

ADAPTATION PLANNING USING NATURE'S BOUNDARIES

SF Regional Water Quality Control Board

Oakland | April 10, 2019

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Outline

- An update on the Waterboard funded **Adaptation Atlas**
- Applications of the **Adaptation Atlas** and **Operational Landscape Units** that are underway
- Plans for **Phase 2** of the project

As sea levels continue to rise, SF Bay communities will need to adapt in order to build social and ecological resilience



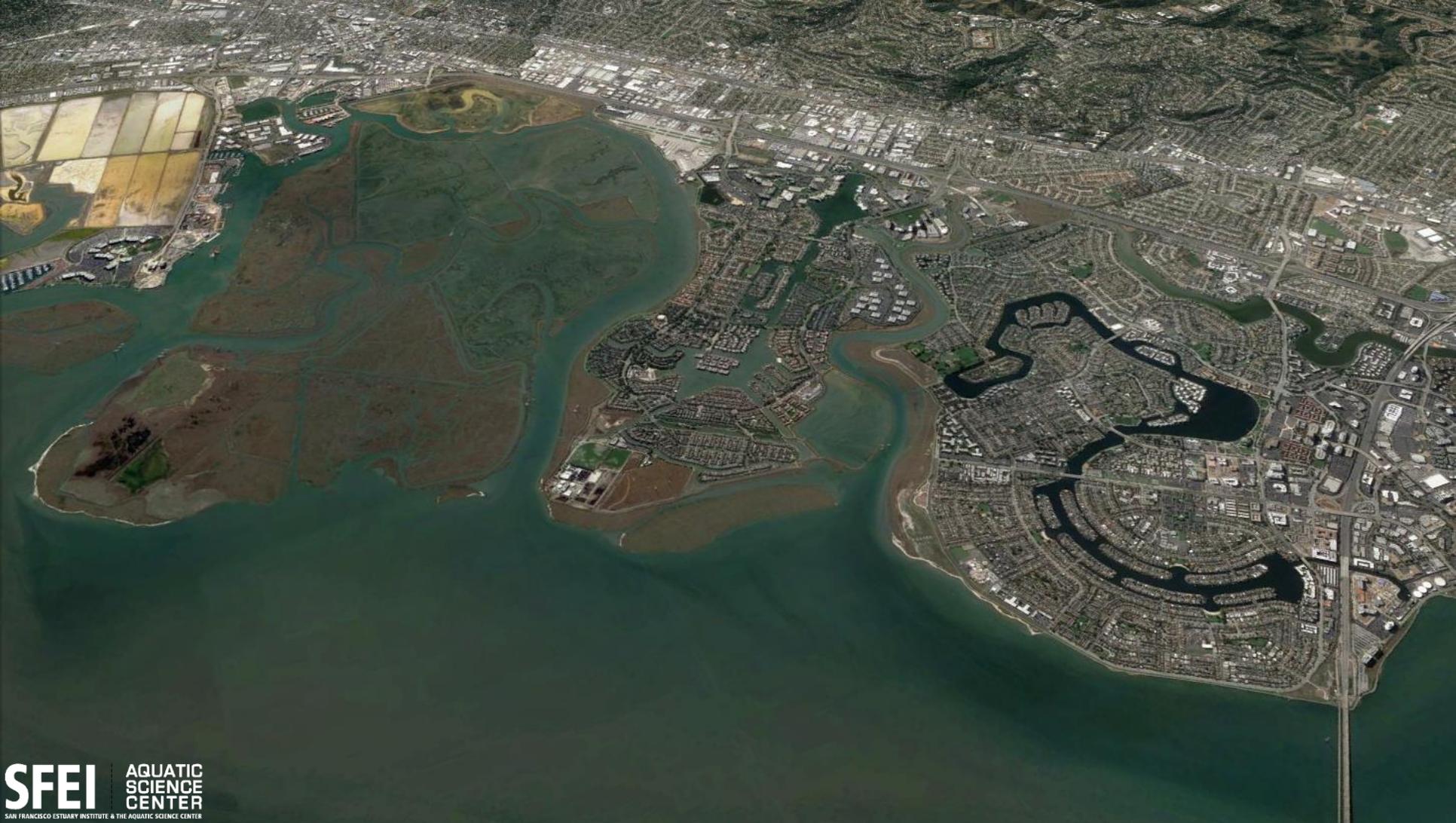


In this urbanized estuary

- The Bay and shoreline are **heterogeneous and dynamic**
- There is **no one-size-fits-all approach** for SLR adaptation
- We can make our shoreline and communities more resilient **by working with people and nature and at the right scale** to implement sea-level rise solutions.
 - Where are nature-based strategies most appropriate?



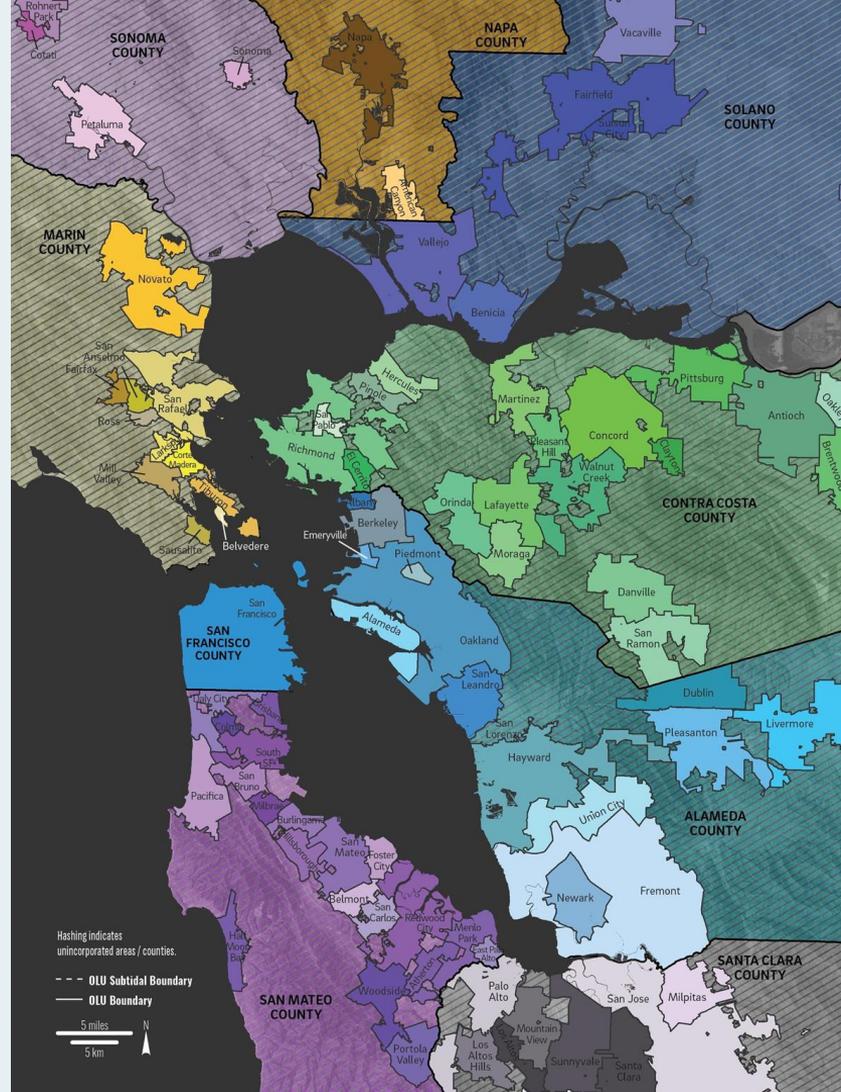






Traditional Jurisdictions

- 9 counties
- 101 cities
- Multiple special districts
- Regulatory jurisdictions
- Frontline communities in low-lying areas



Physical processes that govern the shoreline happen at the **Bay scale**.

Too large and complex for individual projects.

OCEAN / BAY PROCESSES

WATERSHED PROCESSES

ESTUARINE PROCESSES

**Sea-level rise
will not stop at
city boundaries.**



Addressing this challenge by:

- Dividing up the Bay into manageable units that respond to the **physical and ecological processes**
- Mapping **suitability for nature-based adaptation measures**
- **Integrating across the land-water divide**, and connecting bayside measures with landside measures





STEP 1

**Plan using
nature's
boundaries**

*(instead of traditional
boundaries)*

STEP 2

**Identify
adaptation
measures that
could work well
in a given place**

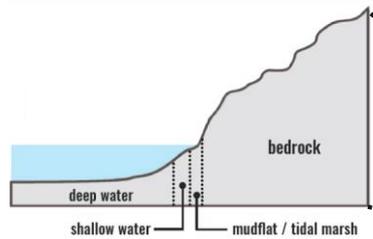
*(and use nature as much
as you can)*

STEP 3

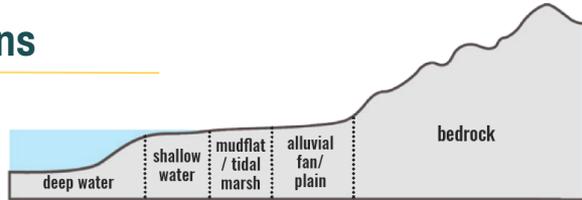
**Use when
bringing
stakeholders
together to
envision a
resilient future**

Geomorphic Unit Types

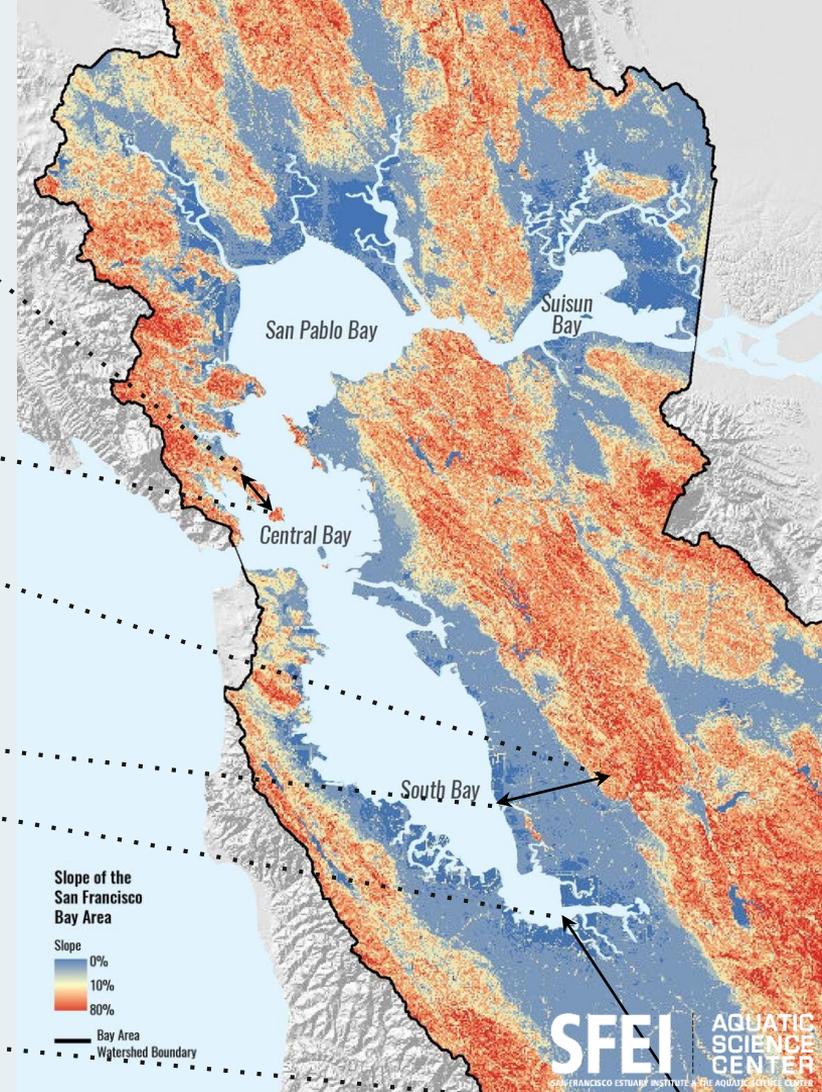
1 Headlands & small valleys

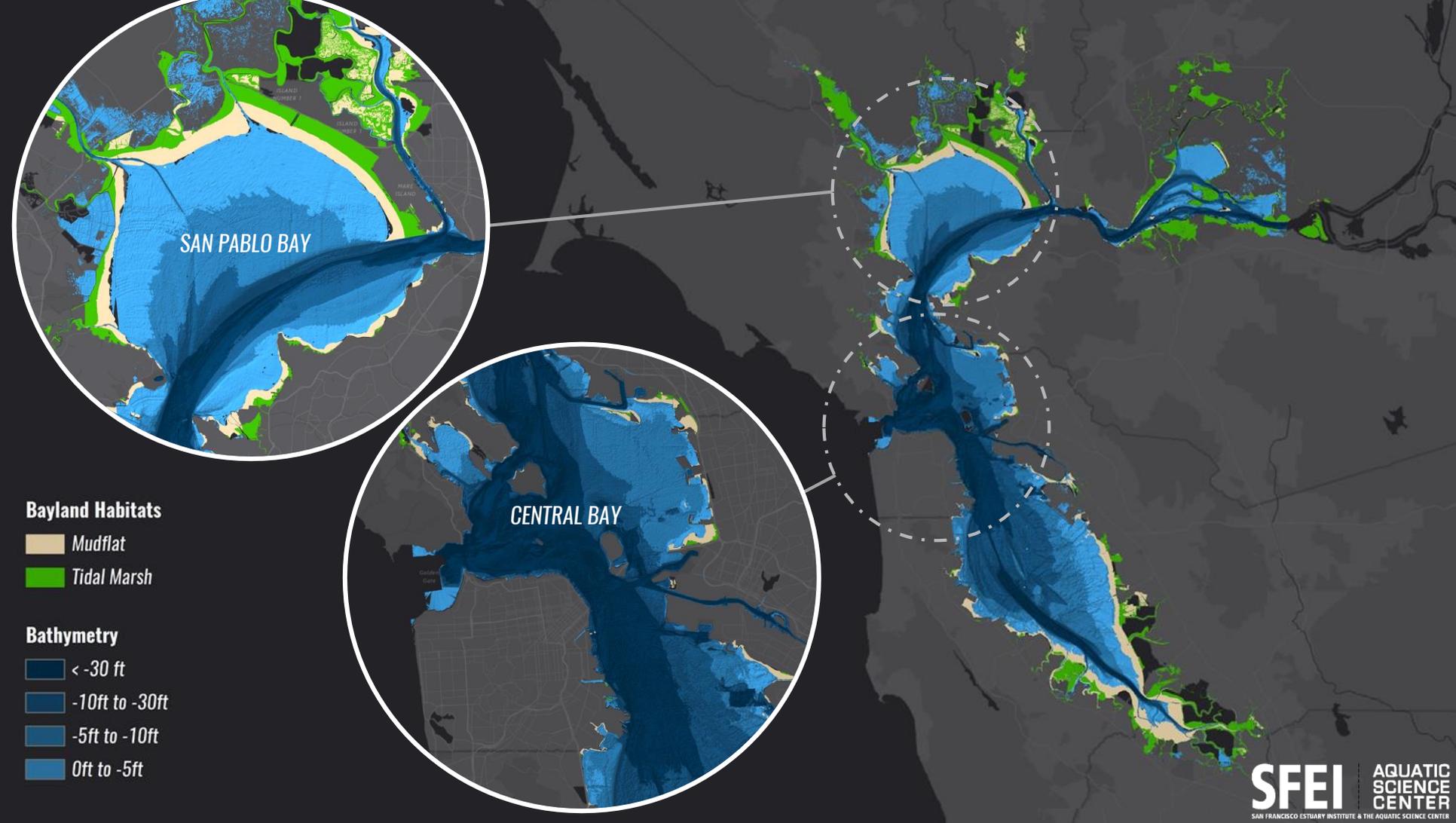


2 Alluvial fans & plains



3 Wide alluvial valleys





SAN PABLO BAY

CENTRAL BAY

Bayland Habitats

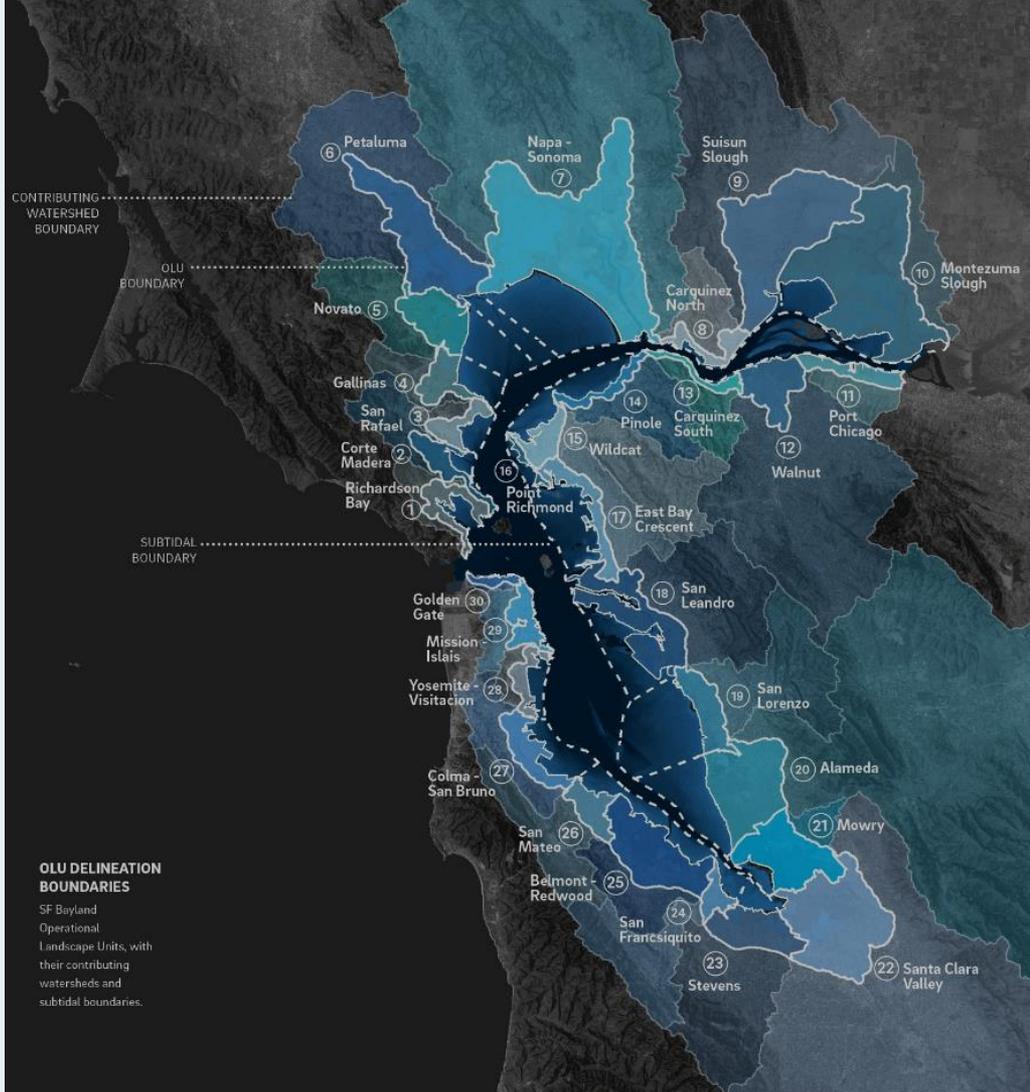
-  Mudflat
-  Tidal Marsh

Bathymetry

-  < -30 ft
-  -10ft to -30ft
-  -5ft to -10ft
-  0ft to -5ft

Data inputs

- Defined by geomorphic units & bathymetry
- Characterized by
 - Physical and ecological factors
 - Built environment patterns
 - Key vulnerabilities

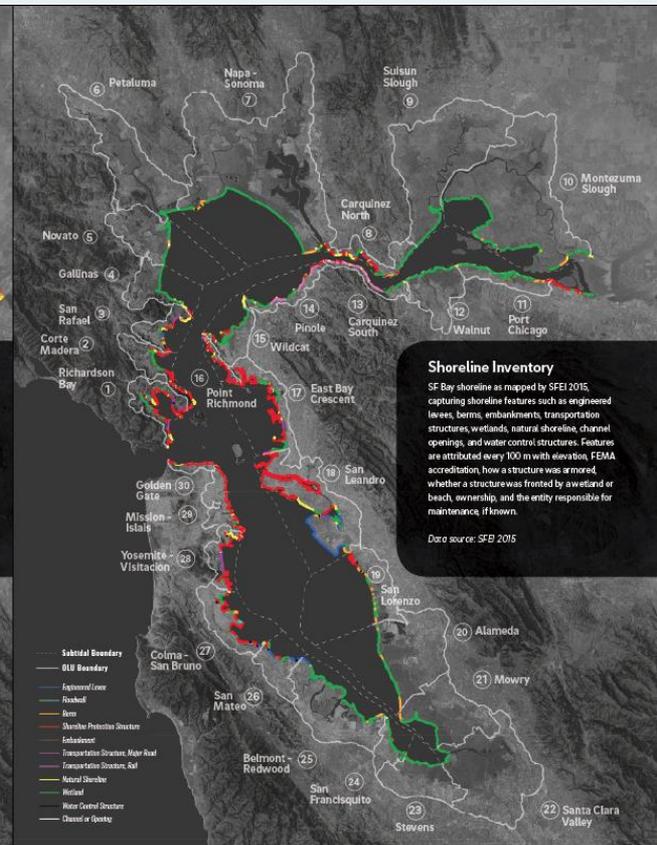


Shoreline characteristics

Tidal range

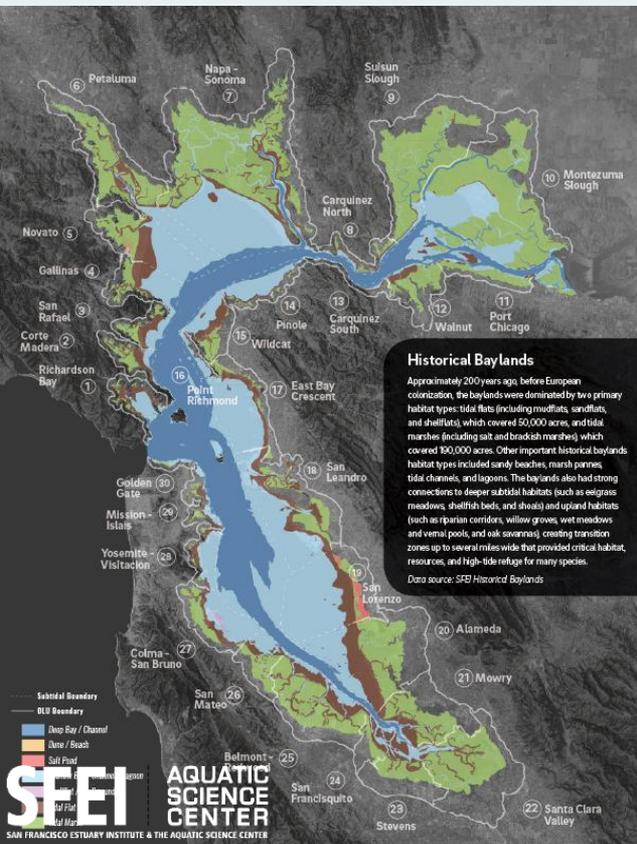
Wind-wave heights

Shoreline composition

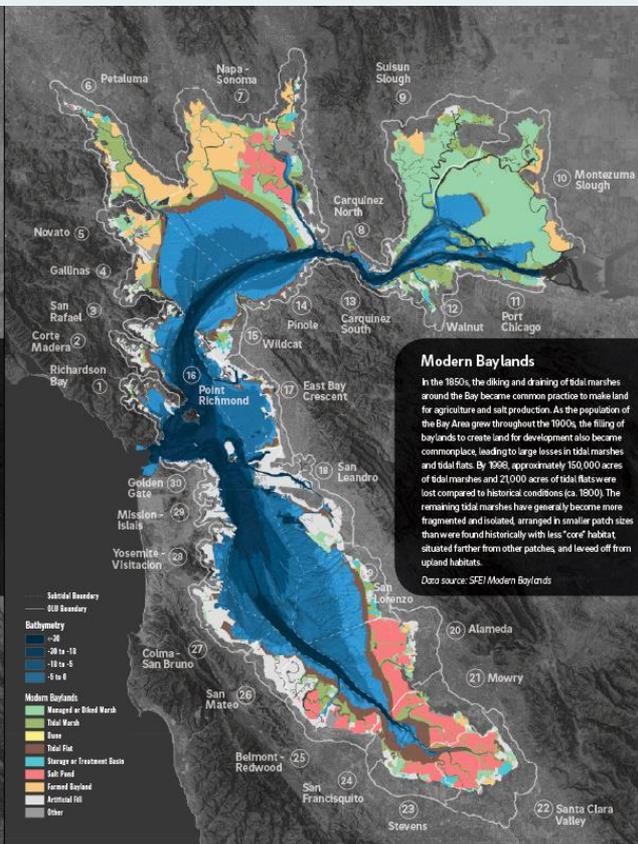


Baylands

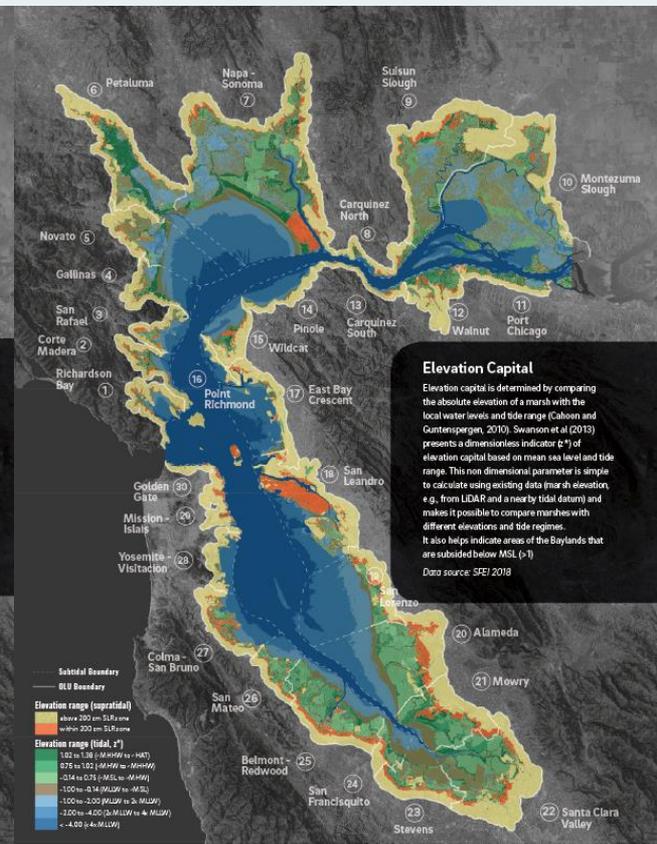
Historical baylands



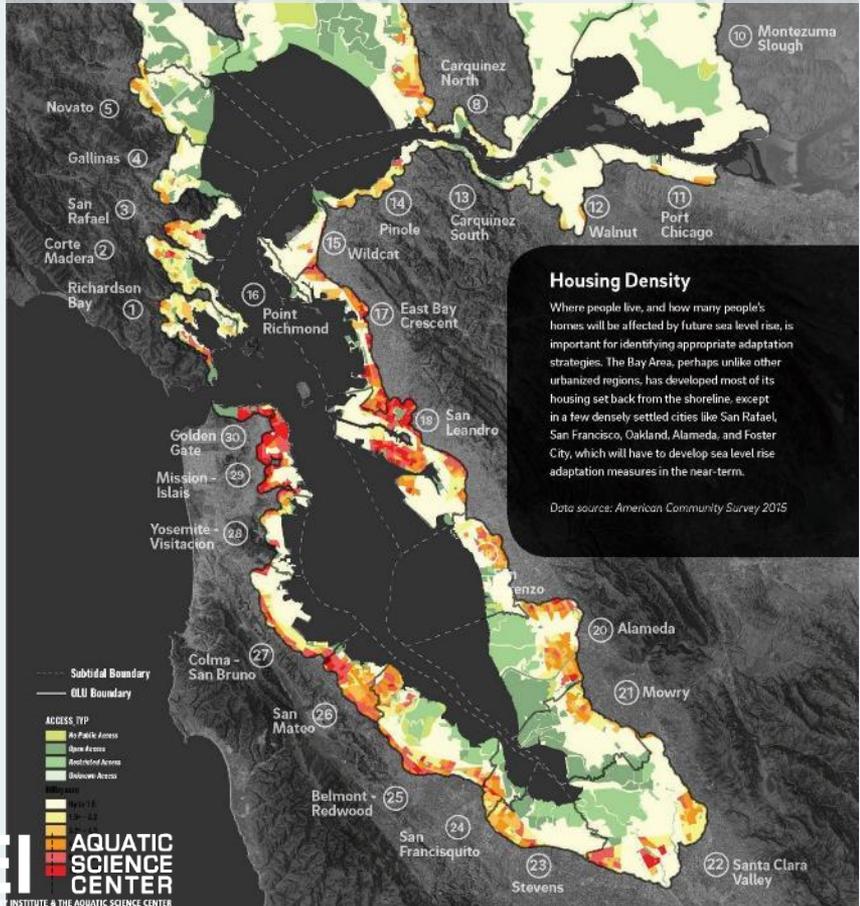
Modern baylands



Elevation capital



Housing density





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**Use when
bringing
stakeholders
together to
envision a
resilient future**







Photo: Mike Lowery



*7.12 ft NAVD - King Tide, 2019
Crab Cove Alameda*

Adaptation measures

Nature-based measures

- Nearshore reefs
- Submerged aquatic vegetation (eelgrass)
- Beaches (sand, cobble, shell)
- Tidal marshes
- Polder management
- Ecotone levees
- Migration space preparation
- Creek-to-bayland reconnections
- Green stormwater infrastructure

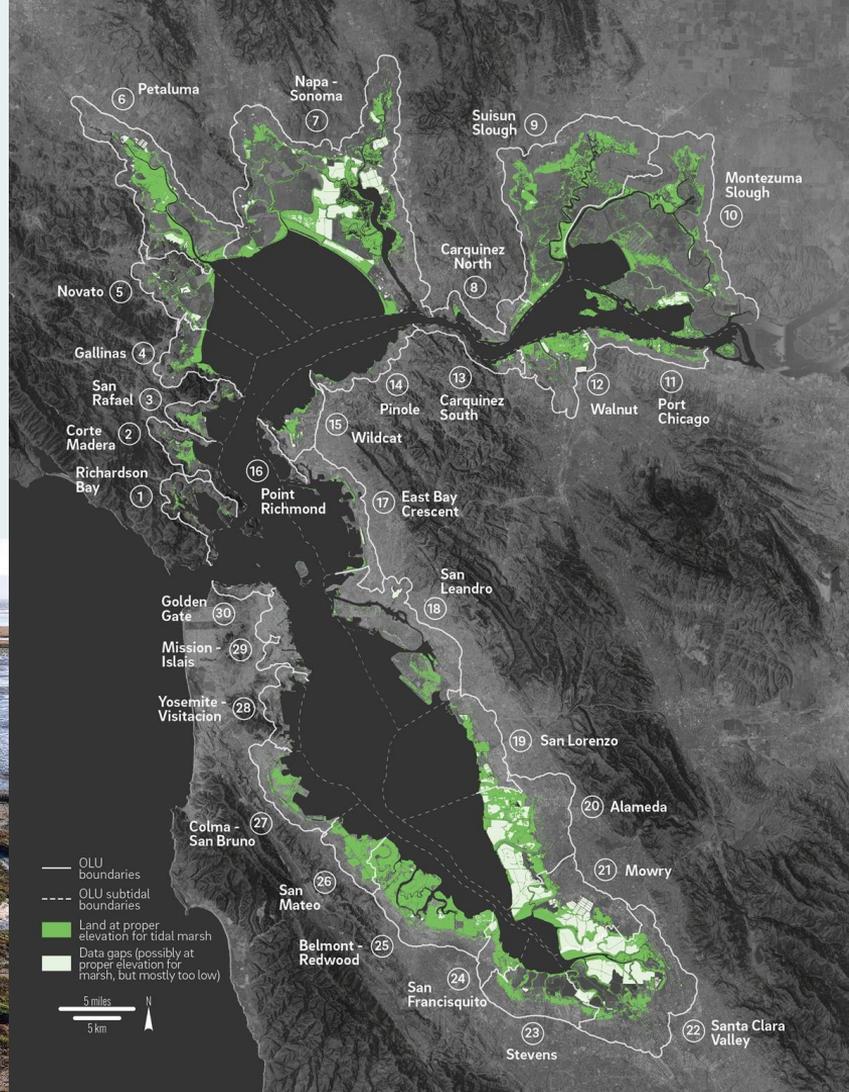
Regulatory, financial, policy tools

- Zoning and overlay zones
- Setbacks, buffers, and clustering
- Building codes and building retrofits
- Rebuilding and redevelopment restrictions
- Conservation easements
- Tax incentives and special assessments
- Geologic Hazard Abatement District
- Transfer of Development Rights
- Buyouts

Marsh restoration

Methods:

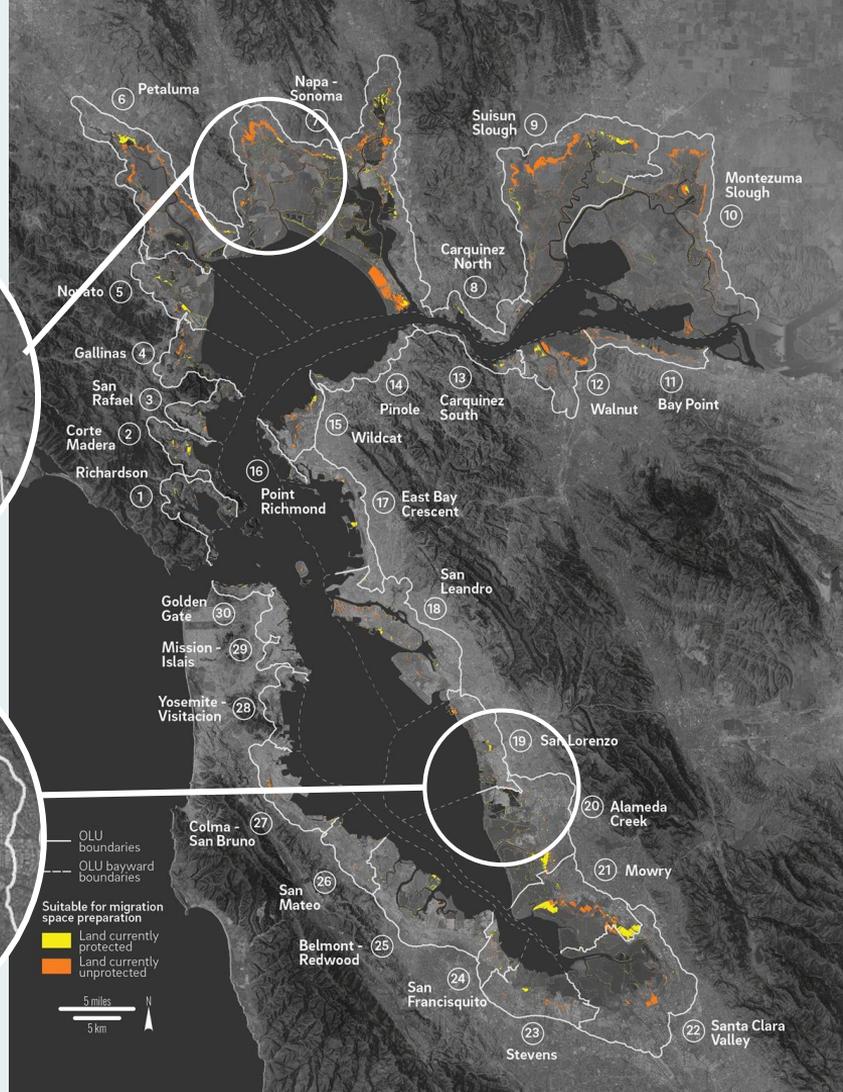
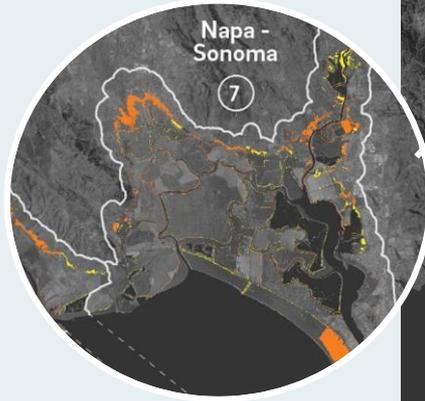
- Identify areas currently at the right elevation to potentially support tidal marshes using z^* (\sim MSL and \sim HAT)
- Assess width of marsh needed to knock 100-year waves down to \sim 1 ft (0.3 m)

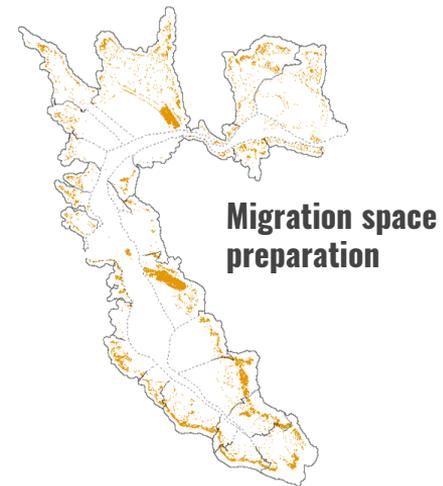
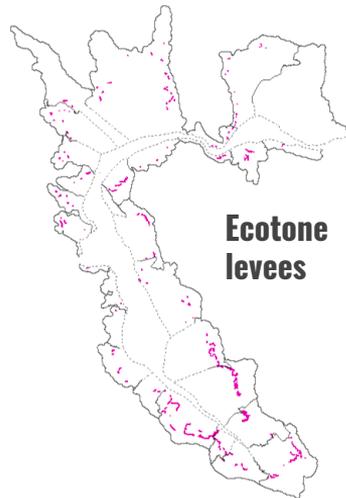
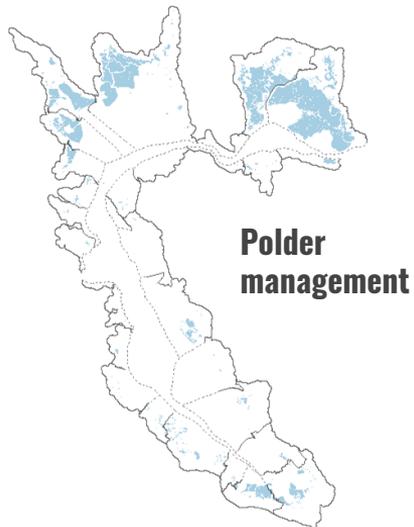
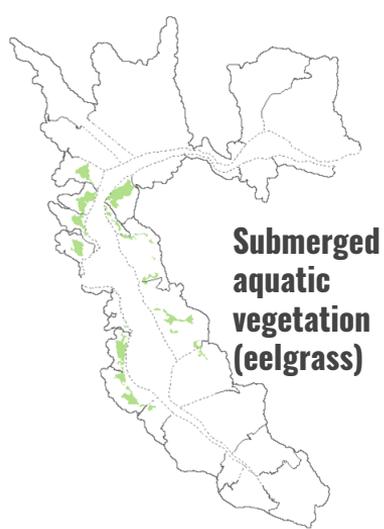
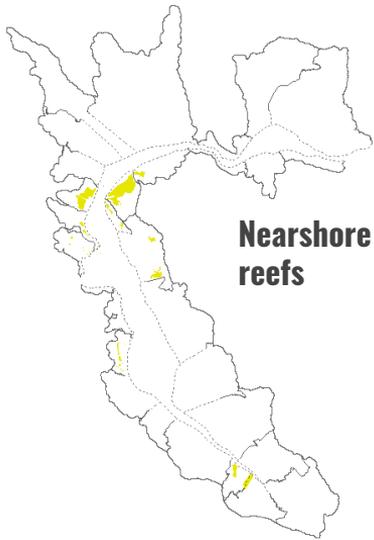


Migration Space

Methods:

- Identify areas that are above tidal range now, but will be within tidal range in the future (areas where wetlands could migrate)





Suitability of nature-based measures

Suitability Rating

○ Limited suitability

◐ Some suitability

● High suitability

	Nearshore reefs	Submerged aquatic vegetation (eelgrass)	Beaches	Tidal marshes	Polder management	Ecotone levees	Migration space preparation
1. Richardson	●	●	●	◐	○	◐	○
2. Corte Madera	●	●	●	◐	◐	◐	◐
3. San Rafael	●	●	●	◐	◐	◐	○
4. Gallinas	◐	●	○	●	●	◐	●
5. Novato	○	○	○	●	●	◐	●
6. Petaluma	○	○	○	●	●	○	●
7. Napa - Sonoma	○	○	○	●	●	◐	●
8. Carquinez North	○	○	○	●	○	◐	●
9. Suisun Slough	○	○	○	●	●	◐	●
10. Montezuma Slough	○	○	○	●	●	○	●
11. Bay Point	○	○	○	●	●	◐	●
12. Walnut	○	○	○	●	●	●	●
13. Carquinez South	○	○	○	◐	○	●	●
14. Pinole	●	○	●	◐	○	◐	○
15. Wildcat	●	●	●	●	◐	●	●
16. Point Richmond	●	●	●	○	○	○	○
17. East Bay Crescent	●	●	●	◐	○	●	○
18. San Leandro	○	●	●	◐	◐	○	○
19. San Lorenzo	○	●	●	●	◐	●	◐
20. Alameda Creek	○	○	●	●	●	●	●
21. Mowry	○	○	○	●	●	●	●
22. Santa Clara Valley	○	○	○	●	●	●	●
23. Stevens	◐	○	○	●	●	◐	◐
24. San Francisquito	●	○	○	●	◐	●	◐
25. Belmont - Redwood	○	○	●	●	●	●	○
26. San Mateo	○	●	●	◐	◐	◐	○
27. Colma - San Bruno	○	●	●	◐	◐	◐	○
28. Yosemite - Visitacion	●	●	●	○	◐	○	○
29. Mission - Islais	○	●	●	○	○	○	○
30. Golden Gate	○	○	●	○	○	○	○

When the water crosses over (the horizontal levee)

- What is the landscape like in the **'dry land'** part of the OLU?
- What are the **land uses** that may be potentially **inundated?**
- What is the **'menu'** of available **structural, policy, financial, and regulatory** measures?







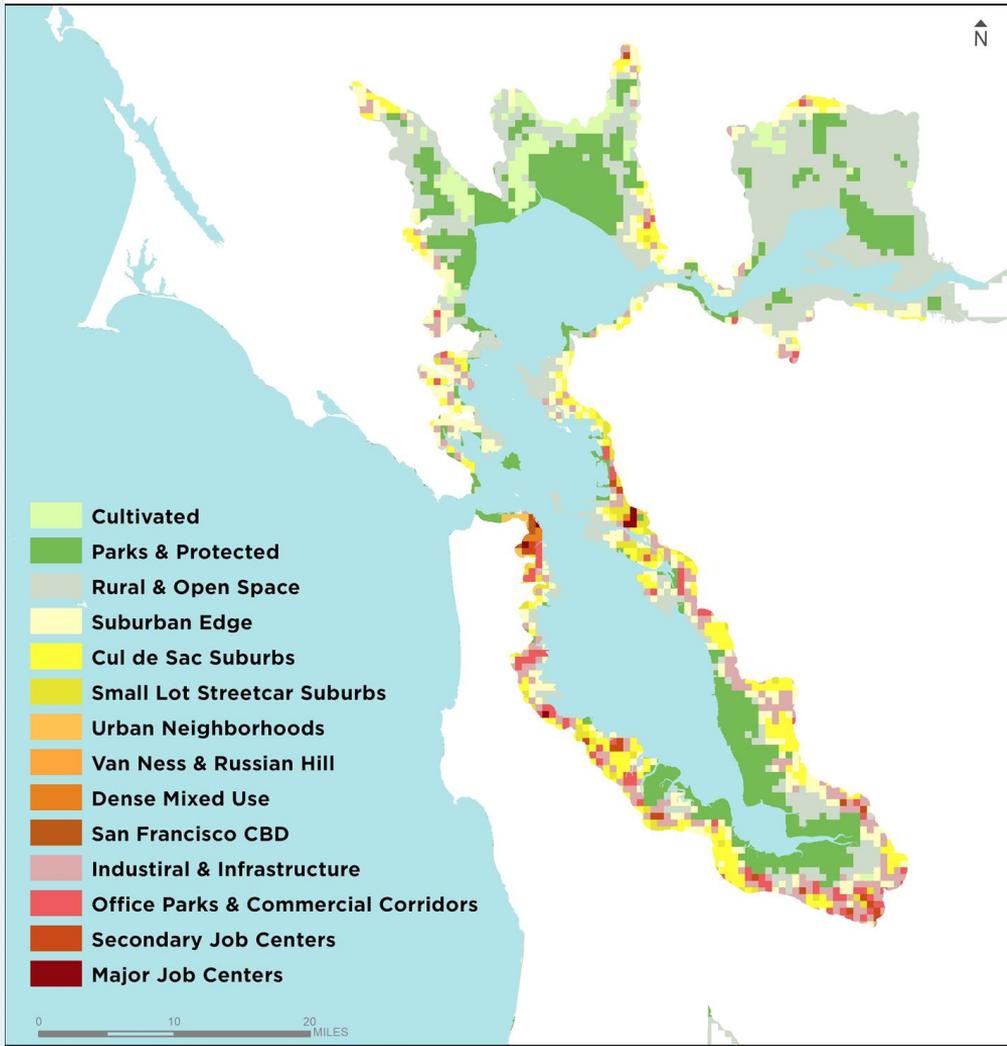
Place-Types Index

Five factors in characterizing land uses as place-types:

- Intersection density
- Permeability
- Housing unit density
- Job density
- Land use mix

Open space categories additionally classified using CPAD, NLCD

SPUR Place Types in OLU





Open space

Suburban edge



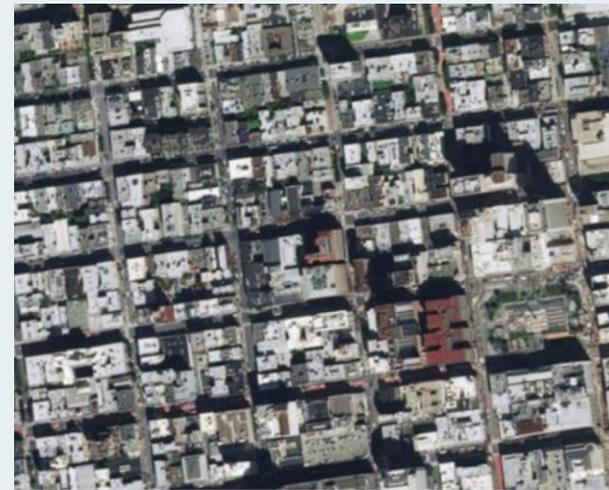
Urban neighborhoods

Office parks and commercial



Secondary job centers

Dense mixed use



Adaptation measures

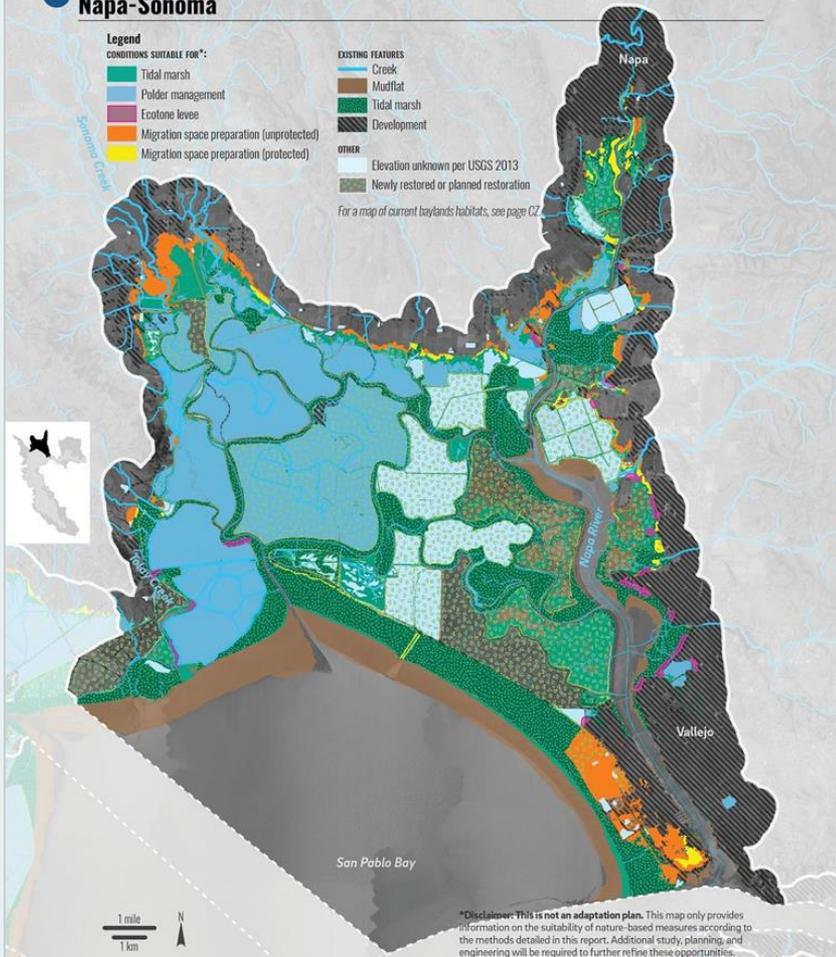
Nature-based measures

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Regulatory, financial, policy tools

- Zoning and overlay zones
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- Transfer of Development Rights
- Buyouts

7 NATURE-BASED ADAPTATION OPPORTUNITIES MAP
Napa-Sonoma



*Disclaimer: This is not an adaptation plan. This map only provides information on the suitability of nature-based measures according to the methods detailed in this report. Additional study, planning, and engineering will be required to further refine these opportunities.

7 NAPA - SONOMA

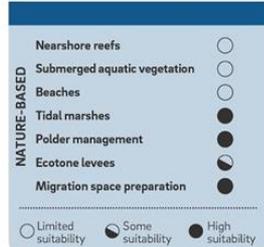
Nature-based Adaptation Measures

Polder management
Marsh Restoration
Migration Space
Creek connections

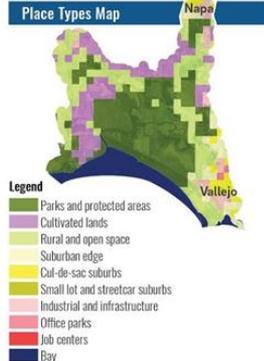
In the Napa-Sonoma OLU there has been significant landscape-scale marsh restoration in areas such as the Napa-Sonoma Salt Ponds and other areas. There are also considerable opportunities to restore large connected patches of tidal marsh in the remaining diked baylands closer to Sonoma Creek. Road and rail corridors that cross the marshes create considerable constraints to the restoration of the marshes: they need existing levees to protect them from flooding, their creek crossings are narrow, and the marshes are in a transition zone. All of the existing and planned marsh restoration from preparing migration space for the marsh to move upland as sea level rises. The majority of marsh restoration opportunities are in areas such as it being marsh restoration opportunities in these areas will be key to creating marsh migration pathways. Much of the existing tidal marsh is adjacent to the creeks and is disconnected from undeveloped migration space by large and deep polders such as Skaggs Island. If raised to intertidal elevations, these polders could be converted to tidal marsh. However, the amount of sediment needed is considerable and realigning the shoreline may be more feasible. Significant opportunities exist to improve the delivery of freshwater, nutrients, and sediment from Sonoma Creek and the Napa River to build better elevation capital closer to upland in these subsided baylands, and to reduce flooding issues. There are also opportunities for widening the bridge crossings at Sonoma Creek and Tolay Creek if Highway 37 is raised on some combination of embankment and pilings. Ecotone levee creation is less critical in this OLU due to limited presence of development in need of protection, but ecotone levees could be incorporated into the design of embankments to raise Highway 37 or the railroads.

Other Adaptation Opportunities

Like Petaluma, the very large Napa-Sonoma OLU—by far the largest in the OLU Atlas—has a wide range of land uses, providing a wide range of potential adaptation candidate for adaptation measures that allow flooding to occur and that facilitate the transition from recreational and agricultural uses to habitat or ecological uses over time, through restoration work, transition zone acquisition, and realigning public access. This OLU is not a good place for traditional shoreline protection, but shoreline adaptations here can maximize nature-based solutions. A wide range of adaptation opportunities exist in the urban areas of the OLU that may experience sea level rise further in the future, but the most significant opportunities might be suitable alternative adaptation measures. Depending on what the community prefers to invest in, elevating Highway 37 to allow tidal action northwards toward formerly diked wetlands would significantly support the large areas of restoration possible in this OLU.

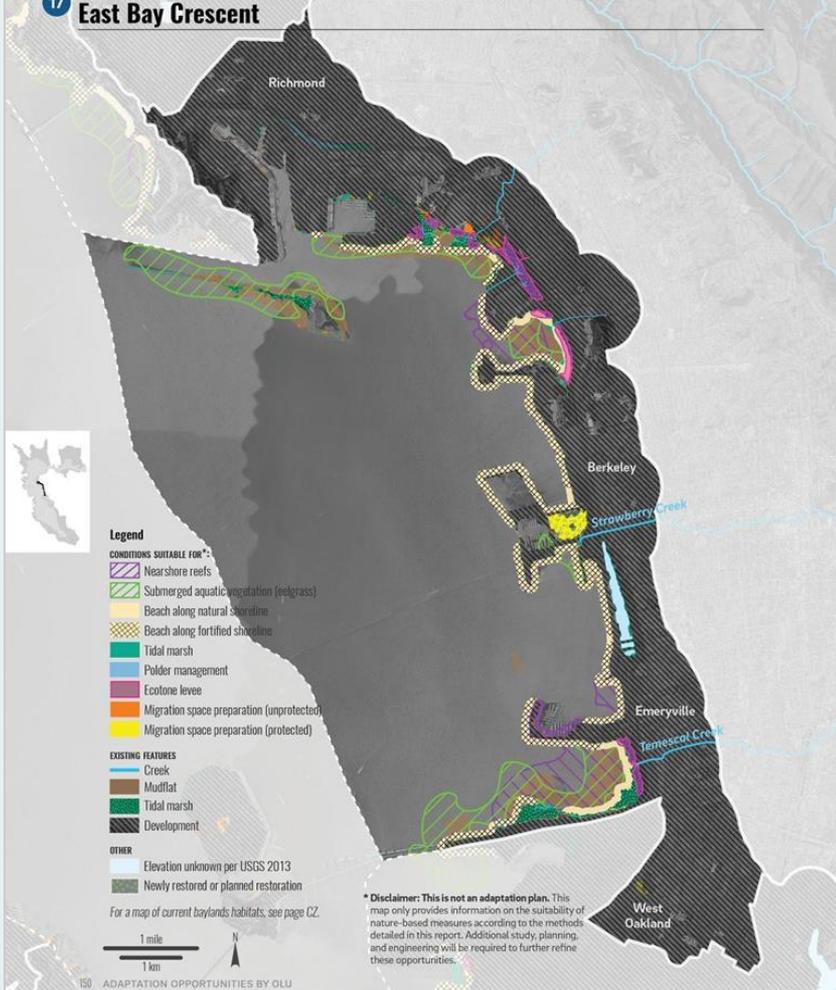


Aerial view looking downstream of the Napa River towards the Napa-Sonoma baylands (Photo by WineCountry Media, CC BY 2.0)



draft

East Bay Crescent



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Nature-based Adaptation Measures

The East Bay Crescent is characterized by the headlands and landfills of Emeryville, Berkeley Marina, Albany Blvd, and Point Isabel. The I-80 corridor, including the historical Fleming Beach, constrained the present-day marshes, and limited opportunities for marsh migration. In the short term, opportunities are limited to nearshore reefs, eelgrass, and beach-focused natural and nature-based strategies. Both nearshore reefs and eelgrass beds are suitable. Creeks draining to the Bay, such as Temescal, Strawberry, Codornices, and Cerrito, have been modified by culverting and channelizing. Their connection to the bay marshes could be enhanced to direct sediment loads to support mudflats or beaches. Coarse or composite beaches are appropriate along the length of shoreline as an alternative to riprap, and could be stabilized by the artificial headlands. The small areas of marsh could be enhanced with ecotone or horizontal levees that back up to the roads. These measures are meant to be layered and have been shown to have more adaptation potential when used in combination.

Horizontal Levees

Beaches

Eel grass

Selected Measures Suitability

Selected Measures	Suitability
Nearshore reefs	●
Submerged aquatic vegetation	●
Beaches	●
Tidal marshes	●
Polder management	○
Ecotone levees	●
Migration space preparation	○

○ Limited suitability ● Some suitability ● High suitability



Highways I-580/I-80 located next to tidal marsh in the East Bay Crescent OLU (Photo by Jay Huang Photography, CC BY 2.0)

Other Adaptation Opportunities

This OLU has a mixed set of relatively intensive land uses, including a significant amount of low-density and moderate-density residential suburban, most small lot "streetcar" suburbs of any OLU—reflecting older neighborhoods—and it also has some suburban job centers, office parks, and industrial lands. As a result of these diverse uses, the OLU has a complex mix of land uses. This area is complex, with many parcels, landowners, tenants, and businesses. The OLU has a mix of land uses, including a significant amount of perimeter protection with grey or hybrid green/grey infrastructure, intensive and opening up floodable areas to retain water and reduce inland flooding—most likely with green infrastructure. This area is complex, with many parcels, landowners, tenants, and businesses. The OLU has a mix of land uses, including a significant amount of perimeter protection with grey or hybrid green/grey infrastructure, intensive and opening up floodable areas to retain water and reduce inland flooding—most likely with green infrastructure. This area is complex, with many parcels, landowners, tenants, and businesses. The OLU has a mix of land uses, including a significant amount of perimeter protection with grey or hybrid green/grey infrastructure, intensive and opening up floodable areas to retain water and reduce inland flooding—most likely with green infrastructure.

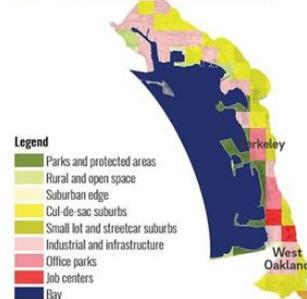
GHAD

Transfer of development rights

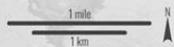
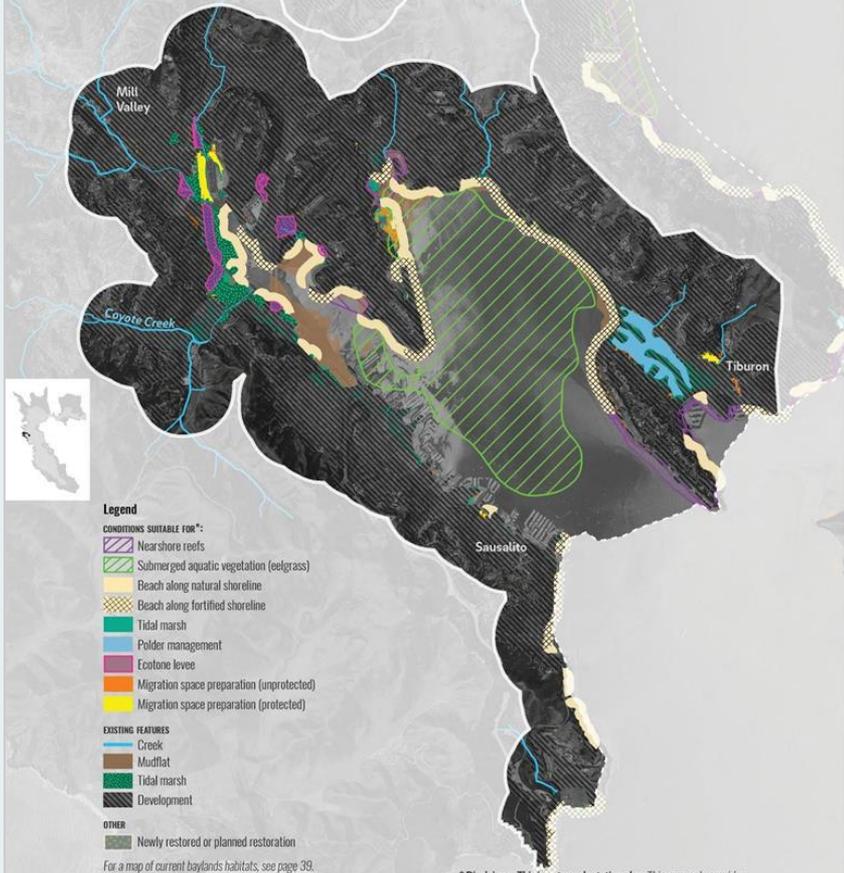
Elevating roadways

Highways I-580/I-80 near the bayward edge of the OLU could be redesigned or elevated to a levee to provide upland flood protection.

Place Types Map



1 NATURE-BASED ADAPTATION OPPORTUNITIES MAP
Richardson



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1 RICHARDSON

Nature-based Adaptation Measures

The Richardson OLU has limited space near the Bay with steep headlands confining a small valley that restricts bayfront development. There are also opportunities for natural and nature-based adaptation such as marshes.

The mouth of Coyote Creek is an area prone to flooding and erosion. Sediment supply to the marsh and for creating an ecotone levee. Sediment supply to the marsh has been impeded by the presence of levees as well as low sediment concentrations in the Bay and the placement of sediment should be considered. Setting back the levees near the mouth of the creek to reduce backwater effects along the floodplain. Nearshore reefs and submerged aquatic vegetation would provide habitat while eroding wave energy. Beaches could replace eroding shorelines, or along eroding shorelines such as has been piloted at Aramburu Island. Coarse beach faces could also be used to protect existing marsh scarps from wave erosion. Green stormwater infrastructure could be implemented in the upper watershed to slow down runoff, reduce fluvial flooding in the developed valleys, and slow the conveyance of floodwater to the Bay.

Oyster reefs
Horizontal Levees
Beaches
Eelgrass
Creek connections

Selected Measures

Suitability

Selected Measures	Suitability
NATURE-BASED	
Nearshore reefs	●
Submerged aquatic vegetation	●
Beaches	●
Tidal marshes	●
Polder management	○
Ecotone levees	○
Migration space preparation	○
○ Limited suitability ● Some suitability ● High suitability	



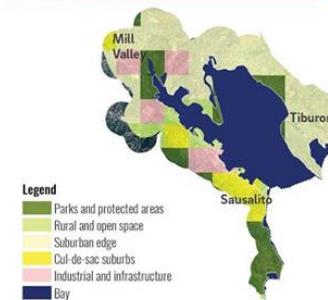
Housing along Sausalito's shoreline in Richardson OLU (Photo by Shira Bezael, SFEI)

Other Adaptation Opportunities

The predominant place types in Richardson are suburban edge, rural and open space, and industrial and infrastructure. Over time, the place types most vulnerable to sea level rise are rural and open space, cul-de-sac suburbs, and cul-de-sac suburbs. For parks and protected areas, suitable adaptation opportunities include securing wetlands transition zone through easements or buyouts, allowing sea level rise to take its course. For industrial and infrastructure, and single-family residential areas—suitable areas include not intensifying development, elevating roads and buildings, re-zoning, and commercial activities to higher ground than the floodplain.

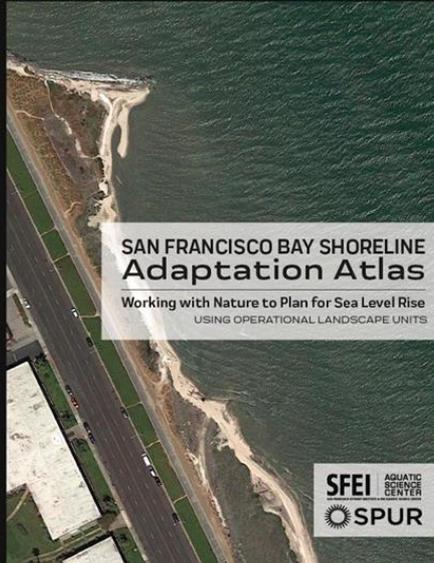
Easements, buyouts in open/protected areas
Not intensifying development, elevating roads, buildings, re-zoning

Place Types Map

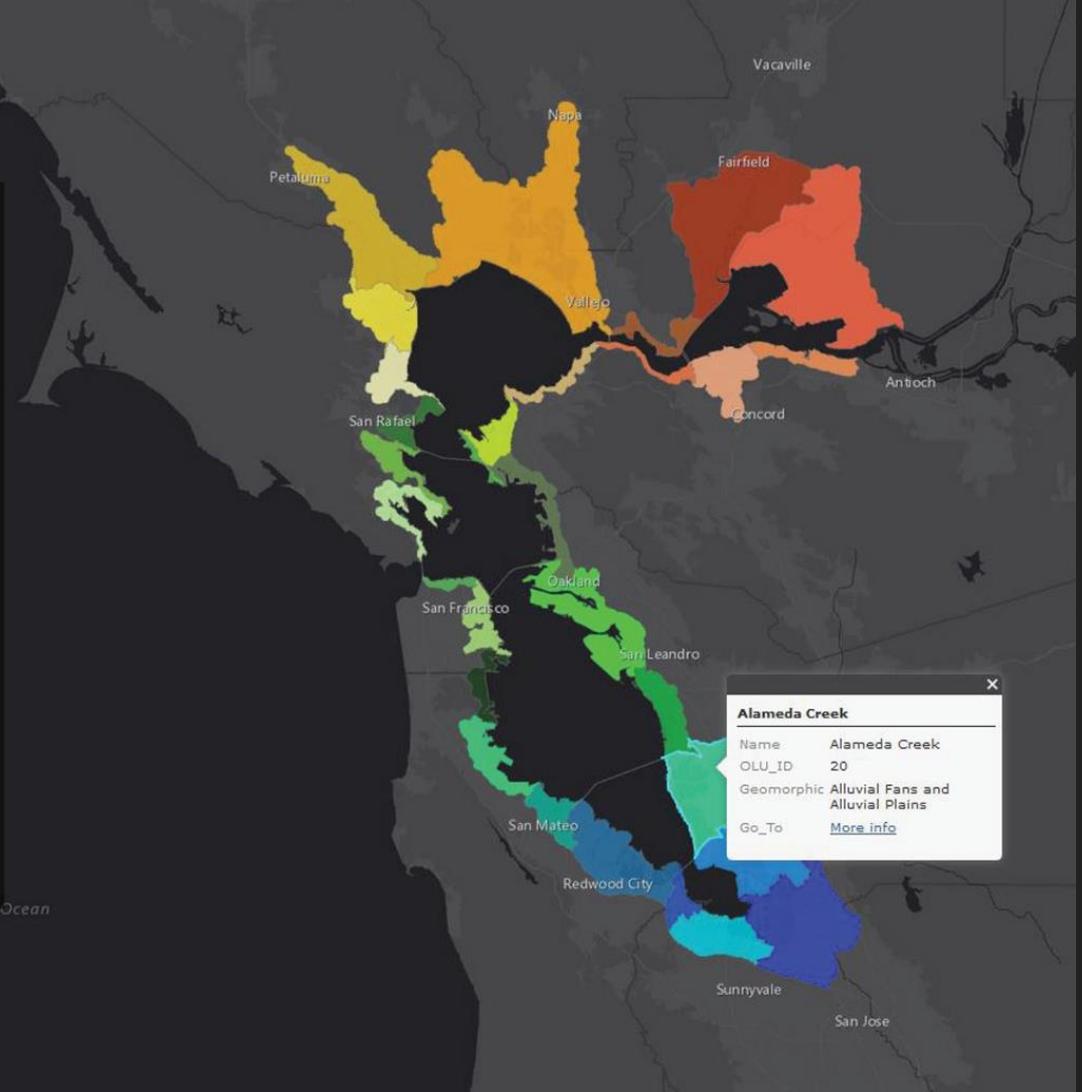


draft

For more information on the OLU framework, [click here](#) to download the PDF. To view the opportunity maps for each OLU, scroll down to enable the interactive map.



Pacific Ocean





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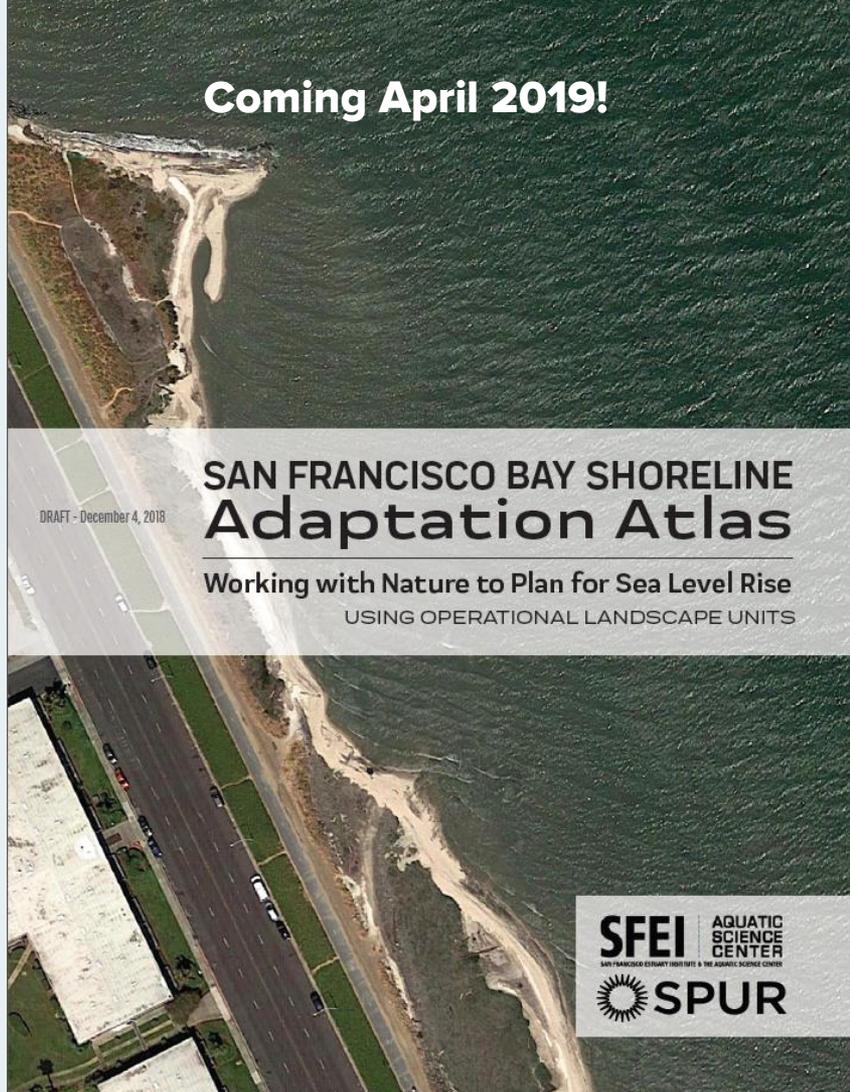
*(and use nature as much
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STEP 3

**Use when
bringing
stakeholders
together to
envision a
resilient future**

Who is using this?

- **BCDC** using OLUs as their unit of analysis for ART Bay Area
- **MTC** staff using OLUs to build scenarios for Horizons (precursor to Plan Bay Area 2050)
- **San Mateo and Marin Counties** using OLUs to gather stakeholders, begin adaptation planning
- **Local cities** doing adaptation planning
- **National networks:** “Coastal Collaborative” with Jamaica Bay





OLU Profile Sheet – 15. Wildcat

Date Updated: 02/27/19

Lead: Todd Hallenbeck (todd.hallenbeck@bcdcc.ca.gov)

ART Bay Area

- **BCDC using OLUs as their unit of analysis for ART Bay Area**
- **Analyzing 4 asset classes by OLUs**
- **Summarizing ecosystem services by OLU and regionally**
- **Using as a framework as they transition to adaptation planning**

I. OLU – Introduction, Set the Stage, Where Are We? What’s Here, Who’s Here

LEAD TO-DO: Write a **new description for 2. OLU, and pull information together for additional que*

1. OLU NUMBER. NAME	15. Wildcat							
2. OLU Description/Overview: Short paragraph: where is it generally (use features), what is the shoreline type, unique characteristics/urban trends, what are general uses within?	Located in the Western portion of Contra Costa County, the Wildcat OLU stretches from Point Pinole to Point San Pablo. This OLU is characterized by tidal wetlands, numerous tidal creeks and channels, treatment ponds, light heavy industrial parcels associated with the Chevron Refinery, railyards, and some residential uses primarily in unincorporated North Richmond. Current historic industrial uses have left a legacy of contamination along the shoreline. The shoreline is characterized by a mix of levees, berms, embankments, tidal marsh wetlands, transportation structures (e.g., rail and road beds), and structures that provide flood mitigation for the City’s shoreline and creek channels.							
3. OLU Typology	Alluvial Fans and Plains							
4. ASSETS BEING ASSESSED WITHIN EACH OLU	Transportation <ul style="list-style-type: none"> • Union Pacific Railroad (UPRR) • Burlington-Northern Santa Fe railroad (BNSF) • Richmond Pacific Railroad (RPRR) 	PDA’s <ul style="list-style-type: none"> • North Richmond 	PCAs <ul style="list-style-type: none"> • San Francisco Bay Trail 	Vulnerable Communities <ul style="list-style-type: none"> • North Richmond <table border="1" data-bbox="1690 857 1932 1092"> <thead> <tr> <th data-bbox="1690 857 1932 889">Other Facilities</th> </tr> </thead> <tbody> <tr> <td data-bbox="1690 889 1932 922">• West Contra County Sanitary Landfill (W)</td> </tr> <tr> <td data-bbox="1690 922 1932 955">• Golden Bear Transit Station</td> </tr> <tr> <td data-bbox="1690 955 1932 1092">• Household Hazardous Waste Recycling</td> </tr> </tbody> </table>	Other Facilities	• West Contra County Sanitary Landfill (W)	• Golden Bear Transit Station	• Household Hazardous Waste Recycling
Other Facilities								
• West Contra County Sanitary Landfill (W)								
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Marin Adaptation Framework

- Challenge of transitioning from vulnerability assessments to adaptation solutions
- Lots of interest in nature-based options, where are they appropriate?
- **Goal:** Develop a **framework process and set of tools** to support the transition from vulnerability assessment to adaptation strategies at a useful scale

*With funding from Marin Community Foundation

FRAMEWORK

Planning within nature's boundaries

STEP 1

Assess vulnerability

what assets are vulnerable & where; what is the source of vulnerability

STEP 2

Identify adaptation measures

that could work well in a given place and use nature as much as you can

STEP 3

Envision desired future(s)

*what are desired outcomes?
Develop visions/themes*

STEP 4

Develop adaptation strategies

*Strategy = a combination of "measures";
Develop for each desired future or theme*

STEP 5

Evaluate and prioritize

assess benefits and tradeoffs among strategies

STEP 3

Envision desired futures

(What are desired outcomes? Articulate visions/themes for the future)

- **A “strategy” combines adaptation measures within an OLU**

Combining measures into a strategy



STEP 3

Envision desired futures

(What are desired outcomes? Articulate visions/themes for the future)

- **A “strategy” combines adaptation measures within an OLU**
- **A distinguishing goal/theme and criteria are needed to develop strategies**
- **Strategy themes should be developed with stakeholders**

STEP 3

Envision desired futures

(What are desired outcomes? Articulate visions/themes for the future)

- **Strategy 1: Hold the line**
- **Strategy 2: Buffer with public open space**
- **Strategy 3: Maximize habitat**

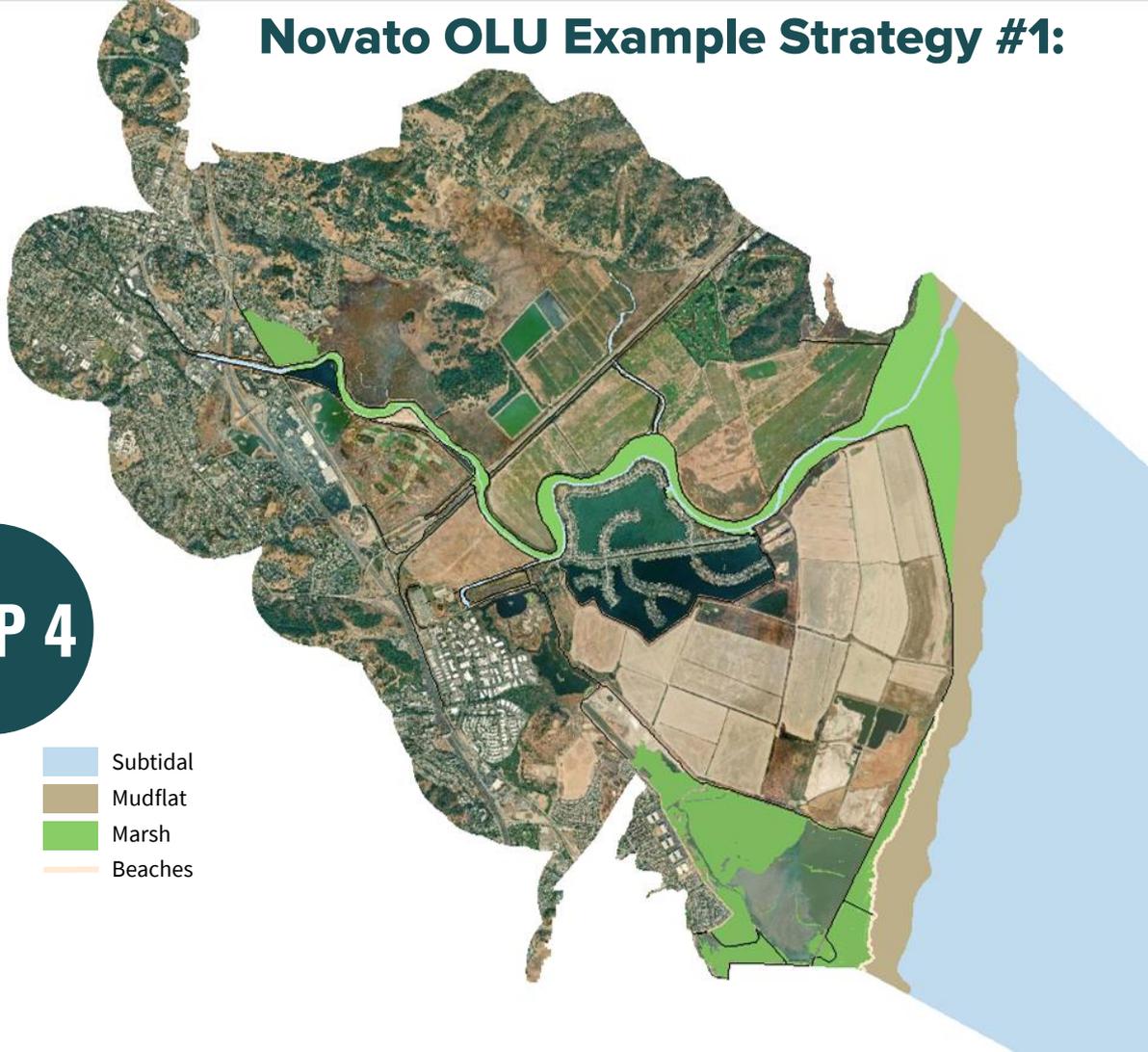
STEP 3

Example Theme #1 “Hold the line”

- Build up existing defenses
- Employ nature-based adaptation options bayward of existing first line of defense

Novato OLU Example Strategy #1:

STEP 4

- 
- The map displays the coastal area of Novato, California, with various land use zones highlighted. A green line follows the coastline, indicating the 'Hold the line' strategy. The map shows a mix of urban areas, agricultural fields, and natural coastal features. A legend in the bottom left corner identifies the following features:
- Subtidal
 - Mudflat
 - Marsh
 - Beaches

STEP 3

Example Theme #2: "Buffer w/ public open space"

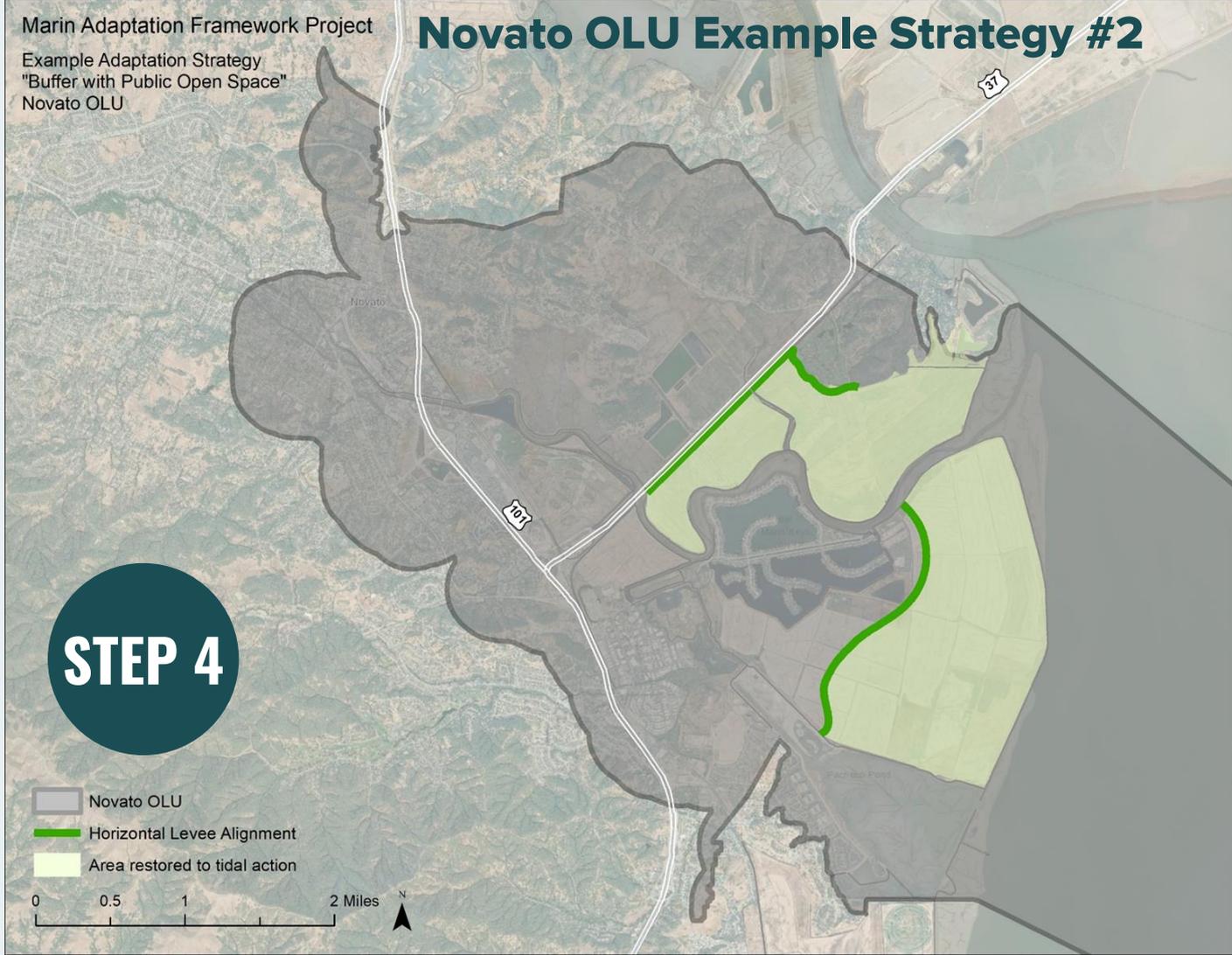
- Existing people and infrastructure remain protected in place
- Retreat first line of defense only on public open space
- Retreat allows more space for additional nature-based options

Marin Adaptation Framework Project
Example Adaptation Strategy
"Buffer with Public Open Space"
Novato OLU

Novato OLU Example Strategy #2

STEP 4

- Novato OLU
- Horizontal Levee Alignment
- Area restored to tidal action



STEP 3

Example Theme #3: "Maximize habitat"

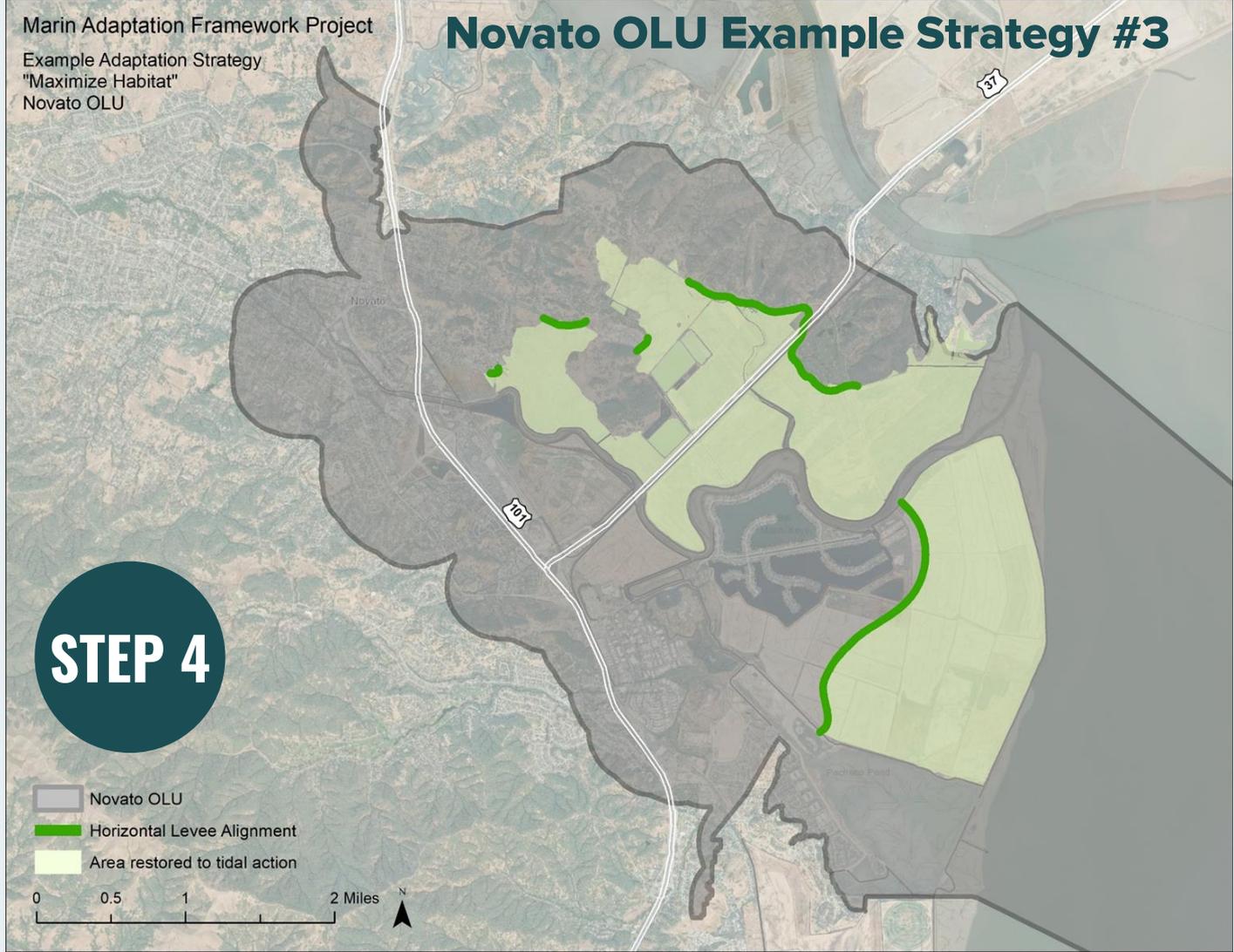
- Maximize opportunities for habitat enhancement
- Existing people/homes remain in place
- Key infrastructure may need to be re-aligned/ re-designed

Marin Adaptation Framework Project
Example Adaptation Strategy
"Maximize Habitat"
Novato OLU

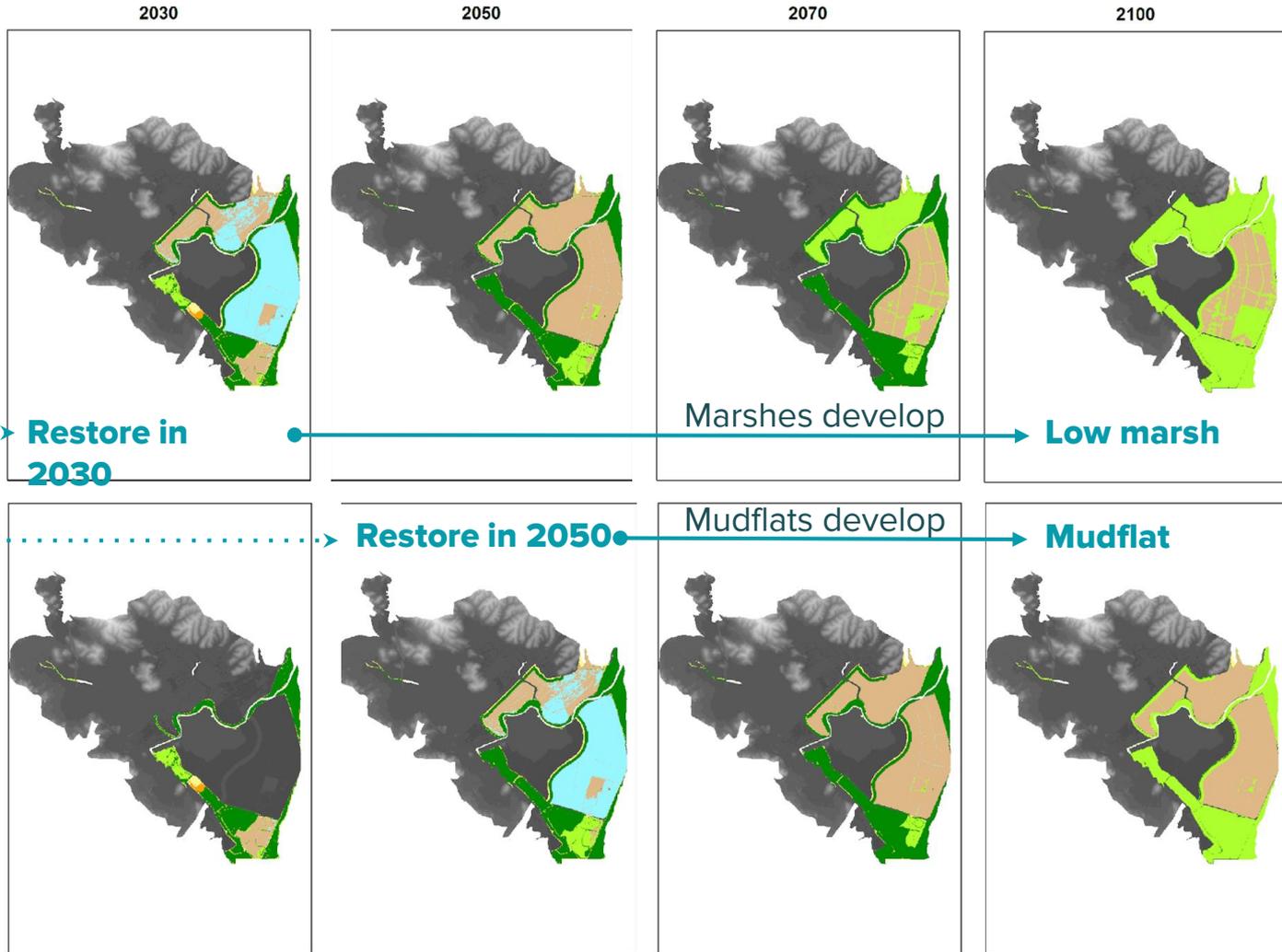
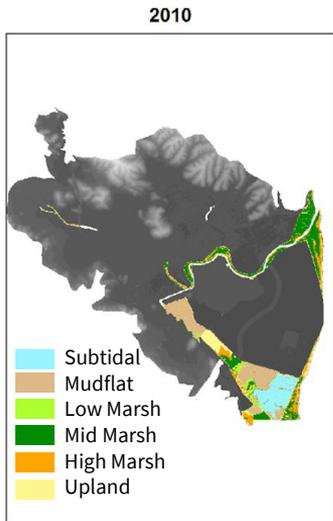
Novato OLU Example Strategy #3

STEP 4

- Novato OLU
- Horizontal Levee Alignment
- Area restored to tidal action

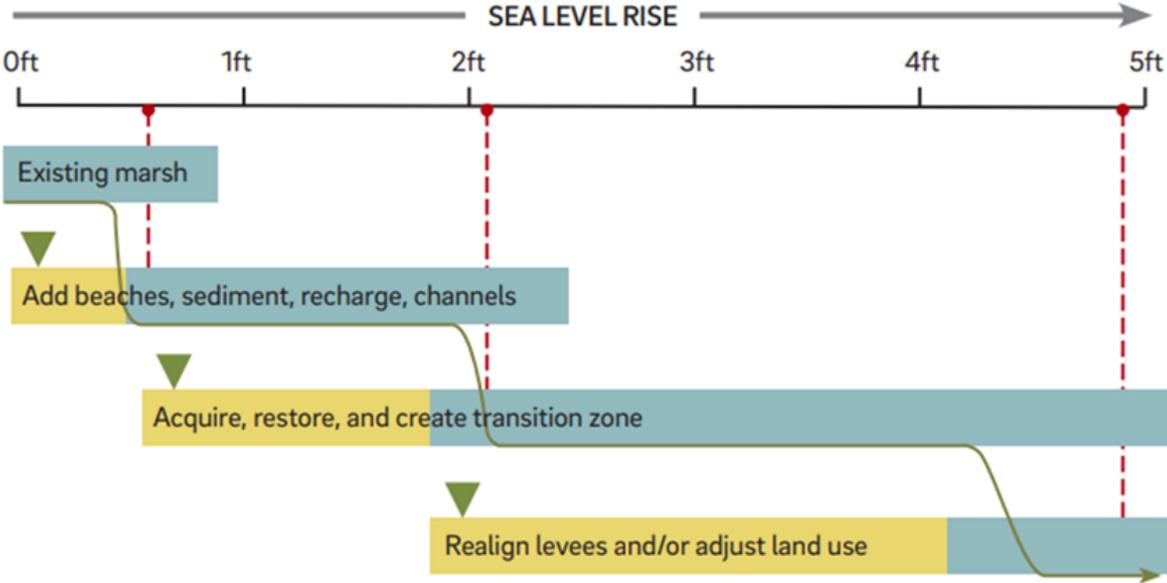


Timing Matters



How might objectives change with SLR?

Adaptation pathways



KEY

- Threshold
- Decision point
- Lead time required to implement
- Timing of actions to be effective

Conceptual phasing of measures triggered by sea-level rise, rather than a chronological timeline (adapted from Goals Project 2015).

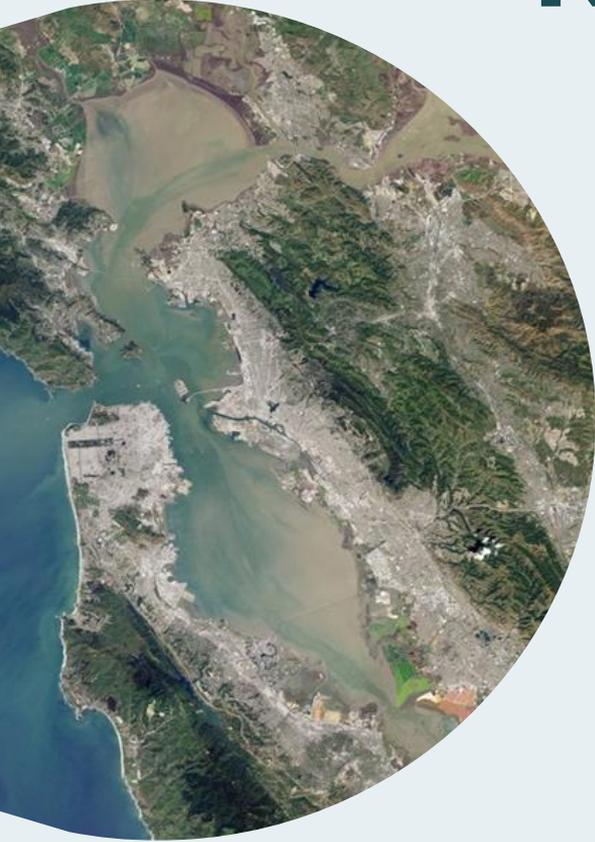
STEP 5

Evaluate and Prioritize Strategies



- Higher values mean “more benefit”
- **Compare total benefits** of strategies, while still **seeing the tradeoffs**
- Can **weight** certain benefits more than others
- Supports an **informed choice**
- May lead to developing **alternative strategies**

Next steps // RB2 Phase 2



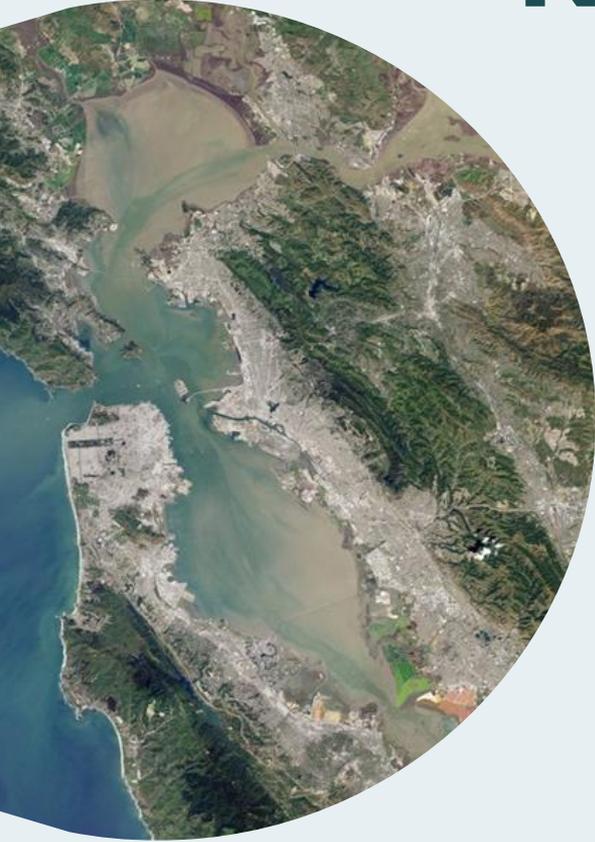
1. Filling science data gaps

- Sediment supply and demand
- Mudflat shape/evolution
- Links to water quality data (contingencies)
- Development of phased approaches

2. Refinement of adaptation measures

- Watershed connections, stormwater
- Detail on beaches (orientation, grainsize etc.)
- Upland transition zone connectivity

Next Steps // RB2 Phase 2



3. **Links** to Policies

- **Nutrients** Management Strategy
 - Integration with infrastructure ie. POTWs
 - SFEP WQIF grant
- **Supporting** Waterboard climate change policies

THANK YOU

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Laura Tam, Sarah Jo Szambelan, SPUR**

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