDC 2016), and the local assessment for the San Leandro OLU conducted as part of the ART Bay Area report (BCDC 2020). Several other stakeholders have also completed vulnerability assessments and/or climate resilience plans, including the City of Alameda (City of Alameda 2019), the Port of Oakland (Port of Oakland 2019), and the East Bay Regional Park District (EBRPD 2021).

The Alameda County Shoreline Vulnerability Assessment (BCDC 2015) mapped inundation vulnerability for the Alameda County shoreline, including the San Leandro OLU, and identified potential actions to build resilience along the shoreline. The assessment notes that one of the most vulnerable parts of the Alameda County shoreline is the San Leandro Bay shoreline along Doolittle Drive. Since the development of this study, the mapping conducted by the ART program has been expanded to the region as a whole and provided as a resource through the ART Bay Area Flood Explorer. A snapshot of flooding in the San Leandro OLU with 3 feet (ft) of SLR from the Flood Explorer is shown in Figure 2. Many of the areas predicted to flood as sea levels rise are included within the Federal Emergency Management Agency (FEMA) 100-year floodplain (Figure 3).

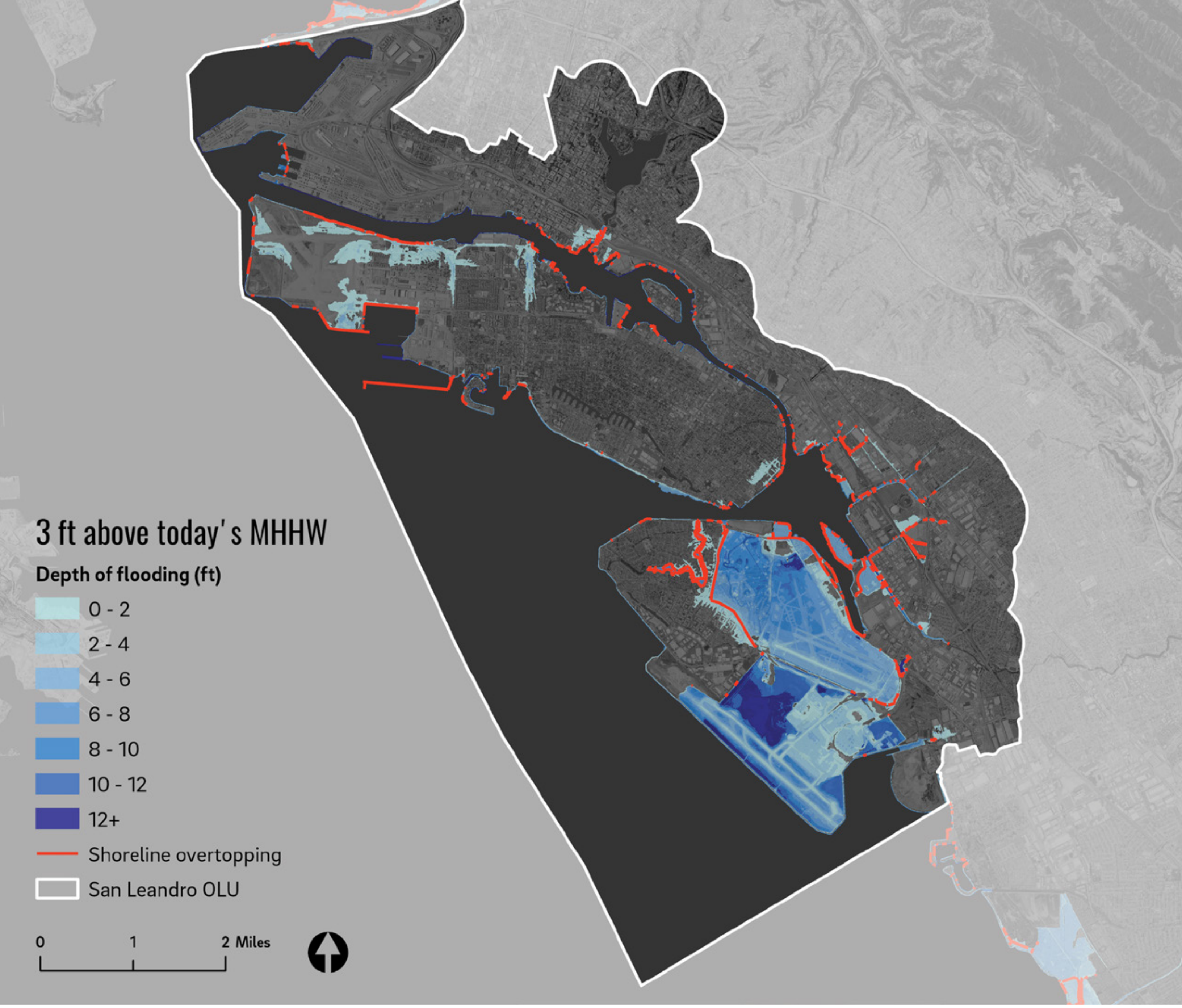


Figure 2. Flooding in the San Leandro OLU at 3 ft above today's Mean Higher High Water (MHHW) elevation. MHHW is the average of the higher of the two daily high tides. Data from BCDC's ART Bay Area Flood Explorer.

The Oakland-Alameda Resilience Study (BCDC 2016) furthered the findings of the ART Alameda County project, engaging many of the stakeholders serving as members of the current Working Group to evaluate issues related to SLR and flooding. The study emphasizes the impacts of combined riverine and coastal flooding near the Oakland Coliseum area, as well as seismic risk in the area. It also touches on the potential for rising groundwater to impact the Oakland/Alameda area and elaborates on the flood vulnerability of Bay Farm Island by identifying low spots on Doolittle Drive most likely to overtop with rising sea levels. Finally, the study identifies key planning issues, including preserving access to and from Bay Farm Island, protecting vulnerable neighborhoods including communities on Bay Farm Island and in the Coliseum area, and enhancing limited high-tide refuge habitat for the endangered California Ridgway's rail and other species.

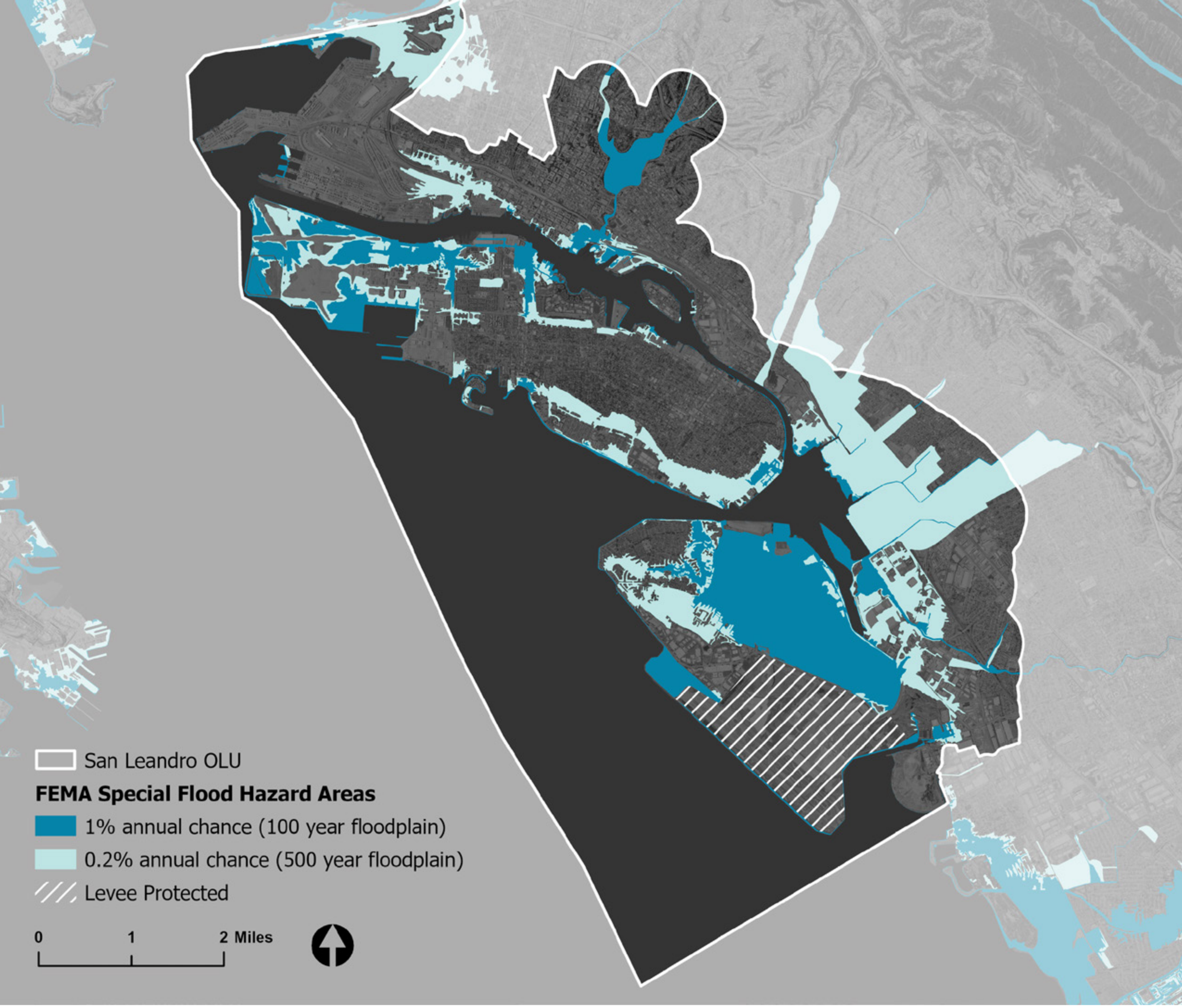


Figure 3. FEMA Special Flood Hazard Areas in the San Leandro OLU.

The most recent assessment for the area is the San Leandro OLU local assessment from the ART Bay Area Regional Sea Level Rise Vulnerability and Adaptation Study (BCDC 2020). This study provides a detailed overview of the SLR threats facing the OLU, with an emphasis on vulnerable communities, transportation, priority development areas, and priority conservation areas. A number of key areas are identified as being at risk, including the East Oakland and West Oakland communities, the Oakland airport and seaport, and a number of surface transportation assets including the Webster and Posey tubes as well as SR 61/ Doolittle Drive.

The City of Alameda's Climate Action and Resilience Plan (CARP) identifies SR 61/Doolittle Drive as a priority asset at risk of flooding from both rainfall and SLR. Among the other areas determined to be vulnerable were Eastshore Drive, the Webster and Posey Tubes, and Veteran's Court on Bay Farm Island, where flooding contributes to widespread issues along Doolittle Drive and in adjacent neighborhoods. Phased adaptation ideas are proposed in the CARP for each of these areas.

The City of Oakland does not yet have a comprehensive vulnerability assessment and adaptation plan, but the City does have several plans related to SLR and flooding which identify the need for such an assessment. These include the 2016-2021 Local Hazard Mitigation Plan, the Sea Level Rise Road Map (2017), and the 2030 Equitable Action Plan (2020). Oakland's Local Hazard Mitigation Plan identifies the risks and vulnerabilities to the City from SLR. The SLR Road Map investigates some of these vulnerabilities in more detail and identifies the Coliseum area as having the greatest SLR vulnerability in Oakland. A coincident high tide and storm surge causes temporary flooding in the Coliseum complex today.

Much of the San Leandro Bay OLU shoreline is owned and managed by the Port of Oakland. The Port's Vulnerability Assessment, completed in 2019, provides an assessment of port assets, and includes SLR mapping, vulnerability analysis, potential adaptation strategies, and financial cost analysis. The SLR vulnerability analysis utilizes flood extent layers from the BCDC ART program as well as 2-dimensional flood modeling completed by the Port of Oakland. Several areas were found to have high vulnerability to SLR, including the North Field area, a large, low-lying area of airport facilities protected by Doolittle Drive but subject to overtopping with SLR and/or a large storm event. The next step for the North Field area is to conduct a Stormwater Management and Tidal Flooding Vulnerability study to assess the existing storm water system and future SLR impacts at the Airport and propose improvements to the infrastructure. This study is anticipated to be completed in 2022.

The East Bay Regional Park District's Risk Assessment and Adaptation Prioritization Plan uses a risk assessment framework (hazard, vulnerability, and consequence) to assess the SLR risk for each segment of the Bay Trail along the East Bay shoreline. Two segments within the San Leandro OLU received high risk scores and were deemed priority sites for adaptation: MLK Shoreline, which runs along the San Leandro Bay shoreline, and Alameda Point shoreline, along the northwestern edge of Alameda Island.

COMMUNITY PLANS

The East Oakland Neighborhoods Initiative Community Plan (EONI 2019) is focused on five goals: to reduce greenhouse gases, prevent displacement, improve public health, build economic empowerment, and plan by and with the community. Many of the community priorities identified in the plan relate to adaptation planning, including adaptation to flooding from SLR and rising groundwater. Neglected urban and community centers, lack of public transportation, and environmental hazards due to climate change were the top neighborhood concerns identified. Top improvement priorities were urban greening and increased affordable housing. Several specific project ideas called out in the plan relate to improved public access to the MLK Shoreline. Ideas include a San Leandro Creek greenway linking the Elmhurst neighborhood to the shoreline, and a bicycle and pedestrian bridge over I-880. To address shoreline access, the East Oakland Collective is now collaborating with the City of Oakland's Department of Transportation on a project called "Power the People: MLK Jr. Shoreline Action Study," which will study the feasibility of implementing a new zero emissions bus route to facilitate access to the MLK Shoreline for residents of East Oakland.

The West Oakland Environmental Indicators Project's Oakland Shoreline Leadership Academy (OSLA) recently concluded its first session in December 2020, with a continued engagement process planned. Academy participants developed a wide range of ideas to improve shoreline conditions for members of the East and West Oakland communities. Many of the proposals focused on enhancing the recreational and educational experience along the Bay Trail. One area in particular identified as a potential area for enhancement was the trail behind Damon Marsh from East Creek Slough to Damon Slough, where participants proposed an interactive spiritual and mental wellness space integrated with native vegetation plantings (Walker and Santos 2021).

HABITAT GOALS

Though the San Leandro OLU is highly urbanized, it hosts some important habitat areas, including patches of marsh, oyster, and eelgrass habitat. The 2015 Baylands Ecosystem Habitat Goals identify a number of priorities for habitat preservation and restoration in the context of climate change in the San Leandro OLU. These goals include creating a string of pocket habitats of sand beaches, eelgrass, oyster beds, macroalgal beds, mudflats, and rocky intertidal areas. The Habitat Goals suggest restoring any area possible to marshland if opportunities for managed retreat arise, in particular emphasizing connected segments of tidal marsh. Goals for specific species include: (1) enhancing and protecting habitat for snowy plover and least tern; (2) improving opportunities for cover and high tide refuge for Ridgway's rail; (3) restoring low-lying beaches to support reintroduced California sea-blite; and (4) increasing habitat for harbor seals. Overall, the Goals Project recognizes that fringing marsh in this segment does not have much available migration space and is very vulnerable to drowning with rising sea levels.

San Leandro Bay is an important hotspot for Ridgway's rail, supporting about 110 birds in 2020, the majority of these at Arrowhead Marsh and adjacent MLK "New Marsh" aka "MLK Marsh" (Olofson Environmental, Inc. 2020). Management efforts have focused on preserving habitat for rail, including navigating the tradeoff between eradicating invasive smooth cordgrass (*Spartina alternifora*) and preserving rail populations, which respond negatively to invasive cordgrass eradication efforts. These eradication efforts benefit other species, including native shorebirds, which forage on mudflats that can be colonized by invasive cordgrass (Grosholz et al., 2009). There is also a focus on enhancement of high tide refuge habitat, given the reliance of Ridgway's rail on high tide refuge cover to avoid predation during high water events. Efforts have included native revegetation efforts in the limited marsh-upland transition zone as well as placement of artificial floating refuge islands. These artificial habitats may provide effective refuge for rail in the context of rising sea levels, at least in the short term (Overton et al. 2015).

Experimental floating high tide refuge island at Arrowhead Marsh (from Overton et al., 2015)

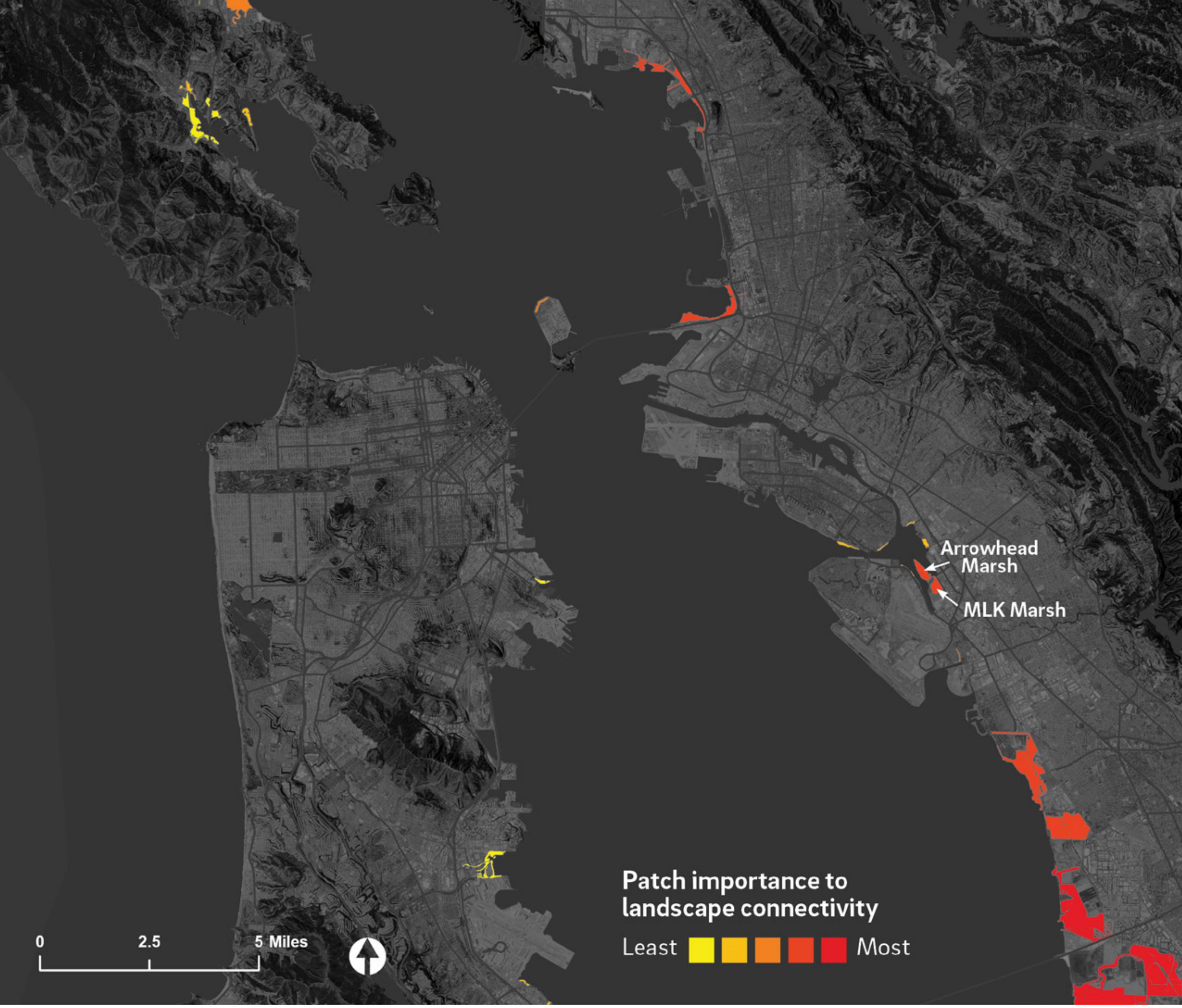


Figure 4. Connectivity of existing and planned marsh patches for California Ridgway's rail in central San Francisco Bay. From SFEI 2021.

A recent analysis conducted as an addendum to the Adaptation Atlas confirmed the importance of Arrowhead and MLK Marshes in terms of habitat connectivity for Ridgway's rail (SFEI 2021). With limited habitat "stepping stones" along the highly developed East Bay shoreline (Figure 4), these patches serve an important role in promoting the longevity of the San Francisco Bay Ridgway's rail population. Rail also make use of channels and sloughs when foraging, so protection and enhancement of this habitat type in addition marsh plain and high tide refuge habitat can be important for rail populations.

ADAPTATION ATLAS

Because there is little open space in the San Leandro OLU, the Adaptation Atlas notes that the significant opportunities for natural and nature-based strategies are on the shoreline or in subtidal areas, particularly in and around San Leandro Bay. Eelgrass beds and other submerged aquatic vegetation are suitable and could help increase ecosystem services and attenuate wave energy, though wave energy is already fairly low within San Leandro Bay. Coarse beaches, which can buffer wave energy and soften shorelines for habitat and recreation, may be suitable for the high-energy wave environments on the San Francisco Bay side of Alameda and Bay Farm Islands, particularly when combined with stabilizing groins and nourishment. Management of these beaches would have to take into account the significant longshore transport of material into the Bay and nearshore areas. There is little room for ecotone levees adjacent to existing marshes, though in some locations they may be appropriate following the realignment of shoreline protection structures.

The Atlas also provides some information related to adaptation of developed areas. Much of the residential and industrial development along the shoreline in the San Leandro OLU is on fill material over historical baylands and is subject to impacts from rising groundwater, including increased liquefaction risk. Opportunities identified in the Adaptation Atlas include: (1) elevating land and roads; (2) requiring retrofits of buildings and flood-proofing of ground floors; (3) creating floodable spaces upland in the watershed to minimize combined flooding; (4) adding green infrastructure; (5) establishing a SLR overlay zone to identify high-hazard areas and the policies and financial strategies that may be used to help them adapt; and (6) building inland flood walls and berms as needed. A mix of gray and green infrastructure will likely be needed. Some businesses or industrial areas with repeat-flood issues in the future may be supported in moving to higher ground through a transfer of development rights program or tax incentives; residential neighborhoods could establish a Geologic Hazard Abatement District to finance needed protections.

3. Subunits

Given the complexity and highly urbanized nature of the San Leandro OLU, as well as the wide variety of stakeholders, smaller project-relevant breakout groups may be needed at the sub-OLU scale. The OLU-wide working group is valuable for high-level coordination, and smaller focus groups can help stakeholders coordinate on specific projects and planning efforts that are likely to impact direct neighbors. Some of these groups have already started to coalesce around specific subunits vulnerable to SLR. For example, the Doolittle Drive Adaptation Coordination group already convenes for monthly check-ins, and initial conversations have explored the idea of an Oakland-Alameda Estuary coordination group. In this chapter, several subunits are suggested for the San Leandro OLU based on shared physical characteristics.

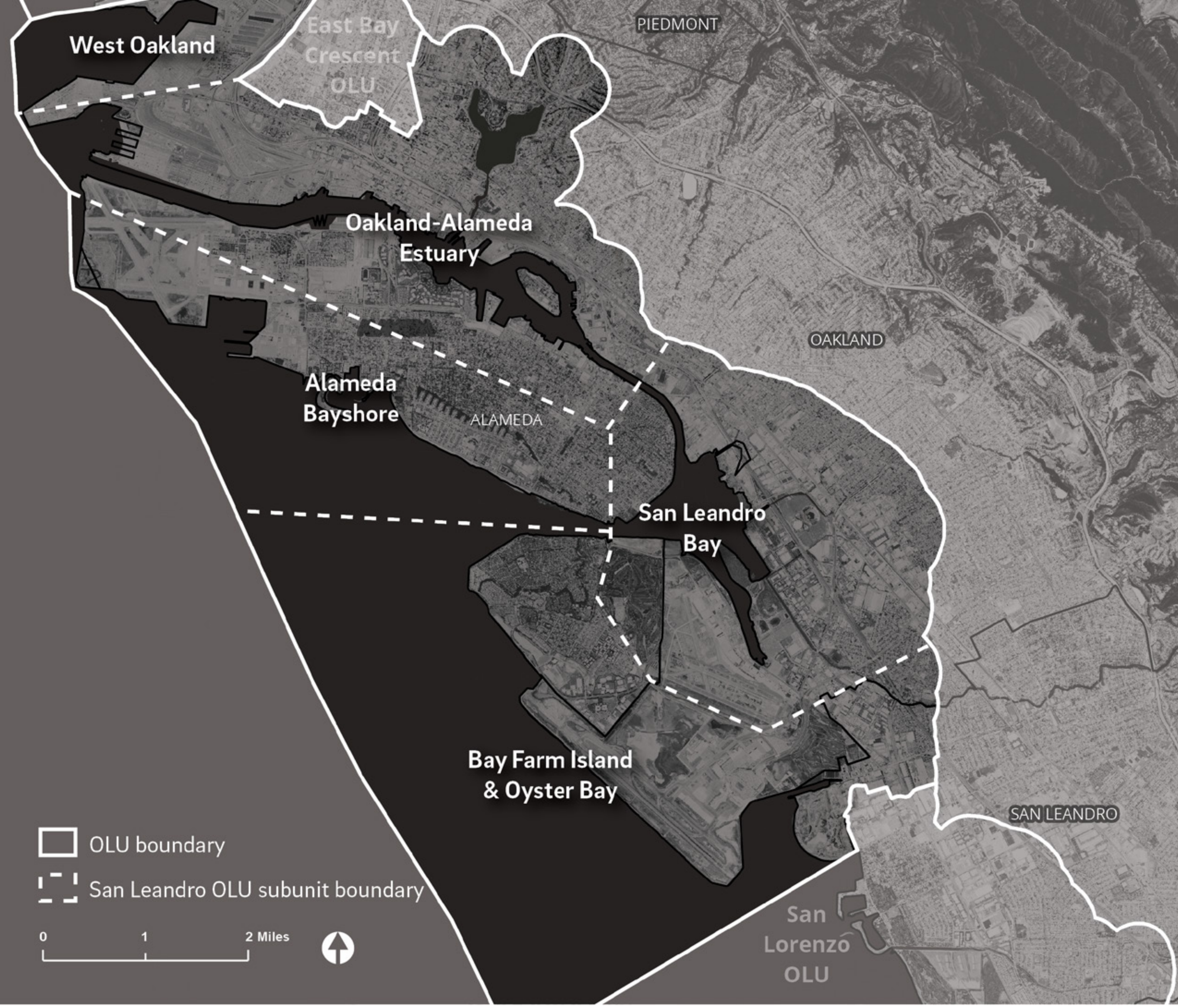


Figure 5. Suggested subunits for the San Leandro OLU.

SUGGESTED SUBUNITS FOR THE SAN LEANDRO OLU

Figure 5 outlines suggested subunits for the San Leandro OLU. The West Oakland subunit is wave-exposed, with seawalls, quays, and subtidal habitat. The Oakland-Alameda Estuary subunit (which also includes Lake Merritt) is a highly urbanized estuary with a shoreline dominated by seawalls. San Leandro Bay is a small embayment relatively protected from wave action, with patches of marsh habitat and wide mudflats. Alameda Bayshore is wave-exposed with beaches. Bay Farm Island is exposed to high wave action and surrounded by deep subtidal habitat, and includes the Oakland airport (a low-lying development surrounded by a levee) and the Bay Farm island neighborhoods (a "high fill" development with no levee).

1. West Oakland

The West Oakland shoreline is primarily owned and managed by the Port of Oakland. Industrial activity around the Port terminals has significantly altered the physical characteristics of the shoreline. Much of the shoreline is hardened and deepwater channels have been dredged for access by oceangoing ships. According to the ART Bay Area Flood Explorer, widespread daily flooding from SLR is not anticipated in this area until sea levels reach 4.3 ft (52 in) above today's MHHW, with storm surge and rising groundwater impacts occurring sooner. Wave heights in this reach of the shoreline are moderate to high. The primary potential nature-based SLR adaptation measure for this shoreline identified in the Adaptation Atlas is coarse beaches along the fortified shoreline. Restoration of shallow subtidal habitat (beneficial reuse of dredge spoils and planting of eelgrass beds) is already underway at Middle Harbor Shoreline Park.

2. Oakland-Alameda Estuary and Lake Merritt

The Oakland-Alameda Estuary (aka Oakland Inner Harbor) is a former tidal inlet that is dredged to connect San Francisco Bay through to San Leandro Bay. It is bordered to the north by the City of Oakland and to the south by Alameda Island (City of Alameda). Both sides of the estuary are hardened and heavily developed. Water levels in Lake Merritt, a tidal lagoon connected to the estuary, are controlled by a tide gate with a pump system. According to the ART Bay Area Flood Explorer, the Alameda Island estuary shoreline and the banks of the Lake Merritt channel will start to overtop with water levels just 2 ft above today's MHHW, and rising groundwater is likely to cause issues even sooner. Wave heights in this reach of the shoreline are low. Few potential nature-based SLR adaptation measures for this shoreline were identified in the Adaptation Atlas, though there may be opportunities for coarse beaches and subtidal habitat features on hardened structures.

3. Alameda Bayshore

Historically, there were large mudflats and beaches along this reach of the Alameda shoreline. Extensive fill and development has highly altered the shoreline, including at the former Alameda Naval Air Station (Alameda Point). Redevelopment, including development of large parks/open space and ecological restoration projects, is underway at Alameda Point. The Baylands Goals Update identifies this area as an opportunity to protect and enhance habitat for snowy plover and least tern (Goals Project 2015). South of Alameda Point, Crown Beach is artificially nourished with dredged sediment, which reduces wave erosion of the shoreline and provides habitat for shorebirds as well as recreational opportunities. According to the ART Bay Area Flood Explorer, the first area to overtop from SLR in this reach is at Alameda Point (at the location planned for restoration of a future DePave Park). The Alameda Bayshore is one of the most exposed areas to wave action in the San Leandro OLU. Widespread flooding from overtopping of Shore Line Drive (behind Crown Beach) is not predicted until sea levels reach 4 ft above today's MHHW, though impacts may occur sooner due to storm surges, waves, and rising groundwater. The primary potential nature-based SLR adaptation measures for this shoreline identified in the Adaptation Atlas are beach nourishment, creation of coarse beaches along the fortified shoreline, and eelgrass restoration.

4. Bay Farm Island & Oyster Bay

The shoreline along the San Francisco Bay shore of Bay Farm Island experiences the highest wave heights in the San Leandro OLU, and among the highest wave heights in the Bay. The shoreline, which is highly developed with a hardened edge, is therefore vulnerable to wave erosion. Built almost entirely on fill over historic marsh, mudflat, and open water, the area is low-lying and subject to both overtopping from storm surges and flooding from emergent groundwater. Land uses along the shoreline include residential neighborhoods, business parks, and the Oakland International Airport. External levees are relatively high, especially at the Oakland airport, where the perimeter dike has just been raised to meet FEMA certification standards. Pumping is already required to manage shallow groundwater. The primary potential nature-based SLR adaptation measures for this shoreline identified in the Adaptation Atlas are coarse beaches along the fortified shoreline and eelgrass restoration.

5. San Leandro Bay

San Leandro Bay, a shallow tidal inlet that was historically ringed by extensive tidal marshes, has undergone significant diking, draining, dredging, and filling that have substantially altered the landscape since the late 19th century, when the channel connecting San Leandro Bay to the Oakland Inner Harbor was dredged. Despite massive losses of tidal marsh in the area during the same period, some new marsh was added in 1874 when the sediment that had been placed for a dam at Lake Chabot washed down San Leandro Creek and formed Arrowhead Marsh. Today, Arrowhead Marsh provides important habitat for a variety of species including endangered salt marsh harvest mouse and Ridgway's rail. The marsh is a feature of San Leandro Bay beloved by visitors to the MLK Shoreline, including residents of nearby East Oakland.

Almost totally surrounded by land, San Leandro Bay is relatively sheltered from wind waves. However, due to low elevations, much of the San Leandro Bay shoreline is highly vulnerable to rising sea levels. According to the ART Bay Area Flood Explorer, areas along the San Leandro Bayshore likely to experience daily flood impacts at 3 ft of SLR (with overtopping occurring sooner in some areas) include Eastshore Drive in Alameda, Doolittle Drive in Oakland and Alameda, and the Bay Trail along the MLK Shoreline. Due to low elevations and lack of migration space, Arrowhead Marsh and other marsh patches in San Leandro Bay are highly vulnerable to drowning with rising sea levels.

An analysis of suitable nature-based adaptation strategies and a set of example adaptation pathways for San Leandro Bay and Oakland-Alameda Estuary subunits are presented in the following chapter.

4. San Leandro Bay Subunit: Case Study & Pathways

To develop example adaptation pathways, we used the following process: (1) identify focus areas and key resources vulnerable to SLR; (2) list vulnerabilities and opportunities associated with each resource; (3) determine key SLR thresholds; (4) develop adaptation strategies to address vulnerabilities and pair with key SLR thresholds. Each of these steps is described in more detail below.

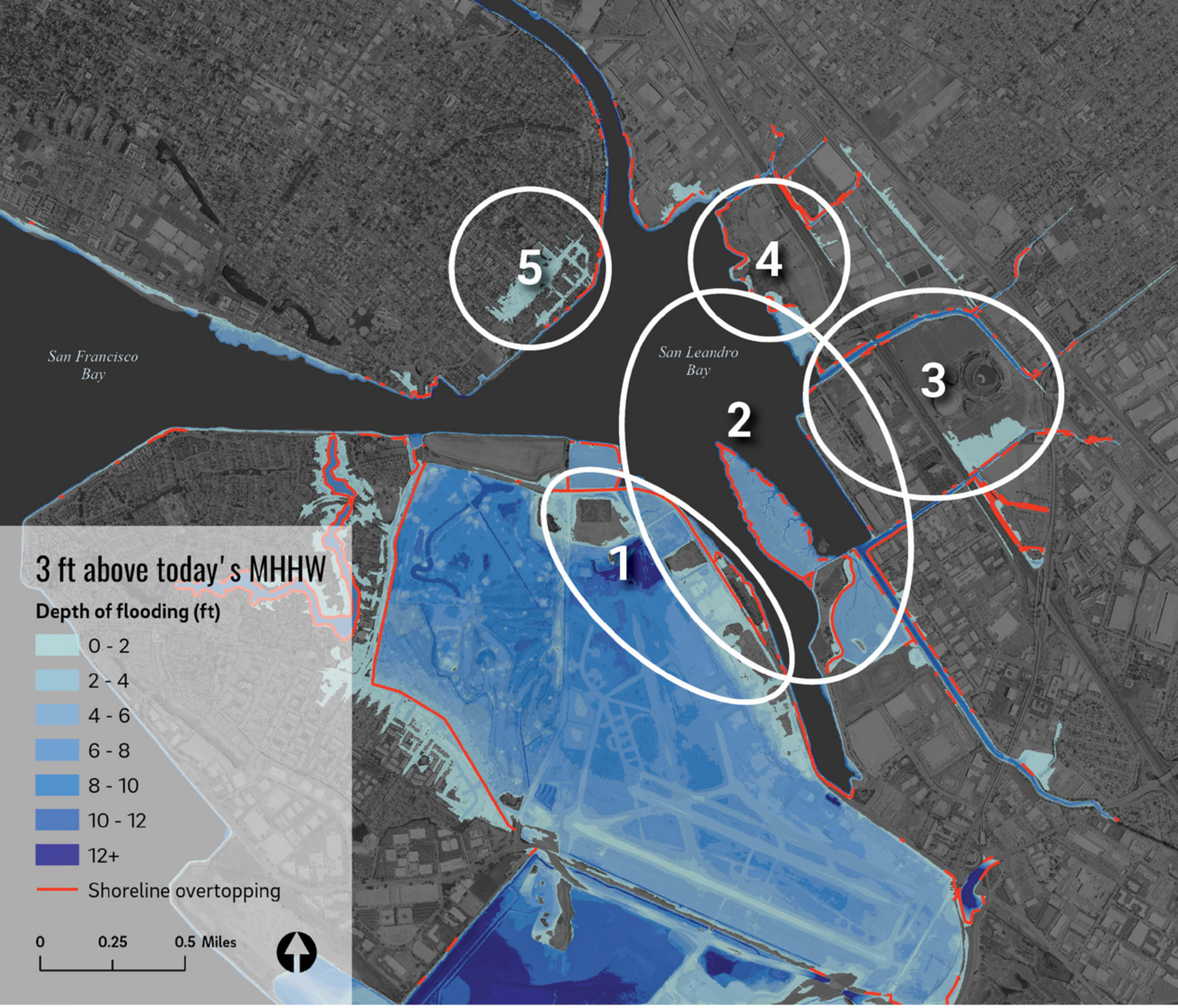


Figure 6. Identified focus areas for the San Leandro Bay subunit: (1) Doolittle Drive; (2) San Leandro Bay marshes; (3) Oakland Coliseum area/ Damon Slough; (4) MLK Shoreline/Bay Trail; (5) Alameda's Eastshore neighborhood. Flood mapping from ART Bay Shoreline Flood Explorer.

FOCUS AREAS

A synthesis of key vulnerabilities and opportunities revealed focus areas requiring adaptation planning in San Leandro Bay. The vulnerability assessments and planning documents described above in Chapter 2 identify the following places as SLR hotspots: (1) SR 61/Doolittle Drive; (2) San Leandro Bay marshes; (3) Oakland Coliseum area/Damon Slough; (4) MLK Shoreline/Bay Trail; and (5) Alameda's Eastshore neighborhood (Figure 6). The present document focuses on SR 61/Doolittle Drive, San Leandro Bay Marshes, and the MLK Shoreline/Bay Trail. The Oakland Coliseum and Alameda Eastshore neighborhoods are identified as important areas for future adaptation pathway development.

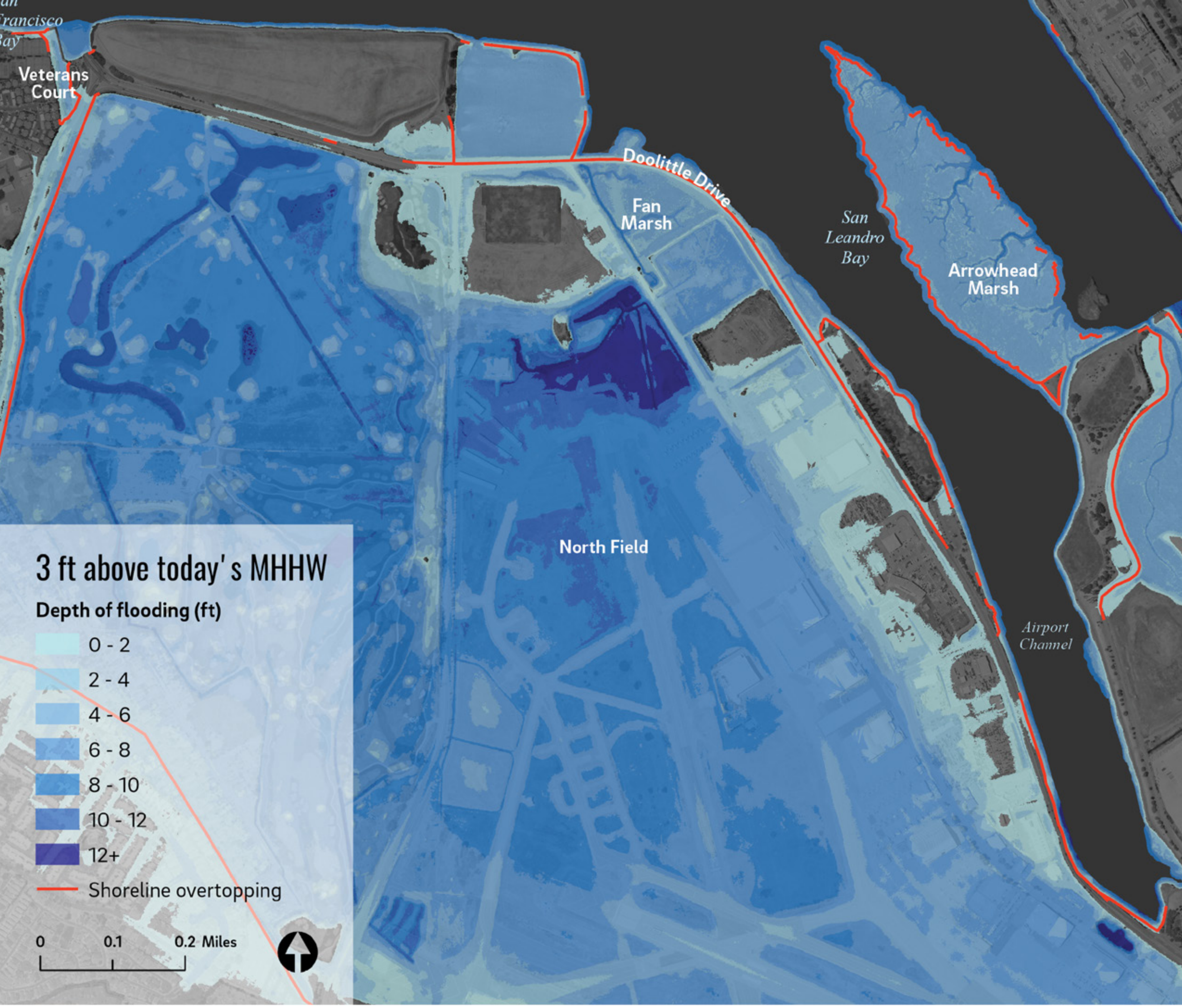


Figure 7. Flooding in the Doolittle Drive area at 3 ft above today's high tides. Data from BCDC's ART Bay Area Flood Explorer.

SR 61/ Doolittle Drive

Vulnerabilities at Doolittle Drive include overtopping of the roadway, backflow through culverts, rising groundwater, and flooding of the large low-lying North Field area protected by Doolittle Drive, which serves as a de facto levee (Figure 7). There may be opportunities to reconstruct the roadway to reduce flood risk and maintain an important transportation connection, while providing additional benefits for habitat and recreation. Recent restorations along Airport Channel may provide some habitat benefit and road protection, but these areas will be flooded in the coming decades (EBRPD 2021). Floodwaters also enter Bay Farm Island from the north at Veterans Court (west of the Alameda-Bay Farm Island bridge). However, Veterans Court and other Bay Farm Island overtopping locations like the lagoon outfall/tide gate on the northern shore are outside the San Leandro Bay subunit and the scope of this effort. Other efforts are actively addressing adaptation planning for this area; for example, upgrading the Veterans Court seawall was identified as a near-term priority in the Alameda Climate Action and Resiliency Plan and planning for the upgrade is now underway.

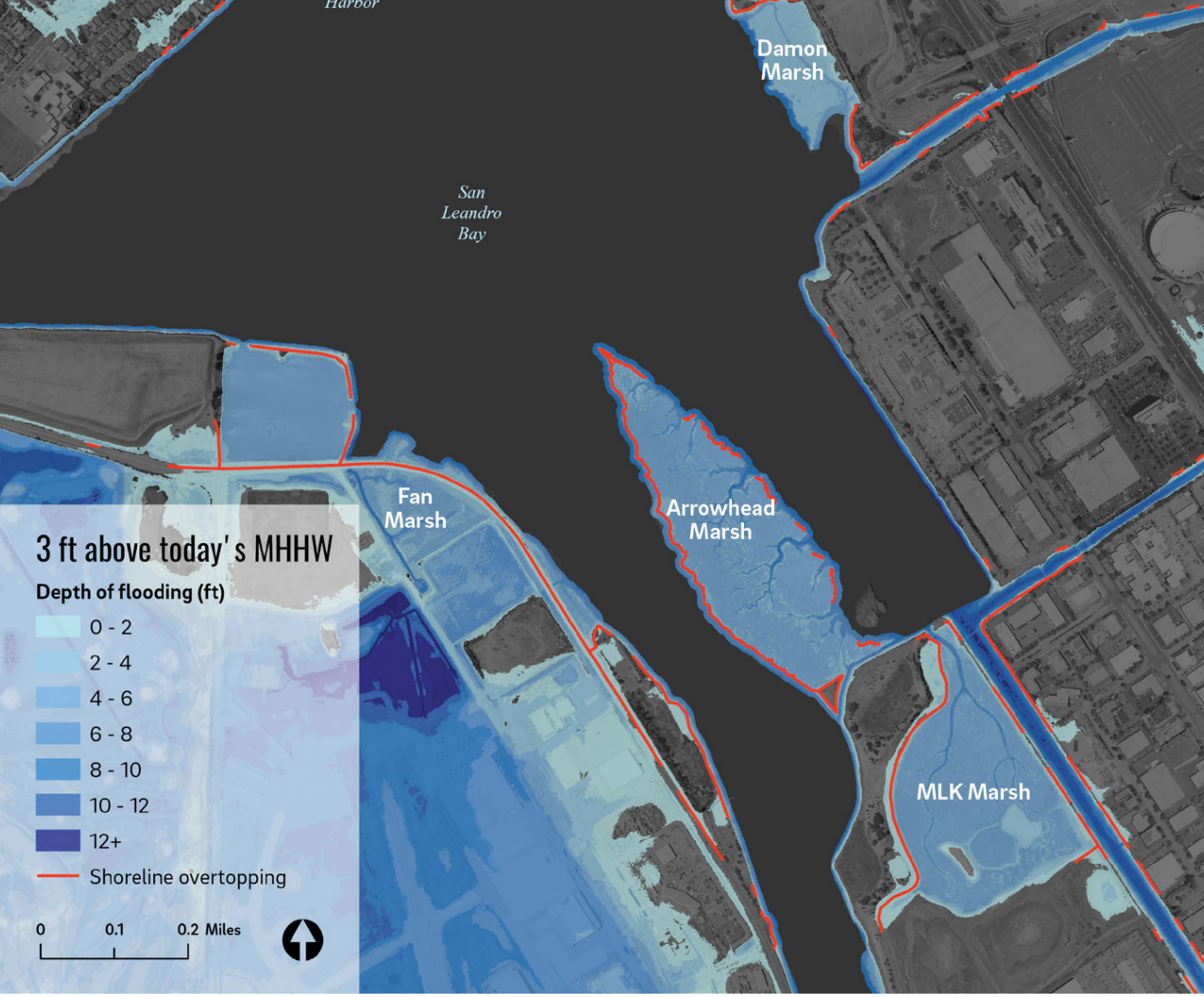


Figure 8. Flooding of San Leandro Bay marshes at 3 ft above today's high tides. Data from BCDC's ART Bay Area Flood Explorer.

San Leandro Bay marshes

Key marsh habitat patches are found in San Leandro Bay at Fan, Arrowhead, MLK, and Damon Marshes (Figure 8). These marshes are fairly low in elevation and are dominated by low marsh vegetation today. Much of the Bay's remaining invasive cordgrass (*Spartina alterniflora* and hybrids) is found in San Leandro Bay, and work is ongoing to eradicate invasive cordgrass while minimizing impacts of eradication efforts on the endangered California Ridgway's rail (Rohmer and Kerr 2021). In addition to threats from invasive species, San Leandro Bay marshes are at risk of drowning due to sea-level rise. Without high sediment inputs, they will be submerged on a more and more regular basis until the marsh habitat is lost altogether. Despite some existing constraints, especially at Arrowhead Marsh, there may be opportunities to promote upland migration of these marshes if existing infrastructure currently restricting marsh migration (trails and recreational facilities) are reconfigured. Active adaptation planning could help prolong the lifespan of these marsh patches, which provide important habitat connections for Ridgway's rail and other species.

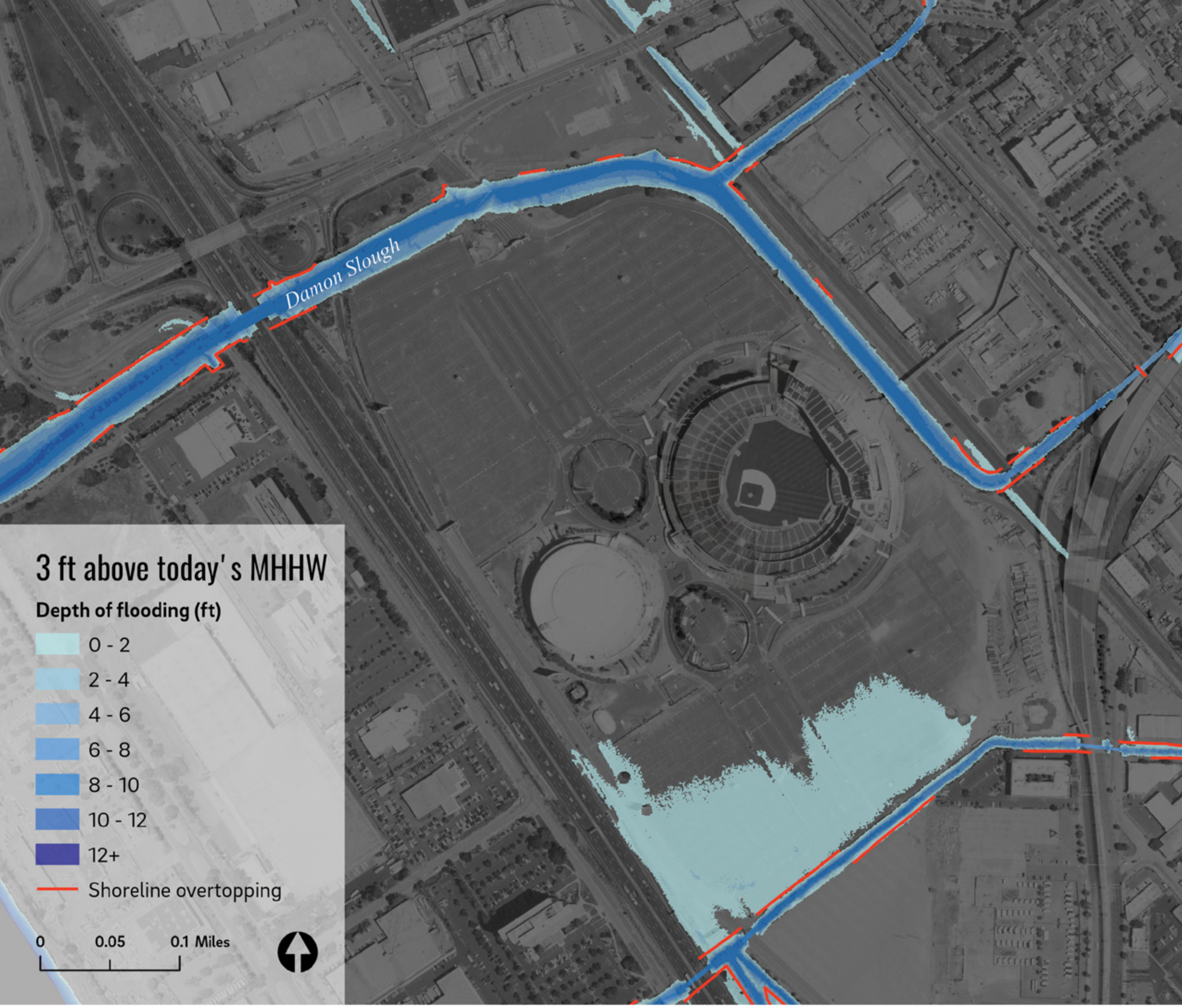


Figure 9. Flooding in the Oakland Coliseum area at 3 ft above today's high tides. Data from BCDC's ART Bay Area Flood Explorer.

Oakland Coliseum area and Damon Slough

The Oakland Coliseum, including parking lots and the surrounding area, is vulnerable to flooding from overtopping at adjacent sloughs (Figure 9). It is also subject to combined flooding from SLR and riverine flooding, as well as rising groundwater. A detailed analysis of the vulnerabilities of this area was conducted for the Metropolitan Transportation Commission (MTC)'s Climate Adaptation Pilot Study (AECOM 2014a). A number of past studies have proposed adaptation options for the area, including a living levee along Damon Slough as well as floodable and floating development in the Coliseum complex (AECOM 2014a, All Bay Collective 2018). Extensive adaptation will be required and can be implemented as part of the upcoming redevelopment of the Coliseum complex, as envisioned in the City of Oakland's Coliseum Area Specific Plan (City of Oakland 2015), which calls for the redevelopment of a vibrant mixed-use area at this transit-served location. Developing adaptation pathways for this major redevelopment effort is outside the scope of the present document and is an important next step for the Working Group.

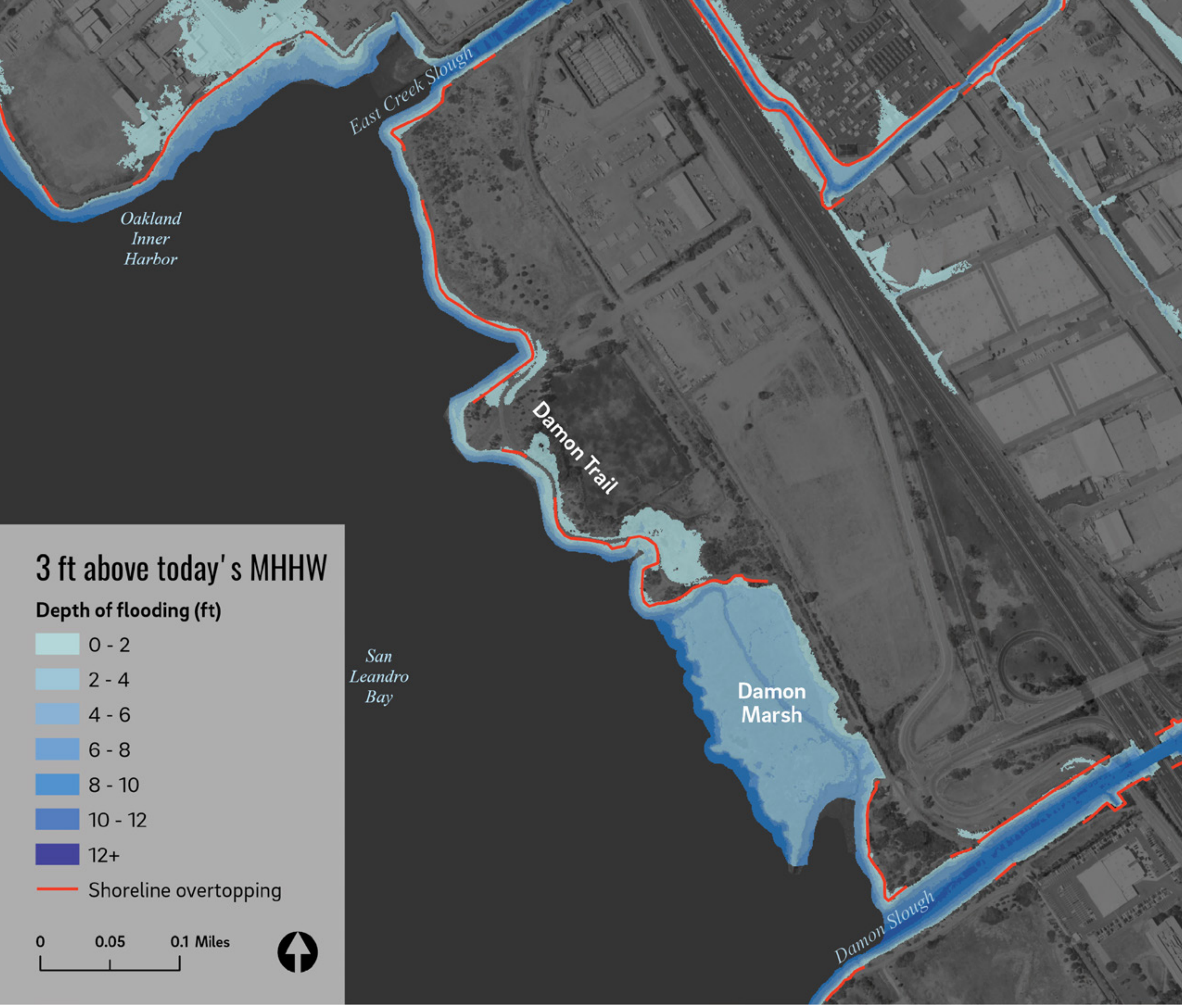


Figure 10. Flooding in the Damon Trail area at 3 ft above today's high tides. Data from BCDC's ART Bay Area Flood Explorer.

MLK Shoreline / Bay Trail

The Bay Trail along the MLK Shoreline wis identified as being vulnerable to SLR (Figure 10) in the East Bay Regional Park District's recent risk assessment (EBRPD 2021). There are opportunities to enhance the resilience of the trail and recreational facilities to SLR and expand access for the East Oakland Community. Better access and connectivity from East Oakland to San Leandro Bay has been identified as a major community priority by the East Oakland Neighborhoods Initiative and the East Oakland Collective is leading planning to improve transportation connections. There are also opportunities to enhance the recreational experience at the MLK Shoreline. Several proposals by participants in the 2021 Oakland Shoreline Leadership Academy, hosted by the West Oakland Environmental Indicators Project, focused on this topic. The present document focuses on adaptation of the "Damon Trail," the Bay Trail along the MLK Shoreline from East Creek Slough to Damon Slough.

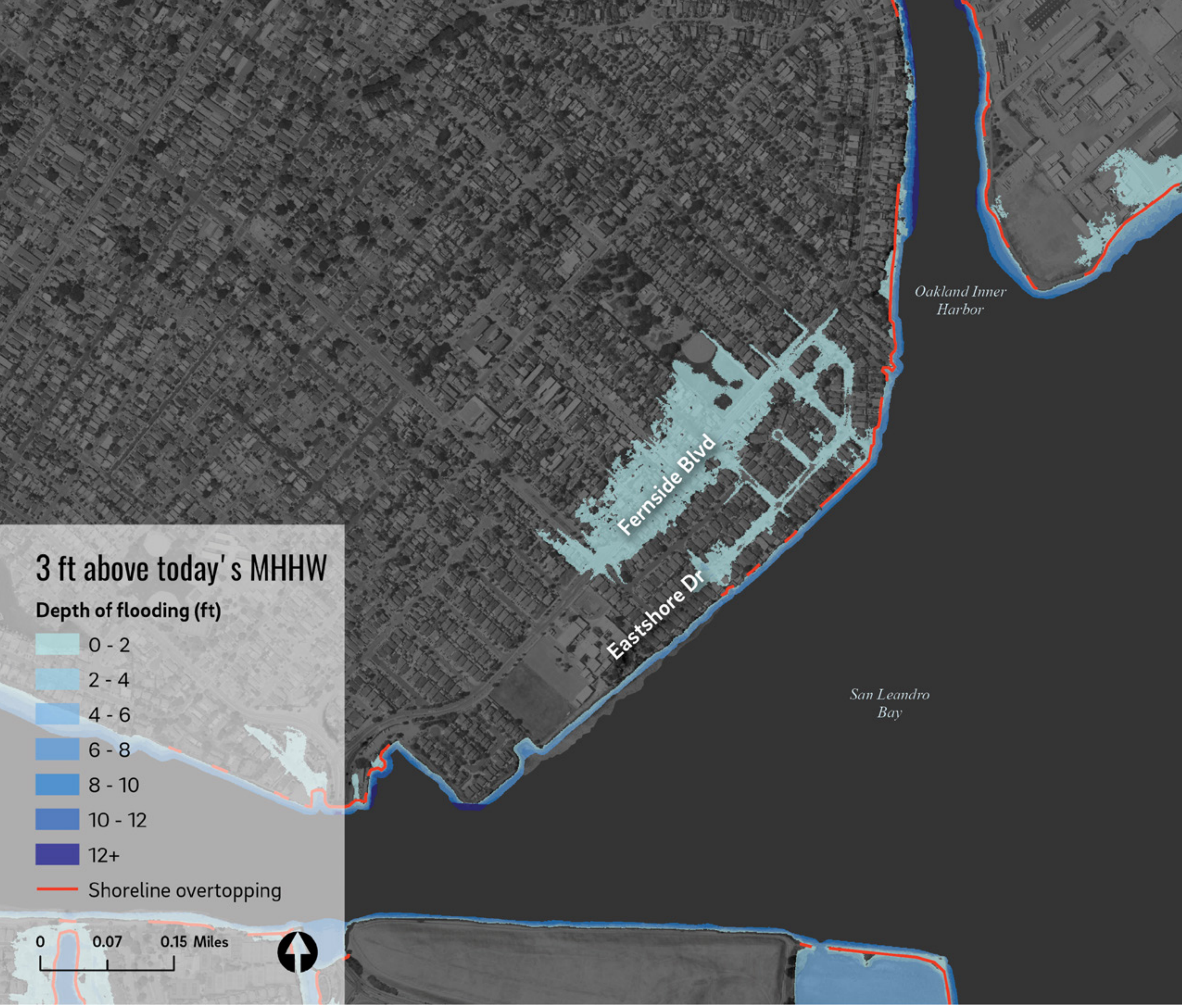


Figure 11. Flooding in Alameda's Eastshore Drive area at 3 ft above today's high tides. Data from BCDC's ART Bay Area Flood Explorer.

Alameda's Eastshore Neighborhood

Alameda's Climate Action and Resiliency Plan (CARP) (City of Alameda 2019) identifies the neighborhood along Eastshore Drive as being vulnerable to SLR (Figure 11) and notes that parts of the neighborhood were recently determined by FEMA to be within the 100-year flood zone (Figure 3). The CARP lays out some potential adaptation actions for the neighborhood, including raising barriers, mudflat augmentation, and exploring the floating neighborhoods proposal from the Estuary Commons proposal in the Resilient By Design competition (All Bay Collective 2018). Due to the limited scope of the present effort, adaptation pathways were not developed for this residential community. This will be an important next step for the Working Group.

SEA-LEVEL RISE THRESHOLDS

Overtopping

Water levels in San Leandro Bay under various SLR, tide, and storm surge scenarios are shown in Table 1. These water levels are compared with ground elevations (Figure 12) to determine overtopping thresholds.

Table 1. Water levels in San Leandro Bay. Compiled from National Oceanic and Atmospheric Administration (NOAA) tidal datums for station 9414711, Oakland Airport (southern tip of Airport Channel in San Leandro Bay) and SLR and Extreme Tide Matrix for Alameda County (Vandever et al. 2017). MHHW is "Mean Higher High Water," the average of the higher of the two daily high tides. NAVD refers to the North American Vertical Datum of 1988, a set elevation reference point on the earth's surface.

Total Water Level (ft NAVD)	**Ft above today's MHHW**	**SLR (ft)**	**Tide**	**Storm surge**	**Approx. year** (Med-High Risk Aversion Scenario, High Emissions) (CA OPC 2018)
6.5	0	0	MHHW	-	2022
7.5	1.0	0	King Tide	-	2022
8.0	1.5	0	MHHW	2-year surge	2022
8.0	1.5	0.5	King Tide	-	2030
8.0	1.5	1.5	MHHW	-	2040-2050
9.0	2.5	0	MHHW	10-25 year surge	2022
9.0	2.5	0.5	MHHW	5-year surge	2030
9.0	2.5	1.0	MHHW	2-year surge	2030-2040
9.0	2.5	1.5	King Tide	-	2040-2050
10.0	3.5	0	MHHW	100-year surge	2022
10.0	3.5	1.5	MHHW	5-year surge	2040-2050
10.0	3.5	2.0	MHHW	2-year surge	2050-2060
10.0	3.5	2.5	King Tide	-	2060

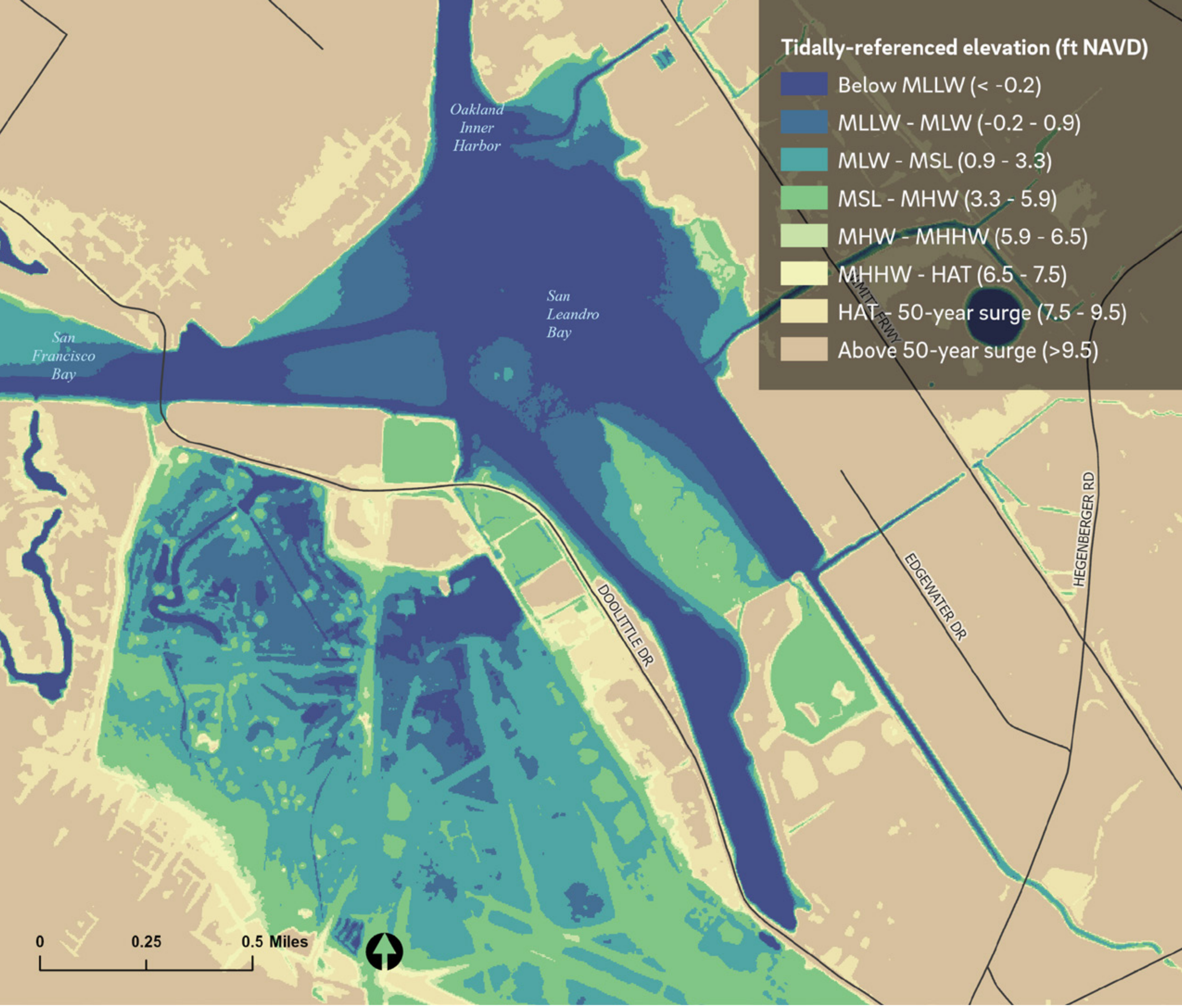


Figure 12. Ground elevations for San Leandro Bay. Elevation data from the United States Geological Survey (USGS) vegetation-corrected dataset for SF Bay (Buffington and Thorne 2019). Note the large low-lying area on Bay Farm Island, which is protected from flooding by Doolittle Drive. Grade changes may have occurred in some places since the aerial survey data used to create the digital elevation model were collected. MLLW is Mean Lower Low Water; MLW is Mean Low Water; MSL is Mean Sea Level; MHW is Mean High Water; MHHW is Mean Higher High Water; HAT is Highest Astronomical Tide.

For the shorelines of interest, ground elevations were extracted from the San Francisco Bay Shore Inventory (SFEI 2016). Elevations of Doolittle Drive in particular are important to consider because the road serves a de facto levee protecting low-lying inland areas on Bay Farm Island. Doolittle Drive is a fairly flat road, with elevation ranging from 8.4-13.1 ft NAVD along the segment of interest (Figure 13). Low spots in the Bay Shore Inventory data aligned with the analysis conducted for MTC by AECOM in 2014 (AECOM 2014b). However, a more detailed analysis conducted in the AECOM report of the LiDAR data underlying the digital elevation model, which smooths out peaks when averaging point returns, revealed that the actual peak elevation of Doolittle Drive in these low spots is closer to 9 ft than 8.5 ft, meaning there could be impacts to the roadway at 8.5 ft but large scale overtopping and flooding of Bay Farm Island is unlikely before 9 ft (AECOM 2014b).

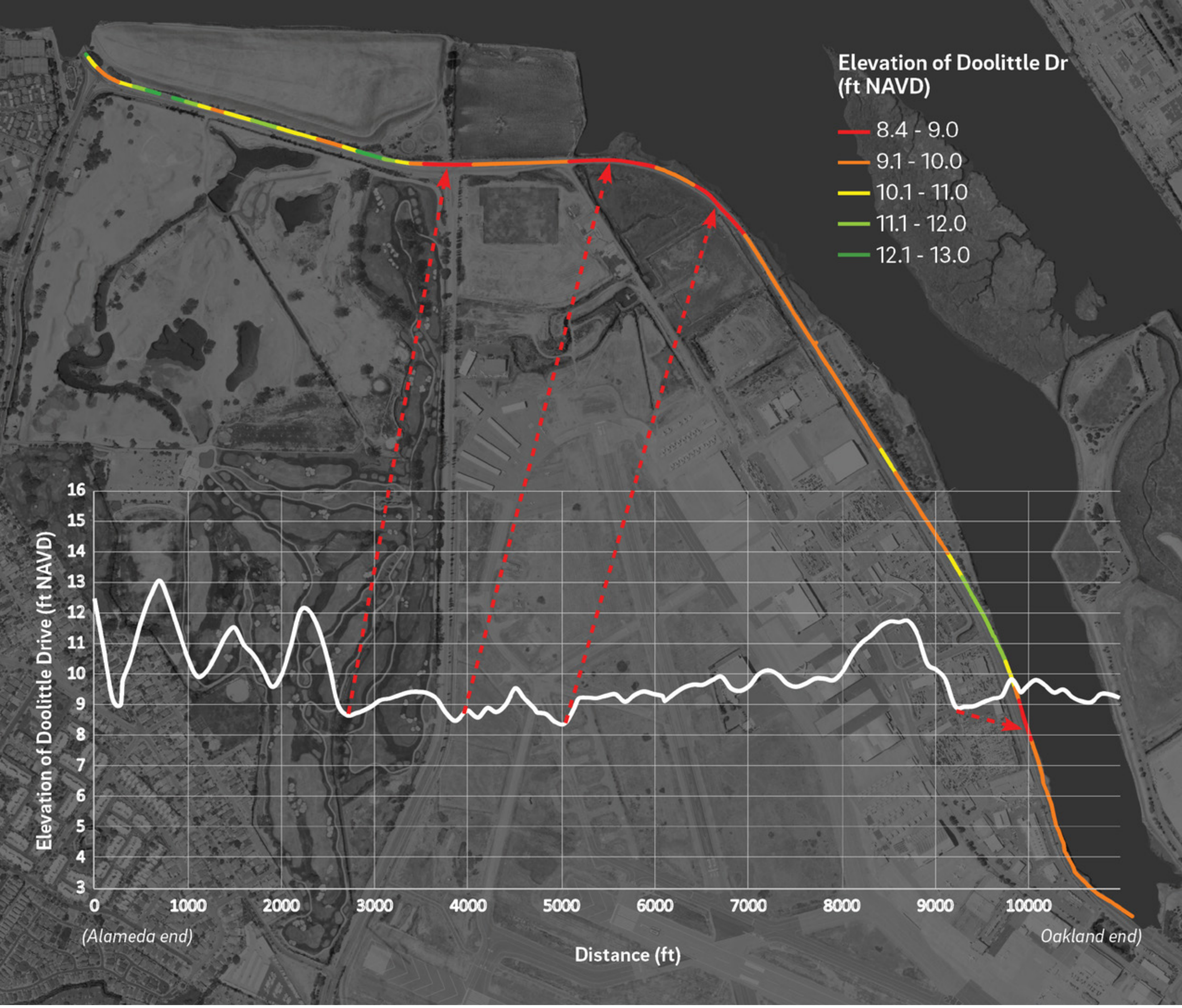


Figure 13. Elevation of Doolittle Drive, from the SF Bay Shore Inventory (SFEI 2016), with low points highlighted in red.

This information was used to determine total water level thresholds at Doolittle Drive. 9 ft NAVD is a key threshold where widespread flooding of Bay Farm Island from overtopping of Doolittle Drive is possible. This water level corresponds to a king tide with 1.5 ft of SLR, or a 10-25 year storm surge today. Other water levels of interest are shown relative to the elevation of Doolittle Drive in Figure 14.

The same process of comparing ground elevations to predicted water levels was conducted for the Damon Trail (Figure 15). The trail does not follow the mapped first line of defense in the Bay Shore Inventory precisely, and in some places lies slightly inland. However, the trail is still likely to be impacted if this shoreline is overtopped.

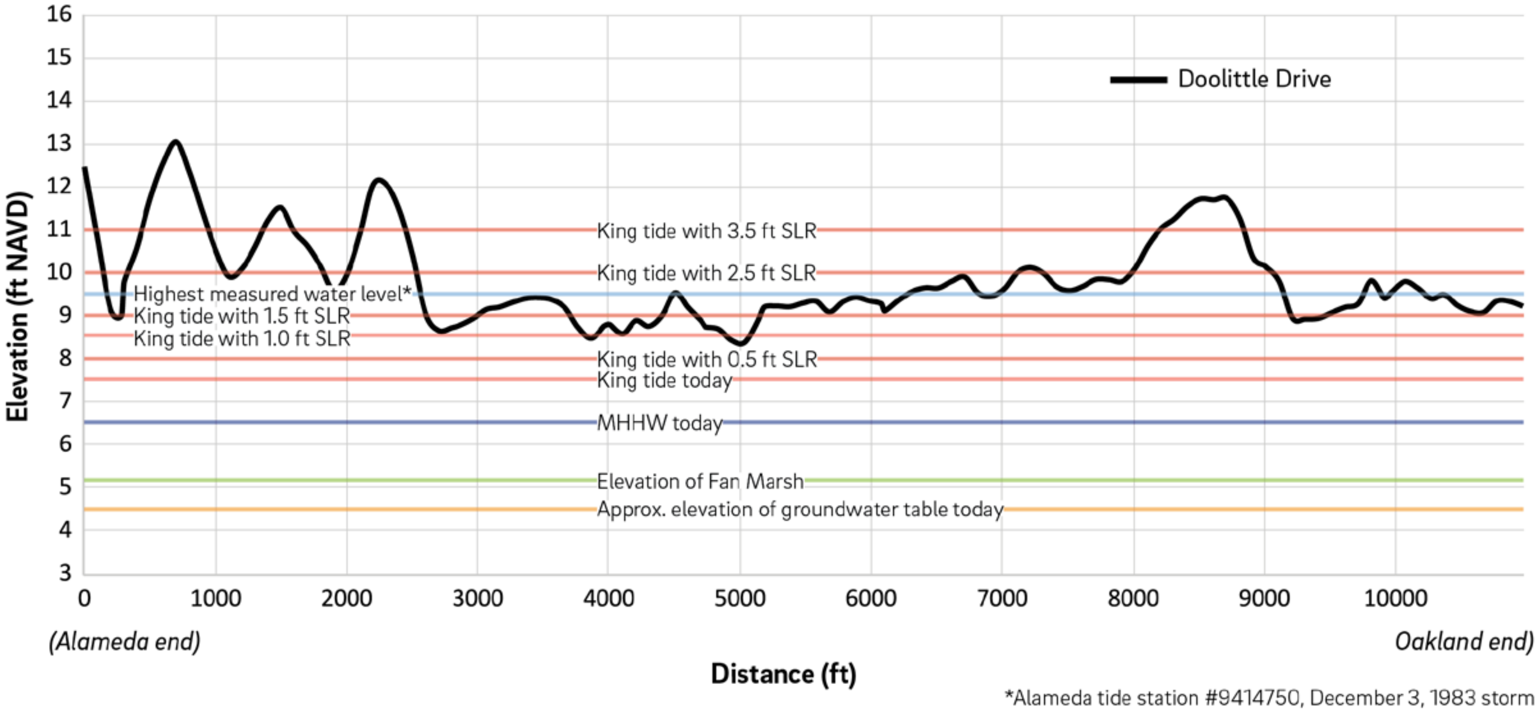


Figure 14. Water levels compared to Doolittle Drive elevation.

King tide at Doolittle Drive near Swan Way at 12:04pm on February 9, 2020. The water level at Alameda tide gauge (NOAA station 9414750) was 7.1 ft NAVD. Courtesy CA King Tides Project.

Some of the adaptation pathways outlined below use the state guidance to build for resiliency to 3.5 ft of SLR by 2050 and 6.0 ft by 2100 (CA State Sea-Level Rise Leadership Team 2022). Actual design heights for shoreline infrastructure will be determined by engineers during the planning and design phase for relevant projects and include margins for storm surge, freeboard, etc.

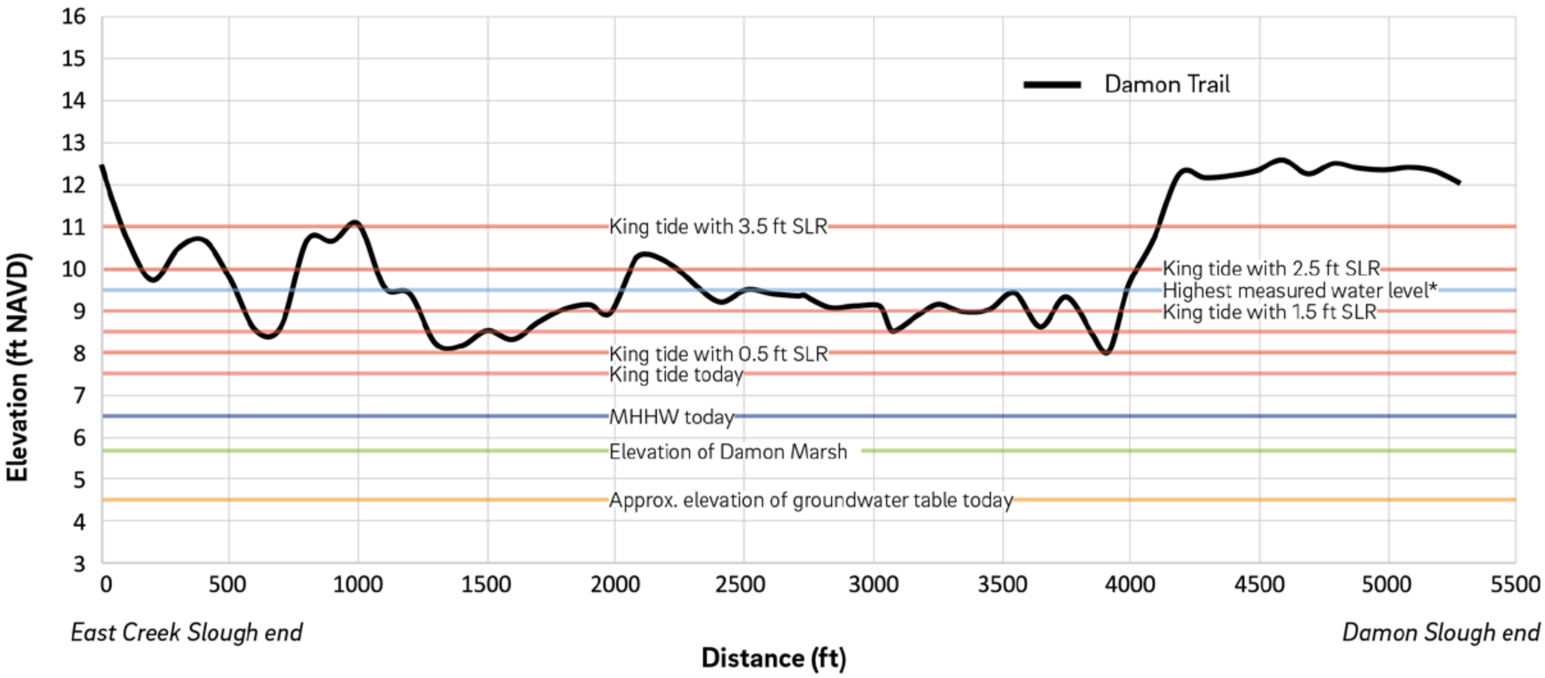


Figure 15. Water levels compared to Damon Trail elevation.

Rising groundwater

Most of the developed area surrounding San Leandro Bay is built on artificial fill over historical baylands, and groundwater lies close to the ground surface in many places (Figure 16). In areas that were filled to a higher elevation, groundwater lies farther below the ground surface. For the key shoreline segments mapped here, daily tides (MHHW) will overtop the shoreline at 2.5 ft of SLR (9 ft NAVD). For comparison, groundwater at the shoreline tends to lie slightly above mean sea level. With 2.5 ft of SLR, groundwater levels at the shoreline will be at about 7 ft NAVD, still below the elevation of Doolittle Drive and Damon Trail. Therefore, overtopping is likely to occur before groundwater emerges above ground surface at the road and trail. However, emergence is not the only concern with rising groundwater levels. For example, shallow groundwater can damage subsurface infrastructure, and constant saturation of roadbeds can impact pavement conditions. Rising groundwater levels are also likely to cause ponding in the low-lying North Field area behind Doolittle Drive and should be accounted for in the redesign of shoreline infrastructure and stormwater systems.

Figure 16. Approximate depth to groundwater in the San Leandro Bay subunit during a wet winter, from May et al. (2020).

In summary, while the SLR thresholds used in the pathways are primarily based on overtopping thresholds, which can be more clearly identified, the actions dictated by these thresholds should include and emphasize adaptation to rising groundwater levels. For example, any new roadbeds should be designed to withstand groundwater levels predicted for the future, rather than those measured in the past. Redesigned stormwater management systems should include capacity to manage runoff from emergent groundwater in addition to rainfall.

Marsh drowning

Studies from the USGS have assessed the predicted rate of marsh drowning and conversion to mudflat using the WARMER (Wetland Accretion Rate Model of Ecosystem Resilience) model (Figure 17). Arrowhead Marsh is one of several San Francisco Bay marshes analyzed to assess habitat trajectory under increasing rates of SLR (Takekawa et al. 2013). The model predicts accelerating conversion of mid marsh to low marsh at Arrowhead Marsh at about 1 ft SLR (about 2030 - 2040), and accelerating conversion of low marsh to mudflat at about 2.2 ft SLR (about 2070). These were used as approximate thresholds in the adaptation pathways for San Leandro Bay marshes. However, the underlying assumptions used in the model mean that these thresholds may shift, and adaptive management thresholds based on observable marsh transitions may be more appropriate than SLR thresholds set in advance. Fan Marsh, a muted tidal marsh connected to San Leandro Bay through culverts, is at approximately the same elevation as Arrowhead marsh, so a similar trajectory was assumed in the development of the adaptation pathways. Damon Marsh is about 0.6 ft higher in average elevation and may undergo these transitions on a somewhat delayed trajectory.

Some argue that invasive cordgrass (*Spartina alterniflora*) is preferential in marshes at risk of drowning due to its higher sediment trapping capacity and faster growth rates than native Pacific cordgrass (*Spartina foliosa*). However, invasive cordgrass colonizes mudflats as well as high marsh and transition zone and displaces other species such as pickleweed, reducing diversity and essential habitat within the marsh (Latta et al., 2015). Therefore invasive cordgrass colonization is not an advisable solution for combatting marsh drowning in San Francisco Bay marshes (Goals Project 2015).

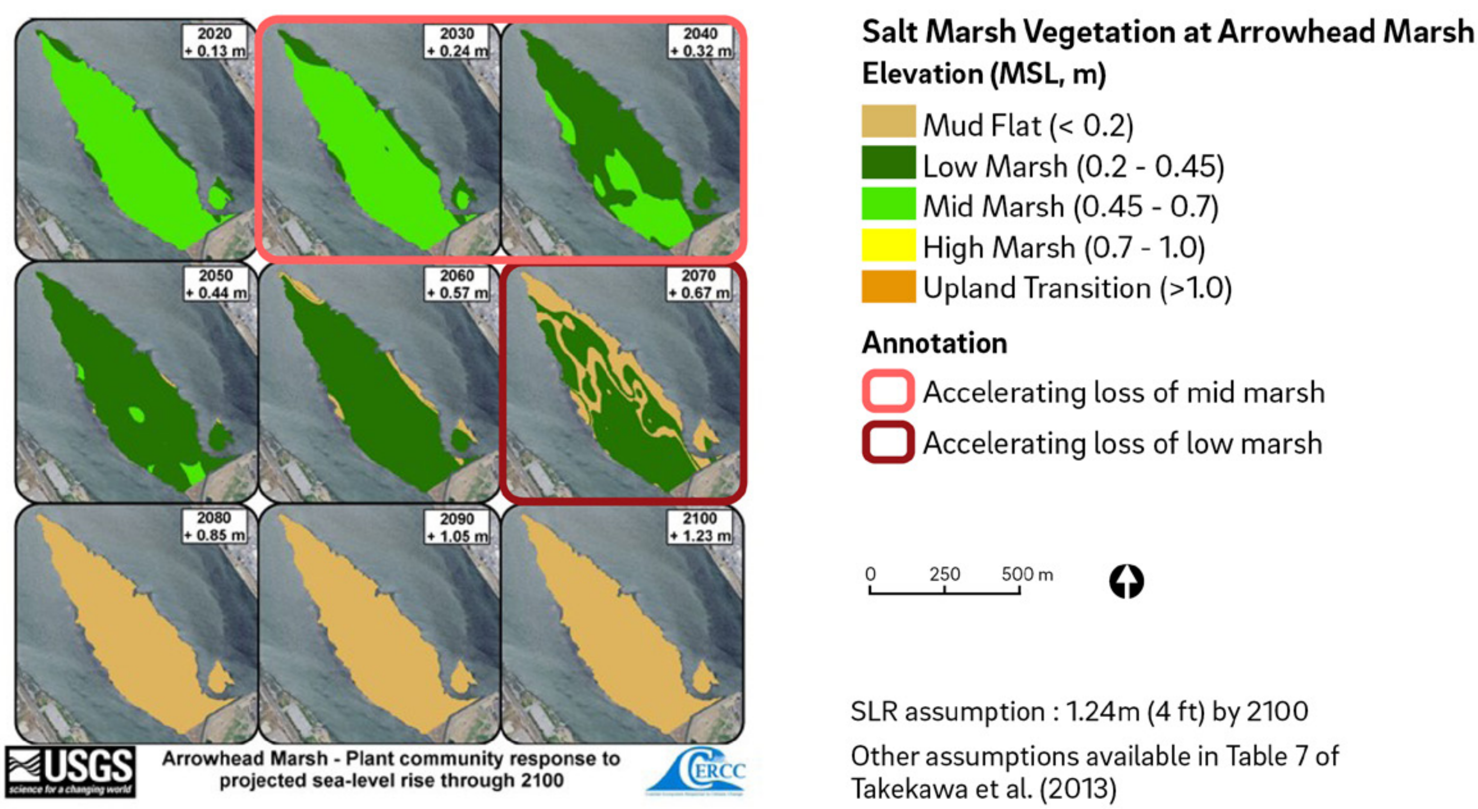


Figure 17. WARMER model results (habitat transitions with SLR) for Arrowhead Marsh from (Takekawa et al. 2013).

PLANNED PROJECTS AND PROJECT IDEAS

The ideas mapped in Figure 18 are compiled from a wide variety of sources and are in various stages of development, from early concept to active construction. Some project ideas for San Leandro Bay may not be represented. The focus was on adaptation and improvement projects for the San Leandro Bay shoreline. Sources included:

- Port of Oakland Sea-Level Rise Assessment (Port of Oakland 2019)
- City of Alameda Climate Action and Resilience Plan (CARP) (City of Alameda 2019)
- City of Oakland Sea-Level Rise Roadmap (City of Oakland 2017)
- ART Oakland-Alameda study (BCDC 2016)
- Estuary Commons report from the Resilient By Design Competition (All Bay Collective 2018)
- San Francisco Bay Shoreline Adaptation Atlas (SFEI and SPUR 2019)
- Oakland Shoreline Leadership Academy participants' project ideas (WOEIP 2021)
- East Oakland Neighborhoods Initiative (EONI 2019)
- The SF Bay Trail Risk Assessment and Adaptation Prioritization Plan (EBRPD 2021)
- Doolittle Drive Adaptation Coordination Meetings (fall 2021-spring 2022)

Many of these project ideas proposed in previous planning and visioning efforts were weaved into the adaptation pathways developed for San Leandro Bay.

Airport Channel during a king tide. Photo by Ellen Plane, SFEI.

Figure 18. Planned projects and project ideas.

ADAPTATION PATHWAYS

Nature-based adaptation strategies can be used to increase the resilience of the San Leandro Bay shoreline to rising sea levels. Due to development constraints, an extensive restoration vision is not possible while keeping current development in place. However, marsh drowning is inevitable if marshes are not allowed to migrate upland and inland. The pathways described here present a set of options that could be expanded in the longer term meet a more visionary future condition for the area (e.g. the vision for San Leandro Bay created by the All Bay Collective for the Resilient By Design Challenge). The pathways focus on improving the resilience of the San Leandro Bay shoreline to rising sea levels using nature-based adaptation strategies, which will need to be paired with traditional engineering strategies to meet the challenge of SLR adaptation in this area.

The two sets of pathways described in this section (*Approach 1: Protect in Place* and *Approach 2: Expand Migration Space Early*) are based on an initial assessment of adaptation strategies. A more expansive vision than either of these approaches may be possible depending on opportunities and constraints identified by shoreline stakeholders in future phases of the planning process. Parts of these approaches may also be mixed and matched to create new pathways. These pathways do not constitute a plan and are meant to spur further conversation and collaboration among San Leandro Bay stakeholders to develop a larger vision.

The goals of both approaches are to:

- maintain transportation corridors;
- improve community access to recreational opportunities at the shoreline;
- improve flood protection for the low-lying areas behind Doolittle Drive;
- maintain existing tidal marshes and improve high tide refuge opportunities for wildlife; and
- create more marsh migration space and protect marsh-upland transition zone habitat.

Migration space vs. transition zone

In this report, migration space refers to the area at appropriate topographic elevations to support marsh migration with SLR. In the Adaptation Atlas, "migration space" was defined as the area expected to be inundated by 2.0 meters (6.6 ft) of SLR (SFEI and SPUR 2019). Transition zone is used here to describe a broader buffer area where key physical and biological transitions occur between tidal marshes and uplands and includes areas within 500 m (1640 ft) horizontally inland from today's highest tides (Robinson et al. 2017). As such, "migration space" fits within and is a part of the "transition zone."

Approach 1: Protect in place

This approach maintains the current alignment of Doolittle Drive, and initially leaves trails in place, realigning later when flooding interrupts access.

Compared to Approach 2 (Expand marsh migration space early), this approach is likely easier to implement in the short term because it initially stays within the existing alignments of roads and trails. However, it does not allow Fan Marsh to be connected to San Leandro Bay, so there is no wide marsh buffer bayward of Doolittle Drive to protect the roadway from wave run-up. Instead, Fan Marsh must be managed inland of the levee, likely requiring upgrades to the berm at the back of the marsh in addition to the roadway. This approach also does not proactively prepare marsh migration space, with a more reactive strategy for realigning trails and allowing marsh migration that provides fewer habitat benefits in the short and long term.

To develop the pathways, we listed the vulnerabilities associated with each resource, then paired these with the SLR thresholds and adaptation strategies to address the vulnerabilities (Table 2)

This table was used to create a set of pathways outlining adaptation strategies over time. The parts of the pathway include the following:

- ***Trigger:*** the point in time where planning for the next phase begins
- ***Lead time:*** the length of time required to prepare the project
- ***Threshold:*** water level or other measurable criterion where a transition occurs from one adaptation strategy to the next
- ***Effective period:*** timeframe in which adaptation strategies implemented are effective in addressing the listed vulnerabilities

For this effort, specific lead times for each adaptation measure were not calculated and these triggers and lead times will need to be refined by the Working Group. Here, we assume the trigger is 7-8 years in advance of the threshold (about 1-2 years for design and planning, 1-2 years for permitting, and 4-5 years for construction). The pathways are shown in Figures 19 to 21. Associated maps demonstrating each phase are shown in Figures 22 to 25.

Table 2. Vulnerabilities, thresholds, and strategies for Approach 1: Protect in Place

Resource	Vulnerabilities	Elevation	Threshold 1	Strategies	Threshold 2	Strategies
Doolittle Drive	Overtopping, backflow through culverts, rising groundwater, large low-lying area protected by road	8.5-13 ft NAVD	Lowest point affected 8.5 ft NAVD, overtopping at 9 ft NAVD. Target fixes by **0.5 ft SLR** to avoid flooding of Bay Farm Island with 5-year storm surge	Raise road in place (Protection to 10 ft NAVD)	With **1.5 ft SLR**, a 5-year storm surge will reach 10 ft NAVD	Raise again. Consider rerouting and raising (set back roadway/ levee realignment)
Fan Marsh	Reduced tidal exchange, lack of high tide refuge, marsh drowning	Mean marsh elevation 5.1 ft NAVD	Aligned with **road strategy**	Improve tidal exchange to ensure adequate flows to marsh, improve berm at back of marsh	Aligned with **road strategy**	Limit highest tides with water control structure (managed marsh habitat) OR raise berm at back of marsh
Arrowhead Marsh	Lack of high tide refuge, marsh drowning. Loss of essential marsh habitat patch for Ridgway's rail	Mean marsh elevation 5.1 ft NAVD	Already rapidly losing mid marsh habitat, need to implement strategies soon. Near total loss of mid marsh at **1 ft SLR**	Implement interim high tide refuge measures (marsh mounds, floating islands, or similar), thin layer placement, migration space preparation	Verge of losing all marsh habitat at **2.2 ft SLR**. Facilities (parking areas) start to flood.	Reroute of MLK Jr shoreline trail and reconfigure recreational facilities, enhance transition zone (grading and vegetation), allow marsh migration
Damon Trail	Overtopping	8-12.5 ft NAVD	8 ft NAVD is the lowest point, but occasional flooding is likely acceptable. Focus on other community targets for Phase I	Implement Oakland Shoreline Leadership Academy ideas (wellness zones and native plantings). Improve access from East Oakland.	**1.5 ft SLR**: trail overtopping at king tide	Reroute trail
Damon Marsh	Lack of high tide refuge, marsh drowning	Mean marsh elevation 5.7 ft NAVD	Starting 0.6 ft higher than Arrowhead. Implement near term strategies at **0.6 ft SLR**	Implement interim high tide refuge measures (marsh mounds, floating islands, or similar), thin layer placement, migration space preparation	Aligned with **trail strategy**	Enhance transition zone (grading and vegetation), allow marsh migration

Doolittle Drive and Fan Marsh | *Approach 1: Protect in place*

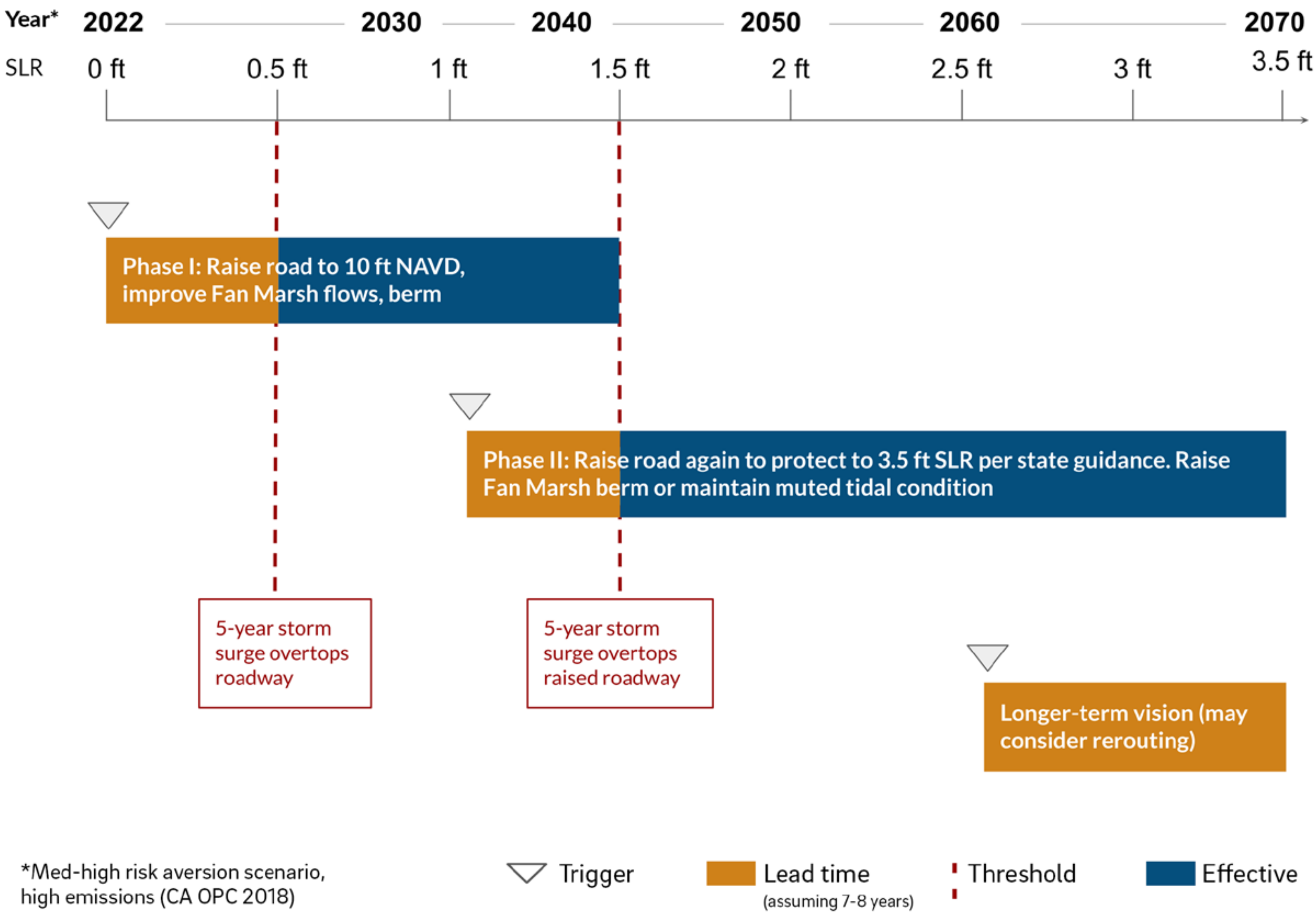


Figure 19. Doolittle Drive and Fan Marsh adaptation pathway, "Protect in place" approach.

In Phase I, Doolittle Drive is raised and culverts modified to improve flows to Fan Marsh, continuing management of the muted tidal marsh while ensuring adequate stormwater and groundwater management inboard of the raised roadway (potentially to include addition of flap gates on culverts, pumps, etc). These adaptations are implemented by 0.5 ft SLR, when a 5-year storm surge at high tide could overtop the road and flood a large area of Bay Farm Island. This relatively limited roadway raising is expanded into a larger levee raising project (Phase II) when SLR reaches 1.5 ft, to protect to the recommended design level of 3.5 ft by 2050 (CA State Sea-Level Rise Leadership Team 2022). In the latter half of the century, a longer-term vision, potentially including rerouting the road inland, is required.

POSSIBLE ADAPTATION PATHWAY

Arrowhead Marsh | *Approach 1: Protect in place*

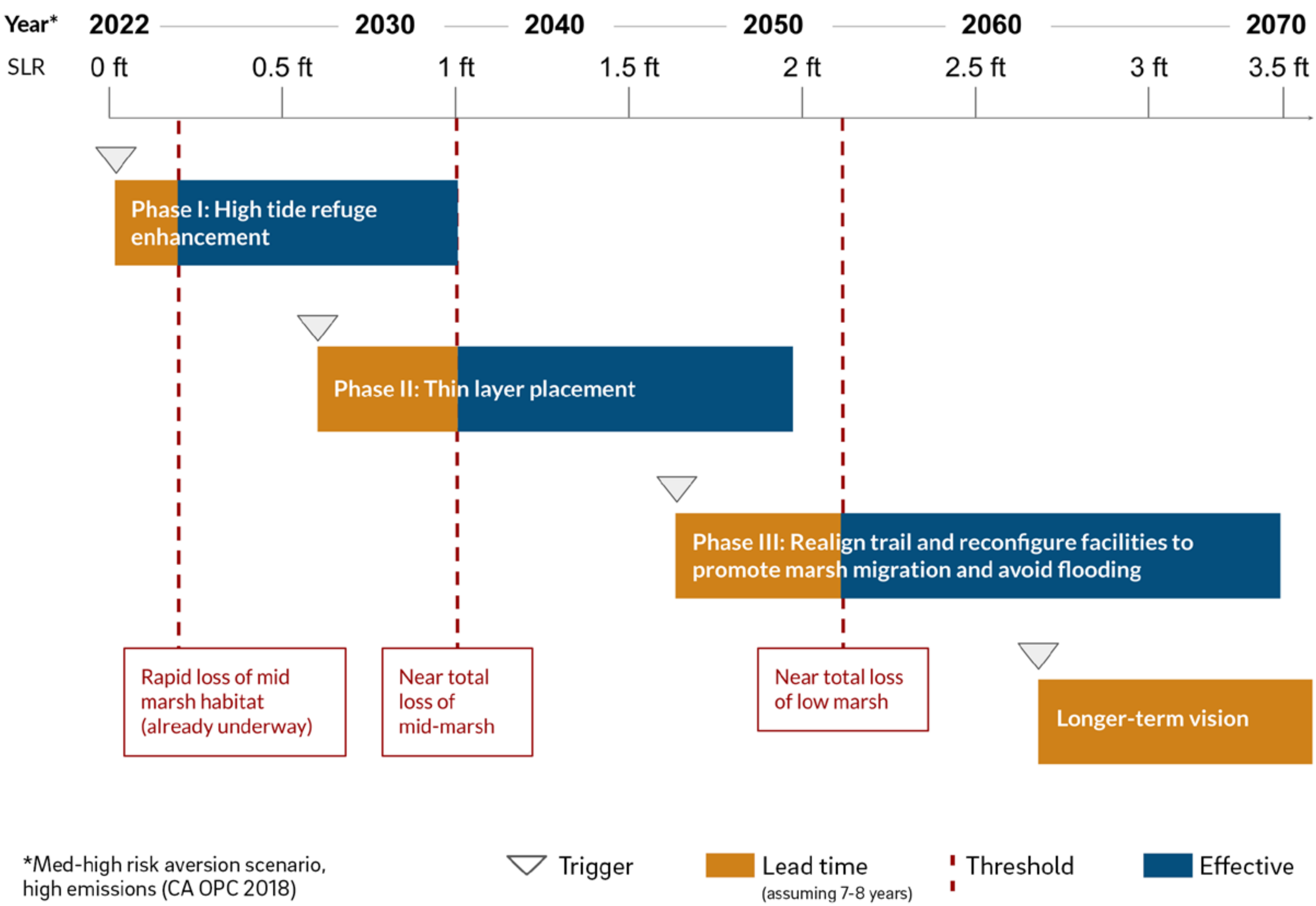


Figure 20. Arrowhead Marsh adaptation pathway, "Protect in place" approach.

In Phase I, high tide refuge enhancements, such as floating refuge islands, marsh mounds, and/or edge vegetation enhancements, are implemented at Arrowhead Marsh. High tide refuge enhancement can also include measures like removing potential perches near wetlands for raptors, which can prey on marsh species, and reducing non-native predators by reducing food sources including garbage. These improvements may be completed in conjunction with invasive cordgrass eradication and native revegetation efforts. At 1 ft SLR, when mid marsh habitat is nearly all converted to low marsh (depending on natural sediment inputs), thin layer placement is conducted to add additional sediment to the surface of the marsh (Phase II). When SLR reaches 2.2 ft, low marsh converts to mudflat and parking lots begin to flood. At this stage (Phase III), the trail is realigned and facilities reconfigured to give more space for Arrowhead and MLK Marshes to migrate inland, while protecting recreational access. Toward the end of the century, a longer-term vision is required. For marsh pathways, adaptive management threshold based on observable characteristics (marsh elevation relative to tides, vegetation conversion) will be more appropriate than predetermined SLR thresholds.

POSSIBLE ADAPTATION PATHWAY

Damon Marsh | *Approach 1: Protect in place*

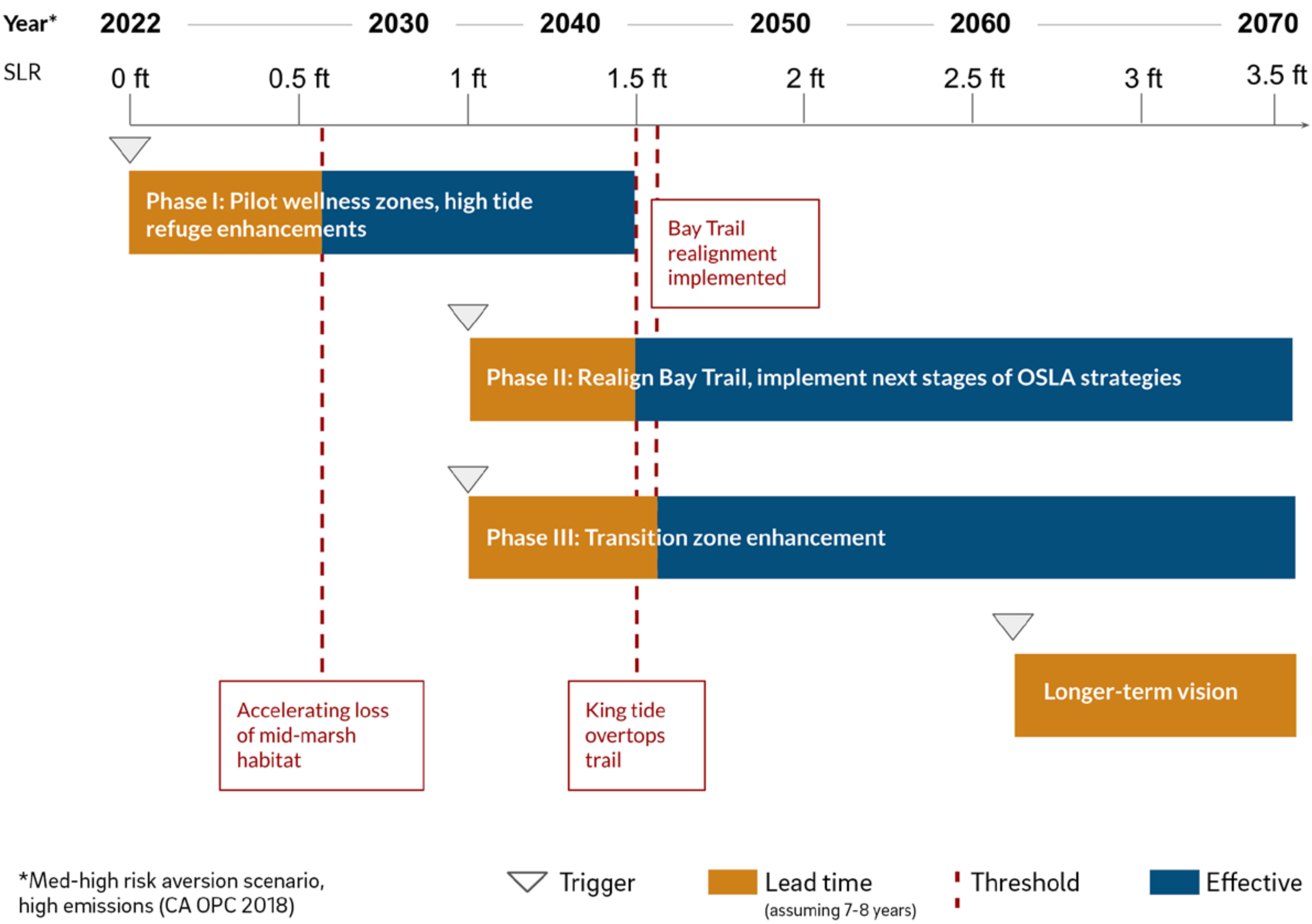


Figure 21. Damon Trail and Marsh adaptation pathway, "Protect in place" approach.

In Phase I, ideas from the Oakland Shoreline Leadership Academy are implemented along the Damon Marsh trail, in close coordination with community members who use the space. Improvements could include the "Sacred Spaces" concept, with four zones along the trail including native vegetation plantings and interactive spiritual and mental wellness spaces (Walker and Santos 2021). When SLR reaches 1.5 ft, king tides begin to overtop the trail. At this point (Phase II) the Bay Trail is realigned (one possible alignment is shown in Figure 24, but the alignment would need to be determined in partnership with key stakeholders). Bayward of the trail, grading and vegetation plantings could be established to prepare migration space. In the third phase, Damon Marsh is allowed to migrate inland as sea levels continue to rise. This phase could include enhancement measures like vegetation management, coordinated with ongoing invasive cordgrass eradication and native revegetation efforts. In the latter half of the century, a longer term vision may be needed to ensure continued recreational access and marsh persistence.

The following series of maps shows how the Approach 1 pathways for each focus area fit together across San Leandro Bay. Adaptation phases are grouped in each map to allow visualization, though the thresholds for implementation of each phase differ across locations.

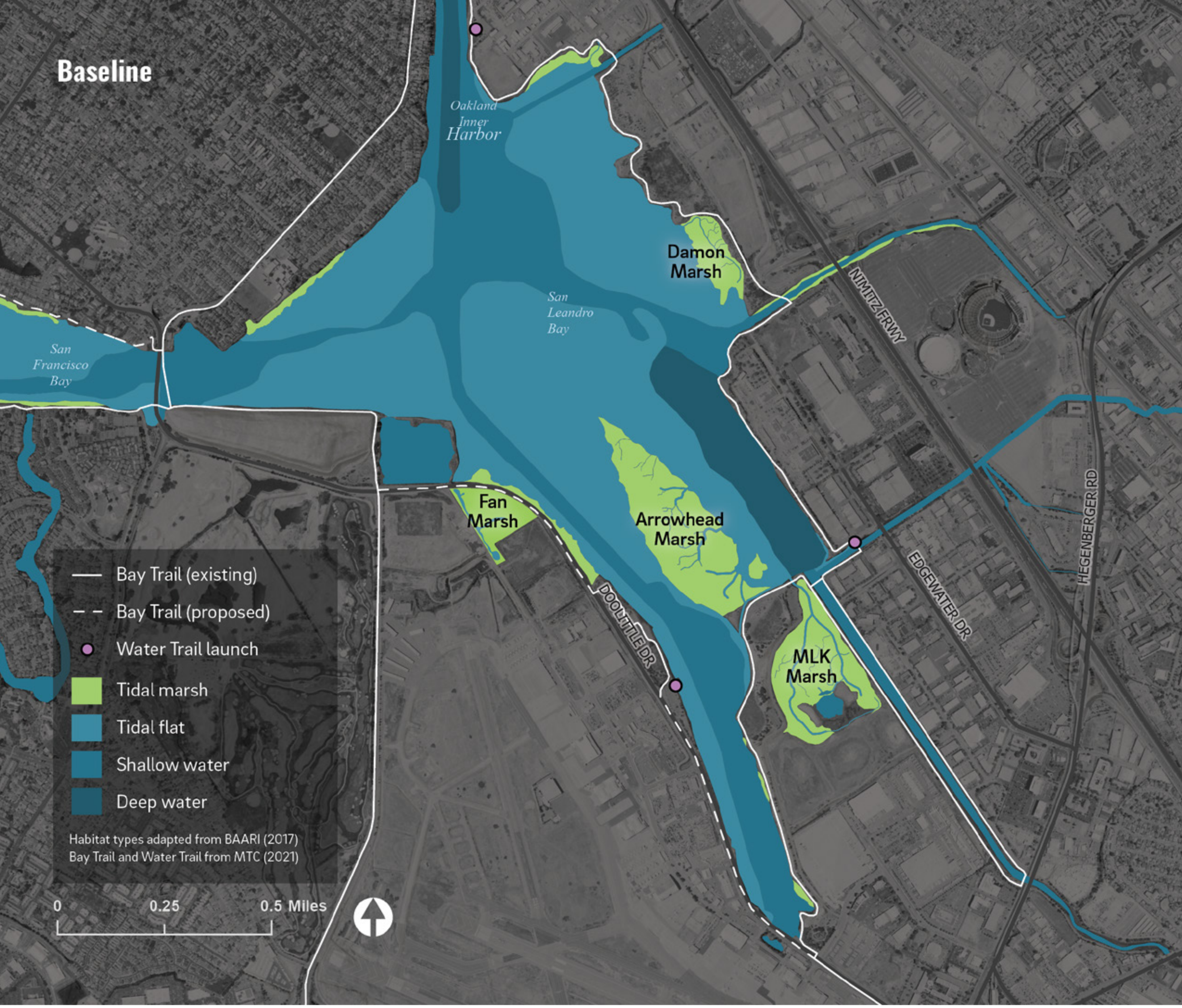


Figure 22. Baseline/existing conditions.

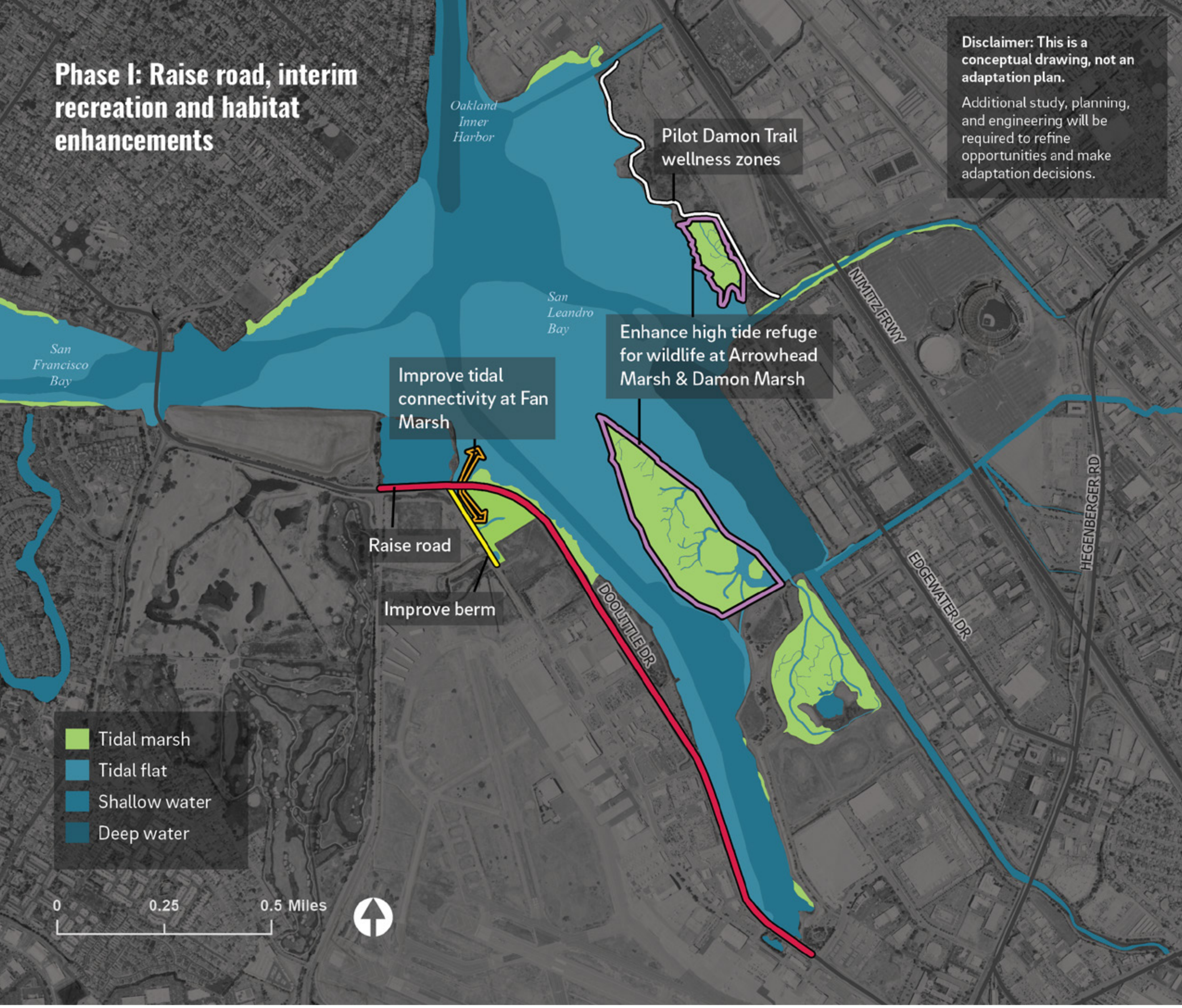


Figure 23. Phase I adaptation actions for Approach 1 "Protect in place" (actions may be implemented at different times depending on locations and associated thresholds).

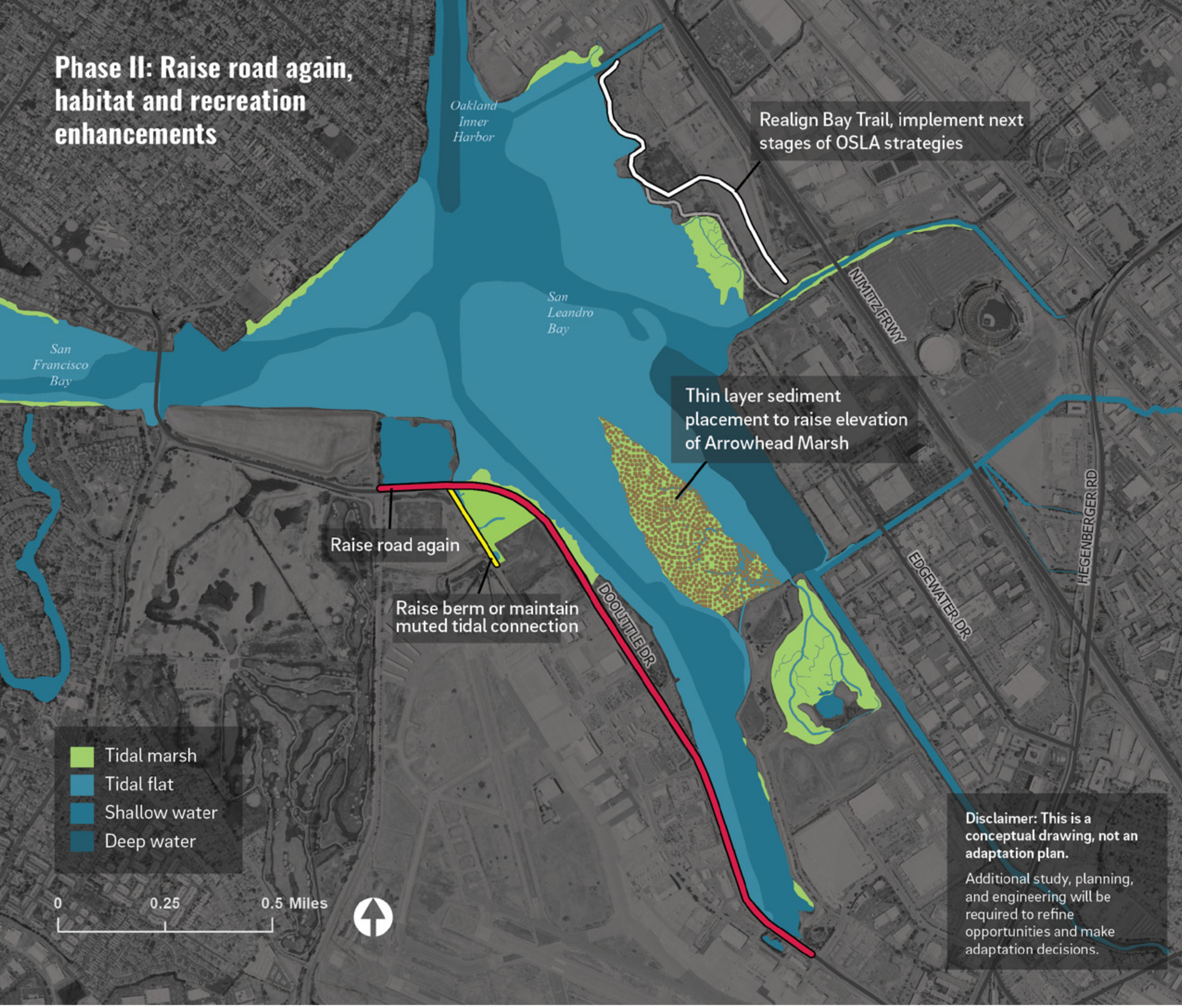


Figure 24. Phase II adaptation actions for Approach 1 "Protect in place" (actions may be implemented at different times depending on locations and associated thresholds).

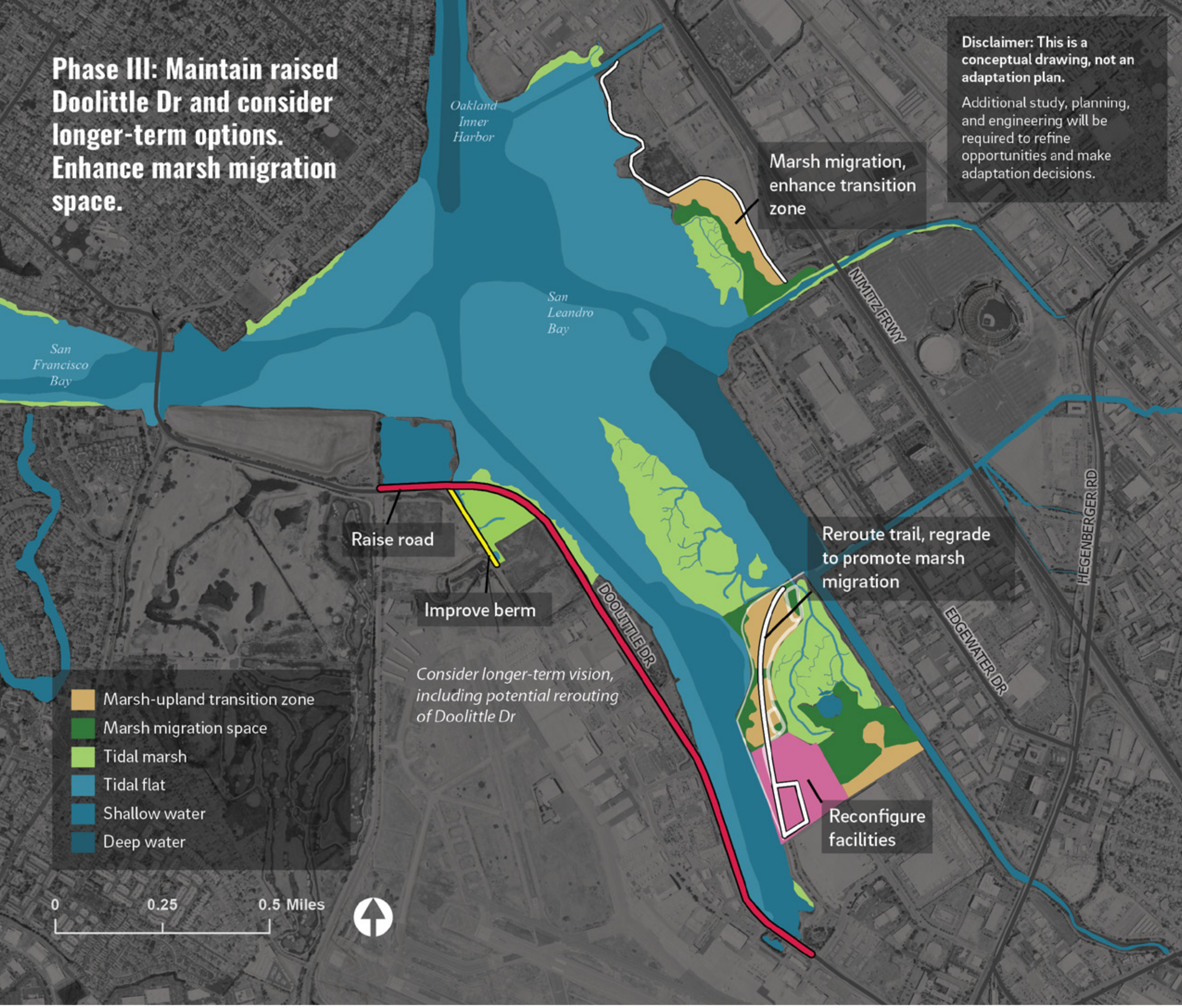


Figure 25. Phase III adaptation actions for Approach 1 "Protect in place" (actions may be implemented at different times depending on locations and associated thresholds).

Approach 2: Expand marsh migration space early

The focus of this approach is on protecting and expanding essential marsh and transition zone habitats in San Leandro Bay, setting back trails and levees as much as possible to create more space for marsh migration and allowing marshes to naturally move inland as tides rise higher. This space also provides more essential refuge for Ridgway's rail and other species during high water events today. Where possible, setback levees to promote marsh migration are tied into larger flood protection efforts for low-lying areas (i.e. Doolittle Drive).

Compared to Approach 1 (Protect in place), this approach is likely more difficult to implement in the short term because it requires realignment of roads and trails. However, it allows Fan Marsh to be connected to San Leandro Bay, creating a wide marsh buffer bayward of Doolittle Drive to protect the roadway from wave run-up. Realigning the roadway could also mean construction can take place with less interruption to the flow of traffic on the existing alignment. This approach proactively prepares marsh migration space at Fan Marsh, Damon Marsh, and Arrowhead Marsh, realigning trails before they flood to provide protected transition zone habitat for wildlife in the short term and natural migration opportunities over the long term.

To develop the pathways, we listed the vulnerabilities associated with each resource, then paired these with the SLR thresholds and adaptation strategies to address the vulnerabilities (Table 3). This table was used to create a set of pathways outlining adaptation strategies over time. The pathways are shown in Figures 26 to 29. Associated maps demonstrating each phase are shown in Figures 30 to 33.

Riprap at the MLK Shoreline. Photo by Ellen Plane, SFEI.

Table 3. Vulnerabilities, thresholds, and strategies for Approach 2: Expand marsh migration space early

Resource	Vulnerabilities	Elevation	Threshold 1	Strategies	Threshold 2	Strategies
Doolittle Drive	Overtopping, backflow through culverts, rising groundwater, large low-lying area protected by road	8.5-13 ft NAVD	Lowest point affected 8.5 ft NAVD, overtopping at 9 ft NAVD. Target fixes by 0.5 ft SLR to avoid flooding of Bay Farm Island with 5-year storm surge	Interim patch fixes (regrading, flap gates, etc). Protection up to 9.5 ft NAVD	1 ft SLR: 5-yr storm surge reaches 9.5 ft NAVD	Rerouting and raising (roadway levee realignment) to protect to 3.5 ft SLR (per state guidance)
Fan Marsh	Reduced tidal exchange, lack of high tide refuge, marsh drowning	Mean marsh elevation 5.1 ft NAVD	Aligned with road strategy	Improved tidal exchange, restoration preparation, interim high tide refuge measures	Aligned with road strategy	Reconnection to Bay, expansion of marsh and migration space (depending on use of/plans for adjacent properties)
Arrowhead Marsh	Lack of high tide refuge, marsh drowning	Mean marsh elevation 5.1 ft NAVD	Already rapidly losing mid marsh habitat, need to implement strategies soon. Near total loss of mid marsh at 1 ft SLR	Reroute trail to centerline and regrade to promote marsh migration, high tide refuge. Consolidate facilities	Verge of losing all existing marsh habitat at 2.2 ft SLR	Truncate trail, move viewing platform inland. Possible thin layer placement
Damon Trail	Overtopping	8-12.5 ft NAVD	8 ft NAVD is the lowest point, but occasional flooding is likely acceptable. Focus on other community targets for Phase I	Implement Oakland Shoreline Leadership Academy ideas (wellness zones) and reroute trail during upgrades.	Early action for trail adaptation, no second threshold. Adaptive management.	Continued community coordination to expand and build on OSLA ideas
Damon Marsh	Lack of high tide refuge, marsh drowning. Loss of essential marsh habitat patch for Ridgway's rail	Mean marsh elevation 5.7 ft NAVD	Starting 0.6 ft higher than Arrowhead. Near total loss of mid marsh at 1.6 ft SLR	Migration space preparation and transition zone enhancement	Verge of losing all marsh habitat at 2.8 ft SLR	High tide refuge enhancement, thin layer placement

POSSIBLE ADAPTATION PATHWAY

Doolittle Drive and Fan Marsh | *Approach 2: Expand marsh migration space early*

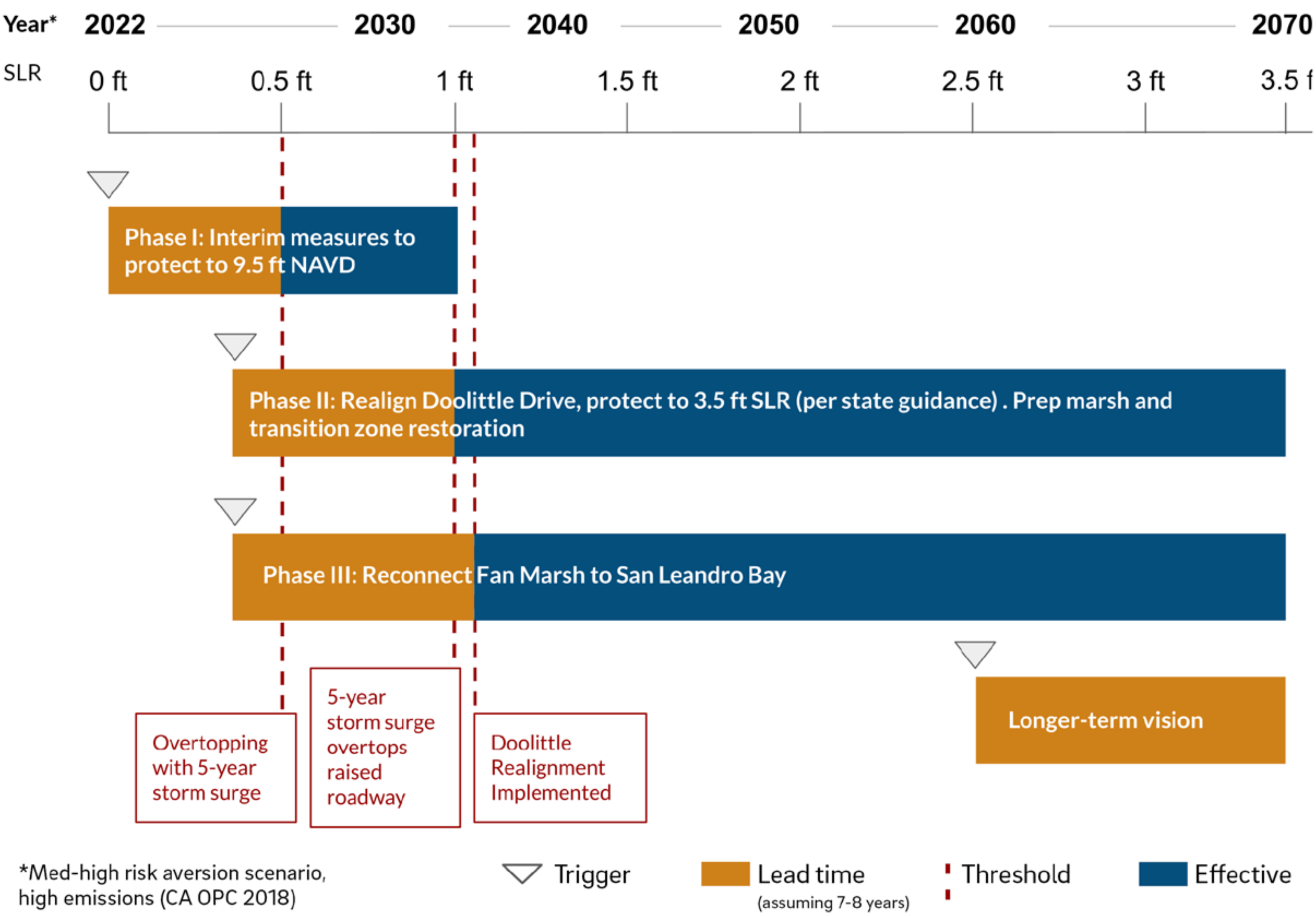


Figure 26. Doolittle Drive and Fan Marsh adaptation pathway, "Expand marsh migration space early" approach.

In Phase I, interim measures are implemented to prevent flooding in the short term. These could include regrading/repaving in low spots to reduce likelihood of overtopping and provide protection for Bay Farm Island. In the meantime, plans are developed to realign Doolittle Drive inland (Phase II), setting back the roadway and raising the elevation to protect to 3.5 ft of SLR (CA State Sea-Level Rise Leadership Team 2022). This would allow full reconnection of Fan Marsh to San Leandro Bay once the roadway is completed (Phase III). Depending on feasibility considerations including land use, land ownership, and contamination, adjacent parcels could also be restored to tidal marsh and transition zone. Various roadway realignments are possible and a rerouted alignment would need to be agreed upon by key stakeholders (Figure 27). Parts of the roadway not realigned that are exposed to flooding would need to be raised. The realigned roadway should be designed to accommodate rising groundwater, including the roadbed and stormwater management system. In the latter half of the century, discussions would begin for a longer-term vision for the area.

Figure 27. Possible alternate routes for Doolittle Dr (not an exhaustive list of potential options, and some options shown here may be infeasible). The ultimate route will need to be determined in collaboration with appropriate stakeholders. Length of route will likely be an important consideration when weighing tradeoffs. The routes shown here range from 0.64 mi in length (original alignment) to 0.79 mi (yellow-orange alignment). Low-lying segments of road that are not realigned will likely need to be raised.

Arrowhead Marsh | *Approach 2: Expand marsh migration space early*

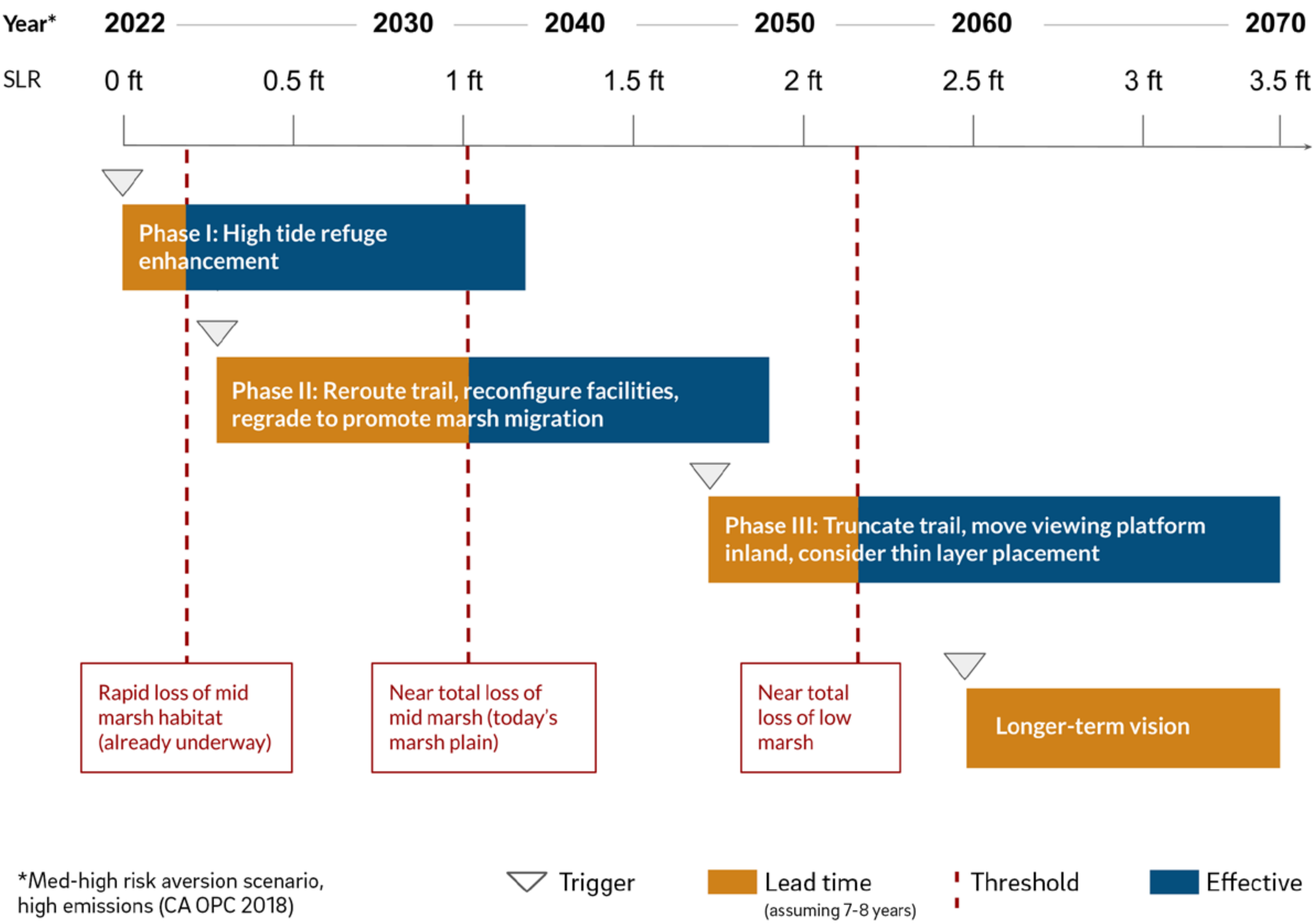


Figure 28. Arrowhead Marsh adaptation pathway, "Expand marsh migration space early" approach.

In Phase I, high tide refuge enhancements such as floating refuge islands are implemented at Arrowhead Marsh. These improvements may be completed in conjunction with invasive cordgrass eradication and native revegetation efforts. At 1 ft SLR, when mid marsh habitat is nearly all converted to low marsh (depending on natural sediment inputs), trails are rerouted and facilities, including parking lots, reconfigured and consolidated to make room for high tide refuge and marsh migration space (Phase II). When SLR reaches 2.2 ft, low marsh is in the process of converting to mudflat habitat. At this stage (Phase III), the trail is truncated and the viewing platform moved inland to protect even more migration space and transition zone. Depending on marsh health, thin layer placement could be considered at this stage as well. Toward the end of the century, a longer-term vision is required. For marsh pathways, adaptive management threshold based on observable characteristics (marsh elevation relative to tides, vegetation conversion) will be more appropriate than set SLR thresholds.

POSSIBLE ADAPTATION PATHWAY

Damon Marsh | *Approach 2: Expand marsh migration space early*

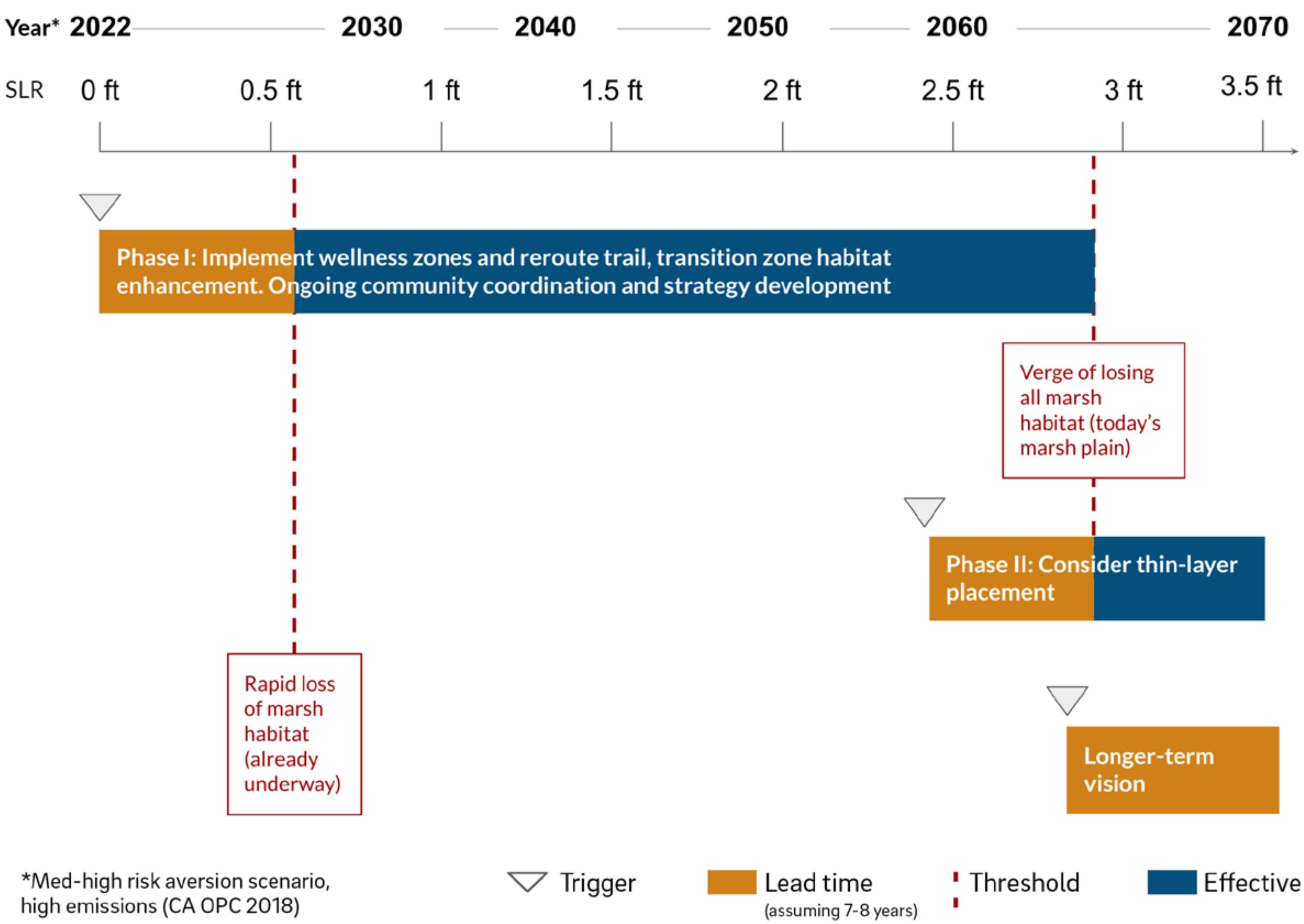


Figure 29. Damon Trail and Marsh adaptation pathway, "Expand marsh migration space early" approach.

This pathway proposes big moves in the near term to enhance migration space and allow long term marsh migration. In Phase I, ideas from the Oakland Shoreline Leadership Academy are implemented along the Damon Marsh trail in coordination with community members who use the space. Improvements could include the "Sacred Spaces" concept, with four zones along the trail including native vegetation plantings and interactive spiritual and mental wellness spaces (Walker and Santos 2021). The trail is rerouted and marsh migration space prepared in conjunction with these recreational and vegetation enhancements. The pathway focuses primarily on marsh migration as a marsh persistence strategy; however, depending on marsh health in the latter half of the century, thin layer placement could be considered as an additional adaptation strategy (Phase II). Enhancement actions for foraging habitat in adjacent sloughs could also be implemented. Toward the end of the century, a longer-term vision is required.

The following series of maps shows how the Approach 2 pathways for each focus area fit together across San Leandro Bay.

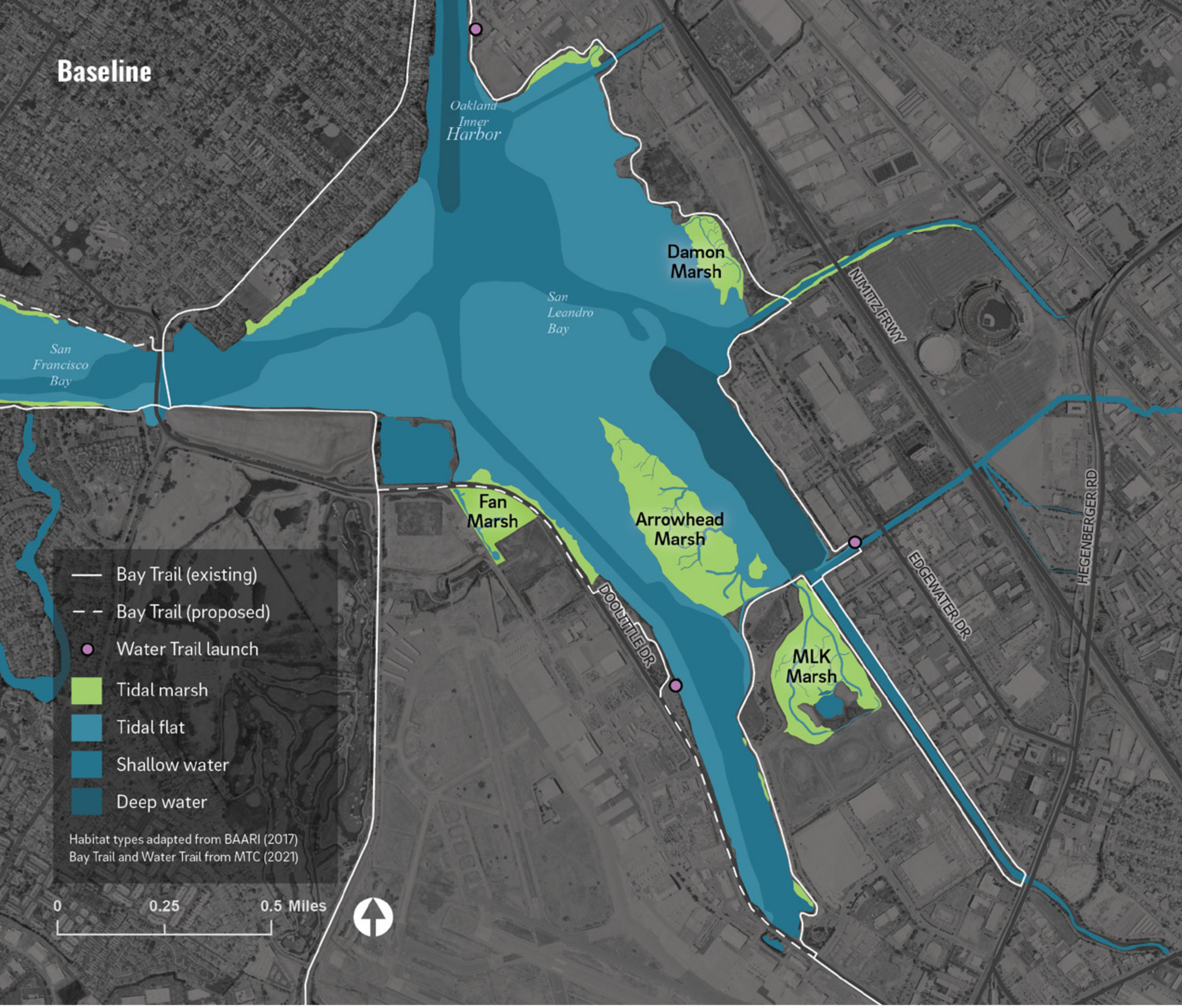


Figure 30. Baseline/existing conditions.

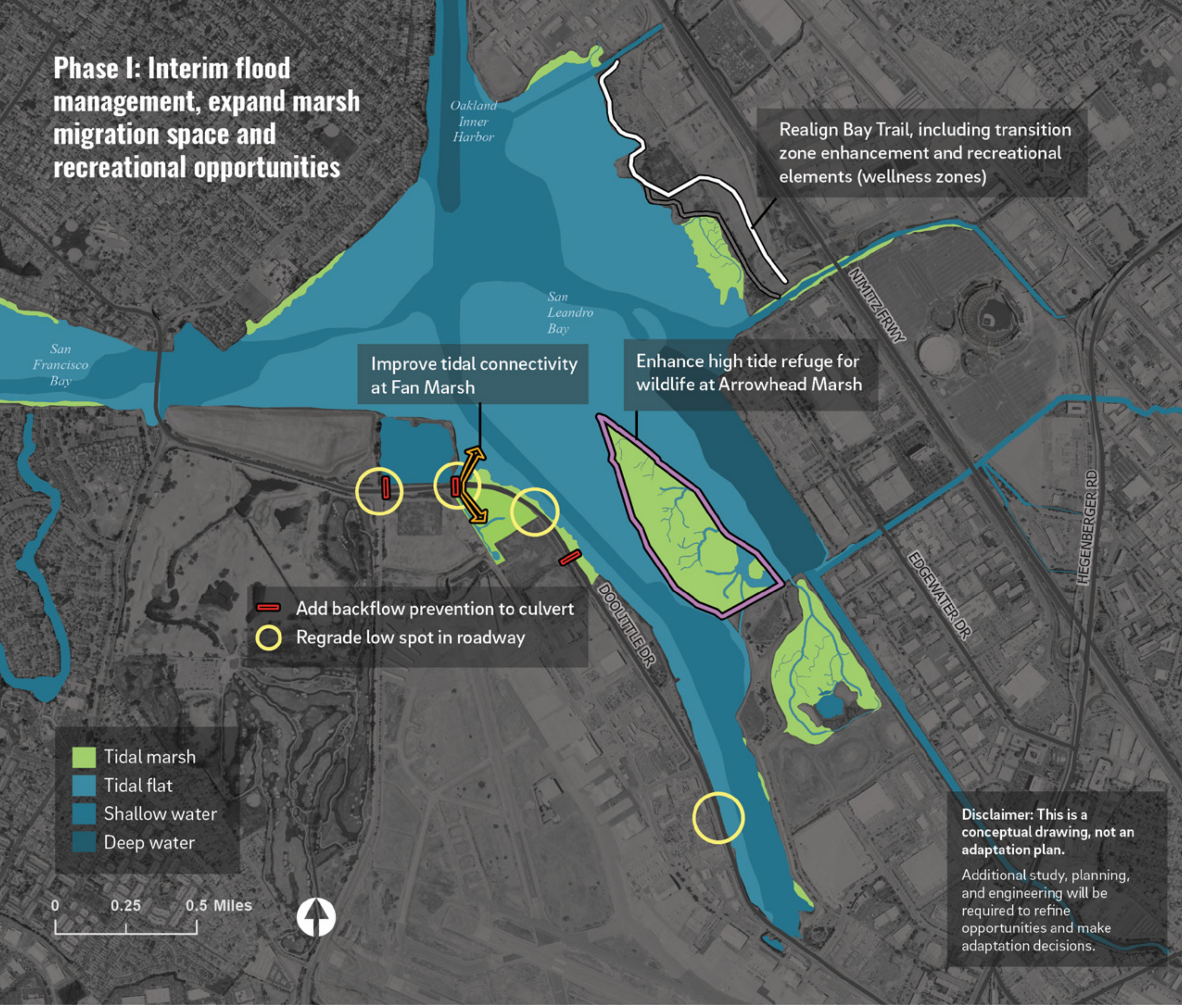


Figure 31. Phase I adaptation actions for Approach 2 “Expand marsh migration space early” (actions may be implemented at different times depending on locations and associated thresholds).

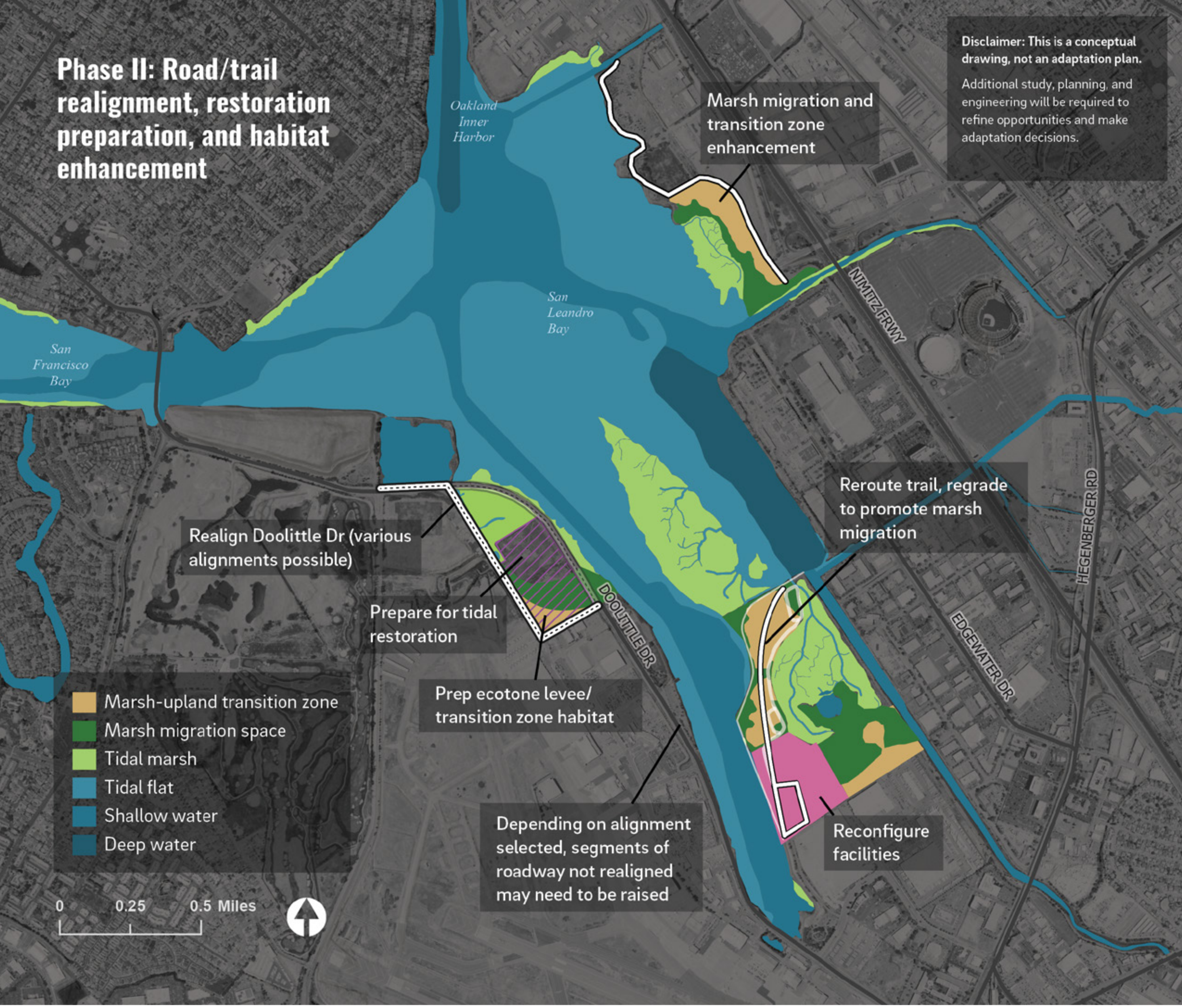


Figure 32. Phase II adaptation actions for Approach 2 "Expand marsh migration space early" (actions may be implemented at different times depending on locations and associated thresholds).

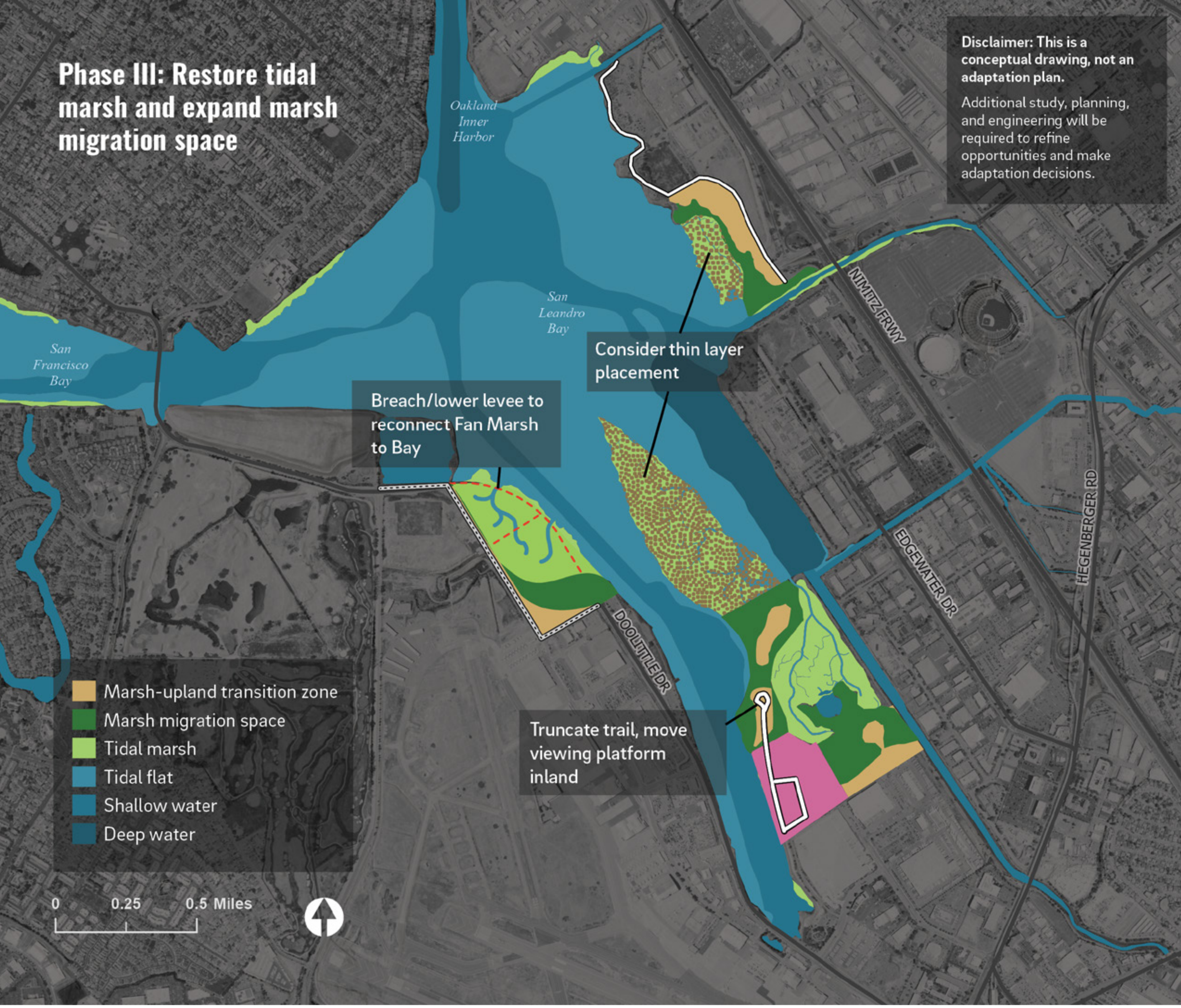


Figure 33. Phase III adaptation actions for Approach 2 “Expand marsh migration space early” (actions may be implemented at different times depending on locations and associated thresholds).

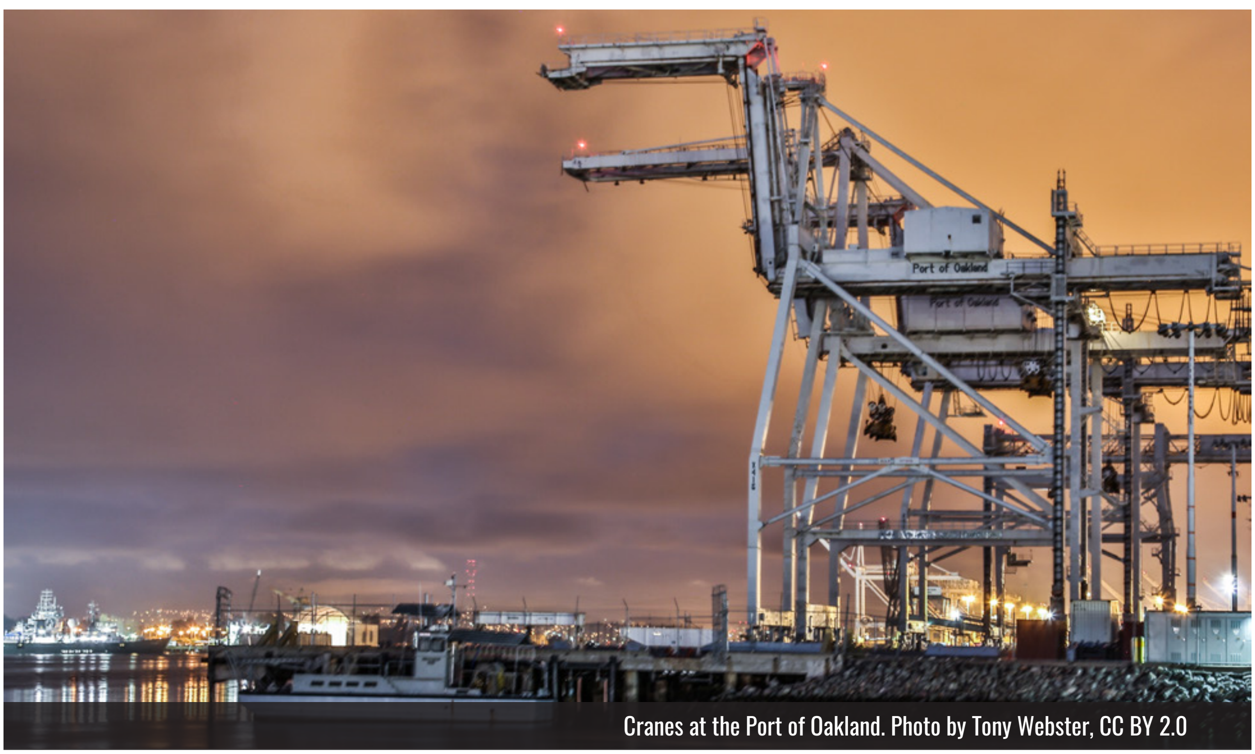
5. Oakland-Alameda Estuary Subunit: Case Study & Pathways

This section contains some preliminary information regarding adaptation pathway development for the Oakland-Alameda Estuary subunit. Additional research and planning is needed to more fully develop a range of pathways, including alternative approaches.

FOCUS AREAS

Based on flood mapping from the ART Bay Area Flood Explorer (Figure 2) and the existing FEMA flood maps (Figure 3), areas exposed to flooding were identified. Areas that are exposed to flooding at 3 ft SLR include: (1) the Lake Merritt channel; (2) the Posey and Webster tubes; and (3) Alameda Point (Figure 34). Resources vulnerable to flooding at the Lake Merritt channel include the Capitol Corridor railway, a pedestrian path along the channel, the Jack London Aquatic Center and park, and a warehouse/industrial area. The Posey and Webster tubes are a key transportation connection between Oakland and Alameda. Alameda Point is a former naval base in the process of being redeveloped. Part of the area will be dedicated to residential and commercial development. The northwest end of the island will be developed as a new East Bay Regional Park.

Though not covered by the present report, the West Oakland neighborhood is also identified as a focus area where adaptation pathways should be developed soon in coordination with the local community. West Oakland is not exposed to overland flooding as early as the other focus areas, but other factors make it vulnerable to SLR. These factors include the legacy of environmental contamination and injustice, exposure to rising groundwater, an aging stormwater management system, and reliance on the Port of Oakland and other shoreline property managers for protection from overland flooding (BCDC 2020). This is an area where early coordination will be required for effective adaptation planning.



Cranes at the Port of Oakland. Photo by Tony Webster, CC BY 2.0

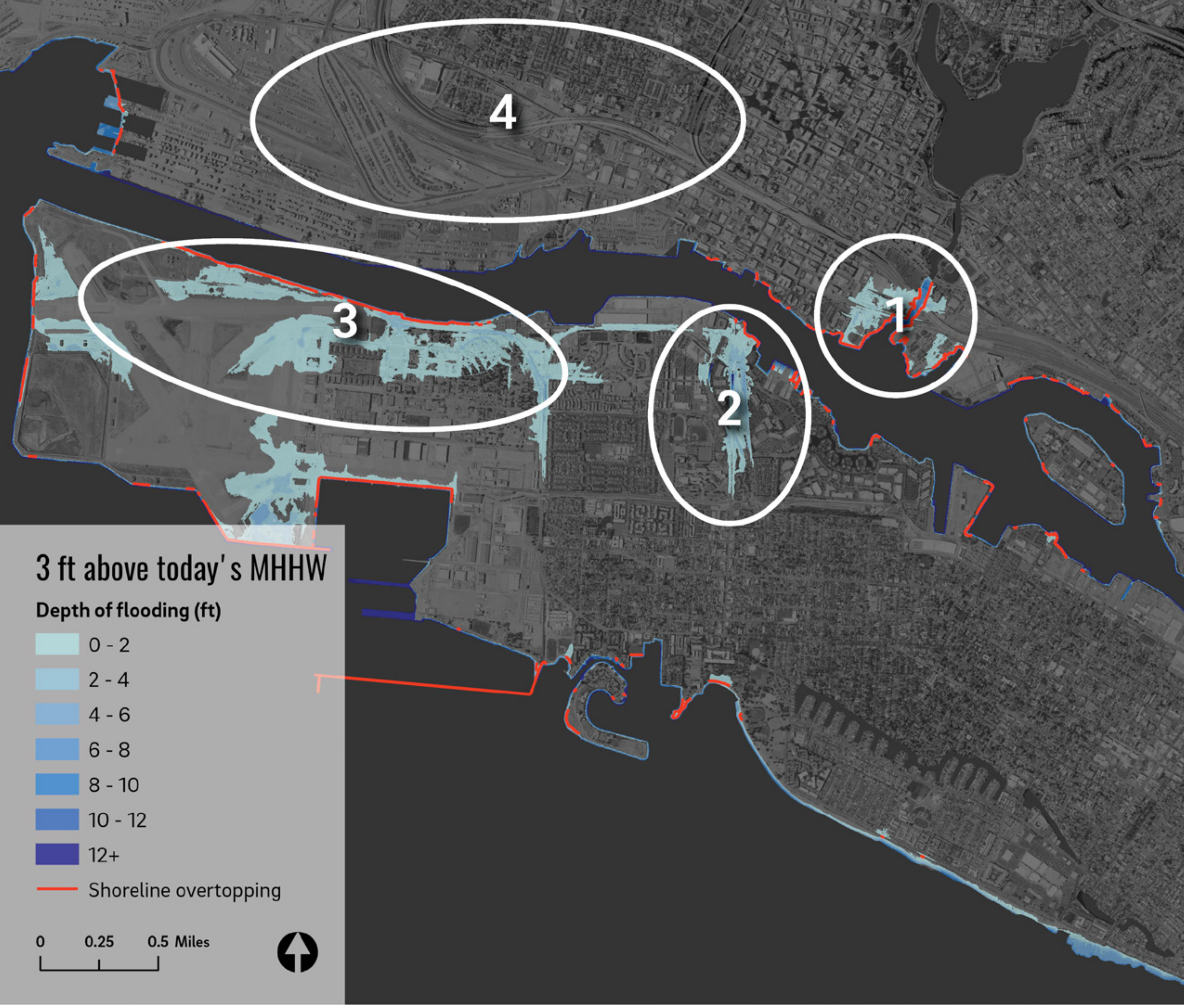


Figure 34. Identified focus areas for the Oakland-Alameda Estuary subunit: (1) Lake Merritt channel; (2) Webster/Posey Tubes; (3) Alameda Point; (4) West Oakland.

SEA-LEVEL RISE THRESHOLDS

Overtopping

Water levels in the Oakland-Alameda Estuary under various SLR, tide, and storm surge scenarios are shown in Table 4. These water levels are compared with ground elevations (Figure 35) to determine overtopping thresholds.

Table 4. Water levels in the Oakland-Alameda Estuary. Compiled from NOAA tidal datums for station 9414764, Oakland Inner Harbor, and SLR and Extreme Tide Matrix for Alameda County (Vandever et al. 2017).

Total Water Level (ft NAVD)	Ft above today's MHHW	SLR	Tide	Storm surge	Year (Med-High Risk Aversion Scenario, High Emissions) (CA OPC 2018)
6.3	0	0	MHHW	-	2022
7.3	1	0	King Tide	-	2022
7.8	1.5	0	MHHW	2-year surge	2022
7.8	1.5	0.5	King Tide	-	2030
7.8	1.5	1.5	MHHW	-	2040-2050
8.8	2.5	0	MHHW	10-25 year surge	2022
8.8	2.5	0.5	MHHW	5-year surge	2030
8.8	2.5	1.0	MHHW	2-year surge	2030-2040
8.8	2.5	1.5	King Tide	-	2040-2050
9.3	3.0	0	MHHW	50-year surge	2022
9.3	3.0	0.5	MHHW	10-25 year surge	2030
9.3	3.0	1.0	MHHW	5-year surge	2030-2040
9.3	3.0	2.0	King Tide	-	2050-2060
9.8	3.5	0	MHHW	100-year surge	2022
9.8	3.5	1.5	MHHW	5-year surge	2040-2050
9.8	3.5	2.0	MHHW	2-year surge	2050-2060
9.8	3.5	2.5	King Tide	-	2060

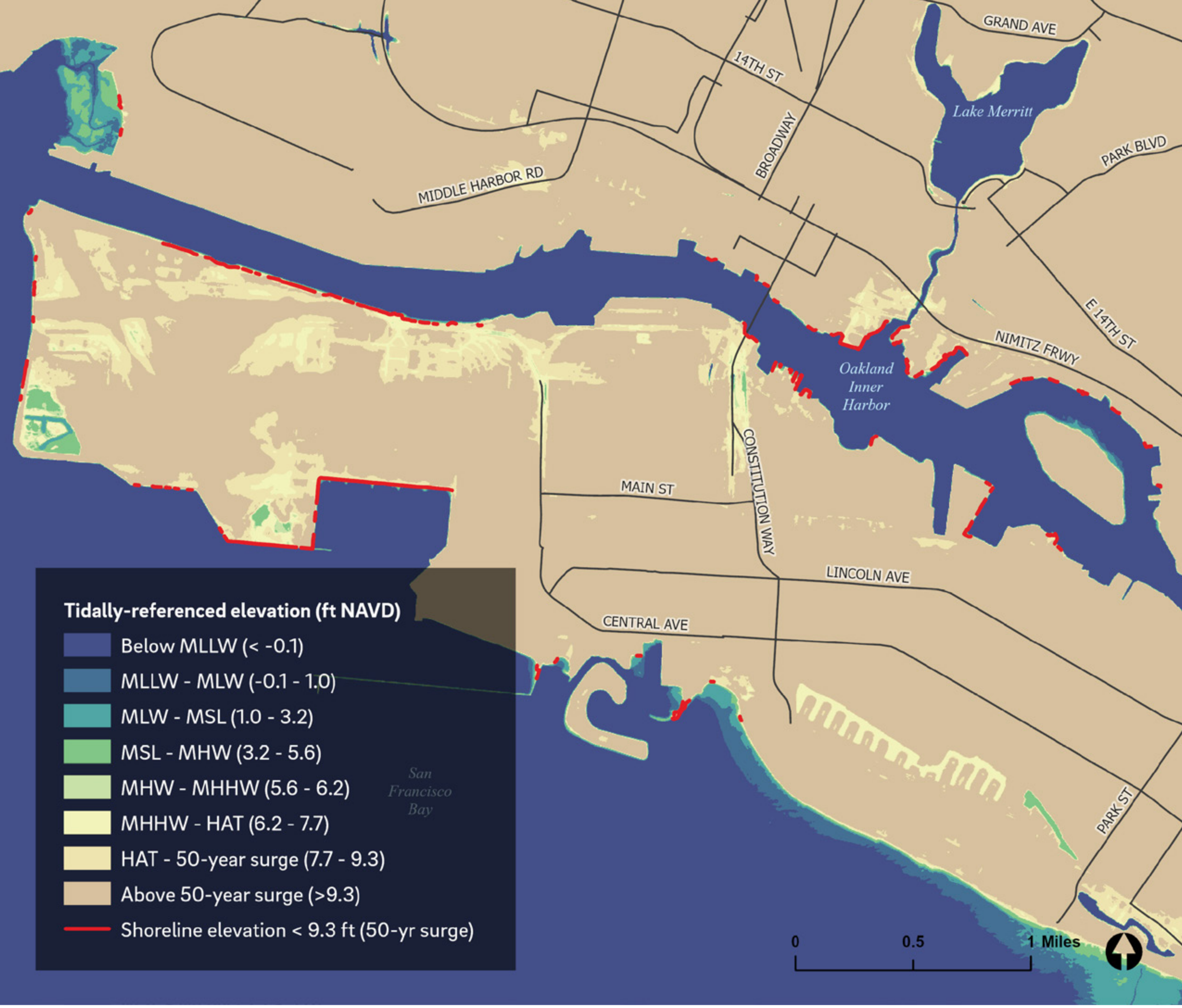


Figure 35. Ground elevations for the Oakland-Alameda Estuary area, with shoreline elevations from the San Francisco Bay Shore Inventory (SFEI 2016). Elevations from the USGS vegetation-corrected dataset for SF Bay (Buffington and Thorne 2019). Grade changes may have occurred at Alameda Point and other areas since the aerial survey data used to create the digital elevation model and the Bay Shore Inventory were collected.

Along the Lake Merritt channel, there is some overtopping and localized flooding at 1 ft above MHHW (current king tide), including at the underpass between 7th and 8th Streets. The low point on this shoreline is at about 6-7 ft NAVD. At 3 ft above today's MHHW, flooding from overtopping becomes more widespread.

Entrances to the Posey and Webster tubes on the Alameda side flood at 3 ft above today's MHHW. The low point on the northern Alameda shoreline protecting this area is between 8-9 ft NAVD.

Along the northern shore of Alameda Point, there is some overtopping and street flooding at 2 ft above today's MHHW, with more widespread flooding at 3 ft above today's MHHW. The low points in the shoreline in this area are between 7-8 ft NAVD.

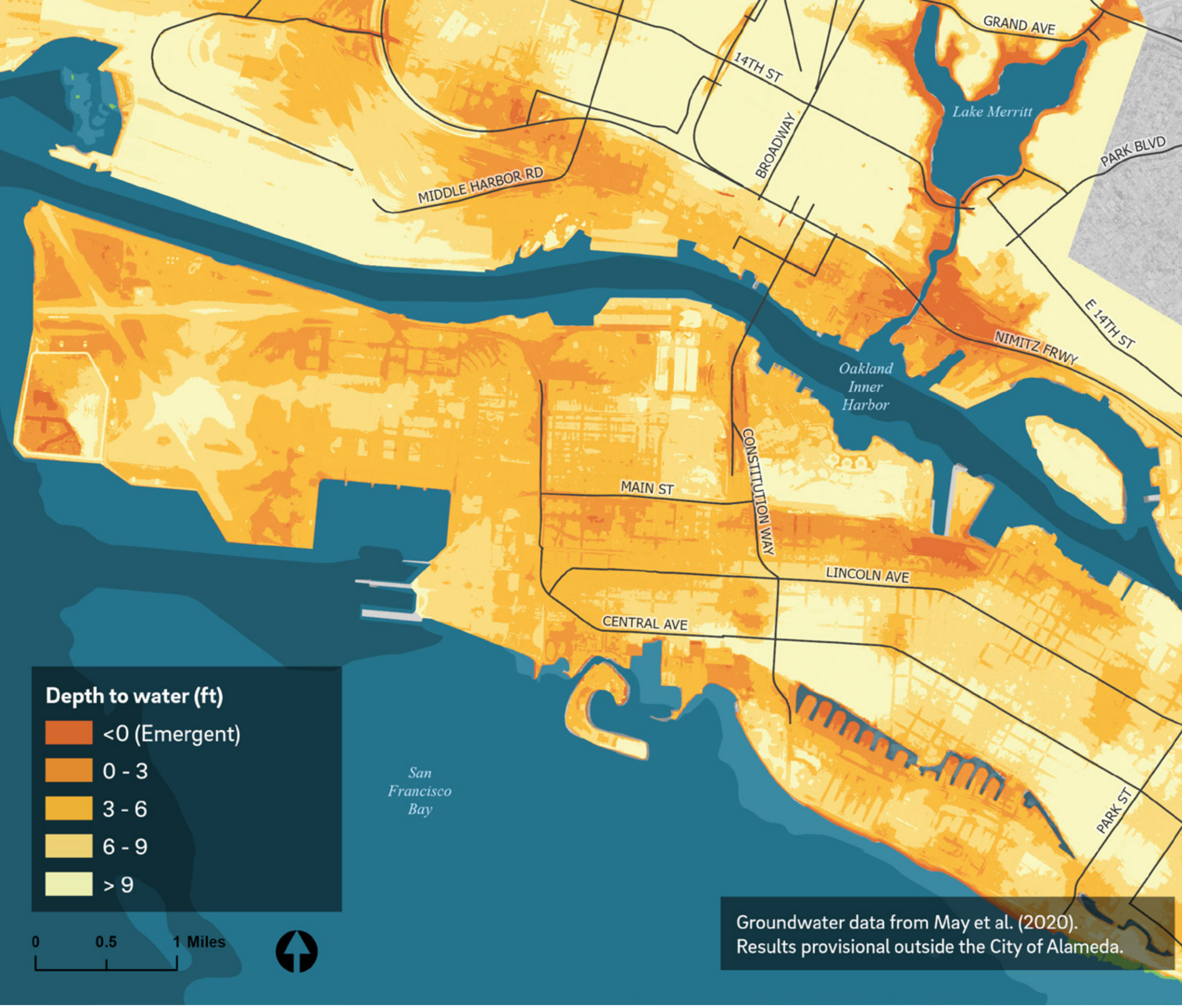


Figure 36. Approximate depth to groundwater during a wet winter in the Oakland-Alameda Estuary subunit, from May et al. (2020).

Some of the adaptation pathways outlined below use the state guidance to build for resiliency to 3.5 ft of SLR by 2050 and 6.0 ft by 2100 (CA State Sea-Level Rise Leadership Team 2022). Actual design heights for shoreline infrastructure will be determined by engineers during the planning and design phase for relevant projects and include margins for storm surge, freeboard, etc.

Rising groundwater

As in San Leandro Bay, much of the shoreline development in this area is built on artificial fill over historical baylands. Depth to groundwater is largely dictated by how much fill was placed. All three focus areas have shallow groundwater today and are at risk of rising and emergent groundwater with SLR (Figure 36). Groundwater is already near or at the ground surface along the Lake Merritt channel during wet winters. With even 1 ft of SLR, emergent groundwater is likely to become much more problematic in this area. Groundwater is also very shallow at the entrance to the Posey and Webster tubes, and emergent groundwater could become an issue at 1 ft above today's MHHW, before overland flooding impacts the tubes. However, a large storm surge could cause overland flooding impacting the tubes even at today's sea level. An analysis conducted as a supplement to the City of Alameda CARP recommends installing additional monitoring wells in this area to track groundwater levels (May et al. 2020). At Alameda Point, ongoing development efforts including placement of fill and stabilization efforts to reduce liquefaction risk (e.g. deep soil mixing) are likely to impact groundwater levels and groundwater flow. The City of Alameda has been proactive in incorporating the latest science on rising groundwater (e.g. May et al. 2020) into requirements for new development.

PLANNED PROJECTS AND PROJECT IDEAS

Upgrade ideas for the Posey and Webster tubes, including improvements for the northern waterfront seawall and roadway upgrades in the tunnels themselves, are outlined in the Alameda CARP (City of Alameda 2019). The CARP also includes a vision for the Alameda Point shoreline, including beach, grassland, and wetland habitats to support SLR adaptation as well as wildlife habitat. These ideas are also captured in some early concepts for the new Northwest Territories park (EBRPD 2021). The Alameda Point Master Infrastructure Plan (City of Alameda 2014) and the 2020 update lay out a plan for a perimeter levee and elevated land for the developed areas, with less detail about adaptation in undeveloped areas/open space.

ADAPTATION PATHWAYS

The adaptation strategies outlined in this section are a first pass and not an exhaustive list of all potential adaptation options for the Oakland-Alameda Estuary subunit. A more expansive vision than this approach may be possible depending on opportunities and constraints identified by shoreline stakeholders in future phases of the planning process. These pathways do not constitute a plan and are meant to spur further conversation and collaboration among San Leandro Bay stakeholders to develop alternative approaches and a larger vision.

The goals of this approach are to:

- Maintain transportation and recreation corridors
- Reduce flood exposure in developed areas
- Create and/or restore marsh, upland, and transitional habitat

To develop the pathways, we listed the vulnerabilities associated with each resource, then paired these with the SLR thresholds and adaptation strategies to address the vulnerabilities (Table 5). The pathways are shown in Figures 37-39.

Table 5. Vulnerabilities, thresholds, and strategies for Approach 1: Protect in Place

Resource	Vulnerabilities	Shoreline Elevation (range)	Threshold 1	Strategy 1	Threshold 2	Strategy 2
Lake Merritt Channel	Overtopping, rising groundwater	6-9 ft	Lowest point overtops at 1 ft above today's MHHW. Flood impacts expand at **0.5 ft** plus king tide	Raise low spots in shoreline along the channel. Implement strategy to address rising groundwater, potentially including waterproofing where necessary, improving drainage systems, and/or pumping. Protect to 9 ft NAVD	**1.5 ft SLR**: King tide overtops raised shoreline with wider groundwater emergence and overtopping impacts	Refurbish tide gate in place and improve channel berms, or rebuild new tide gate closer to Estuary. Improve pump capacity to meet climate challenges (rising groundwater, more intense storm events). Start planning process for longer-term scenario when regular tide levels become too high to allow tidal flows into the lake.
Posey/ Webster Tubes	Overtopping, flooding of tubes from entrance/exit on Alameda side, rising groundwater	8-9 ft	Floods from overtopping at 3 ft SLR. Construct by **1 ft SLR** to prevent 5-year storm surge flooding	Upgrade shoreline levee (including subtidal habitat features). Upgrade tubes including groundwater management, retaining walls, electrical equipment. State guidance is 3.5 ft protection by 2050.	**3.5 ft SLR**: overtopped	Raise seawall again, consider other options
Alameda Point (Lake Merritt Channel area)	Overtopping, rising groundwater, shoreline erosion	7-9 ft	Street flooding at 2 ft above MHHW. Construct by **1 ft SLR** to prevent king tide flooding.	Perimeter levee (neighborhood and park); coarse beaches, tidal wetland, ecotone levee, seasonal wetlands (NW territories). State guidance 3.5 ft protection by 2050 (may consider higher design level including storm surge etc)	Adaptive management: Monitor beaches, marshes to determine management actions needed to maintain. **3.5 ft SLR**: perimeter levee overtopped	Raise levee, nourish beaches, add material to ecotone, etc.

POSSIBLE ADAPTATION PATHWAY

Lake Merritt Channel

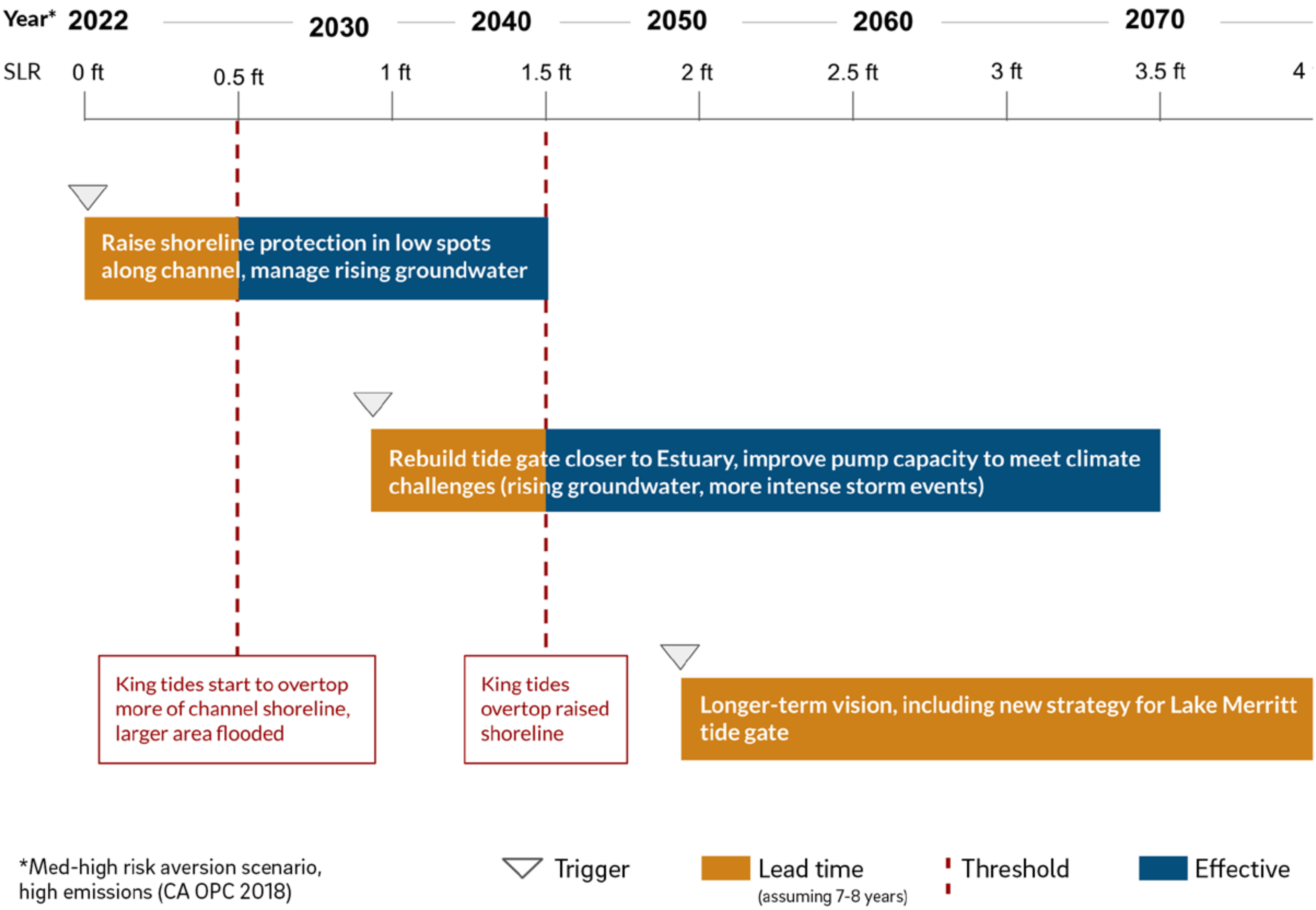


Figure 37. A potential adaptation pathway for Lake Merritt Channel

In the first phase, a shoreline berm along Lake Merritt Channel is raised to prevent overtopping, and groundwater management strategies, potentially including waterproofing of sensitive structures and utilities, and drainage/stormwater management improvements are implemented. At 1.5 ft SLR, more major modifications are required to prevent widespread flooding. The Lake Merritt tide gate could be upgraded to improve pump capacity for managing water levels inboard of the gate, including during intense storm events and wet winters, when groundwater levels are highest. The tide gate will not function as designed forever; as water levels in the Estuary rise higher, the tide gate will need to be closed more and more often until eventually it must be closed all the time. Therefore, a long-term management strategy beyond the tide gate upgrade will be needed, and planning for this should begin early. With this and other projects, modeling should be done to determine impacts of shoreline changes on flooding in other parts of the Oakland-Alameda Estuary.

POSSIBLE ADAPTATION PATHWAY

Posey and Webster Tubes

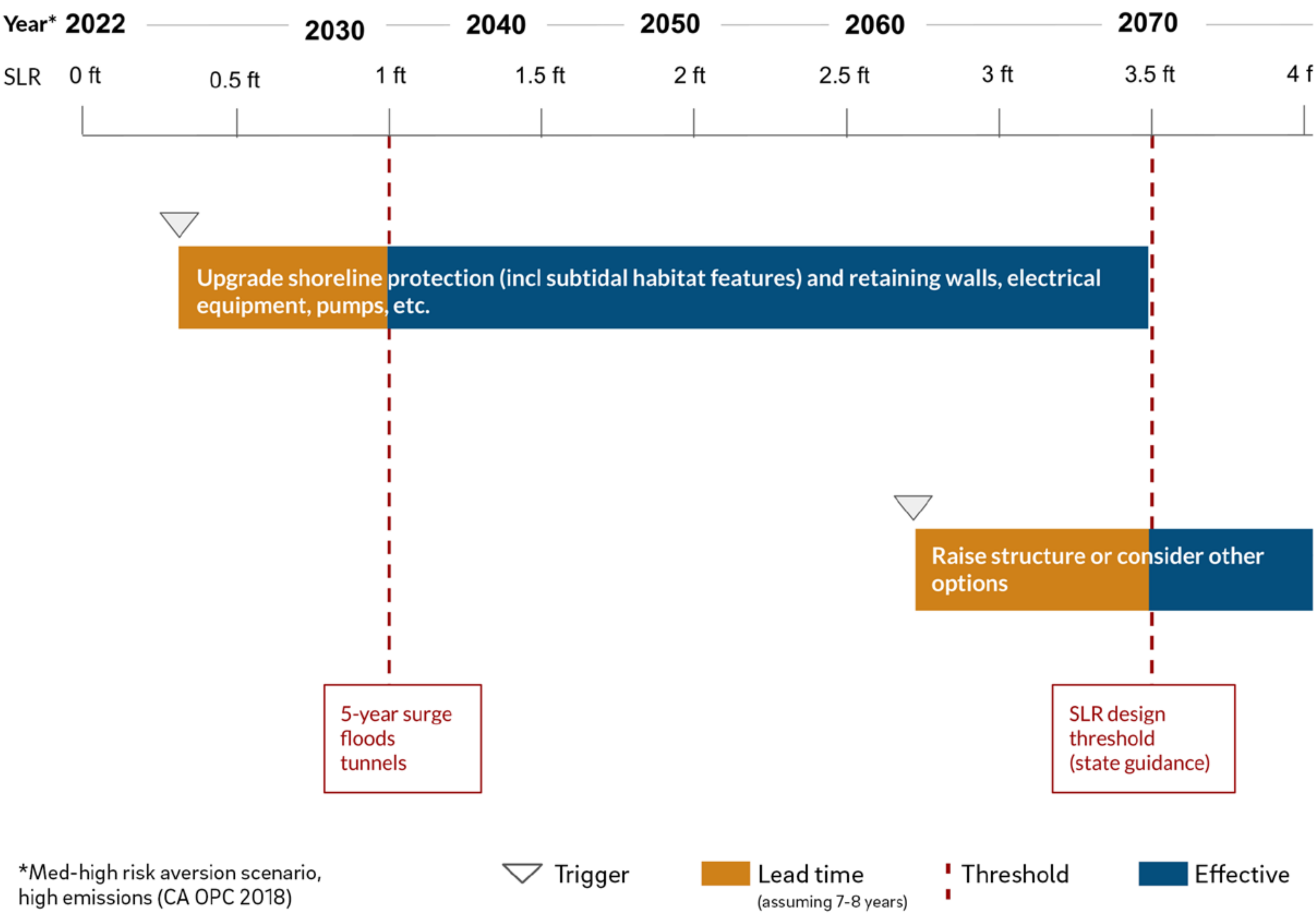


Figure 38. A potential adaptation pathway for the Posey and Webster tubes

In the first phase, the seawall along Alameda's northern shoreline is upgraded to protect the entrance of the Posey and Webster tubes from flooding. Funding to start developing plans for this project is included in Alameda's 2021-2023 Capital Improvement Program (City of Alameda 2021). The seawall can be enhanced with "living seawall elements" of various shapes and textures (such as grooves, nooks, and shelves) to improve subtidal habitat conditions for fish and other species. These elements should be designed with the habitat requirements of San Francisco Bay species in mind. Current state guidance recommends building resilience to 3.5 ft of SLR by 2050 (CA State Sea-Level Rise Leadership Team 2022). If the seawall is designed for that amount of SLR, a second threshold will be reached at 3.5 ft of SLR, and the structure will need to be raised or other options considered. In addition to seawall upgrades, improvements are likely needed in the tubes themselves (such as waterproofing, electrical upgrades, etc.) as well as in the Mariner Court area to manage rising groundwater. With this and other projects, modeling should be done to determine impacts of shoreline changes on flooding in other parts of the Oakland-Alameda Estuary.

POSSIBLE ADAPTATION PATHWAY

Alameda Point

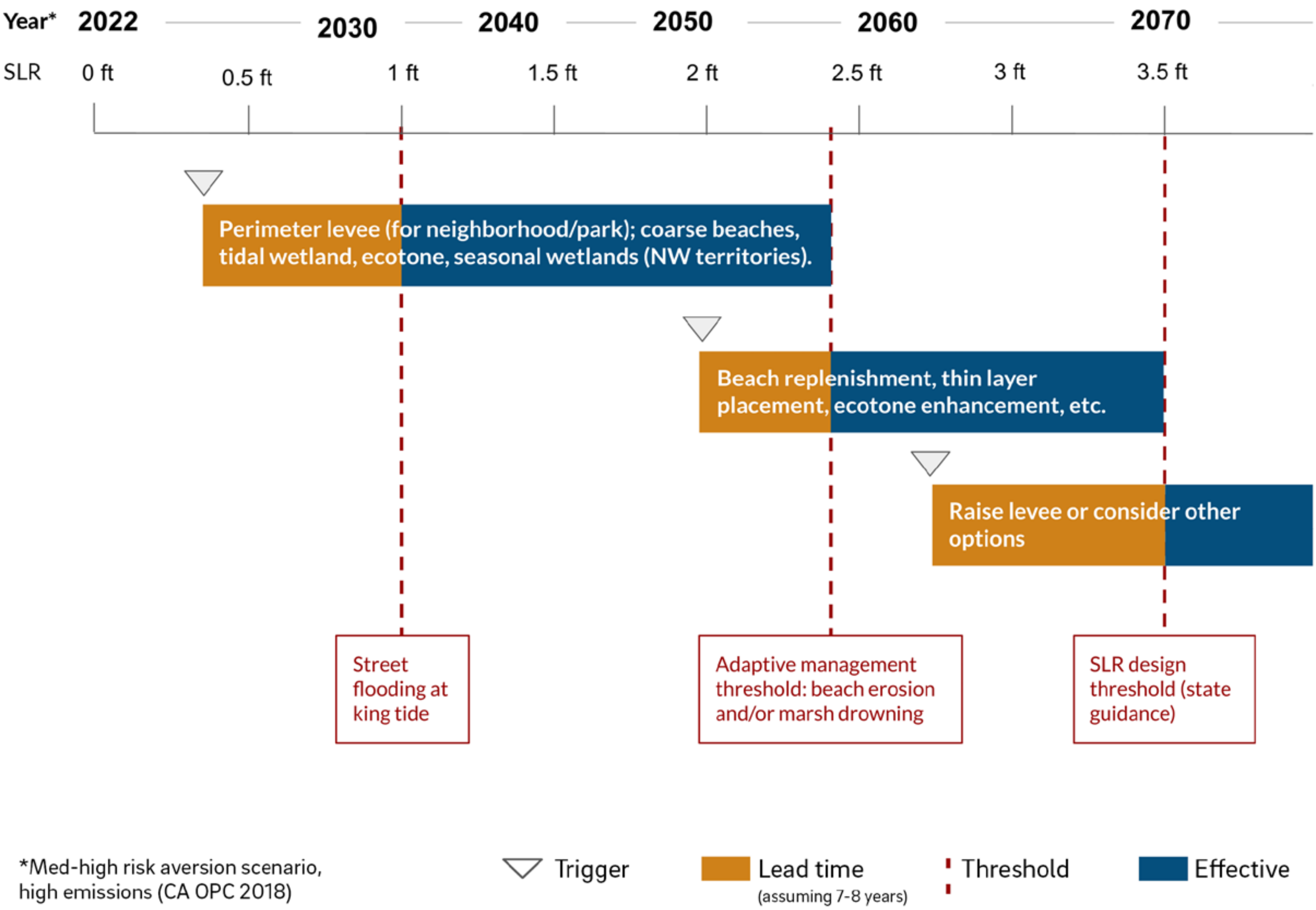


Figure 39. A potential adaptation pathway for Alameda Point.

In the first phase, a perimeter levee is constructed to protect the newly developed neighborhoods. Along the Northwest Territories shoreline, natural habitats are created and/or restored. These may include coarse beaches, especially on the wave-dominated western shoreline where beaches historically existed in the area, small patch(es) of tidal marsh (extent depending on restoration potential in contaminated areas), some transitional habitat, and upland/seasonal wetland areas. Some initial concepts are shown in the SF Bay Trail Risk Assessment and Adaptation Prioritization Plan (EBRPD 2021). As part of the planning process for these new habitats, adaptive management thresholds can be set (e.g. beach erosion, marsh drowning thresholds) to determine when action, such as beach replenishment, thin layer placement etc. is required to maintain shorelines. In the latter half of the century, as sea levels approach design levels of shoreline protection structures, levees may need to be raised and/or other adaptation options pursued. With this and other projects, modeling should be done to determine impacts of shoreline changes on flooding in other parts of the Oakland-Alameda Estuary.

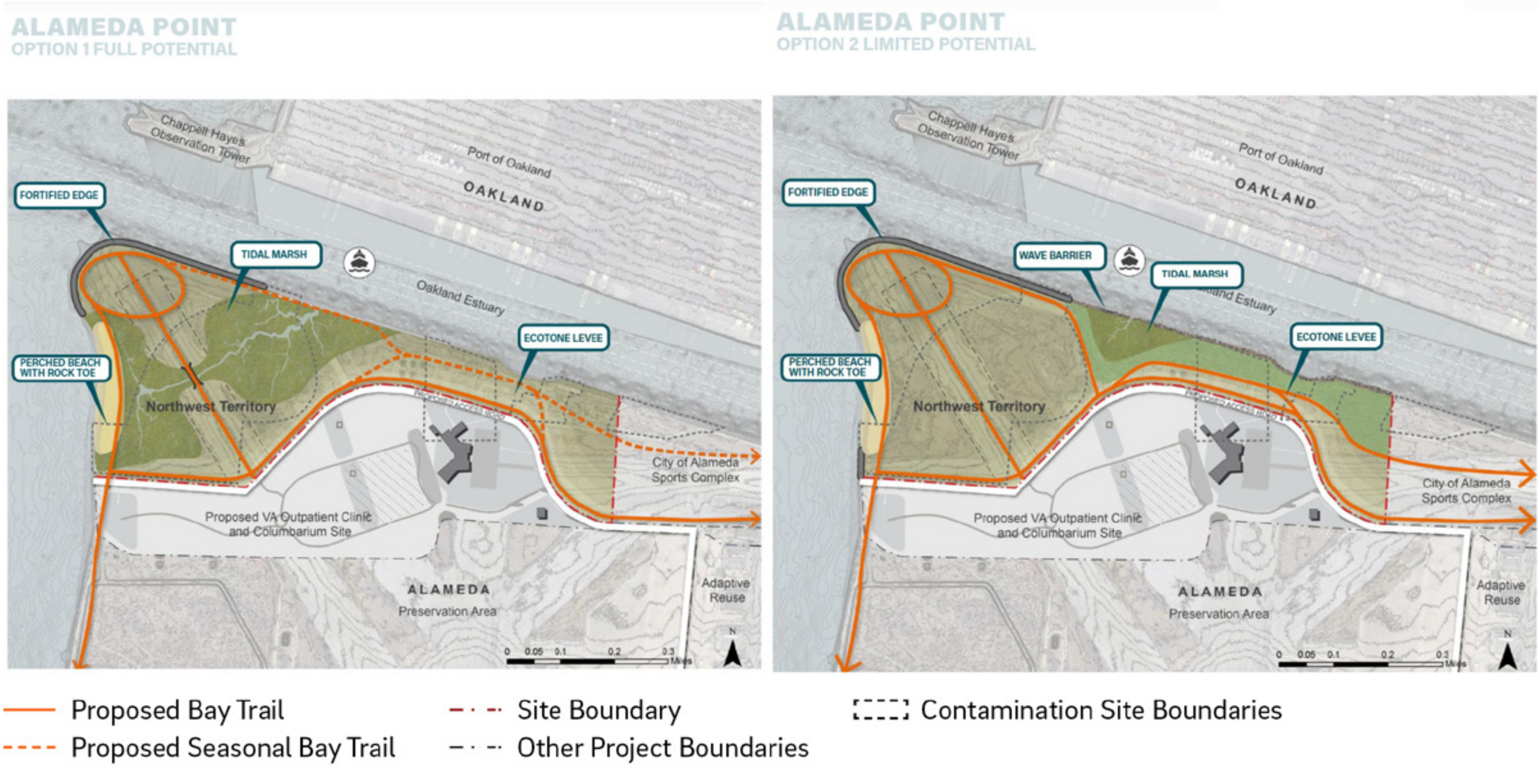


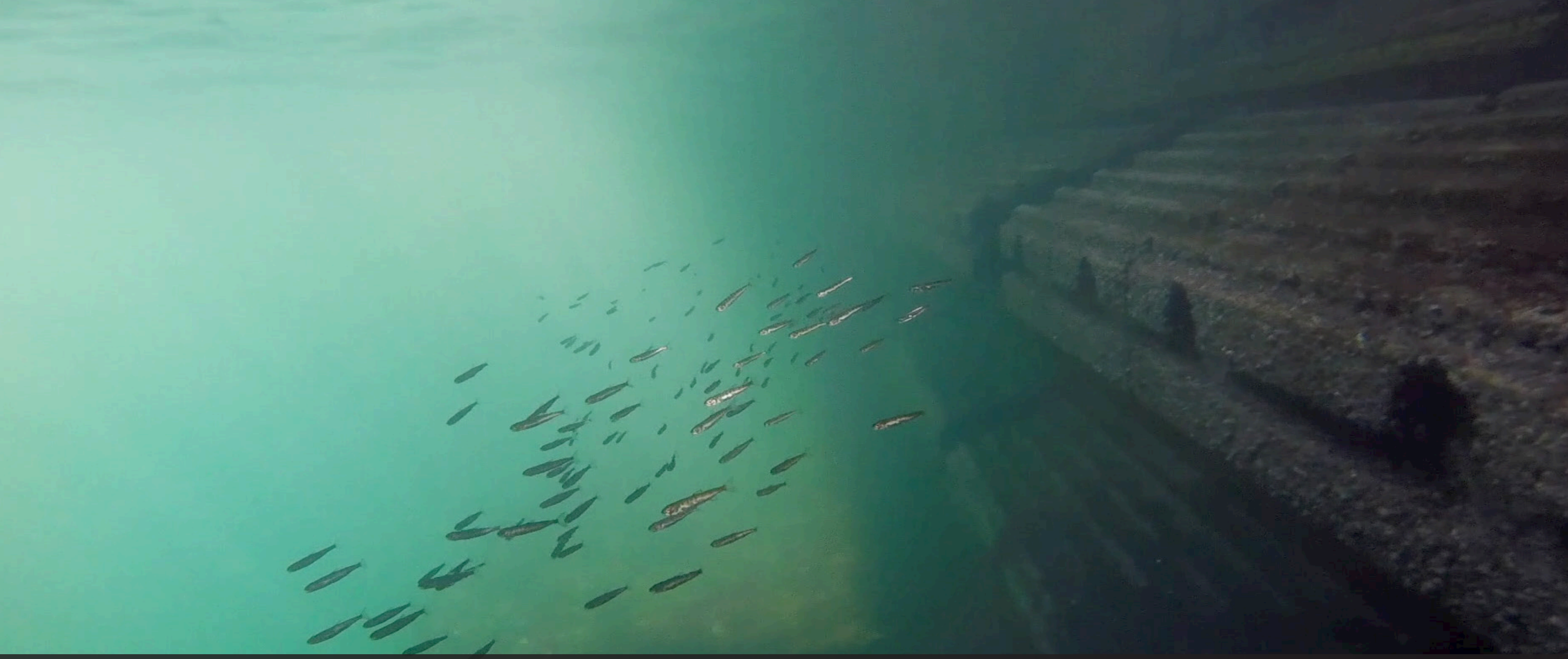
Figure 40. Two potential options for shoreline adaptation and ecological restoration at the new EBRPD Northwest Territories park. Figures from the SF Bay Trail Risk Assessment and Adaptation Prioritization Plan (EBRPD 2021).

Wildlife at Alameda Point

This chapter is focused on the Oakland-Alameda estuary and the north shore of Alameda Point. However, it is important to note some key species living nearby at Alameda Point. Conservation and protection of habitat for these species should be carefully considered when choosing and implementing adaptation pathways for the surrounding area.

Alameda Point is home to the largest breeding colony of endangered California least tern north of San Luis Obispo County (Elliott et al. 2007). The colony is protected in a conservation management area overseen by Veterans Affairs and the US Fish and Wildlife Service.

On the south side of Alameda Point is one of the few harbor seal haulouts in the East Bay, where harbor seals make use of a specially-designed floating haulout platform to rest and warm up out of the water.



Seattle's seawall was specifically designed to improve habitat for migratory salmon in a degraded urban environment, and has been successful in boosting salmon populations. Similar seawall improvements to benefit Bay species could be implemented when upgrading seawalls along the Oakland-Alameda Estuary. Photo by Mike Caputo, University of Washington.

6. Next steps

Prior to agreeing upon adaptation pathways, the Working Group should set a clear governance structure and decision-making process to ensure the voices of all stakeholders are heard. The governance structure could draw on elements of this report; for instance, subcommittees could be formed for each of the subunits outlined in section 3. A subcommittee has already coalesced around the Doolittle Drive area and could serve as a model for other subunits. BCDC is set to release an Adaptation Roadmap this spring which is focused on helping stakeholder groups structure the adaptation process, including guidance on moving from vulnerability assessments to adaptation visions. This document will set out useful guiding principles for decision making that the Working Group may consider adopting.

After the governance structure and decision-making process is decided, stakeholders in the Working Group can gather and consider a wide range of possible adaptation approaches for each subunit, using these pathways as a springboard to develop ideas. Some pathways proposed may be more visionary and require more changes to existing development than those proposed here. In addition to expanding the set of potential pathways on the table, stakeholder review and conversation can help refine pathways. For example, transportation agencies will be better able to pinpoint what water levels are likely to trigger a road closure and assess what level of flood risk is appropriate. This type of information can help determine what levels of SLR are selected as thresholds for the pathways. Likewise, planners and project managers familiar with the types of projects being proposed will be better able to assess likely lead times, based on expected timeframes for planning, design, permitting and construction. Community groups will be best able to advise on how planned projects can be designed with local input to ensure community ownership of planned shoreline adaptation projects.

In the near term, the Working Group has an opportunity to jump start adaptation planning by making early moves on the adaptation pathways that will set up the group for success in achieving longer-term goals. Early stages of adaptation pathways may include key demonstration projects to bring public attention to the goals of the Working Group, and show its potential as a model for cross-jurisdictional planning.

7. Acronyms and abbreviations

ART: Adapting to Rising Tides (BCDC sea-level rise adaptation program)

BCDC: Bay Conservation and Development Commission

Bay/SF Bay: San Francisco Bay

Alameda CARP: City of Alameda Climate Action and Resiliency Plan

EBRPD: East Bay Regional Park District

FEMA: Federal Emergency Management Agency

HAT: Highest Astronomical Tide

MHHW: Mean Higher High Water

MHW: Mean High Water

MLK Shoreline: Martin Luther King, Jr. Regional Shoreline

MLLW: Mean Lower Low Water

MLW: Mean Low Water

MSL: Mean Sea Level

NAVD: North American Vertical Datum of 1988

NOAA: National Oceanic and Atmospheric Administration

OLU: Operational Landscape Unit

OPC: Ocean Protection Council

OSLA: Oakland Shoreline Leadership Academy

SLR: Sea-level rise

SR: State Route

USGS: United States Geological Survey

Working Group: San Leandro Bay/Oakland-Alameda Estuary Adaptation Working Group

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