Washington State Department of Transportation

SR 105 MP 20 Washaway Beach

2018 Dynamic Revetment Monitoring Report

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1.0 Introduction and Purpose

In the fall of 2017 WSDOT constructed a dynamic revetment to protect SR 105 near Milepost (MP) 20, on a low segment of highway that runs along the north side of the Willapa Bay entrance channel near Tokeland (Figure 1). Dynamic revetments are a relatively new method of shoreline protection that mimics the natural energy dissipation provided by coarse beach deposits. WSDOT worked with the Department of Ecology to develop a monitoring plan for the project to help with adaptive management and the design of future projects. This report describes the results of the first season of monitoring, beginning after project completion in January 2018.

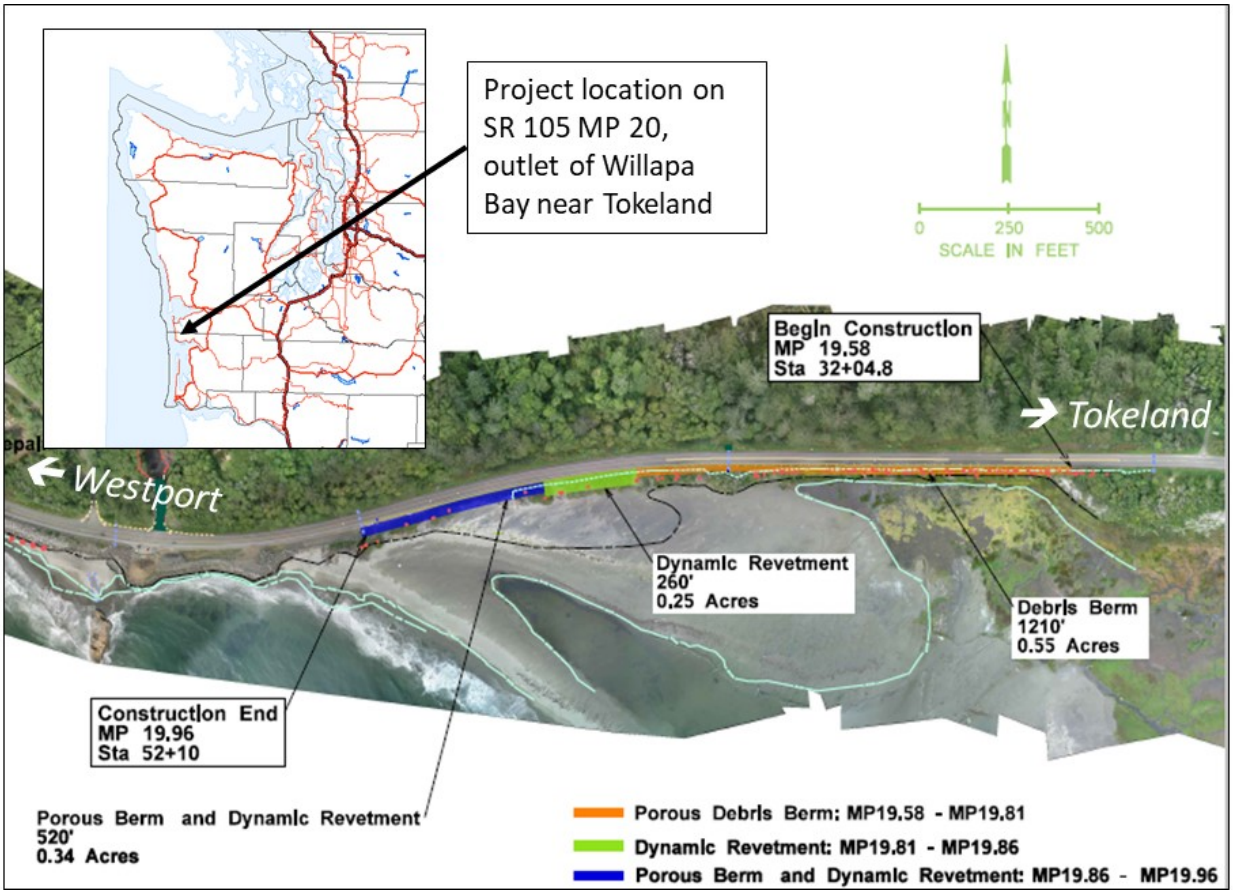


Figure 1 Vicinity map and project plan view

2.0 Description of the Constructed Project

The dynamic revetments were constructed in the fall of 2017, and WSDOT SW Region survey crews performed an as-built survey on December 21, 2017. Figure 1 shows the locations of the dynamic revetments, and Figures 2 and 3 show typical as-built conditions. The revetments were constructed as trapezoidal berms with flat tops and 1.5 to 2:1 (Horizontal:Vertical) side slopes. The berms were built of rounded cobbles with a size distribution designed for local wave energy conditions. The berms are intended to deform into a sloping beach as they are exposed to wave action.

The eastern 260 feet of dynamic revetment was constructed with a 26-foot top width (Figure 2). The back side of the berm sloped at about 2:1 to meet the edge of the roadway a few feet behind the guardrail. The berm was constructed of 10-inch minus streambed cobbles.

The western 520 feet of dynamic revetment was constructed in front of a smaller berm of angular rock that functions as a barrier to floating debris (Figure 3). The dynamic revetment here has a narrower top width of about 11 feet because it was designed as a revision to an original angular rock revetment, and therefore was constrained by previously-defined permitting limits on the footprint. The westernmost portion was built in a trench behind an existing upland terrace that at the time of construction still buffered the highway from the beach. This segment of dynamic revetment was constructed of 12-inch minus streambed cobbles because of the higher anticipated wave energy in this area. The dynamic revetment transitions at the west end to an angular rock revetment constructed as an emergency repair in 2016.

The project also included a stockpile of about 100 cubic yards of dynamic revetment cobbles, to be used as needed by WSDOT maintenance to repair small pockets of erosion.

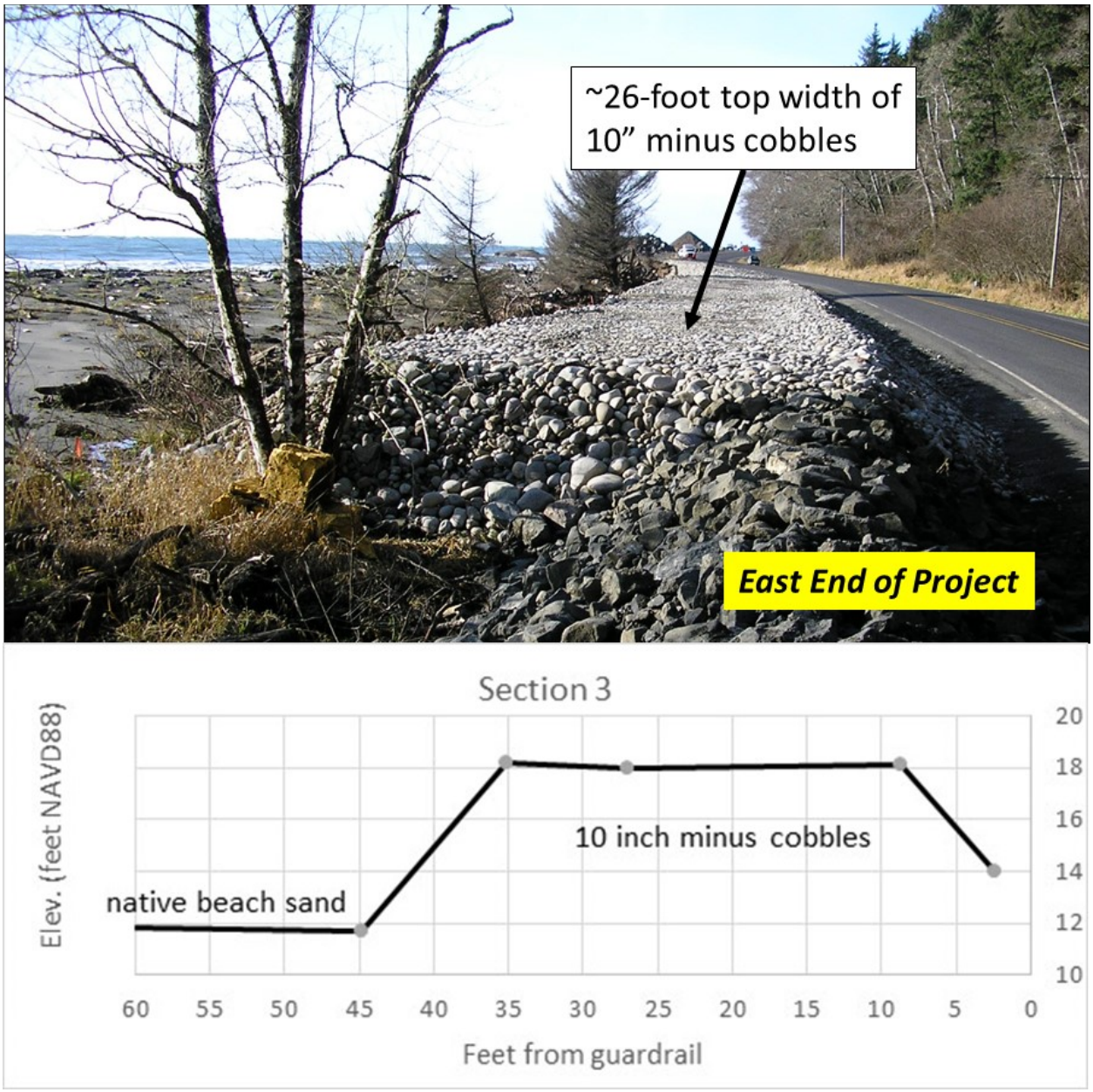


Figure 2 As-built condition of the eastern dynamic revetment (looking west)

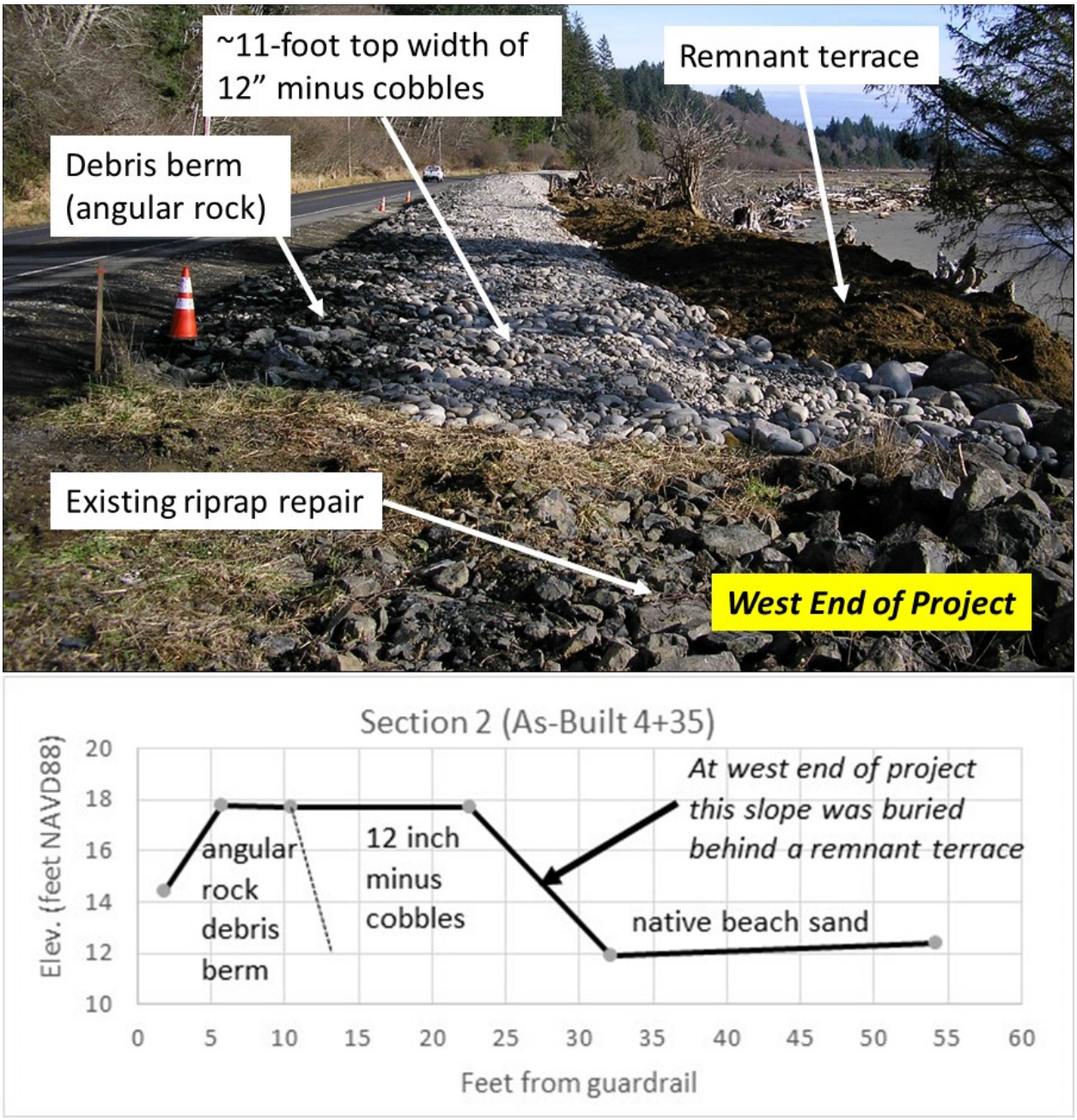


Figure 3 As-built condition of the western dynamic revetment (looking east)

3.0 Monitoring Methods

The performance of the project was monitored by WSDOT following procedures and criteria outlined in the Monitoring and Adaptive Management Plan finalized with the Department of Ecology's input on August 17, 2017 (Appendix A). The sections below describe specific methods used to meet the objectives of the plan.

3.1 Routine Inspection by Maintenance

WSDOT maintenance personnel inspected the site weekly beginning after project completion in January 2018 and ending in the last week of March 2018. In subsequent years these inspections will occur throughout the typical October-March storm season.

WSDOT installed lines of markers spaced every five feet along the top of the dynamic revetment at the four monitoring transects shown in Figures 4 and 5. During the weekly inspections WSDOT personnel recorded changes in the top width of the dynamic revetment based on visual observation of the transect markers. These observations as well as any other significant changes in the condition of the revetment were entered into a tablet-based form that ties into WSDOT's HATS database for maintenance activities. Photos were also taken as needed to document observations. The form includes a box for "no change" for instances when no significant change has occurred since the last observation.

3.2 Dynamic Revetment and Beach Surveys

WSDOT Hydrology Program staff performs more detailed surveys of the condition of the revetment twice each season:

- Within a few days after the first storm when sustained wind gusts above 35 knots (40 mph) occur at tides greater than 8 feet MLLW. Wind data at the NOAA Toke Point buoy (Station TOKW1 – 9440910, http://www.ndbc.noaa.gov/station_page.php?station=TOKW1) and tide data at the Toke Point tide gage (Station ID: 9440910, https://tidesandcurrents.noaa.gov/stationhome.html?id=9440910) are used to characterize storm conditions for the site.
- At the end of the storm season (around mid-April).

During each survey a total station level is used to survey elevations along the four transect lines shown in Figure 4, beginning on the pavement on the seaward side of the guardrail and ending far enough out on the beach to record changes in the beach profile (typically 150- to 200-feet out from the toe of the dynamic revetment). Additional transects are surveyed as needed to characterize areas of concern. The surveys are tied into a hub stake installed on the north side of SR 105 between Transects 2 and 3. At each transect survey points are taken to define break points in the profile of the dynamic revetment. The beach is surveyed at less detail, with only enough points to define major breaks in the beach profile shape. Photo points were also established and repeated each survey at the points shown on Figure 6 and Table 1.

Figure 4 Location of monitoring transects

Figure 5 Photo of stakes at monitoring transect 1

Figure 6 Map of photo points established in January 2018

Location	Description
At each transect	Toe of berm looking east and west along road
	Top of berm at first stake, looking east and west
	Looking out towards the beach from the top of the berm
	Top of the berm at the last stake, looking east and west
	Toe of the berm on the beach, looking east and west
	Looking back towards the berm from about 100 feet out on the beach
50 feet west of west end of berm	Looking east along the top of the berm
From the beach at the west end	Looking at the face of the berm at the west transition to existing maintenance repairs

Table 1 List of photo points for detailed monitoring surveys

4.0 Monitoring Results

4.1 Winter 2018 Wind Conditions

Table 2 and Figure 7 summarize wind conditions from January through April 2018. The only significant wind gusts at higher tides occurred between January 17 and 24, 2018. Our first monitoring survey was conducted after this set of storms on January 24. The remainder of the season was relatively calm.

Date	Time Range (GMT)	Peak gust (knots)	Direction (degrees)
January 17, 2018	21:42 – 23:12	41	190
January 24, 2018	1:06 – 1:36	38	190
April 7, 2018	1:12 – 1:12	37	199

Table 2 Periods with wind gusts greater than 35 knots and tides greater than 8 feet MLLW

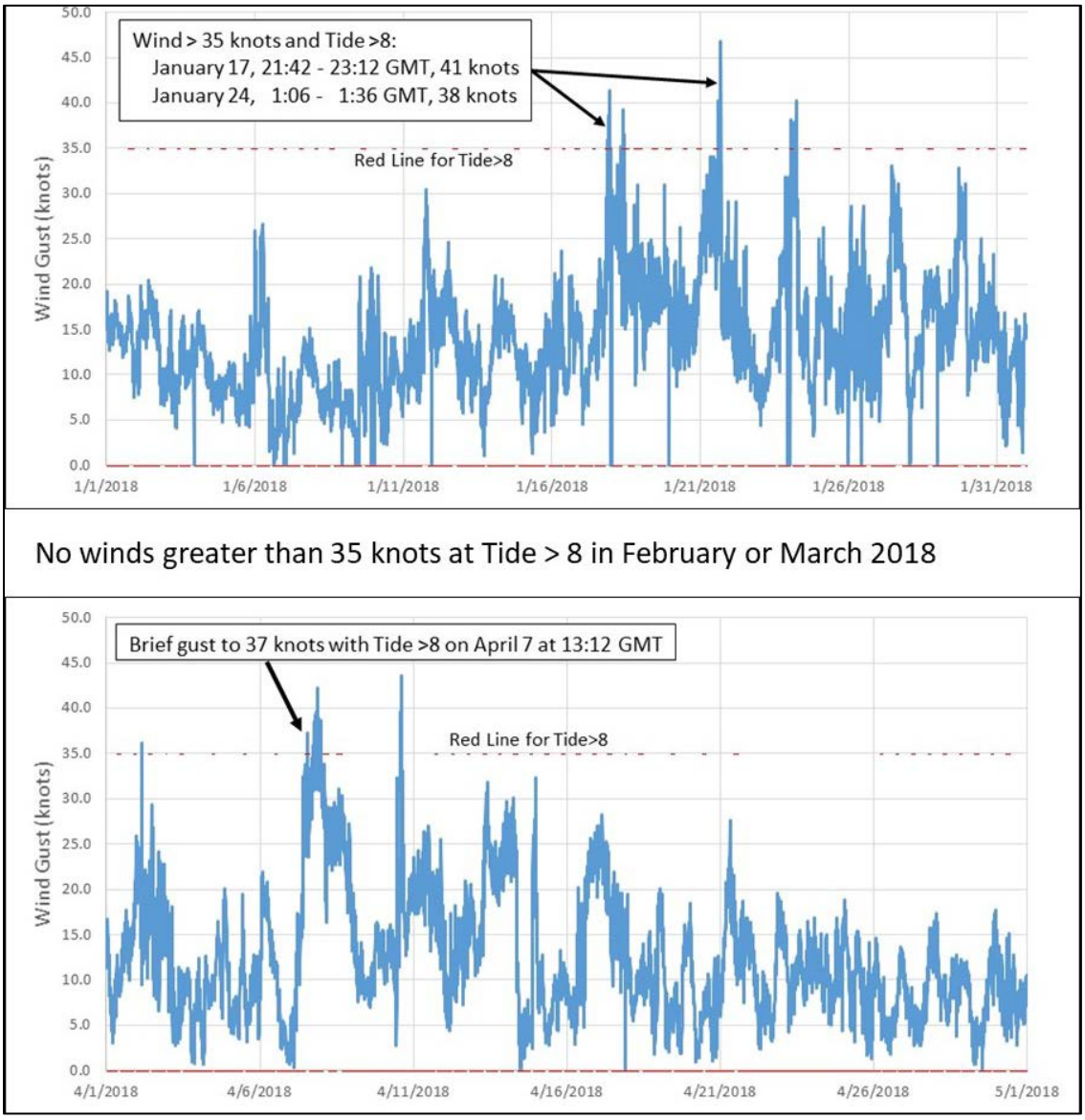


Figure 7 Observed gusts at the Toke Point wind buoy, January-April 2018

4.2 Routine Monitoring and Repairs by Maintenance

In late January WSDOT Maintenance observed erosion of the terrace that previously buffered the western end of the dynamic revetment from wave action. This exposed the roots of the remnant trees in this area and caused some displacement of cobbles on the seaward slope of the dynamic revetment (Figure 8). No significant changes were observed after January. No significant loss of berm width was observed at the transect stakes, and no emergency repairs were performed.

Figure 8 Loss of remnant terrace material at the west end of the project after the January storms

4.3 Dynamic Revetment and Beach Surveys

Detailed site surveys were performed on January 24 and May 18, 2018. Appendix B compares representative photos from each monitoring visit, and Figure 9 compares the transect survey data. Most of the dynamic revetment east of Section 1 saw little wave action and has not significantly deformed relative to the As-built condition. Changes in this area are subtle and are likely caused by settlement and shifting of the loose cobble material.

The west transition from dynamic revetment to older maintenance repairs saw the most significant changes. Figure 10 shows a cross section in this area. This segment was constructed in a trench behind remnant upland terrace material. Most of this terrace material was removed during the January storms, exposing the face of the dynamic revetment to wave action between Section 1 and the west end. This reduced the revetment top width by about 2- to 3-feet in a 35-foot long segment as cobbles along the face slumped and rolled down to the beach (Figure 11). The face of the dynamic revetment here is now somewhat uneven due to pockets of remnant terrace material. Gravel and small cobbles were found scattered among driftwood on the beach east of this area, indicating downdrift transport of material eroded from the face of the revetment (Figure 12).

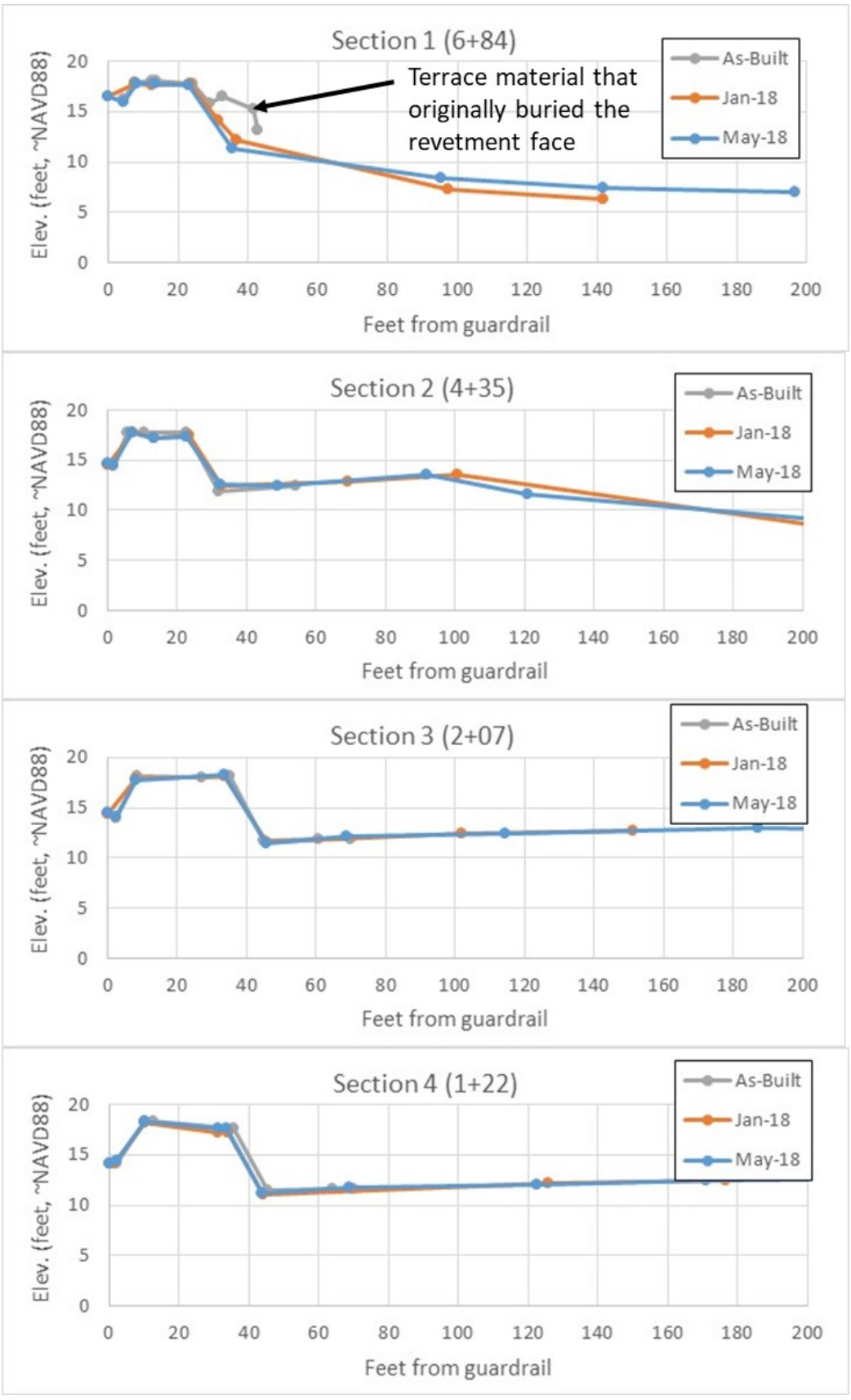


Figure 9 Comparison of As-Built, January, and May transect surveys

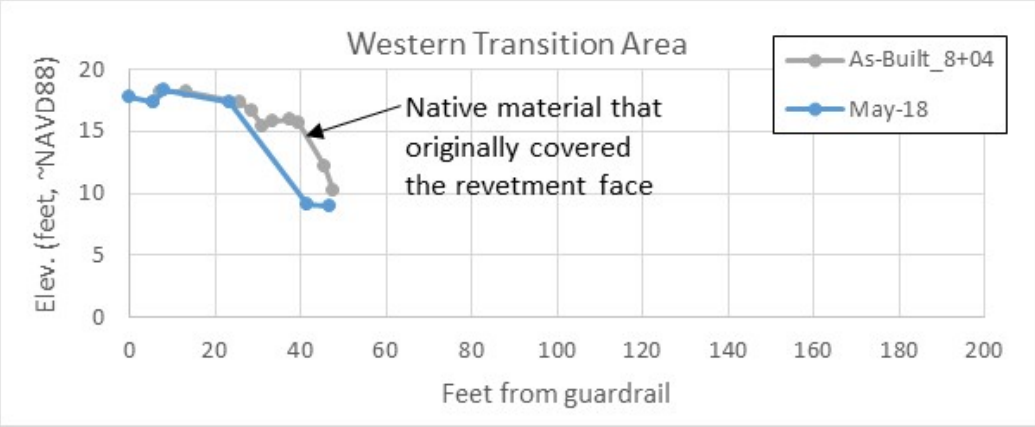


Figure 10 Transect in the center of the west transition area

Figure 11 Photo of slumping material in the west transition area

Figure 12 Photo of gravel transported east from the eroded segment of the dynamic revetment

5.0 Conclusions and Recommendations

Most of the dynamic revetment saw little wave action in this relatively mild winter. However, wave erosion has removed the upland terrace that originally buried the west transition to older emergency repairs. This has exposed a rough transition to the older riprap, leaving the dynamic revetment face vulnerable to edge effects and swirling currents behind remnant trees. We therefore recommend adding material to the face of the revetment here to provide better protection of the transition point, and to integrate the toe of the slope with the tree roots.

This repair would cover about 35 feet of revetment face at the western end of the project. Figure 13 illustrates the recommended repair cross section. The top of the berm would be extended outward 10 feet, and slope down at 2:1 to meet the beach on the landward side of remnant tree trunks. This would require about 90 cubic yards of dynamic revetment cobbles.

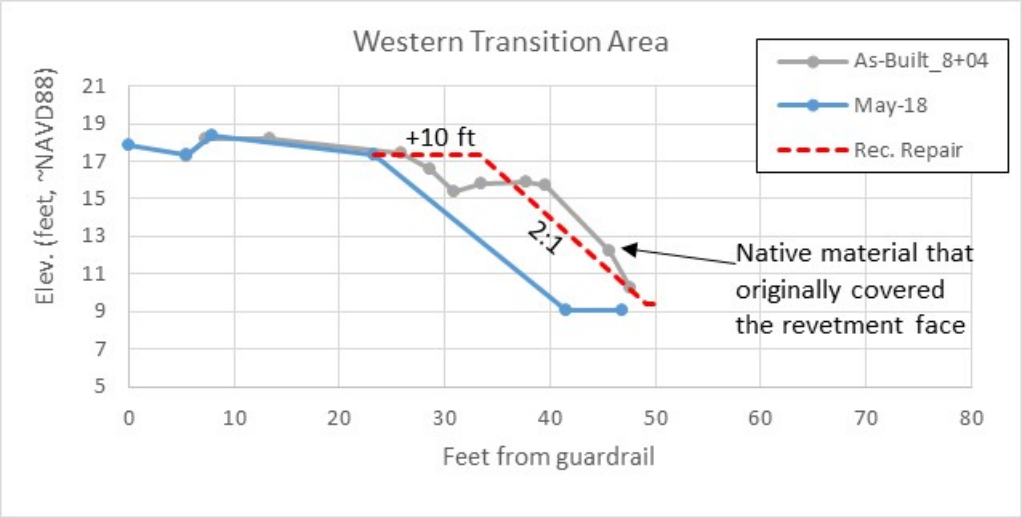


Figure 13 Recommended cross section for additional material at the west end of the project

Appendices

Appendix A – Monitoring Plan

Appendix B – Select Photo Comparisons

Appendix A—Monitoring Plan

Monitoring and Adaptive Management Plan

SR 105 North Cove Vicinity/Washaway Beach Erosion Protection Project –

Dynamic Revetment Test Designs

1.0 Introduction/Purpose

The Washington State Department of Transportation (WSDOT) SR 105 North Cove Vicinity/Washaway Beach Erosion Protection Project – 2017 (Project) will repair sections of existing revetments and place new shoreline revetments along the southwest side of SR 105 for approximately one mile (MP 19.58 to 20.58), in Pacific County, Washington. The purpose of the Project is to repair and address the highly vulnerable embankments along the SR 105 roadway and increase the safety of the travelling public by preventing storm debris from washing onto the roadway.

The project includes the installation of dynamic revetments and debris barrier berms from MP 19.58 to 19.96 including: a 520-foot-long combination dynamic revetment and porous berm (test design); a 260-foot-long dynamic revetment (test design); and 1,210-foot-long porous (debris barrier) berm. All work for the new revetments would occur above the MHHW and OHW mark. Original WSDOT design for the new revetments included a much shorter dynamic revetment test, and a combined buried revetment and debris barrier berm. In response to concerns and comments from Washington State Department of Ecology (Ecology) and the public, WSDOT altered the project to make the dynamic revetment test section longer along the shore, and to replace the buried revetment portion with another dynamic revetment design.

This document describes WSDOT's plan for test dynamic revetment monitoring necessary to comply with Section 401 of the Clean Water Act (40 CFR 230).

2.0 Monitoring Plan

WSDOT will perform topographic monitoring and inspection of the dynamic revetments along SR 105 to (1) characterize trends in the evolution of the revetment with sufficient detail to inform adaptive management, (2) identify failures that require emergency repairs, and (3) provide data on performance and maintenance needs to inform future applications of this treatment in other areas.

2.1 Monitoring Methods:

WSDOT will conduct topographic surveys a minimum of twice per year for a minimum for 5 years. One survey will occur at the end of each storm season, during mid-April. The other will be done in winter (to characterize response of revetment to individual storms or in the event of rapid shore retreat (see below). The following criteria will be used to determine when to conduct the winter monitoring:

- Storm events when wind gusts reach 40 miles per hour or greater during high tides above 8-feet MLLW, or
- Maintenance observation of an erosion rate of 10 feet in a four week period, or
- Emergency repair as further defined below or by February 1, whichever happens first.

Surveys will provide a minimum of two cross sections in each of the two treatment areas, and will extend out into adjacent beach at sufficient distance to characterize changes in sand deposition patterns.

- Prior to the onset of the 2017-2018 storm season, highway guide posts will be driven in at 5-foot intervals at cross section locations to allow rapid observation and recording of the width of revetment remaining by maintenance staff. A log of these observations will be kept by WSDOT. WSDOT maintenance staff will inspect the condition of the revetment weekly beginning in early October (before any significant storms) until the end of March to identify imminent failures and provide further data. After each inspection, maintenance staff will send an email describing the conditions of dynamic revetment to HQ Hydrology. If maintenance crews observe a top width retreat rate of greater than 10 feet within a 4-week period during any of the winter months, they will notify HQ Hydrology immediately. HQ Hydrology will then conduct the winter topo survey to document these changes.
- Photo points will be established to provide a visual record of the evolution of the revetment, with repeat photos taken during each topographic surveys and opportunistically during maintenance inspections.

2.2 Adaptive Management

WSDOT anticipates two types of maintenance:

1. Emergency repairs. Emergency repairs will occur after major storm events where the top width of the dynamic revetment is less than 5 feet wide in the eastern test area and less than 5 feet from the toe of the debris berm in the western test area. Maintenance will notify HQ Hydrology whenever emergency repairs are needed. Emergency repair projects are reviewed and permitted (if needed) as separate projects. The 2017 construction project will include a stockpile of dynamic revetment material with sufficient volume to repair two pocket failures, about 100 cubic yards. Emergency repairs will use this material to reconstruct the revetment top width sufficiently to restore erosion control and wave dissipation functions. Angular rock of similar size may be mixed in with the stockpiled cobble material if the volume needed exceeds the available stockpiled material. Riprap or other suitable material may be needed to reconstruct embankments where erosion has removed the dynamic revetment entirely and is threatening the structural integrity of the road. Where practicable dynamic revetment material would still be placed in front of these reconstructed embankments. Maintenance staff will record and document all repairs to inform future applications of dynamic revetments. HQ Hydrology staff will be notified whenever emergency repairs are performed, including volume of material placed.
2. Long-term maintenance. WSDOT and Department of Ecology staff will review monitoring data annually after each storm season to identify trends in deformation and erosion of the dynamic revetments and adjacent beach. During this review, WSDOT may determine a repair is needed

to replace lost dynamic revetment material. In this event, WSDOT will propose an initial design to be programmed into WSDOT budget as a potential project to perform this repair. The WSDOT, Federal Highway Administration and Washington State Legislature decision to perform a repair will reflect the anticipated remaining project life as well as the nature of the loss of material (steady erosion vs. a temporary pulse of erosion during an extreme event, for instance), in balance with other programmed projects in the State.

2.3 Reporting

WSDOT will provide a brief annual report, in electronic format, after each storm season documenting survey results, maintenance observations, and any emergency repairs. As discussed above, this report may have recommendations to address repairs and/or revisions on the upcoming year's monitoring. This report shall be shared with Ecology staff through the Liaison.

An adaptive management meeting with WSDOT and Ecology staff will be held each year following the distribution of the report and before September to discuss monitoring results, maintenance efforts, and decide any changes needed in management strategy. At the end of the 5-year monitoring period, discuss long-term maintenance in the context of larger repair project, and adjust monitoring parameters if needed.

Maintenance will provide a record of their observations and repair history each year to HQ Hydrology for use in the annual monitoring report. Maintenance will also coordinate closely with HQ Hydrology and Region staff in planning and implementing emergency repairs. In most cases, the repair design will be developing in consultation with HQ Hydrology and Region staff. During rapid erosion events, maintenance may need to implement an immediate repair to protect the safety of the traveling public; in these cases, maintenance will review the repair with HQ Hydrology and Region staff within a few days after completion to determine if further action is needed to stabilize the site.

2.4 Roles and Contacts

See attached workflow chart

WSDOT Topographic surveys, data evaluation, design of repairs, monitoring reports:

Garrett Jackson, Hydrology Program Manager (360) 705-7485

Rob Schanz, Hydrologist (360) 704-6322

Colin Newell, Chehalis Office Area Engineer (360) 740-8603

Barb Aberle, Southwest Region Environmental Services Manager (360) 905-2186

Sue Mickelsen, SW Region Environmental Coordinator (360) 905-2179

WSDOT Maintenance – reports observations of dynamic revetments to

Charles Hazen, Area 3 Maintenance Superintendent (360) 942-2092

Tom Kohl, Regional Maintenance Environmental Coordinator (360) 905-2183

Washington State Department of Ecology

Penny Kelley, 401 Permitting & Compliance, WSDOT Liaison (360) 407-7298

Brenden McFarland, Environmental Review Section Manager (360) 407-6976

George Kaminsky, Coastal Engineer, Coastal Zone Management Program (360) 407-6797

Bobbak Talebi, Coastal Planner, Coastal Zone Management Program (360) 407-6529


WSDOT Adaptive management work flow
SR105 dynamic revetment
September
October
November
December
January
February
March
April
May
June
July
August
September
October
November
December
Dynamic Revetment Construction (2017)
Stakes placed at 4 monitoring locations, every 5 feet from edge of pavement to seaward end of structure
Maintenance conducts "drive-by" monitoring through winter; reports top width and repair history to Hydrology
IF <5' top width or >10' retreat/month
HQ Hydrology conducts post-storm survey, makes recommendation for repair
Repair revetment to re-establish profile
IF roadway affected/imminently endangered
Conduct emergency repiars & notify HQ
HQ Hydrology conducts annual monitoring, reports back to Region and Ecology on condition of revetment, top widths, and annual repair history
Adaptive management meeting - discuss effectiveness trends, upcoming monitoring, potetnial repairs, and projection of replenishment cycle
Data indicates loss of >50% of revetment volume
Plan additional replenishment in future, adjust monitoring parameters, if needed
No immediate change needed
replenish stakes, if needed, and cobble stockpile, if needed
Maintenance conducts "drive-by" monitoring (Oct-Apr)

Appendix B—Photo Comparisons

View from west end of project looking east

- *EndSect3-South*
- *PH1*
- *EastShot (1)*

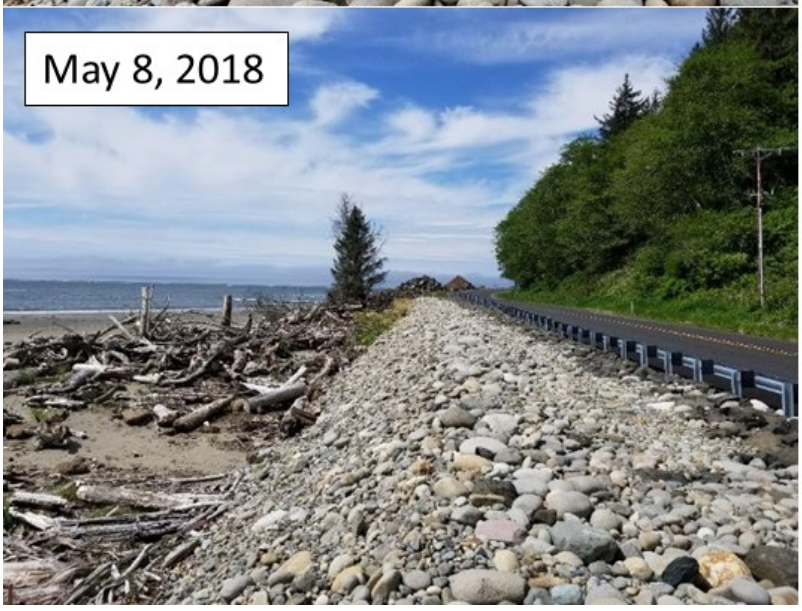
Seaward face looking west from Section 1

- *Seaward 3-2*
- *3a*
- *Sect1 (7)*

No As-Built

Seaward face looking east from Section 1

- *PH 3b*
- *Sect1 (6)*

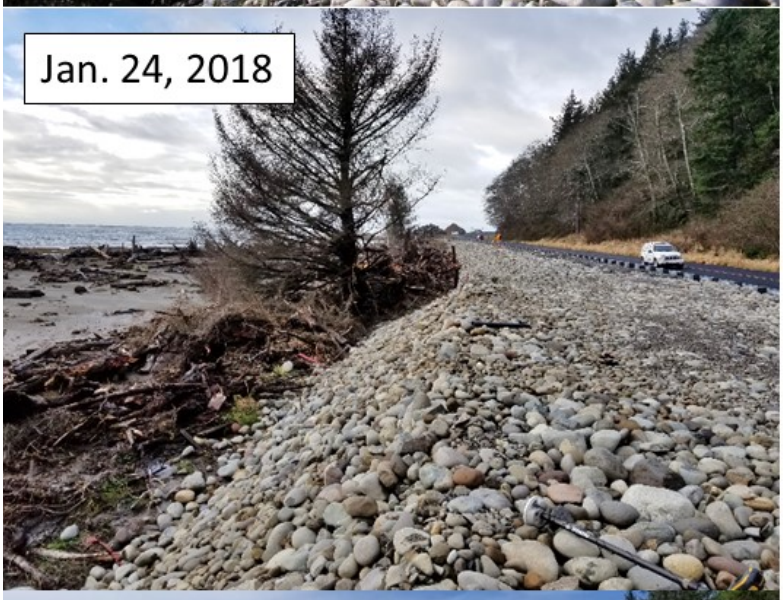


Seaward face looking west from Section 2

- *Seaward Sect3-1*
- *PH5a*
- *Sect2 (7)*

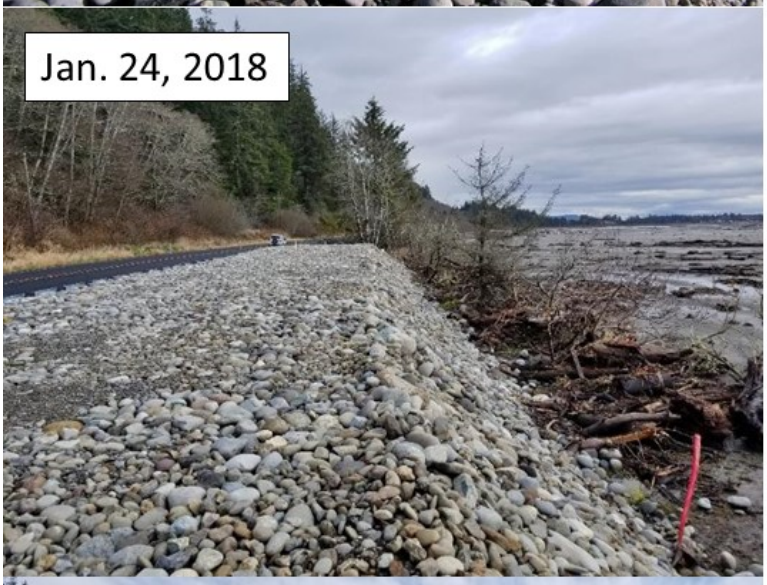
Seaward face looking east from Section 2

- *Endsect2-south*
- *PH 5b*
- *Sect2-6*



Seaward face looking west from Section 3

- *Seaward Sec2*
- *PH 7a*
- *Sect3 (7)*



Seaward face looking east from Section 3

- *EndSect2 South*
- *PH 7b*
- *Sect3 (6)*

Seaward face looking west from Section 4

- *BeginSectNorth*
- *PH 9a*
- *Sect4 (6)*

Seaward face looking east from Section 4

- *EndSect1South*
- *Ph 9b*
- *Sect4 (7)*

West transition from beach

- *PH 15b*
- *Slump (1)*

Back side of tree buried in Dec, exposed in January and May

West Transition Area

- *Seawardsect3-3*
- *Slump 3, 6*