MOTT MACDONALD

Willapa North Shoreline Protection Demonstration Project

Design Report

March 31, 2020

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Contents

Tables

Figures

1. Introduction and Overall Project Description

The overall objective of the shoreline protection Demonstration Project, initiated by Pacific County, is to integrate the best knowledge and data from previous and ongoing projects to provide sufficient long-term erosion protection to the endangered state and federal infrastructure elements, and to the extent possible, the private properties located in the coastal areas of North Cove, WA. The Project Area covers approximately 5,800 ft. of shoreline between Tamarack Street in the north and Drainage Ditch #1 to the south, as shown in Figure 1. The state and federal infrastructure elements considered under this project include but are not limited to State Route (SR) 105, Grayland Drainage District, Tribal land, and beach areas below Ordinary High Water (OHW) managed by Washington State Parks. The entire North Cove shoreline has been subject to severe long-term erosion that has resulted in progressive and extreme[1] landward migration of the Ordinary High Water Mark (OHWM) toward public infrastructure and private property. A preferred shoreline protection system in the Project Area will be achieved through several steps including:

- Coordinate between local, state, and federal agencies and stakeholders as part of project-specific committees to develop a preferred alternative;
- Develop a Basis of Design (BOD) for acceptance by a team of technical experts and stakeholders (Project Technical Committee);
- Design the Demonstration Project to provide long-term[2] shoreline erosion protection along the critical part of North Cove shoreline (current phase of the project);
- Implement the Demonstration Project;
- Conduct monitoring program;
- Develop a refined Master Plan for guiding a regional-scale strategy for erosion protection in North Willapa Bay, based on Demonstration Project data, coastal engineering analysis, and expertise.

The North Cove Project Area was previously segmented into three regions (MM, 2016) which have different physical drivers of shoreline erosion, as shown in Figure 1, to aid in development of the project area extents. These segments were discretized based on the pattern of the North Tidal Channel, the conduit through which tidal flows enter and exit Willapa Bay, and performance of prior shoreline stabilization projects. Details can be found in the 2016 MM study findings, but are summarized below:

- Regions 1 and 3, where the shoreline may potentially be affected by North Tidal Channel migration.
- Region 2, where northward migration of the North Tidal Channel has been terminated by the 1997 SR105 shoreline protection project[3].

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[1] The historical rate of shoreline erosion was estimated in a range of 150-250 ft per year, that apparently corresponds to one of highest rates of erosion in the world.

[2] Long-term is consistent with a project lifetime of 40 years with maintenance, as defined in the Basis of Analysis Memorandum titled *Willapa North Shoreline Protection Demonstration Project (WNSPDP) Input Data, Assumptions, and Design Criteria* dated 10/2/2018.

[3] Please note that the boundaries of the regions are shown on the figure conceptually and shall not be used for any other purposes rather than presentation of the report.

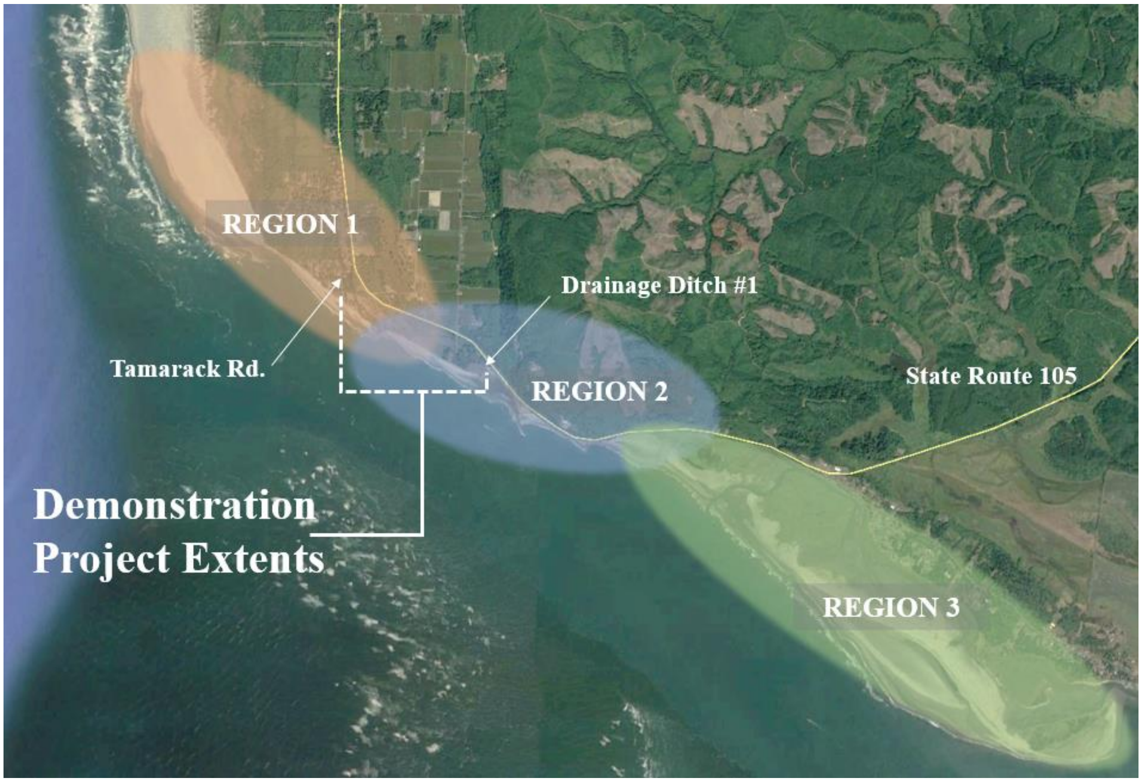

Figure 1 North Willapa Bay shoreline conceptual shoreline erosion processes division over the three regions[4]. Region 1 – North Tidal Channel Migration. Region 2 – Wave Attack. Region 3 – Flattening of the tidal channel slope.

Upon direction from Pacific County and the Technical Committee (see Section 2), the Demonstration Project has been designed to extend along Region 2 and parts of Region 1 to assure that data and information gathered from the project are applicable to the entire North Willapa shoreline. The shoreline protection Demonstration Project is designed to include installation of soft-shore protection in the form of dynamic cobble-sized rock material, otherwise known as a dynamic revetment. The Demonstration Project includes an Adaptive Management Plan (AMP) to monitor project performance. The AMP will help to estimate actual requirements for maintenance repair and determine if contingency measures (such as a groin) are needed to meet the project objectives or not.

This report contains details on the Project Team and Process of Major Project Decisions (Section 2), Erosion Processes in the Project Area (Section 3), Site Conditions (Section 4), Alternatives Analysis (Section 5), Preferred Alternative Details (Section 6), Monitoring and Adaptive Management Plan (Section 7), and Regional Master Plan Summary (Section 8).

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[4] The boundaries of the regions are shown conceptually and shall not be scaled.

2. Project Team and Process of Major Project Decisions

To ensure that the project is designed to the highest industry standards and meets the State and Federal requirements, the Project Team was assembled to include Technical and Steering Committees in addition to the Lead Engineering Firm (Mott MacDonald Team). The Steering Committee was to provide input from perspectives on policy, regulatory affects, funding and community impact. Participants will provide feedback on project deliverables and priorities, including design alternatives and long-term implications for the community. It was assembled with senior level management and regulatory specialists from the following participating entities:

- State and Federal Agencies
  - USACE
  - WDOE
  - WSDOT
  - Washington State Department of Fish and Wildlife (WDFW)
  - Washington State Parks (WSP)
- Local Representatives
  - Grayland Drainage District
  - Pacific County
  - Pacific Conservation District
  - Port of Willapa Harbor
  - Shoalwater Bay Tribe
  - Private citizens.

The Technical Committee was assembled to provide a comprehensive review of assembled datasets and documentation covering relevant aspects of the region's coastal conditions, economic and cultural perspectives, environmental habitats, and construction costs. It includes multi-disciplinary experienced professionals from the following organizations:

- State and Federal Agencies
  - US Army Corps of Engineers (USACE)
  - WA State Department of Ecology (WDOE)
  - WA State Department of Transportation (WSDOT)
- Local Representatives
  - Grayland Drainage District
  - Pacific County Conservation District.

The Technical Committee reviewed and commented on all technical information, engineering recommendations and design decisions (including the selection of preferred alternative) that were developed by Mott MacDonald. Upon acceptance by the Technical Committee, all technical information and design decisions were then coordinated with the Steering Committee. The information from the Technical and Steering Committee meetings (PowerPoint slides and meeting notes) are included as Appendix D.

A public meeting was held in April 2019. This public meeting included a presentation summarizing the alternatives analysis and providing details on the proposed alternative. A number of agencies participated in the public meeting, including USACE, WDOE, the Grayland Drainage District, and private citizens. Poster boards from this public meeting are attached to this memorandum as Appendix B. The selection of the preferred alternative was finalized after the public meeting, with additional design details coordinated with the Technical Committee and County Representatives through preliminary and final design.

3. Erosion Processes in Project Area

There have been numerous studies along the North Willapa Bay shoreline to investigate dynamics of coastal processes, determine causes of such extreme erosion, and develop effective engineering solutions. A short list of these studies is presented in Appendix A. There has also been a large number of shoreline erosion protection projects implemented in the region of the North Willapa Bay shoreline. A summary of the most pronounced projects, including those currently under way are presented in Figure 8. Wave erosion is a primary factor for design development of shoreline protection, but an overall assessment evaluated the broader coastal processes contributing to erosion at North Cove. Through this assessment, two major factors that contribute to North Willapa Bay shoreline erosion processes have been identified and confirmed by previous studies and project data as follows:

- Cause 1- North Tidal Channel migration.
- Cause 2- Wave-induced erosion in combination with sediment deficit.

The details of these processes are described in the following two sections.

Cause 1 – North Tidal Channel Migration

A system of tidal channels that provides passage of the tidal prism[5] in (flood) and out (ebb) of the bay has naturally developed and constantly migrates in the Willapa Bay area. The North Tidal channel that aligns along North Willapa coastline has been a major conduit of this system, at least for the last 100-150 years. Figure 2 shows a bathymetry survey of Willapa Bay in color format (deep water in blue and shallow water in yellow) and the location and dimensions of the North Tidal channel at the time of the survey (2016). General dimensions of the North Tidal channel (depth and width) vary in time and along the length of channel, but are typically in a range of:

- Depth: 70-130 ft; and
- Width: 2,000-3,000 ft.

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[5] The tidal prism is the volume of water flowing into and out of Willapa Bay over the course of a tidal cycle. The tidal prism of Willapa Bay is one of the largest in a world, considering dimensions of the bay (largest estuary on US West Coast, after San Francisco Bay) and tidal range of 11 ft.

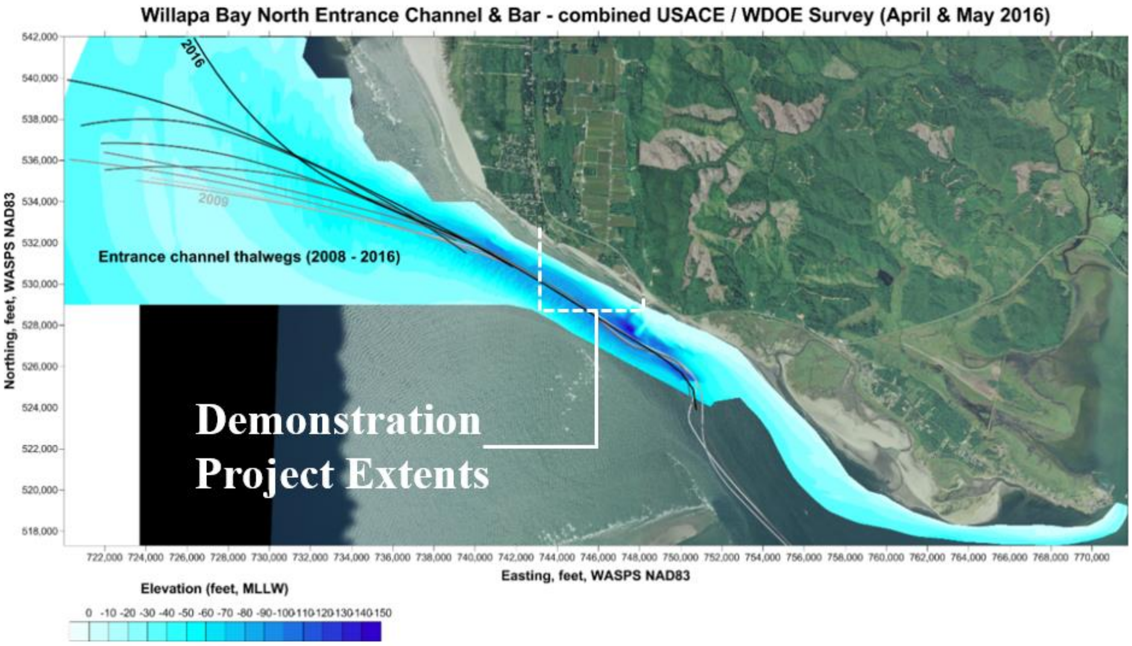

Figure 2 – Migration of the North Tidal Channel 2008-2016 (USACE).

Discharge through this channel during peak flood and ebb flows may reach 25,000 – 50,000 cubic yards per second, which is comparable to the discharge of the largest rivers in the world (e.g. the Mississippi River). The North Tidal Channel has migrated constantly during extreme tidal and ocean wave storm events, with a trend of migration (for the last century or longer) towards the North. While migrating to the north, the North Tidal Channel undermines the bottom slope, allows ocean waves to propagate closer to the shoreline, and causes large parts of shoreline to slide into the deep channel. The SR105 project, constructed in 1998, was originally designed to prevent northward migration of the North Tidal Channel along a limited length (approximately 2,500 ft) of shoreline in the vicinity of the most exposed and eroding segment of Highway 105. The analysis of recent data demonstrated the positive effect of the 1998 SR105 project in preventing northward migration of the North Channel and that this effect has extended beyond the expected 2,500 ft. Figure 3 compares the bathymetric surveys in the vicinity of the SR105 project for a period of 21 years, from 1997 (just prior to construction) to 2018 (most recent US Army Corps of Engineers survey).

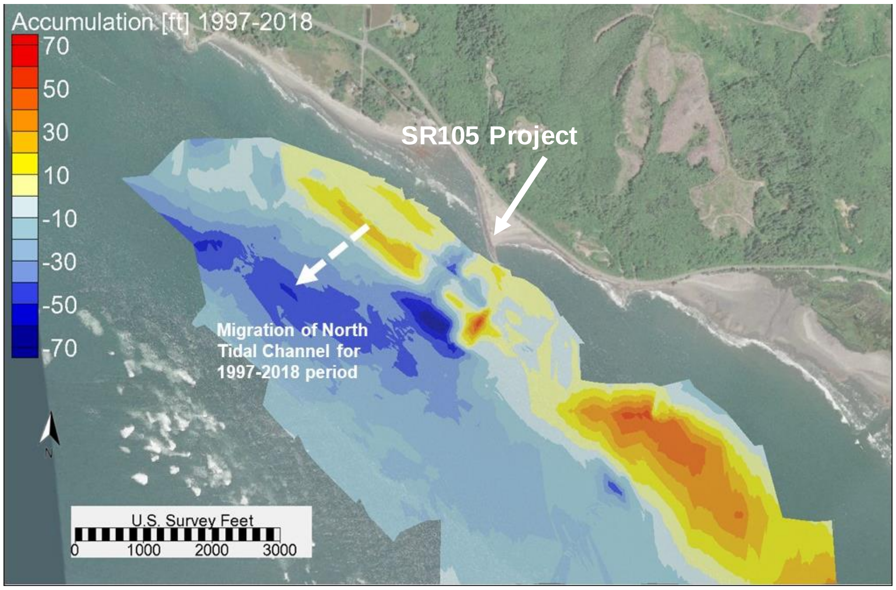

Figure 3 - Bottom depth differences for a recent period of 21 years, between 1997 and 2018. Blue areas in the channel indicated the channel migration to the Southwest.

The figure shows accumulation of sediment in the old thalweg of the North Tidal Channel (in some locations the thickness of accumulation exceeds 50ft) and erosion of the bottom slope seawards of the old thalweg (in some areas the depth of scour exceeds 50 ft). The pattern of bottom depth changes, with accumulation of sediment in the nearshore and deepening (scour) of the bottom slope further offshore, is an indication of North Tidal Channel migration away from the shoreline. The length of the tidal channel affected by this offshore migration is approximately 6,000 ft, which is significantly larger than the 2,500 ft of shoreline expected to be impacted by the SR105 Project. The shoreline within this reach has been protected from northward migration of the channel. Therefore, ongoing erosion of this part of shoreline apparently is driven by a different mechanism: wave erosion combined with a deficit of sediment in the local littoral system (Cause 2). However, for other parts of the North Willapa Bay shoreline (specifically toward the northwest), shoreline erosion may result from a combination of the two major factors: tidal channel migration (Cause 1) and wave-induced erosion (Cause 2). The majority of the Demonstration Project is proposed for the areas where tidal channel migration has been protected (Region 1), and as requested by the Technical Committee was extended into a portion of Region 2 where the tidal channel is migrating.

Cause 2 – Wave-Induced Erosion

In some areas of the shoreline the bottom slope of the North Shore Willapa Bay has become steep and is incapable of sufficiently attenuating wave power[6] due to tidal channel migration and intrusion (Cause 1 above). Typically beaches with a flat nearshore bottom slope are better able to attenuate wave power and avoid significant shoreline erosion, as was the case in this area prior to North Channel migration. A sufficient supply of sediment (sand) is also important for accommodating variation of this slope while maintaining a profile in dynamic equilibrium. A reduction of sediment supply into the regional NW Pacific littoral system and alterations of sediment transport by local coastal projects contribute to the steepening of the bottom slope and reduction in the ability of the profile to maintain dynamic equilibrium. In the area of the

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[6] The North Willapa Bay Shoreline is subjected to enormous wave power from propagating open ocean waves as well as locally generated waves, approaching the shoreline from the northwest and southwest directions.

Demonstration Project the main driver of erosion is Cause 2 – Wave-Induced Erosion (primarily within Region 2). The Demonstration Project area was selected to be primarily within Region 2 where wave-induced erosion is the primary erosion process, as it is applicable to the shoreline in all regions (Regions 1, 2 and 3).

4. Site Conditions

As part of the project development site conditions were compiled, and changes to the site during the course of the design were documented relative to design elements. Site condition assessment included beach elevations, metocean conditions, littoral processes, geologic, and cultural resources. Details of these conditions are included in this report as Appendices A, E, and F. This work includes:

- *North Cove Dynamic Revetment Monitoring: Winter 2018-2019* (Weiner et al., 2019) WDOE Report, an analysis of waves, water levels, and morphodynamic response in the 2018-2019 winter season; and
- Geologic Review Summary, North Willapa Bay Shoreline Protection Project, Pacific County, Washington.
- Cultural Resource Survey for The North Willapa Shoreline Protection Project, Pacific County, Washington

As a basis for the shoreline protection Demonstration Project, the most recent elevation data (June 2018) and aerial imagery (August 2016) were used to develop a basemap. At the time of construction, the site conditions will likely differ from that of the basemap utilized for this project. Beach elevations may change due to extreme storms, seasonal beach profile variations, or placement of additional material by the Grayland Drainage District.

Existing Conditions

Coastal Processes and Environmental Conditions

Design environmental conditions were outlined in the Basis of Design (MM, 2018), and also included as Appendix C.

Geologic Review Summary

Geologic conditions at the project site have been compiled from available information and a reconnaissance-level site visit. A review and compilation of available surface and subsurface data was conducted, and is included in more detail in Appendix E.

Geologic units mapped in the area and encountered in explorations consist of Holocene beach deposits overlying Pleistocene terrace deposits. Based on the studies and borings reviewed a variable geologic setting within a highly dynamic landscape is interpreted. It's been observed that the depth and properties of the geologic materials vary significantly over short distances. Therefore, it is difficult to use available data to inform site specific conditions at prposed mitigation sites. To perform geotechnical design for future shoreline migration mitigation measures (e.g. stability, hardening, etc.), site specific subsurface data should be collected. The site-specific data should include one or more over-water borings that extend through the beach and terrace deposits into underlaying tertiary rock, which is anticipated to be below about elevation -100ft. Mean Sea Level (MSL)

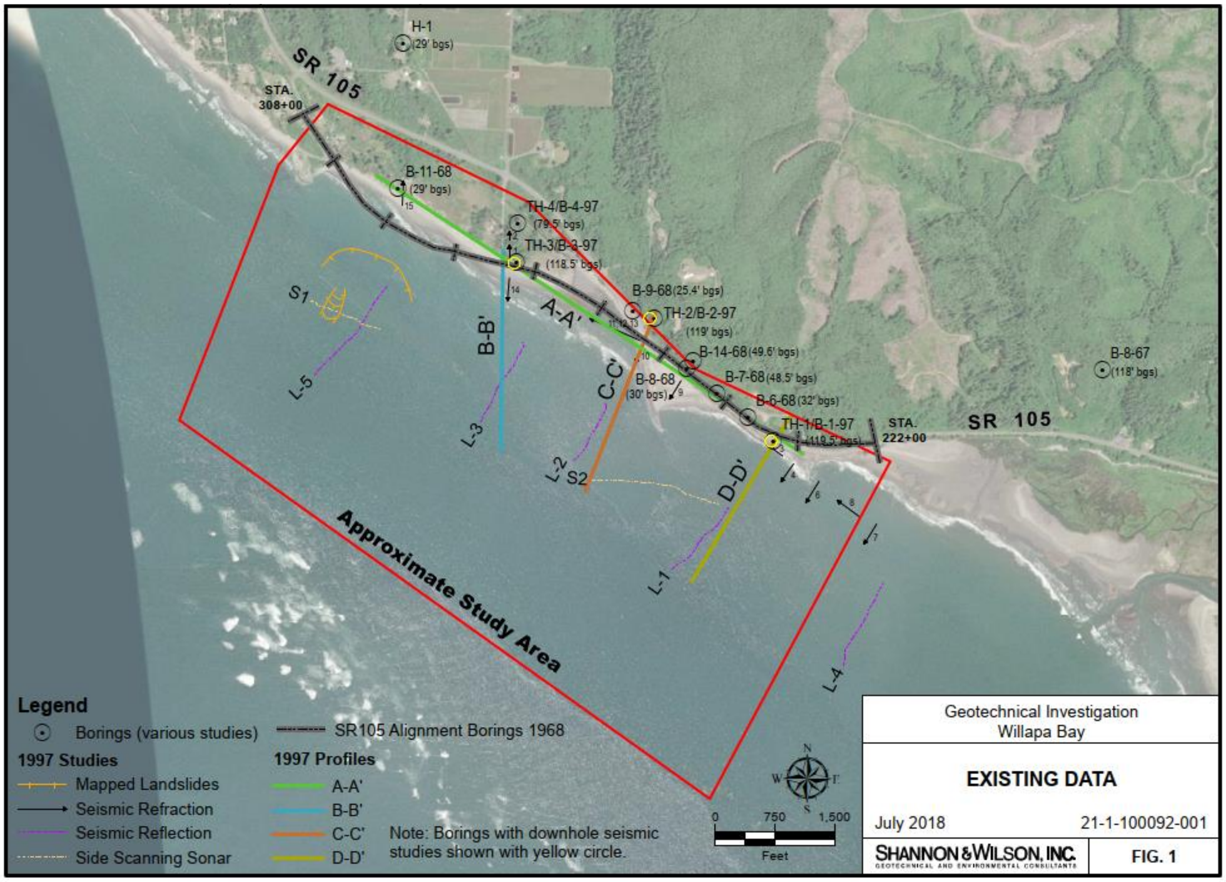

Figure 4 - Summary of geologic investigation of the North Willapa Bay shoreline.

Cultural Resources

Since a permit from the U.S. Army Corps of Engineers (USACE) will be required for the proposed project, the cultural resources study was done to meet the federal standards under Section 106 of the National Historic Preservation Act of 1966 (as amended) and its implementing regulations under 36CFR800. Project Team professionals who meet the professional qualifications of the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation performed the work. The study was also conducted to meet Washington State Department of Archaeology and Historic Preservation (DAHP) standards. The study included a records search, a literature review, local tribe consultation, and a pedestrian survey to determine if cultural resources were present in the Area of Potential Effects (APE). Archeological and Historic Resource Findings are listed below, and details are available in Appendix F:

Archaeological Resources

- No pre-contact or historic-period archaeological resources were identified in the Area of Potential Effects (APE).
- A poster identifying the location of remnants from the Avalon shipwreck was found at the eastern limit of the APE. The exact location of the shipwreck is unknown and no remnants of a shipwreck were identified in the APE.

- Archaeological monitoring is recommended at the eastern portion of the APE. It is recommended a Monitoring Plan and an Inadvertent Discovery Plan (IDP) be prepared for the project before construction begins. The IDP should outline specific protocols to follow in the event remnants of a shipwreck are encountered during construction.

Historic Resources:

- No historic-period buildings or structures were present within the APE.

Recommendation

The Project Team recommends a finding of "No Historic Properties Affected" for the North Willapa Shoreline Protection project

Observations: Winter 2018-2019

North Cove Dynamic Revetment Monitoring: Winter 2018-2019 (Washington Department of Ecology Report 19-06-008)

The Washington Department of Ecology conducted monitoring of the dynamic revetment and shoreline adjustments over the 2018-2019 winter in coordination with the Grayland Drainage District. Monitoring included topographic surveys and rock tagging (to track individual rocks from the dynamic revetment). Findings from this monitoring assessment were used to validate the design approach for the Demonstration Project. A summary of this monitoring report (Weiner et al., 2019) is provided below.

- Construction appears to have prevented significant loss of uplands. Surveys indicated little to no landward retreat.
- Surveys indicated that the sand elevation loss due to winter storms rebounded by March 2019.
- Rock material has migrated between 0-165ft.
- Rocks that moved furthest were between 4 to 8 inches in diameter. Most tagged rocks stayed within 3.3ft of initial tagging.
- General trend of material south of the private revetment was movement to the SE and slightly offshore, which confirms our previous assumptions.

Findings from the 2018-2019 monitoring period relating to the Demonstration Project (per Mott MacDonald) include:

- The beach continues to be dynamic with elevations changing month-to-month. The exact surface of the beach during the construction window cannot be predicted.
- The direction of movement of the dynamic revetment material aligns with project team assumptions for sediment transport in the area.
- Dynamic revetment performance during 2018-2019 was sufficient to limit shoreline erosion to negligible levels for the wave climate and water levels during this season.

Relative Extreme Wave and Water Level Analysis

Wave and water level data were analyzed by Mott MacDonald over the 2018-2019 season relative to previously reported extremal analysis and calculated total water levels from other key storm years. Findings are below:

- Performance of the rock dumped during this winter (2018-2019) is not indicative of how the dynamic revetment will perform under the most extreme (combined WL + Hs) conditions, such as those observed in December 2007 or January 2018. The calculated Total Water Level[7] from the 2018-2019 season is shown in Figure 5.

- Highest observed Hs in winter 2018-2019 corresponds to a 2-year event (~26ft.)

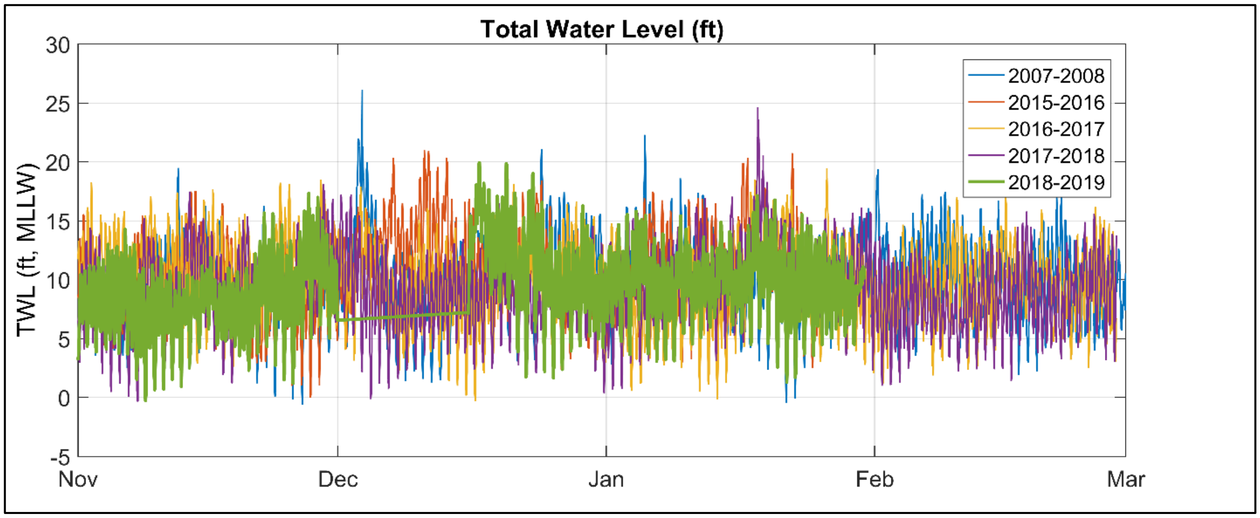

Figure 5 - Concept Level Calculations Total Water Level for key years, 2007-2019. Note that the 2019-2019 season (green line) calculated Total Water Level appears less extreme relative to other key years.

Key Takeaways from the 2018-2019 Monitoring Period

- Performance of rock this year indicates performance during a typical winter.
- Should a more energetic winter occur, the performance of the existing dynamic revetment may differ from the 2018-2019 season; this has been considered in development of the final design.

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[7] Based on Buoy 46211 Grays Harbor, WA and Tide Gage 9440910 Toke Point, WA. Total water levels at the project site differ. Available data used as a proxy to estimate relative storminess of different years.

5. Alternatives Analysis

An alternatives analysis was conducted to select the preferred alternative. The alternatives analysis included an initial screening of all shore protection concepts that could potentially meet the project purpose followed by an evaluation of 5 screened alternatives, which was coordinated with the Technical Committee. The screened alternatives include the following[8]:

A. Dynamic Revetment
    a. Cobble material (12” diameter maximum) along the length of the project area.
B. Dynamic Revetment + Groin
    a. Cobble material (12” diameter maximum) along the length of the project area; and
    b. A rock groin (D50 ~ 3ft. to 4ft.) installed at the southern terminus of the dynamic revetment to retain sediment and potentially reduce maintenance needs and increase sediment bypass. Not intended to stabilize the tidal channel.
C. Dynamic Revetment + Standard Rock Revetment
    a. Cobble material (12” diameter maximum) for a portion of the project area near the existing private rock revetment (to reduce risk of wave reflection damaging the existing structure); and
    b. A transition to a standard rock revetment (D50 ~3ft. to 4ft.) in the southeast portion of the project area.
D. Dynamic Revetment + Combination Revetment
    a. Cobble material (12” diameter maximum) for a portion of the project area near the existing private rock revetment (to reduce risk of wave reflection damaging the existing structure); and
    b. A transition to a combination revetment in the southeast portion of the project area. The combination revetment consists of a bottom layer of armor stone (3ft. to 4ft. diameter), with dynamic revetment material placed on top.
E. Beach Nourishment
    a. Sand material placed along the length of the project area. To meet performance objectives, it was estimated that 400 CY per linear foot of beach is needed (~475’ feet in cross-shore direction).
    b. Because the estimated construction cost for this alternative is an order of magnitude larger than Alternatives A-D, this alternative was screened out.

The five alternatives were assessed qualitatively by each member of the Technical Committee relative to the agreed-upon evaluation criteria. The alternatives were scored on a numerical scale, which is shown in Table 1, for each of the assessment criteria. The results of the alternative assessment by each member of the Technical Committee were compiled and discussed by the committee.

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[8] Also described and shown in Appendix A

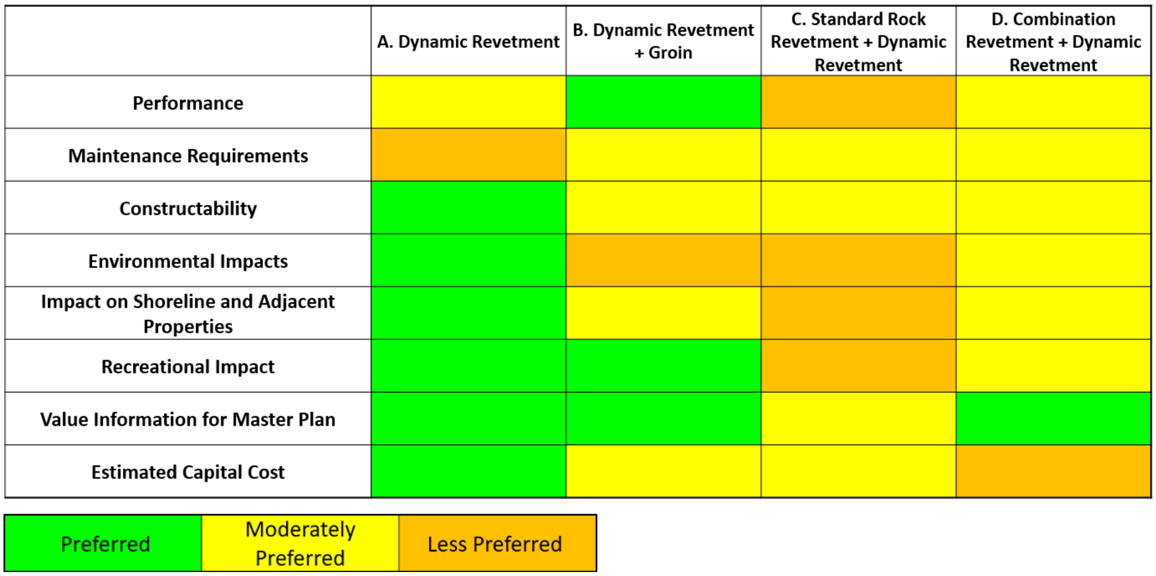
Table 1 – Alternatives Evaluation Criteria

Criteria	Maximum Score
Performance to meet the project objectives	**5**
Construction Cost[1]	**5**
Maintenance Requirement[1]	**5**
Constructability	**5**
Least Adverse Environmental Impacts	**5**
Impact on Adjacent Shoreline and Natural Coastal Processes	**5**
Least Recreational Impact - Maximize Beach Area	**3**
Value of the technical information for Master Plan	**3**

1 – Preliminary construction (capital) and maintenance (over 40-year project lifetime) costs were estimated for each alternative by Mott MacDonald.

The Technical Committee developed an agreement of the assessment of each alternative relative to the evaluation criteria. A summary of results of the assessments are shown in Table 2, relative to whether the alternative was preferred, moderately preferred, or less preferred by the Technical Committee for each criterion. The dynamic revetment alternative was shown to be the preferred alternative for six of the eight criteria and was selected as the preferred alternative for the project. Due to uncertainties with the dynamic revetment option, it was recommended to develop a monitoring and maintenance program as part of an Adaptive Management Plan.

Table 2 - Alternatives Assessment Results



	A. Dynamic Revetment	**B. Dynamic Revetment + Groin**	**C. Standard Rock Revetment + Dynamic Revetment**	**D. Combination Revetment + Dynamic Revetment**
Performance	🟨	🟩	🟧	🟨
Maintenance Requirements	🟧	🟨	🟨	🟨
Constructability	🟩	🟨	🟨	🟨
Environmental Impacts	🟩	🟧	🟧	🟨
Impact on Shoreline and Adjacent Properties	🟩	🟨	🟧	🟨
Recreational Impact	🟩	🟩	🟧	🟨
Value Information for Master Plan	🟩	🟩	🟨	🟩
Estimated Capital Cost	🟩	🟨	🟨	🟧

🟩 Preferred	🟨 Moderately Preferred	🟧 Less Preferred

6. Preferred Alternative: Dynamic Revetment

The basic strategy of a dynamic revetment is to construct a dynamic nearshore slope that adjusts in response to storm wave action to provide more dissipation and absorption of destructive wave energy. Material of dynamic revetment (presented predominately by gravel-to-cobble size of rock) is mobile, unlike the larger static rock typical of a conventional revetment (Allan and Komar, 2002). Conceptually, a dynamic revetment is similar to a natural cobble beach, found at many locations along the Washington Coast.

The dynamic revetment is designed to be placed along approximately 5,800 ft. of North Willapa shoreline. As discussed below (Section 6.2) approximately 1,300 ft. of that length (shoreline protection) is located in Region 1; while the remaining 4,500 ft, is located in Region 2. The part of shoreline protection located in Region 1 is referenced as the northern part of the project, and that in Region 2 is referenced as the southern part of the project.

The design concept was further developed into the final and bidding-level design stages[9]. Details of the design and estimated maintenance requirements are included in the following subsections.

Design Parameters and Construction Material

The design of cross-sectional configurations (slope, crest elevation, toe configuration, and volume of material per linear unit length) and the type of construction material were developed based on compilation, review, and analysis of technical information from project prototypes in combination with extensive numerical modeling of wave transformation and slope morphology. In addition, data from the ongoing Grayland Drainage District emergency shoreline erosion stabilization project and WDOE monitoring of the North Willapa Bay shoreline were utilized to supplement the limited state of global knowledge and understanding of dynamic revetment performance, and to optimize the design parameters of the project[10]. Additional details on the design methodology are presented in Appendix A. Using the methodology described in this appendix, the dynamic revetment was designed to account for differences of shoreline conditions at the northern and southern parts of the project. As a result, two designed cross sections have been developed for northern and southern part of the project. The dimensions of these cross sections are presented below and shown in Figure 6.

- Cross-sectional design volume: 17.5 CY/linear foot (LF); volume may vary slightly along sections, depending on specific existing conditions.
- Crest Height: 21 ft. MLLW
  - Note that select sections are higher to tie into existing contours.
- Crest Width
  - Southern: 6 ft.
  - Northern: Varies depending on location.
- Front Slope: 3H:1V

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[9] It should be noted that certain design details will need to be revisited based on actual conditions of shoreline at the time of construction.

[10] The dynamic revetment is a relatively new shoreline erosion protection measure and there is a limited number of guidelines or data that can be used as reference for the design.

- Back Slope:
  - Southern: 3H:1V
  - Northern: Flat to meet existing slope
- Toe Bottom Elevation: 5 ft. MLLW
- Toe Bottom Width:
  - Southern: 10 ft. to provide a buffer to allow for adjustment of the seaward portion of the toe prior to sloughing.
  - Northern: 30 ft. @ slope of 10H:1V (to reduce excavation volume). Then slopes up at 3H:1V until MHHW.
- Excavation Slope (toe): 3H:1V
- Excavated Material Re-use:
  - Placed on top of dynamic revetment to feed natural system.
  - Thickness of material will vary but should be evenly distributed on top of the front slope of the dynamic revetment to create a dune-like appearance.
- Rock Size:
  - 12” minus (no stones larger than 12-inch diameter)
  - Selected to give an allowance for fracturing of the larger rocks and to reduce the maintenance requirements, while allowing for a mobile, dynamic profile.
- Rock Type
  - Two types of rock (Type A and Type B) have been specified to increase the value of information provided by the Demonstration Project.
  - Specific gravity, water absorption, L.A. abrasion, and degradation tests will be used to specify the different rock types. Type B will be a slightly higher quality rock than Type A.
  - Different rock types will be placed in different areas of the project to test how rock quality (and breakage) affects the functionality of the dynamic revetment.

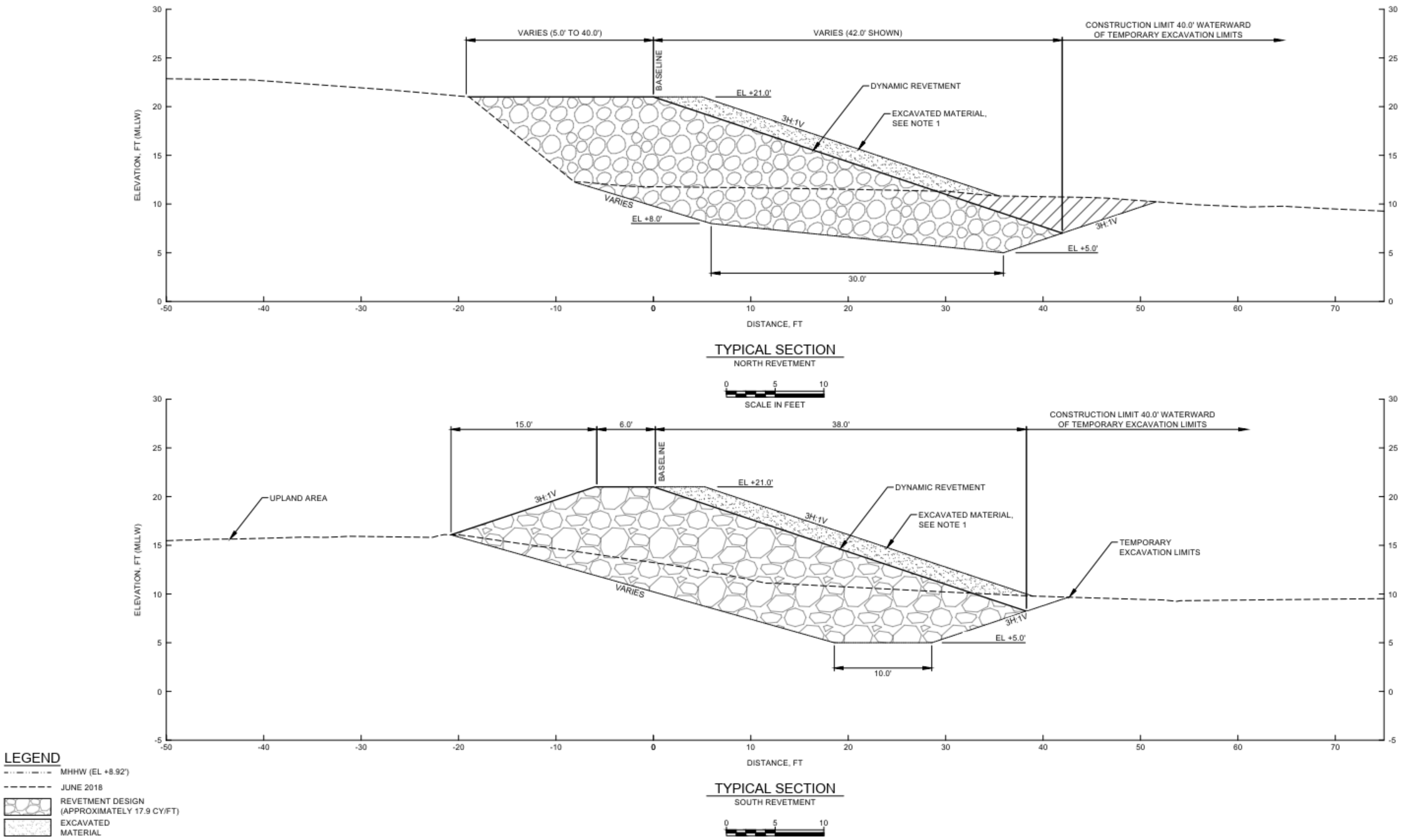

Figure 6 - Representative Cross-Sections of dynamic revetment in the northern (top) and southern (bottom) parts of the project.

Project Extent and Planview

The Demonstration Project extents were coordinated by the Technical Committee, as discussed in Section 2. However, specific details needed to be assessed to refine transition locations. Analysis was conducted to refine the southern and northern terminus, the locations of material type transitions, and the locations of transitions to the existing private revetment. The transition length and locations are detailed below. Additional details are located in Appendix A.

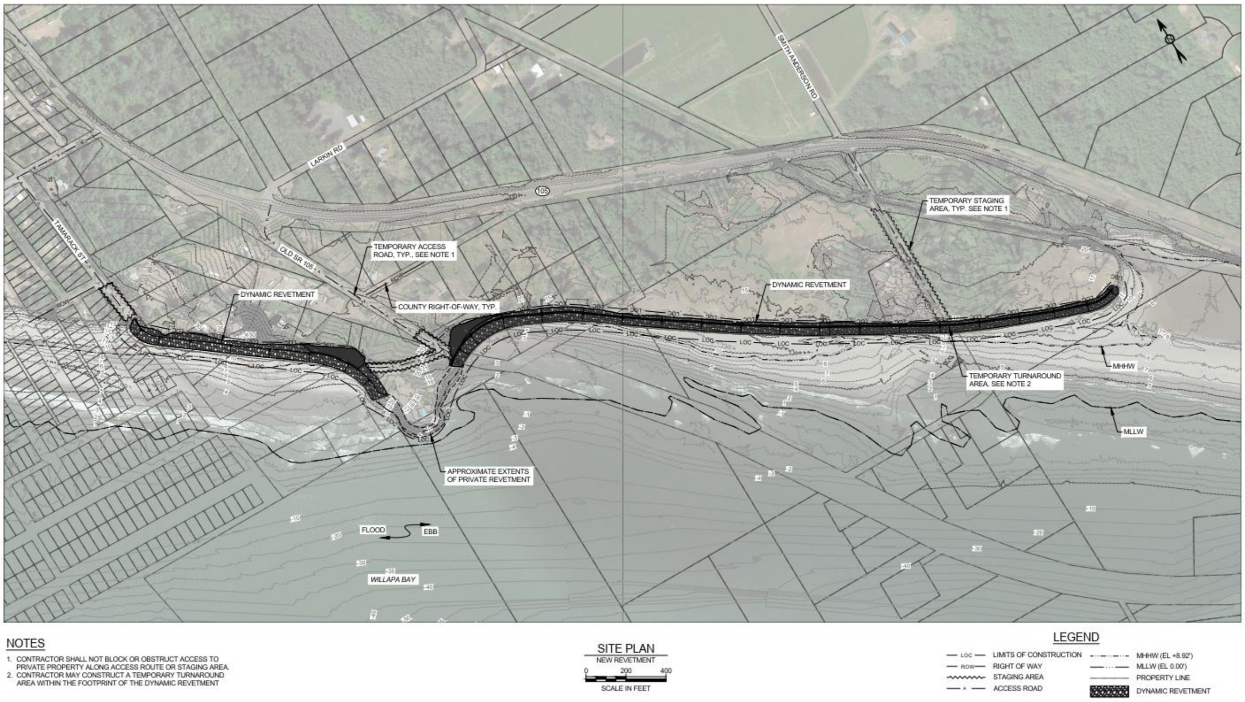

Figure 7 - Representative Plan View

- North Terminus
  - Criteria – Extend dynamic revetment into area stabilized by the private revetment (which acts as a groin) and minimize edge effects.
  - Based on analysis (Appendix A) the transition should be at a minimum 900 feet away from the Private Revetment. This location aligns with Tamarack Road.
  - Designed the transition as a gentle curve into the existing County ROW to minimize edge effects, reduce impacts to private property, and reduce risk of being undermined.
  - Extents and transition coordinated with Pacific County and Technical Committee.
- Private Revetment
  - Criteria – no negative effects on existing private revetment.
  - No excavation seaward of the existing private revetment.
  - Dynamic revetment rock placed for a length of 3x the maximum diameter of private revetment rock (D_{100} estimated as 4ft). Cross-sectional volume of dynamic revetment rock increased by 30% as contingency for this portion of the shoreline.
- Southern Terminus
  - Criteria – do not impact meandering of ditch. The Grayland Drainage District is actively managing the ditch meandering to ensure drainage.

  - Design constraint determined based on review of historical ditch locations from orthorectified aerial photographs. Terminus of dynamic revetment is outside the envelope of prior ditch locations.
- Material Type Transition
  - Criteria – two sections of different rock types (Rock Type A and Rock Type B) to be placed within areas with similar coastal conditions to be able to compare performance of the two rock types.
  - It has previously been observed that a structure such as a rock groin will affect the shoreline for 3x the shore-normal length of the structure. This hypothesis was confirmed for the existing SR105 rock groin south of the Demonstration Project.
  - Using this rule of thumb, the existing private revetment is assumed to act as a roughly 500 ft. rock groin affecting approximately 1,500 ft. of shoreline on either side.
  - Therefore, the transition between the different rock types is located 2,000 ft. south of the private revetment to provide a 500 ft. section of Rock Type B to compare to Rock Type A further south along the shoreline.
- Material Compaction Test Area
  - Criteria – Test whether compaction effects the dynamic revetment performance.
  - Provide a test section of dynamic revetment where the contractor compacts the angular rock in lifts as they install it. To be able to compare the compacted rock section and noncompacted rock, the compacted rock section should be in an area that is subjected to similar coastal conditions as the 500 ft. sections of Type A and Type B angular rock discussed above.

7. Monitoring and Adaptive Management Plan

To guide post-construction maintenance procedures for the dynamic revetment within the Demonstration Project an adaptive management plan (AMP) has been developed. The AMP includes three parts: monitoring, maintenance, and considerations for potential contingency actions[11] as outlined in the following sections.

Monitoring

A detailed monitoring plan should be developed and implemented[12] to measure and evaluate the following project elements and features:

- Dynamic revetment material transport and performance.
- Changes in physical composition of intertidal beach.
- Effect on adjacent areas.
- Shoreline erosion (if any); and,
- Nearshore hydrodynamic conditions.

To meet these goals, the detailed monitoring program will need to include:

- Systematic topographic surveys of the dynamic revetment and sandy beach area in the vicinity of the project. Surveys transects should be aligned with historical WA Ecology transects (e.g., spacing of approximately 300 feet). The survey should include areas between the WSDOT Dike-Groin and at least 500 feet to the NW of the Demonstration Project area. Survey data should be collected between MLLW and the backside of the design template.
- Aerial photography of the project area to identify and track the interface between sand and dynamic revetment material. Data processing of the data will be required. Data should be collected at a high enough resolution to estimate percentage sand versus rock along segments of the shoreline (automated processes may be developed).
- Nearshore wave buoy to confirm wave conditions in the nearshore. Buoy should have the capabilities to measure and transmit landward wave parameters (height, period, directions) on hourly basis for fall-winter periods of first two postconstruction years.
- Yearly estimates of remaining rock quantity based on as-built information and the topographic survey data.
- Monitoring of maintenance events to track performance of the dynamic revetment relative to anticipated maintenance requirements and available funding. Tracking the maintenance requirements is key for evaluation of acceptable levels of performance.

To capture seasonal variability and longer-term trends, monitoring activities will need to be conducted both in the summer and winter each year starting after construction of the dynamic revetment. The timing of surveys should be consistent from year to year.

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[11] Please note that contingency actions are not part of this demonstration project.

[12] Considering the highly dynamic conditions of the North Cove shoreline and significant activities (by various entities) on shoreline stabilization, a detailed monitoring plan shall be prepared at the time a decision on implementation of the demonstration project is made and sufficient funds are appropriated.

Maintenance

Maintenance of the dynamic revetment is expected, but the exact year-to-year volume will depend on the actual stability/deterioration of shoreline and will be determined based on results of the monitoring program. The level of maintenance of the dynamic revetment will likely vary across the site based on wave conditions and material transport patterns. The maintenance actions could consist of the following:

a) Re-arrange dynamic material that was displaced by waves and currents, for example, transport material back updrift if naturally transported (longshore) out of the project area.
b) Import and install additional dynamic revetment material of the same type
c) Import and install a different type dynamic revetment material (for example rounded or coarser material)

Maintenance may be triggered when the volume of dynamic revetment material remaining at specific cross-sections falls below critical levels (e.g., less than 25-50% of original installation volume) or if shoreline erosion is observed (see Figure 8). The critical volume of dynamic revetment may be represented by a volume per linear foot, a critical cross-shore profile, or a combination of both. It has been estimated that on an annual basis, the average maintenance requirements volume is estimated to be approximately 6,500 CY per year over the next ten years[13]. The post-project monitoring will track the performance of the dynamic revetment and better calibrate the long-term maintenance requirement estimates. The need for contingency measures will be measured against the estimated maintenance levels and maintenance funding availability.

Contingency Measures

Though not anticipated, if the monitoring and maintenance programs indicate the cost to maintain the dynamic revetment exceeds planned funding levels then contingency measures (actions) would be initiated. Contingency actions should be defined based on conditions present at the time of assessment. Potential contingency actions could include installation of a groin[14],[15] at the southern end of the project area, additional dynamic revetment, or other shoreline protection concepts.

No contingency actions are proposed within this project, as the need and type of action are to be determined based on the monitoring program. Figure 8 shows a schematic representation of scenarios that could trigger maintenance of the dynamic revetment or the need to pursue contingency measures.

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[13] However, as discussed above the exact volume and frequency of maintenance repairs will be determined based on results of the monitoring program.

[14] Based on the project data and evaluations of coastal processes it appears that groin may reduce maintenance requirements by stabilizing a portion of the shoreline, and encourage formation of stable sand beach at the southern end of Demonstration Project area and minimize footprint of exposed rock in the natural sandy substrate of the intertidal area

[15] Allan (2005) also noted that a low-crested groin constructed across the beach berm could reduce maintenance needs for a dynamic revetment.

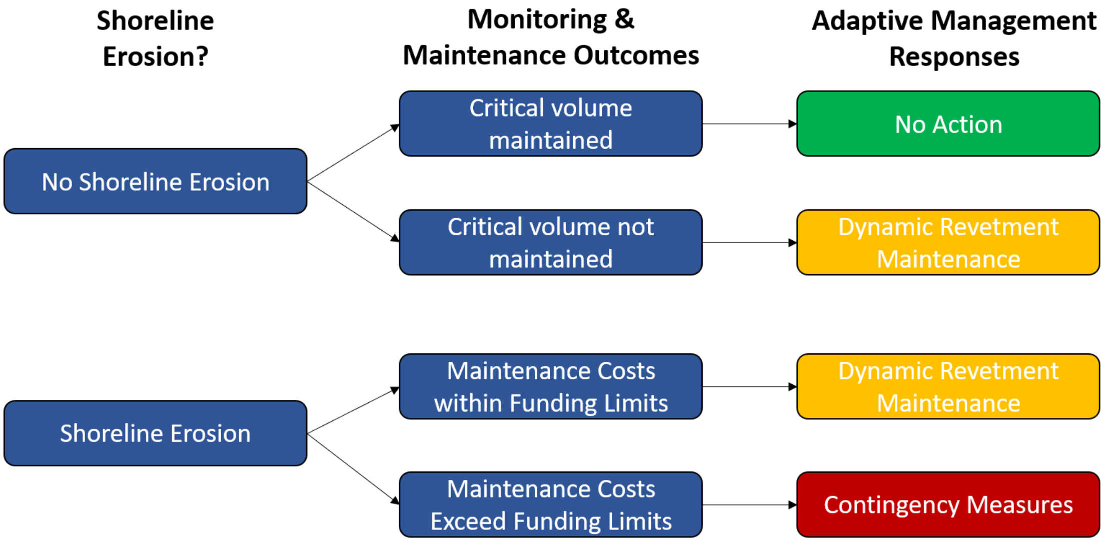

Figure 8 - Conceptual Adaptive Management Scheme

8. Cost Estimate

An estimate of project budget was developed for planning purposes. The project budget includes construction costs, a 10-year monitoring program, a 10-year adaptive management program, and engineering services during bidding and construction. Costs in Table 3 were developed in 2020 dollars, and may require adjustment depending on when construction takes place. A 3-year inflation contingency was applied to the cost estimate to account for potential construction schedule. The monitoring program costs were developed based on the recommended requirements in Section 7, and the maintenance costs developed based on the estimated maintenance requirements described in Section 7. The cost basis for materials and other work items were based on a combination of supplier outreach, contractor engagement, and internal cost database information. Excavation volume is based on the project survey (June 2018) and is subject to change based on new survey information.

Table 3 - Planning Cost Estimate Required for Construction

Item	Description	Quantity	Unit	Unit Price	Cost
1	Mobilization & Demobilization	1	LS	$760,000	$760,000
2	Temporary Traffic Control	1	LS	$10,000	$10,000
3	Erosion Control and Water Pollution Control	1	LS	$20,000	$20,000
4	Construction Surveying	1	LS	$35,000	$35,000
5	Site Preparation & Construction Access	1	LS	$30,000	$30,000
6	Removal of Structures and Obstructions	1	LS	$20,000	$20,000
7	Structure Excavation	38,000	CY	$15	$570,000
8	Angular Rock A	77,000	TON	$45	$3,465,000
9	Angular Rock B	62,000	TON	$55	$3,410,000
10	Access Road Restoration	8,000	SF	$6.50	$52,000
11	Trimming and Clean-up	1	LS	$10,000	$10,000
				Subtotal Cost	$8,382,000
				Pacific County Sales Tax (8.1%)	$678,942
				Total Construction Cost:	$9,060,942
				10-year Monitoring Program	$900,000
				10-yr Adaptive Management Program	$5,000,000
				Engineering Services During Bidding and Construction:	$300,000
				Inflation Contingency (Assuming Construction in 2023)	$1,905,542
				Recommended Project Budget:	$17,166,542

9. Regional Master Plan Summary

As part of this project, MM evaluated potential program for long and medium term shoreline stabilization measures in Region 1, 2 and 3. The dynamic revetment Demonstration Project is intended to provide proof of concept for long-term wave protection solutions in Regions 1, 2, and 3. If the dynamic revetment Demonstration Project meets performance expectations, the concept may be appropriate for use as long-term wave induced shoreline erosion stabilization at other areas on the Shoreline in Regions 1 or 3. Region 1 also is subject to the risk of shoreline erosion due to channel migration, which would only temporarily be mitigated by installation of a dynamic revetment. As shown by the Dike/Groin constructed in 1998, channel migration risk will be reduced with installation of an appropriately designed channel training structure, such as a groin/jetty, or other. During the course of this study and subsequent design, The USACE has formalized federal interest in the North Cove Shoreline through the Section 103 process (see below). During the course of the 103 process the USACE will further investigation concepts and designs for long-term shoreline stabilization solutions to the northwest of the Demonstration Project area (Region 1).

Considering the Section 103 process, and adjacent and on-going complimentary projects (Figure 8) the Steering Committee developed a preferred action and funding plan for the Demonstration Project. Table 4 and Figure 9 summarize the different projects and their status in the area. The following subsections describe the action and funding plans for local and federal sponsors.

Local Sponsors - Pacific County, Grayland Drainage District, Pacific County Conservation District

The existing emergency shoreline stabilization construction design and methodology has continued to be developed utilizing results of this Demonstration Project design process. As a result, the emergency stabilization work has met performance goals for the storm conditions encountered since its construction. Based on this success, it is understood that Pacific County has secured additional funding from the state to continue with the existing emergency shoreline erosion stabilization work conducted by the Grayland Drainage District through 2021. Pacific County has therefore indicated that the Demonstration Project construction should not be conducted until at least the next biennium. The Demonstration Project will likely not be required until the existing rock structure requires significant maintenance or replacement due to storm damage.

Federal - USACE Section 103 Project

Section 103 Background

Section 103 of the 1962 River and Harbor Act authorizes the USACE to study, design, and construct small coastal storm damage reduction projects in partnership with non-Federal government agencies, such as cities, counties, special authorities, or units of state government. Projects are planned and designed under this authority to provide the same complete storm damage reduction project that would be provided under specific congressional authorizations. The maximum cost for planning, design, and construction of any one Section 103 project is $10,000,000. Each project must be economically justified, environmentally sound, and technically feasible. Storm damage reduction projects are not limited to any particular type of improvement.

North Cove

The North Cove Shoreline, which includes the area of the Demonstration Project, has been approved as a Section 103 project. This action which formalizes federal interest in long-term stabilization of the shoreline in North Cove. The application for the Section 103 designation utilized findings and engineering analysis from both the existing emergency shoreline protection measures, and the Demonstration Project and covers portions of Region 1 and Region 2 (Figure 1). The construction cost limit for the Section 103 project is $10 million, which includes maintenance[16]. The construction cost of $10 million does not include the area of the shoreline where the WSDOT/Ecology project is proposed (as shown in Figure 9). It is estimated that through this program there would be a minimum of 5 years until construction of a long-term solution (Section 103 Project) starts. However, the USCE Section 103 project can tie into existing projects, such as the Demonstration Project. If the Demonstration Project were constructed, more money could be available for maintenance of the 103 project since this portion of the project will have been previously constructed.

USACE must complete a feasibility study in order to fund construction of a shoreline stabilization system in this area. The Feasibility Study (FS) is funded 100% up to $100,000, and costs exceeding $100,000 are funded with 50-50 match with a non-federal sponsor. As part of this FS, geophysical investigations would be required. The match includes easements secured by the sponsor. The local sponsor is a combination of Pacific County, and the Shoalwater Tribe.

Next Steps

As part of the final Steering Committee Meeting the following next steps were identified:

- Pacific County
  - Demonstration Project
    - Apply for capital funding for the Demonstration Project, timing dependent on performance of emergency measures. Costs should include dollars for engineering updates based on changed site conditions, construction inspection, and project administration.
    - Develop project management plan for maintenance of the dynamic revetment beyond 2021.
  - Section 103
    - The local sponsor will be finalized based on discussions between USACE, Pacific County, and The Shoalwater Tribe.
- United States Army Corps of Engineers (USACE)
  - Develop a Feasibility Cost Sharing Agreement with the non-federal sponsor.
  - Coordinate with WDOE and WSDOT on the Graveyard Spit shoreline protection project design and construction.
- Grayland Drainage District
  - Conduct installation of dynamic revetment material through 2021, and manage drainage ditch meandering.
- Pacific County Conservation District
  - Oversee monitoring of the dynamic revetment material through 2021.

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[16] Note that USACE 103 program will only fund maintenance of portions of the shoreline that were constructed upon or improved by USACE.

- Washington Department of Ecology (WDOE)
  - Conduct survey monitoring of the dynamic revetment through 2021.
  - Work with USACE and WSDOT on the Graveyard Spit shoreline protection project design and construction.
- Washington State Department of Transportation (WSDOT)
  - Work with USACE and WDOE on the Graveyard Spit shoreline protection project design and construction.

Figure 9 - On-going and Proposed Project Area Construction Timelines (Approximate extents only).

Table 4 - On-going and Proposed Projects

Entity	**USACE Section 103**	**Drainage District**	**Pacific County**	**Shoalwater + USACE**	**WSDOT**	**WSDOT+WDOE + USACE**
Project Name	*North Cove Shoreline Protection Project*	*North Cove Emergency Shoreline Protection*	*Willapa North Shoreline Protection Demonstration Project*	*Shoalwater Bay Shoreline Erosion Project*	*WSDOT SR 105 North Cove Beach Erosion Protection*	*Graveyard Spit Restoration and Resilience*
Feasibility Study	2020-2021	N/A	2018-2019	2009	N/A	2018 (USACE)
Design	2021-2022	On-going	2019	2009	Pre-2017	2020
Construction	2023	2015-2021	2021	On-Going	2017	TBD
Maintenance	2023+	2019-2021	2021+	On-Going	On-going	TBD

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Appendix A: Dynamic Revetment Design Appendix

Technical Memorandum
Dynamic Revetment Design Appendix

Project:	North Willapa Bay Erosion Assessment		
Our reference:	507396239		
Prepared by:	Aaron Porter	**Date:**	March 23, 2020
Approved by:	Shane Phillips	**Checked by:**	Patrick McLoughlin
Subject:	Dynamic Revetment Design Appendix		

1 Introduction

1.1 Background

The primary purpose of a dynamic revetment is to construct a sustainable beach that can dynamically withstand storm wave action. The ability to adjust and reform in response to storm events is achieved through the continual movement of stone, which is absent in a more static, conventional revetment that utilizes larger armor stones (Allan and Komar, 2002). In concept, the dynamic revetment is similar to a cobble beach, found at many locations along the Washington Coast. The dynamic revetment provides protection because the sloping, porous cobble beach is able to disrupt and dissipate wave energy (Allan, 2005). Because it induces less turbulence than a conventual revetment, it would induce less erosion at the toe and adjacent beach area (USACE, 2013). Stone size is smaller than required for traditional armor and so placement does not require special care, leading to simpler construction methods than that of a conventional revetment (Ahrens, 1990).

There are a limited number of guidelines or existing dynamic revetment projects to use as reference for design of the geometry. Thus, the cross-sectional geometry was developed from a combination of sources, including: an engineering analysis utilizing available empirical formulae (Ahrens, 1991 & Allan, 2005), performance review of existing projects, literature review, and consideration of the site-specific details with members of the technical committee.

1.2 Methodology

Based on experimental data, it has been found that a key parameter for design of a dynamic revetment is the initial cross-sectional volume, or critical mass (Ahrens, 1990). Therefore, this initial volume was the starting point for design of the dynamic revetment cross-section. The volume was estimated based on Ahrens (1991), Allan (2005), and review of existing dynamic revetments installed on the U.S. West Coast:

- Ahrens (1991)
  - Based on the empirical formulae in Ahrens, the range of volumes associated with the design event is approximately 10-25 CY/LF. The range is based on the water levels and beach elevation at the time of the storm, which may differ from existing conditions.

- Allan (2005)
  - Based on the empirical formula in Allan (2005), which parameterizes expected natural cobble/gravel volume based on the width of the dynamic revetment (or natural berm). The estimated volume of material is between approximately 15 – 20 CY/LF (for a width of 60-70 ft).
- Prototype Projects
  - Based on a review of existing dynamic revetments in the Pacific NW, the volume per linear foot of shoreline varies from 10-15 CY/LF (Cape Lookout) to 40 CY/LF (Clatsop Spit), with varying expectations for maintenance. For example, the dynamic revetment at Clatsop Spit anticipates maintenance to be required every 10-15 years, and is also on a wide beach where it could be installed entirely above MHHW. Details and contextual factors for these projects (and additional prototypes) were discussed within the Technical Committee.
  - USACE conducted an independent analysis for WSDOT to determine the potential volume that a dynamic revetment would require in approximately the same project area. Their concept-level design included 17 CY/LF (WSDOT/USACE, 2018).

Based on the above information, the selected cross-sectional design volume is 17.5 CY/linear foot (LF), with minor variation along the shore. The findings of these analyses and reviews were presented to the technical committee and accepted by the team. It is important to note that due to the lack of information and data available, no perfect design criteria or empirical formula is available for both this estimate, as well as the required interpretation and discussion among the technical committee.

2 Design

Considering the recommended cross-sectional volume, the design geometry was developed based on review of seasonal site conditions, long-term erosion modeling, estimated run-up elevations, and optimization between excavation volume and seaward extent of the toe (with permitting considerations in mind). The information in this section includes the general design parameters for the dynamic revetment. Please note that at transitions, and along specific segments of the shoreline, the design criteria may differ.

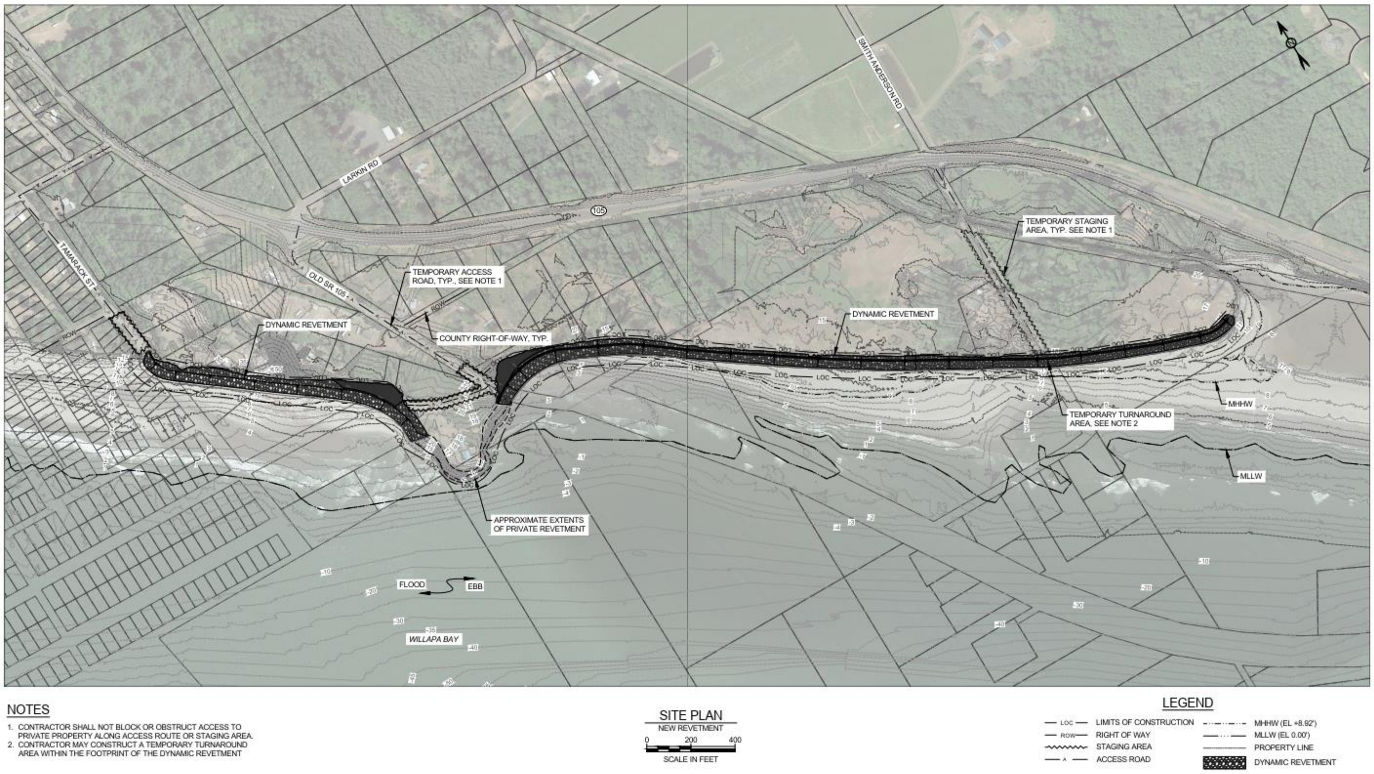
2.1 Extents

The general Demonstration Project area was defined by the technical committee. However, specific details needed to be assessed in order to refine transition locations. Analysis was conducted to refine the southern and northern extents, the locations of material type transitions, and the transitions to the existing private revetment.

- Northern Extent: Tamarack Road
  - The termination of the dynamic revetment should be outside the influence of the Private Revetment (which acts as a groin). This distance has been estimated to be a minimum 900 feet away from the Private Revetment, this distance aligns with Tamarack Road.
  - The location has been coordinated with Pacific County and the Technical Committee.
  - The Northern Extent has been designed to curve in order to minimize edge effects and reduce risk of being undermined or flanked.
- Private Revetment
  - In the area of transition to the Private Revetment it has been assumed that no excavation should occur within the vicinity of the existing structure. Therefore, additional dynamic revetment material should be

installed on top of the existing private revetment to provide a protected transition. The length of this transition has been estimated to require a 12-foot length minimum, based on the existing rock size.

- Southern Extent: Drainage Ditch
  - The criteria for this transition is to minimize risk to affecting operation of the existing drainage ditch. The plan view constraint area was determined based on aerial review of the ditch location and meandering utilizing 13 years of aerial data (Figure 2). The terminus of the dynamic revetment is outside the terminus of the ditch and has been located to minimize influence on ditch meandering or operations. The Drainage District is assumed to manage risk of ditch meandering.



NOTES

1. CONTRACTOR SHALL NOT BLOCK OR OBSTRUCT ACCESS TO PRIVATE PROPERTY ALONG ACCESS ROUTE OR STAGING AREA.
2. CONTRACTOR MAY CONSTRUCT A TEMPORARY TURNAROUND AREA WITHIN THE FOOTPRINT OF THE DYNAMIC REVETMENT

Figure 1 - Representative Plan View

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 2 - Historical Drainage Ditch Thalweg Location

2.2 Cross-Section Geometry

The constructed dynamic revetment should follow the following criteria for the site conditions that exist at the time of construction. **Error! Reference source not found.** includes generic representative plan view extents north and south of the private revetment (shown in Figure 3), respectively.

- Crest Height: 21 ft. MLLW
  - Based on discussion with Technical Committee and review of total water elevation (TWL) estimates for the region. Select areas are higher in order to tie into existing contours.
- Toe Elevation: 5 ft. MLLW
  - Based on design surface and review of winter profiles.
- Front slope: 3H:1V
  - Estimated stable slope to minimize need for in-water construction. Natural slope in response to storms will differ and is dependent on specific storm conditions.
  - The natural slope is estimated to be between 4H:1V and 7H:1V (surveys of natural cobble beaches on the Oregon coast indicated a natural slope of 4-5H:1V, natural slope of the emergency project was measured between 4-6H:1V).
- Excavation slope (toe): 3H:1V
  - Estimated stable slope for beach sands, to reduce need for shoring at toe.
- Back Slope:
  - Southeast: 3H:1V
    - Estimated stable slope for cobble rubble mound.

  - Northwest: Flat to meet existing slope
- Crest Width:
  - Southeast: 6 ft.
  - Northwest: Varies depending on location.
- Toe Width:
  - Southeast portion: 10 ft. to provide a buffer allowing for adjustment of the seaward portion of the toe prior to sloughing.
  - Northwest portion: 30 ft. at a slope of 10H:1V (to reduce excavation volume). Then slopes up at 3H:1V until MHHW.
- Reuse of excavated material:
  - Placed on top of dynamic revetment to feed natural system. The thickness of material will vary, but should be placed approximately equally on top of the front slope of the dynamic revetment. This would create a dune-like appearance and keep the sand material within the littoral system.

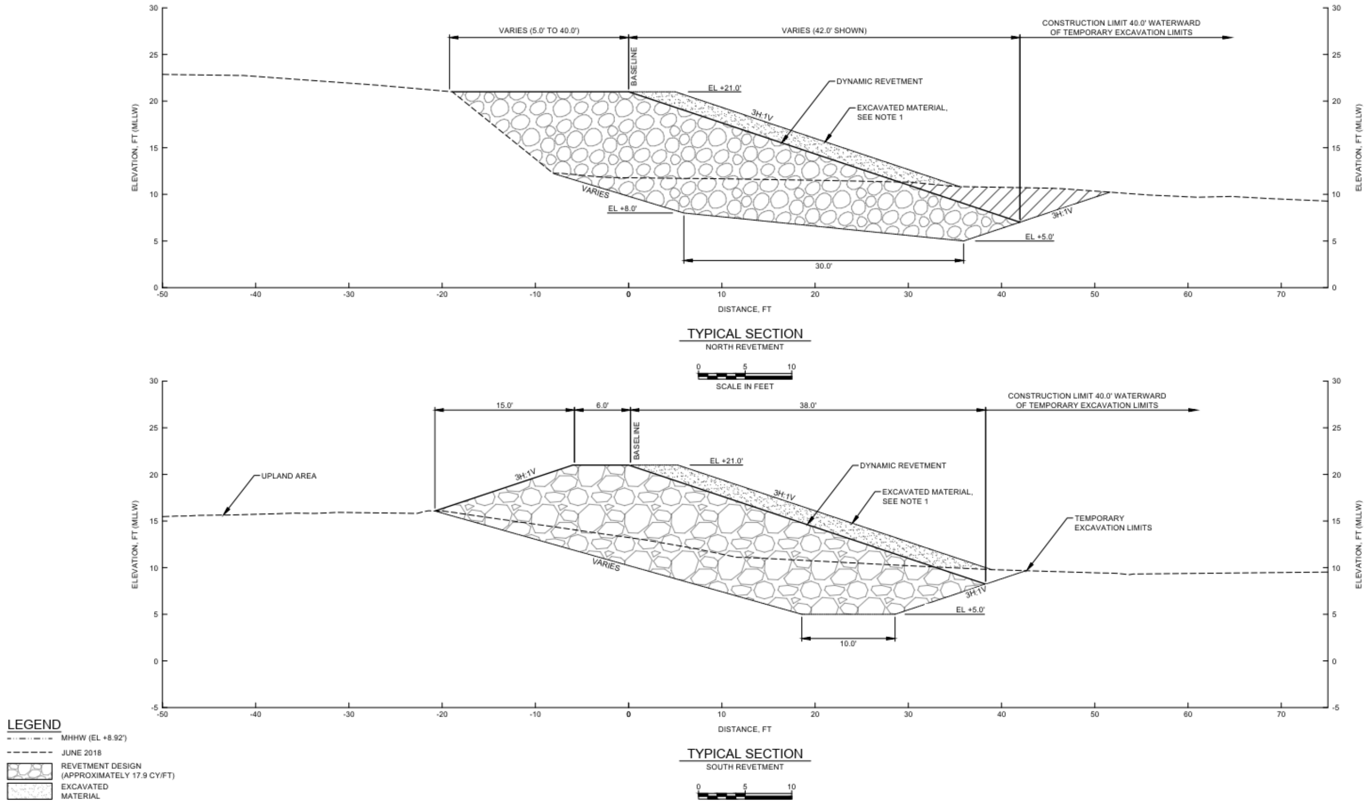


Figure 3 - Representative Cross-Sections

2.3 Material Size and Type

Rock size was determined based on a combination of data available. This included: review of the performance and monitoring of the rock presently on site as part of the short-term dynamic revetment, stability formula, assessment of maintenance requirement risk, and coordination within the Technical Committee. Two specifications of rock type were selected in order to fulfill the performance and maintenance requirements for two types of rock sources.

Utilizing the stability formula (Van Der Meere, Melby) and the design wave conditions, it was estimated that the "stable" medium for the nearshore wave storm condition is approximately 6-10 inches, assuming a 40-50 percent "damage" factor. Note that "damage factor" indicates the percent of rock that has become dislodged. In the case of a dynamic revetment, the acceptable "damage" factor may be higher than 50 percent.

The present rock at the site consists of "boney pit run" material and is not a defined gradation. It consists primarily of angular rock and some rounded rock. The material ranges in size from less than 1-inch diameter to greater than 12-inch diameter (as defined by the intermediate axis)[1]. As noted in the Washington State Dept of Ecology 2018-2019 Monitoring Report at the site (Weiner, 2019), rocks that moved the most at site were 8-inch diameter or less, however, rocks up to approximately 10 inches in diameter were also observed to have been mobile. Note that the monitoring program occurred in a season which did not include an extreme storm with greater than a 2-year return period. The Monitoring Report also noted no significant difference between rounded and angular rocks.

Based on discussions with suppliers, 12" minus rounded cobble would be significantly more expensive than either 12" minus angular, or 10" minus rounded cobble. Since no performance difference was observed in the 2018-2019 season, angular was selected as preferred option.

Material quality will affect the maintenance interval that is required at the site. The more rock that is fractured into smaller pieces, means more material will be lost offshore during increasing smaller storm events. In order to gain a better understanding of this relationship two separate rock types were developed and placed in different regions of the beach. The two different rock types will be used to monitor breakdown of the rocks and determine what specifications for rock should be used in the future to reduce maintenance. The different rock was placed following the criteria below:

- Placing more durable rock south of the private revetment, which is a high wave energy location.
  - Comparing the two rock types under similar conditions by placing in an area not effected by the private revetment, which acts as a groin-like structure.
    - The private revetment area of influence is conservatively estimated to be approx. 1,500 ft along the shoreline.
    - The more durable rock was therefore extended 2,000 ft south of the private revetment. This provides a 500 ft section of the higher quality rock, under similar conditions, to compare to the lower quality rock at the south end of the dynamic revetment.

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[1] Based on visual inspection.

3 Maintenance Requirements

Unlike more traditional riprap rock revetments, there is no specific methodology to calculate maintenance requirements for dynamic revetments. Therefore, estimated maintenance requirements were developed based on a combination of literature and prototype review efforts, review of the 2018-2019 winter season, and empirical rock stability calculations. The maintenance estimate coordinated with the technical committee after reviewing the information below was to assume 35 percent replacement every 5 years over the lifetime of the project to maintain the design cross-sectional volume (on average).

- Literature review
    - As noted in Allan (2005), it is recommended that dynamic revetment projects should include a program for periodic maintenance. Also noted, is that a groin constructed across the (beach) berm could reduce maintenance needs.
- Prototype review
    - Cape Lookout – approximately 25-30 percent replacement after 5 years.
        - Located within the intertidal zone.
    - Ediz Hook – approximately 30 percent replacement after 5-12 years.
        - Located within the intertidal zone.
    - Clatsop Spit – estimated to be 10-25 percent replacement after 10-15 years.
        - Located outside the intertidal zone.
- Analysis of Winter 2018-2019 conditions + morphology season data from Washington State Dept. of Ecology Monitoring Report and NOAA Buoy Data
    - No measurable loss of rock material was observed from January to March; storm events were not extreme; data record not long enough to provide confidence in assumption regarding future maintenance requirements.
- Empirical Estimates
    - Utilizing the stability formula (Van Der Meere, Melby) and the design (Depth limited) wave conditions, it was estimated that the “stable” medium for the nearshore wave storm condition is approximately 6-10 inches, assuming a 40-50 percent “damage” factor. The “damage” factor was assumed to be approximately equal to “lost” material.

4 References

See Master Report

Appendix B: Public Meeting Boards

Project Purpose & Partners

1.

Develop long-term shoreline erosion protection design to protect the highway, drainage district, maximize protection of private lands

2.

Demonstrate shoreline protection concept is successful

3.

Develop masterplan and guidance for implementation of the next phase of shoreline erosion protection

US Army Corps of Engineers®

Pacific County Washington

Drainage Ditch Number One Pacific County Washington 1900

Washington Department of Fish and Wildlife

Mott MacDonald

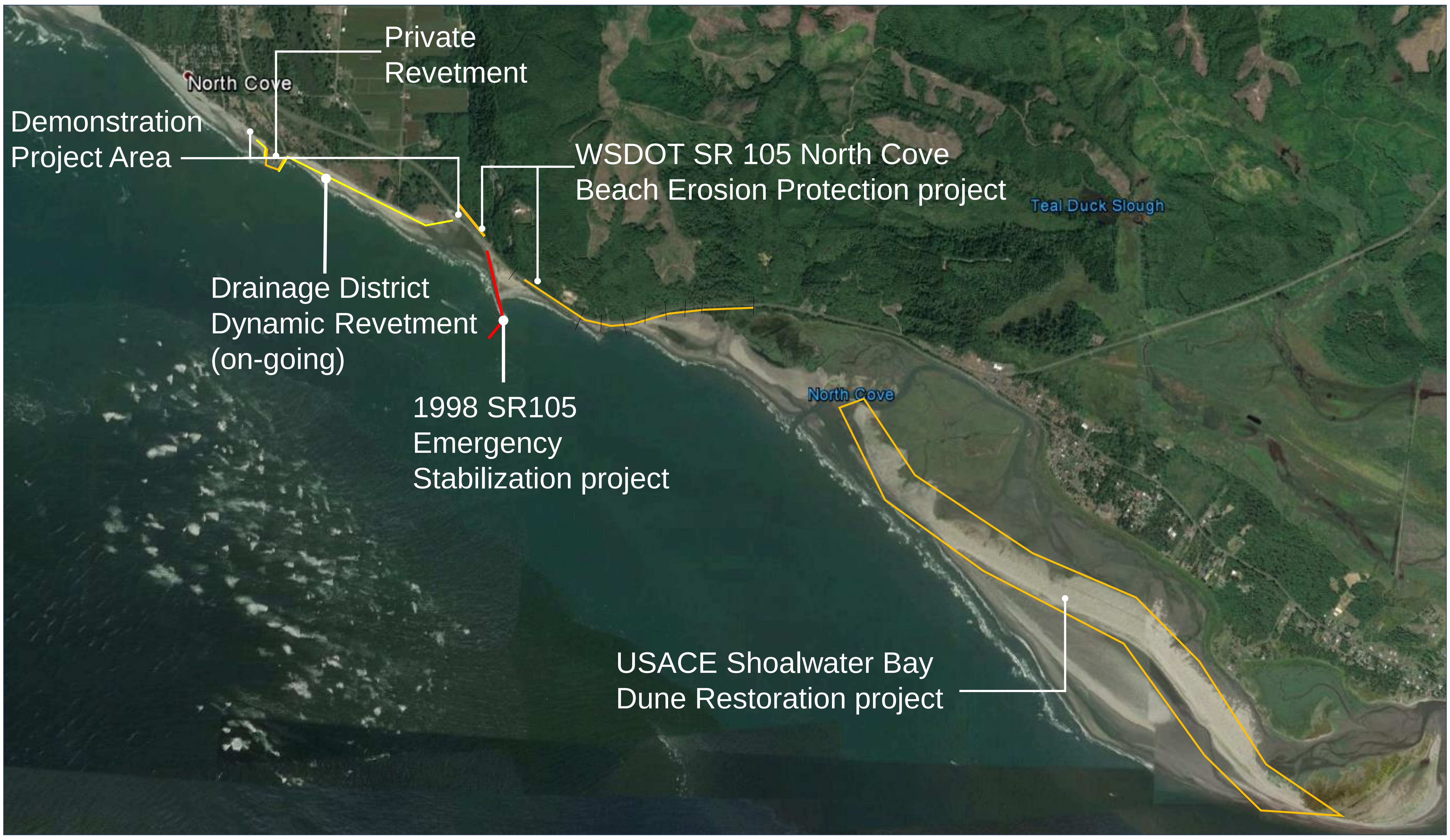
WSDOT

Shoalwater Bay Tribe

Department of Ecology State of Washington

North Cove Vicinity Projects

Existing Protection and On-Going Projects

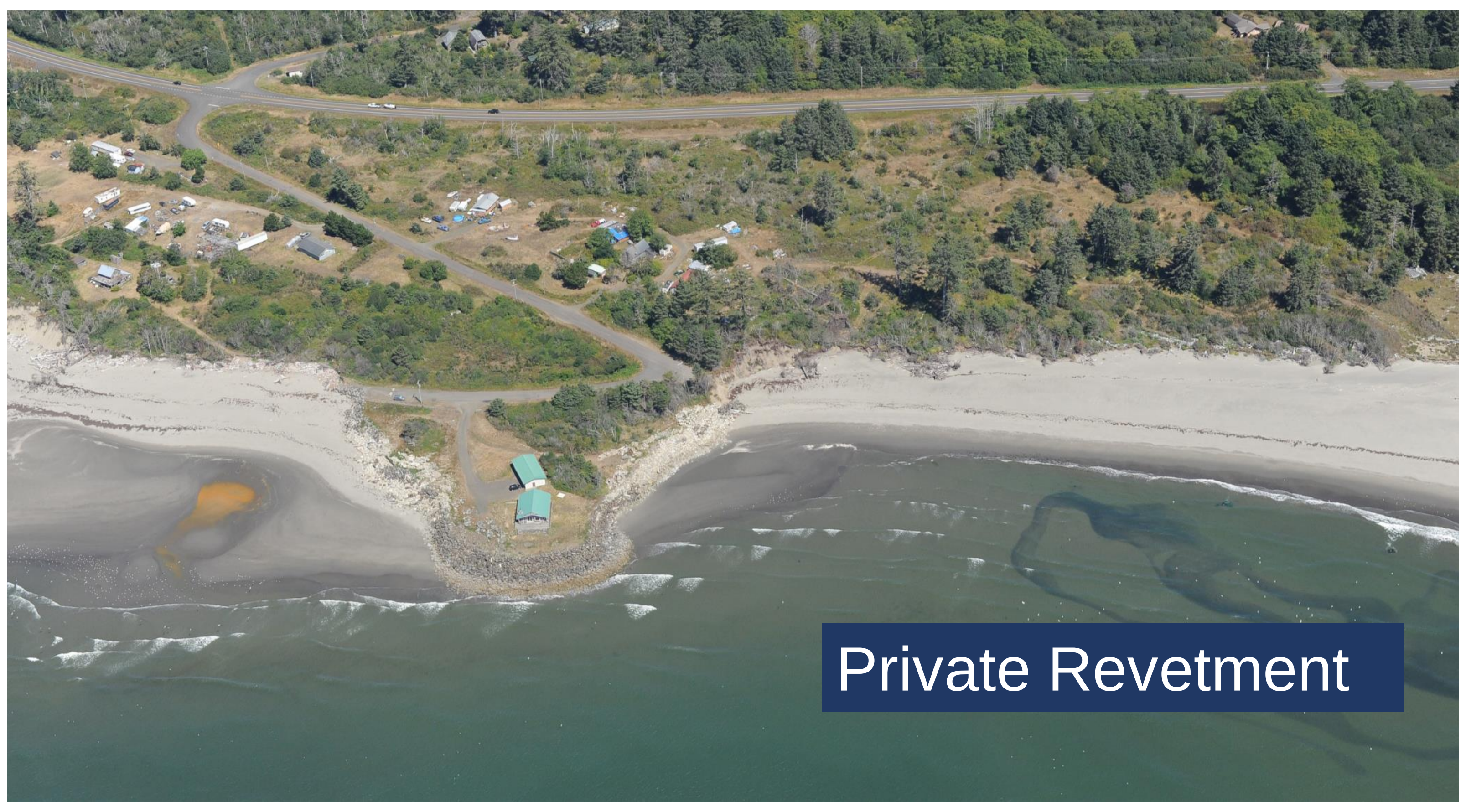


Drainage District Dynamic Revetment (on-going)

Photo Courtesy of David Cottrell

1998 SR 105 Emergency Stabilization project

Photo Courtesy of WSDOT, October 2018



Private Revetment

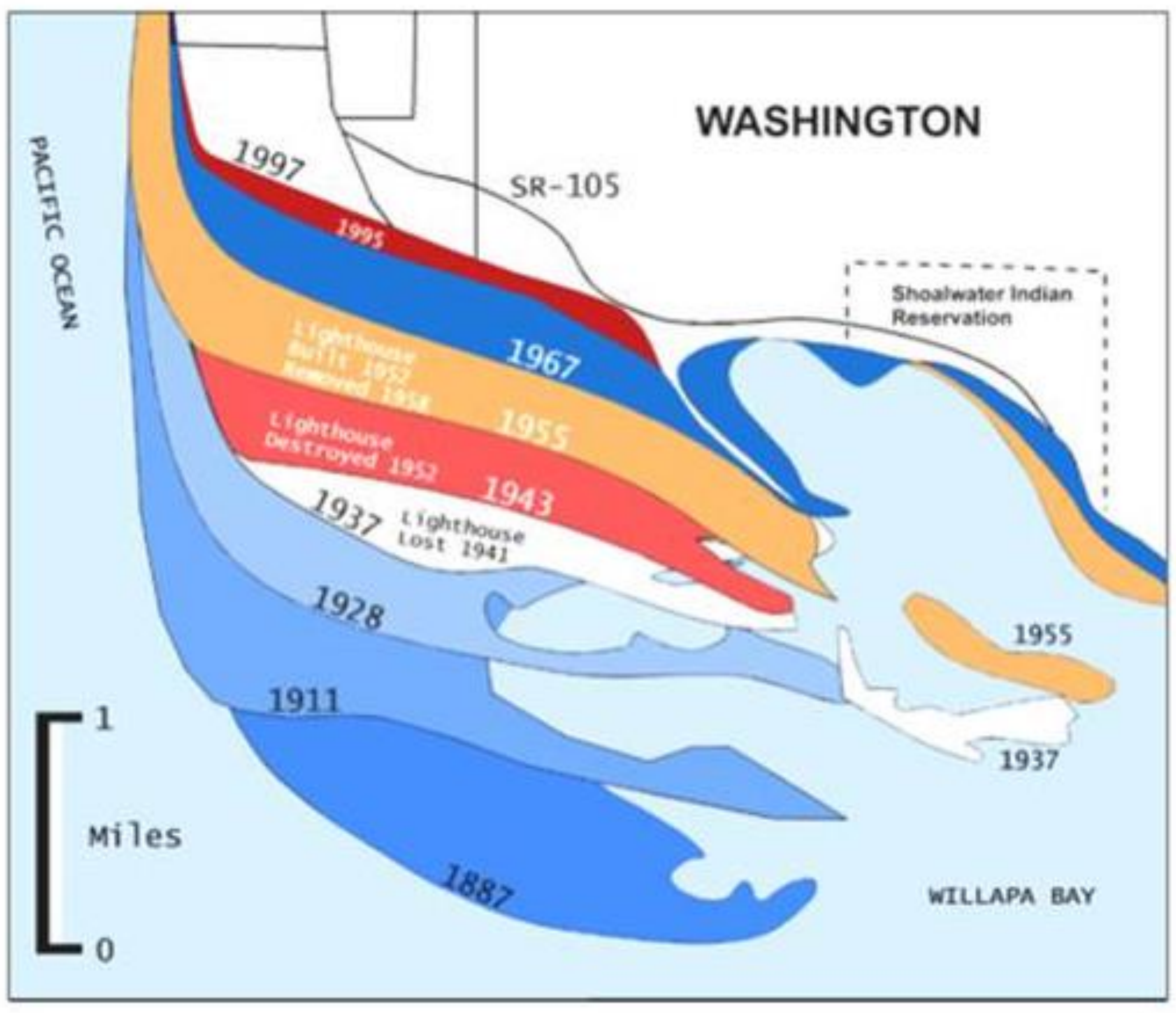
Photo Courtesy of Washington Coastal Atlas, WA Ecology, August, 2016

USACE Shoalwater Bay Dune Restoration project

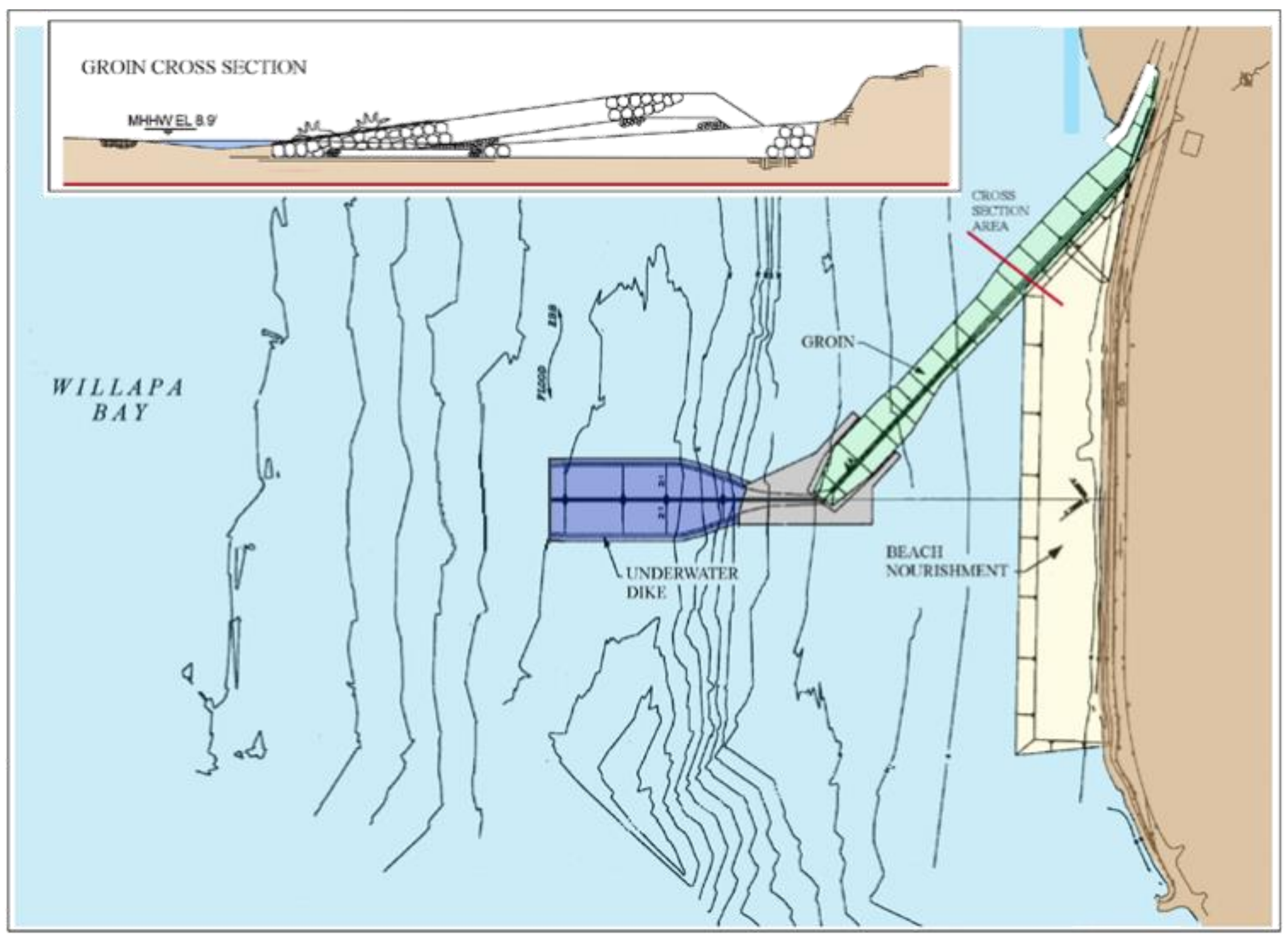
Photo Courtesy of Ross Island Sand and Gravel

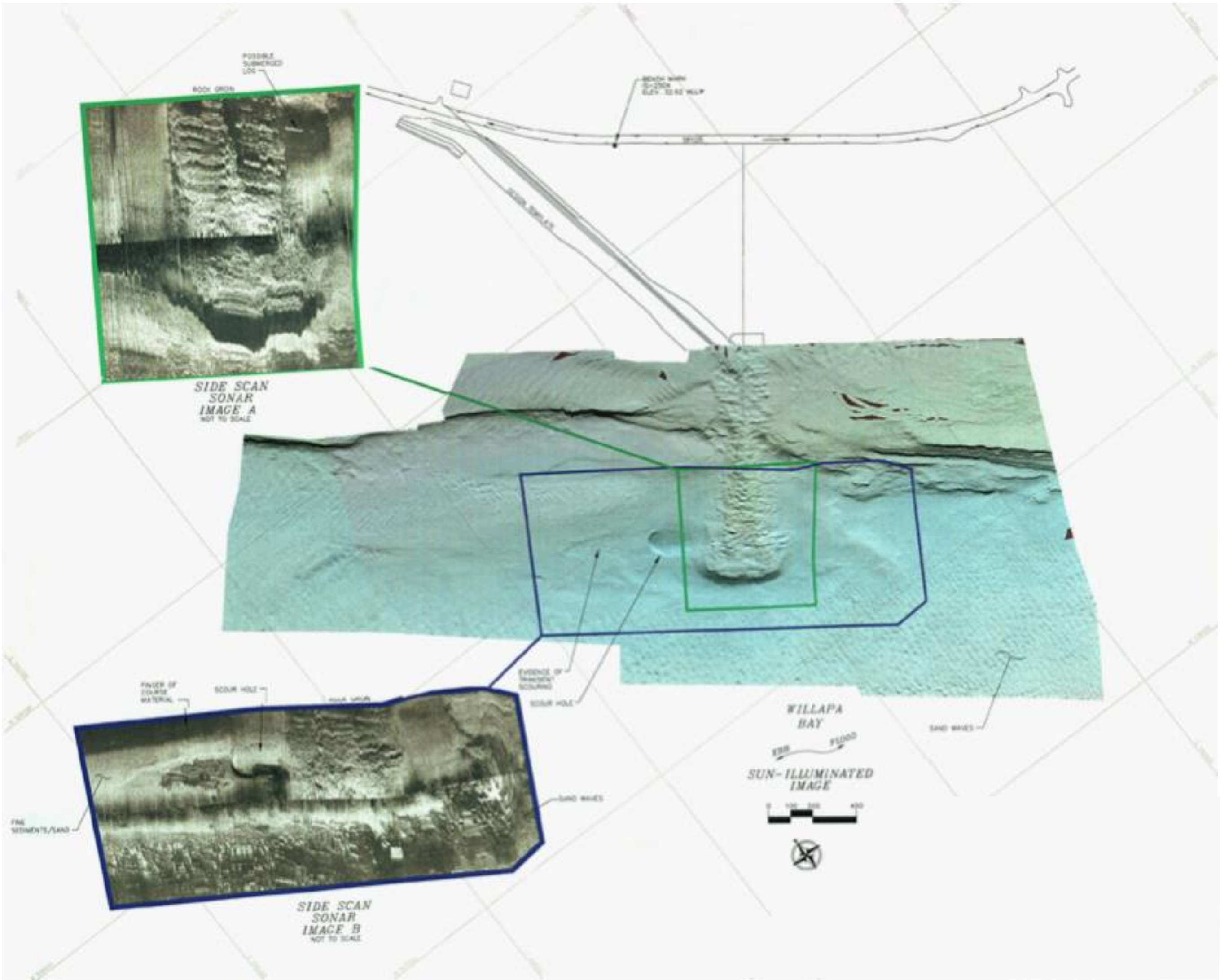
Project History

Historical Erosion

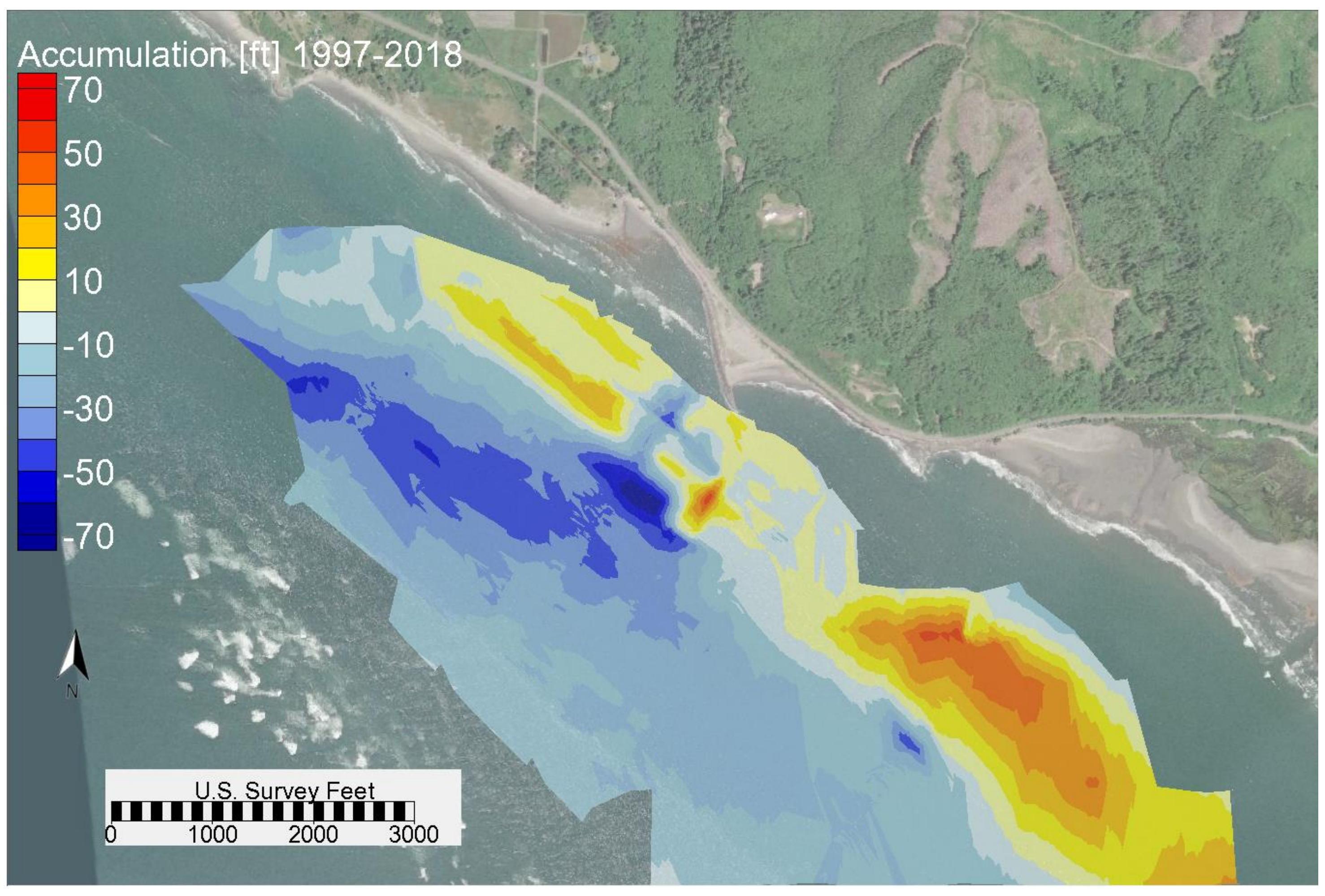


1998 Construction





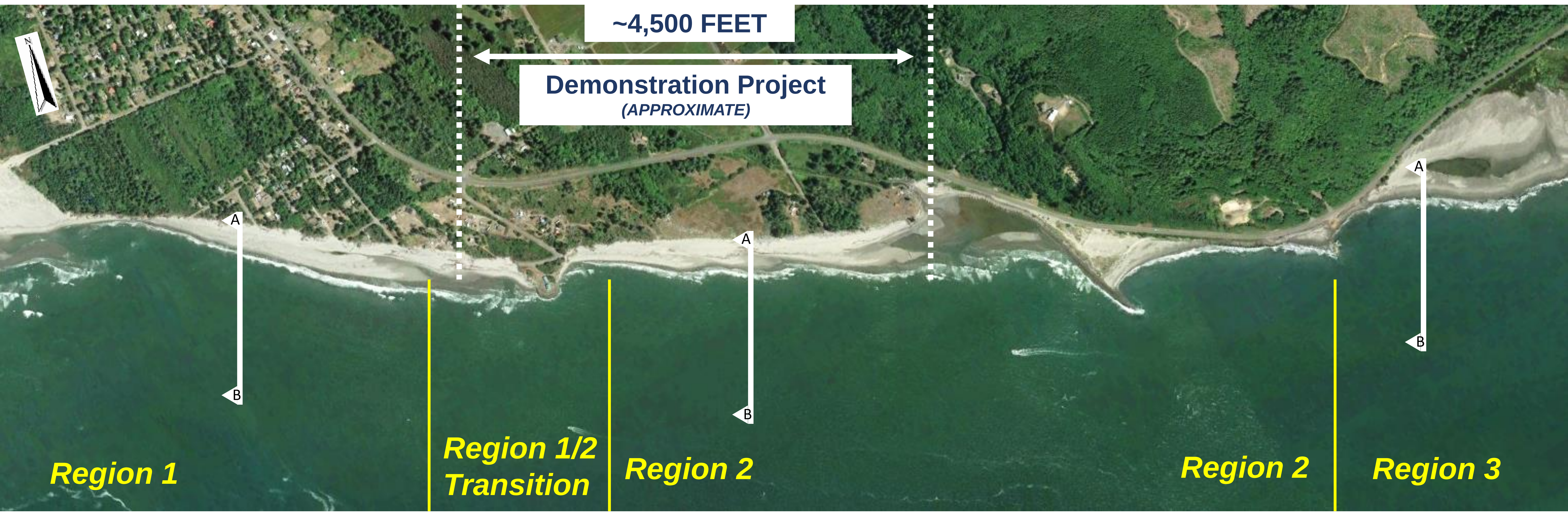
Bathymetry: 1997-2018



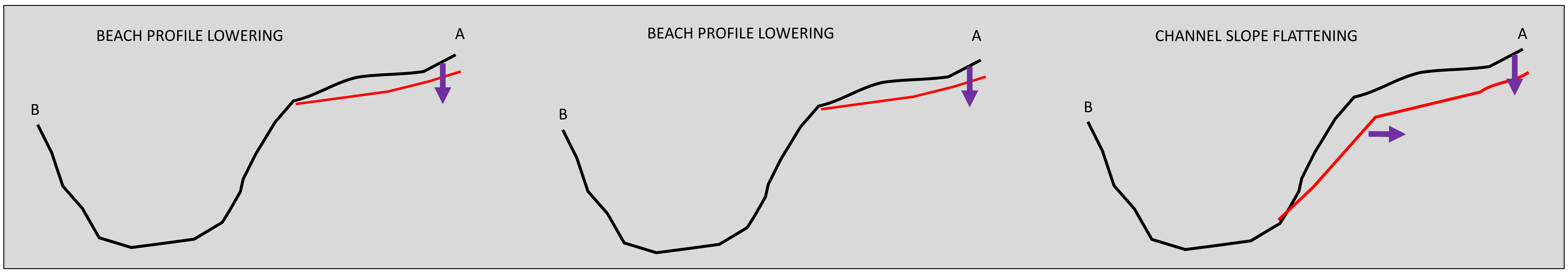
2018 Status

Photo Courtesy of WSDOT, October 2018

Coastal Processes

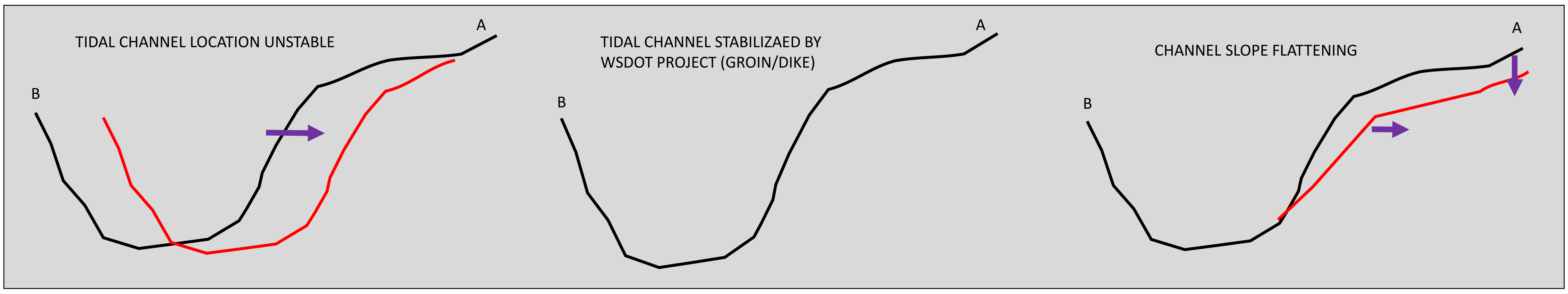


NEAR-TERM PROCESSES: Waves



Region 1 **Region 2** **Region 3**

LONG-TERM PROCESSES: Channel



Region 1 **Region 2** **Region 3**

LONG-TERM ASSESSMENT

Predominantly controlled by channel tidal northward migration, also susceptible to wave induced erosion

Erosive shoreline subject to impact from waves and localized hydrodynamic effects

Deepening of landward slope provided increased wave energy to shoreline

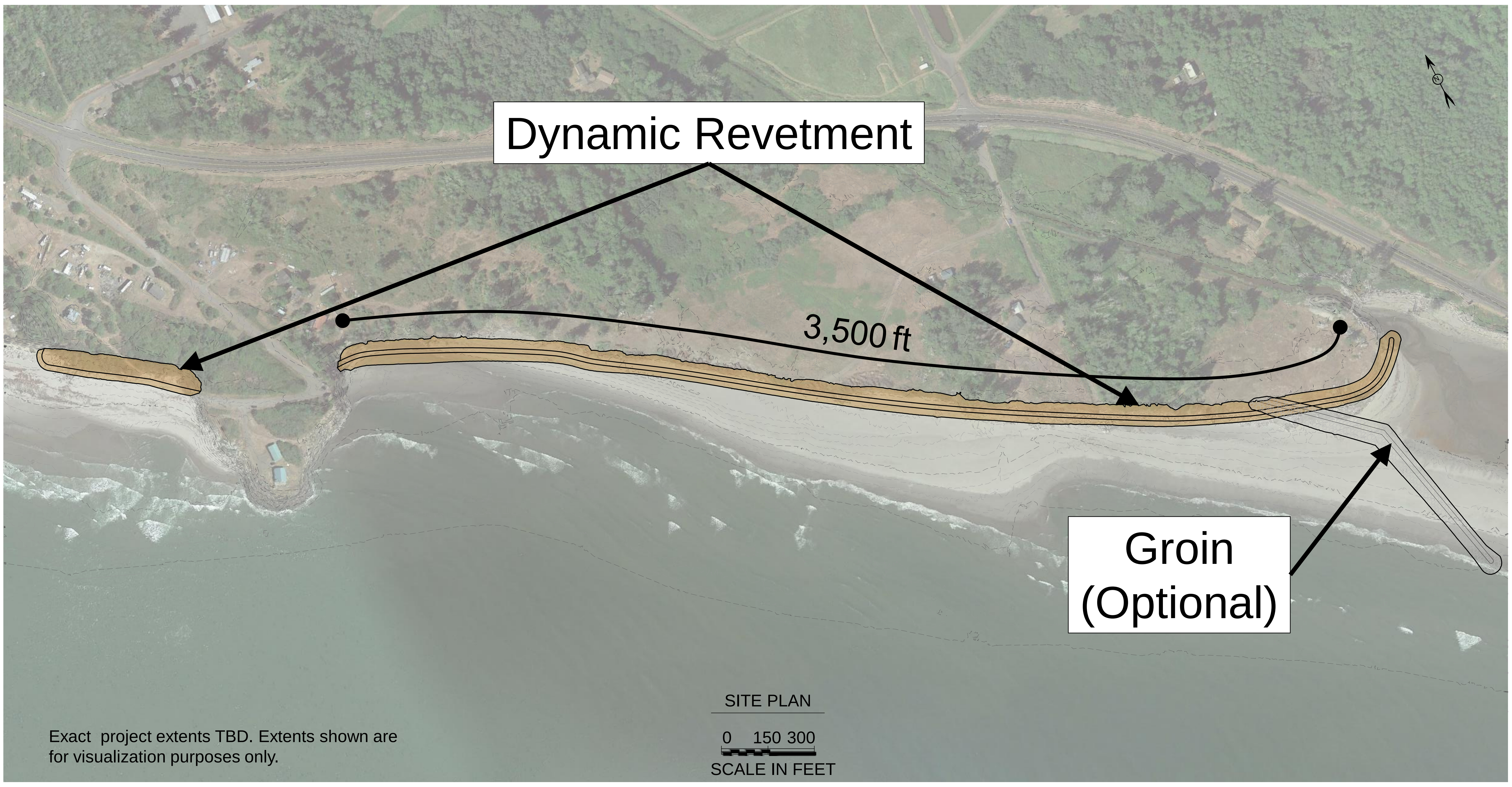
North Willapa Shoreline Protection Demonstration Project

PACIFIC COUNTY WASHINGTON

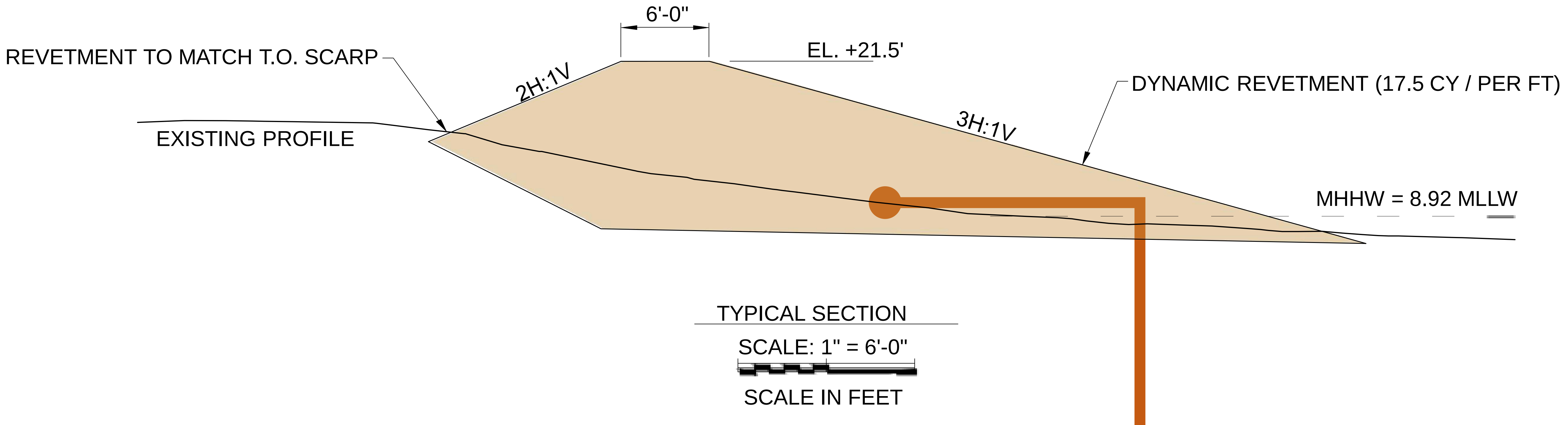
MOTT MACDONALD

Preferred Alternative

Demonstration Project Plan View



Dynamic Revetment Cross-Section



North Willapa Shoreline Protection Demonstration Project

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Appendix C: Project Input Data, Assumptions, and Design Criteria

COAST & HARBOR ENGINEERING
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Technical Memorandum – DRAFT

Willapa North Shoreline Protection Demonstration Project (WNSPDP) Input Data, Assumptions, and Design Criteria

This document was developed to coordinate with the Project Team the project data, assumptions, and design criteria to be used by Coast & Harbor Engineering, a Division of Mott MacDonald (CHE) for coastal engineering and design of the Willapa North Shoreline Protection Demonstration Project. The overall goal of this project is to prepare the final design and submit the permit application for the shoreline erosion protection demonstration project along Region 2 of the North Willapa Bay shoreline[1]. The technical and environmental information, obtained upon the demonstration project will be the base for a master plan to stabilize the critical shoreline areas in North Cove, WA, to be prepared in the future. The project design criteria, presented in Section 2, are based on requirements and constraints provided by the Project Team as well as standard engineering practice.

1. Project Data

1.1. Bathymetry and Topography

The bathymetric and topographic datasets, listed in Table 1 were combined to generate a single elevation database, also referenced as a basemap. The image of this elevation database is shown in Figure 1 in color format[2].

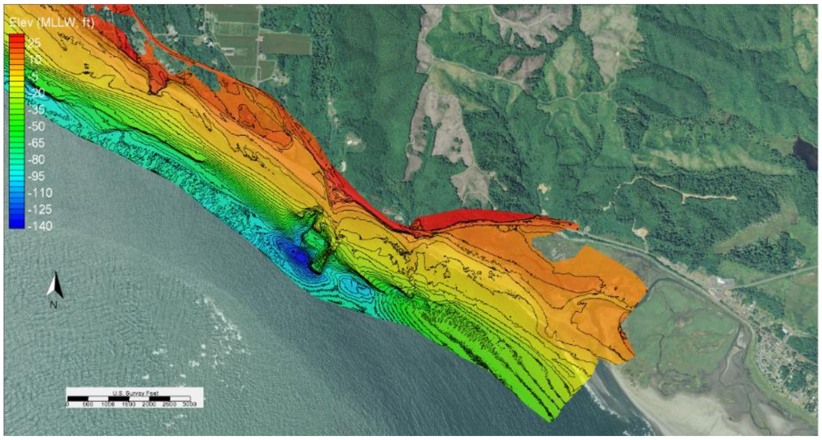

Figure 1. Design surface elevation

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[1] More detailed discussion on specific project goals is presented in Section 3.1.

[2] Coverage of the datasets varied over the project area; therefore, some extrapolations were applied in developing a basemap.

Table 1. Bathymetric and Topographic Datasets

Source	Description	Comments
Topographic Data		
PIE	Transects	2003, 2006
WDOE	Transects	2014, 2015, 2016, 2018
Bathymetric Data		
PIE	Transects	2000, 2006
USACE	Transects	2001, 2002, 2003, 2005, 2006, 2008, 2012, 2018
WSDOT	Single-Beam	2005, 2008, 2010, 2012
USACE	Multi-Beam	2016
WDOE	Multi-Beam	2014, 2015, 2016, 2018

1.2. Wave Data

Wave data for design of the demonstration project were obtained from compilation, review, and analysis of available measured wave data and information on wave data from previous studies (COE 2009, Delft 2009). Various assumptions and empirical approximation[3] to the available data were applied to develop statistical estimates on extreme wave storm events that are applicable for the project site[4]. The results of these estimates are plotted in Figure 2.

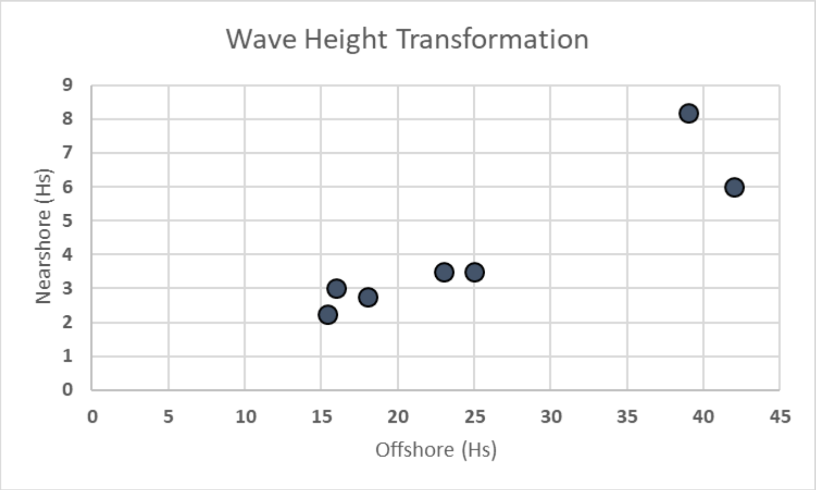

Figure 2. Empirical nearshore wave transformation

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[3] Note that depth-limited wave height may differ, depending on the storm condition and water level.

[4] Note that the actual wave measured data in the vicinity of the project is very limited and not sufficient to develop statistical estimates on extreme storm events. It is also noted that statistical estimates of extreme wave events, developed in a previous study (COE 2009), is not also directly applicable to the project site.

1.3. Beach Sediment Data

Beach sediment data for design of the demonstration project were obtained from the Washington State Department of Ecology and Washington State Department of Transportation. A summary of the sources is shown in Table 2. The grain size distribution for beach surface sediment is assumed to be similar to the following:

- D15: 0.11 mm
- D50: 0.17 mm
- D85: 0.26 mm

Table 2. Beach Sediment Data Sources

Source	Description	Comments
WA State Department of Ecology	Southwest Washington Coastal Erosion Study Sediment Sample Sieve Results (summer 1997-summer 1999).	Samples taken along CSW Profile (0.3 miles east of the base of the groin) at elevations ranging from 3.3-16.4 ft NAVD88.
WA State Dept. of Transportation	SR-105 North Cove Vicinity Sediment Boring Laboratory Results (February 1997).	Four boring locations between Smith Anderson Road and the rock revetment east of the groin.

1.4. Geotechnical Data

Geotechnical data for design of the demonstration project were obtained from a variety of archive sources including archives of WSDOT and USACE. A summary of available geotechnical data is shown in Figure 3 and Table 3. The data available suggests that the sediment profile is consistent below the surface. Geotechnical analysis will be conducted further in application to specific alternatives to be considered, but no new data will be collected for this demonstration project.

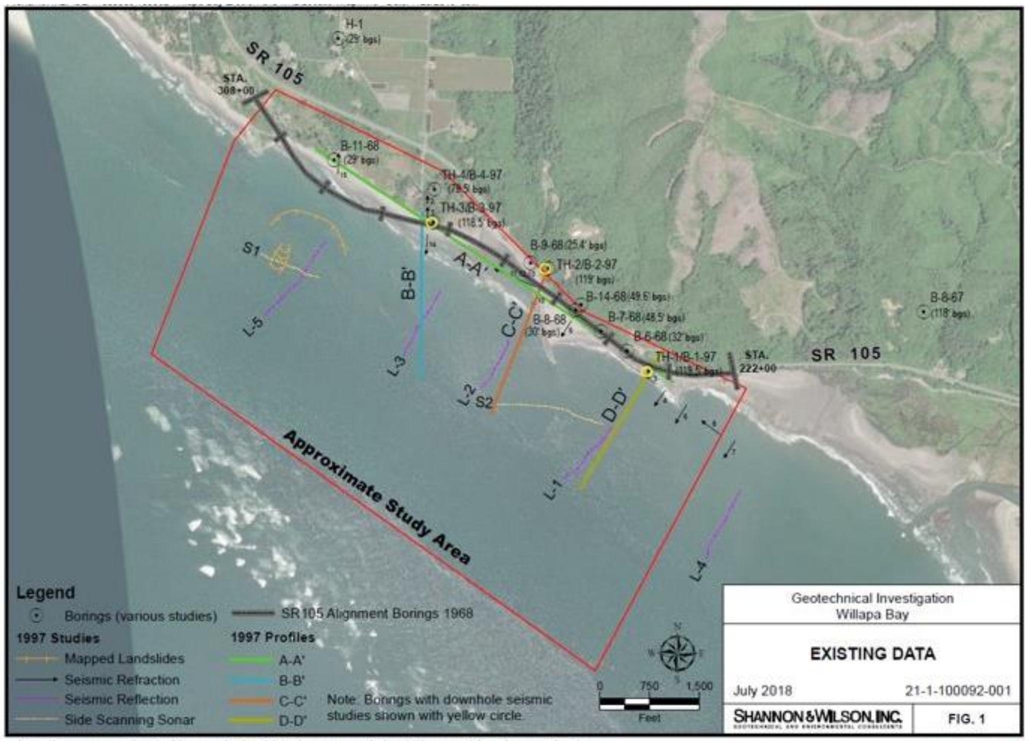

Figure 3. Graphic showing available existing geotechnical data

Table 3. Summary of Available Geotechnical Data

Source	Description	Comments
WA State Department of Transportation	SR-105 North Cove Vicinity Sediment Boring (February 1997)	Nine soil boring locations to depths exceeding 30'
WA State Department of Transportation	SR-105 Geological Study of the North Channel of Willapa Bay – Vicinity of North Cove, Washington	Includes description and interpretation of geotechnical data available in North Cove area (seismic refraction surveys, p-wave surveys, bathymetric cross-sections, boring logs, and lab results).

2. Assumptions

2.1. North Tidal Channel Migration

No tidal channel migration will be accounted for in design of the demonstration project in the vicinity of Region 2. North tidal channel landward migration in the area to the northwest of Region 2 will be included in the demonstration project design, where appropriate. The yearly rate of channel migration will be estimated and prorated through the project life, based on available U.S. Army Corps of Engineers' survey data.

2.2. SR105 project at Dike/Groin

The existing rock dike and groin will be maintained to preserve its function for protecting the portion of Region 2 from continued channel migration.

2.3. Possible Work for Maintenance of 1998 SR105 Project

The dike and groin of the 1998 SR105 project are at reasonably stable conditions and will restrict landward migration of the tidal channel for the project lifetime. No work for rehabilitation or modification of the 1998 SR105 Shoreline Erosion Protection Project will be considered under the demonstration project.

2.4. Cranberry Bog Ditch Shoreline

Erosion of the shoreline and bottom slope at the area, referenced as a “Ditch Area” (See Figure 4), is subjected to localized hydrodynamic and morphologic processes that are different from that along the rest of the project area. This part of shoreline may require a special solution that is not applicable to other areas along the project coastline. If this is the case, a solution may be designed but not recommended for implementation as a demonstration project.

Ditch flow and discharge for use in evaluation of alternatives will be based on the 1961 Drainage District Design Report. The culvert was originally sized for a maximum discharge of 250 cubic feet per second. Due to the date of the existing study, it is possible that the ditch discharge volume could now be higher due to any changes in practices or groundwater levels.

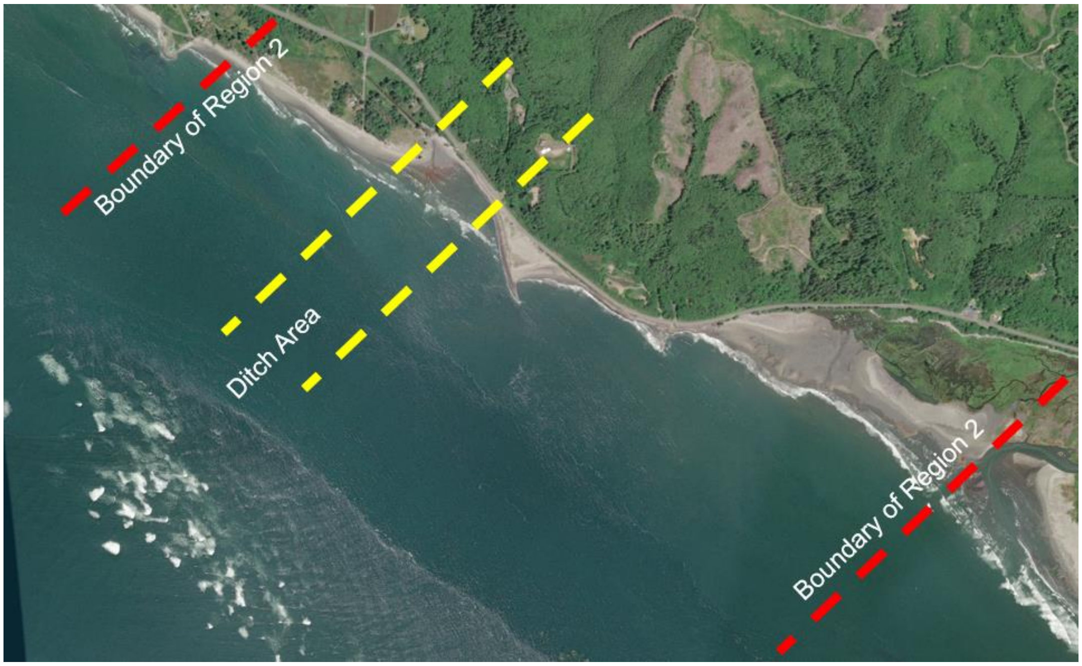

Figure 4. Boundary of Region 2, including Ditch Area

3. Design Criteria

3.1. Objectives

- Protect the stretch of highway located landward from the demonstration project from wave erosion and flooding.
- Preclude flooding of cranberry boughs along the stretch of shoreline protected by the demonstration project.
- Protect private property from land losses along the stretch of shoreline with the demonstration project. At the same time, the demonstration project may not protect private properties from flooding during extreme storm events at high tides.
- Minimize adverse environmental impacts.
- Maximize beach area, at least during summer period.
- Protection of Tribal lands within the project area.

3.2. Maintenance Requirement

The design will be completed to minimize maintenance requirements. Maintenance requirements will be evaluated as part of characteristics for each alternative

3.3. Design Wave Storm Event

Please note that there are not any generally acceptable standards (engineering or regulatory) identified to select the design storm event criteria for shoreline erosion protection projects, specifically for projects as complicated as WNSPDP. Depending on the purpose, shoreline erosion protection projects may have different design storm event return periods. An example is shown in Table 4.

Table 4. Example Shoreline Erosion Protection Project Design Condition

Purpose	Design Condition
Infrastructure	50 to 100 years
Land	25 to 50 years

Considering the objectives of the demonstration project (see above), three offshore wave height criteria were selected, as shown in Table 5. All wave height design criteria will be applied at a period of 10 sec[5]. Note that depth-limited wave height may differ depending on the storm condition and water level.

Table 5. Selected Nearshore (>25ft. water depth) Wave Height Criteria

Return Period	Hs (Feet)	Tp (Seconds)
2-Year	5 feet	10 seconds
50-Year	6 feet	10 seconds
100-Year	10 feet	10 seconds

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[5] It has been assumed that the longer period waves (e.g., greater than 10 seconds) are significantly dissipated by the Willapa bar system.

3.4. Sea Level Rise

Sea level rise criteria is not accounted for in design of the demonstration project. For the assumed project lifetime, a recent study by Miller (2018) indicates a likely range[6] of 2.4-10.8 inches at the project site. Long-term NOAA water surface elevation data at Toke Point (STA. 9409110) indicates a long-term SLR rate of 0.7 inches. Because of the relatively low magnitude of localized SLR expected throughout the project lifetime, relative to other physical processes, no SLR criteria is included.

3.5. Tide Elevation Design Criteria

Standard tide elevations (1981-2001 Epoch) in Willapa Harbor relative to MLLW and NAVD88 datums are depicted in Table 6. MLLW is assumed to be the project datum. Extreme water levels are provided by NOAA for the Toke Point Station (9440910).

Table 6. Standard Tide Elevations (1981-2001 Epoch) in Willapa Harbor

Datum	Elevation, ft MLLW
Highest Observed	14.41
Mean Higher High Water	8.92
Mean High Water	8.18
Mean Sea Level	4.78
Mean Low Water	1.37
North American Vertical Datum 1988	0.82
Mean Lower Low Water	0.00

1-Year Return Period WSE:	11.1 ft MLLW
2-Year Return Period WSE:	12.5 ft MLLW
10-Year Return Period WSE:	13.6 ft MLLW
100-Year Return Period WSE:	14.8 ft MLLW

Two tide levels will be used for engineering analysis and design: Mean Higher High Water (MHHW) and Extreme High. MHHW tide elevation will be used for design of stability of the upper part of the shoreline, while Extreme High will be used to ensure stability of shoreline structures.

3.6. Design Beach Cross Section

The beach along Region 2 (profile between approximate elevations of MHHW and –15 ft MLLW) is subject to erosion and lowering its elevations. It is assumed that lowering of beach elevations (and erosion) would halt once dynamic equilibrium to hydrodynamic forces induced by a system of design wave storms is achieved. A design cross-section has been developed based on this concept of dynamic equilibrium. For this purpose, numerical modeling of deformation of beach elevations was conducted with software SBEACH. Modeling was performed using various combinations of design storm events and variable tides, including extreme tides. The

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[6] According to the Miller, a likely range is between 17% and 83% likelihood.

obtained design cross- section, superimposed to the existing (2018) configuration is shown in Figure 5.

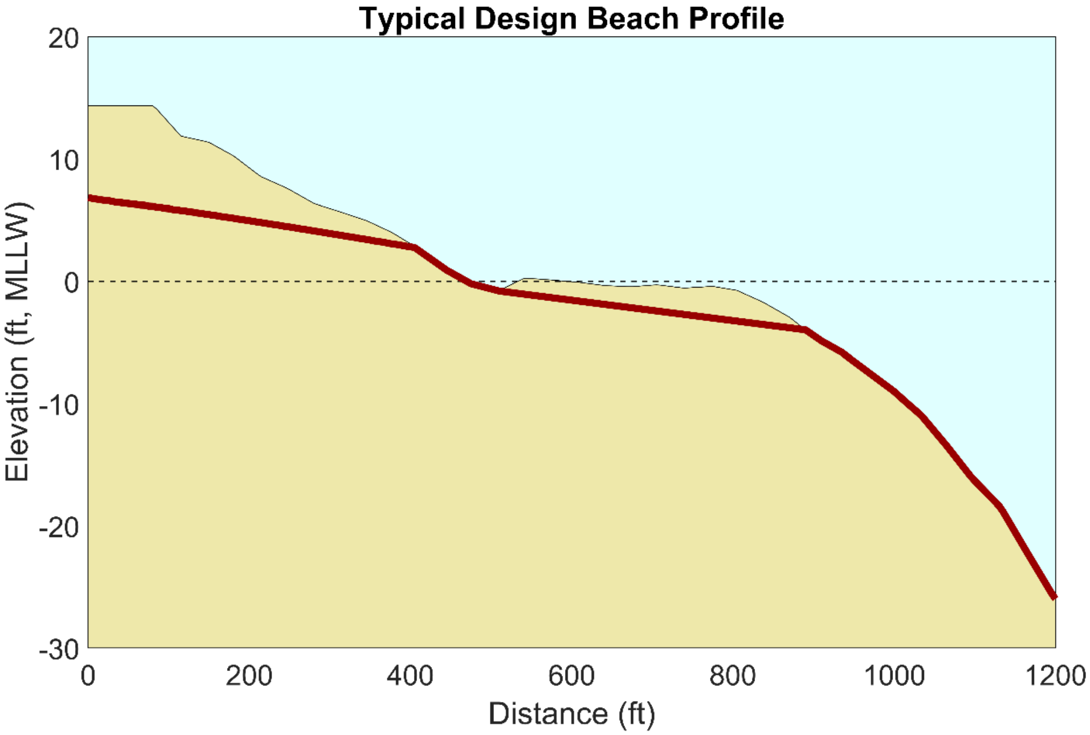

Figure 5. Typical Design Cross-Section Profile (red) and existing ground (brown)

3.7. Tsunami/Seismic

Tsunami wave criteria is not accounted for in the design. Project goals do not include resiliency to tsunami inundation or scour. No significant land subsidence due to seismic activity was assumed.

3.8. Demonstration Project Limits

The project boundary originally was established by the Scope of Work in the vicinity Region 2. Further, upon preliminary analysis the Boundaries of Region 2 were established in relation to SR105 shoreline erosion protection project: 3,000 ft to the NW and 3,000 to the SE from the submerged dike of the previous (1998) SR105 shoreline erosion protection project. As described in Section 2.3 the demonstration project limits will not include the “Ditch Area” shown in Figure 4.

3.9. Project Life Time

For the demonstration project inside of Region 2 the lifetime criteria is 40 years. Because the demonstration project is to be designed assuming channel stability, the portion of the demonstration project construction northwest of Region 2 the project lifetime dependent on channel migration.

3.10. Material Type

Material type and quality requirements will be specified by the engineer in order to meet performance requirements. U.S. Army Corps of Engineers standards for shoreline protection projects will be used as a basis for development of material quality and type.

3.11. Transitions

Details of the transitions (between the coastal engineering elements and transitions to the existing shoreline) will be designed to avoid any adverse impact to the adjacent shoreline.

3.12. Concurrent/Prior Project Integration

The demonstration project will use lessons learned from ongoing or prior projects in the region. The location of existing projects within Region 2 will not preclude locating the demonstration project within any part of Region 2 (unless specifically specified by the steering committee), including, but not limited to:

- Grayland Drainage District Dynamic Revetment
- WSDOT SR 105 North Cove Beach Erosion Protection Project
- WSDOT Dike/Groin
- USACE Shoalwater Bay Dune Restoration Project
- Private Property Revetment Projects

3.13. Shore Protection Alternative Considerations

Alternatives considered for the demonstration project will be compatible with those shoreline erosion protection measures that currently undertaken by USACE, WSDOT, and the Grayland Drainage District. Alternatives will consider the sub-regional coastal processes, such as channel migration and wave induced erosion. Selected Master Plan alternatives for further evaluation may therefore differ between sub-regions based on the coastal processes.

4. References

USACE, Engineering Appendix of Final Post-Authorization Decision Document and Final Environmental Assessment; Shoalwater Bay Shoreline Erosion, WA. April 2009.

Giles Lesser. TU Delft University & UNESCO IHE, An Approach to Medium-term Coastal Morphological Modelling. June 2009.

Miller, I.M., Morgan, H., Mauger, G., Newton, T., Weldon, R., Schmidt, D., Welch, M., Grossman, E. 2018. Projected Sea Level Rise for Washington State – A 2018 Assessment. A collaboration of Washington Sea Grant, University of Washington Climate. Impacts Group, Oregon State University, University of Washington, and U.S. Geological Survey. Prepared for the Washington Coastal Resilience Project.

Appendix D: Steering Committee Presentations

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A Division of Mott MacDonald

North Willapa Shoreline Protection Demonstration Project

Project Kick-off Meeting – 6/20/2018

Pacific County, WA

Agenda

Topic	Action	Leader
Welcome	Engage	Lisa / Kathy
Agenda and Outcomes	Inform	Kelly
Introductions	Inform	All
Communication / Points of Contact	Inform	Shane
• County – Kathy & Lisa • Study Team – Shane, Vlad, Kelly • Technical Committee – Vladimir & Shane • Steering Committee – Lisa & David		
Project Purpose & Goals	Inform	Vladimir
Workplan	Inform / Feedback	Shane
Outreach / Communications	Inform	Shane / Kelly
Meetings Plan	Inform	Shane

Topic	Action	Leader
Background & Baseline Information • Project History • Data still needed	Inform/ Feedback	Vladimir
Connected Activity	Inform	
• Dynamic Revetment		David
• HWY105 Protections		Chad
• Shoalwater Bay Berm		Evan
Next steps	Inform	Kelly
Adjourn		
Preview of site visit • What we'll see • What to pay attention to	Engage	Shane / Vladimir

Meeting Purpose & Agenda

1 Introduce Project Team

2 Discuss Study Objectives, Goals, Outcomes

3 Initiate planning for Stakeholder / Public Outreach

4 Establish Project Schedule

PACIFIC COUNTY
WASHINGTON

Project Team

COAST & HARBOR ENGINEERING
A Division of Mott MacDonald

Archaeological Investigations Northwest, Inc.

BERGLUND, SCHMIDT & ASSOCIATES, INC.
professional engineers & land surveyors

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

DEPARTMENT OF ECOLOGY
State of Washington

SHANNON & WILSON
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Lead To Results, LLC

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Points of Contact

Pacific County	Kathy Spoor County Administrative Officer kspoor@co.pacific.wa.us
Facilitator	Kelly Rupp LeadToResults, LLC kelly.rupp@leadtoresults.com
Project Leader	Shane Phillips Mott MacDonald shane.phillips@mottmac.com
Chair, Technical Committee	Vladimir Shepsis Mott MacDonald vladimir.shepsis@mottmac.com
Co-Chairs, Steering Committee	Lisa Ayers layers@co.pacific.wa.us David Cottrell cranberrydavid@yahoo.com

Technical Committee

Shane Phillips	Coast & Harbor Engineering/Mott MacDonald
Vladimir Shepsis	Coast & Harbor Engineering/Mott MacDonald
George M. Kaminsky	Dept of Ecology, Coastal Monitoring & Analysis Program
David Cottrell	Cranberry Grower/Owner; Grayland Drainage District
Rick Mraz	Dept of Ecology, Shorelands and Environmental Assistance Program
Dave Michalsen	U.S. Army Corps of Engineers
Gavin Glore	Pacific County Conservation District

Steering Committee

Chad Hancock	WSDOT	**Lisa Ayers**	Commissioner District #3, Pacific County
Connie Allen	North Cove Community		
David Cottrell	Grower/Owner; Grayland Drainage District	**Rebecca Chaffee**	Director, Port of Willapa Harbor
		Bob Merrill	North Cove Community
Evan G. Carnes	Senior Project Mgr, U.S. Army Corps of Engineers	**Charlene Nelson**	Shoalwater Bay Tribe
		Bobbak Talebi	Coastal Planner, Dept of Ecology
Jeremy Bartheld	North Cove Community	**Bethany Nickison**	Project Manager, Biologist U.S. Army Corps of Engineers
Marcus Reaves	Habitat Program Mgr, WDFW		
Kathy Spoor	Pacific County Administrative Officer	**Mike Nordin**	Pacific Conservation District
		Miles Wenzel	WA Dept of Parks

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Stakeholders

Community

- North Cove and Tokeland home- and landowners
- Shoalwater Bay Tribe
- Ocean Spray Cranberry Cooperative Growers
- Willapa Grays Harbor Oyster Growers Association
- Tokeland Chamber of Commerce
- Pacific County Tourism Bureau
- Pacific County Economic Development Council

“Woke” General Public

- Pacific and Grays Harbor County residents
- Communities of Westport, Ocean Shores
- The Nature Conservancy, Washington Sea Grant, etc

Public Sector

- Washington Dept’s of Fish & Wildlife, Parks, Transportation, Ecology, Commerce, Agriculture
- U.S. Army Corps of Engineers
- Pacific County Board of County Commissioners, Dept’s of Health, Community Development, and Public Works
- Pacific County Marine Resources Council (MRC)
- Pacific Conservation District
- Elected officials: State and Federal

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Agenda

Topic	Action	Leader
Welcome	Engage	Lisa / Kathy
Agenda and Outcomes	Inform	Kelly
Introductions	Inform	All
Communication / Points of Contact	Inform	Shane
• County – Kathy & Lisa • Study Team – Shane, Vlad, Kelly • Technical Committee – Vladimir & Shane • Steering Committee – Lisa & David		
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Topic	Action	Leader
Background & Baseline Information • Project History • Data still needed	Inform/ Feedback	Vladimir
Connected Activity • Dynamic Revetment • HWY105 Protections • Shoalwater Bay Berm	Inform	 David Chad Evan
Next steps	Inform	Kelly
Adjourn		
Preview of site visit • What we'll see • What to pay attention to	Engage	Shane / Vladimir

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Project Purpose & Goals

Design, Permitting, and Plan for Construction and Monitoring for erosion protection demonstration project along a particularly vulnerable section of shoreline:

- ✓ Develop long-term shoreline erosion protection
- ✓ Develop expertise in construction technique and materials requirements.
- ✓ Develop maintenance and repair requirements for the existing SR105 dike and groin structure.
- ✓ Develop protocol (masterplan and guidance) for implementation of the next phases (for all three regions) of shoreline erosion protection that minimizes or eliminates adverse environmental impacts and meets state and federal regulatory requirements.

Workplan

I. Data Collection (New & Existing)

- Field Site Assessment
- Hydrographic/Topographic Surveys
- Geotechnical
- Sediment Grain Size

II. Preliminary Engineering

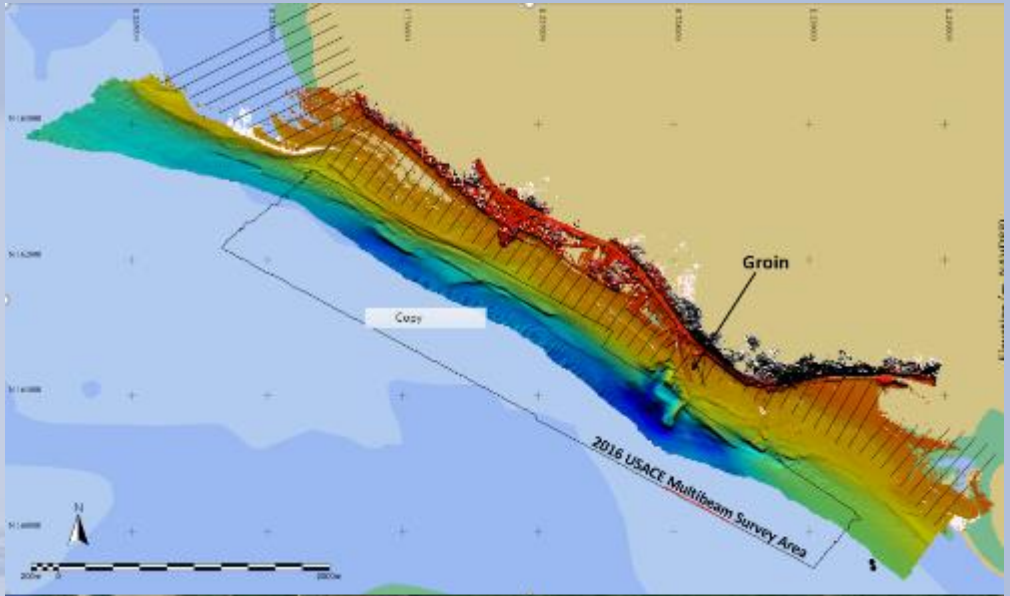
- Design Criteria Development
- Coastal Analysis
- Alternatives Development
- Alternative Evaluation
- Constructability Assessment
- Cost Assessment

III. Regulatory Permitting

- Agency Consultation
- Permit Application Documents

IV. Final Engineering Design

- Plans/Specifications/Estimates for Bidding



Region 1, West Area – Predominately controlled by tidal channel northward migration.

Region 2, Middle Area – Stable channel conditions, but erosive shoreline subjected to impact from waves and localized hydrodynamic effects.

Region 3, East Area – Deepening of the bottom slope that provides increased wave energy propagation to the shoreline.

DRAFT SCHEDULE*

TASK	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Contract Start Date	1st												
Kickoff Meeting	20th												
Data Collection	15th		15th										
Basis of Design & Criteria		15th											
Public/Stakeholder Involvement Plan	29th												
Public/Stakeholder Involvement Process		15th		13th	17th	14th	12th	16th					
Coastal Engineering Analysis	15th			13th									
Preferred Alt Selection					17th								
Preliminary Engineering Design				13th			12th						
Regulatory Permitting – Consultation		15th			17th								
Regulatory Permitting – Documentation					17th			2nd					
Permit Process								3rd					30th
Final Engineering Design							13th						30th

* Some milestones may change upon obtaining new data, but deadline for the project will be maintained.

Agenda

Topic	Action	Leader
Welcome	Engage	Lisa / Kathy
Agenda and Outcomes	Inform	Kelly
Introductions	Inform	All
Communication / Points of Contact	Inform	Shane
• County – Kathy & Lisa • Study Team – Shane, Vlad, Kelly • Technical Committee – Vladimir & Shane • Steering Committee – Lisa & David		
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Next steps	Inform	Kelly
Adjourn		
Preview of site visit • What we'll see • What to pay attention to	Engage	Shane / Vladimir

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Outreach & Public Engagement

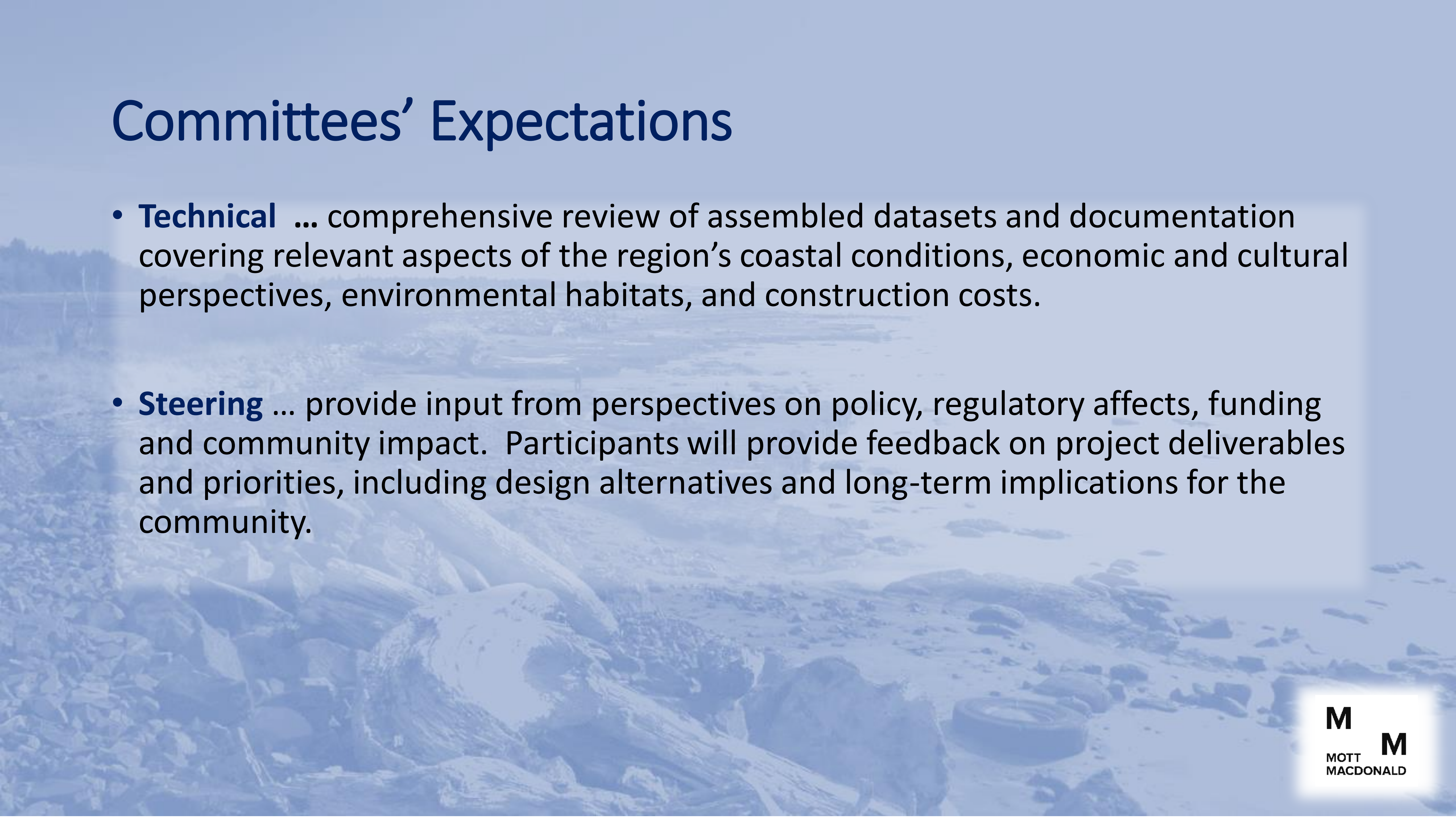
- Website
- Social Media
- Print Media
- Public Meetings

Public/Stakeholder Involvement

Multi-Step Approach

- ✓ Steering & Technical Committees
- ✓ Open Houses
  - 2 Total – Late Sept & Winter
- ✓ Social Media
  - Periodic updates through WECAN, others
- ✓ Stakeholder Outreach
- ✓ Interviews
- ✓ Website
  - Fact sheets, notifications, status updates, project information
- ✓ Press Releases
  - Notification of meetings, etc..

Committees' Expectations



- **Technical** **…** comprehensive review of assembled datasets and documentation covering relevant aspects of the region's coastal conditions, economic and cultural perspectives, environmental habitats, and construction costs.

- **Steering** … provide input from perspectives on policy, regulatory affects, funding and community impact. Participants will provide feedback on project deliverables and priorities, including design alternatives and long-term implications for the community.

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DRAFT SCHEDULE*

TASK	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Contract Start Date	1st												
Kickoff Meeting	20th												
Data Collection	15th		15th										
Basis of Design & Criteria		15th											
Public/Stakeholder Involvement Plan	29th												
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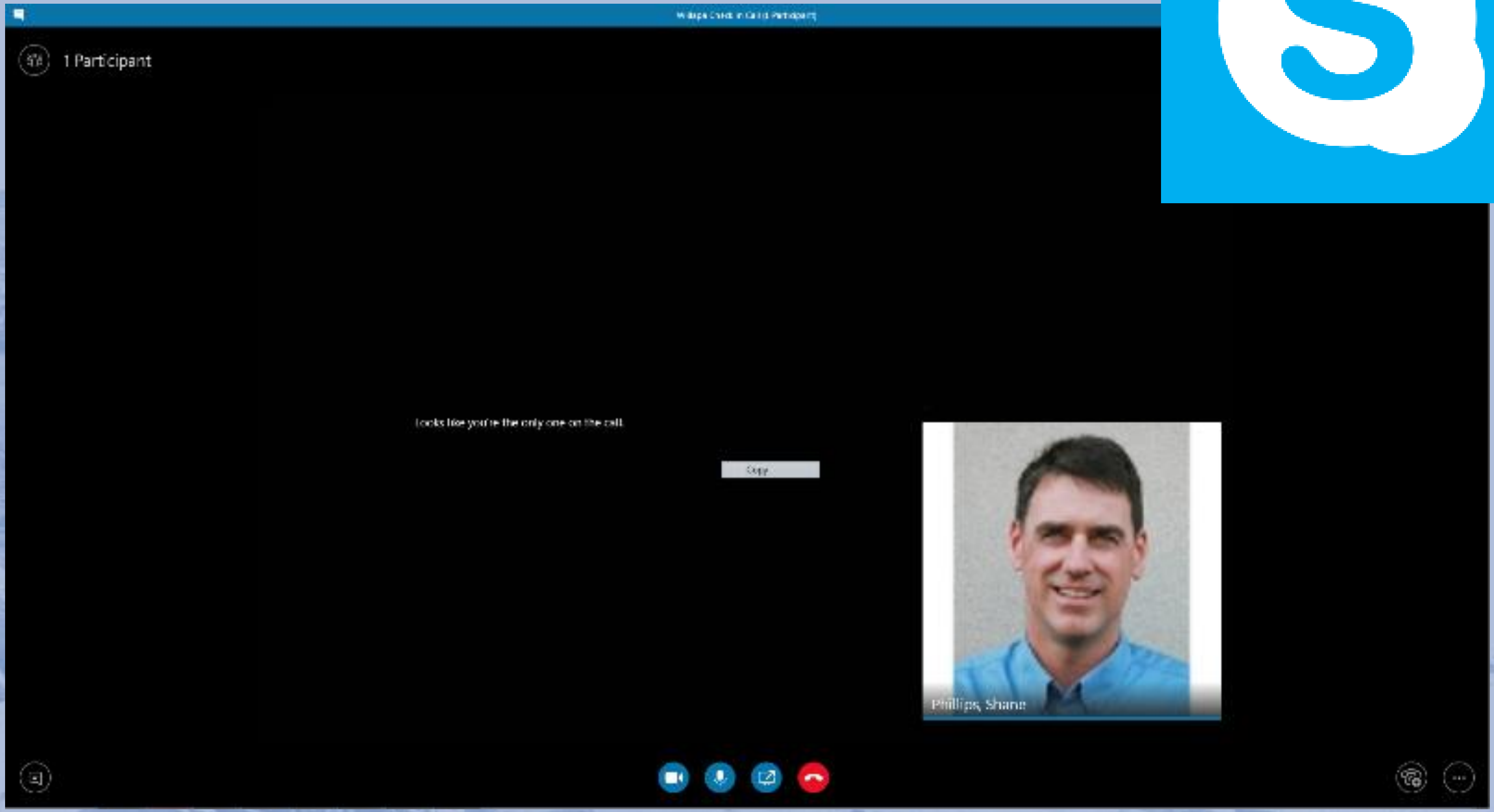
Regulatory Permitting – Consultation		15th			17th								
Regulatory Permitting – Documentation					17th			2nd					
Permit Process								3rd					30th
Final Engineering Design							13th						30th

* Some milestones may change upon obtaining new data, but deadline for the project will be maintained.

Telecon Meetings - Skype

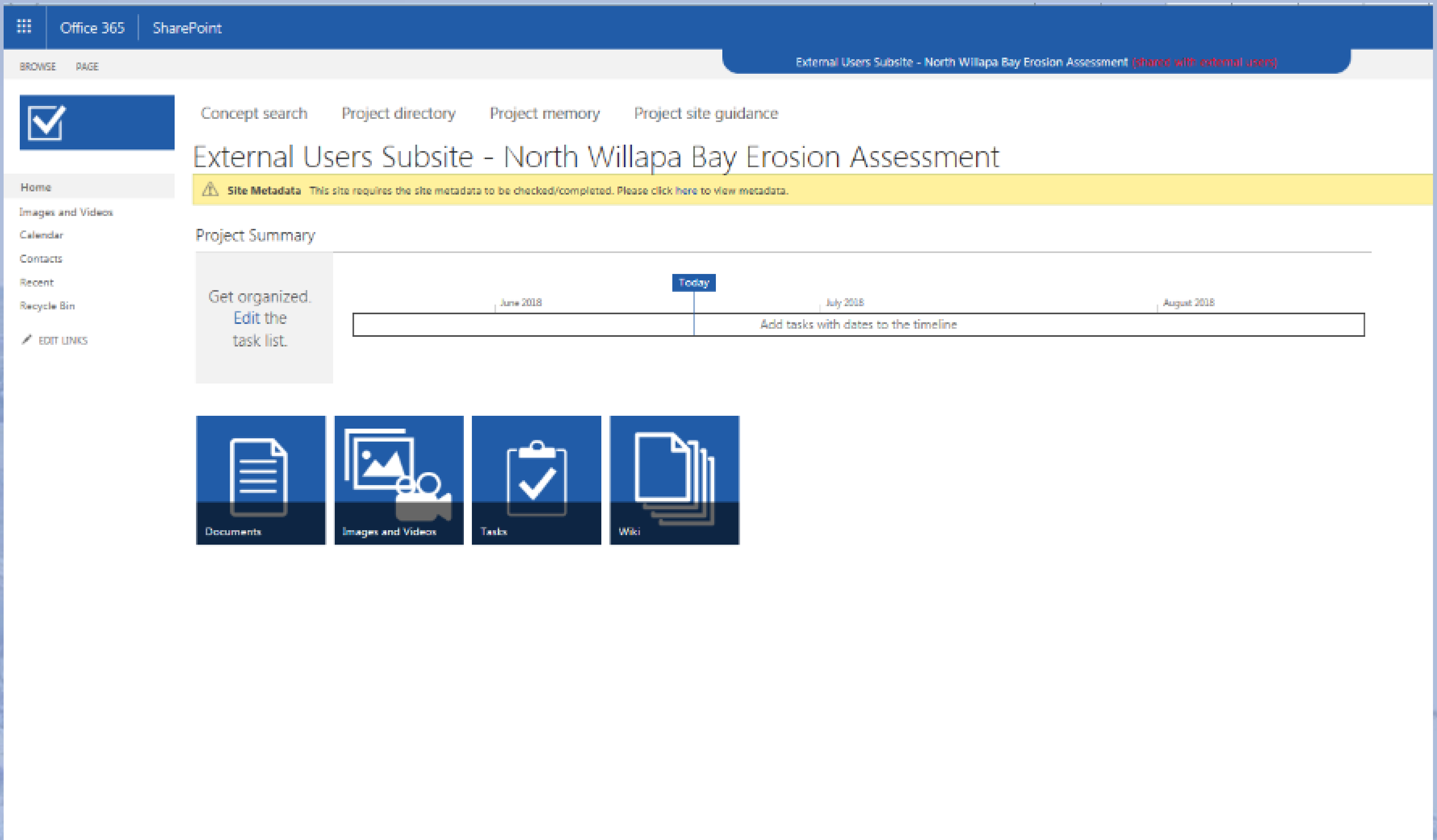
- Microsoft Skype
- Download software in advance of meeting
- Dial in number and screen sharing on computer



Looks like you're the only one on the call.

File Sharing

- Microsoft SharePoint
- Access Credentials
- For internal purposes – steering committee, consultant team and technical advisory team.



External Users Subsite - North Willapa Bay Erosion Assessment

Site Metadata This site requires the site metadata to be checked/completed. Please click here to view metadata.

Get organized. Edit the task list.

Add tasks with dates to the timeline

Agenda

Topic	Action	Leader
Welcome	Engage	Lisa / Kathy
Agenda and Outcomes	Inform	Kelly
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Topic	Action	Leader
Background & Baseline Information • Project History • Data still needed	Inform/ Feedback	Vladimir
Connected Activity	Inform	
• Dynamic Revetment		David
• HWY105 Protections		Chad
• Shoalwater Bay Berm		Evan
Next steps	Inform	Kelly
Adjourn		
Preview of site visit • What we'll see • What to pay attention to	Engage	Shane / Vladimir

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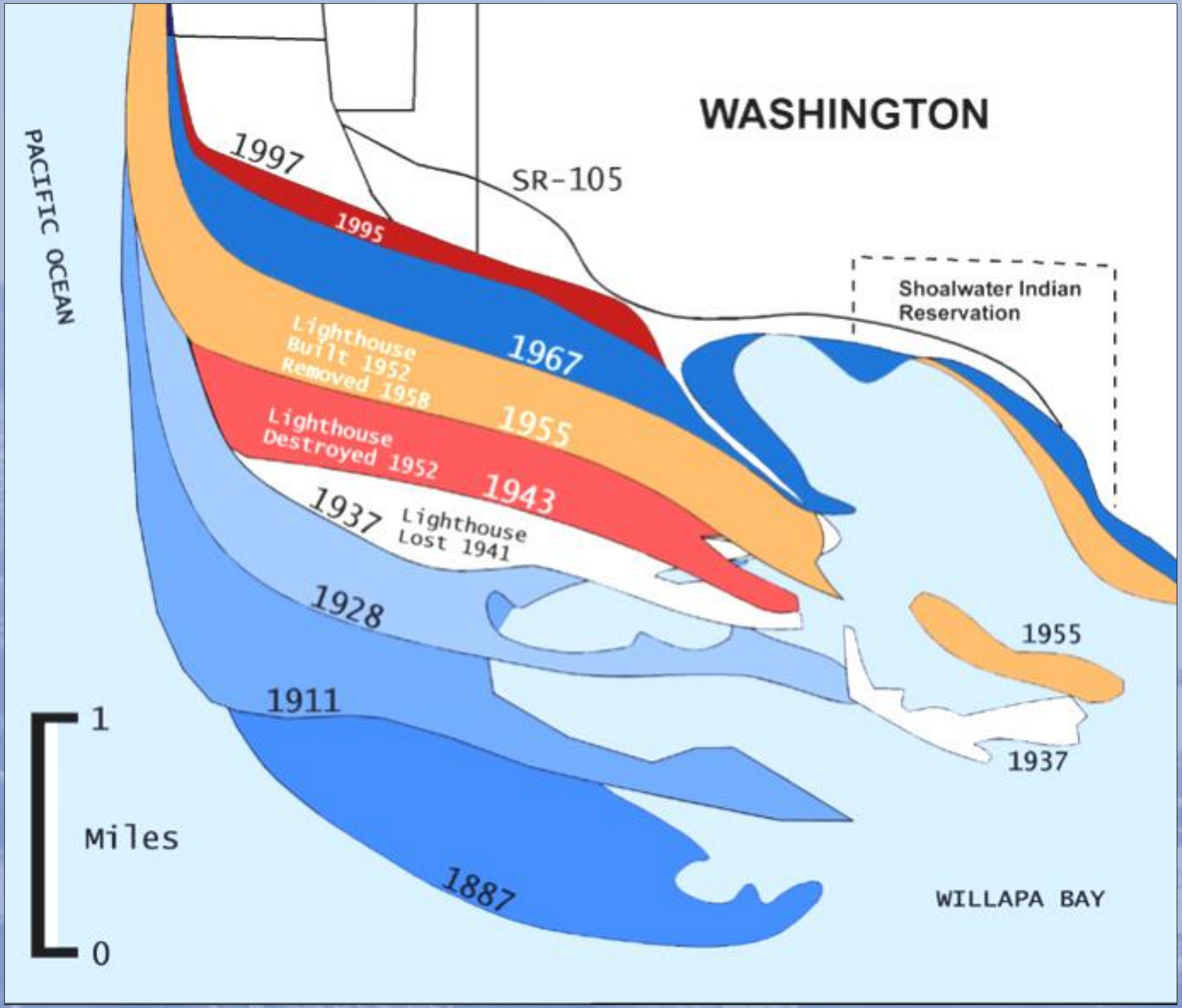
Background



Historical Shoreline Map

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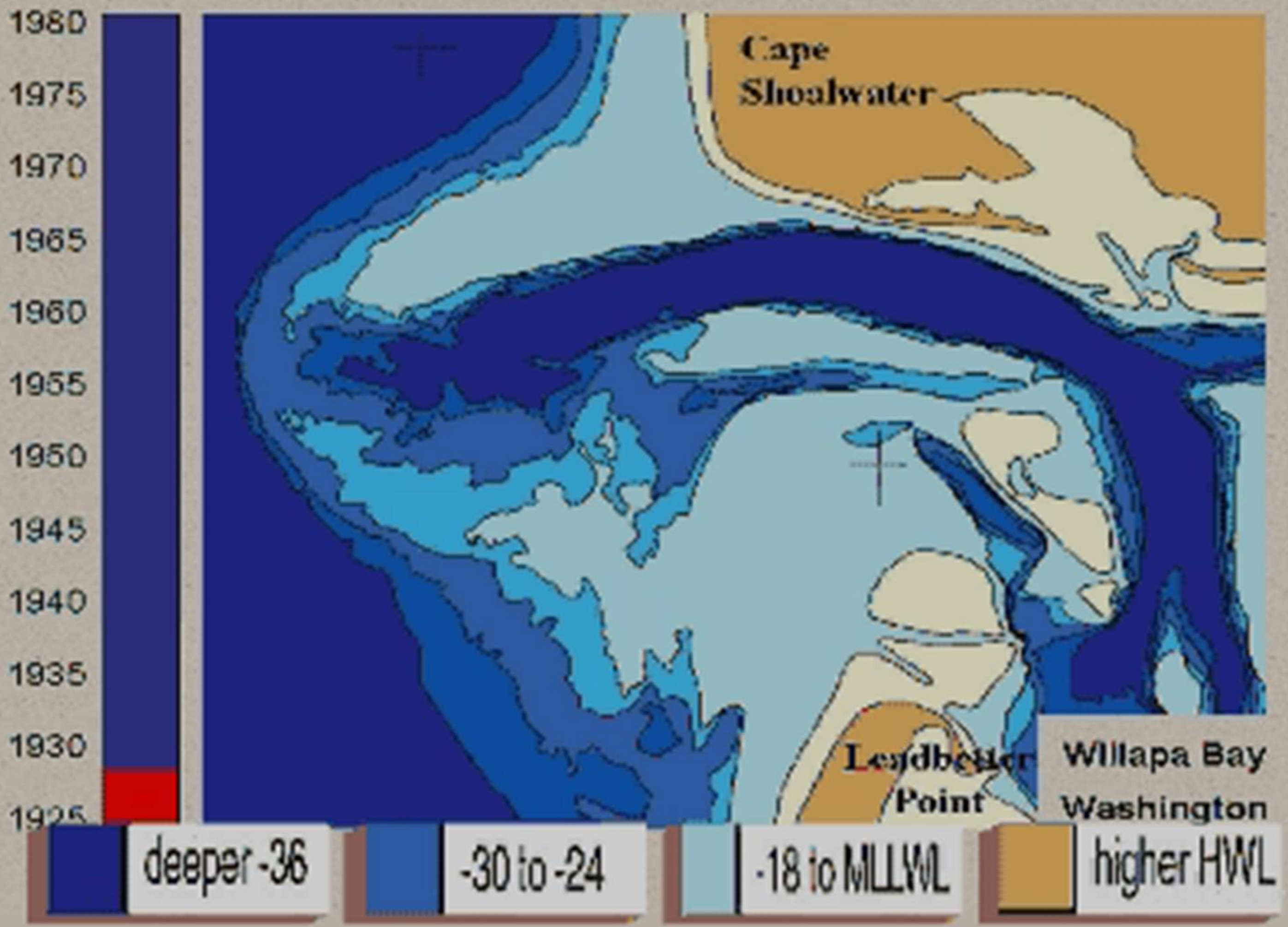
1997-1999 Washington State and US Army Corps of Engineers Joint Study



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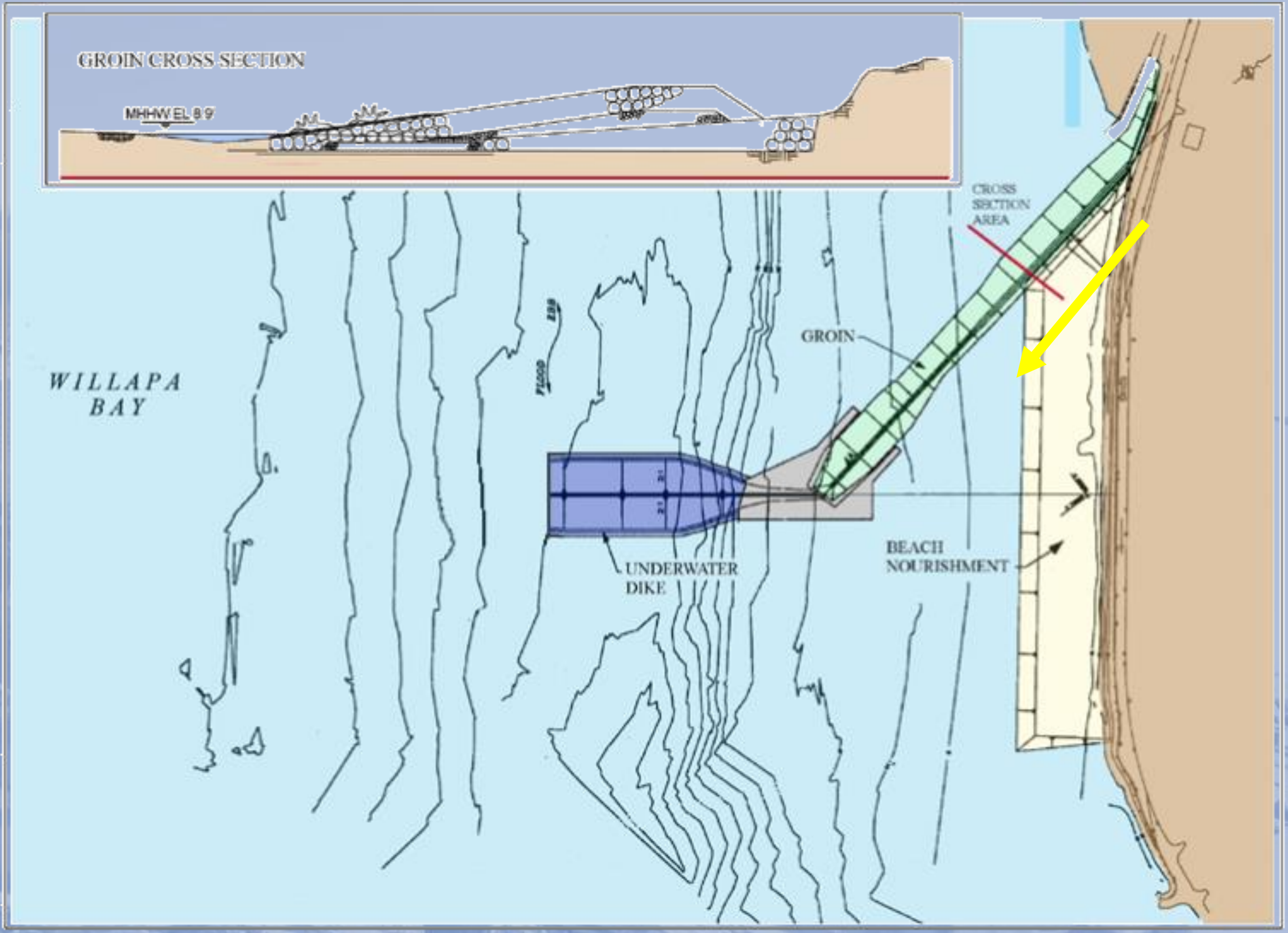
Constructed Project



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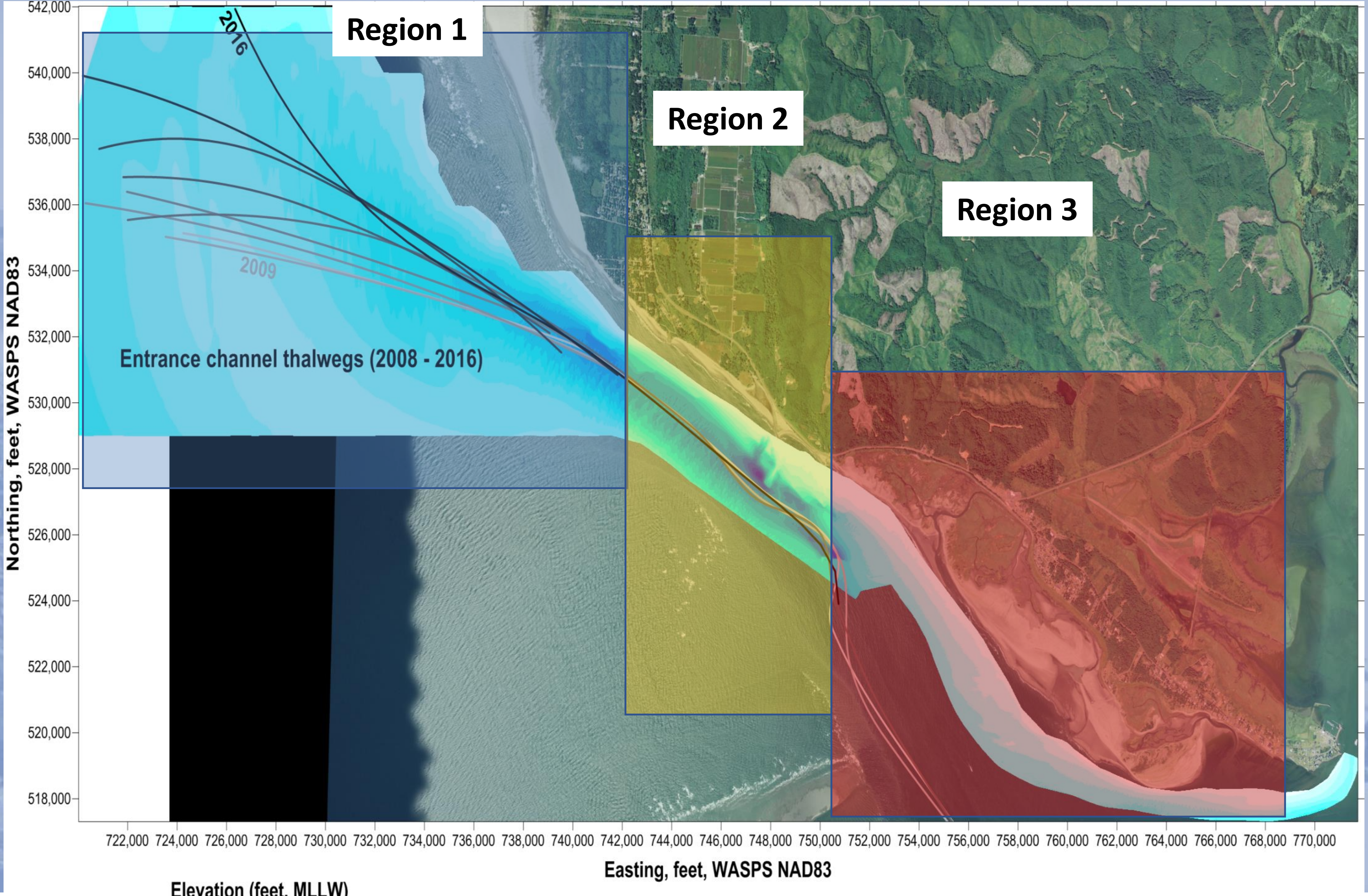
September 1998, Willapa Bay, Dike Construction

September 20, 1997

September 14, 2000

North Willapa Bay, Division on Regions with Relatively Common Coastal Features and Processes



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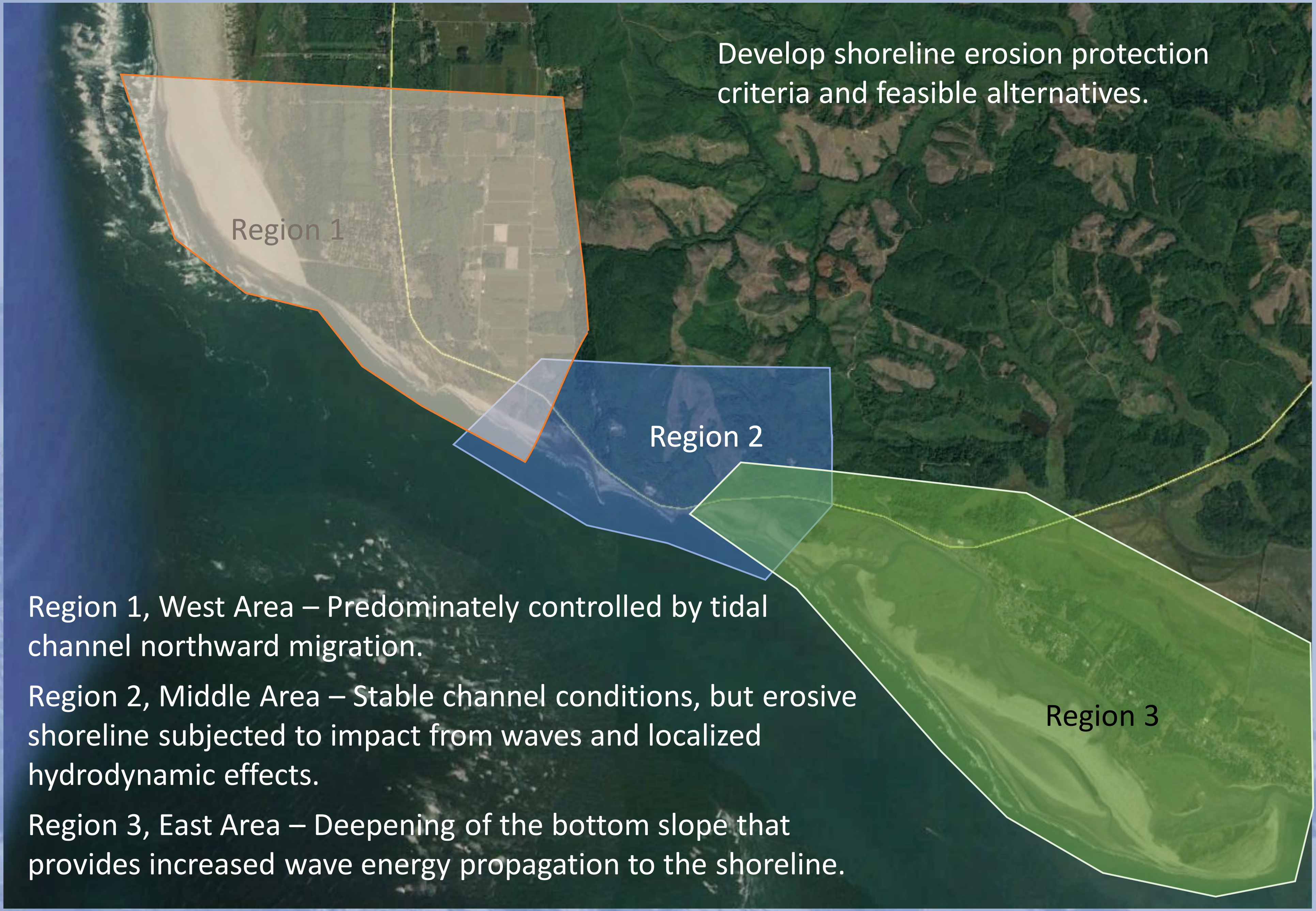

Develop shoreline erosion protection criteria and feasible alternatives.

Region 1, West Area – Predominately controlled by tidal channel northward migration.

Region 2, Middle Area – Stable channel conditions, but erosive shoreline subjected to impact from waves and localized hydrodynamic effects.

Region 3, East Area – Deepening of the bottom slope that provides increased wave energy propagation to the shoreline.

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Criteria for Shoreline Erosion Protection Scenarios

- Area-Object
  - SR-105
  - Cranberry bogs
  - Tribal lands
  - Private lands
- Durability
  - Short-term (10-20 years)
  - Long-term (>20)
- Environmental Aspects
  - Coastal wetlands protection
  - Snowy plover habitat enhancement and protection
- Coastal Flood Protection
- Coastal Resilience Aspects
- Navigation
- Other

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Preview of site visit • What we'll see • What to pay attention to	Engage	Shane / Vladimir

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SR 105 - Washaway Beach

Chad Hancock
Project Development Engineer

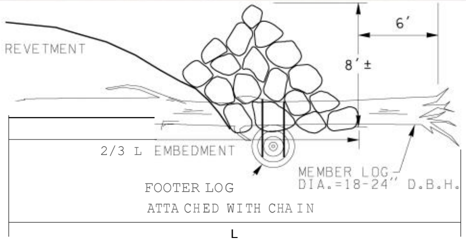
June 20th, 2018

SR 105 – Erosion Protection Projects

SR 105 – Current Project

SR 105 – Dynamic Revetment

SR 105 – Future Project



SR 105
MP 20.70 TO MP 20.80

FILE **NAME** G:1444304104 - Desi n\05-Scopin ID10512E - SR 105 - Embankment Erosion Repair **MP** 20.05 to 20.10\CADD\Seastrand Creek Cross Section.d n
TIME 3:02:03 PM
DATE 11/14/2013
PLOTIED BY flsherbr
DESIGNED BY
ENTERED BY
CHECKED BY
PROJ. ENGR.
REGIONAL **ADM.**

REVISION DATE **BY**

RE;6N STATE FED.AID PROJ.NO.
10 WAS
JOB NUMBER
CONTRACT NO. LOCATION NO.

DATE
P.E. STAMP BOX
DATE
P.E. STAMP BOX

Washington State Department of Transportation

Plot:!
PLAN REF NO
SHEET
OF
SHEETS

SHOALWATER BAY DUNE REPAIR – FY2018

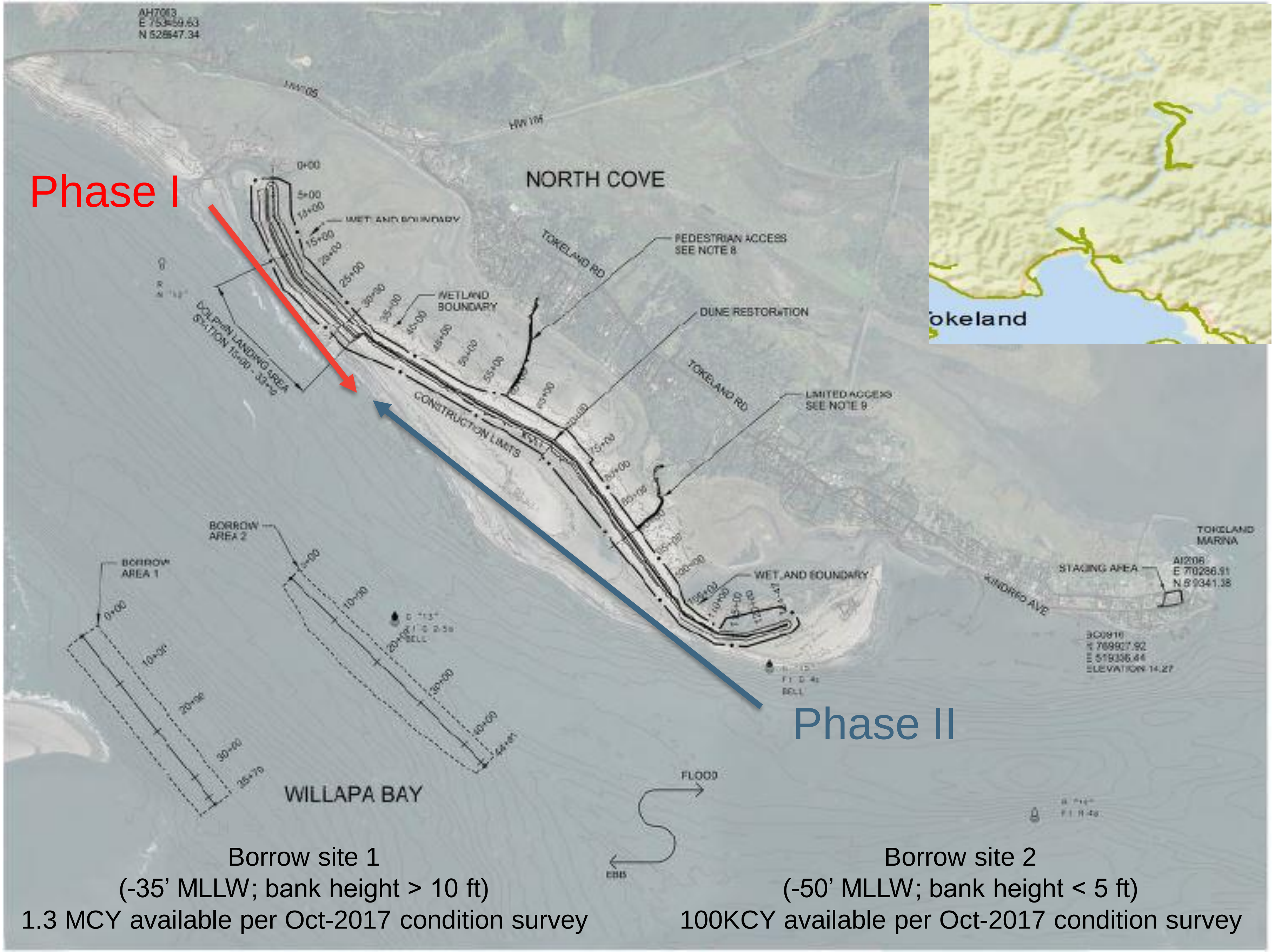
23 October 2017

DESIGN OVERVIEW

1. A 12,500-foot Dune on Empire Spit was authorized to provide Coastal Storm Damage Reduction in 2000 for the Shoalwater Bay Tribe
2. Originally Constructed in 2013 with 710,000 cubic yards of dredged material
3. 2018 Repair, approximately 750,000 cubic yards of sand will be dredged from the two designated offshore borrow sites, approximately 1-2 miles offshore.
4. Work window 1-June to 14 February
5. Heavy equipment (Dozers, loaders, pipeline) will be brought by barge
6. Phase I work will begin on the Northern section of the dune and proceed southward to a designated point where ESA avoidance is determined, then move to the Phase II Southern section and proceed northward until complete.
7. Sand Fence and/or dune grass shall be installed on leeward side of dune

US Army Corps of Engineers.

U.S.ARMY

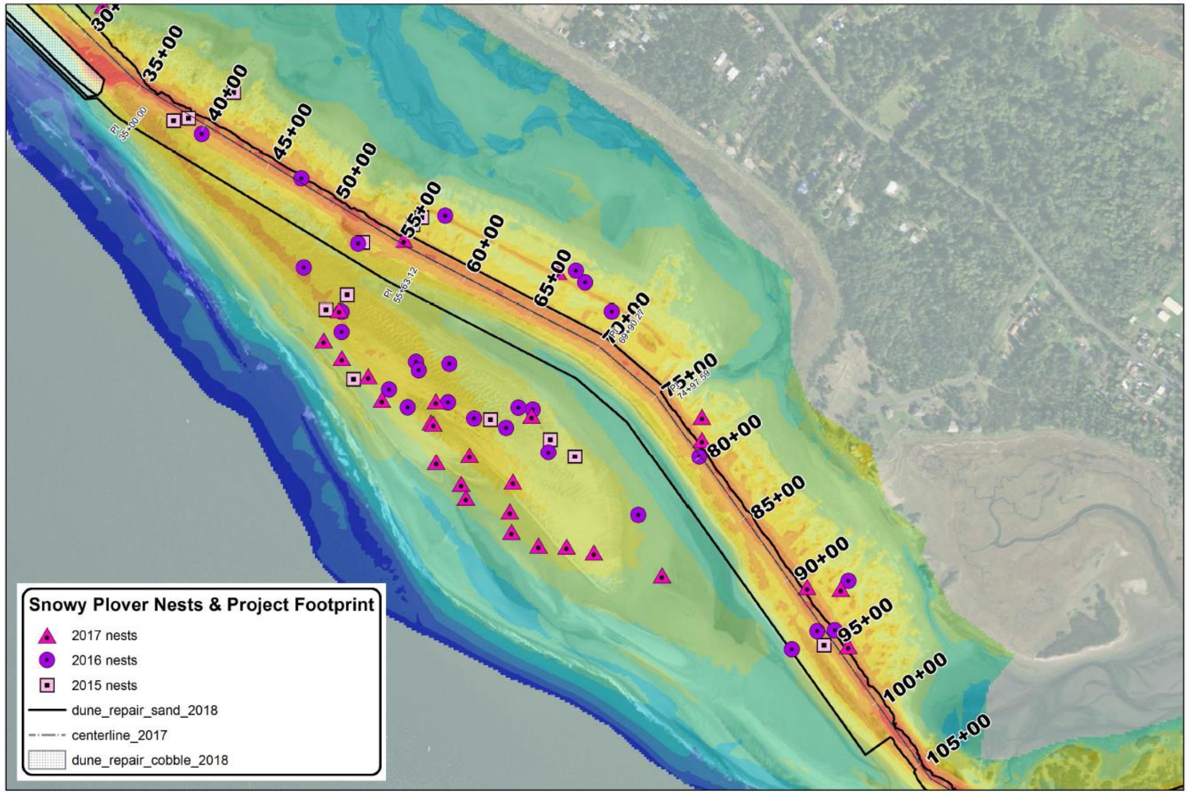


Borrow site 1
(-35’ MLLW; bank height > 10 ft)
1.3 MCY available per Oct-2017 condition survey

Borrow site 2
(-50’ MLLW; bank height < 5 ft)
100KCY available per Oct-2017 condition survey

ENVIRONMENTAL OVERVIEW

1. Project is critical habitat for ESA Western Snowy Plover and Streaked Horned Lark.
2. A Construction buffer will be enforced by USFWS/WDFW from any nesting birds. Historically, nests have been observed between Sta. 40+00 and 100+00. Majority of nests occur seaward of dune on un-vegetated sand.



SCHEDULE

1. $19.1 million contract awarded to Manson Co. in May 2018
2. Mobilization on-going
3. Construction – Jul to Oct 2018

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Next steps	Inform	Kelly
Adjourn		
Preview of site visit • What we'll see • What to pay attention to	Engage	Shane / Vladimir

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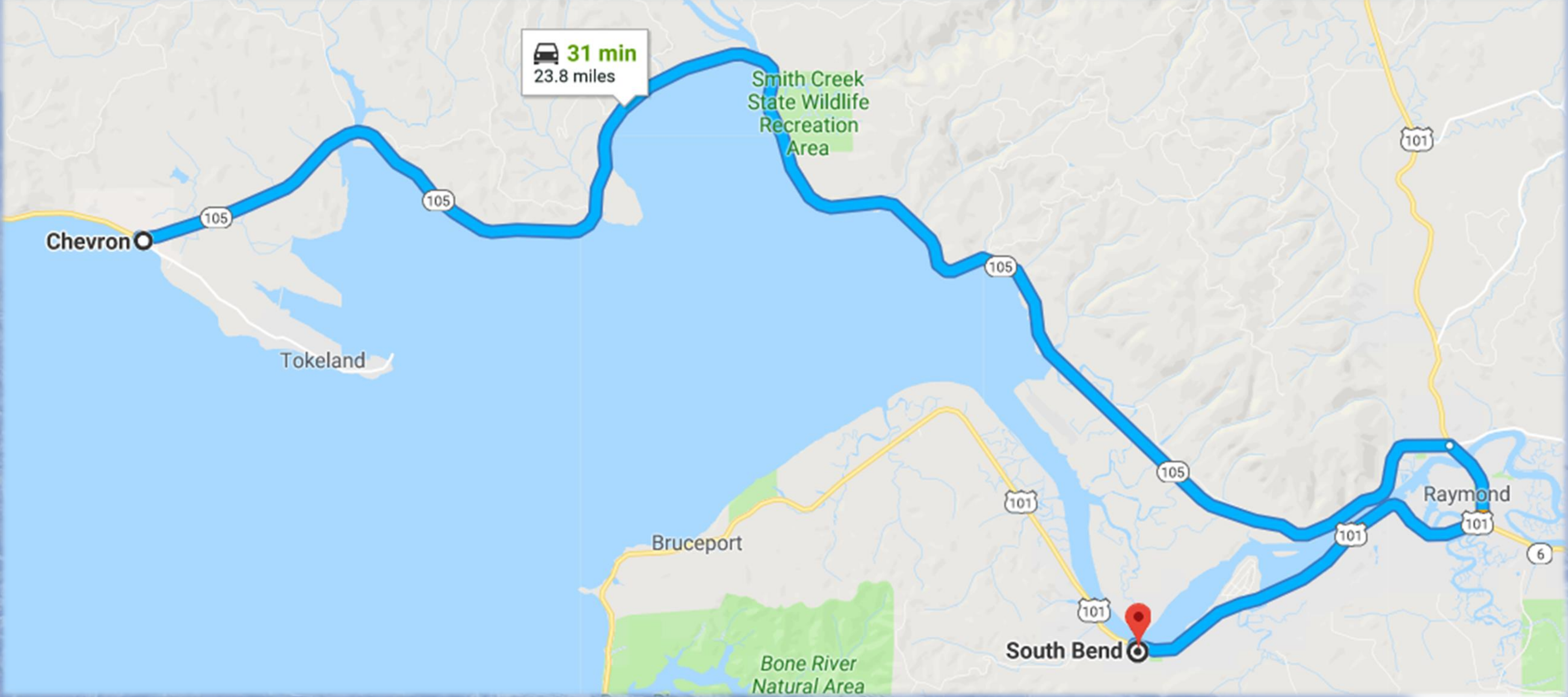
Meet-up @ Chevron Station, Tokeland



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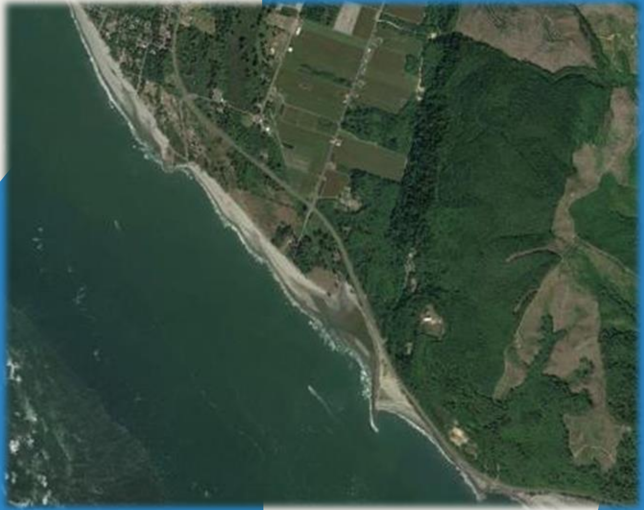
COAST & HARBOR ENGINEERING
A Division of Mott MacDonald

North Willapa Shoreline Protection Demonstration Project

Steering Committee Meeting: 5 September 2018

Pacific County, WA



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Demonstration Project Update	Inform	Shane / Vladimir
Discussion/Feedback	Engage	All

Topic	Action	Leader
ACE Continuing Authorities Program (CAP) Section 103	Inform/ Feedback	
Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

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Project Purpose & Goals

Design, Permitting, and Plan for Construction and Monitoring for erosion protection demonstration project (in Region 2) along a particularly vulnerable section of shoreline:

- ✓ Develop long-term shoreline erosion protection
- ✓ Develop expertise in construction technique and materials requirements.
- ✓ Develop maintenance and repair requirements for the existing SR105 dike and groin structure.
- ✓ Develop protocol (masterplan and guidance) for implementation of the next phases (for all three regions) of shoreline erosion protection that minimizes or eliminates adverse environmental impacts and meets state and federal regulatory requirements.

Project Team

PACIFIC COUNTY WASHINGTON

COAST & HARBOR ENGINEERING
A Division of Mott MacDonald

Archaeological Investigations Northwest, Inc.

BERGLUND, SCHMIDT & ASSOCIATES, INC.
professional engineers & land surveyors

DEPARTMENT OF ECOLOGY
State of Washington

SHANNON & WILSON
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Lead To Results, LLC

M M
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Points of Contact

Pacific County	Kathy Spoor County Administrative Officer kspoor@co.pacific.wa.us
Facilitator	Kelly Rupp LeadToResults, LLC kelly.rupp@leadtoresults.com
Project Leader	Shane Phillips Mott MacDonald shane.phillips@mottmac.com
Chair, Technical Committee	Vladimir Shepsis Mott MacDonald vladimir.shepsis@mottmac.com
Co-Chairs, Steering Committee	Lisa Ayers layers@co.pacific.wa.us David Cottrell cranberrydavid@yahoo.com

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Committees' Expectations

Technical … comprehensive review of assembled datasets and documentation covering relevant aspects of the region's coastal conditions, economic and cultural perspectives, environmental habitats, and construction costs.

Steering … provide input from perspectives on policy, regulatory affects, funding and community impact. Participants will provide feedback on project deliverables and priorities, including design alternatives and long-term implications for the community.

Technical Committee

Shane Phillips	Coast & Harbor Engineering/Mott MacDonald
Vladimir Shepsis	Coast & Harbor Engineering/Mott MacDonald
George M. Kaminsky	Dept of Ecology, Coastal Monitoring & Analysis Program
David Cottrell	Cranberry Grower/Owner; Grayland Drainage District
Rick Mraz	Dept of Ecology, Shorelands and Environmental Assistance Program
Rob Schanz	Dept of Transportation, Hydraulics Section
Dave Michalsen	U.S. Army Corps of Engineers
Gavin Glore	Pacific County Conservation District

Steering Committee

Chad Hancock	WSDOT	**Lisa Ayers**	Commissioner District #3, Pacific County
Connie Allen	North Cove Community	**Rebecca Chaffee**	Director, Port of Willapa Harbor
David Cottrell	Grower/Owner; Grayland Drainage District	**Bob Merrill**	North Cove Community
Evan G. Carnes	U.S. Army Corps of Engineers	**Charlene Nelson**	Shoalwater Bay Tribe
Jeremy Bartheld	North Cove Community	**Bobbak Talebi**	Coastal Planner, Dept of Ecology
Marcus Reaves	Habitat Program Mgr, WDFW	**Bethany Nickison**	U.S. Army Corps of Engineers
Kathy Spoor	Pacific County Administrative Officer	**Mike Nordin**	Pacific Conservation District
		Miles Wenzel	WA Dept of Parks

Stakeholders

Community

North Cove and Tokeland home- and landowners
Shoalwater Bay Tribe
Ocean Spray Cranberry Cooperative Growers
Willapa Grays Harbor Oyster Growers Association
Tokeland Chamber of Commerce
Pacific County Tourism Bureau
Pacific County Economic Development Council

General Public

- Pacific and Grays Harbor County residents
- Communities of Westport, Ocean Shores
- The Nature Conservancy, Washington Sea Grant, etc

Public Sector

- Washington Dept's of Fish & Wildlife, Parks, Transportation, Ecology, Commerce, Agriculture
- U.S. Army Corps of Engineers
- Pacific County Board of County Commissioners, Dept's of Health, Community Development, and Public Works
- Pacific County Marine Resources Committee (MRC)
- Pacific Conservation District
- Elected officials: State and Federal

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Next steps	Inform	Kelly
Adjourn		

Slide 1: Unprotected shoreline

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Slide 2: Forested shoreline with woody debris

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Slide 3: Stone being deposited

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Slide 4: Vegetated foredune

Agenda

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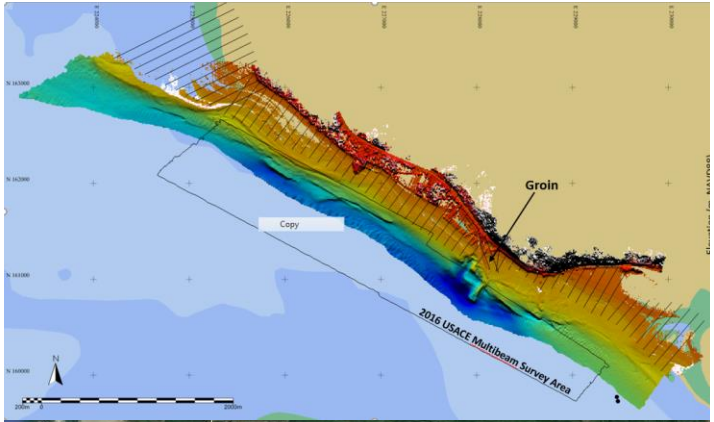
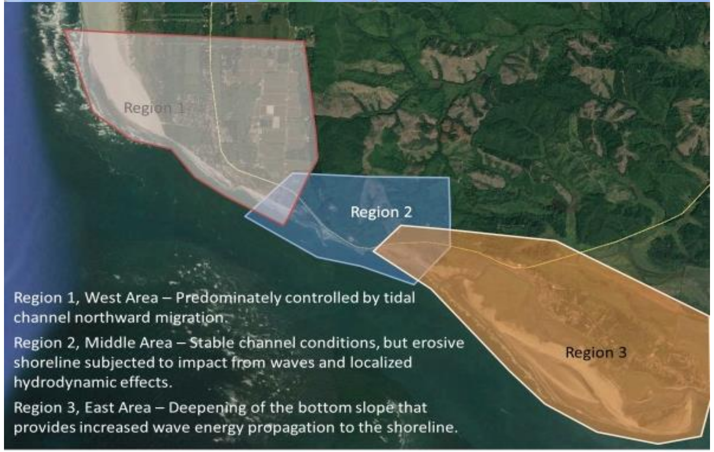
Next steps	Inform	Kelly
Adjourn		

Workplan

Note: Yellow Text = Work conducted since kickoff meeting

- Data Collection (New & Existing)
  - Field Site Assessment
  - Hydrographic/Topographic Surveys
  - Geotechnical
  - Sediment Grain Size
- Preliminary Engineering
  - Design Criteria Development
  - Coastal Analysis
  - Alternatives Development
  - Alternative Evaluation
  - Constructability Assessment
  - Cost Assessment
- Regulatory Permitting
  - Agency Consultation
  - Permit Application Documents
- Final Engineering Design
  - Plans/Specifications/Estimates for Bidding
- Public Involvement
  - Meetings & Outreach
  - Technical & Steering Committee Meetings
  - Website





Region 1, West Area – Predominately controlled by tidal channel northward migration.

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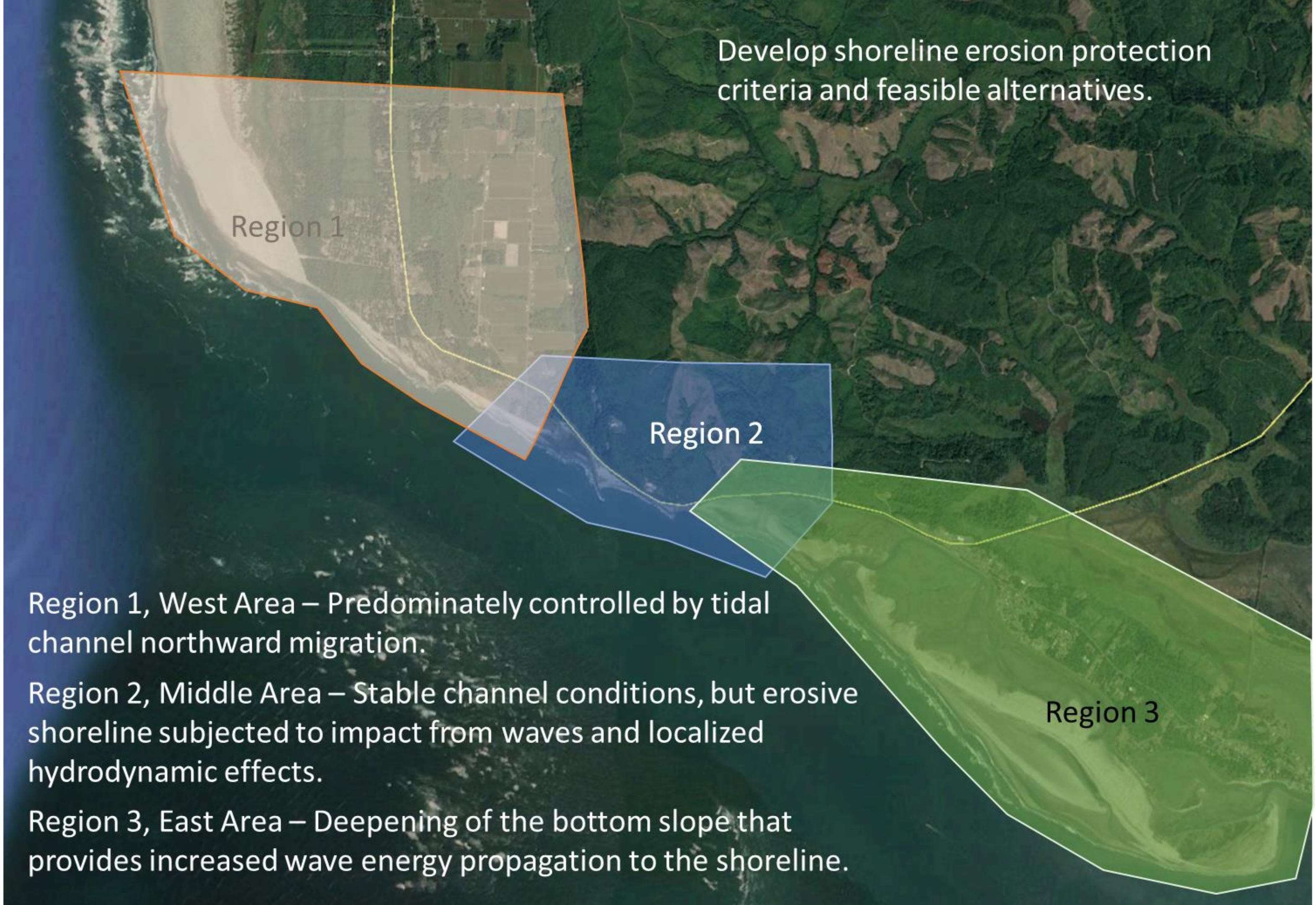
Region 3, East Area – Deepening of the bottom slope that provides increased wave energy propagation to the shoreline.

Develop shoreline erosion protection criteria and feasible alternatives.



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Schedule

Legend

✓ = complete or nearly complete
− = In progress
✖ = Not initiated

	DRAFT SCHEDULE													
Status	TASK	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
✓	Contract Start Date	1st												
✓	Kickoff Meeting	20th												
✓	Data Collection	15th		15th										
−	Basis of Design & Criteria				15th									
✓	Public/Stakeholder Involvement Plan	29th												
−	Technical Advisory			16th	20th	9th	14th							
−	Steering Committee				5th	4th	7th							
✖	Public Meeting					16th or 25th		5th						
−	Public/Stakeholder Involvement Process		15th		13th	17th	14th	12th	16th					
−	Coastal Engineering Analysis	15th			13th									
✖	Preferred Alt Selection					17th								
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✖	Regulatory Permitting – Consultation		15th			17th								
✖	Regulatory Permitting – Documentation					17th			2nd					
✖	Permit Process								3rd					30th
✖	Final Engineering Design								14th					30th

Data Compilation

Short List of Compiled Bathy/Topo Data

Date	Source	Type
Jun 2003	PIE	Topo (groin)
Jul 2003	WSDOT	Topo (Transects)
2003	USACE	Bathy (Transects)
2005	USACE	Bathy (Transects)
2005	WSDOT	Bathy
Mar 2006	PIE	Bathy
Apr 2006	PIE	Topo
2008	USACE	Bathy (Transects)
2008	WSDOT	Bathy
2009	USACE	Bathy (Transects)
2010	USACE	Bathy (Transects)
2010	WSDOT	Bathy
2011	USACE	Bathy (Transects)
2012	USACE	Bathy (Transects)
2013	USACE	Bathy (Transects)
2013	WSDOT	Bathy (Contours)

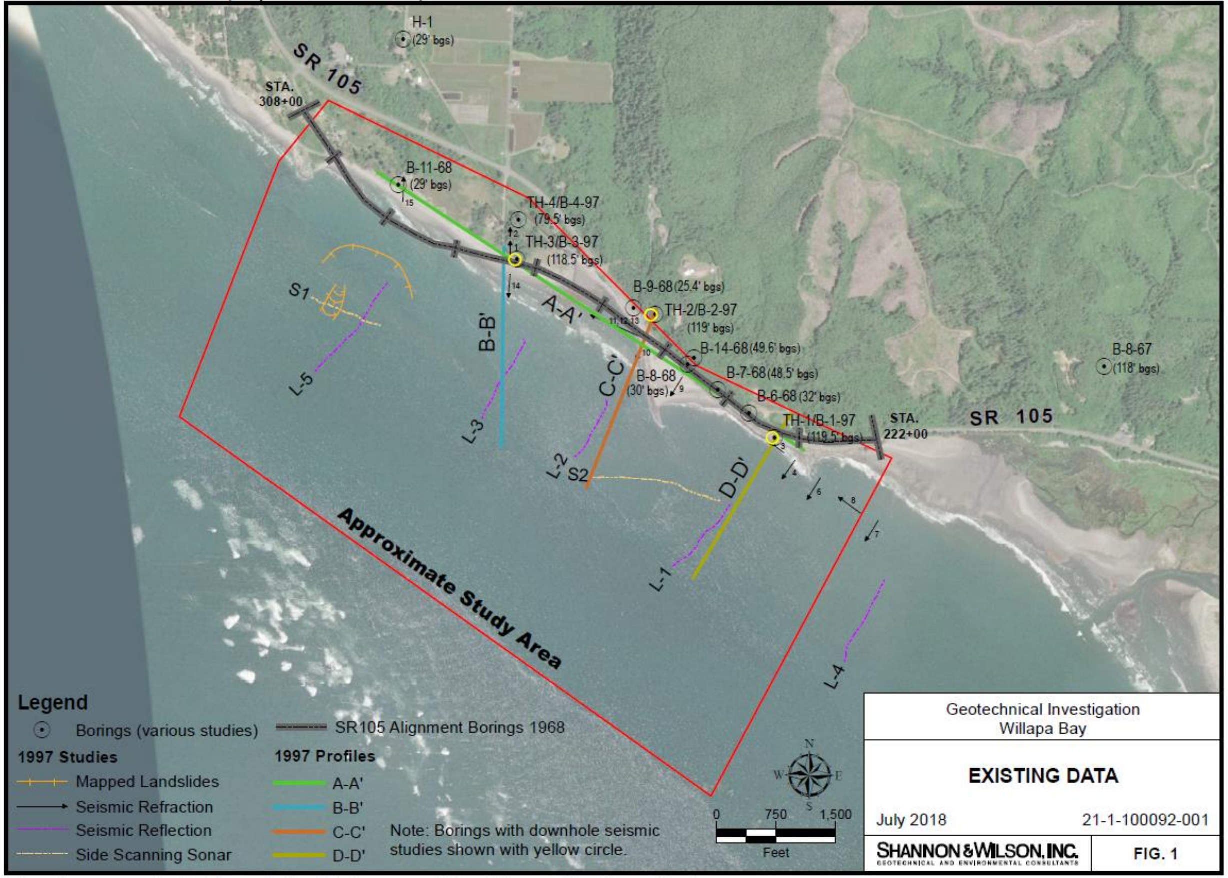
Date	Source	Type
Sept 2014	WDOE	Topo, MLS topo, MBES Bathy
2014	USACE	Bathy (Transects)
Apr 2015	WDOE	Topo, MLS topo, MBES Bathy
2015	USACE	Bathy (Transects)
Sept 2016	WSDOT	Topo (UAV)
2016	USACE	Bathy (MBES, Transects)
Jun 2018	WDOE	Topo, MLS topo, MBES Bathy

Example Extents of Elevation Data

Geotechnical Data

In the process of incorporating additional data received from the USACE

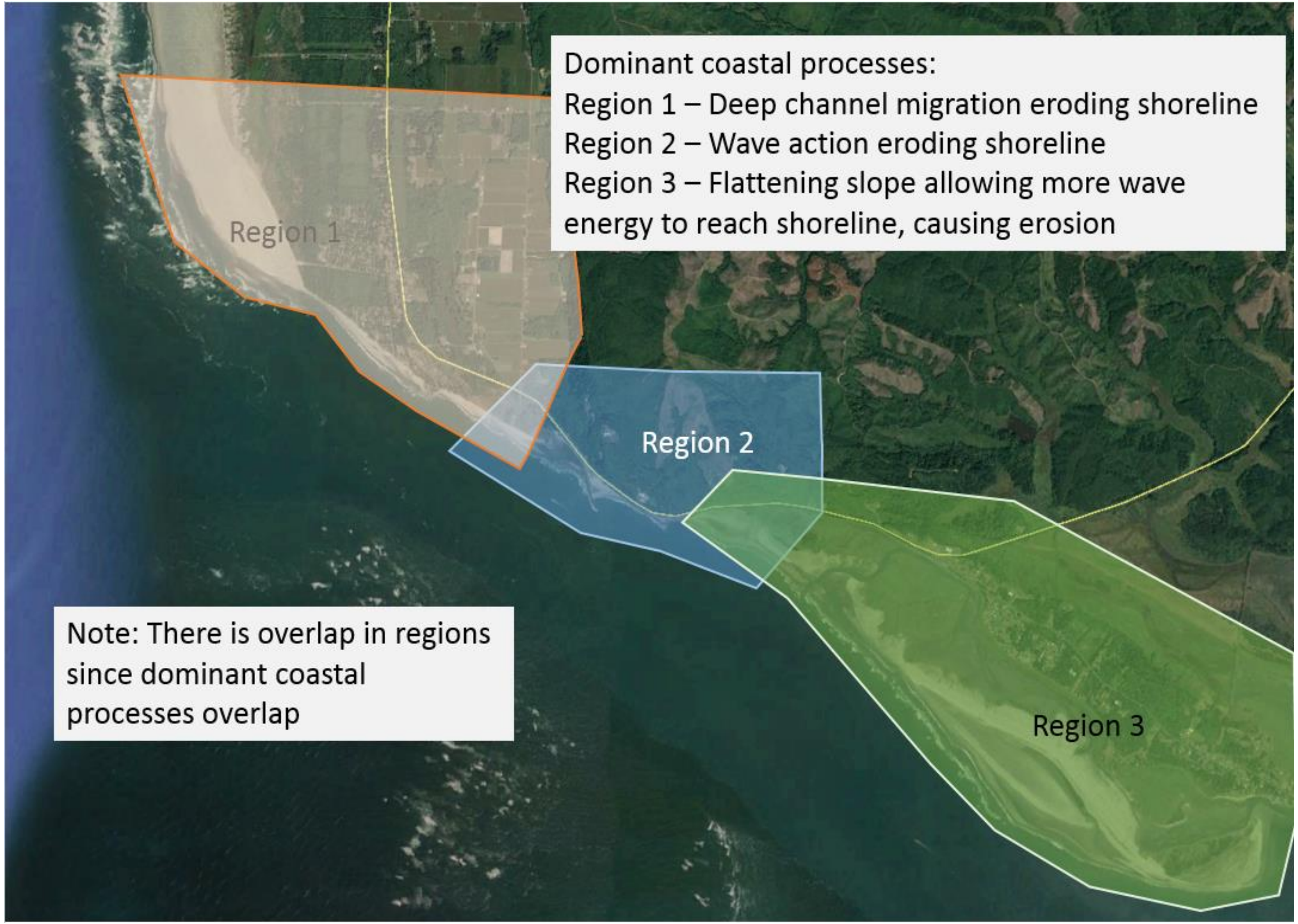
Filename: I:\EF\SEA\100000s\100092 Willapa Bay Erosion\GIS-kmz\LocationMap.mxd Date: 7/25/2018 saw



Locations were estimated by overlaying historic maps and should be considered approximate.

DRAFT

Preliminary Data Analysis & Trends



Dominant coastal processes:
Region 1 – Deep channel migration eroding shoreline
Region 2 – Wave action eroding shoreline
Region 3 – Flattening slope allowing more wave energy to reach shoreline, causing erosion

Note: There is overlap in regions since dominant coastal processes overlap

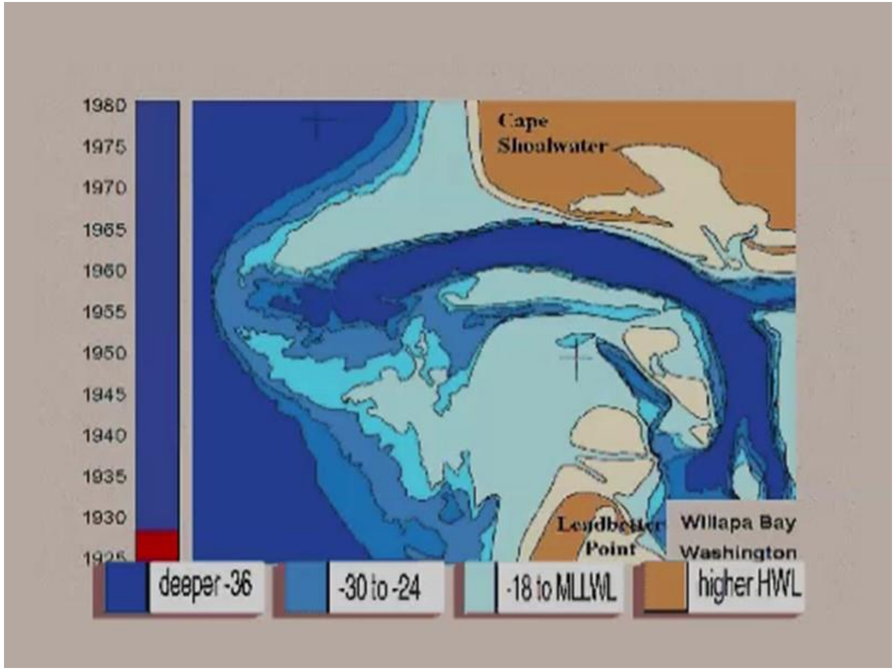
Question for Clarifications Originated by Technical Committee

- There are three regions identified along the North Willapa Bay shoreline that are currently (or possibly in a future) are subject to severe erosion. Accordantly, the entire North Willapa Bay shoreline is divided on three regions. What is the basis of these divisions?
- The demonstration project is scheduled (scoped) for Region 2. Why is it?
- Will the results of demonstration project be applicable to Regions 1 and 2?
- There are several ongoing long-term and short-term coastal protection projects along North Willapa Bay shoreline. How does the demonstration project fits into and what are the relationships between all of these ongoing projects?

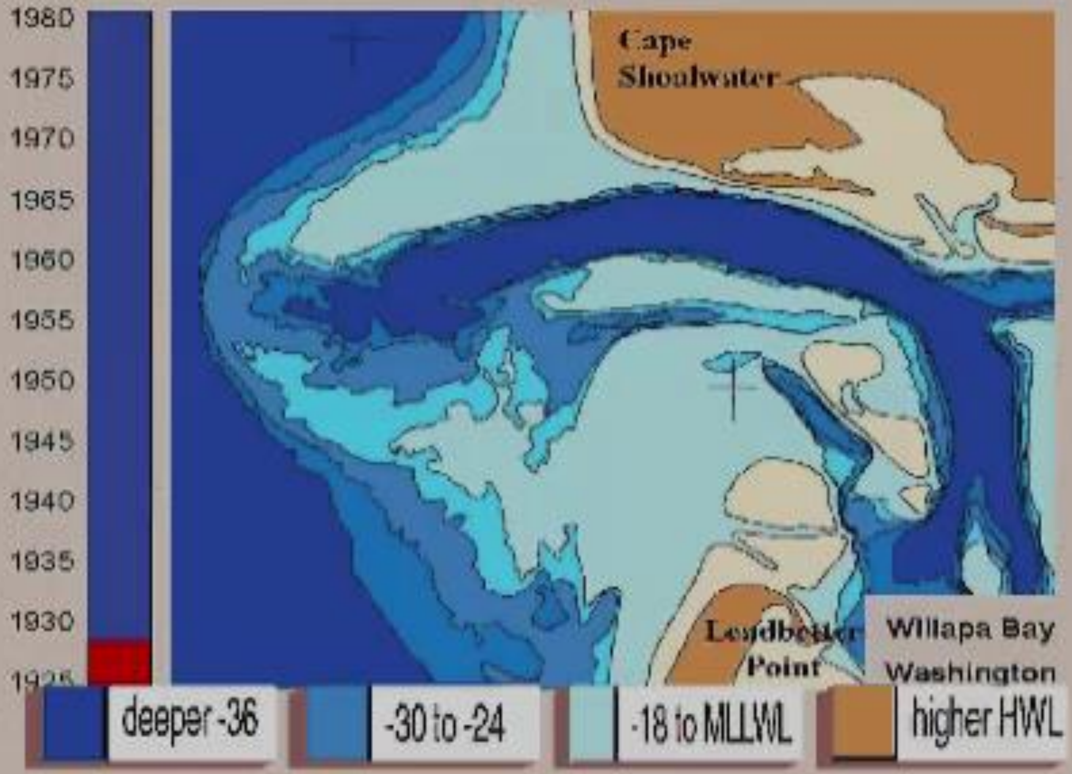
Two Major Factors Controlling Willapa North Shoreline Erosion

Wave Induced Erosion

North Tidal Channel Migration

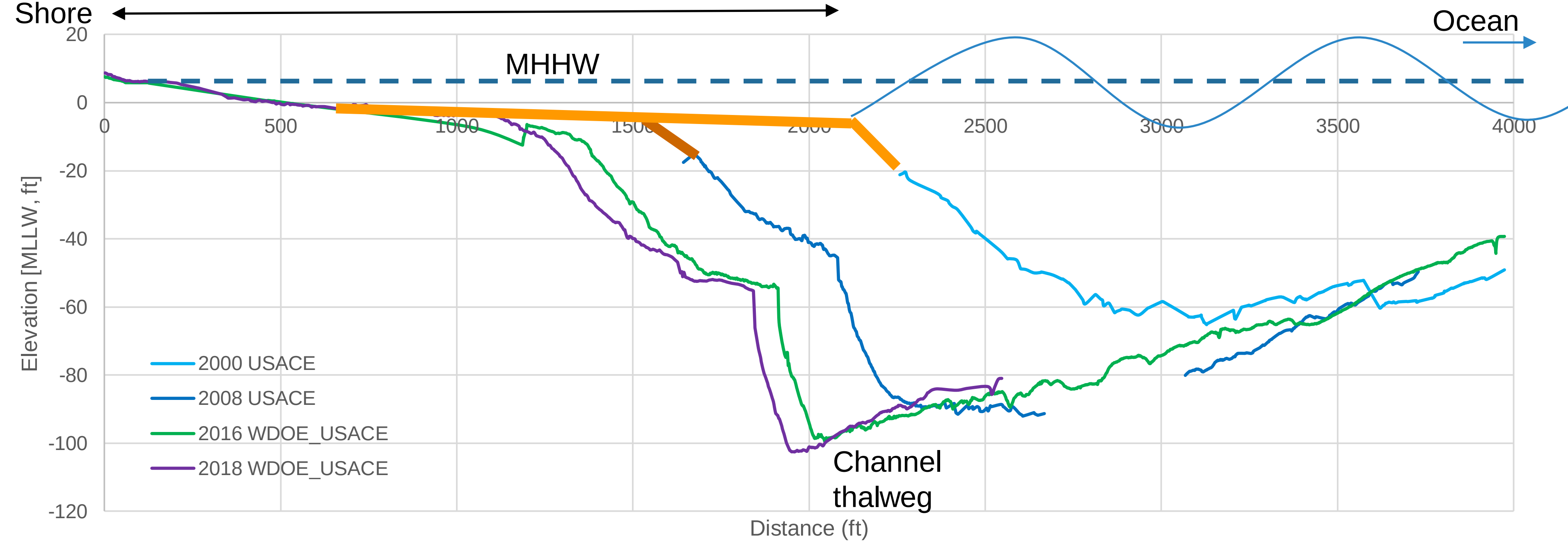


Tidal Channel Migration History



Dynamic Coastal Processes

2,200’



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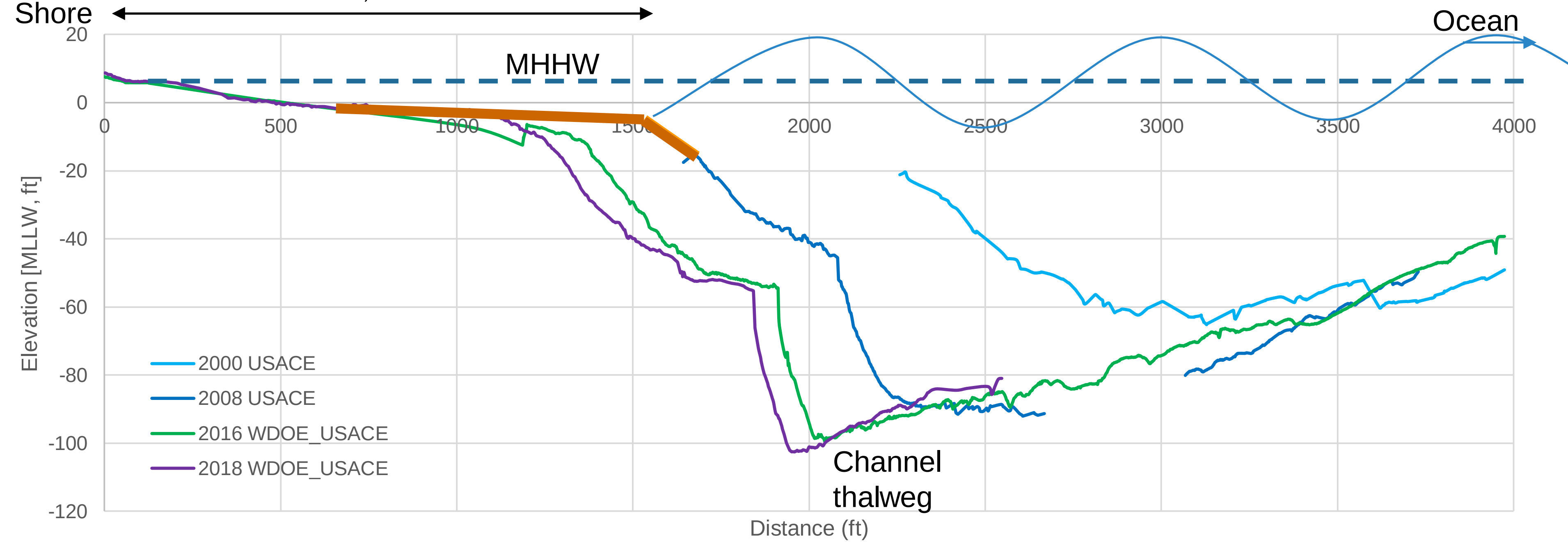

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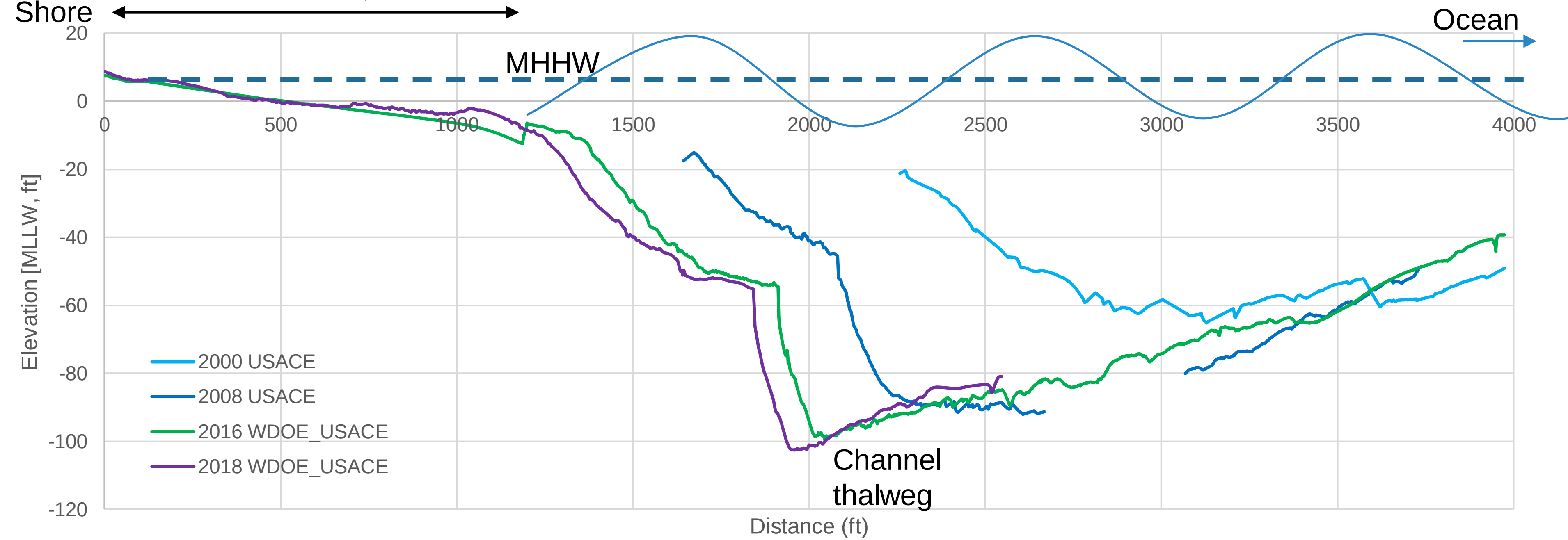


Shore

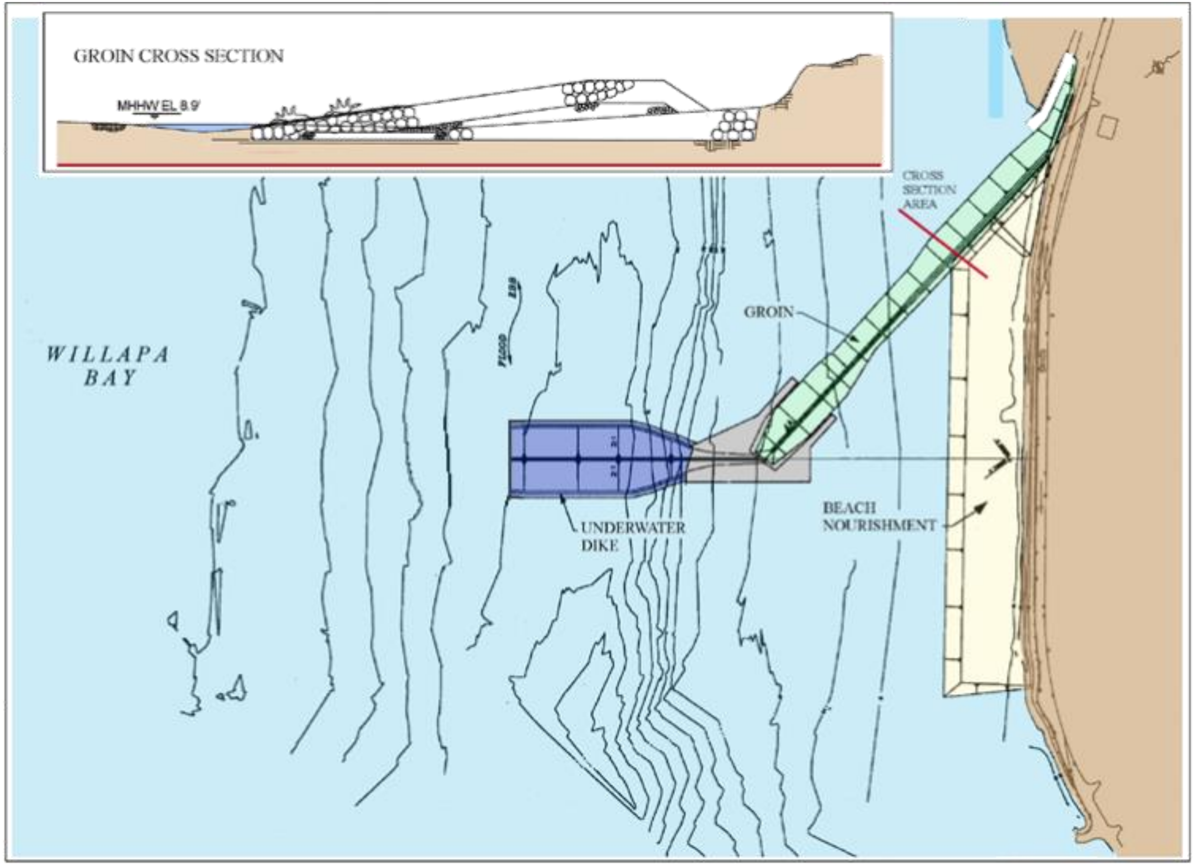
1,100’

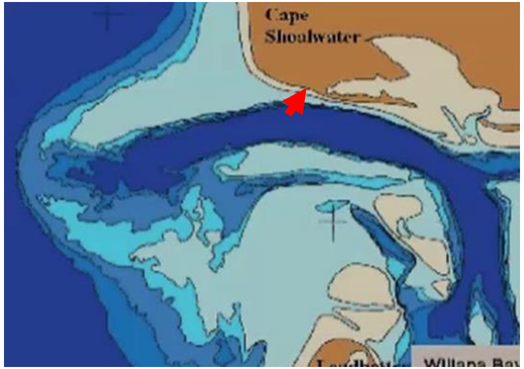
Ocean

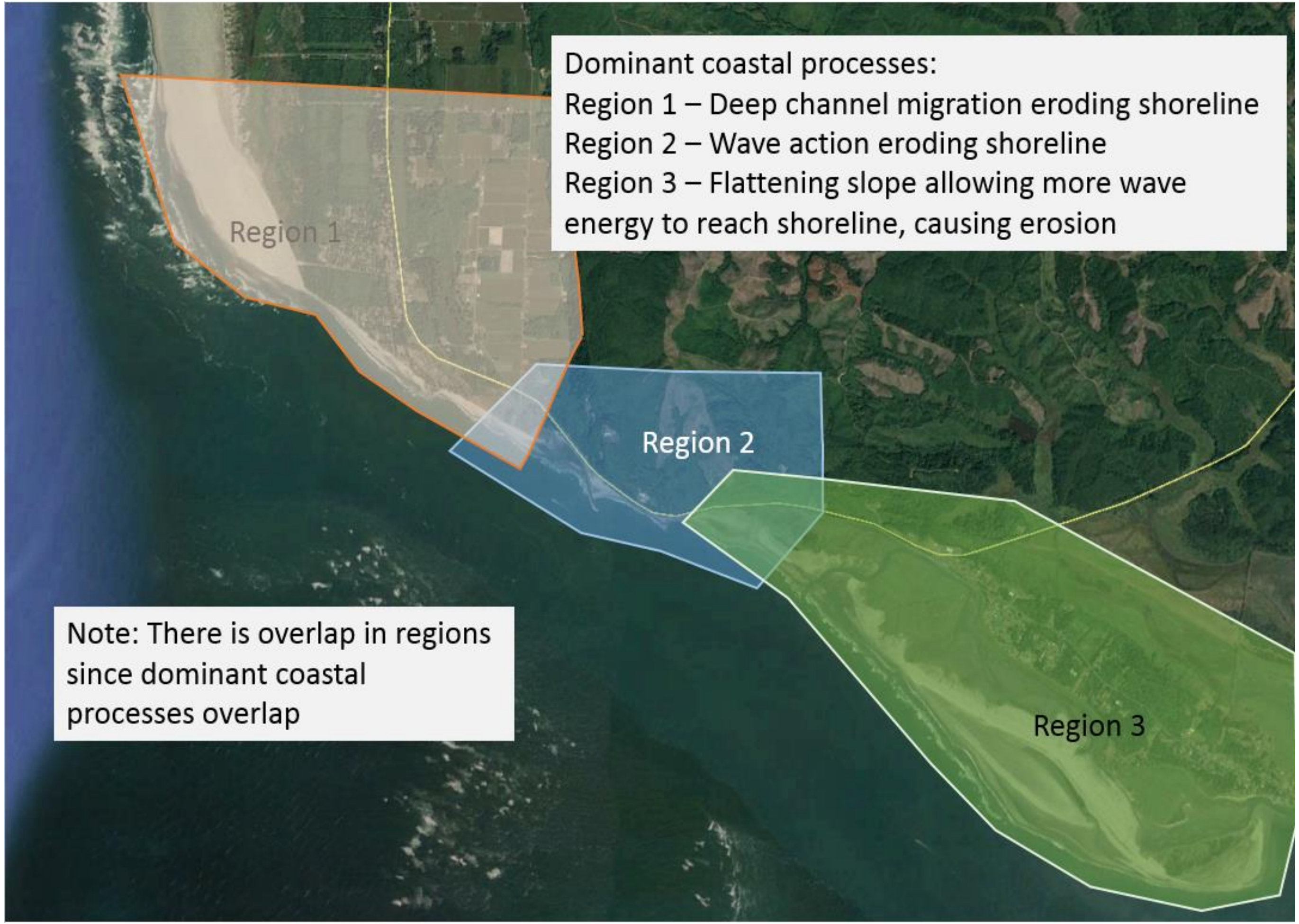
MHHW

Channel thalweg

SR105 Shoreline Erosion Protection Project







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Region 3 – Flattening slope allowing more wave energy to reach shoreline, causing erosion

Note: There is overlap in regions since dominant coastal processes overlap

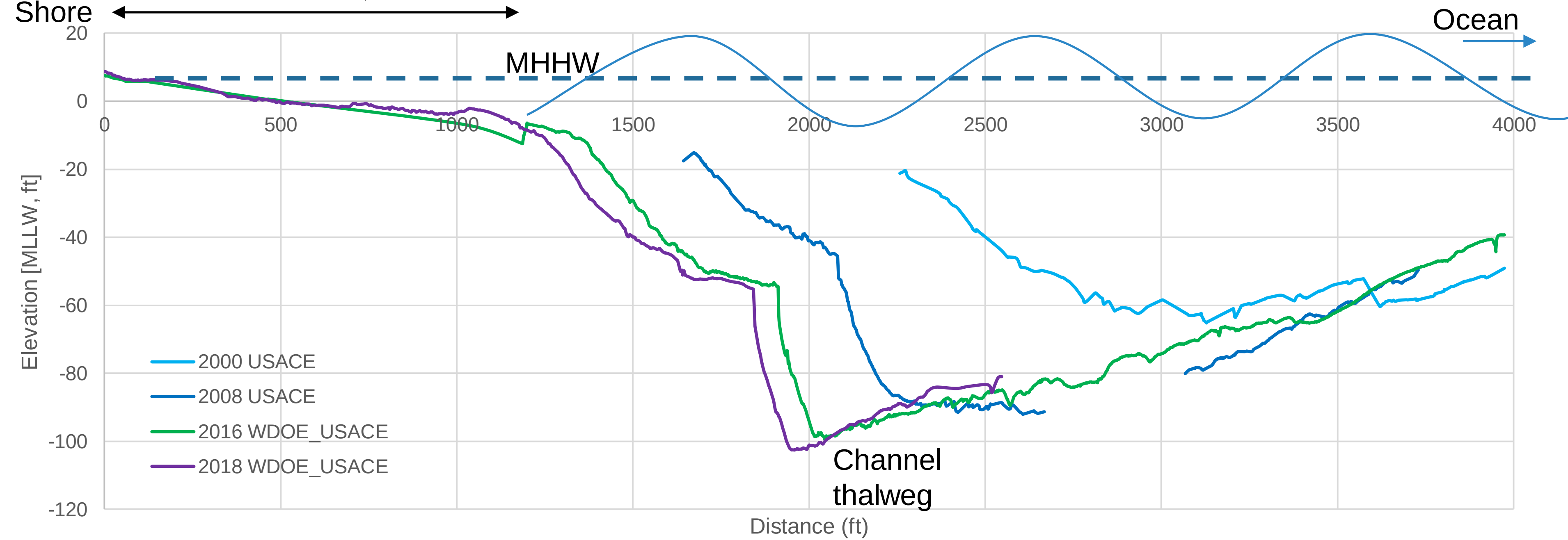
Question for Clarifications Originated by Technical Committee

- There are three regions identified along the North Willapa Bay shoreline that are currently (or possibly in a future) are subject to severe erosion. Accordantly, the entire North Willapa Bay shoreline is divided on three regions. What is the basis of these divisions,
- The demonstration project is scheduled (scoped) for Region 2. Why is it?
- Will the results of demonstration project be applicable to Regions 1 and 2?
- There are several ongoing long-term and short-term coastal protection projects along North Willapa Bay shoreline. How does the demonstration project fits into and what are the relationships between all of these ongoing projects?

Dynamic Coastal Processes

Region 2 Conditions
600’-700’

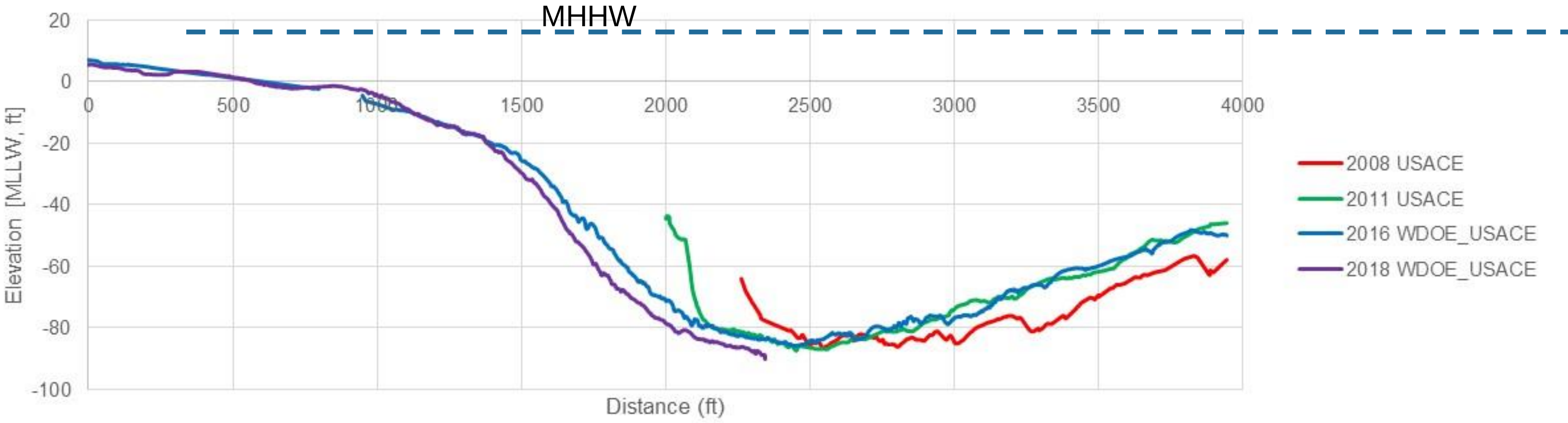
1,100’



Dynamic Coastal Processes

Region 2 Conditions
600’-700’

1,500’



Question for Clarifications Originated by Technical Committee

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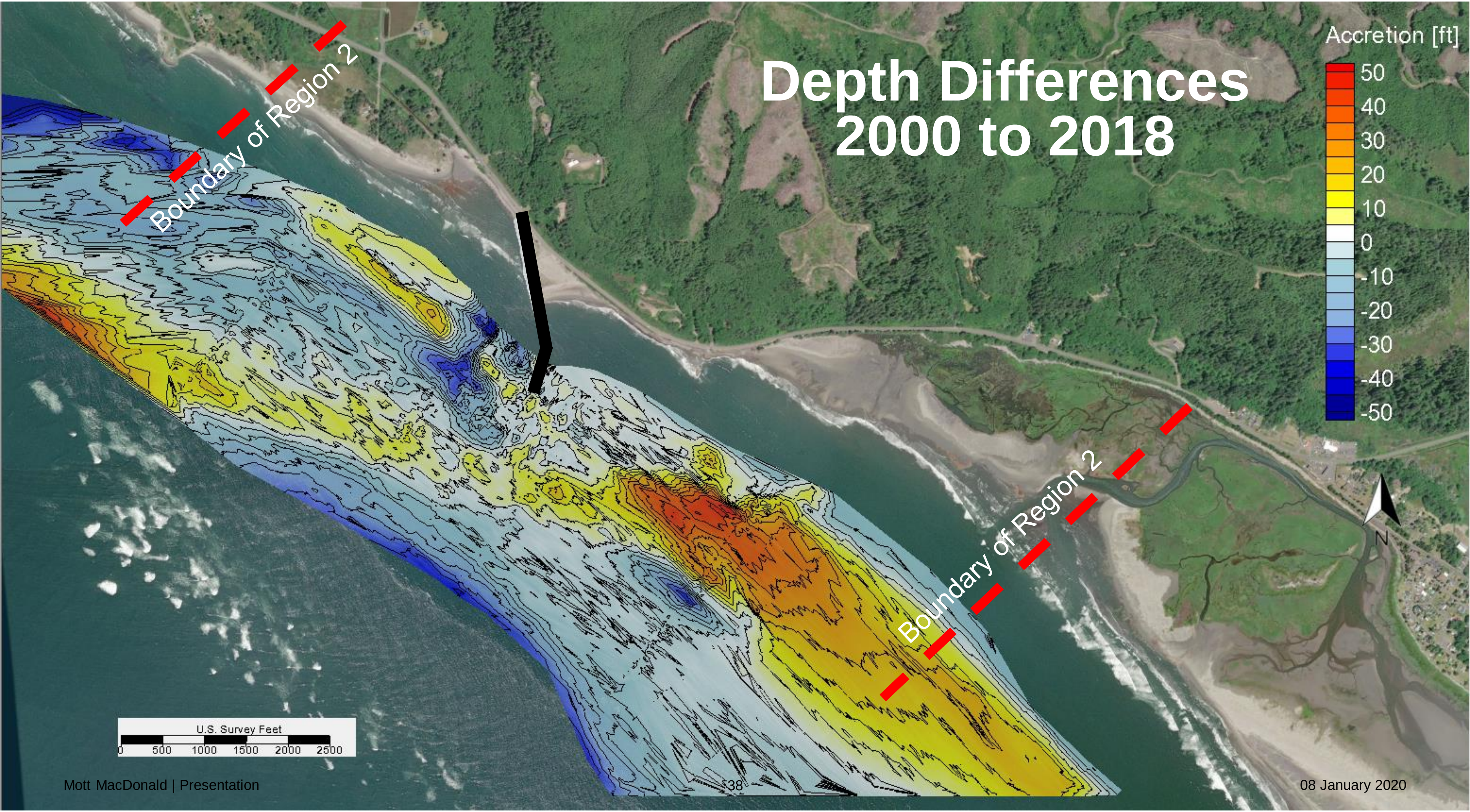
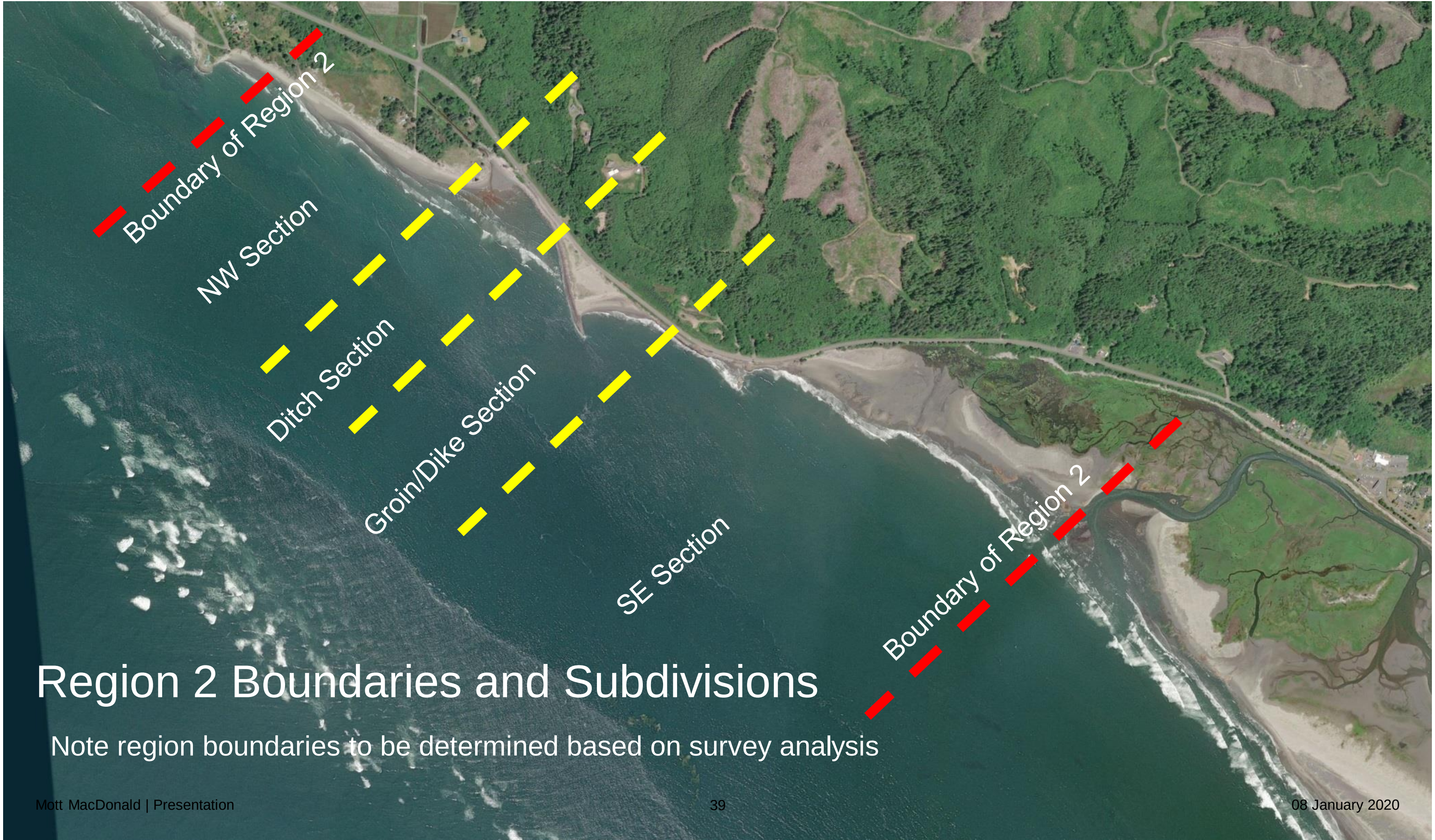
Steps of Coastal Engineering on the Project

- Verify Region 2 boundaries
- Define major morphologic trends that control shoreline processes and erosion in Region 2
- Evaluate conditions and performance of previous and ongoing shoreline erosion protection projects in Region 2 (SR105, dynamic revetment, other)
- Identify location of the demonstration project
- Develop perspective engineering alternatives of shoreline erosion protection for demonstration project and select the preferred one
- Project design
- Conduct analysis to support permitting

Depth Differences
2000 to 2018

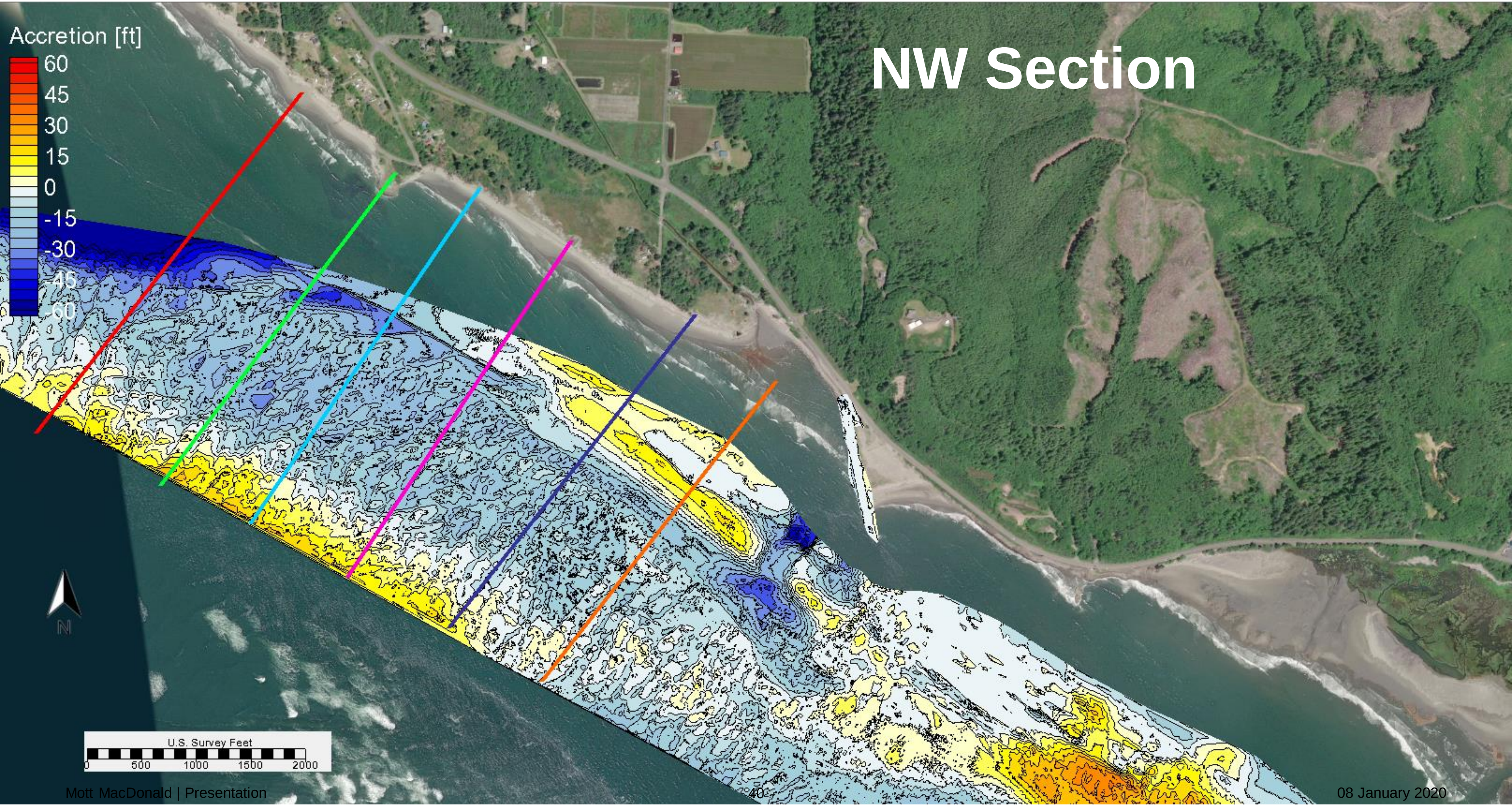




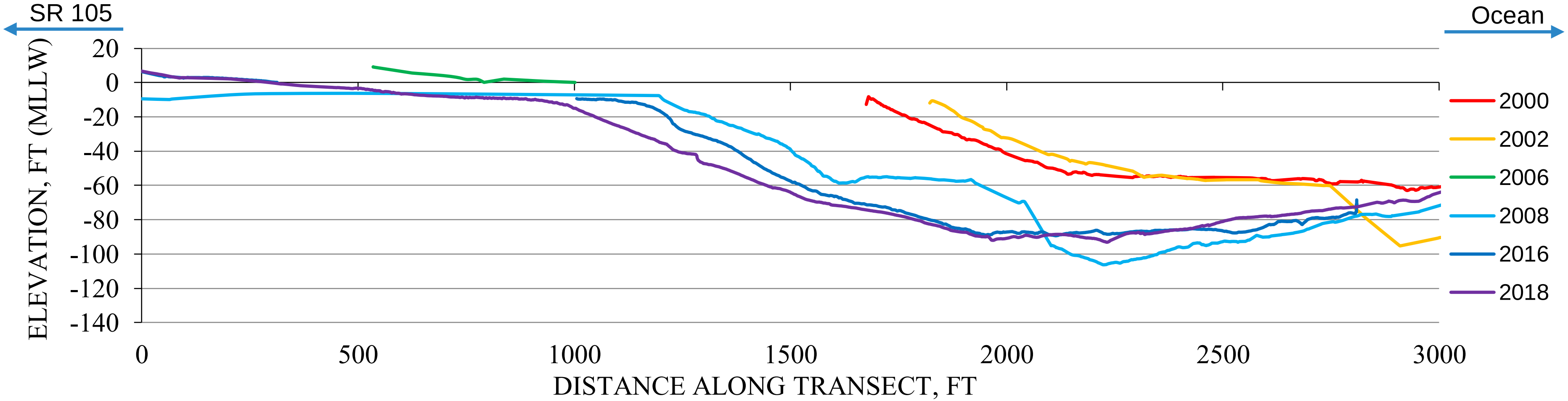
Region 2 Boundaries and Subdivisions

Note region boundaries to be determined based on survey analysis

NW Section


Accretion [ft]
60
45
30
15
0
-15
-30
-45
-60
N
U.S. Survey Feet
0
500
1000
1500
2000

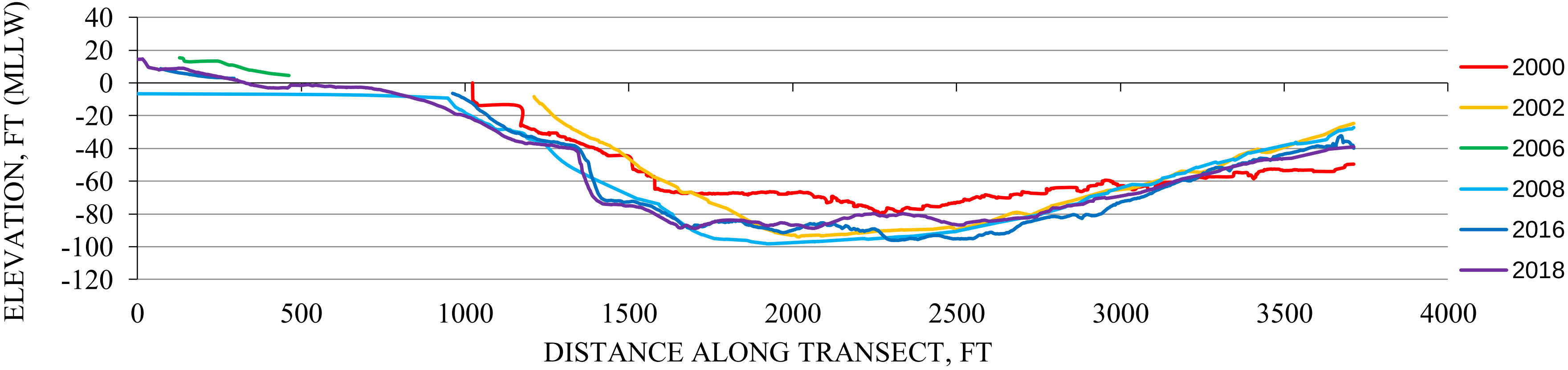
NW of SR 105 stabilization project – Cross-section 1 – North of Beach House



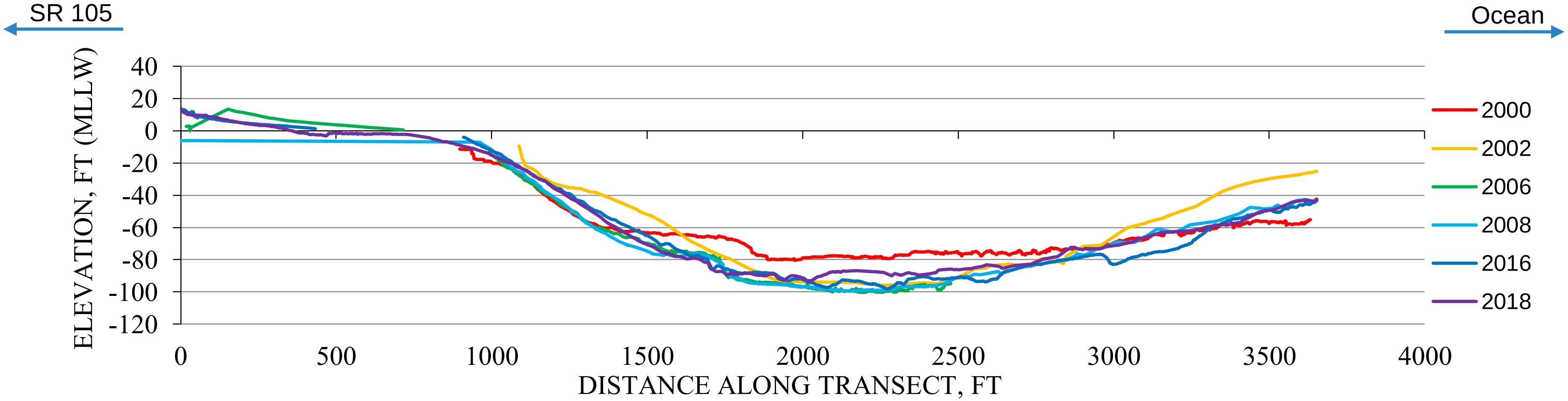
NW of SR 105 stabilization project – Cross-section 4 – south of Beach House

SR 105

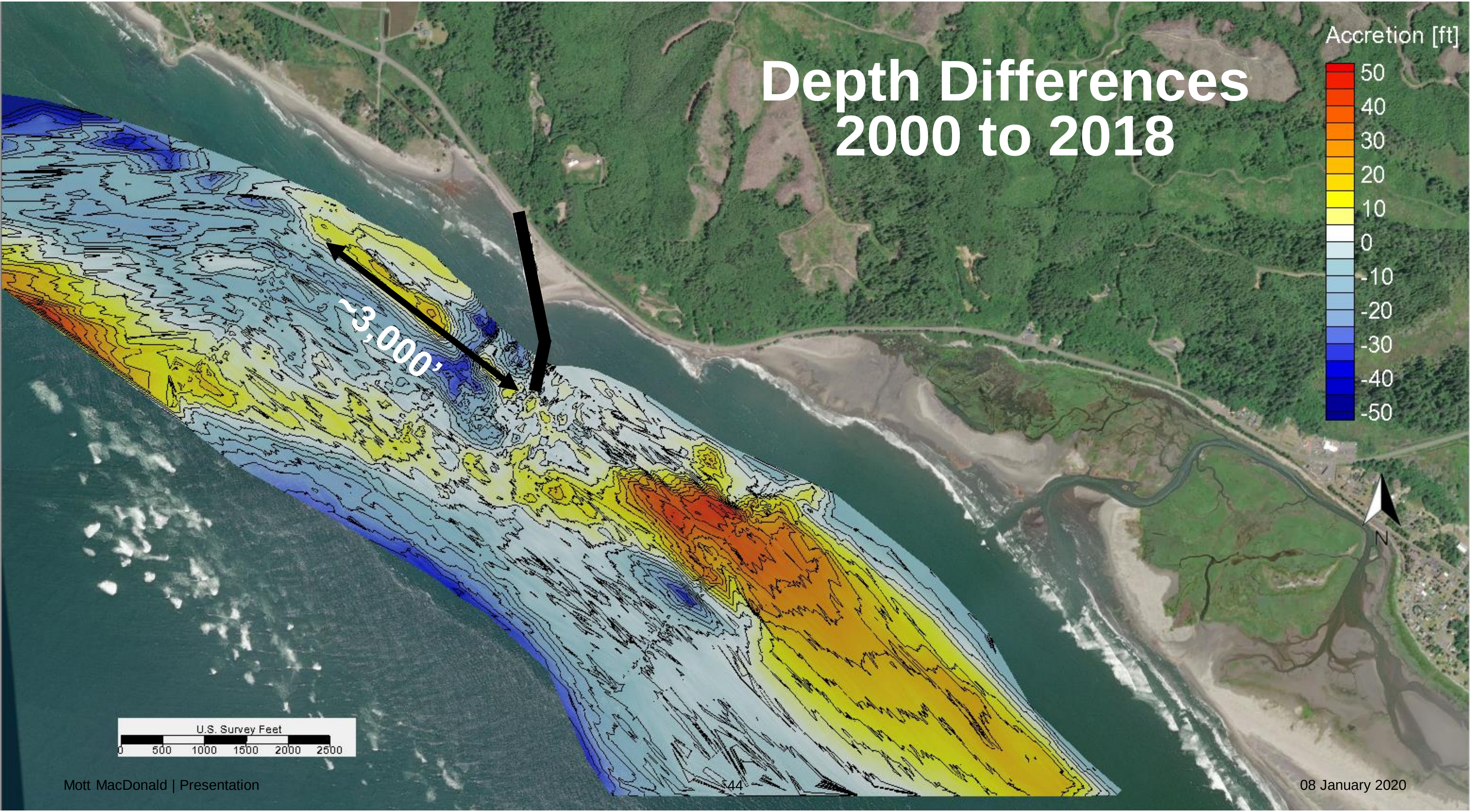
Ocean



NW of SR 105 stabilization project – Cross-section 5 – north of ditch outlet



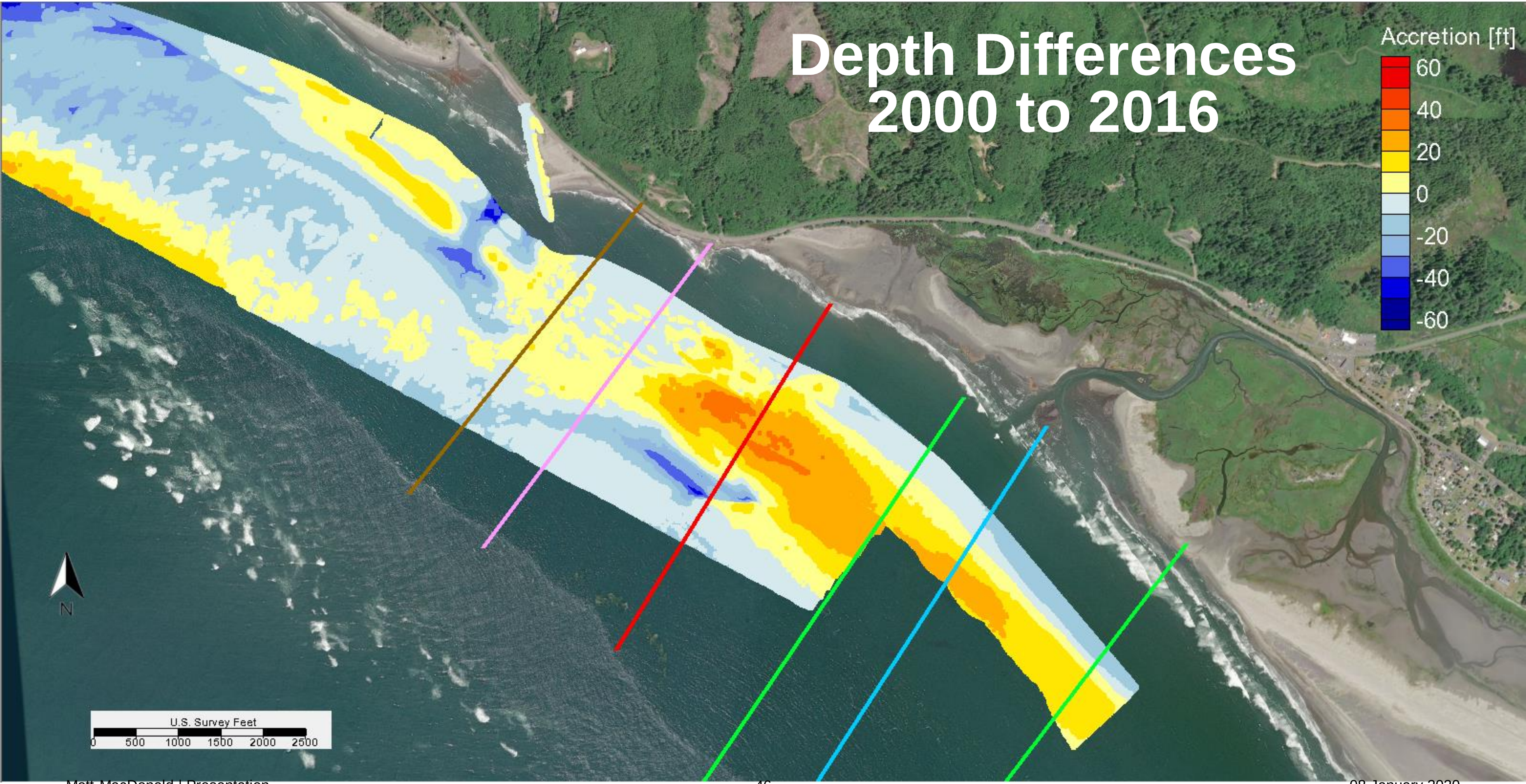
Depth Differences 2000 to 2018



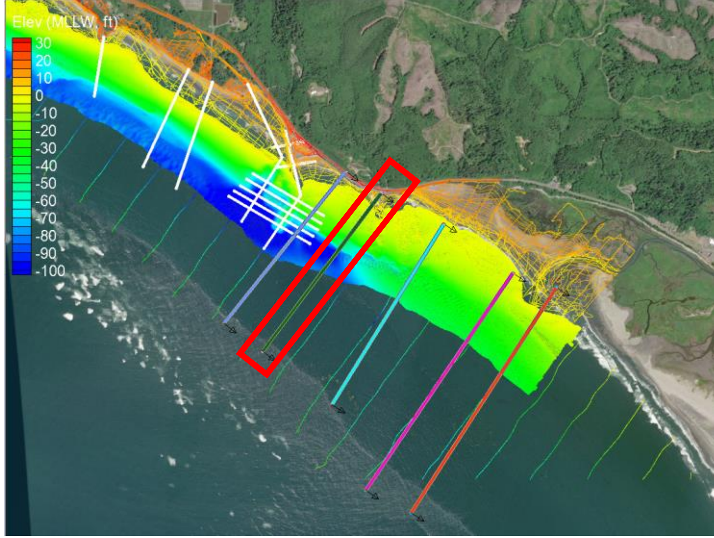
NW Summary

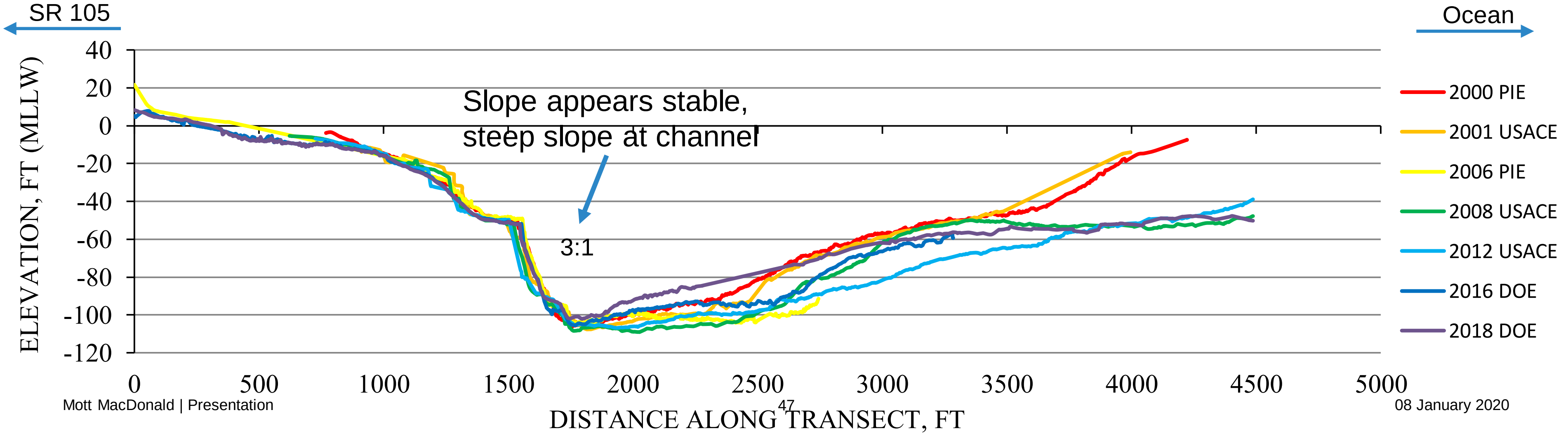
- A part of tidal channel, approximately 3,000 ft from the dike (SR105 project) toward NW is reasonably stable for last 20 years. The NW boundary of the stable part of tidal channel should define NW boundary of Region 2
- Bottom elevations of the upper beach of shoreline (above -10-15 ft MLLW) along the tidal channel stable area has lowered due to wave erosion, adjustment of the bottom slope, sediment deficit, other.
- Seaward slope of tidal channel (in a stable area and beyond) trends to significantly accumulate sediment. This accumulation is a result of migration the shoal (also known as Deadman Island) from south to the north. The phenomenon of migration the shoal from the south to the north was well observed and explained by previous studies, based on historical, Corps of Engineers survey data from 1924 to 1980.

Depth Differences
2000 to 2016



SE of SR 105 stabilization project – Cross-section 2

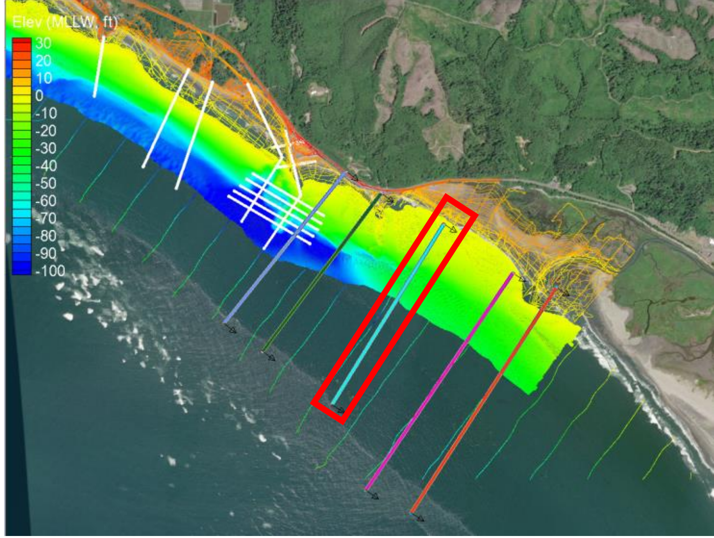


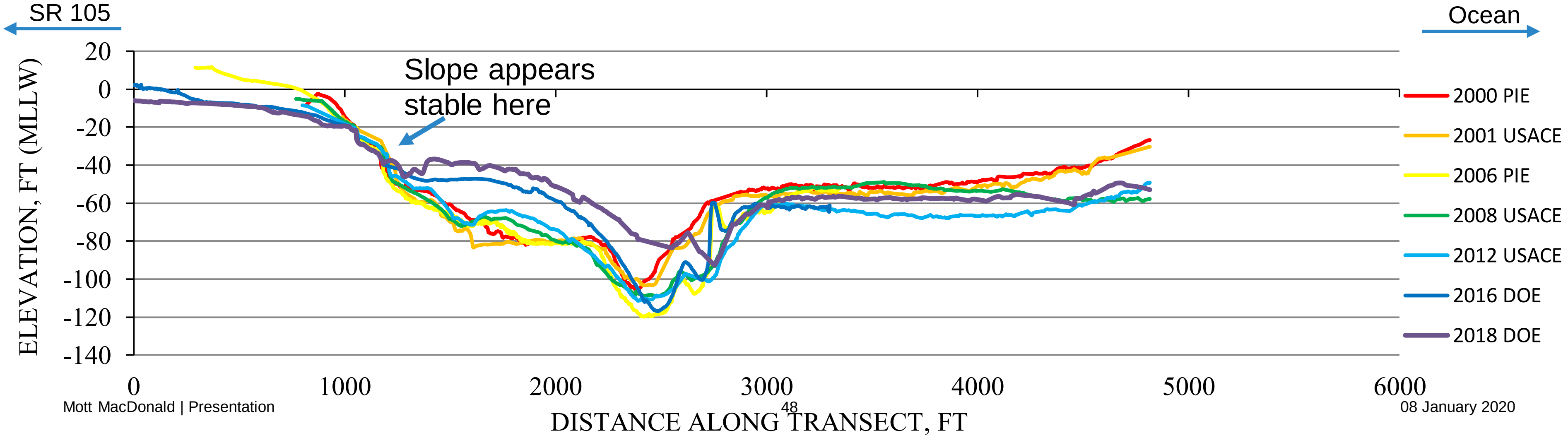


Slope appears stable, steep slope at channel

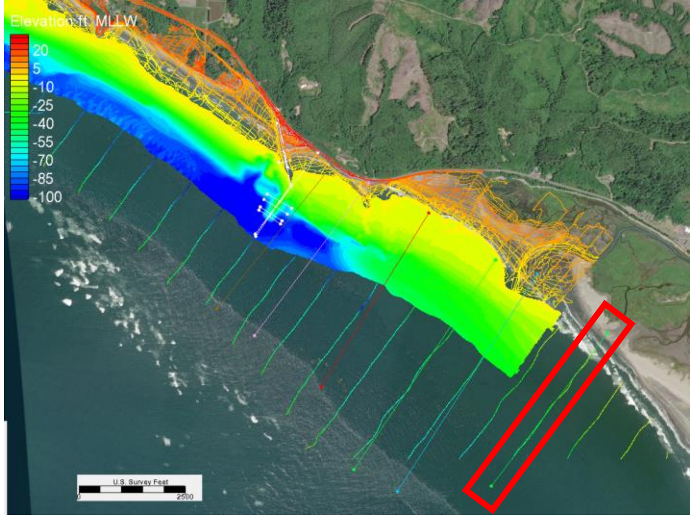
3:1

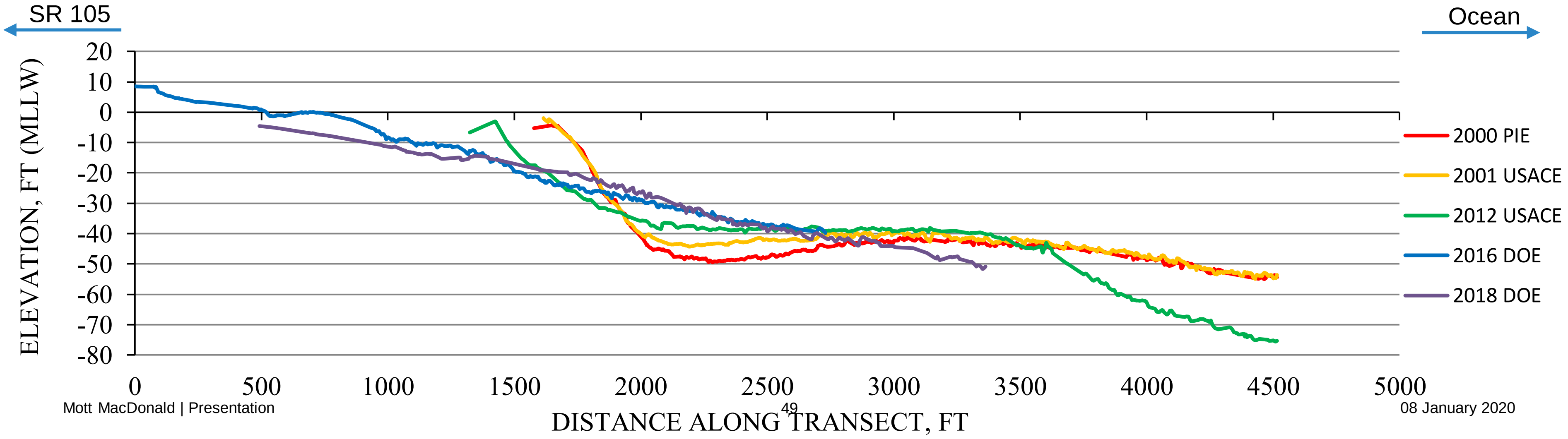
SE of SR 105 stabilization project – Cross-section 3




Slope appears stable here

SE of SR 105 stabilization project – Cross-section 6

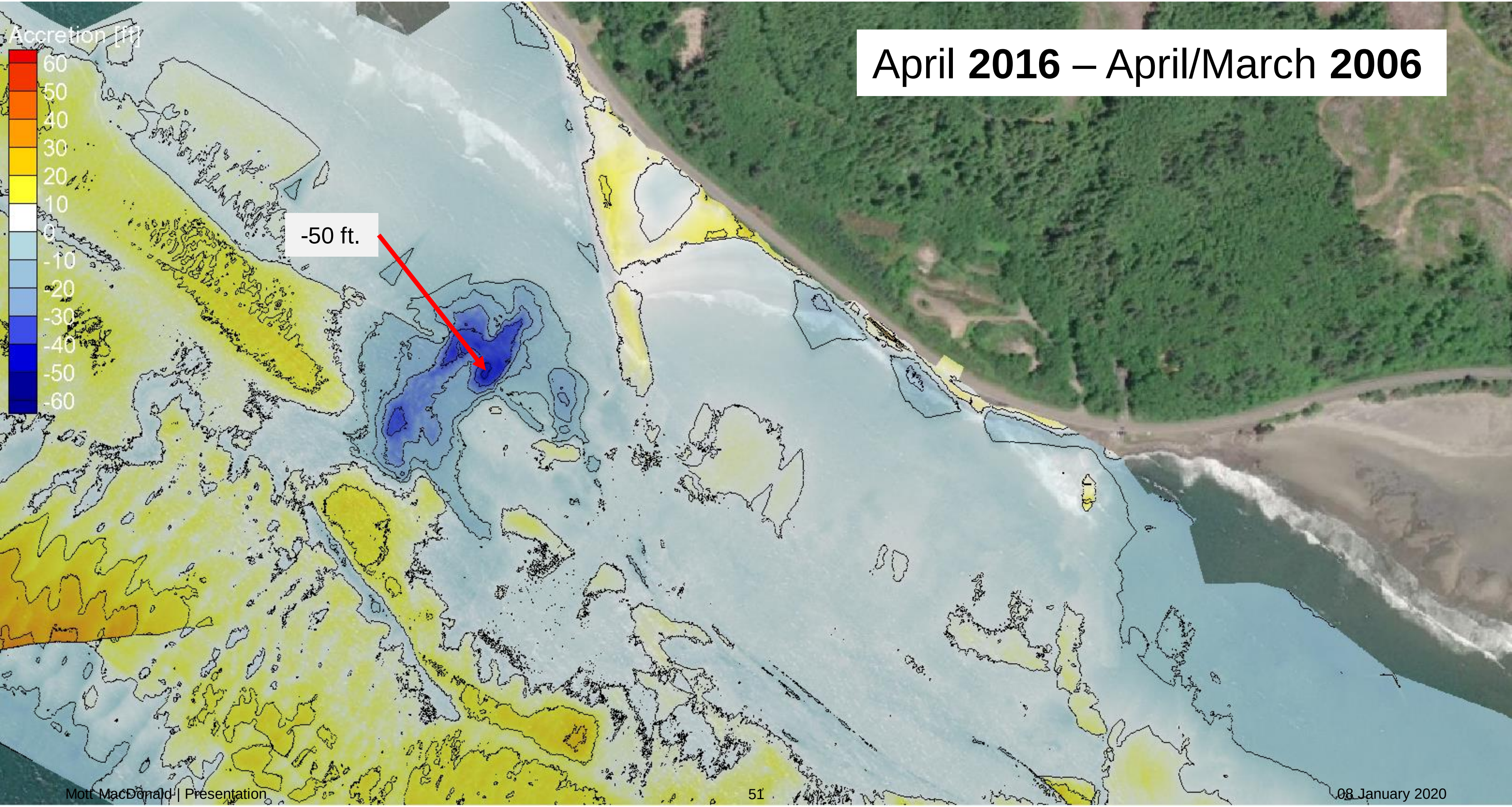




SE Summary

- The part of tidal channel from the dike (SR105) toward SE along the entire area of investigation (approximately 6,000’) is stable or migrates offshore, toward the south
- In the vicinity of SR105 dike, approximately 2000 ft the landward slope of tidal channel is stable, or trends to accumulate sediment (further toward SE).
- Significant accumulation has occurred at the SE part of tidal channel (in front of Tribal property) bellow depth 25-30 ft MLLW).
- At the same time, erosion has occurred at the upper part of the slope, above elevations -20 ft MLLW. Combination of these accumulation and erosion has resulted in formation of very flat and gradual bottom slope in Region 3. This phenomena (slope flattering) may benefit and should be accounted for the shoreline erosion protection project performed in this areas by COE and DOT.

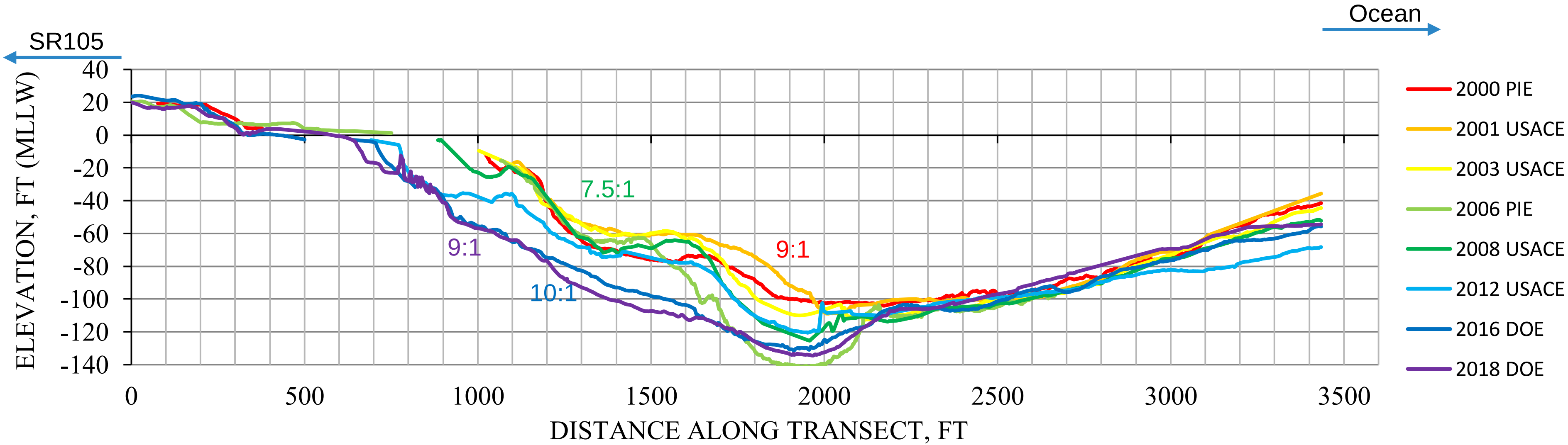
April **2016** – April/March **2006**



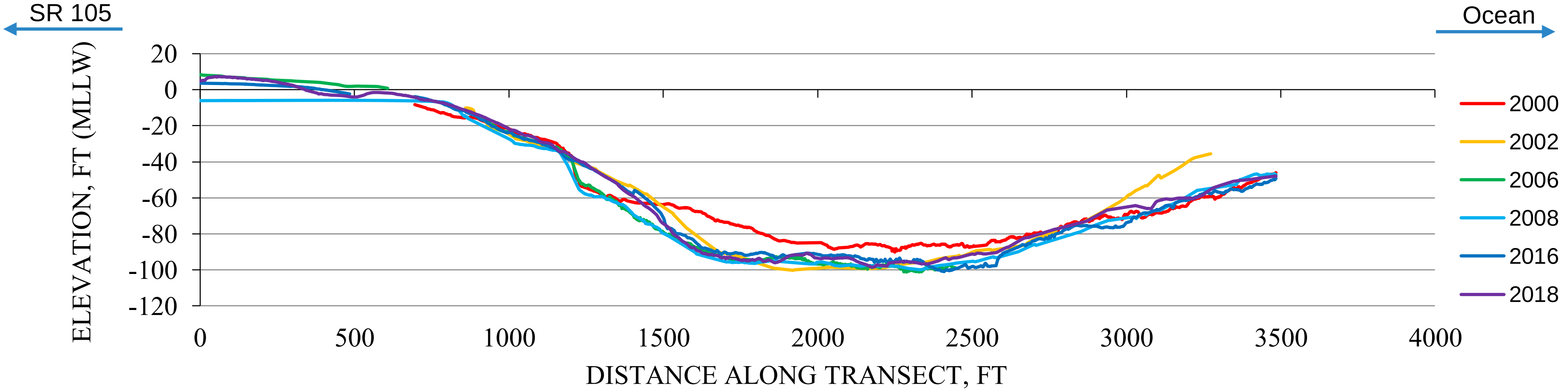
-50 ft.

June **2018** WDOE/USACE Surveys – April **2016** WDOE/USACE Surveys

Trench Thalweg cross-section



Lower Ditch cross-section



Ditch Summary

- Formation of a deep trench has occurred in the area where ditch outflows meets the tidal channel slope. Justifiable explanation to this phenomena has not been developed yet. It may be result of wave or/and flow hydrodynamics, slope instability, avalanching, all of the above, or other.
- Apparently the process of trenching and deepening of the slope and ditch meandering is still going on. It is recommended do not site the demonstration project at the vicinity of this area until clear understanding on this process is achieved.

Steps of Coastal Engineering on the Project

- Verify Region 2 boundaries
- Define major morphologic trends that control shoreline processes and erosion in Region 2
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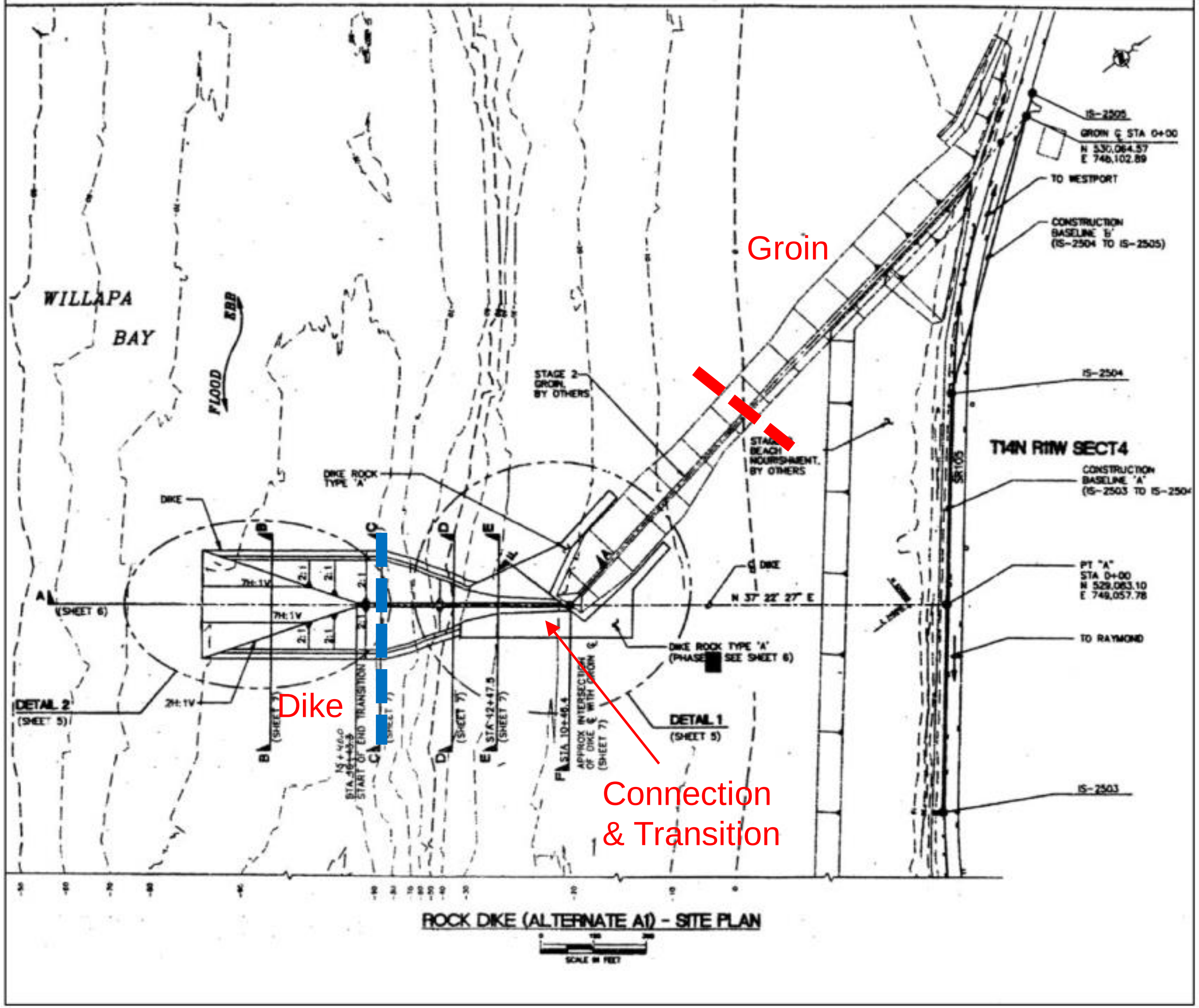
1998 SR105 Project

- Constructed in 1998
- No major changes in construction
- Dike, Groin, Beach Nourishment

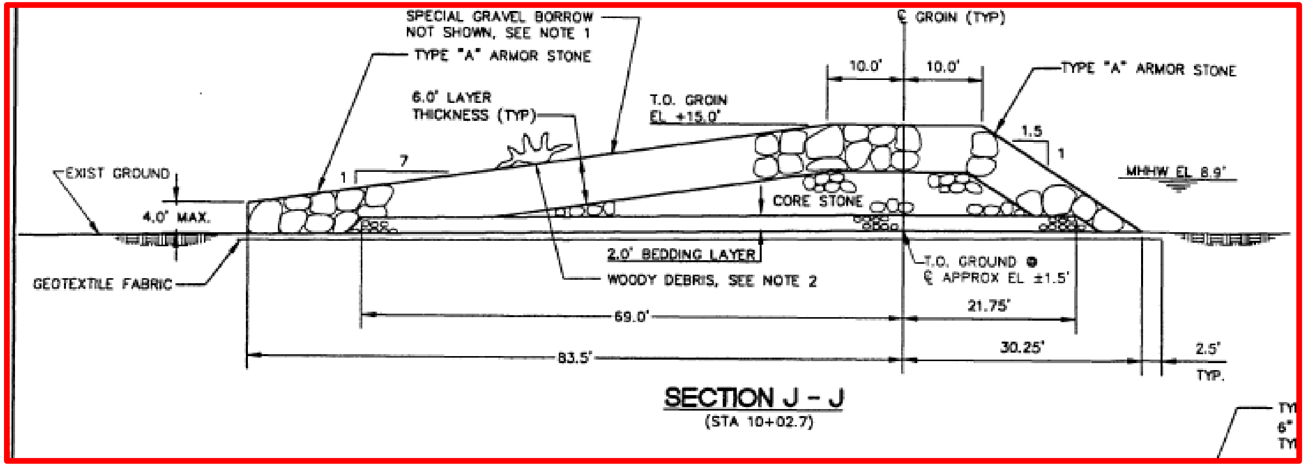


ROCK DIKE (ALTERNATE A1) - SITE PLAN

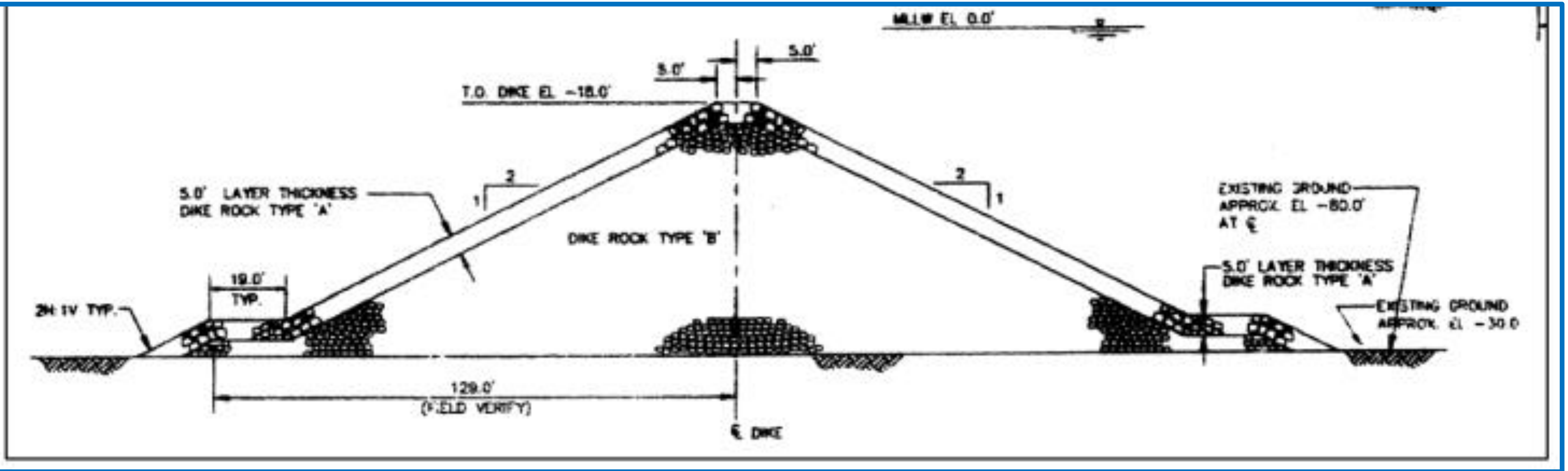
1/8/2020

Groin Cross-sections

- Flat Front Slope
- Profile followed beach grades
- Flatter slopes both sides seaward of beach fill



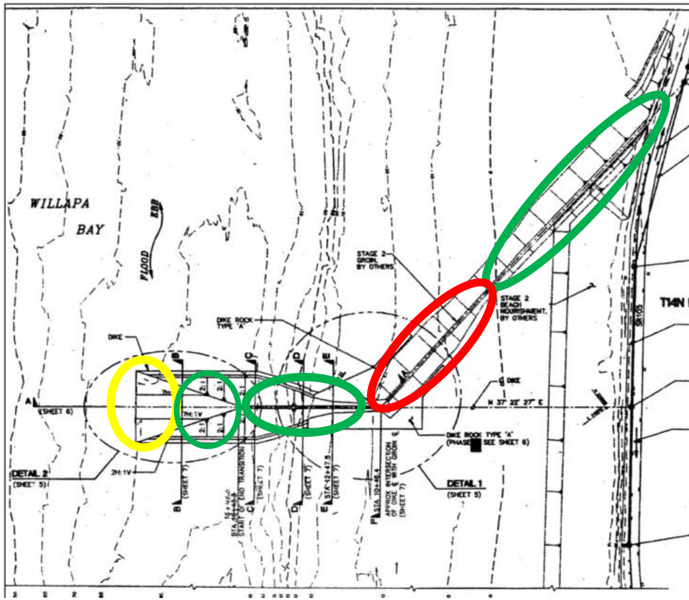
Dike Cross-section

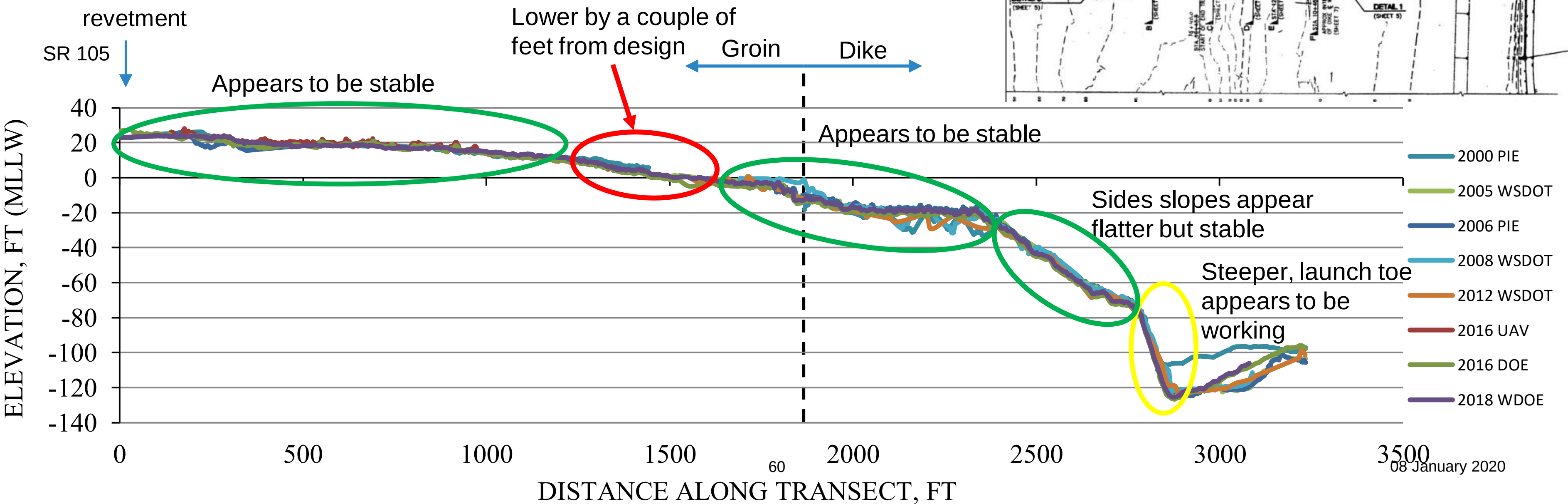


- Contractor over built armor layer for ease of construction
- Cross-section achieved during construction

Takeaways

- 🔴 Area of concern
- 🟢 Area in good condition





revetment

SR 105

Appears to be stable

Lower by a couple of feet from design

Groin

Dike

Appears to be stable

Sides slopes appear flatter but stable

Steeper, launch toe appears to be working

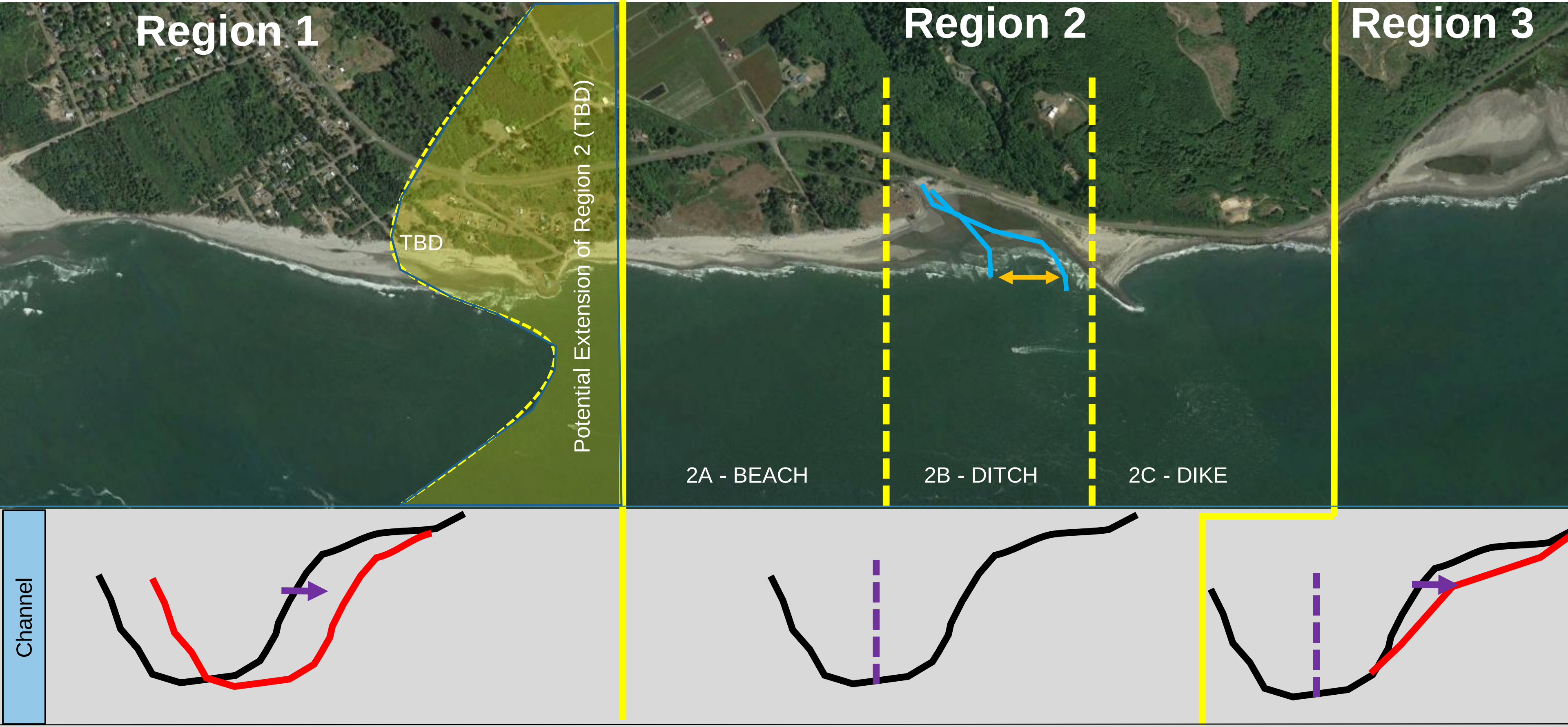
Takeaways

1. Dike and groin appear to be in okay condition
2. Slight flattening of the side slopes of the dike
3. End of groin appears to have dropped a couple of feet in elevation in localized area
4. Toe in scour hole is steep; presence of armor protection is unknown
5. Armor stability and groin cross section not analyzed

Additional Analysis

1. Geotechnical stability (in progress) → Dike and trench
2. Assess toe scour → Rock Cover?

Coastal Processes Summary



North Willapa Bay Shoreline Existing Protection On-going Projects

Private Revetment

Drainage District Dynamic Revetment (on-going)

Area for demonstration project

WSDOT SR 105 North Cove Beach Erosion Protection project

1998 SR105 Emergency Stabilization project

2012 USACE Shoalwater Bay Dune Restoration project

Dynamic Revetment - Rock Placement Areas (2015-2018)

Revised Rock Placement Summary

Site	Site Name	Date of Installation	Length	Volume (Estimated)	CY/LF
A	Seamobile	Jan. 2018-Mar. 2018, Dec. 2018	2000 ft.	216 CY	~0.1
B	Ron’s	Oct. 2017, Nov. 2017	1000 ft.	408 CY	~0.4
C	Ron’s (Buried Rip Rap)	Nov. 2017 – Jan. 2017	400 ft.	2014 CY	~5
D	Brenda’s	Dec. 2016, Nov. 2017, Jan. 2018	1000 ft.	400 CY	~1.0-1.5
E	Sandy’s	Feb. 2017, Nov. 2017	650 ft.	960 CY	~1.5
F	Lonnie’s	Feb. 2017	700 ft.	692 CY	~1.0

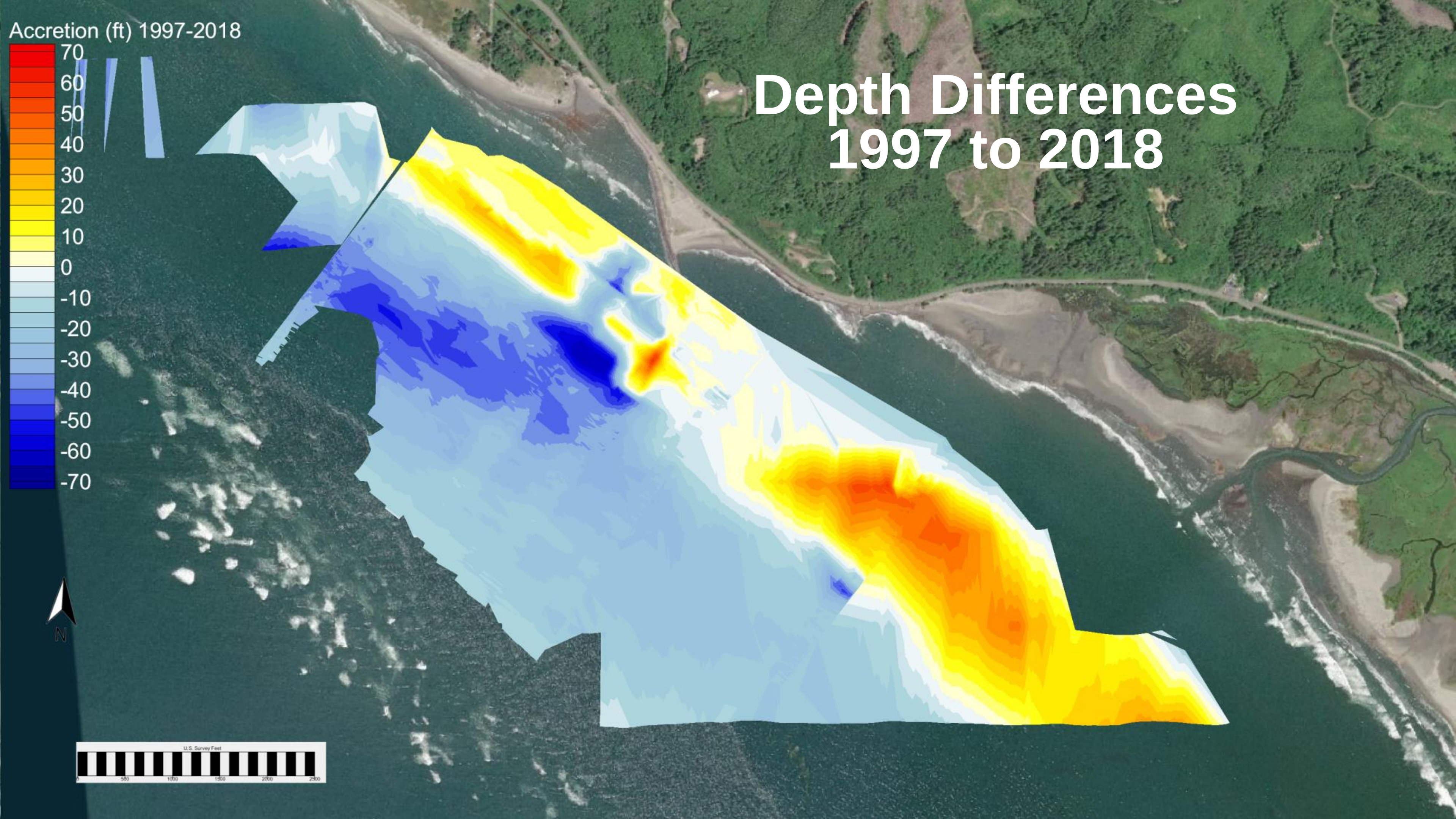
***Volumes estimated from truck tickets**

- There are several ongoing long-term and short-term coastal protection projects along North Willapa Bay shoreline. How does the demonstration project fits into and what are the relationships between all of these ongoing projects?

On Wednesday, August 29, 2018, 9:04:46 AM PDT, Porter, Aaron <Aaron.Porter@mottmac.com> wrote:
As discussed, we have developed preliminary/conceptual recommendations for the upcoming dynamic revetment placements.

We've already begun stockpiling cobble near the orange area. Just acquiring and transporting the material is going to keep us pretty busy for a while.
David

Depth Differences 1997 to 2018



Summary from Coastal Processes Analysis and Technical Committee Meeting

- It appears that the underwater dike and the groin of SR105 project have been able to maintain position of deep tidal channel (preclude propagation toward and undermining the land) at least along 5,000 ft of coastline (3,000 ft from the dike towards NW and > 2000 ft toward SE)
- Bottom elevations of the upper beach of shoreline along the tidal channel stable area has lowered due to wave erosion and other factors
- Formation of a deep trench has occurred in the area where ditch outflows meets the tidal channel slope. Justifiable explanation to this phenomenon has not been developed yet.
- Significant accumulation has occurred at the SE part of tidal channel (in front of Tribal property) below depth 25-30 ft MLLW. That has resulted in the formation of a very flat and gradual bottom slope in Region 3. This phenomenon (slope flattering) may benefit and should be accounted for in the shoreline erosion protection project performed in this areas by COE and DOT.
- SR 105 project dike and groin are in reasonably good conditions. Slight flattening of the side slopes, end of groin appears to have dropped a couple of feet in elevation in localized area. The analysis of stability the SR105 project is still underway.
- The boundaries of Region 2 have been identified as the region of stable channel conditions. In order to maximize the benefits from the demonstration project the Technical Committee recommends extending the area of demonstration project beyond the boundaries of Region 2, at least to the beach house or further.
- There are several ongoing long-term and short-term coastal protection projects along North Willapa Bay shoreline, including DOT, Diking District, and COE. The Project Team should clearly define the boundaries and objectives of the demonstration project to assure that there shall be continuity and beneficial relationships between all of these on-going projects.

Steps of Coastal Engineering on the Project

- Verify Region 2 boundaries
- Define major morphologic trends that control shoreline processes and erosion in Region 2
- Evaluate conditions and performance of previous and ongoing shoreline erosion protection projects in Region 2 (SR105, dynamic revetment, other)
- Identify location of the demonstration project
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- Project design
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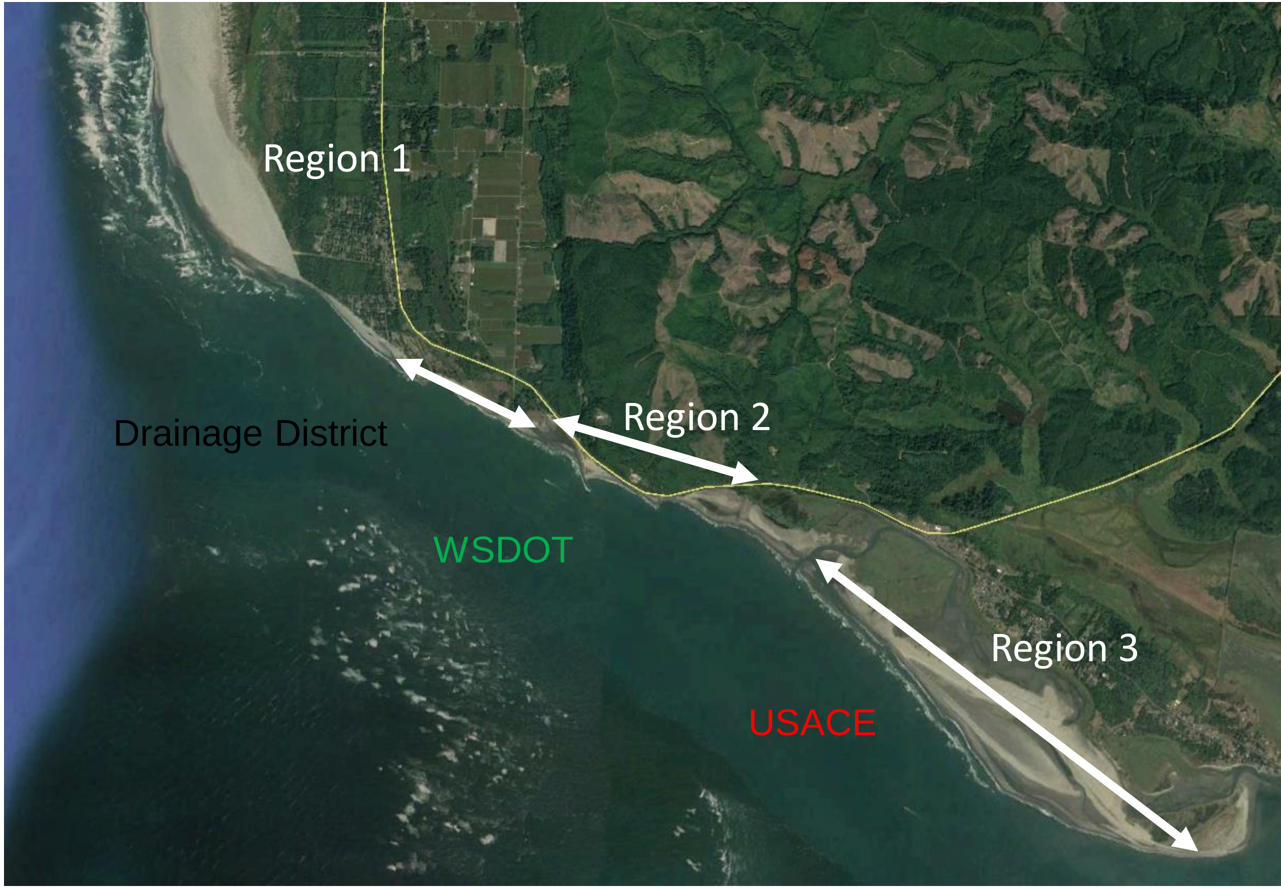
Compilation of Previously Presented Alternatives

Drainage District:
- Dynamic revetment (angular rock)
- Buried revetment

WSDOT:
- Buried revetment
- Debris berm
- Shoreline revetment
- Floodplain fill/flood-proof structures
- Relocation of structures
- Armor and elevate SR 105
- Groins
- Beach nourishment
- Highway relocation
- Dynamic revetment (rounded rock)

USACE:
- No action
- Barrier dune restoration
- Dune restoration with flood berm extension
- Sea dike
- Hydraulic modification
- Channel relocation

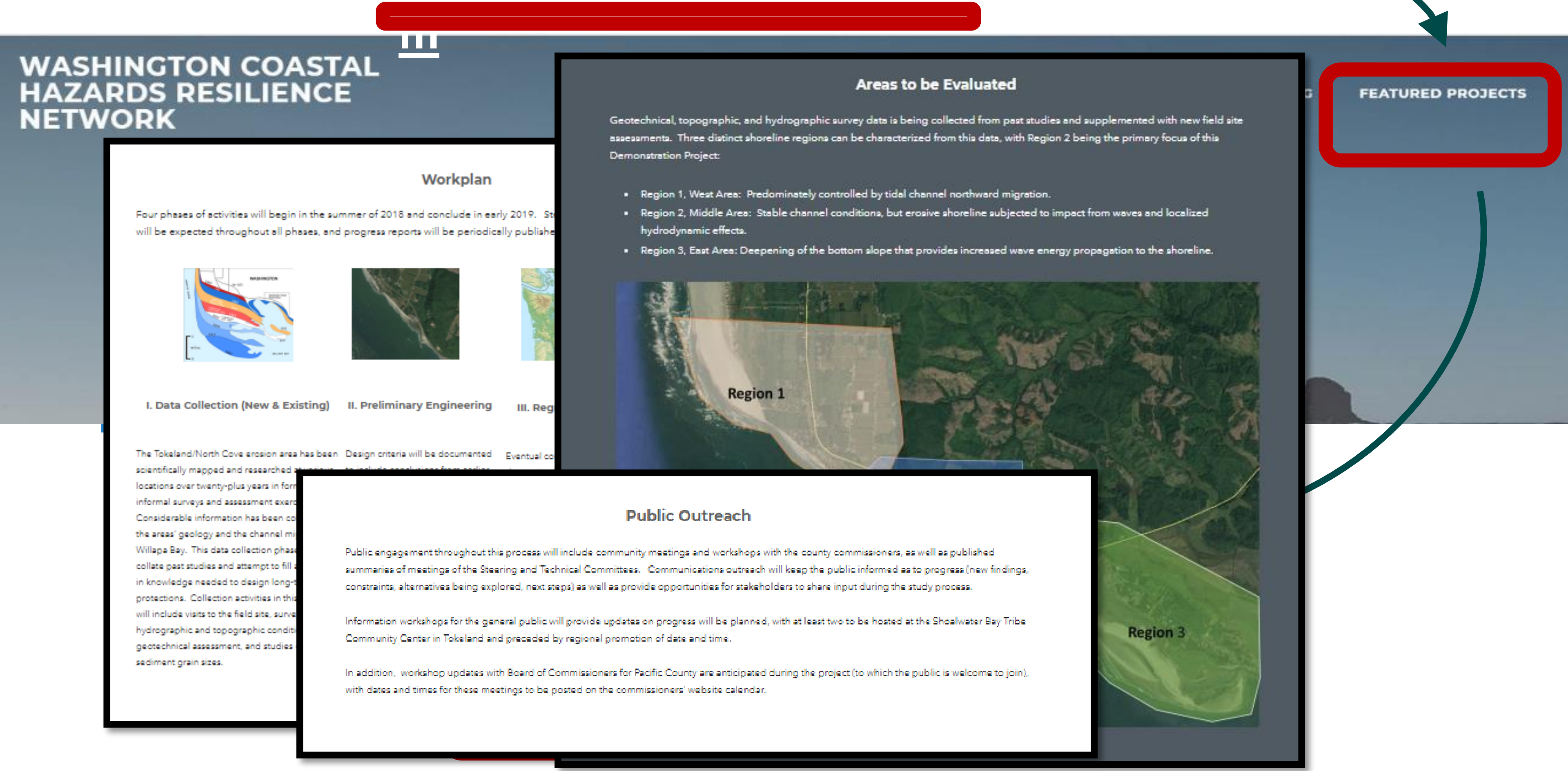


Agenda

Topic	Action	Leader
Welcome	Engage	Kathy / David
Agenda and Outcomes	Inform	Kelly
✓ Agree on results of preliminary data and conclusions prepared for Tech Committee ✓ Update the boundary for demonstration project ✓ Determine outcomes for upcoming public meeting ✓ Confirm the coordination process		
Drainage District Revetment Project Status	Inform	David
Demonstration Project Update	Inform	Shane / Vladimir
Discussion/Feedback	Engage	All

Topic	Action	Leader
ACE Continuing Authorities Program (CAP) Section 103	Inform/ Feedback	
Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

Outreach:



Workplan

Four phases of activities will begin in the summer of 2018 and conclude in early 2019. St
will be expected throughout all phases, and progress reports will be periodically publishe

I. Data Collection (New & Existing)

II. Preliminary Engineering

III. Reg

The Tokeland/North Cove erosion area has been
scientifically mapped and researched a
locations over twenty-plus years in for
informal surveys and assessment exer
Considerable information has been co
the areas' geology and the channel mi
Willapa Bay. This data collection phas
collate past studies and attempt to fill
in knowledge needed to design long-
protections. Collection activities in thi
will include visits to the field site, surv
hydrographic and topographic conditi
geotechnical assessment, and studies
sediment grain sizes.

Design criteria will be documented

Eventual co

Areas to be Evaluated

Geotechnical, topographic, and hydrographic survey data is being collected from past studies and supplemented with new field site assessments. Three distinct shoreline regions can be characterized from this data, with Region 2 being the primary focus of this Demonstration Project:

- Region 1, West Area: Predominately controlled by tidal channel northward migration.
- Region 2, Middle Area: Stable channel conditions, but erosive shoreline subjected to impact from waves and localized hydrodynamic effects.
- Region 3, East Area: Deepening of the bottom slope that provides increased wave energy propagation to the shoreline.

Public Outreach

Public engagement throughout this process will include community meetings and workshops with the county commissioners, as well as published summaries of meetings of the Steering and Technical Committees. Communications outreach will keep the public informed as to progress (new findings, constraints, alternatives being explored, next steps) as well as provide opportunities for stakeholders to share input during the study process.

Information workshops for the general public will provide updates on progress will be planned, with at least two to be hosted at the Shoalwater Bay Tribe Community Center in Tokeland and preceded by regional promotion of date and time.

In addition, workshop updates with Board of Commissioners for Pacific County are anticipated during the project (to which the public is welcome to join), with dates and times for these meetings to be posted on the commissioners' website calendar.

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Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

MOTT MACDONALD

CAP Section 103

US Army Corps of Engineers

Project application: top project in Seattle District, now to Congress

Next steps:

- Federal determination process
- Project management plan
- Cost chare agreement
- Feasibility study

Feasibility: the first $100K funded by ACE, remainder cost-shared 50/50 with PacCo

Construction: cost-share 65/35 with PacCo

Net-net: difficult to evaluate PacCo support without seeing agreements and assessment of cost-share match

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Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
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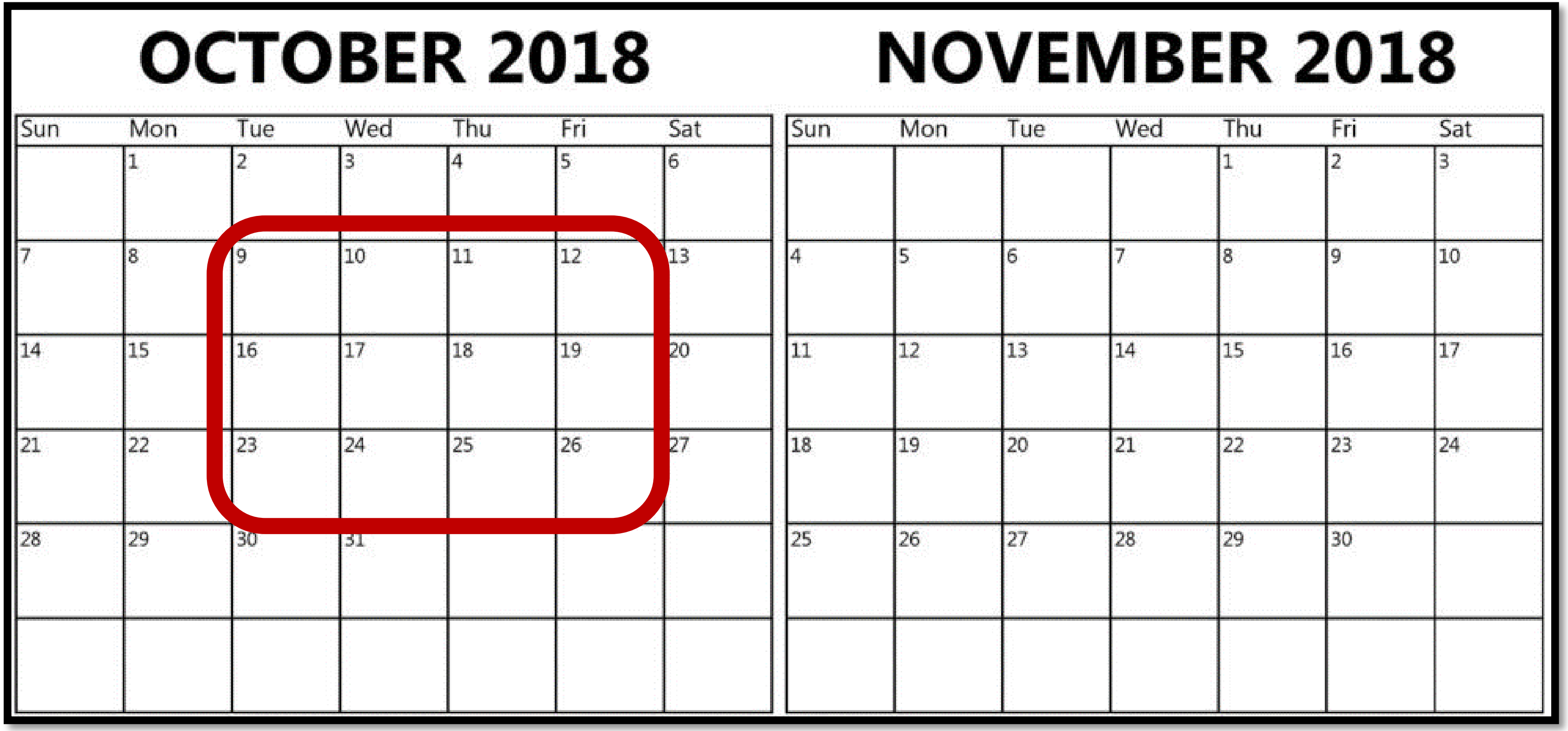
Adjourn		

Community Meeting



OCTOBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Public/Stakeholder Involvement
Multi-Step Approach

- ✓ Steering & Technical Committees
- ✓ Open Houses
  - 2 Total – Late Sept & Winter
- ✓ Social Media
  - Periodic updates through WECAN, others
- ✓ Stakeholder Outreach
- ✓ Interviews
- ✓ Website
  - Fact sheets, notifications, status updates, project information
- ✓ Press Releases
  - Notification of meetings, etc..

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Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

MOTT
MACDONALD

North Willapa Shoreline Protection Demonstration Project

Steering Committee Meeting #2 11-13-2018

Demonstration Project Alternatives

Pacific County, WA

Agenda

Topic	Action	Leader
Welcome	Engage	Kathy / David
Agenda and Outcomes	Inform	Kelly
✓ Technical Work Update ✓ Review feedback from Tech Committee ✓ Share updates: Revetment, ACE Section 103 ✓ Determine plan for upcoming public meeting		
Drainage District Revetment Project Status	Inform	David
Demonstration Project Update	Inform	Shane / Vladimir
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Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
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Adjourn		

WSDOT Drone Pix

ftp://ftp.wsdot.wa.gov/incoming/US105WashAway_12OCT18/

Agenda

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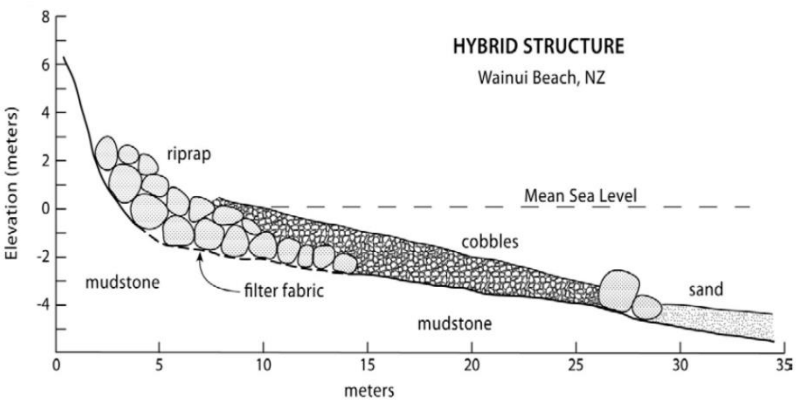
Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

Designed based on Nature



Agenda

Topic	Action	Leader
Welcome	Engage	Kathy / David
Agenda and Outcomes	Inform	Kelly
✓ Technical Work Update ✓ Review feedback from Tech Committee ✓ Share updates: Revetment, ACE Section 103 ✓ Determine plan for upcoming public meeting		
Drainage District Revetment Project Status	Inform	David
Demonstration Project Update	Inform	Shane / Vladimir
Discussion/Feedback	Engage	All

Topic	Action	Leader
ACE Continuing Authorities Program (CAP) Section 103	Inform/ Feedback	
Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

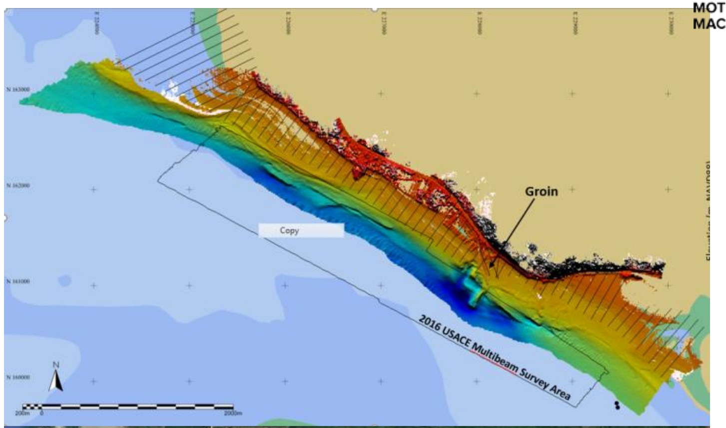
Technical Update Outline

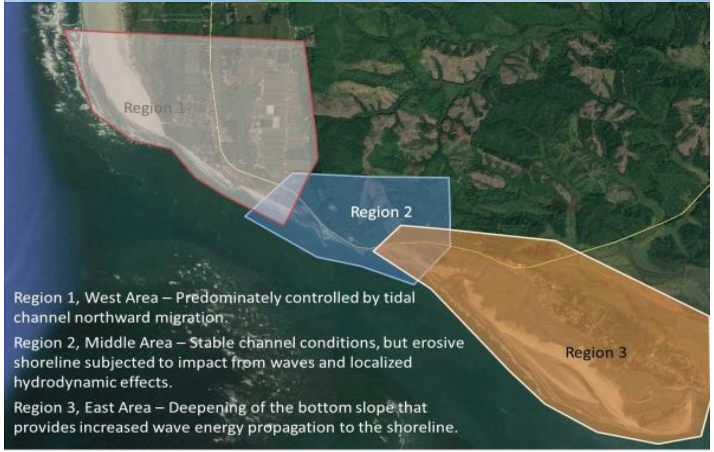
- Workplan Update
- Stakeholder and Technical Committee Meeting Summary
- Demonstration Project Boundaries
- Demonstration Project Alternatives
- Region 2 Master Plan Scenarios
- Next Steps

Workplan

Note: Yellow Text = Work conducted since last meeting
Green Text = Work previously conducted

- Data Collection (New & Existing)
  - Field Site Assessment
  - Hydrographic/Topographic Surveys
  - Geotechnical
  - Sediment Grain Size
- Preliminary Engineering
  - Design Criteria Development
  - Coastal Analysis
  - Alternatives Development
  - Alternative Evaluation
  - Constructability Assessment
  - Cost Assessment
- Regulatory Permitting
  - Agency Consultation
  - Permit Application Documents
- Final Engineering Design
  - Plans/Specifications/Estimates for Bidding
- Public Involvement
  - Meetings & Outreach
  - Technical & Steering Committee Meetings
  - Website





Region 1, West Area – Predominately controlled by tidal channel northward migration.

Region 2, Middle Area – Stable channel conditions, but erosive shoreline subjected to impact from waves and localized hydrodynamic effects.

Region 3, East Area – Deepening of the bottom slope that provides increased wave energy propagation to the shoreline.

Schedule

Legend
✓ = complete or nearly complete
— = In progress
✖ = Not initiated

	DRAFT SCHEDULE								
Status	TASK	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
✓	Contract Start Date								
✓	Kickoff Meeting								
✓	Data Collection								
✓	Basis of Design & Criteria								
✓	Public/Stakeholder Involvement Plan								
—	Technical Advisory	1th	7th	7th		14th			
—	Steering Committee	13th		14th					
✖	Public Meeting			22nd		TBD			
—	Public/Stakeholder Involvement Process	14th	12th	16th					
—	Coastal Engineering Analysis	Ongoing							
—	Preferred Alt Selection								
✖	Preliminary Engineering Design	2nd			11th				
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✖	Regulatory Permitting – Documentation	15th				1st			
✖	Permit Process					1st	-	-	30th
✖	Final Engineering Design				22nd	-	-	-	30th

Technical Committee Meeting – 8-16-18
Project Data and Coastal Processes

- Comments and recommendations from the Technical Committee meeting were incorporated into the engineering analysis and Technical Memorandum on Demonstration project data and design criteria was issued and distributed to the Committee members. Further the comments from the Team (mostly D.C.) were incorporated into the Technical memorandum and the Final version that will govern the design of alternatives will be issued for Steering Committee and Public Meeting shortly

Steering Committee Meeting – 9-5-18

- Approved presentation and plan of action by technical committee
- Presented: Data Compilation, Preliminary Analysis Results

Technical Committee Meeting – 11-13-18
Demonstration Project Alternatives

- Approved Alternatives
- New alternative, Beach Nourishment recommended
- Recommended to account the WSDOT study results, conducted by the Corps

Technical Update Outline

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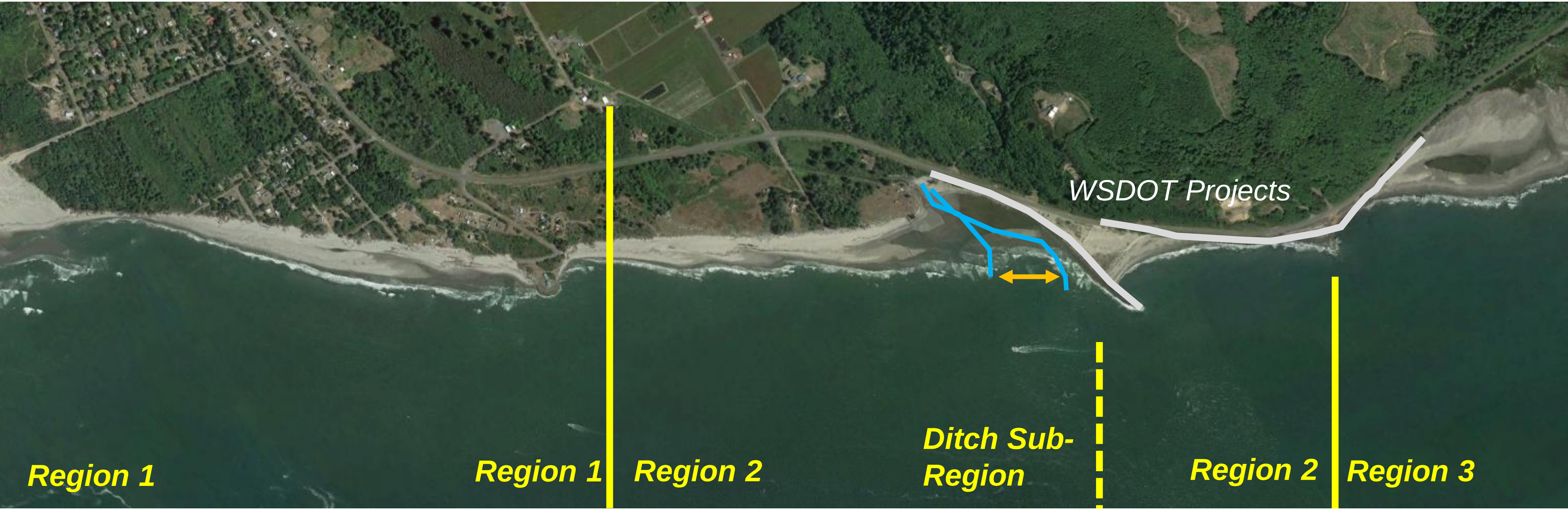
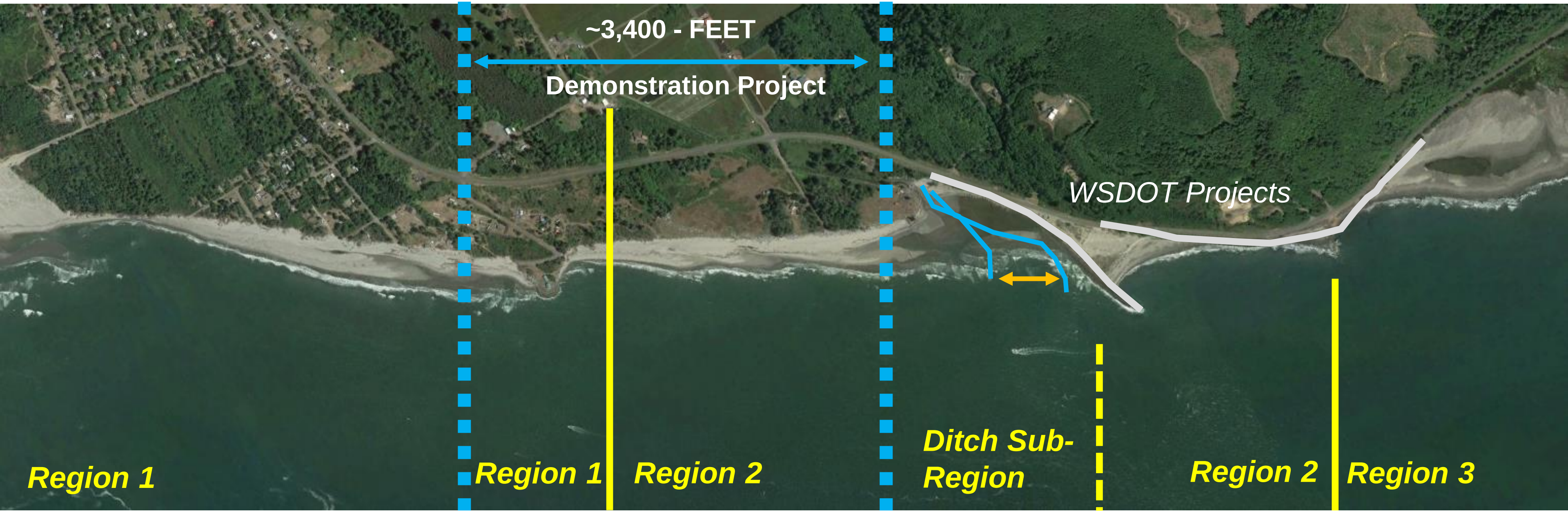
Demonstration Project Extents



1. Cover the beach areas most vulnerable to erosion.
2. Cover the unprotected critical areas of Region 2.
3. Protect highway, drainage district infrastructure, and private properties.
4. Information from demonstration project will be applicable to Region 1 and potentially for Region 3.

Demonstration Project Extents



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2. Cover the unprotected critical areas of Region 2.
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Demonstration Project

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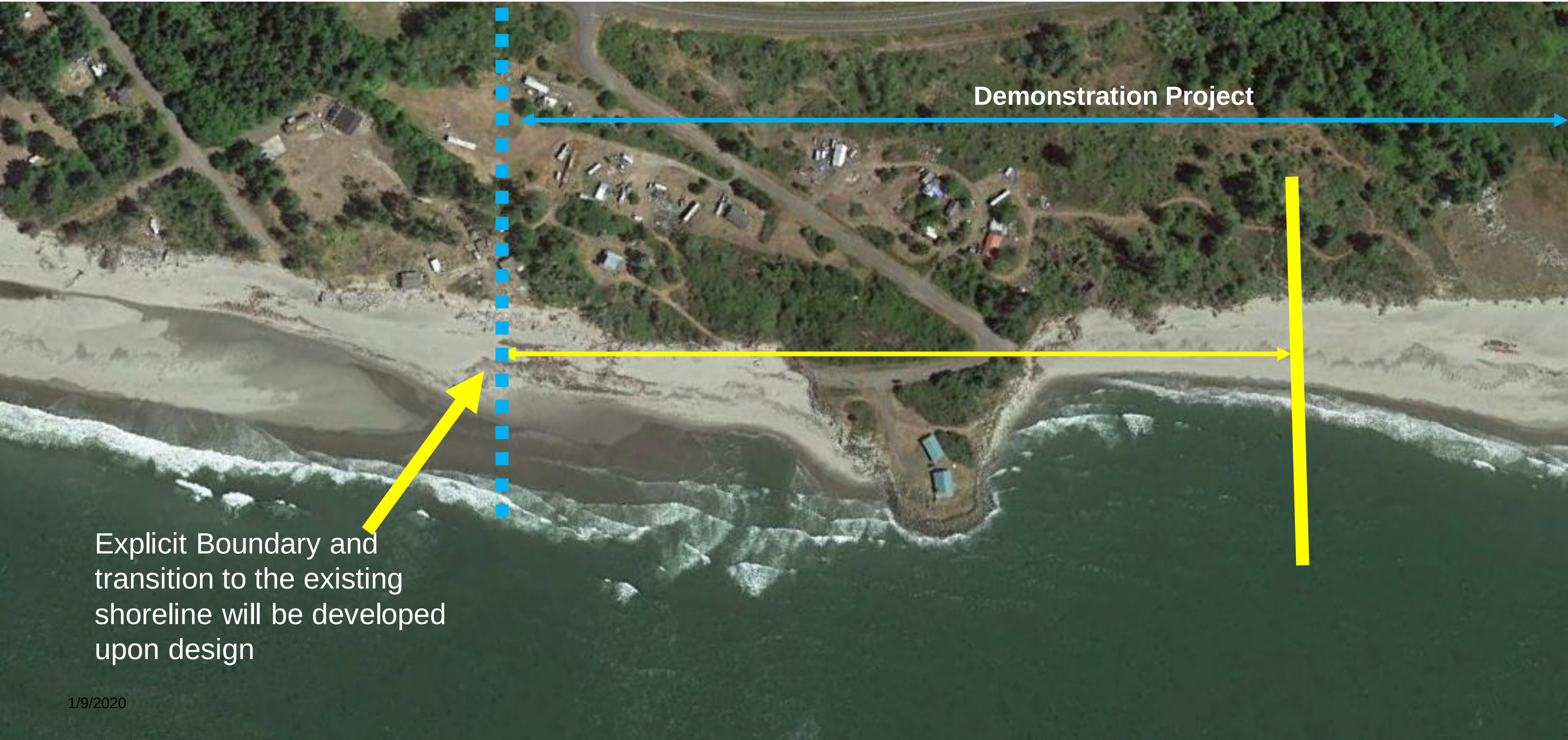
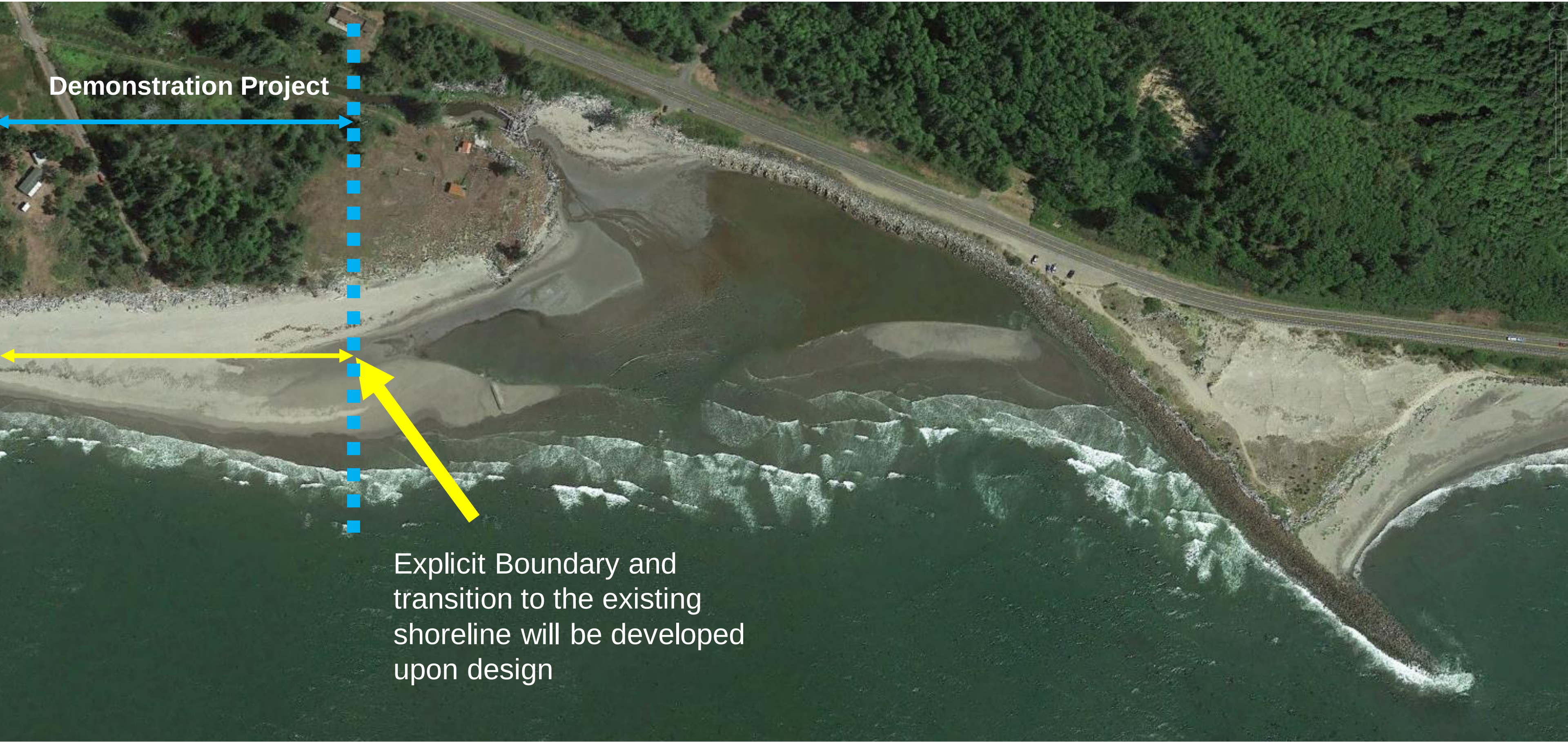
Demonstration Project NW Boundary



Explicit Boundary and transition to the existing shoreline will be developed upon design

1/9/2020

Demonstration Project SE Boundary



Explicit Boundary and transition to the existing shoreline will be developed upon design

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Alternative Screening Process

Sources

- Drainage District
- Pacific County
- WSDOT
- USACE
- Project Team
- Other


Beach Nourishment


Armor Rock Revetment


Dynamic Revetment


Groyne

Sea-Dike


Log Matrix


Dune Construction

Alternatives Screening Criteria

General

- Protect highway from wave erosion and flooding.
- Preclude flooding of cranberry bogs
- Protect private property from land losses- maintain the existing shoreline
- Minimize adverse environmental impacts.
- Maximize beach area, at least during summer period.
- Protection of Tribal lands within the project area.
- Minimize maintenance requirements

Design Wave Storm Event: Withstand forces from wave storm events of 50 to 100 years return period

Tide Elevation Design Criteria: 100-Year Return Period WSE: 14.8 ft MLLW

Design Beach Cross Section: Predicted long-term lowest beach cross section

Demonstration Project Limits: Vicinity of Regions 2 with possible extension to Region 1. “Ditch Area” is not included as Demonstration Project but will be addressed under Masterplan Project.

Project Life Time - 40 years.

Material Type - Meet performance requirements and existing State and Federal standards

List of Screened Alternatives for Further Evaluation

- Dynamic Revetment
- Conventional Revetment
- Low Crest Revetment

  w/Overtopping Protection Sacrificial Berm
- Advance Burial Armor Rock

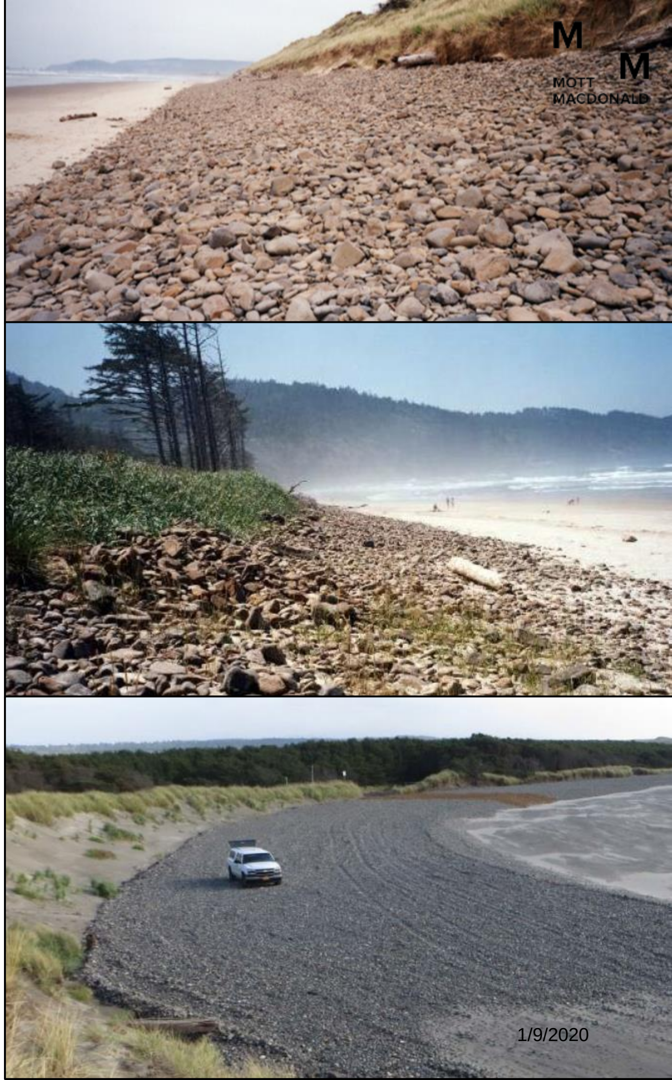
  w/Sacrificial Berm
- Beach Nourishment

Dynamic Revetment Alternative

- Compilation and review of available pertinent data
- Prototype analysis
- Engineering analysis of the dynamic revetment alternative
- Recommended dimensions
- Estimated maintenance requirements

Dynamic Revetment Prototypes

- Pacific Coast Cobble Beaches
- Cape Lookout State Park
- Columbia River South Jetty
- WSDOT Dynamic Revetment - Willapa
- Hatfield Marine Science Center
- Ediz Hook – Gravel/Cobble Beach Nourishment
- North Cove – Drainage District



Prototype Construction Volumes

Prototype	**Toe Elevation**	**Volume**	**Performance Characteristics** ***(Estimated)***	**Notes**
Cape Lookout	~MSL	~20 CY/LF	Intermediate	Open coast
Columbia River Jetty	>MHHW	40 CY/LF	Safe/ Intermediate	Open coast
Allen (OR Coast)	~MSL	~30 CY/LF	Safe/ Intermediate	Open coast
Drainage District	>MHHW	1-5 CY/LF	High Maintenance	Oblique waves
WSDOT	>MHHW	5-8 CY/LF	Safe/ Intermediate	Wide forebeach
Ediz Hook	~MLLW	12 CY/LF	Intermediate	Ripap
Hatfield	~MSL	~ 1CY/LF	Intermediate	Protected Bay

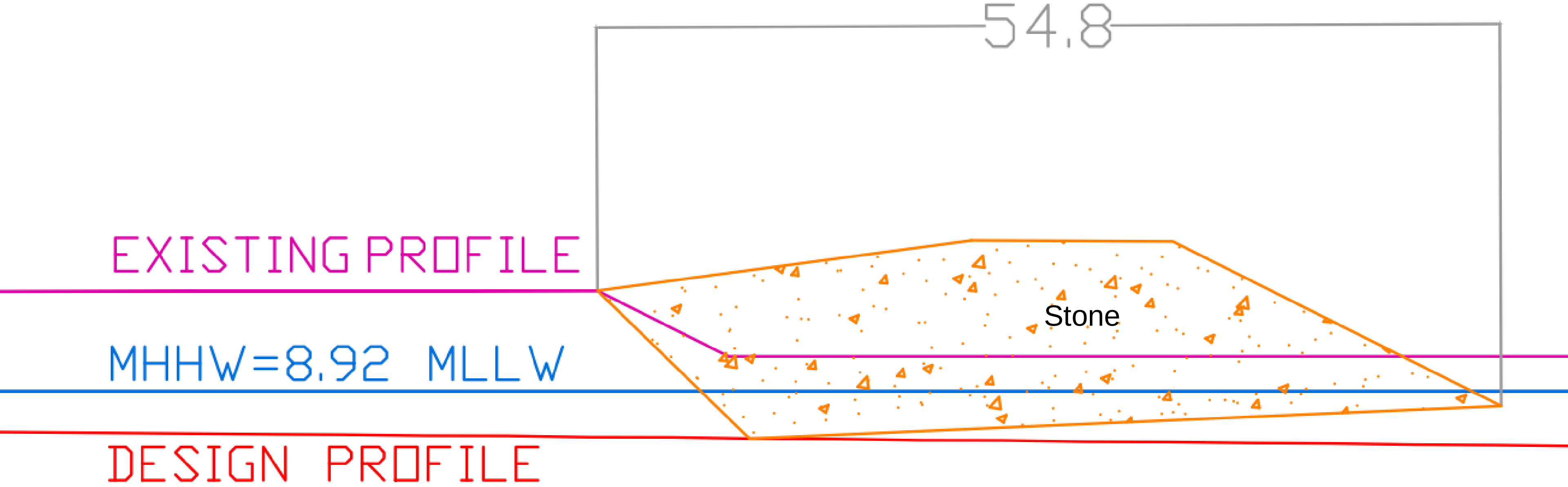
Maintenance Prototypes: Dynamic Revetment

Project	Maintenance Interval	Maintenance Volume (relative %)	Toe Elevation
Cape Lookout	5yrs	25-30%	~MSL
Ediz Hook	5-12yrs	30%	MLLW
Columbia River	10-15yrs (expected).	10-25%	>MHHW

- **Toe Elevation:** Material installed lower on the beach profile likely require replacement sooner than higher on the beach
- Storm waves may displace stone into deep channel (lost)
- **Material quality:** affects maintenance interval
- Poor quality rock fractures into smaller rock → lost offshore in smaller events
- **Oblique waves:** increase maintenance requirements
- **Preliminary Assumption:** 30-40% replacement every 5 years
- Less initial rock → more maintenance

Alt. 1: Dynamic Revetment (10-25 CY/LF)

Example: 16 CY/LF



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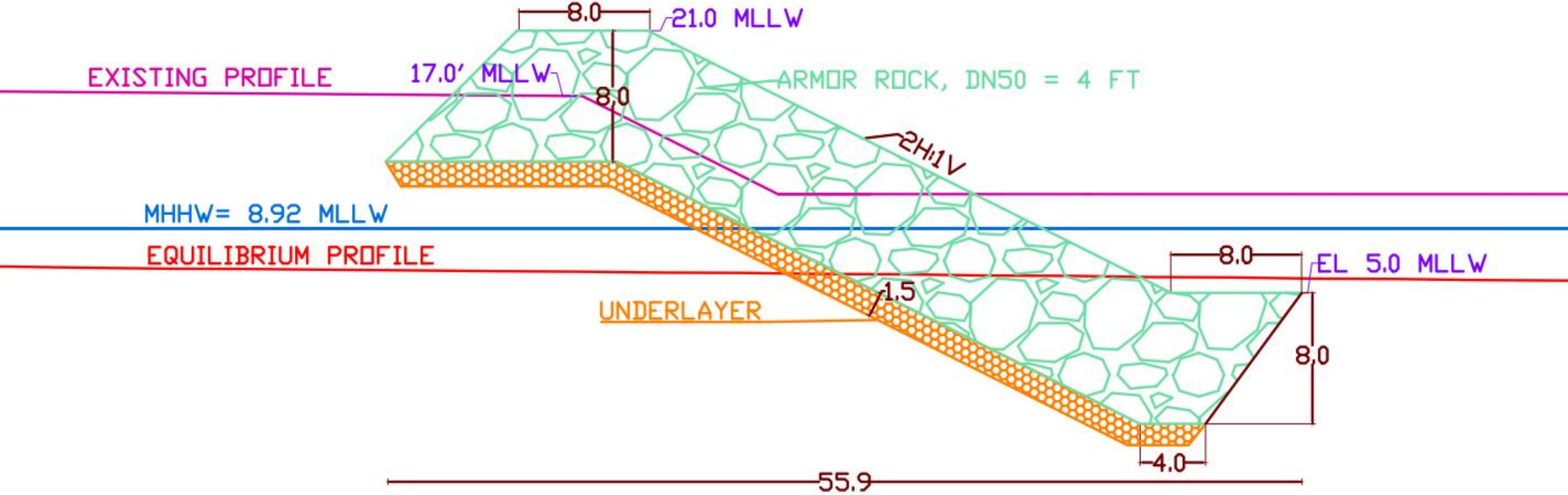
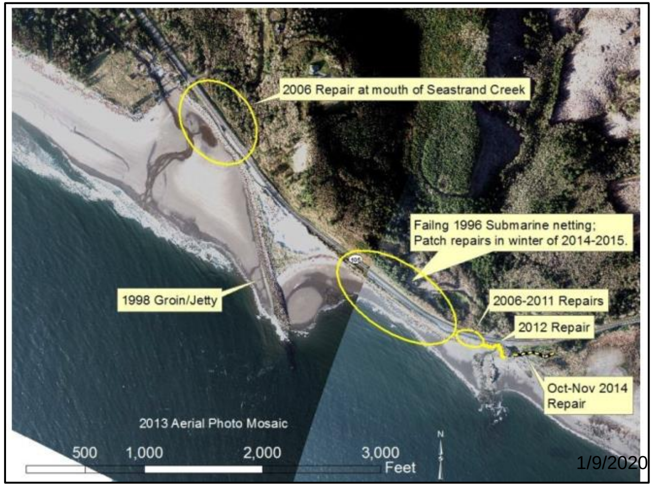
  w/Sacrificial Berm

Alt. 2: Conventional Revetment

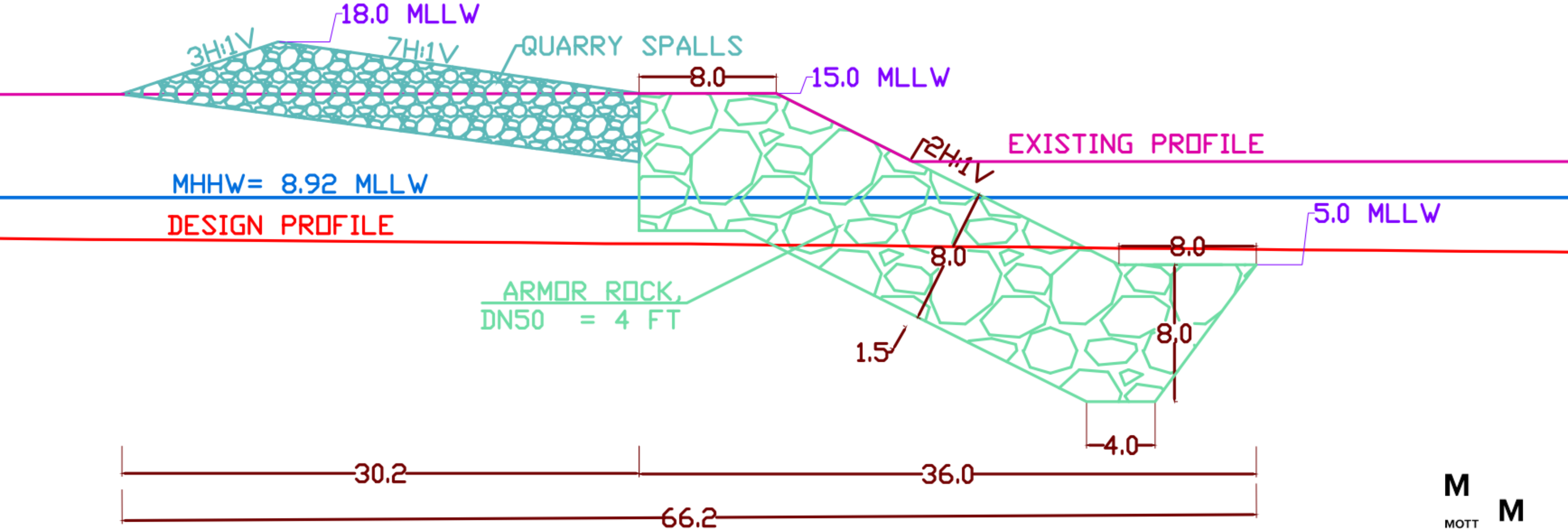


Maintenance Requirement

Project	Maintenance Interval	Maintenance Volume (relative %)
US Army Corps of Engineers Practice	20yrs	25-30%
Local DOT experience	6-20yrs	Varies



Alt. 3: Low Crest Revetment with Overtopping Protection Sacrificial Berm



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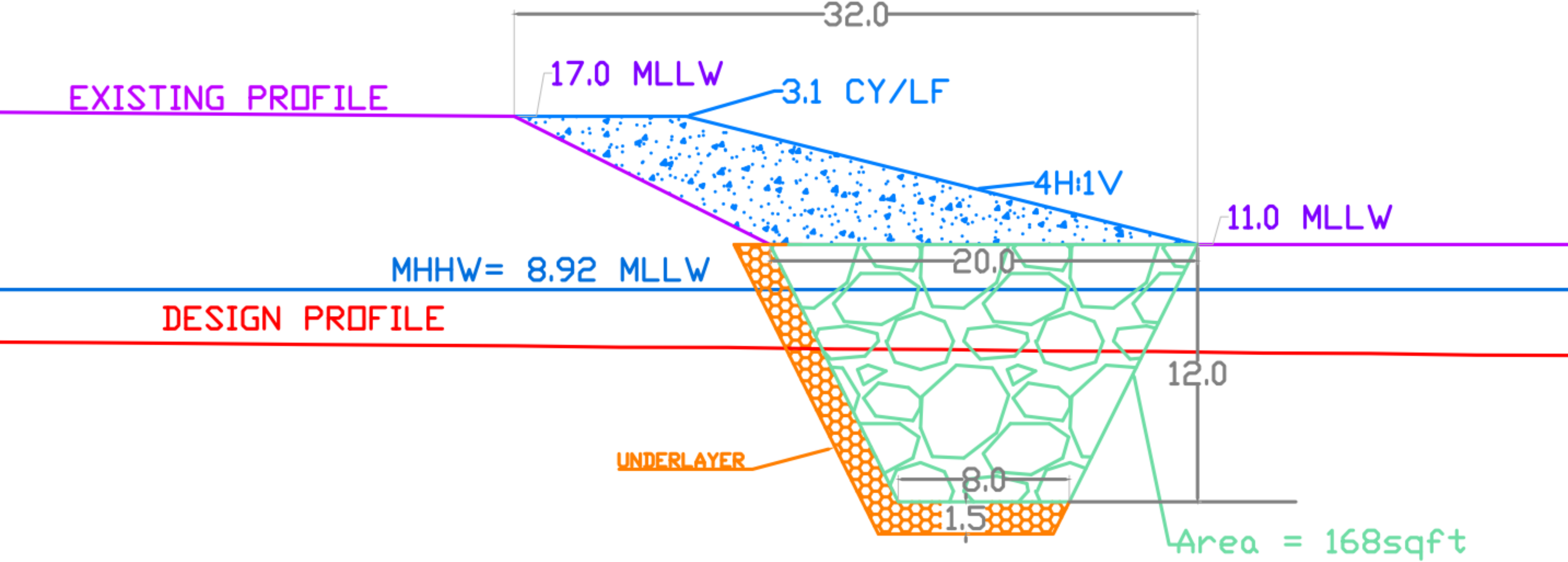
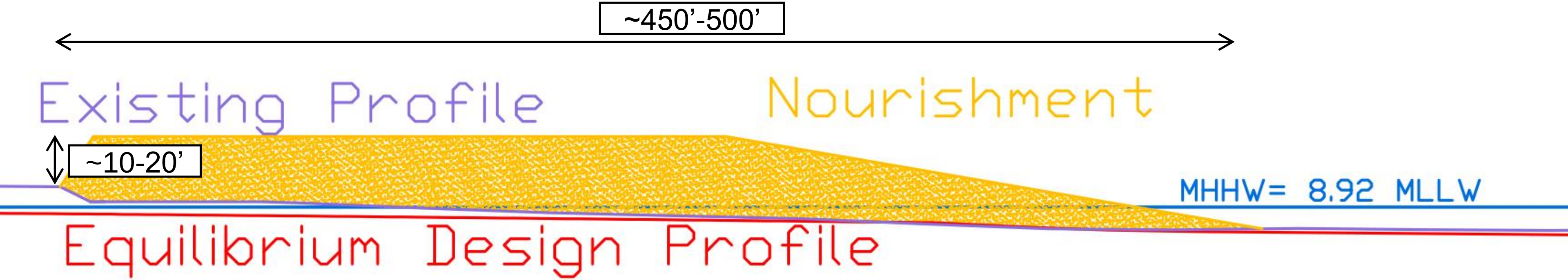
Alt. 4: Advance Burial Armor Rock with Sacrificial Berm



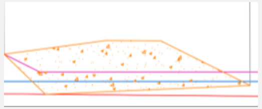
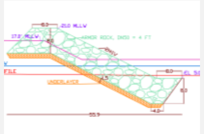
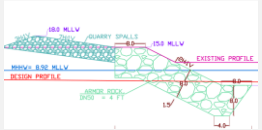
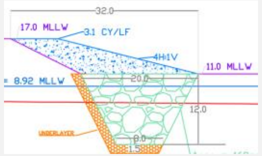
Alternative 5, Beach Nourishment

Alternative 5, Beach Nourishment

~400 CY/LF Material



Benefits/Risks – Alternatives

<u>**Cross-Section Alternative**</u>	**Benefits**	**Risks**
Dynamic Revetment 	• Natural in appearance • Simple installation • Less susceptible to toe scour • May be naturally buried by sand in summer	• Frequent maintenance may be required • Cobbles can be strewn upland • Largest footprint • Potentially large area waterward of MHHW
Conventional Revetment 	• Standard Design • Low maintenance • Reduces overtopping (not a criteria) • Upland of MHHW	• Exposed large rock structure
Low Crest Revetment with Overtopping Berm 	• Shorter (upland) than conventual revetment • Minor reduction of overtopping • Upland of MHHW	• Exposed large rock toe structure • Overtopping berm maintenance
Buried Revetment with Sacrificial Berm 	• Narrow footprint • No exposed rock until beach lowers • Similar appearance to dynamic revetment upon construction • Upland of MHHW	• Loose armor rock structure may require higher levels of maintenance in future • Performance of two material types • May require more rock
Beach Nourishment 	• Wider beach, recreational benefits • Natural in appearance	• Large area waterward of MHHW • Frequent maintenance may be required

Qualitative Cost Estimate

Cross-Section Alternative	**Capital Cost**	**Maintenance Cost**	**Total Cost (TBD)**
Dynamic Revetment	**Low (10CY) - Medium (20CY)**	**High**	
Armor Rock Revetment	**High**	**Low**	
Low Crest Revetment with overtopping Berm	**Medium**	**Medium**	
Buried Revetment with Sacrificial Berm	**Medium/Low**	**Medium**	
Nourishment	**High**	**High**	

Alternative Discussion

- **Alternatives developed assuming no change of existing shoreline but the worst case scenario of the bottom slope**
- **Quality of materials is important for all alternatives**
- **Cost estimate should include lifecycle costs (40-yr life)**
- **Alternatives can likely be installed above (present) MHHW line (depending on final dynamic revetment volume)**
- **Maintenance vs. Capital costs**

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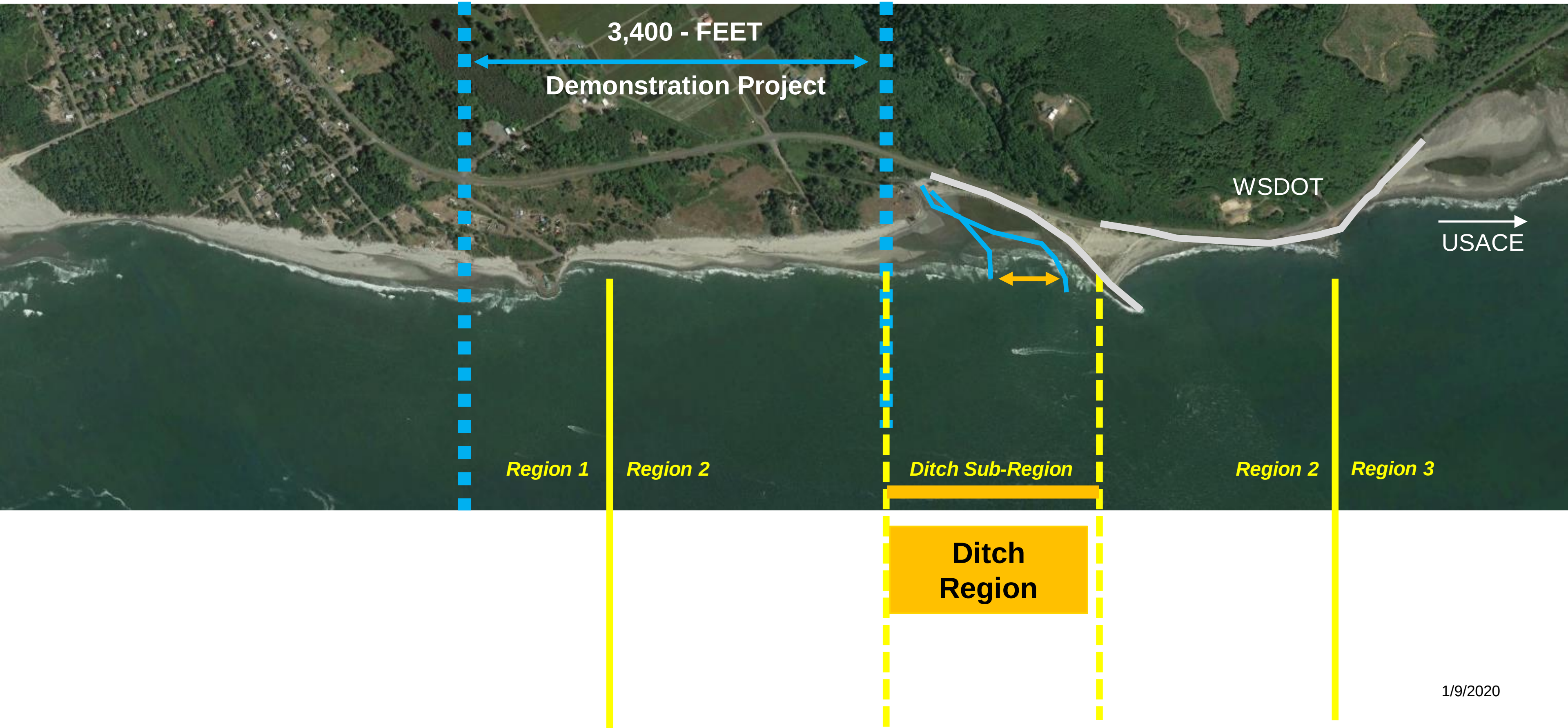
- Summary/Next Steps

Region 2 Master Plan Considerations



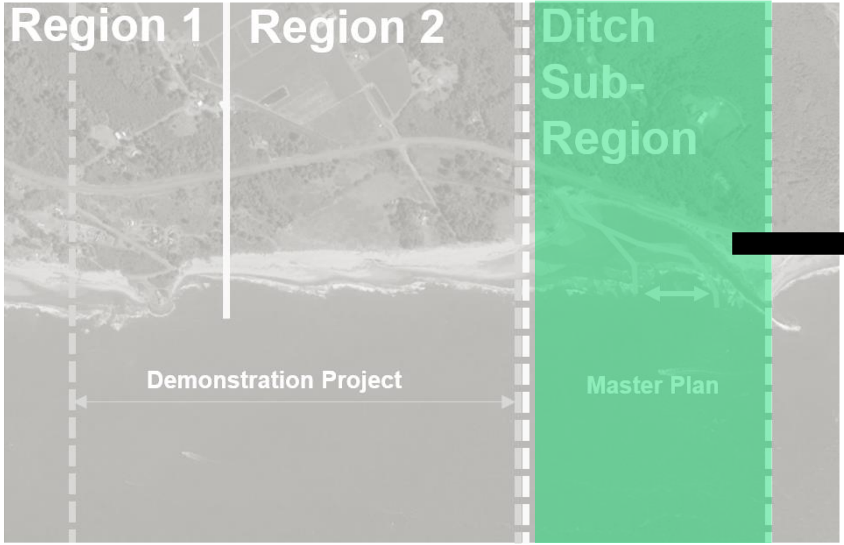
Ditch Summary

- Formation of a deep trench has occurred in the area where ditch outflows meets the tidal channel slope. Justifiable explanation to this phenomena has not been developed yet. It may be result of wave or/and flow hydrodynamics, slope instability, avalanching, all of the above, or other.
- Apparently the process of trenching and deepening of the slope and ditch meandering is still going on. It is recommended do not site the demonstration project at the vicinity of this area until clear understanding on this process is achieved.
- Ditch has created significant obstruction to longshore sediment to SE
- Dynamics of ditch results in excessive loss of sand to channel

1/9/2020

Ditch-Sub Region – Master Plan Update

Project Boundaries



Type of Alternatives

- No Action
- Ditch Relocation
- Sediment Retention

No Action

Possible restriction on deepwater trench development

Continued beach material lost offshore

1/9/2020


Ditch Alternative 1
Ditch Relocation
North Cove
500'
2900'
Culvert
←Trench
Conduit →
Culvert
© 2018 Google
Google Earth

1/9/2020

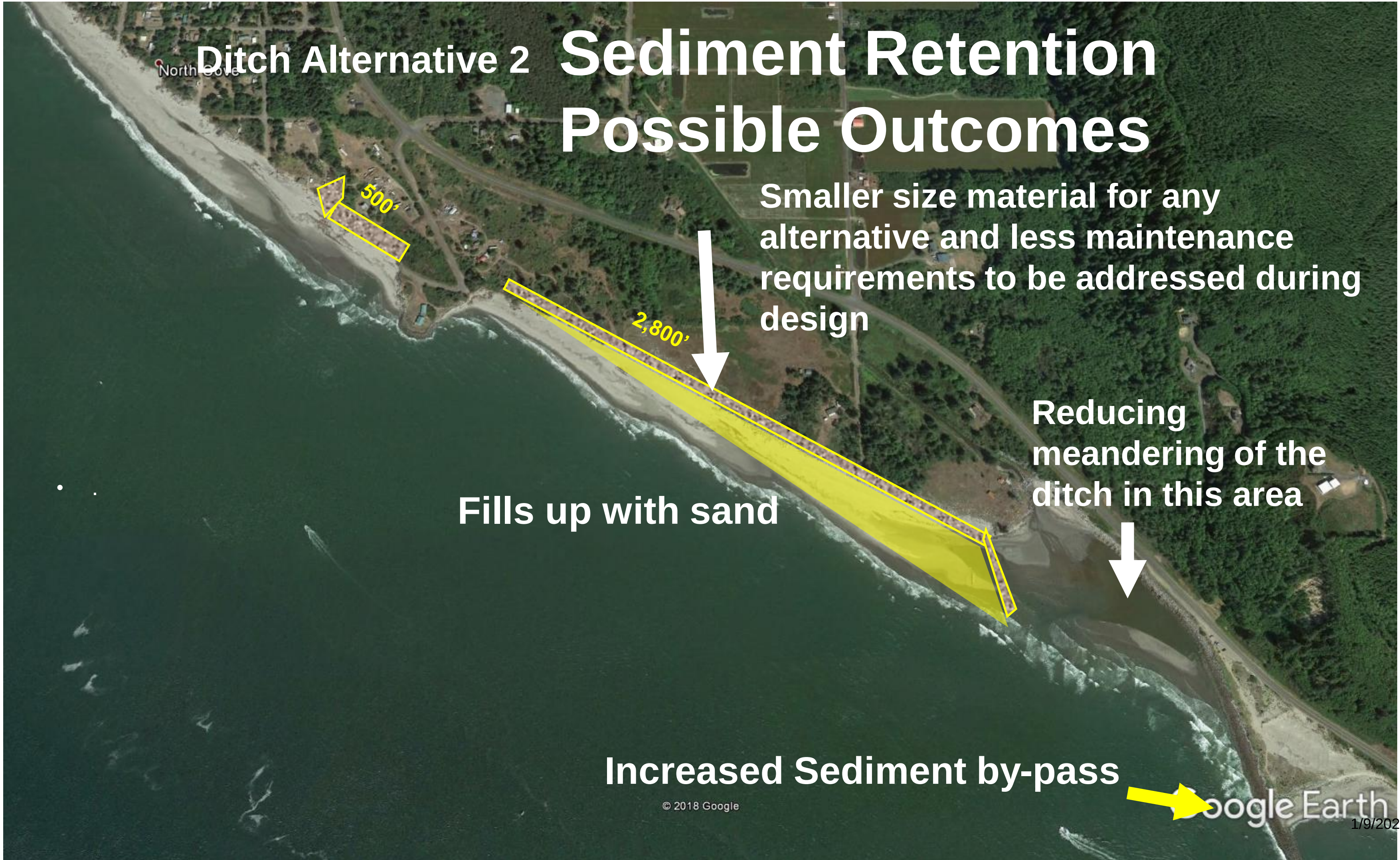
Ditch Alternative 1

Ditch Relocation Expected Outcome

Some complications may occur at the new outflow area to be addressed during design

Ditch Alternative 2 Sediment Retention

Sediment Retention Possible Outcomes



Ditch Alternative 2

Smaller size material for any alternative and less maintenance requirements to be addressed during design

Fills up with sand

Reducing meandering of the ditch in this area

Increased Sediment by-pass

1/9/2020

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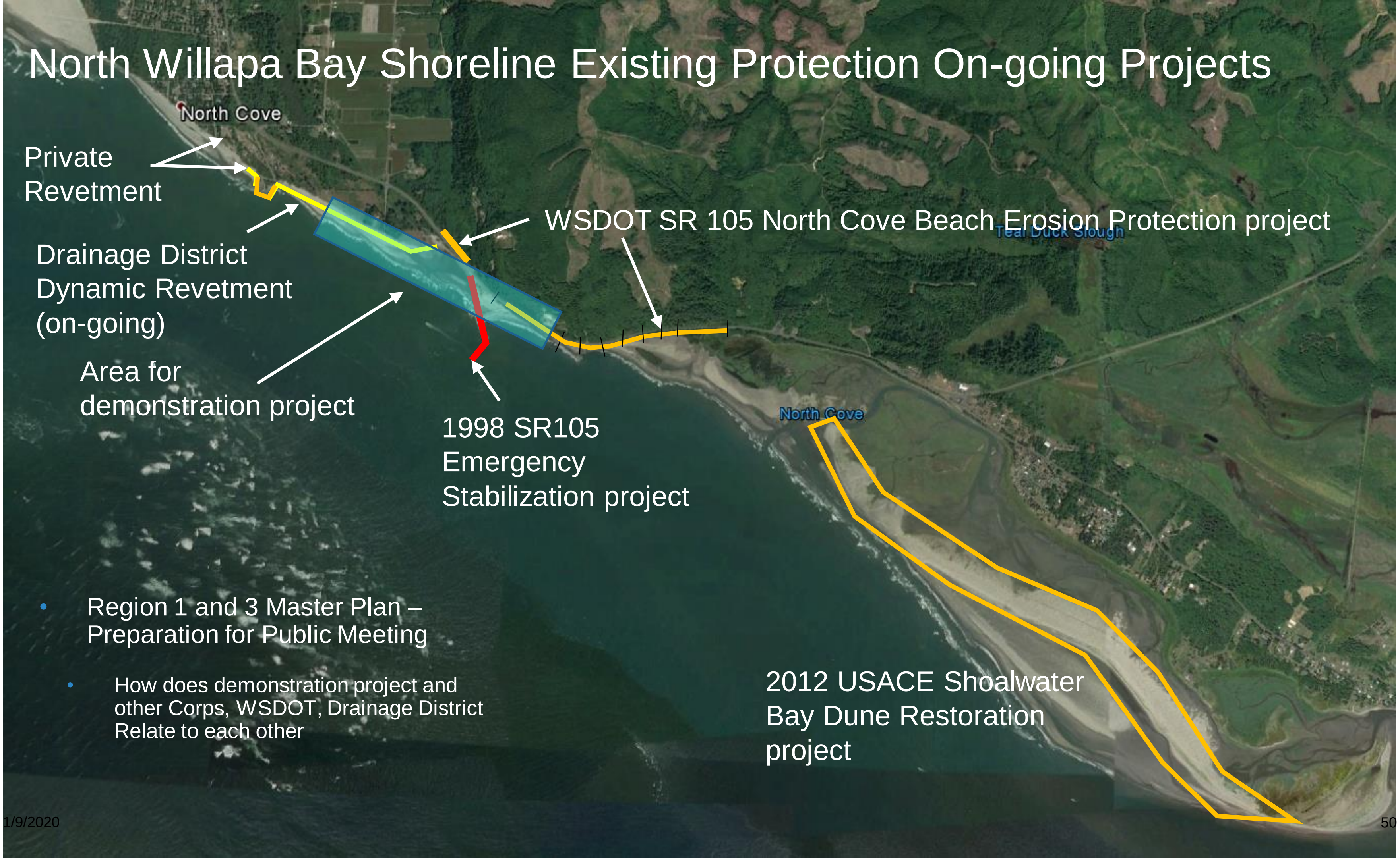
Next steps

- Dynamic revetment material
- Cost Estimates
- Master Plan screening
- Steering Committee Update – Jan 2019
- Preferred Alternative Selection
- Public Meeting – Jan 2019
- Preliminary Design and Permitting

North Willapa Bay Shoreline Existing Protection On-going Projects



Private Revetment

Drainage District Dynamic Revetment (on-going)

Area for demonstration project

WSDOT SR 105 North Cove Beach Erosion Protection project

1998 SR105 Emergency Stabilization project

2012 USACE Shoalwater Bay Dune Restoration project

- Region 1 and 3 Master Plan – Preparation for Public Meeting
  - How does demonstration project and other Corps, WSDOT, Drainage District Relate to each other

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Public Meeting Prep • Expectations • Dates • Content responsibilities • Other?	Engage / Feedback	Kelly
Next steps	Inform	Kelly
Adjourn		

CAP Section 103

US Army Corps of Engineers

✓ Project application **approved**

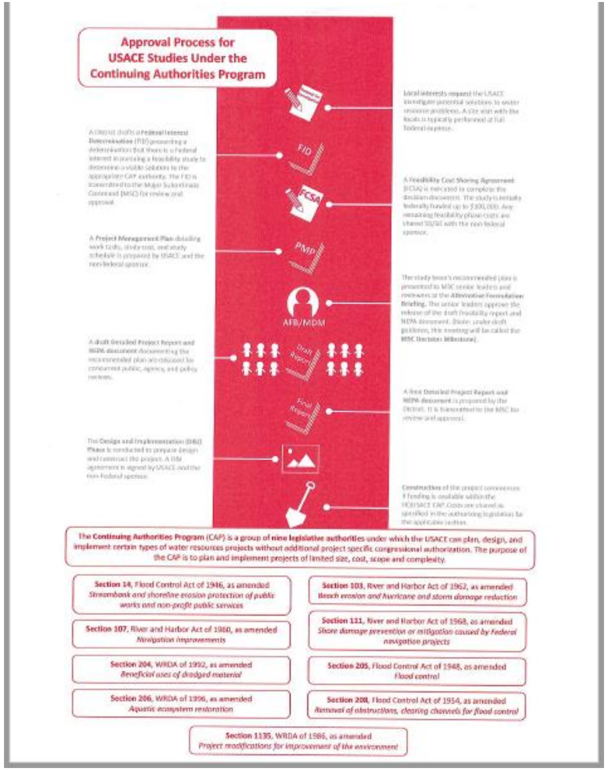
Next steps:

1. Federal Interest Determination
2. Feasibility Cost Share agreement
3. Project Mgmt Plan

Feasibility: the first $100K funded by ACE, remainder cost-shared 50/50 with PacCo

Construction: cost-share 65/35 with PacCo

Workshop with BoCC: **Nov 26 @ 11:30am**



Approval Process for USACE Studies Under the Continuing Authorities Program

The **Continuing Authorities Program** (CAP) is a group of **nine legislative authorities** under which the USACE can plan, design, and implement certain types of water resources projects without additional project specific congressional authorization. The purpose of the CAP is to plan and implement projects of limited size, cost, scope and complexity.

Section 14, Flood Control Act of 1946, as amended
Streambank and shoreline erosion protection of public works and non-profit public services

Section 103, River and Harbor Act of 1962, as amended
Beach erosion and hurricane and storm damage reduction

Section 107, River and Harbor Act of 1960, as amended
Navigation improvements

Section 111, River and Harbor Act of 1968, as amended
Shore damage prevention or mitigation caused by Federal navigation projects

Section 204, WRDA of 1992, as amended
Beneficial uses of dredged material

Section 205, Flood Control Act of 1948, as amended
Flood control

Section 206, WRDA of 1996, as amended
Aquatic ecosystem restoration

Section 208, Flood Control Act of 1954, as amended
Removal of obstructions, clearing channels for flood control

Section 1135, WRDA of 1986, as amended
Project modifications for improvement of the environment

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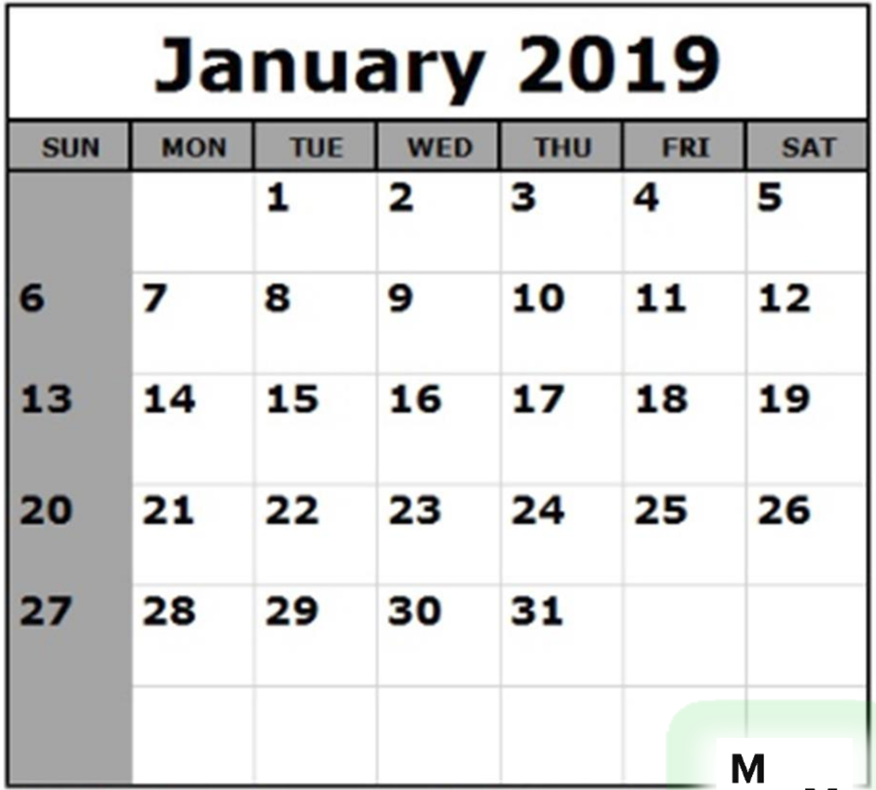
Community Meeting

December 2018

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					



January 2019

SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

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North Willapa Shoreline Protection Demonstration Project

Steering Committee Meeting #2 11-13-2018

Demonstration Project Alternatives

Pacific County, WA

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North Willapa Shoreline Protection Demonstration Project

Steering Committee Meeting # 3, January 31, 2019

Evaluation of Demonstration Project Alternatives

Pacific County, WA

Today's Meeting Agenda

- Project Schedule Update
- Diking District Dynamic Revetment Project
- Demonstration Project Work Progress since 11/13/18 Steering Committee Meeting
- Jan 22 Technical Committee Meeting Summary
- Preparation & Guidance for Community Meeting

Workplan

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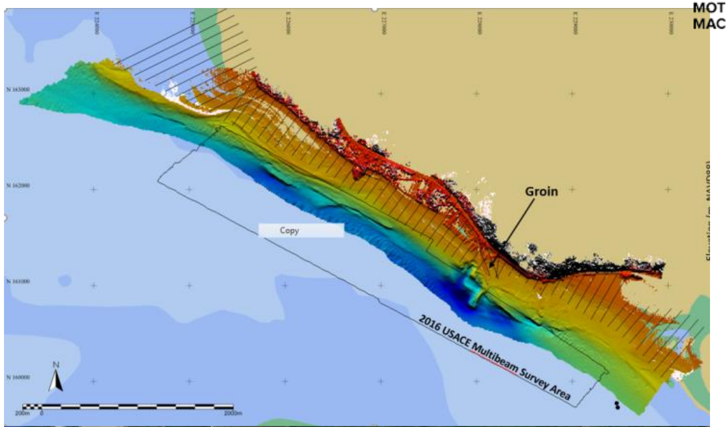

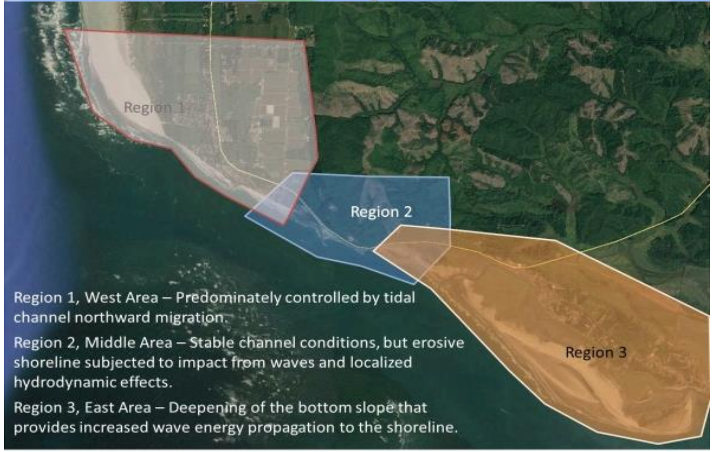

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✖	Final Engineering Design					1st	-	-	30th

Previous, 11-13-2019 Steering Committee Meeting: Information Presented & Next Steps Decisions

- Information Presented
  - Demonstration Project Boundaries
  - Overall and Preliminary Screened Project Alternatives
  - Conceptual design of preliminary screened alternatives
- Next Steps Decisions
  - Refine and select alternatives for analysis and evaluation
  - Developed Preliminary Cost Estimates
  - Develop alternative evaluation criteria
  - Steering Committee Update – Jan 2019
  - Preparation for Public Meeting
  - Preferred Alternative Selection
  - Preliminary Design and Permitting

Refined Project Alternatives

- Demonstration Project Alternatives
- **Beach Nourishment**
- **Dynamic Revetment**
- **Conventional Revetment**
- **Combined Dynamic and Conventional Revetment**
- **Longitudinal Composite of the Above**
- Ditch Region Master Plan Alternatives in Combination with Demonstration Project Alternatives
- **Groin with combination of the above**

Longitudinal Composite Alternative

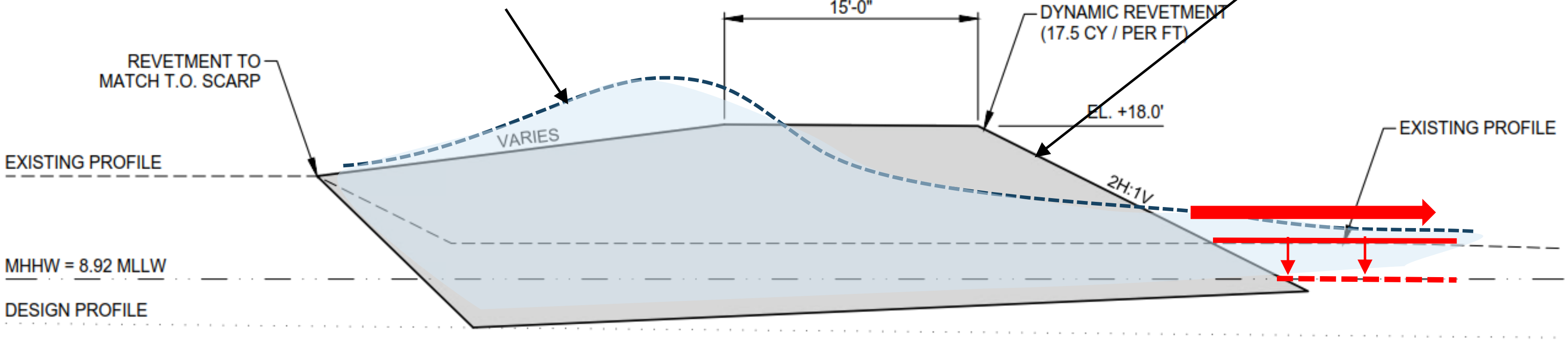
Demonstration Project Boundaries from 11-01-2018 Technical Committee Meeting

Longitudinal Composite Alternative Concept

DYNAMIC REVETMENT

Design- Post construction profile

Projected post-storm profile example



TYPICAL SECTION

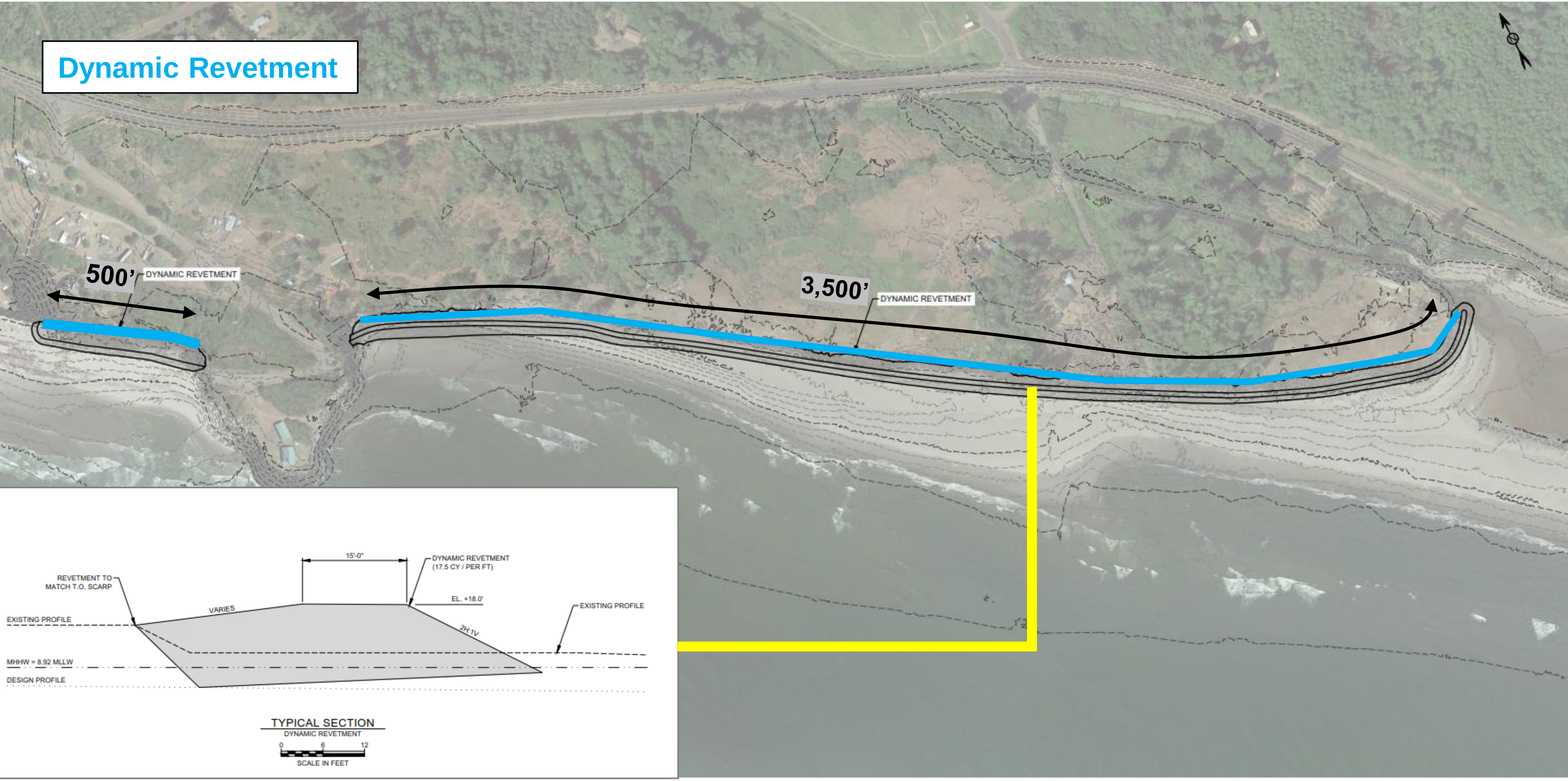
DYNAMIC REVETMENT

SCALE IN FEET

DYNAMIC REVETMENT

- Material: Angular Cobble –12” minus
- Maintenance: 35% replacement every 5 years (or equivalent)

Dynamic Revetment

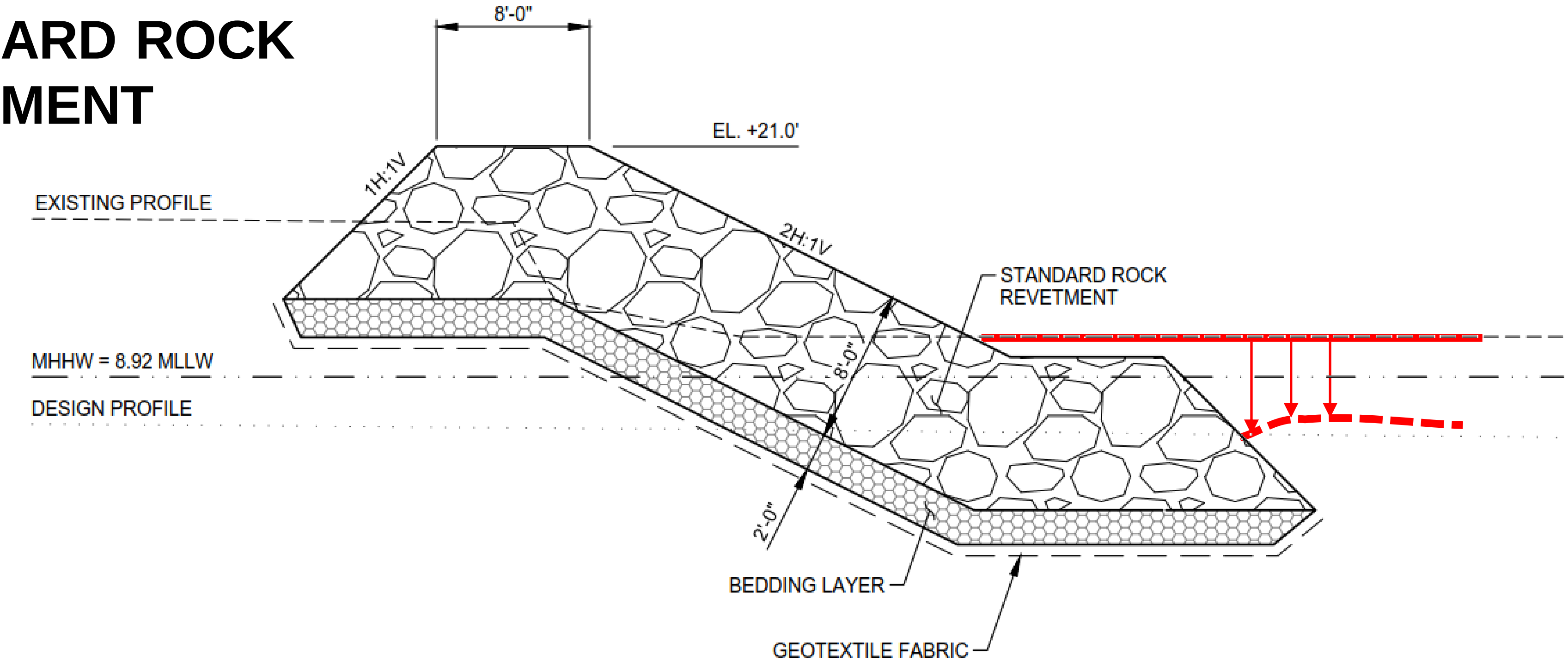


TYPICAL SECTION
DYNAMIC REVETMENT

SITE PLAN
ALL DYNAMIC REVETMENT

0 150 300
SCALE IN FEET

STANDARD ROCK REVETMENT

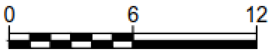


STANDARD ROCK REVETMENT

- Material: Armor Rock (D50 = 4 ft)
- Maintenance: 50% replacement once in 20 years

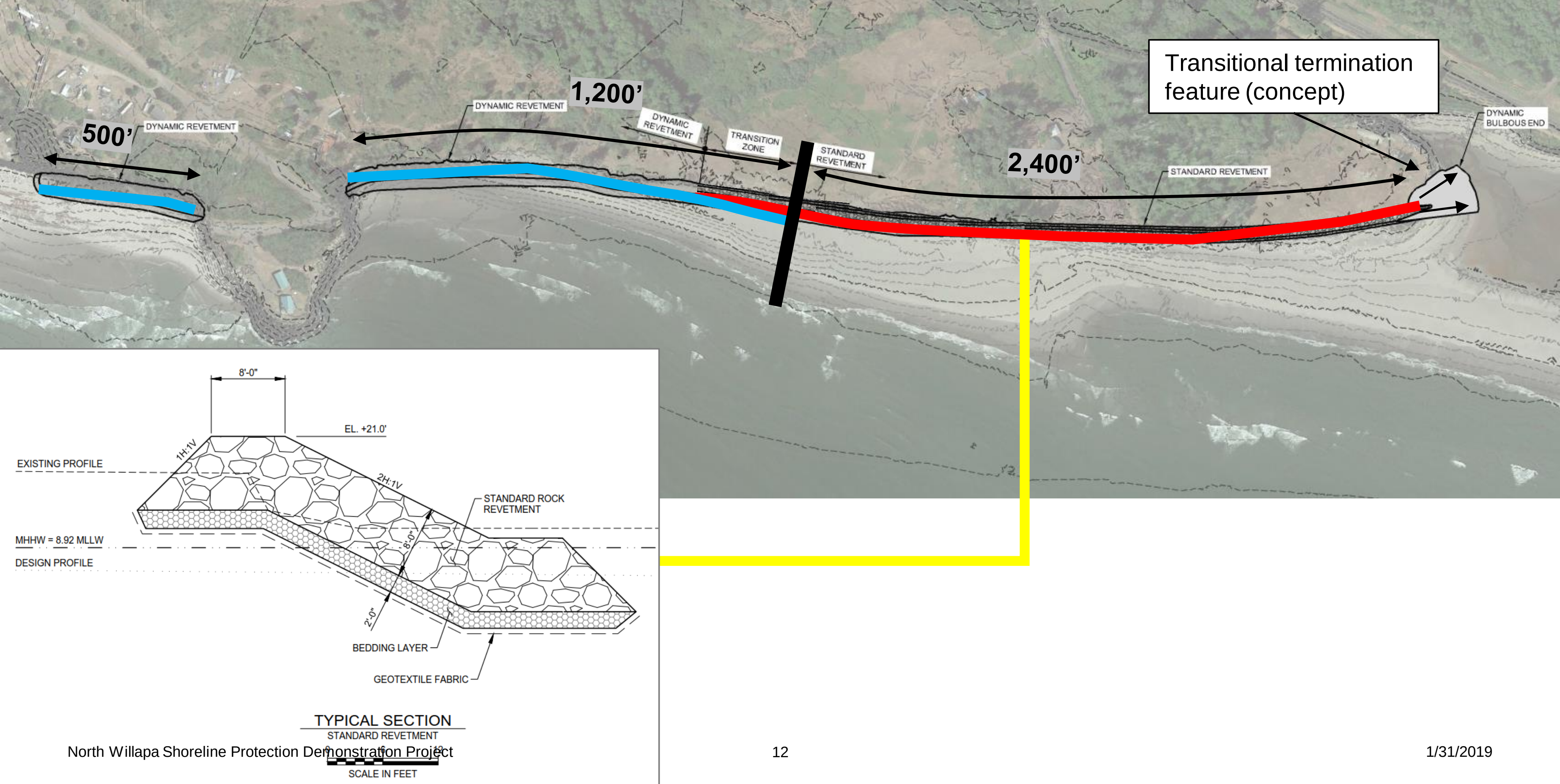
TYPICAL SECTION

STANDARD REVETMENT



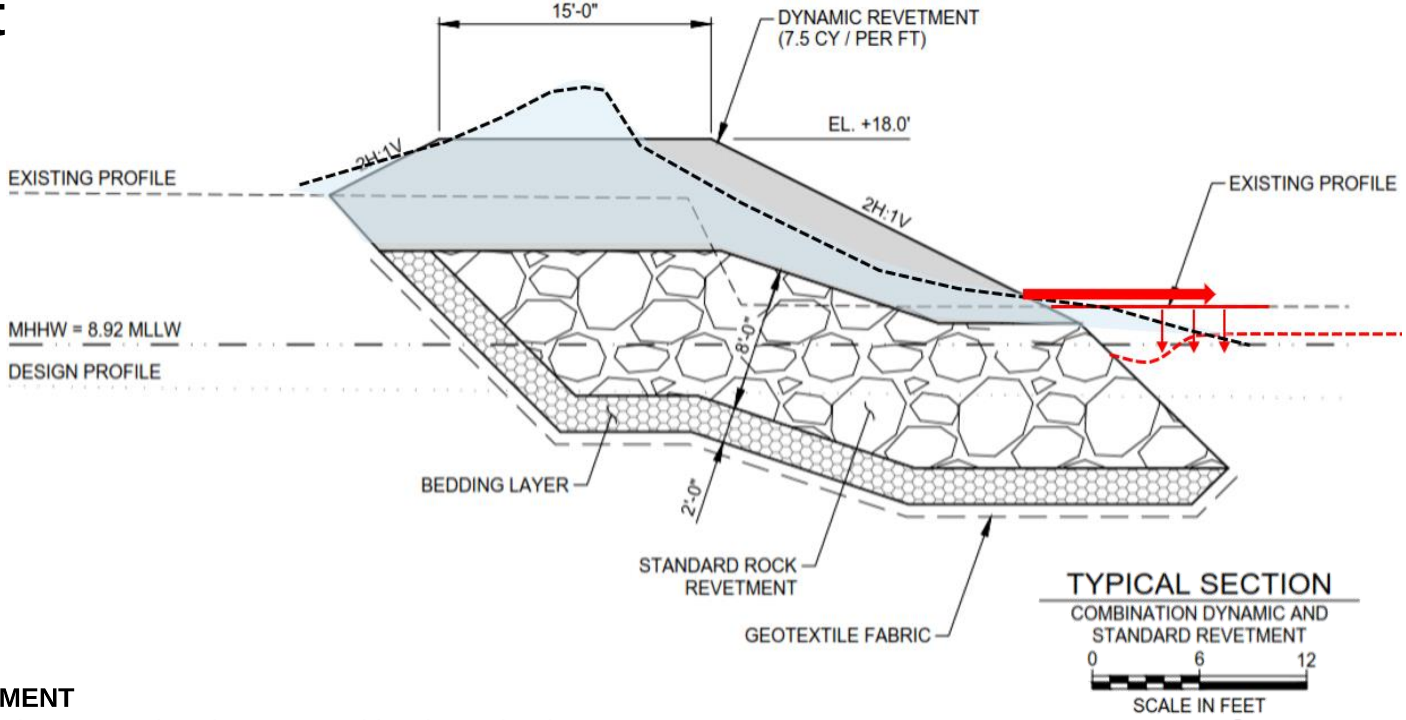
SCALE IN FEET

Dynamic Revetment + Standard Rock Revetment



Transitional termination feature (concept)

Combined Revetment

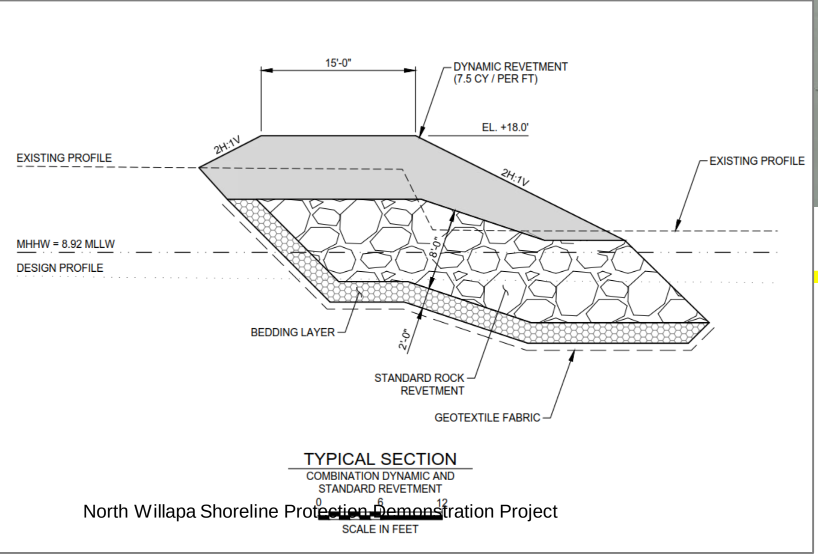


COMBINATION REVETMENT

- <u>Material</u>: Armor Rock (D50 ~3-4ft.) and Angular Cobble (12”-minus)
- <u>Maintenance</u>: 35% original volume of dynamic revetment every 5 years

Dynamic Revetment + Combination Revetment

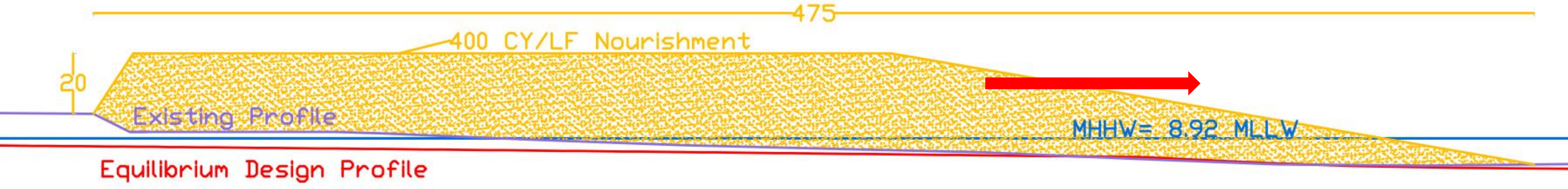
Transitional termination feature (concept)



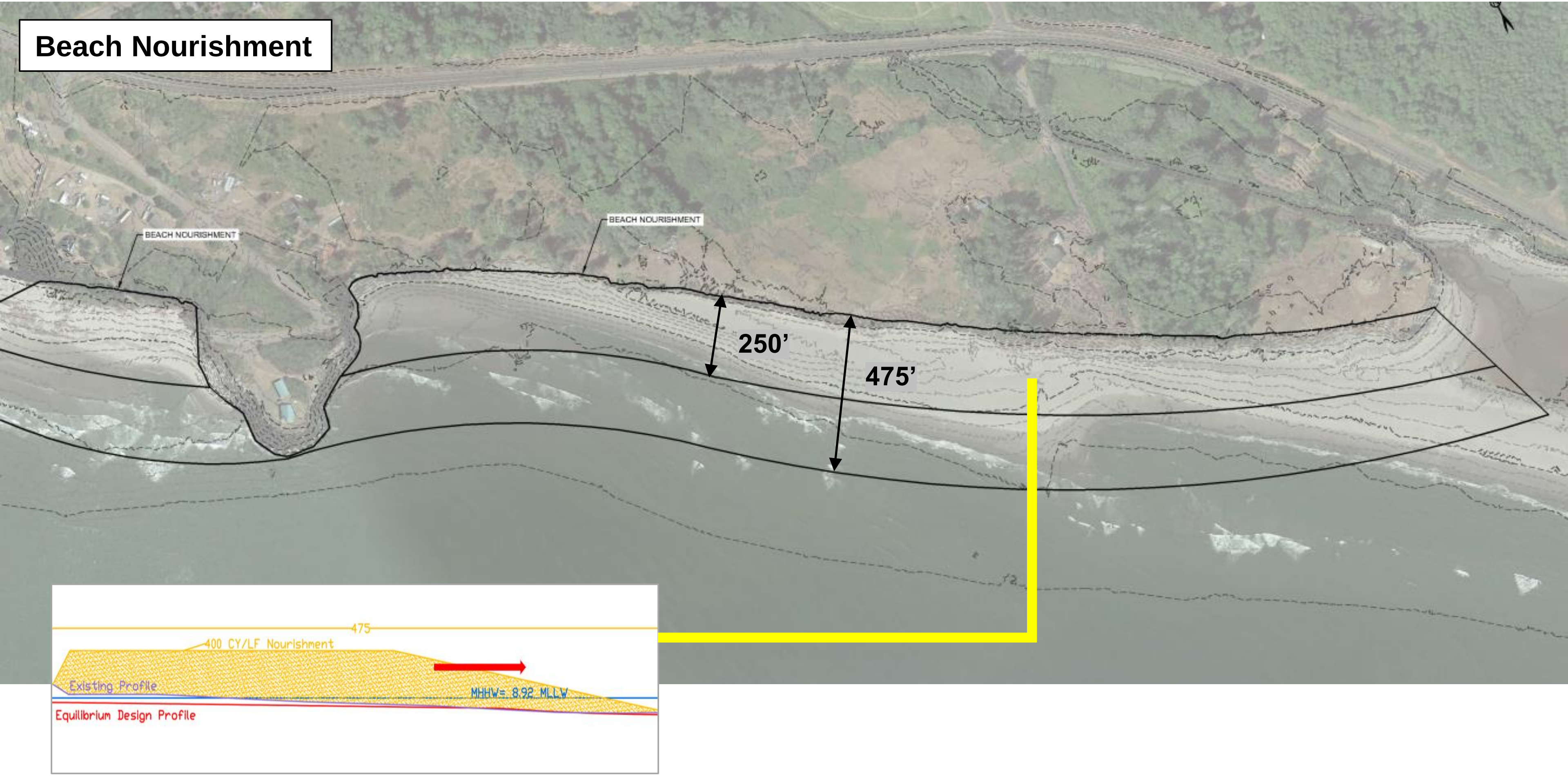
TYPICAL SECTION
COMBINATION DYNAMIC AND STANDARD REVETMENT

Beach Nourishment Alternative

- First time placement volume 400 CY/linear ft
- Maintenance re-nourishment 200 CY/linear ft per 5 years



Beach Nourishment

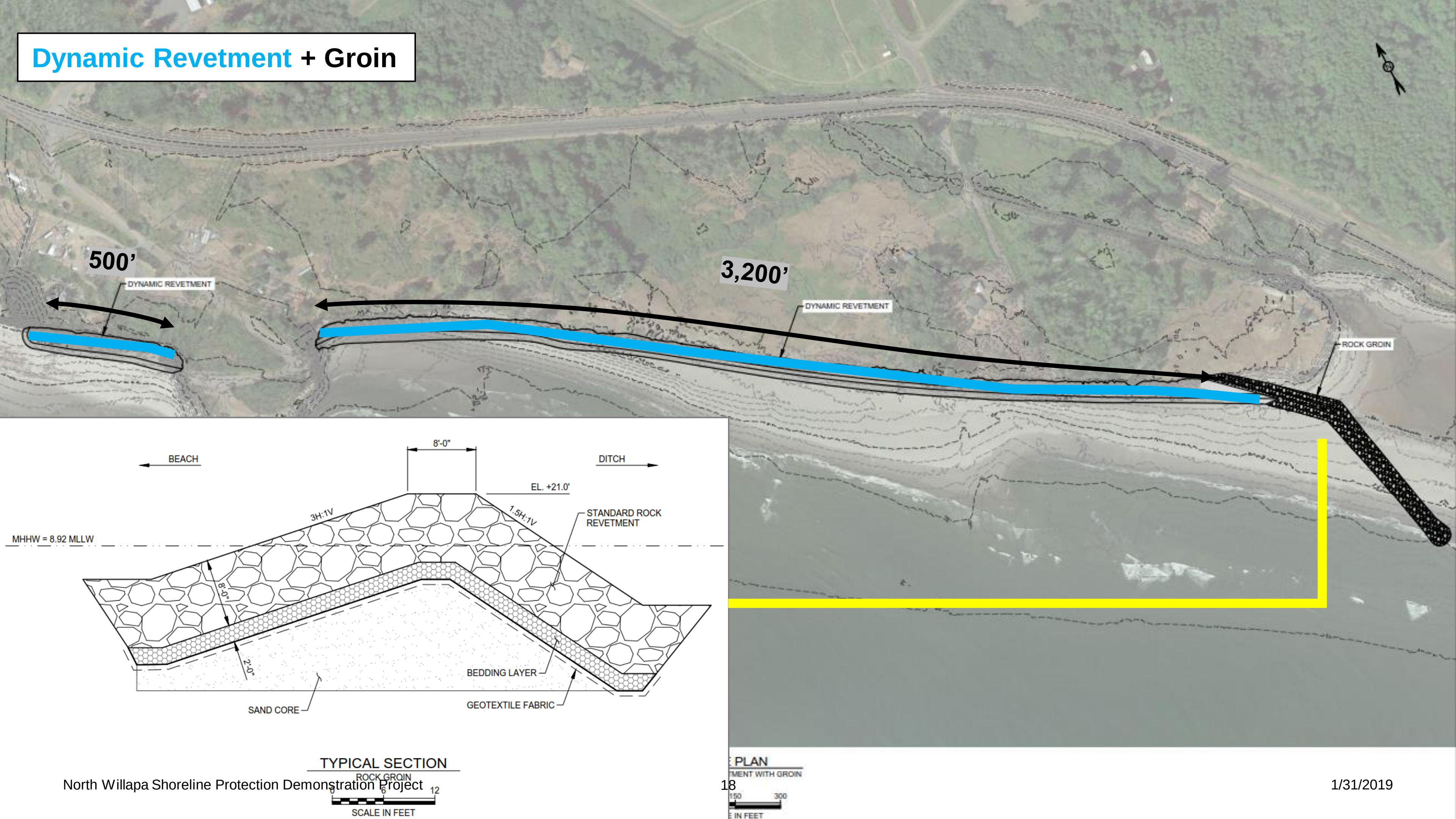


Refined Project Alternatives

- Demonstration Project Alternative
- **Beach Nourishment**
- **Dynamic Revetment**
- **Conventional Revetment**
- **Combined Dynamic and Conventional Revetment**
- **Longitudinal Composite of the above**

- Ditch Region Master Plan Alternatives in Combination with Demonstration Project Alternatives
- **Groin with combination of the above**

Dynamic Revetment + Groin



Hypothesis on Groin Benefits and Risks

- Benefits:
- Provides longevity for dynamic revetment and minimize maintenance cycles
- Results in formation of the beach in front of significant part of the length of dynamic revetment
- Reduce loss of sediment into the deep hole off the ditch
- Enhance southeast bypass of sediment to adjacent shoreline
- Provides protection to the portion of WSDOT revetment

- Risks:
- May result in scour at terminus of new groin
- May complicate hydrodynamics at the Ditch area
- Possible deepening along upper part of existing groin

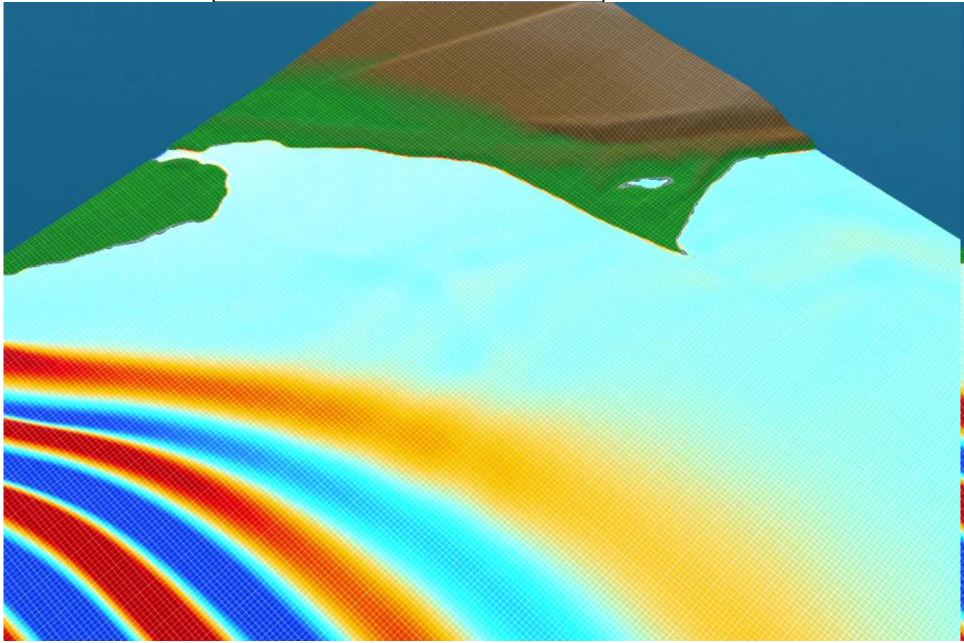
Hypothesis on Groin Benefits

Enhance southeast bypass of sediment to adjacent shoreline

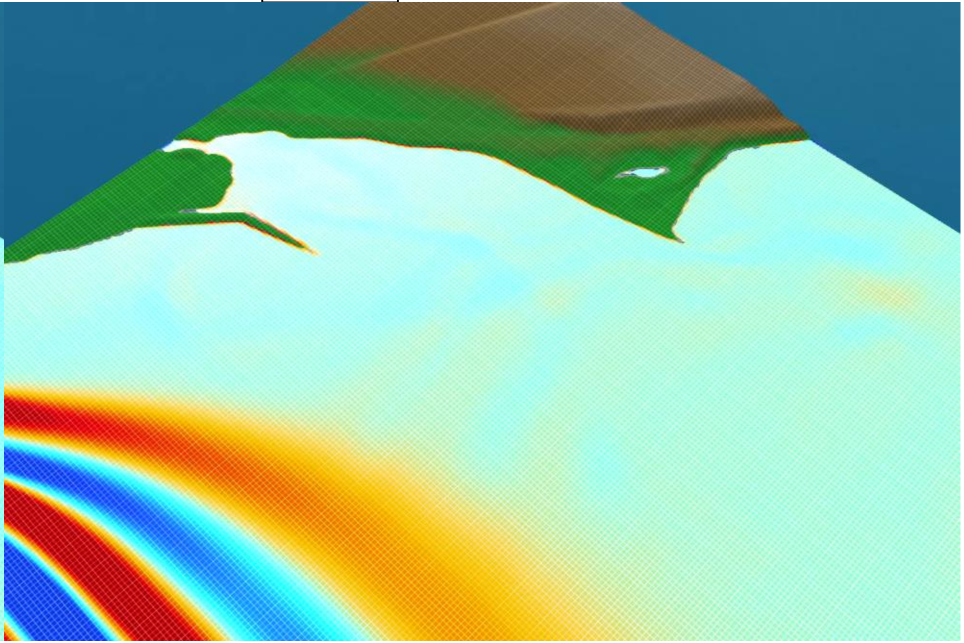
Results in formation of the beach in front of significant part of the length of dynamic revetment

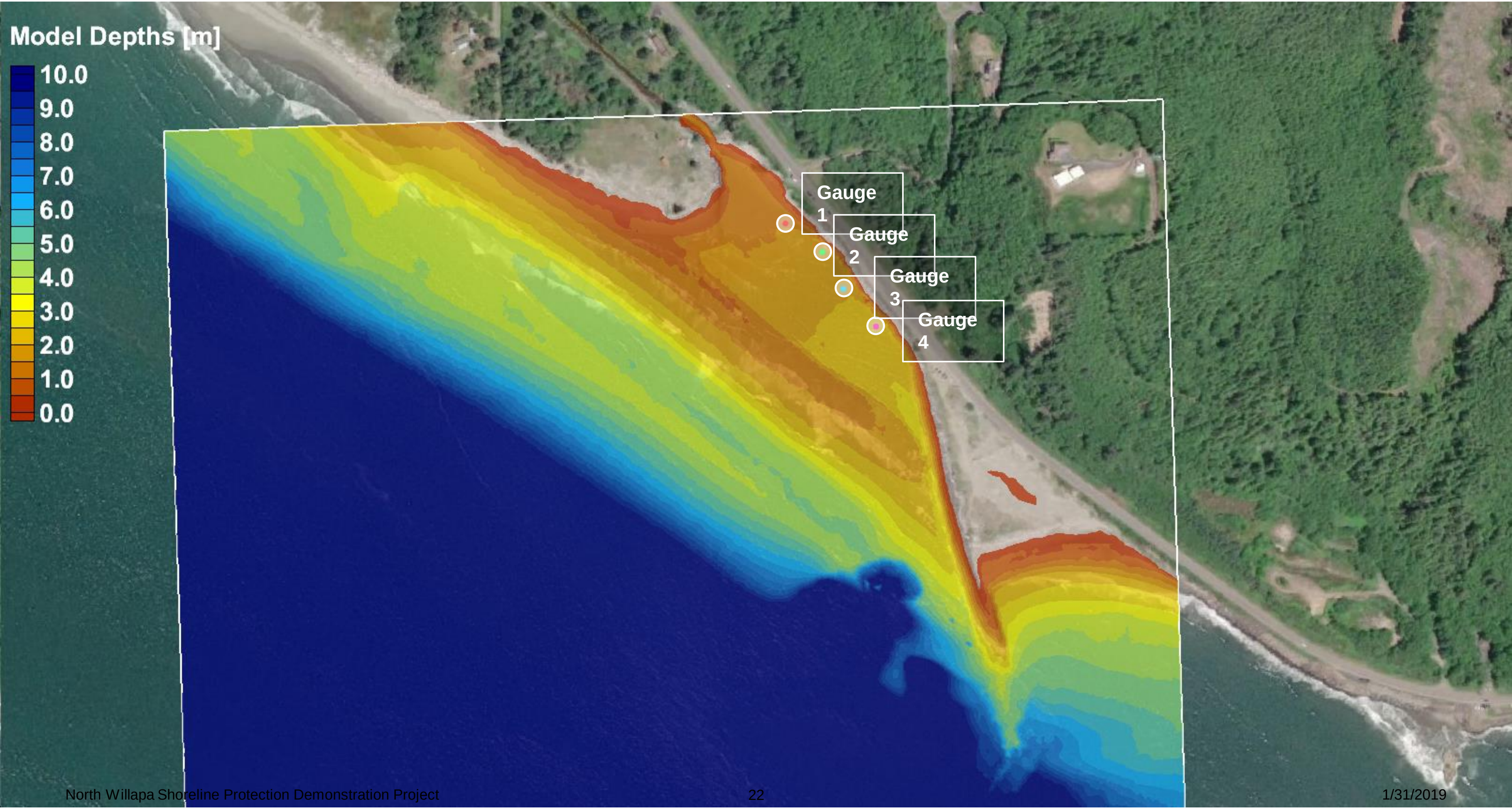
Sediment to be lost into deep hole off ditch in fall/winter period.

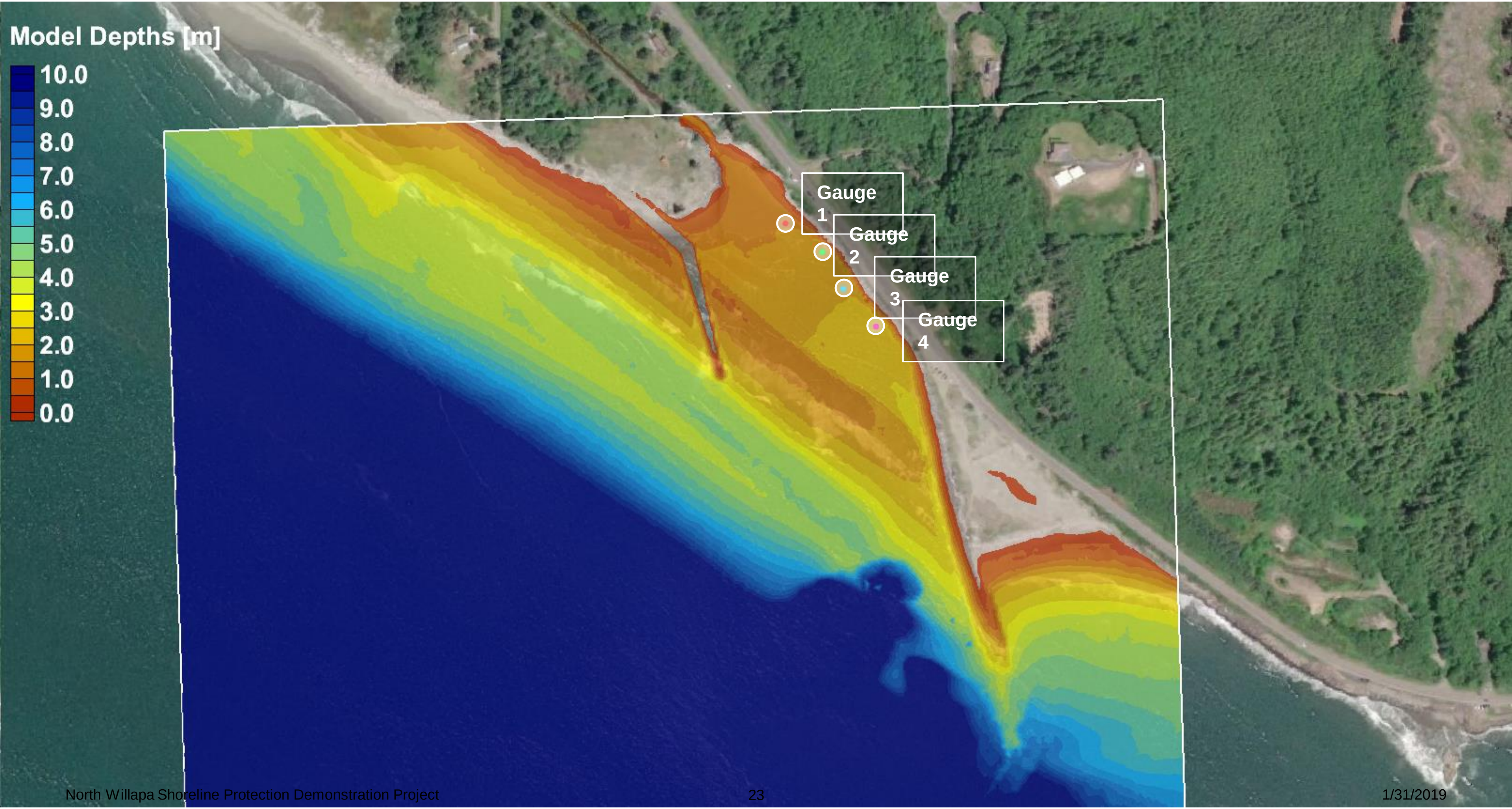
Existing Conditions



Groin




Model Depths [m]
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Gauge 1
Gauge 2
Gauge 3
Gauge 4


Model Depths [m]
10.0
9.0
8.0
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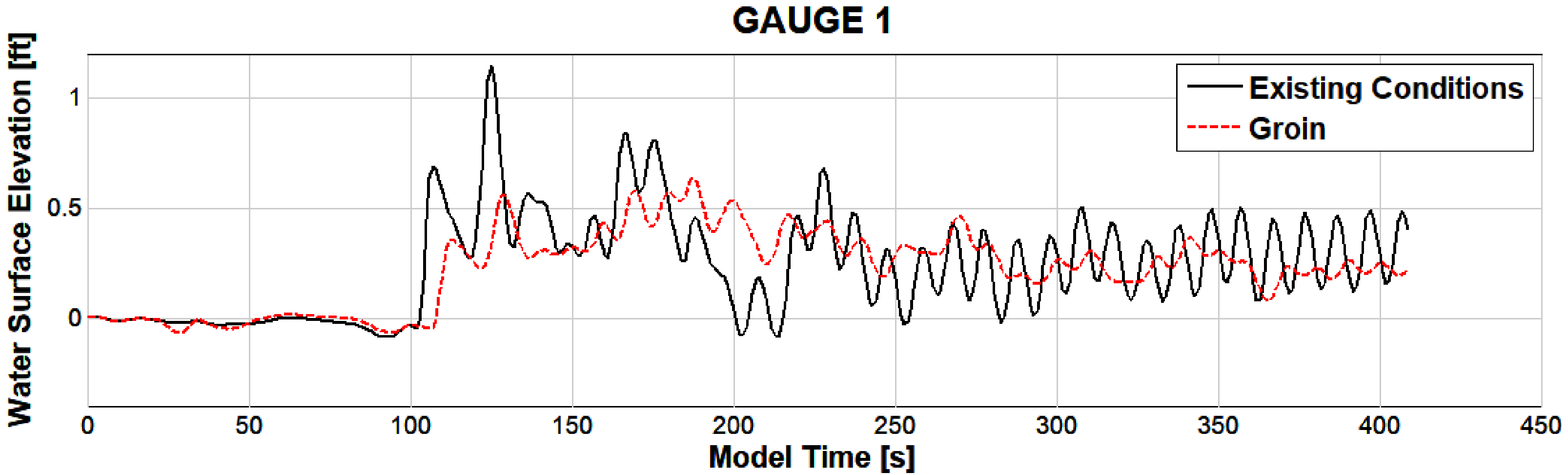
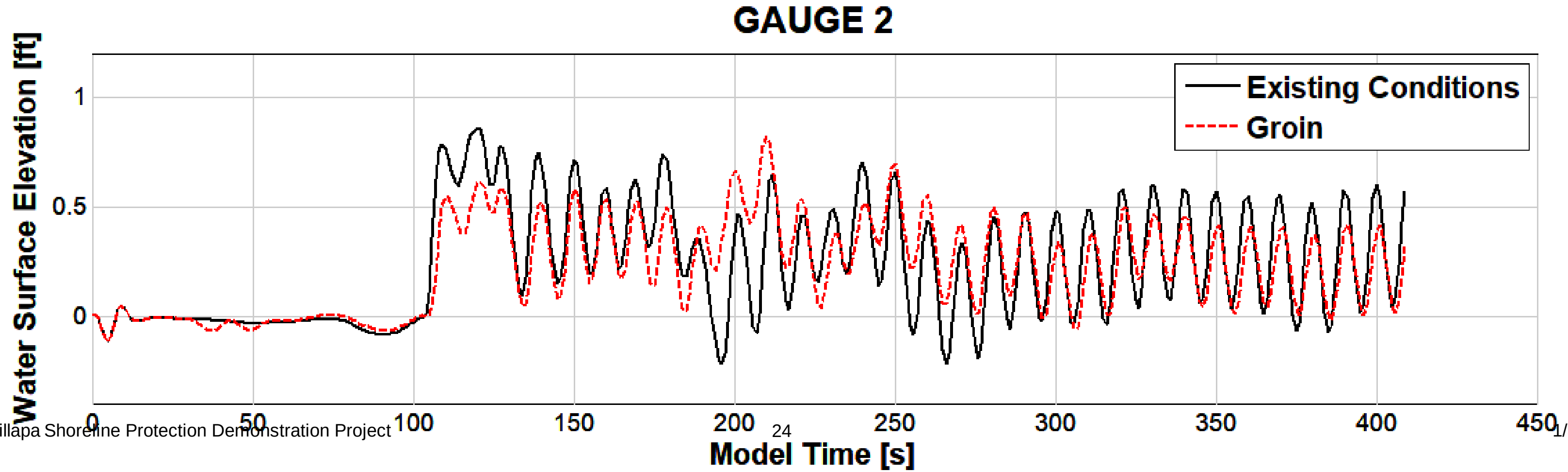
3.0
2.0
1.0
0.0
Gauge 1
Gauge 2
Gauge 3
Gauge 4


GAUGE 1
Water Surface Elevation [ft]
1
0.5
0
Model Time [s]
0
50
100
150
200
250
300
350
400
450
Existing Conditions
Groin


GAUGE 2
Water Surface Elevation [ft]
1
0.5
0
Model Time [s]
0
50
100
150
200
250
300
350
400
450
Existing Conditions
Groin

Refined Shortlisted Project Alternatives

- Demonstration Project Alternatives
- Beach Nourishment
- Dynamic Revetment
- Conventional Revetment
- Combined Dynamic and Conventional Revetment
- Longitudinal Composite of the Above
- Ditch Region Master Plan Alternatives in Combination with Demonstration Project Alternatives
- Groin with combination of the above

Demonstration Project Evaluation Criteria

- Performance to meet the project objectives:
  - Protect highway from wave erosion and flooding
  - Preclude flooding of cranberry bogs
  - Protect private property from land losses - maintain the existing shoreline
- Construction Cost
- Maintenance Requirement
- Constructability
- Least Adverse Environmental impacts - including impact on adjacent shoreline and natural coastal processes
- Least Recreational Impact - Maximize beach area, at least during summer period
- Value of the technical information for Master Plan

Preliminary Cost Estimate

Alternative	Initial Capital Cost	Maintenance Cost	Total Lifecycle Cost
A. All Beach Nourishment	$ 43,000,000	$ 126,000,000	$ 169,000,000
B. All Dynamic Revetment	$ 6,000,000	$ 13,000,000	$ 18,000,000
C. All Dynamic Revetment + Groin	$ 8,000,000	$ 11,000,000	$ 19,000,000
D. Standard Revetment Segment	$ 8,000,000	$ 7,000,000	$ 15,000,000
E. Combination Revetment Segment	$ 9,000,000	$ 8,000,000	$ 16,000,000
Comparative Structure Types			
All Typical Revetment	$ 10,000,000	$ 4,000,000	$ 14,000,000
All Combination Revetment	$ 11,000,000	$ 5,000,000	$ 16,000,000

Maintenance costs need to be factored for future value

Demonstration Project Evaluation Criteria

	Max Score
• Performance to meet the project objectives: – Protect highway from wave erosion and flooding – Preclude flooding of cranberry bogs – Protect private property from land losses - maintain the existing shoreline	5
• Construction Cost	5
• Maintenance Requirement	5
• Constructability	
• Least Adverse Environmental impacts - including impact on adjacent shoreline and natural coastal processes	5
• Least Recreational Impact - Maximize beach area, at least during summer period	3
• Value of the technical information for Master Plan	3

Preliminary Evaluation Matrix

	A. Beach Nourishment	B. Dynamic Revetment	C. Dynamic Revetment + Groin	D. Standard Rock Revetment + Dynamic Revetment	E. Combination Revetment + Dynamic Revetment
Performance (/5)					
Construction cost (/5)					
Maintenance requirements (/5)					
Constructability (/5)					
Minimize adverse environmental impacts (/5)					
Impact on adjacent shoreline and coastal processes (/5)					
Minimize Recreational impact (/3)					
Value information for Master Plan (/3)					

Community Meeting

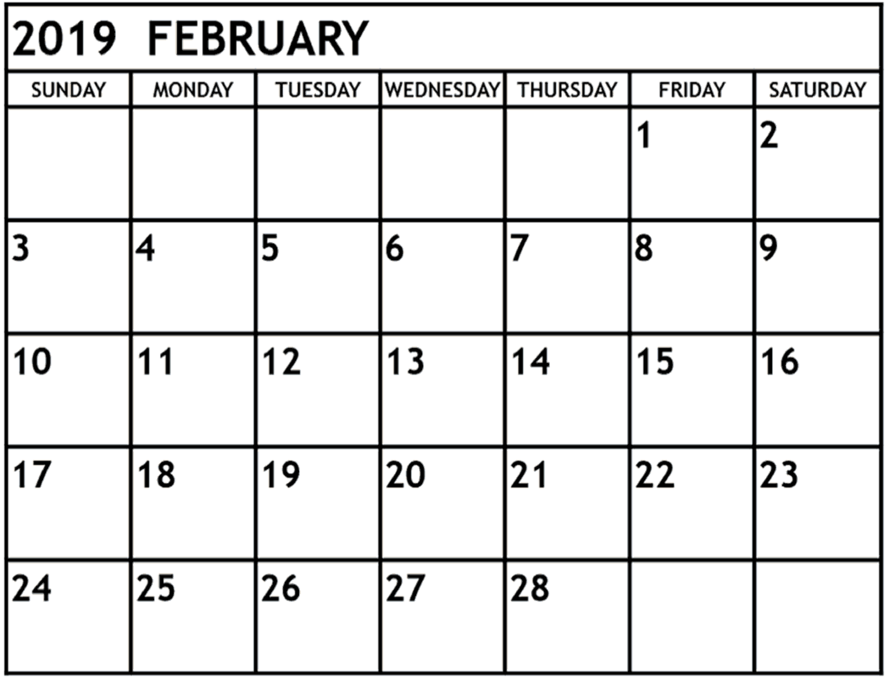
- Preparation for public meeting and corresponding information to be presented

- Selection of date for public meeting – (Feb 14th, Feb 24th, or week of March 4th)

- Agenda for public meeting

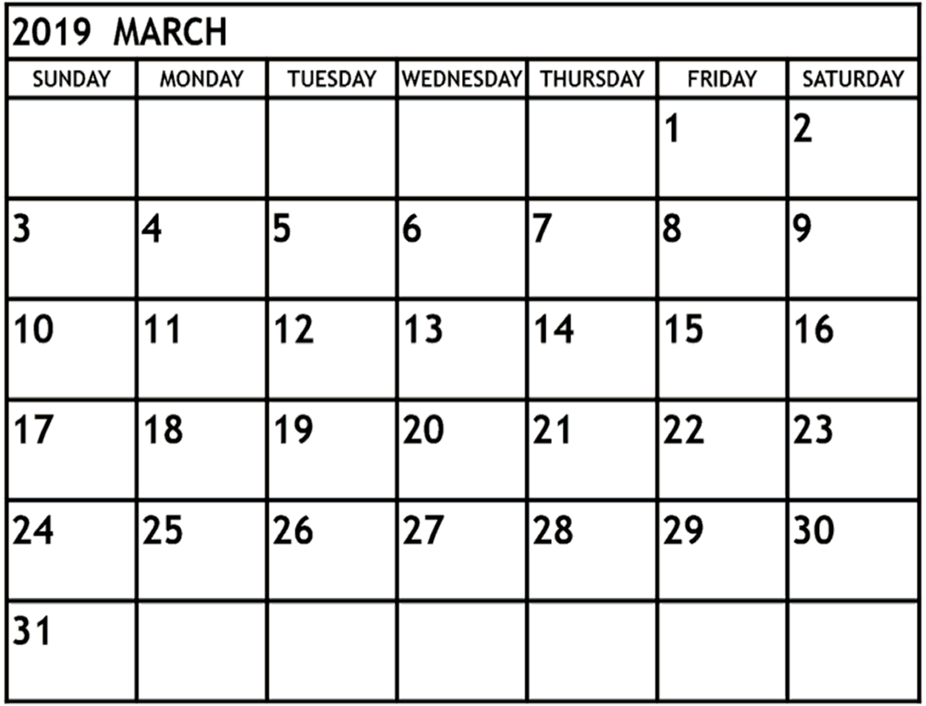
- Format for public meeting

Community Meeting



2019 FEBRUARY

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28		



2019 MARCH

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Community Meeting Topics

- Project Purpose, Schedule and Location/Extents
- Coastal Processes
- Conceptual Alternatives – Demonstration Project
- Ongoing Washaway Beach Area Erosion Stabilization Efforts
  - Diking District Dynamic Revetment
  - US Army Corps – Shoalwater Shoreline Protection
  - US Army Corps – Section xxxx Study
  - WSDOT – SR105 Shoreline Protection
  - US Army Corps/WSDOT Study
- Other?

MOTT MACDONALD

North Willapa Shoreline Protection Demonstration Project

Technical Committee Meeting # 3 –

Demonstration Project Alternatives

Pacific County, WA

MOTT MACDONALD

North Willapa Shoreline Protection Demonstration Project

Steering Committee Meeting #4

03/14/19

Demonstration Project

Selection of Preferred Alternative(s)

Pacific County, WA

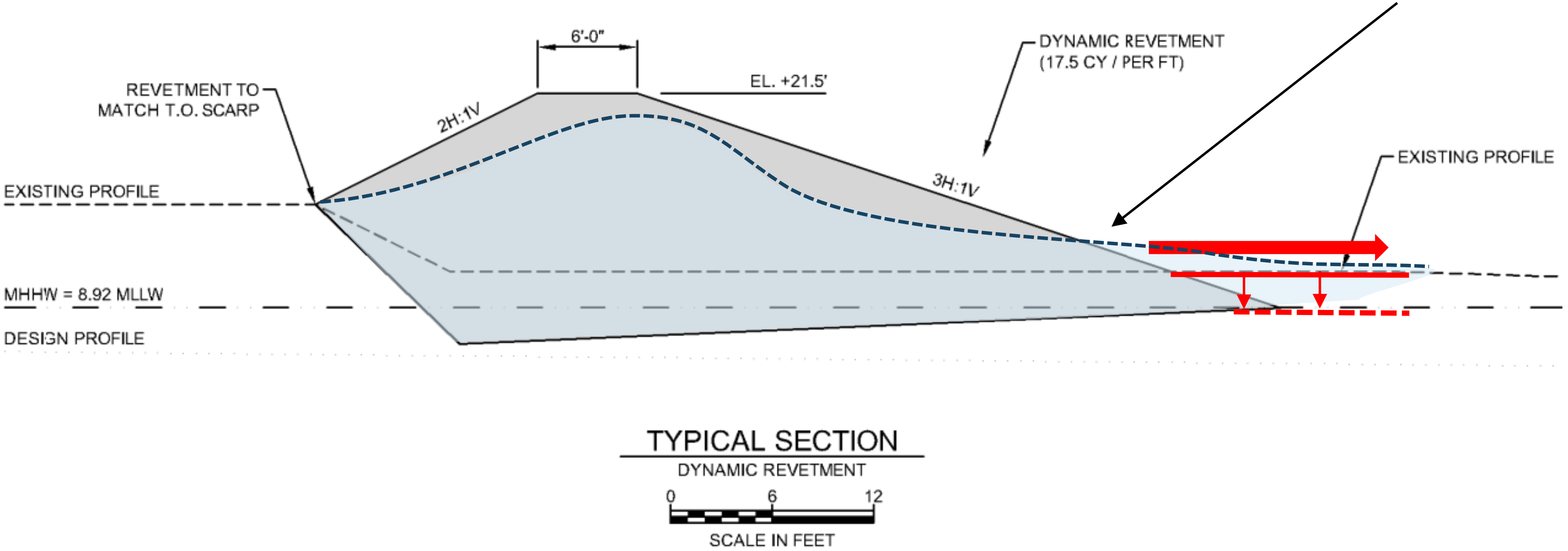
Shortlisted Project Alternatives for Evaluation (fromxxx)

- **Beach Nourishment**
- **Dynamic Revetment**
- **Dynamic Revetment + Groin**
- **Dynamic Revetment + Standard Revetment**
- **Dynamic Revetment + Combined Revetment**

DYNAMIC REVETMENT

Projected post-storm profile example

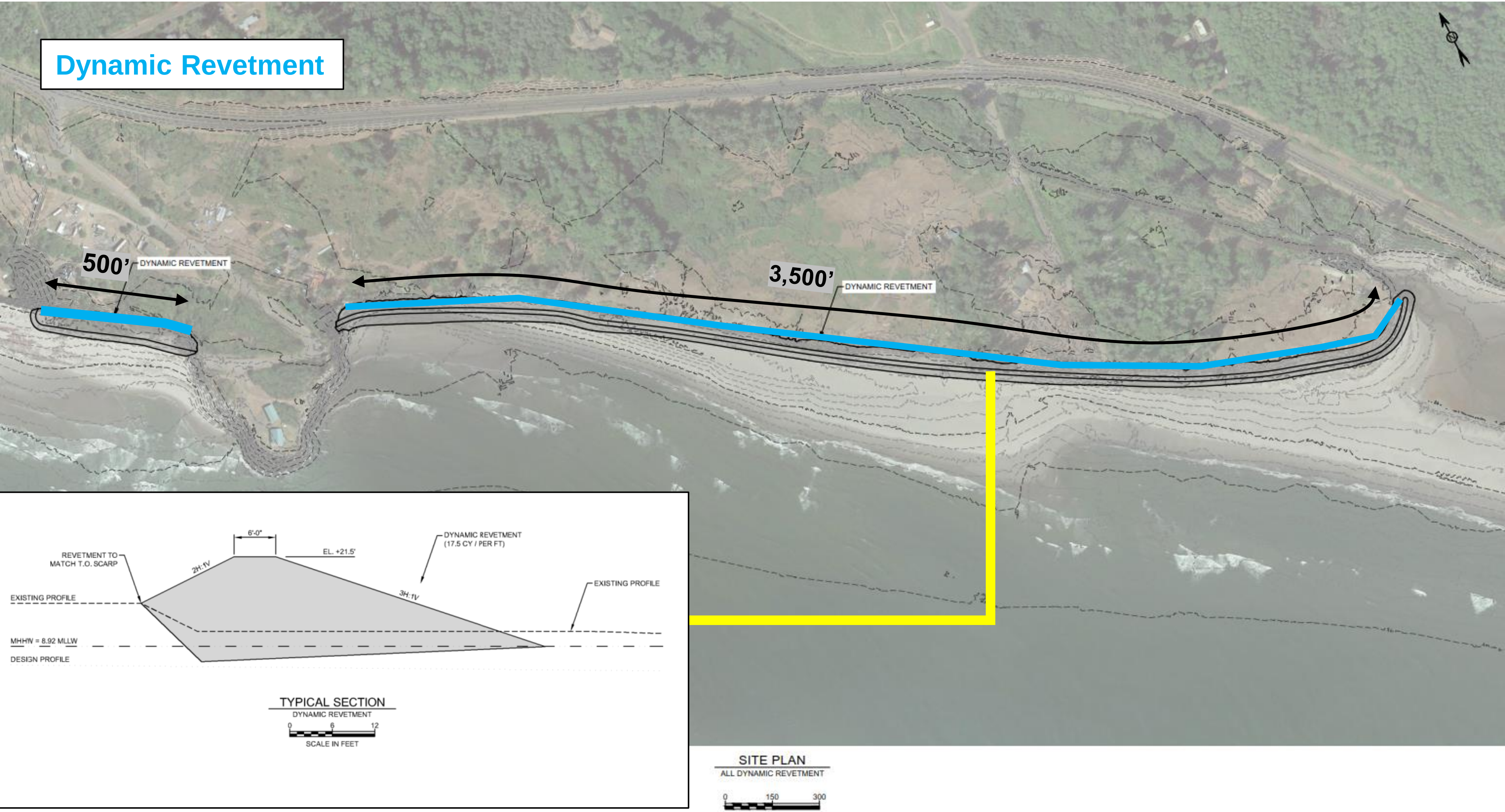
Design- Post construction profile



DYNAMIC REVETMENT

- Material: Angular Cobble –12” minus
- Maintenance: 35% replacement every 5 years (or equivalent)

Dynamic Revetment



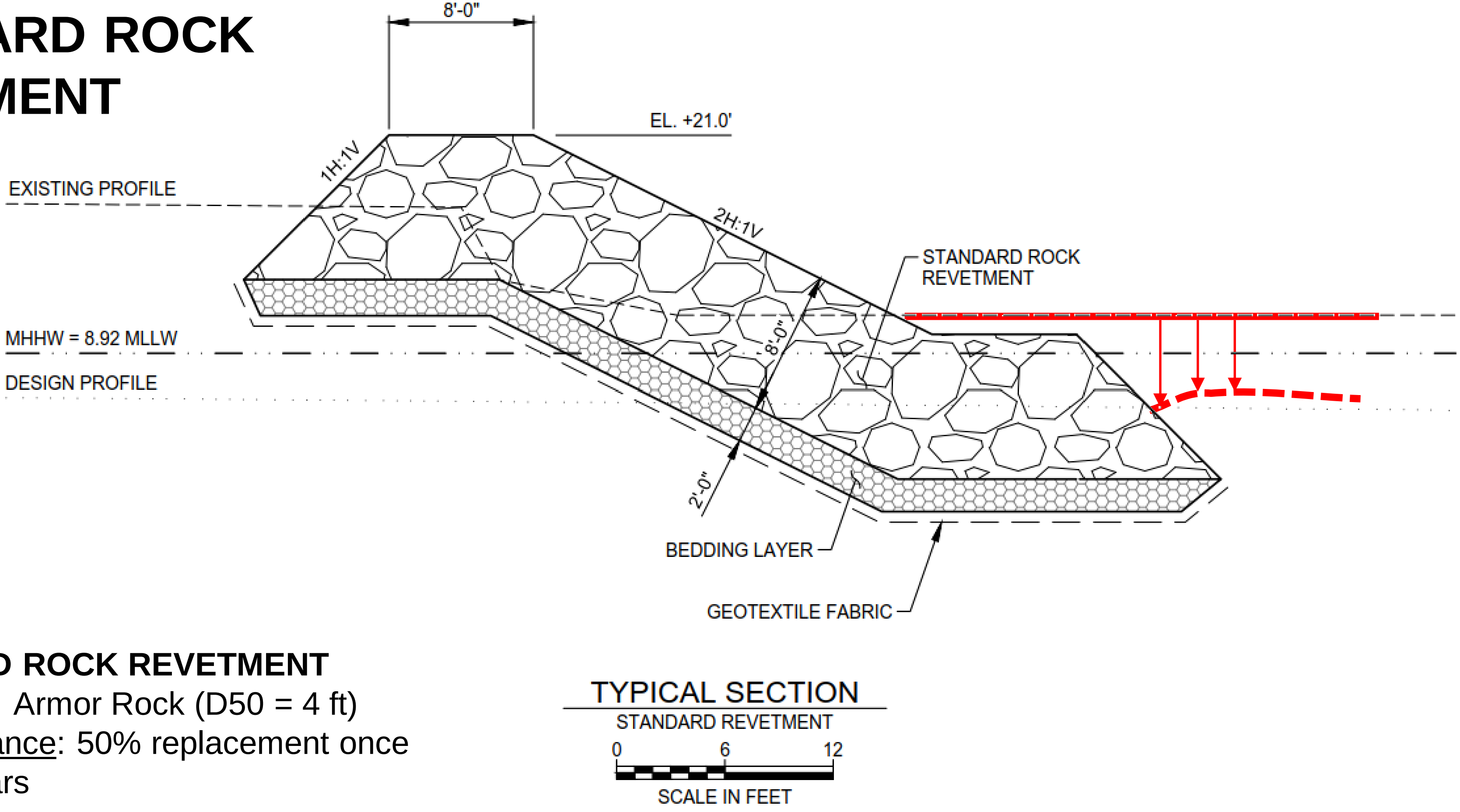
TYPICAL SECTION

DYNAMIC REVETMENT

SITE PLAN

ALL DYNAMIC REVETMENT

STANDARD ROCK REVETMENT

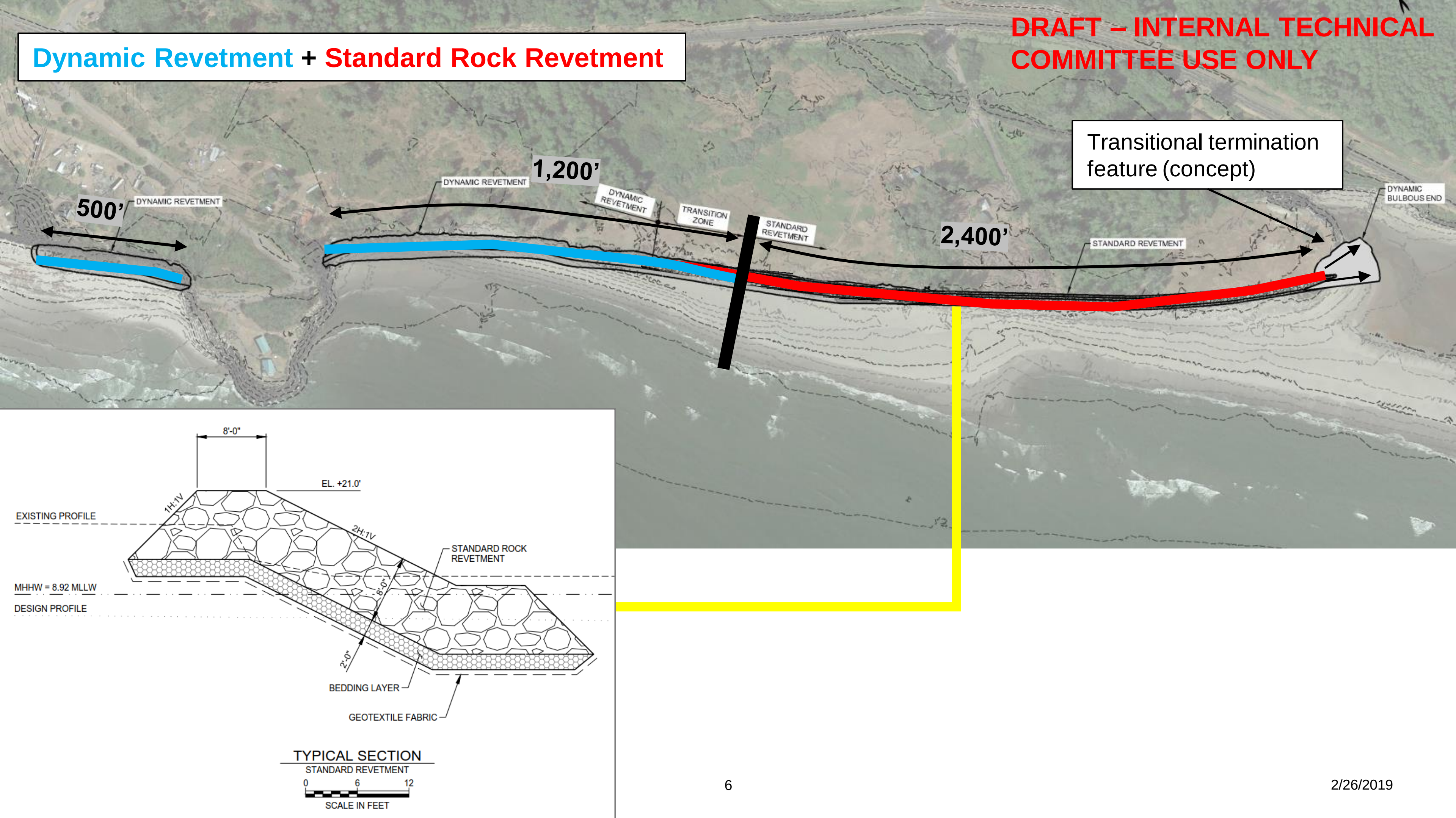


STANDARD ROCK REVETMENT

- Material: Armor Rock (D50 = 4 ft)
- Maintenance: 50% replacement once in 20 years

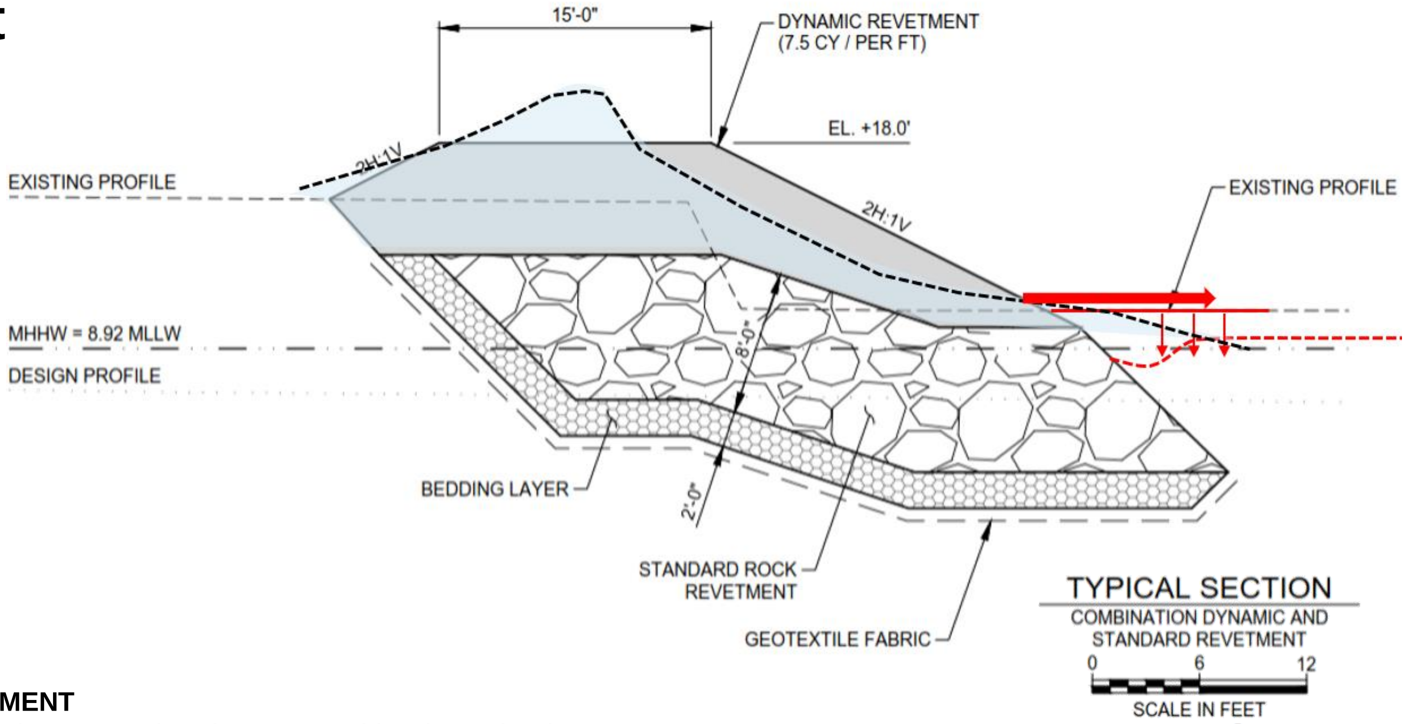
Dynamic Revetment + Standard Rock Revetment

DRAFT – INTERNAL TECHNICAL COMMITTEE USE ONLY



2/26/2019

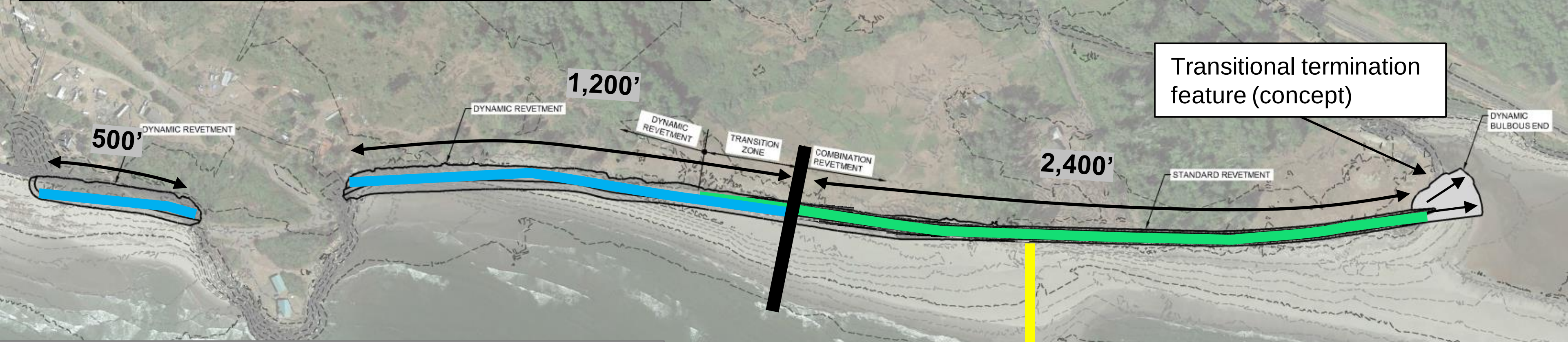
Combined Revetment



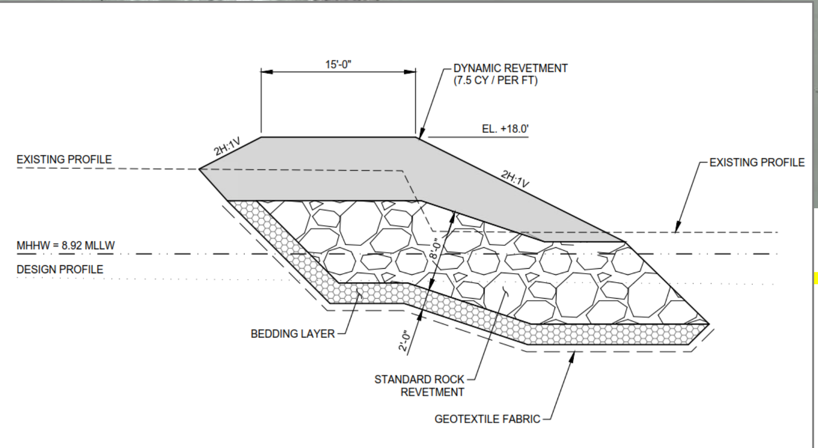
COMBINATION REVETMENT

- Material: Armor Rock (D50 ~3-4ft.) and Angular Cobble (12”-minus)
- Maintenance: 35% original volume of dynamic revetment every 5 years

Dynamic Revetment + Combination Revetment



Transitional termination feature (concept)

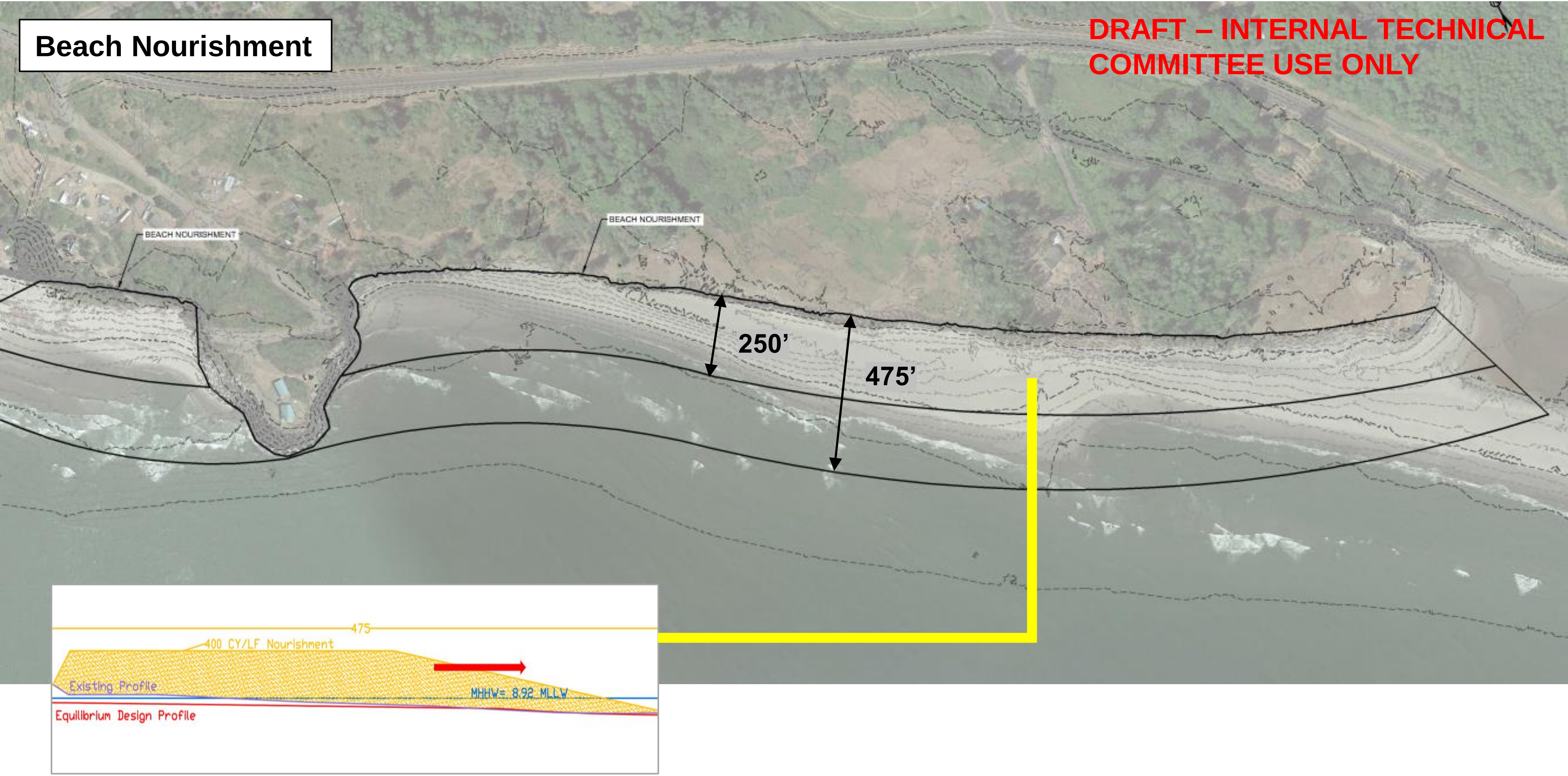


TYPICAL SECTION

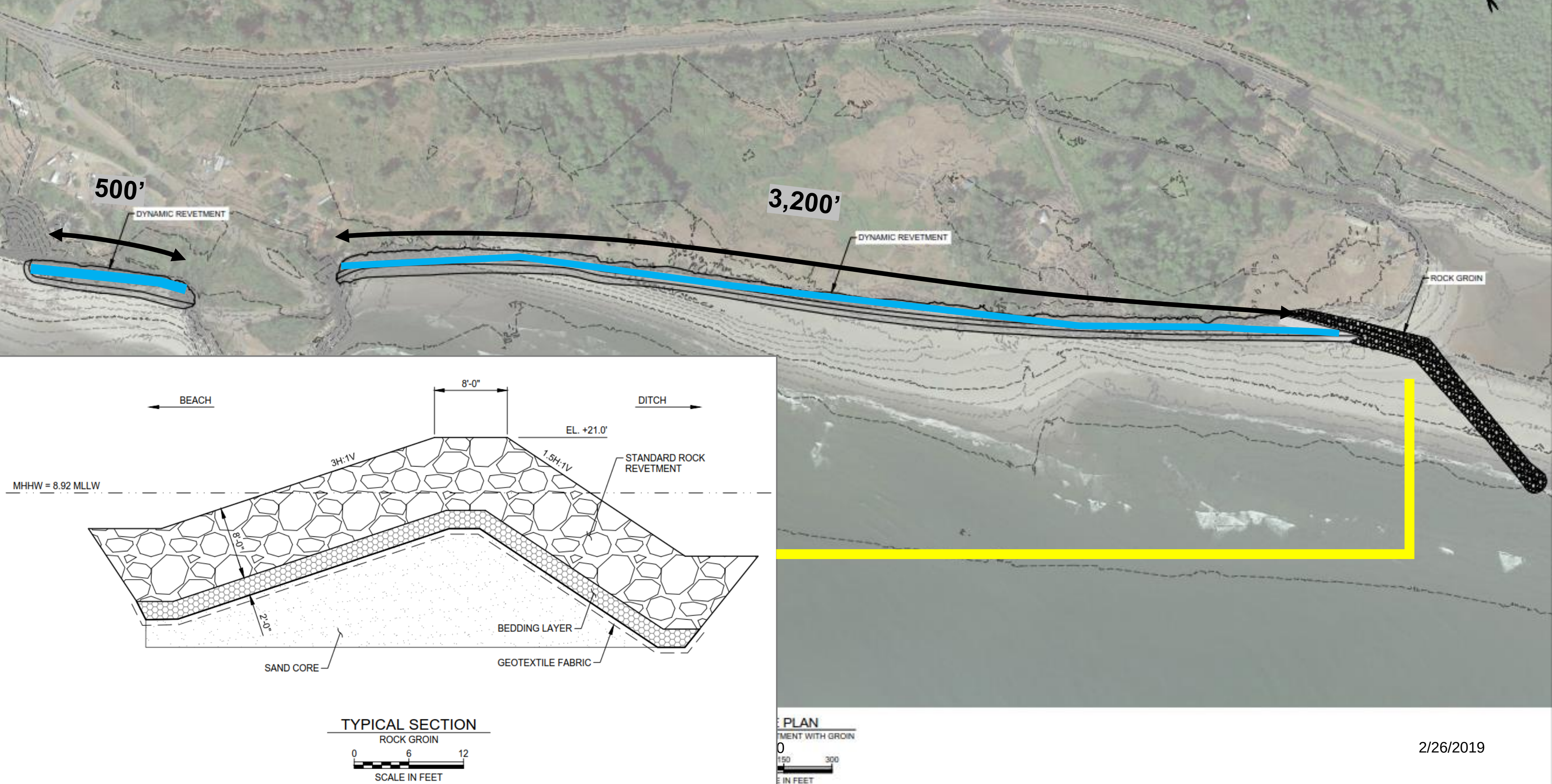
COMBINATION DYNAMIC AND STANDARD REVETMENT

Beach Nourishment

DRAFT – INTERNAL TECHNICAL COMMITTEE USE ONLY



Dynamic Revetment + Groin



2/26/2019

Preliminary Cost Estimate

Alternative	Initial Capital Cost	Maintenance Cost	Total Lifecycle Cost
Beach Nourishment	$ 43,000,000	$ 84,000,000	$ 127,000,000
Dynamic Revetment	$ 6,000,000	$ 13,000,000	$ 18,000,000
Dynamic Revetment + Groin	$ 8,000,000	$ 11,000,000	$ 19,000,000
Standard Revetment + Dynamic Revetment	$ 8,000,000	$ 7,000,000	$ 15,000,000
Dynamic Revetment + Combined Revetment	$ 9,000,000	$ 8,000,000	$ 16,000,000

Maintenance costs need to be factored for future value
Costs are included for comparative measures only, and are not intended for project funding purposes.
All values rounded to nearest $1 million.

Shortlisted Project Alternatives for Evaluation (from 01-22-2019)

- **Beach Nourishment**
- **Dynamic Revetment**
- **Dynamic Revetment + Groin**
- **Dynamic Revetment + Standard Revetment**
- **Dynamic Revetment + Combined Revetment**

Demonstration Project Evaluation Criteria

	Max Score
Performance to meet the project objectives: – Protect highway from wave erosion and flooding – Preclude flooding of cranberry bogs – Protect private property from land losses - maintain the existing shoreline	**5**
Maintenance Requirement	**5**
Constructability	**5**
Least Adverse Environmental impacts	**5**
Least Impact on shoreline and adjacent property	**5**
Minimize Adverse Recreational Impacts	**3**
Value of the technical information for Master Plan	**3**
Capital Cost	**5**

Example of Evaluation Performance (/5)

Technical Committee Members Dynamic Revetment	A. Dynamic Revetment	B. Dynamic Revetment + Groin	C. Standard Rock Revetment + Dynamic Revetment	D. Combination Revetment + Dynamic Revetment
A	3.0	3.6	4.6	2.9
B	4.0	4.0	3.0	5.0
C	4.0	4.0	3.0	4.0
E	4.5	5.0	3.5	4.0
F	4.0	4.0	3.0	3.0
	Moderately Preferred	Preferred	Less Preferred	Moderately Preferred

Summary

	A. Dynamic Revetment	B. Dynamic Revetment + Groin	C. Standard Rock Revetment + Dynamic Revetment	D. Combination Revetment + Dynamic Revetment
Performance	🟨	🟩	🟧	🟨
Maintenance Requirements	🟧	🟨	🟨	🟨
Constructability	🟩	🟨	🟨	🟨
Environmental Impacts	🟩	🟧	🟧	🟨
Impact on Shoreline and Adjacent Properties	🟩	🟨	🟧	🟨
Recreational Impact	🟩	🟩	🟧	🟨
Value Information for Master Plan	🟩	🟩	🟨	🟩
Estimated Capital Cost	🟩 $ 6,000,000	🟨 $ 8,000,000	🟨 $ 8,000,000	🟧 $ 9,000,000

🟩 Preferred	🟨 Moderately Preferred	🟧 Less Preferred

Summary

	A. Dynamic Revetment	B. Dynamic Revetment + Groin	C. Standard Rock Revetment + Dynamic Revetment	D. Combination Revetment + Dynamic Revetment
Performance	🟨	🟩	🟧	🟨
Maintenance Requirements	🟧	🟨	🟨	🟨
Constructability	🟩	🟨	🟨	🟨
Environmental Impacts	🟩	🟧	🟧	🟨
Impact on Shoreline and Adjacent Properties	🟩	🟨	🟧	🟨
Recreational Impact	🟩	🟩	🟧	🟨
Value Information for Master Plan	🟩	🟩	🟨	🟩
Estimated Capital Cost	🟩 $ 6,000,000	🟨 $ 8,000,000	$ 8,000,000	🟧 $ 9,000,000

🟩 Preferred	🟨 Moderately Preferred	🟧 Less Preferred

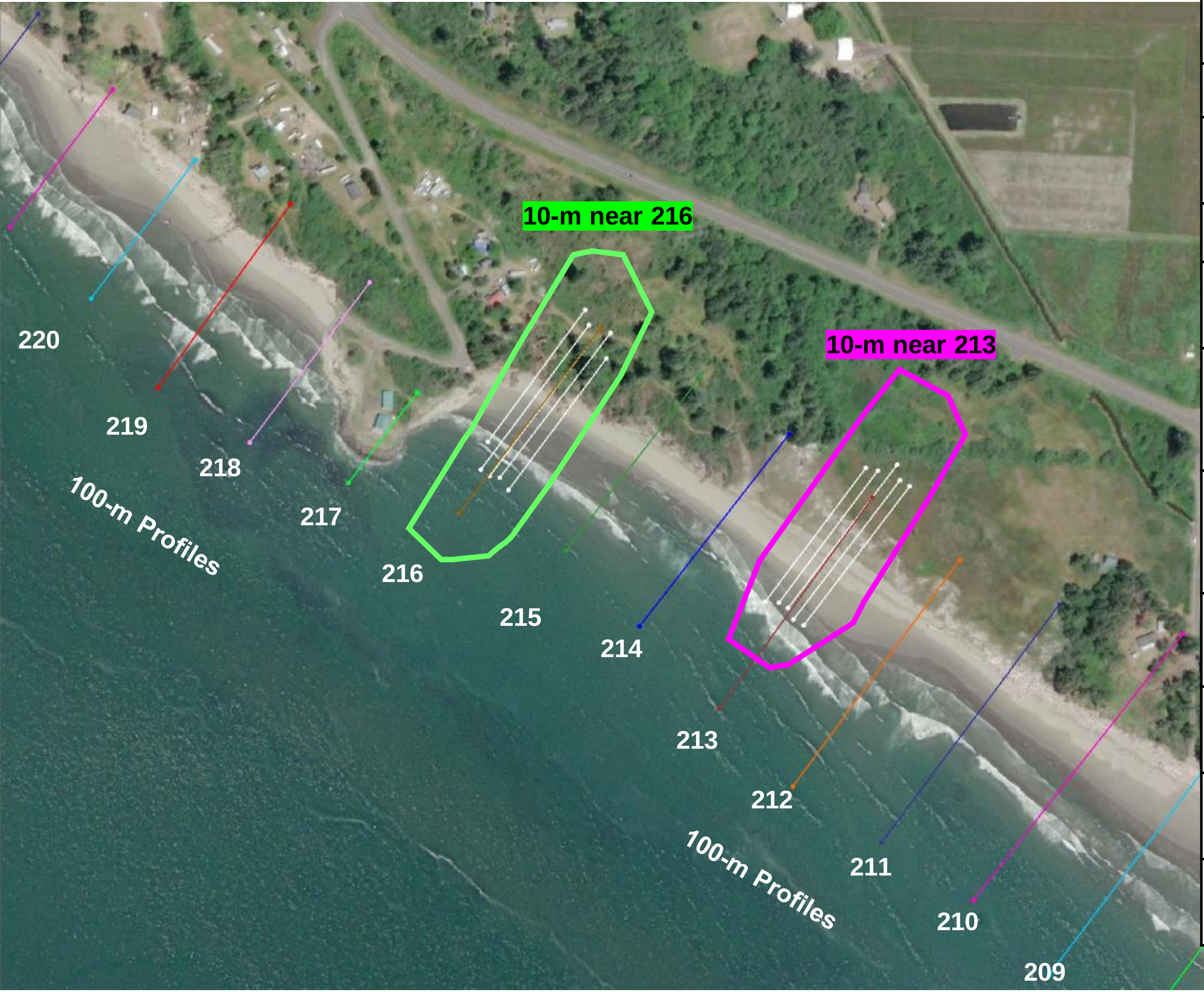
Summary

	A. Dynamic Revetment	B. Dynamic Revetment + Groin	C. Standard Rock Revetment + Dynamic Revetment	D. Combination Revetment + Dynamic Revetment
Performance	🟨	🟩	🟧	🟨
Maintenance Requirements	🟧	🟨	🟨	🟨
Constructability	🟩	🟨	🟨	🟨
Environmental Impacts	🟩	🟧	🟧	🟨
Impact on Shoreline and Adjacent Properties	🟩	🟨	🟧	🟨
Recreational Impact	🟩	🟩	🟧	🟨
Value Information for Master Plan	🟩	🟩	🟨	🟩
Estimated Capital Cost	🟩 $ 6,000,000	🟨 $ 8,000,000	🟨 $ 8,000,000	🟧 $ 9,000,000

🟩 Preferred	🟨 Moderately Preferred	🟧 Less Preferred

Additional Information/Data for Selection of Preferred Alternative

- Recent data on behavior of dynamic revetment
- Storm conditions for the period of dynamic revetment vs. extreme event
- Sand transport



DATA SUMMARY

Date	Available Data
June 2018	100-m Profiles + Topo 10-m 216
Sept 2018	100-m Profiles + Topo
Dec 20, 2018	100-m Profiles + Topo 10-m 216
Dec 21, 2018	100-m Profiles + Scarp top/toe 10-m 216
Jan 17, 2019	100-m Profiles + Topo 10-m 216 10-m 213
Jan 18, 2019	10-m 216 10-m 213
Jan 19, 2019	10-m 213
Jan 24, 2019	10-m 213
Jan 25, 2019	10-m 216

Preliminary Summary on Dynamic Revetment Behavior

- During a short period the average loss of dynamic revetment along a cross-section at the project site is estimated at approx. 0.5-1CY per linear ft, that is 10-20% of original placement
- Possible fates of dynamic revetment material are as follows:
  - Subsides into a sand layer
  - Moves rapidly along the shoreline outside of the project area
  - Moves offshore into the deep area
- Based on results of measurement it is possible that estimated volume of maintenance for the dynamic revetment alternative is not on a conservative side

Extreme Wave Heights @ Grays Harbor Buoy (per USACE-WSDOT Feasibility Study)

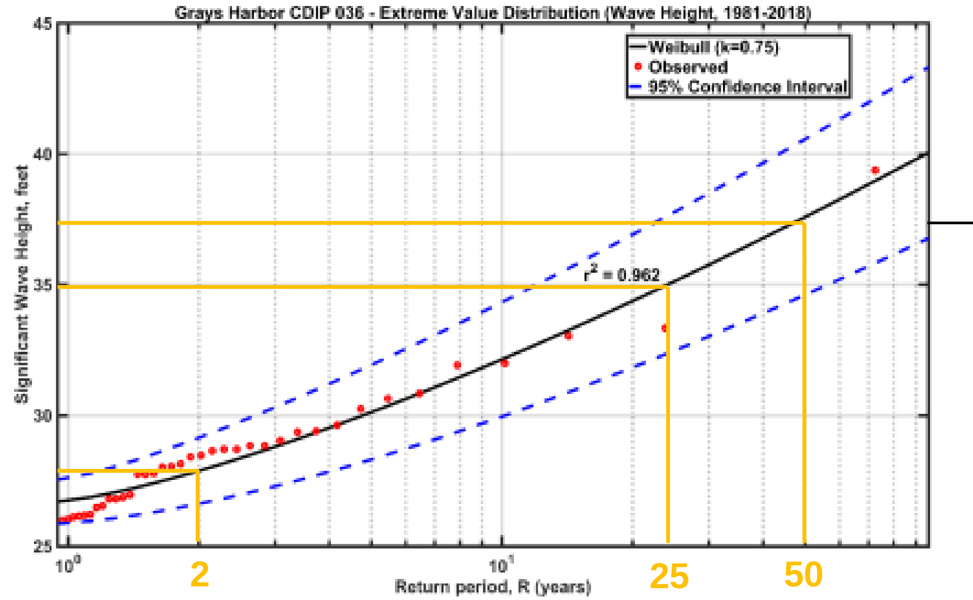
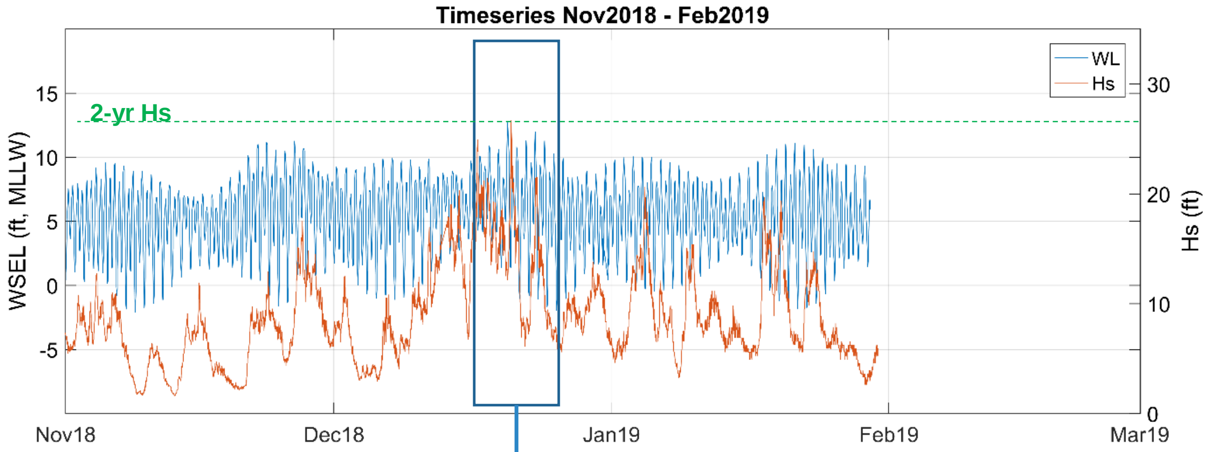
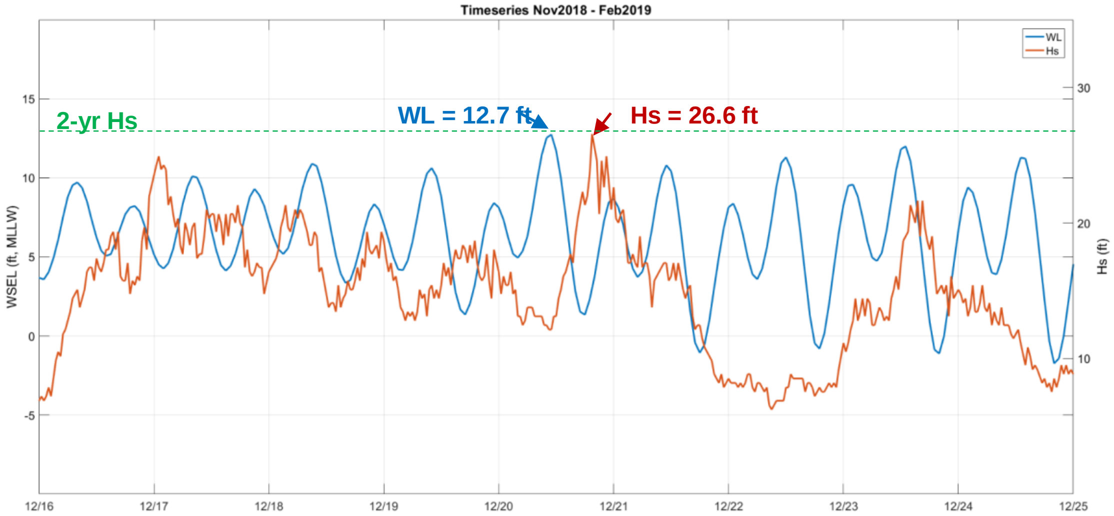


Figure 9: Nearshore extreme value distribution for significant wave height, 1% annual exceedance (100 year Return period) is 40.2 feet MLLW.

- 2-year Hs = 26 ft
- 25-year Hs = 35 ft
- 50-year Hs = 37.5 ft
- 100-year Hs = 40.2 ft



2018-2019

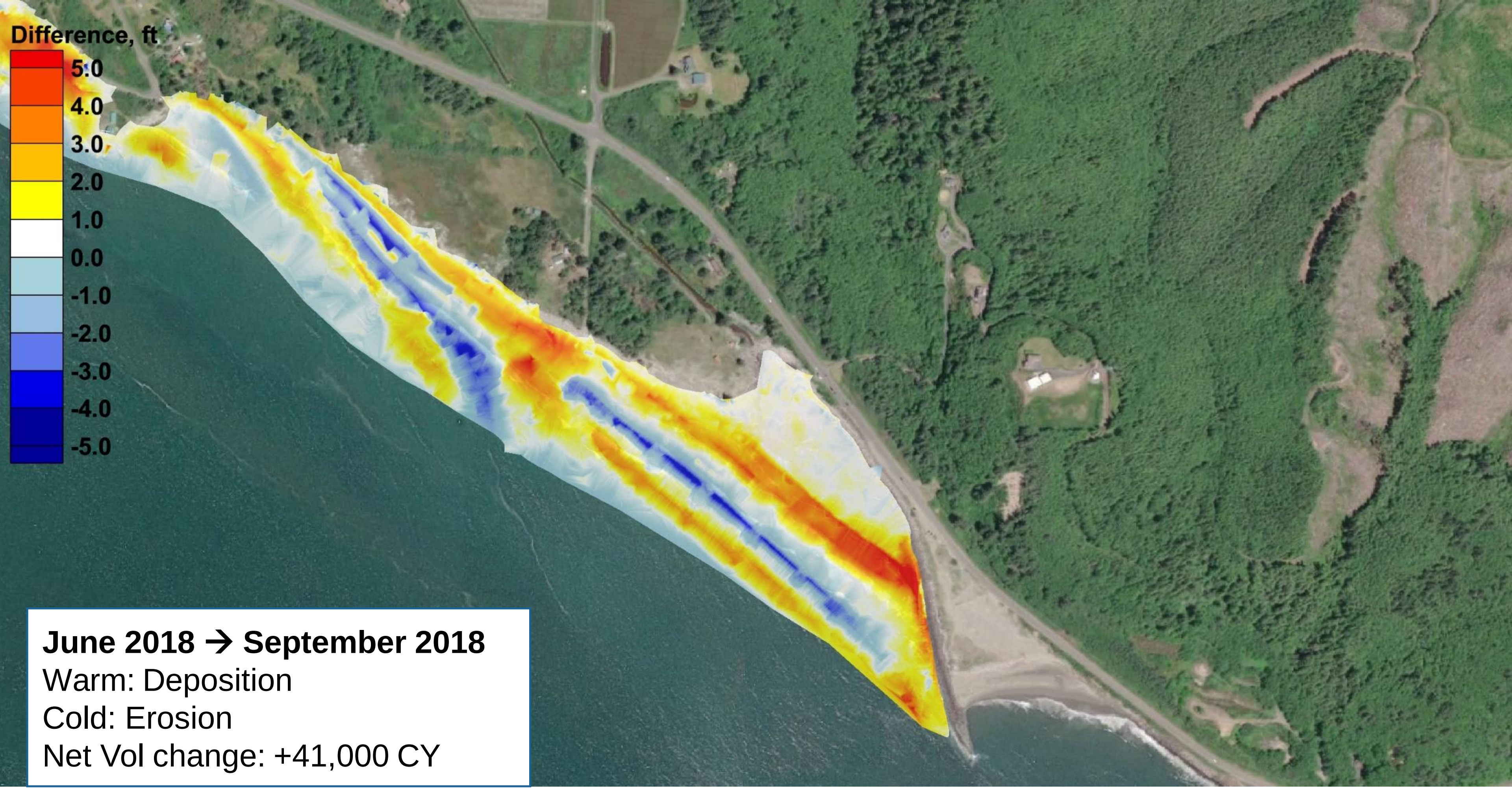


Winter 2018-2019:
Highest WL = 12.7 ft MLLW
Highest Hs = 26.6 ft (~2 year event)

	Highest Hs	**Highest WSEL**
Nov 2018	Hs = 17.5 ft WL = 8.7 ft	Hs = 9.1 ft WL = 11.2 ft
Dec 2018	Hs = 26.6 ft WL = 3.7 ft	Hs = 12.1 ft WL = 12.7 ft
Jan 2019	Hs = 20.7 ft WL = 0.8 ft	Hs = 7.2 ft WL = 11.1 ft

Preliminary Summary

- Performance of the dynamic revetment during this winter (2018-2019) is not indicative of how the dynamic revetment will perform under more extreme conditions, such as those observed in December 2007
- The estimates of maintenance requirements for the dynamic revetment alternative include significant uncertainties because of lack of measured data during more extreme storm events

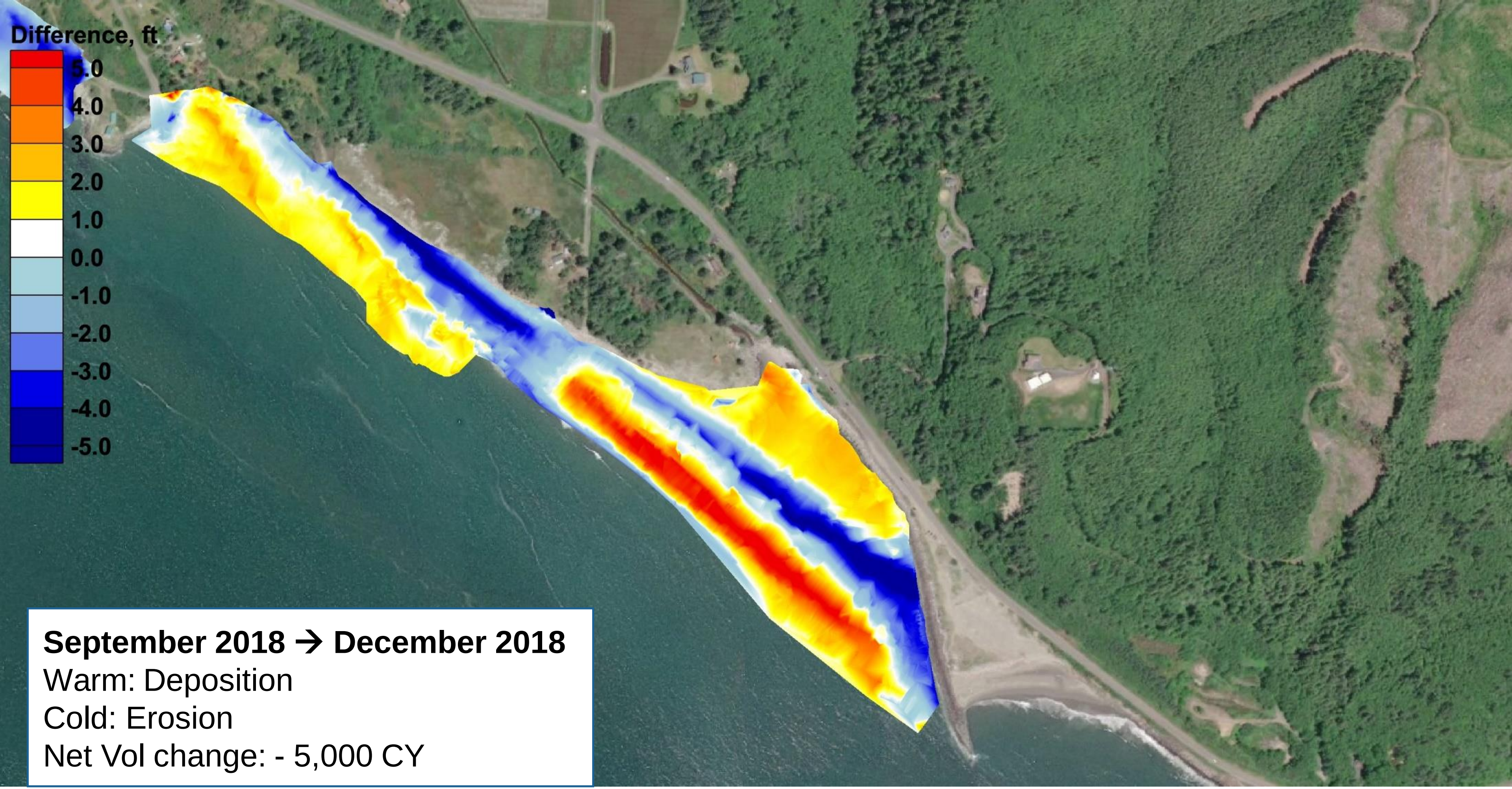


June 2018 → September 2018

Warm: Deposition

Cold: Erosion

Net Vol change: +41,000 CY

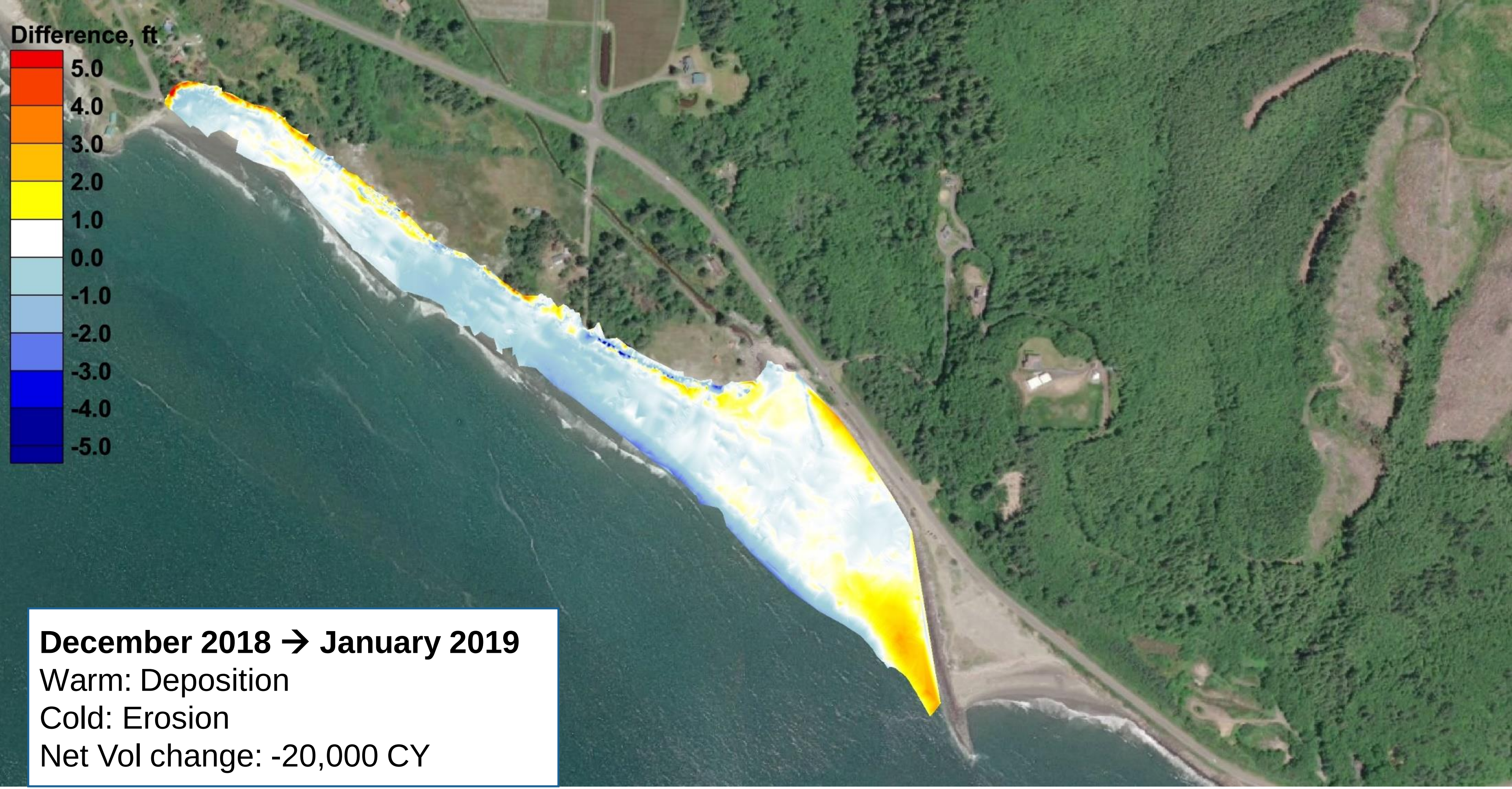


September 2018 → December 2018

Warm: Deposition

Cold: Erosion

Net Vol change: - 5,000 CY

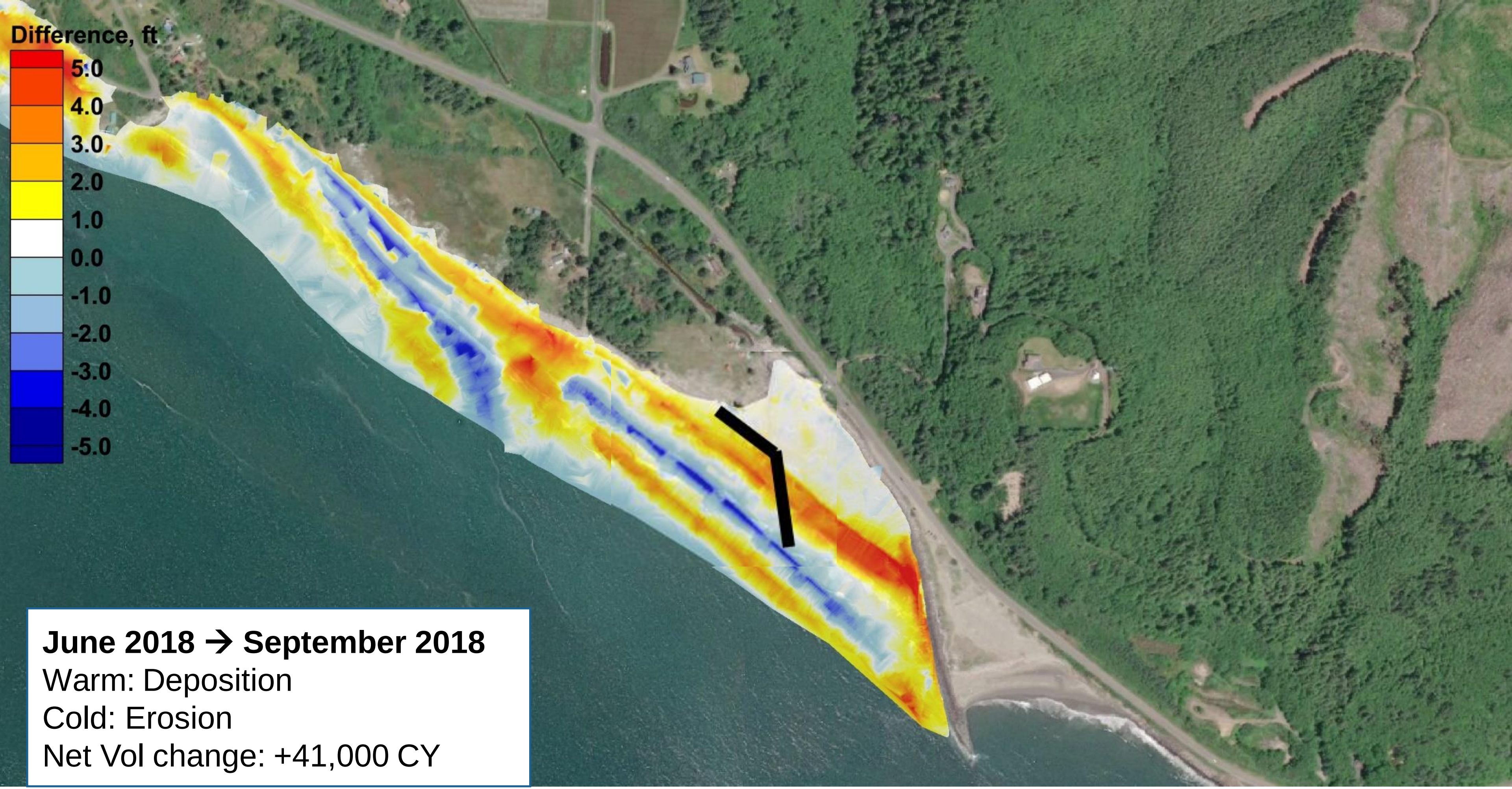


December 2018 → January 2019

Warm: Deposition

Cold: Erosion

Net Vol change: -20,000 CY



June 2018 → September 2018
Warm: Deposition
Cold: Erosion
Net Vol change: +41,000 CY

Technical Committee Outcomes (2/26/19)

- 5 shortlisted alternatives were evaluated and screened to two final alternatives: Dynamic Revetment and Dynamic Revetment with Groin
- The Dynamic Revetment alternative will provide adequate protection for shoreline, meet most of the design criteria, but may require significant level of frequent maintenance.
- Dynamic Revetment and Groin alternative will provide adequate protection for the shoreline, meet most of the design criteria, reduce maintenance requirements relative to the Dynamic Revetment alternative, but may include some (not yet identified) risk related to ditch region.
- If estimated maintenance requirements are acceptable for the County proceed with Dynamic Revetment as preferred alternative. Continue to evaluate Dynamic and Groin Alternative, which may be part of the master plan.

MOTT MACDONALD

North Willapa Shoreline Protection Demonstration Project

Technical Committee Meeting # 4

3/14/19

Demonstration Project Alternatives

Pacific County, WA

MOTT MACDONALD

North Willapa Shoreline Protection Demonstration Project

Steering Committee Meeting # 5

8/30/2019

Demonstration Project Alternatives

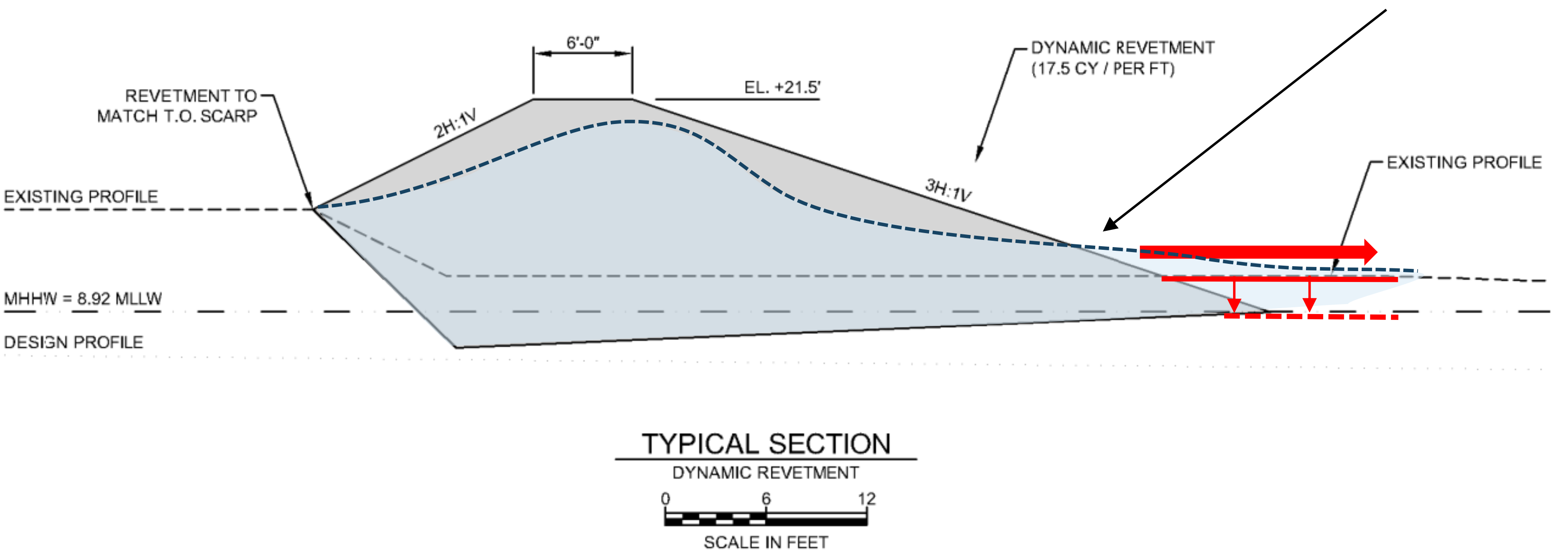
Pacific County, WA

Recent Progress & Next Steps

- Since last meeting:
- Public Meeting
- Permit Application Development
- Assessed Monitoring Results
- Design Refinements
- Technical Committee Meeting #7 (permitting strategy and adaptive management plan)

- Next Steps:
- Finalize permit application documents (Late Sept/Early Oct)
- Conduct Final Engineering Design (Fall/Winter 2019)

DYNAMIC REVETMENT



DYNAMIC REVETMENT

- Material: Angular Cobble –12" minus
- Maintenance: 35% replacement every 5 years (or equivalent)

Design Recommendations

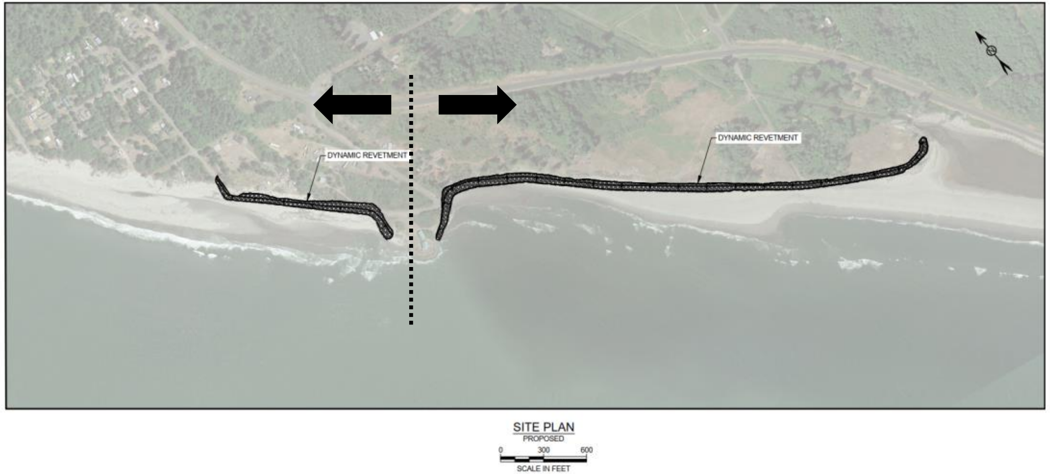
- Phased Approach

- 30% Design

- Dynamic Revetment – 17 CY/LF
- Southeast – ~3,500 feet
- Northwest – ~1,000 feet

- Adaptive Management Plan

- Monitoring Program
- Maintenance Plan
- Contingency measures and triggers identified – measures may include groin

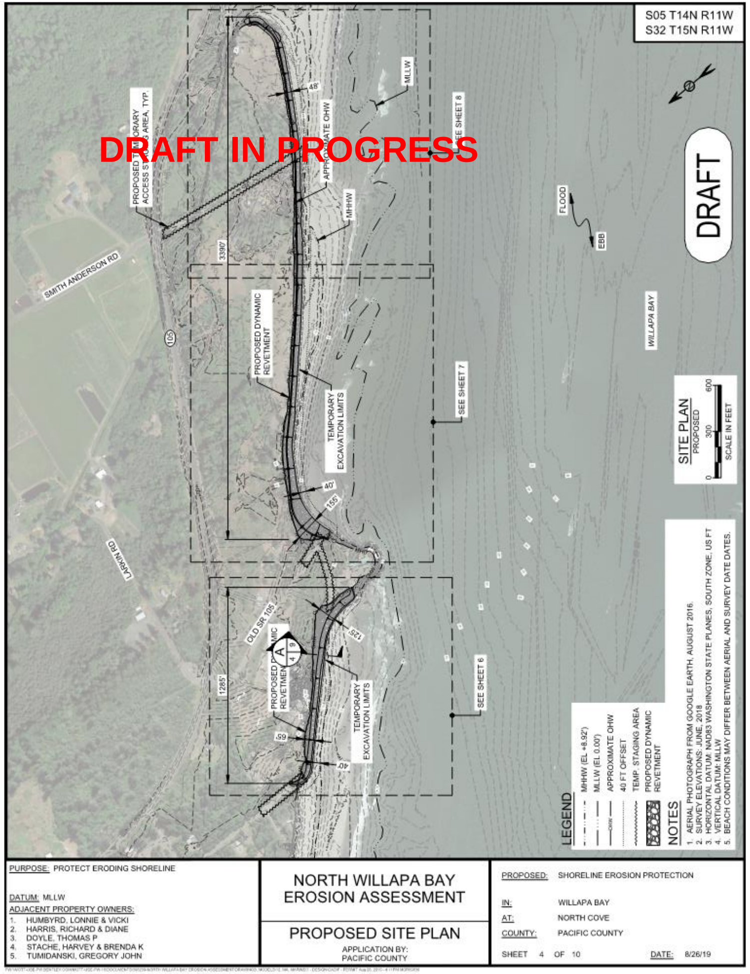


Dynamic Revetment – Northwest extents

- Project extent should be far enough north to demonstrate effect (~900 feet)
- Dynamic revetment should have return to shoreline to reduce risk of undermining and edge effects.
- Permit options tying into Tamarack (~1,000 ft.)

Regulatory Permitting Preparation

- On Track for submittal early fall
- Regulatory Agency Outreach
- Preliminary Design
- Construction access & staging areas – Public right-of-way
- Construction methods and duration
- Permit drawing refinements



Permit Strategy

- Permitted Actions
- Dynamic Revetment
    - Preferred alternative, within SMP
    - Favorable agency response, imitated mitigation required
- Maintenance Plan
    - 10-years, proposed to be in permit.
    - Total volume permitted, flexibility on when placement of rock can occur
    - Monitoring program required
        - Recommend 10-years of elevation and habitat surveys

- Actions not permitted, but discussed as part of Adaptive Management Plan
- Contingency Actions, including groin

Site Access

- Permitting access across public right of way (Pacific County) and not private property.
- Private Property agreements at later date

Easements

- Assistance on outreach
- Letter to landowners

Next Steps

- Easement outreach
- Pre-Application Meetings
- Development of Monitoring and Adaptive Management Strategy
- Design Refinements & Permit Submittal
- Final Design and Design Report

MOTT
MACDONALD

Thank you

Appendix E: Geotechnical Memorandum

SHANNON & WILSON
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

December 20, 2019

Shane Phillips
Mott Macdonald
1601 5th Avenue, Suite 850
Seattle, WA 98101

RE: GEOLOGIC REVIEW SUMMARY, NORTH WILLLAPA BAY SHORELINE PROTECTION PROJECT, PACIFIC COUNTY, WASHINGTON

Dear Mr. Phillips

This letter presents the extent and conclusions of our geologic review of a specified study area named "Region 2" in North Willapa Bay in southwest Washington (Figure 1). Shannon & Wilson is subcontracted to Mott MacDonald (MMD) to provide geotechnical services for the North Willapa Shoreline Protection Demonstration Project (Project). To date, we have completed the following efforts for Region 2 of the Project:

- reviewing and compiling available surface and subsurface data,
- performing geologic site reconnaissance, and
- preparing this summary letter.

We have also attended meetings and provided preliminary geotechnical engineering opinions via email, but have not performed geotechnical design of the shoreline erosion protection system. This letter includes our recommendations for geotechnical data that could be collected in the future to inform final design.

PROJECT UNDERSTANDING

The site is located on the northwest side of Willapa Bay, near Tokeland, Washington, as shown in Figure 1. State Route (SR) 105 along North Willapa Bay has sustained considerable long-term erosion over the past 100 or so years based on historic maps and abandoned and/or realigned infrastructure. The North Cove area of Willapa Bay has been the subject of many studies dating back to the 1960's and earlier because of continual northward shoreline migration and erosion impacting the north entrance to Willapa Bay at SR 105, particularly in the area identified in this study (Figure 2). Moving the highway landward, fortifying the shoreline, and creating artificial wave/erosion attenuators seaward of the highway are among the mitigation strategies employed to date. However, as the main channel of Willapa Bay has continued to move northward, the highway is increasingly impinged upon and constrained between a steepening sea channel bank and steep uplands.

We understand MMD has participated in numerous studies of this area over the years and has participated in mitigation alternative evaluations. The current study seeks to continue to develop methods for mitigating the migration of the shoreline in an area defined as Region 2.

EXISTING DATA REVIEW

We reviewed the following available information in Region 2 of the Project:

- Published historic topographic maps.
- Published geologic maps.
- Existing subsurface data available online from the Department of Natural Resources (DNR) Geologic Information Portal.
- Subsurface data and reports provided by MMD, the Washington State Department of Transportation (WSDOT), and the Washington Geological Survey (WGS).

Figure 2 shows the locations of existing exploration studies near Region 2 that provided relevant geotechnical and geologic information for our review. Excerpts from these data sources are compiled in Appendix A, and include the following:

- WSDOT geotechnical reports dated 1997 – Logs of borings B-1-97 through B-4-97. Other geologic and geotechnical studies in this report included seismic refraction and reflection, side scanning sonar, surficial Pleistocene deposits mapped, submarine landslides. Appendix A includes the generalized profiles and results of seismic refraction performed by Golder Associates.
- Larkin Bridge Log of Boring Hole No. 1 by Drilling Unlimited, Inc. dated 1985 (designated H-1-85 in Figure 2).
- WSDOT soils report dated 1968 – Logs of Borings B-6-68 through B-9-68, B-11-68, and B-14-68.
- Shannon and Wilson Hill Line Relocation report dated 1967 – Boring B-8 (designated B-8-67 in Figure 2).

We compiled these data spatially in a Geographic Information System (GIS) database, summarized geologic properties, and performed a geologic reconnaissance to investigate the geologic conditions, as discussed in subsequent sections.

GEOLOGY

Regional Geology

Southwest Washington along the Pacific coast is part of the Willapa Hills physiographic province, bounded by the Olympic Mountains to the north and the Columbia River to the south. It is comprised of rolling hills on a coastal plain with large estuaries lining the coast, embayed by unconsolidated sand spits. Steep cliffs of consolidated sediments are present as headlands or promontories adjacent to beach and estuaries locally, along the inside of Willapa Bay. This region has experienced uplift and erosion, fluctuating sea levels, and aggradation of beaches and spits along the coast to form its present configuration.

The Geologic Map of the Chehalis River and Westport quadrangles (Logan, 1987) shows beach deposits along the coast and Pleistocene terrace deposits adjacent to SR 105 in higher relief areas in north Willapa Bay.

Site Geology

Our understanding of site geology in the Project area is based on these studies:

- Explorations, including borings and geophysical surveys performed in the vicinity of the Study area (compiled Appendix A);
- Washington Geological Survey, Geologic Information Portal (WSG, 2018);
- Discrimination between subtidal and intertidal facies in Pleistocene deposits, Willapa Bay, Washington (Clifton, 1983);
- The Geologic Map of the Chehalis River and Westport Quadrangles, Washington (Logan, 1987);
- Framework geology in Cape Shoalwater and northwest Willapa Bay, WA: Assessing potential geologic impacts on recent shoreline change (Wadman, H.M. and others, 2018 in progress)

Geologic units mapped in the area and encountered in explorations consist of Holocene beach deposits overlying Pleistocene terrace deposits. The Pleistocene terrace deposits likely overly Tertiary volcanic deposits. However, the depth to these volcanic deposits is unknown because they were not encountered in the borings. Pillow basalts outcrop at the North River bridge on SR 105 about 4 miles to the east. The following paragraphs describe the deposits described in the explorations and/or documented in reports or geologic maps.

Holocene deposits include beach, estuarine, and peat bog deposits. Beach deposits consist of fine to coarse sand, forming beaches and dunes. Estuarine deposits consist of clay, silt, mud, and fine sand with occasional shells and roots or other organics. Peat bog deposits consist of highly organic soils, decaying organic material, and wood.

Pleistocene terrace deposits include a wide variety of sediments, primarily of fluvial and marine origin, that have been uplifted to their current location on a coastal plain. These deposits generally range from iron-stained cemented gravel to fine sand with clay and silt layers and occasionally gravel and peat layers. Cementation of these sediments is variable throughout the deposits, such that a cemented sand could be referred to as a sandstone and a cemented gravel could be referred to as a conglomerate.

Clifton subdivided Pleistocene terrace deposits in Willapa Bay into 5 units in 1983. Wadman and others (2018 in progress) further adapted these subdivisions to describe a Pleistocene sequence for the Willapa Bay area comprised of partially indurated (hardened) fluvial, estuarine, intertidal, and subtidal deposits:

- Unit 1 (oldest): intertidal deposits, laminated blueish fine sand and mud and an erosional contact with Unit 2.
- Unit 2: generally fine-grained sediment, muddy and/or cross-bedded sand (indicating deposition by running water) with occasional tidal flow and upland runoff channel deposits.
- Unit 3: tidal channel deposits comprised of mainly mud and abundant wood, trace and discontinuous gravel, and locally cuts into lower units (Units 1 and 2).
- Unit 4: still-stand (deposited during relatively static sea level) sand and mud, and layers of cross-bedded gravels, sands, and mud.
- Unit 5 (youngest): estuarine to fluvial channel fill including laminated mud and silty fine sand that cuts through all units (Units 1 through 4), and contains sequences of fine gravel and coarse sand.

These deposits are overlain by beach sand, marine muds, and peat bog deposits in the project area.

GEOLOGIC RECONNAISSANCE

We performed a geologic site reconnaissance in Region 2 on September 10, 2018. The reconnaissance targeted a predicted low tide of -1.3 feet Mean Lower Low Water (MLLW), which is -2.0 feet North American Vertical Datum of 1988 (NAVD88). The National Oceanic and Atmospheric Administration (NOAA) low tide level at Station 9440910, Toke Point in

Willapa Bay, was -1.2 feet MLLW (-1.9 feet NAVD) at 6:42 a.m. on September 10, 2018 (NOAA tides and currents, 2018). Performing the geologic site reconnaissance at low tide allowed observation of as many Pleistocene terrace deposits along the shoreline as possible during our study period. Our site reconnaissance was directed towards trying to observe if hardened, cemented, or more erosion resistant versions or subunits exist within the Pleistocene terrace deposits along the shoreline. Goals of the geologic reconnaissance included:

- identify and map Pleistocene outcrops in Region 2, particularly near the jetty.
- investigate the top of a submarine scarp on the south and west flank of the jetty and groin as shown in bathymetric surveys provided by MMD.
- photograph outcrops and collect samples for general geologic characterization.
- differentiate or correlate Pleistocene terrace deposit subunits referenced by Clifton (1983) and Wadman and others (2018).

The geologic site reconnaissance included 22 recorded stops. Figure 3 shows Stops 1 through 14, which are relevant to Region 2. Photos taken during the site reconnaissance are provided in Appendix B. For context of tidal levels during the reconnaissance, the photographs in Appendix B includes the time each photograph was taken (low tide at 6:42 a.m.). Appendix B also includes a table describing the soil samples we collected and reviewed.

During our September 10, 2018 site visit we could not see the submarine scarp on the south and west flank of the jetty and groin. We did observe several isolated outcrops of indurated or cemented sand (sandstone) and iron-stained gravel (conglomerate) about 1,000 feet southeast of the jetty and groin and focused around a prominent Pleistocene outcrop near the outlet of Cannery Slough (Figure 3, see also photos in Appendix B). These outcrops represent the hardened or cemented, erosion resistant end-members of the Pleistocene terrace deposits. Outcrops were observed for about 1,500 feet, at Stops 6 through 11. Fine to medium-grained sandstone was observed more often than any other type of material. The proximity of the sandstone (Stop 7) and iron-stained conglomerate (Stop 8), shown in Figure 3, demonstrates the spatial variability in density and grain size in these materials. This variability will likely continue into the subsurface, as well. Holocene deposits appear to be actively eroding, including the peat bog deposits at Stops 5, 12 and 13 and Estuarine deposits at Stop 14 are being actively eroded. These deposits likely remain because of the clay and silt content, whereas sandy beach deposits more easily wash away.

CONCLUSION AND FUTURE STUDIES

Based on the studies outlined in this letter, we interpret a variable geologic setting within a highly dynamic landscape. We observe that the depth and properties of the geologic materials vary significantly over short distances. Therefore, it is difficult to use available data to inform site specific conditions at proposed mitigation sites. To perform geotechnical design for future shoreline migration mitigation measures (e.g. stability, hardening, etc.), site-specific subsurface data should be collected. The site-specific data should include one or more over-water borings that extend through the beach and terrace deposits into underlying tertiary rock, which is anticipated to be below about elevation -100 Mean Sea Level (MSL). The schedule for future studies should consider that environmental permitting for the boring can take in excess of 6 months to obtain.

REFERENCES

Logan, R.L., 1987, Geologic map of the Chehalis River and Westport quadrangles, Washington: Washington Division of Geology and Earth Resources Open File Report 87-7, scale 1:100,000.

Clifton, H. E., 1983, Discrimination between subtidal and intertidal facies in Pleistocene deposits, Willapa Bay, Washington. Journal of Sedimentary Research, 53(2), 353-369.

National Oceanic and Atmospheric Administration (NOAA), 2018, Tide predictions at station 9440747, Nahcotta, Willapa Bay, WA, for September 10, 2018: Tides and currents, tides/water levels, available: https://tidesandcurrents.noaa.gov/noaatidepredictions.html?id=9415020&units=standard&bdate=20180202&edate=20180204&timezone=LST/LDT&clock=12hour&datum=MLLW&interval=hilo&action=dailychart.

Shannon & Wilson, Inc., 1968, Soils investigation, Washington State Highway SSH 13-A, Hill Line relocation, vicinity North Cove, Washington: Report prepared by Shannon & Wilson, Inc., Portland, Oreg., O-67-289, for Pettijohn Engineering Co., Inc., Portland, Oreg., January.

Washington State Department of Transportation (WSDOT), 1997, Geotechnical report, SR-105: geological study of the north channel of Willapa Bay – vicinity of North Cove, Washington, Willapa Bay Channel Restoration Project, C.S. 2532; OL-2431, section: North Cove vicinity: Olympia, Wash., Washington State Department of Transportation, Field Operation Support Service Center, Materials Laboratory – Geotechnical Branch, 124 p., June.

Washington State Department of Highways (WSDOT), 1968, Soils report, C.S. 2532R; SR-105; L-3577, section: North Cove vicinity, sta. 222+00 to sta. 308+00: Vancouver, Wash., Washington State Department of Highways, WAX 43057AO, 7233-40-01, 16 p., December.

Wadman, H.M., McNinch, J.E., Smith, J., 2018, Framework geology in Cape Shoalwater and northwest Willapa Bay, WA: Assessing potential geologic impacts on recent shoreline change.

Washington Geological Survey (WSG), 2018, Geologic information portal, geologic mapping and subsurface data: Available: https://www.dnr.wa.gov/geologyportal, accessed July.

CLOSURE

We appreciate being involved with you on this interesting and unique project. Please contact us for future geotechnical assistance for the proposed mitigation measures.

Sincerely,

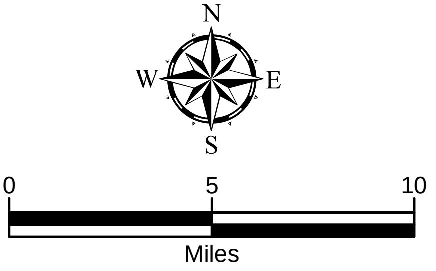
SHANNON & WILSON

Geologist
2993
Stephanie Wanderer

Stephanie Wanderer, LG
Geologist

SAW:MAA/saw

Enc. Figure 1: Vicinity Map
Figure 2: Existing Data Map
Figure 3: Geologic Reconnaissance Map
Appendix A: Existing Subsurface Data
Appendix B: Geologic Reconnaissance Records



Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

N. Willapa Bay Shoreline Projection Project
Pacific County, Washington

VICINITY MAP

December 2019

100092-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 1

Filename: I:\EF\SEA\100000s\100092 Willapa Bay Erosion\GIS-kmz\LocationMap.mxd   Date: 11/9/2018   saw

Legend

⊙ Borings (various studies)

1997 Studies
- Mapped Landslides
- Side Scanning Sonar
- Seismic Refraction
- Seismic Reflection

1997 Profiles
- A-A'
- B-B'
- C-C'
- D-D'

- SR 105 Alignment (current)
- SR 105 Alignment and Stationing (WSDOT, 1968)
- SR 105 Alignment (pre-1968)
- Pleistocene deposits (1992 aerial)

N W E S

0 750 1,500
Feet

N. Willapa Bay Shoreline Projection Project
Pacific County, Washington

EXISTING DATA MAP

December 2019 100092-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 2

Filename: I:\EF\SEA\100000s\100092 Willapa Bay Erosion\GIS-kmz\ReconMap.mxd Date: 11/9/2018 saw

Legend

● Geologic reconnaissance stops

⊙ Borings (various studies)

— - — SR 105 Alignment (current)

- - - SR 105 Alignment and Stationing (WSDOT, 1968)

—— SR 105 Alignment (pre-1968)

- - - Pleistocene deposits (1992 aerial)

N
W E
S

0 300 600
Feet

N. Willapa Bay Shoreline Projection Project
Pacific County, Washington

GEOLOGIC RECONNAISSANCE MAP

December 2019 100092-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 3

APPENDIX A
EXISTING SUBSURFACE DATA

APPENDIX A
EXISTING SUBSURFACE DATA

CONTENTS

WSDOT, 1997, SR-105, C.S. 2532, OL-2431, Final Geotechnical Report, Willapa Bay Channel Restoration Project, June

- B-1-97 boring log
- B-2-97 boring log
- B-3-97 boring log
- B-4-97 boring log

WSDOT, 1968, SR 105, L-3577, North Cove Vicinity

- B-6-68 boring log
- B-7-68 boring log
- B-8-68 boring log
- B-9-68 boring log
- B-11-68 boring log
- B-14-68 boring log

Newell, C. O., 1985, Pacific County, Washington, Foundation Investigation, Larkin Bridge no. 5151.

- Hole 1 boring log

Shannon & Wilson, Inc., 1967, Soils Investigation, Washington State Highway SSH 13-A, Hill Line Relocation, vicinity North Cove, Washington, O-67-289

- B-8 boring log

WSDOT, 1997, SR-105, C.S. 2532, OL-2431, Final Geotechnical Report, Willapa Bay Channel Restoration Project, June

- Generalized Geologic Section A – A’
- Generalized Geologic Section B – B’
- Generalized Geologic Section C – C’
- Generalized Geologic Section D – D’

Golder Associates, 1997, Marine Geophysical Investigation of SR-105 North Cove Area, in Willapa Bay, Washington, 973-1025

- Seismic Reflection Line 1 Interpretation Cross Section with Borehole 1 Data
- Seismic Reflection Line 2 Interpretation Cross Section with Borehole 2 Data
- Seismic Reflection Line 3 Interpretation Cross Section with Borehole 3 Data
- Seismic Reflection Line 4 Interpretation Cross Section
- Seismic Reflection Line 5 Interpretation Cross Section

LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-1-97**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

S.R. **105**

Station **See Location - Appendix I**

Offset

C.S. **2532**

Equipment **BK-80**

Casing **HW X 20', HQ X 118'**

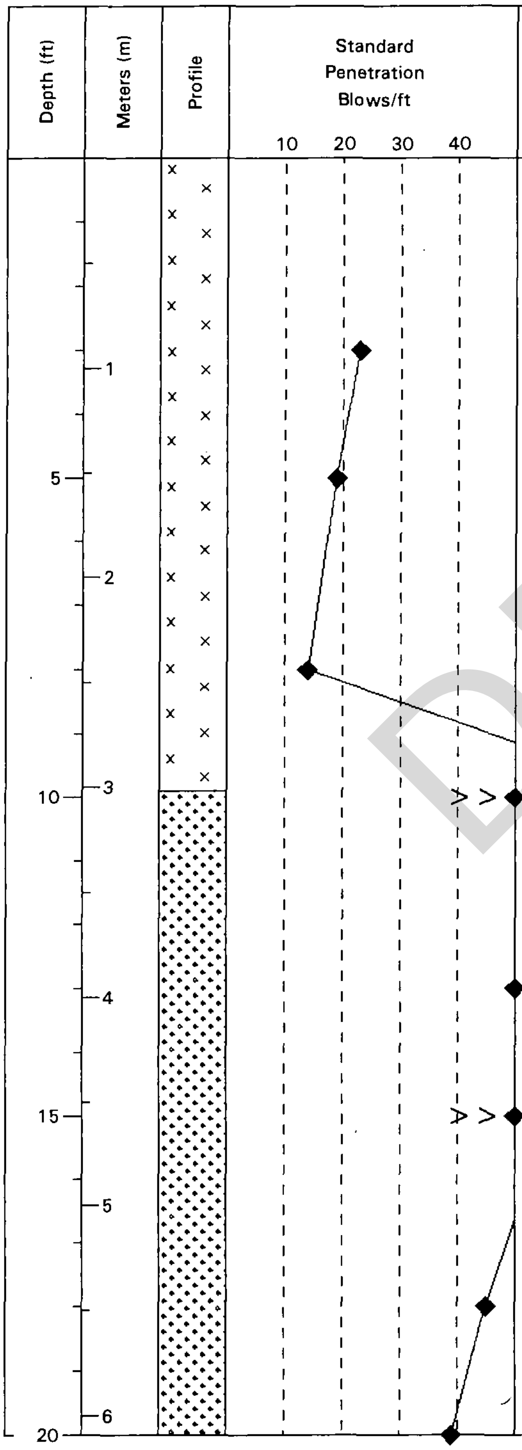
Ground El **(m)**

Method of Boring **Wet Rotary**

Start Date **January 23, 1997**

Completion Date **January 24, 1997**

Sheet **1** of **6**



1 ft.=0.3048 m.

SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
9 12 11 12 (23)	D-1		Poorly graded SAND, medium dense, reddish brown, moist, homogeneous. (Fill). Retained 1.0 ft.
9 10 9 11 (19)	D-2	GS MC	SP, M.C.=12% Poorly graded SAND, medium dense, brown, moist, homogeneous. (Fill). Retained 1.0 ft.
3 4 10 48 (14)	D-3		Poorly graded SAND with silt and gravel, medium dense, reddish brown, moist, stratified. (Fill). Retained 1.0 ft.
42 40 38 46 (78	D-4		PLEISTOCENE TERRACE DEPOSITS (UNIT 2B) Poorly graded SAND with silt and gravel, very dense, brown, moist, stratified. Retained 1.0 ft.
17 22 28 40 (50	D-5		Poorly graded SAND, very dense, brown, moist, homogeneous. Retained 1.0 ft.
14 23 33 43 (56	D-6	GS MC	SP-SM, M.C.=17% Poorly graded SAND with silt, very dense, brown, moist, homogeneous. Retained 1.0 ft.
10 18 27 39 (45	D-7		Poorly graded SAND, dense, brown, moist, homogeneous. Retained 1.0 ft.

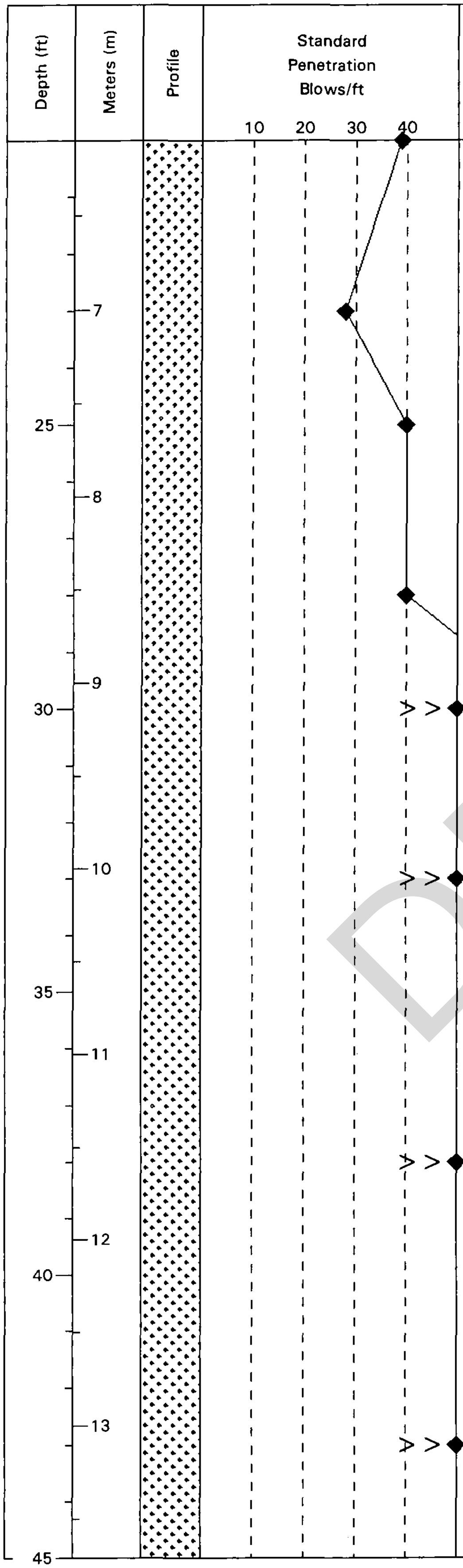
LOG OF TEST BORING

HOLE No. **B-1-97**

Sheet **2** of **6**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
12 16 23 32 (39	D-8		Poorly graded SAND, dense, brown, wet, homogeneous. Retained 1.0 ft.
	C-9		No recovery.
5 11 17 28 (28)	D-10		Poorly graded SAND, dense, brown, wet, homogeneous. Retained 1.0 ft.
7 16 24 48 (40)	D-11		Poorly graded SAND, dense, brown, wet, homogeneous. Retained 1.0 ft.
8 15 25 50 (40)	D-12	GS MC	SP-SM, M.C.=28% Poorly graded SAND with silt, dense, brown, wet, homogeneous. Retained 1.0 ft.
15 28 40 50 (68	D-13		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
16 27 40 40 (67	D-14		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
15 22 32 42 (54	D-15		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
19 32 47 (79)	D-16		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.

Groundwater

Instrument

LOG OF TEST BORING

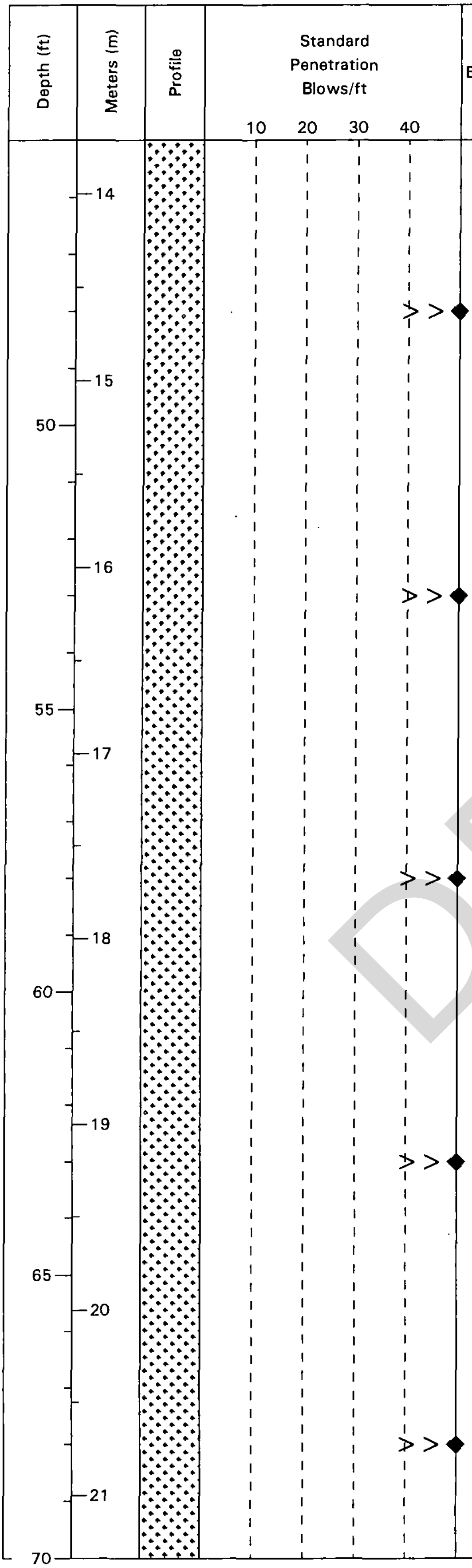
Washington State
Department of Transportation

HOLE No. **B-1-97**

Sheet 3 of 6

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
16 25 45 (70)		D-17		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
14 21 31 (52)		D-18	GS MC	SP-SM, M.C. = 30% Poorly graded SAND with silt, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
14 21 36 (57)		D-19		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
14 21 36 (57)		D-20		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
14 21 36 (57)		D-21		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		

LOG OF TEST BORING

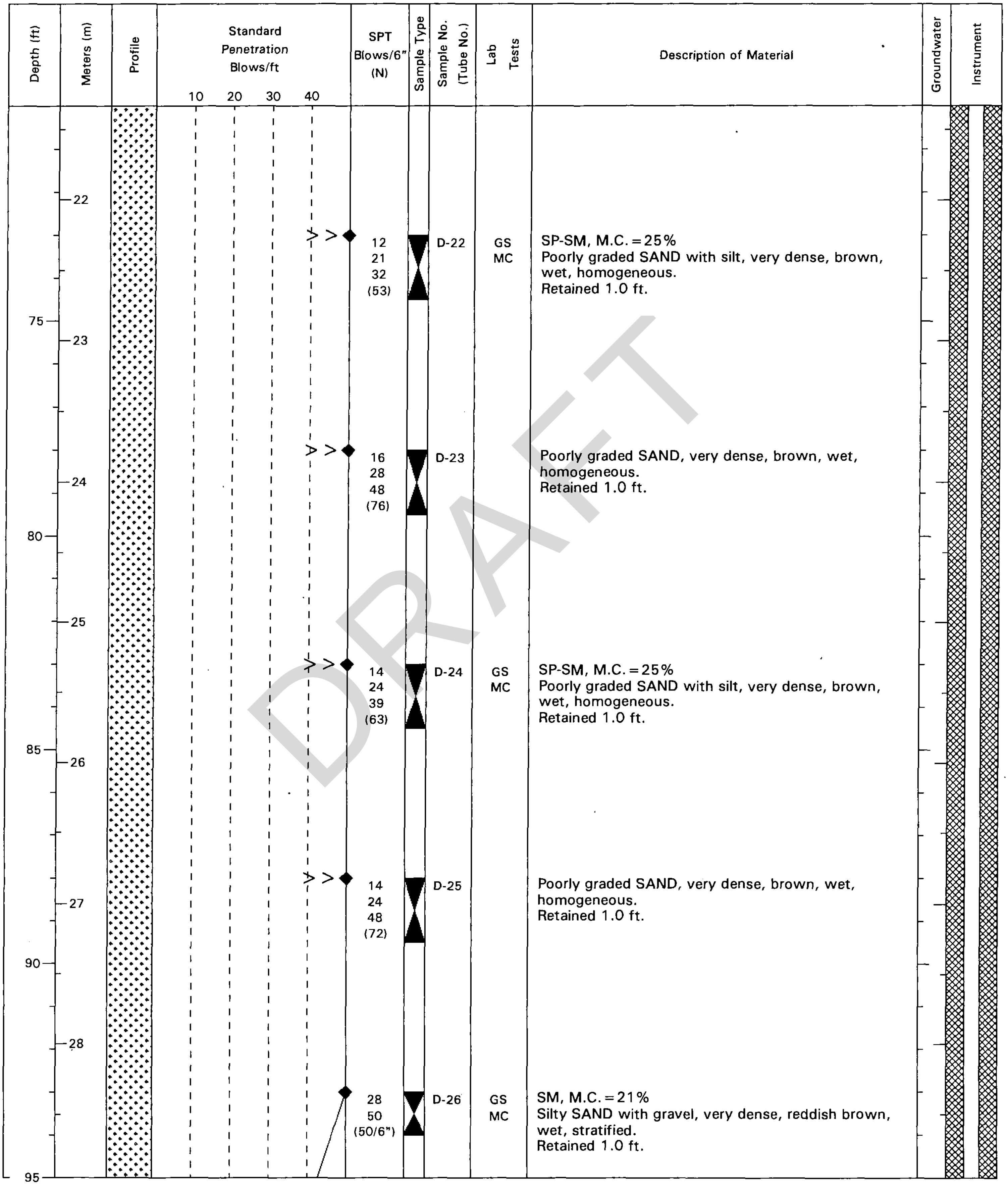
Washington State
Department of Transportation

HOLE No. **B-1-97**

Sheet **4** of **6**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
12 21 32 (53)	D-22	GS MC	SP-SM, M.C. = 25% Poorly graded SAND with silt, very dense, brown, wet, homogeneous. Retained 1.0 ft.
16 28 48 (76)	D-23		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
14 24 39 (63)	D-24	GS MC	SP-SM, M.C. = 25% Poorly graded SAND with silt, very dense, brown, wet, homogeneous. Retained 1.0 ft.
14 24 48 (72)	D-25		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
28 50 (50/6")	D-26	GS MC	SM, M.C. = 21% Silty SAND with gravel, very dense, reddish brown, wet, stratified. Retained 1.0 ft.

LOG OF TEST BORING

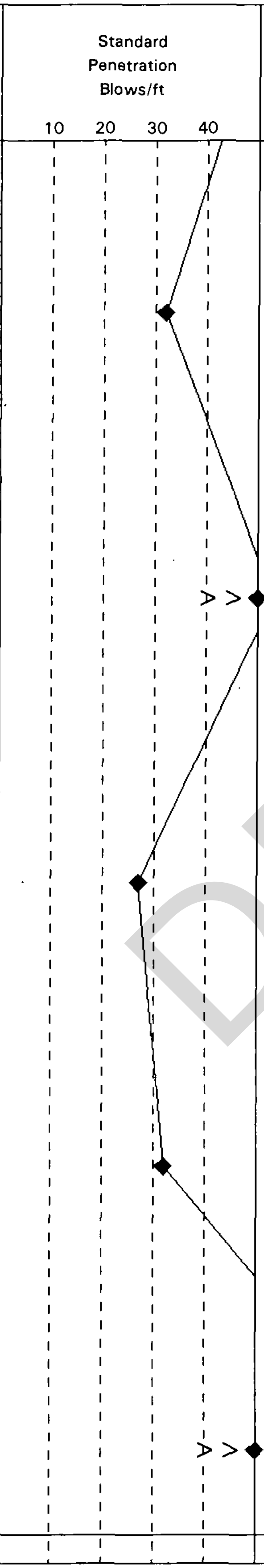
Washington State Department of Transportation

HOLE No. **B-1-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **5** of **6**

Job No. **OL-2431**



Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
	29				
		8 10 22 (32)	D-27		Poorly graded SAND, dense, brown, wet, homogeneous. Retained 1.0 ft.
	30				
100					
	31				
		11 19 34 (53)	D-28	GS MC	SM, M.C. = 31% Silty SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
105	32				
		8 11 16 (27)	D-29		Poorly graded SAND, dense, brown, wet, stratified. Retained 1.0 ft.
	33				
110					
	34				
		8 12 20 (32)	D-30		Poorly graded SAND, dense, brown, wet, stratified. Retained 1.0 ft.
115	35				
	36	15 31 47 (78)	D-31	GS MC	SM, M.C. = 29% Silty SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
120					

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **B-1-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **6** of **6**

Job No. **OL-2431**

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft 10 20 30 40	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
125 130 135 140 145	37 38 39 40 41 42 43 44							End of test hole boring at 119.5 ft below ground elevation. Installed 2" PVC. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		

LOG OF TEST BORING

HOLE No. **B-2-97**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

S.R. **105**

Station **See Location - Appendix I**

Offset

C.S. **2532**

Equipment **BK-80**

Casing **HW X 118'**

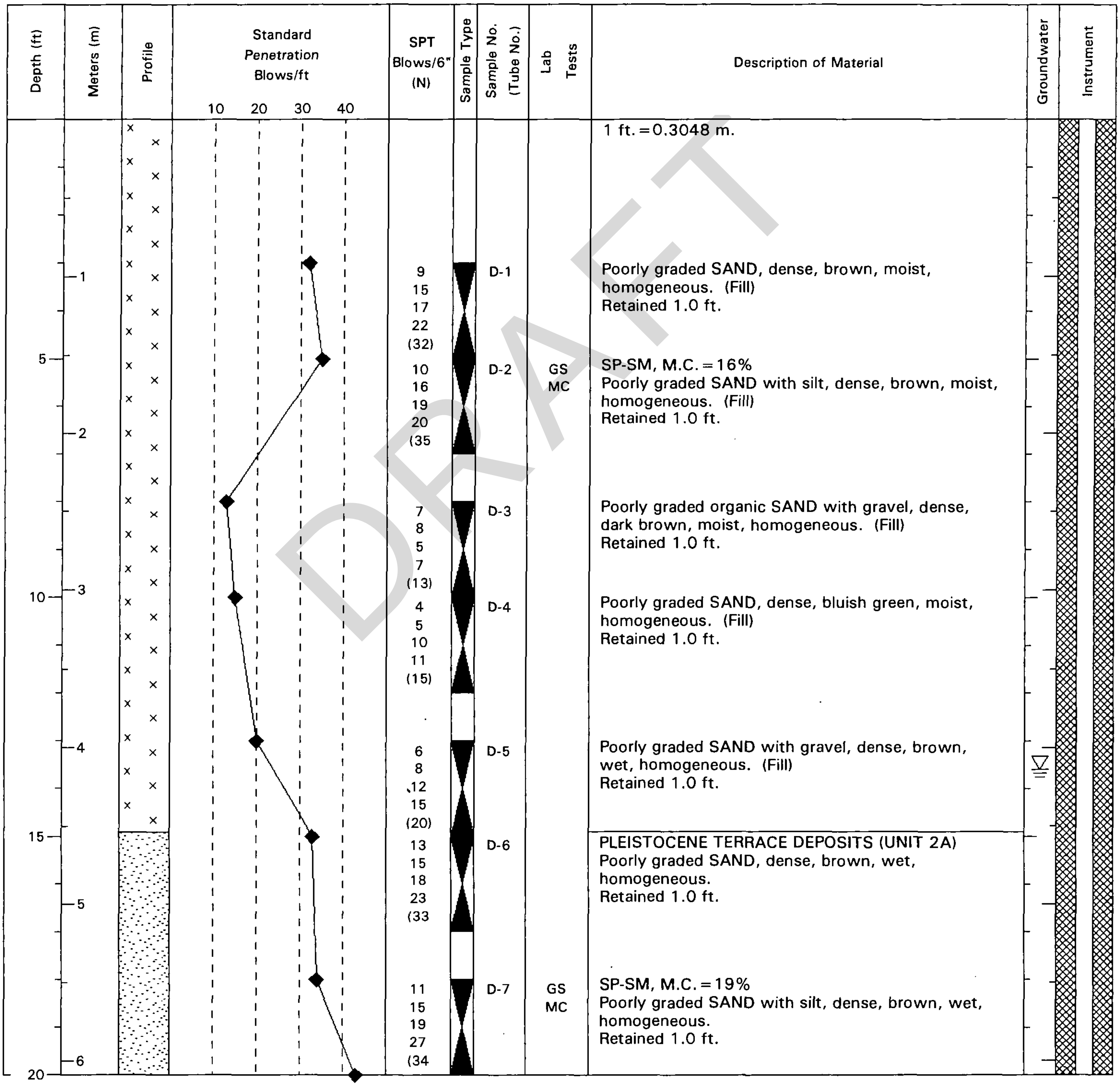
Ground El **(m)**

Method of Boring **Wet Rotary**

Start Date **January 17, 1997**

Completion Date **January 22, 1997**

Sheet **1** of **6**



1 ft. = 0.3048 m.

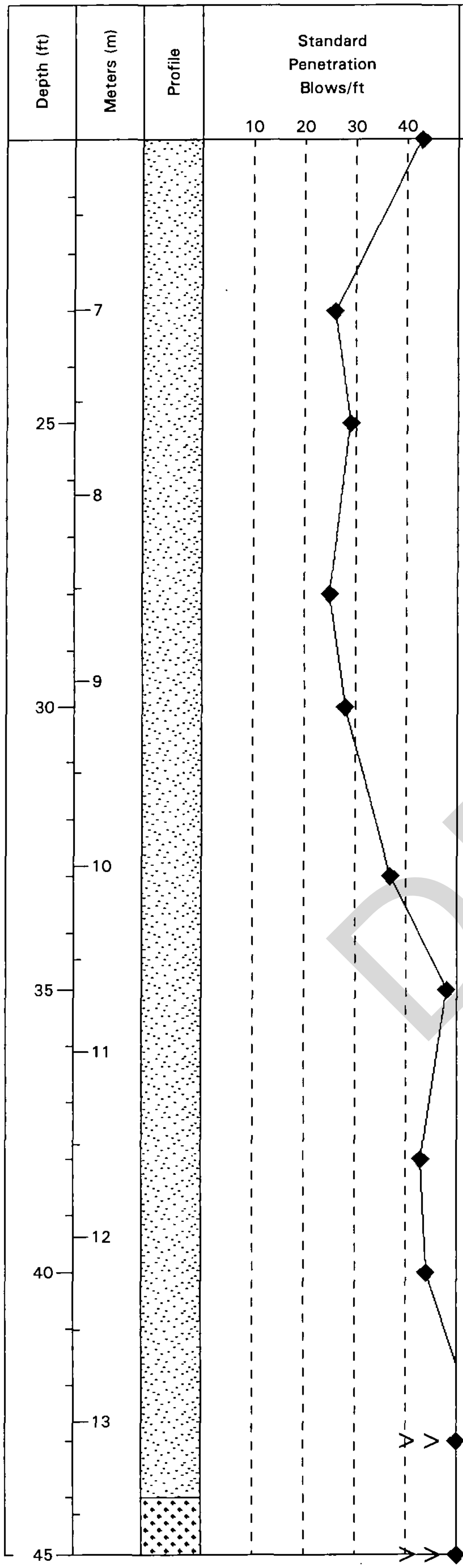
SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
9 15 17 22 (32)	D-1		Poorly graded SAND, dense, brown, moist, homogeneous. (Fill) Retained 1.0 ft.
10 16 19 20 (35	D-2	GS MC	SP-SM, M.C. = 16% Poorly graded SAND with silt, dense, brown, moist, homogeneous. (Fill) Retained 1.0 ft.
7 8 5 7 (13)	D-3		Poorly graded organic SAND with gravel, dense, dark brown, moist, homogeneous. (Fill) Retained 1.0 ft.
4 5 10 11 (15)	D-4		Poorly graded SAND, dense, bluish green, moist, homogeneous. (Fill) Retained 1.0 ft.
6 8 12 15 (20)	D-5		Poorly graded SAND with gravel, dense, brown, wet, homogeneous. (Fill) Retained 1.0 ft.
13 15 18 23 (33	D-6		PLEISTOCENE TERRACE DEPOSITS (UNIT 2A) Poorly graded SAND, dense, brown, wet, homogeneous. Retained 1.0 ft.
11 15 19 27 (34	D-7	GS MC	SP-SM, M.C. = 19% Poorly graded SAND with silt, dense, brown, wet, homogeneous. Retained 1.0 ft.

LOG OF TEST BORING

HOLE No. **B-2-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **2** of **6**
Job No. **OL-2431**



SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
15 18 25 35 (43	D-8		Poorly graded SAND with gravel, dense, reddish brown, wet, stratified. Retained 1.0 ft.
10 14 11 14 (26	D-9		Poorly graded SAND, dense, brown, wet, homogeneous. Retained 1.0 ft.
11 12 17 17 (29	D-10		Poorly graded SAND, dense, reddish brown, wet, stratified. Retained 1.0 ft.
4 8 17 20 (25)	D-11		Poorly graded SAND with gravel, dense, brown, wet, homogeneous. Retained 1.0 ft.
6 14 14 16 (28)	D-12	GS MC	SP, M.C. = 12% Poorly graded SAND with gravel, dense, brown, wet, homogeneous. Retained 1.0 ft.
14 15 22 35 (37	D-13	GS MC	ML, M.C. = 35% Sandy SILT, dense, brown, wet, homogeneous. Retained 1.0 ft.
8 17 31 39 (48)	D-14		Poorly graded SAND with silt, dense, brown, wet, homogeneous. Retained 1.0 ft.
9 16 27 32 (43)	D-15		Poorly graded SAND with silt, dense, brown, wet, homogeneous. Retained 1.0 ft.
8 17 27 38 (44)	D-16		Poorly graded SAND with silt, dense, brown, wet, homogeneous. Retained 1.0 ft.
11 21 34 49 (55	D-17		Poorly graded SAND with silt, very dense, brown, wet, homogeneous. Retained 1.0 ft. PLEISTOCENE TERRACE DEPOSITS (UNIT 2B)

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **B-2-97**

Sheet 3 of 6

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
	14	>>	10 19 37 51 (56	D-18		Poorly graded SAND with silt, very dense, brown, wet, homogeneous. Retained 1.0 ft.
	15	>>	14 23 35 (58)	D-19	GS MC	SM, M.C.=32% Silty SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
50						
	16	>>	14 30 80 (110)	D-20		Poorly graded SAND with silt, very dense, brown, wet, homogeneous. Retained 1.0 ft.
55	17					
	18	>>	16 42 80 (122)	D-21		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
60	19					
		>>	26 80 (80/6")	D-22		Poorly graded SAND with silt, very dense, reddish brown, wet, stratified. Retained 1.0 ft.
65	20					
	21	>>	29 89 (89/6")	D-23		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
70						

LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-2-97**

Sheet 4 of 6

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

Depth (ft)	Meters (m)	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
	22					
		> >	25 80 (80/6")	D-24	GS MC	SP-SM, M.C.=27% Poorly graded SAND with silt and gravel, very dense, brown, wet, stratified. Retained 1.0 ft.
75	23					
		> >	17 36 50 (86)	D-25		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
	24					
80						
	25					
		> >	15 30 42 (72)	D-26		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
85	26					
			18 50 (50/6")	D-27		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
	27					
90						
	28					
		> >	16 39 50 (89)	D-28		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.
95						

LOG OF TEST BORING

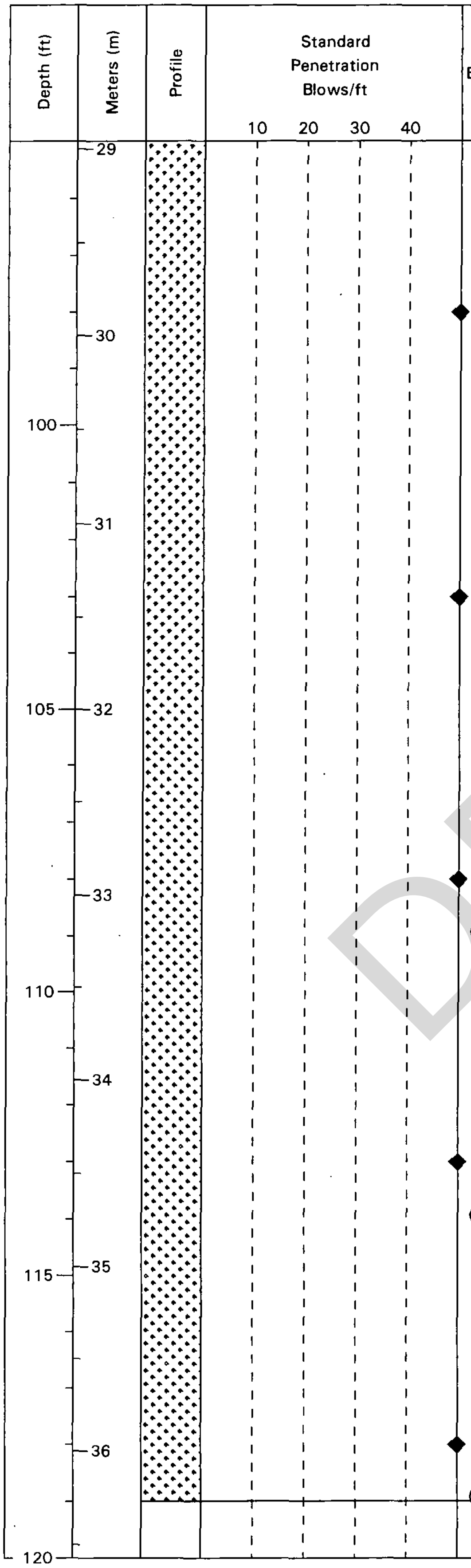
Washington State
Department of Transportation

HOLE No. **B-2-97**

Sheet **5** of **6**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
17 50 (50/6")	⧗	D-29	GS MC	SM, M.C.=29% Silty SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
17 50 (50/6")	⧗	D-30		Poorly graded SAND, very dense, reddish brown, wet, homogeneous. Retained 1.0 ft.		
24 50 (50/6")	⧗	D-31		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
27 50 (50/6")	⧗	D-32	GS MC	SM, M.C.=28% Silty SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
26 50 (50/6")	⧗	D-33		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
				End of test hole boring at 119.0 ft.		

LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-2-97**

Sheet **6** of **6**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft 10 20 30 40	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	37							Installed 2" PVC. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
	38									
125										
	39									
130										
	40									
	41									
135										
	42									
140										
	43									
	44									
145										

LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-3-97**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

S.R. **105**

Station **See Location - Appendix I**

Offset

C.S. **2532**

Equipment **BK-80**

Casing **HW X 50', HQ X 118'**

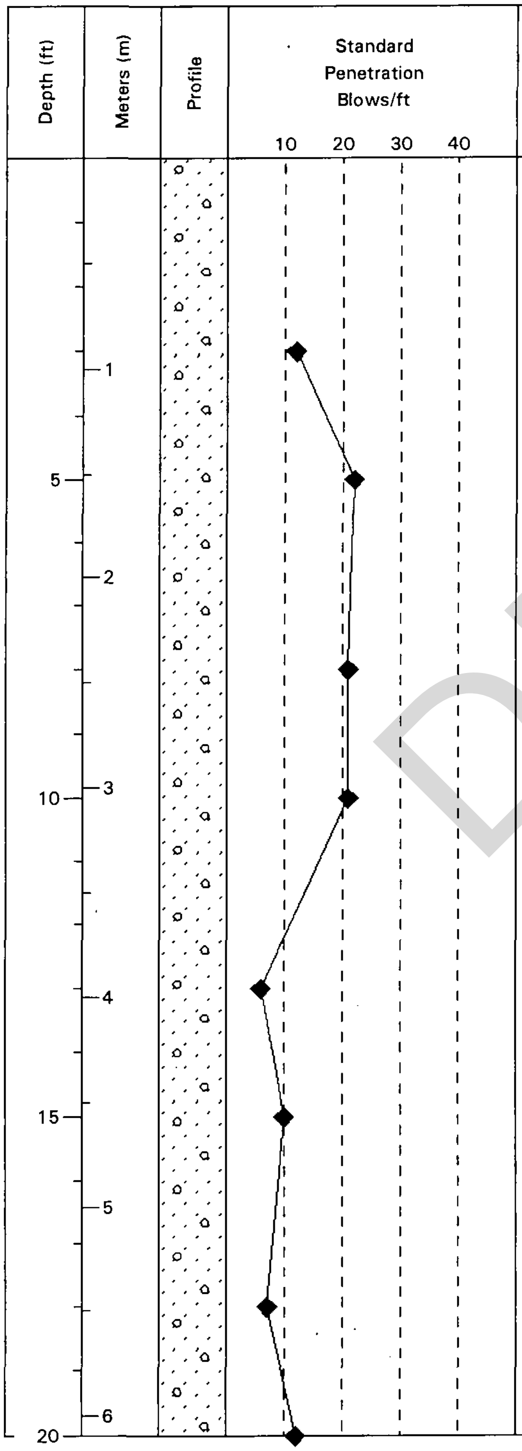
Ground El **(m)**

Method of Boring **Wet Rotary**

Start Date **January 25, 1997**

Completion Date **January 27, 1997**

Sheet **1** of **6**



SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				1 ft.=0.3048 m.		
				HOLOCENE DUNE AND BEACH DEPOSITS (UNIT 1)		
2 6 6 8 (12)		D-1		Poorly graded SAND, medium dense, brown/reddish brown, moist. stratified. Retained 1.5 ft.		
6 10 12 15 (22)		D-2	GS MC	SP, M.C.=12% Poorly graded SAND, medium dense, gray, moist, stratified. Retained 1.4 ft.		
4 9 12 15 (21)		D-3		Poorly graded SAND, medium dense, gray, moist, stratified. Retained 1.4 ft.		
7 10 11 14 (21)		D-4		Poorly graded SAND with gravel, medium dense, gray, moist, stratified. Retained 1.3 ft.		
6 2 4 3 (6)		D-5		Poorly graded SAND, loose, gray, wet, homogeneous. Retained 1.3 ft.		
3 5 5 6 (10)		D-6		Poorly graded SAND, loose, gray, wet, homogeneous. Retained 1.3 ft.		
1 3 4 7 (7)		D-7		Poorly graded SAND with organics and wood, loose, gray, wet, homogeneous. Retained 1.2 ft.		

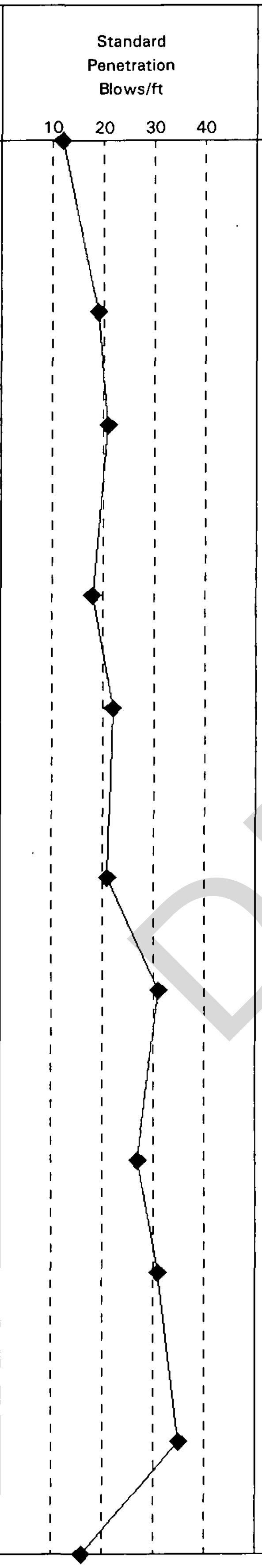
LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-3-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **2** of **6**
Job No. **OL-2431**



Depth (ft)	Meters (m)	SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
		3 4 8 8 (12)	D-8		Poorly graded SAND with wood, medium dense, gray,wet, homogeneous. Retained 1.8 ft.
	7	5 8 11 13 (19)	D-9		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.4 ft.
25	8	10 11 10 14 (21	D-10	GS MC	SP-SM, M.C. = 14% Poorly graded SAND with silt, medium dense, gray, wet, stratified. Retained 1.8 ft.
	9	5 7 11 14 (18)	D-11		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.4 ft.
30		6 9 13 16 (22)	D-12		Poorly graded SAND with gravel, medium dense, gray, wet, stratified. Retained 1.5 ft.
	10	7 8 13 17 (21)	D-13		Poorly graded SAND with gravel, medium dense, gray, wet, stratified. Retained 1.8 ft.
35	11	8 12 19 32 (31)	D-14		Poorly graded SAND with gravel, dense, gray, wet, stratified. Retained 2.0 ft.
	12	8 11 16 20 (27)	D-15		Poorly graded SAND, dense, bluish gray, wet, homogeneous. Retained 1.7 ft.
40		8 13 18 21 (31)	D-16	GS MC	SP-SM, M.C. = 26% Poorly graded SAND with silt, dense, bluish gray, wet, homogeneous. Retained 1.6 ft.
	13	10 17 18 20 (35	D-17		Poorly graded SAND, dense bluish gray, wet, homogeneous. Retained 1.5 ft.
45					

Profile | Sample Type | Groundwater | Instrument

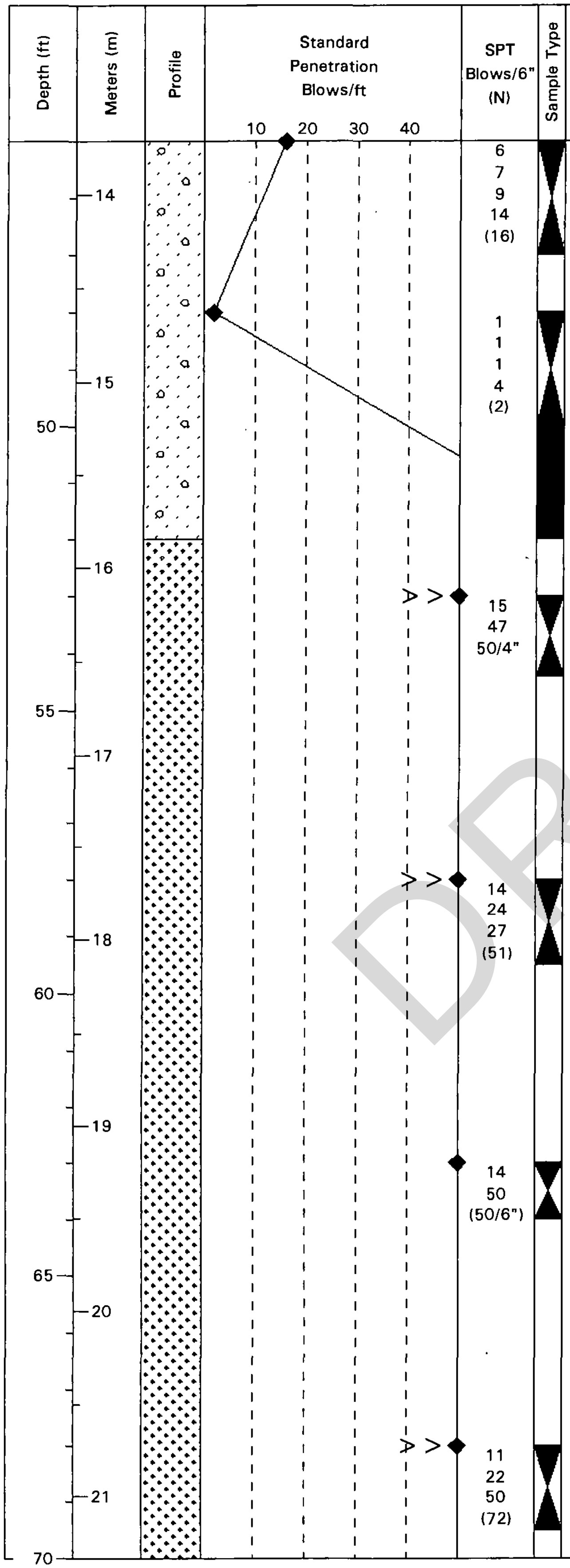
LOG OF TEST BORING

HOLE No. **B-3-97**

Sheet **3** of **6**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
6 7 9 14 (16)	D-18		Poorly graded SAND, dense, bluish gray, wet, homogeneous. Retained 1.8 ft.
1 1 1 4 (2)	D-19		FAT CLAY with sand lenses, soft, gray, wet, stratified. Retained 2.0 ft.
	U-20		No recovery.
			PLEISTOCENE TERRACE DEPOSITS (UNIT 2B)
15 47 50/4"	D-21	GS MC	SP-SM, M.C.=22% Poorly graded SAND with silt and gravel, very dense, brown,wet, stratified. Retained 1.3 ft.
14 24 27 (51)	D-22	GS MC	SW-SM, M.C.=11% Well graded SAND with silt and gravel, subrounded, very dense, wet, stratified. Retained 1.0 ft.
14 50 (50/6")	D-23		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 0.8 ft.
11 22 50 (72)	D-24		Poorly graded GRAVEL with sand, subrounded, very dense, brown, wet, homogeneous. Retained 0.2 ft.

Groundwater

Instrument

LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-3-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **4** of **6**
Job No. **OL-2431**

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft 10 20 30 40	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	22									
			> >	16 34 50 (84)		D-25		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 1.4 ft.		
75	23									
				31 50 (50/6")		D-26		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 1.0 ft.		
	24									
80										
	25									
				31 50/2 (50/2")		D-27		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 0.7 ft.		
85	26									
			> >	26 38 68 (106)		D-28		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 1.4 ft.		
	27									
90										
	28									
			> >	29 40 78 (118)		D-29	GS MC	SP, M.C. = 13% Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 1.3 ft.		
95										

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **B-3-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **5** of **6**

Job No. **OL-2431**

SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
23 25 36 (61)	D-30	GS MC	SP-SM, M.C. = 12% Poorly graded SAND with silt and gravel, very dense, brown/reddish brown, moist, stratified. Retained 1.3 ft.
24 31 39 (70)	D-31		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 1.3 ft.
24 50 (50/6")	D-32		Poorly graded SAND, very dense, brown, wet, homogeneous. Retained 0.3 ft.
33 50 (50/6")	D-33	GS MC	SP-SM, M.C. = 24% Poorly graded SAND with silt and gravel, very dense, brown, wet, homogeneous. Retained 1.0 ft.
50/6" (50/6")	D-34		Poorly graded SAND with gravel, very dense, brown, wet, homogeneous. Retained 0.5 ft.

End of test hole boring at 118.5 ft below ground elevation.

LOG OF TEST BORING

Washington State Department of Transportation

HOLE No. **B-3-97**

Sheet **6** of **6**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft 10 20 30 40	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	37							Installed 2" PVC. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
125	38									
	39									
130	40									
	41									
135	42									
140	43									
	44									
145										

LOG OF TEST BORING

Washington State
Department of Transportation

HOLE No. **B-4-97**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**

S.R. **105**

Station **See Location - Appendix I**

Offset

C.S. **2532**

Equipment **BK-80**

Casing **HW X 78'**

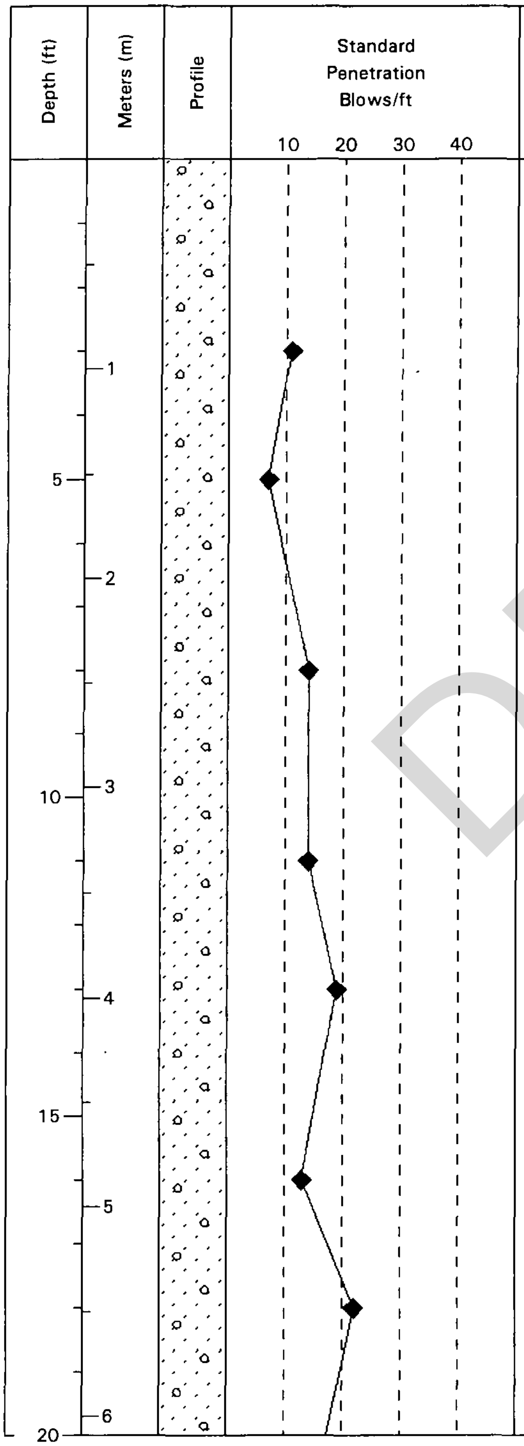
Ground El **(m)**

Method of Boring **Wet Rotary**

Start Date **January 28, 1997**

Completion Date **January 29, 1997**

Sheet **1** of **4**



SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater
			1 ft.=0.3048 m.	
3 5 6 6 (11)	D-1	GS MC	HOLOCENE DUNE AND BEACH DEPOSIT (UNIT 1) SP, M.C=20% Poorly graded SAND, medium dense, gray, moist, stratified. Retained 1.3 ft.	
2 3 4 5 (7)	D-2		Poorly graded SAND, medium dense, gray, moist, stratified. Retained 1.9 ft.	
3 6 8 10 (14)	D-3		Poorly graded SAND, medium dense, gray,wet, homogeneous. Retained 1.4 ft.	▽
3 6 8 10 (14)	D-4		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.2 ft.	
4 8 11 13 (19)	D-5		Poorly graded SAND with gravel, medium dense, gray, wet, homogeneous. Retained 1.2 ft.	
4 5 8 11 (13)	D-6		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.2 ft.	
7 10 12 16 (22)	D-7		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.3 ft.	

LOG OF TEST BORING

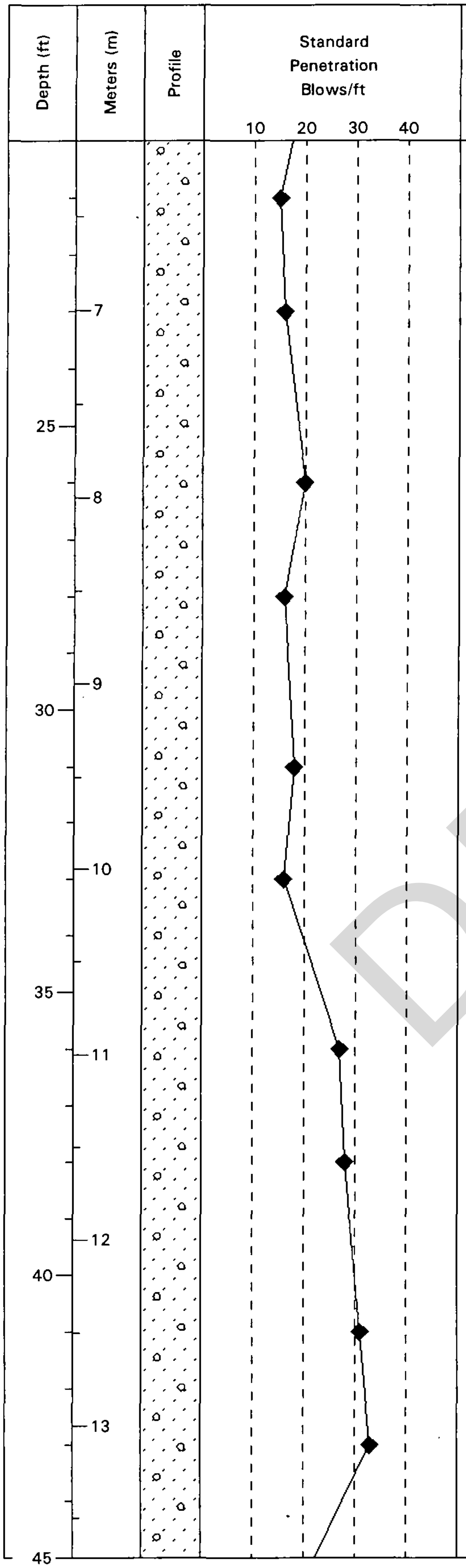
Washington State
Department of Transportation

HOLE No. **B-4-97**

Sheet **2** of **4**

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



SPT Blows/6" (N)	Sample No. (Tube No.)	Lab Tests	Description of Material
4 7 8 11 (15)	D-8		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.1 ft.
4 7 9 11 (16)	D-9		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.4 ft.
7 10 10 11 (20)	D-10	GS MC	SP-SM, M.C. = 25% Poorly graded SAND with silt, medium dense, gray, wet, homogeneous. Retained 1.3 ft.
5 8 8 13 (16)	D-11		Poorly graded SAND with gravel, medium dense, gray, wet, stratified. Retained 1.3 ft.
8 8 10 12 (18)	D-12		Poorly graded SAND, medium dense, gray, wet, homogeneous. Retained 1.6 ft.
6 8 8 12 (16)	D-13		Poorly graded SAND with gravel, medium dense, gray, wet, homogeneous. Retained 1.6 ft.
5 11 16 17 (27)	D-14		Poorly graded SAND with gravel, dense, gray,wet, homogeneous. Retained 1.5 ft.
9 14 14 15 (28)	D-15		Poorly graded SAND with gravel, dense, gray, wet, stratified. Retained 1.7 ft.
8 13 18 22 (31)	D-16		Poorly graded SAND, dense, gray, wet, homogeneous.
12 20 13 15 (33	D-17	GS MC	SP-SM, M.C. = 13% Poorly graded SAND with silt and gravel, dense, gray, wet, stratified. Retained 1.4 ft.

Groundwater

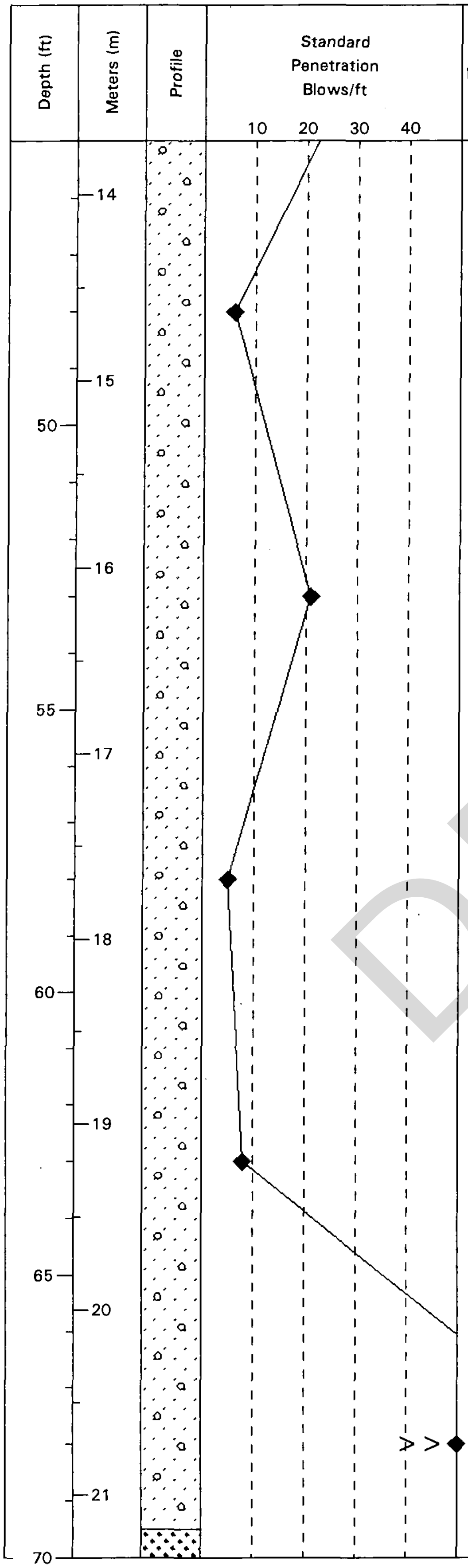
Instrument

LOG OF TEST BORING

HOLE No. **B-4-97**

PROJECT **Willapa Bay Channel Restoration Project**

Sheet **3** of **4**
Job No. **OL-2431**



SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
3 3 3 5 (6)	⧗	D-18	GS MC	SM, M.C.=29% Silty SAND, loose, bluish gray, wet, homogeneous. Retained 1.5 ft.		
2 9 12 17 (21)	⧗	D-19		Poorly graded SAND with gravel, medium dense, bluish gray, wet, stratified. Retained 1.4 ft.		
2 2 3 3 (5)	⧗	D-20		Poorly graded SAND with silt, loose, bluish gray, wet, homogeneous. Retained 1.6 ft.		
3 4 4 5 (8)	⧗	D-21		Poorly graded SAND with silt, loose, bluish gray, wet, homogeneous. Retained 0.2 ft.		
12 27 50 (77)	⧗	D-22	GS MC	SW-SM, M.C.=16% Well graded SAND with silt and gravel, very dense, bluish gray, wet, stratified. Retained 0.2 ft.		
				PLEISTOCENE TERRACE DEPOSIT (UNIT 2B)		

LOG OF TEST BORING

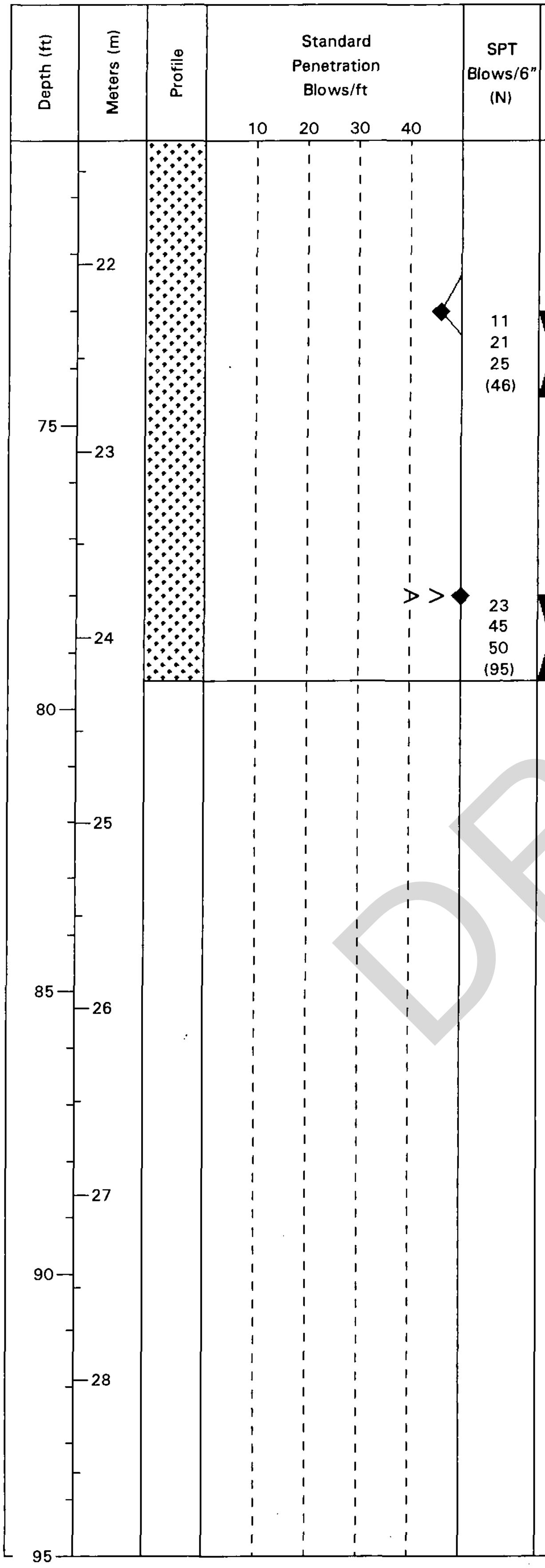
Washington State
Department of Transportation

HOLE No. **B-4-97**

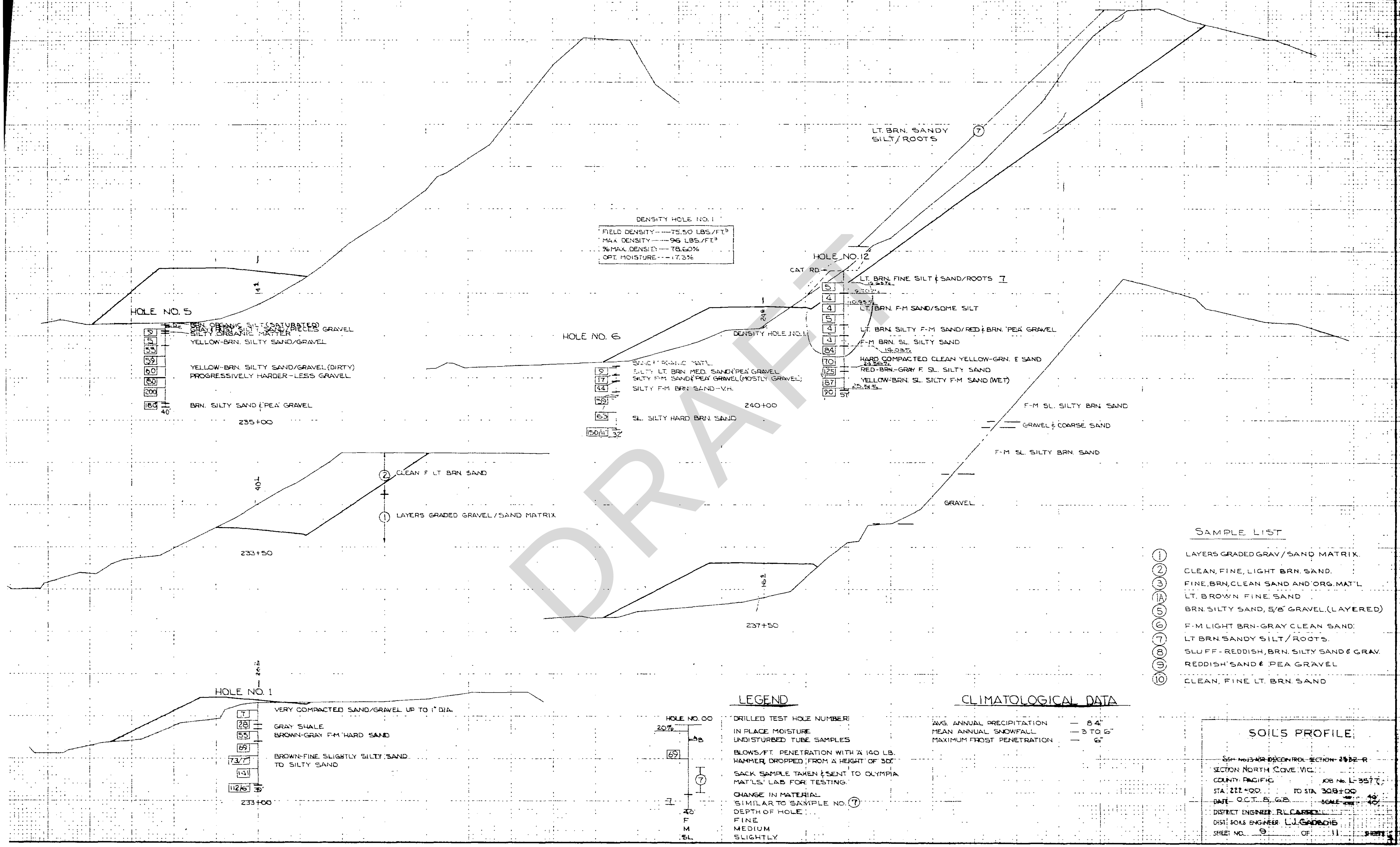
Sheet 4 of 4

PROJECT **Willapa Bay Channel Restoration Project**

Job No. **OL-2431**



Depth (ft)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	11 21 25 (46)	⧗	D-23		Poorly graded SAND, dense, reddish brown, wet, stratified. Retained 1.6 ft.		
	23 45 50 (95)	⧗	D-24	GS MC	SP-SM, M.C. = 20% Poorly graded SAND with silt, dense, brown, wet, homogeneous. Retained 1.4 ft.		
80					End of test hole boring at 79.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		



SAMPLE LIST

① LAYERS GRADED GRAV / SAND MATRIX.
② CLEAN, FINE, LIGHT BRN. SAND.
③ FINE, BRN, CLEAN SAND AND ORG. MAT'L
(1A) LT. BROWN FINE SAND
⑤ BRN. SILTY SAND, 5/8" GRAVEL. (LAYERED)
⑥ F-M LIGHT BRN-GRAY CLEAN SAND.
⑦ LT BRN. SANDY SILT / ROOTS.
⑧ SLUFF - REDDISH, BRN. SILTY SAND & GRAV.
⑨ REDDISH SAND & PEA GRAVEL
⑩ CLEAN, FINE LT. BRN. SAND

LEGEND

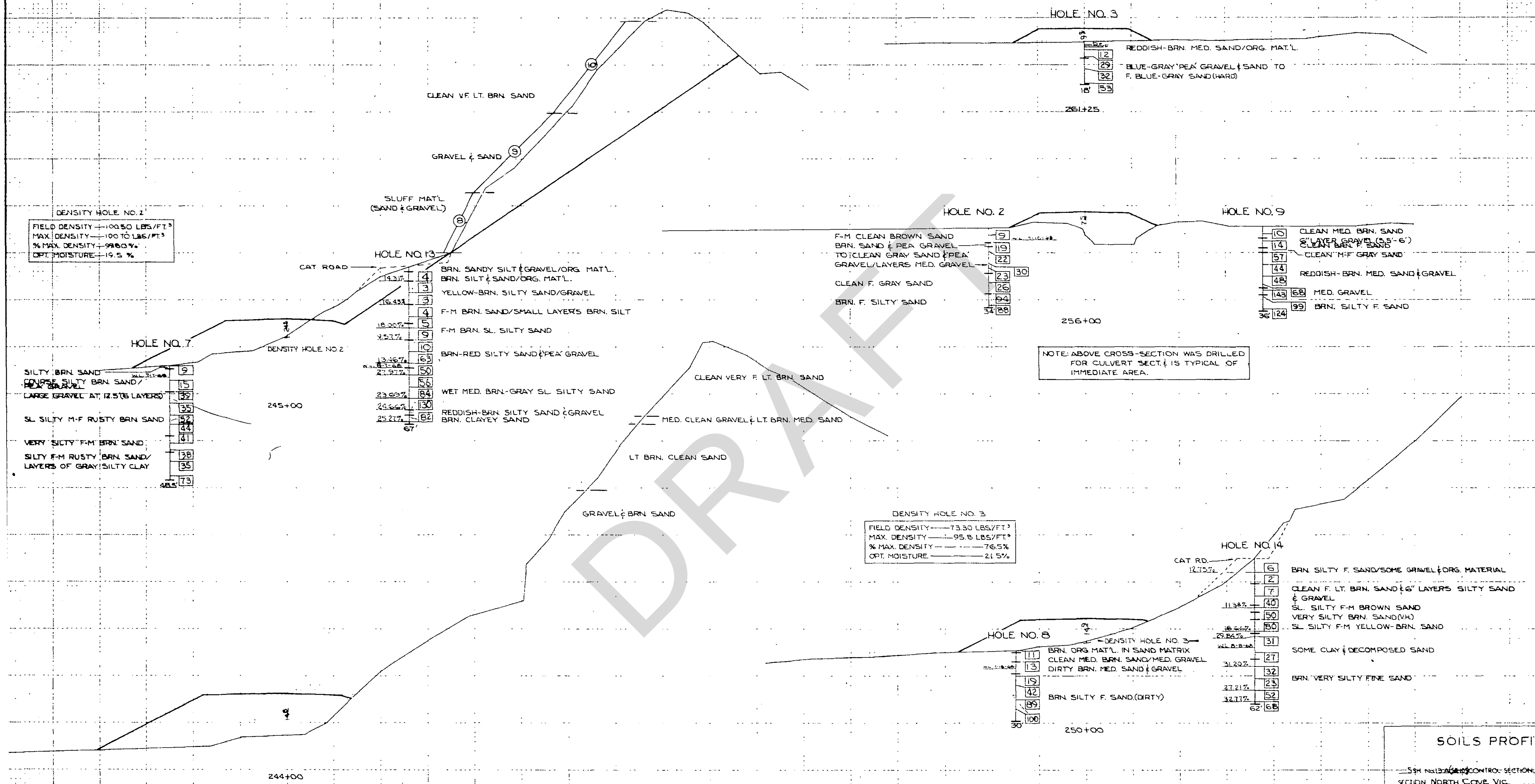
HOLE NO. 00	DRILLED TEST HOLE NUMBER
20%	IN PLACE MOISTURE
AB	UNDISTURBED TUBE SAMPLES
69	BLOWS/FT. PENETRATION WITH A 140 LB. HAMMER, DROPPED FROM A HEIGHT OF 30"
⑦	SACK SAMPLE TAKEN & SENT TO OLYMPIA MAT'LS. LAB FOR TESTING.
+	CHANGE IN MATERIAL
7	SIMILAR TO SAMPLE NO. ⑦
40'	DEPTH OF HOLE
F	FINE
M	MEDIUM
SL	SLIGHTLY

CLIMATOLOGICAL DATA

AVG. ANNUAL PRECIPITATION	— 84"
MEAN ANNUAL SNOWFALL	— 3 TO 6"
MAXIMUM FROST PENETRATION	— 6"

SOILS PROFILE

~~SSH No.13-A(SR 105) CONTROL SECTION 2532-R~~
SECTION NORTH COVE VIC.
COUNTY PACIFIC JOB No. L-3577
STA. 222+00 TO STA. 308+00
DATE OCT. 8, 68 SCALE 40' 40'
DISTRICT ENGINEER R.L. CARROLL
DIST. SOILS ENGINEER L.J. GADBOIS
SHEET NO. 9 OF 11 SHEETS



DENSITY HOLE NO. 2

FIELD DENSITY — 100.50 LBS/FT.³
MAX. DENSITY — 100.70 LBS/FT.³
% MAX. DENSITY — 99.80 %
OPT. MOISTURE — 19.5 %

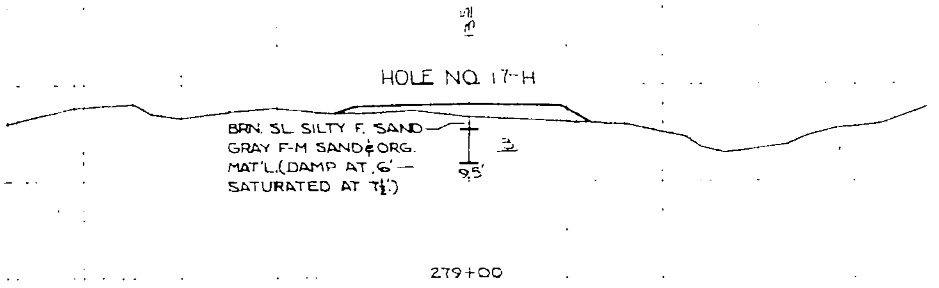
NOTE: ABOVE CROSS-SECTION WAS DRILLED FOR CULVERT SECT. & IS TYPICAL OF IMMEDIATE AREA.

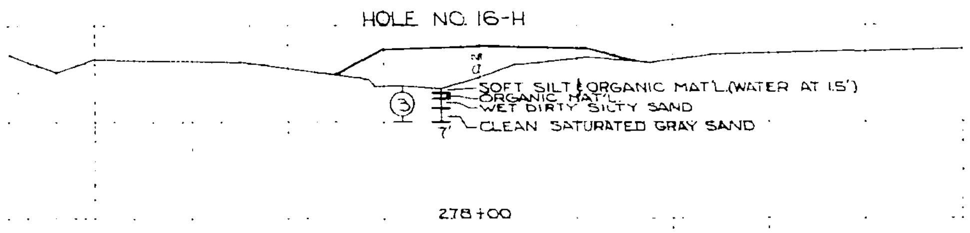
DENSITY HOLE NO. 3

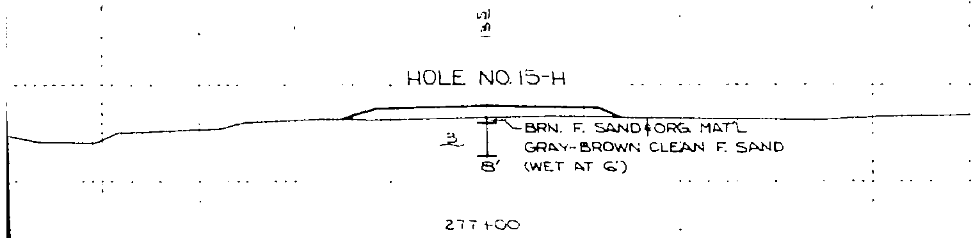
FIELD DENSITY — 73.30 LBS/FT.³
MAX. DENSITY — 95.8 LBS/FT.³
% MAX. DENSITY — 76.5%
OPT. MOISTURE — 21.5%

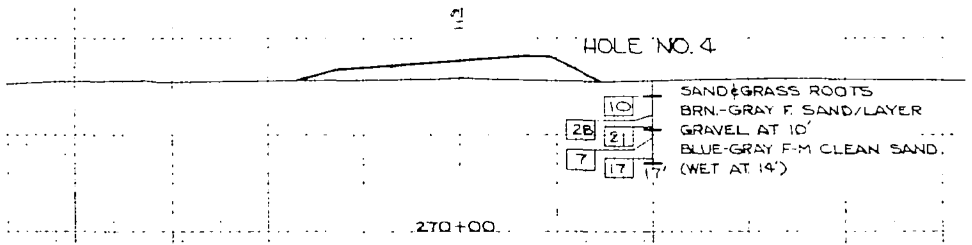
SOILS PROFILE

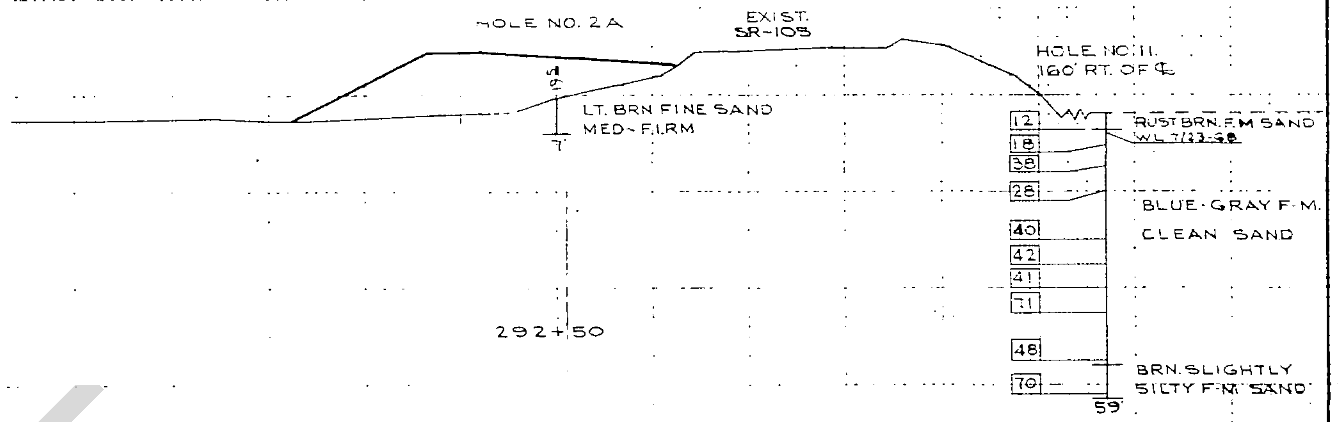
SSH No. 13 A (SR 105) CONTROL SECTION 2532-R
SECTION North Cove Vic.
COUNTY PACIFIC JOB No. L-3577
STA. 222+00 TO STA. 308+00
DATE OCT. 8, 68 SCALE VERT. 10' HORIZ. 50'
DISTRICT ENGINEER R.L. CARROLL
DIST. SOILS ENGINEER L.J. GADBOIS
SHEET NO. 10 OF 11 SHEETS

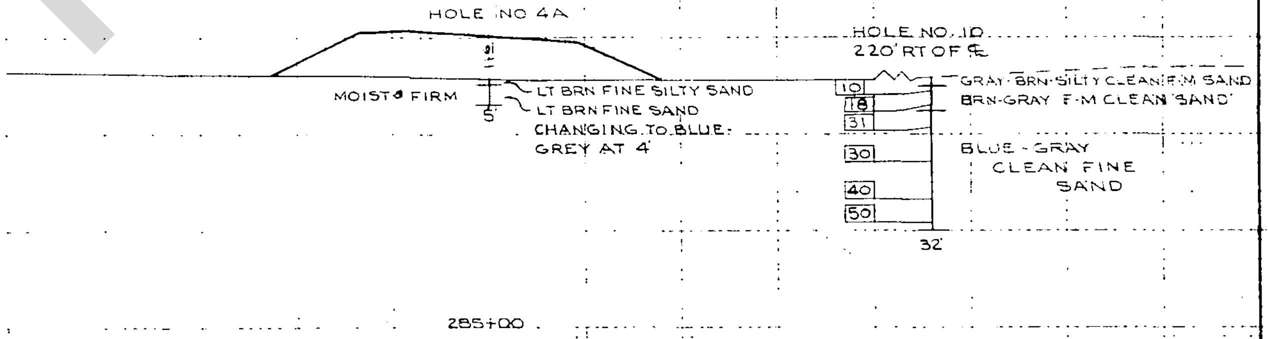




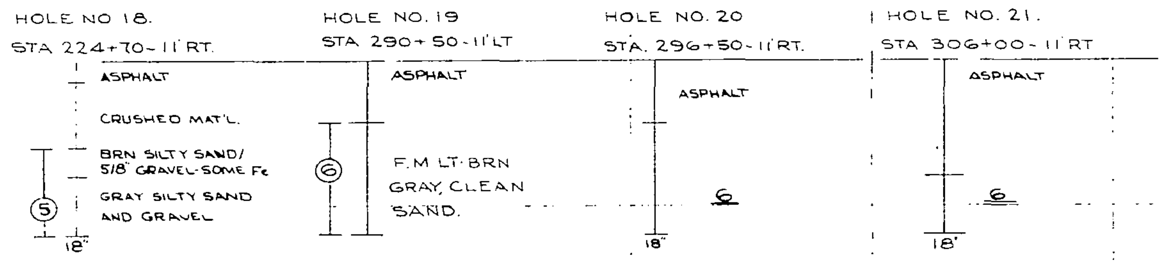








PAVEMENT DEPTH DETERMINATION



* NOTE: SCALE OF STRAIGHT-LINE PROFILE —
VERT: 1" = 10"
HORZ: NONE

SOILS PROFILE

SSH No 13-A ~~(SR 105)~~ CONTROL SECTION 2532-R
SECTION: NORTH COVE VIC.
COUNTY: PACIFIC JOB No. L-3577
STA 222+00 TO STA 308+00
DATE OCT. 8, 68 SCALE VERT 1" = 40' HOR 1" = 40'
DISTRICT ENGINEER R. L. CARROLL
DIST. SOILS ENGINEER L. J. GADBOIS
SHEET NO. 11 OF 11 SHEETS

June 17, 1985

DRILLING UNLIMITED, INCORPORATED

Page 1 of

PROJECT: Larkin Bridge No. 5151 - CRP No. 316

HOLE NO. 1 LOCATION: Sec 32 T.15N., R.11W., W.M. Sta 3+05, 2.0' Lt

ELEV.: Br. Deck WATER TABLE: 8.5' below grade REMARKS:

DEPTH	BLOWS PER FT.	LITH-OLOGY	SAMPLE DEPTH	BLOWS INCHES			DESCRIPTION
0							
1							3" asphalt paving 1' crushed rock base to 2"
2							
	6		2½	2 6	3 6	5 6	
3							Brownish-gray medium to coarse
4							organic loose sand - approach fill
5							
6							
7							
	6		7½	1 6	3 6	9 6	
8							Gray @ 8.0' wet, micaceous
9							Organic zone @ 10.0'
10							Gray medium to coarse micaceous wet
11							sand
12							
	30		12½	8 6	15 6	21 6	
13							Fine to medium sand @ 12½'
14							Sand texture is sharp
15							
16							
17							
	32		17½	8 6	16 6	21 6	
18							
19							
20							
21							
22							
	34		22½	13 6	17 6	21 6	
23							
24							
25							

June 14, 1985

DRILLING UNLIMITED, INCORPORATED

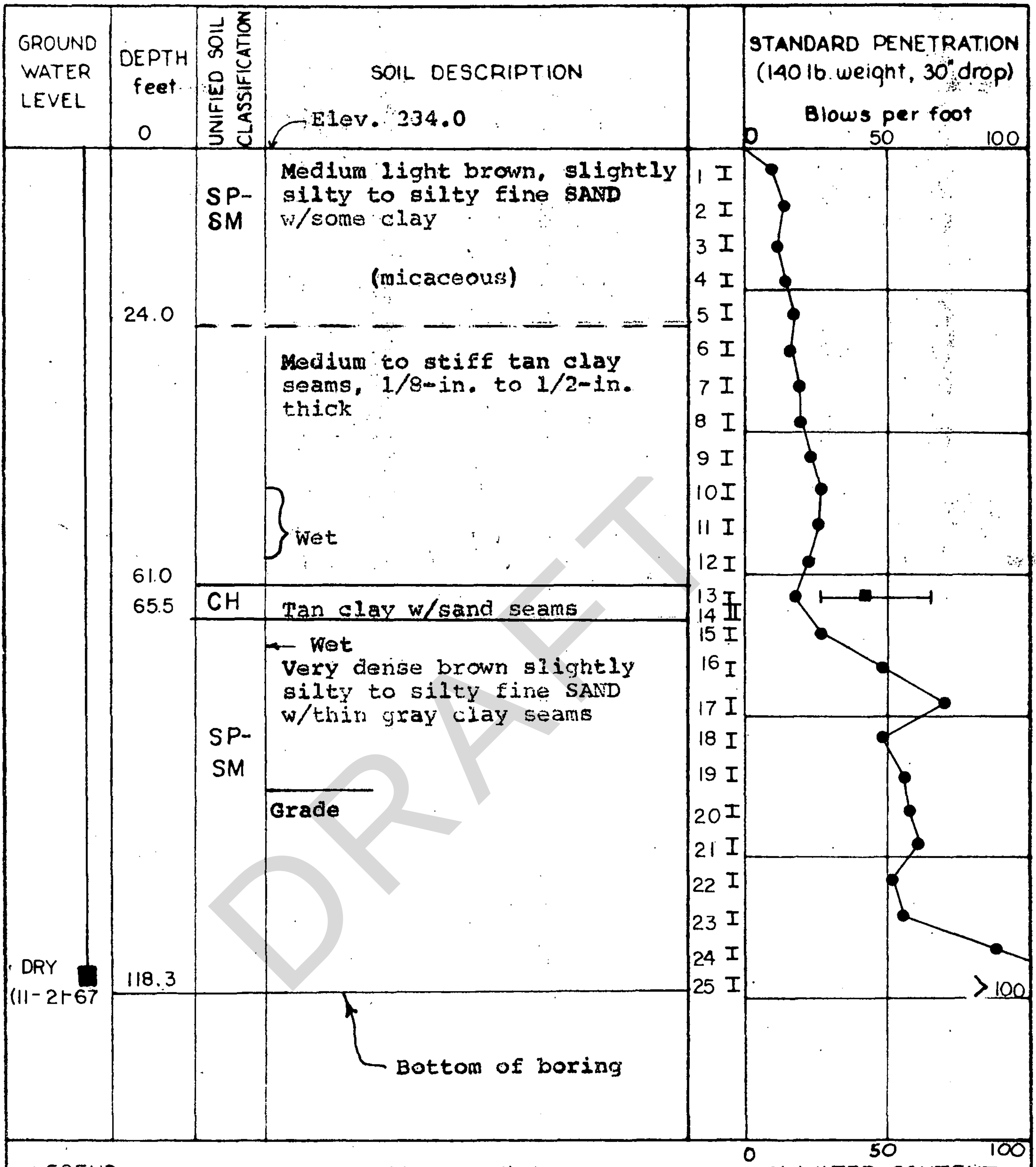
Page 2 **of** 2

PROJECT: Larkin Bridge No. 5151 (cont'd)

HOLE NO. 1 **LOCATION:**

ELEV.: **WATER TABLE:** **REMARKS:**

DEPTH	BLOWS PER FT.	LITH-OLOGY	SAMPLE DEPTH	BLOWS			DESCRIPTION
				INCHES			
25							
26							Gray fine to medium, well sorted
27							micaceous sand. Wet
	48		27½	9 6	24 6	46 6	
28							
29							
		29.0					



LEGEND

I 2" O.D. split spoon sample

II 3" O.D. Shelby sample

I 2¼" O.D. Shelby sample

P Sampler pushed

* Sample not recovered

▽ Water level

Atterberg limits:

Liquid limit

Natural water content

Plastic limit

Impervious seal

Piezometer tip

BORING B-8

0-67-289 November, 1967

SHANNON & WILSON
SOIL MECHANICS & FOUNDATION ENGINEERS

FIG 10

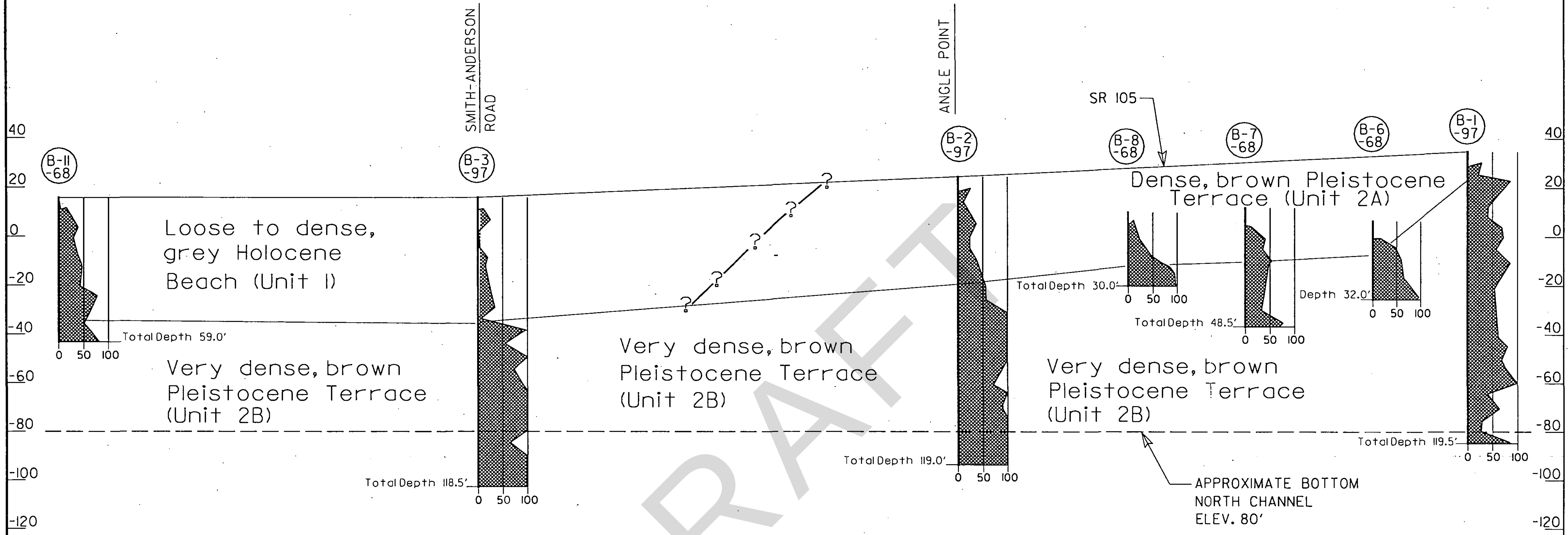


FIGURE 8: GENERALIZED GEOLOGIC SECTION A - A'

JOB OL-2431 S.R. 105 C.S. 2532

WILLAPA BAY CHANNEL RESTORATION PROJECT

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
D. C. JACKSON MATERIALS ENGINEER

DATE MAR. 1997
SCALE 1"=40' VERT.
1"=400' HORIZ.
SHEET ____ OF ____
DRAWN BY LSHOI

c:\dgn\willapa3.dgn Jun. 19, 1997 13:19:47

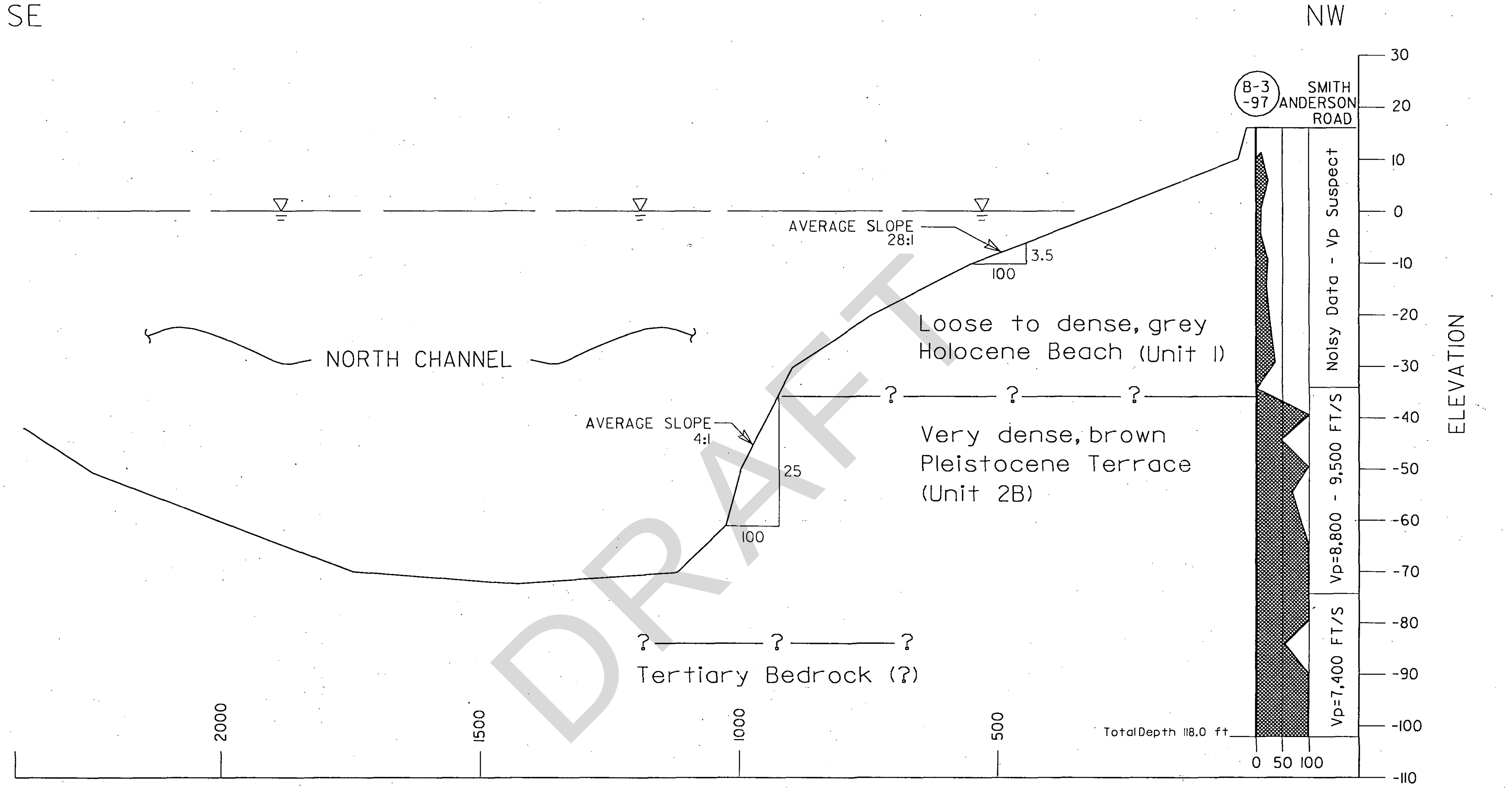


FIGURE 9: GENERALIZED GEOLOGIC SECTION B - B′

JOB OL-2431 S.R. 105 C.S. 2532

WILLAPA BAY CHANNEL
RESTORATION PROJECT

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
D. C. JACKSON MATERIALS ENGINEER

DATE MAR. 1997
SCALE 1"=20′ VERT.
1"=200′ HORIZ.
SHEET ___ OF ___
DRAWN BY LSHOI

c:\dgn\willapa.dgn Jun. 19, 1997 13:14:52

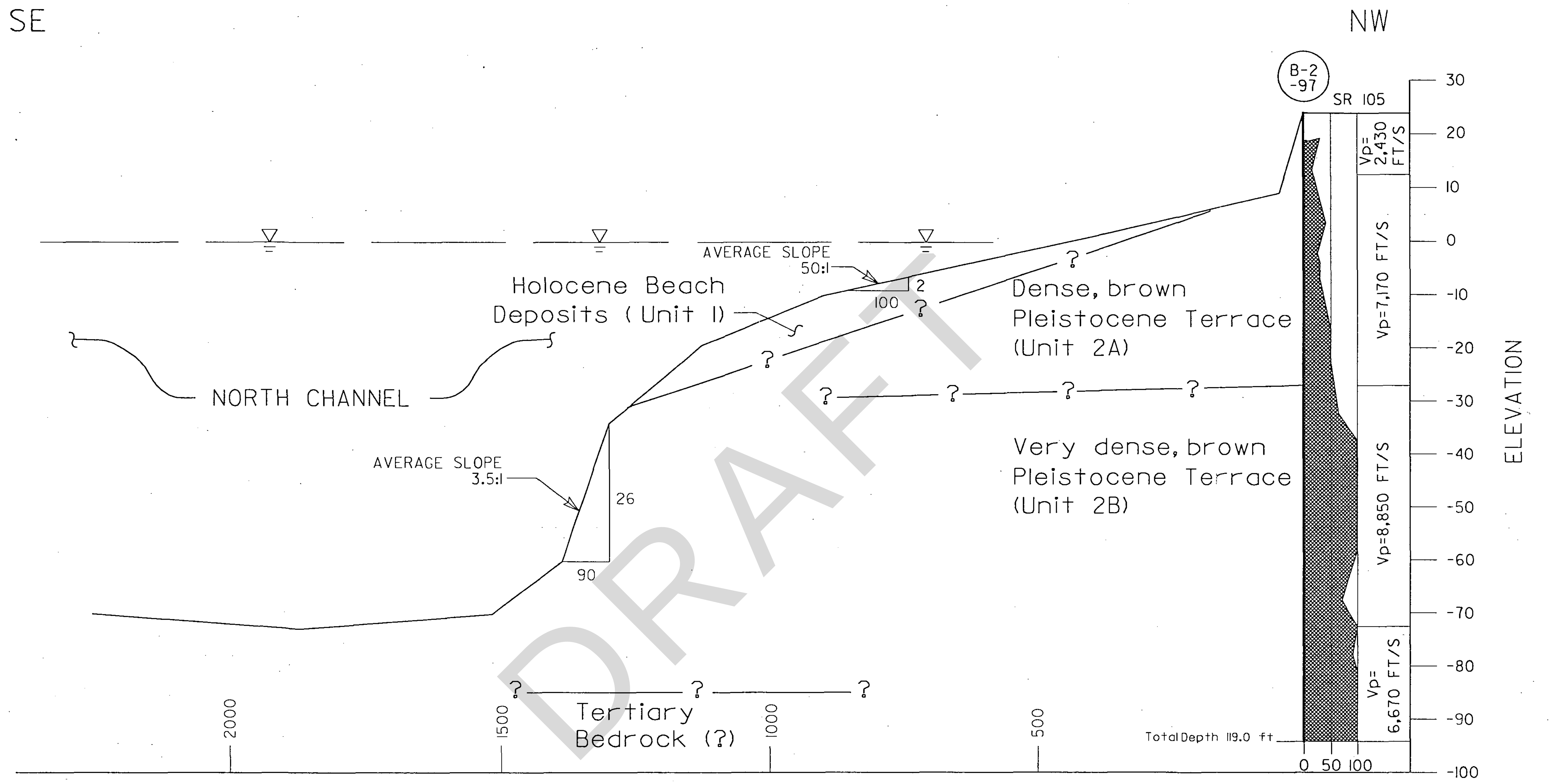


FIGURE 10: GENERALIZED GEOLOGIC SECTION C - C′

JOB OL-2431 S.R. 105 C.S. 2532

WILLAPA BAY CHANNEL
RESTORATION PROJECT

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
D. C. JACKSON MATERIALS ENGINEER

DATE MAR. 1997
SCALE 1"=20′ VERT.
1"=200′ HORIZ.
SHEET ____ OF ____
DRAWN BY LSHOI

c:\dgn\willapa1.dgn Jun. 19, 1997 13:18:46

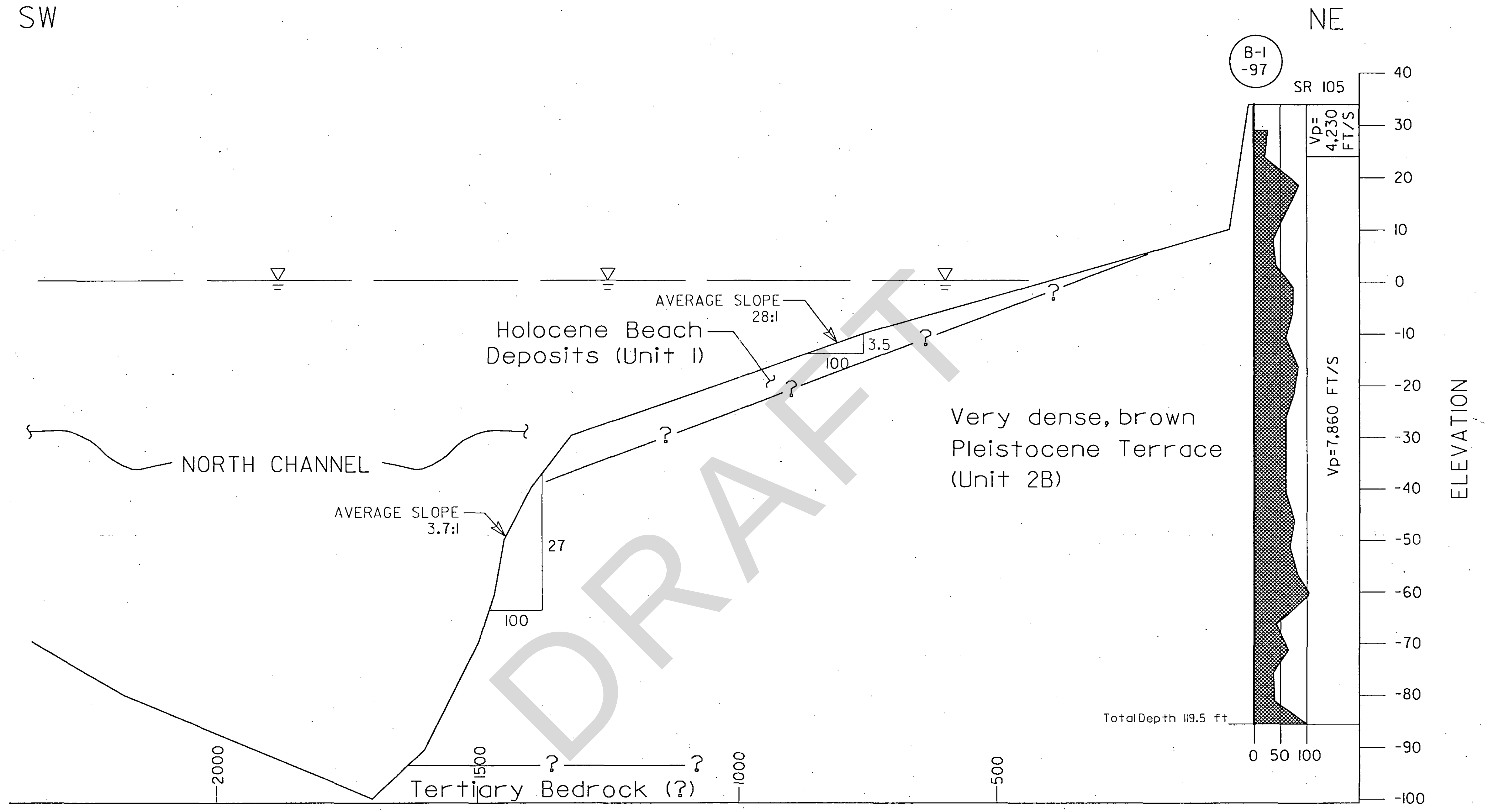


FIGURE 11: GENERALIZED GEOLOGIC SECTION D - D′

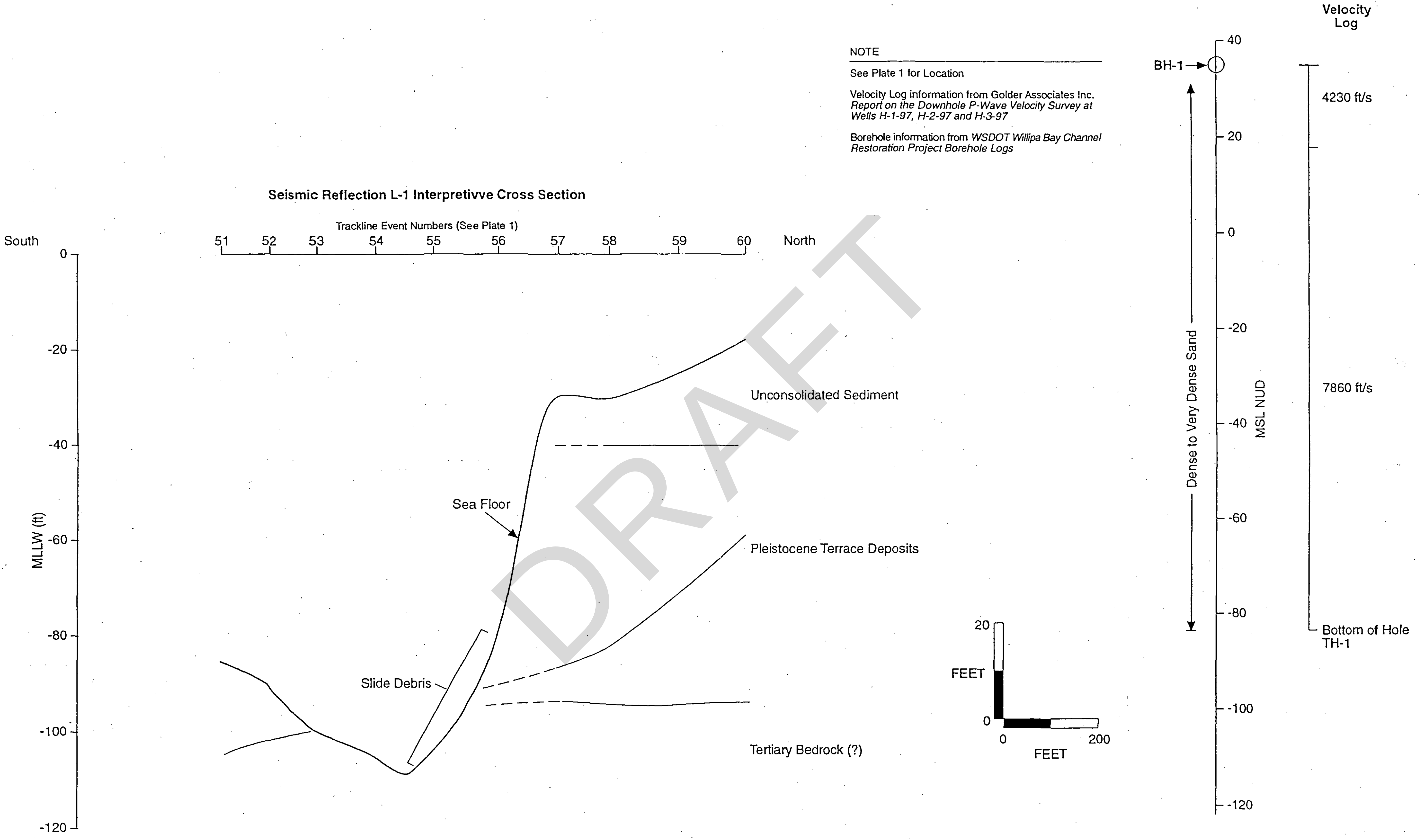
JOB OL-2431 S.R. 105 C.S. 2532

WILLAPA BAY CHANNEL
RESTORATION PROJECT

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
D. C. JACKSON MATERIALS ENGINEER

DATE MAR. 1997
SCALE 1"=20′ VERT.
1"=200′ HORIZ.
SHEET ____ OF ____
DRAWN BY LSHOI

c:\dgn\willapa2.dgn Jun. 19, 1997 13:19:21



NOTE

See Plate 1 for Location

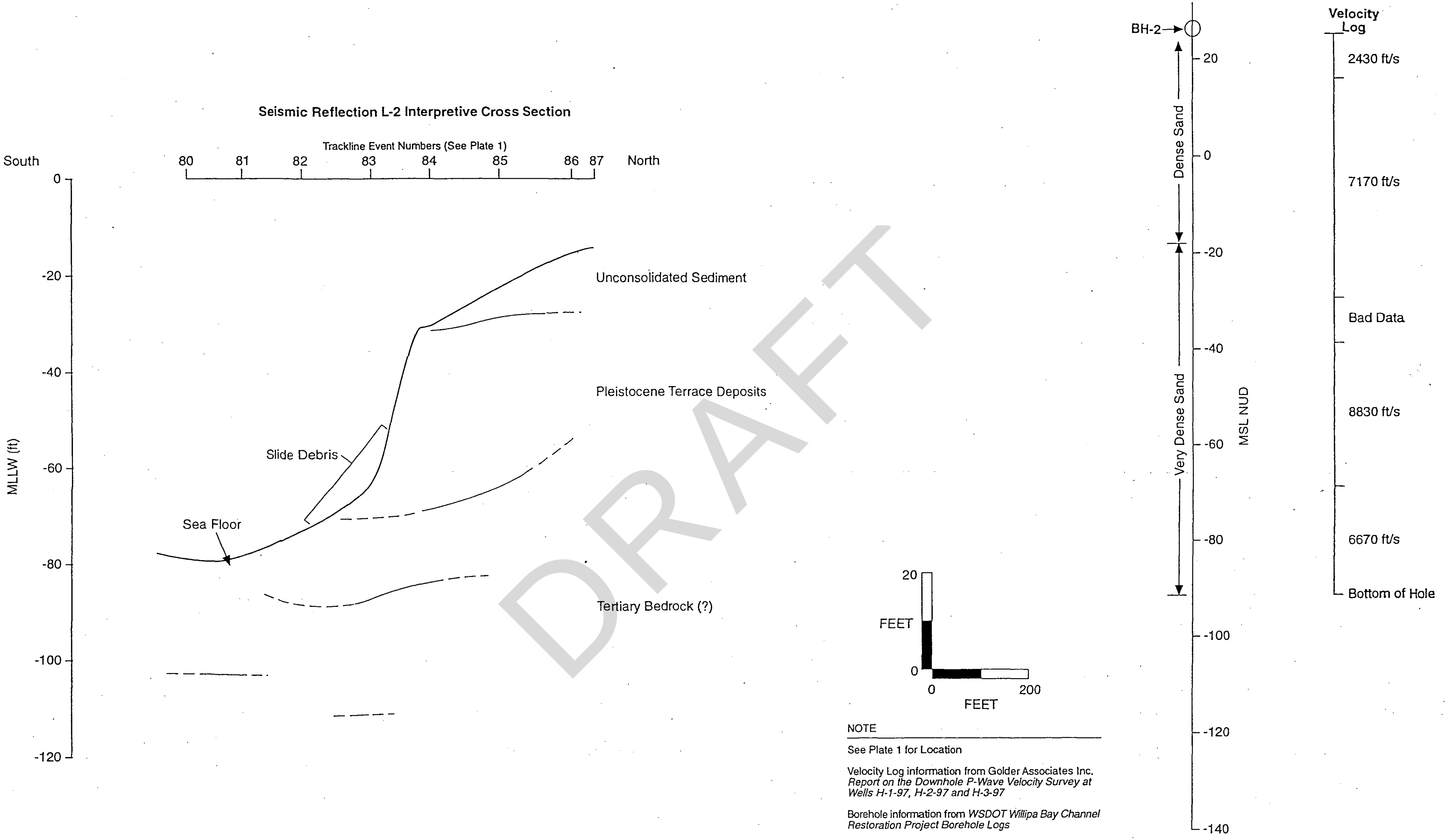
Velocity Log information from Golder Associates Inc. *Report on the Downhole P-Wave Velocity Survey at Wells H-1-97, H-2-97 and H-3-97*

Borehole information from *WSDOT Willipa Bay Channel Restoration Project Borehole Logs*

FIGURE 4

SEISMIC REFLECTION LINE 1 INTERPRETATION CROSS SECTION WITH BOREHOLE 1 DATA

WSDOT/WILLAPA BAY GEOPHYS/WA



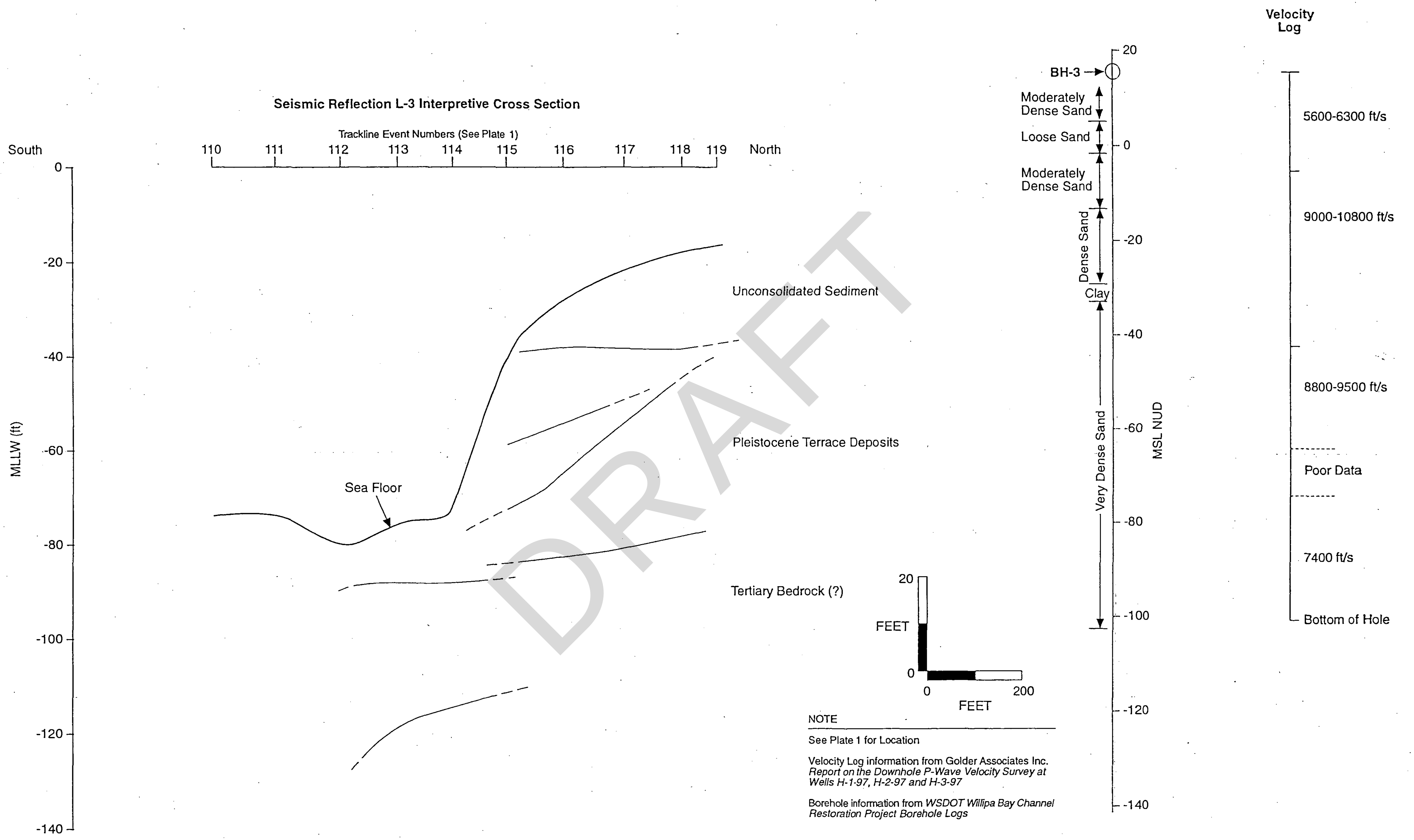
NOTE

See Plate 1 for Location

Velocity Log information from Golder Associates Inc. *Report on the Downhole P-Wave Velocity Survey at Wells H-1-97, H-2-97 and H-3-97*

Borehole information from WSDOT *Willipa Bay Channel Restoration Project Borehole Logs*

FIGURE 3
SEISMIC REFLECTION LINE 2 INTERPRETATION CROSS SECTION WITH BOREHOLE 2 DATA
WSDOT/WILLAPA BAY GEOPHYS/WA



NOTE

See Plate 1 for Location

Velocity Log information from Golder Associates Inc. *Report on the Downhole P-Wave Velocity Survey at Wells H-1-97, H-2-97 and H-3-97*

Borehole information from *WSDOT Willipa Bay Channel Restoration Project Borehole Logs*

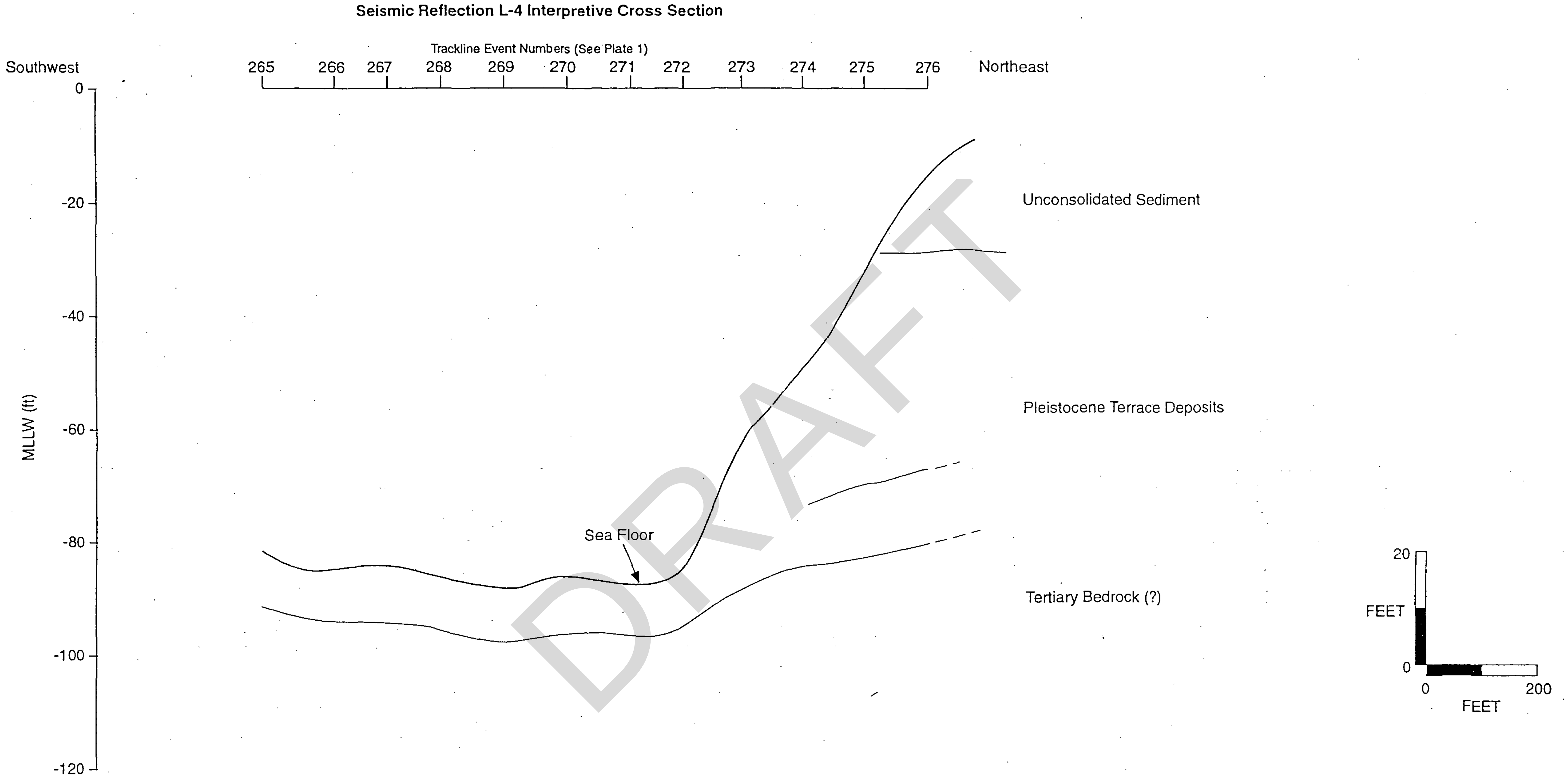
FIGURE 2

SEISMIC REFLECTION LINE 3 INTERPRETATION CROSS SECTION WITH BOREHOLE 3 DATA

WSDOT/WILLAPA BAY GEOPHYS/WA

PROJECT NO. 973 1025 DRAWING NO. 69472 DATE 4/17/97 DRAWN BY EA

Golder Associates



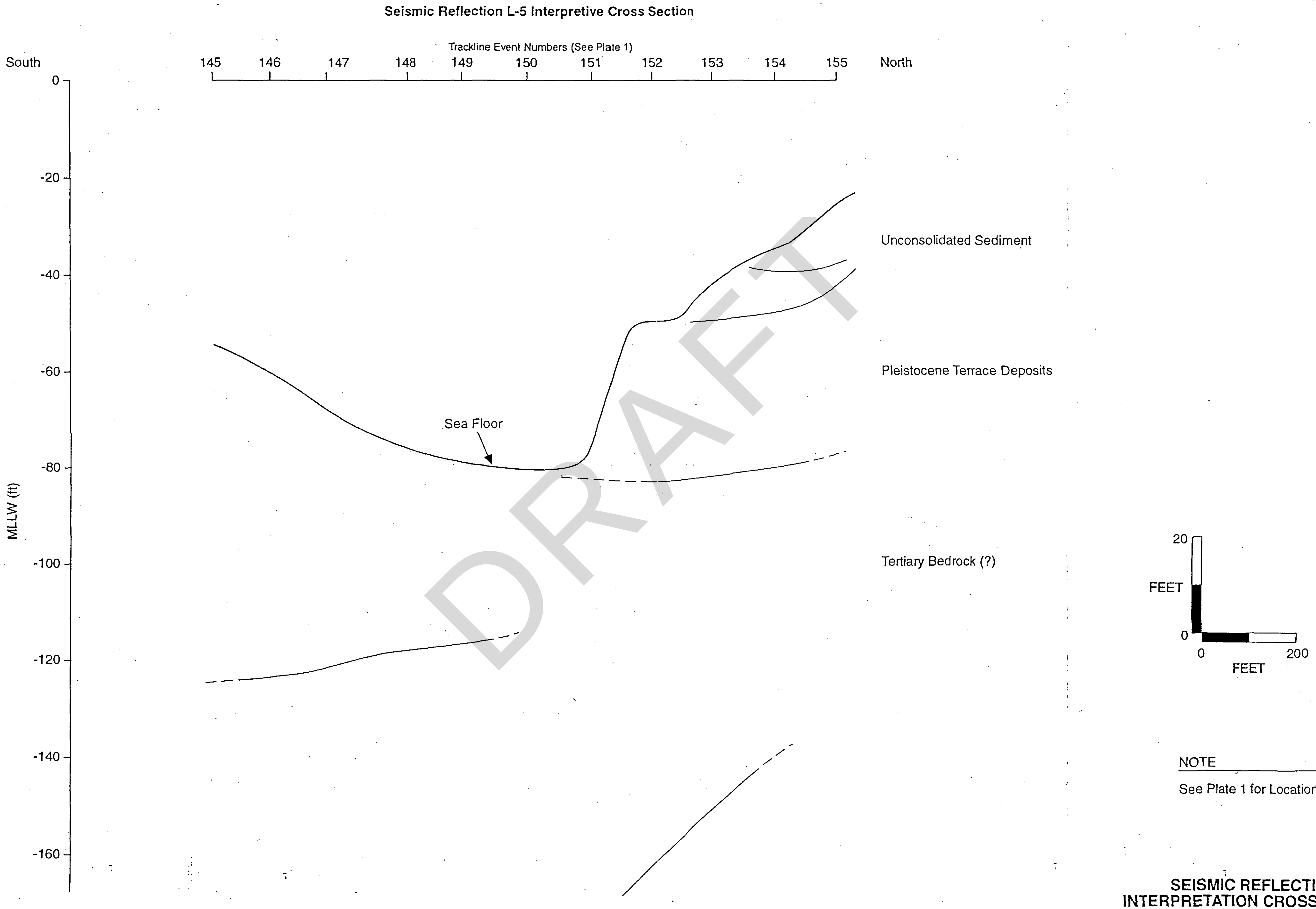
NOTE

See Plate 1 for Location

FIGURE 5
SEISMIC REFLECTION LINE 4
INTERPRETATION CROSS SECTION
WSDOT/WILLAPA BAY GEOPHYS/WA

PROJECT NO. 973 1025 DRAWING NO. 69473 DATE 4/21/97 DRAWN BY EA

Golder Associates



NOTE

See Plate 1 for Location

FIGURE 1
SEISMIC REFLECTION LINE 5
INTERPRETATION CROSS SECTION
WSDOT/WILLAPA BAY GEOPHYS/WA

APPENDIX B
GEOLOGIC RECONNAISSANCE RECORDS

GEOLOGIC DESCRIPTION AND PLEISTOCENE TERRACE DEPOSIT SUBUNIT OF COLLECTED SAMPLES.

Recon Point*	Sample Review
5	Peat bog deposit: dark brown, peat, wood debris, and organic soil, containing upright cut stump
6	Sandstone – few blocks outcropping at beach level adjacent (north and east) to peat deposits: red, fine to medium sand, trace fine gravel, iron-oxide staining
8	Conglomerate outcrop at beach level adjacent to and south of prominent outcrop: red, poorly graded fine gravel, strong iron-oxide staining, bedded and strongly cemented
9	Sandstone prominent outcrop: light brown, fine to medium sand, few silty and gravelly layers and silt rip-up clasts in sandy matrix layers, trace iron-oxide staining locally, bedded and gently inclined cross-bedded layers
10	Sandstone at beach level east of prominent outcrop: red, fine gravel and coarse sand, bedded
11	Conglomerate: red, poorly graded fine gravel, strong iron-oxide staining, bedded and strongly cemented
14	Estuarine deposits: gray, silty clay with sand and shells, trace organics

* See Figure 3 for Point Locations

SITE PHOTOGRAPHS

Region 2 from west to east

Stop 1: Western end of Region 2 at the old SR 105 eroded bank looking east, September 10, 2018, 7:02 a.m.

Stop 2: Western flank of the jetty where the drainage ditch meets the jetty and flows out to the Pacific Ocean, September 10, 2018, 7:07 a.m.

Stop 3: Southwestern flank of the jetty, September 10, 2018, 7:17 a.m.

Stop 4: Southern tip of the jetty looking south along jetty, September 10, 2018, 7:24 a.m.

Stop 4: Southern tip of the jetty, looking southwest, Monday, September 10, 2018, 7:26 a.m.

Stop 5: Stump in peat bog at east of the jetty, looking northeast inland, September 10, 2018, 8:16 a.m.

Stop 5: Peat beds with stump, looking west toward jetty, September 10, 2018, 8:19 a.m.

Stop 6: Pleistocene deposits of sandstone with peat bog deposits in background, September 10, 2018, 8:21 a.m.

Stop 6: Close up of Pleistocene deposits comprised of iron-stained sandstone, September 10, 2018, 8:21 a.m.

Stop 6: Pleistocene deposit blocks outcropping at beach level, looking east toward prominent Pleistocene deposit outcrop, September 10, 2018, 8:21 a.m.

Stop 7: West side of prominent Pleistocene deposit outcrop with cross-bedding at the outlet of Cannery Slough, September 10, 2018, 8:46 a.m.

Stop 7: Closeup of Pleistocene deposit outcrop, silt rip-up clasts in a fine silty sandstone matrix. Outcrop comprised mainly of cross-bedded sandstone with gravelly, sandy, and silty sand layers, September 10, 2018, 8:46 a.m.

Stop 8: Pleistocene deposits (sandy gravel conglomerate) at beach level south of prominent Pleistocene outcrop, September 10, 2018, 8:52 a.m.

Stop 8: Iron-stained, sandy gravel conglomerate, Pleistocene deposits Monday, September 10, 2018, 8:52 a.m.

Stop 9: East side of prominent Pleistocene deposit outcrop looking north inland, September 10, 2018, 8:59 a.m.

Stop 9: East side of prominent Pleistocene deposit outcrop looking south toward North Channel Stop 8, September 10, 2018, 8:59 a.m.

Stop 10: Pleistocene deposit outcrop at beach level looking east September 10, 2018, 9:02 a.m.

Stop 10: Pleistocene deposit outcrop at beach level comprised of iron-stained, coarse-grained sandstone and gently dipping east beds (looking south), September 10, 2018, 9:02 a.m.

Stop 11: Pleistocene deposit outcrop (sandy gravel conglomerate to sandstone) at beach level looking west with gently dipping west beds, September 10, 2018, 9:10 a.m.

Stop 12: Eroding peat bog deposits at beach level looking north inland, September 10, 2018, 9:10 a.m.

Stop 13: Peat bog deposits at beach level looking west towards previous stops, September 10, 2018, 9:12 a.m.

Stop 14: Estuarine deposits at beach level looking west towards previous stops, September 10, 2018, 9:17 a.m.

Appendix F: Cultural Resource Survey

CULTURAL RESOURCE SURVEY FOR THE NORTH WILLAPA SHORELINE PROTECTION PROJECT, PACIFIC COUNTY, WASHINGTON

Prepared For
Mott McDonald, LLC
Portland, Oregon

January 2, 2020

REPORT NO. 4360

Archaeological Investigations Northwest, Inc.

3510 NE 122nd Ave. • Portland, OR • 97230 Phone 503 761-6605 • Fax 503 761-6620

CULTURAL RESOURCE SURVEY FOR THE NORTH WILLAPA SHORELINE PROTECTION PROJECT, PACIFIC COUNTY, WASHINGTON

PROJECT: Shoreline erosion protection

TYPE: Cultural resource survey

LOCATION: Section 5, Township 14 North, Range 11 West; and
Section 32, Township 15 North, Range 11 West, Willamette Meridian

USGS QUAD: *North Cove, WA,* 7.5-minute, 1995

COUNTY: Pacific

PROJECT APE: 16.6 acres

AREA SURVEYED: 16.6 acres

FINDINGS: Archaeological Resources:

- No pre-contact or historic-period archaeological resources were identified in the Area of Potential Effects (APE).
- A poster identifying the location of remnants from the *Avalon* shipwreck was found at the eastern limit of the APE. The exact location of the shipwreck is unknown and no remnants of a shipwreck were identified in the APE.
- Archaeological monitoring is recommended at the eastern portion of the APE. It is recommended a Monitoring Plan and an Inadvertent Discovery Plan (IDP) be prepared for the project before construction begins. The IDP should outline specific protocols to follow in the event remnants of a shipwreck are encountered during construction.

Historic Resources:

- No historic-period buildings or structures were present within the APE.

Recommendation:

- AINW recommends a finding of "**No Historic Properties Affected**."

PREPARERS: Carmen Sarjeant, Ph.D., R.P.A., Ron L. Adams, Ph.D., R.P.A., and
Terry L. Ozbun, M.A., R.P.A.

INTRODUCTION

Mott MacDonald, LLC (Mott McDonald), on behalf of Pacific County, proposes to protect a section of the North Willapa Bay shore along the north side of the entrance to the bay in the northwestern portion of Pacific County (Figure 1). The North Willapa Bay shoreline is susceptible to erosion that has been threatening homeowner properties, cranberry farmers, and the Shoalwater Bay Reservation lands for decades. The protection measures proposed by Mott McDonald represent a "demonstration project" to be conducted on a section of the shoreline that is particularly susceptible to erosion. The demonstration project is being undertaken to assess the feasibility of implementing protection measures for a larger area along the adjacent shoreline.

The 16.6-acre project Area of Potential Effects (APE) encompasses the shoreline of beach and upland. The project proposes to construct a dynamic revetment, the placement of cobble rock along shorelines to protect them from erosion. The construction will require some excavation and three temporary staging areas are proposed on Tamarack Street, Old State Route 105 and Sea Mobile Road, and Smith Anderson Road (Figure 2).

Mott MacDonald, subcontracted with Archaeological Investigations Northwest, Inc. (AINW), to perform a cultural resource survey of the APE. Since a permit from the U.S. Army Corps of Engineers (USACE) will be required for the proposed project, the cultural resources study was done to meet the federal standards under Section 106 of the National Historic Preservation Act of 1966 (as amended) and its implementing regulations under 36CFR800. AINW professionals who meet the professional qualifications of the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation performed the work. The study was also conducted to meet Washington State Department of Archaeology and Historic Preservation (DAHP) standards.

AINW performed a cultural resource survey including a records search, a literature review, local tribe consultation, and a pedestrian survey (Figure 2). No pre-contact or historic-period archaeological resources were identified during the survey. No historic-period buildings or structures were identified during the survey. AINW recommends a finding of "**No Historic Properties Affected**."

A poster identifying the location of remnants from the *Avalon* shipwreck was found at the eastern limit of the APE (Figure 2). While no archaeological materials were found in association with a shipwreck during the survey, AINW recommends archaeological monitoring during construction at the eastern portion of the APE, near the *Avalon* shipwreck poster. It is recommended a Monitoring Plan and an Inadvertent Discovery Plan (IDP) be prepared for the project before construction begins. The IDP should outline specific protocols to follow in the event remnants of a shipwreck are encountered during construction.

LOCATION AND ENVIRONMENTAL SETTING

The project APE is located at the northwest edge of the Willapa Bay estuary where the bay meets the Pacific Ocean on the southern coast of Washington in Section 5 of Township 14 North and Section 32 of Township 15 North, Range 11 West, Willamette Meridian. The northwestern shore of Willapa Bay at the APE location is an unstable landform that has been eroding for more than one hundred years, a pattern that has been attributed to the northward migration of the bay's deep-water entrance channel (Talebi et al. 2017:1).

Overall, Willapa Bay is one of the largest estuaries in the Pacific Northwest and is fed by six rivers: Willapa River, North River, Palix River, Nasele River, Bears River, and Cedar River. Estimates of the area covered by the bay at mean high tide range between approximately 59,000 and 70,400 acres (Jennings et al. 2003:21; U.S. Fish and Wildlife Service 2011). Approximately 50% of this area is covered by water at low tide, creating a substantial intertidal zone (Jennings et al. 2003:21). The extensive tidelands of the bay are ideal for oyster cultivation, making Willapa Bay the largest producer of commercial oysters in the United States. The Willapa Bay watershed is also home to the majority of Washington's annual harvest of cranberries, which are cultivated in bogs that collectively cover about 1,400 acres (Jennings et al. 2003:21).

In the broader regional context, Willapa Bay lies on the western edge of the Coast Range physiographic province of Oregon and Washington. Most of the province is characterized by a narrow band of coastal lowlands at its west end and the relatively low Coast Range Mountains that rise to the east and separate the coastline from the Puget-Willamette interior lowlands. The mountains of the Coast Range were created by the uplifting of Paleocene and Eocene basalts and overlying sediments during the late Miocene (Orr and Orr 1992:316). The Willapa Hills represent the northern extent and topographically lowest portion of this mountain range. These hills extend from the Columbia River in the south to just north of the Chehalis River in the north and rise to a maximum elevation of approximately 948 meters (m) (3110 feet [ft]) (Washington State Department of Natural Resources 2019a, 2019b).

In terms of vegetation, the APE and surrounding vicinity are within the *Picea sitchenthis* vegetation zone, which occupies a narrow band of vegetation that extends along the coasts of Oregon and Washington. The zone is characterized by some of the densest stands of temperate forests in the world. In western Washington, the most common tree types within the *Picea sitchenshis* (Sitka spruce) zone are Sitka spruce, western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*). Understory species include sword fern (*Polystichum munitum*), and various herbaceous species, such as Oregon Oxalis (*Oxalis oregana*), snakeberry (*Maianthemum dilatatum*), pink purslane (*Montia sibirica*), and evergreen violet (*Viola sempervirens*) (Franklin and Dyness 1973:58-64).

CULTURAL SETTING

Native Peoples – Prehistoric Period

People likely began living in the project area more than 12,500 years ago, based on the presence of archaeological sites in northwestern Washington and southeastern Oregon that contain evidence for human occupation dating to the period between 12,000 and 14,000 years ago (Haynes 1991; Jenkins et al. 2012; Kenady et al. 2011; Kopperl et al. 2015; Waters et al. 2011). This early period is in many cases associated with the presence of Clovis fluted projectile points, which have been found throughout North America. Based on evidence from very early archaeological sites in other parts of North America, it is likely that people during these times were highly mobile and relied on large and small game hunting and gathering wild plant foods for subsistence (Ames and Maschner 1999:65, 66; Carlson 1990:60).

In the Pacific Northwest, the period after the earliest phase of human occupation is generally referred to as the Archaic (12,500 to 6,400 years before present [B.P.]) (Ames and Maschner 1999:67-86). Archaeological deposits in the region that date to the early part of the Archaic period are typically attributed to the Windust Phase on the Columbia Plateau, and are marked by the presence of broad, stemmed Windust projectile points, large scrapers, flaked cobble tools, and rare items such as lancolate points, burins, and bone tools (Leonhardy and Rice 1970:4). The Windust Phase was followed by the Cascade Phase "…named for its hallmark artifact, the lanceolate Cascade projectile point" (Leonhardy and Rice 1970:6). In western Washington contemporary archaeological horizons are typically referred to as Olcott (Ozbun and Fagan 2010).

Throughout most of the Archaic period, archaeological evidence indicates that people practiced a broad spectrum subsistence strategy that emphasized terrestrial resources. Commonly found material culture of this period includes dart points that would have been hafted on spears and launched with an atlatl or throwing stick. Towards the end of the Archaic, subsistence shifted towards a more extensive use of riverine resources as climate changed (Ames 1994:64-66; Ames and Maschner 1999:67-86).

Locally, the Archaic period was followed by what is referred to as the Pacific period (6400 B.P. to A.D. 1775), which was marked by the emergence of complex hunter-gatherers who lived in large, semi-permanent villages. Warmer and drier conditions of the early Holocene gave way to cool and wet climates, and oceans rose to approximately modern levels. These changes produced environments similar to today in the Pacific Northwest, and pre-contact people adapted to the use of the resources associated with temperate rain forests and productive fisheries.

The Pacific Period is characterized by a shift from semi- to full-sedentism (Ames 1994), and villages were located in places with abundant resources. Some resource procurement activities took place away from the main residential areas; however, these resources were generally transported back to the main camps. The material culture of this period included a continuation of dart points and later the introduction of smaller notched points indicative of bow-and-arrow technology, as well as bone tools, and ground stone milling equipment (Ames and Maschner 1999:88-96). Subsistence during this time became increasingly focused on seasonally abundant food resources, such as salmon and camas, and the development of storage technology for preserving food for the winter (Wessen 1990).

Native Peoples – Contact Period

The APE is within an area traditionally inhabited by the Lower Chehalis, one of several groups in western Washington that spoke a related Salishan language (Hajda 1990:503). In the ethnographic literature, Willapa Bay as a whole is generally treated as an area where both the Lower Chehalis and Lower Chinook resided. The Chinookan-speaking Lower Chinook reportedly occupied the southern portion of the bay, and the Lower Chehalis occupied the northern portion of the bay (Hajda 1990; Silverstein 1990). However, the division of the bay between these two groups does not appear to have been strictly demarcated, as there are indications that people from both groups lived in the northern part of the bay in villages in which both Lower Chehalis and Chinookan languages were spoken (Indian Claims Commission 1974:14, 15; Ray 1938:36, 38).

Several Lower Chehalis and Chinookan village locations were scattered along different parts of the Willapa Bay shore and adjacent areas, including a village between present-day Tokeland and North

Cove known as *na·´mst’cat’s* and later referred to as Georgetown. This village was occupied primarily in winter and was located approximately 4 kilometers (km) (2.5 miles [mi]) southeast of the APE (Ray 1938:37, 41).

Typically, the houses at villages of both the Lower Chehalis and Lower Chinook were made of cedar wood, were oriented parallel to a river or stream, and had gabled roofs and doors at each end (Hajda 1990:508; Miller 1999:10; Ray 1938:124-126; Silverstein 1990:537). They accommodated multiple families and, among the Lower Chehalis, the largest houses could be up to about 24 m (79 ft) in length and 12 m (40 ft) in width (Miller 1999:11). Multi-family houses of the Lower Chinook could be even larger and measure up to approximately 30 m (98 ft) in length (Silverstein 1990:538).

There was no formal level of political organization above the individual village among the Lower Chinook or the Lower Chehalis (Hajda 1990:511; Ray 1938:35). Village leaders were hereditary chiefs (Hajda 1990:541; Miller 1999:22). The chiefly class consisting of these village leaders and their descendants represented the highest social stratum among both the Lower Chinook and Lower Chehalis. Commoners and slaves represented the remaining social classes. Commoners were free people who could not elevate their social standing to the level of chiefs, although there were wealth differences among commoners, and wealth accumulation permitted some commoners to attain a greater relative social standing (Silverstein 1990:541). At the lowest end of the social spectrum within both Lower Chinookan and Lower Chehalis groups were slaves, who were obtained through purchases or raids and were typically affiliated with faraway groups (Miller 1999:22; Silverstein 1990:542, 543).

Lower Chinook and Lower Chehalis villages were mainly occupied during the winter months, as the seasonal availability of subsistence resources necessitated movement throughout the remainder of the year. From early spring to late fall, families, households, and task groups left the village for days or weeks at a time in order to move to seasonal resource locations. At the seasonal camps, people lived in temporary structures made with cedar bark and/or cattail mats (Hajda 1990:509; Miller 1999:11; Silverstein 1990:538).

Among the resources procured during seasonal subsistence forays, salmon and other types of fish (e.g., sturgeon and eulachon) were particularly important and were procured at fishing locales in the vicinity of seasonal camps in late spring and summer, and smoke-dried for winter consumption. The Lower Chinook and Lower Chehalis hunted both sea mammals (e.g., sea lions, seals, and porpoises) and land mammals (deer, elk, bear, and small animals). Roots, mainly wapato and camas, and berries were also important foods (Hajda 1990:507; Miller 1999:17-22; Silverstein 1990:537). During the times of seasonal resource procurement, people would occasionally return to the winter village to store foods and other goods for winter (Curtis 1913:6; Hajda 1990:505-507; Silverstein 1990:535-537).

Shellfish were also an important part of subsistence among groups living in the area, and they were plentiful at Willapa Bay. In particular, clams were gathered in large numbers at Willapa Bay and were dried for later consumption and trade (Boyd and Hajda 1987; Hajda 1990:506). Mussels and oysters were also collected (Miller 1999:18).

The traditional ways of life for the Lower Chinook and Lower Chehalis changed dramatically with the coming of Euroamericans to the region. Diseases, such as measles and smallpox, introduced into North America by Euroamericans, decimated Native American populations. Traditional lifeways and economies were also altered due to extensive trade (especially for furs) with Euroamericans along the Columbia River, which resulted in the introduction of various European goods and the incorporation of European traders into a complex traditional system of regional trade (Hajda 1990; Silverstein 1990).

As a result of increased demand for land for Euroamerican settlement in the 1840s, numerous treaties, many of which were never ratified, were negotiated between the U.S. government and Native American groups in the region during the 1850s and 1860s, and reservations were subsequently created. The Shoalwater Bay Indian Reservation (originally the Georgetown Indian Reservation) in the northern portion of Willapa Bay was established in 1866 for the Lower Chehalis and Lower Chinook inhabiting Willapa Bay (Hajda 1990:515). Chehalis are also present at the Chehalis Indian Reservation inland to the east on the Chehalis River. The Quinault Indian Nation Reservation on the Washington coast about 70 km (44 mi) to the north of Willapa Bay includes people affiliated with both the Chehalis and Chinook (Hajda 1990:515). Many Lower Chinookan people were also removed to the Grand Ronde Reservation in western Oregon in the 1850s (Beckham 1990:181-184). Other Lower Chinookan people of the Willapa Bay area are affiliated with the Chinook Nation (currently not federally recognized) based at Bay Center on the east side of Willapa Bay (Chinook Nation 2019).

Historical Background

The earliest Euroamericans to travel to the Pacific Northwest were British and American explorers. British maritime trader John Meares passed by Willapa Bay while exploring the Pacific Coast in 1788. He named the bay "Shoalwater Bay," which he attempted, but failed, to enter by boat (Nokes 1990). Lewis and Clark also passed through the area while traveling along the Columbia River in 1805 and 1806 (Moulton 1990). While camped at the north side of the Columbia River, Clark and a small party ventured northward along the southern Washington coast to present-day Long Beach, a short distance to the southwest of Willapa Bay (Moulton 1990:48-78).

The earliest Euroamerican settlement in the vicinity of the APE was Fort Astoria in present-day Astoria, Oregon (about 60 km [37 mi] southeast of the APE), which was established in 1811 by John Jacob Astor's Pacific Fur Company (Johanson and Gates 1967:93-95). The fort was soon after operated by the British Northwest Company in 1813, and by the Hudson's Bay Company between 1821 and 1846 (Johansen and Gates 1967:106-107, 122-149). The British fur traders operating out of Astoria developed trading and familial relationships with the Lower Chinookan people living in the area (Silverstein 1990).

Pacific County was created by the Oregon Territorial Legislature in 1851. It encompassed the southwestern portion of present-day Washington and was the third county formed within what would later become the Washington Territory. Euroamericans were initially drawn to Pacific County for its abundant lumber and oysters (Story 2006). However, this early development does not appear to have extended into the project APE vicinity, which is shown largely undeveloped on an 1858 General Land Office (GLO) map. The only building depicted in the vicinity of the APE on the GLO map is a light house approximately 1.6 km (1 mi) southwest of the APE at a location now submerged under water. A trail is also depicted on the map extending from northwest to southeast approximately 0.8 km (0.5 mi) southwest of the APE (GLO 1858).

Elsewhere in Willapa Bay, the abundance of oysters drove historic-period development. By the early 1850s, ships began visiting the area to establish oyster businesses that were fueled, in large part, by demand created by the California Gold Rush. Among the early communities that developed as a result of the oyster trade was Bruceport (founded in 1851) on the northeastern portion of Willapa Bay, and Oysterville (founded in 1854), located on the west side of the bay. This shellfish industry eventually depleted the native oyster population in Willapa Bay, which was eventually replaced by farmed Atlantic oysters in the late nineteenth century and then by Japanese oysters by the early twentieth century. Oysters remain an important aspect of the Willapa Bay economy, and the area has become one of the largest producers of farmed shellfish in the United States (Story 2006).

The forested uplands surrounding Willapa Bay offered a great opportunity for logging, and the timber industry became a driving force for the local economy by the late nineteenth century. The town of South Bend near the mouth of the Willapa River boomed as a mill town (as well as an oyster town) at this time and became the Pacific County seat in 1892 (City of South Bend 2019; Story 2006). However, the timber industry gradually declined after World War I due to a drop in lumber prices and a drop in the availability of old-growth timber in the area (Story 2006).

Cranberry cultivation also helped propel commercial activity and settlement in the area in the latter part of the nineteenth and into the early- to mid-twentieth century. Large-scale commercial production of cranberries in the bogs around Willapa Bay began in 1881, when Anthony Chabot planted 35 acres of cranberries near present-day Long Beach and successfully grew large quantities of cranberries. The continued growth of the local cranberry industry into the twentieth century was due, in large part, to the establishment of a State College of Washington (now Washington State University) Cranberry-Blueberry Experiment Station in Long Beach in 1923. In addition, local growers became affiliated with the nationwide Ocean Spray co-op of cranberry farmers in 1937, which helped with the processing and marketing of the cranberries (Story 2006). Commercial cranberry bogs are currently found throughout the Willapa Bay vicinity, including the area to the immediate north of the APE.

The APE is immediately southeast of the community of North Cove, a bustling community in the late 1880s. People passed through the area, arriving by steamboat and taking a stagecoach to access the Olympic Peninisula and the Puget Sound to the north (*The Daily World* 2017a). North Cove and the area surrounding the APE have experienced longstanding problems with coastal erosion. North Cove has lost large amounts of land to erosion over the years, which has destroyed homes, businesses, a schoolhouse, a grange hall, and a Coast Guard Station. The Willapa Bay Lighthouse, formerly at the north side of the bay entrance, was also destroyed by erosion in 1940, after having been in operation since 1858 (Hanable 2004). The erosion problems extend southeast towards the Shoalwater Bay Indian Reservation and the community of Tokeland, about 7 km (4.3 mi) southeast of the APE (Telebi et al. 2017; USACE 2009).

A review of U.S. Coast and Geodetic (USCGS) nautical maps and U.S. Geological Survey (USGS) topographic quadrangle maps dating between 1884 and 1984 depict the historic-period changes in the shoreline area on the north side of Willapa Bay. Notable among these changes are the disappearance of roads and buildings in the North Cove area throughout this time, the disappearance of the Willapa Bay Lighthouse between 1928 and 1948, and the shifting of the alignment of State Route 105 to the northeast between 1973 and 1984 to protect it from erosion (USCGS 1884, 1898, 1928, 1948, 1966, 1968; USGS 1938, 1956a, 1956b, 1956c). The entire APE was inland from the shoreline as recently as 1990, and a number of residences have been lost along the shoreline within the APE (Google Earth 1990, 2018).

PREVIOUS CULTURAL RESOURCE STUDIES

AINW conducted a search of records available online from the Washington Information System for Architectural and Archaeological Records Data (WISAARD) database and from the AINW library to identify previously recorded cultural resources within and near the APE. The records search was also conducted to identify cultural resource studies conducted within 1.6 km (1 mi) of the APE. The statewide predictive model identifies the APE within a moderate to very high probability area for pre-contact archaeological resources.

The nearest cultural resource to the APE is the historic-period Grayland Drainage Ditch #1 (site 45PC131). The drainage ditch covers a distance of approximately 12.8 km (8 mi) between the South Bay section of Grays Harbor in Grays Harbor County to North Cove. The ditch is immediately north of the Smith Anderson Road staging area in the APE, and its outlet is north of the southeastern limit of the APE. The ditch was completed in 1916, and was built in order to drain fields to make them suitable for cranberry cultivation. The ditch currently still serves a drainage function and measures about 2.5 m (8.2 ft) in width and has a depth of greater than 1.5 m (5 ft). The site was recorded as part of two cultural resource surveys for bridge improvements on Schmid Road in Grays Harbor County approximately 9 km (5.6 mi) northwest of the current APE (Miller and Johnson 2007; Miller et al. 2007).

Also in the immediate vicinity of the APE is the North Cove Pioneer Cemetery (45PC171) that was originally located approximately 0.25 km (0.15 mi) to the south of the APE. It contained graves dating to between 1889 and 1958. Among those buried at the cemetery were pioneers, shipwreck victims, and members of the U.S. Coast Guard. The burials at the cemetery were moved to higher ground (1.2 km [0.75 mi] inland) in 1977 due to seawater encroachment. The original location of the cemetery is currently underwater (Washington State Department of Archaeology and Historic Preservation n.d.). The hraves removed from the cemetery are now located about 0.3 km (0.2 mi) southeast of the APE on the north side of State Route 105.

The nearest previous cultural resource study to the current project was a cultural resource survey conducted by the Washington State Department of Transportation for the State Route 105/North Cove Vicinity Erosion Protection project along a portion of State Route 105 located approximately 0.3 km (0.2 mi) to the southeast of the APE. No cultural resources were identified during this survey (Kiers 2016).

Other studies conducted in the vicinity of the project include a historic properties investigation for the Shoalwater Bay Indian Reservation Shoreline Erosion project on shoreline area of Willapa Bay approximately 2.4 km (1.5 mi) and 7 km (4.3 mi) southeast of the APE (Kent 2006). During shovel testing conducted for the project, fire-cracked rock and historic-period artifacts were identified, possibly in association with a previously documented pre-contact shell midden/village archaeological site (45PC17). This village site was originally recorded by Daugherty (1947) on the then Georgetown Indian Reservation (now the Shoalwater Bay Indian Reservation) about 4 km (2.5 mi) southeast of the APE, but the site has been impacted by erosion. Other nearby studies did not identify evidence of site 45PC17 during field investigations (Smith and Gall 2009).

ARCHAEOLOGICAL FIELD SURVEY METHODS AND FINDINGS

Charlene Nelson, Chairwoman for the Shoalwater Bay Tribe, was consulted by AINW Supervising Archaeologist Ron L. Adams, Ph.D., R.P.A., by telephone on July 19, 2018. Nelson noted that there is concern throughout the community about the erosion, loss of land, and flooding of cranberry bogs behind the shoreline. Nelson has walked the shoreline within the APE many times but has not observed Native American artifacts, only the remains of a shipwreck. Nelson had no specific concerns regarding archaeological resources for the current project.

The archaeological pedestrian survey was conducted on December 16, 2019, by AINW Supervising Archaeologist Carmen Sarjeant, Ph.D., R.P.A., and AINW Staff Archaeologist Lea Loiselle, B.A. AINW's work was under the overall supervision and management of Terry Ozbun, M.A., R.P.A. The pedestrian survey was conducted by walking the APE in northwest-southeast oriented transects no more than 10 m (33 ft) apart (Figure 2). Approximately 5% of the APE along the southwestern edge was not surveyed due to incoming tidal activity. No pre-contact or historic-period archaeological resources or historic-period buildings or structures were identified during the pedestrian survey.

The APE generally consisted of the beach with scattered cobbles and wood debris, a steep eroding slope or cut bank, and the upland covered in grass (Photos 1 and 2). Loose fine sand was noted throughout the APE. Mineral soil visibility was generally good (50%) on the beach and along the exposed slope or cut bank, and poor (5%) in the upland and where the slope had been covered for stabilization. Cobble rock had been placed along many segments of the eroding slope in the APE to prevent erosion. The cobbles obscured the ground surface in these areas. Wood debris and soil has also been placed on top of the cobbles and sand in some areas as a result of both natural coastal activity and erosion protection measures.

Scattered stands of Sitka spruce and areas of shrubs and grass were noted along the upland portion of the coastline. Low-lying areas and drainages with dense vegetation were observed either side of the roads within the three staging areas in the APE (Photo 3). The historic-period Grayland Drainage Ditch #1 (site 45PC131), to the north of the staging area along Smith Anderson Road, is outside of the APE and will not be affected by the project (Figure 2; Photo 4).

Shells and fragments of nondiagnostic and modern glass, plastic, metal, concrete, and timber were identified on the surface throughout the APE. None of these items were archaeological. Some charcoal and burnt wood was noted on the upland portion of the APE and eroding downslope, but did not represent a pre-contact cultural deposit.

A layer of light yellowish brown fine sand with iron staining was observed in the eroding slope under the deposited cobbles and wood debris in the middle portion of the APE (Photo 5). No charcoal, shell, or pre-contact artifacts were identified in this older substrate. Dark grayish brown sandy loam mixed with shell and gravels had been redeposited on top of the slope as an erosion protection effort in one area to the north and outside of the APE. No charcoal or pre-contact artifacts were observed in association with this soil.

While no historic-period buildings or structures were identified within the APE, a number of structures were identified adjacent to and outside of the APE, most of which were modern or mobile (Google Earth 1990, 2018). One of the oldest residences in the area is the "Old Gumm House," approximately 20 m (66 ft) north and outside of the APE and 130 m (427 ft) west of Old State Route 105 (Figure 2; Photo 6). David Cottrell of the Pacific County Drainage District No. 1 met with the AINW archaeologists during the survey fieldwork, and outlined the history of the Old Gumm House. The house was built circa 1890, and was where travelers would change stagecoaches. The Richman family who lived in the house ran stables and managed the horses for the stagecoaches (David Cottrell, personal communication 2019). The current project will not impact the Old Gumm House. A possible fragment of a wood stove of an undetermined age was identified at the northern edge of the APE, approximately 35 m (115 ft) southeast of the Old Gumm House.

A poster attached to a tree stump identifying the location of remnants from the *Avalon* shipwreck was found at the eastern limit of the APE (Figure 2; Photo 7). This is presumably the shipwreck mentioned by Nelson of the Shoalwater Bay Tribe. The lumber schooner was built in 1912 and wrecked in 1927 off Willapa Harbor North Spit. The poster mentions that a piece of the wreck was found at this location but that sand sometimes covers it except for a few large nails. Other pieces of the wreck are reportedly to the east and outside of the APE (*KNKX* 2017). Researchers have hypothesized that the remnants may be associated with other possible ships, including the *Trinidad* and the *Canadian Exporter* (*The Daily World* 2017b; *KNKX* 2017; *MFame.guru* 2017; *The Seattle Times* 2010). No shipwreck remnants were identified in the APE during the survey, and the exact location of the shipwreck is unknown. The remnants of the shipwreck have reportedly moved substantial distances along the shoreline due to tidal activity and dynamic coastal erosion (*Chinook Observer* 2010; *MFame.guru* 2017; *The Daily World* 2017b).

While most of the APE has been subjected to volatile coastal activity, the upland in the southeastern portion of the APE, from Smith Anderson Road to the east, was comparatively stable (Photo 8). Farmlands were to the north of this portion of the APE. This portion of the APE contains the greatest potential for intact subsurface deposits; however, no pre-contact or historic-period cultural materials were identified on the surface and on the exposed eroding slopes at this location. Subsurface testing is not recommended within the APE for the current project as erosion has provided adequate exposure of the subsurface throughout the APE.

SUMMARY AND RECOMMENDATIONS

AINW has completed a cultural resource survey for the North Willapa Shoreline Protection project in Pacific County, Washington. The study included a records search, a literature review, local tribe consultation, and a pedestrian survey to determine if cultural resources were present in the APE. The APE is within an area that has been subjected to volatile coastal activity and land loss. Mineral surface visibility was generally good throughout the APE, particularly along the eroding slope where cobbles have not been placed. Subsurface testing is not recommended within the APE for the current project.

The historic-period Grayland Drainage Ditch #1 (site 45PC131) and the Old Gumm House are not within the APE and will not be affected by the project. No pre-contact or historic-period archaeological resources were identified during the cultural resource survey. No historic-period buildings or structures were identified during the survey. AINW recommends a finding of "**No Historic Properties Affected**" for the North Willapa Shoreline Protection project.

While no archaeological materials were found in association with a shipwreck during the survey, AINW recommends archaeological monitoring during construction at the eastern portion of the APE, near the *Avalon* shipwreck poster. The exact location of the shipwreck is unknown and the shipwreck remnants have moved along the shoreline in recent years. It is recommended a Monitoring Plan and an IDP be prepared for the project before construction begins. The IDP should describe protocols to follow in the event unanticipated archaeological resources are encountered during construction for the project. The IDP should also outline specific protocols to follow in the event remnants of a shipwreck are encountered during construction. The steps for consultation, to record the shipwreck as an archaeological resource, to evaluate the resource, and to mitigate the effects to the resource by the project should be outlined in the IDP.

If unanticipated archaeological resources are encountered during construction, all ground-disturbing activities near the find(s) should be halted and DAHP promptly notified. If evidence of a burial is encountered, all ground-disturbing activities in the vicinity should be stopped immediately, and the Pacific County Coroner, the Pacific County Sherriff's Office, and DAHP should be notified.

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