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DRAFT MEMORANDUM

To:	Arthur Kapell, Washington State Department of Ecology	**Date:**	October 3, 2016
From:	John Laplante, P.E., Anchor QEA	**Project:**	160388-01.01 T02
Cc:	Linda Berry-Maraist, PR/OPG Clay Patmont, Anchor QEA		
Re:	Final Design - Revised SMA-2 Dredge Plan Port Gamble Bay Cleanup Project		

10-3-16

This memorandum summarizes engineering evaluations supporting design refinements of dredge prisms and scour aprons in Sediment Management Area 2 (SMA-2) for the Port Gamble Bay Cleanup Project (Project). The engineering evaluations discussed herein include geotechnical assessment of slope stability, as well as contingency measures that will be used in the event that additional wood waste is encountered after the planned dredge cut elevations are reached. The design revisions presented in this memorandum reflect feedback from and discussions with the Washington Department of Ecology (Ecology) on the various options for revising the dredge design in this area.

BACKGROUND

As discussed in our June 13, 2016, memorandum (Anchor QEA 2016), the SMA-2 dredge prism has been refined to optimize wood waste removal in this area, incorporating the results of jet probing conducted in the spring of 2016 to more accurately delineate the extent of wood waste in this area.

Over the course of spring and summer 2016, Anchor QEA prepared several alternatives for refining the dredge prism. Based on discussions with Ecology, the final design combines elements of these alternatives with the intent to balance habitat and slope stability. The final selected design is presented in this memorandum. Accordingly, this memorandum updates and supersedes all prior design memoranda on the same subject.

The final dredge prism presented herein is based on the refined contact elevation between wood waste and underlying native sediments along the northern portion of SMA-2, which requires steeper dredge cut slopes than those described in the Engineering Design Report (EDR) for the Project (Anchor QEA 2015). The following discussion describes both the geotechnical evaluations that were conducted to confirm the protectiveness of the revised design, as well as contingency measures for managing unexpected deposits of wood waste that could be encountered below the planned dredge surface.

GEOTECHNICAL ENGINEERING EVALUATION METHODS

Consistent with the EDR methodology, slope stability of the revised dredge prism was evaluated using limit equilibrium methods (LEM) with the software package Slide 7.0 (Rocscience). As was done for the EDR dredge prism, conservative model input parameters were used to evaluate the revised dredge prism to compute the factor of safety (FOS) against sliding. A FOS less than 1 implies that there is potential movement of the constructed side slope.

The LEM evaluation considered both long-term static factors of safety, as well as factors of safety during a design-level earthquake (seismic evaluation). In addition to calculating seismic factors of safety, potential slope deformations during an earthquake were assessed using a simplified sliding block model as first proposed by Newmark (1965) for estimating seismic slope performance, consistent with similar evaluations presented in the EDR. The LEM model was used to compute a "yield acceleration" for the various slope transects, and this yield acceleration was compared to the seismic acceleration during the 475-year earthquake to estimate deformation, as described and using the methods presented in the EDR.

Slope Stability Evaluation Results

The final design uses dredge cut side slopes of 2 horizontal to 1 vertical (2H:1V) and 2.5H:1V, depending on location. Where the steeper 2H:1V dredge cuts are used, the slope will be backfilled using angular gravel with a 1-foot thick rounded substrate habitat overlay, to a final slope configuration no steeper than 2.5H:1V. Figure 1 presents a plan view of the final dredge prism design, and Figure 2 through Figure 10 presents cross sections for Transects 1 through 9. The final design slopes would require removal of some of the intertidal cap constructed during Season 1, and might also require removing some clean material beneath the wood waste contact. Table 1 summarizes the LEM factors of safety associated with this design. Based on the results presented in Table 1, the final SMA-2 design refinement meets appropriate factors of safety and tolerable seismic deformations that are consistent with design presented in the approved EDR. Deformations predicted for these slopes are less than the design cap thickness, and as such pose negligible risk to the protectiveness of the cap during and following a design-level earthquake.

Table 1
Slope Stability Factors of Safety

Transect	Cut Slope Angle (H:V)	Post-dredge Backfill	Long-Term Factor of Safety	Seismic Factor of Safety	Seismic Yield Acceleration	Estimated Seismic Deformation
1	2:1	Yes	1.93	0.93	0.15	1 to 2 inches
2	2:1	Yes	2.04	0.99	0.17	1 to 2 inches
3	2:1	Yes	1.85	0.94	0.17	1 to 2 inches
4	2.5:1	No	1.78	0.82	0.12	3 to 6 inches
5	2.5:1	No	1.84	0.85	0.13	3 to 6 inches
6	2.5:1	No	1.78	0.82	0.12	3 to 6 inches
7	2.5:1	No	1.79	0.82	0.12	3 to 6 inches
8*	2.5:1	No	1.71	0.81	0.12	3 to 6 inches
9*	2.5:1	No	1.62	0.82	0.12	3 to 6 inches

* Factors of safety reported for initial dredge cut to elevation -35 feet MLLW. Removal of deeper deposits that may be present at the toe of slope would reduce the factors of safety as follows: Long-term: 0.88; Seismic: 0.45.

OVEREXCAVATION AND CAPPING CONTINGENCY MEASURES

It is possible that additional deep deposits will be encountered that were not identified by the probing. As described in the CQAP, deposits of sediment with TVS > 15% that are greater than 6 inches thick will require additional cleanup action. Depending on the location of these deposits, different contingency measures will be employed as discussed subsequently.

Contingency Measures in Shallower Water Areas

It is possible that deposits of wood waste may be encountered below the revised dredge prism at elevations shallower than -20 feet MLLW (i.e. "shallower water areas"), which is the elevation above which Ecology has expressed a strong preference for full removal. This section discusses contingency actions in the event that post-dredge sampling encounters significant deposits, as defined by the CQAP, above elevation -20 MLLW.

In areas where significant deposits are encountered in the post-dredge confirmation sampling above elevation -20 MLLW, localized additional dredging will be conducted. Such localized dredging will require over-steepening the slope. During this targeted removal, CM and Contractor staff will visually monitor the material being removed, and if visual indication suggests that the clean contact has been reached, dredging will be stopped.

In the event that localized dredging will destabilize the top of the bank, PR/OPG and Anchor QEA will confer with Ecology to determine the appropriate path forward.

Areas of localized dredging will be backfilled with angular gravel with a 1-foot thick rounded substrate habitat overlay to achieve a final surface no steeper than 2.5H:1V.

Contingency Measures in Deeper Water Areas

Dredge cuts will be verified with post-dredge core sampling consistent with the procedures presented in the CQAP. It is possible that some areas of deeper wood waste may be encountered during the dredge cut verification sampling in deeper water areas – for example in Transects 6, 8 and 9. In the location of Transects 6, 8, and 9, additional excavation significantly below the target elevation to attempt to remove deeper wood deposits could potentially destabilize the dredge cut slope. Thus, if post-dredge sampling indicates that a substantial thickness of wood waste remains below elevation -35 feet mean lower low water (MLLW), the following contingency options will be reviewed with Ecology and employed as appropriate:

- In relatively level areas at the toe of slope, the contingency would be to install the 4-foot-thick SMA-2 subtidal sand cap, consistent with the design approved in the EDR for other deep subtidal areas in SMA-2. In cases where the contingency cap will be constructed adjacent to the SMA-2 subtidal cap, the contingency 4-foot-thick sand cap would be placed in such a manner as to connect to the edge of the planned subtidal SMA-2 cap so that a continuous final cap surface results.

- Where deposits are encountered mid-slope, angular gravel material is needed for a contingency cap to be stable. For slope areas, the contingency cap would consist of 6 to 9 inches of Type 3 armor rock (as described in the EDR), covered with a 1-foot-thick overlay of rounded habitat substrate.

The plan view on Figure 1 and cross sections for Transects 6, 8 and 9 present in concept where a contingency caps could be installed if further removal below elevation -35 feet MLLW is not practicable due to slope stability concerns.

Connection between Revised SMA-2 Dredge Prism and SMA-2 Subtidal Cap

The final horizontal limits of the SMA-2 dredge prism will be controlled in part by the as-constructed side slope. The dredging is being conducted immediately adjacent to the SMA-2 subtidal cap. As part of their sequencing and to prevent cap recontamination, the contractor will maintain a buffer between the SMA-2 subtidal cap and the dredging work, and will install the SMA-2 subtidal cap within this buffer area only after dredging is complete.

The horizontal limits of the SMA-2 subtidal cap will be adjusted in the field as appropriate to ensure complete coverage of either SMA-2 subtidal cap, dredging, or dredging + contingency 4-foot thick cap in the work area. This concept is illustrated as a callout on the transects that abut the SMA-2 subtidal cap.

REFERENCES

Anchor QEA, 2015. Engineering Design Report Port Gamble Bay Cleanup Project. Prepared for Pope Resources, LP/OPG Properties, LLC. May 2015.

Anchor QEA, 2016. Revisions to Sediment Management Area 2 Dredge Prism Design Memorandum. Prepared for Washington Department of Ecology. June 13, 2016.

Newmark, N.M., 1965. Effects of Earthquakes on Dams and Embankments. Geotechnique Vol. 15, No. 2, 1965.

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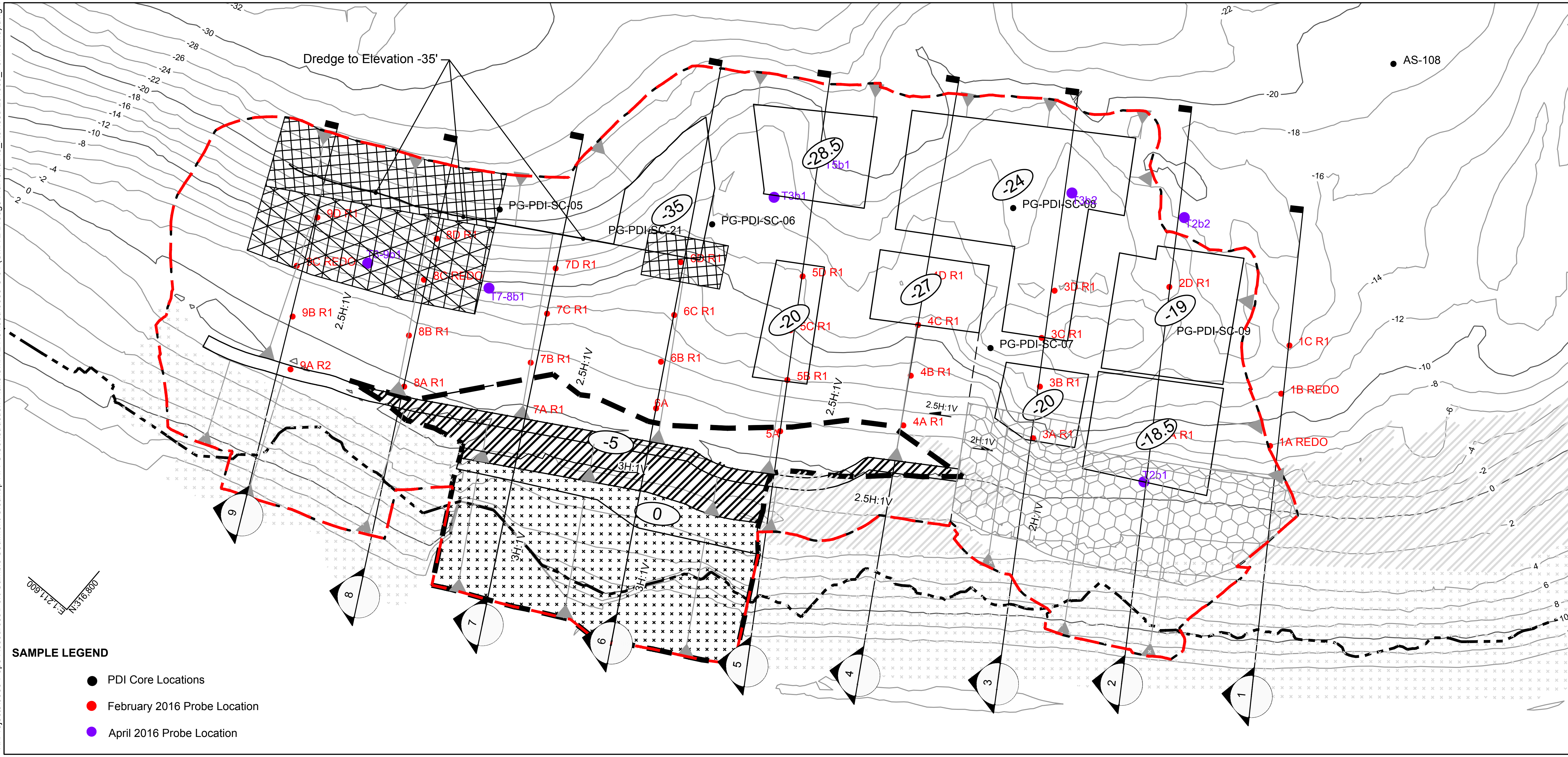

SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Mudline Contours (2' And 10' Interval)
- Existing Mean Higher High Water Line (Elevation 10.3' MLLW)
- Bank Excavation Area Performed in the Dry (> Approx. Elevation 0' MLLW)
- Intertidal Work Not Yet Completed
- Extent of Dredge Prism Revision
- Proposed Angular Gravel Backfill To 2.5h:1v Slope With Habitat Overlay
- Contingent Capping Area
- Contingent Type 3 Armor Cap Area
- Place Intertidal Type 2 Cap, Per Contract Drawing C-17
- Place Intertidal Type 3 Cap, Per Contract Drawing C-17
- Type 2 Cap Placed During Season 1
- Type 3 Cap Placed During Season 1

-15 Required Dredge Elevation (ft MLLW)
Top of Sideslope (Slopes Vary)
Final Grade
Dredge Boundary (Denotes Change in Elevation)
-18
2 FT 2-foot Cut Below Existing Grade

0 40
Scale in Feet

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Figure 1
SMA-2 Dredge Revision, October 3, 2016
Port Gamble Sediment Remediation

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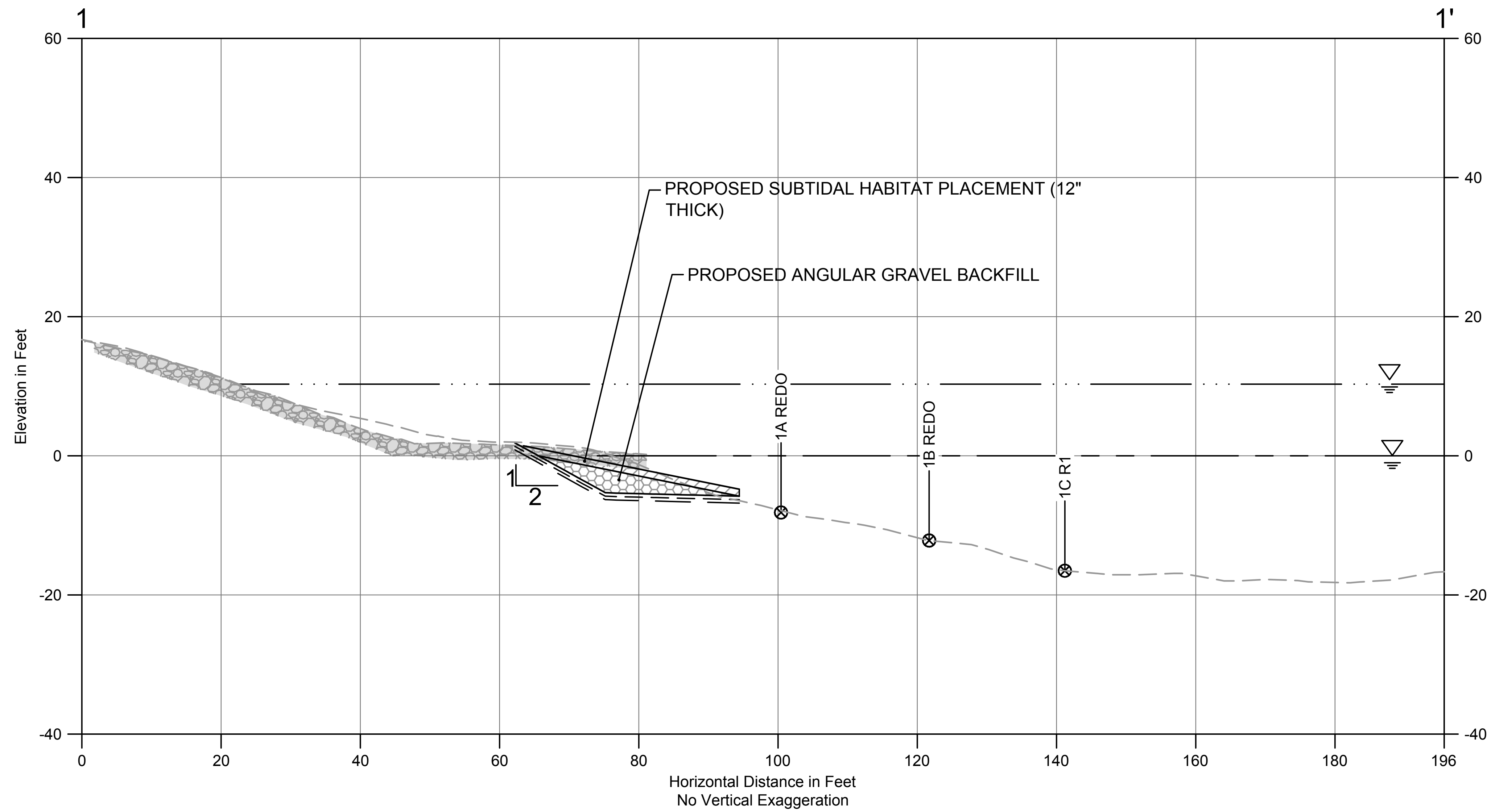

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SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

0 20
Scale in Feet

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Figure 2
Transect 1
Port Gamble Sediment Remediation

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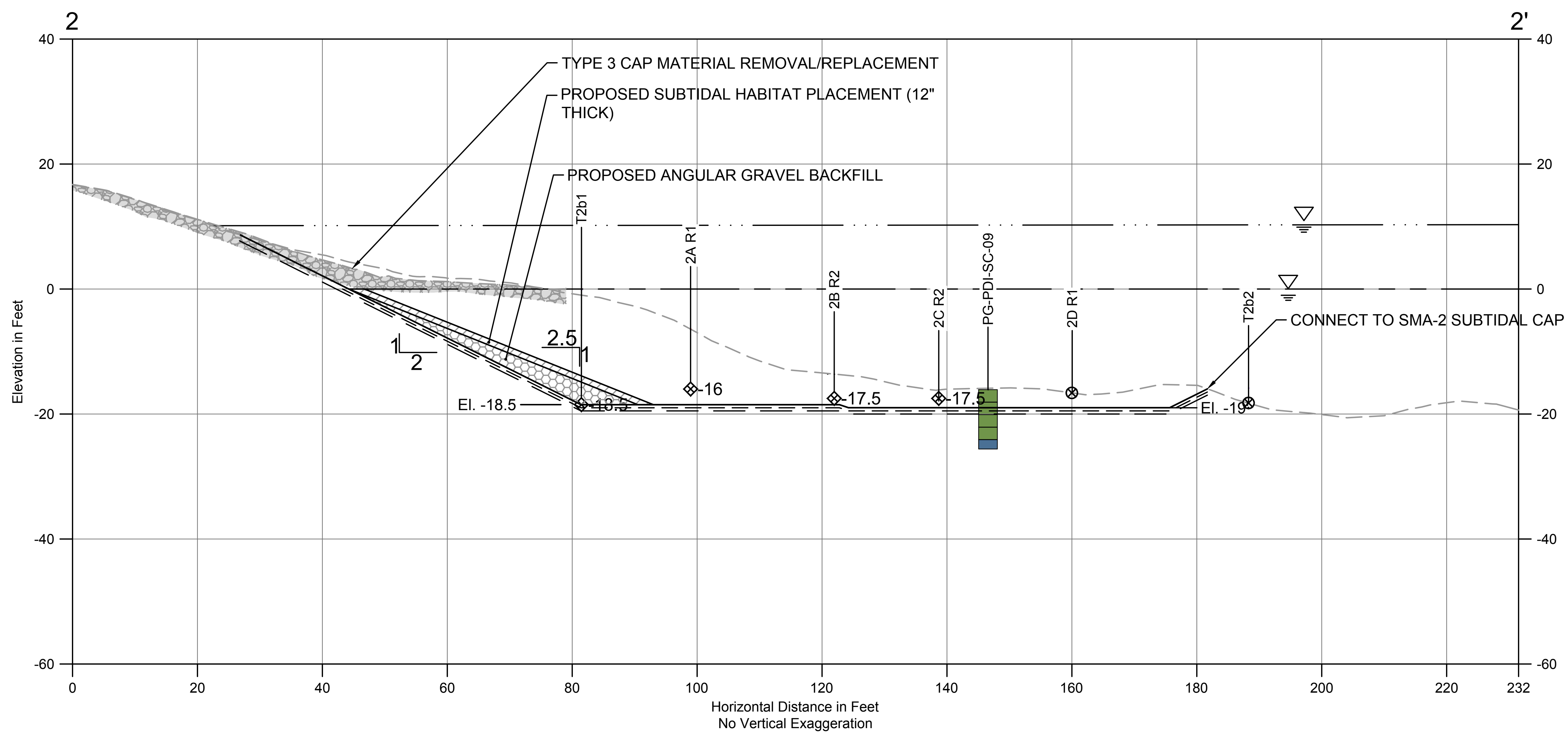

Oct 03, 2016 2:29pm chewett

SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

PG-PDI-SC-01 Existing PDI Core Sample Identification
Existing PDI Core Sample Location
Sample Interval

TVS (%)

- Greater than 15
- Less than 15
- Archived Sample

0 20
Scale in Feet

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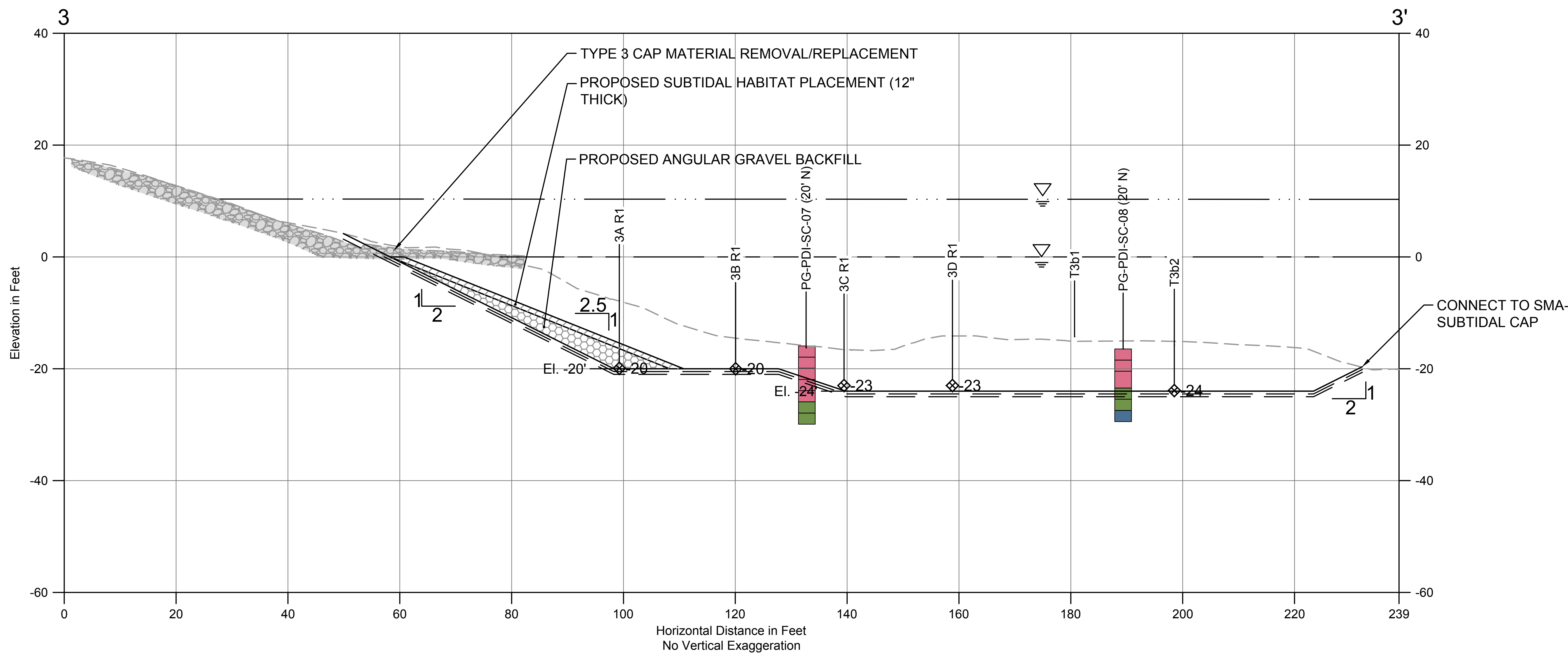
Figure 3
Transect 2
Port Gamble Sediment Remediation



SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

PG-PDI-SC-01 Existing PDI Core Sample Identification
Existing PDI Core Sample Location
Sample Interval

TVS (%)

- Greater than 15
- Less than 15
- Archived Sample

0 20
Scale in Feet

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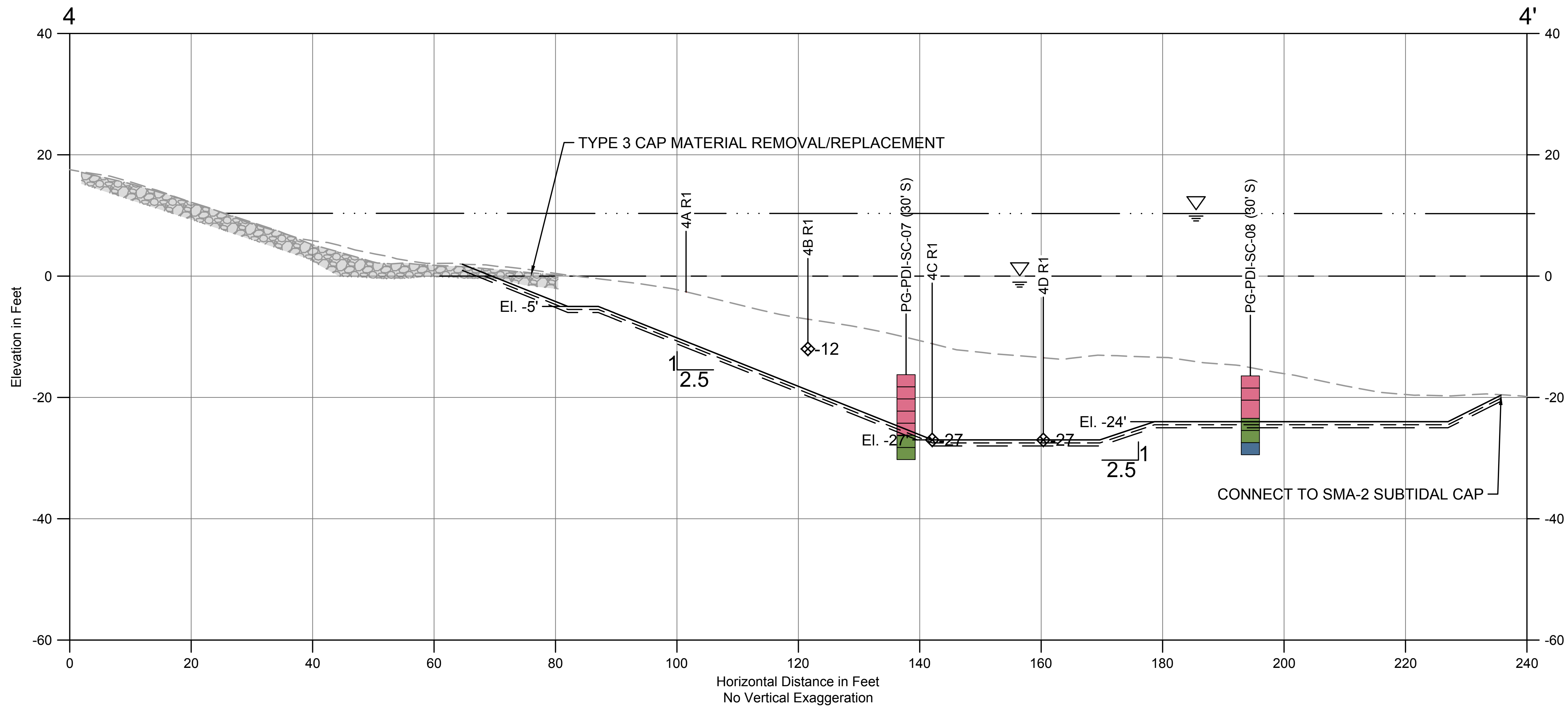
Figure 4
Transect 3
Port Gamble Sediment Remediation



SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

PG-PDI-SC-01 Existing PDI Core Sample Identification
Existing PDI Core Sample Location
Sample Interval

TVS (%)

- Greater than 15
- Less than 15
- Archived Sample

0 20
Scale in Feet

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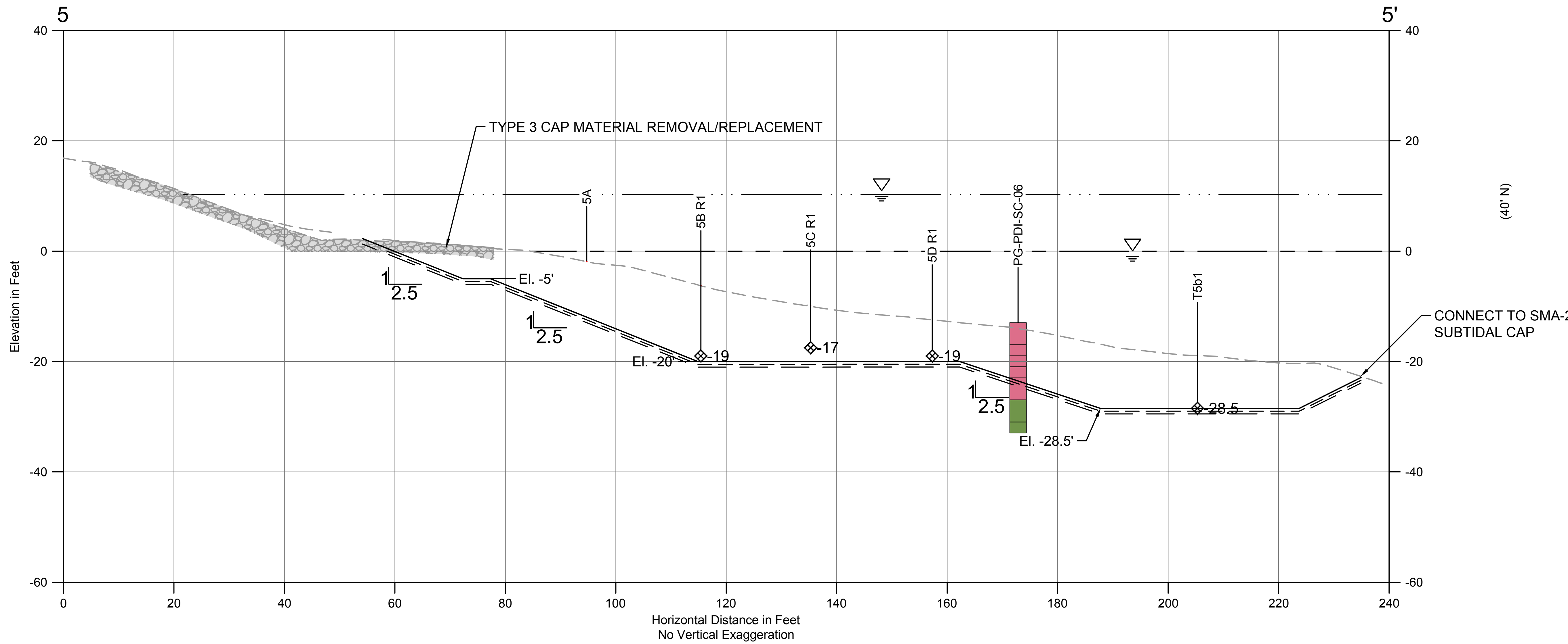
Figure 5
Transect 4
Port Gamble Sediment Remediation



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SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:
- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:
- No Wood Debris Observed
- Contact and Elevation

PG-PDI-SC-01 Existing PDI Core Sample Identification
Existing PDI Core Sample Location
Sample Interval

TVS (%)
- Greater than 15
- Less than 15
- Archived Sample

0 20
Scale in Feet

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Figure 6
Transect 5
Port Gamble Sediment Remediation

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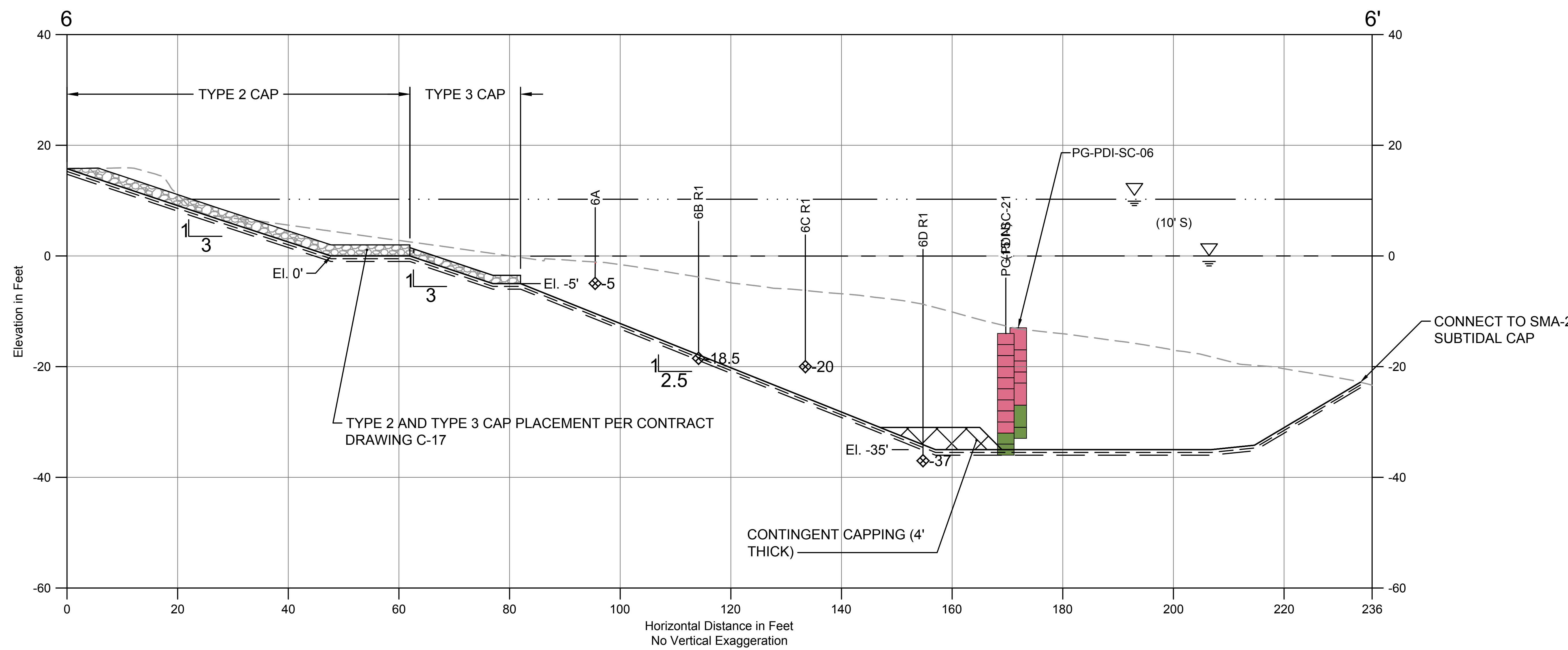

SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

PG-PDI-SC-01 Existing PDI Core Sample Identification
Existing PDI Core Sample Location
Sample Interval

TVS (%)

- Greater than 15
- Less than 15
- Archived Sample

0 20
Scale in Feet

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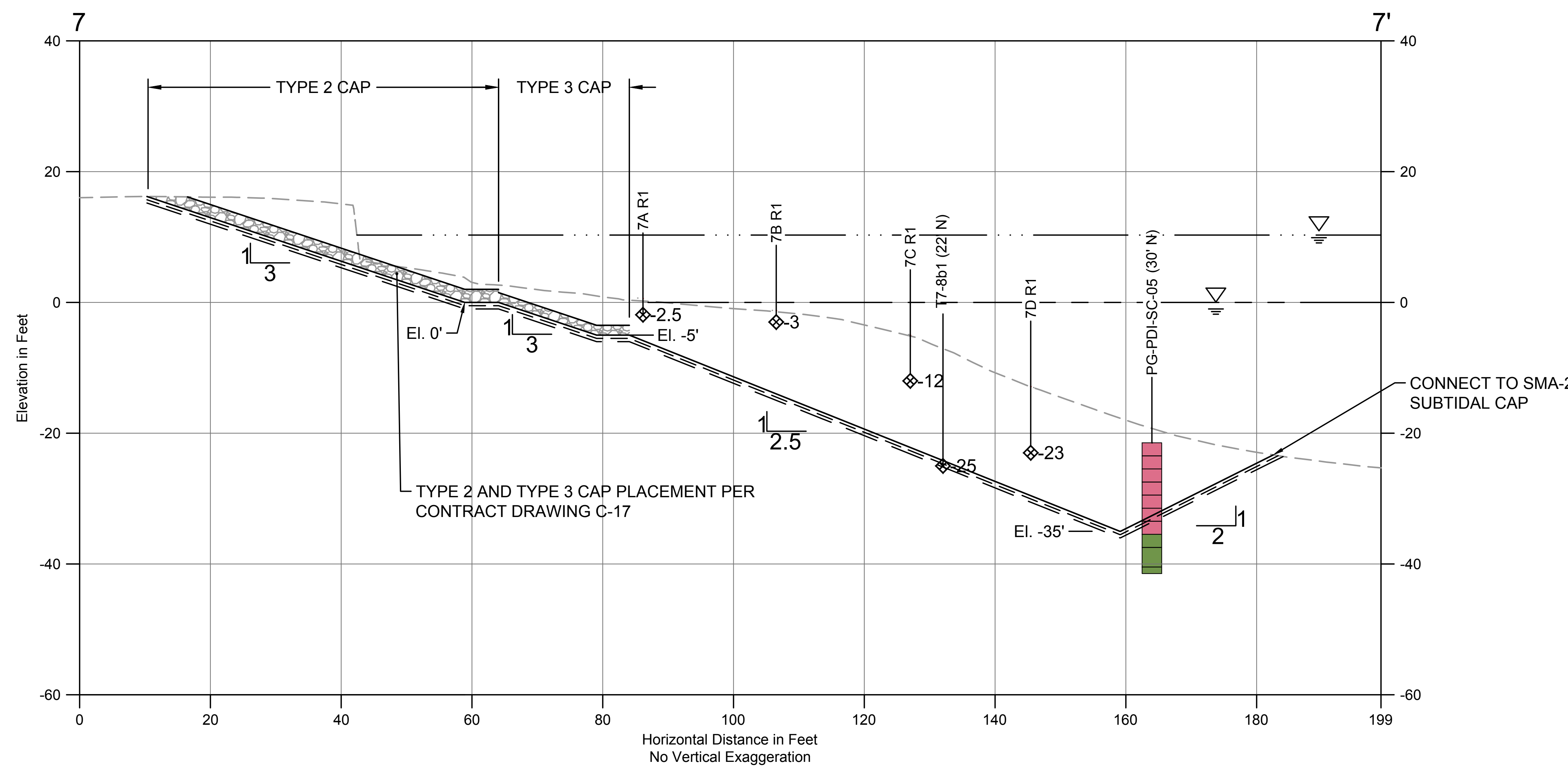
Figure 7
Transect 6
Port Gamble Sediment Remediation



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Oct 03, 2016 2:29pm chewett

SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
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- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

PG-PDI-SC-01 Existing PDI Core Sample Identification
Existing PDI Core Sample Location
Sample Interval

TVS (%)

- Greater than 15
- Less than 15
- Archived Sample

0 20
Scale in Feet

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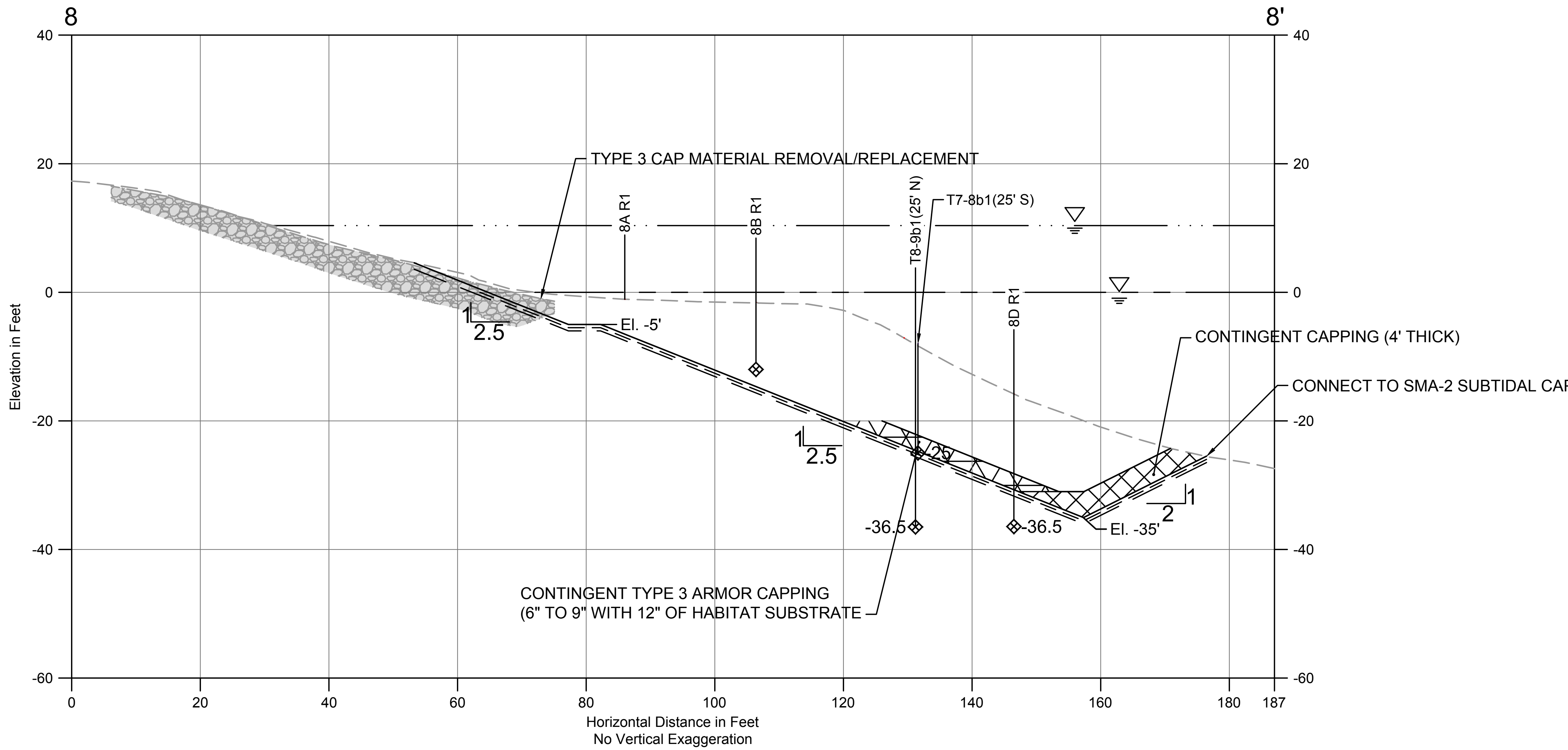
Figure 8
Transect 7
Port Gamble Sediment Remediation



SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- Existing Grade (from January 20, 2016 and July 27, 2016 Surveys By eTrac And AES)
- Required Dredge Elevation
- 0.5-ft Payable Allowable Overdepth Line
- 1-ft Maximum Allowable Overdepth Line
- Mean Higher High Water Line (Elevation 10.3' MLLW)
- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

0 20
Scale in Feet

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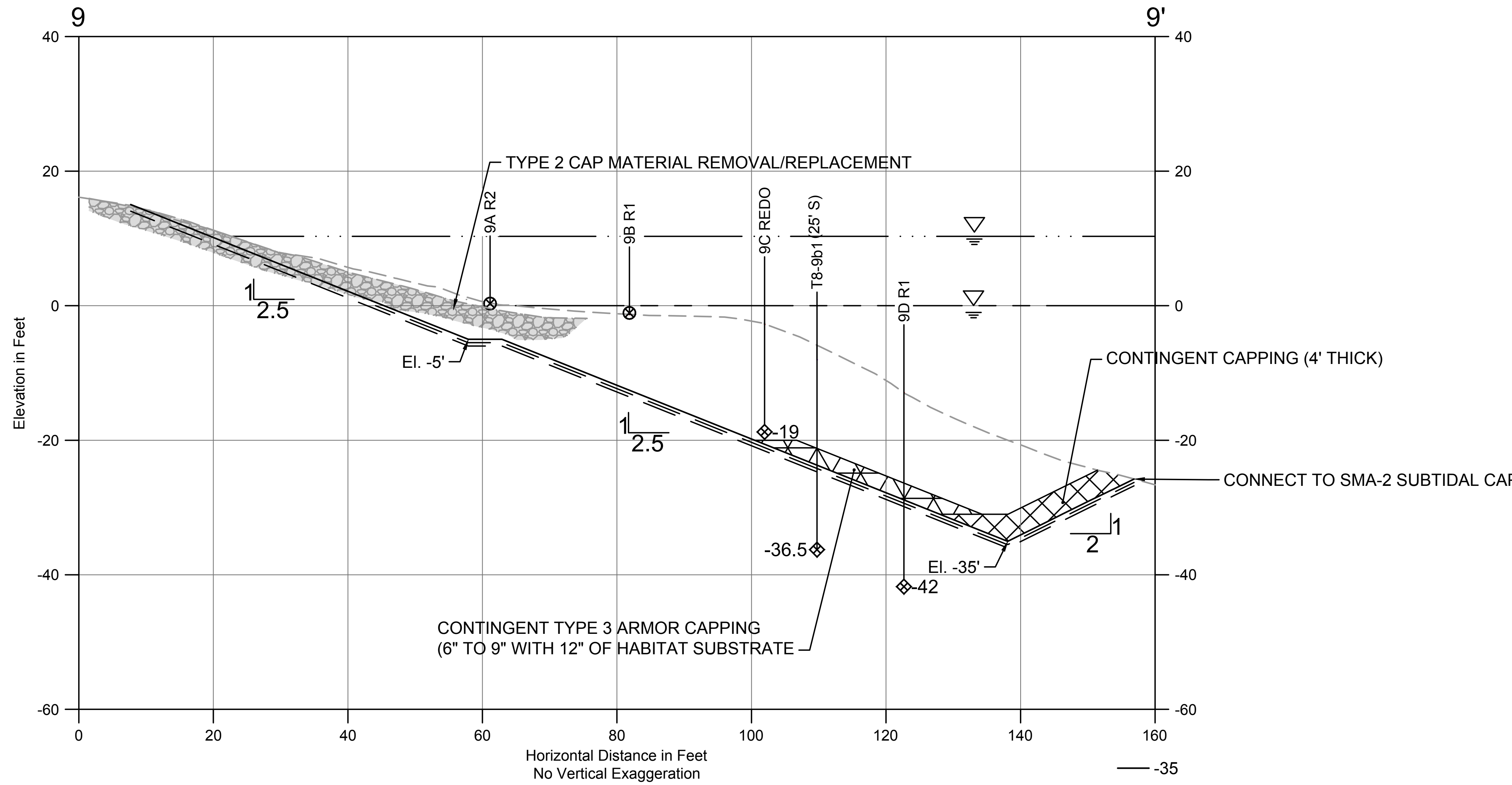
Figure 9
Transect 8
Port Gamble Sediment Remediation



SOURCE: Bathymetry from eTrac, dated January 20, 2016.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

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- Mean Lower Low Water Line (Elevation 0.0' MLLW)
- Proposed Angular Gravel Backfill
- Contingent Capping
- Subtidal Habitat Layer
- Cap Material Placed In Season 1

PROBE LEGEND:

- No Wood Debris Observed
- Contact and Elevation

0 20
Scale in Feet

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Figure 10
Transect 9
Port Gamble Sediment Remediation