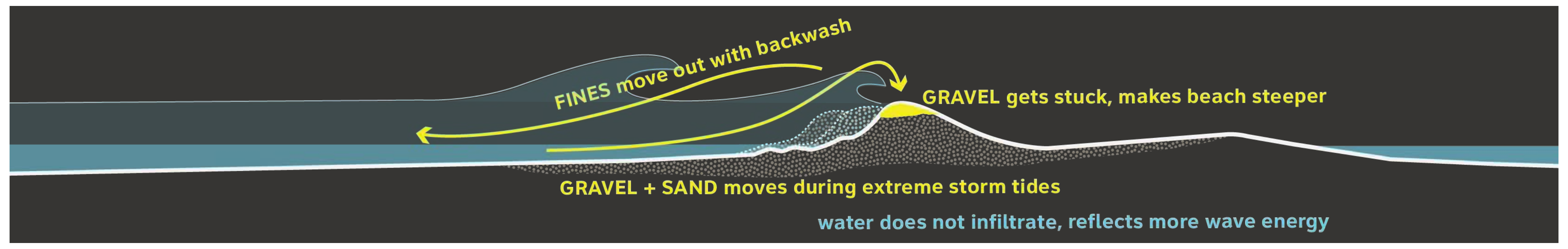
FINE AND COARSE GRAIN BEACHES

DESIGN STRATEGY REFINEMENT

DESCRIPTION. Coarse or composite estuarine beaches are dynamic features that can consist of a mixture of sand, shell, gravel, or cobble. Beaches include a supratidal beach berm and a beach face. Gravel and cobble beaches can dissipate wave energy over shorter distances and are generally more suitable within the urbanized and constrained estuary. They can be placed in front of levees, roads or other vulnerable infrastructure to reduce erosion. Many beaches have habitat benefits to shorebirds.



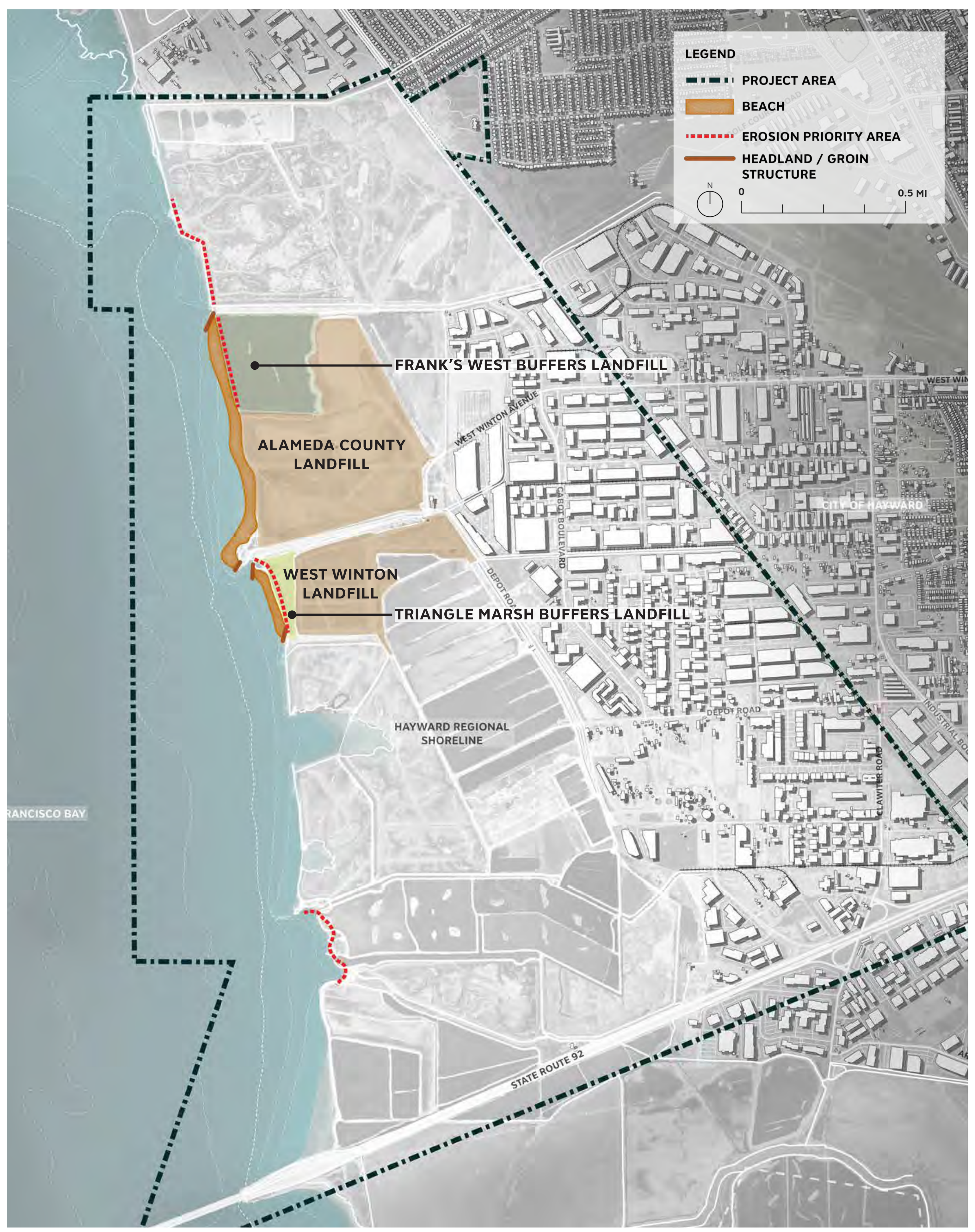
SECTION: Mixed gravel beach, Public Sediment

PRECEDENT: Foster City shell hash beach

PRECEDENT: Arambaru Island Enhancement Project

OPTION 1 BEACHES IN FRONT OF LANDFILLS

ON THE BAY SIDE OF OUTBOARD LEVEES OR BERMS



PROS

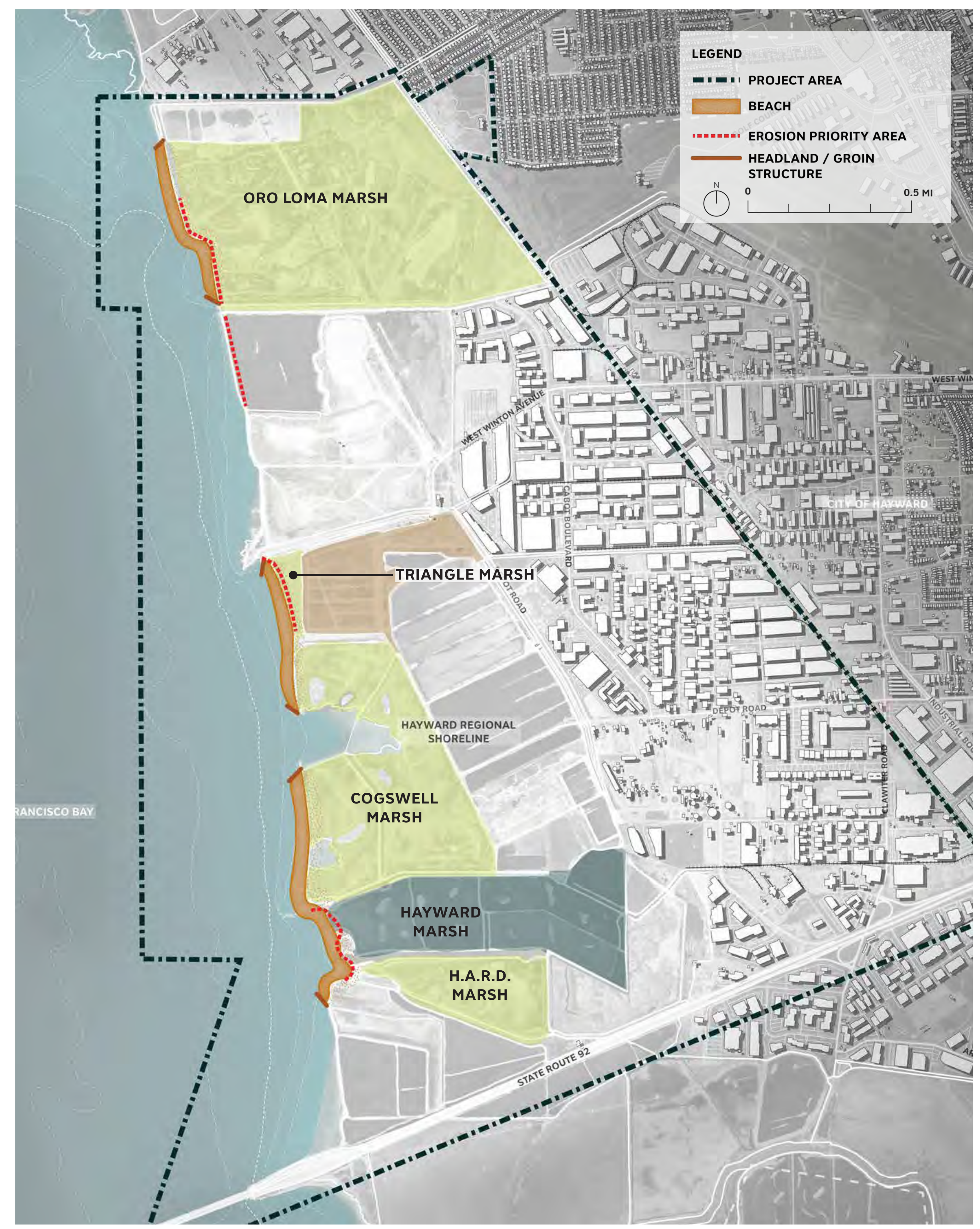
- Reduce erosion to landfill edges
- Reduce levee/berm maintenance adjacent to landfills
- Could enhance shorebird and beach habitat

CONS

- May require artificial replenishment
- Considered fill- permitting challenge

OPTION 2 BEACHES IN FRONT OF EXISTING MARSHES

ON THE BAY SIDE OF ALL MARSH BERMS OR LEVEES



PROS

- Reduce erosion of outboard marsh edges
- Potential to lower maintenance of bayside levee/ berms
- Reduced maintenance costs of outboard berms

CONS

- May require artificial replenishment
- Considered fill- permitting challenge

OPTION 3 BEACHES ALONG ENTIRE SHORELINE

ON THE BAY SIDE OF ALL SHORELINE BERMS OR LEVEES

PROS

- Reduce erosion to all outboard shoreline structures
- Reduce erosion and maintenance costs of shoreline berms and levees

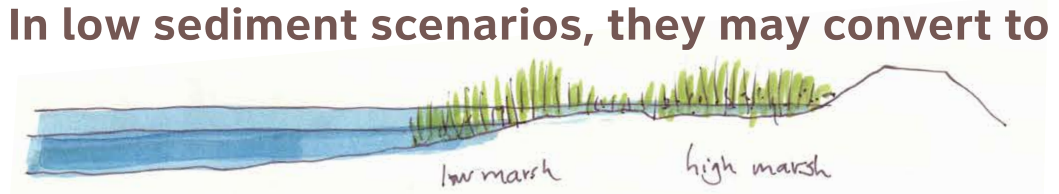
CONS

- May require artificial replenishment- long-term cost
- Could require a lot of material- high initial cost
- Could require multiple groins to hold beaches between channels
- Considered fill- permitting challenge

TIDAL MARSH RESTORATION

DESIGN STRATEGY REFINEMENT

DESCRIPTION. Protecting, maintaining, and restoring tidal marshes and their associated mudflats is critical to maintain flood control and ecosystem services with climate change. Techniques include restoring diked baylands, planting native species to accelerate colonization, placing sediment to raise subsided areas, and creating high tide refugia within marshes. Existing marshes have the capacity to vertically accrete along with sea level rise if they have sufficient sediment supply. In low sediment scenarios, they may convert to mudflats or subtidal ecosystems.



SKETCH: Bay edge marsh

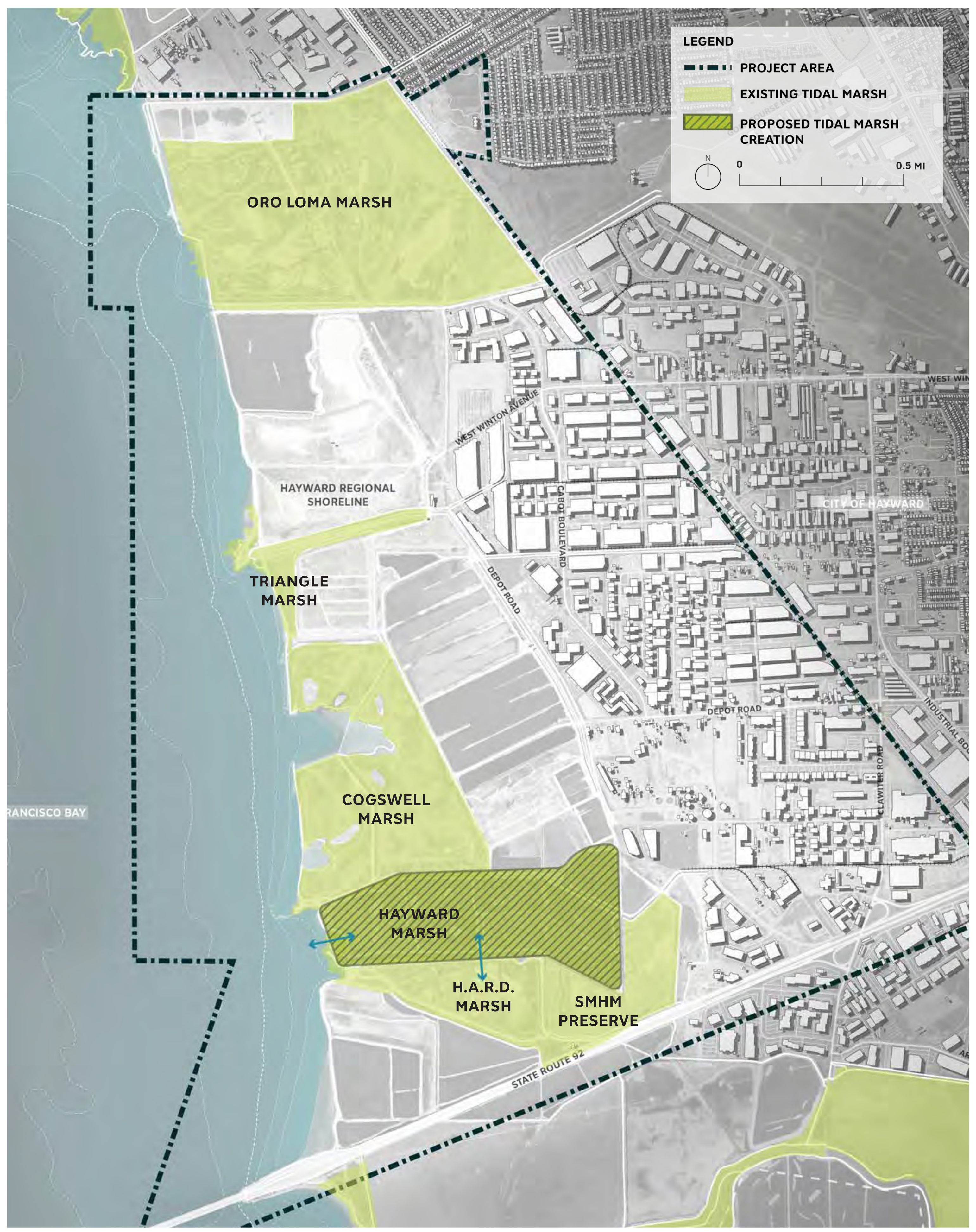
SKETCH: Marsh in diked pond

PRECEDENT: Bair Island Wetland Restoration

PRECEDENT: Sears Point Wetland Restoration

OPTION 1 HAYWARD MARSH RESTORATION

MOST NEAR-TERM PROJECT



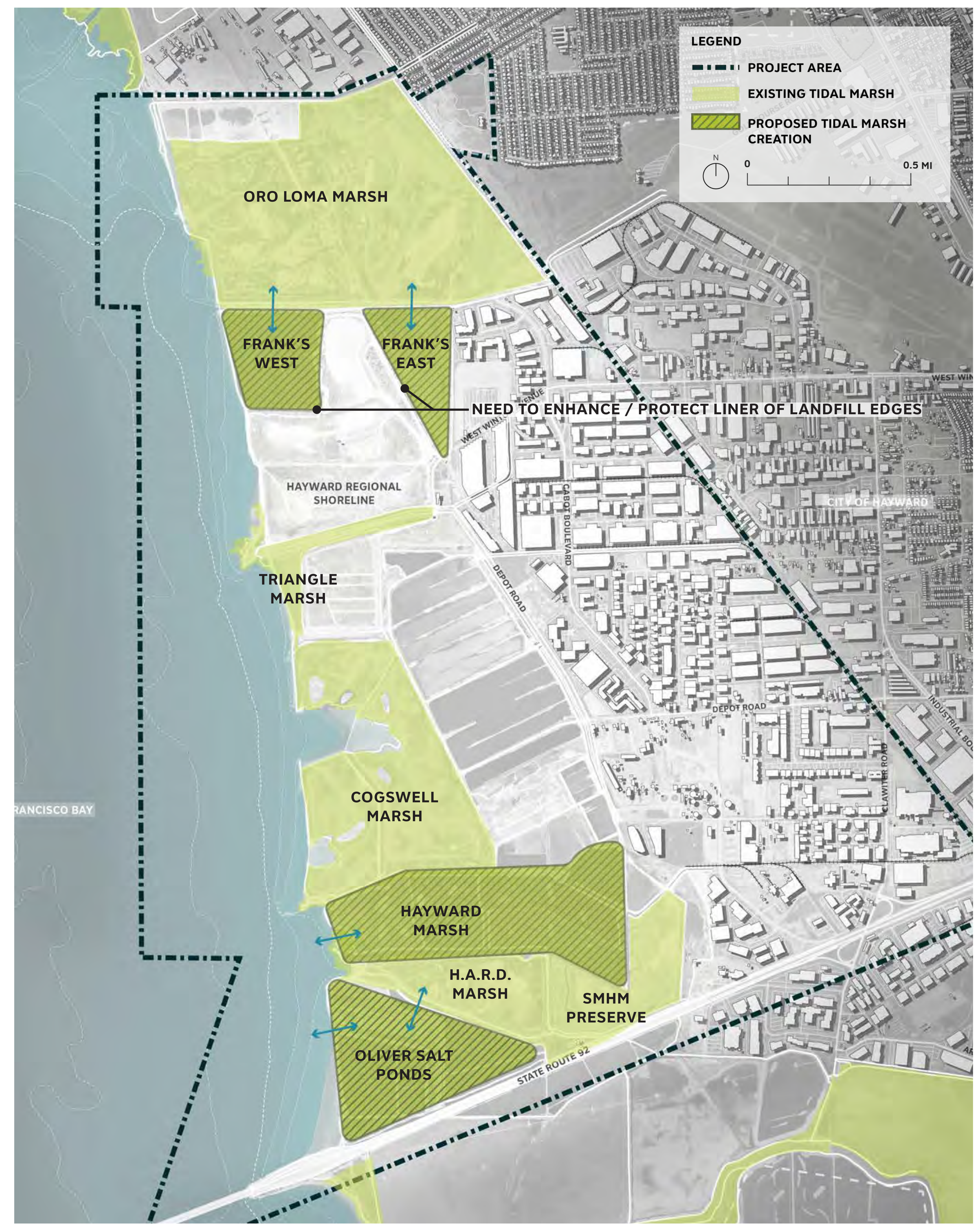
PROS

- Hayward marsh restoration is already planned

CONS

- If hayward marsh is restored as a muted marsh, it may not accrete as much sediment as a fully tidal system

OPTION 2 RESTORE BAY-SIDE PONDS TO TIDAL MARSH



PROS

- Marshes at bay edge may be able to accrete more sediment (from bay and fluvial sources)
- Pair with fine sediment augmentation to adapt marshes with SLR
- Frank's east and west could help buffer landfill against erosion

CONS

- Lose existing salt pond shorebird habitat- impacts endangered species habitat

OPTION 3 RESTORE ALL DIKED PONDS

MAXIMUM RESTORATION

PROS

- Increased marsh buffer to reduce erosion and buffer shoreline
- Increased habitat benefits
- Larger tracts of connected marsh

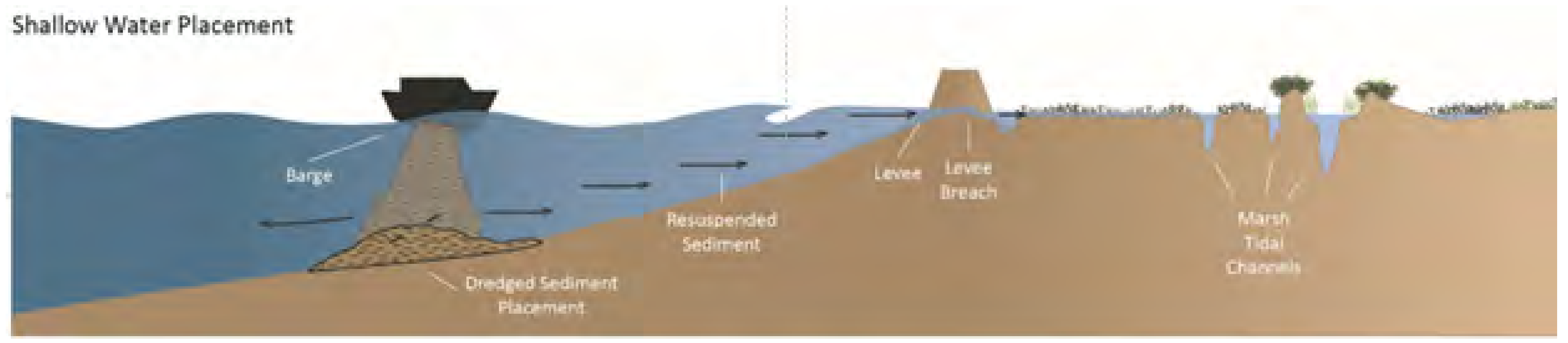
CONS

- Lose stormwater detention storage space
- Removes oxidation ponds and uses
- Lose existing salt pond shorebird habitat- impacts endangered species habitat
- Lose Oro Loma sludge ponds

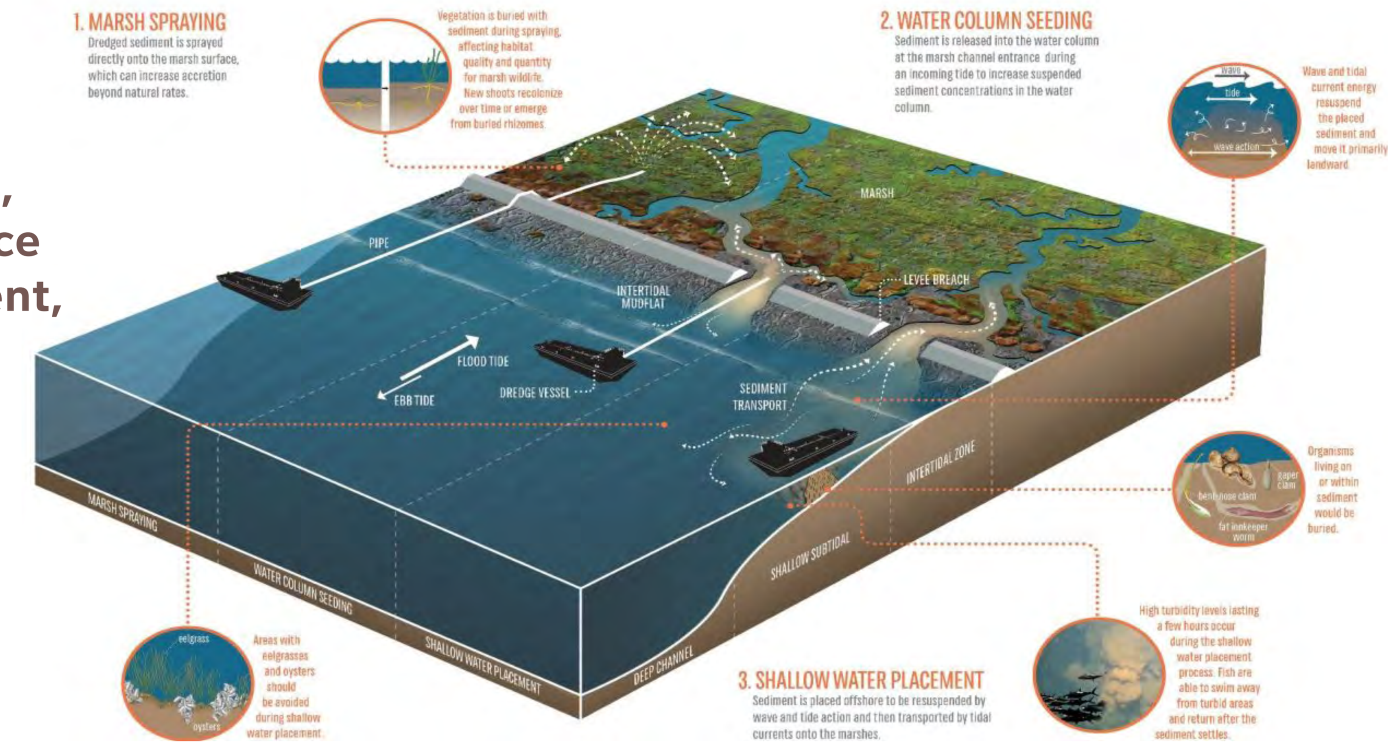
FINE SEDIMENT AUGMENTATION

DESIGN STRATEGY REFINEMENT

DESCRIPTION. The direct or indirect placement of fine sediments to increase mudflat elevation relative to the tides. This can help protect and sustain marshes, mudflats, and shorelines when sediment is low to help them accrete and keep pace with sea level rise. Techniques include water column seeding, nearshore placement, and thin layer placement.

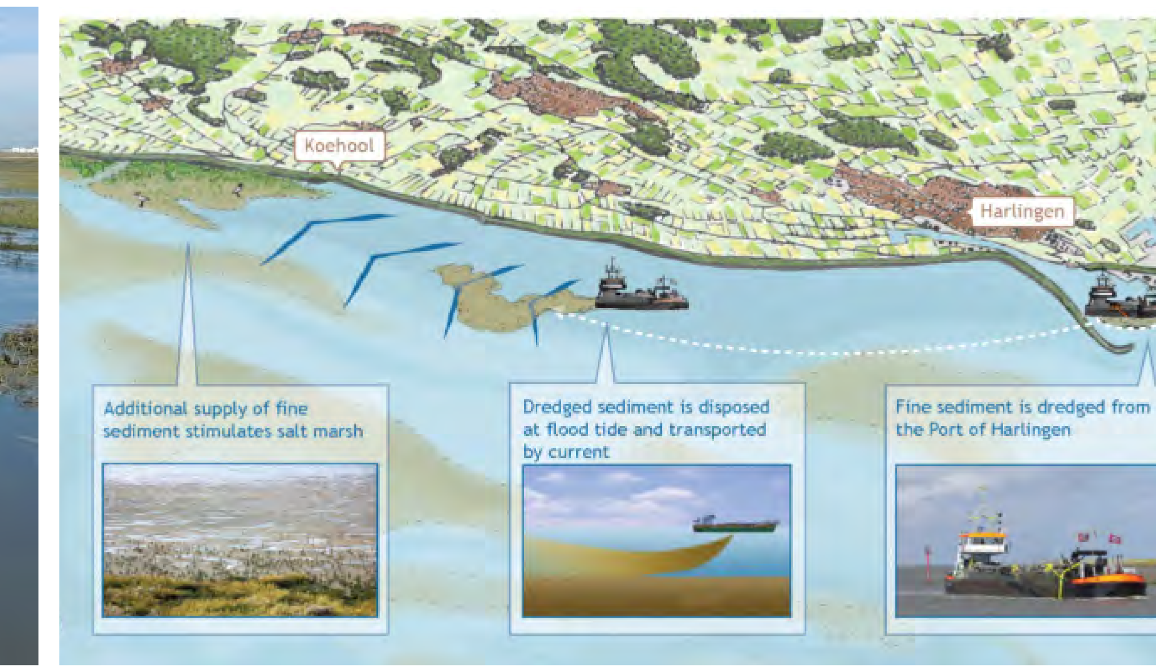


SECTION: Shallow Water Placement
Source: USACE Strategic Placement Report



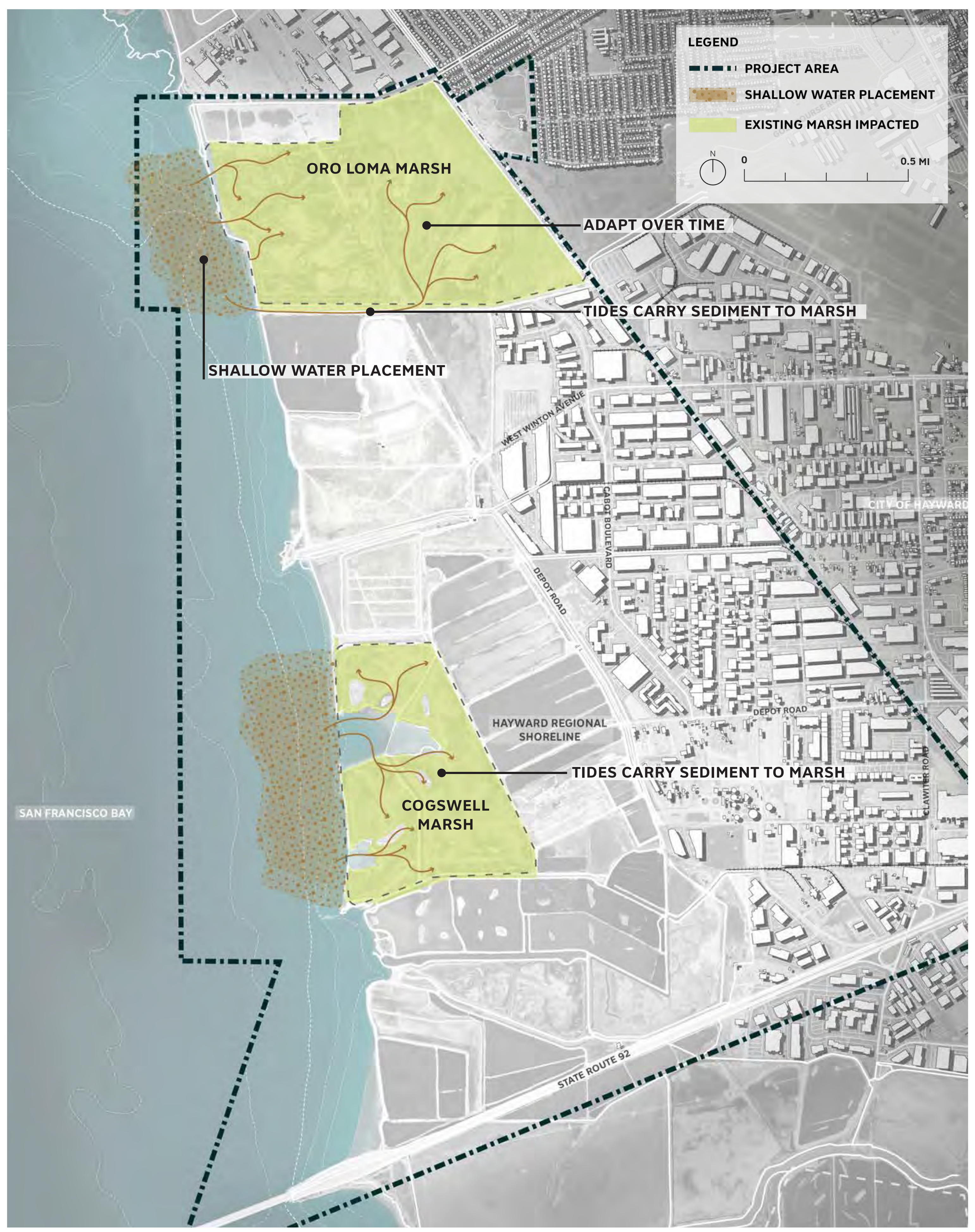
AXON: Mudflat Augmentation Strategies
Source: SFEI, Stantec

PRECEDENT: Seal Beach Sediment Augmentation Project, CA



PRECEDENT: The Mud Motor, Netherlands

OPTION 1 FEED FROM THE BAY



PROS
- Allow natural processes to facilitate accretion
- Prioritize large marsh adaptation to keep pace with SLR
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CONS
- Filling the bay is a regulatory challenge
- Does not help smaller marshes
- Hard to get material to the mudflat because it is so shallow
- Many unknowns about sediment transport and retention
- Potential negative impacts to existing habitat
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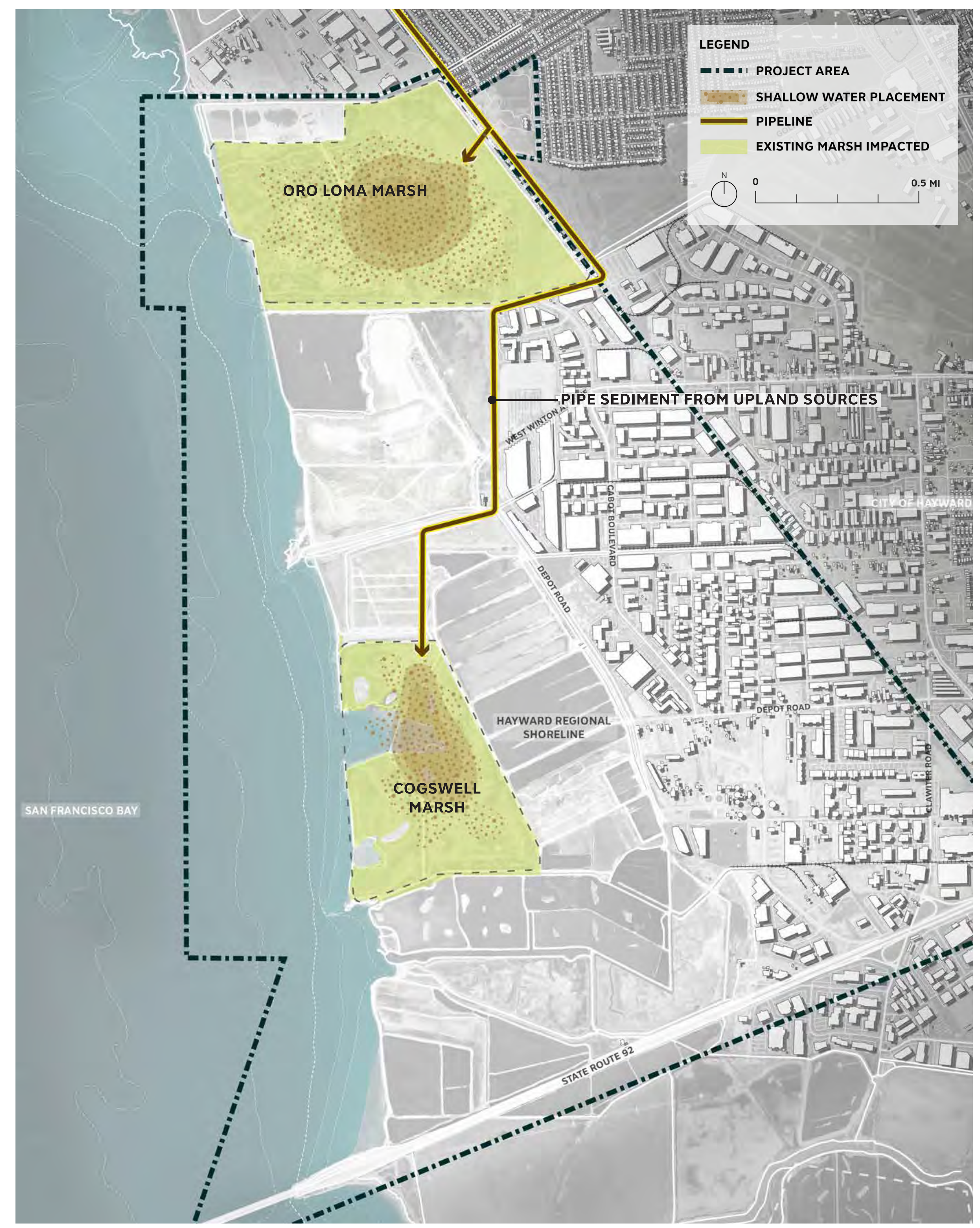
OPTION 2 NOURISH FROM AN UPLAND PIPELINE



PROS
- Set up infrastructure for sediment delivery over time
- Utilize upland sediment sources
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CONS
- Filling the bay is a regulatory challenge
- Does not help smaller marshes
- Pipeline infrastructure could be costly
- Many unknowns about sediment transport and retention
- Potential negative impacts to existing habitat
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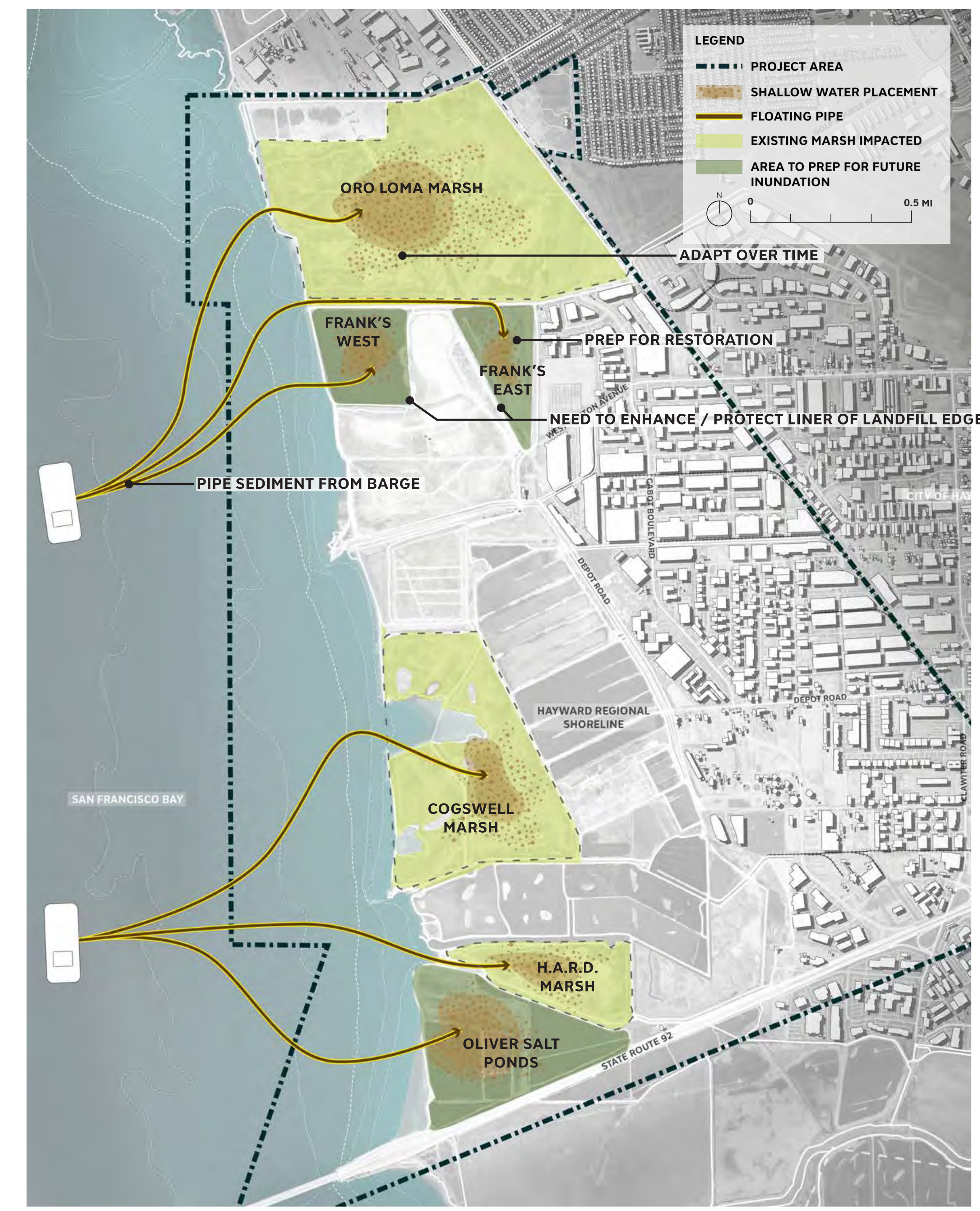
OPTION 3 BAY SEDIMENT PIPE



PROS
- Proactive approach to prep diked baylands for marsh restoration
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CONS
- Spraying existing marshes disrupts endangered species habitat
- Many unknowns about sediment transport and retention
- Potential negative impacts to existing habitat
- Power for pumping the sediment is very expensive
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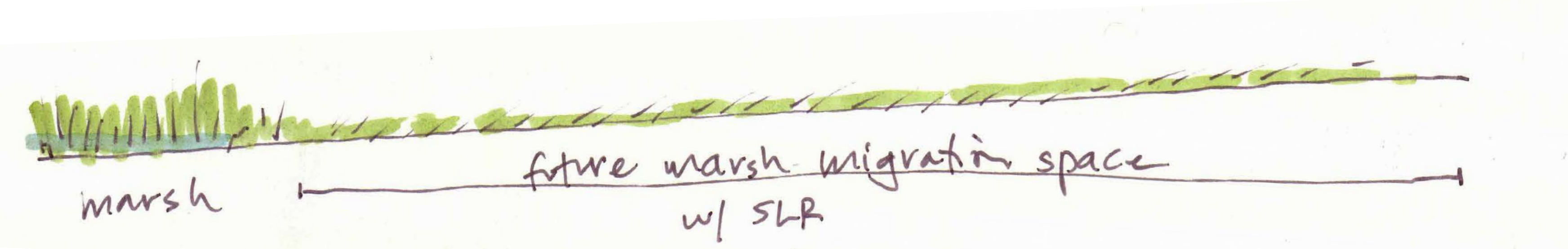
MARSH AND MUDFLAT MIGRATION PLANNING

DESIGN STRATEGY REFINEMENT

DESCRIPTION. Natural wetland-upland transition zones adjacent to present and potential marshes can be protected, enhanced, or restored to allow marshes to migrate landward as sea level rises. This can be paired with levee / berm realignment and other flood control projects and may require the removal of berms to ensure hydrological connectivity.



SKETCH: section of migration space

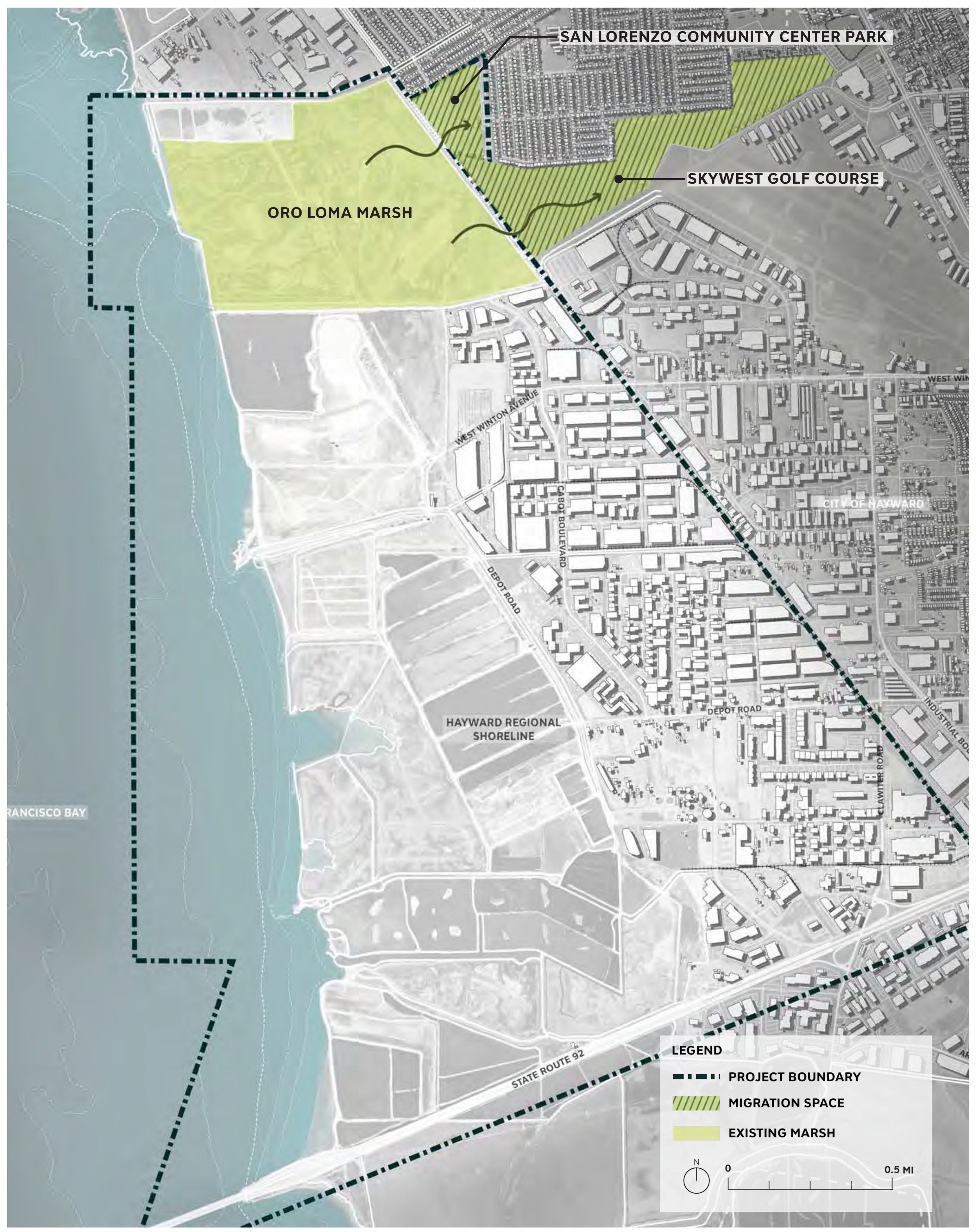
PRECEDENT: North Richmond Shoreline Vision

Hayward Shoreline Mudflat

Hayward Shoreline Marsh

OPTION 1 ORO LOMA MARSH MIGRATION

ALLOW ORO LOMA TO MIGRATE OVER TIME



PROS

- Large space for migration
- Connect new recreation space to adjacent community
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CONS

- Need to cross railroad through culverts, which is a tough right of way
- Land could require significant prep to facilitate migration and disrupt the current uses
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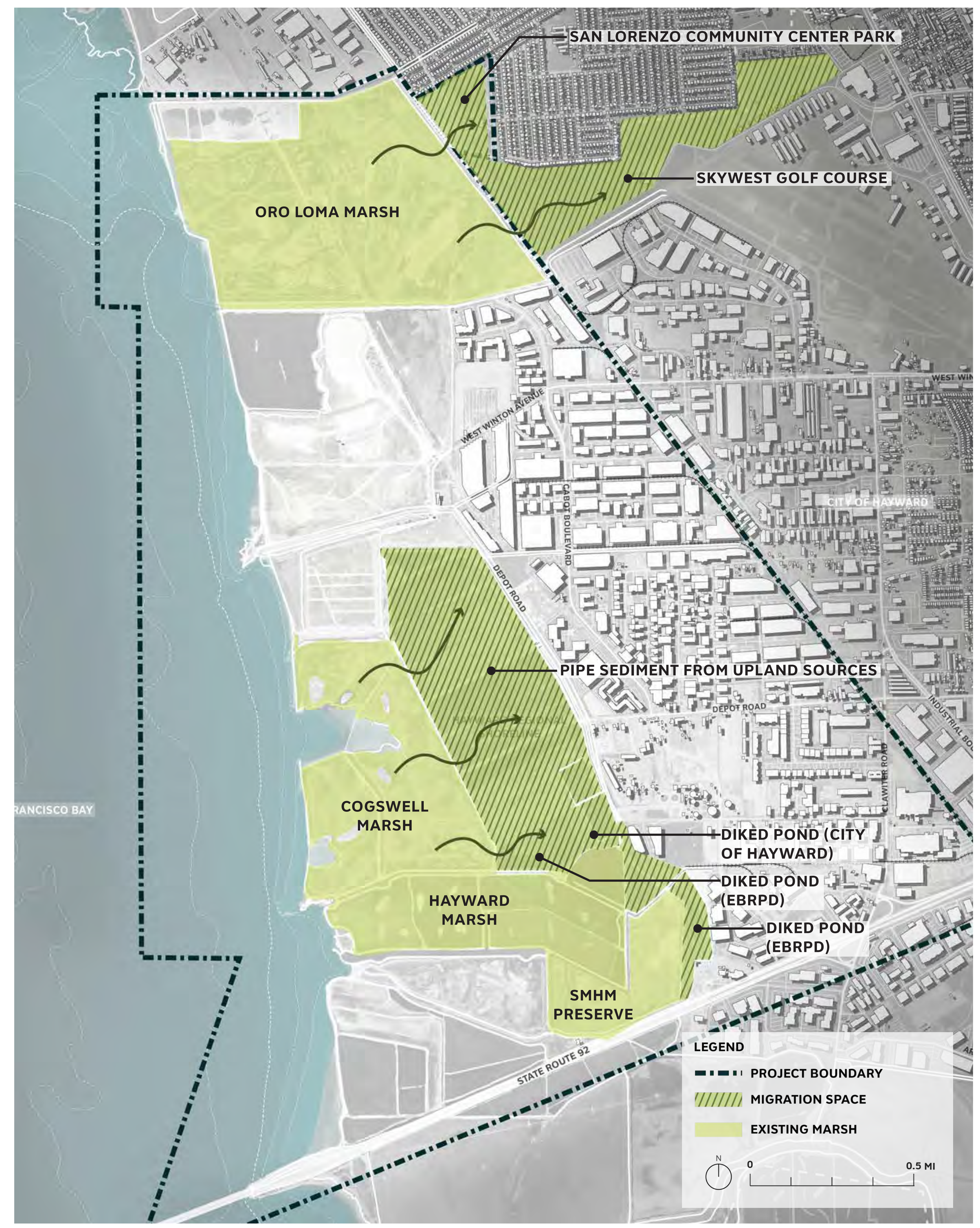
OPTION 2 LARGER MIGRATION POTENTIAL

PRIORITIZE MIGRATION OF EXISTING LARGE MARSHES



PROS

- Two large migration spaces
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CONS

- Lose stormwater detention capacity at oxidation ponds
- Land could require significant prep to facilitate migration and disrupt the current uses
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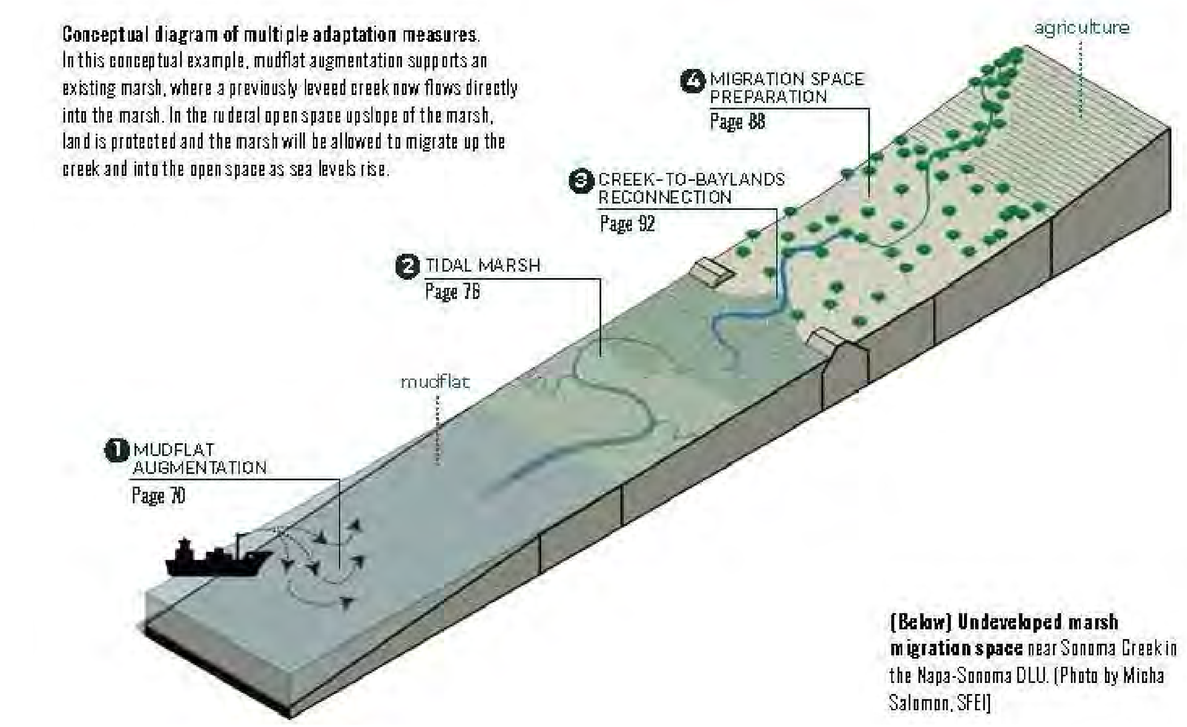


AXON: SFEI Adaptation Atlas

PRECEDENT: Undeveloped marsh migration space along Tolay Creek
Source: SFEI, Julie Beagle

PRECEDENT: Undeveloped marsh migration space near Sonoma Creek
Source: SFEI, Micha Salomon

PRECEDENT: Rush Ranch grasslands act as migration space preparation

DIKED POND MANAGEMENT
DESIGN STRATEGY REFINEMENT

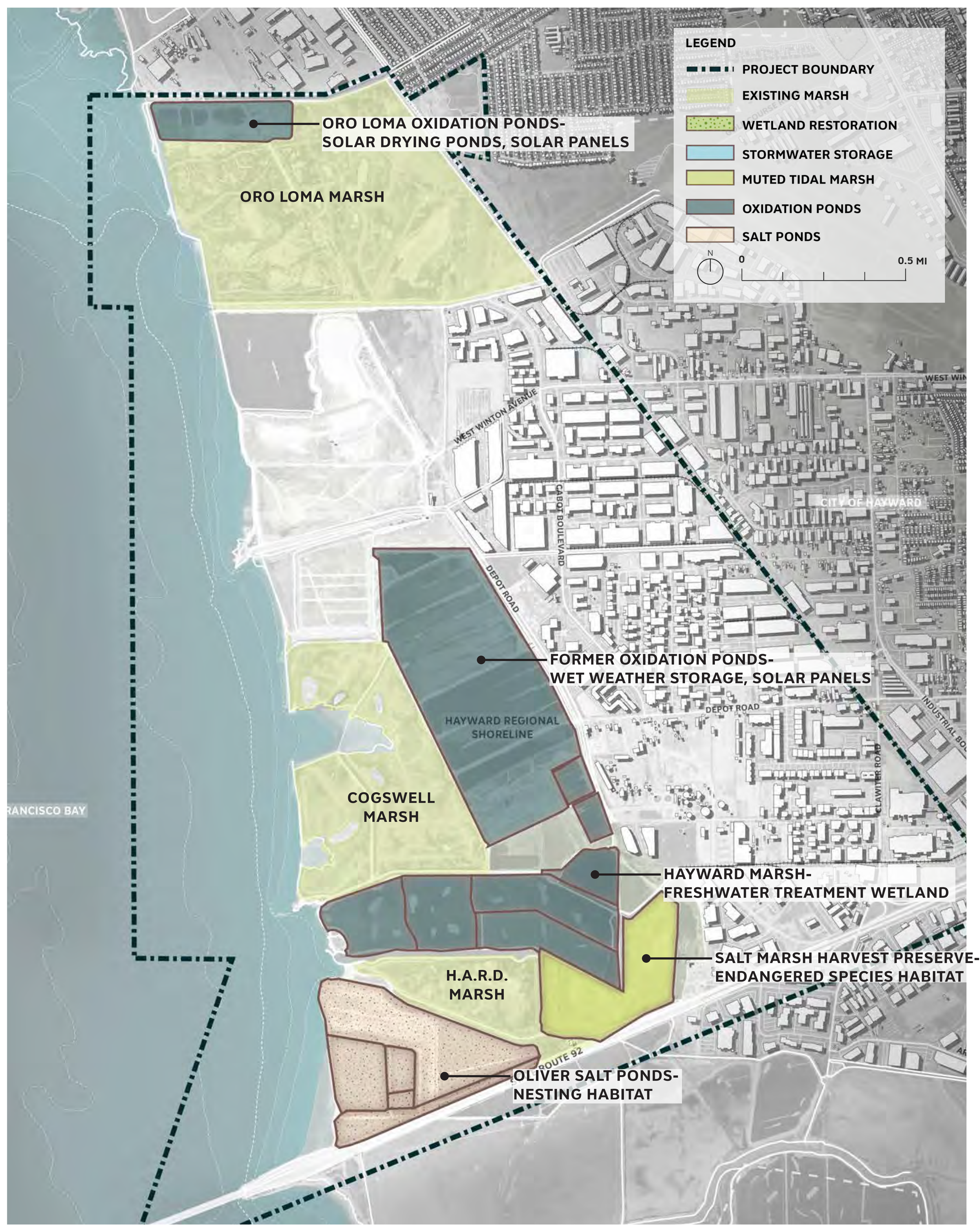
DESCRIPTION. Diked baylands are managed as flood retention basins or for habitat, and are also used for transmission lines, rail lines, wastewater lines, and other infrastructure. The low-lying diked baylands often accumulate runoff that needs to be drained and pumped to the bay. Diked ponds can be used or expanded to increase flood water storage from precipitation-based floods, and/or store groundwater pumped from urban areas. Salt ponds provide critical habitat to endangered species.


Oliver Salt Ponds, 2019


Frank's East, 2019


Skywest Golf Course, 2017

OPTION 1 NO ACTION
MAINTAIN DIKED PONDS AND THEIR CURRENT USES



PROS
- Maintain current uses and stormwater storage capacity
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CONS
- Costly strategy long-term to maintain uses with sea level rise
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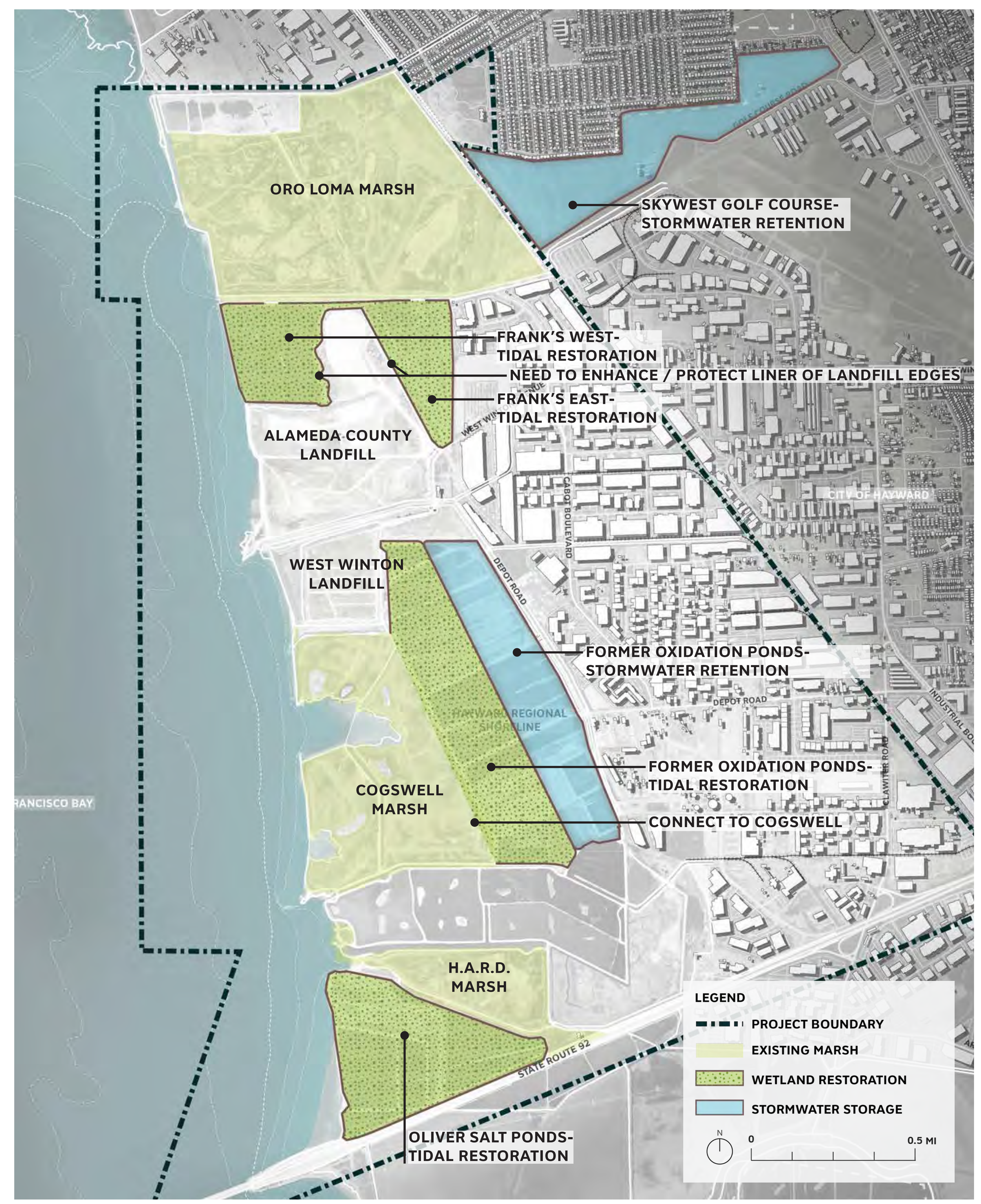
OPTION 2 TIDAL RESTORATION + STORMWATER MANAGEMENT
USE INLAND PONDS FOR STORMWATER MANAGEMENT AND RESTORE BAYSIDE PONDS TO TIDAL MARSHES



PROS
- Increase stormwater detention capacity
- Large areas of new marsh restoration
- New marshes at bay edge that may accrete and sustain with SLR
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CONS
- Disrupt shorebird habitat at salt ponds
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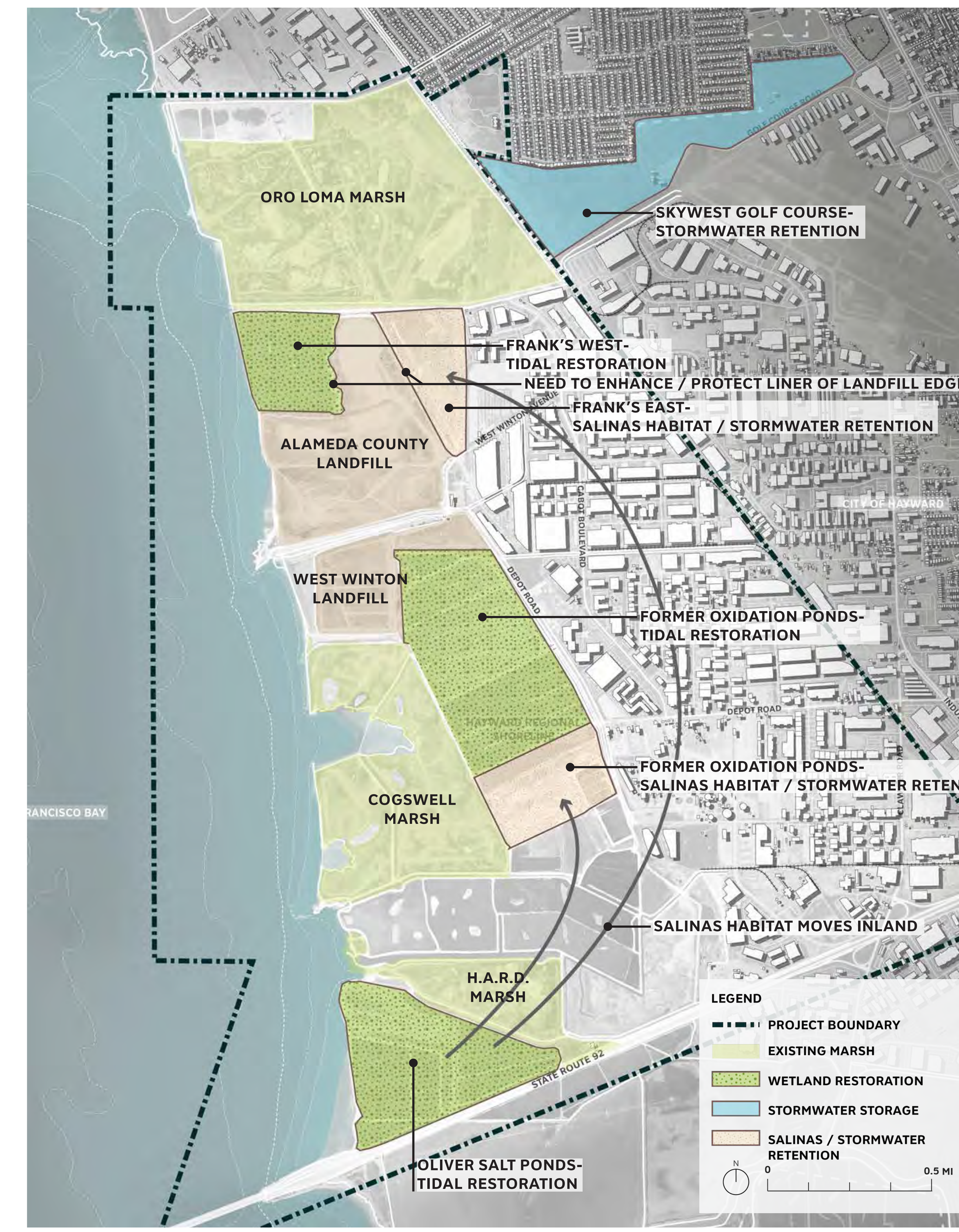
OPTION 3 SALINAS SWAP
RESTORE SALINAS INLAND, DOUBLE AS STORMWATER DETENTION



PROS
- Maintain salinas habitat, move inland so it's less vulnerable to sea level rise
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CONS
- Lose existing oxidation pond uses
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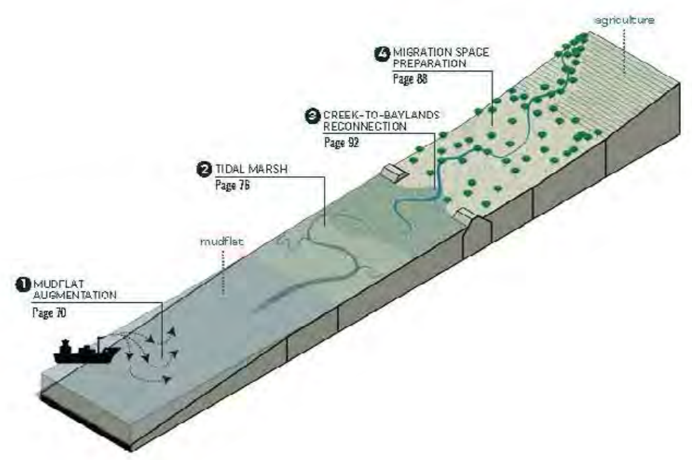
TRIBUTARY CONNECTION TO BAYLANDS

DESIGN STRATEGY REFINEMENT

DESCRIPTION. Reconnecting creeks to their adjacent baylands through levee breaching or removal helps improve sediment, nutrient, and freshwater delivery to the baylands while achieving flood risk management and habitat benefits.

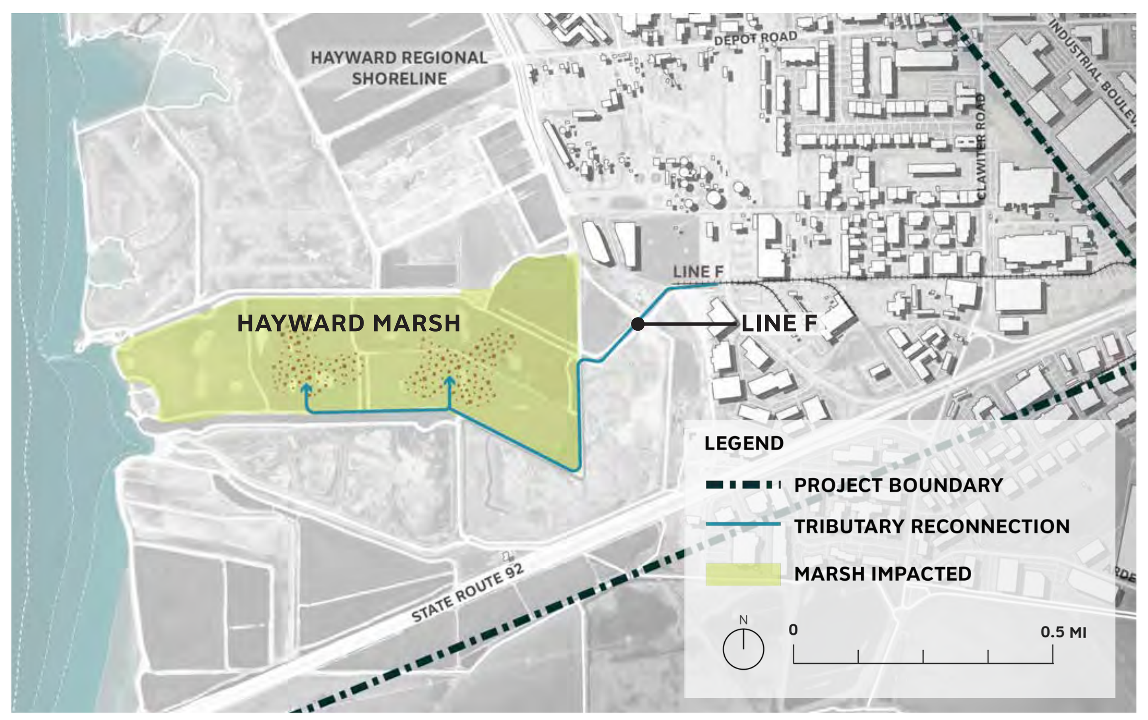


AXON: SFEI Adaptation Atlas

PRECEDENT: Lower Walnut Creek Restoration Project

Bockman Channel, 2019

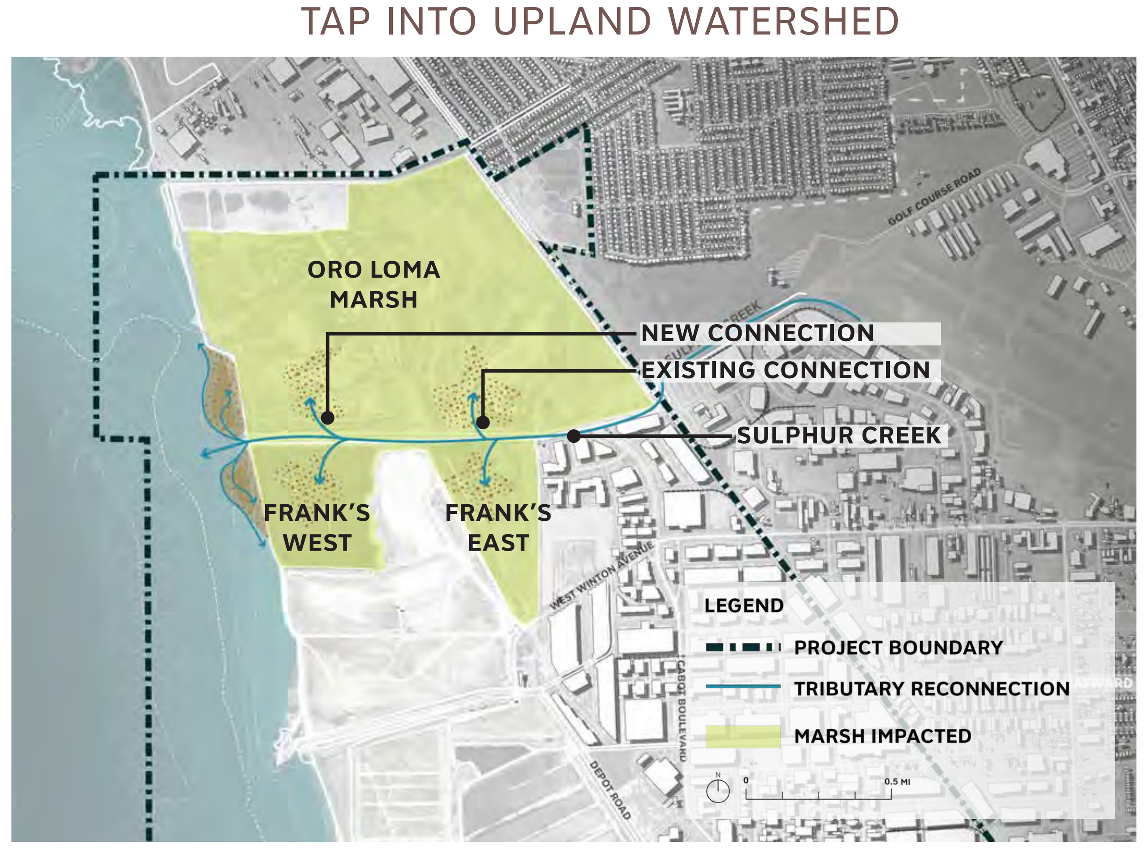
OPTION 1 LINE F
FEED HAYWARD MARSH



PROS
- Already under consideration with hayward marsh restoration
- Help restore salinity gradient

CONS
- May not be a large source of sediment for marsh nourishment
- Does not do much for flood protection or SLR adaptation

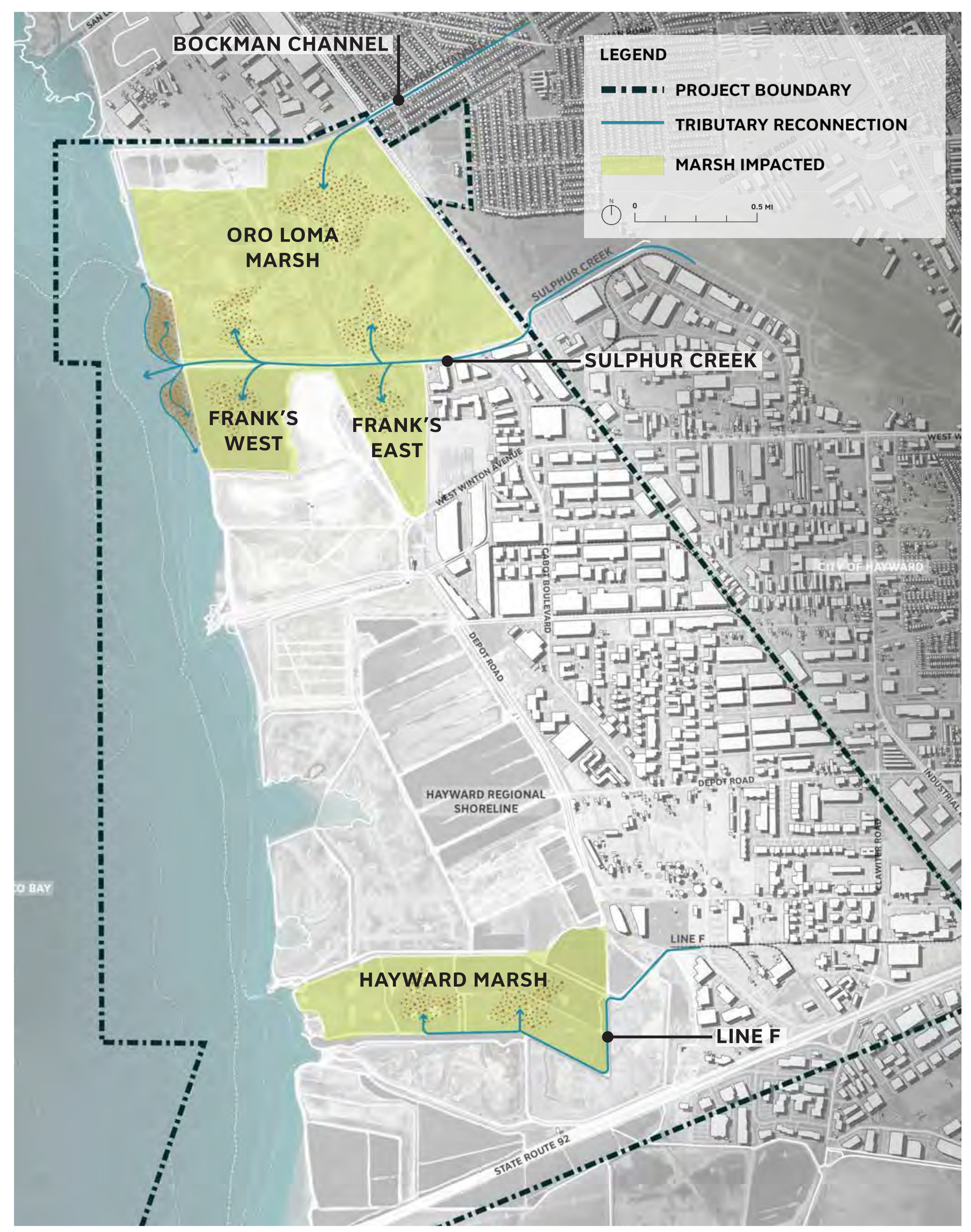
OPTION 2 SULPHUR CREEK
TAP INTO UPLAND WATERSHED



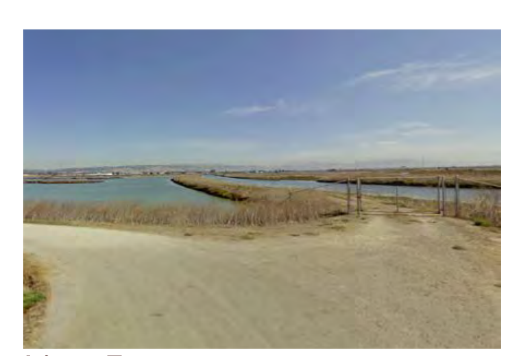
PROS
- Connected to largest upland watershed
- Can potentially be breached into new restoration projects

CONS
- May impact flood control upstream- need to relocate tide gate
- Does not do much for flood protection or SLR adaptation

OPTION 3 ALL CHANNELS
RESTORE SALINITY GRADIENTS IN ADJACENT BAYLANDS



PROS
- Connects to most viable upland watersheds
- Potential to nourish a large amount of marsh with sediment



Line F

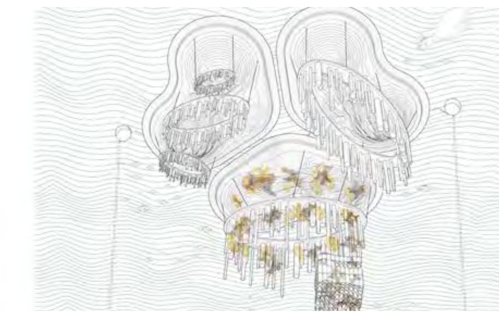
CONS
- May impact flood control upstream- need to relocate tide gate
- Bockman channel has low water quality, may negatively impact Oro Loma marsh
- Does not do much for flood protection or SLR adaptation

Sulphur Creek

REEFS AND LIVING BREAKWATERS

DESIGN STRATEGY REFINEMENT

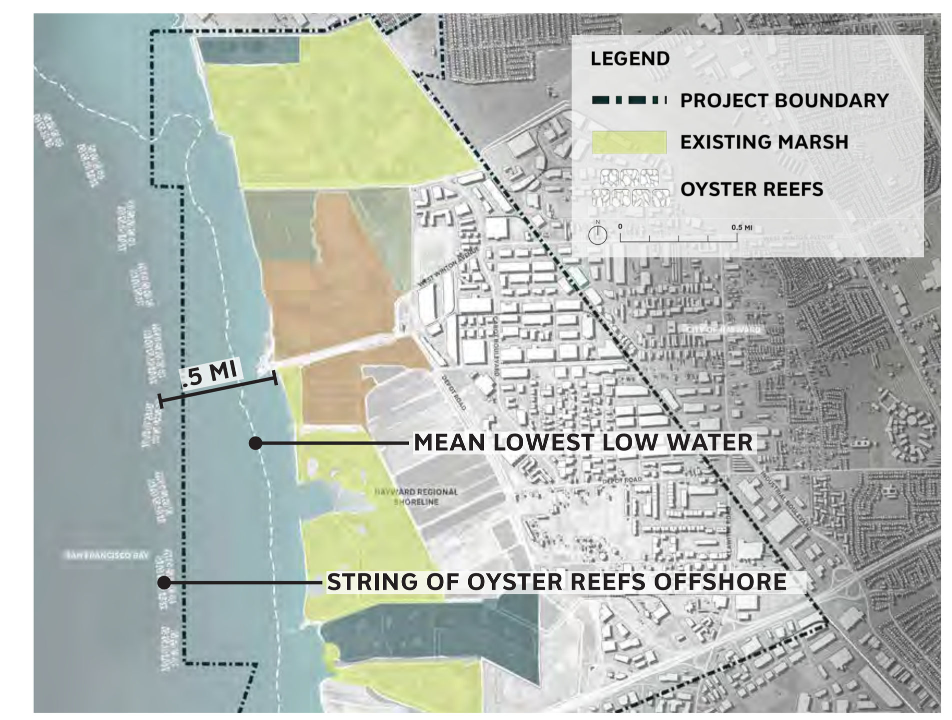
DESCRIPTION. Nearshore reefs made of oyster shell and baycrete (a cement mixture composed mostly of Bay sand and shells) provide hard substrate for shellfish and other aquatic plants and animals. They can reduce wave transmission at lower tidal elevations and stabilize areas in their lee.



PRECEDENT: Floating breakwater, Architectural Ecologies Lab

PRECEDENT: Giant Marsh, Point Pinole

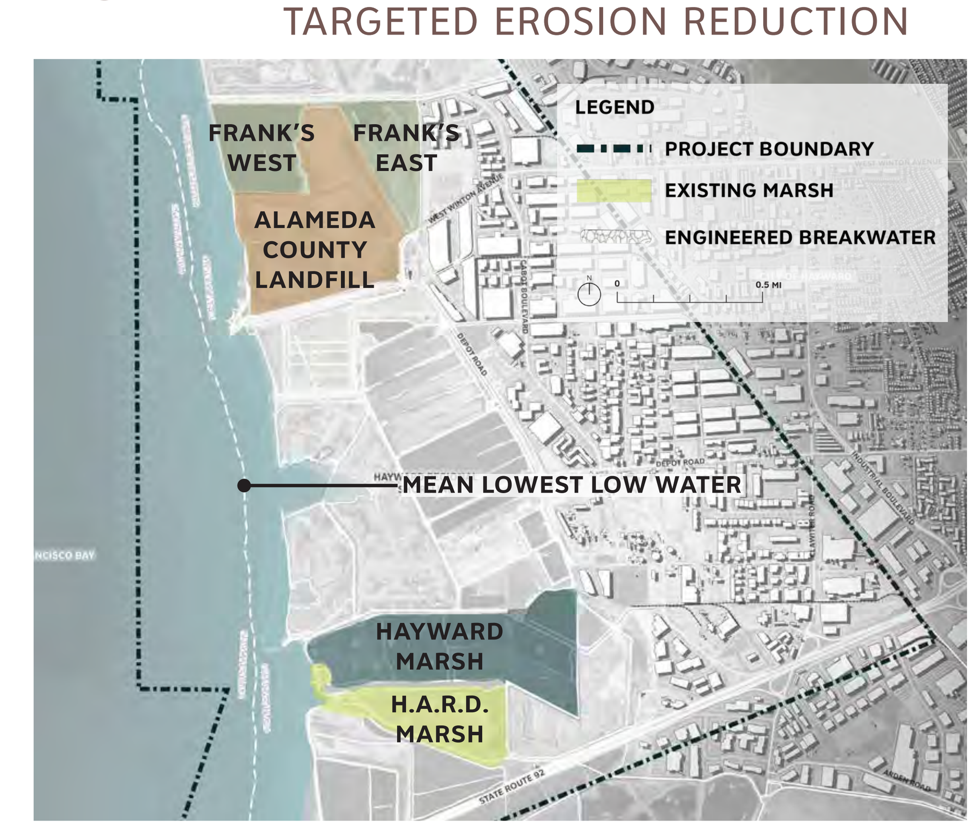
OPTION 1 OFFSHORE OYSTER REEFS
HABITAT BENEFITS AND EROSION REDUCTION



PROS
- Reduce erosion along shoreline
- Provide hard substrate habitat

CONS
- Has to be far offshore- may not get as much accretion along shoreline
- May not be stable on bay mud- potential to sink

OPTION 2 ENGINEERED BREAKWATER
TARGETED EROSION REDUCTION



PROS
- Reduce erosion to outboard levees and berms in front of critical infrastructure

CONS
- May not get much accretion along shoreline
- May not be stable on bay mud- potential to sink
- May have negative impacts to habitat
- May be a permitting challenge

OPTION 3 FLOATING BREACH BREAKWATERS
REDUCE EROSION AT MARSH BREACHES

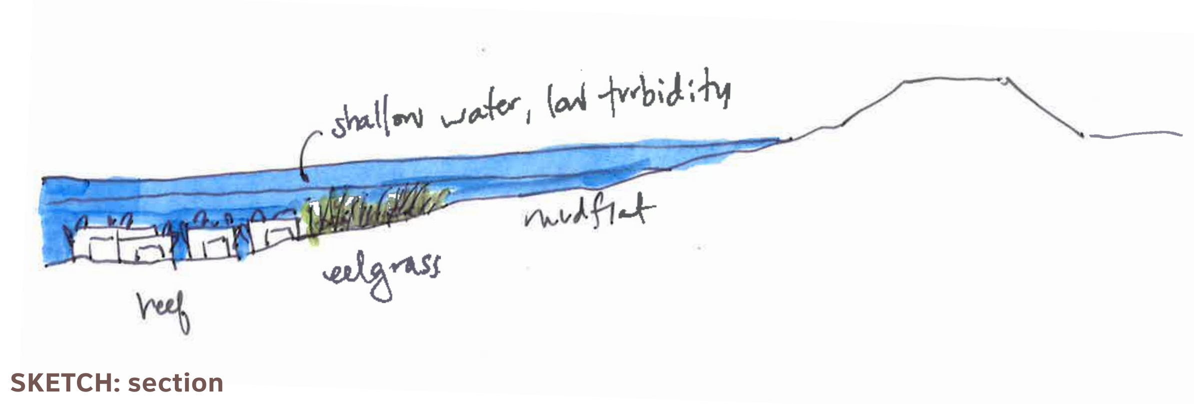
PROS
- Less risk of sinking into bay mud
- May help accrete sediment along shoreline
- Reduce erosion on shoreline during daily tides

CONS
- Hard to anchor in bay mud
- Won't reduce erosion during storm surge, only daily tides
- May not get as much accretion along shoreline

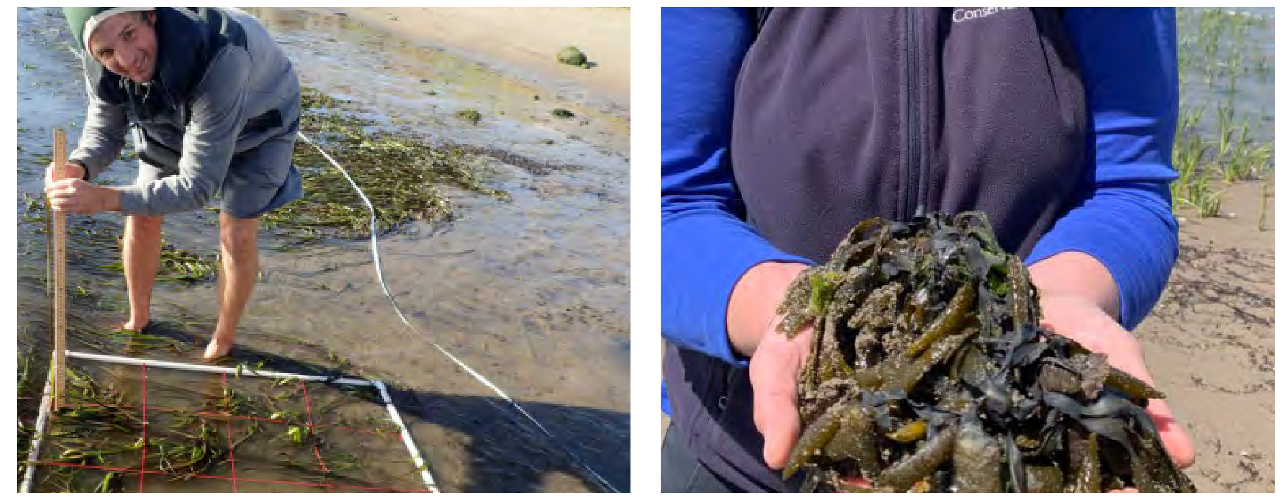
EELGRASS RESTORATION

DESIGN STRATEGY REFINEMENT

DESCRIPTION. Eelgrass is submerged aquatic vegetation that contributes to trapping sediment and slowing shoreline erosion. Habitat suitability depends on depth of water, light, current speed, exposure to wind waves, water temperature, and salinity.



SKETCH: section



PRECEDENT: Giant Marsh, Point Pinole

OPTION 1 ENHANCE EXISTING BED

PROS

- Eelgrass is already located at the breach in conditions that facilitate growth
- Eelgrass could help erosion at breaches
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CONS

- Highly erosive environment
- Eelgrass is highly sensitive to changing environmental conditions
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OPTION 2 PROMOTE AT BREACHES

PROS

- Eelgrass could help reduce erosion at breaches
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CONS

- May not be ideal conditions for eelgrass
- May need to increase open water to encourage eelgrass growth
- Eelgrass is highly sensitive to changing environmental conditions
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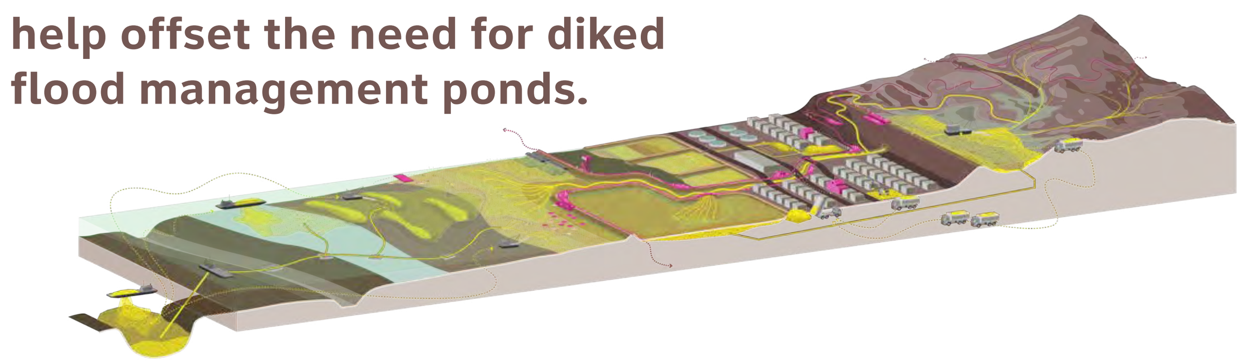
UPLAND SEDIMENT STRATEGIES

DESIGN STRATEGY REFINEMENT

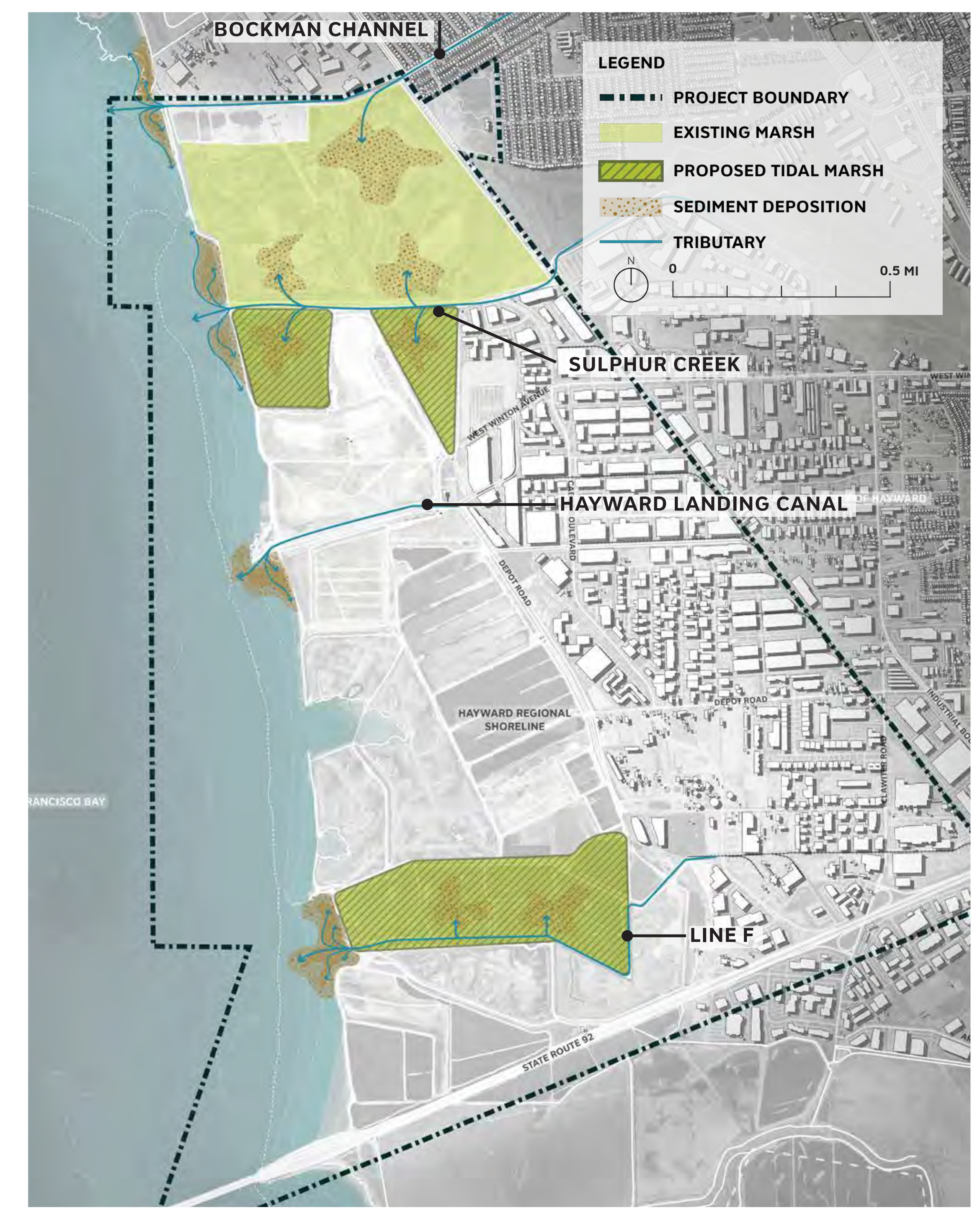
DESCRIPTION. The identification of upland sediment sources or the preparation of areas that will be inundated in the future. Other strategies include preparing for future inundation, raising land to marsh plain elevation for restoration, or enhancing the landward edge to buffer against increased water inundation. Green infrastructure can also help offset the need for diked flood management ponds.



AXON: Public Sediment proposal

Don Castro Dam and Reservoir

OPTION 1 FLUVIAL SEDIMENT DELIVERY



PROS

- Allow natural processes to deliver sediment to marshes and mudflats
- Formation of mini-deltas
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CONS

- Increase of sediment in fluvial channels decreases flood capacity
- Water flows may not be significant enough to distribute sediment
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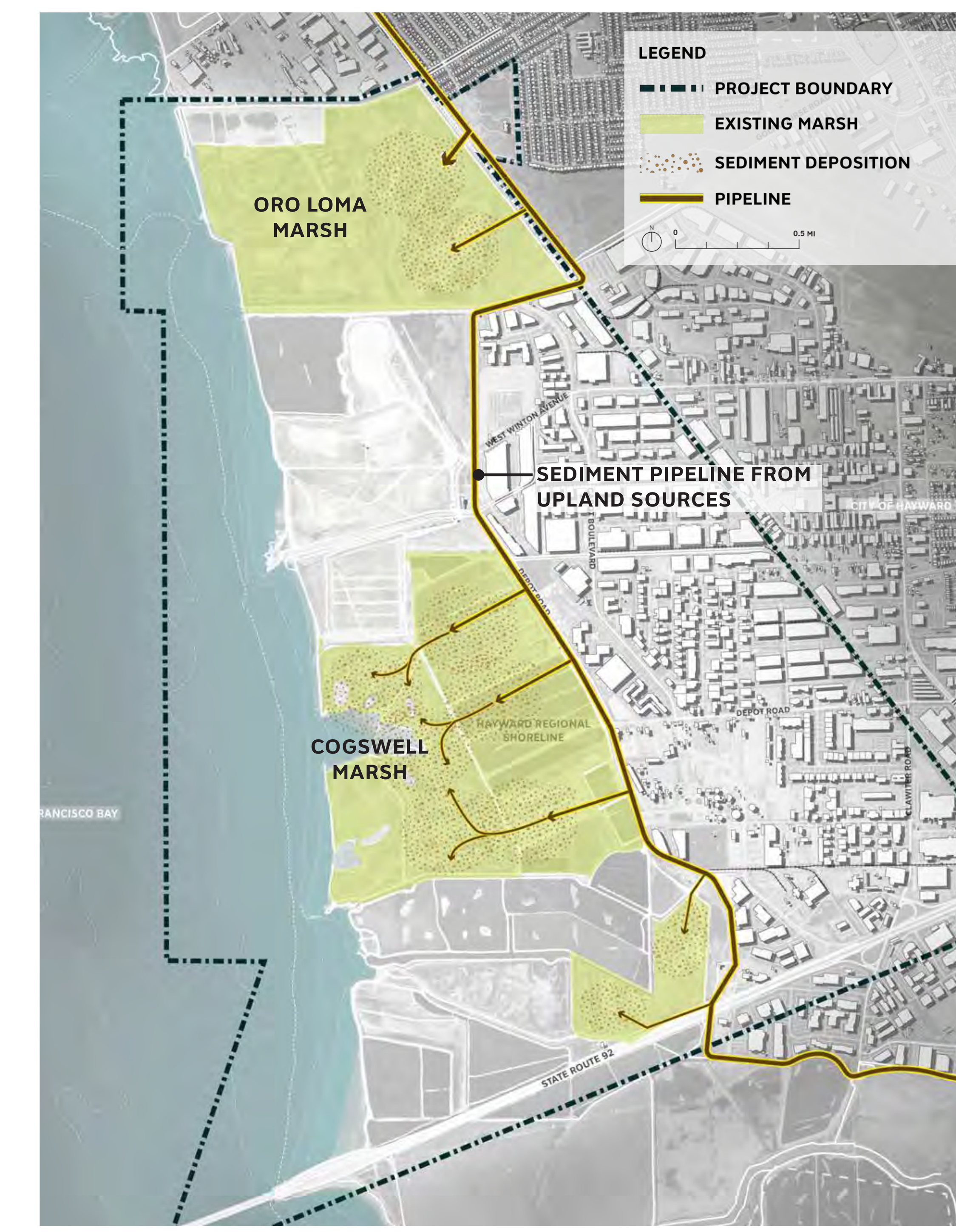
OPTION 2 REGIONAL SEDIMENT DELIVERY



PROS

- Set up infrastructure to deliver sediment over time
- Utilize upland sediment sources
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CONS

- May not be the right material
- Pipe infrastructure is costly
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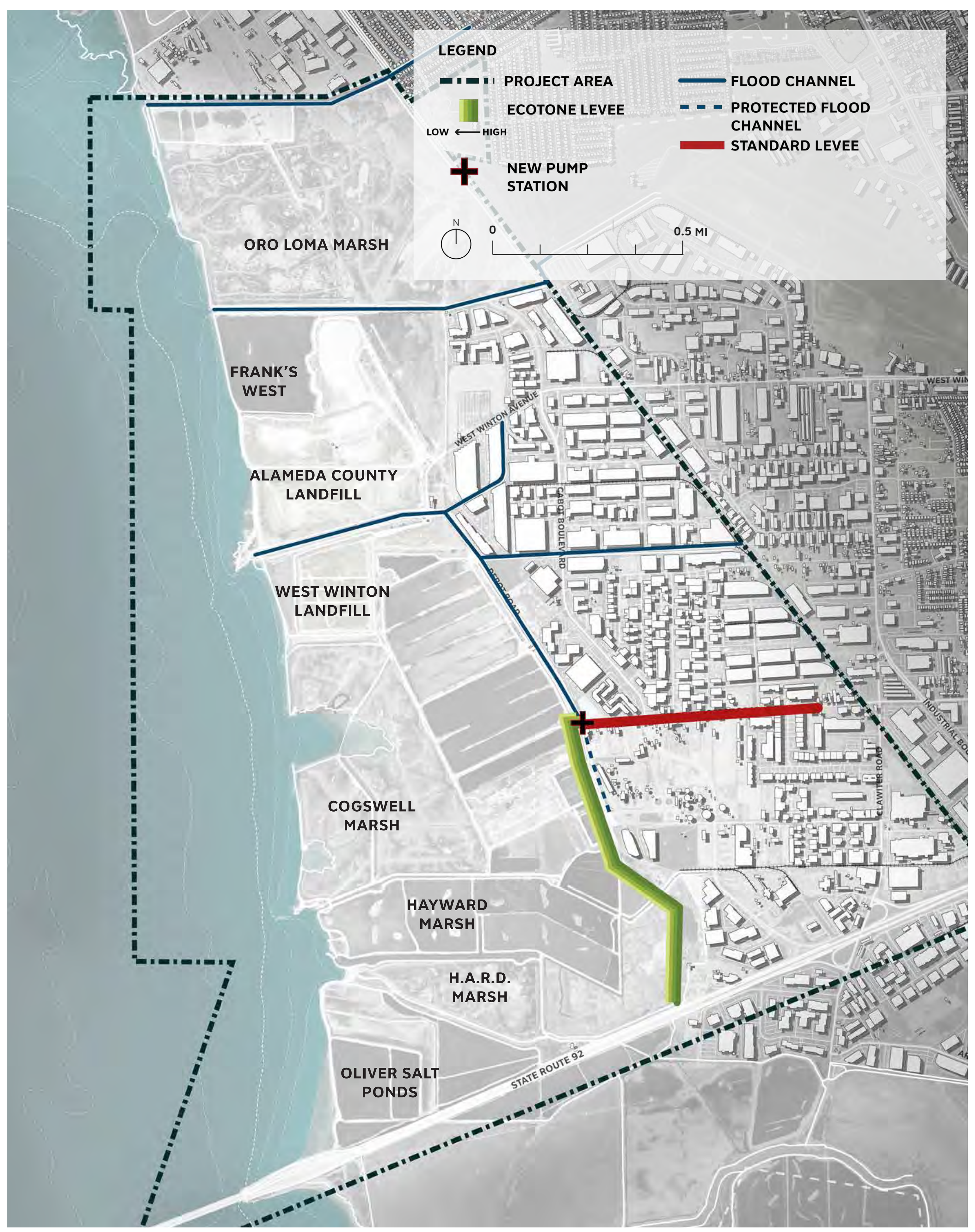
ECOTONE LEVEE

DESIGN STRATEGY REFINEMENT

Ecotone levees are vegetated gentle slopes or ramps on the bay side of a levee. They can attenuate waves, provide high-tide refuge for marsh wildlife, and allow room for marshes to migrate upslope with sea level rise. Ecotone levees have a larger footprint but can provide many resilience benefits.

TYPICAL ECOTONE SECTION

OPTION 1 PROTECT CRITICAL INFRASTRUCTURE



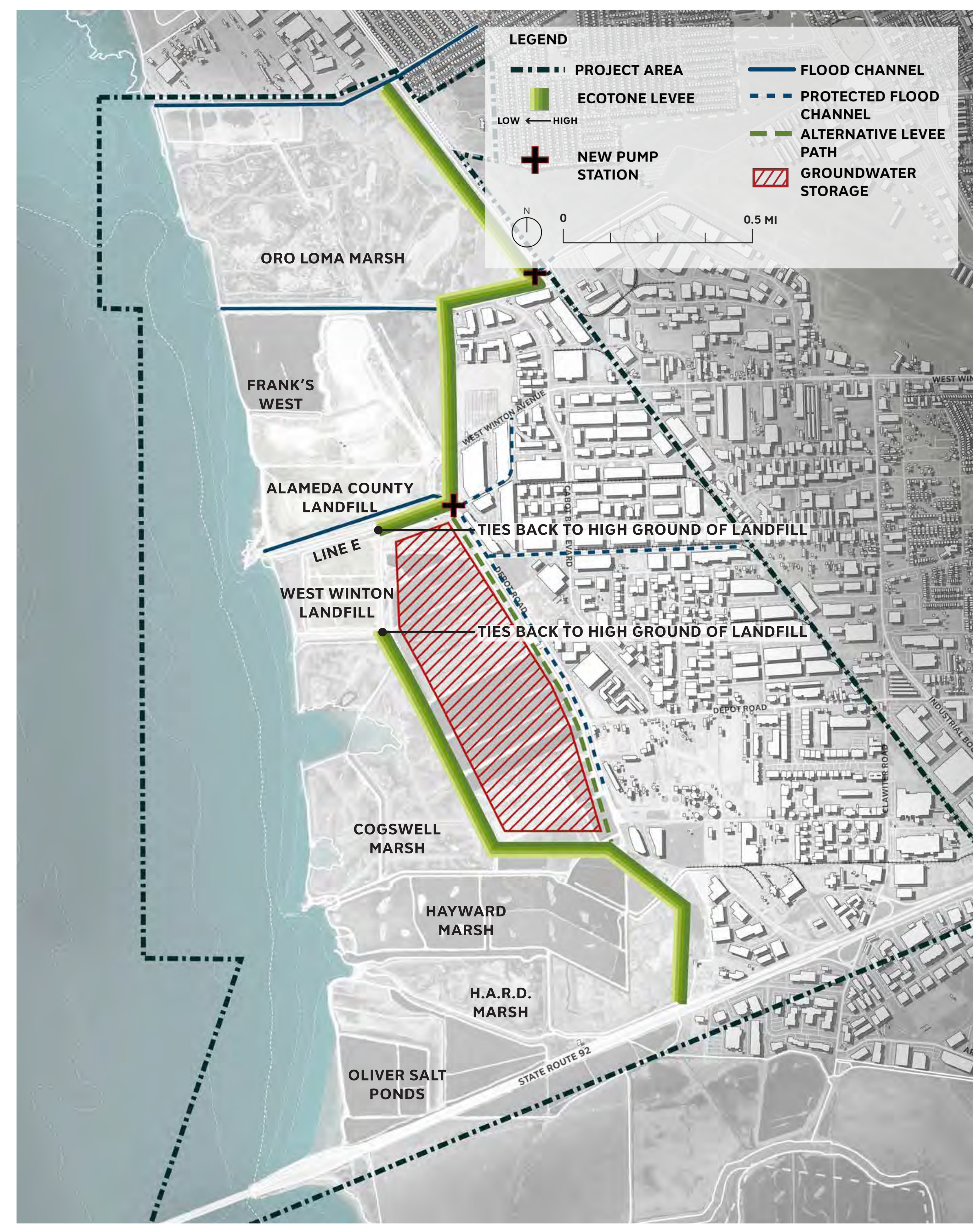
PROS

- Existing tidal connections remain
- Sulphur creek remains in place
- Some water control structures will be preserved (line A)
- Combines well with creating a buffer area for groundwater pooling

CONS

- Only partially protects critical infrastructure
- Hayward marsh not protected
- Sulphur creek not protected
- May require channels to be relocated
- No storage for Hayward WWTP effluent

OPTION 2 UPLAND LEVEE

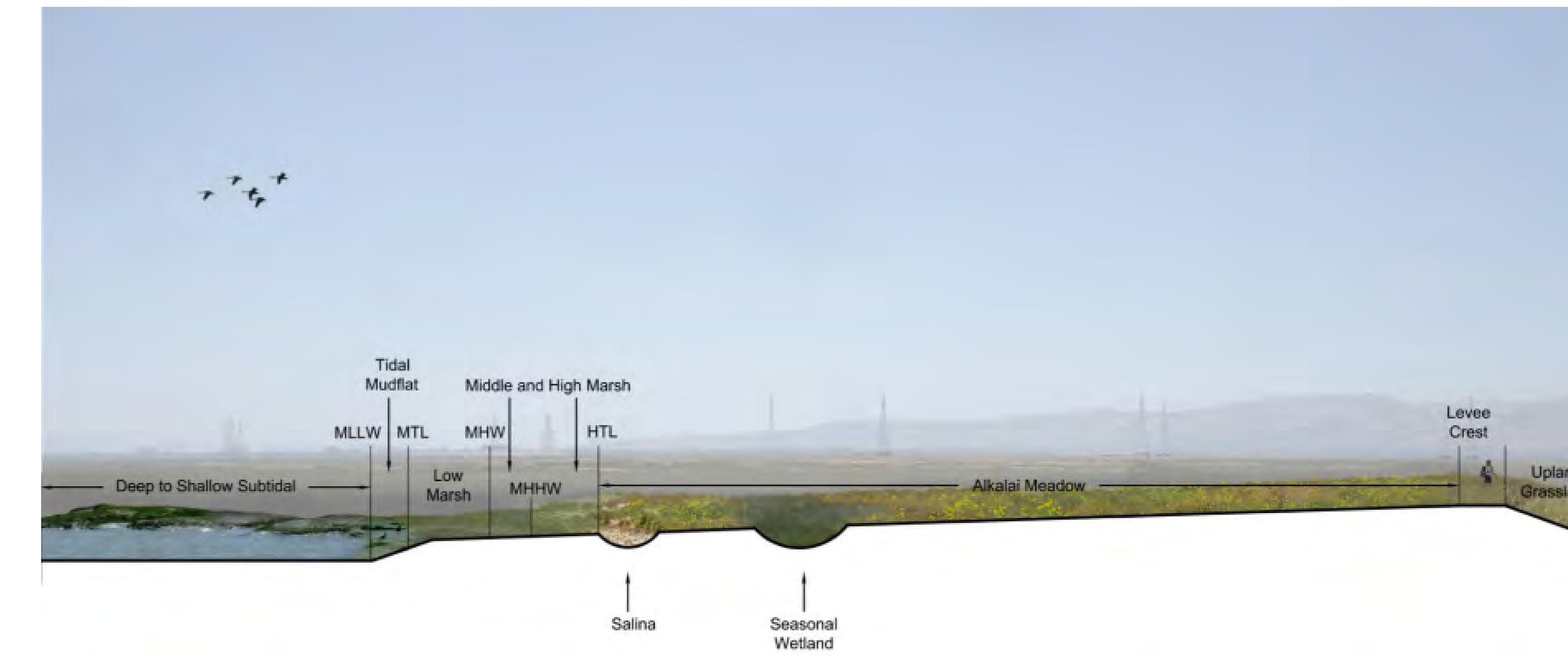


PROS

- Preserves Oro Loma marsh
- Preserves hayward landing
- Provides potential groundwater storage areas in oxidation ponds
- Allows for upland marsh migration
- Attenuates waves, reduce wave run up, prevent overtopping of levee crest
- Low-gradient slope does not need to be constructed from highly engineered levee core
- Reduces erosion

CONS

- Line E unprotected
- Line A to be relocated
- Sulphur creek to be re-routed
- Hayward marsh not protected
- FEMA does not certify transition slope levees
- Construction would require filling the bay and modifying shoreline topography - requires multiple permits
- Largely untested



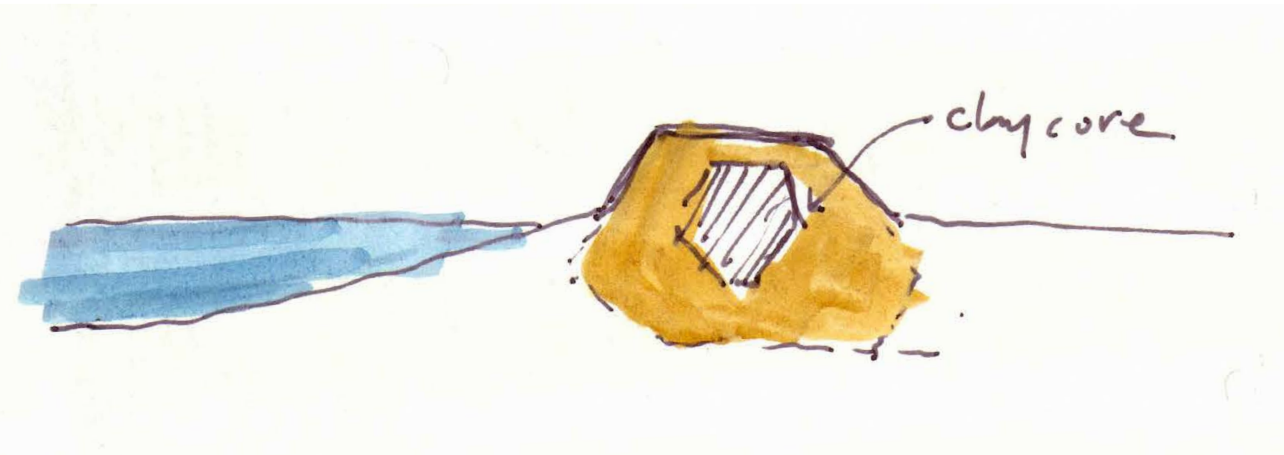
PRECEDENT: South San Francisco Bay Shoreline Project

PRECEDENT: Oro Loma Horizontal Levee

PRECEDENT: Deer Island, Marin Independent Journal, 2019

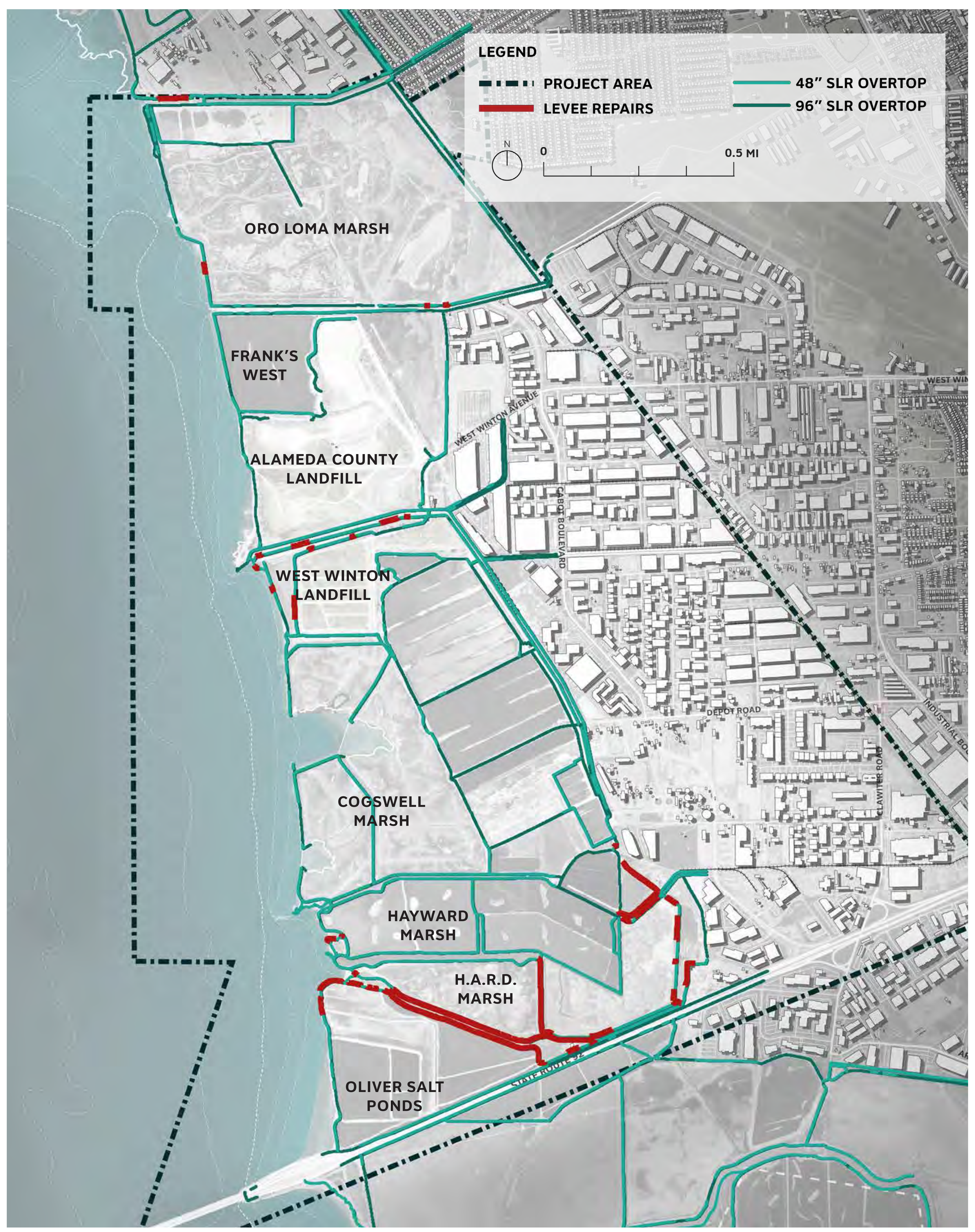
LEVEE IMPROVEMENTS
DESIGN STRATEGY REFINEMENT

Existing levees can be modified or improved to increase their resiliency to storms and sea level rise.



SKETCH: IMPROVED LEVEE WITH CLAY CORE

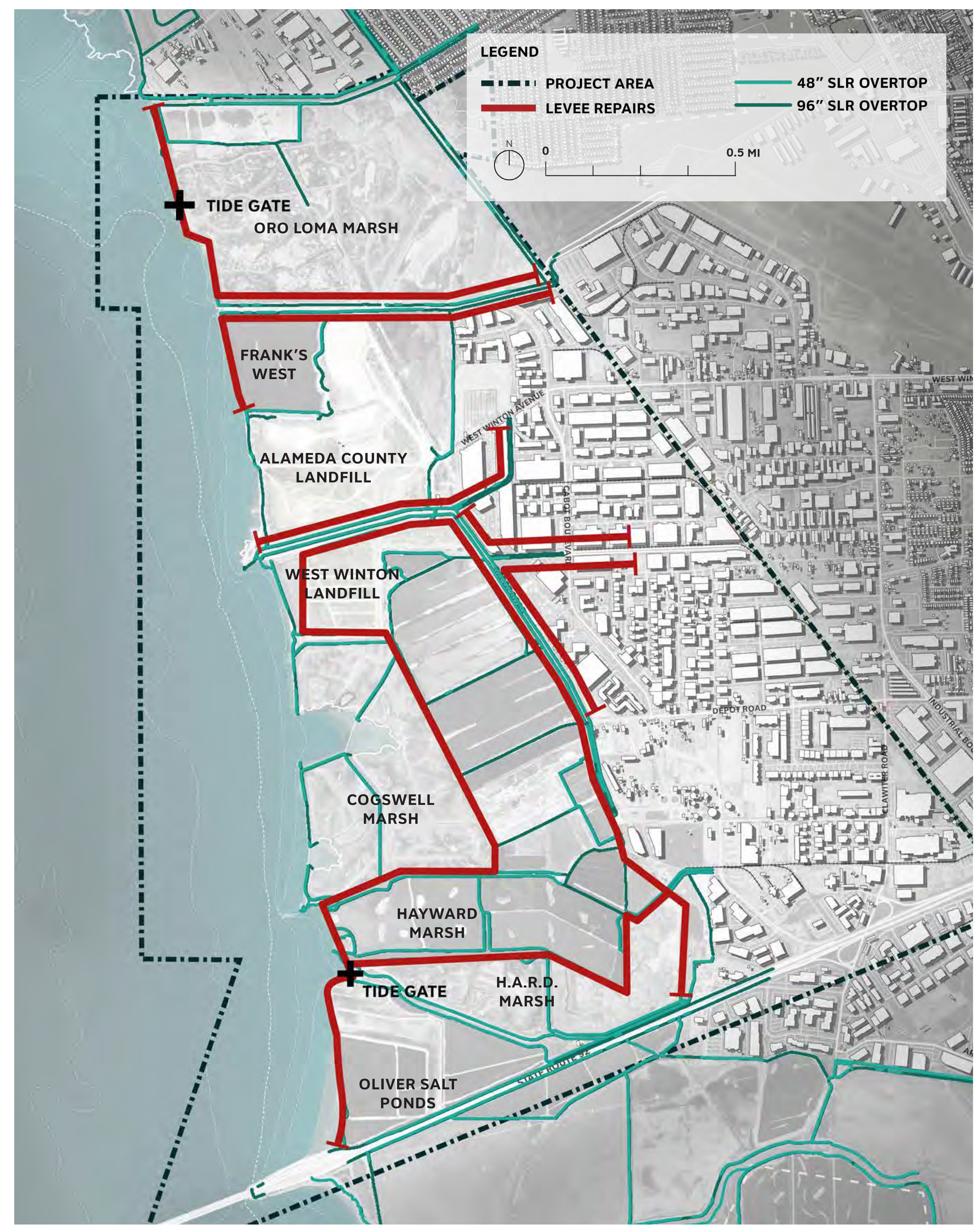
OPTION 1 TARGETED REPAIRS



PROS
- Protects Oro Loma Marsh
- Hayward landing remains intact
- Prevents flooding and erosion

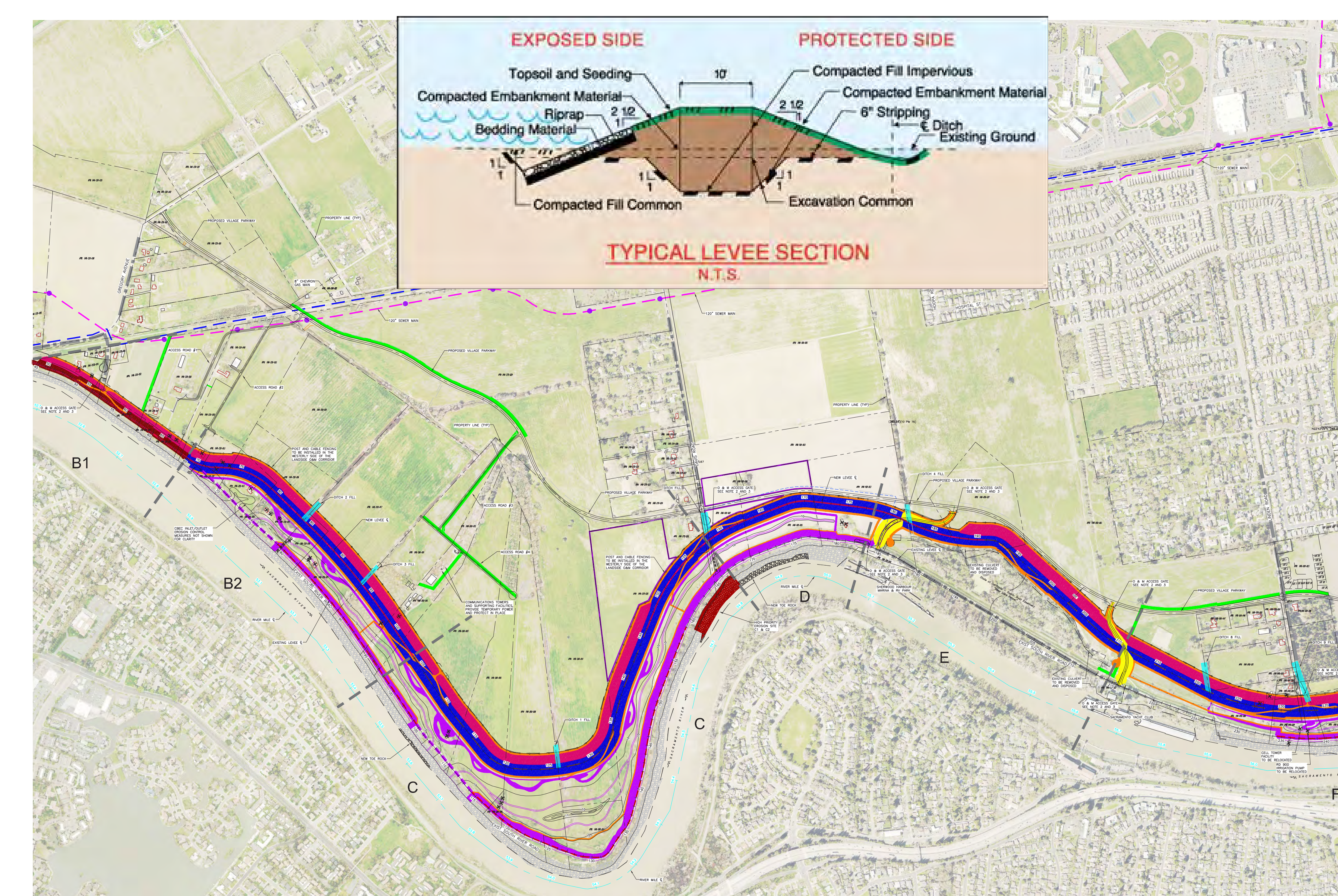
CONS
- Does not address future storm surge with sea level rise

OPTION 2 ADDRESS 4' OF SEA LEVEL RISE



PROS
- Provides full protection to upland communities
- Prevents flooding from sea level rise
- Permits may be easier to attain if there is precedent in the area
- Preserves existing infrastructure, less disruptive than demolishing or replacing with a new construction

CONS
- Requires pump stations on all flood control channels
- Removes tidal connection for all marshes
- Could be extremely tall and wide
- May cause displacement of people, infrastructure and wildlife
- Requires demolition of pre-existing structures to raise ground



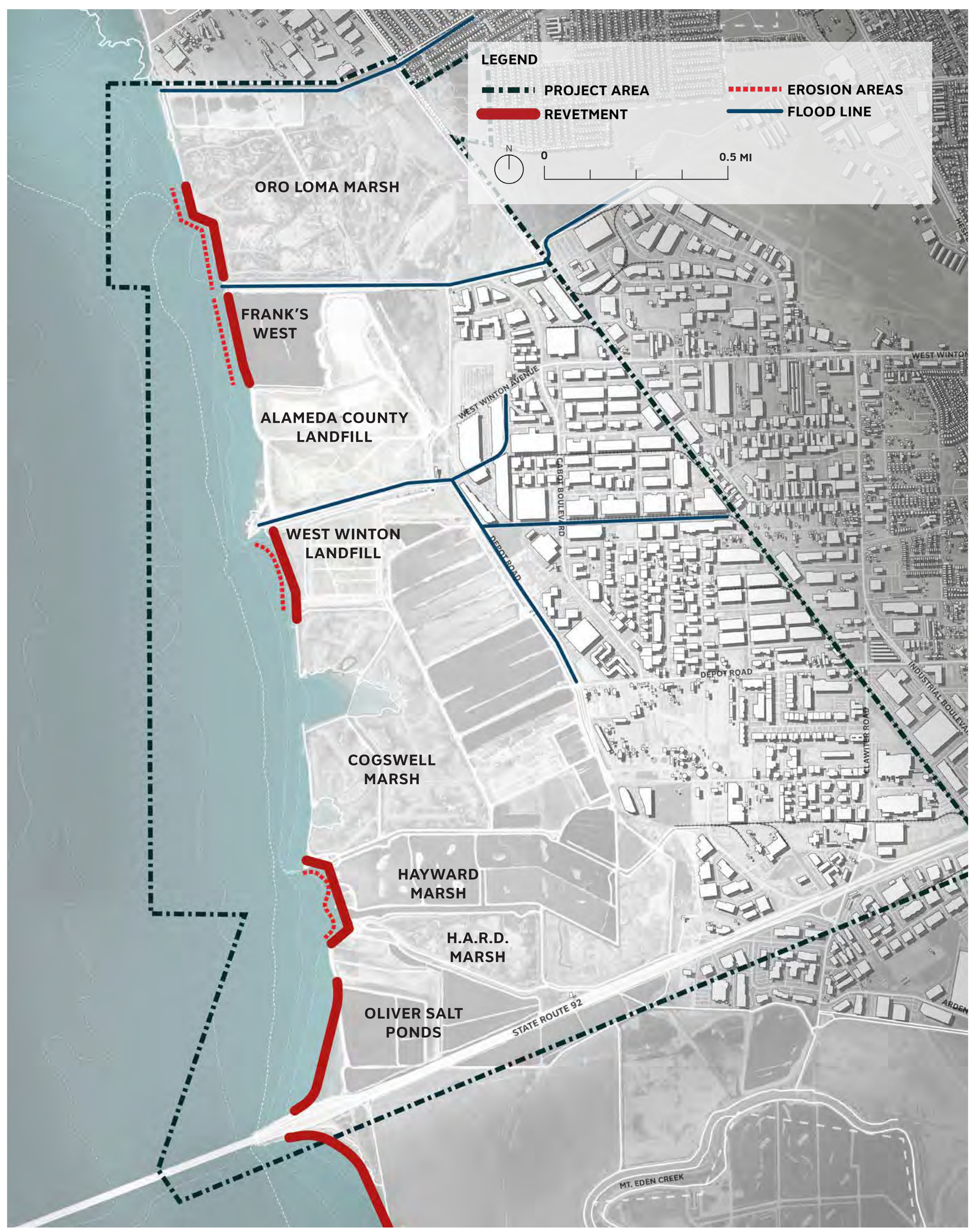
PRECEDENT: SOUTHPORT SACRAMENTO RIVER LEVEE IMPROVEMENT PROJECT, CA

REVETMENTS

DESIGN STRATEGY REFINEMENT

Edge stabilization provides protection along tidal areas to prevent erosion. Revetments are hardened structures made of concrete, rocks, wood, or other materials that are placed along waterways to stabilize them against waves and erosion. Riprap, which is made of rock or concrete rubble, is the most common form of shoreline protection revetment structure in San Francisco Bay.

OPTION 1 REVETMENT STABILIZATION

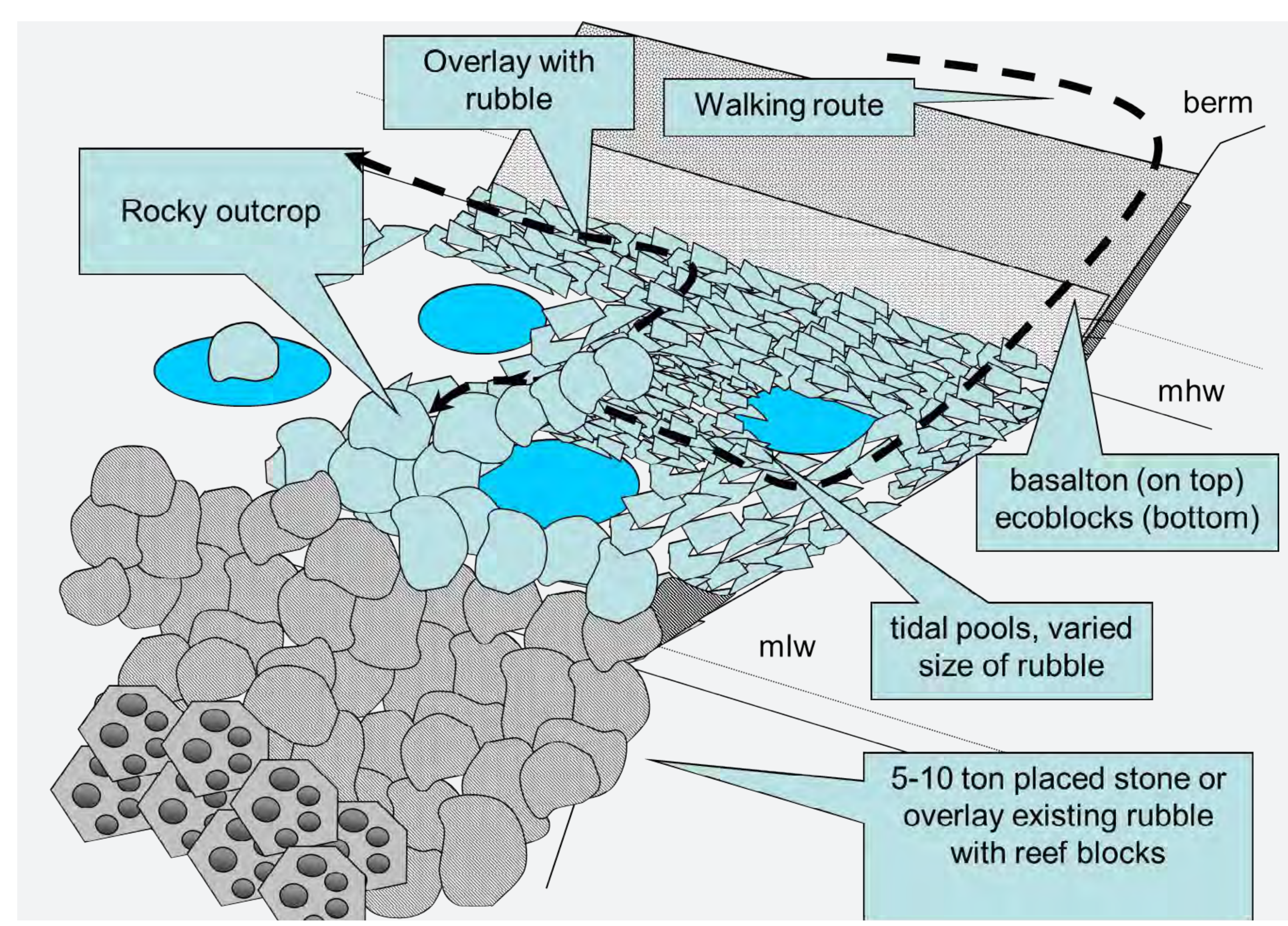


PROS

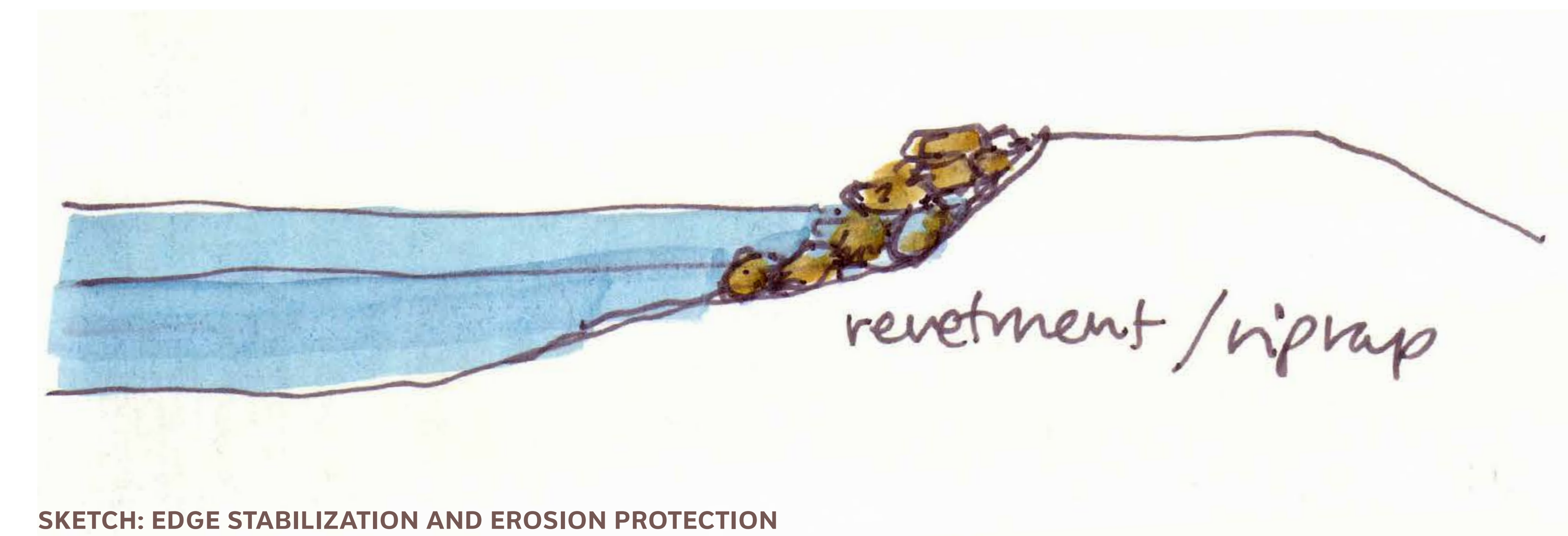
- Preserves Oro Loma marsh
- Hayward landing remains intact
- Stabilizes landfill edges / erosion control
- More cost-effective than bulkheads or seawalls; requires less engineering
- Can be designed to provide habitat value
- May facilitate water access
- Can incorporate habitat for oysters, shellfish, other species, and plants

CONS

- Requires more space for implementation (typically 2:1 slope)
- Requires multiple permits
- __________
- __________
- __________
- __________
- __________



PRECEDENT: EASTERN SCHELDT DIKE ENHANCEMENT, THE NETHERLANDS



SKETCH: EDGE STABILIZATION AND EROSION PROTECTION

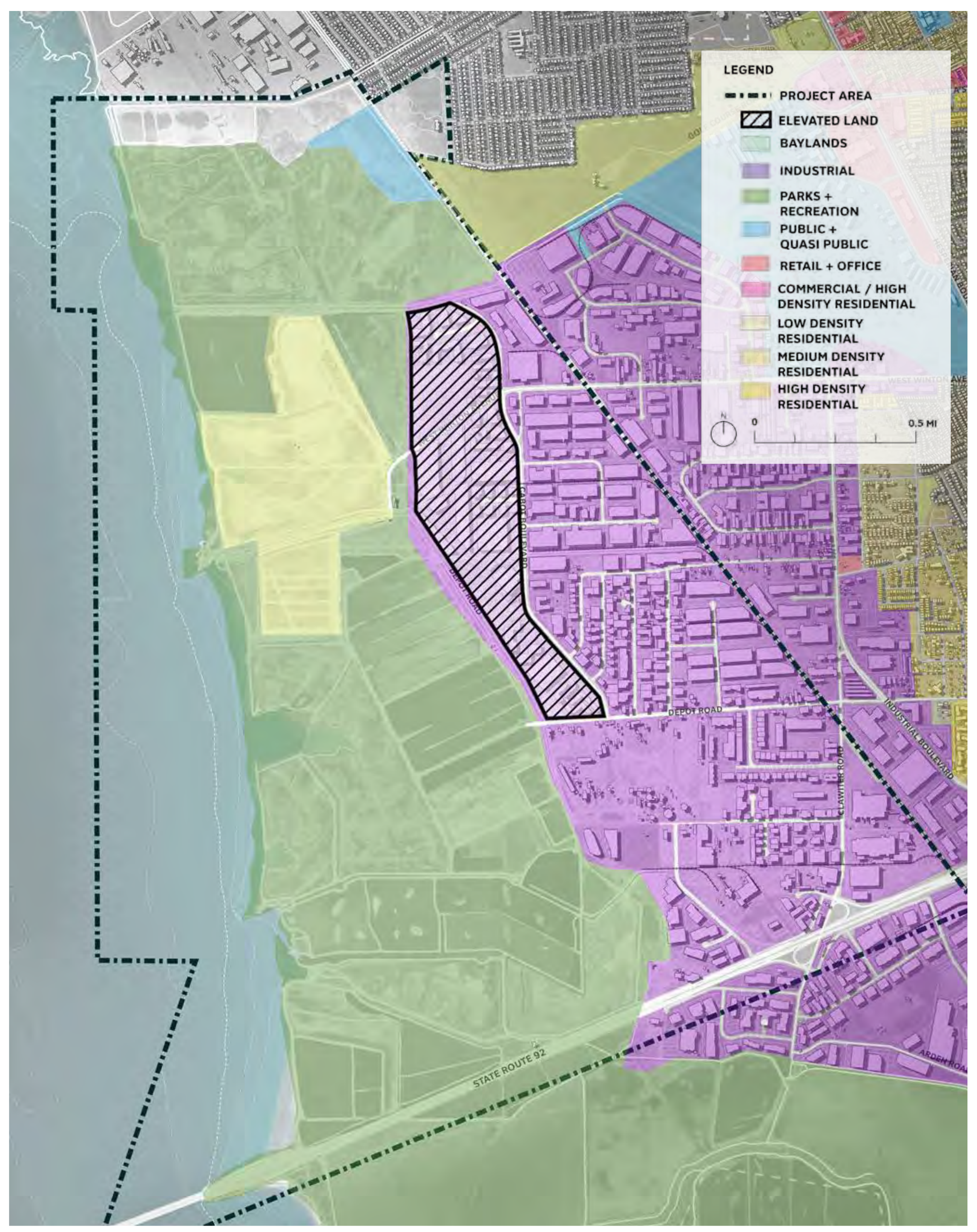
PRECEDENT: EDEN LANDING, UNION CITY, CA

LAND ELEVATION
DESIGN STRATEGY REFINEMENT

Elevating land at the site or district scale above a design flood elevation to lift future development and transportation assets out of the flood zone. This is often done to reduce the risk of flooding for new development or new uses.


PRECEDENT: ARVERNE-BY-THE-SEA

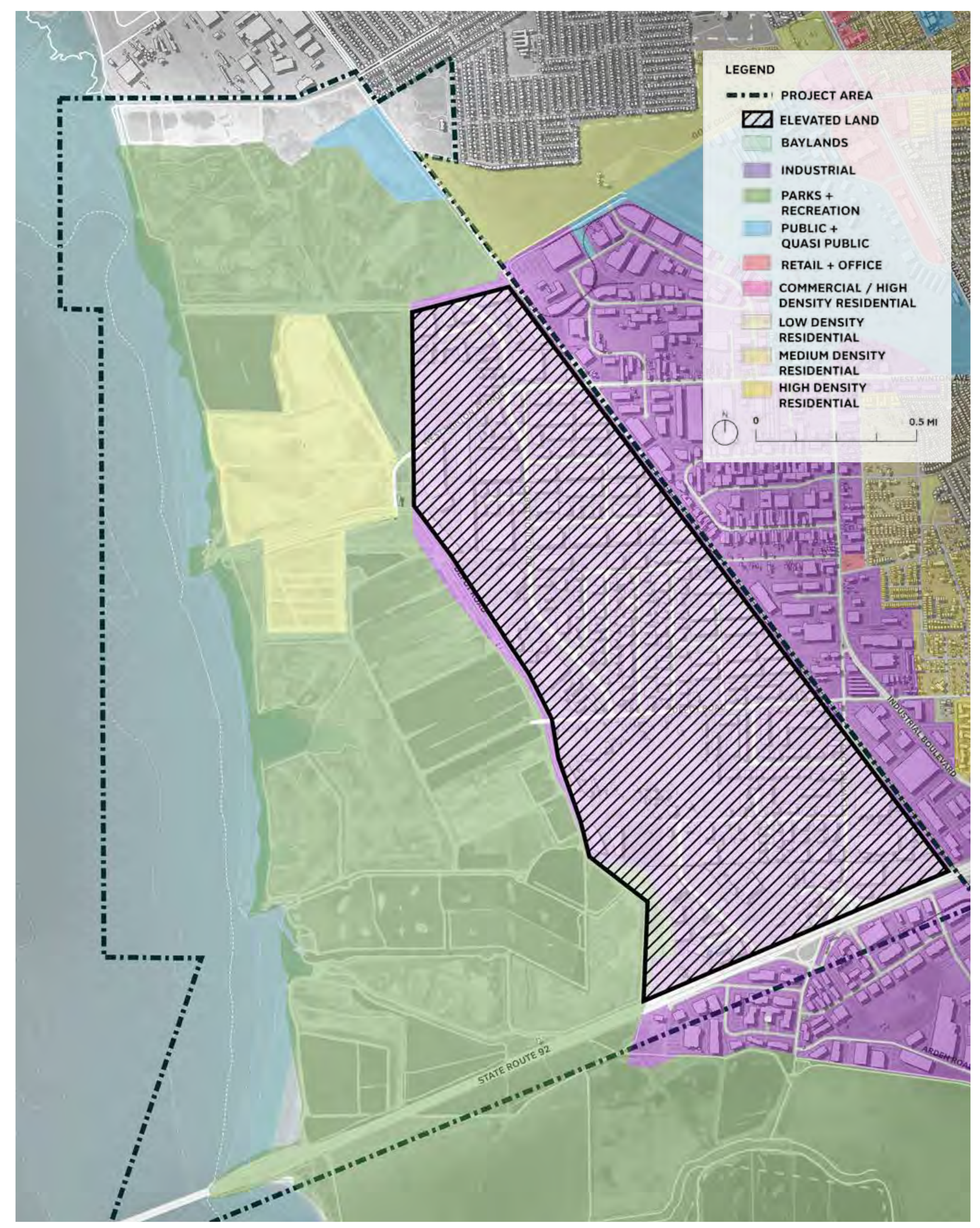
OPTION 1: WEST OF CABOT BOULEVARD



PROS
- Reduces risk of future development and transportation assets to flooding and groundwater emergence in targeting area of highest risk
- May help remediate brownfields and reduce flood insurance rates
- ________
- ________
- ________

CONS
- Requires a significant amount of clean dirt or fill
- Raising elevations in a patchwork pattern is difficult for transportation and drainage connectivity
- Can lead to compaction and subsidence
- May cause disturbance to adjacent land
- May only provide short-term solution for sea level rise
- ________
- ________
- ________

OPTION 2: INDUSTRIAL NEIGHBORHOOD

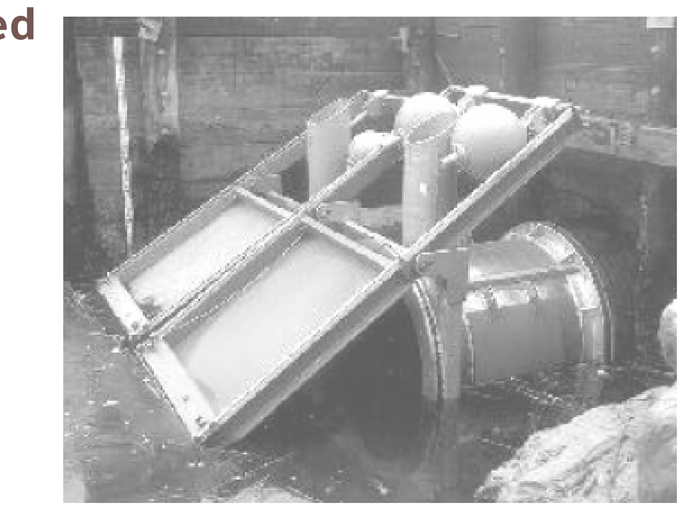


PROS
- Reduces risk of industrial park to flooding and groundwater emergence
- May help remediate brownfields and reduce flood insurance rates
- ________
- ________
- ________

CONS
- Requires complete redevelopment of industrial park, causing significant temporary displacement
- Requires a significant amount of clean dirt or fill
- Raising elevations in a patchwork pattern is difficult for transportation and drainage connectivity
- Can lead to compaction and subsidence
- May cause disturbance to adjacent land
- May only provide short-term solution for SLR
- ________
- ________

TIDE GATES & WATER CONTROL STRUCTURES
DESIGN STRATEGY REFINEMENT

Tide gates control the movement of water, specifically from a tidewater area and a drained, upland area. Hinged doors at the end of culverts make up the gates and they are controlled by mechanisms that regulate when they open or close.



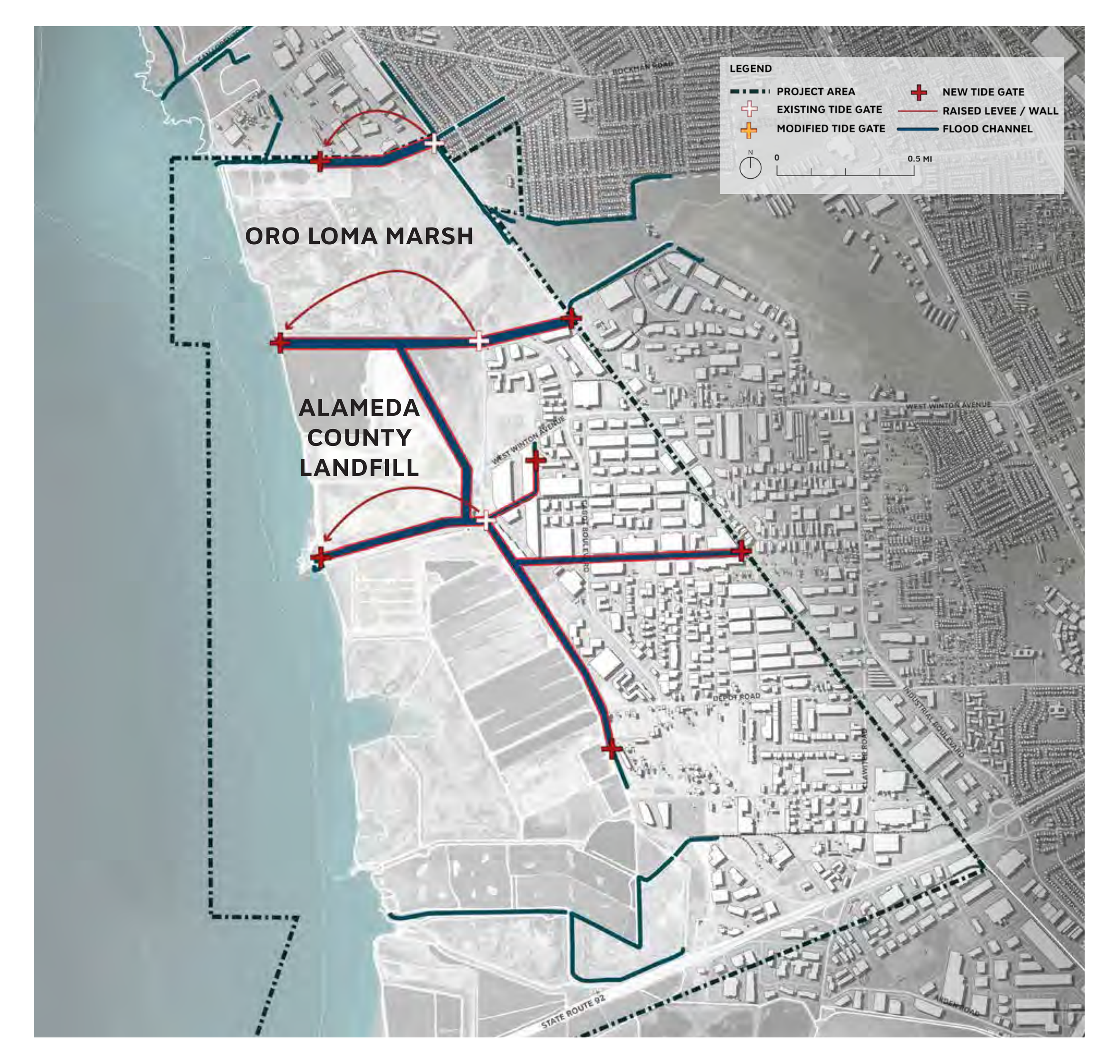

PRECEDENT: Lower Walnut Creek Restoration Project, CA

OPTION 1: TIDE GATE RELOCATION

PROS
- Provides tidal connection to frank's east
- Cheaper to locate control structures as close to the line of protection as possible
- ________

CONS
- Need for automated tide gate in a more complex hydraulic system
- ________
- ________

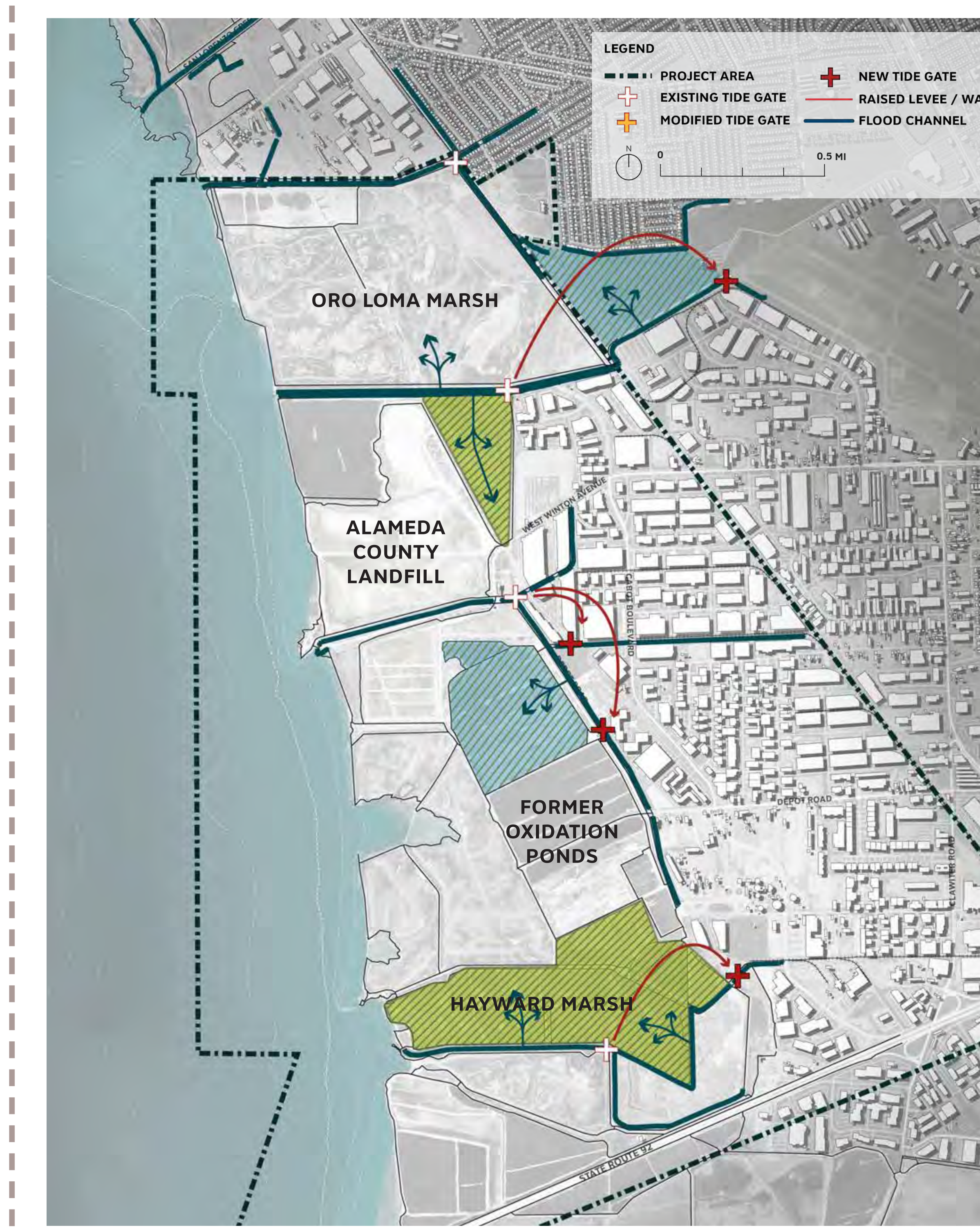
OPTION 2: STORAGE IN FLOOD CHANNELS



PROS
- Improved storage is beneficial
- ________
- ________
- ________
- ________

CONS
- Would require pump stations
- Few viable locations for significant storage volumes
- ________
- ________

OPTION 3: IMPROVING FLOOD CHANNELS



PROS
- Provides further protection from sea level rise
- Minimal impact to channel footprint
- Does not require additional space
- ________
- ________
- ________
- ________
- ________

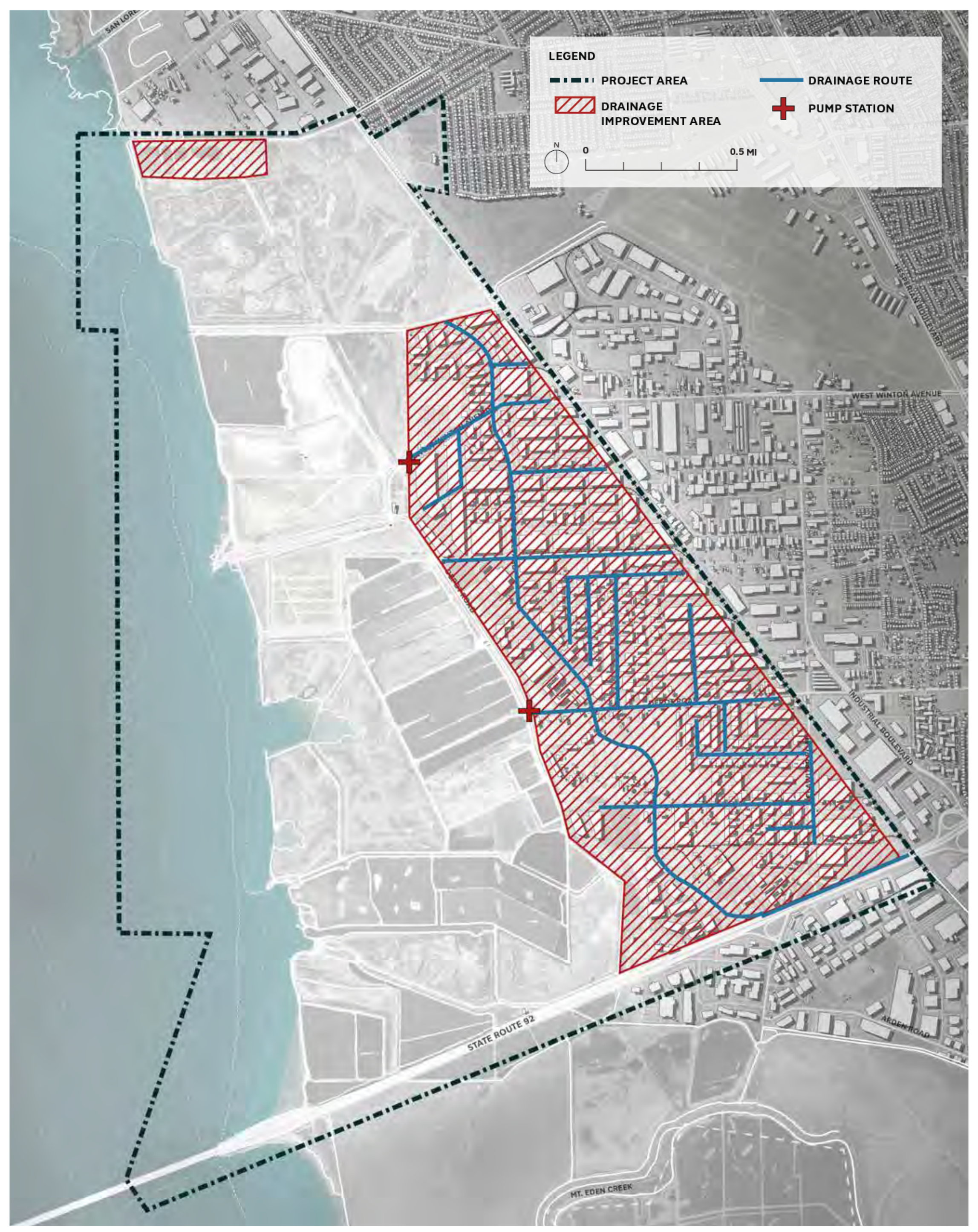
CONS
- Removes visual connection to bay
- May contribute to groundwater ponding
- May exacerbate flooding if water cannot be channeled
- Public Works is concerned about the loss of oxidation ponds
- ________
- ________

GROUNDWATER SOLUTIONS

DESIGN STRATEGY REFINEMENT

Rising groundwater tables can be addressed through an expanded subsurface drainage network that feeds into trenches/canals that flow to the bay at low tide. Tide gates are needed to prevent influx of high tides. Would require additional inland storage space to manage groundwater storage.

OPTION 1: DRAINAGE + TIDE GATES



PROS
- Addresses rising groundwater tables
- Good short to medium-term strategy
-
-
-
-

CONS
- Requires additional inland storage space
- Need to use in combination with other measures, such as tide gates and making use of the existing flood control structures.
- Needs an outlet for the collected water, and therefore it is not a long-term solution
- Requires the creation of a high density system of trenches/ditches and perforated pipelines
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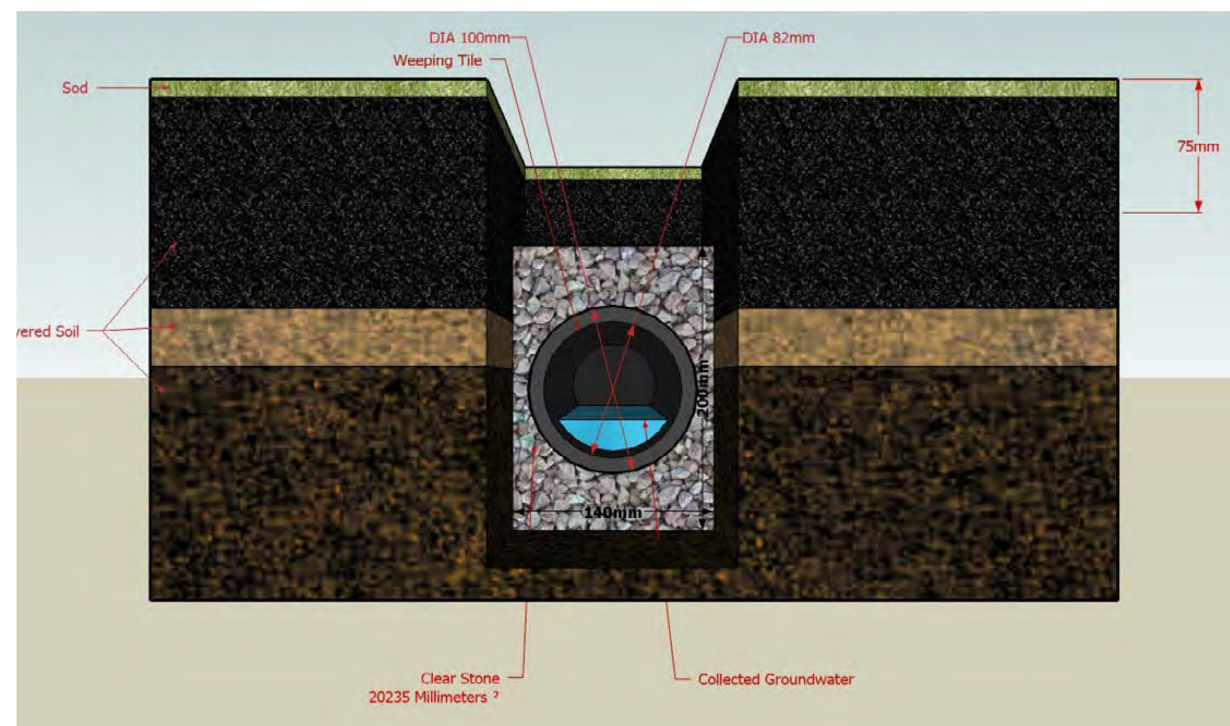
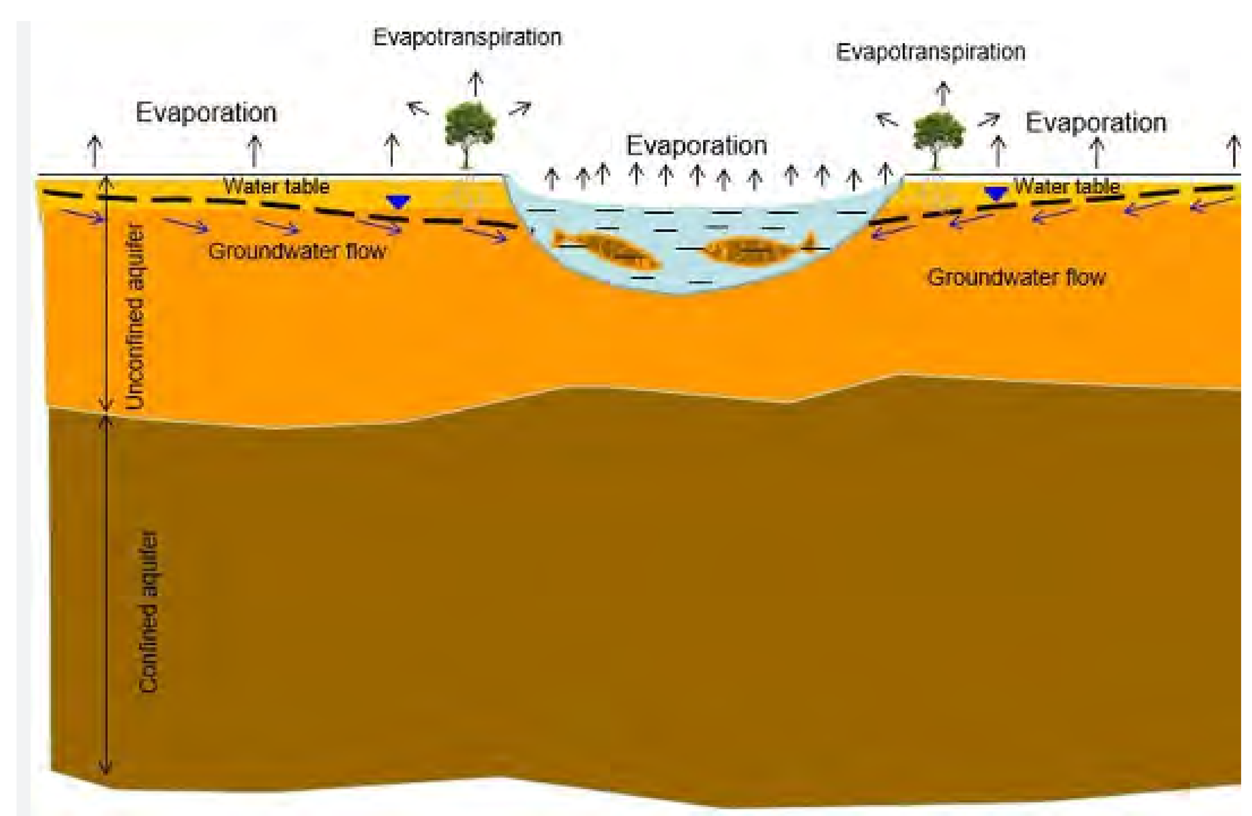
-



Source: https://en.wikipedia.org/wiki/French_drain



Source: https://www.mdpi.com/2306-5338/3/3/30

WASTEWATER TREATMENT ADAPTATION

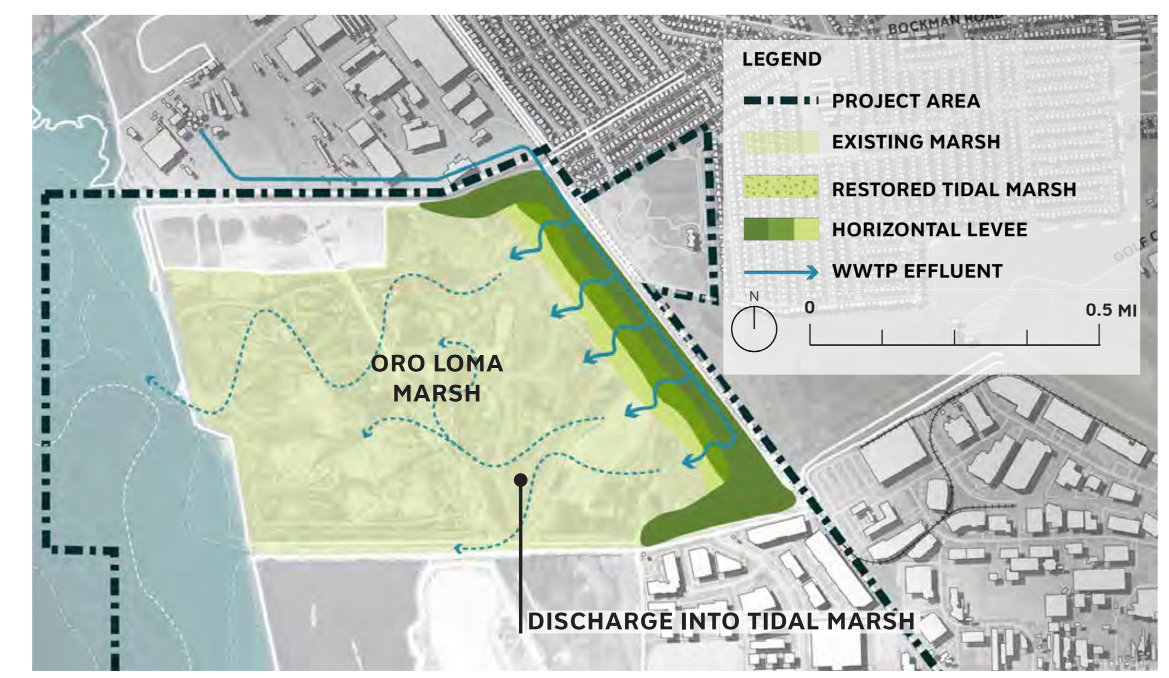
DESIGN STRATEGY REFINEMENT

DESCRIPTION. There is potential to retrofit wastewater treatment plants along the shoreline, which are vulnerable to sea level rise. There is interest in studying the decentralization of WWTP treated discharge, the decommissioning of the EBDA pipeline, and the potential to introduce freshwater inputs to the shoreline with horizontal levee features and other methods of water polishing and local discharge.

PRECEDENT: Novato Wastewater Treatment Plant

OPTION 1 ORO LOMA LOCAL DISCHARGE

WWTP EFFLUENT DISCHARGED INTO TIDALLY INFLUENCED ORO LOMA MARSH

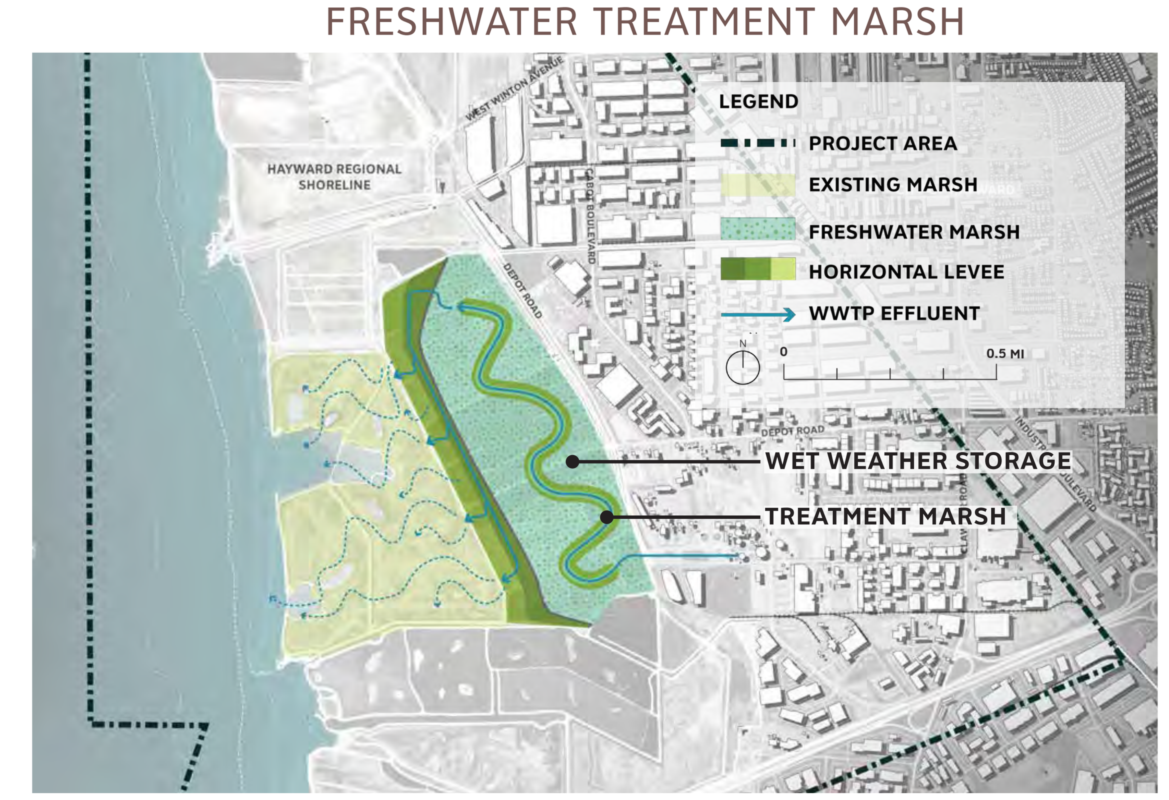


PROS
- Restore salinity gradient to tidal marsh
- Local discharge with EBDA retirement
-
-
-
-
-

CONS
- Not directly connected to the bay
- Need to maintain and raise levee in with sea level rise
- May have negative impacts to Oro Loma marsh
- Endangered species habitat loss
-
-

OPTION 2 HAYWARD LOCAL DISCHARGE

WWTP EFFLUENT DISCHARGED INTO FRESHWATER TREATMENT MARSH



PROS
- Pair with horizontal levee
- Hayward is one of the only WWTP's that can do wet weather discharge
-
-

CONS
- Not directly connected to the bay
- Need to maintain and raise levee in with sea level rise
- Water board permit is difficult
-

OPTION 3 FULLY TIDAL DISCHARGE

ORO LOMA AND HAYWARD WWTP EFFLUENT DISCHARGED LOCALLY INTO TIDAL MARSHES

PROS
- May be able to discharge from other WWTP's
- Fully tidal system, able to accrete and connect to cogswell marsh
- Pair with horizontal levee
- Restore salinity gradient to tidal marsh
- Local discharge with EBDA retirement
-
-
-

CONS
- Restrictions on discharge into fully tidal system- not permitted yet
- Nearshore discharge would be less likely than maintaining the EBDA pipeline
-
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-

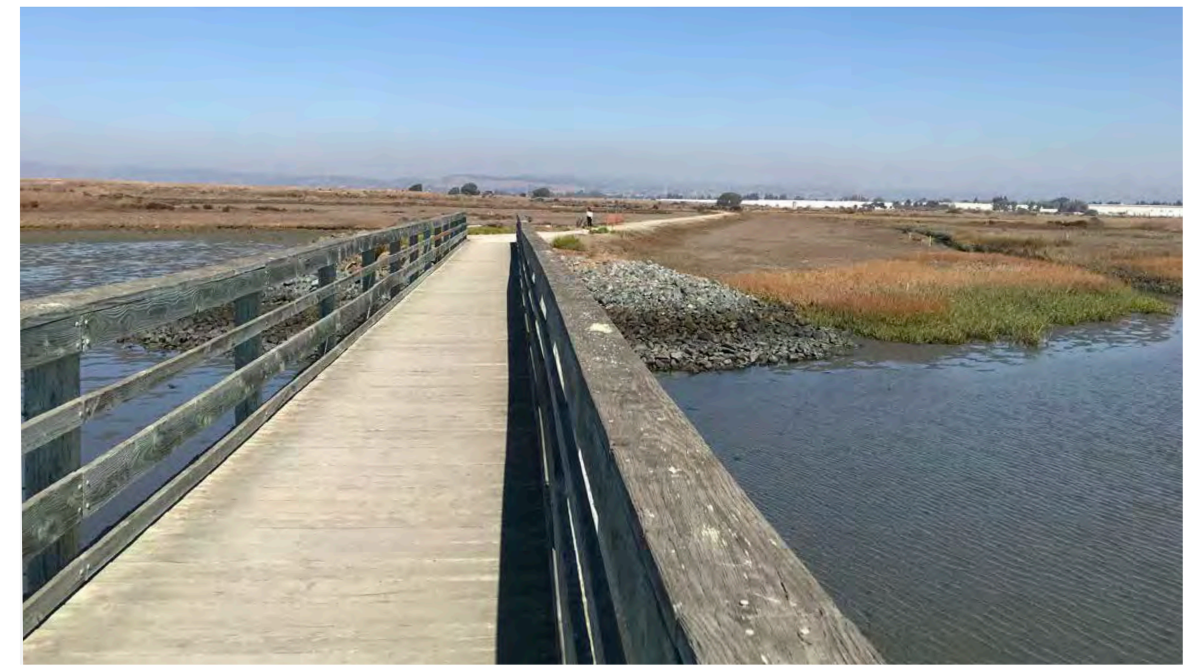
PUBLIC ACCESS + THE BAY TRAIL

DESIGN STRATEGY REFINEMENT

DESCRIPTION. Public access strategies include Bay Trail adaptation plans, additional sites for public access, new types of recreation, expansion of the SF Bay Water Trail, and enhanced connections. Aligning with other adaptation and restoration projects may enhance recreation benefits and increase community



Bay Trail Existing Conditions, 2019

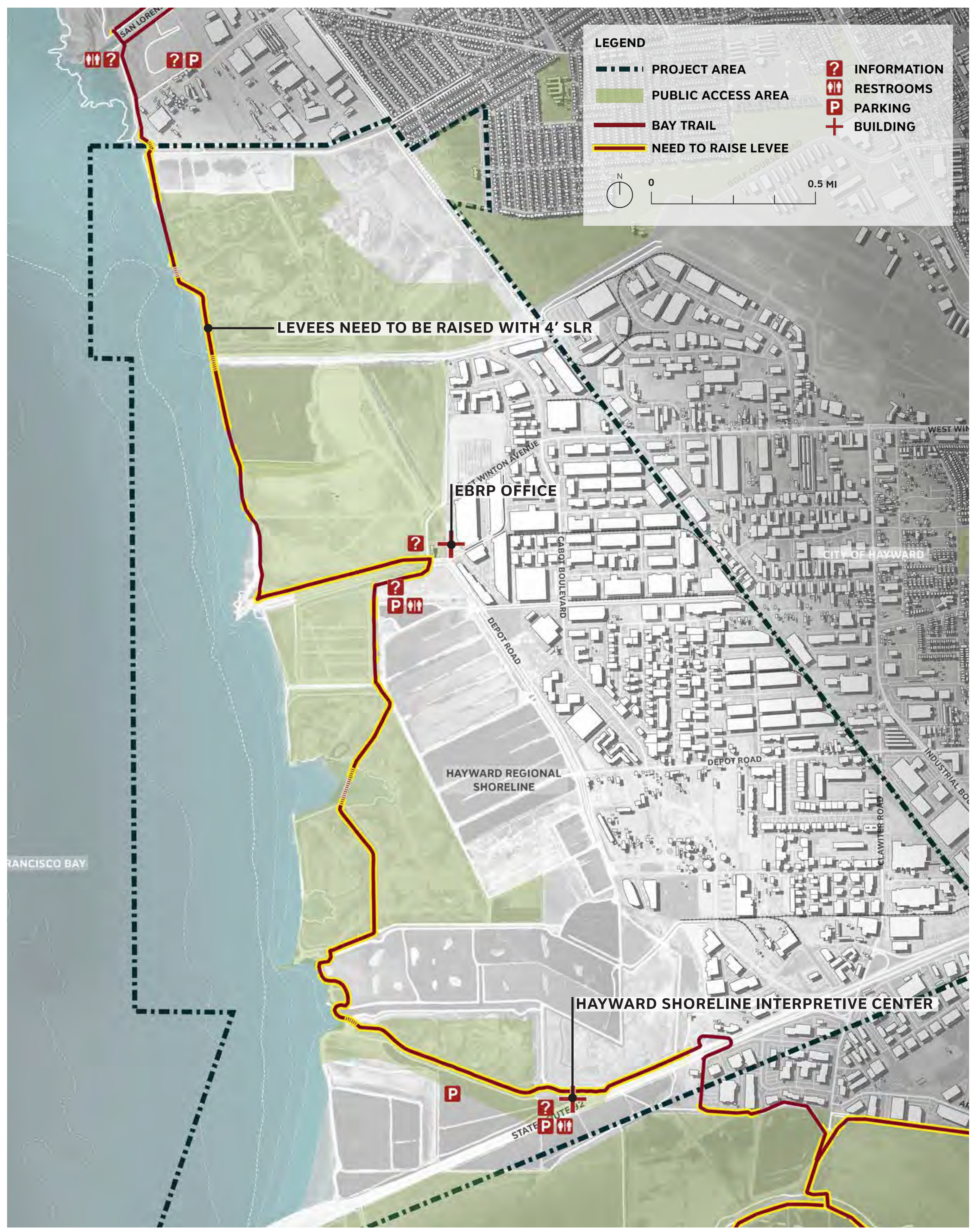



Bay Trail Existing Conditions, 2019

Bay Trail flooding during Jan 2017 King Tide
Source: H.A.R.D.

OPTION 1 MAINTAIN CURRENT ALIGNMENT OF THE BAY TRAIL

RAISE LEVEES TO ACCOMMODATE 4' SLR



PROS

- Diverse bay experience adjacent to blue water
- Maintains current alignment which is existing and permitted
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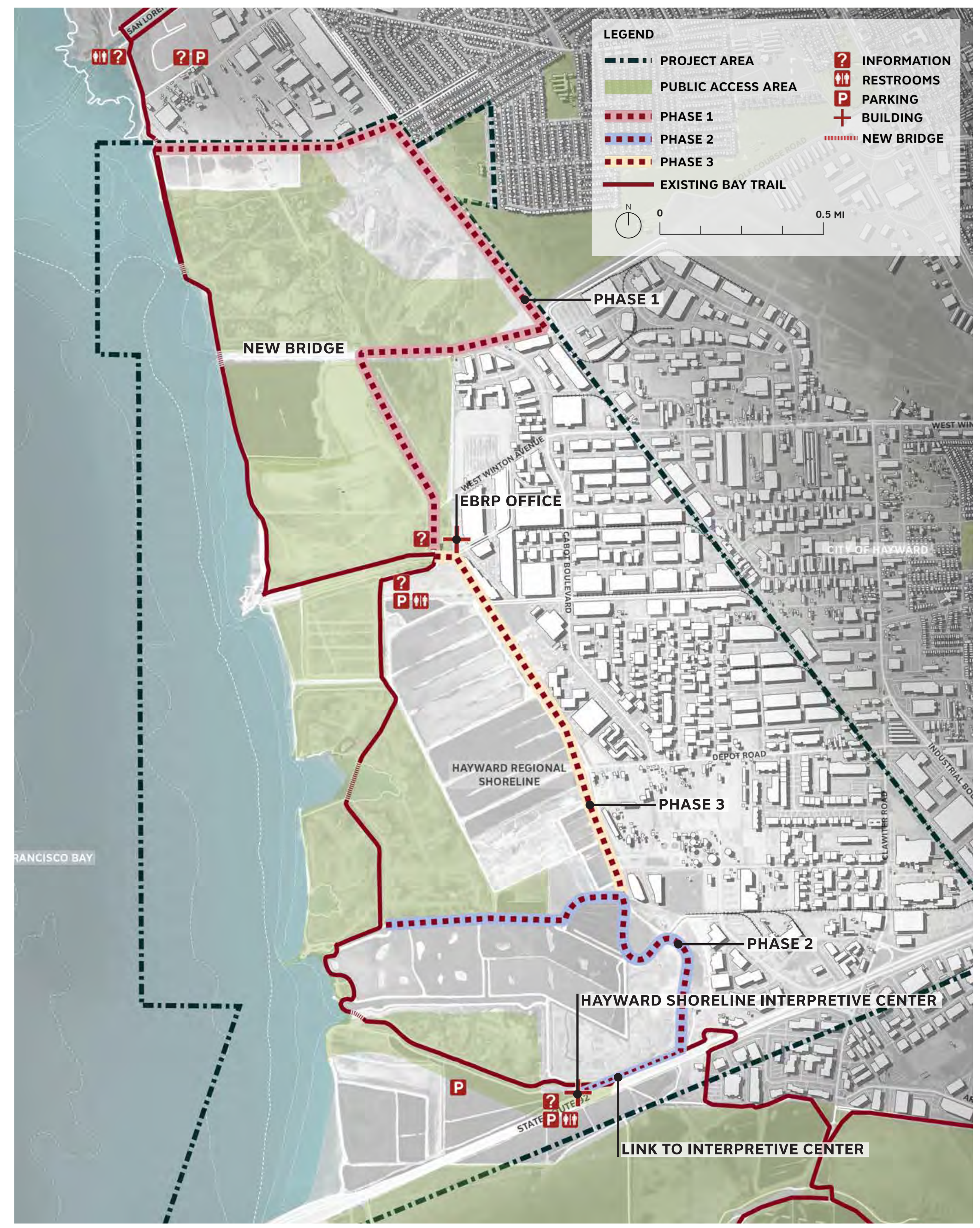
CONS

- Bay trail remains in exposed position near bay edge
- May have to elevate, repair levees that are not associated with other restoration / flood protection projects
- Costly to elevate and repair levees
-
-
-

OPTION 2 ADAPT THE BAY TRAIL OVER TIME

PHASED REALIGNMENT



PROS

- Phased approach may be easier to implement and fund
-
-
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CONS

- Trail connections at the bay will be vulnerable with SLR
-
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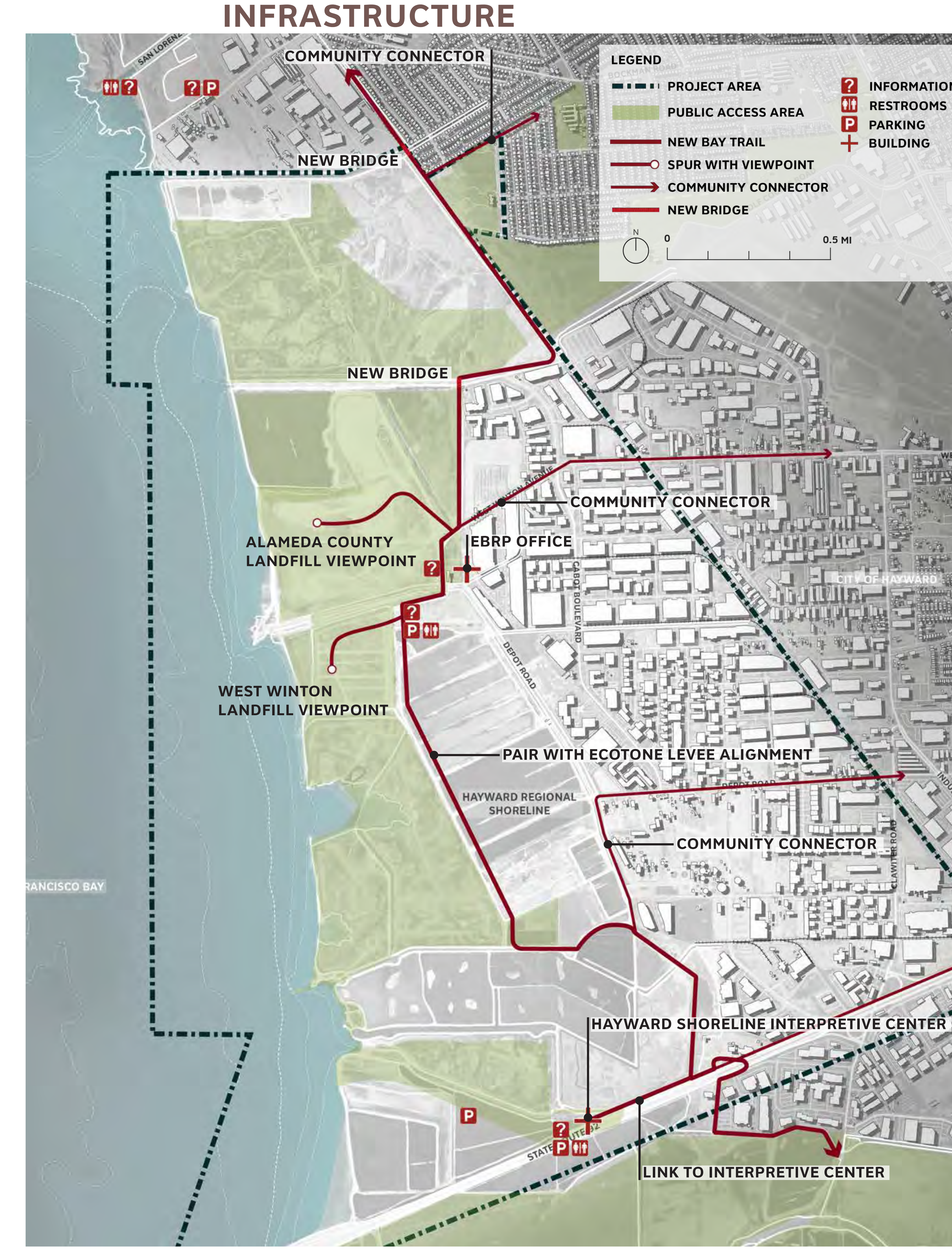
OPTION 3 REALIGN WITH NEW COASTAL PROTECTION INFRASTRUCTURE



PROS

- Closer to adjacent community- enhance key connections inland
- Could be paired with horizontal levee / other infrastructure projects
- Landfill spurs provide unique views of the shoreline and bay
- Buffered from direct wave erosion from the bay
- Bypasses existing infrastructure (restrooms, parking, etc.)

CONS

- Bay trail could be far from blue water if the construction occurs before slr inundates
-
-
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-

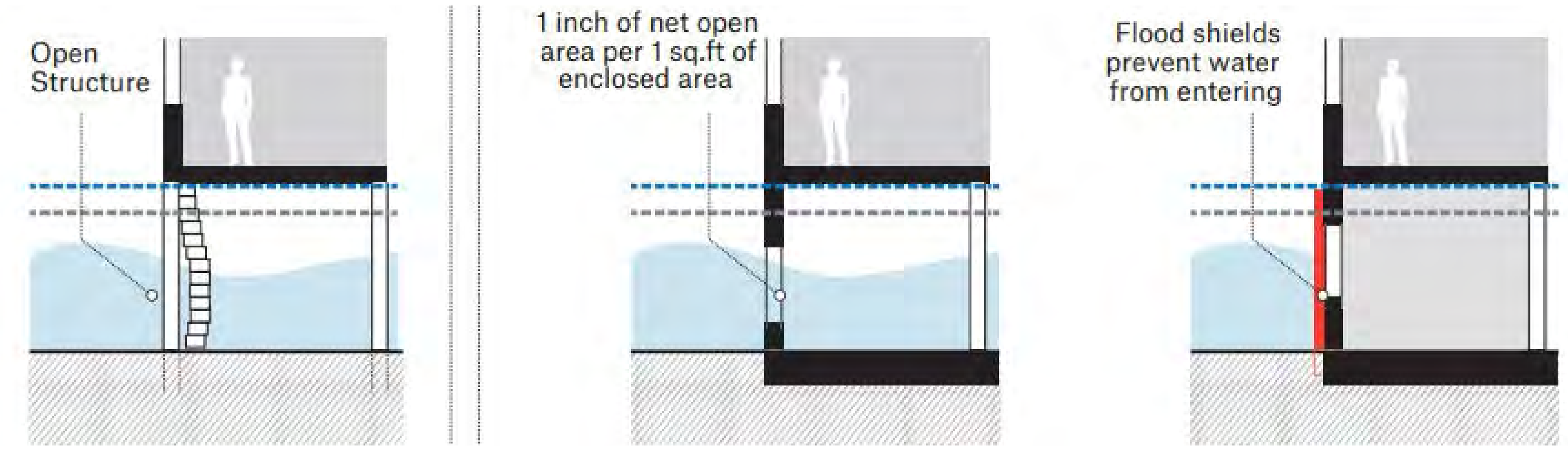
BUILDING SCALE STRATEGIES

DESIGN STRATEGY REFINEMENT

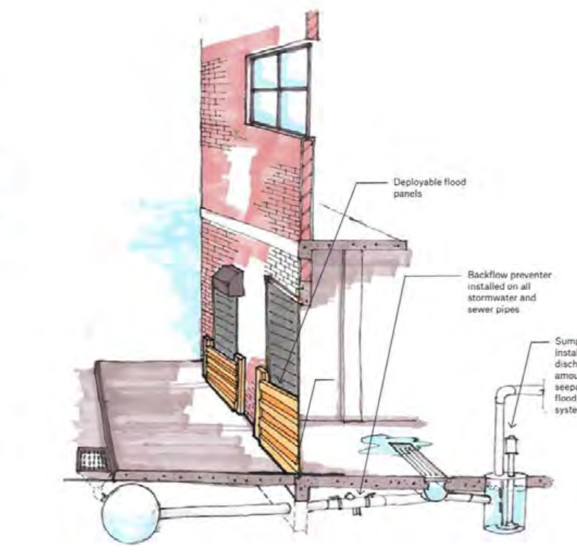
DESCRIPTION. There are many building scale strategies that can be implemented to adapt to sea level rise. From improving standards, such as building codes and removing regulatory impediments, such as zoning height restrictions The City can also aid businesses and homeowners to assist them with understanding the resilience options available to them and with finding the funding to support those options.

PHYSICAL STRATEGIES

PRECEDENT: Brooklyn Grange, Rooftop Farm
(Industry City, Sunset Park, NY)



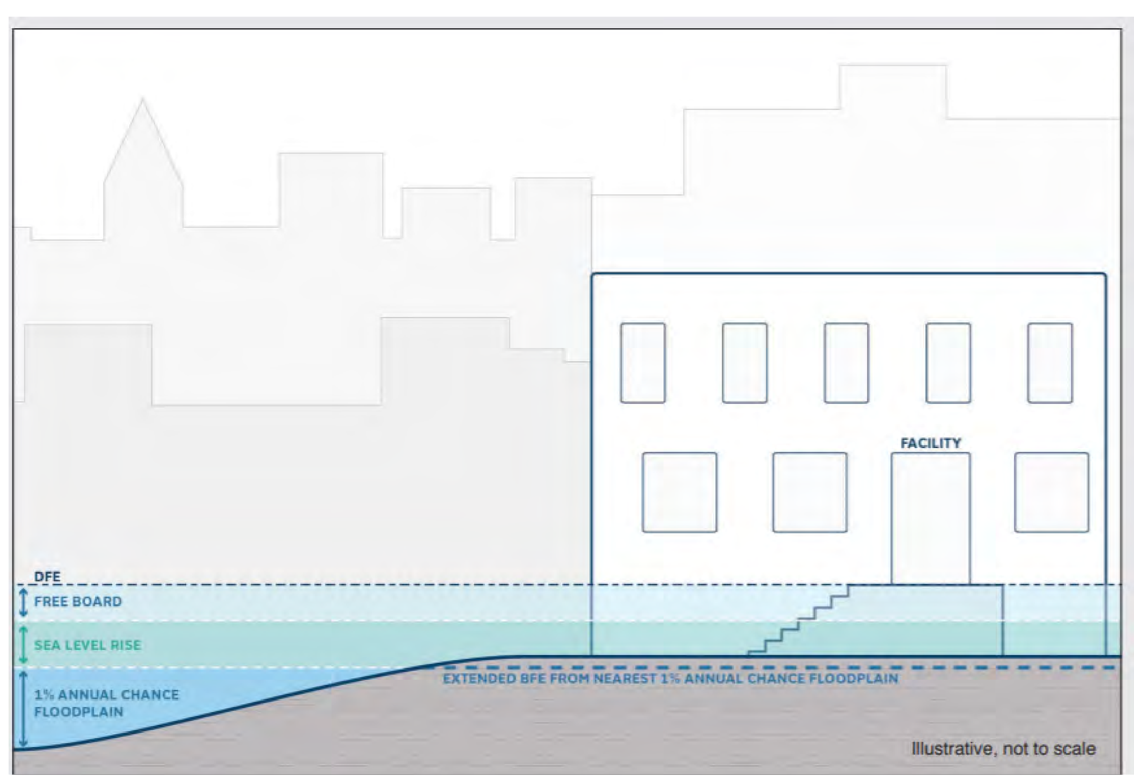
Floodproofing strategies (elevate, wet floodproof, dry floodproof)



On-site pumping, storage

IMPLEMENTATION OPTIONS

OPTION 1 INCREASING STANDARDS FOR NEW CONSTRUCTION



EXAMPLES
- Incorporating sea level rise (image above)
- Extending requirements to 500-yr floodplain
- Storage requirements for hazard materials

PROS
- Reduces risk to future development
- Ensures resilient development

CONS
- Could be costly
- Older developments still at risk

OPTION 2 PROVIDING LOANS/GRANTS/ TAX INCENTIVES FOR IMPLEMENTATION

EXAMPLES
- Competitive funding for innovative flood mitigation technologies (e.g. NYC rise program)
- Loans/grants modeled on CA water board brownfield remediation loans/grants
- Tax incentives modeled on CA solar tax credit

PROS
- Supports businesses and homeowners before, during, and after an emergency or other disruption
- Funding will allow more vulnerable areas to adopt resilient measures

CONS
- Requires funding
- Need to ensure people will take advantage of offerings

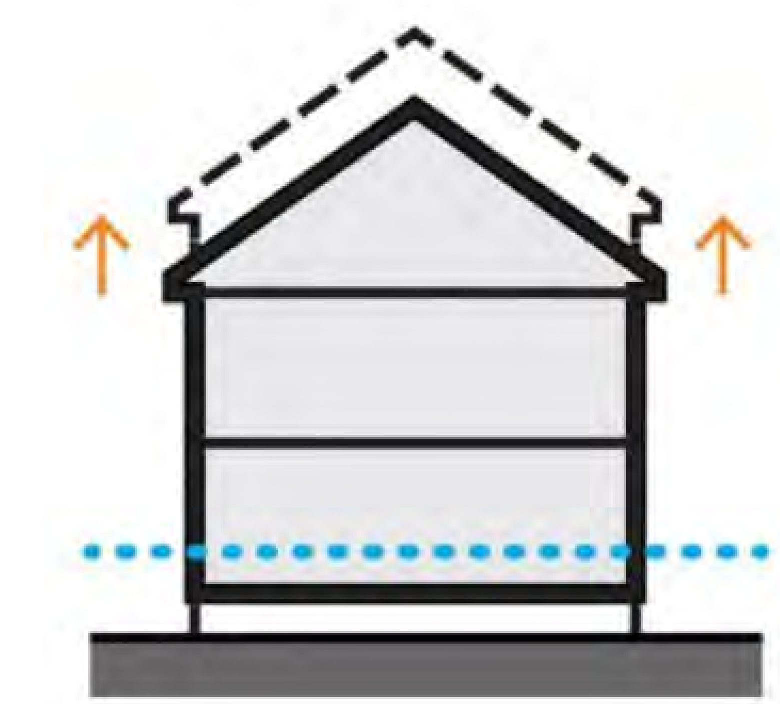
OPTION 3 TECHNICAL SUPPORT & EDUCATION

EXAMPLES
- Modeled after seismic retrofitting awareness campaigns
- NYC business emergency preparedness risk audits

PROS
- Provides resources to recover from and prepare for future floods and climate risks
- Cost-effective way to prepare residents / property owners for future challenges

CONS
- May require additional staff and funding to coordinate support and education levels
- Requires effective community engagement to ensure participation in programs

OPTION 4 REMOVING REGULATORY IMPEDIMENTS



EXAMPLES
- Zoning height limits (image above)
- Permitting requirements & fees

PROS
- Provides the structure to allow for resilience initiatives to be adopted
- Makes its easier, faster, and more affordable to adopt resilience measures

CONS
- Could require overhaul of existing building or zoning standards
- Could be unintended side effects of removing regulatory impediments

MANAGED RETREAT

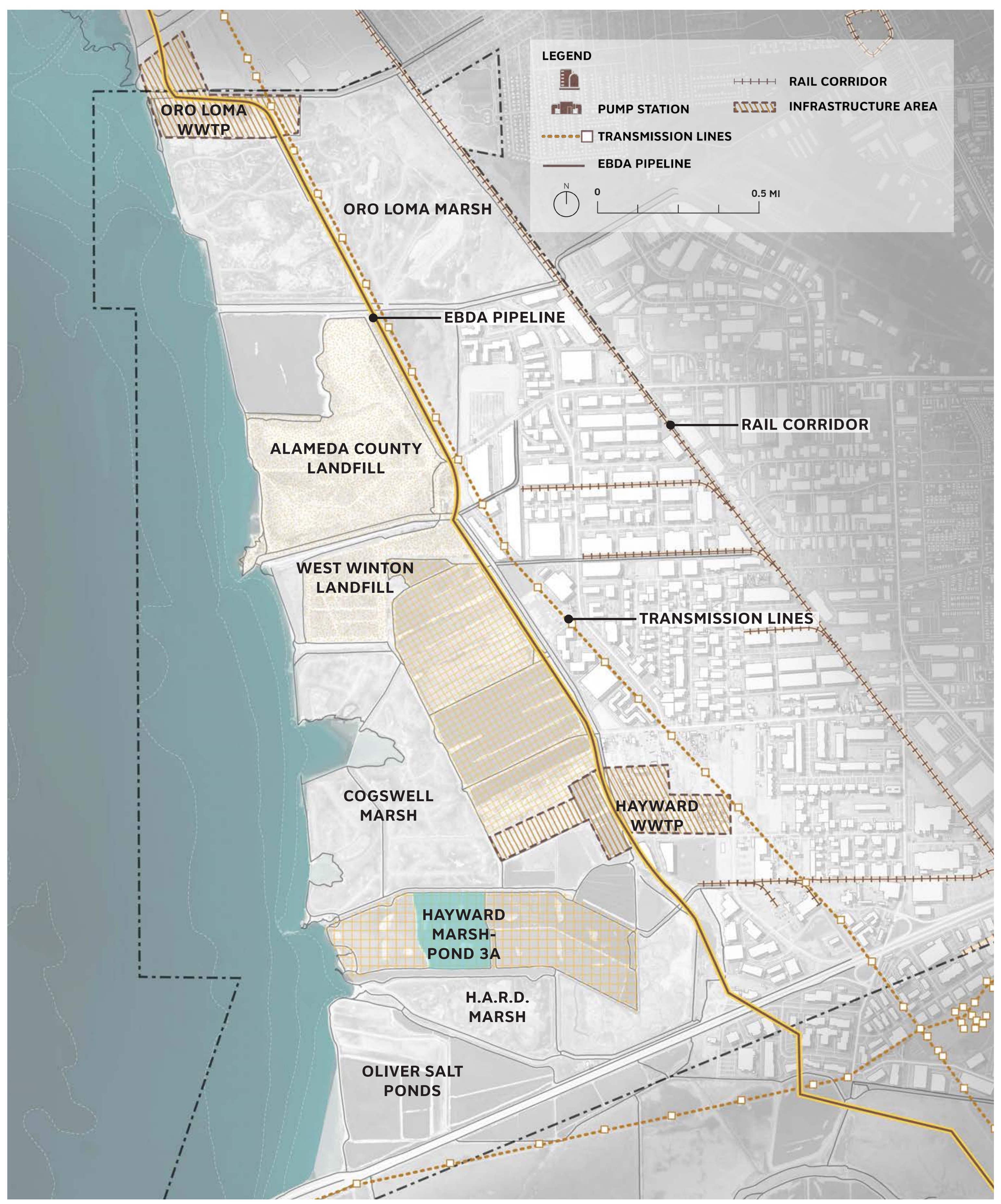
DESIGN STRATEGY REFINEMENT

DESCRIPTION. Managed retreat is a management strategy for retreating from vulnerable coastal areas, moving the shoreline inland and restoring natural areas thereby providing a buffer from flooding and better managing hazard risk.

PRECEDENT: Surfers Point Managed Retreat, Ventura, CA

PRECEDENT: Ile de Jean Charles

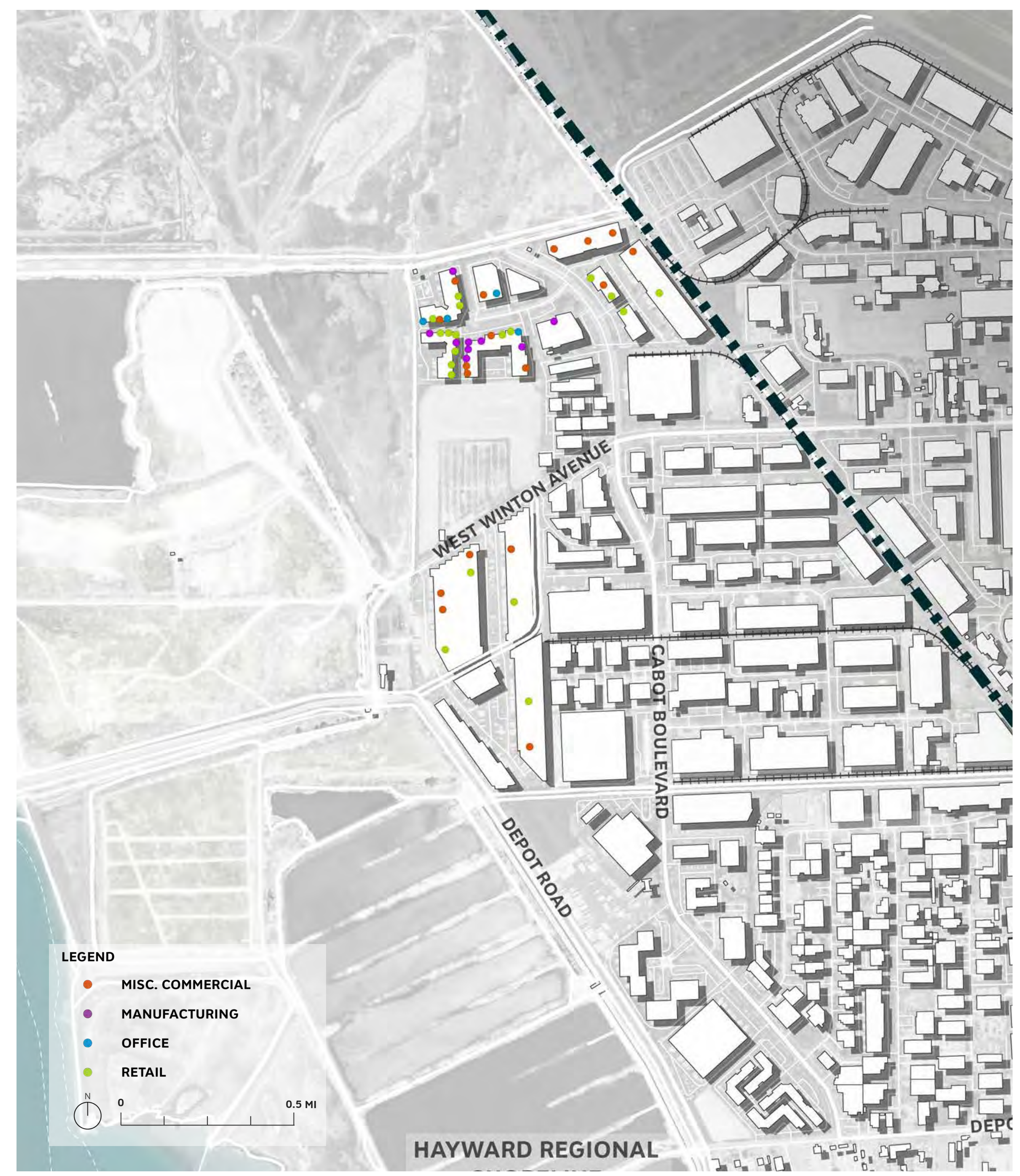
OPTION 1 RELOCATION OF KEY ASSETS



PROS
- Reduce risk of damage from future SLR and flooding
- Maintain access to coastal areas while enhancing protection
- Enhance ecosystem function with natural infrastructure by returning land to natural habitat

CONS
- Very costly
- Lack of available land to move these assets, which may require eminent domain
- Requires multiple-agency coordination and long-term planning
- "Takings" Law

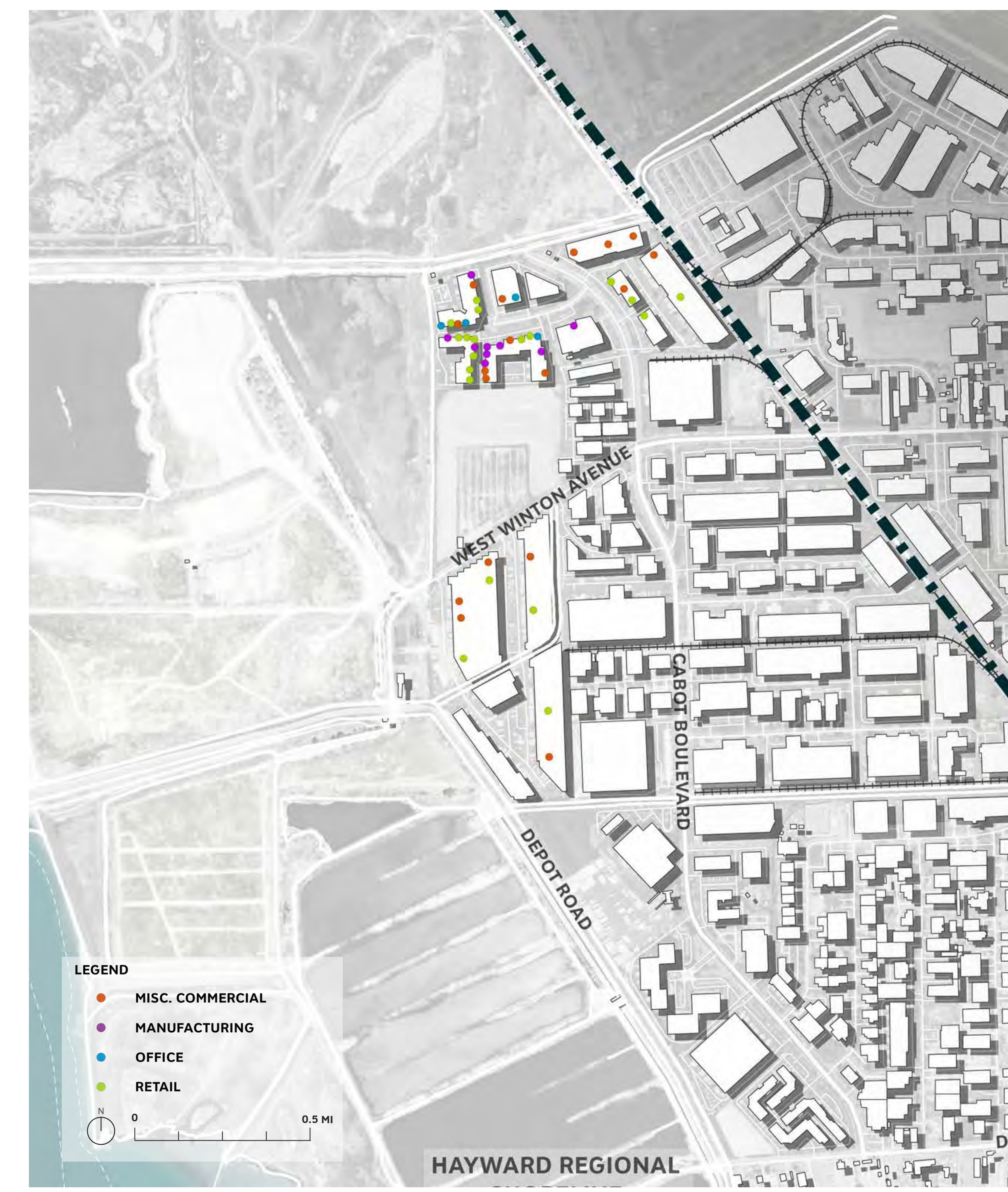
OPTION 2 MANAGED RETREAT OF VULNERABLE NEIGHBORHOODS/ INDUSTRIAL AREAS (4' SLR)



PROS
- Reduce risk of damage from future SLR and flooding
- Reduce cost associated with recovery if not relocated
- Maintain access to coastal areas while enhancing protection
- Enhance ecosystem function with natural infrastructure by returning land to natural habitat

CONS
- Requires available land to move neighborhoods and industrial areas to
- Industrial land use encroaching on other land use further inland
- Potential remediation concerns
- Very costly
- No precedent for buyout program of industrial area
- Counter to City's goals for economic development
- Requires property-owner buy-in
- Reduce tax base

OPTION 3 LIMITATIONS OF FUNDING AND RESTRICTIONS ON REBUILDING POST-DISASTER (4' SLR)



PROS
- Reduce risk of damage from future SLR and flooding
- Maintain access to coastal areas while enhancing protection
- Enhance ecosystem function with natural infrastructure by returning land to natural habitat
- Can be integrated into Land Use code

CONS
- Could be placing those who are unable to retreat at a disadvantage
- Displacement
- Legal aspects of restricted development
- Reduce tax base