Livingston Bay Pocket Estuary Restoration Feasibility Assessment

September 15, 2011

COAST & HARBOR ENGINEERING

PENTEC ENVIRONMENTAL

Outline

- Project Objectives
- Scope of Work & Schedule
- Data Compilation & New Data Collection
- Observations from Site Visit
- Coastal Processes
- Biological Processes
- Basis of Design
- Conceptual Design Alternatives
- Next Steps

Project Objectives

- Restore tidal habitats within the 10 acres of the project site
- Improve access for juvenile salmonids and other fish
- Restore salt marsh habitat on the interior of the pocket estuary
- Restore natural hydrologic and shoreline processes in a manner that is cost-effective and ecologically sustainable
- Minimize site disturbance during construction
- Maximum re-use of site materials and limited import/export of materials

Scope of Work

Task 1. Feasibility Assessment

- 1.1 Data Collection
- 1.2 Feasibility Analysis

Task 2. Engineering Design

- 2.1 Preliminary Engineering Design
- 2.2 Final Engineering Design

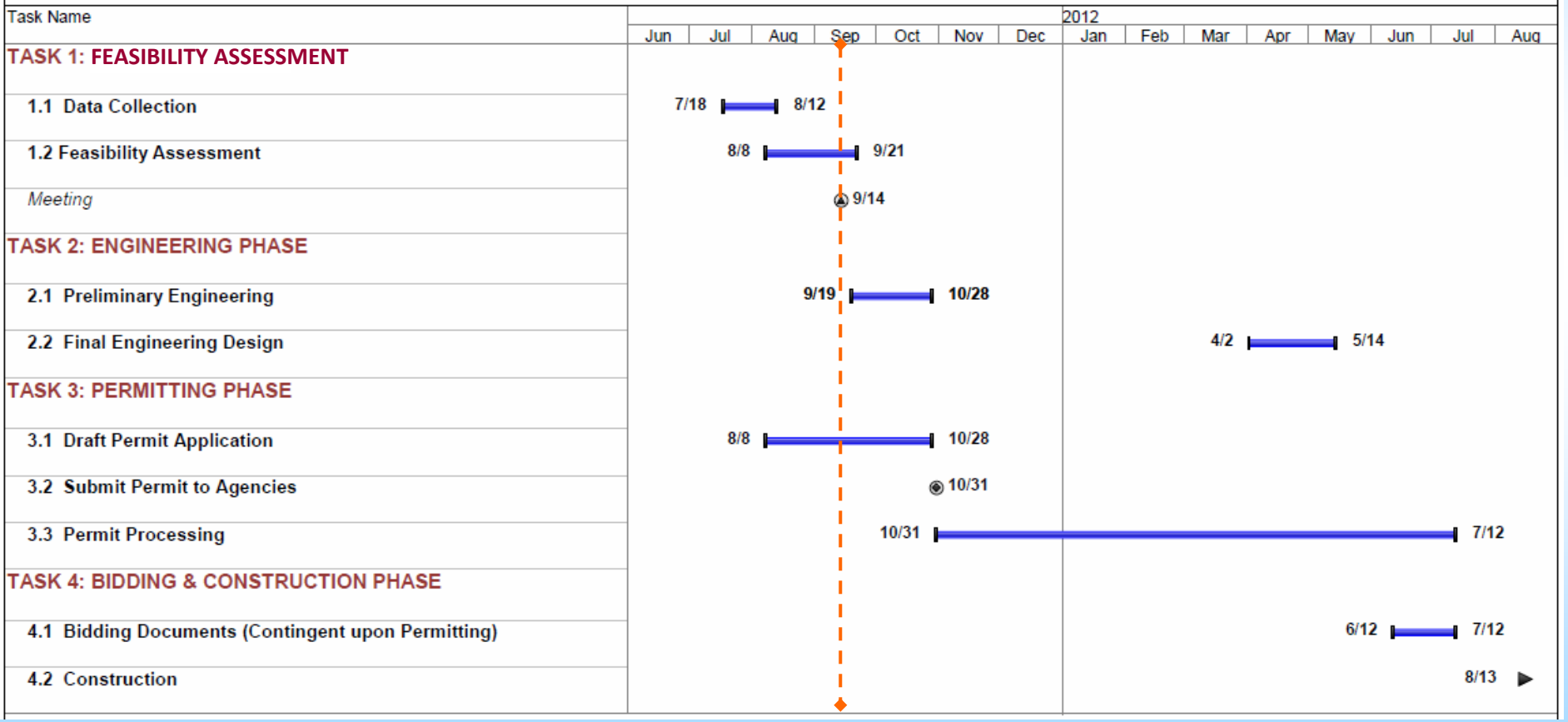
Task 3. Regulatory Permitting

Task 4. Bidding & Construction Assistance

Project Schedule

The Nature Conservancy
Livingston Bay Pocket Estuary Restoration

Project Schedule



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Data Compilation

- Charts and Maps
  - USCGS T-Sheet (1886)
- Bathymetry
  - US Navy Bathymetry (1886 & 1962)
  - LIDAR (2002 & 2005)
- Aerial Photos

Low Quality Photo (not shown)

- Vertical (1941, 1972, 1977, 1980, 1990, 2004-2007, 2009)
- Oblique (1977, 1993, 2001, 2006)
- 2011 TNC aerial (requested)

Data Compilation

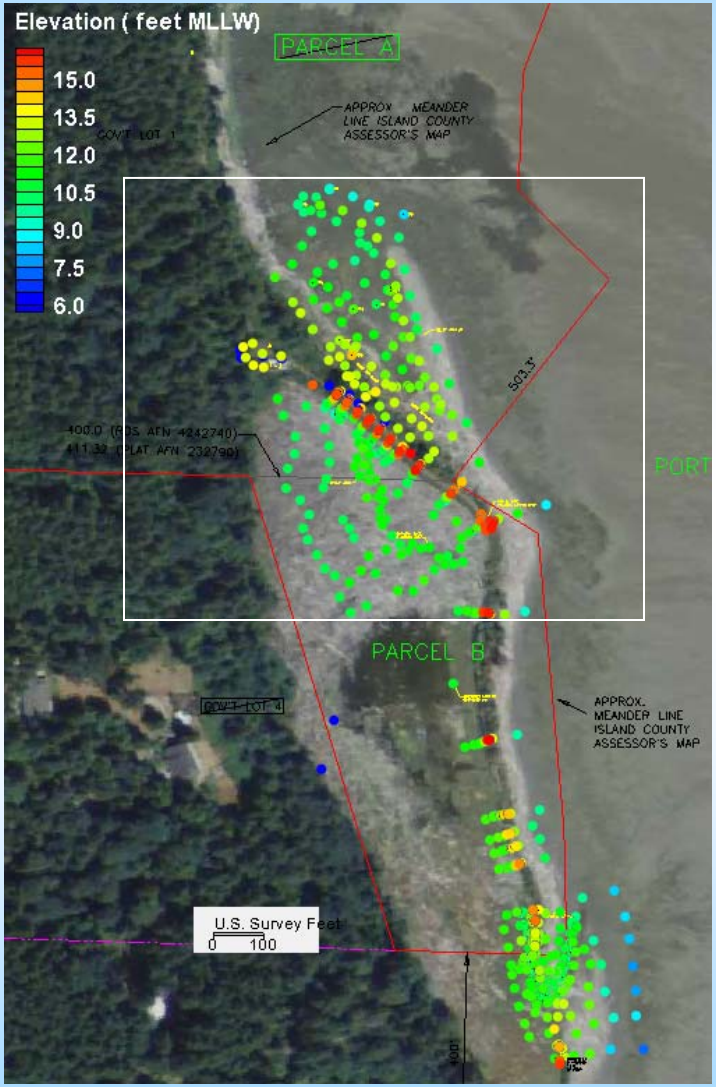
- Tides
  - Tulalip, Everett, Stanwood
  - TNC in Port Susan (requested)
- Wind
  - West Point Seattle, Paine Field Everett, Padilla Bay Farm
- Studies by Others

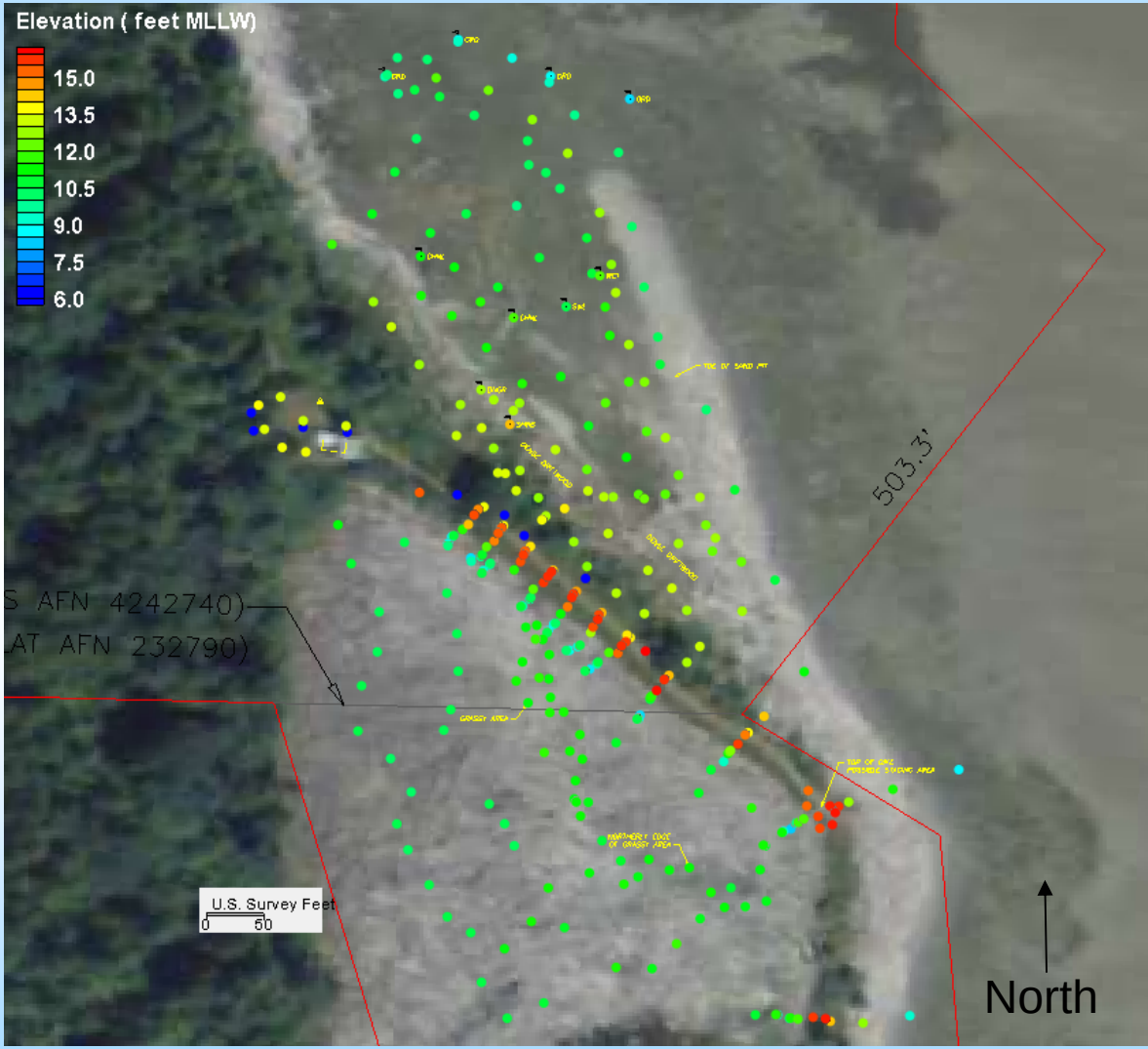
  - TNC provided studies in Port Susan

New Survey Data Collection

- Surveyor: Harmsen Associates (Jim Smith, PLS)
- Performed to develop engineering level drawings and quantities
- Capable to ground truth available LIDAR data
- Start 08/02/2011 & Complete 08/09/2011

New Survey Data Coverage





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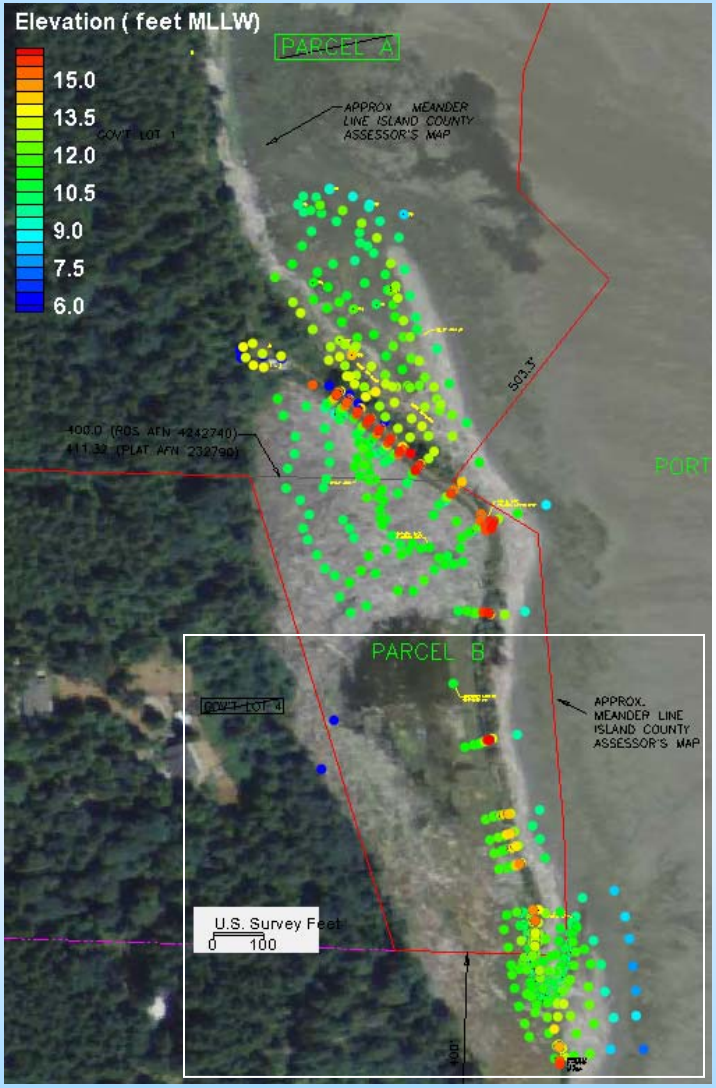

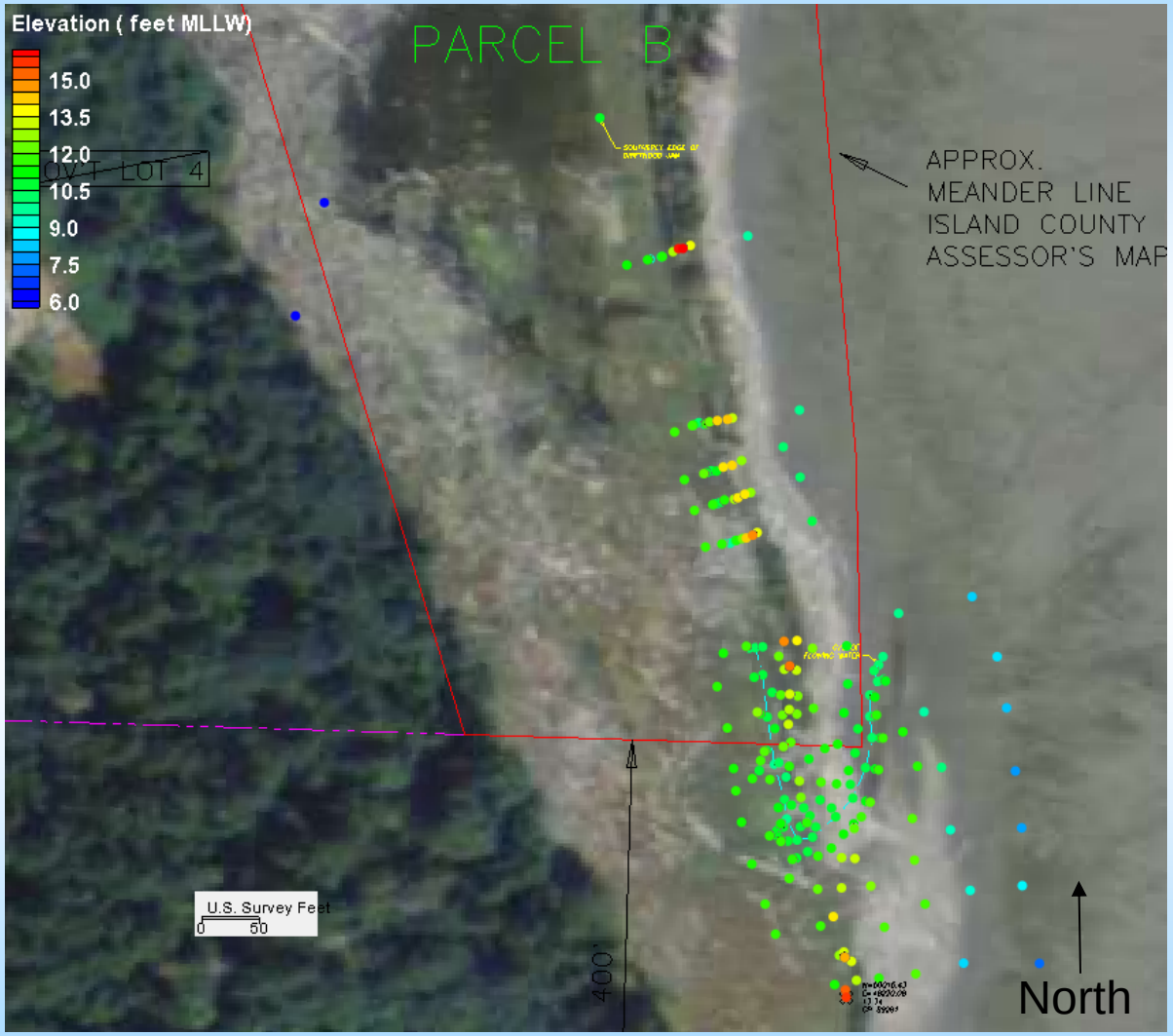

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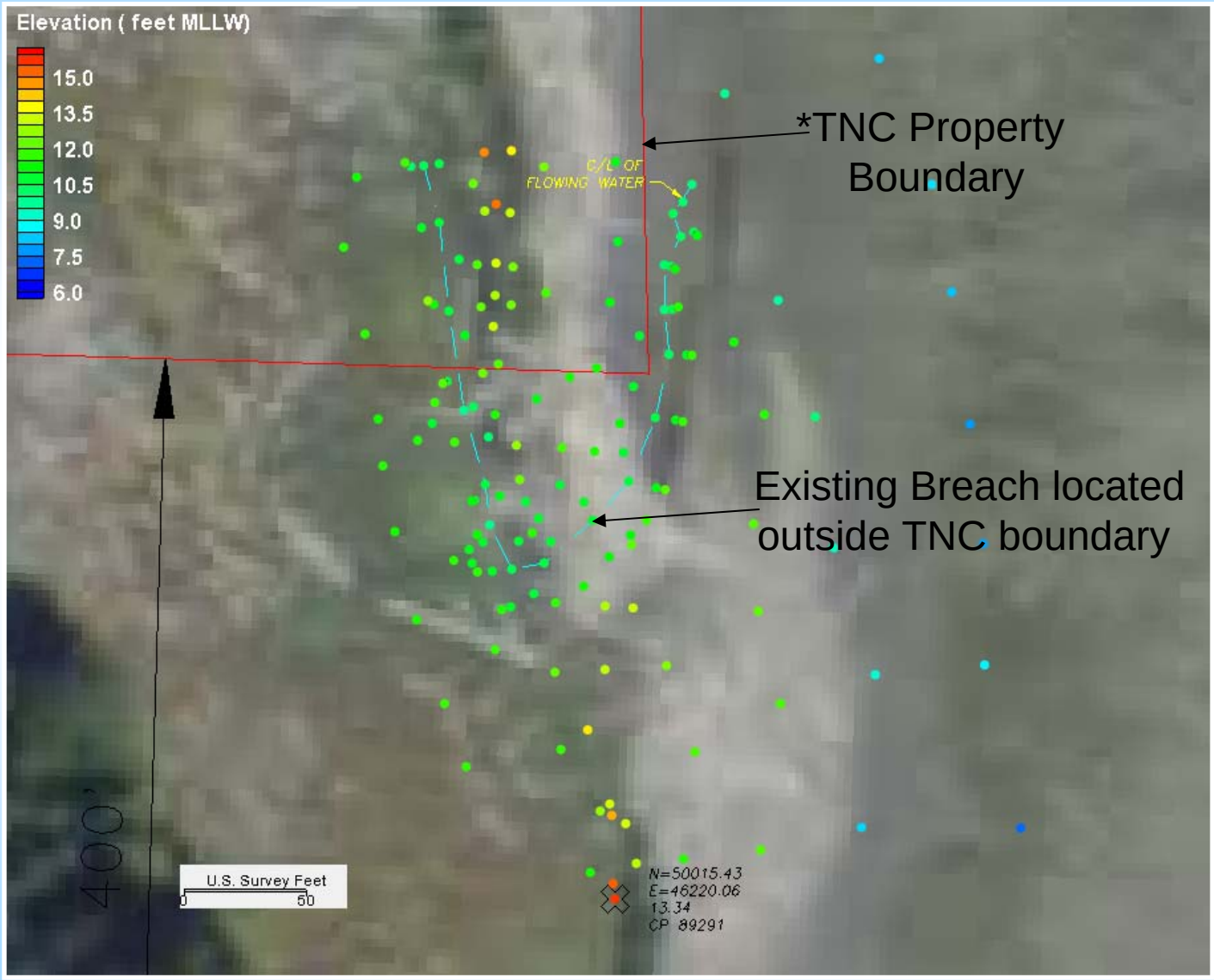
Property Boundary



North

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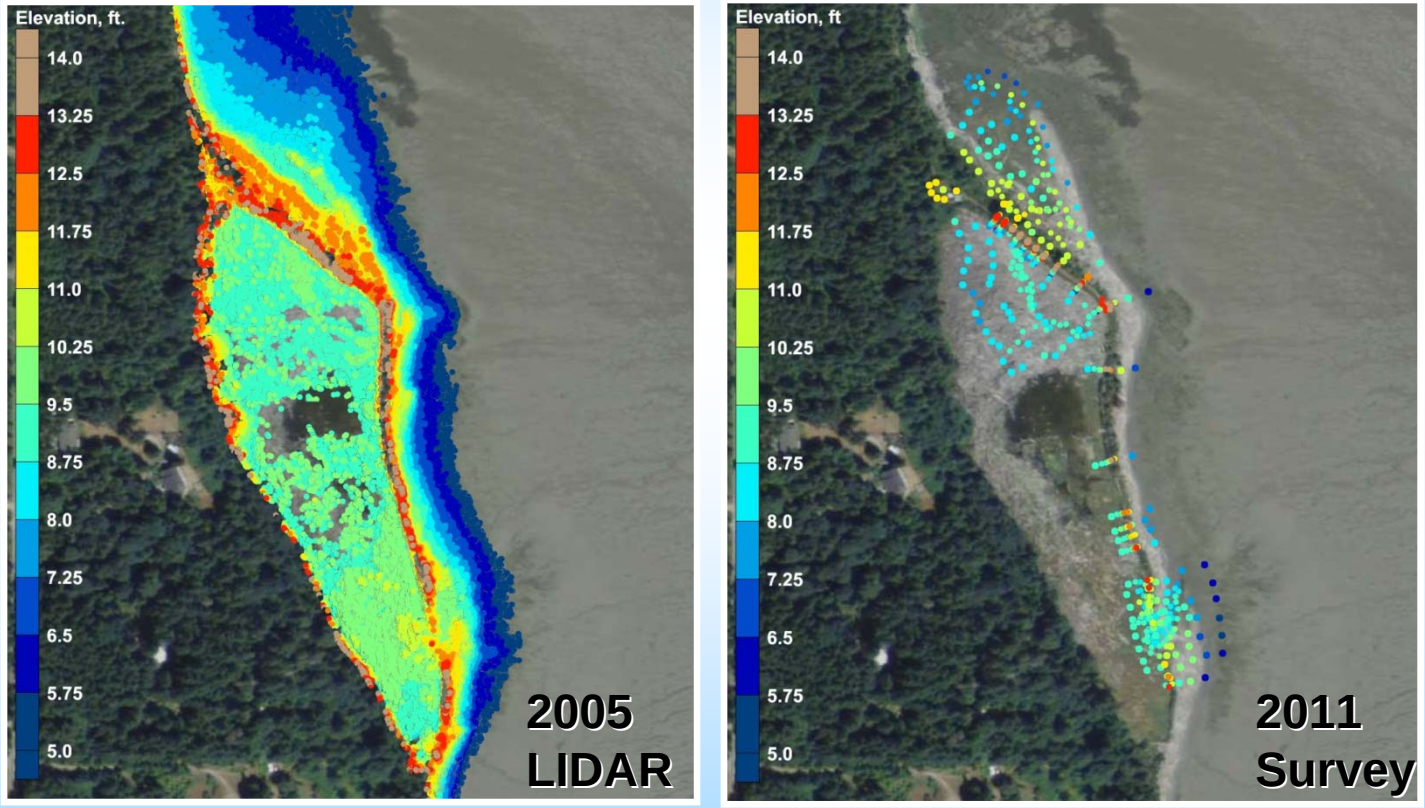
* Property boundary from County records, not staked in the field

LIDAR Ground Truthing

- Compared LIDAR (2001 & 2005) to ground survey



Comparison of LIDAR and ground survey, elevations ft NAVD88

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2009 Aerial Photograph

LIDAR Ground Truthing

- North spit location changed between 2011 & 2005
- LIDAR picks up the floating logs and thus gives higher elevations than the ground survey in the marsh (about 1.0 to 1.5 feet higher)
- Dike elevations match well (within 0.5 ft) however vegetation is not well removed from the bare earth LIDAR along the levee crest.
- South breach channel appears to have migrated to the north
- Mudflat elevations are within about 0.2 ft between LIDAR and survey, this is very good agreement
- LIDAR precision is about ±0.25 ft on hard surfaces, accuracy on the order of ± 0.5 ft
- Surface gradient in the marsh plain is about 2.0 ft (10.0' to 12.0' MLLW) and LIDAR inaccuracy eats up about ¼ of that range.
- For numerical modeling LIDAR must be adjusted down in vegetated marsh area; mudflats data be used directly with some confidence.
- LIDAR inaccuracy forces us to rely upon ground survey to estimate tidal prism and for design drawings/quantities.

Task 1.1 – Data Collection

Outstanding Questions/Issues:

- Property Boundary Resolution

Additional Data Needs:

- TNC - 2011 Aerial Photo
- TNC – Archeological update (cultural resources on site ?)
- CHE supplemental GPS data during follow up site visit

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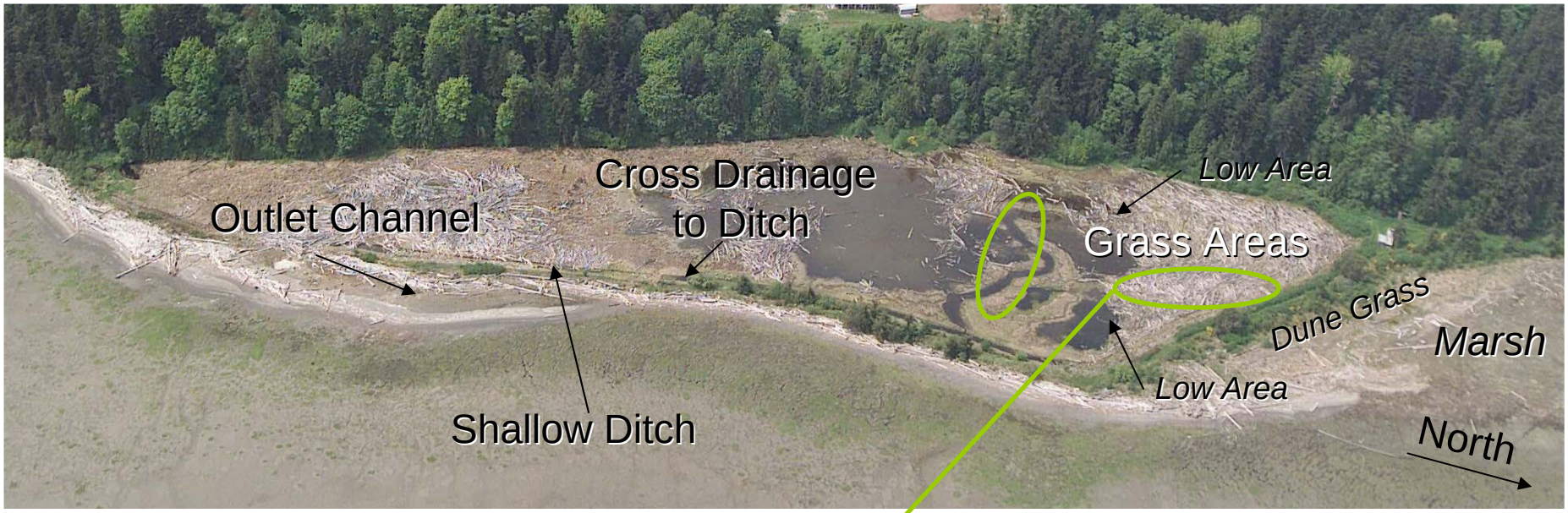
Site Visit Observations



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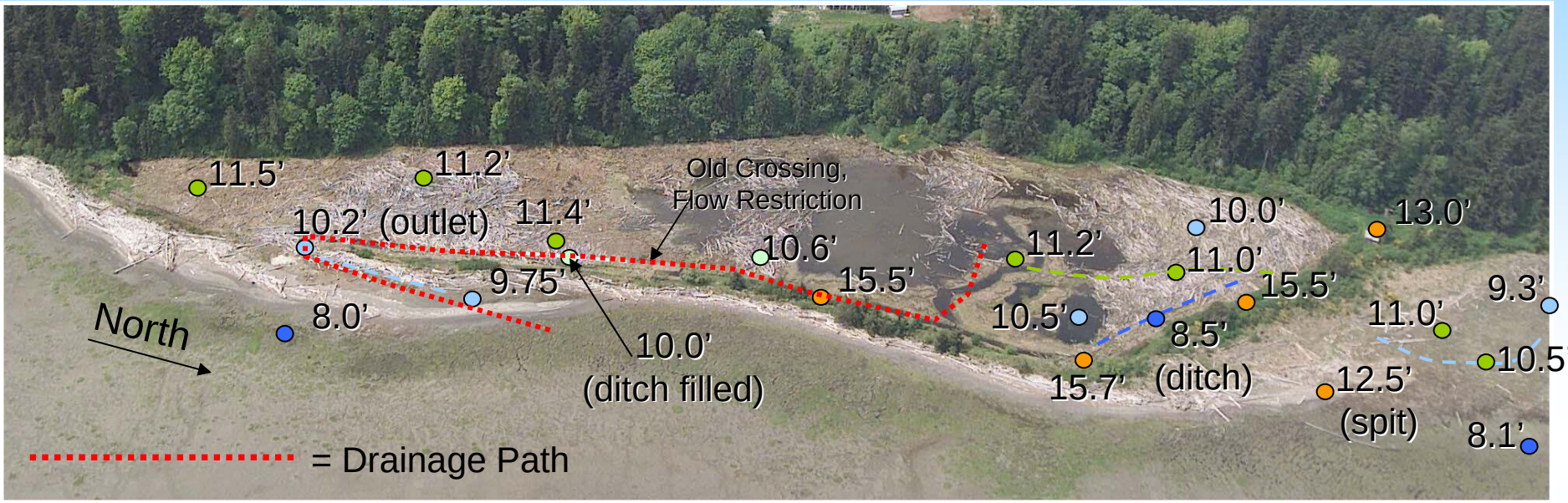
2001 DOE Oblique Photograph

Site Conditions (cont)



Typical Elevation of site features relative to MLLW. MHHW = 11.2’.

Summary

- Majority of Tidal Prism located at north end of estuary
- Existing outlet is a long drainage path w/ high resistance ~ inefficient flow routing
- Estuary around current outlet is very high elevation ~ at or above MHHW
- Breach Outlet Channel at High Level (1’ below MHHW)
- Restriction at old road crossing and filled ditch
- Growth of North Spit continues
- Ponding or tidal water “hold-in”

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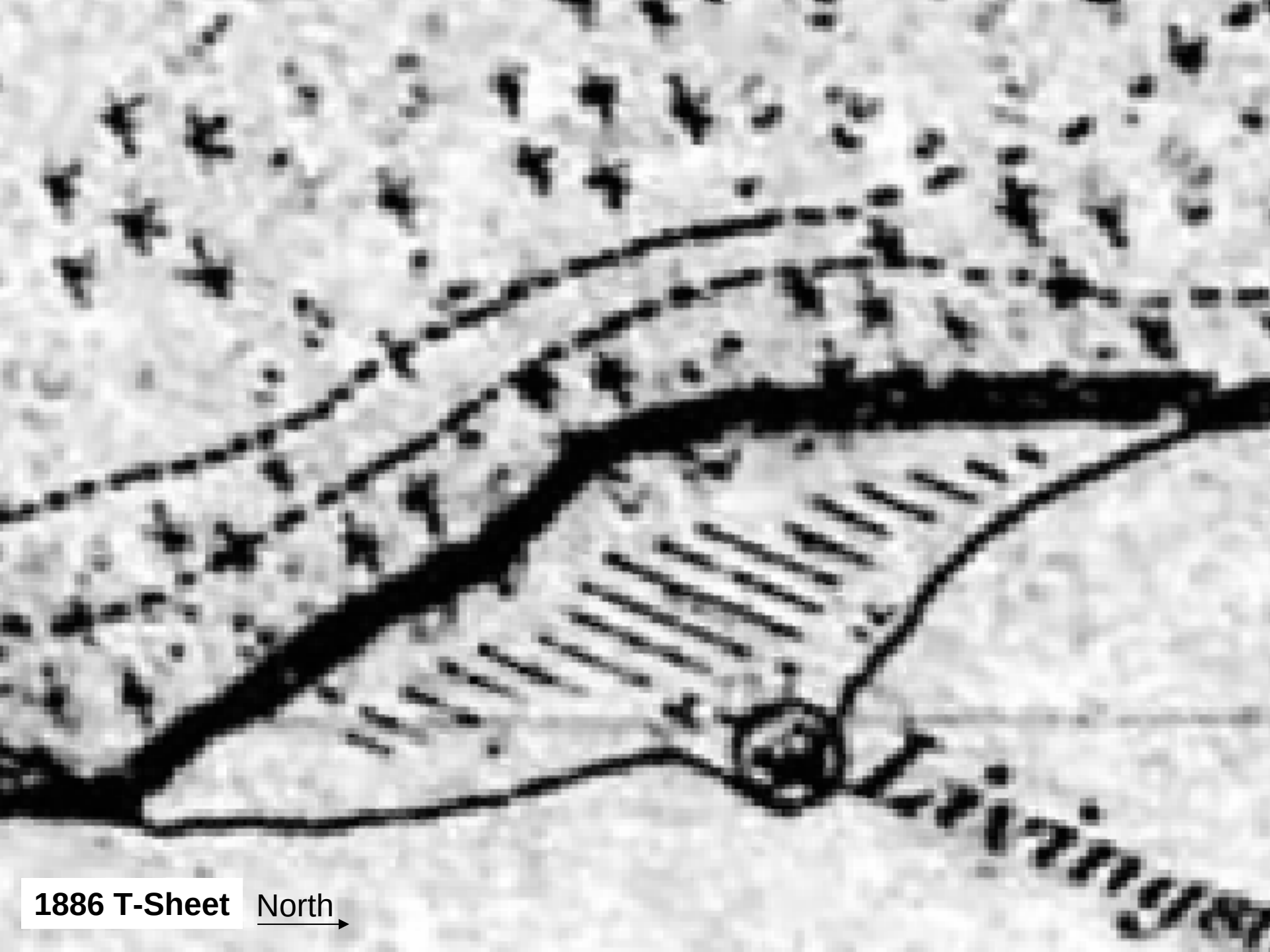
Coastal Processes Analysis

Purpose: Establish understanding of project site physical conditions for purpose of Alt. Evaluation & Design

- Aerial Photo Analysis
- Characterize waves, water levels, tidal currents, sediment transport, and water quality
- Geomorphology
  - Describe geomorphology of diked shoreline sediment processes
- Estuary & channel prototype analysis
  - Development of Estuary & Tidal channel conceptual model
- Driftwood evaluation

Photo Analysis


1886 T-Sheet
North


1941
North


1972
North


1977
North


1990
North


7/31/2005
7/2005
North


4/29/2006
2009
3/2006
North


5/26/2007
2009
5/2007
North


7/2007
North
1990
7/4/2007
2009

8/2007 North


5/30/2009
4/2009
North

4/2009 North

Summary of Photo Analysis

- Prior to 1850 – Undeveloped
- 1886 - USGS establish control, maps site as marsh/grassy area
- 1886 to 1942 – Uncertain, presumed diked for grazing
- 1942 to 1970 - Dike straightened & repaired
- 1972 - Initial breaching evident at south
- 1977 - Slight breach and overtopping evident
- 1980 to 1990 – large breach develops + driftwood
- 1990 to 2005 – unvegetated interior areas develop
- 2005 to 2006 – rapid driftwood shift to north end
- 2006 to 2009 – new driftwood continues, rapid spit growth
- 2009 to Present – south relatively stable, spit growth continues with additional driftwood accumulations

Tidal & Geodetic Datum

	MLLW Datum (ft)
Maximum Recorded Tide	X
Mean Higher High Water	11.2
Mean High Water	10.3
Mean Sea Level	6.6
Mean Tide Level	6.6
Mean Low Water	2.8
North American Vertical Datum 1988	2.1
Mean Lower Low Water	0.0

Tide Stations

1. MHHW and MLLW relation to NAVD88 confirmed by HAI survey.
2. Other tidal datums computed using VDATUM software.

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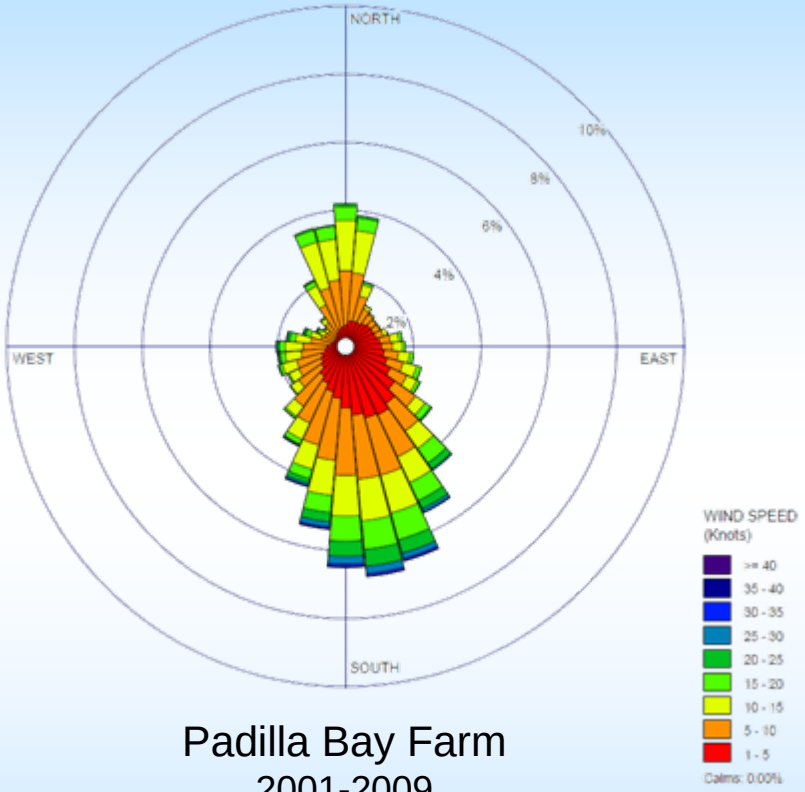
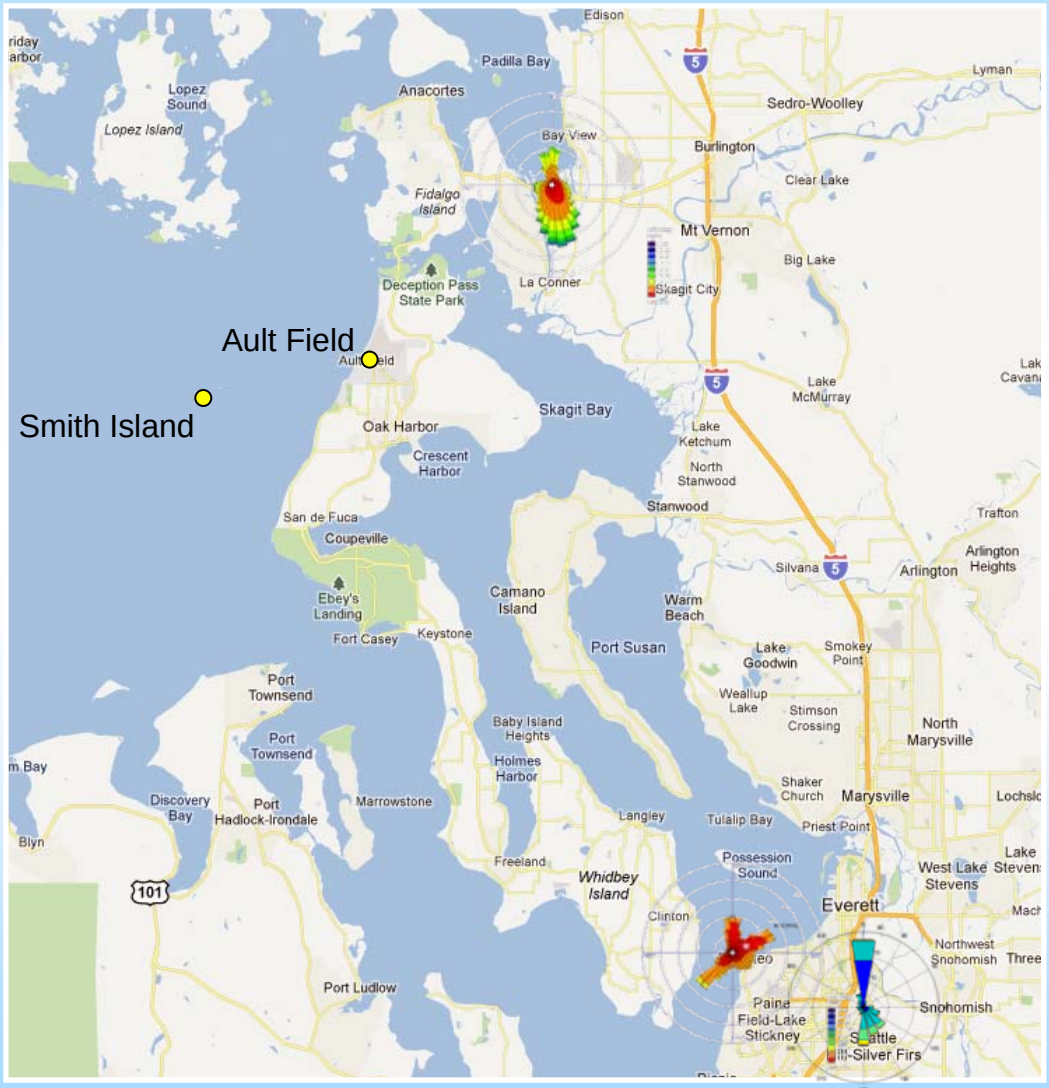
Wind Data



Padilla Bay Farm
2001-2009



Wind rose for Ault Field and Smith Island not shown

- Wave Analysis
- Geomorphology Evaluation

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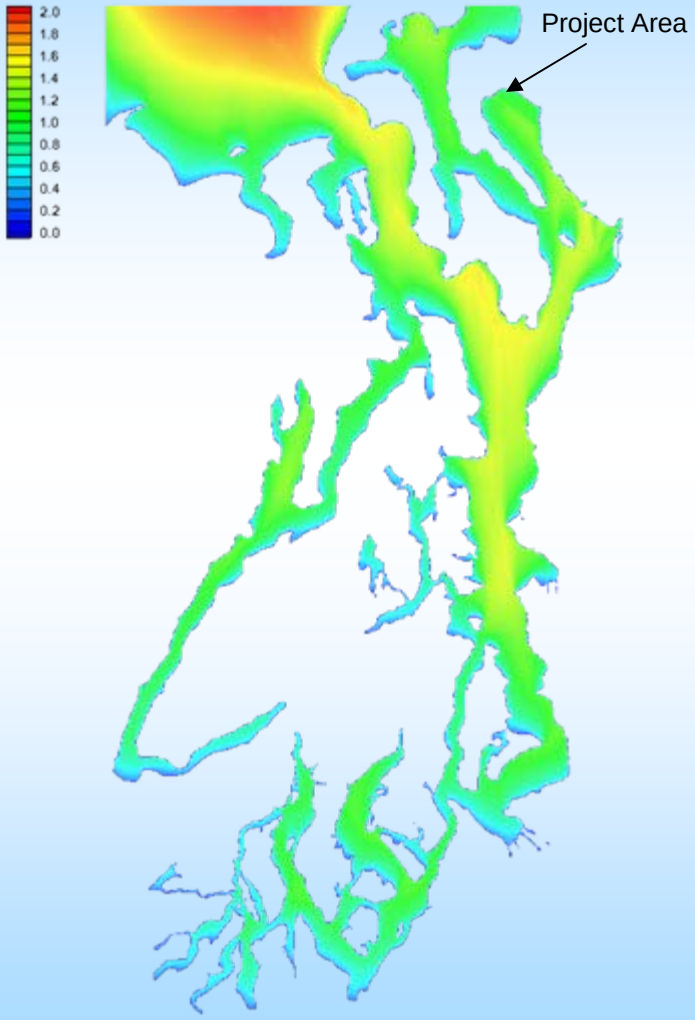
Wave Model Database

Return Period. (Year)	Significant Wave Height (m)	Peak Wave Period (sec)
2	0.85	4.6

Useful for order of magnitude estimate of storm wave conditions at various return periods prior to detailed analysis

- Geomorphology Evaluation
- South Breach Fill Design



Puget Sound Wave Model
2-year Wind Storm from 190°

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Sea Level Rise

- Local ground level change
- Eustatic sea level rise

<u>Predictions & Studies:</u>

- IPCC
- UW Climate Impact Group
- NOAA Long Term Measurements
  - Seattle 2.06 mm/yr
  - Port Townsend 1.98 mm/yr

Freshwater Input

- Stillaguamish River (to east)
- Groundwater from adjacent bluff (rate unknown)

- Not critical for project design or analysis

Geomorphology

Sediments Onsite

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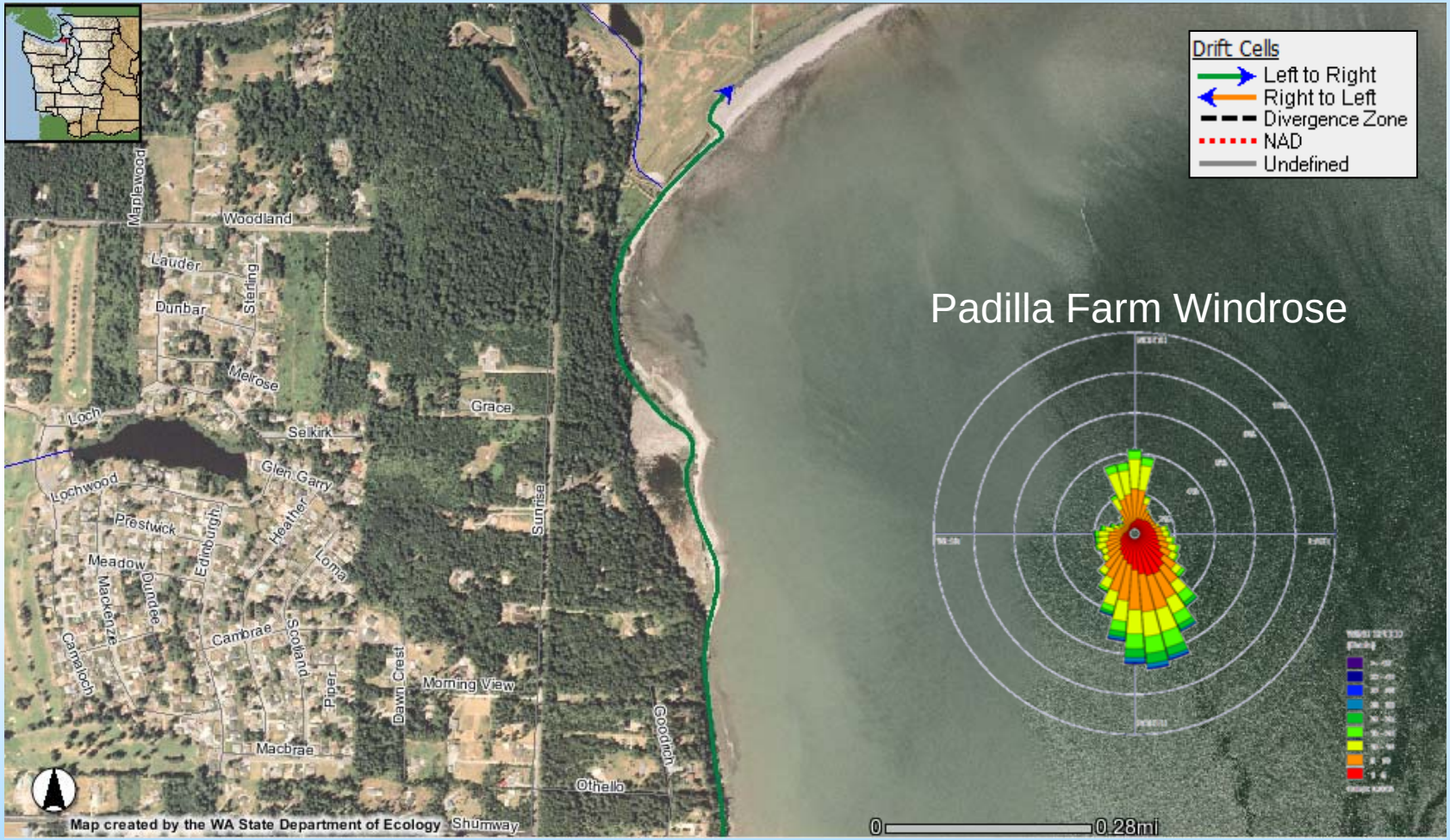
2001 DOE Oblique Photograph

Longshore Drift from DOE



Net drift to the north with predominant wind and waves.

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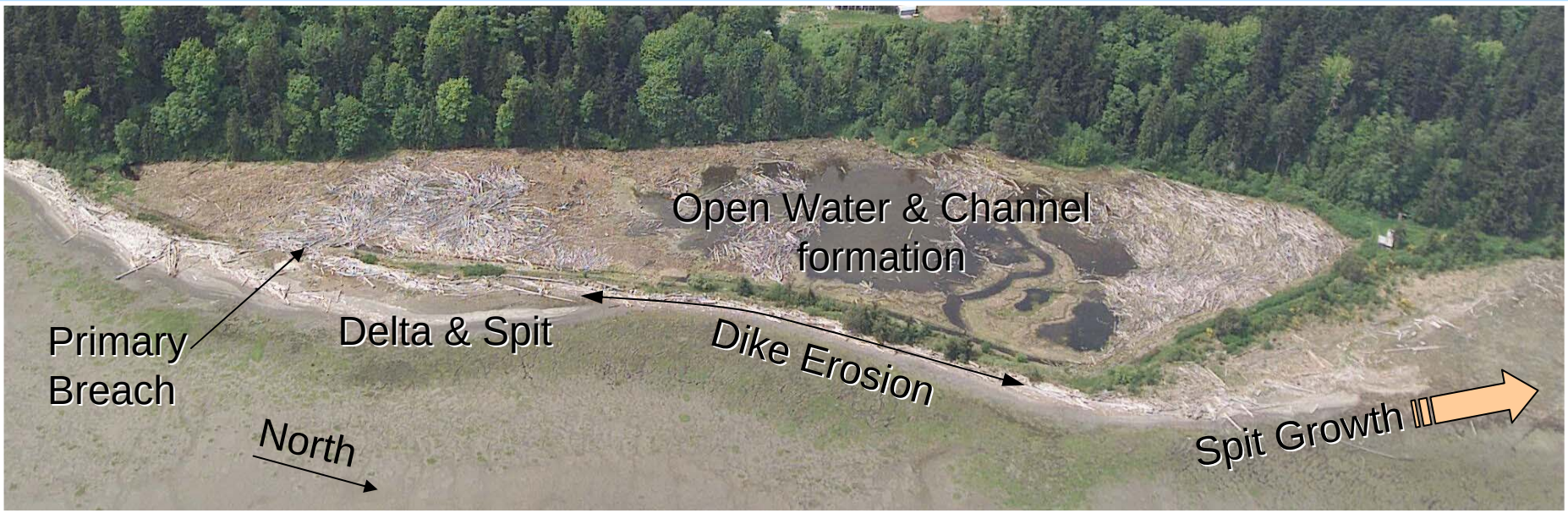
Geomorphologic Features



2001 DOE Oblique Photograph

Growth of North Spit

Recent net growth on the order of 250 to 300 m^3/year to the north

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Development of South Breach & Spit

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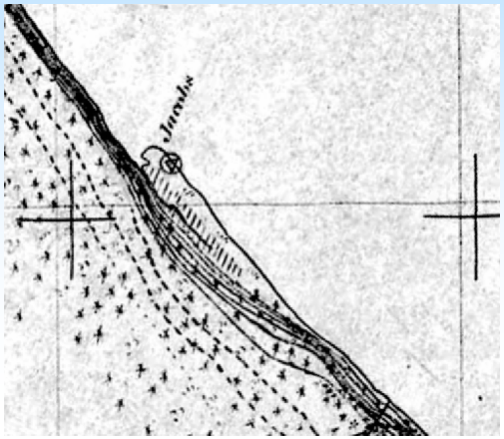
2001 DOE Oblique Photograph

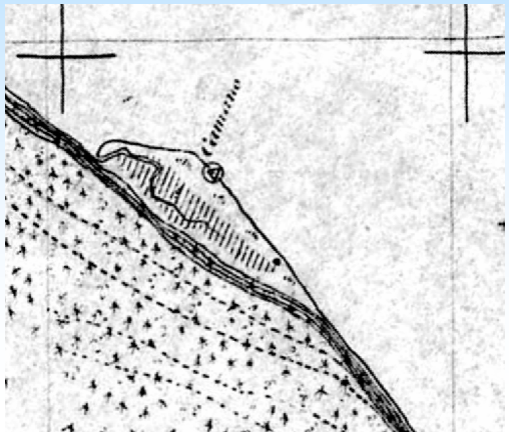
Geomorphology Summary

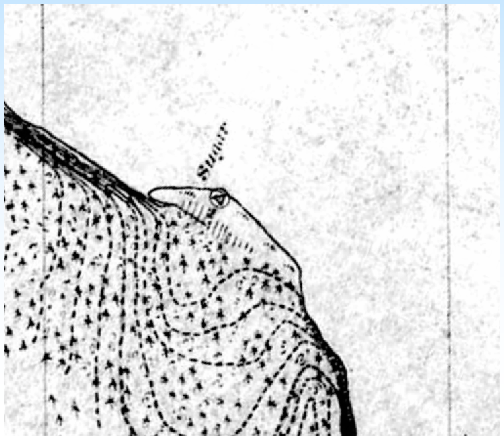
- South breach outflow delta
  - Locally interrupts down drift sediment processes
- Net longshore transport
  - Poorly sorted near south end (closer to source; feeder bluff to south)
  - North area is depositional (north spit development)
- East dike erosion ongoing process
- Beach Profile
  - Low tide terrace at high elevation (high sediment, lower wave energy)
  - Upper profile adjustment along east dike
- Wave and debris overtopping
  - South breach low elevation

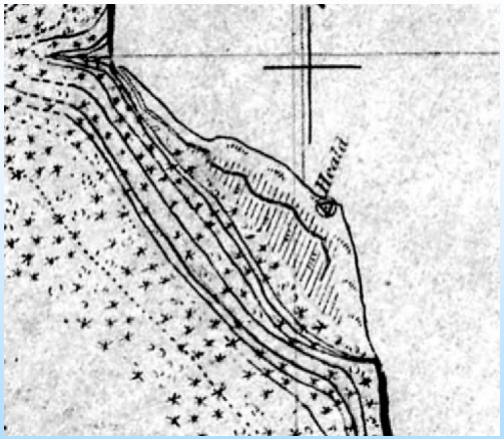
Estuary Prototype Analysis

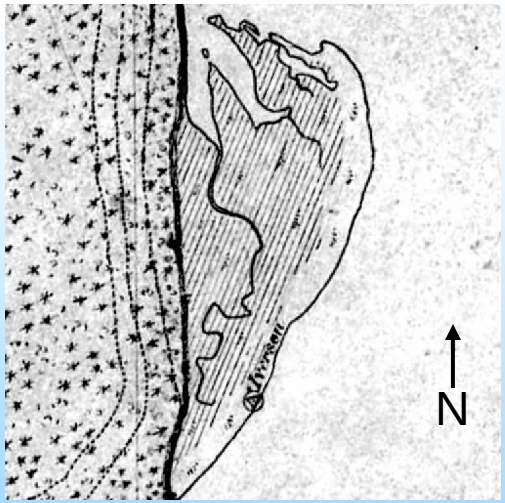
Pocket Estuaries in Port Susan - From 1886 USCGS T-Sheet











PROJECT SITE

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Prototype Tidal Channels

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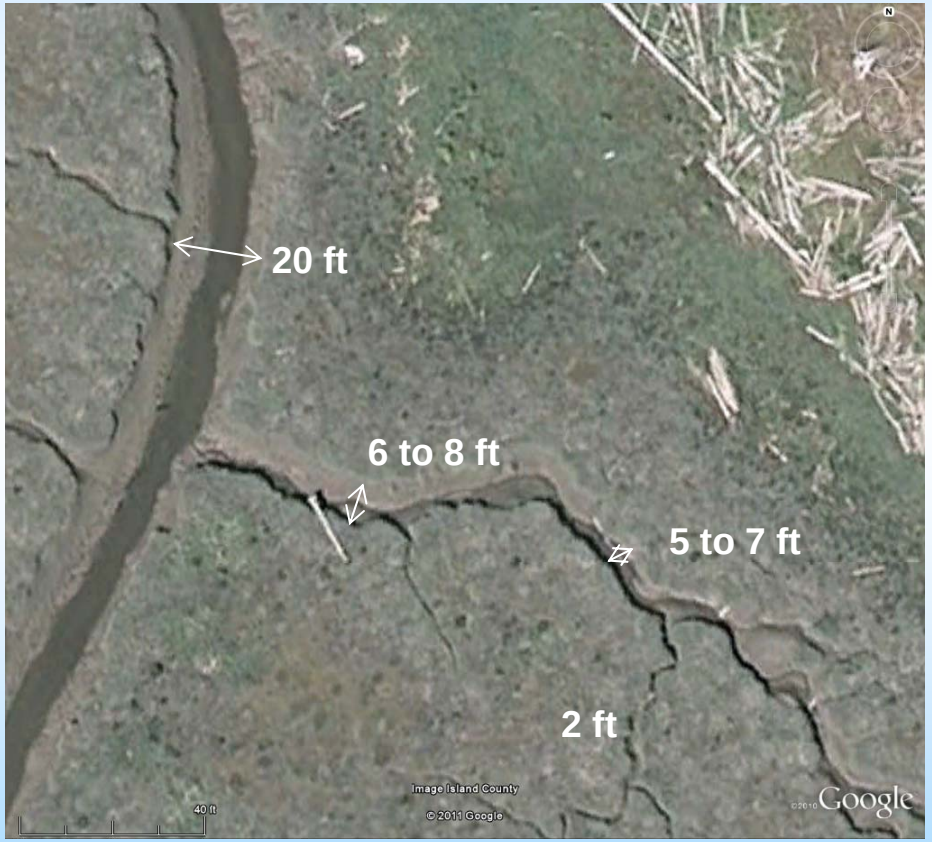
1. Prototype Tidal Channels



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1. Prototype Tidal Channels

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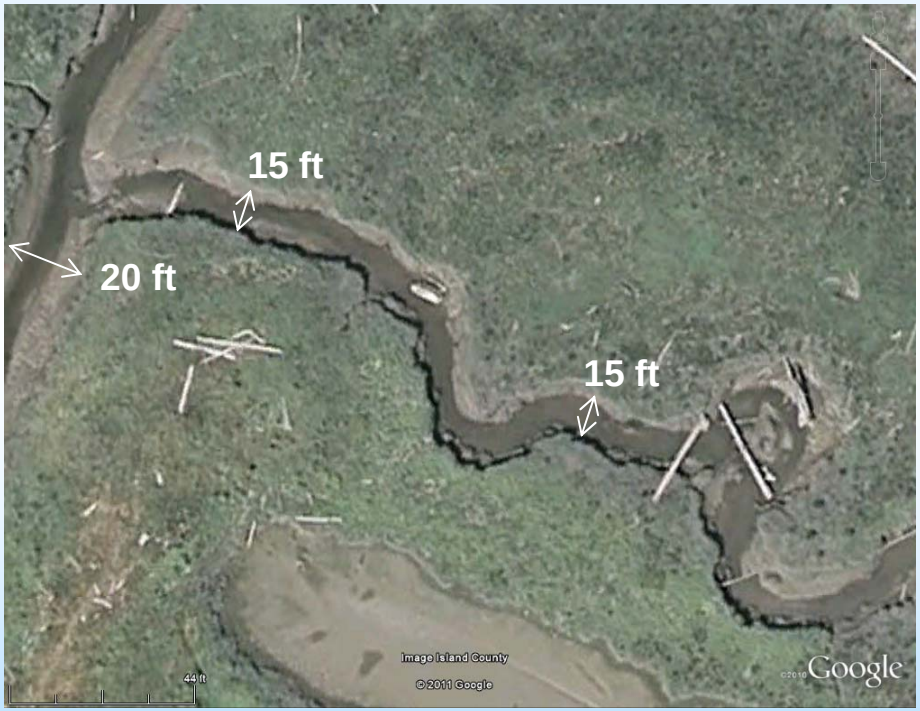

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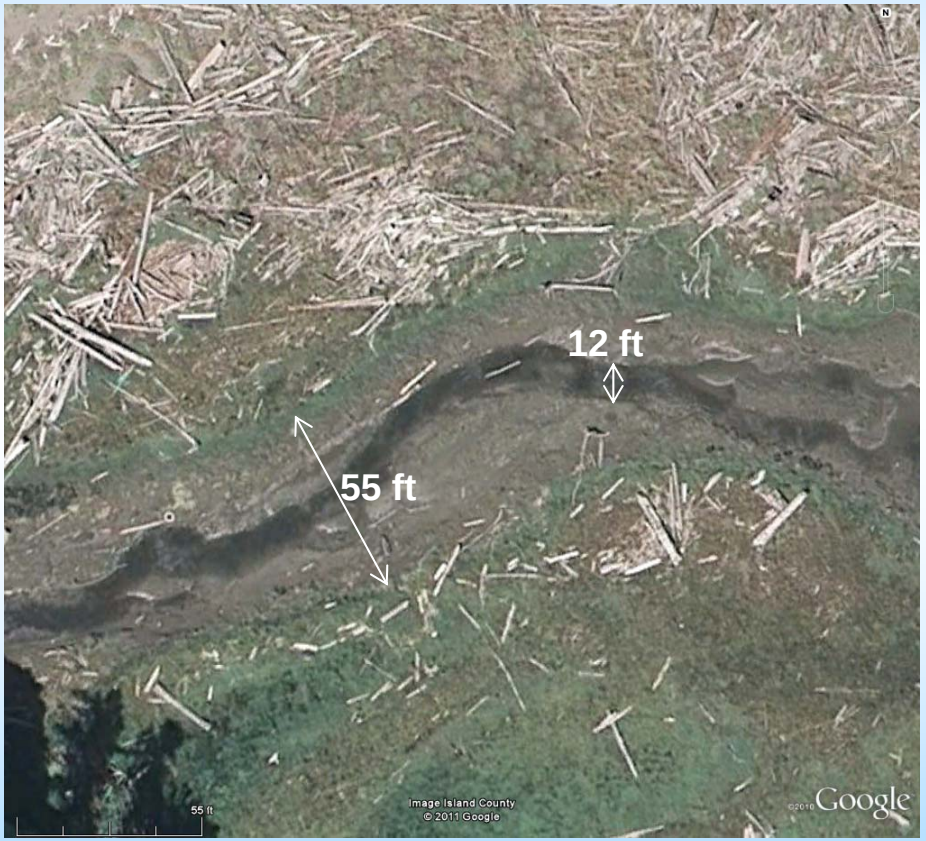
2. Prototype Tidal Channels



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Prototype Tidal Channel Summary

Site	Primary	Secondary	Tertiary
1	20 ft	6 to 8 ft	2 to 3 ft
2	12 to 15 ft	NA	NA

Expected tidal channel at our site, based upon similar tidal prism

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Driftwood Characterization

- Driftwood Source
  - Bay via south breach; secondary source from overtopping of dike along lower south dike
- Size
  - Length varies, typical lengths 25 to 45 ft
  - Diameter varies, typical 12 to 24 inches
- General
  - Wood appears relatively mobile in recent years
  - Interior driftwood accumulations at north are not constant/steady but appear to be event-based.
  - Winds combined with high tides drive accumulations and transport of logs, with net north transport due to predominant winds and fetch.
  - Side by side with minimal large gaps
  - Generally 1 log thick

Driftwood Evaluation

- Reviewed Aerial Photos
- Coverage by Year
  - 1980 0 acres
  - 1990 18,300 m^2 (4.5 acres)
  - 2005 18,500 m^2 (4.5 acres)
  - 2006 18,700 m^2 (4.5 acres, mass shifted north)
  - 2009 24,000 m^2 (5.9 acres)
  - 2011 ? Increase, amount to be determined from TNC photos
- Reviewed wind/tide records
  - El Nino effects play a role to elevate tides and generate storms
- Large driftwood shift in 2005-2006 photos may be attributable to combined windstorm & high tides from Feb. 4, 2006; was a 25 to 50-Year event.
- Driftwood natural removal will take time

Biological Processes & Ecological Functions

- Riparian Vegetation
  - Protect/Enhance
- Estuary Accessibility & Use
  - Target juvenile salmonids
- Tidal Prism
  - Tidal water ponding vs. near complete exchange of estuary water
  - Has an effect on biology & outlet channel morphology

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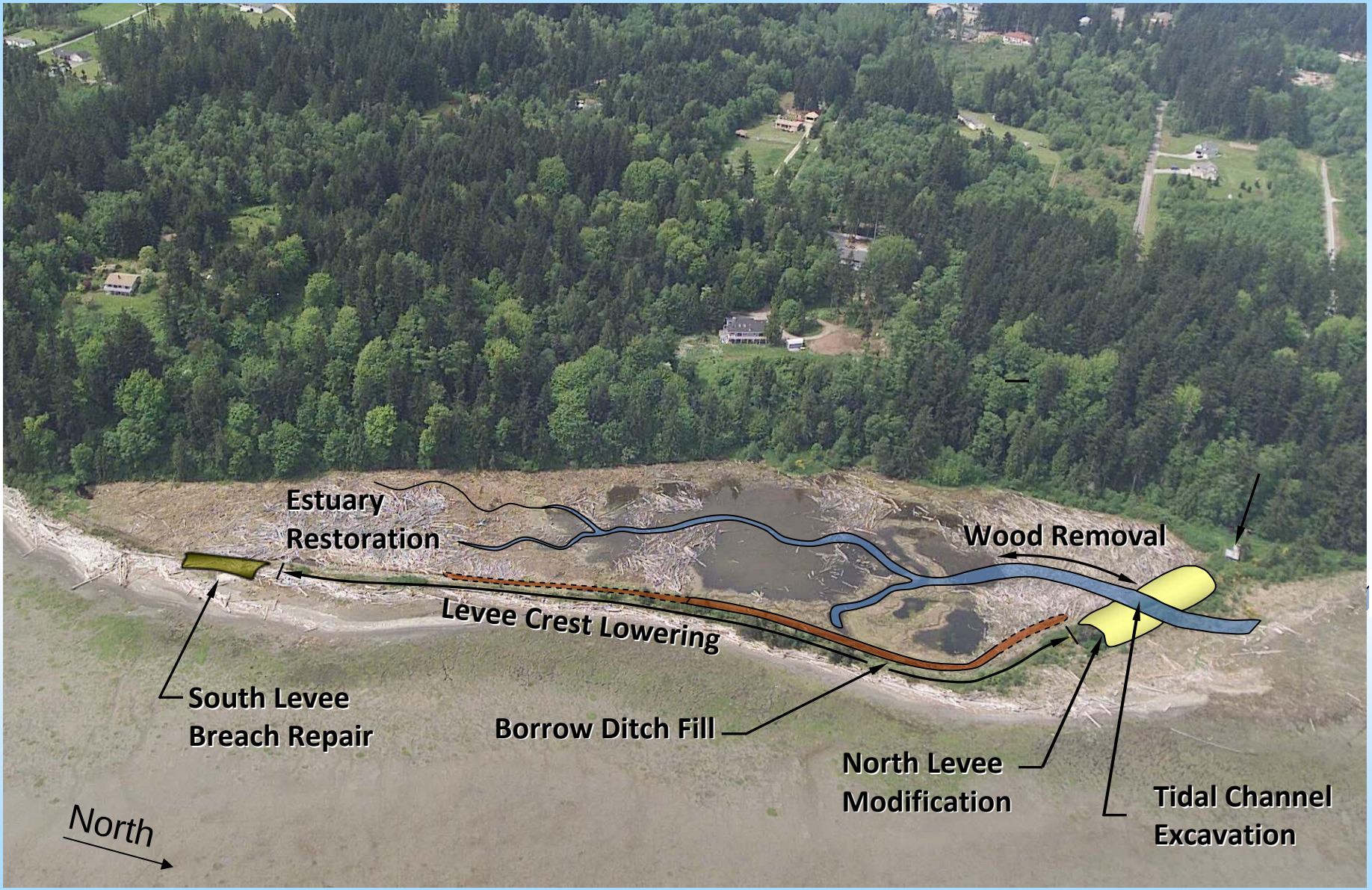
June 2011 Concepts & Approach



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Approach Discussion

- Dike Breach & Reconnection
  - North Dike Breach is best location
  - South Dike Breach should be partially repaired
  - Dike crest lowering may have minimal benefit and only along north dike to facilitate natural removal of wood at very high tides.
  - Fish accessibility can be increased over existing conditions
  - Driftwood removal will be a partial removal in areas for north dike breach, requiring long term natural recovery for remainder

Approach Discussion (based on results of analysis & data review)

- Dike Breach & Reconnection
  - South Breach Closure
    - Existing delta will adjust & restore local longshore processes
    - Prevent logs from continuing to enter/accumulate in the estuary
    - Maximize Hydraulics – Single outlet channel (shorter distance)
    - Hydraulic efficiency of outlet channel (larger cross section)
  - North Breach & Reconnection
    - Lower risk of outlet channel closure due to long shore sediment processes
    - Opportunity to provide greater tidal prism than south breach
    - Ideally located closest to deep estuary
- Dike Crest Lowering
  - North Dike
    - Limited assistance in driftwood removal during extreme storms
    - Impacts to vegetation would be negative
  - East Dike
    - Minimal benefits
    - Natural removal through erosion processes will continue
    - No driftwood removal assistance & may aid in driftwood recruitment
    - Impact to riparian vegetation would be negative

Basis of Design – Location Map

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2009 Aerial Photograph

Basis of Design – Project Constraints

- Construction Budget: Construction funding $160,000
- Construction Window: July 15 to February 14 with possible extension
- Project Limits: Project analysis will consider adjacent properties; project design features will be limited to the TNC property unless directed otherwise
- Maintained Access: North dike breach less than 100 feet at MHHW, assumed.
- Cultural Resources: TNC will conduct its own investigation and provide direction
- Site Disturbance: Some existing vegetation will be damaged during construction. To the extent possible, site disturbance will be minimized by the design and construction.
- Existing Site Features: The location of the spit is likely to change from the location surveyed in August 2011. Natural log removal to the north via the pilot channel will be constrained by the continued spit formation to the northwest.
- Construction Access: Water-based equipment and material delivery is anticipated. Access to the site by foot during the construction phase (for personnel) will be resolved by TNC.

Basis of Design – General

- Construction Materials:
  - Maximize use of onsite material
  - Minimize use of imported materials.

- Maintenance:
  - Minimize post-construction maintenance.

- Material Disposal:
  - Onsite within nearshore and uplands on TNC Property
  - Offsite disposal only for demolition items

Basis of Design – Project Features

Existing North Dike Modifications


VIEW OF NEW BREACH ZONE, FACING WEST

- Ecological Function.
  - Fish and invertebrate access
  - Provide a deeper water refugium for juvenile salmonids at low tide.
- Location.
  - Breach and pilot channel to be located to take advantage of existing topographic features, oriented to the north.
- Size & Extent.
  - To equilibrium depth and width resulting from the estimated tidal prism and study of adjacent pocket estuaries.
  - Breach top width will be sized to at least the average length of driftwood within the site. Top width constrained to less than 100 feet.
- Hydraulic Performance:
  - Sufficient to provide tidal exchange and mobilize existing sediments in the tidal channel at peak ebb and flood tide.
  - Remove wood from the project area.

Basis of Design – Project Features

Existing South Dike Breach Modifications


EXTERIOR EXISTING BREACH, FACING NORTH


INTERIOR EXISTING BREACH, FACING SOUTH

- Ecological Function.
  - Restore Long Shore Sediment Processes
  - Increase shoreline riparian area
  - Aid in driftwood removal
- Location.
  - Primary existing south breach
- Size & Extent.
  - Rebuild Beach Berm
- Hydraulic Performance.
  - Route tidal flows through north pilot channel.

Basis of Design – Project Features

Dike Crest Lowering

EXISTING DIKE FROM BEACH, FACING NORTHWEST

- Ecological Function.
  - Aid in natural LWD removal from estuary – north dike only.
- Location.
  - Primarily along north dike
  - Minimal benefit along east dike.
- Size & Extent.
  - Within footprint of existing north dike
- Hydraulic Performance.
  - Increased wave overtopping during storms.

Basis of Design – Project Features

Driftwood Removal

- Ecological Function.
  - Wood removal improves fish access and directly restores estuarine marsh
- Location.
  - At minimum, in the vicinity of pilot channel.
  - Strategic locations determined by hydraulic analysis.
- Size & Extent.
  - Pilot channel to provide unobstructed tidal channel flow between the bay and estuary.
  - Partial Removal due to budget limitations. Focus on areas most critical for connectivity and restoration.
  - Natural Recovery. Residual driftwood would be allowed to mobilize through natural processes upon completion of construction.

Basis of Design – Project Features

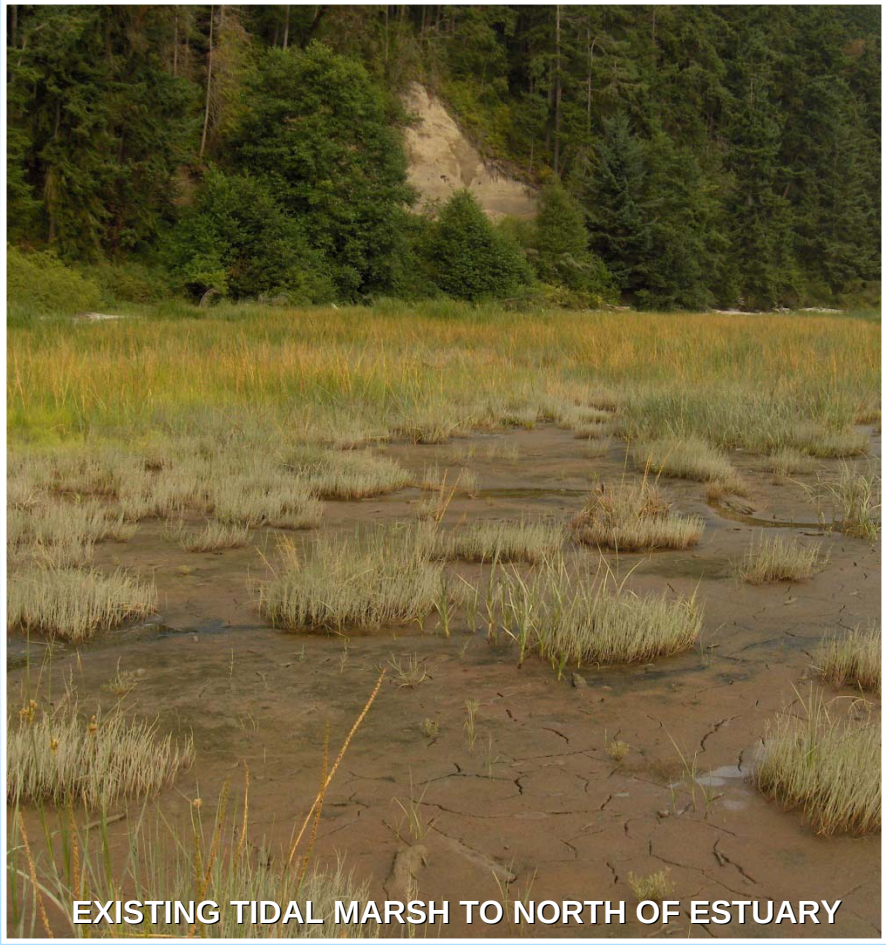
Existing Borrow Ditch Modifications


EAST DITCH, FACING NORTH

- Ecological Function. Improved fish access and deep water refugia.
- Location. Location varies; orientation follows existing ditch.
- Size & Extent. Filling/Excavating of borrow ditches to be evaluated to aid in new outlet channel hydraulic and geomorphic processes.
- Hydraulic Performance. Ensure flow routing to new pilot channel to maximize hydraulic performance.

Basis of Design – Project Features

Estuary Restoration

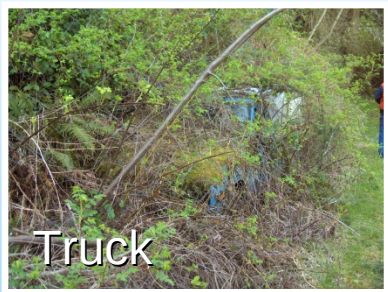


EXISTING TIDAL MARSH TO NORTH OF ESTUARY

- Ecological Function.
  - Provide suitable elevations to establish target vegetation communities.
- Location.
  - Interior estuary.
  - Due to budget limitations, the development of tidal channels and bench features within the interior estuary area will be limited to establishing the primary levee breach and reconnection to the pocket estuary.
- Size & Extent.
  - Varies.

Basis of Design – Project Features

Demolition



- <u>Ecological Function.</u>
  - Reduced potential for contaminants entering the restored estuary. No other specific ecological benefits were identified.
- <u>Location.</u>
  - At three existing structures/vehicles.

Basis of Design Summary

- Confirmation by TNC of Constraints
- Extent of Estuary Restoration
  - Limited to reconnection w/ natural recovery
  - Or expansion through additional improvements
- Demolition
  - If budget is tight, do all 3 need to occur?

Outline

- Project Objectives
- Scope of Work & Schedule
- Data Compilation & New Data Collection
- Observations from Site Visit
- Coastal Processes
- Biological Processes
- Basis of Design
- Conceptual Design Alternatives
- Next Steps

Conceptual Design Discussion

CHE CONCEPTUAL DESIGN PRIORITY

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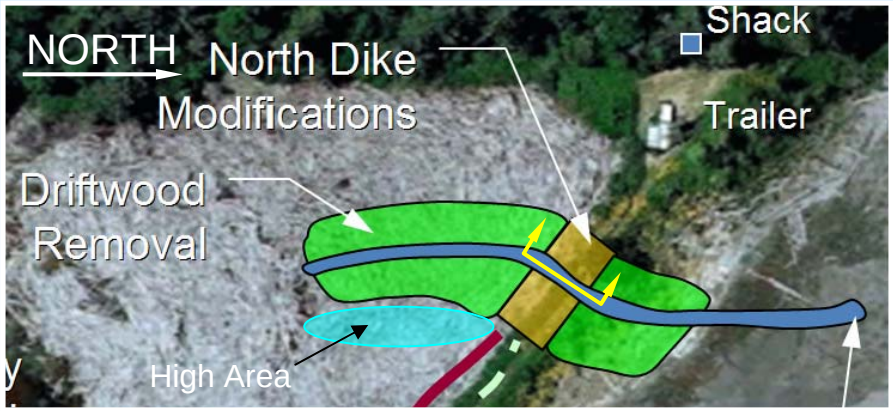
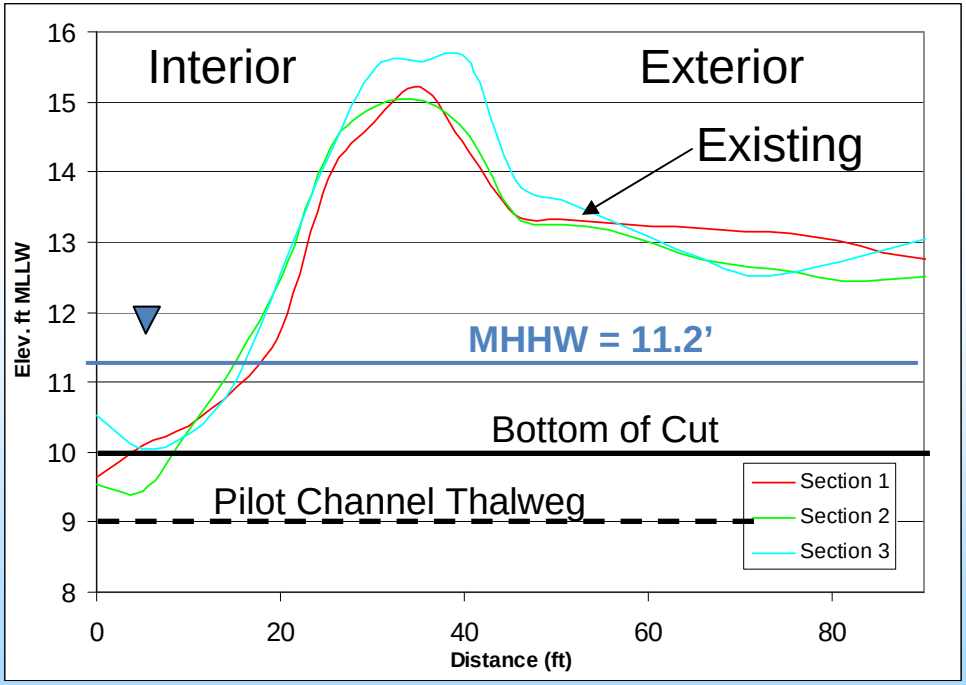
2009 Aerial Photograph

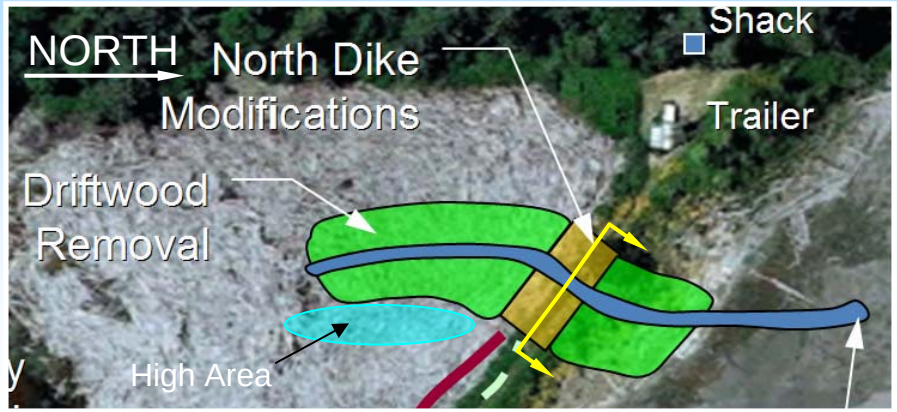
North Dike Modifications

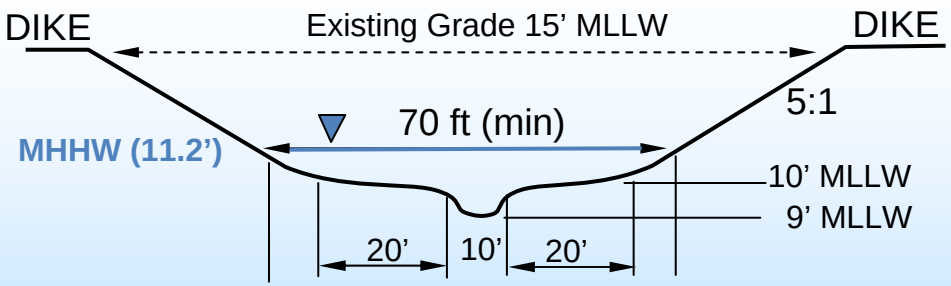




- Excavate bottom of cut to existing interior/exterior grade levels (~ 10 ft MLLW)
- Incise pilot channel thalweg about 1 ft below bottom of cut at 10 to 15 ft wide.
- To reach proper exterior grades for pilot channel, cut must extent north into existing wetlands.

North Dike Modifications

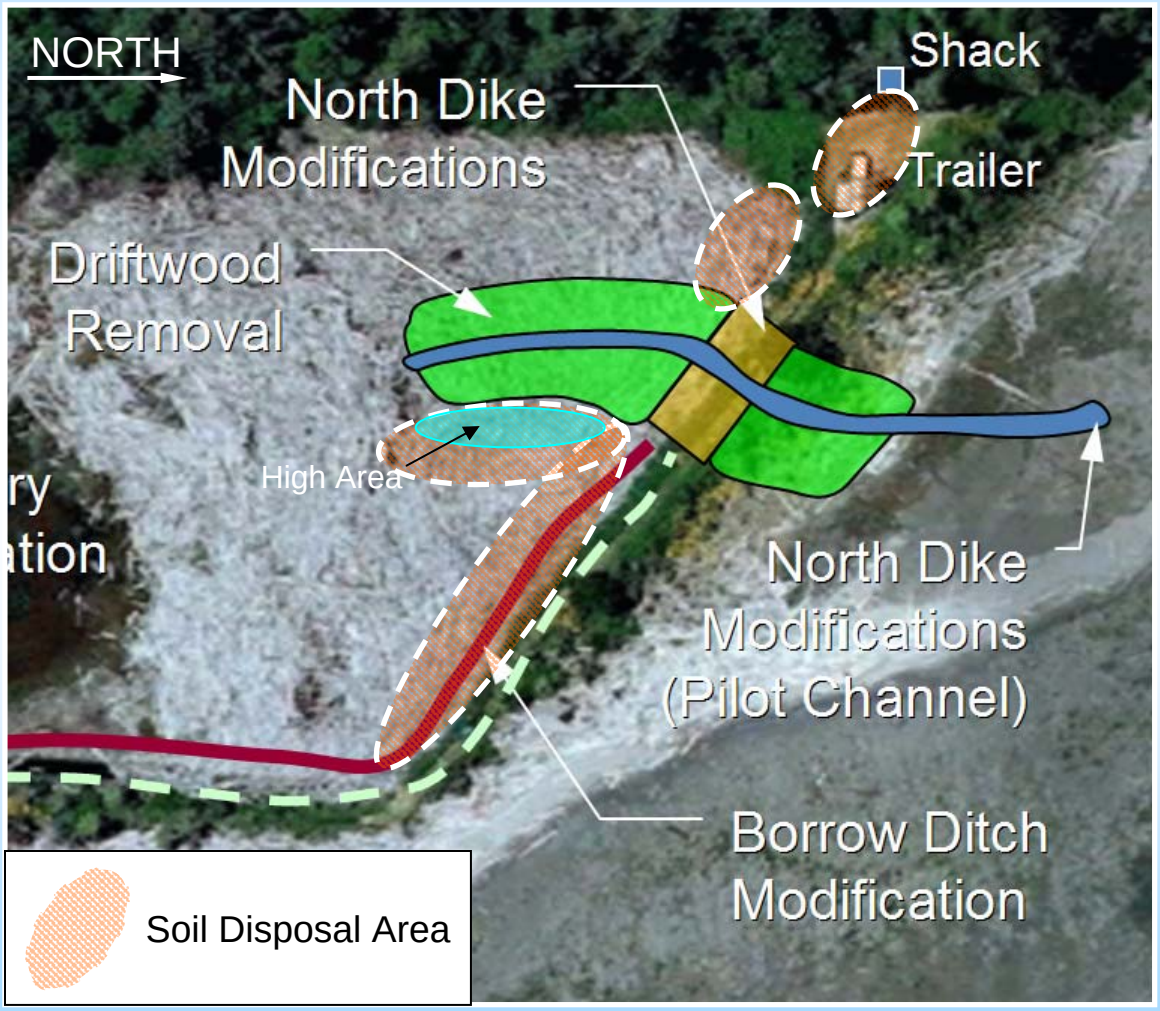




- Max. breach 100 ft at MHHW
- Create gradual transition from upper intertidal to uplands along cut side slopes.
- Total volume of cut may range from 1,100 to 1,500 CY, depending on width.
- Disposal of this material in uplands is constrained; potential disposal in estuary should be considered.

North Dike Modifications

- Disposal of 1,100 to 1,500 CY



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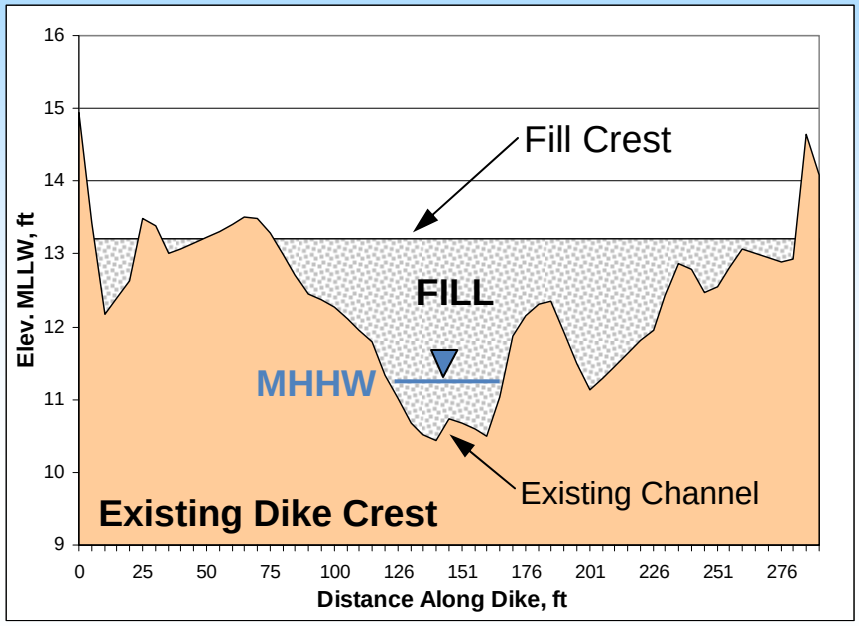
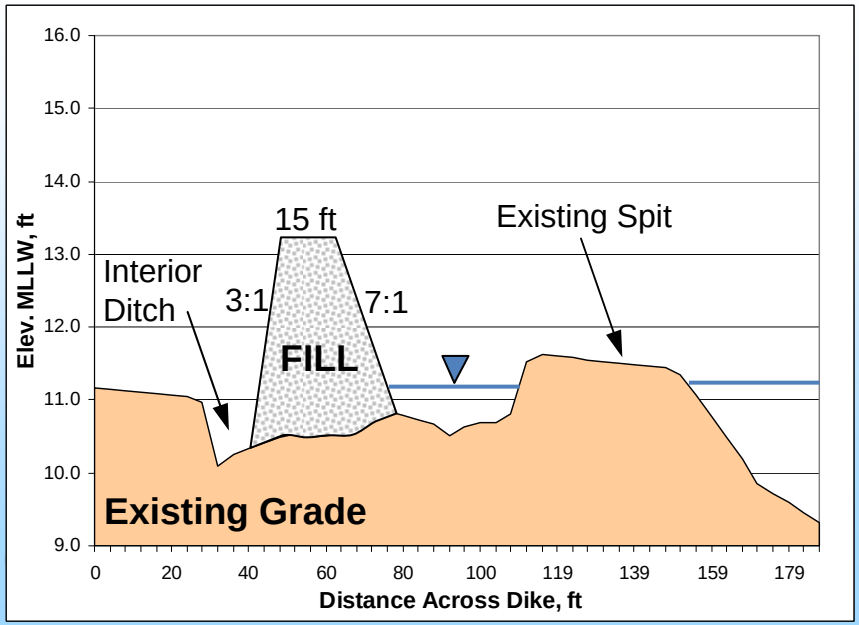
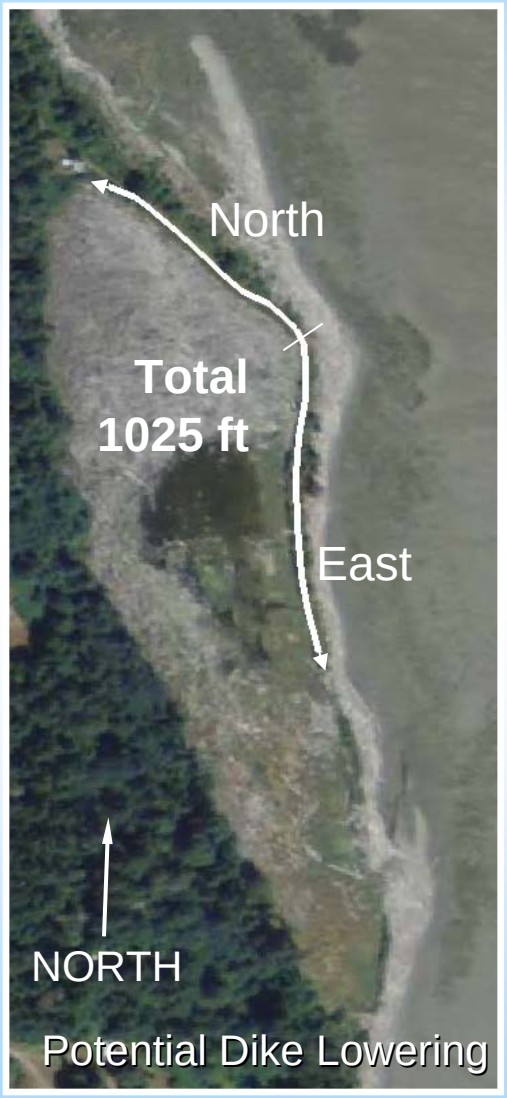
South Dike Breach Modifications





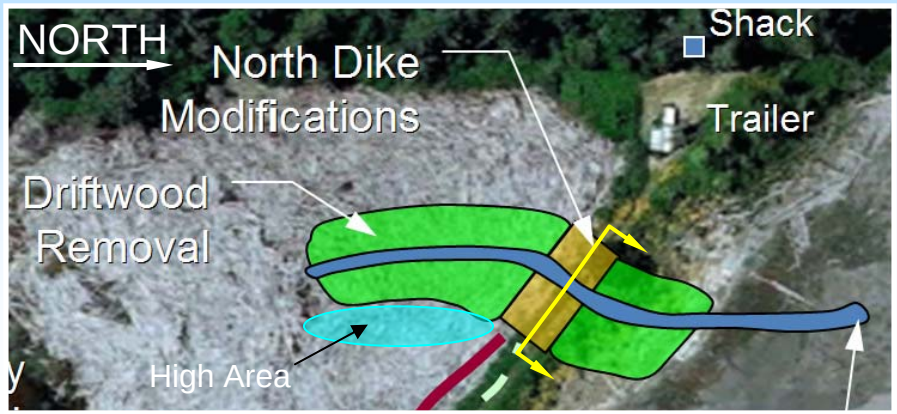
- Fill with imported sand/gravel materials to dynamically resist storms as new channel stabilizes
- Potential to use excavated material, if suitable.
- Gentle slide slopes on seaward side to dissipate wave energy naturally
- Length 150 to 200 feet
- Fill thickness 1.5 to 3 feet
- Top width 15 feet
- Crest Elev. near 13.2 ft MLLW
- Fill volume approx. 225 CY

Dike Crest Lowering



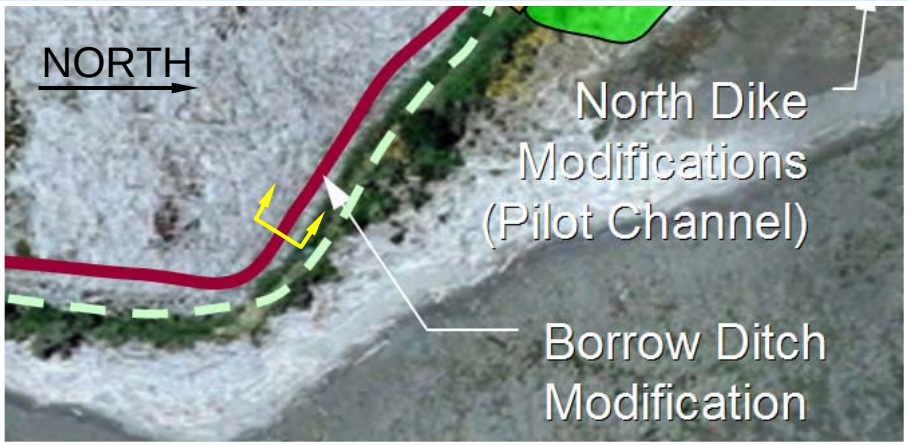
- Highest areas along north and east dike (see figure to left)
- Cut crest down to about 2 ft above MHHW (13.2 ft MLLW)
- Typical cut 1.5 to 2.0 CY/ft of dike length (disposal into adjacent ditch)
- Total cut vol. approx. 1,500 CY, excluding north breach area.
  - North 650 CY (some benefit)
  - East 850 CY (no benefit)
- Would reduce riparian veg. and increase driftwood overtopping the dike where currently doesn't occur
- Can be performed incrementally as Additive Bid as budget allows.

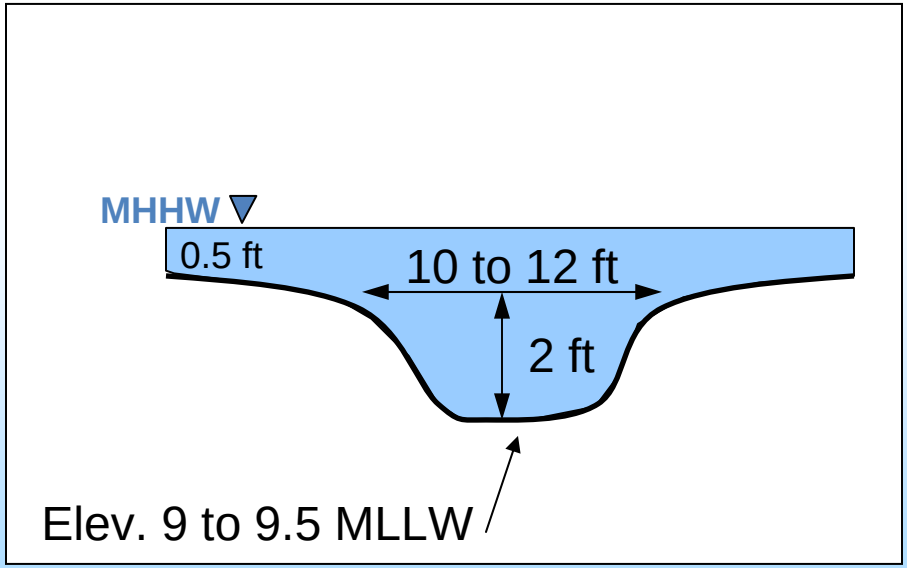
Driftwood Removal



- Driftwood removal required to support excavation of north dike breach and pilot channel
- Dispose of removed driftwood along existing beach/shoreline.
- Length 185 feet (interior)
- Length 60 feet (exterior)
- Width 100 ft at dike and into interior estuary
- Base Bid at north dike Breach
- Additive Bid (for example along the dike) if budget allows

Borrow Ditch Modifications





Existing ditch typ. cross section

- Fill ditch with onsite materials excavated from north dike
- Strategic locations to be evaluated in detailed design/modeling
- Proximity to cut area is key to economics of ditch filling
- Approx 1 CY/ft length
- Base Bid or hydraulics near the new pilot channel
- Additive Bids for material disposal as budget allows

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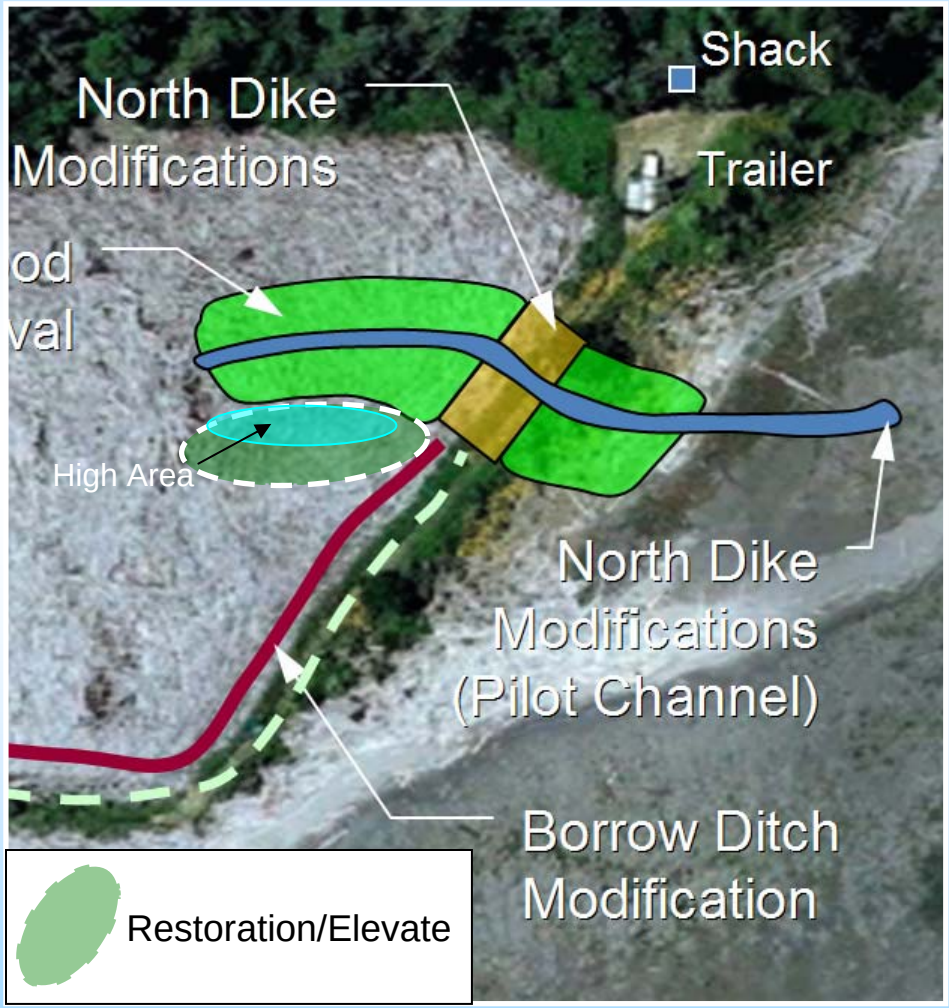
Estuary Restoration



- Primarily related to re-grading interior estuary to promote specific habitat functions.
  - Additional deeper pools & ponded water areas
  - Potential to re-use excavation materials to build up existing riparian areas
  - Borrow ditch filling to promote drainage
  - Operating in estuary presents risk of damage to existing features
- Planting post-construction
- Recommendations
  - Conduct where needed to reduce costs of dike breach ~ elevate estuary area & localized borrow ditch
  - Plantings?
  - Minimize additional work unless additional budget is available

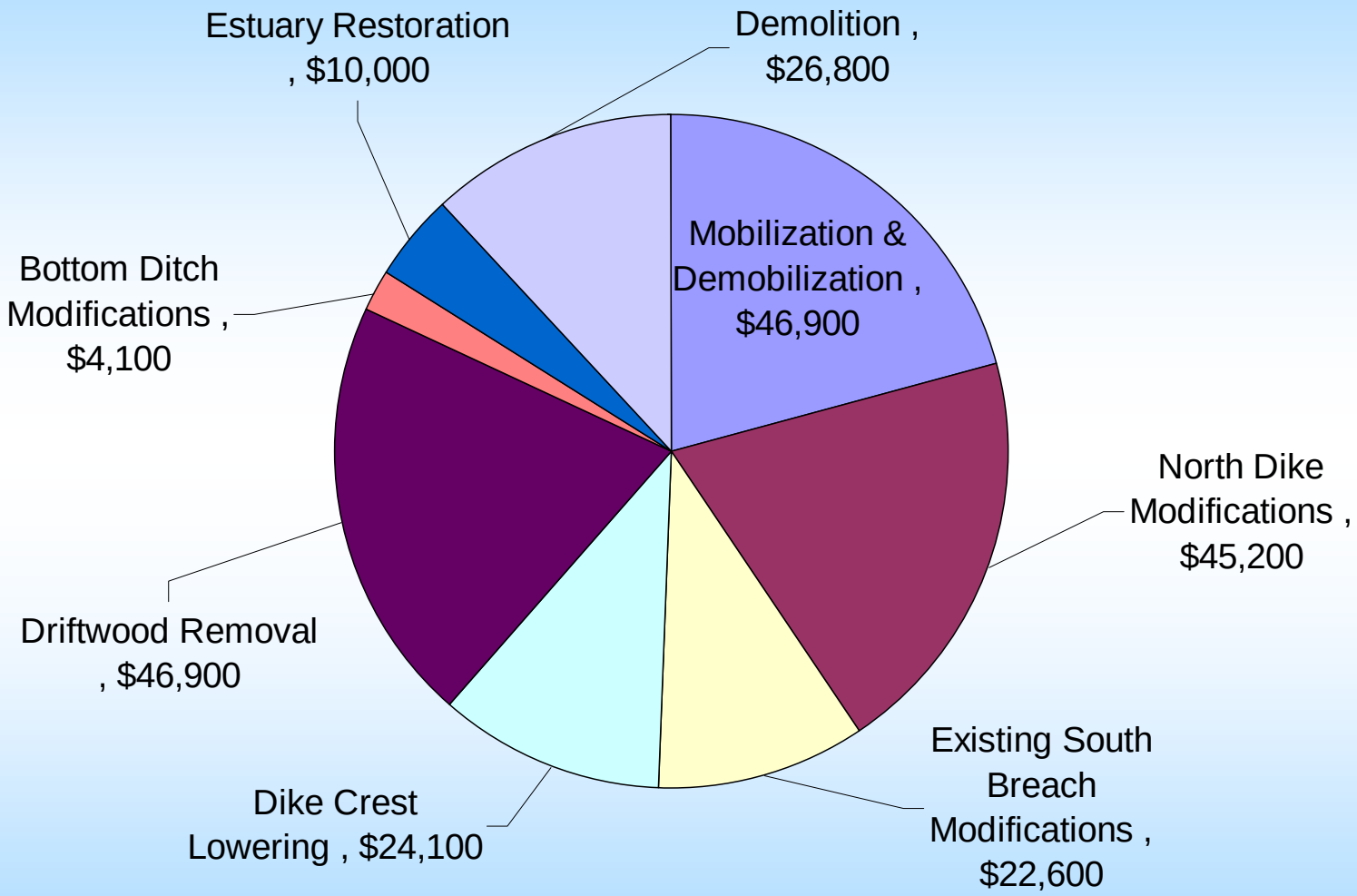
Demolition

- Few direct habitat benefits
- Trailer/shack removal supports disposal of excavated material from north dike modifications.
- Trailer and shack removal benefit disposal of excavated materials
- Light truck demo expected to have relatively high cost due to 950’ distance from primary work area.
- Do all these have equal priority ?
- Consider Truck as Additive Bid

Conceptual Construction Cost Summary

- Mobilization/Demobilization
- North Dike Modifications
- Existing South Breach Modifications
- Dike Crest Lowering
- Driftwood Removal
- Borrow Ditch Modifications
- Estuary Restoration
- Demolition

Conceptual Construction Cost Summary



Total: $226,600

Includes Sales Tax & 25% Design Contingency

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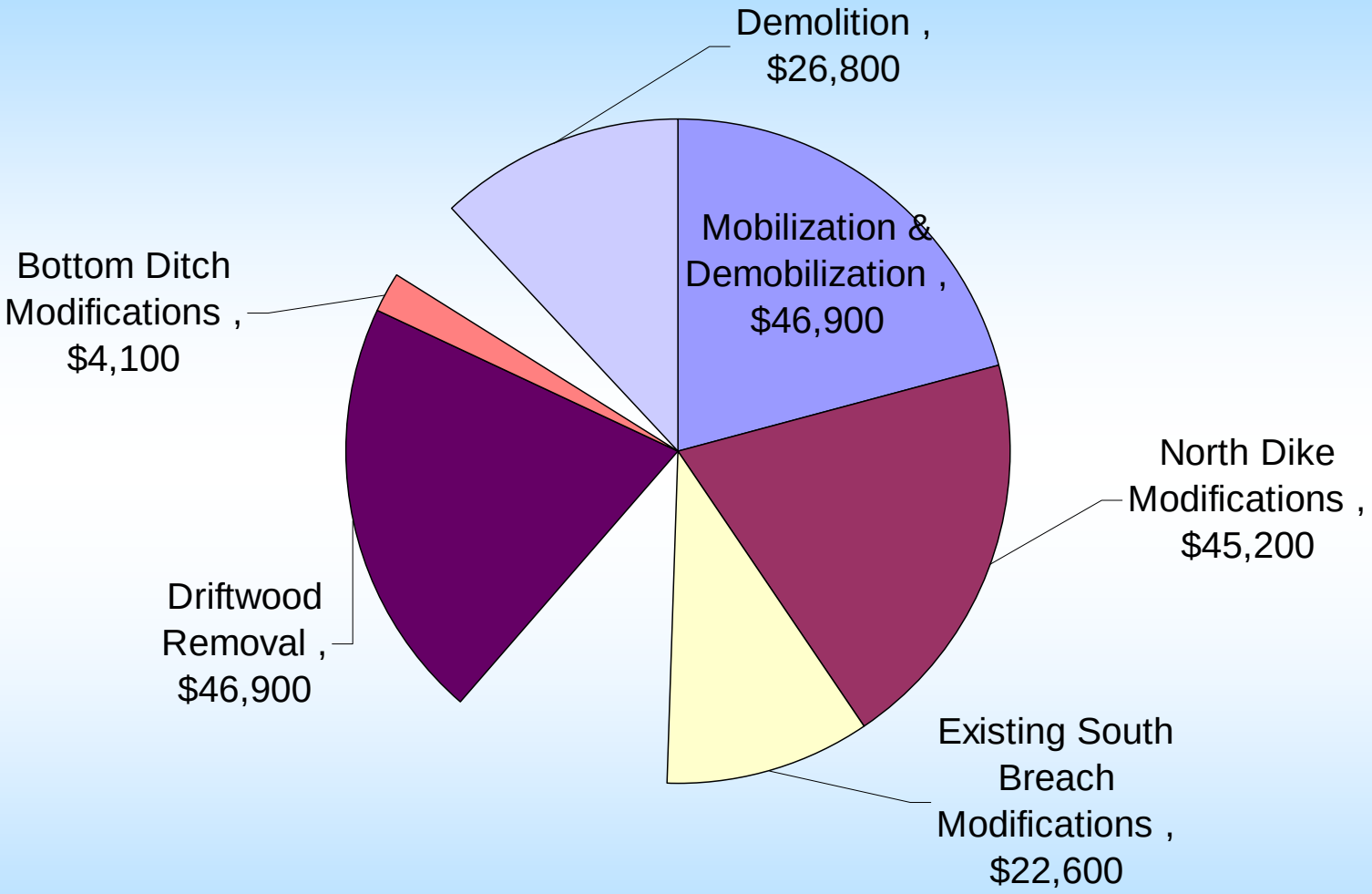
Optimization for TNC Conceptual Priorities

- North Dike Modifications
- Driftwood Removal
- Existing South Breach Modifications
- Borrow Ditch Modifications (partial)
- Demolition

EXCLUDE BELOW

- Dike Crest Lowering
- Estuary Restoration (other than reconnection & natural recovery)

Conceptual Construction Cost Summary



Total: $192,500

Includes Sales Tax & 25% Design Contingency

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Task 1.2 – Feasibility Analysis

Questions/Issues:

- Does this meet TNC objectives ?
- Comments on BOD and approach
- Confirm construction budget
- Prioritize project features for prelim design
- TNC preferred contractors
- Permitting Approach

Summary of Findings

- Data are sufficient to proceed with preliminary design, assuming TNC provides their existing data
- Project is feasible, with constraints due to project budget of $160,000
- Not all project features may be constructed, need TNC to provide feedback to prioritize features for permitting/prelim design
- Natural recovery timeline 10 to 25 years

Next Steps

- TNC to provide…
- CHE to provide…
- Preliminary Design
  - Engineering Analysis & Design of preferred concepts
  - Refinement of concept designs
  - Cost Estimating
  - Drawings
- Regulatory Permitting
  - Agency Site Visit
  - Pre-application & agency coordination
  - Application documents
  - Permit Package

Livingston Bay Pocket Estuary Restoration Feasibility Assessment

September 15, 2011

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PENTEC ENVIRONMENTAL