OAAC ADAPT: Oakland-Alameda Adaptation Projects

Oakland Alameda Multi-Hazard Adaptation and Community Benefits Project

Technical Report

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Prepared By

Pathways Climate Institute

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Disclaimer

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Acronyms / Abbreviations

Acronym	Signification
Airport	Oakland International Airport
BRIC	Building Resilient Infrastructure and Communities
Caltrans	California Department of Transportation
CDRZ	Community Disaster Resilience Zone
EBRPD	East Bay Regional Park District
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
MHHW	mean higher high water
OAAC	Oakland Alameda Adaptation Committee
Port	Port of Oakland
SFHA	Special Flood Hazard Area
SLR	sea level rise
SWL	stillwater level
TWL	total water level

1 Introduction

The Oakland Alameda Multi-Hazard Adaptation and Community Benefits Project will reduce existing and future flood risk within the Oakland International Airport (the Airport) Community Disaster Resilience Zone (CDRZ) and will address existing and future flood risks along San Leandro Creek within east Oakland underserved communities. The project includes flood mitigation elements that will remove the Airport, and communities within the Cities of Oakland and Alameda from the Federal Emergency Management Agency (FEMA) Special Flood Hazard Area (SFHA) while also protecting important transportation corridors, enhancing access to the San Leandro Bay shoreline, and providing adaptive capacity and resilience for future sea level rise.

This project requires collaboration across multiple jurisdictions due to the connected nature of coastal flooding that occurs when coastal waters overtop multiple locations along the shoreline. Projects implemented within a single jurisdiction would be insufficient to remove the project area from the FEMA SFHA. A multi-hazard, multi-jurisdictional adaptation project is required to address the complex, compounding, and co-mingled existing and future flood hazards across the Cities of Alameda and Oakland and the Airport and within the CDRZ.

2 Project Area

San Leandro Bay is located on the western shoreline of San Francisco Bay in the County of Alameda (Figure 1), nestled between the Cities of Alameda and Oakland and the Airport where San Leandro Creek enters the bay (Figure 2). San Leandro Bay is a sheltered estuary with high-quality marsh habitat for the endangered California Ridgway rail (*Rallus obsoletus obsoletus*) and the salt marsh harvest mouse (*Reithrodontomys raviventris*). San Leandro Bay is surrounded by a mix of marsh habitat, the Airport, industrial areas, transportation corridors, and residential areas.

A portion of the City of Oakland, including the Airport, ~~are~~ is located within a CDRZ, a geographic area that FEMA identified as most at-risk ~~and in need~~ from natural disasters and climate change (FEMA 2023a). The CDRZ is ~~identified~~ listed as disadvantaged by the White House Council on Environmental Quality Climate and Economic Justice Screening Tool. The Airport, and much of the surrounding area, is also over the 99th percentile for FEMA's National Risk Index (NRI), highlighting its very high risk to natural hazards (FEMA 2023b).

The Airport opened in 1927 with the world's longest runway and it continues to serve as one of the three international airports serving the larger San Francisco Bay Area. The Airport has 14 airlines operating out of its two terminals and nine rental car agencies as well as supporting businesses in the Airport CDRZ. The Airport saw 13.3 million passengers pass through its terminals in 2019 and is expected to grow beyond 20 million over the next decade (Port of Oakland 2021). Airport employees mainly live in the adjacent cities of Oakland (435,000 population) and Alameda (76,000 population), with east Oakland (95,000 population) having the highest concentration of Airport workers, along with other areas in the far East Bay, which often have a high National Risk Index, also benefitting from Airport employment.

Figure 1. San Francisco Bay and San Leandro Bay

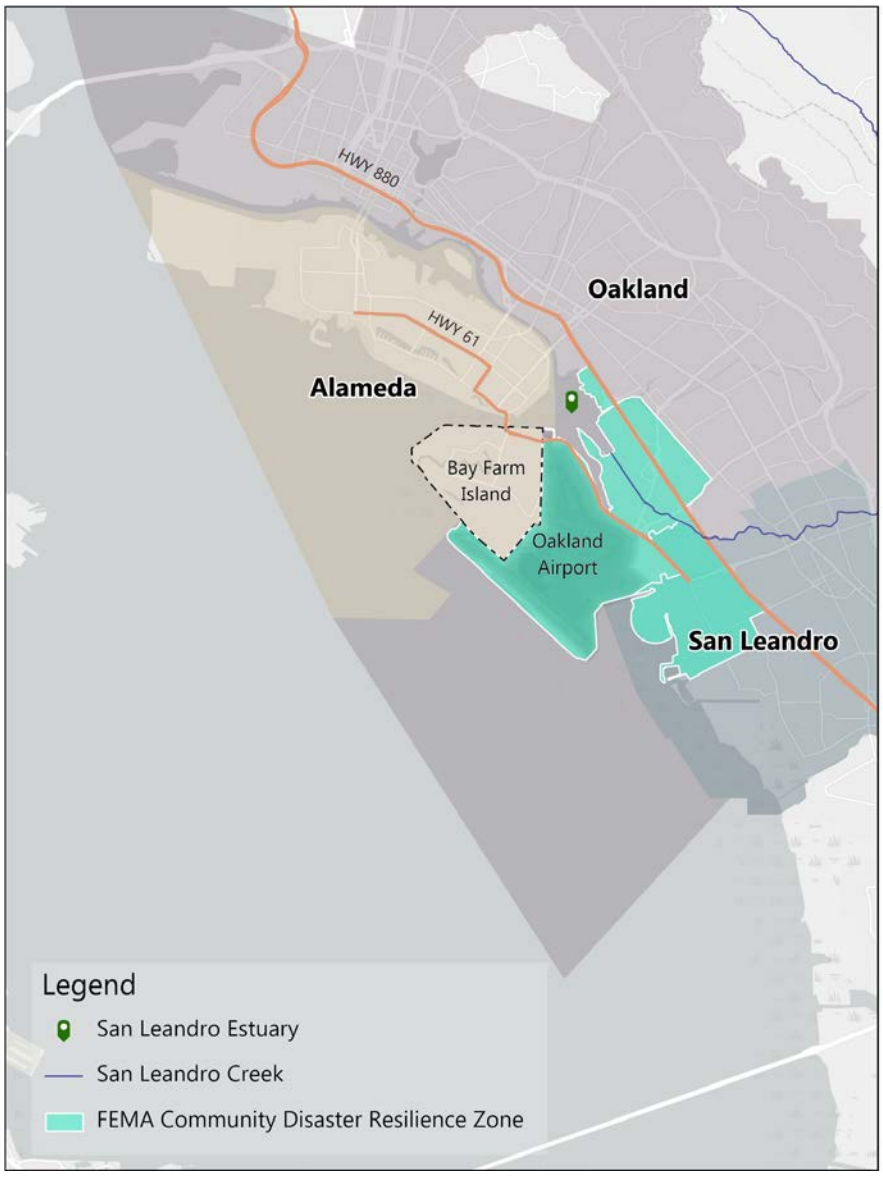


Figure 2 Project Area and FEMA Community Disaster Resilience Zone

State Highway 61 (Doolittle Drive) is located between the Airport and San Leandro Bay and is the primary throroughfare for accessing the Airport service industries. Doolittle Drive is a critical evacuation route for residents on Bay Farm Island in the event of an earthquake, tsunami, severe flood, or other dsaster. Owned and operated by the California Department of Transportaiton, Doolittle Drive is a busy and low-lying roadway that experiences coastal overtopping during extreme high tides and coastal storm surge events (Photo 1).

Underserved and marginalized east Oakland communities are located east of Doolittle Drive and along San Leandro Creek with the CDRZ. Migrations from the American south starting in 1914 and from the adjacent I-580 freeway construction in 1947 caused east Oakland to become a predominately Black and now Latinx community due to the federal policy of redlining, which began in 1934, adjacent industrial jobs, and restrictive covenants in other neighborhoods. Currently, east Oakland residents experience a lower life expectancy at 72 years, higher rates of obesity at 32 percent and 48 percent for children and lack of access to healthy food and affordable housing. Due to the adjacent I-880 freeway, which was built in 1958, higher rates of asthma and soot impact these communities. Consequently, East Oakland is recognized as a Justice40 community and currently has a median household income of about $40,000 with a disproportionately Black (37%) and Other/Latino (32%) population.

Commented [LL1]: Lindsay to rework this sentence

Commented [LL2]: Lindsay to rework this sentence

Bay Farm Island is located within the City of Alameda, directly adjacent to the Airport. Bay Farm Island includes the Chuck Corica Gulf Complex, office and retain complexes, and approximately 14,600 residents. A portion of the San Francisco Bay Trail wraps around the bay-edge of Bay Farm Island, and along Doolittle Drive, providing public access to the bay and recreation. The San Francisco Bay Trail within Alameda County is managed by the East Bay Regional Park District (EBRPD).

Photo Credit: Sergio Ruiz, Flickr 2019

Photo 1. Low-lying Doolittle Drive (State Highway 61) adjacent to San Leandro Bay

3 Flood Hazards

San Francisco Bay is the largest estuary in the western U.S., with a contributing watershed that includes nearly 40% of California, and substantial freshwater flows entering through the Sacramento River. The 300-foot-deep Golden Gate inlet connects the Bay with the Pacific Ocean, and the tides, ocean-driven swells, and extreme ocean water levels all enter the Bay through this single inlet. The large expanse of the Bay and the complex topography surrounding the Bay can transform storm-driven winds in a multitude of directions depending on the primary driver of the onshore or offshore winds or the track of the large storm system descending on the Bay Area. The water levels and wave heights of the Bay exhibit a high degree of variability driven by many factors, including the bathymetry, astronomical and oceanic cycles, windspeeds and direction, and atmospheric events (May et al. 2016b). In the Bay, no single storm event produces the highest water level and highest wave hazard along the entire shoreline (May et al. 2016a).

Although large wave hazards (e.g., up to 5 feet) can occur on the San Francisco Bay side of the Airport, San Leandro Bay is protected from large waves due to its sheltered location and much smaller size. FEMA analyzed coastal water levels and wave hazards for the entire San Francisco Bay shoreline, resulting in updated Flood Insurance Rate Maps (FIRMs) for the nine Bay Area counties, including the County of Alameda (DHI 2011; FEMA 2018). Figure 3 shows FEMA SFHA within the project area. The Airport's levee along San Francisco Bay is accredited, allowing a portion of the Airport to be removed from the SFHA as an area with reduced risk protected by a levee (see the hatched area on Figure 3).

This project seeks to mitigate the flood risks within the CDRZ, which includes flood risk mitigation~~ng flood risks~~ for the Airport and Bay Farm Island~~, and mitigating flooding flood risks~~, as well for East Oakland's Columbia Gardens neighbood. Additional mitigation on Bay Farm Island will enhance the effectiveness and long-term resilience of the project.

3.1 The Airport and Bay Farm Island

The Airport's North Field and supporting industries remain within the FEMA SFHA. Removing this area from the FEMA SFHA will require addressing multiple areas where coastal floodwaters can overtop the shoreline (Figure 4):

- Doolittle Drive (State Highway 61): Doolittle ~~Road~~ Drive is low-lying along its entire length adjacent to the Airport's North Field and supporting industries. Overtopping can occur at multiple locations along Doolittle Drive. Fringing marsh is located on the bayside of Doolittle Drive for much of its length within the project area, although a portion is armored with rock revetment. The Martin Luther King Jr. Shoreline Park, with parking, a kayak/boat launch, and open space, is located along Doolittle Drive between Langley and Grumman Streets. Improvements along Doolittle Drive to address flooding will require coordination between the Airport, Caltrans, and EBRPD.
- Lagoon Shoreline: At the northern end of the Lagoon on Bay Farm Island within the City of Alameda's ~~jurisdiction~~jurisdiction, where the shoreline and tide gate structure are low spots along the existing shoreline.

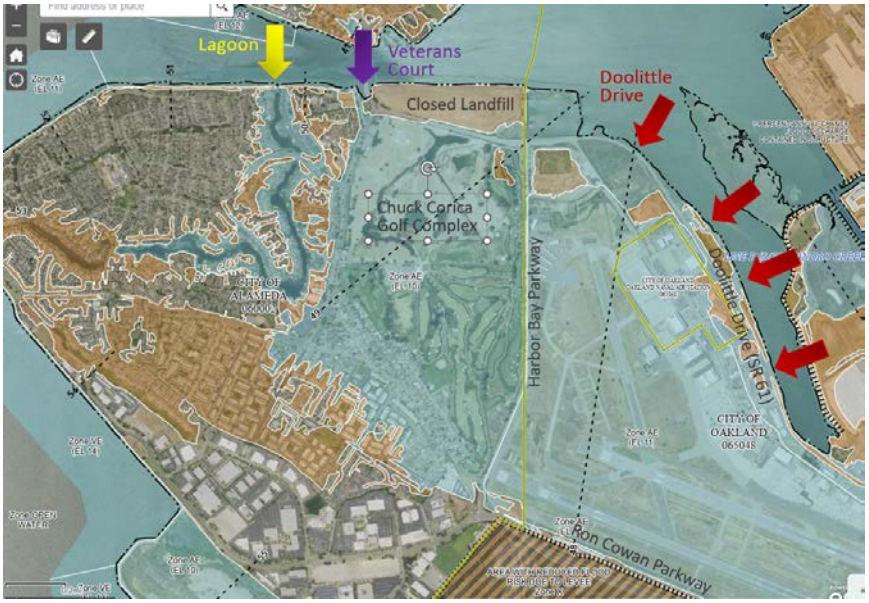
- Veterans Court: Floodwaters can overtop the shoreline near the touchdown of the Bay Farm Bridge (State Highway 61), between the closed Alameda landfill and Veterans Court, within the City of Alameda's ~~Jurisidtion~~Jurisdiction. The shoreline includes an aging seawall, rock riprap, and fringing marsh habitat.

Coastal overtopping along Doolittle Drive, and at the Lagoon Shoreline and Veterans Court must all be addressed to mitigate flood risks along Doolittle Drive and the Airport. The Port of Oakland (which owns the Airport) completed a two-dimensional hydrodynamic modeling study to better assess stormwater and coastal flood risks and mitigation strategies. The Port determined that, in additional to mitigation elements along Doolittle Drive, the Airport would either have to construct a floodwall along much of Harbor Bay Parkway, from Doolittle Drive to Ron Cowan Parkway to address the flood hazards coming from the City of Alameda into the Airport property, or collaborate with the City of Alameda to mitigate the coastal overtopping occurring at the Lagoon Shoreline and Veterans Court (Port of Oakland 2023). An earlier study completed by the San Francisco Bay Conservation and Development Commission as part of the Adapting to Rising Tides program agrees with this finding (AECOM 2014).

The converse of this equation is also true. The City of Alameda can mitigate the flood risks at the Lagoon and Veterans Court low points, but they cannot remove the Bay Farm Island residents that live along the Bay Farm Lagoon from the FEMA SFHA until the flooding along Doolittle Drive, outside of their jurisdiction, is also mitigated (AECOM 2014). The most cost-effective solution to mitigate flood risks within these areas requires coordination between both entities (Port of Oakland 2023). This coordination is occurring through the Oakland-Alameda Adaptation Committee.

Source: (FEMA 2023c)

Figure 3. Project Areas in FEMA Effective Flood Insurance Rate Map

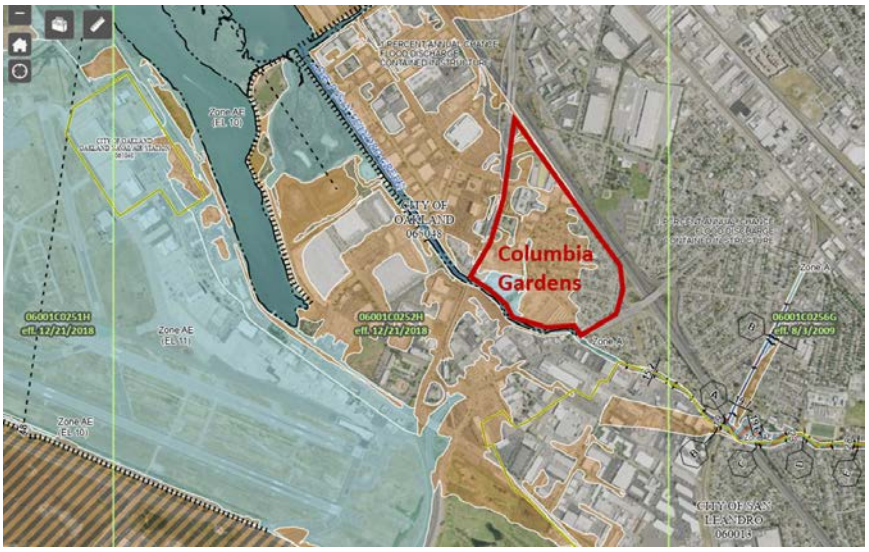


Source: (FEMA 2023c)

Figure 4. Shoreline Overtopping Locations

3.2 East Oakland (Columbia Gardens)

In addition to the Airport and Bay Farm Island, the Columbia Gardens neighborhood is mapped within FEMA's SFHA (Figure 5). This area experiences regular flooding during heavy rainfall events, due to overtopping along a drainage channel adjacent to the neighborhood, and flooding during extreme bay (coastal) water levels due to overtopping along San Leandro Creek (Figure 6). This neighborhood is low-income and recognized as a Justice 40 community with a median annual household income of about $40,000 and is disproportionately Black (37%) and Other/Latino. Removing this community from FEMA's SFHA requires addressing both sources of flooding (City of Oakland 2022).



Source: (FEMA 2023c)

Figure 5. East Oakland's Columbia Gardens in FEMA's Flood Insurance Rate Map

Source: Google Earth Aerial Imagery

Figure 6. Columbia Gardens Overtopping Locations

3.3 Additional Bay Farm Island Flood Risks

3.3.1 Lagoon Stormwater Flood Risk Mitigation

A system of lagoons is used to manage stormwater and reduce rainfall-driven flood risks on Bay Farm Island. Bay waters are pumped into the Bay Farm lagoon on the San Francisco Bay edge, and water flows via gravity through the lagoon and out a tide gate at the Lagoon overtopping point shown on Figure 4. The lagoons provide public access and recreation benefits, with a network of trails and playgrounds along the lagoon shoreline. Prior to significant rainfall events, the lagoons are drawn down (i.e.., the water level of the lagoon is lowered) by gravity flows by opening the tide gate when Bay water levels are low (Photo 2). Drawing down the lagoon provides stormwater flood storage capacity, and Bay Farm Island's stormwater network largely drain to the lagoon system. Raising the shoreline elevation of the Lagoon overtopping low point will require enhancements to the lagoon operations to maintain the stormwater flood risk reduction capacity of the system.

Photo Credit: Kris May

Photo 2. Bay Farm Lagoon Tide Gate

3.3.2 Northern Bay Farm Island Shoreline Improvements

The San Francisco Bay trail wraps around Bay Farm Island, providing recreation and public access to the bay (Photo 3). However, portions of the shoreline are experiencing wave- and storm-driven erosion,

threatening the trail, and reducing the flood risk reduction capacity of the shoreline. In some areas, the shoreline has eroded by up to 30 feet, placing former public benches and irrigation lines in areas of open bay water (Photo 4). Addressing this ongoing hazard will improve the overall resilience of the flood risk mitigation actions on Bay Farm Island.

Photo Credit: Kris May

Photo 3. Bay Farm Island Trail

Photo Credit: Kris May

Photo 4. Bay Farm Trail Erosion

4 Project Benefiting Area

The project benefiting area includes the CDRZ, and the area around the Bay Farm Lagoon that would be removed from the FEMA SFHA. The Chuck Corica Golf Complex is not included within the project benefitting area. The Golf Complex has raised grades to mitigate potential flood hazards. These activities occurred after 2018 FIRMs became effective. The residential homes in the vicinity of Maitland Drive are not included within the project benefiting area. This area is low lying, with ground elevations that are 5 to 10 feet below the surrounding areas (at about mean sea level or below). This area would still experience stormwater driven flood risks after implementation of this project.

Figure 7. Project Benefiting Area

5 Mitigation Actions

Addressing existing and future flood risks requires a coordinated, multi-jurisdictional effort between the Cities of Oakland and Alameda, the Port of Oakland, Caltrans, EBRPD, community-based organizations (CBOs) including Tribal partners, and other local and state agencies. Together, these entities are collaborating to reduce existing and future flood risks with hybrid nature-based solutions and habitat enhancements along both estuarine and riverine shorelines. Led by the City of Alameda, the group is called the Oakland Alameda Adaptation Committee (OAAC). OAAC is paying CBOs as Community Partners to bring much-needed benefits to, and build capability and capacity in, underserved and marginalized communities within the project area.

This project includes mitigation actions that were developed through separate planning processes by the Cities of Alameda and Oakland, the Port of Oakland, and the EBRPD. The OAAC has brought these mitigation actions together as one cohesive solution to mitigate existing flood risks within the CDRZ, as well as two feet of future sea level rise to provide future climate change resilience. Combining these projects together reduces project costs, provides opportunities to enhance project benefits, and maximizes the likelihood of achieving a comprehensive flood risk reduction solution.

The following sections describe the mitigation actions included within the overall project:

1. Doolittle Drive
2. Lagoon and Northern Bay Farm Shoreline
3. Veterans Court
4. Columbian Garden
5. Lagoon
6. Wetland Enhancements to Maintain and Reduce Flood Risks as Sea Levels Rise

Source: Google Earth Aerial Imagery

Figure 8 Flood Risk Mitigation Actions

5.1 The Airport and Bay Farm Island

5.1.1 Doolittle Drive (State Highway 61)

The Port of Oakland analyzed for project alignments to mitigate coastal overtopping along Doolittle Drive (Item 1, Figure 8), as well as three potential flood risk reduction measures (i.e., sheet pile floodwall, earthen levee, and a concrete floodwall). The concrete floodwall was about twice the total costs of the sheet pile floodwall and earthen levee measures, respectively. The sheet pile floodwall and earthen have comparable total costs; however, the earthen levee required a much larger project

footprint. Constructing an earthen levee along Doolittle Drive would either impact State Highway 61, requiring roadway re-alignments to maintain traffic flow, or the earthen levee would require bay fill within San Leandro Bay, including filling the fringing marsh habitat which serves two endangered species, the California Ridgeway rail and salt marsh harvest mouse.

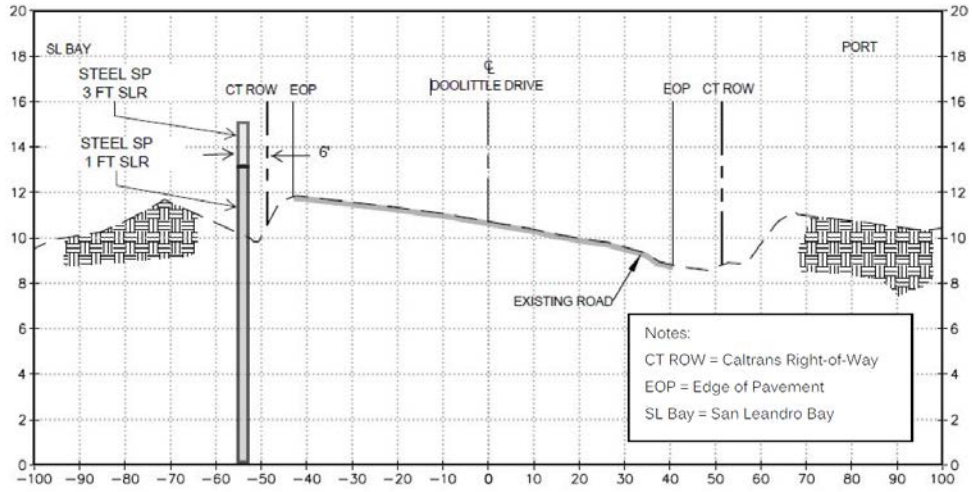
The sheet pile floodwall is a cost-effective solution and requires a minimal project footprint (i.e., horizontal cross section). The sheet pile floodwall would be constructed between Doolittle Drive and San Leandro Bay, adjacent to the San Francisco Bay trail, providing an opportunity to increase safety for pedestrians and bicyclists. The flood walls' aesthetics would be enhanced with the use of a concrete cap. This solution is similar to that used by Foster City, California on the eastern shore of San Francisco Bay to mitigate flood risks (Photo 5 and Photo 6). The Foster City project also provides a recent comparable for construction costs (Foster City 2016, 2020a, b).

Photo Credit: San Mateo Daily Journal

Photo 5. Foster City Bay Trail Before Project

Photo Credit: Riex, Flickr User

Photo 6. Foster City Bay Trail After Project



Source: (Port of Oakland 2023)

Figure 9. Sheet Pile Floodwall (Outboard of Doolittle Drive) Example Cross Section

Table 1. Doolittle Drive (State Highway 61) Construction Costs

Item	Length (feet)	Cost	Unit	Construction Cost
Sheet Pile Floodwall	5,000	$1,095	LF	$5,475,000
Concrete Cap	5,000	$300	LF	$1,500,000
Flood Break Structure (1)	60	$12,000	LF	$720,000
Subtotal				$7,695,000
40% Soft Costs				$3,078,000
Total Construction Costs				**$10,773,000**
Maintenance (15%, 35 years)				**$1,615,950**

Source: (Foster City 2020a; Port of Oakland 2023)

5.1.2 Lagoon and Northern Shoreline

The northern Bay Farm shoreline, from Veterans Court to the northwest corner, would be improved by raising the shoreline elevation and the associated Bay Train with an 18-foot-wide earthen levee (Item 2, Figure 8). In areas where erosion is occurring, existing rock riprap will be re-used on site, and ecological armoring will be used to augment the existing rock slop protection. The Port of San Diego used bio-enhanced concrete to construct ecological enhancements of riprap areas protecting the shoreline adjacent to the San Diego International Airport (Krasna and Rella 2023). In addition to erosion and slope protection, the project provided a solution that mimicked natural rock pools and provided habitat that increased shoreline biodiversity (Krasna and Rella 2023). The Port of San Francisco is currently conducting a living seawall pilot study, with a goal of enhancing biodiversity along coastal and marine infrastructure (USACE 2024). The use of engineering with nature to mimic natural processes and increase the resilience of flood protection infrastructure is a growing practice within FEMA and USACE (Bridges et al. 2021; Holmes et al. 2022; FEMA 2023d).

Table 2. Lagoon and Northern Shoreline Construction Costs

Item	Length (feet)	Cost	Unit	Construction Cost
Earthen Levee	4,500	$990	LF	$4,455,000
Ecological Armoring	2,000	$400	LF	$800,000
Subtotal				$5,255,000
40% Soft Costs				$2,102,000
Total Construction Costs				**$7,357,000**
Maintenance (15%, 35 years)				**$1,103,550**

Source: Moffatt & Nichol 2023

5.1.3 Veterans Court

In Veterans Court (Item 3, Figure 8), the existing cul-de-sac will be moved about 250 feet to the south, providing space to expand the wetland area in the relatively sheltered cove surrounding the Bay Farm Bridge (SR 61) touchdown on Bay Farm Island (Figure 10). And earthen levee with 18-foot-wide Bay Train would be constructed along the existing Bay Train alignment, between the Harbor Bay Club tennis course and San Leandro Bay.

This alternative will require reconstructing the pedestrian and bike path that passes under the Bay Farm Bridge, connecting the Bay Train from the closed landfall to the east to the Veterans Court area. This cost is not included within the FEMA BRIC grant application.

Figure 10. Veterans Court Shoreline Realignment and Flood Risk Mitigation Actions

Table 3. Veterans Court Construction Costs

Item	Length (feet)	Cost	Unit	Construction Cost
Earthen Levee	800	$1,100	LF	$880,00
Ecological Armoring	400	$400	LF	$396,000
Wetland Expansion	0.5 (acre)	$1,000,000	acre	$500,000
Subtotal				$1,776,000
40% Soft Costs				$710,400
Total Construction Costs				**$2,486,400**
Maintenance (15%, 35 years)				**$372,960**

5.2 East Oakland (Columbian Gardens)

The mitigation actions described below in Section 5.2.1 and Section 0 are recommended for stormwater flood risk reduction and air quality benefits. The mitigation action described in Section 5.2.3 would address overtopping along San Leandro Creek that could impact the Columbia Gardens neighborhood; however, the private landowner who owns the property may be amenable to working with the City of Oakland on the shoreline improvements.

5.2.1 Stormwater Flooding

The City of Oakland evaluated a range of alternatives to mitigate the stormwater flooding in the Columbia Gardens neighborhood (City of Oakland 2022). This area was found to have maintenance deficiencies related to debris collection, sediment deposition, and vegetation overgrowth. However, even with improved maintenance, the conveyance capacity of the stormwater pipes and drainage channel was determined to be insufficient and a major source of flood risk. The City of Oakland performed detailed hydrologic and hydraulic modeling to develop and evaluate alternatives (City of Oakland 2022).

The preferred alternative includes constructing a bypass dual 18” storm drainpipe system along Cairo Road that will work with the existing storm drain system and driver flows into the channel. The drainage channel would be deepened to increase its capacity, and sheet pile walls would be constructed on either side of the channel to maintain the channel banks and reduce the likelihood of channel overtopping during extreme rainfall events (City of Oakland 2022). The channel would be deepened enough to allow unmaintained channel bottom overgrowth and vegetation, while still maintaining the

required capacity for flood risk reduction. Allowing vegetation to remain within the channel is preferred over maintaining a clear, earthen channel bottom. Although this preferred option has a higher initial capital cost, the longer-term maintenance for vegetation overgrowth would be reduced; and there would be a higher likelihood that the channel would provide sufficient flood risk reduction during heavy rainfall events for the adjacent underserved community.

Figure 11. Columbian Gardens Flood Risk Mitigation

Table 4. Columbian Gardens Stormwater Flood Risk Reduction Construction Costs

Item	Length (feet)	Cost	Unit	Construction Cost
Dual 18" RCPs	475	$1,460	LF	$693,500
Channel Deepening	700	$1,000	LF	$700,000
Sheet Pile Flood Walls	1,400	$1,995	LF	$2,793,000
Subtotal				$4,186,500
40% Soft Costs				$1,674,600
Total Construction Costs				**$5,861,100**

Maintenance (15%, 35 years)		**$879,165**

5.2.2 Green Instructure

Columbian Gardens would also benefit from flow-thru bioretention areas (about 6 feet by 35 feet) to provide water quality treatment and stormwater retention (Figure 12 and Figure 13). The bioretention areas can include tree plantings to improve air quality and reduce the heat island effect during high heat days. The neighborhood is directly adjacent to Interstate 880 and is within a corridor of known poor air quality (EDF 2020, 2023). Truck traffic is banned on Interstate 580, which runs parallel to Interstate 880 but more inland near the Oakland hills. Interstate 880 carries the greatest volume of truck traffic in the Bay Area region and among any highway in California. The stretch of Interstate 880 near Columbia Gardens sees on average 200,000 vehicle trips per day.

Figure 12. Columbian Gardens Green Infrastructure Plan

Table 5. Columbian Gardens Green Infrastructure Construction Costs

Item	Number	Cost	Unit	Construction Cost
Bioretention Areas	60	$17,900	--	$1,074,000
Tree Plantings	104	$1,000	each	$380000
Subtotal				$581,600
40% Soft Costs				$1,674,600
Total Construction Costs				**$2,035,600**
Maintenance (15%, 35 years)				**$305,340**

Figure 13. Columbian Garden Bioretention Planters Example

5.2.3 San Leandro Creek Tidal Flooding

Columbian Gardens could also benefit from flood risk reduction structures along San Leandro Creek where floodwaters can overtop the shoreline, as shown on the FEMA SFHA (Figure 5). This structure would be located along the shoreline on privately owned industrial properties. However, the landowner may not cooperate with the City of Oakland; therefore, these costs are not included in the BRIC grant application.

The preferred solution would be to acquire the properties adjacent to the shoreline and use the properties to expand the San Leandro Creek floodplain and provide amenities and open space for the Columbia Gardens and surrounding communities. However, the cost of this acquisition may be cost prohibitive.

Table 6. San Leandro Creek Construction Costs

Item	Length (feet)	Cost	Unit	Construction Cost
Sheet Pile Floodwall	1,000	$1,500	LF	$1,500,000
Subtotal				$1,500,000
40% Soft Costs				$600,000
Total Construction Costs				**$3,600,000**
Maintenance (15%, 35 years)				**$540,000**

5.3 Additional Bay Farm Island Flood Risk Reduction

5.3.1 Lagoon Stormwater Flood Risk Mitigation

Raising the low point along the shoreline at the lagoon tide gate and outfall will prevent coastal floodwater from overtopping the shoreline and causing inland coastal flooding (Section 3.1and 5.1). However, additional improvements of the lagoon operations are required to remove the inland properties along the lagoon shoreline from the FEMA SFHA. Improvements include installing a pump station at the lagoon outfall to facilitate drawing down the lagoon at all stages of the tidal cycle, improving the tide gate structure, and installing emergency back-up power and controls for automatic operation during extreme events.

Table 7. Lagoon Stormwater Construction Costs

Item	Length (feet)	Cost	Unit	Construction Cost
Pump Station	--	$2,520,000	unit	$2,520,000
Tide Gate and Trash Rack	--	$364,000	unit	$364,000
Retaining Wall	50	$3,400	LF	$170,000
Emergency Power and Controls	--	$240,000	unit	$240,000
Subtotal				$3,294,000
40% Soft Costs				$1,317,600
Total Construction Costs				**$4,611,600**
Maintenance (15%, 35 years)				**$691,740**

5.3.2 Northern Bay Farm Island Shoreline Improvements

The shoreline improvements along the eroding areas of the northern Bay Farm Island shoreline are included within the construction costs for the Lagoon shoreline improvements (Section 5.1.2). Economies of scale can be achieved by completing this stretch of shoreline improvements at the same time, and addressing the shoreline erosion will increase the overall resilience of the Bay Farm Island mitigation actions.

5.4 Wetland Enhancement for Flood Risk Reduction

In addition to the 0.5 acres of wetland enhancement and expansion at Veterans Court (Section 5.1.3 and Figure 10), additional wetland enhancement to maintain flood risk reduction. The Port of Oakland conducts routing dredging to maintain the channel and turning basin adjacent to the Port of Oakland outside of the project area but within the Oakland Alameda sub-region. This sediment has been beneficially reused to support wetland restoration along the San Francisco Bay shoreline, most notably to support the conversion of the Hamilton Air Field in Marin County to the Hamilton wetlands was used about 7 million cubic yards of beneficially reused dredge material (Photo 7). Thin-layer sediment placement is a recognized strategy to enhance tidal marsh resilience to sea level rise (Raposa et al. 2020; Mohan et al. 2021).

USACE is completing an Integrated Feasibility Study and Environmental Assessment for widening the turning basins, which will produce additional dredged sediment for potential beneficial reuse (USACE 2023). San Francisco Bay Area has lost 85% of its tidal marsh to development and filling of former marshes and Baylands over the past 150 years, and protecting and enhancing these vital ecosystems is vitally important for long-term resilience in the Bay Area (CSCCC and OPC 2010; Goals Project 2015; SFEI & SPUR 2019; SFEI 2021). Save the Bay, a non-profit foundation, has a goal of restoring 100,000 acres of tidal marsh in the Bay.

Photo Credit: USACE

Photo 7. Hamilton Airfield Wetland Restoration, Novato, California

Martin Luther King, Jr. Regional Shoreline Park and San Leandro Bay provide vital tidal marsh and open water habitat to thousands of birds. Until 1938, San Leandro Bay and its 1,800 acres of tidal marsh were a wildlife paradise, protected as a state wildlife reserve. However, the construction of the Oakland Coliseum Complex, Interstate 880, and the Airport left only 76 acres of tidal marsh remaining by 1986. The Port of Oakland deeded the remaining wetlands, as well as additional 72 acres of restored wetlands, to EBRPD to complete the Martin Luther King, Jr. Regional Shoreline Park. The park offers magnificent views of the wetlands as well as hiking and biking trials. The park is visited by about 300,000 people per year, including the nearby underserved communities.

Arrowhead Marsh dissipates wave energy when the wind fetch is aligned with the San Leandro Airport Channel, and the entire marsh complex also improves water quality in this highly industrialized area. Fringing wetlands can enhance the lifespan of shoreline flood protection infrastructure while providing a host of other beneficial amenities (Bridges et al. 2021). Augmenting the marsh elevations with the beneficial reuse of sediment would protect shorelines, inland infrastructure, and communities from future sea level rise driven flooding. Increasing the marsh elevations would also preserve tidal marsh habitat under threat from sea level rise, supporting critical habitat for the endangered Ridgway rail and salt marsh harvest mouse.

EBRPD, with local partners, recently repurposed the right-of-way along a portion of Doolittle Drive and created a 2,300-foot multi-model paved and protected trail. To offset the impacts of this project, EBRPD restored one acre of new salt marsh habitat at New Marsh. The construction associated with the flood risk reduction projects proposed by this Oakland Alameda Multi-Hazard Adaptation and Community Benefits Project will require more significant offsets. However, San Leandro Bay offers ample opportunities to offset the impacts within the project area, while also enhancing the flood risk benefits of the projects.

Figure 14 identified wetland areas where thin sediment placement can provide habitat as well as flood reduction benefits. Table 8 provides approximate cost estimates for placing a thin layer (3 to 5 inches) of sediment on top of the existing marsh surface. The estimates include all costs associated with sediment placement, but not include the cost of dredging or transport of the material from the dredge location. Transport of the material to the project area could result in a significant cost savings due to the proximity of the Port of Oakland navigation channel. USACE currently dredges the Port of Oakland navigation channel to maintain water depths for container ships. This sediment has been beneficially for wetland restoration, upland placement, deposited in inland landfills, deposited in San Francisco Bay, or deposited outside of San Francisco Bay at a deep ocean disposal site. The Long-Term Management Strategy for the placement of dredged material in the San Francisco Bay has a goal of at least 40% of dredged sediment being beneficially reused (DMMO 2022).

Figure 14. Wetland Enhancement and Flood Risk Reduction Locations

Table 8. San Leandro Bay Wetland Area and Thin Sediment Placement Cost Estimate

Wetland Area	Acreage1	CY Sediment	Cost/CY	Sediment Place Cost
Arrowhead Marsh	45	18,000 – 30,050	$20	$363,000 – $605,000
New Marsh	35	14,000 – 23,500	$20	$282,000 – $470,000
North Fringing Marsh	5	2,000 – 3,500	$20	$40,000 – $67,000
South Fringing Marsh	4	16,00 – 2,700	$20	$32,000 – $54,000
Model Marsh[2]	16			
Subtotal				$718,000 – $1,200,000
40% Soft Costs				**$287,000 – $478,000**
Total Cost				**$1,000,000 – $1,700,000**

[1] Wetland acreage was estimated using ArcGIS and may not reflect EBRPD reported acreage.

[2] Model Marsh includes the creation of a new marsh in an enclosed area of open water. The cost of creating this marsh is not comparable with thin layer sediment and may be more comparable with the cost of restoring New Marsh.

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