



Natural Shoreline Infrastructure in Humboldt Bay for Intertidal Coastal Marsh Restoration and Transportation Corridor Protection

Technical Working Group Meeting #1
August 3, 2020



NFWF



OCEAN
PROTECTION
COUNCIL

PROJECT OVERVIEW

Project Concept and Goals

- ▶ Integrate the natural flood risk reduction properties of salt marsh into the shoreline management strategy for the Eureka-Arcata Highway 101 transportation corridor.
- ▶ Perform site characterization and prepare preliminary design (50%) for a project utilizing tidal benches or similar natural infrastructure techniques.
- ▶ Lay the groundwork for an innovative approach to restore and perpetuate intertidal coastal marsh, increase community resilience to flooding, and demonstrate the use of natural ecological systems for sea level rise adaptation.

Funding



NFWF

\$125,000

(National Coastal Resilience Fund)



OCEAN
PROTECTION
COUNCIL

\$125,000

(Environmental License Plate Fund)

\$250,000

Separate but linked projects:

- Humboldt Bay/Eureka Slough Sea Level Rise Adaptation Plan
- Humboldt Bay Trail South Project
- Highway 101 Corridor Phased Adaptation Plan

Project Team

- ▶ Humboldt County
- ▶ GHD, Inc. and subconsultants
- ▶ Technical Working Group

Technical Working Group

- ▶ Adam Canter, Wiyot Tribe
- ▶ Jennifer Curtis, U.S. Geological Survey
- ▶ Clansey Desmet, Caltrans
- ▶ Julia Elkin, State Coastal Conservancy
- ▶ Cristin Kenyon / Melissa Kraemer, California Coastal Commission
- ▶ Justine Kimball, Ocean Protection Council
- ▶ Aldaron Laird, HSU Sea Level Rise Initiative
- ▶ Conor Shea, U.S. Fish and Wildlife Service
- ▶ Michael Van Hattem, California Department of Fish & Wildlife
- ▶ Adam Wagschal, Humboldt Bay Harbor, Conservation and Recreation District

Note:

- Additional members could be considered
- People are free to step out







Brainard

Bracut

























Historical railroad bed

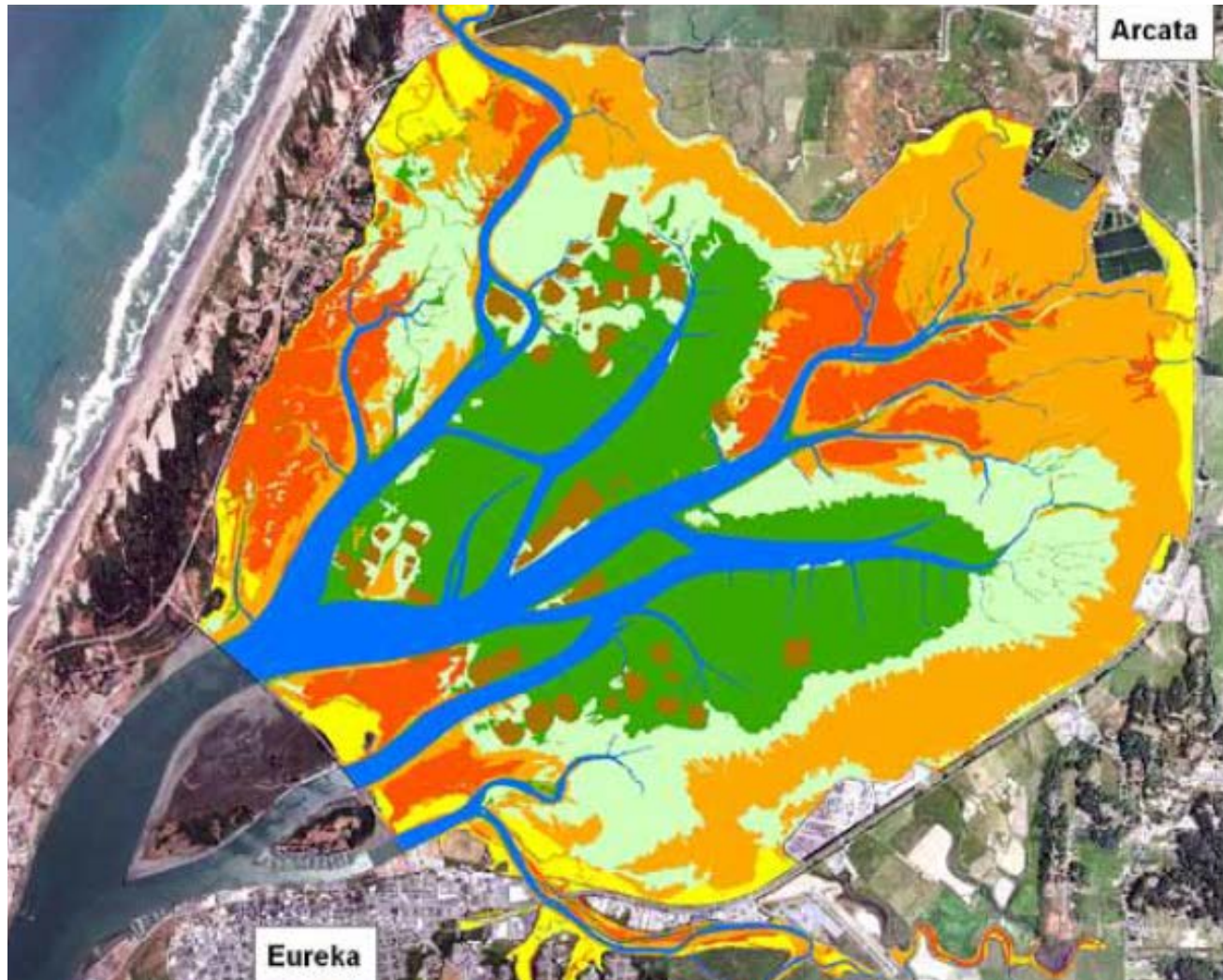
Current railroad bed

Jacoby Creek





North Bay Coastal Wetland Habitats



Legend

- Coastal Marsh
- Eelgrass
- Patchy Eelgrass
- Macroalgae
- Oyster Mariculture
- Subtidal
- Unconsolidated Sediment

Habitat	(acres)
	North Bay
Coastal Marsh	637
Eelgrass	1,880
Patchy Eelgrass	1,697
Macroalgae	1,034
Oyster Mariculture	287
Subtidal	1,380
Unconsolidated Sediment	2,712
Total	9,629

Source: Humboldt Bay and Eel River Estuary Benthic Habitat Project (Schlosser and Eicher, 2012)

North Bay Coastal Wetland Habitats



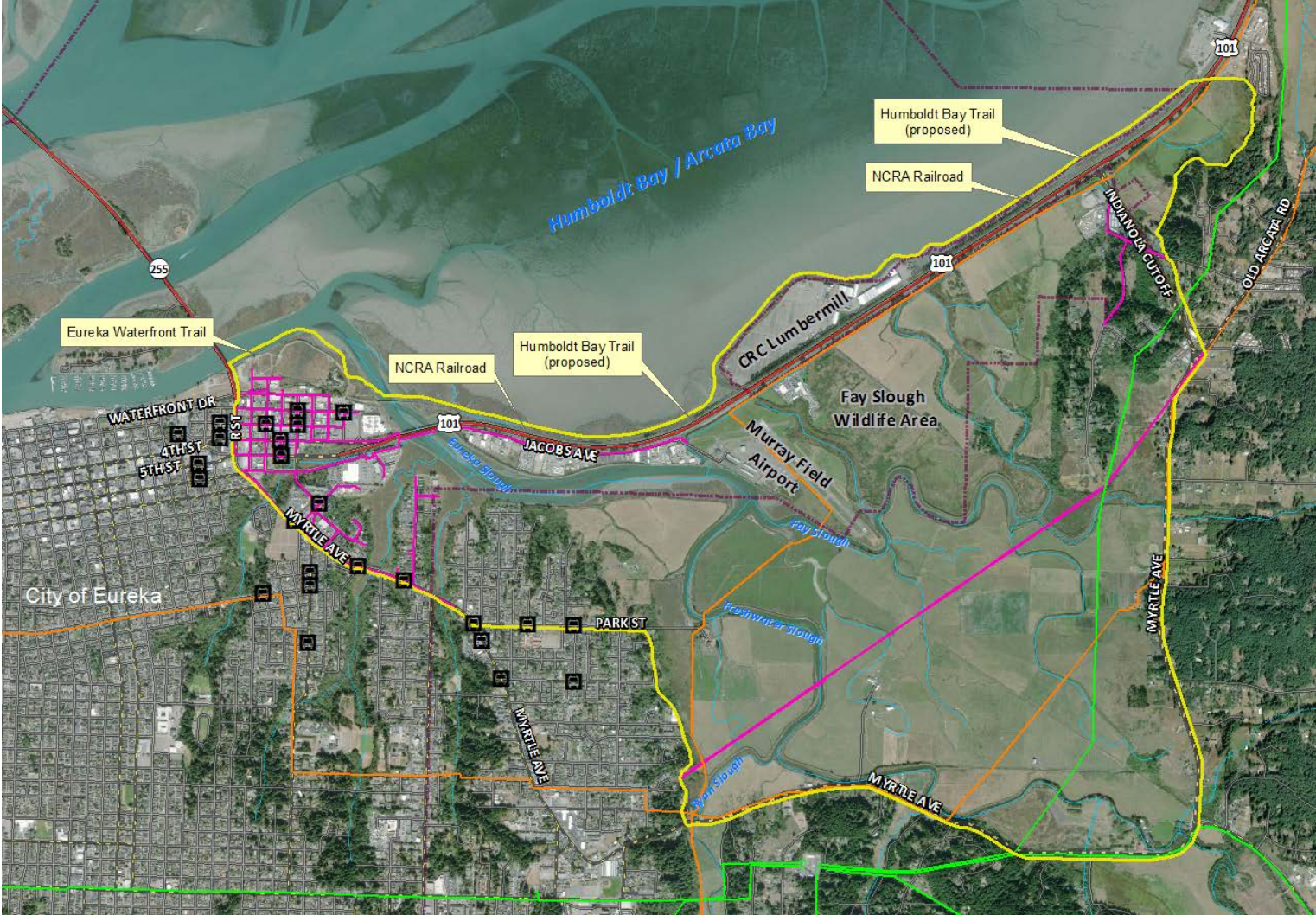
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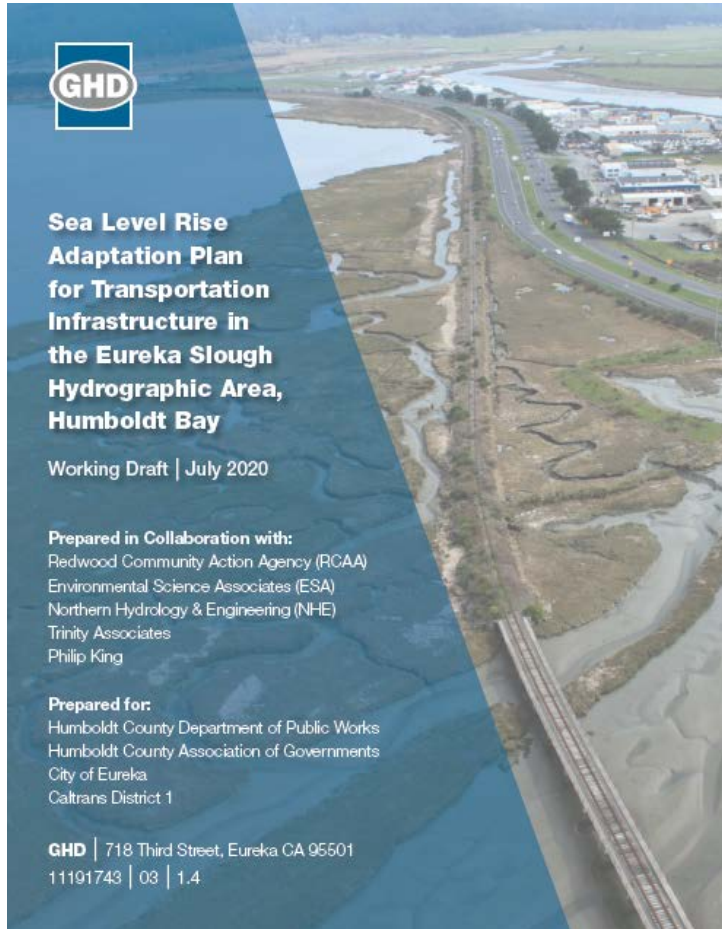
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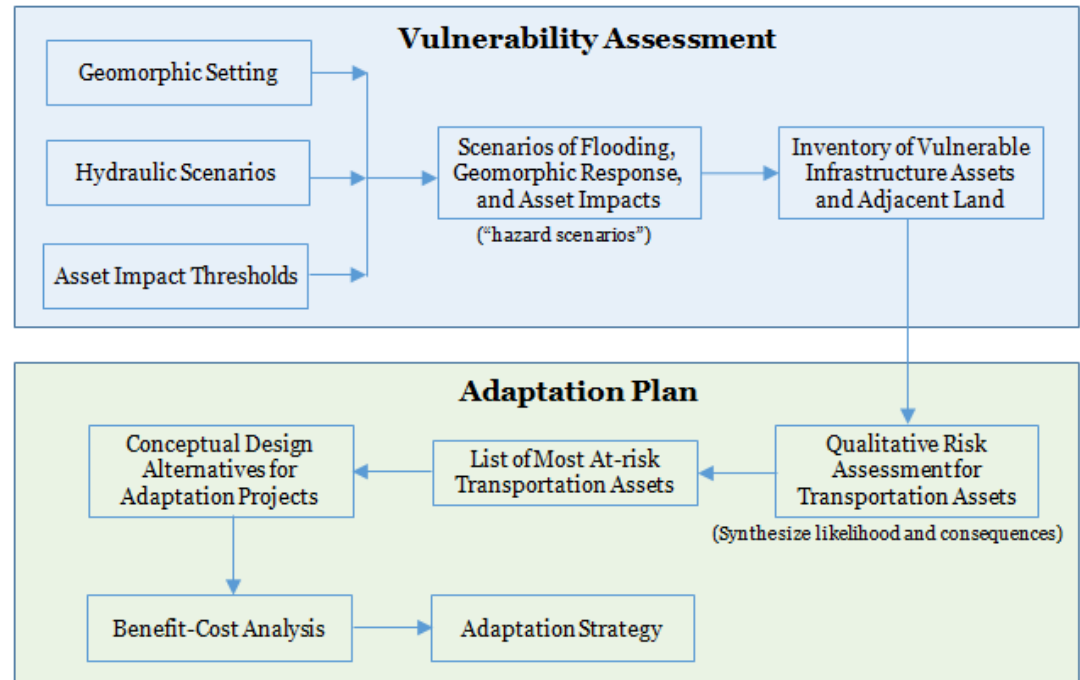
Humboldt Bay/Eureka Slough SLR Adaptation Plan – Planning Area



Humboldt Bay/Eureka Slough SLR Adaptation Plan



Sea Level Rise Adaptation Planning Flow Diagram

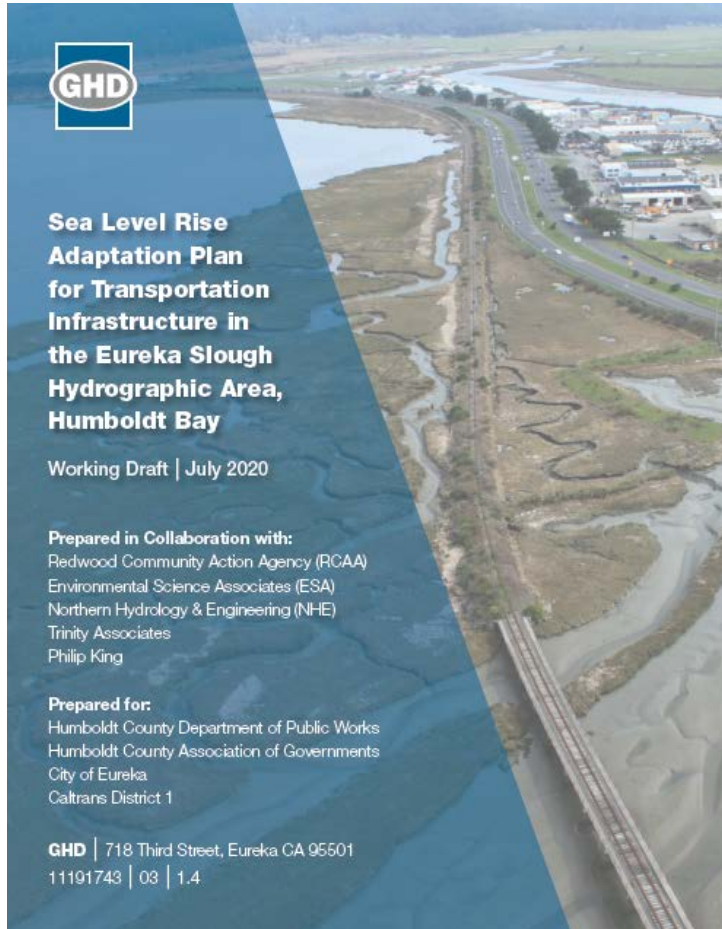


Completion date: December 2020

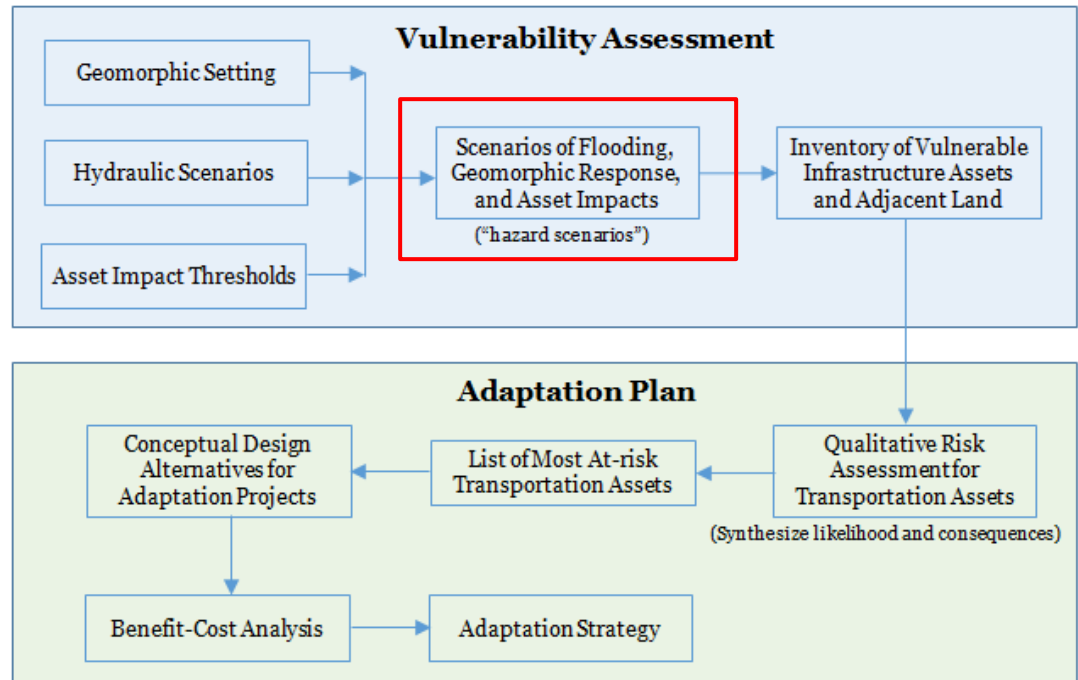
<https://humboldt.gov.org/2487/Sea-Level-Rise>



Humboldt Bay/Eureka Slough SLR Adaptation Plan – Hazard Scenarios



Sea Level Rise Adaptation Planning Flow Diagram



Completion date: December 2020

<https://humboldt.gov.org/2487/Sea-Level-Rise>

Humboldt Bay

Brainard

101

Indianola Cutoff

Bracut


Eureka Slough

Fay Slough



Typical Tidal Conditions

Study Area

 Tidal Still Water & Wind Set-up



Humboldt Bay

Brainard

Bracut

Indianola Cutoff

101

Eureka Slough




Fay Slough

< 0.5 ft






Water Level: 9.3 ft (NAVD)


Hazard Scenario 2

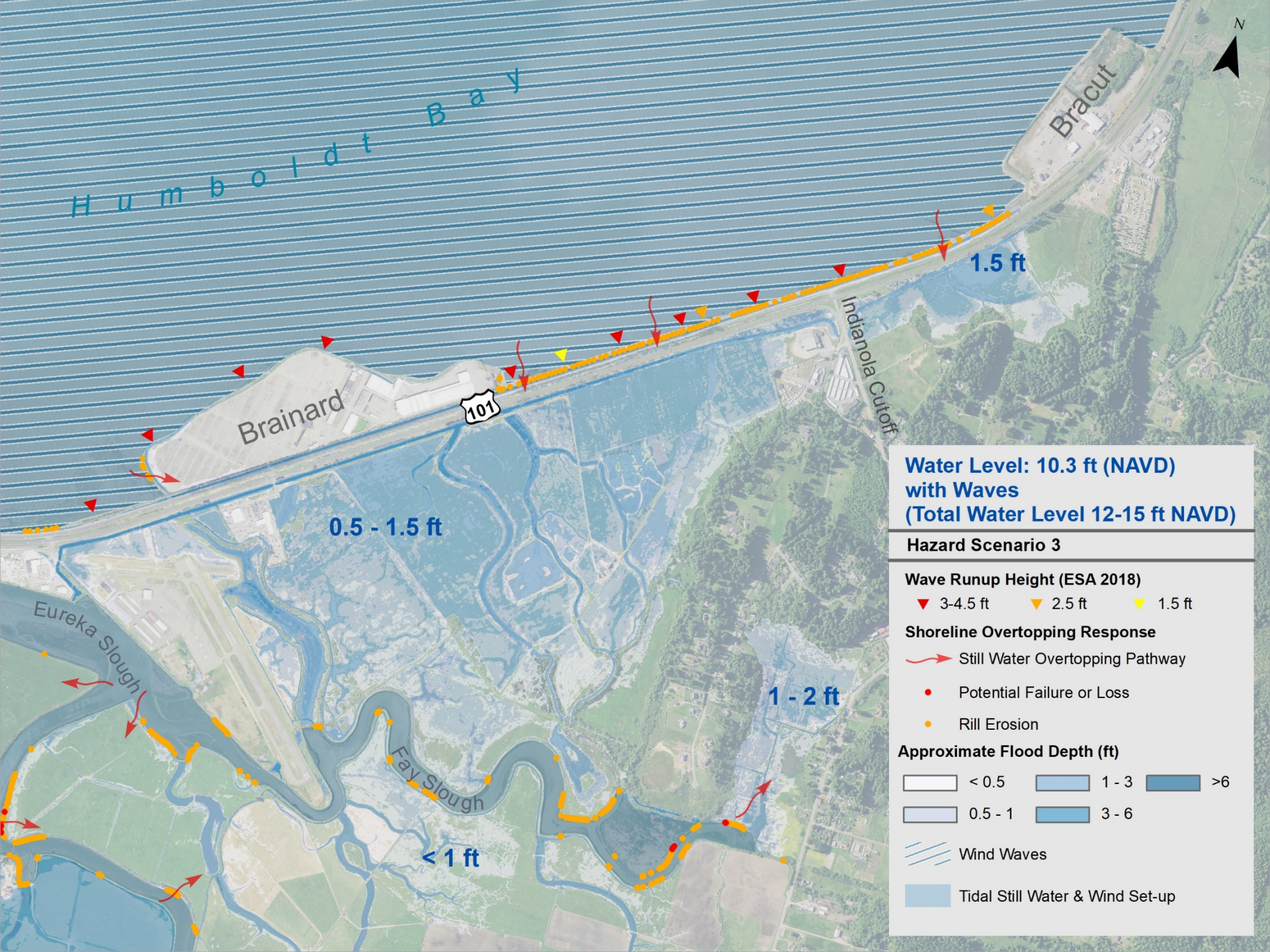
Shoreline Overtopping Response

-  Still Water Overtopping Pathway
-  Potential Failure or Loss
-  Rill Erosion

Approximate Flood Depth (ft)

	< 0.5		1 - 3		> 6
	0.5 - 1		3 - 6		

 Tidal Still Water & Wind Set-up



Humboldt Bay

Brainard

101

Indianola Cutoff

Bracut

Eureka Slough

Fay Slough

0.5 - 1.5 ft

1.5 ft

1 - 2 ft

< 1 ft

**Water Level: 10.3 ft (NAVD)
with Waves
(Total Water Level 12-15 ft NAVD)**

Hazard Scenario 3

Wave Runup Height (ESA 2018)

- ▼ 3-4.5 ft
- ▼ 2.5 ft
- ▼ 1.5 ft

Shoreline Overtopping Response

- Still Water Overtopping Pathway
- Potential Failure or Loss
- Rill Erosion

Approximate Flood Depth (ft)

- | | | |
|-----------|---------|-------|
| □ < 0.5 | □ 1 - 3 | □ > 6 |
| □ 0.5 - 1 | □ 3 - 6 | |

/// Wind Waves

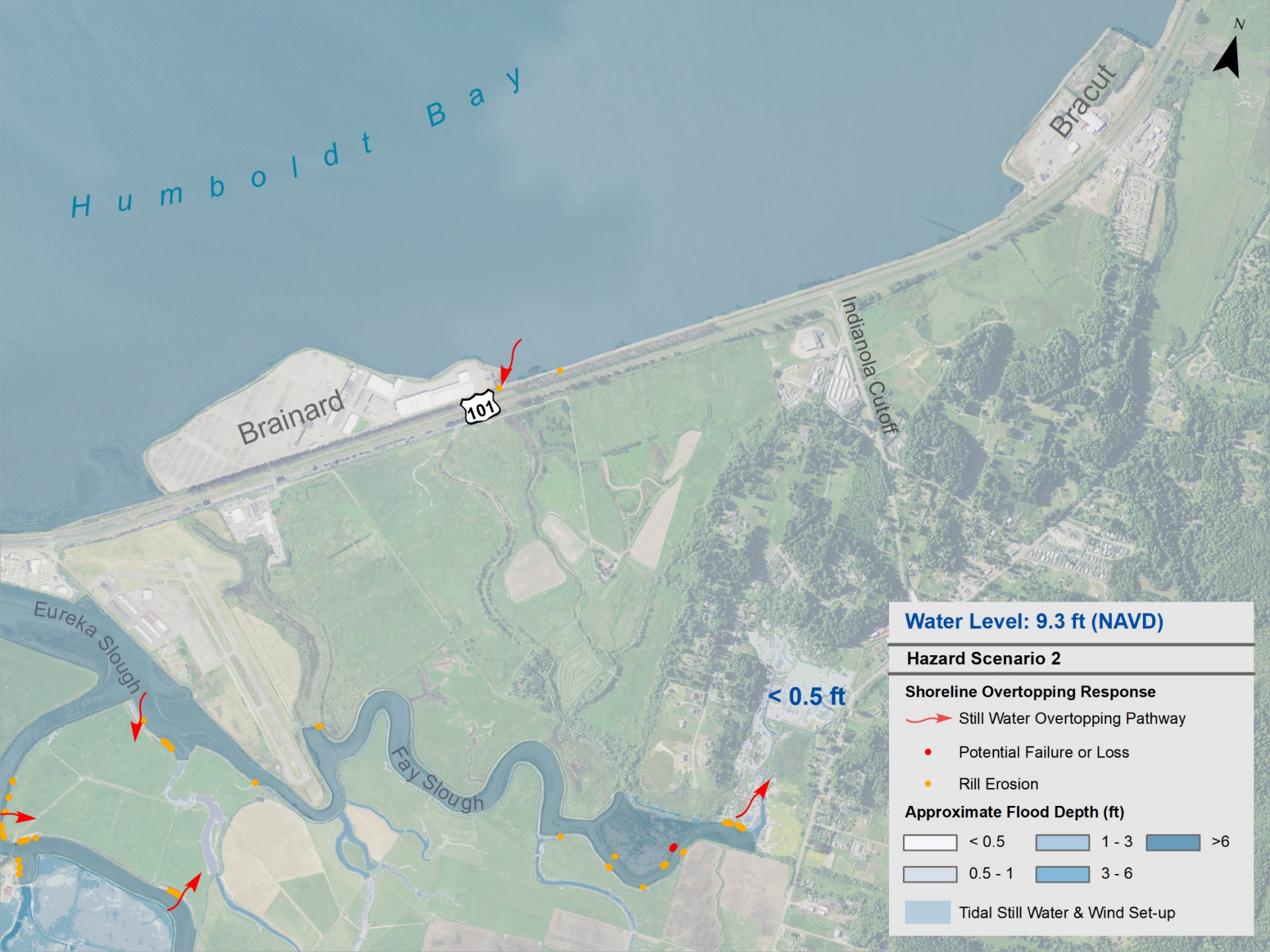
■ Tidal Still Water & Wind Set-up



Eureka-Arcata Highway 101 Corridor

December 31, 2005





Humboldt Bay

Brainard

Bracut

Indianola Cutoff

101

Eureka Slough




Fay Slough

< 0.5 ft






Water Level: 9.3 ft (NAVD)


Hazard Scenario 2

Shoreline Overtopping Response

-  Still Water Overtopping Pathway
-  Potential Failure or Loss
-  Rill Erosion

Approximate Flood Depth (ft)

 < 0.5	 1 - 3	 > 6
 0.5 - 1	 3 - 6	

 Tidal Still Water & Wind Set-up



Humboldt Bay

Brainard

101

Indianola Cutoff

Bracut




Eureka Slough

Fay Slough







Water Level: 9.9 ft (NAVD)

Hazard Scenario 4

Shoreline Overtopping Response

-  Still Water Overtopping Pathway
-  Potential Failure or Loss
-  Rill Erosion

Approximate Flood Depth (ft)

 < 0.5	 1 - 3	 > 6
 0.5 - 1	 3 - 6	
 Tidal Still Water & Wind Set-up		

0.5 - 1.5 ft

< 1 ft





Humboldt Bay

Brainard

101

Indianola Cutoff

Bracut

Eureka Slough

Fay Slough

1.5 - 2.5 ft

1.5 - 2.5 ft

1 - 2 ft


< 1.5 ft


Water Level: 10.6 ft (NAVD)

Hazard Scenario 5

Shoreline Overtopping Response


 Still Water Overtopping Pathway

 Potential Failure or Loss

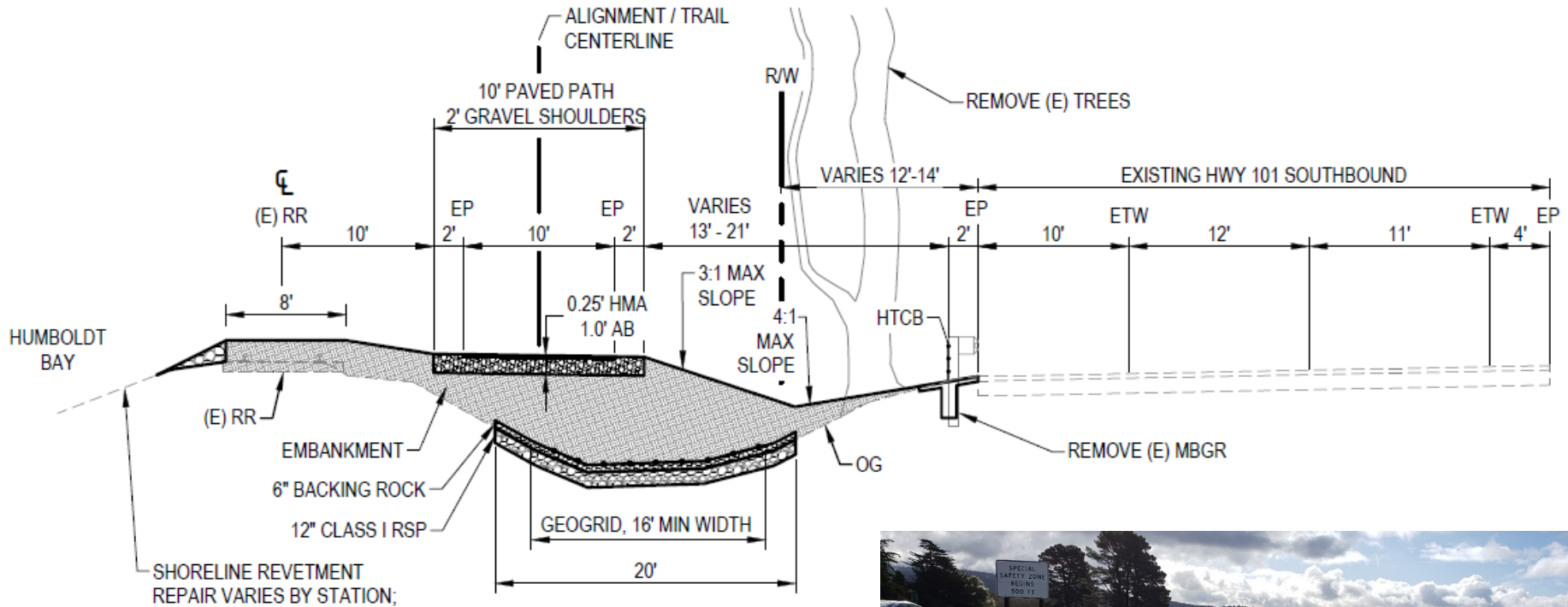
 Rill Erosion

Approximate Flood Depth (ft)

 < 0.5	 1 - 3	 > 6
 0.5 - 1	 3 - 6	

 Tidal Still Water & Wind Set-up

Humboldt Bay Trail South – 60% Design



ELEVATIONS

Feature	Existing	Future
Railroad	9.6-10.3 ft	11.5 ft
Trail	n/a	10.5 ft





Humboldt Bay

Brainard

101

Indianola Cutoff

Bracut

1.5 - 2.5 ft

1.5 - 2.5 ft

Eureka Slough

Fay Slough




1 - 2 ft

< 1.5 ft







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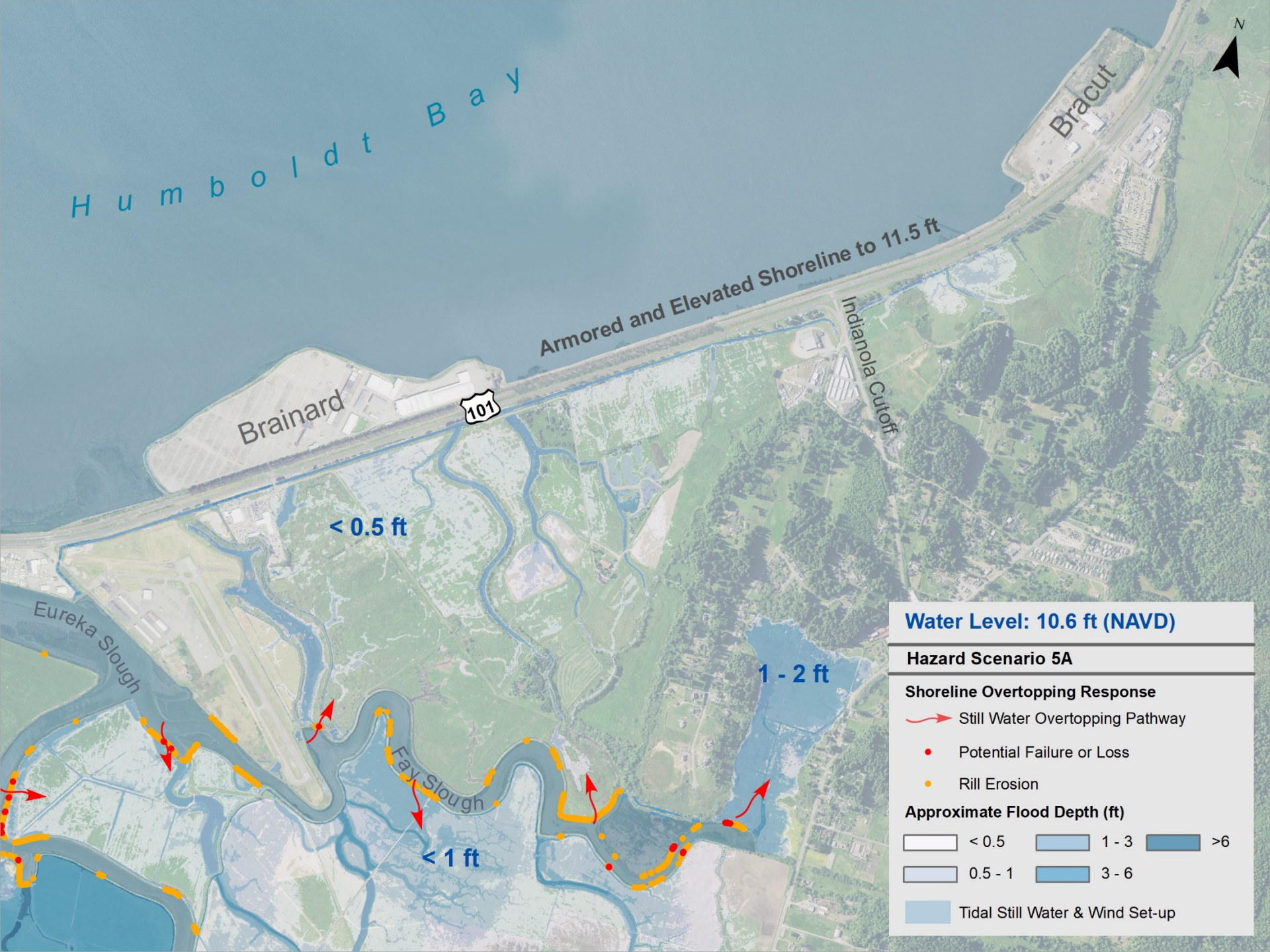
Hazard Scenario 5

Shoreline Overtopping Response

-  Still Water Overtopping Pathway
-  Potential Failure or Loss
-  Rill Erosion

Approximate Flood Depth (ft)

	< 0.5		1 - 3		> 6
	0.5 - 1		3 - 6		
 Tidal Still Water & Wind Set-up					



Humboldt Bay

Armored and Elevated Shoreline to 11.5 ft

Brainard

101

Indianola Cutoff

Bracut

< 0.5 ft

1 - 2 ft

Eureka Slough




Fay Slough

< 1 ft







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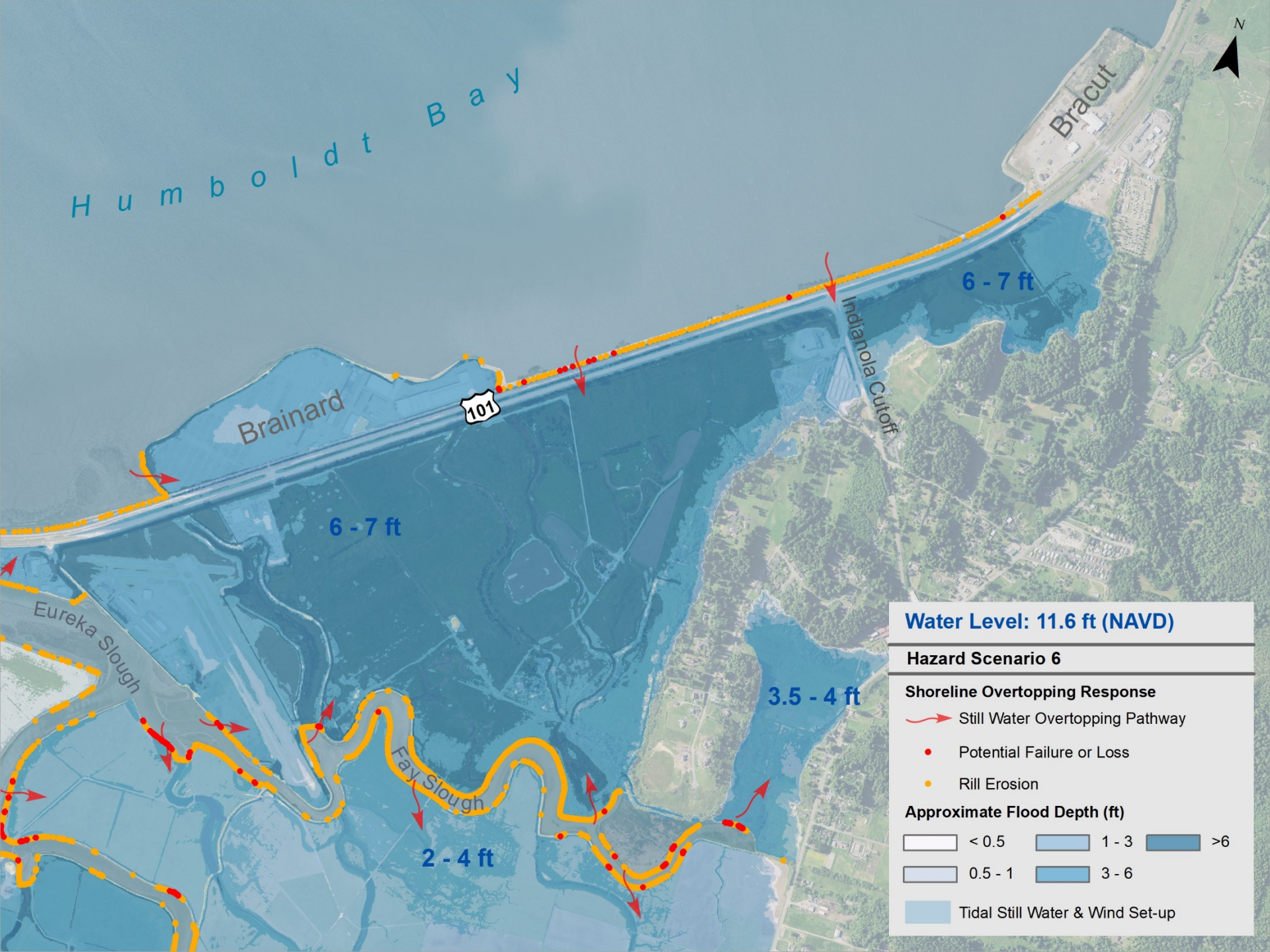
Hazard Scenario 5A

Shoreline Overtopping Response

-  Still Water Overtopping Pathway
-  Potential Failure or Loss
-  Rill Erosion

Approximate Flood Depth (ft)

	< 0.5		1 - 3		> 6
	0.5 - 1		3 - 6		
 Tidal Still Water & Wind Set-up					



Humboldt Bay

Bracut

Brainard

101

Indianola Cutoff

Eureka Slough

Fay Slough

6 - 7 ft

6 - 7 ft




3.5 - 4 ft

2 - 4 ft

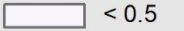


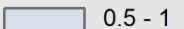

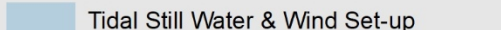
Water Level: 11.6 ft (NAVD)

Hazard Scenario 6

Shoreline Overtopping Response

-  Still Water Overtopping Pathway
-  Potential Failure or Loss
-  Rill Erosion

Approximate Flood Depth (ft)

	< 0.5		1 - 3		> 6
	0.5 - 1		3 - 6		
 Tidal Still Water & Wind Set-up					



Humboldt Bay

Brainard

101

Armored and Elevated Shoreline to 11.5 ft

Indianola Cutoff

Bracut

1 - 2 ft

1 - 2 ft

Eureka Slough

3.5 - 4 ft

Fay Slough

2 - 4 ft

Water Level: 11.6 ft (NAVD)

Hazard Scenario 6A

Shoreline Overtopping Response

→ Still Water Overtopping Pathway

• Potential Failure or Loss

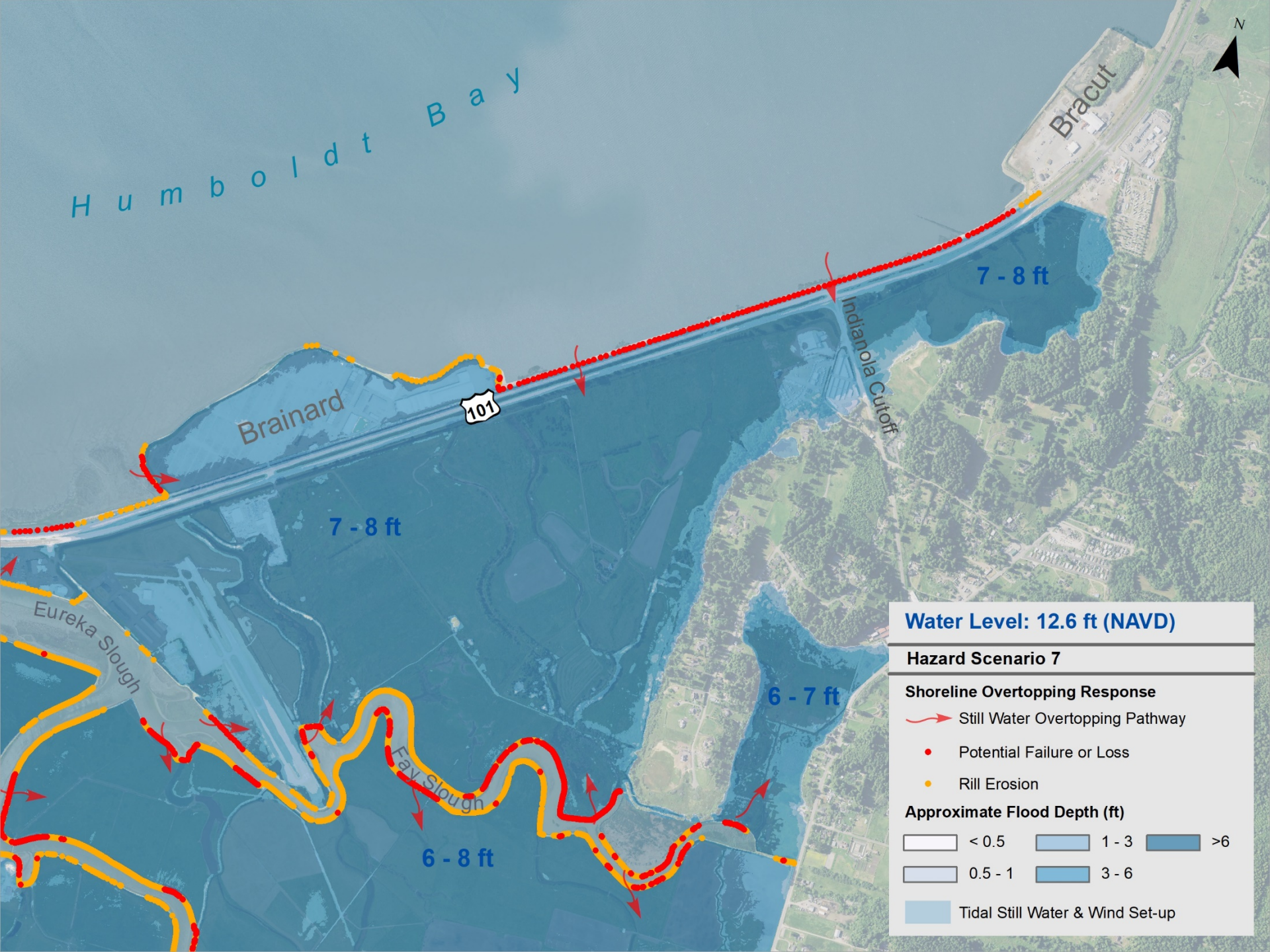
• Rill Erosion

Approximate Flood Depth (ft)

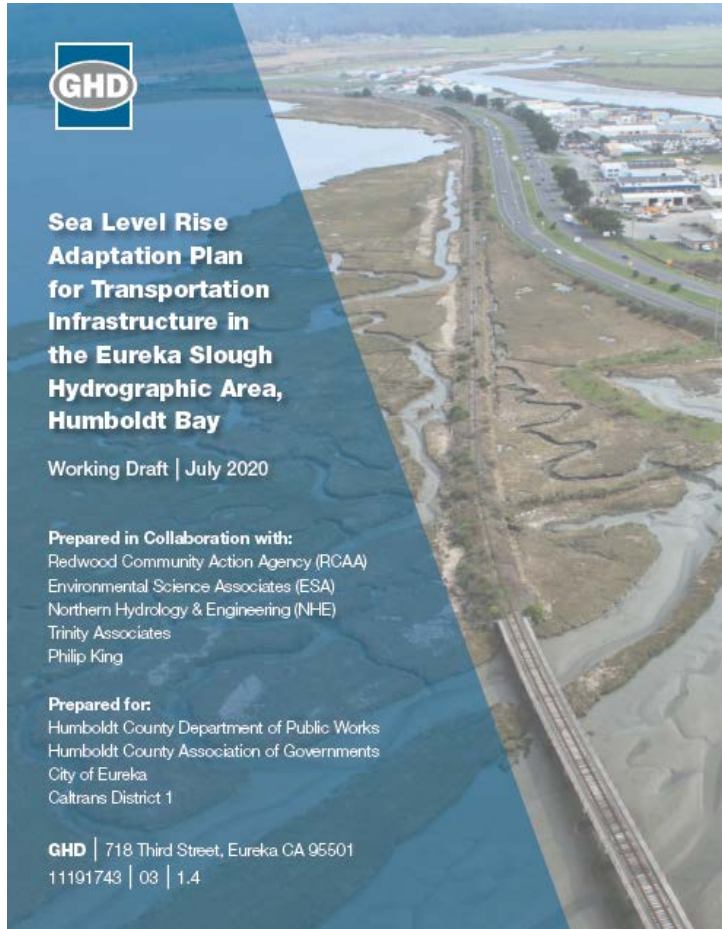
< 0.5	1 - 3	> 6
0.5 - 1	3 - 6	

Tidal Still Water & Wind Set-up

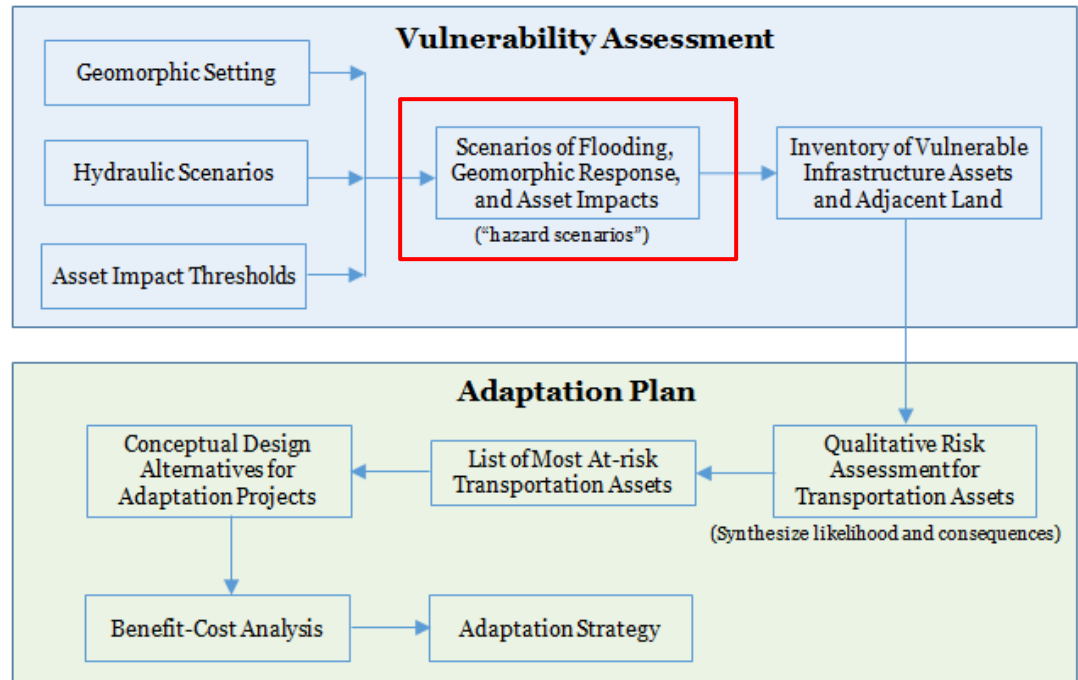




Humboldt Bay/Eureka Slough SLR Adaptation Plan – Hazard Scenarios



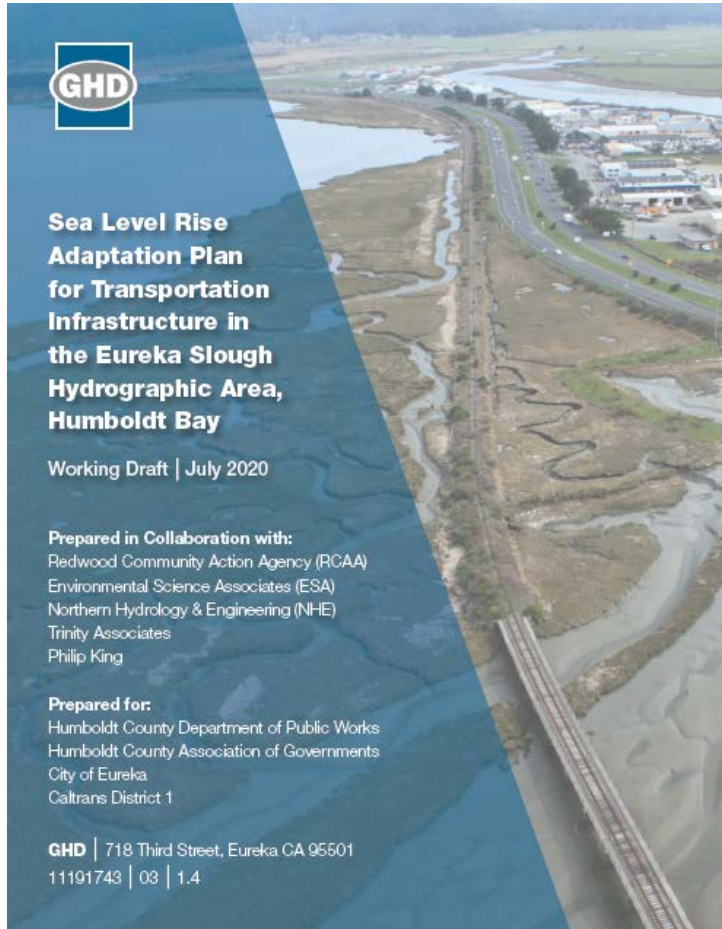
Sea Level Rise Adaptation Planning Flow Diagram



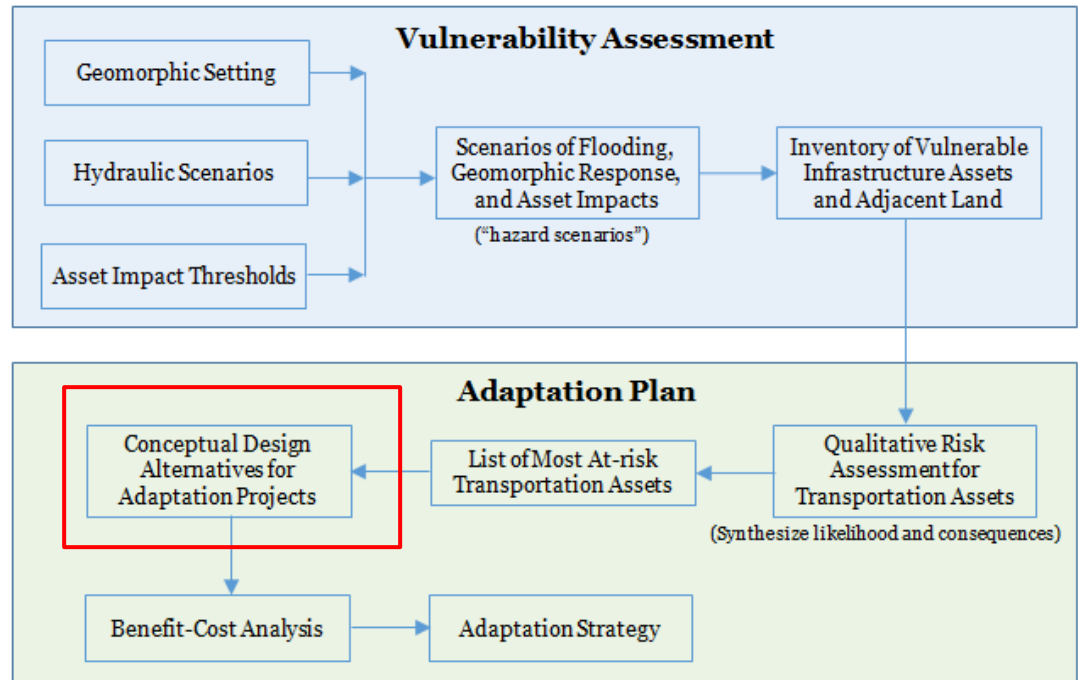
Completion date: December 2020

<https://humboldt.gov.org/2487/Sea-Level-Rise>

Humboldt Bay/Eureka Slough SLR Adaptation Plan – Adaptation Concepts



Sea Level Rise Adaptation Planning Flow Diagram



Completion date: December 2020

<https://humboldt.gov.org/2487/Sea-Level-Rise>



Concept of Natural Shoreline Infrastructure

TOWARD NATURAL SHORELINE INFRASTRUCTURE TO MANAGE COASTAL CHANGE IN CALIFORNIA

A Report for:

California's Fourth Climate Change Assessment

Prepared By:

Sarah Newkirk¹, Sam Veloz², Maya Hayden², Bob Battalio³,
Tiffany Cheng³, Jenna Judge⁴, Walter Heady¹, Kelly Leo¹,
Mary Small⁵

1 The Nature Conservancy
2 Point Blue Conservation Science
3 Environmental Science Associates
4 National Oceanic and Atmospheric Administration
5 California State Coastal Conservancy

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Edmund G. Brown, Jr. Governor

August 2018
CCCA4-CNRA-2018-011

- ▶ *Using natural ecological systems or processes to reduce vulnerability to climate change related hazards while increasing the long-term adaptive capacity of coastal areas by perpetuating or restoring ecosystem services.*



Concept of Natural Shoreline Infrastructure

Table 1: Suitability of Natural Shoreline Infrastructure measures for select wave exposure environments and backshore types. Green (or X) indicates that a type is suitable for the given environmental setting. Yellow (or /) indicates moderate suitability and red (or blank box) indicates that this type is not typically appropriate in this setting.

Backshore Type		Natural Shoreline Infrastructure Type					
		Sand Dune	Cobble Berm	Marsh Sill	Tidal Bench	Oyster Reef	Eelgrass Bed
Sheltered Water (wind-waves)	Beach	X	X	X	X	X	X
	Cliff		X	/	/	/	/
	Marsh			X	X	X	X
Open Coast (swell-exposed)	Beach	X	X				
	Cliff/Rocky Nearshore	/	X				
	River Mouth		X				
	Lagoon Estuary	X	X	X	X	X	X

Source: Toward Natural Shoreline Infrastructure to Manage Coastal Change in California (Newkirk et al, 2018)

Concept of Natural Shoreline Infrastructure

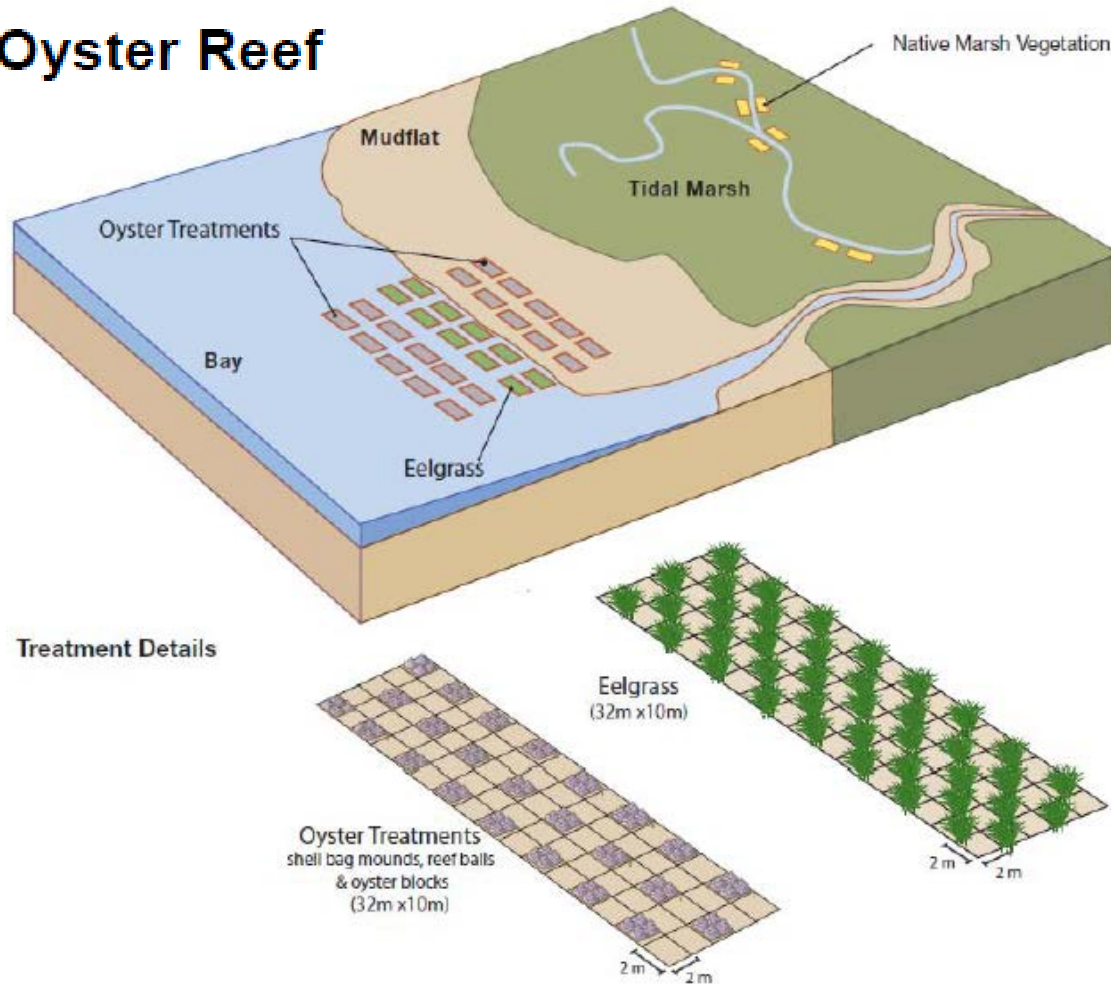
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Backshore Type		Natural Shoreline Infrastructure Type					
		Sand Dune	Cobble Berm	Marsh Sill	Tidal Bench	Oyster Reef	Eelgrass Bed
Sheltered Water (wind-waves)	Beach	X	X	X	X	X	X
	Cliff		X	/	/	/	/
	Marsh			X	X	X	X
Open Coast (swell-exposed)	Beach	X	X				
	Cliff/Rocky Nearshore	/	X				
	River Mouth		X				
	Lagoon Estuary	X	X	X	X	X	X

Source: Toward Natural Shoreline Infrastructure to Manage Coastal Change in California (Newkirk et al, 2018)

Concept of Natural Shoreline Infrastructure

3.6 Native Oyster Reef



Source: Toward Natural Shoreline Infrastructure to Manage Coastal Change in California (Newkirk et al, 2018)

Concept of Natural Shoreline Infrastructure

3.5 Tidal Benches

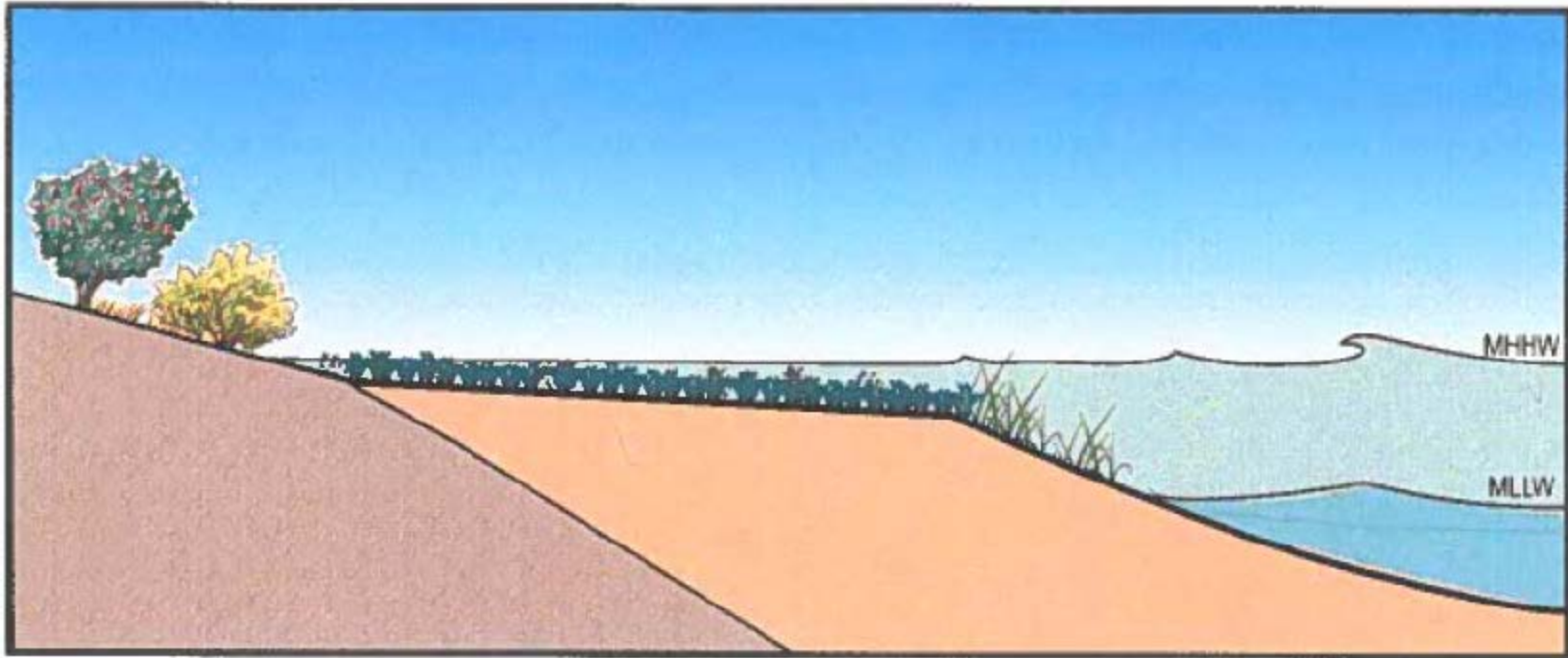


Figure 10. Profile view of tidal bench in estuarine environment (MHHW means mean higher high water, and MLLW means mean lower low water).

Source: Toward Natural Shoreline Infrastructure to Manage Coastal Change in California (Newkirk et al, 2018)

Concept of Natural Shoreline Infrastructure

3.4 Marsh Sills

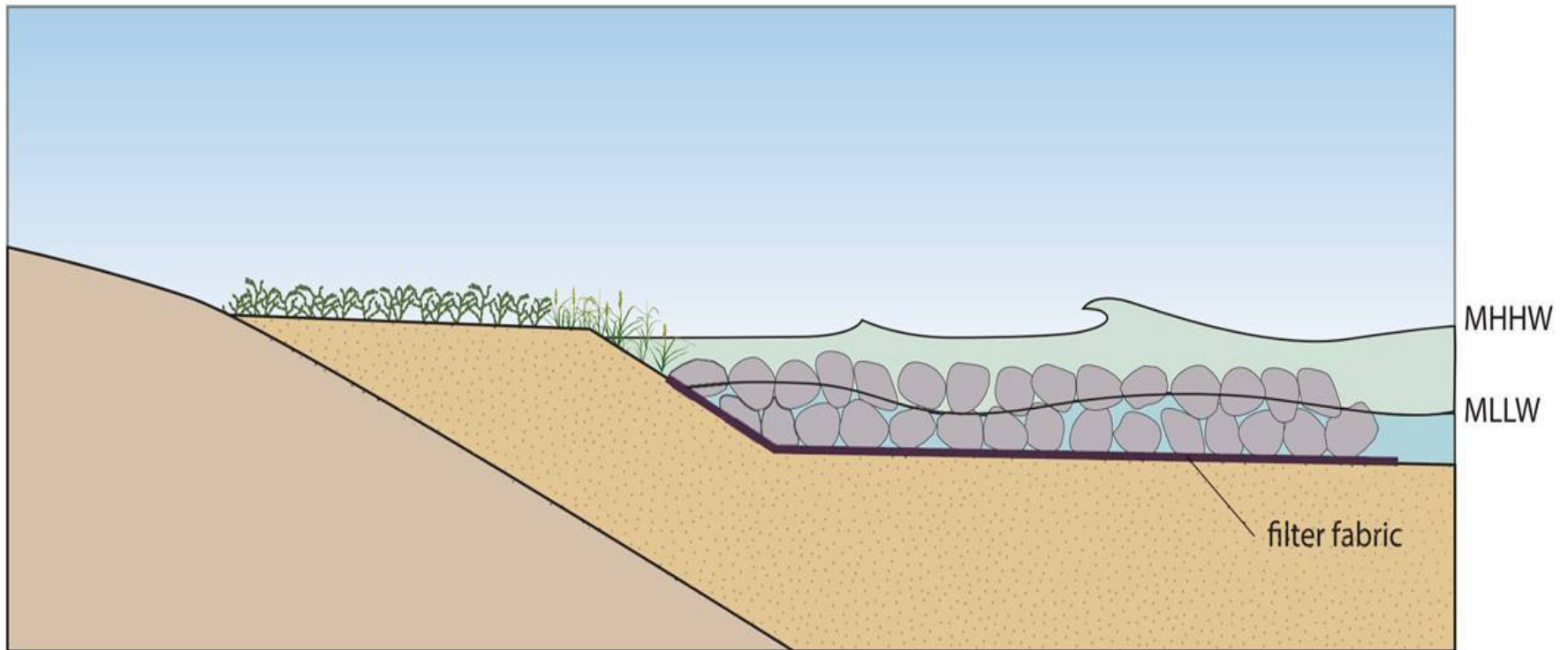


Figure 8. Section view of marsh sill in estuarine environment

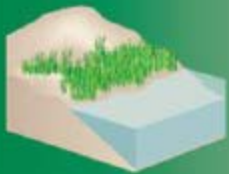
Source: Toward Natural Shoreline Infrastructure to Manage Coastal Change in California (Newkirk et al, 2018)

Concept of Natural Shoreline Infrastructure

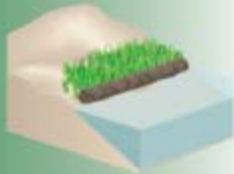
GREEN - SOFTER TECHNIQUES

GRAY - HARDER TECHNIQUES

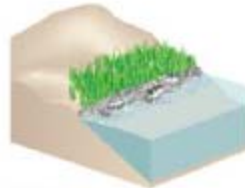
Living Shorelines



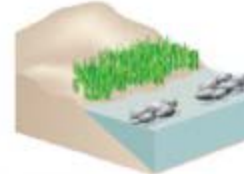
VEGETATION ONLY -
Provides a buffer to upland areas and breaks small waves. Suitable for low wave energy environments.



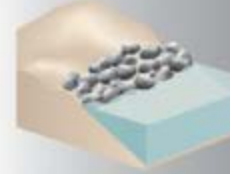
EDGING -
Added structure holds the toe of existing or vegetated slope in place. Suitable for most areas except high wave energy environments.



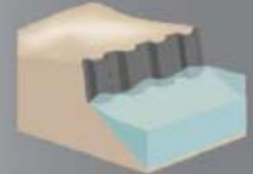
SILLS -
Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.



BREAKWATER -
(vegetation optional) - Offshore structures intended to break waves, reducing the force of wave action, and encourage sediment accretion. Suitable for most areas.



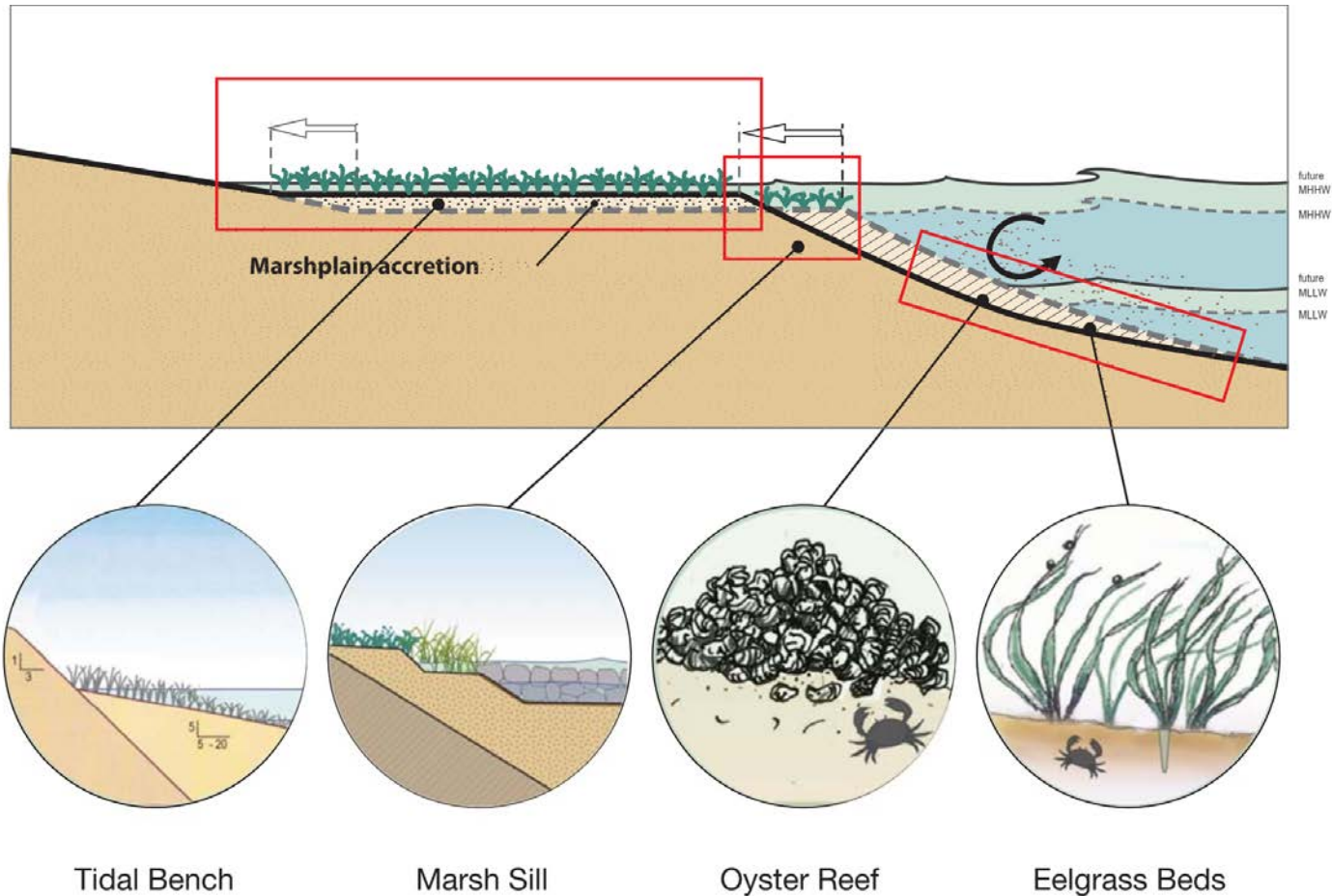
REVETMENT -
Lays over the slope of the shoreline and protects it from erosion and waves. Suitable for sites with existing hardened shoreline structures.



BULKHEAD -
Vertical wall parallel to the shoreline intended to hold soil in place. Suitable for high energy settings and sites with existing hard shoreline structures.

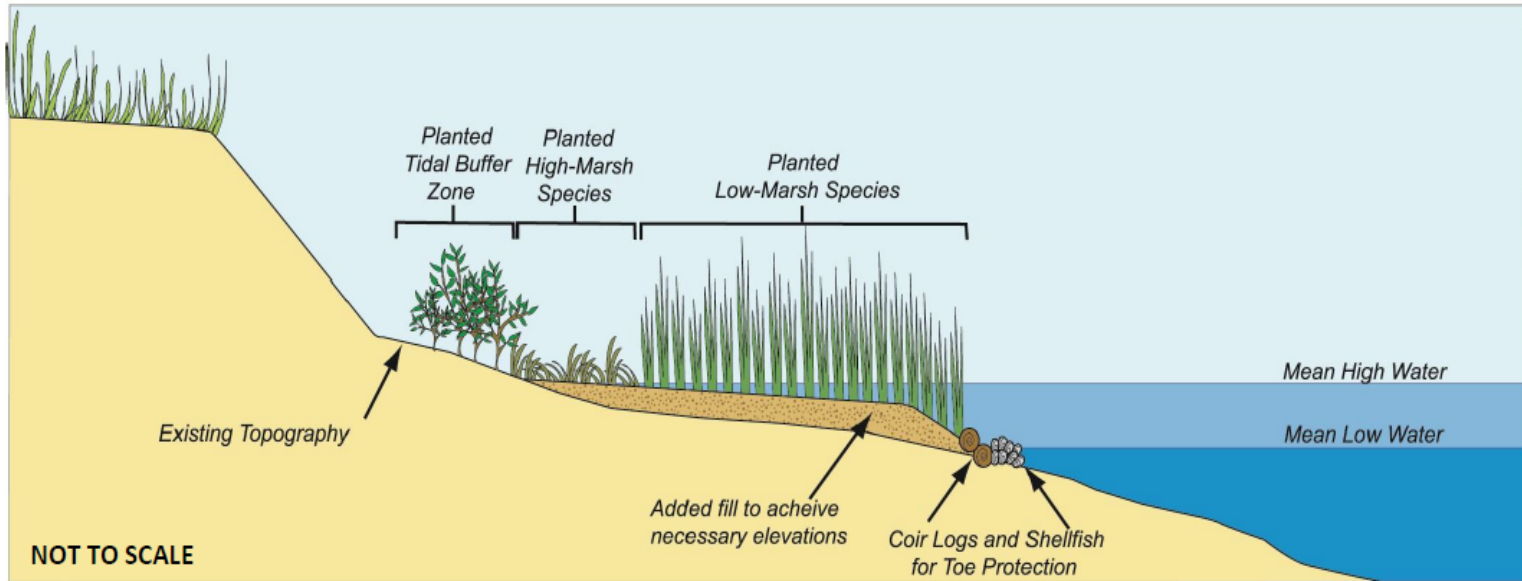
Source: Guidance for Considering the Use of Living Shorelines (NOAA, 2015)

Concept of Natural Shoreline Infrastructure



Source: ESA, TNC, Point Blue

Concept of Natural Shoreline Infrastructure



Source: Living Shorelines in New England: State of the Practice (Woods Hole Group, 2017)

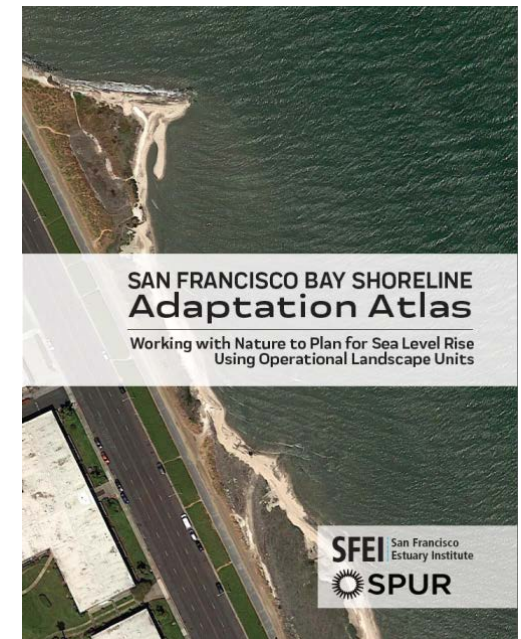
Concept of Natural Shoreline Infrastructure

Arcata Marsh & Wildlife Sanctuary



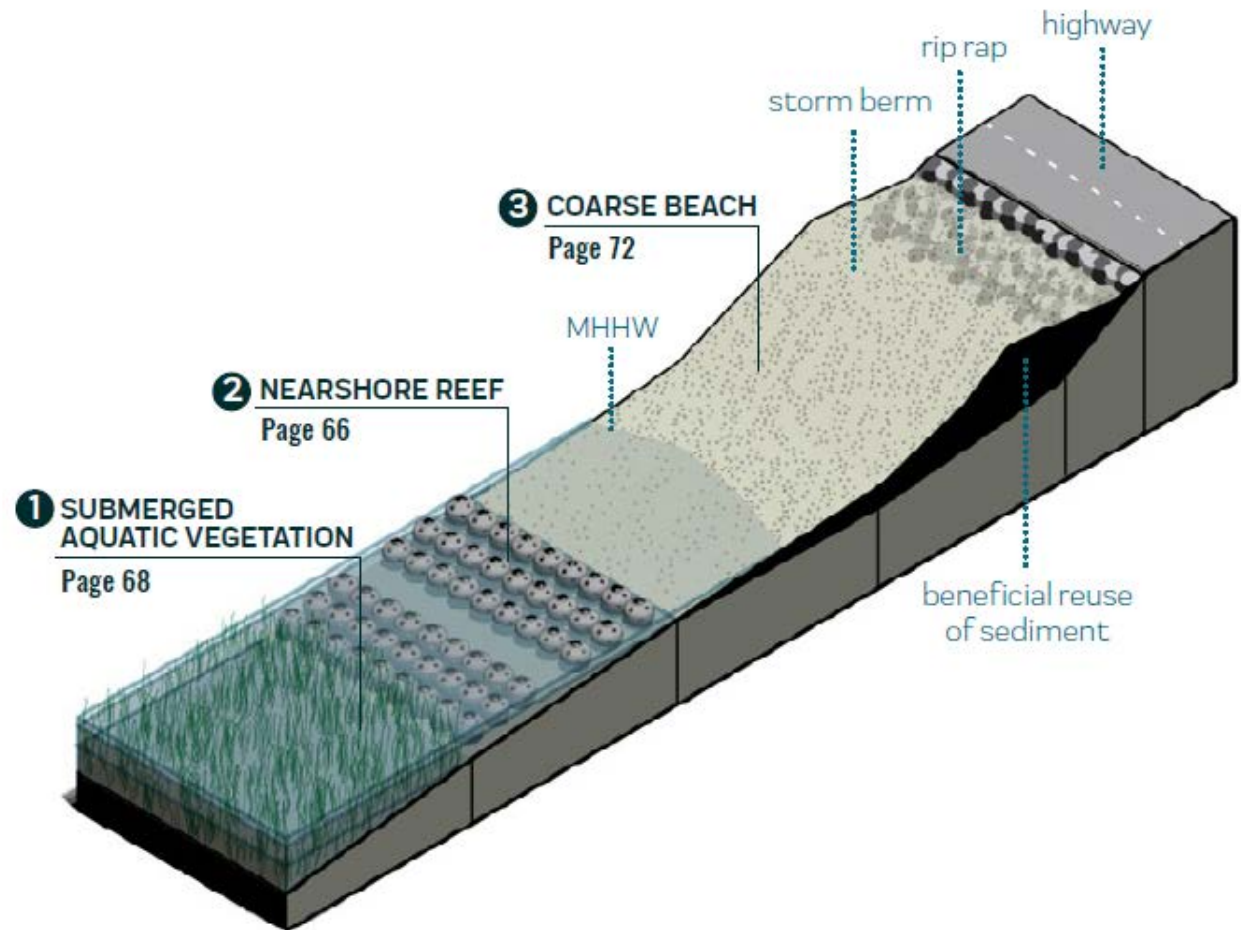
Concept of Natural Shoreline Infrastructure

Class	Category	Adaptation measures
Structural	Natural and nature-based measures	<ul style="list-style-type: none"> Nearshore reefs Submerged aquatic vegetation Mudflat augmentation Beaches Tidal marshes Polder management Ecotone levees Migration space preparation Creek-to-baylands reconnection Green stormwater infrastructure
	Conventional physical (grey) infrastructure	<ul style="list-style-type: none"> Super levees Elevate land Flood walls and berms Elevate or realign transportation Seawalls Bulkheads Revetments and riprap Levees and dikes
Non-structural	Policy and regulatory measures	<ul style="list-style-type: none"> Zoning and overlay zones Setbacks, buffers, and clustering Building codes and building retrofits Rebuilding and redevelopment restrictions
	Financial measures	<ul style="list-style-type: none"> Conservation easements Tax incentives and special assessments Geologic Hazard Abatement Districts (GHAD) Transfer of Development Rights (TDR) Buyouts



Concept of Natural Shoreline Infrastructure

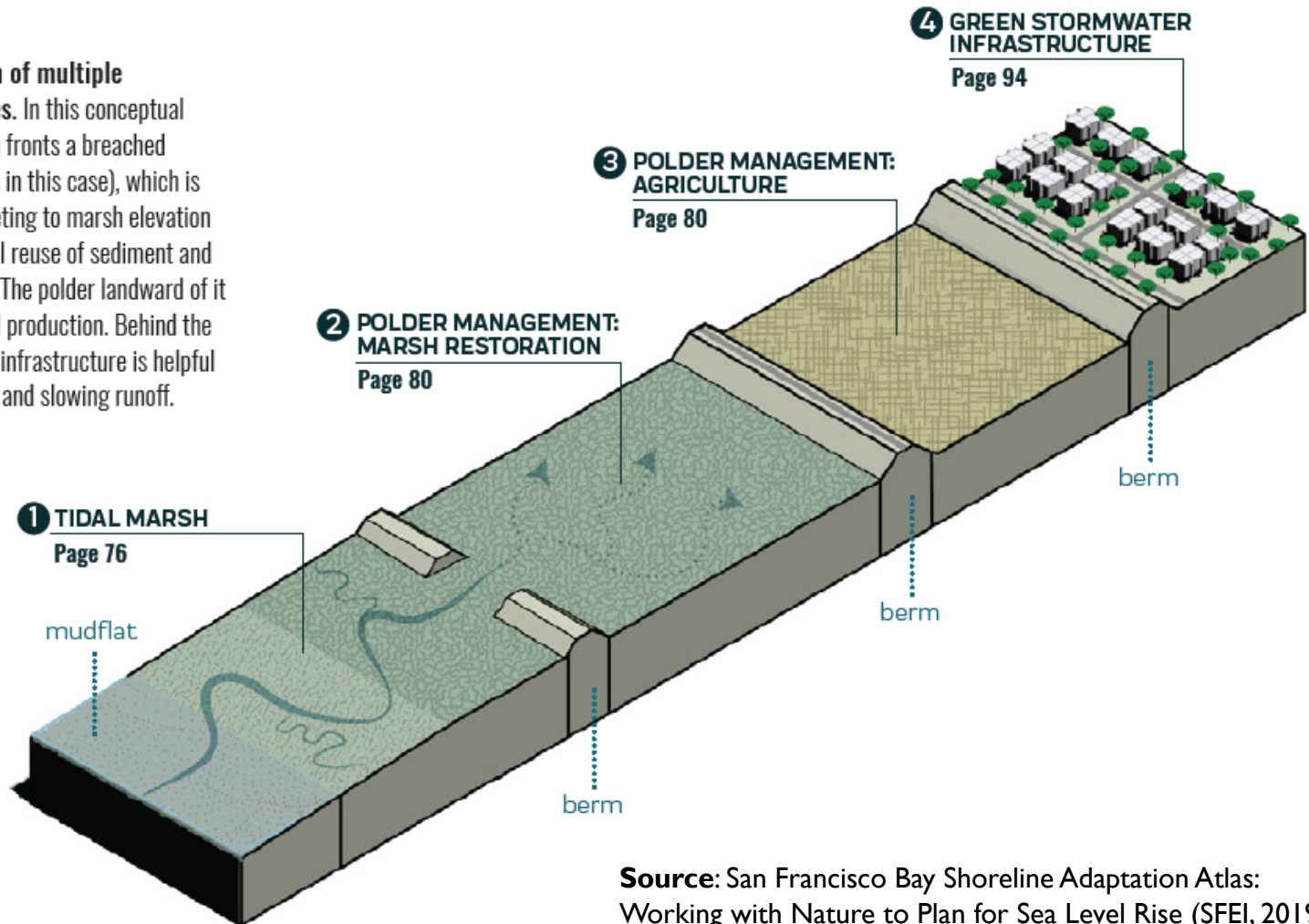
Combining multiple measures into a cohesive strategy. In this conceptual example, submerged aquatic vegetation, a nearshore reef, and coarse beach provide protection to each-other and a highway.



Source: San Francisco Bay Shoreline Adaptation Atlas: Working with Nature to Plan for Sea Level Rise (SFEI, 2019)

Concept of Natural Shoreline Infrastructure

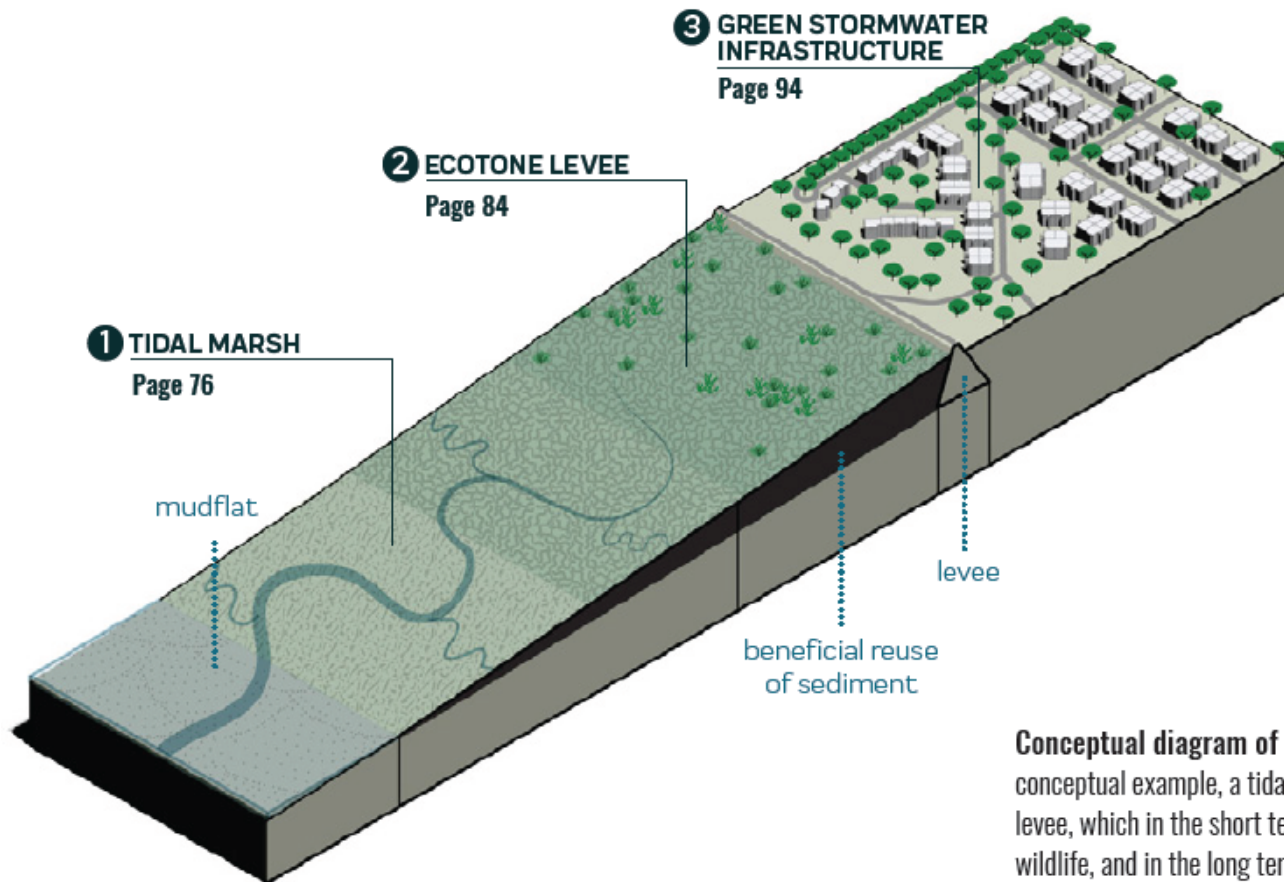
Conceptual diagram of multiple adaptation measures. In this conceptual example, a tidal marsh fronts a breached polder (diked baylands in this case), which is in the process of accreting to marsh elevation both through beneficial reuse of sediment and increased tidal action. The polder landward of it remains in agricultural production. Behind the flood risk levee, green infrastructure is helpful for spreading, sinking, and slowing runoff.



Source: San Francisco Bay Shoreline Adaptation Atlas: Working with Nature to Plan for Sea Level Rise (SFEI, 2019)



Concept of Natural Shoreline Infrastructure



Source: San Francisco Bay Shoreline Adaptation Atlas:
Working with Nature to Plan for Sea Level Rise (SFEI, 2019)

Conceptual diagram of multiple adaptation measures. In this conceptual example, a tidal marsh fronts a gently sloping ecotone levee, which in the short term provides high-tide refuge for marsh wildlife, and in the long term provides space for marsh migration. Behind the flood risk levee at the back of the ecotone levee, green infrastructure is helpful for spreading, sinking runoff, and lowering peak flows.

Scope of Work

Task 1: Grant Administration / Project Management

Task 2: Stakeholder Engagement and Consultation

Task 3: Site Assessment

3.1 – Topographic and bathymetric survey

3.2 – Sediment characterization

3.3 – Habitat evaluation and vegetation mapping

3.4 – Geomorphic evaluation

3.5 – Hydraulic analysis

Scope of Work

Task 4: Preliminary Design

- 4.1 – Goals and objectives
- 4.2 – Options evaluation
- 4.3 – Engineering design
- 4.4 – Re-vegetation plan
- 4.5 – Access and staging plan
- 4.6 – Monitoring plan
- 4.7 – Habitat effects analysis

Task 5: Reporting

Timeline

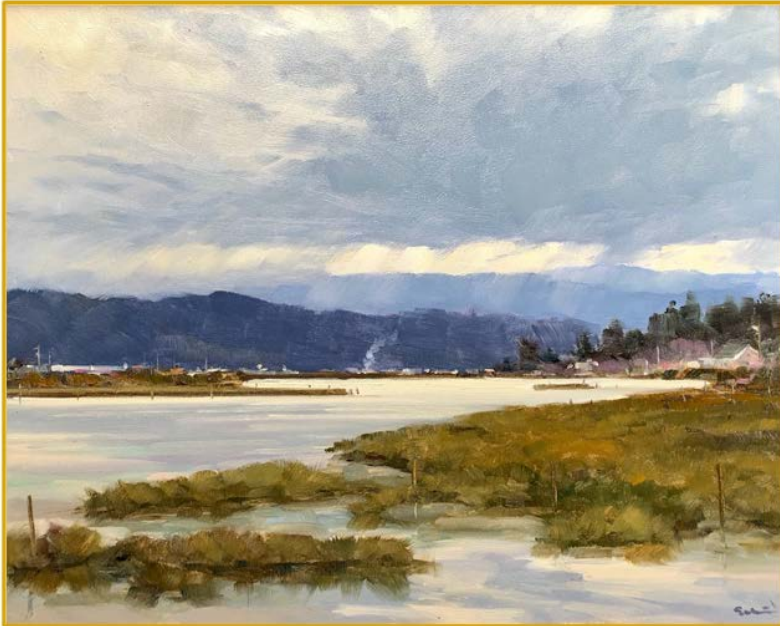
Date	Key Milestones
July-September 2020	<ul style="list-style-type: none">• Initiate site assessment and preliminary design tasks• Technical working group meetings #1 and #2
October-December 2020	<ul style="list-style-type: none">• 10% design plans• Technical working group meeting #3
January-March 2021	<ul style="list-style-type: none">• 35% design plans• Technical working group meeting #4
April-June 2021	<ul style="list-style-type: none">• Technical working group meeting #5
July-September 2021	<ul style="list-style-type: none">• 50% design plans, supporting plans, Final Report• Technical working group meeting #6

Cultural Landscape Investigation (Rohde, 2020)

**Humboldt Bay Shoreline, North Eureka to South Arcata:
A History of Cultural Influences**

Prepared by Jerry Rohde, M.A.

June 2020



Eureka Slough, by Steak Schlueter

<https://humboldt.gov.org/2487/Sea-Level-Rise>



Project Area – 2018 (USDA-NAIP)



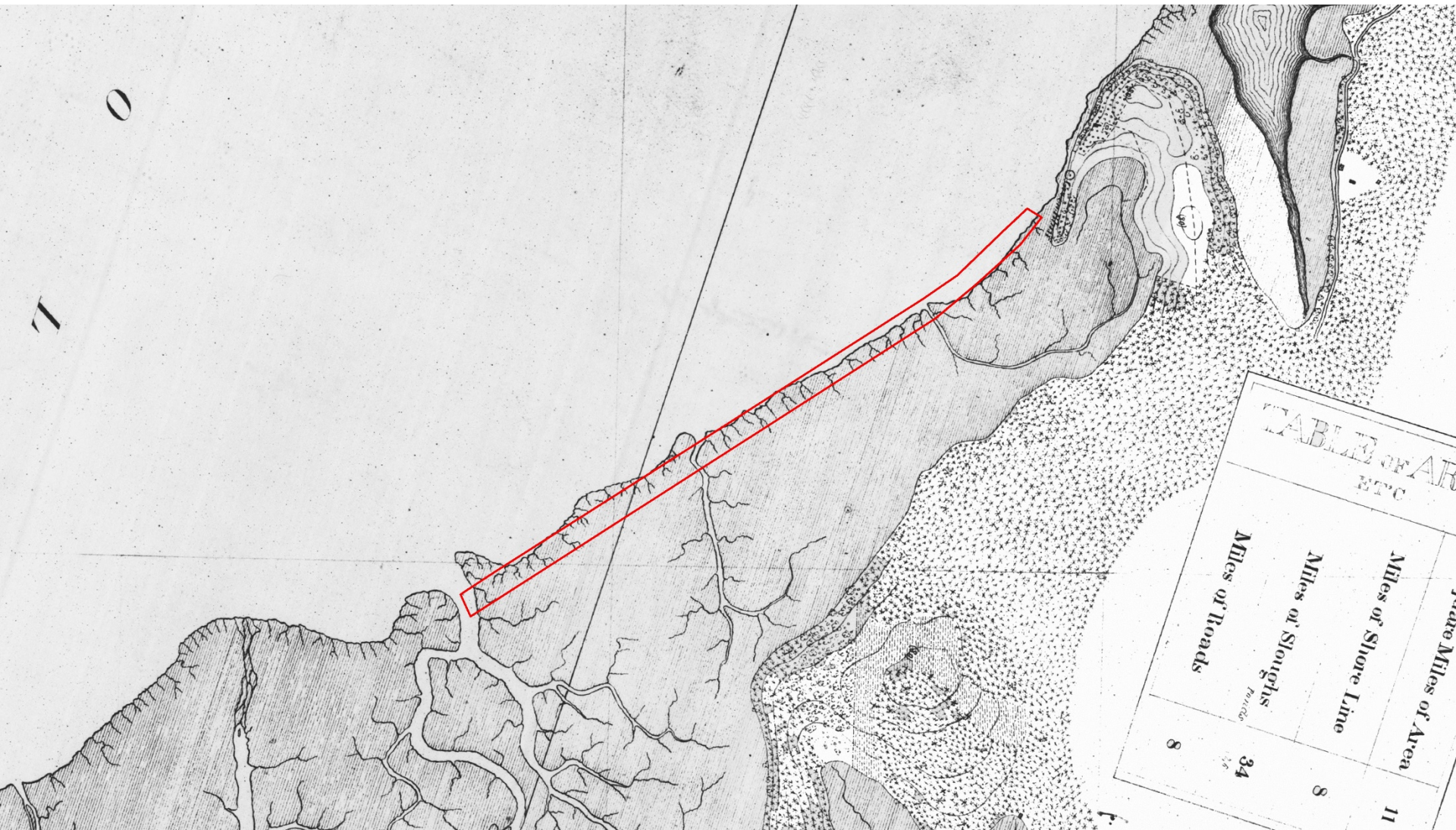
Project Area – 1870 (USCGS)



Project Area – 2018 (USDA-NAIP)




Project Area – 1870 (USCGS)




Role of Technical Working Group

- ▶ Participate in six meetings
- ▶ Provide input on goals and objectives, approach and methods, design concepts and features
- ▶ Help understand context within Humboldt Bay
- ▶ Help identify important studies and reference sites and apply best available science
- ▶ Represent your agency's perspective and mission
- ▶ Technical assistance with site characterization (if possible)

Preliminary Reference List



Natural Shoreline Infrastructure in Humboldt Bay
for Intertidal Coastal Marsh Restoration and
Transportation Corridor Protection



Reference List
July 16, 2020
(work in progress)

Humboldt Bay (tidal wetlands, sediment, hydrodynamics)

Barnhart, Roger A., Milton J. Boyd, and John E. Pequegnat, January 1992. The Ecology of Humboldt Bay, California: An Estuarine Profile. U.S. Fish and Wildlife Service Biological Report.
<http://nps.history.com/publications/usfws/biological-reports/1.pdf>

California Coastal Sediment Management Workgroup, August 2017, Coastal Regional Sediment Management Plan for the Eureka Littoral Cell, California, prepared for U.S. Army Corps of Engineers, August 2017.
https://humboldt.gov/sites/humboldt.gov/files/documents/ELC%20CRSMP%20clean%20draft%2020170510_reduced.pdf

Crawford & Associates, 2019, Geotechnical Report for Humboldt Bay Trail South, Eureka, California, prepared for GHD, June 2019.
<https://humboldt.gov/DocumentCenter/View/87780/HBTS-Final-Geotechnical-Report-20190614>

Curtis, J.A., Freeman, C. and Thorne, K.M., 2019, Early results – salt marsh response to changing fine sediment supply conditions, Humboldt Bay, CA, in SEDHYD 2019.
https://www.sedhyd.org/2019/openconf/modules/request.php?module=oc_proceedings&action=view.php&id=80&file=1/80.pdf&a=Accept

Curtis, J.A., Flint, L.E., Stern, M.A., Lewis, J., and Klein, R.D. (in review) Amplified impacts of climate change on fine-sediment delivery from fluvial sources and implications for building ecosystem-based resiliency to sea-level rise, Humboldt Bay, California, submitted to Estuaries and Coasts.

Eicher, A., 1987, Salt marsh Vascular Plant Distribution in Relation to Tidal Elevation, Humboldt Bay, California, a thesis presented to the faculty of Humboldt State University, May 1987.
https://www.fws.gov/uploadedFiles/Region_8/NWRS/Zone_1/Humboldt_Bay_Complex/Humboldt_Bay/Sections/Documents/Eicher1987.pdf

FEMA, 2014, Intermediate Data Submittal #3: Nearshore Hydraulics Humboldt County, California, BakerAECOM.
<https://humboldt.gov/DocumentCenter/View/70093/FEMA-Open-Pacific-Coast-Study--Nearshore-Hydraulics>

GHD, 2019, Vegetation Mapping and Environmentally Sensitive Habitat Screening for Humboldt Bay Trail South, Eureka, California. November 2017.

H.T. Harvey & Associates and Winzler & Kelly (GHD), 2012, Humboldt Bay Regional *Spartina* Eradication Plan, November 14, 2012.
http://humboldt.gov/sites/humboldt.gov/files/HB_Invasive_Spartina_Eradication_Plan.pdf

July 16, 2020 Page 1 Work in Progress

<https://humboldt.gov/2487/Sea-Level-Rise>

DISCUSSION

Discussion

1. What are the key questions this project needs to address?
2. What studies, projects, or reference sites have important information or learning opportunities?
3. What are important papers to add to the reference list?
4. How can we help the Technical Working Group be most effective?

Wrap Up / Next Steps /
Set Date for Meeting #2

