



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

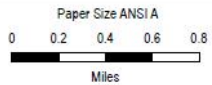
Technical Working Group Meeting #5
March 18, 2022



NFWF



OCEAN
PROTECTION
COUNCIL



Humboldt County Department of Public Works
Humboldt Bay Natural Shoreline Infrastructure

Project No. 11214987
Revision No. -
Date Dec 2020

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California I FIPS 0401 Feet

Project and Reference Areas

FIGURE X

Scope of Work

Tasks

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

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 (Updated)

Date	Key Milestones
August 3, 2020	<ul style="list-style-type: none">• Technical working group meeting #1 (introduction)
December 15, 2020	<ul style="list-style-type: none">• Technical working group meeting #2 (update on site assessment)
May 6, 2021	<ul style="list-style-type: none">• Technical working group meeting #3 (draft goals and design options)
May 31, 2021	<ul style="list-style-type: none">• Due date for receiving written comments on goals/objectives and preliminary design options
September 29, 2021	<ul style="list-style-type: none">• Release draft report for site assessment and design options
October 12, 2021	<ul style="list-style-type: none">• Technical working group meeting #4 (select apparent best option)
November 2021	<ul style="list-style-type: none">• Site Visit (November 2nd)• Received Comments on Draft Existing Condition Report
February/March 2022	<ul style="list-style-type: none">• Respond to Comments on Draft Existing Condition Report
March 18, 2022	<ul style="list-style-type: none">• Technical working group meeting #5 (35% Design Progress Update)
May/June 2022	<ul style="list-style-type: none">• Technical working group meeting #6 (50% Design Progress Update)
June 30, 2022	<ul style="list-style-type: none">• Project Completion (Technical working group meeting #7?)

Presentation Overview

1. **Re-cap Site and Alternative Assessment**
 - a) Site and Geomorphic Assessment (Task 3)
 - b) Goals & Objectives (Task 4.1)
 - c) Alternative Development and Selection (Task 4.2)
2. **35% Design Development (Task 4.3-Task 4.5)**
 - a) Salt Marsh and Shoreline Geometry
 - i. Salt Marsh Analogs
 - ii. Wind Wave Analyses
 - b) 35% Design Components
 - c) Construction Phasing
 - d) Construction Cost
3. **Discussion and Next Steps**
 - a) 50% Design and Re-vegetation Plans
 - b) Monitoring Plan
 - c) Habitat Conversion and Effects Analyses

Re-cap of Site Assessments



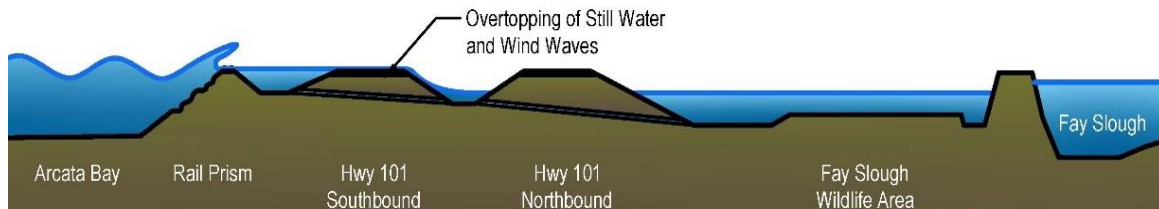
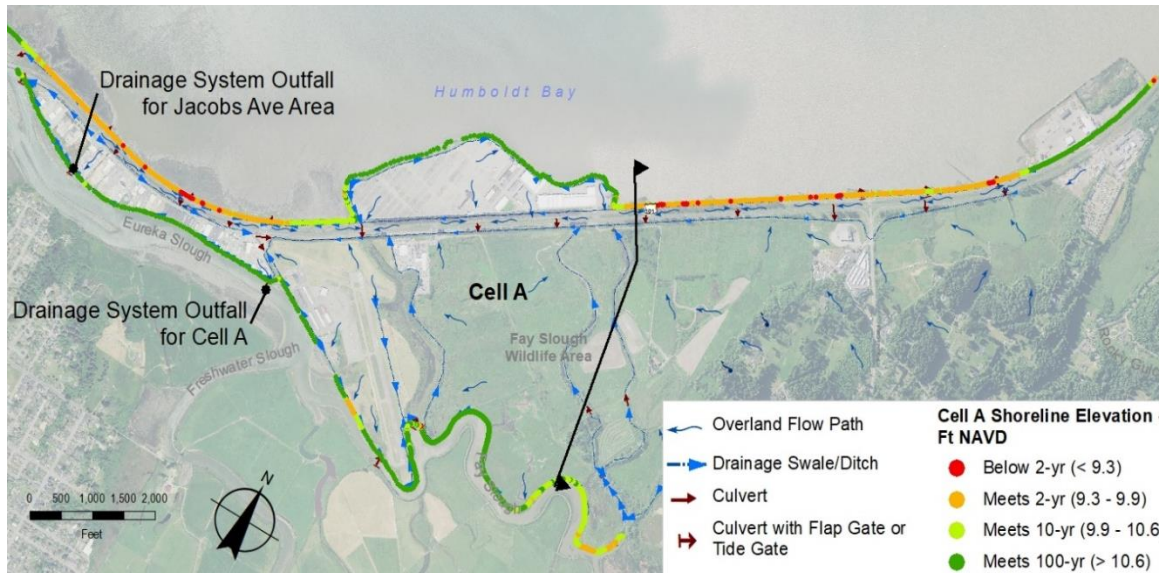
Key Questions:

1. What are the key physical drivers and anthropogenic interventions that influence physical processes along the eastern shoreline of Arcata Bay?
2. Which drivers and processes have attributed to the loss or gain of salt marsh in the project area?
3. Based on these drivers and processes, what potential natural shoreline infrastructure measures could be implemented to achieve the project goals and restore a resilient salt marsh at the project area?



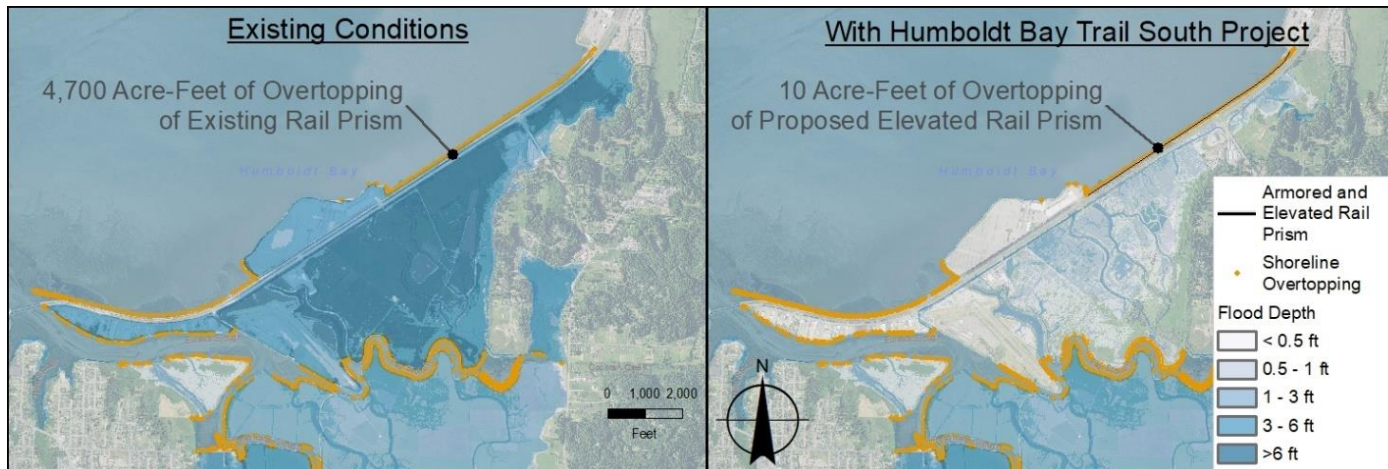
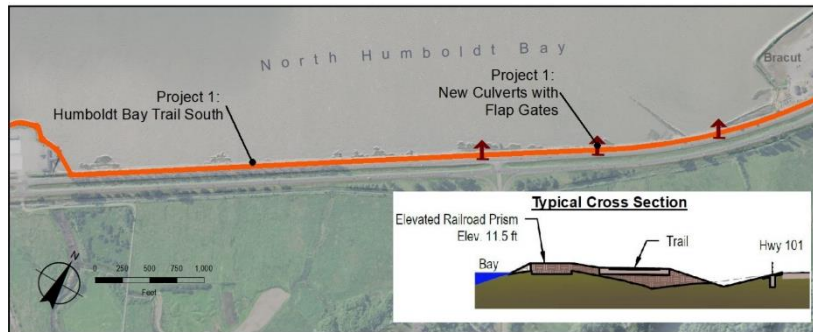
Key Findings:

- The Project shoreline has a high vulnerability to coastal flooding and erosion relative to the balance of shoreline which protects landward critical resources.



Key Findings:

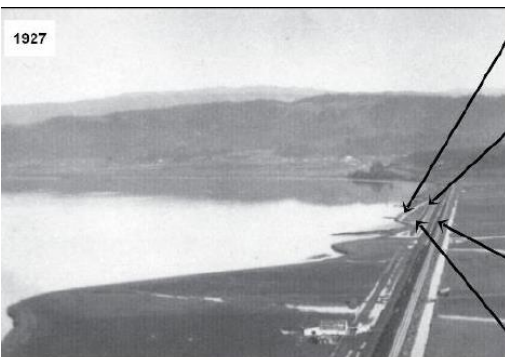
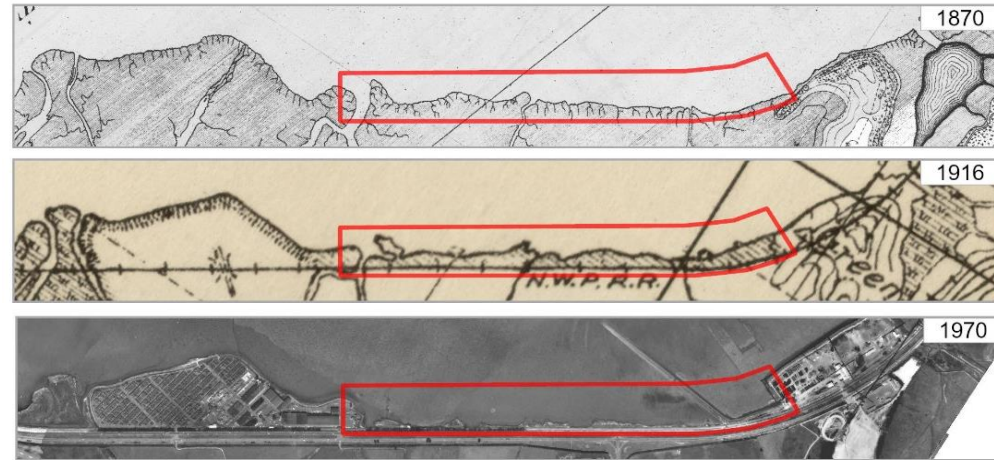
- Humboldt Bay Trail South Project will elevate the existing rail prism from ~9.5ft to 11ft elevation, reducing overtopping frequency, however the shoreline will remain vulnerable to wind-wave erosion and overtopping in areas absent of salt marsh.



Key Findings:

➤ Multiple anthropogenic interventions have disrupted natural shoreline processes:

- ✓ 1896 - Shoreline diked/dredged
- ✓ 1900 - Two rail prisms constructed
- ✓ 1960 - Dike "finger" constructed

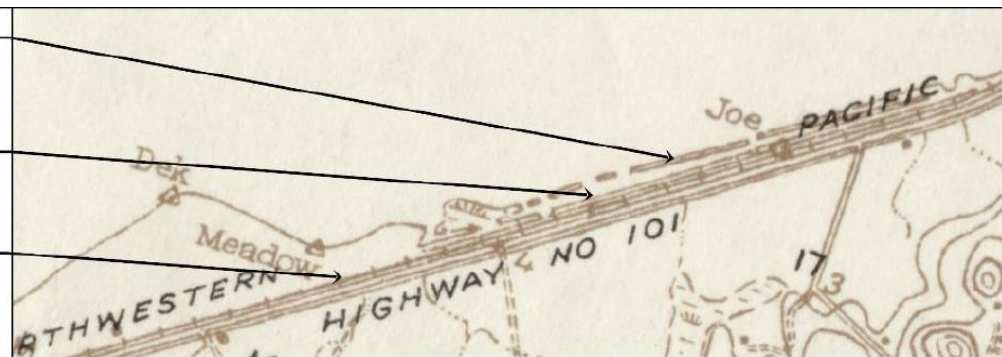


Remnant levee at former marsh edge with discontinuous segments (Constructed 1896-1898)

Incomplete E&KRR Rail Prism (Constructed 1900-1901 between Arcata-Eureka but no tracks laid)

C&N (NWP) Rail Prism with Tracks (Constructed 1900-1901)

Salt Marsh between leveed and E&KRR

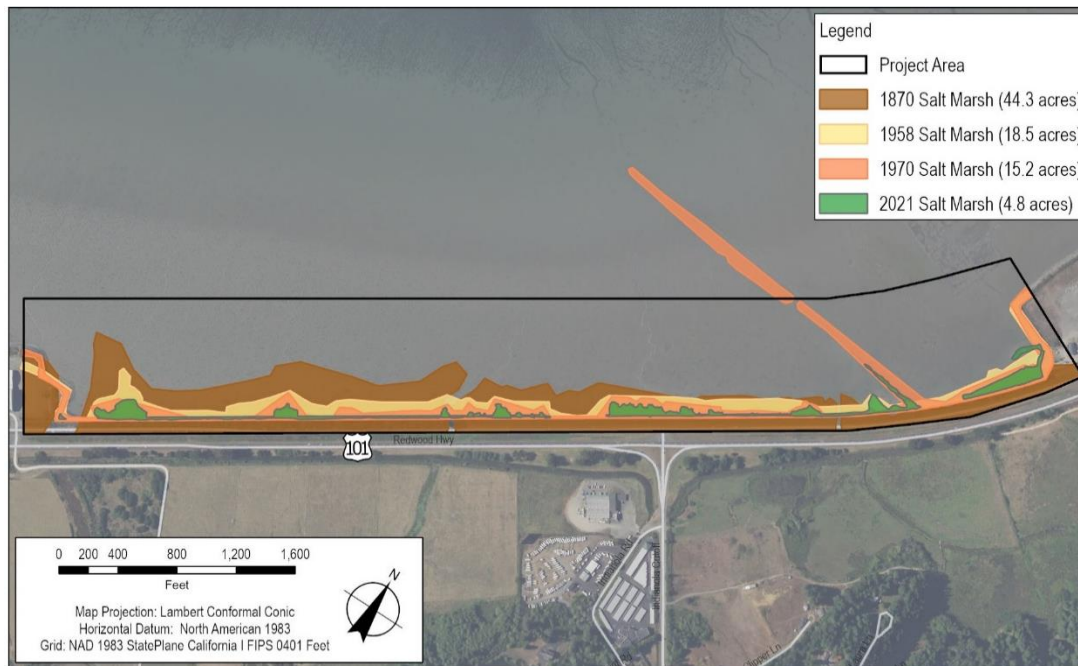


Source: Kerry Kiltum



Key Findings:

- A total of 90% of the pre-disturbance salt marsh has been lost within the project area. While most of the remaining salt marsh is dominated by invasive *Spartina densiflora*, rare salt marsh plants have been observed.



Key Findings:

- Marsh expansion and accretion through natural processes has occurred in isolated areas following 1950's suggesting availability of suspended sediment delivered to depositional areas.

1947



Present

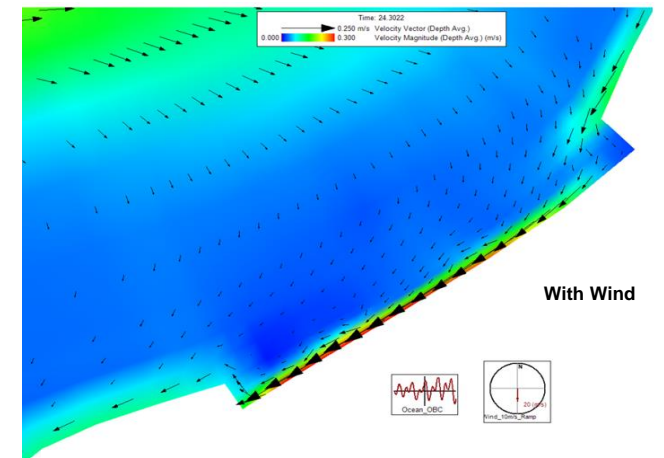
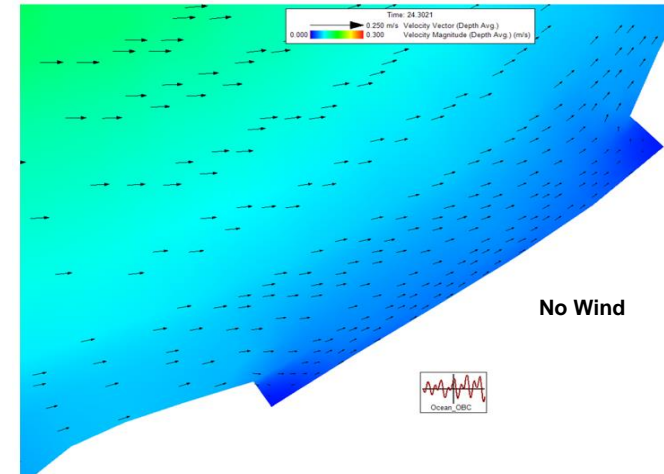
Key Findings:

- Marsh edge morphology in the project area primarily consists of scarps indicating a marsh edge subjected to wave driven erosion.
- Sands and gravels exist from rail prism erosion and have been transported short distances along-shore (south) and have been retained by the fringe marsh



Key Findings:

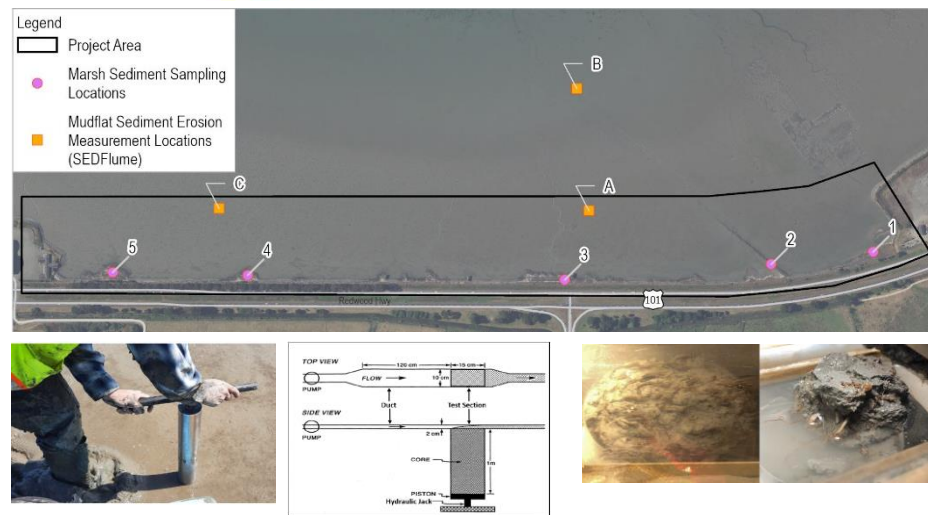
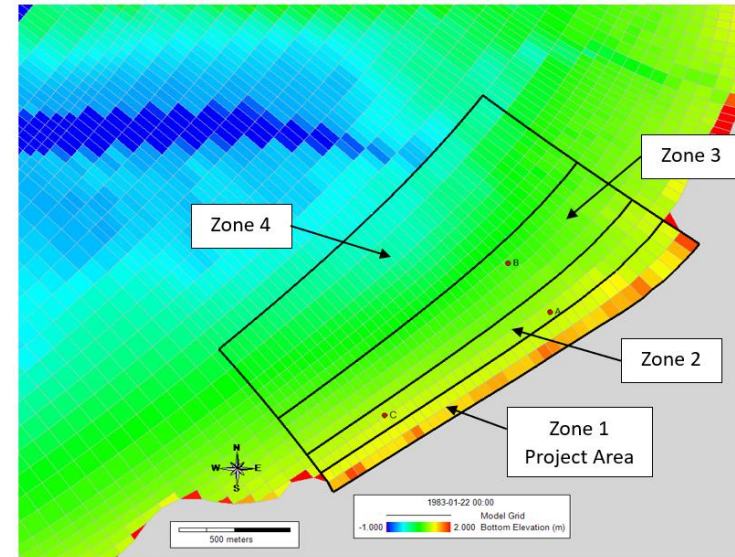
- Wind-generated waves can alter circulation patterns, tidal currents, and increase velocity along the project shoreline. Depositional patterns of gravels and the gravel shoreline sourced from the rail prism erosion corroborate the model results showing an increase in velocity and shear stresses from the dominate north-northwest wind direction resulting in a north-south circulation pattern.



Velocity vectors (magnitude and direction) of tidal currents predicted during a 2-year flood tide along the project shoreline without wind (left), and tidal and wave induced currents from a 22-mph northwest wind (right)

Key Findings:

- The erosion/deposition potential analysis demonstrated that tidal-induced currents alone can erode sediment from deeper water areas (Zones 3 and 4), but in general the total stresses and the potential for erosion is low.
- Wave-induced stresses from NNW and S winds generate total stresses high enough to erode sediment from all zones, demonstrating that wind-waves are the likely dominate driver for mudflat erosion and deposition in the project area.
- Model results indicate that the nearshore zone (Zone 1) has the largest range of total stresses. During wind-wave events the potential exists for sediment to be eroded from offshore mudflat areas and transported to the NSI project area where deposition could occur due to a wider range and lower total stresses.



Key Findings:

- Accretion rates and chronological dating have not been measured in the project area marshes but have in other Arcata Bay marshes including Jacoby Creek marsh (Curtis et al., 2019 and Brown 2019). Recent measured accretion rates appear to be lower than relative sea level rise (Curtis et al., 2019) however historic measured accretion rates appear to have kept pace or slightly greater than relative sea level rise (Brown, 2019).
- Sediment deposition on existing marsh surfaces is evident from high marsh elevations and emphasizes important role of wind waves for transporting sediment from the mudflat onto the marsh surface.
- Ability for marsh to trap sediment is hindered by narrow width and exposure to harsh wind wave environment.
- Sediment delivery to Humboldt Bay is estimated to increase over time with climate change (Curtis et al., 2021), and while sediment distribution patterns in Arcata Bay are not well studied, depositional areas may accrete in conjunction with sea level rise.



Re-cap Goals & Objectives

Goals and Objectives

The fundamental concept of the project is to integrate the natural flood-risk reduction properties of salt marsh into the shoreline management strategy for the Eureka-Arcata Highway 101 transportation corridor in an area where salt marsh was historically abundant but currently exists only in small, isolated patches.

Goal 1: Restore and enhance intertidal coastal marsh habitat

Goal 2: Protect transportation infrastructure

Goal 3: Create opportunities for innovation and learning

Goal 1: Restore and enhance intertidal coastal marsh habitat

▶ Objectives:

1. Provide a tidal ecotone extending from intertidal mudflat through low, middle, and high marsh to the upland transition zone.
2. Increase salt marsh area.
3. Increase habitat for native salt marsh plant communities and rare plant species.
4. Avoid infestation by the invasive dense-flowered chordgrass (*Spartina densiflora*).
5. Create landforms that are in dynamic equilibrium with hydraulic and geomorphic processes under current conditions and projected future conditions.
6. Create conditions where vertical accretion of sediment keeps pace with relative sea level rise.
7. Provide elevation gradients that allow upward migration of salt marsh in response to sea level rise.
8. Provide a diversity of habitat forms that emulate natural systems.

Goal 2: Protect transportation infrastructure

▶ **Objectives:**

1. Prevent substantial erosion of the shoreline by reducing wave height and energy.
2. Reduce wave runup and overtopping onto the railroad, Humboldt Bay Trail, and Highway 101.

Goal 3: Create opportunities for innovation and learning

▶ **Objectives:**

1. Serve as a demonstration project for natural shoreline infrastructure and nature-based sea level rise adaptation strategies within Humboldt Bay.
2. Explore the feasibility of beneficial reuse of dredged sediment.
3. Collect and publish monitoring data.

Re-cap Selection of Apparent Best Alternative



Alternative Development and Evaluation- Preliminary Design Criteria for a Resilient Marsh

Marsh Geometry

1. Sufficient width and elevation to dissipate wave energy and promote colonization of native marsh species.
2. Sufficient width and transitional zone that enhance sediment trapping and promotes deposition.

Stability

3. Provide initial stabilization of marsh edge until marsh vegetation is established.
4. Reduce susceptibility of long-term marsh edge erosion to wave energy.
5. Minimize lateral marsh edge erosion from tidal and wind generated currents at the interface with existing Bracut (north) and Brainard (south) levee rock slope protection.

Tidal Channel Network

6. Restore tidal exchange, sediment delivery and improve marsh drainage.

Alternative Development and Evaluation

1. Horizontal Levee: Low, Mid, and High Salt Marsh Creation
2. Horizontal Levee: High Salt Marsh Creation with and without Armored Toe
3. Breakwater Reef with Passive and Active Salt Marsh Creation
4. Barrier Island Breakwater with Passive and Active Salt Marsh Creation
5. Groins with Passive and Active Salt Marsh Creation
6. Coarse Sediment Shore (sand/gravel/oyster hash)



Alternative Development and Evaluation- Apparent Best Alternative Considerations

▶ Considerations:

1. Goal of restoring/enhancing intertidal marsh habitat resilient to sea level rise and in equilibrium with hydraulic and geomorphic processes.
2. Goal of protecting infrastructure (Humboldt Bay Trail and Highway 101) from wind-wave runup and overtopping.
3. Input from Technical Working Group (TWG) about minimizing the use of shoreline hardening, particularly from rock slope protection.
4. Results and findings from the Geomorphic Assessment and Conceptual Model
5. Desire for beneficial re-use of dredge spoils
6. Ease of Permitting, Cost, Constructability, Phasing/Scalability
7. Others?

Apparent Best Alternative Components

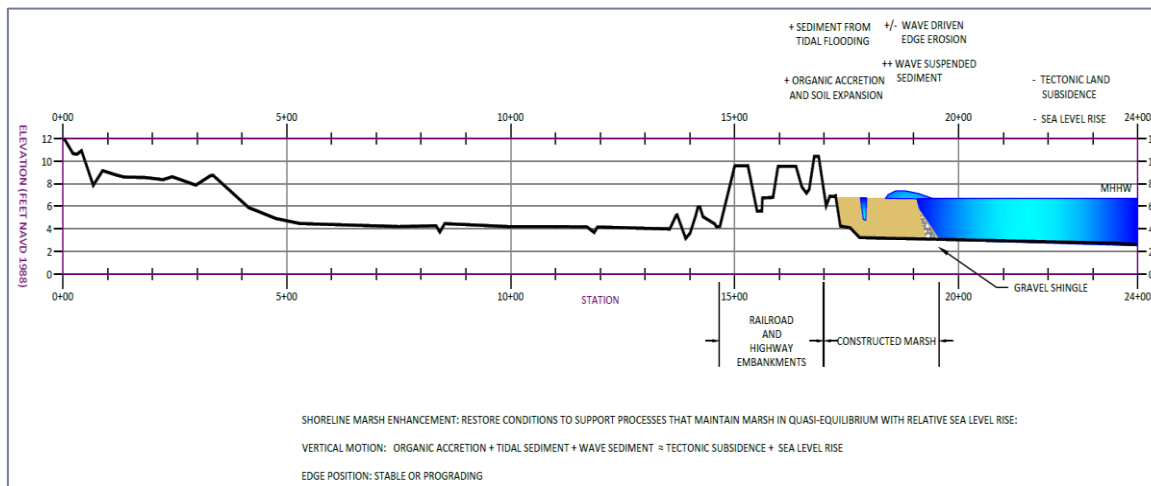
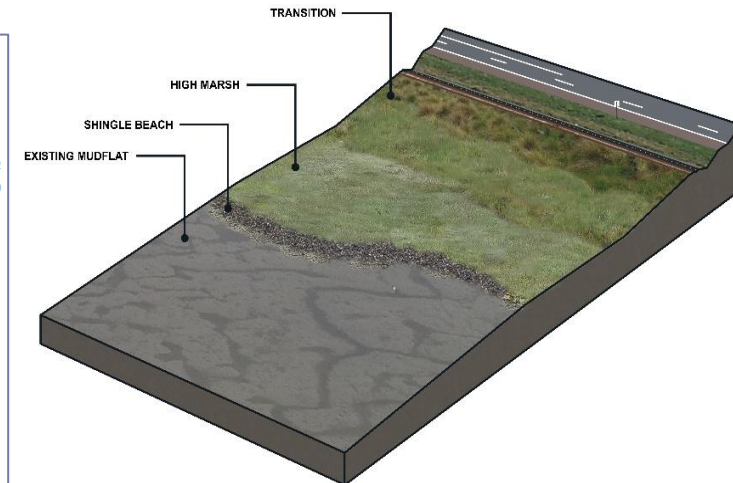
► Hybrid of Alternative 2 and 6

1. Salt Marsh with High Marsh Ecotone Transition Zone

- Promotes Sediment Trapping and Vertical Accretion
- Early Vegetation Colonization

2. Coarse Gravel Shingle/Barrier Beach

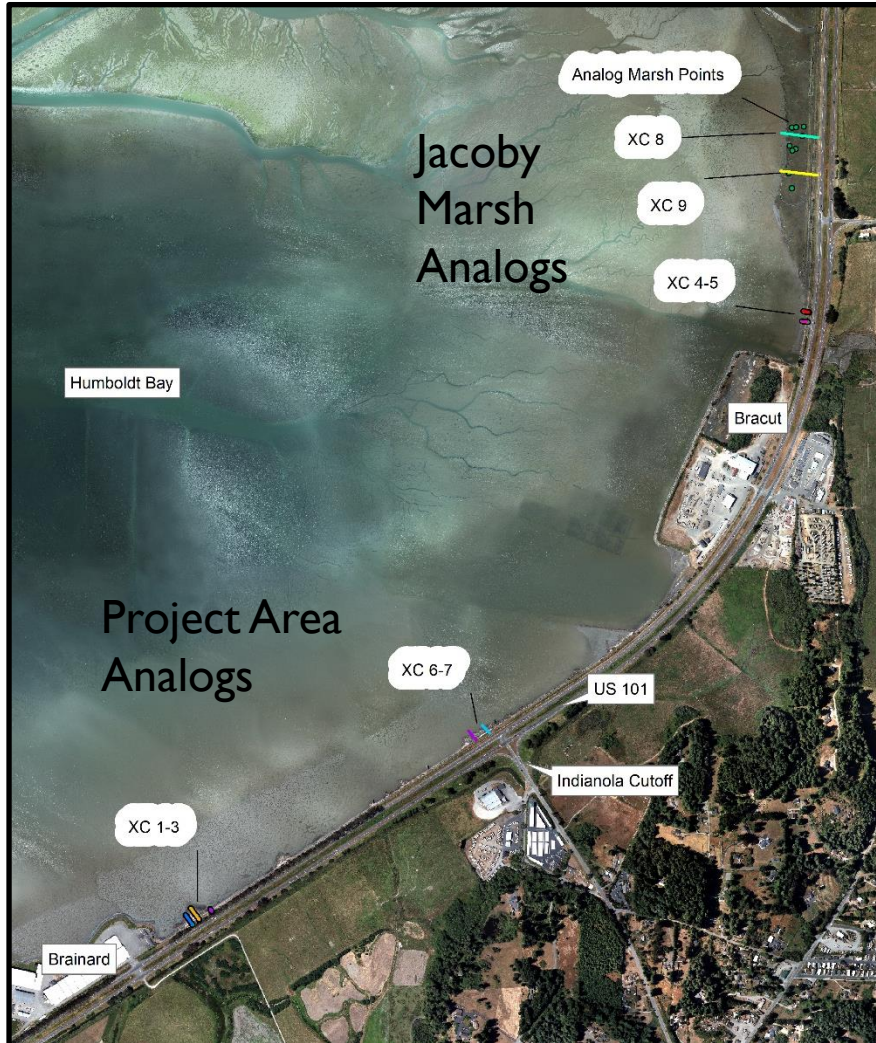
- Gradual Slope from Mudflat to Salt Marsh
- Dissipates Wave Energy to Accommodate Marsh Development



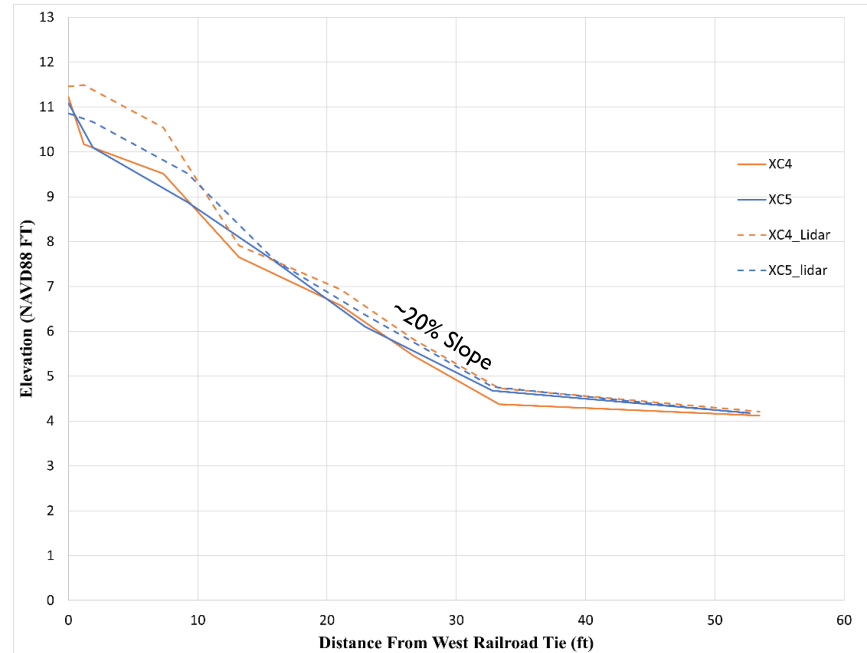
Basis for 35% Design

Design Criteria	Basis For Feature Design
<p>Marsh Geometry</p> <ol style="list-style-type: none"> Sufficient width and elevation to dissipate wave energy and promote colonization of native marsh species Sufficient width and transitional zone that enhance sediment trapping and promotes deposition. 	<p>Salt Marsh Plain</p> <ul style="list-style-type: none"> Elevation: MHHW, Analog Marsh (Project and Jacoby) Width: Support Tidal Channel System Wind Wave Model Results Analog Marsh
<p>Stability</p> <ol style="list-style-type: none"> Provide initial stabilization of marsh edge until marsh vegetation is established. Reduce susceptibility of long-term marsh edge erosion to wave energy. Minimize lateral marsh edge erosion from tidal and wind generated currents at the interface with existing Bracut (north) and Brainard (south) levee rock slope protection. 	<p>Barrier/Shingle Coarse Beach</p> <ul style="list-style-type: none"> Slope and Material Composition: Analog (Project Shoreline) <p>Transition Zone (High Marsh Ecotone)</p> <ul style="list-style-type: none"> Slope and Veg.: Analog (Project and Arcata I St Marsh)
<p>Tidal Channel Network</p> <ol style="list-style-type: none"> Restore tidal exchange, sediment delivery and improve marsh drainage. 	<p>Tidal Channels</p> <ul style="list-style-type: none"> Size and Planform: Analog (Jacoby Marsh) <p>Biotechnical Groins (LWD and/or Coarse Gravel/Cobble)</p> <ul style="list-style-type: none"> Retain beach material and stabilize tidal channel mouth

Basis for 35% Design: Analog Areas



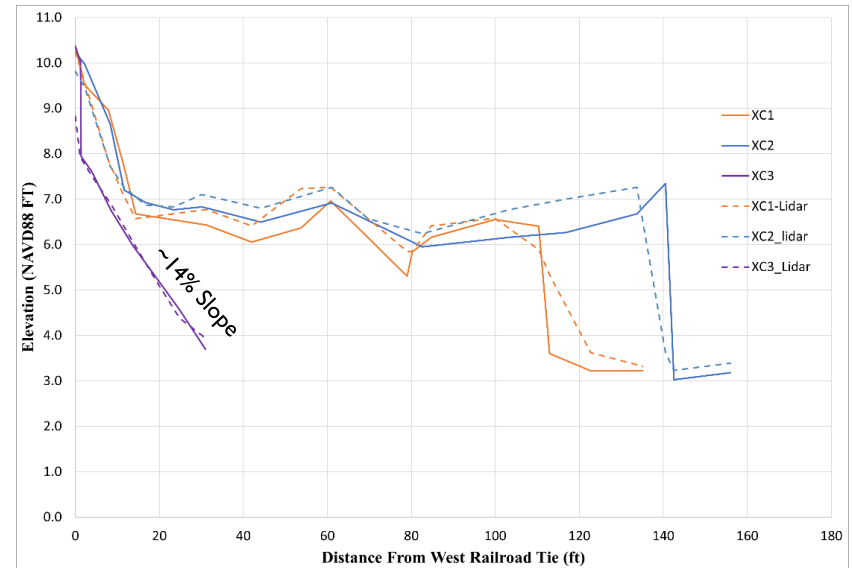
Basis for 35% Design: Barrier/Shingle Beach Jacoby Analog



- ✓ 15-20% Slope
- ✓ Gravels and Cobbles



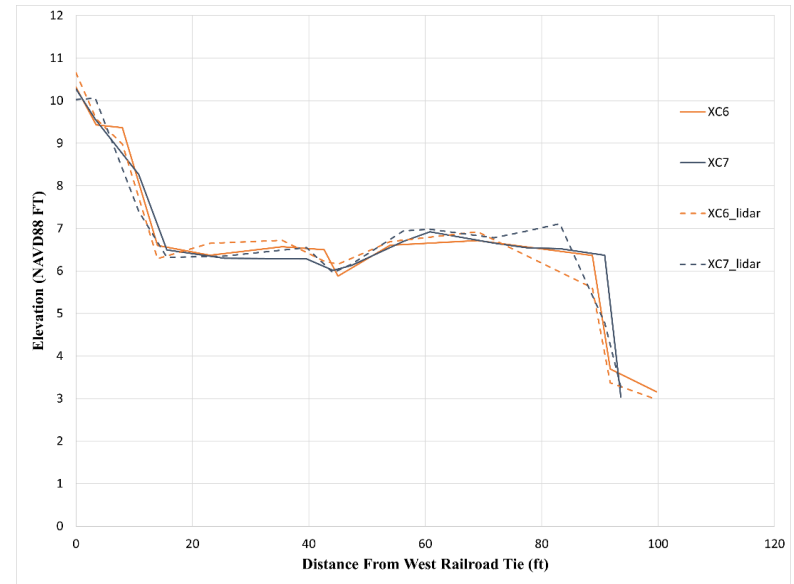
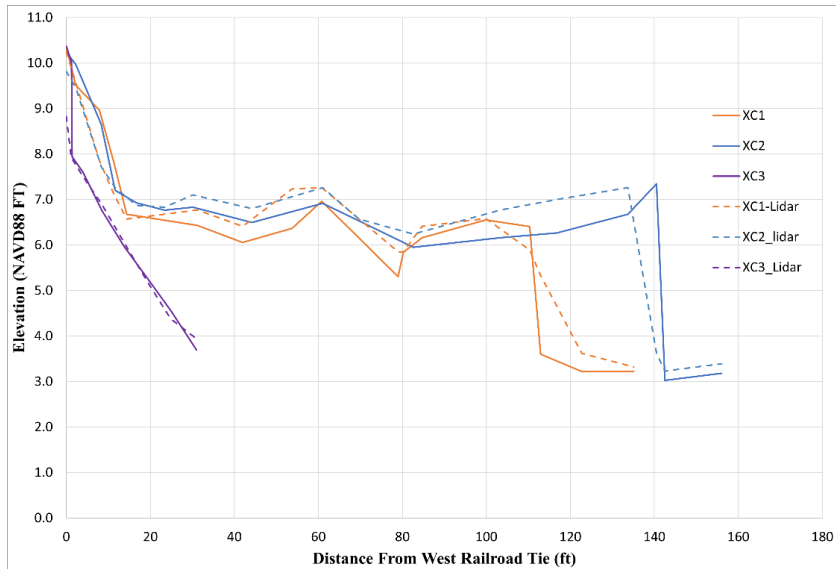
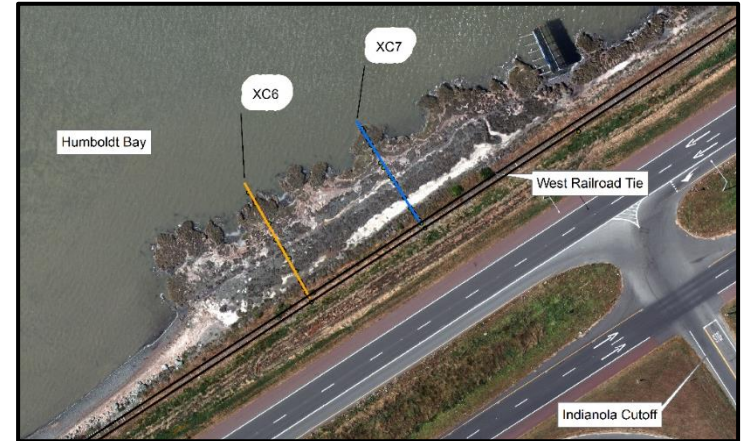
Basis for 35% Design: Barrier/Shingle Beach Project Shoreline Analog



- ✓ 10-15% Slope
- ✓ Sands and Gravels



Basis for 35% Design: Marsh Plain Elevation Project Area Analog



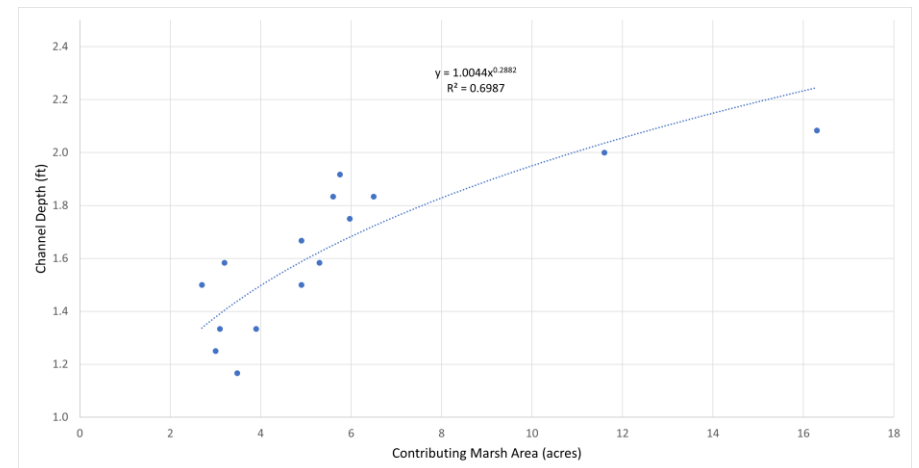
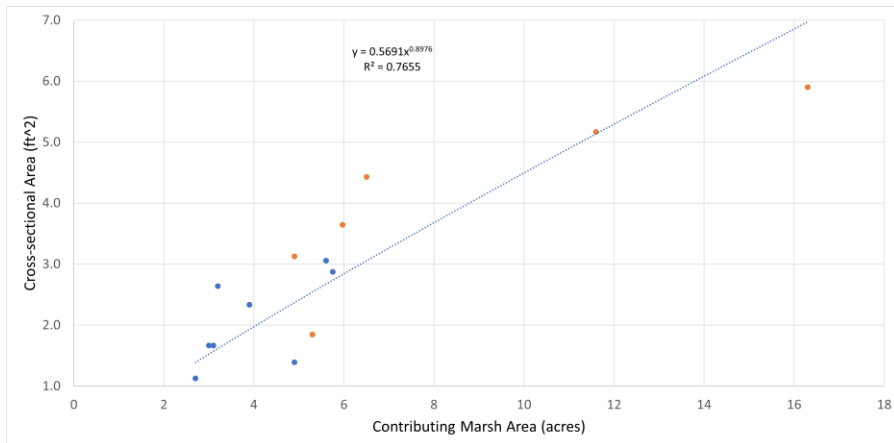
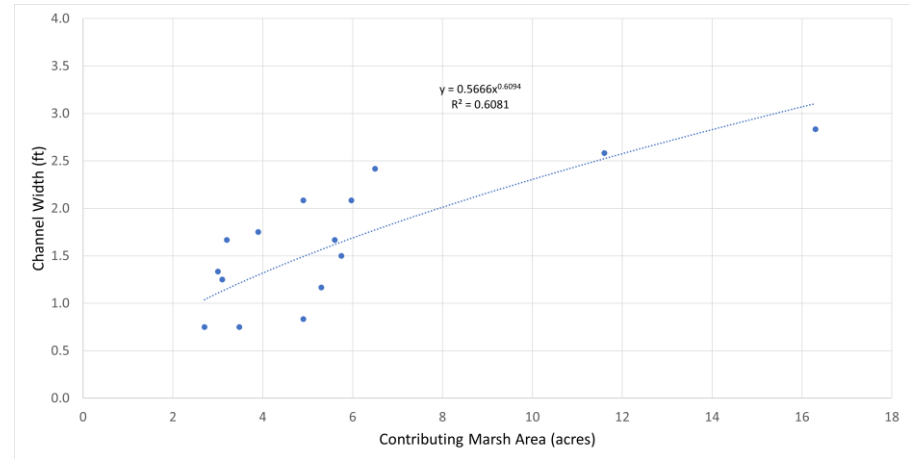
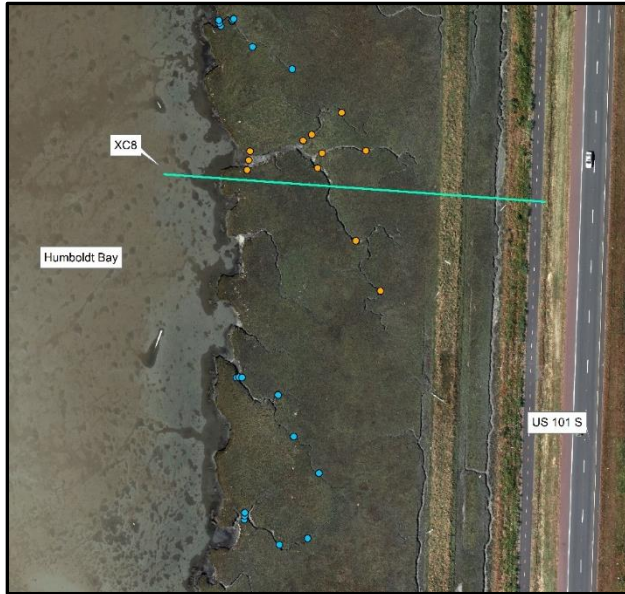
Basis for 35% Design: Transition Zone Project and Arcata I Street Analog



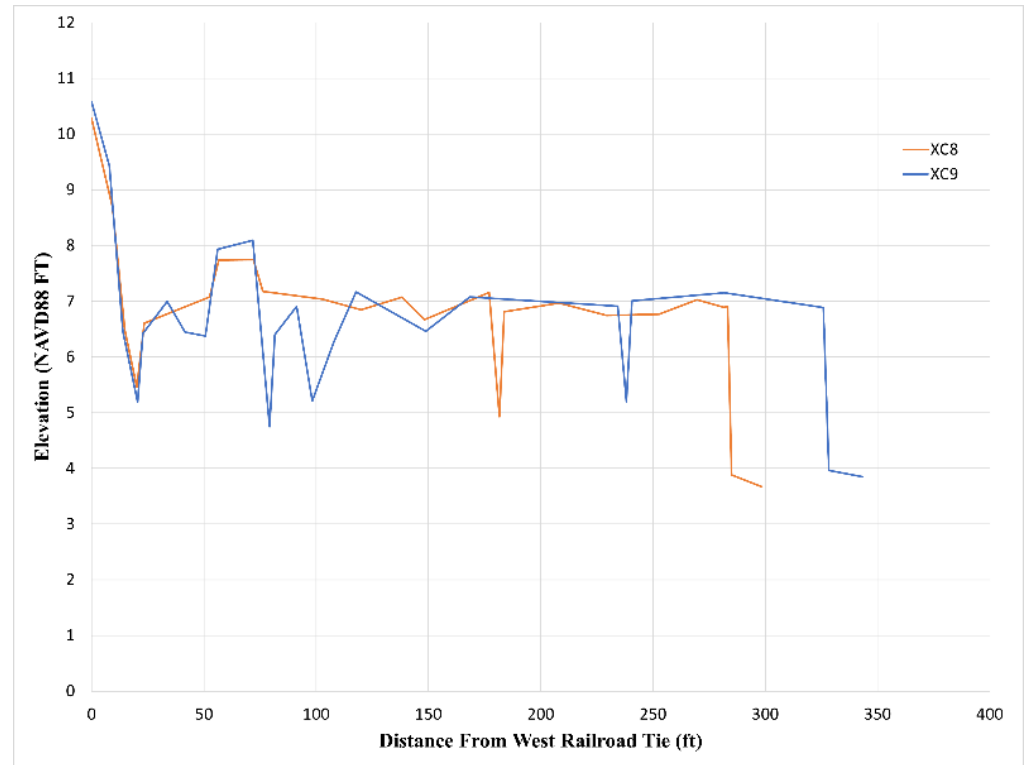
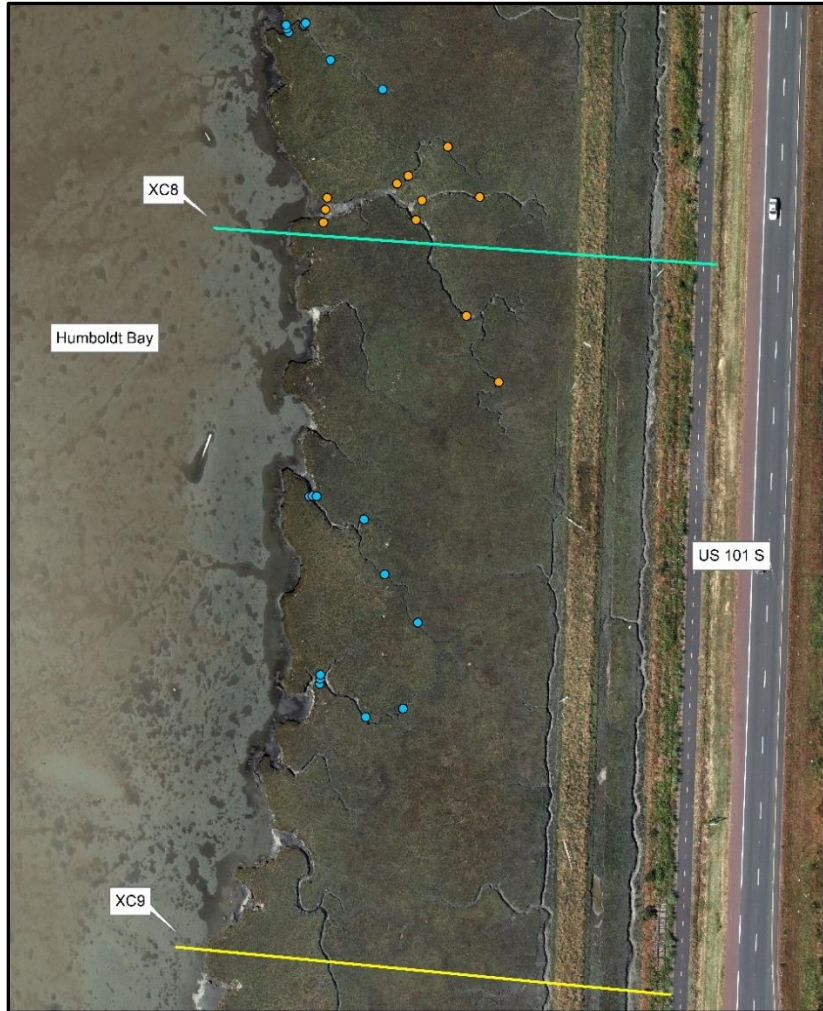
- ✓ MHHW to Supra-Tidal Elevation
- ✓ Brackish Marsh and Coastal Grassland/Scrub Species
 - Tufted hairgrass (*Deschampsia cespitosa*)
 - San Francisco rush (*Juncus lescurii*)
 - Red Fescue (*Festuca rubra*)
 - Coyotebrush (*Baccharis pilularis*)
 - California wax myrtle (*Morella californica*)
 - Cascara sagrada (*Frangula purshiana*)
 - Coast twinberry (*Lonicera involucrata*)

Basis for 35% Design: Tidal Channels

Jacoby Marsh Analog



Basis for 35% Design: Marsh Plain Elev. & Width Jacoby Marsh Analog



Basis for 35% Design: Marsh Plain Width Wind Wave Analyses

➤ Purpose:

1. Determine wind wave dissipation vs marsh width
2. Determine reduction of rail prism overtopping and flooding



Basis for 35% Design: Marsh Plain Width Wind Wave Analyses

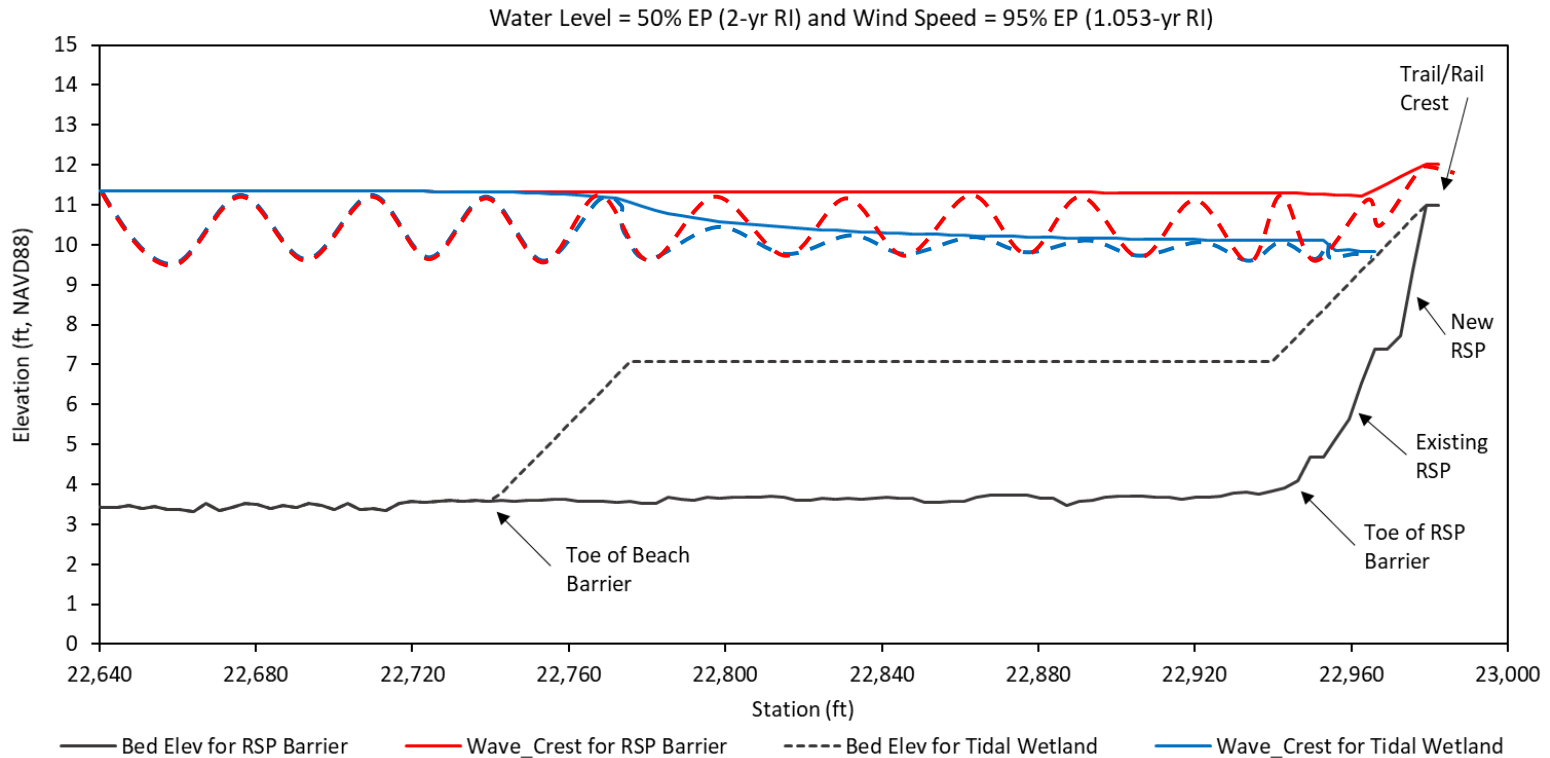
➤ Methods and Results:

SWAN
Simulating WAVes Nearshore

- Wave generation by wind
- Wave dissipation from
 - Breaking
 - White capping
 - Friction
 - Vegetation
 - Other
- Wave-induced set-up
- Other physics



Basis for 35% Design: Marsh Plain Width Wind Wave Analyses



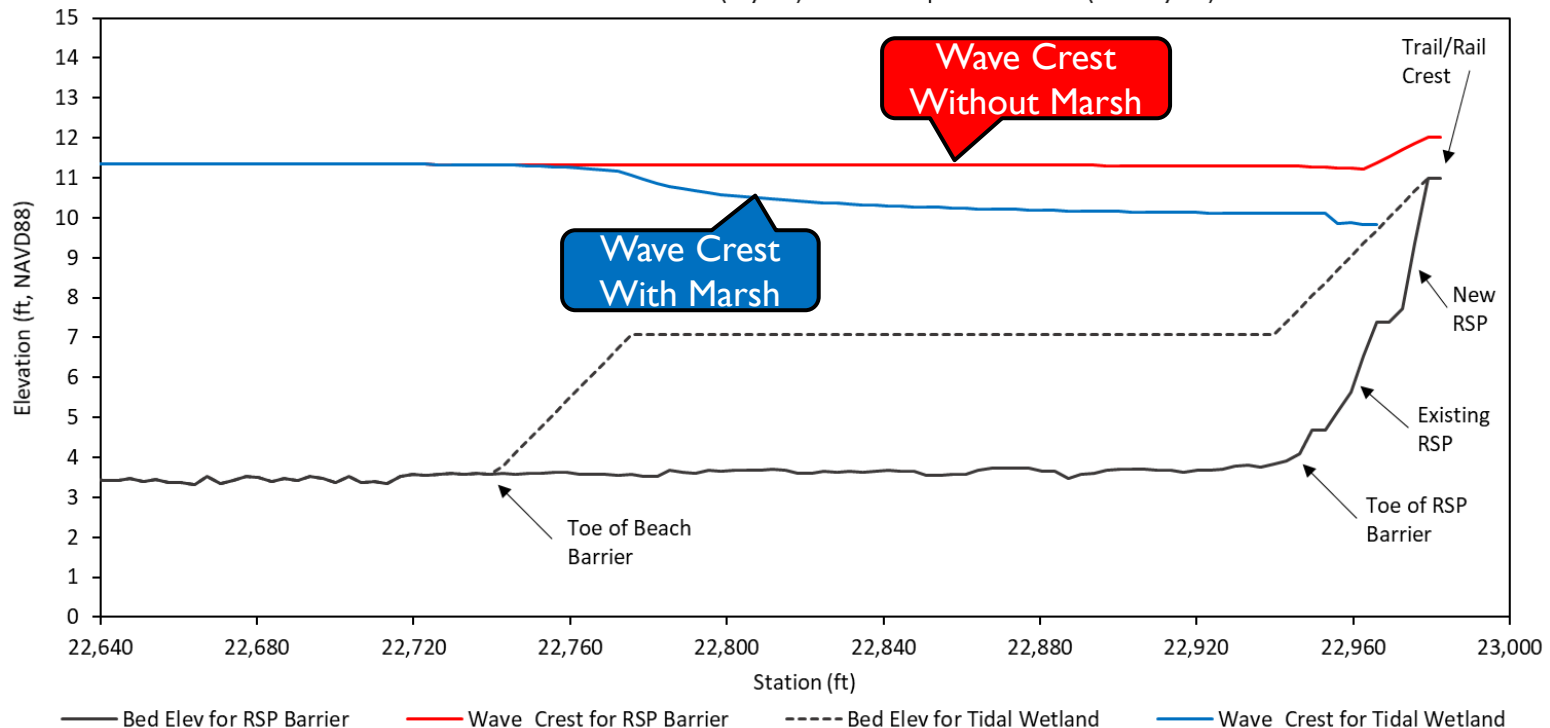
Basis for 35% Design: Marsh Plain Width Wind Wave Analyses

Water Level Definition	Water Level
1% EP (100-yr RI)	10.7 ft
10% EP (10-yr RI)	10.0 ft
50% EP (2-yr RI)	9.4 ft
MMMW	8.4 ft
MHHW	7.1 ft

Wind Speed Definition (2-min Average Speed)
1% EP (100-yr): 48 mph
10% EP (10-yr): 44 mph
50% EP (2-yr): 40 mph
95% EP (1.053-yr): 38 mph

Note: 2-min average wind speed adjusted for fetch and duration in wind-wave analysis

Water Level = 50% EP (2-yr RI) and Wind Speed = 95% EP (1.053-yr RI)

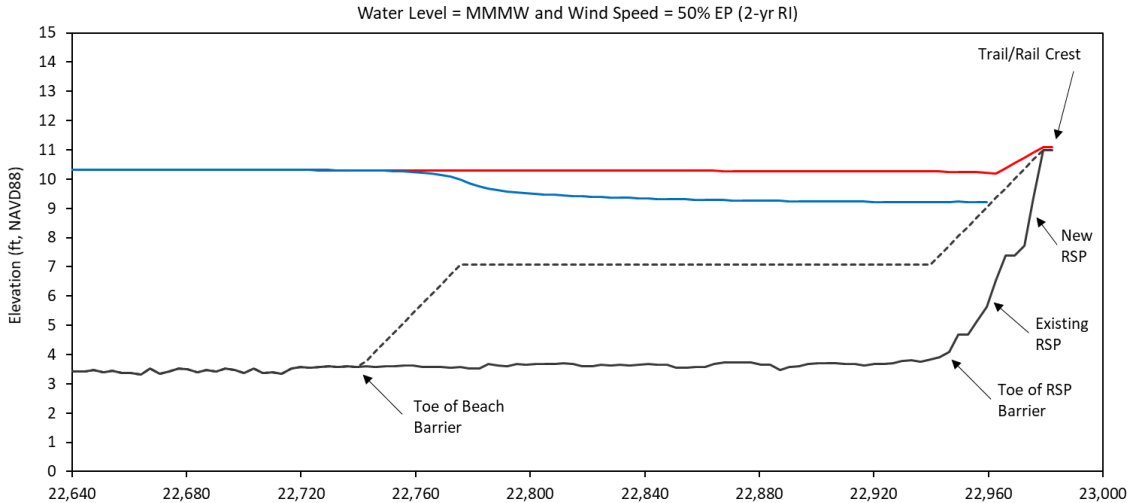


Basis for 35% Design: Marsh Plain Width Wind Wave Analyses

Overtopping Summary for Existing Sea-Levels

Water Level Definition	Water Level	Wind Speed Definition	Without Marsh	With Marsh
1% EP (100-yr RI)	10.7 ft	1% EP (100-yr) to 95% EP (1.053-yr RI)	Overtopping and Flooding of Highway	Overtopping and Flooding of Highway
10% EP (10-yr RI)	10.0 ft	1% EP (100-yr) to 95% EP (1.053-yr RI)	Damage to Rail/Trail Prism Flooding of Hwy 101	No Overtopping, No Flooding of Highway
50% EP (2-yr RI)	9.4 ft	1% EP (100-yr) to 95% EP (1.053-yr RI)	Trail Safety Compromised Flooding of Hwy 101	
MMMW	8.4 ft	1% EP (100-yr RI) to 50% EP (2-yr RI)	Minor Overtopping Flooding of Hwy 101	
		95% EP (1.053-yr RI)		
MHHW	7.1 ft	1% EP (100-yr) to 95% EP (1.053-yr RI)	No Overtopping, No Flooding of Highway	

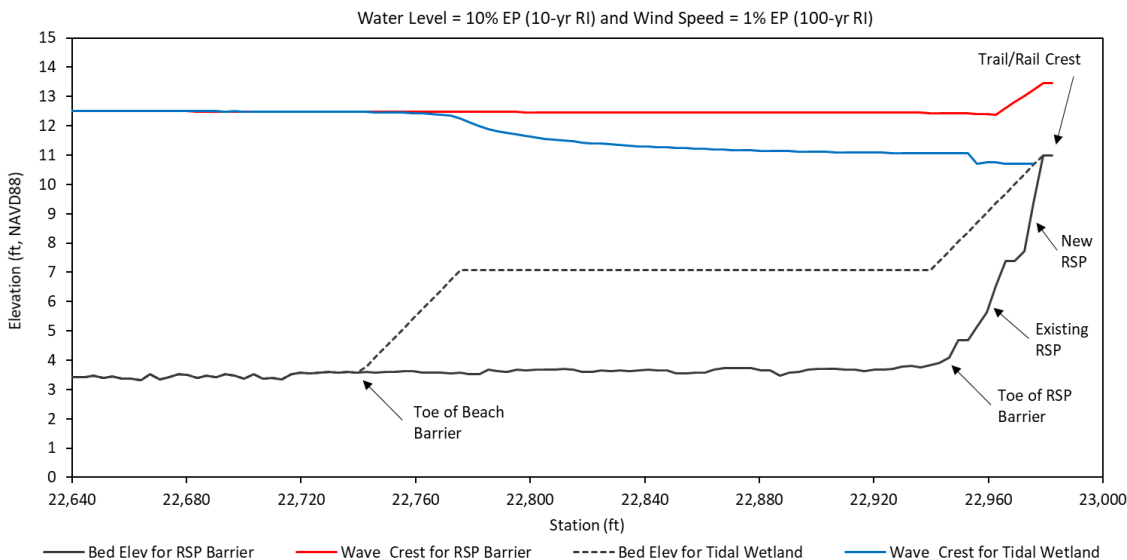
Basis for 35% Design: Marsh Plain Width Wind Wave Analyses



Without Marsh

Wave overtopping and flooding of Highway initiated at MMMW water level (8.4 ft) + 2-yr Wind Event (40 mph)

Rail/trail damage and diminished resiliency as water levels and overtopping flow increase



With Marsh

Resiliency to wave overtopping, damage to rail prism/trail and flooding of Highway up to 10-yr water level (10.0 ft) + 100-yr Wind Event (48 mph)



Basis for 35% Design: Marsh Plain Width Wind Wave Analyses

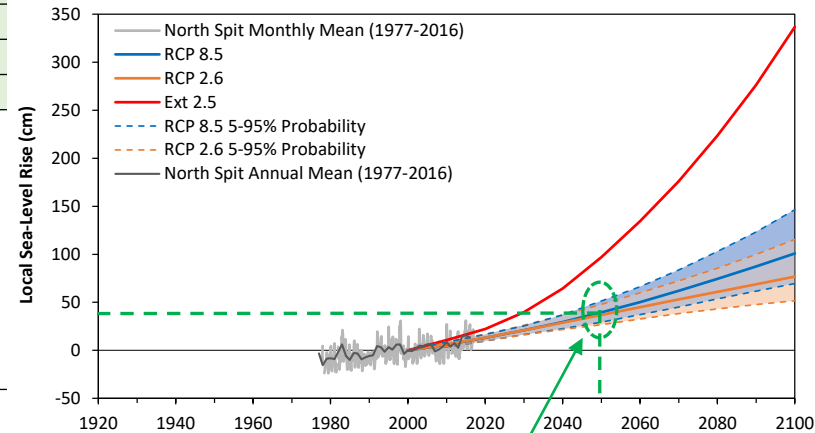
Overtopping for Existing Sea-Levels

Water Level	Wind Speed							
	95% EP (1.053-yr RI)		50% EP (2-yr RI)		10% EP (10-yr RI)		1% EP (100-yr RI)	
	RSP	Wetland	RSP	Wetland	RSP	Wetland	RSP	Wetland
MHHW	N	N	N	N	N	N	N	N
MMMWW	N	N	Y	N	Y	N	Y	N
50% EP (2-yr RI)	Y	N	Y	N	Y	N	Y	N
10% EP (10-yr RI)	Y	N	Y	N	Y	N	Y	N
1% EP (100-yr RI)	Y	Y	Y	Y	Y	Y	Y	Y

Overtopping for 1-ft Sea-Level Rise

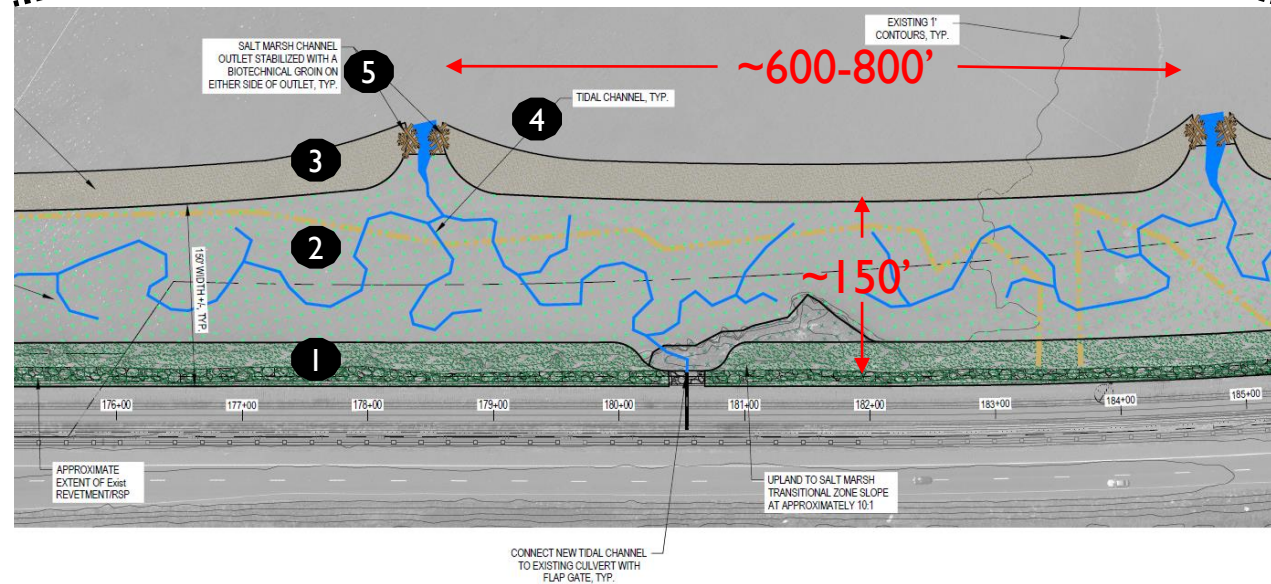
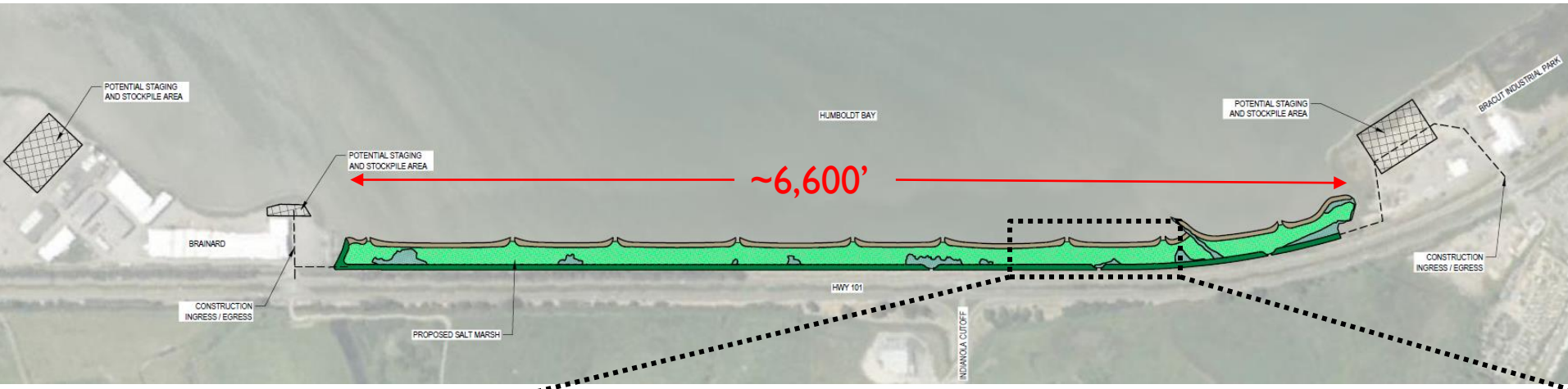
Water Level	Wind Speed							
	95% EP (1.053-yr RI)		50% EP (2-yr RI)		10% EP (10-yr RI)		1% EP (100-yr RI)	
	RSP	Wetland	RSP	Wetland	RSP	Wetland	RSP	Wetland
MHHW	N	N	N	N	N	N	N	N
MMMWW	Y	N	Y	N	Y	N	Y	N
50% EP (2-yr RI)	Y	N	Y	N	Y	Y	Y	Y
10% EP (10-yr RI)	Y	Y	Y	Y	Y	Y	Y	Y
1% EP (100-yr RI)	Y	Y	Y	Y	Y	Y	Y	Y

North Spit Sea-Level Rise Projections (NHE 2018)



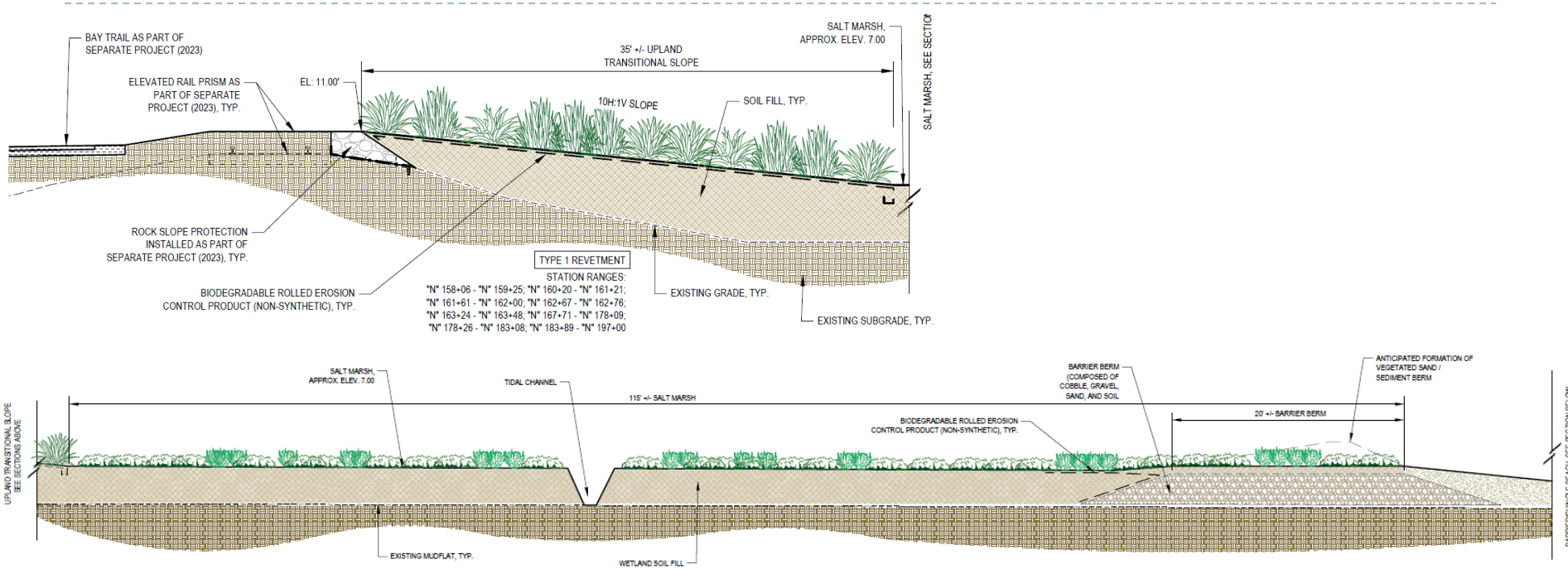
1-ft of Sea-Level Rise occurs around ~2050

Introduction to 35% Design Components



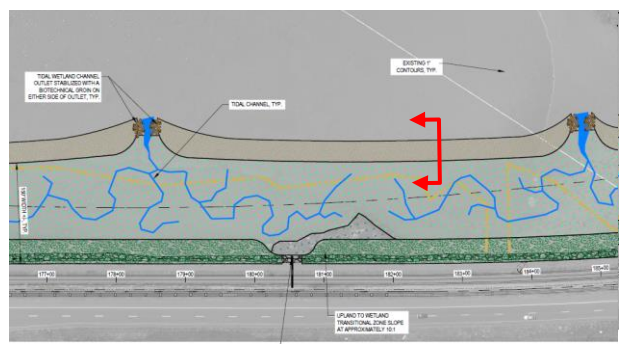
- 1 Transition Zone
- 2 Marsh Plain with Barrier Berm
- 3 Barrier/Shingle Beach
- 4 Tidal Channels
- 5 Biotechnical Groins

Typical Cross-section

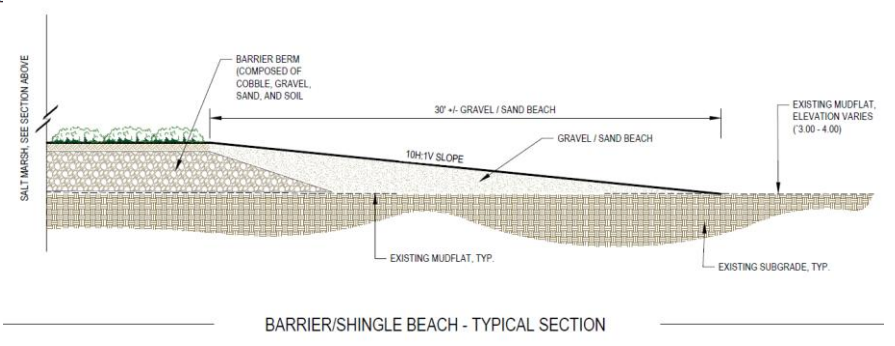


UPLAND TRANSITIONAL SLOPE
 SEE SECTIONS ABOVE

BARRIER/SWINGLE BEACH, SEE SECTION BELOW

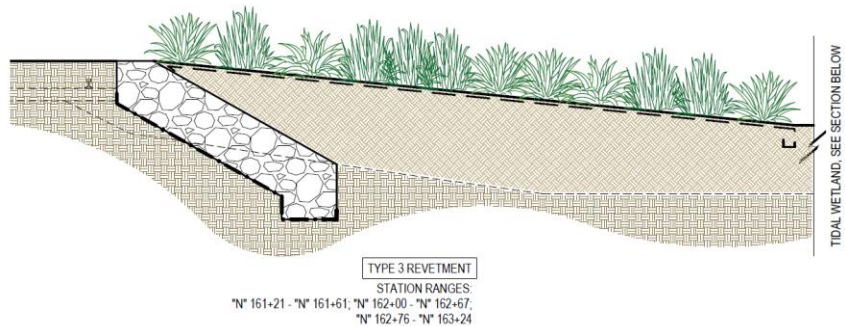
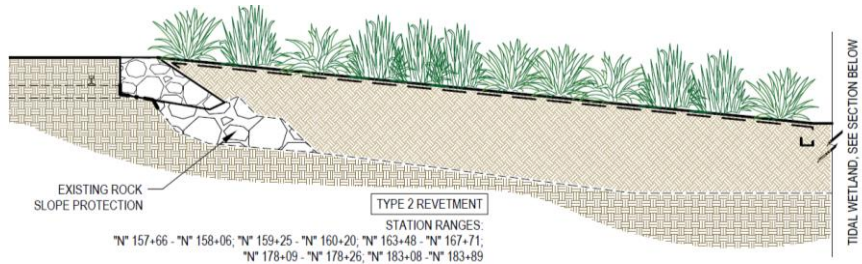
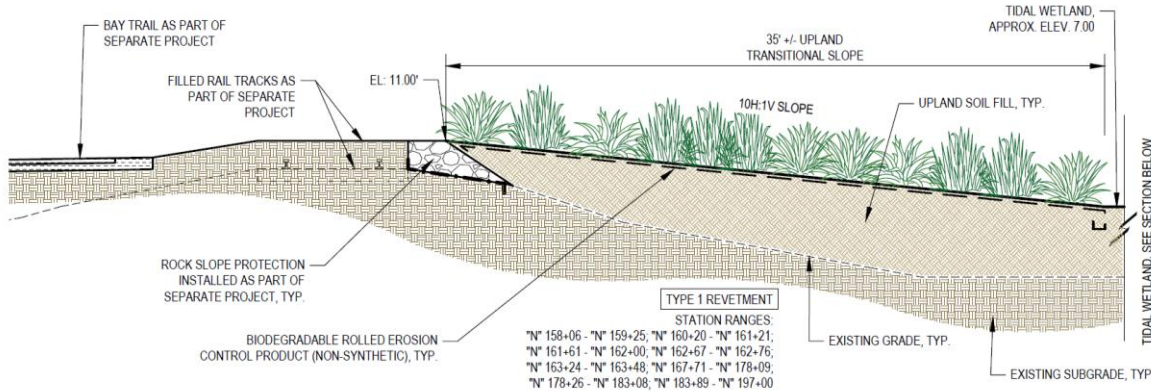


SALT MARSH - TYPICAL SECTION



BARRIER/SWINGLE BEACH - TYPICAL SECTION

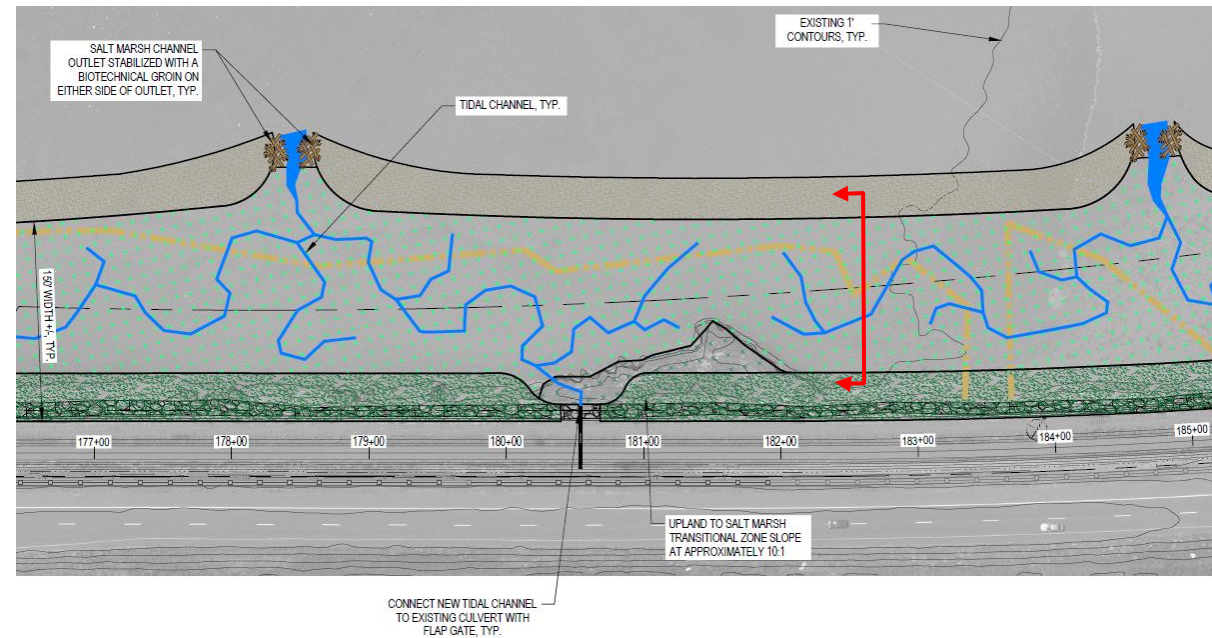
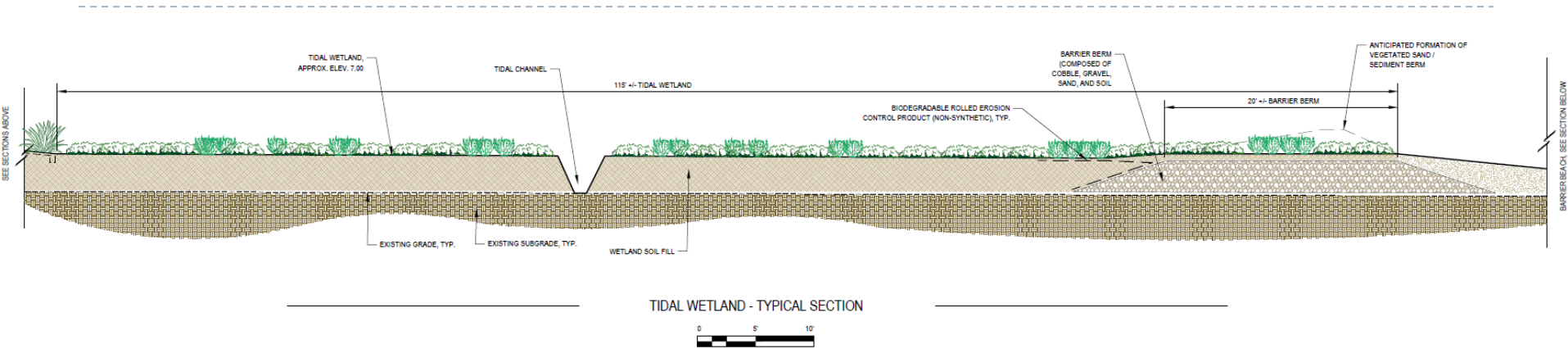
Transition Slope (High Marsh Ecotone)



1. Elevation: 7-11ft (>MHHW)
2. Slope: 10H:1V
3. Revegetation: Actively seeded, wetland plugs and biodegradable coir fabric
4. Compatible with Humboldt Bay Trail South



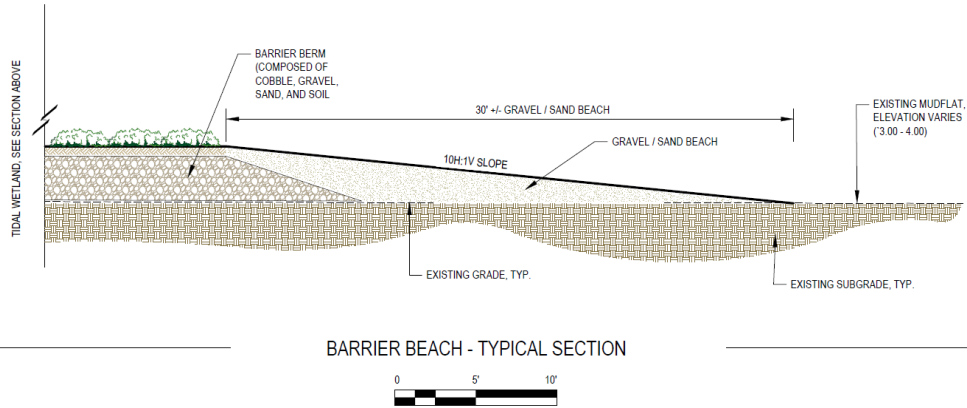
Salt Marsh with Barrier Berm



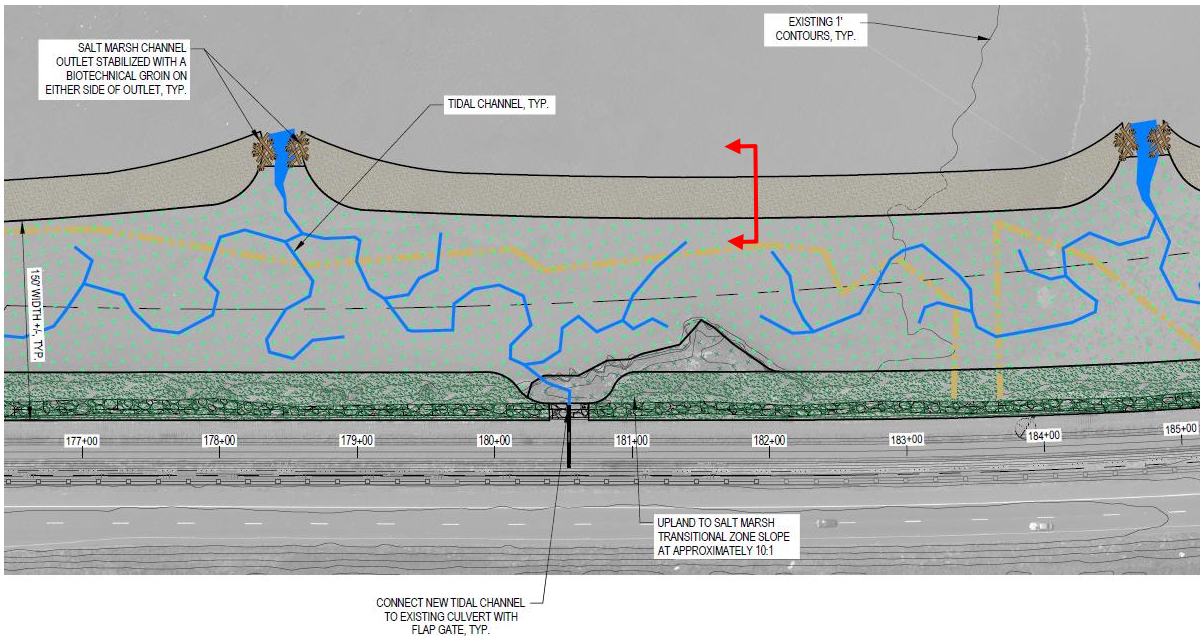
1. Elevation: ~7ft (~MHHW)
2. Revegetation: Natural (Passive) recruitment
3. Barrier berm comprised of sediment, sand, gravel/cobble



Barrier/Shingle Beach

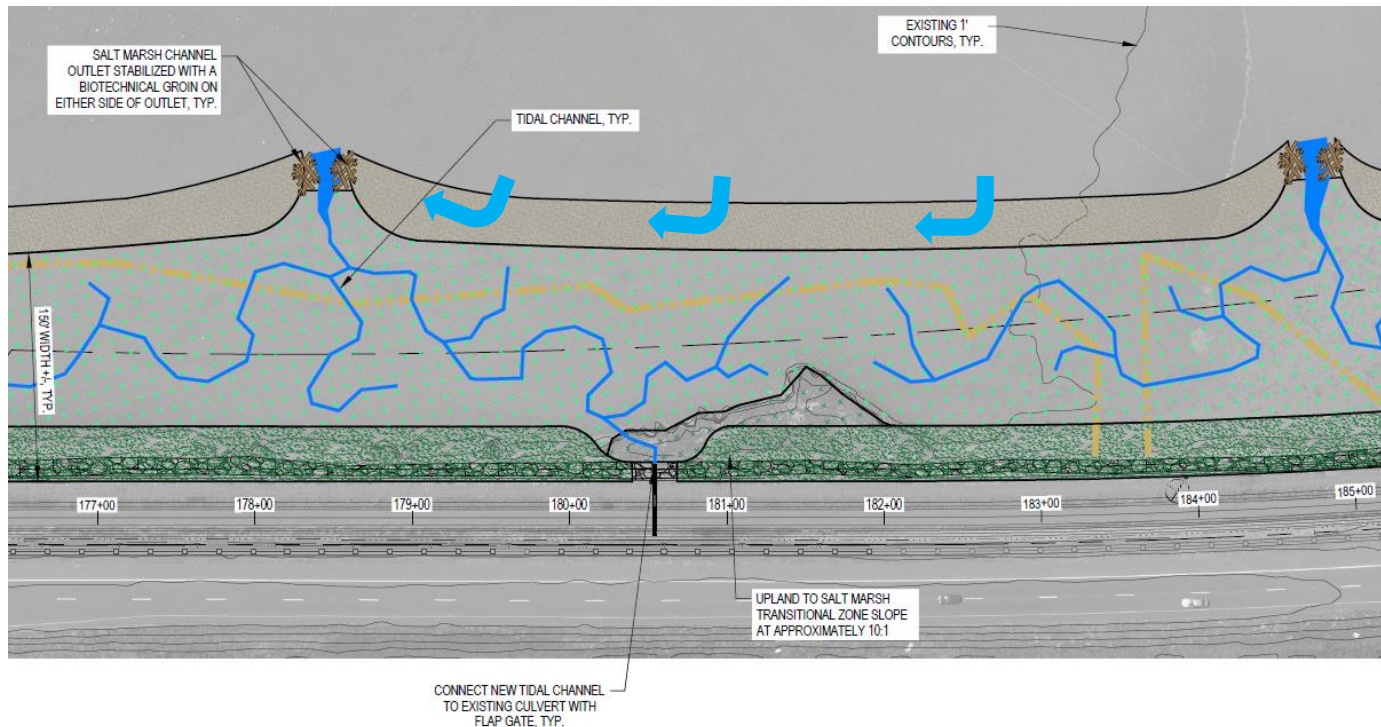


1. Elevation: ~7ft to Mudflat
2. Slope: 10H:1V
3. Comprised of sand/gravel

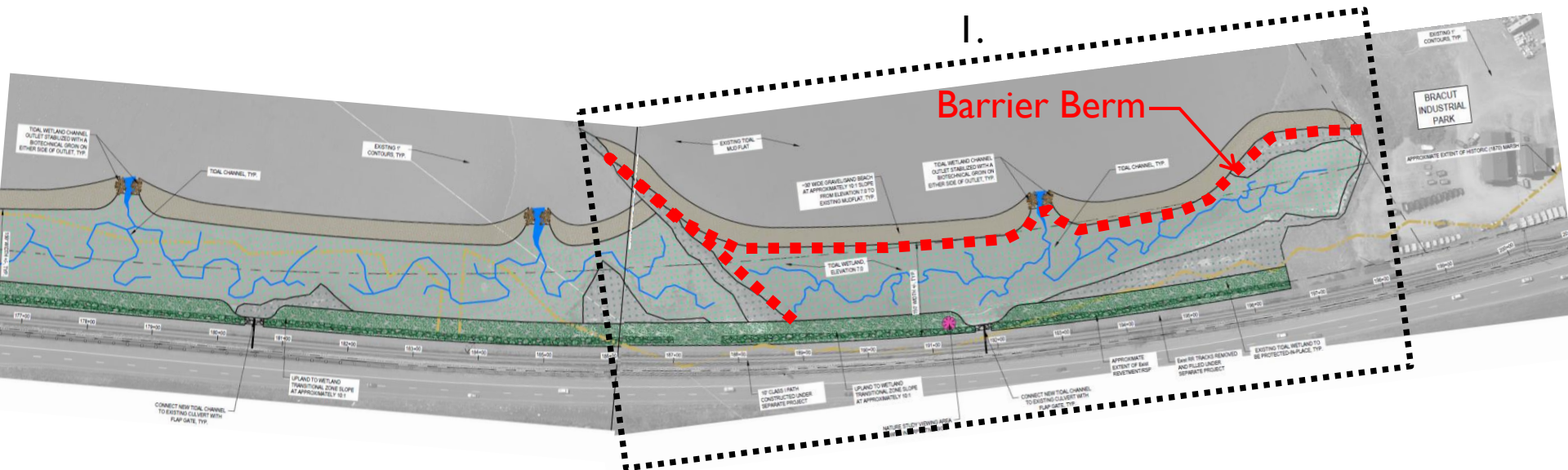


Biotechnical Groin and Tidal Channels

1. Comprised of LWD and/or Barrier Berm materials (Sediment/Sand/Gravel/Cobble)
2. Stabilized tidal channel mouth
3. Retain gravel/sand beach materials from long-shore transport



Construction Phasing & Pilot Project Potential



Construction Cost

Opinion of Probable Construction Cost



Client: County of Humboldt - Department of Public Works
 Project Title: Natural Shoreline Infrastructure (Brainard to Bracut)
 Status of Design: 35% Preliminary Design

Date: 3/15/2022
 GHD Ref: 11214987

Item No.	Description	Unit	Quantity	Unit Cost		Total	
1	Mobilization and Demobilization (Estimated Approx. 4% of Subtotal)	LS	1	\$550,000.00		\$550,000	
2	ROW for Staging/Stockpile Area and Notification/Signage	LS	1	\$100,000.00		\$100,000	
3	Water Management, Erosion/Sediment Control, and Environmental Protection	LS	1	\$200,000.00		\$200,000	
4	Construction Survey Staking	LS	1	\$75,000.00		\$75,000	
5	Clearing and Grubbing	LS	1	\$50,000.00		\$50,000	
6	Invasive Spartina Removal	LS	1	\$50,000.00		\$50,000	
7	Soil Fill for Salt Marsh Plain and Ecotone Transition (including tidal channel grading) ¹	CY	100,000	\$25.00	\$50.00	\$2,500,000	\$5,000,000
8	Gravel/Sand Mix for Shingle Beach	CY	20,000	\$100.00		\$2,000,000	
9	Cobble/Gravel/Soil Mix for Barrier Berm	CY	30,000	\$100.00		\$3,000,000	
10	Biotechnical Groins	EA	16	\$10,000.00		\$160,000	
11	Biodegradable Rolled Erosion Control Product (Netting)	SQFT	530,000	\$0.50		\$265,000	
12	Fiber Rolls	LF	20,000	\$5.00		\$100,000	
13	Broadcast Native Seed	ACRE	6.1	\$10,000.00		\$61,000	
14	Install Wetland Plugs ²	ACRE	6.1	\$25,000.00		\$152,000	
15	Interpretative Areas (Benches and Signs)	LS	1	\$50,000.00		\$50,000	

	Lower	Upper
Construction Subtotal:	\$ 9,320,000	\$ 11,820,000
30% Estimating Contingency:	\$ 2,800,000	\$ 3,550,000
TOTAL CONSTRUCTION COST:	\$ 12,120,000	\$ 15,370,000

Planning, Engineering, and Environmental Compliance @ 20% (Lower) and 25% (Upper):	\$ 2,424,000	\$ 3,842,500
Construction Management and Administration @ 10% (Lower) and 15% (Upper):	\$ 1,212,000	\$ 2,305,500
TOTAL PROJECT COST³:	\$ 15,800,000	\$ 21,600,000

Post Construction Monitoring and Adaptive Management (Assumed 3-years)⁴: \$ 150,000 \$ 300,000

Note:

¹ The total opinion of cost is highly sensitive to the unit cost of soil fill, thus a lower and upper unit cost range was provided to reflect the highly variable costs associated with soil fill procurement and transport.

² Wetland plug planting assumed for Transition Zone only with passive (natural) recruitment of salt marsh species on salt marsh plain.

³ This opinion reflects probable construction costs obtainable for the project location on the date this estimate was prepared. Due to inflation of labor, material and equipment costs and nature of construction cost volatility, prices may vary. Escalation of costs should be considered for future planning and use of this estimate.

⁴ Post construction monitoring cost assumed to require limited management actions and interventions.

Discussion

- ▶ Seek Concurrence on 35% Design

- ▶ Next Steps
 1. Advance to 50% Design
 2. Finalize Design Report
 - a) Design Components
 - b) Re-vegetation
 - c) Construction Phasing
 - d) Construction Cost
 - e) Monitoring Plan
 - f) Habitat Conversion and Effects Analyses
 3. TWG Meeting #6: Tentative May/June 2022
 4. Project Completion: June 30, 2022