Sea-Level Rise and Adaptation

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Source: U.S. Army Corps of Engineers Digital Visual Library

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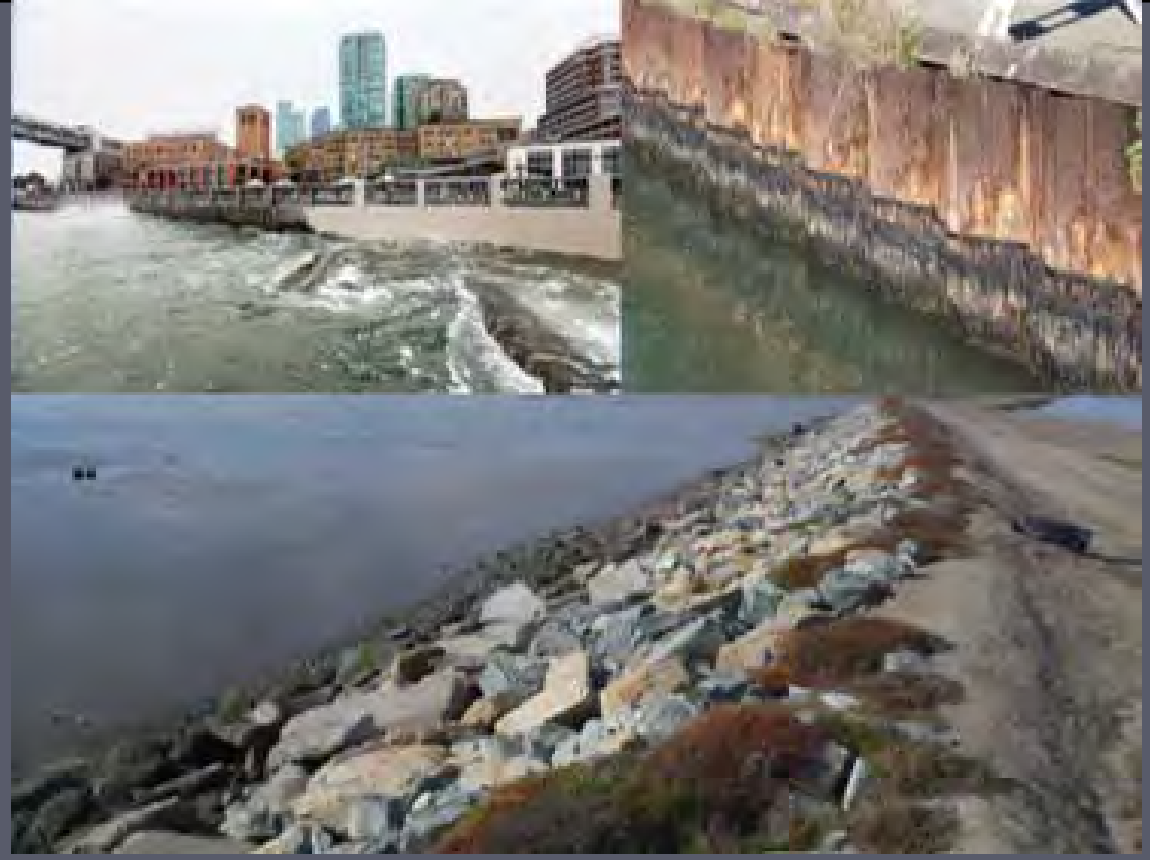
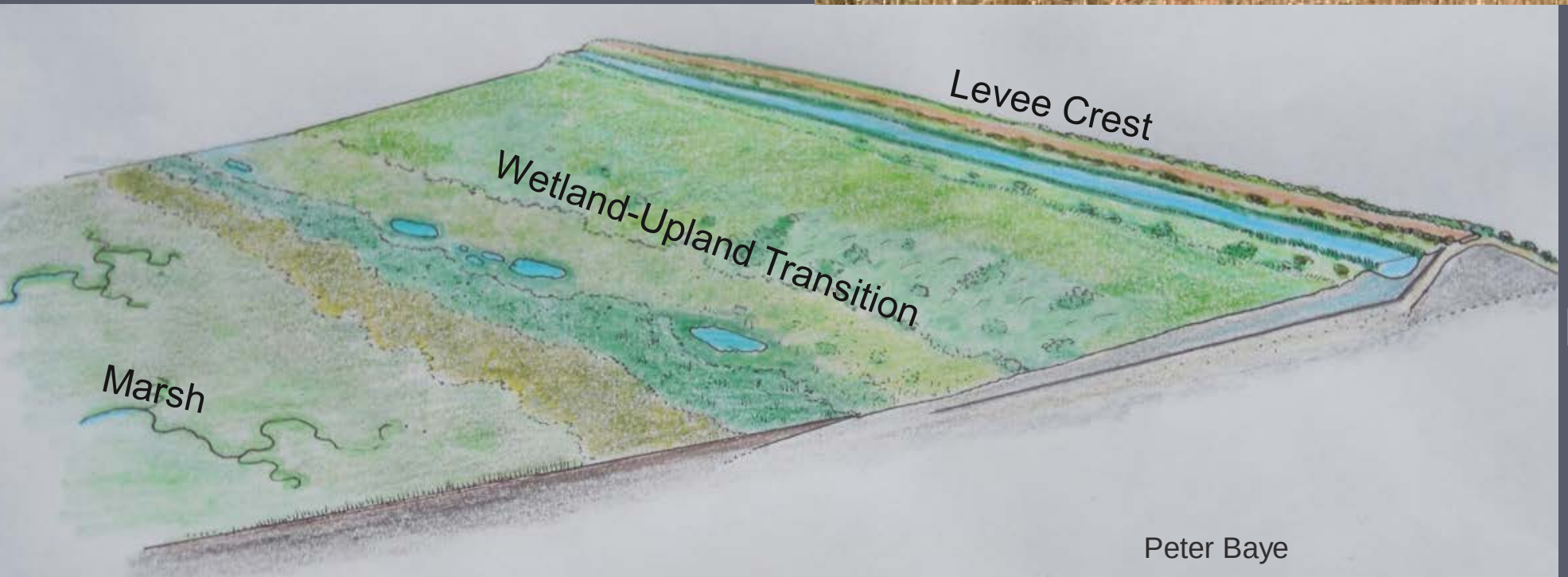
Hard Infrastructure



Nature-Based Infrastructure

Upland

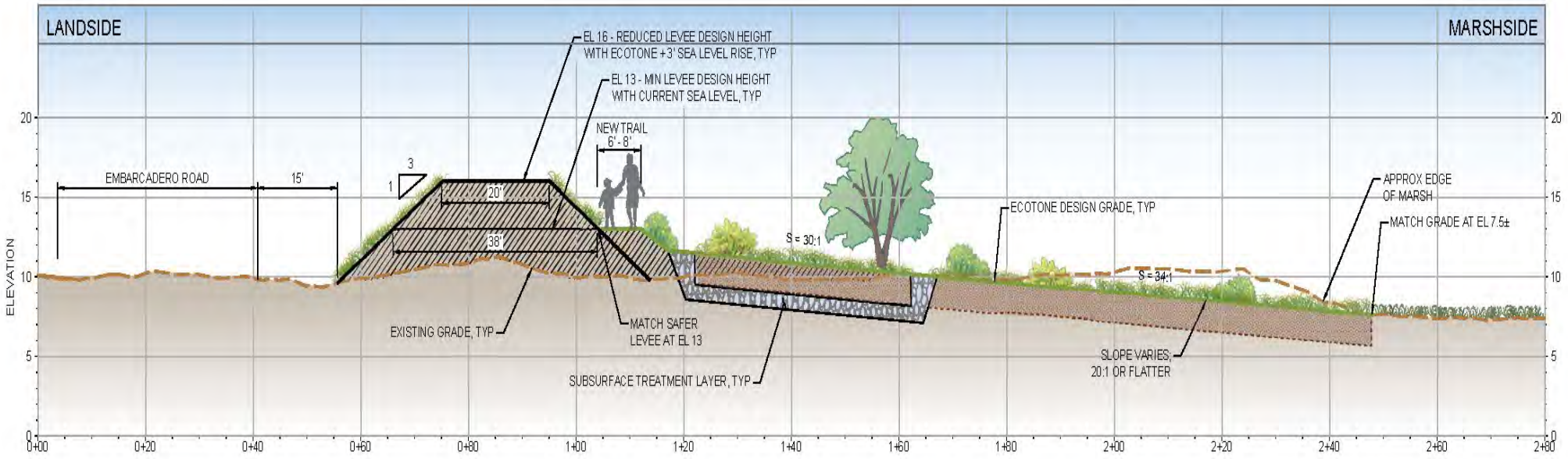
Wetland-Upland Transition



Horizontal Levee

Horizontal Levee Concept - 3 Legged Stool

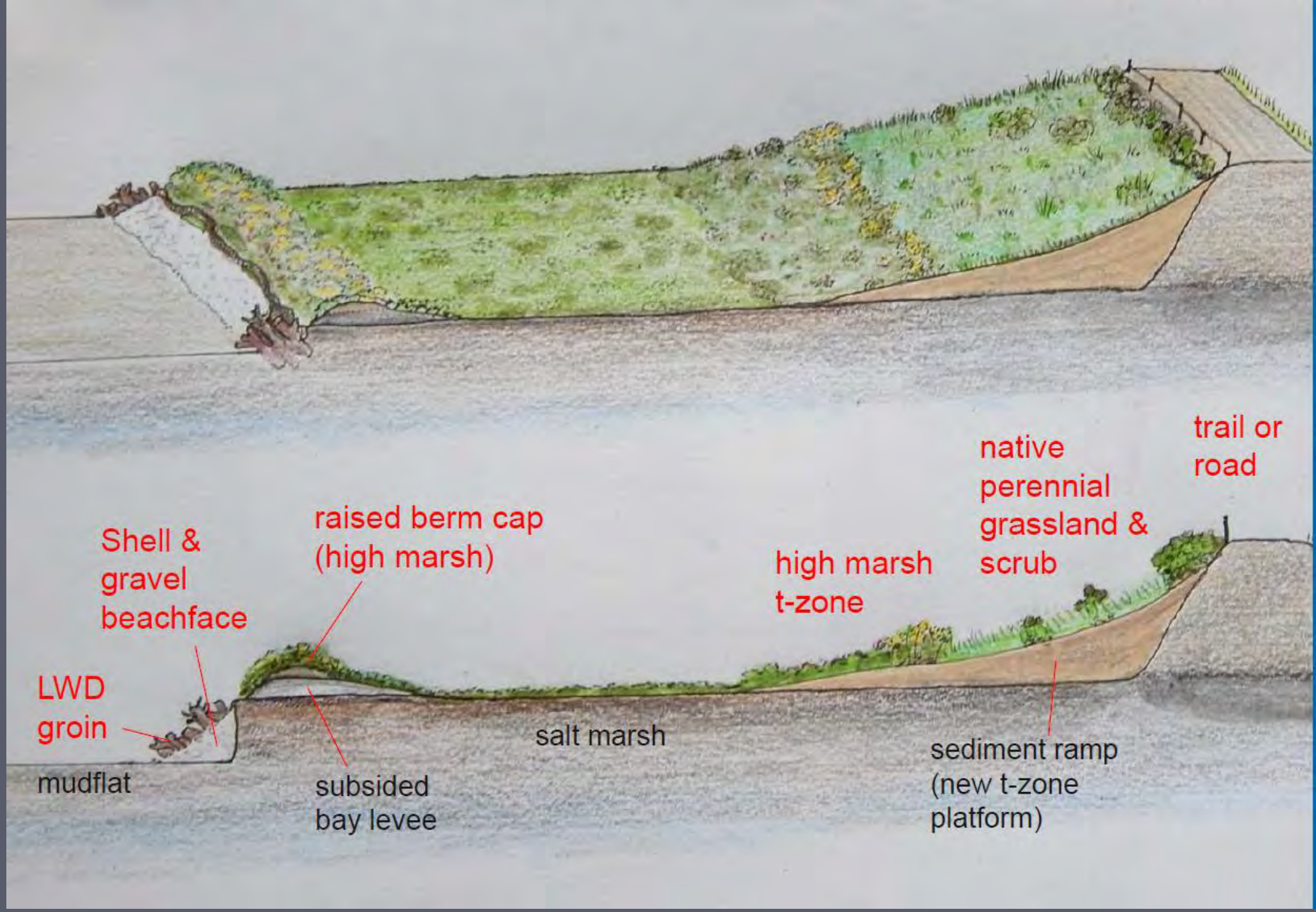
- Habitat
  - Refugia for special status species by restoring transitional ecotone
  - Restoration of wetland-upland transitional habitiat.
- Sea Level Rise Adaptation
  - Freshwater & brackish plants can build organic soils
  - Transgression space for wetlands to move upslope
- Wastewater polishing
  - Subsurface treatment removes 90% of nitrate, 87% of phosphate, 99% of indicator viruses, and significant removal of pharmaceuticals discharged to the Bay.



Source: ESA

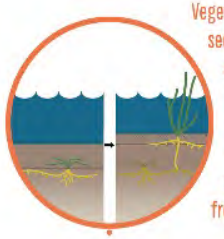

Levee Crest
Wetland-Upland Transition
Marsh

Hybrids


trail or road
native perennial grassland & scrub
raised berm cap (high marsh)
Shell & gravel beachface
high marsh t-zone
LWD groin
salt marsh
mudflat
subsided bay levee
sediment ramp (new t-zone platform)

1. MARSH SPRAYING

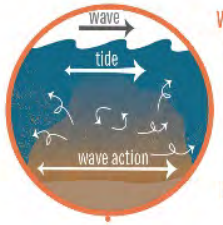
Dredged sediment is sprayed directly onto the marsh surface, which can increase accretion beyond natural rates.



Vegetation is buried with sediment during spraying, affecting habitat quality and quantity for marsh wildlife. New shoots recolonize over time or emerge from buried rhizomes.

2. WATER COLUMN SEEDING

Sediment is released into the water column at the marsh channel entrance during an incoming tide to increase suspended sediment concentrations in the water column.



Wave and tidal current energy resuspend the placed sediment and move it primarily landward.

Organisms living on or within sediment would be buried.

Areas with eelgrasses and oysters should be avoided during shallow water placement.

3. SHALLOW WATER PLACEMENT

Sediment is placed offshore to be resuspended by wave and tide action and then transported by tidal currents onto the marshes.

High turbidity levels lasting a few hours occur during the shallow water placement process. Fish are able to swim away from turbid areas and return after the sediment settles.

Questions to Ask

1. What is the problem?

- What is the hazard, what is at risk and how valuable is it?

2. Where do marshes, beaches, reefs, etc make sense?

- What is appropriate to the natural setting? What is the elevation?
- How much space do you have? What is in front, behind and to the sides?

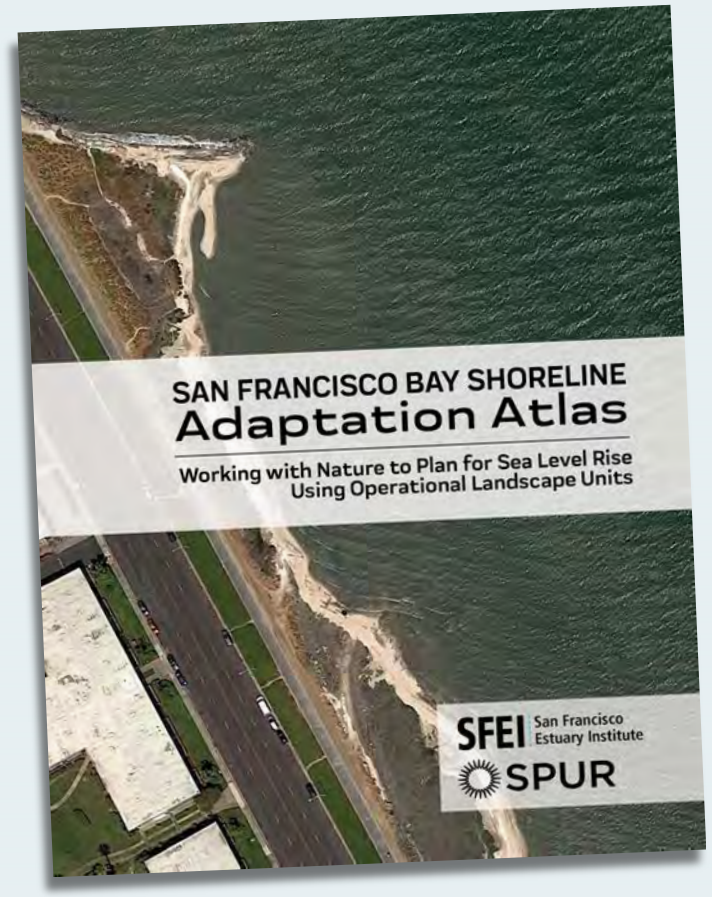
3. How effective, how expensive, and how long will it last?

- How do you prioritize the use of resources?
- How do natural features combine with traditional levee approaches?

What is appropriate where?

- Create spatial framework to guide nature-based adaptation strategies for sea-level rise
- Mapping suitability for nature-based adaptation measures
- Pairing problems with adaptation measures in appropriate places

Adaptation Atlas



NATURAL AND NATURE-BASED MEASURES

Ecotone levees

COASTAL RISKS MANAGED

Storm surge · Erosion · Short term SLR · Long term SLR

OTHER ECOSYSTEM SERVICES

• Biodiversity • Food supply • • Climate regulation* • • Water quality improvement* • • Recreation • • Other cultural services •

* *Service dependent on chosen management approach*

IMPACT ON SHORELINE

Protect

LOCATION
WITHIN TIDAL TRANSECT

SHORE
Supratidal
MHHW
MHW
MTL
MLW
MLLW
Shallow subtidal
Deep subtidal
BAY

EXAMPLES
Oro Loma Sanitary District

DEFINITION

Ecotone levees are gentle slopes or ramps (with a length to height ratio of 20:1 or gentler) bayward of flood risk management levees and landward of a tidal marsh. They stretch from the levee crest to the marsh surface, and can provide wetland-upland transition zone habitat when properly vegetated with native clonal grasses, rushes, and sedges. They can attenuate waves, provide high-tide refuge for marsh wildlife, and allow room for marshes to migrate upslope with sea level rise.

LANDSCAPE CONFIGURATION, DESIGN, & PROCESS GUIDELINES

The significant flood risk management benefits that can be provided by vegetated tidal marshes have been recognized in the Bay for a long time. In parts of the Bay with wide alluvial valleys and alluvial fans/plains, there is a transition of habitat between the marsh and the adjacent upland which is habitat in its own right. This transition zone provides refuge for marsh species, attenuates waves during storms, and provides a gentle slope for marshes to migrate as sea level rises. Much of the natural transition around the Bay has been disconnected from the marshes by the construction of flood risk management levees in the historical marshes and mudflats. These levees create transition zones that are much steeper (with a length to height ratio generally between 3:1 and 4:1) and narrower than natural transition zones.

The slope of an ecotone levee is gentler than a normal flood risk management levee, more akin to the slope of a natural transition zones and so the area of transition zone will be wider—providing more space for transition zone function and services and more space for marsh migration. This slope stretches down from the crest of the flood risk management levee to tidal marsh elevation with a gradient between 20:1 and 30:1. The ecotone levee only makes sense where naturally rising upland is absent and where there is an existing marsh or potential to restore marsh in front of it. Ecotone levees could be included in the restoration of marshes in polders, in which case the toe of the ecotone levee could be initially subtidal and unvegetated, requiring a different design approach than an ecotone levee sloping down into a marsh. The low-gradient slope is outside the core of the flood risk management levee and so, unlike the core, does not need to be constructed from geotechnical material compacted to a specified level. The gentler ecotone slope may reduce wave run up and overtopping of the crest of the flood risk management levee.

Ecotone levees have been included in the South Bay Salt Ponds Restoration Project and the South San Francisco Bay Shoreline Project. An enhancement of the ecotone levee is the "horizontal levee" which introduces subsurface irrigation to support fresh to brackish wetlands on the levee at the back end of the tidal marsh, restoring some functions of the natural salinity gradients that were historically found where small creeks entered the baylands. These brackish wetlands would be expected to support dense stands of tall sedges and bulrush, which would enhance the wave dampening function of the levee and reduce erosion. A horizontal levee is being piloted at the Oro Loma Sanitary District

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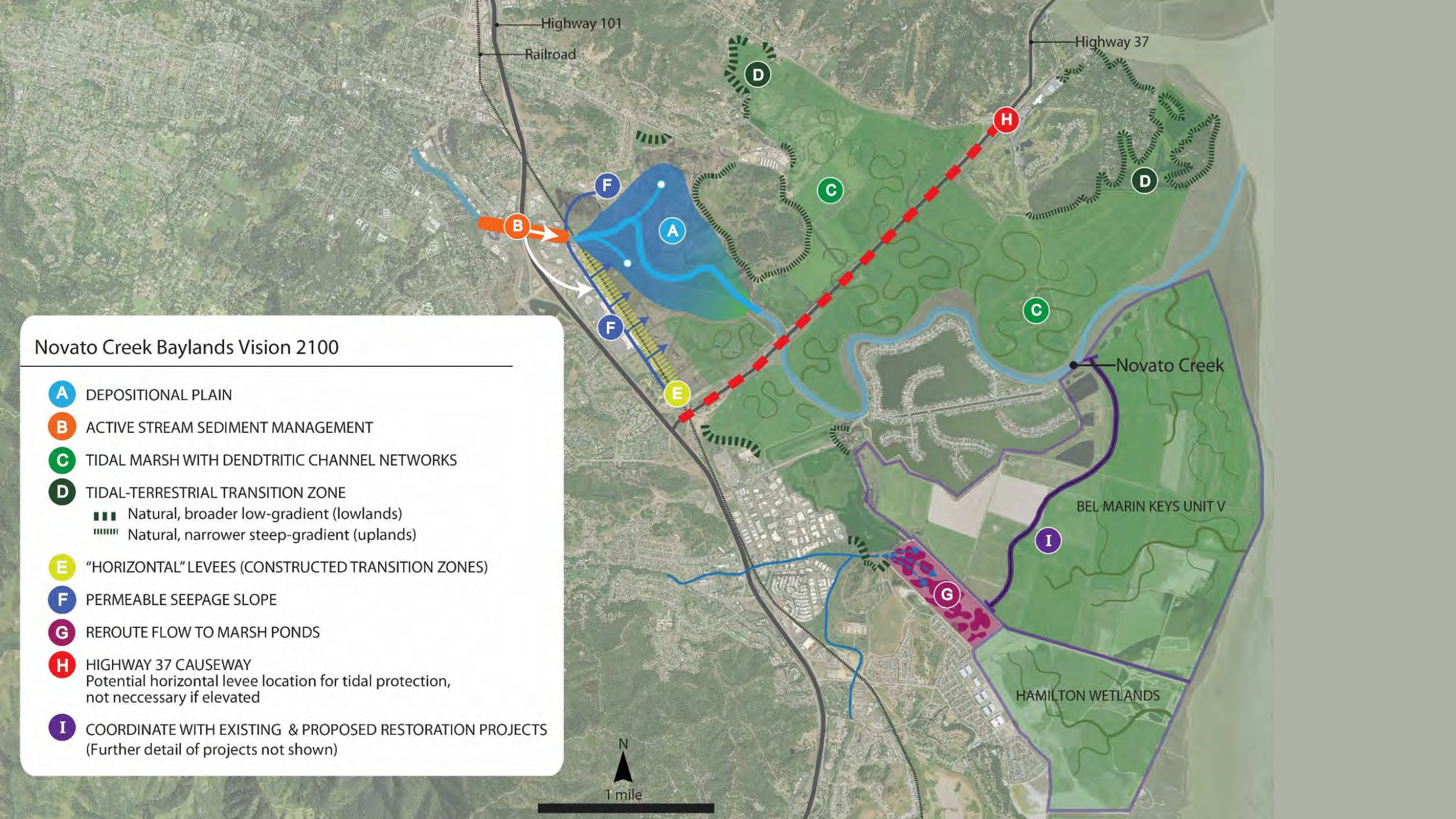
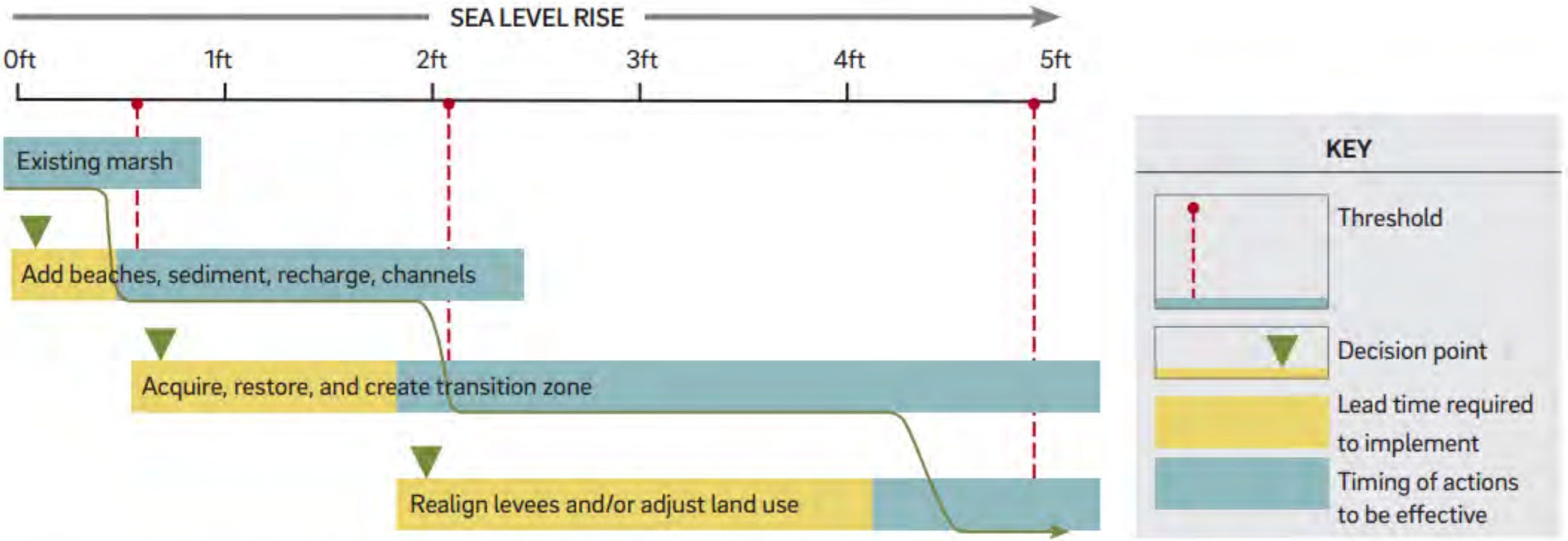


Novato Creek Baylands Vision 2100

- A DEPOSITIONAL PLAIN
- B ACTIVE STREAM SEDIMENT MANAGEMENT
- C TIDAL MARSH WITH DENDTRITIC CHANNEL NETWORKS
- D TIDAL-TERRESTRIAL TRANSITION ZONE
  - Natural, broader low-gradient (lowlands)
  - Natural, narrower steep-gradient (uplands)
- E "HORIZONTAL" LEVEES (CONSTRUCTED TRANSITION ZONES)
- F PERMEABLE SEEPAGE SLOPE
- G REROUTE FLOW TO MARSH PONDS
- H HIGHWAY 37 CAUSEWAY
  Potential horizontal levee location for tidal protection, not neccessary if elevated
- I COORDINATE WITH EXISTING & PROPOSED RESTORATION PROJECTS
  (Further detail of projects not shown)



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

Thank you

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