APPENDIX O

HEAD OF SLIP 3 CAP POST CAP ASSESSMENT TECHNICAL MEMORANDUM

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Memorandum

To: Nicole LaFranchise/Krista Koehl – Port of Portland

From: John Verduin – Anchor Environmental, L.L.C.;
Herb Clough/Stu Albright – Ash Creek Associates

CC: Marcel Hermans/Roger Anderson/John Durst – Port of Portland

Date: November 24, 2008

Re: Head of Slip 3 Cap Post Cap Assessment
Terminal 4 Phase I Removal Action
Port of Portland

This memorandum summarizes the assessment of the Head of Slip 3 cap after construction. Hickey Marine Enterprises (HME) constructed the cap between September 13 and October 1, 2008. Survey data completed after construction indicates that the height of the rock buttress in front of the timber bulkhead is lower than shown on the construction drawings. This memorandum reviews the cap design and interim monitoring requirements, summarizes the cap construction activities and results, and concludes with a recommended path forward.

REVIEW OF HEAD OF SLIP 3 CAP DESIGN

Section 5.1 of the Design Analysis Report (DAR; Anchor 2008) presents the basis of design for the Head of Slip 3 cap. The Head of Slip 3 cap consists of three unique parts: two in front (river side) of the timber bulkhead and one behind (land side) the timber bulkhead. The first part in front of the timber bulkhead is a cap serving to isolate receptors from contaminated sediments that cannot be dredged because of concern for the stability of the adjacent shoreline slope. The second part in front of the timber bulkhead is a rock buttress intended to stabilize the timber bulkhead and overall slope to compensate for the cap behind the timber bulkhead. The third part, the portion of the cap behind the bulkhead, serves both to confine contaminated sediments from receptors and to control sheens associated with the historical seep.

Performance Standards

The following performance standards were developed with U.S. Environmental Protection Agency (USEPA) to help guide the design and were presented in the DAR (Anchor 2008):

- Isolate the surface sediments containing elevated contaminant concentrations from benthic communities and the aquatic environment by applying appropriate long-term erosive, as well as contaminant transport, mechanisms.
- Design the chemical isolation layer, where necessary, to contain sheens exiting from the shoreline.
- Design the armor layer of the cap to resist bed shear velocities induced by the largest of 100-year flood flow, 100-year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area.
- Use import cap material that meets defined chemical goals.
- Conduct the work consistent with the best management practices (BMPs) listed in the Capping specification (Section 352025; Appendix E to the DAR; Anchor 2008), in order to minimize mixing of cap material with underlying contaminated sediments. Water quality BMPs for capping include:
  - The base cap layer shall be placed in a manner to minimize disturbance and mixing of cap material and sediment.
  - Use of spuds is not allowed in areas previously capped.
  - The Contractor will not be allowed to drag cap areas to even out cap overplacements.
  - The Contractor shall install and maintain absorbent booms around the Head of Slip 3 cap construction area.
- Conduct the work consistent with the Water Quality Monitoring Plan (WQMP) (Appendix B to the DAR; Anchor 2008) and the Water Quality Monitoring and Compliance Conditions Plan (WQMCCP), in order to minimize water quality impacts outside the compliance boundary.

Design Objectives and Criteria

Using these performance standards, the following design objectives and criteria were developed as presented in the DAR (Anchor 2008):

- **Delineate cap area in front of the timber bulkhead based on Probable Effects Concentration (PEC) exceedances**. Areas that were not identified for dredging that

had surface concentrations exceeding PEC criteria were identified for capping. As discussed in the DAR, the area in front of the timber bulkhead was initially identified for removal, but due to stability concerns with the bulkhead, this area will require capping instead.

- **Delineate cap area behind bulkhead based on past construction activities and field observations**. The initial and approximate boundaries of the Head of Slip 3 cap can be determined by observations from the Bank Excavation and Backfill Remedial Action (BEBRA). The Construction Drawings (Appendix D; Anchor 2008) present the Contractor with the boundaries of the initial excavation. Observations by the Port of Portland (Port) and USEPA during construction will be needed to determine the final boundaries of the work.
- **Determine cap thickness and composition of the base cap based on the BEBRA work**. Design studies for the BEBRA work, as well as the performance of the BEBRA base cap, can be used to determine the composition and thickness of the base cap layer.
- **Determine armor layer gradation and thickness necessary to resist erosion based on site characteristics**. The cap armor layer was determined based on the following components (from Palermo et al. 1998):
  - Propeller wash
  - Currents
  - Wind waves
  - Vessel-induced waves
- **Minimize water quality impacts outside of the compliance boundary**. The need to meet water quality chemistry and turbidity or total suspended solids (TSS) standards factored into the selection of cap material placement methods. Water quality monitoring activities and criteria for capping are described in detail in the WQMP (Appendix B to the DAR; Anchor 2008).

Cap Thickness and Gradation and Rock Buttress Design

Contaminant transport modeling for the Head of Slip 3 cap determined that an 18-inch-thick base cap layer would be required. In addition, the Head of Slip 3 cap required the use of organoclay-supplemented material. The amount of organoclay was 10 percent by weight. In the plans and specifications, this material is referred to as Base Cap Type 3 material.

To resist potential erosive forces, an armor layer was designed to be placed on top of the base cap layer. The armor layer was designed to resist waves, currents, and propeller wash. A material with a mean grain size of 7 to 10 inches was determined to be adequate for the design erosive forces. The thickness of the armor layer was determined to be at least 18 inches. In the plans and specifications, this material is referred to as Type 3 Armor material.

The rock buttress in front of the timber bulkhead was designed with a 1 horizontal to 1 vertical slope and a 5-foot-wide crest. The slope of the buttress was set at approximately the angle of repose of the rock to minimize the volume of rock in the buttress. The elevation of the crest was set roughly equal to the elevation of the sediment behind the wall, which is roughly 2 feet National Geodetic Vertical Datum (NGVD). It is important to note:

- There are neither performance standards nor design criteria identified for the rock buttress.
- The design size of the rock buttress was very conservative: the design level of the rock buttress is essentially at the level of the sediment behind the wall. The level of the sediment in front of the wall before the buttress was 12 to 16 feet below the sediment level behind the wall. This conservative design was intentional, because the timber bulkhead does not easily allow quantitative analysis of structural integrity.

LONG-TERM MONITORING REQUIREMENTS

Section 3 of Appendix C to the DAR (Interim Monitoring and Reporting Plan; Anchor 2008) identified the following three measures to monitor the performance of the Head of Slip 3 Cap:

- Visual survey of the slope upland of the wall for sloughing/stability:
  - Transects will be walked at low water levels to complete visual surveys of the slope.
  - Transects will be established on 40-foot spacings perpendicular to the shoreline (three transects). The observer will walk the transects looking for evidence of instability.
  - Areas of instability will be noted on drawings.
- Survey of the pinch-pile wall to assess stability:
  - A surveyor's spike will be inserted in the top of the pinch-pile wall at 40-foot spacings (three monitoring points).

  - Successive surveys will be compared to the baseline (immediately after completion of construction) survey.
  - In the event of movement greater than 1 inch compared to baseline, a diver survey will be completed to assess the condition of the wedge in front of the pinch-pile wall.
- Visual survey for sheens:
  - The site will be walked on 20-foot transects parallel to the shoreline to observe the presence of sheens.
  - The site will be walked at a water level of approximately 5 feet NGVD and 10 feet NGVD for the presence of sheens.
  - Any significant sheens observed will be noted on drawings.

Section 6 of the Interim Monitoring and Reporting Plan (Appendix C to the DAR; Anchor 2008) presents potential response actions if instability or sheens are present.

- If the armor layer becomes unstable:
  - Determine the cause of failure.
  - Address the stability based on the findings. Measures to improve the stability may include:
    - Placing additional material down slope of the pinch-pile wall
    - Structurally improving the bulkhead with bracing
- If the armor layer begins eroding:
  - Determine the cause of erosion.
  - Address the erosion based on the findings. Measures to improve the erosion may include:
    - Increasing the gradation and/or thickness of the armor layer
- If sheens are present:
  - Determine the cause of sheens.
  - Address the source based on the findings. Measures to control sheens may include:
    - Placing additional sheen control material

CAP CONSTRUCTION

HME constructed the cap in the following sequence:

- September 12, 2008: completed a pre-cap survey of the submerged portion of the Head of Slip 3 cap.

- September 13, 2008: placed 147 tons of Base Cap Type 3 material in front of the timber bulkhead, covering roughly 1/3 of the target area.
- September 15, 2008: placed 280 tons of Base Cap Type 3 material in front of the timber bulkhead. This completed coverage of the target area. HME completed a survey of the area and found a few low spots.
- September 16, 2008: placed Base Cap Type 3 material in the low spots identified on the previous day's survey. They then placed 179 tons of Type 3 Armor material in front of the timber bulkhead. They placed a single lift of armor over the entire footprint of the rock buttress first to protect the Base Cap Type 3 before moving on to the remaining lifts of the buttress. Remaining lifts were placed from the toe upward.
- September 17, 2008: placed 1,000 tons of Type 3 Armor material in front of the timber bulkhead.
- September 18, 2008: placed 716 tons of Type 3 Armor material in front of the timber bulkhead, followed by a progress survey of the Type 3 Armor material placed to date. The survey showed that the rock slope was oversteepened in the middle portion and below target grade from the middle to the south, immediately adjacent to the timber bulkhead.
- September 19, 2008: removed debris and rock from the slope face behind the timber bulkhead. A spider hoe was used for the upland work.
- September 20, 2008: using the spider hoe, removed debris and rock from the slope face behind the timber bulkhead.
- September 22, 2008: used the spider hoe and clamshell to cut the slope back behind the bulkhead to the BEBRA organoclay layer.
- September 23 and 24, 2008: surveyed excavated upland area behind the bulkhead to determine amount of Base Cap Type 3 material required. HME placed 324 tons of Base Cap Type 3 material behind the timber bulkhead. They then placed the separation geotextile, followed by 257 tons of Base Cap Type 2 sand (filter material) on top.
- September 25, 2008: placed 149 tons of Base Cap Type 2 sand behind the bulkhead. They then placed roughly 115 tons of riprap removed previously from the slope (on September 19 and 20) back at the base of the slope.
- September 30, 2008: placed 450 tons of Type 3 Armor material in front of the timber bulkhead to fill the low areas identified in the September 18 survey (placed along the bulkhead from the middle to the south).

- October 1, 2008: placed 300 tons of Type 3 Armor material behind the timber bulkhead. In the morning, HME completed a survey in front of the timber bulkhead. The survey identified the loss of material in the middle of the rock buttress. About 60 tons of Type 3 Armor remained on the barge and was placed in the newly identified low area in the middle of the buttress. HME completed a second survey in front of the timber bulkhead – the post-cap survey.

Figure 1 shows the post-cap ground surface (behind the bulkhead) and bathymetry (in front of the bulkhead) for the Head of Slip 3 cap and the location of three cross sections through the area. Figures 2a and 2b present the three cross sections. Figure 2a includes the following information:

- The design finish grade of the rock buttress in front of the bulkhead
- Pre- and post-cap surveys completed in front of the bulkhead by David Evans and Associates (DEA) including:
  - The pre-cap survey completed in June 2008
  - Post-cap survey completed on October 10, 2008
  - Post-cap survey completed on October 21, 2008
- Port post-cap survey completed on October 16, 2008 behind the timber bulkhead.

Figure 2b includes:

- HME pre-construction survey completed September 12, 2008
- HME survey completed September 15, 2008, after placement of the Base Cap Type 3

Figure 3 is a three-dimensional rendering of the October 10, 2008 DEA survey.

CONCLUSIONS AND DISCUSSION

1) Multiple Surveys indicate Minimal Continued Settlement

Figure 2a illustrates the results of multiple bathymetric surveys from in front of the bulkhead. These surveys were conducted using multi-beam surveys. From these results, the following may be concluded:

- No ongoing settlement was detected by the surveys. The DEA surveys from October 10 and October 21 show no change at all three sections.

2) Sediment Cap Complies With Performance Standards

Quality assurance for the cap construction included chemical and physical testing of import materials, observation of material placement to verify quantity and thickness, verification of material quantities used, and pre- and post-construction surveys to confirm finish grades achieved. Quality assurance documentation (e.g., lab reports, field notes, photographs, material quantity measures, and bathymetry) have verified that the Head of Slip 3 cap meets all of the performance standards. Compliance with the performance standards is summarized below and will be documented in detail in the final report.

- **Performance Standard 1 – Isolate the surface sediments containing elevated contaminant concentrations from benthic communities and the aquatic environment by applying appropriate long-term erosive, as well as contaminant transport, mechanisms.**
  This standard was addressed in the design with an 18-inch layer of Base Cap Type 3 material (sand and gravel with 10 percent organoclay), covered by a layer of Type 3 Armor material. Field observations (summarized above) indicate that the Base Cap Type 3 material was placed on September 13 through September 16. Figure 2b shows the pre-and post-construction survey for the organoclay Base Cap Type 3 (i.e., see the HME September 12 and September 15 surveys), demonstrating compliance with the performance standard to address contaminant transport. On September 16, HME placed a single lift of Type 3 Armor material over the Base Cap Type 3, addressing the long-term erosive performance standard. Subsequent placement of the rock buttress did not impact the performance of the cap (see further discussion in the next section).

- **Performance Standard 2 – Design the chemical isolation layer, where necessary, to contain sheens exiting from the shoreline.**
  The entire cap behind the timber bulkhead incorporates an 18-inch layer of Base Cap Type 3 material. The cap contains 10 percent organoclay capable of adsorbing sheen prior to entering surface water. This cap was placed on September 23 and 24.

- **Performance Standard 3 – Design the armor layer of the cap to resist bed shear velocities induced by the largest of 100-year flood flow, 100-year waves, vessel-induced waves from typical passing vessels, and anticipated propeller wash from vessels that operate in the area.**

  The design includes an 18-inch layer of Type 3 Armor material. This armor was placed over the caps both in front of and behind the timber bulkhead. On September 16, HME placed a layer of Type 3 Armor material over the entire cap in front of the bulkhead. From September 23 through October 1, HME placed a geotextile, Base Cap Type 2 sand, and Type 3 Armor layer over the cap behind the timber bulkhead. Placement of the cap as designed was verified by field observation.

- **Performance Standard 4 – Use import cap material that meets defined chemical goals.**

  Import materials met the chemical goals, which will be documented in the final report.

- **Performance Standard 5 – Conduct the work consistent with the BMPs listed in the Capping specification (Section 352025; Appendix E to the DAR; Anchor 2008), in order to minimize mixing of cap material with underlying contaminated sediments. Water quality BMPs for capping include:**
  - The base cap layer shall be placed in a manner to minimize disturbance and mixing of cap material and sediment.
  - Use of spuds is not allowed in areas previously capped.
  - The Contractor will not be allowed to drag cap areas to even out cap overplacements.
  - The Contractor shall install and maintain absorbent booms around the Head of Slip 3 cap construction area.

  The work was conducted in accordance with the BMPs, as confirmed by observation during the work, and as will be documented in the final report.

- **Performance Standard 6 - Conduct the work consistent with the WQMP (Appendix B to the DAR; Anchor 2008) and the WQMCCP, in order to minimize water quality impacts outside the compliance boundary.**

The work was conducted in accordance with the WQMP, as will be documented in the final report.

3) Only Height of Rock Buttress Not Compliant With Design

Observation, survey, and bathymetry demonstrate that all parts of the cap installation are in accordance with the design except for the height of the rock buttress. The following discusses conclusions with respect to the as-constructed cap/buttress in relation to the design of the Head of Slip 3 Cap:

- The bathymetry on Figures 1 and 2a shows the following:
  - Sections A and C show that the design quantity of rock was placed (compare the DEA post-cap surveys to the design grade). The final slopes show that some raveling of rock occurred during construction resulting in slopes slightly flatter than the design, but the flatter slope does not impact the performance of the rock buttress.
  - At the timber bulkhead, finish grade ranges from 2 to 9 feet (average of 4 feet) below the design finish grade. The progress bathymetric surveys show that at one time during construction, the slope was above finish grade at Section B. An event occurred between September 18 and October 1 resulting in the loss of rock at Section B. The following is believed to be the sequence of events at Section B:
    - Rock was placed to above grade at Section B, except near the bulkhead where the grade was slightly low.
    - Raveling during construction resulted in the excess material observed beyond the toe (see Figure 3). This raveling resulted in an oversteepened condition. This oversteepened condition was only temporarily stable as a result of accidental "stacking" of the larger rocks (e.g., consider that stacked bricks can stand vertically).
    - The progress bathymetric surveys indicated that the buttress was below finish grade adjacent to the bulkhead beginning at Section B and continuing south to Section C.
    - On September 30, additional rock was placed adjacent to the bulkhead from Section B to Section C. Placement of additional rock between the timber bulkhead and the oversteepened slope caused an abrupt failure of the oversteepened slope. The abrupt failure caused material to deposit out

beyond the toe of the buttress. The presence of rock beyond the toe was verified by hand tamping with a rod from a boat. Figure 3 is a three-dimensional rendering of the rock buttress showing the area of rock flow.

- A survey completed on the morning of October 1 (not shown on Figure 2a) identified the loss of material at Section B (relative to the earlier progress survey). HME placed 60 tons of armor (left over from the upland work) in front of the bulkhead at Section B.

4) Rock Buttress Failure Did Not Impact Sediment Cap

It is our opinion that the failure of the rock buttress slope had no substantive impact on the sediment cap. This conclusion is based on multiple lines of evidence, as follows:

- Construction Method – Following placement of the sand cap, a layer of armor stone was placed across the entire cap. This layer protected the cap from subsequent damage from all but a deep rotational failure through the cap. As discussed above, on October 14 the presence of rock at the toe was verified by hand tamping with a rod from a boat.
- Slope Stability Simulation – Multiple runs of stability calculations were conducted on the rock buttress/cap at Section B. Using a wide range of material properties, none of the simulated failure surfaces penetrated into the sediment cap layer or underlying native material. Attachment A to this memo discusses the slope stability calculation methods and results.
- Bathymetry – The material at the toe and beyond is fan-shaped and extends up to 40 feet from the toe. This is consistent with a debris flow off the slope and not a rotational failure into the sediment cap.

5) As Constructed, Rock Buttress Improves Timber Bulkhead and Overall Slope Stability

Two issues are addressed by the rock buttress: 1) increasing stability of the timber bulkhead, and 2) increasing overall stability of the shoreline slope. Although not as good as the design condition, the as-constructed buttress improves stability for both issues, as follows:

- Timber Bulkhead – Prior to construction, the timber bulkhead was subject to differential sediment heights on each side of the wall, ranging from 12 to 16 feet with

an average of about 14 feet. After construction, the differential sediment heights range from 3 to 11 feet with an average of about 6 feet. Overall, the differential heights on the wall are less than half of what was present prior to construction. Therefore, the maximum stress in the timber piling is greatly reduced (although the location of maximum stress has moved upward in the piling).

- Overall Stability – The overall global stability was calculated for both the before-construction and after-construction conditions. The overall stability of the slope increased by more than 50 percent, to a safety factor of greater than 1.5. Attachment A to this memo discusses the slope stability calculation methods and results.

RECOMMENDED PATH FORWARD

The recommended path forward is to implement and continue monitoring the head of Slip 3 cap in accordance with the Interim Monitoring and Reporting Plan (IMRP; Appendix C of the DAR, Anchor 2008a). Overall stability has been improved relative to the pre-construction condition. However, long-term performance of the timber bulkhead is unknown as the piles age. Therefore, monitoring under the IMRP could indicate a need for additional rock in the low area to reduce the stress on the timber bulkhead.

REFERENCES

Anchor Environmental, L.L.C. (Anchor). 2008. Design Analysis Report: Terminal 4 Phase I Removal Action, Port of Portland, Portland, Oregon. Prepared by Anchor Environmental for Port of Portland. June 30, 2008.

Palermo, M. R., J. Miller, S. Maynord, and D. Reible. 1998. Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments. USEPA 905/B-96/004. Prepared for the Great Lakes National Program Office, United States Environmental Protection Agency, Chicago, Illinois. Website: http://www.epa.gov/glnpo/sediment/iscmain.

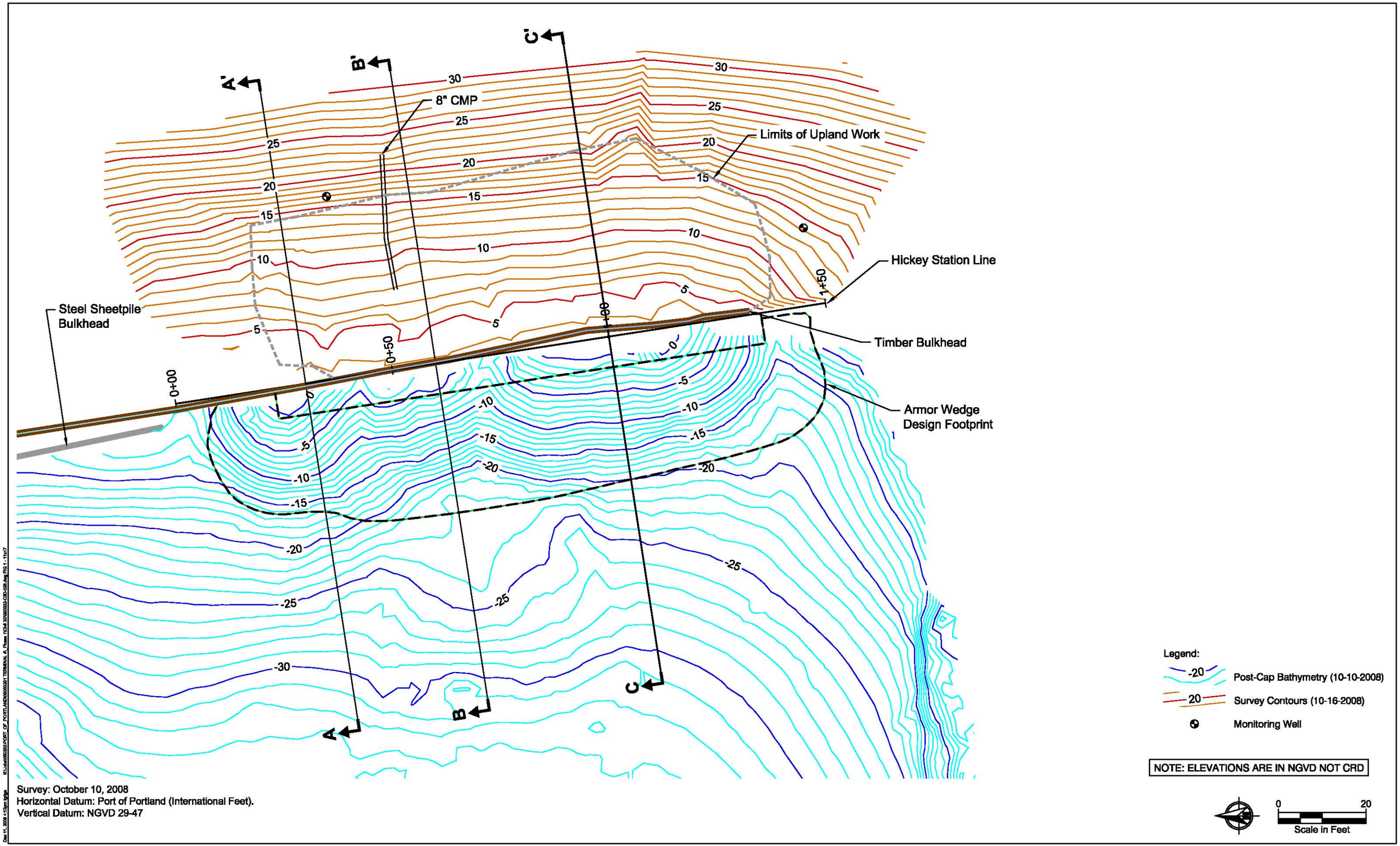
Attachments

Figure 1 – Post-Cap Survey (October 10, 2008)

Figure 2a – Cross Sections A-A′, B-B′, and C-C′ (DEA Surveys)

Figure 2b – Cross Sections A-A′, B-B′, and C-C′ (Type 3 Cap Survey)

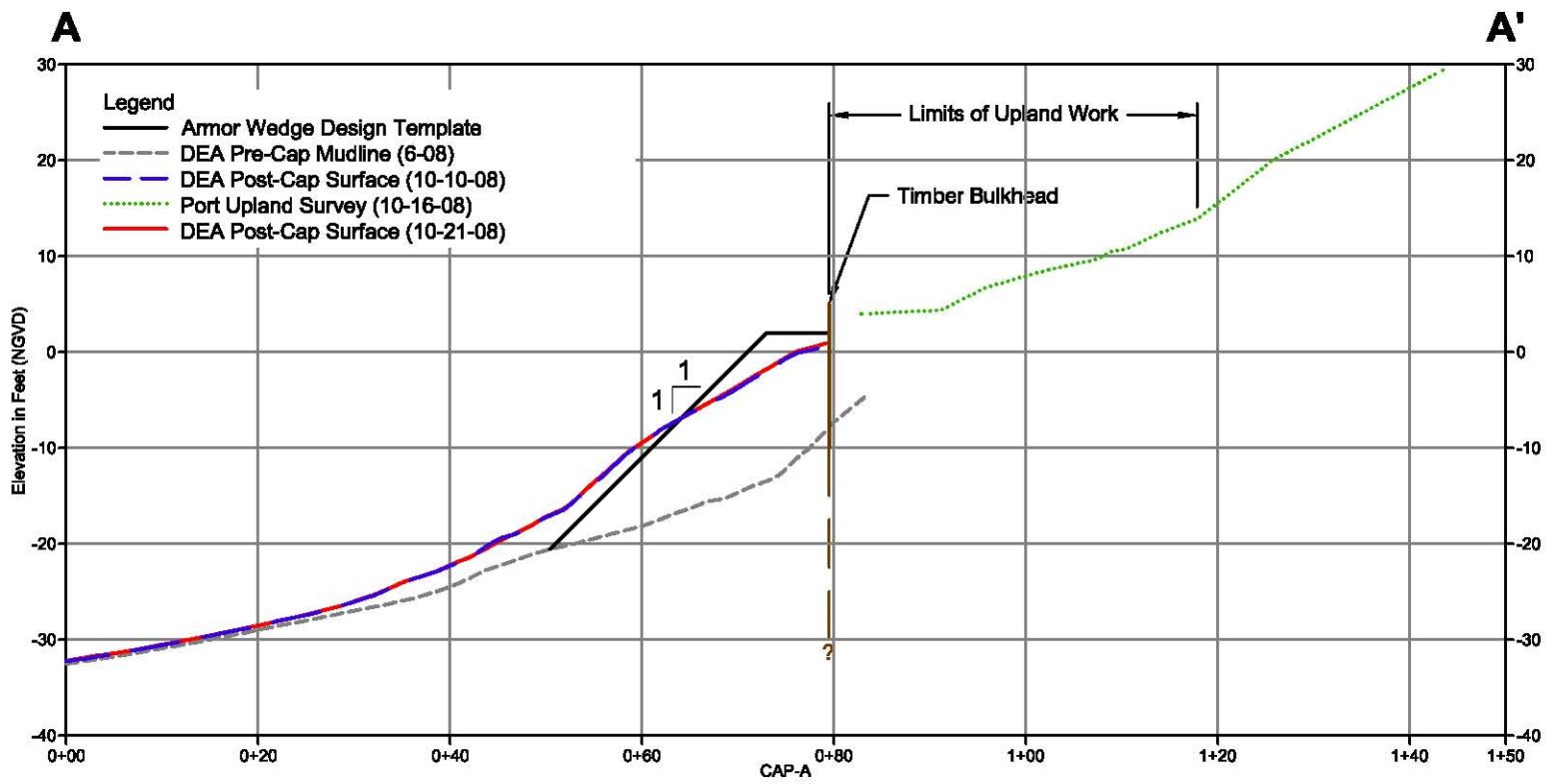
Figure 3 – DEA Survey (10-10-08)



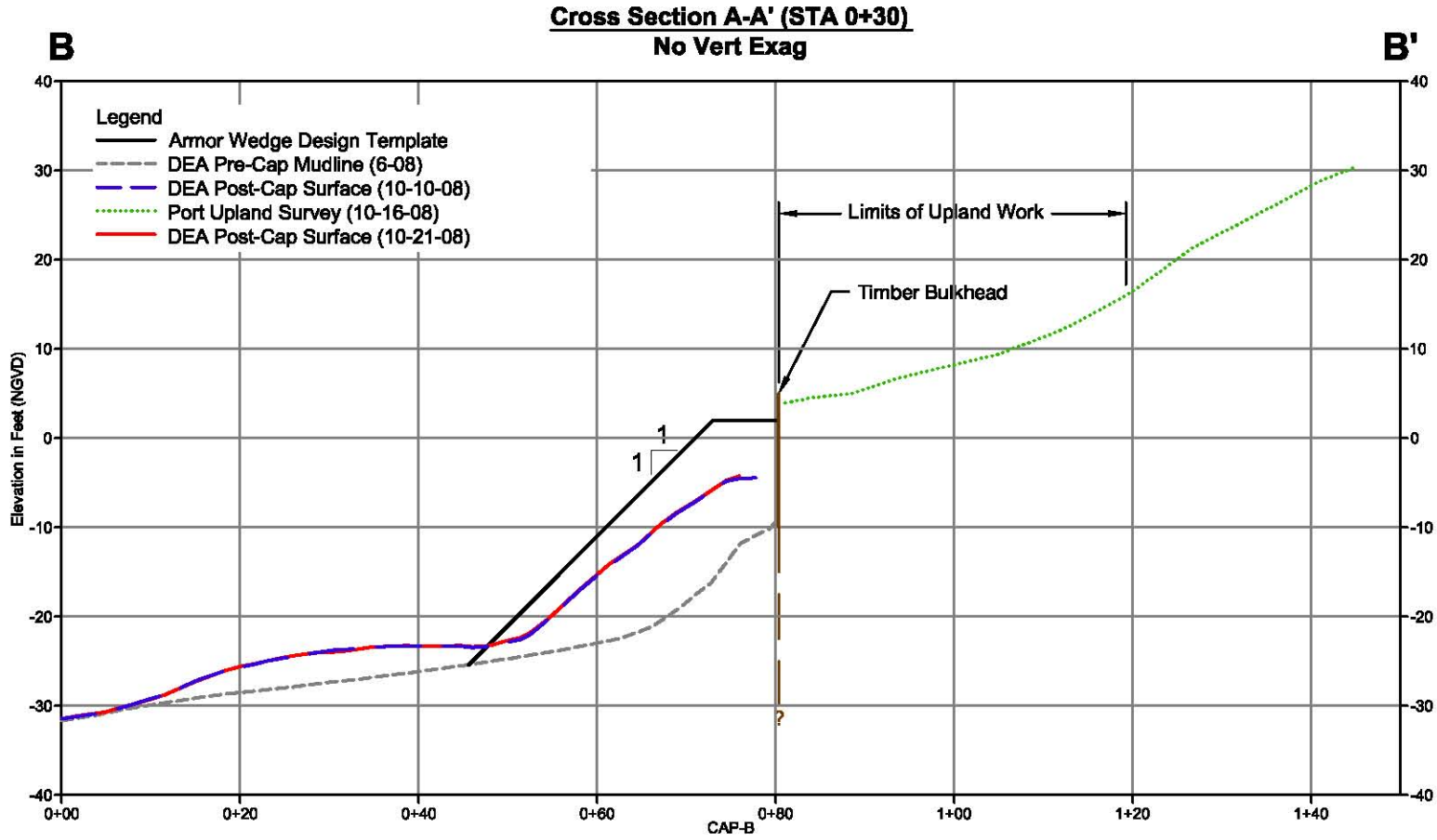
Survey: October 10, 2008
Horizontal Datum: Port of Portland (International Feet).
Vertical Datum: NGVD 29-47

ANCHOR ENVIRONMENTAL, L.L.C.

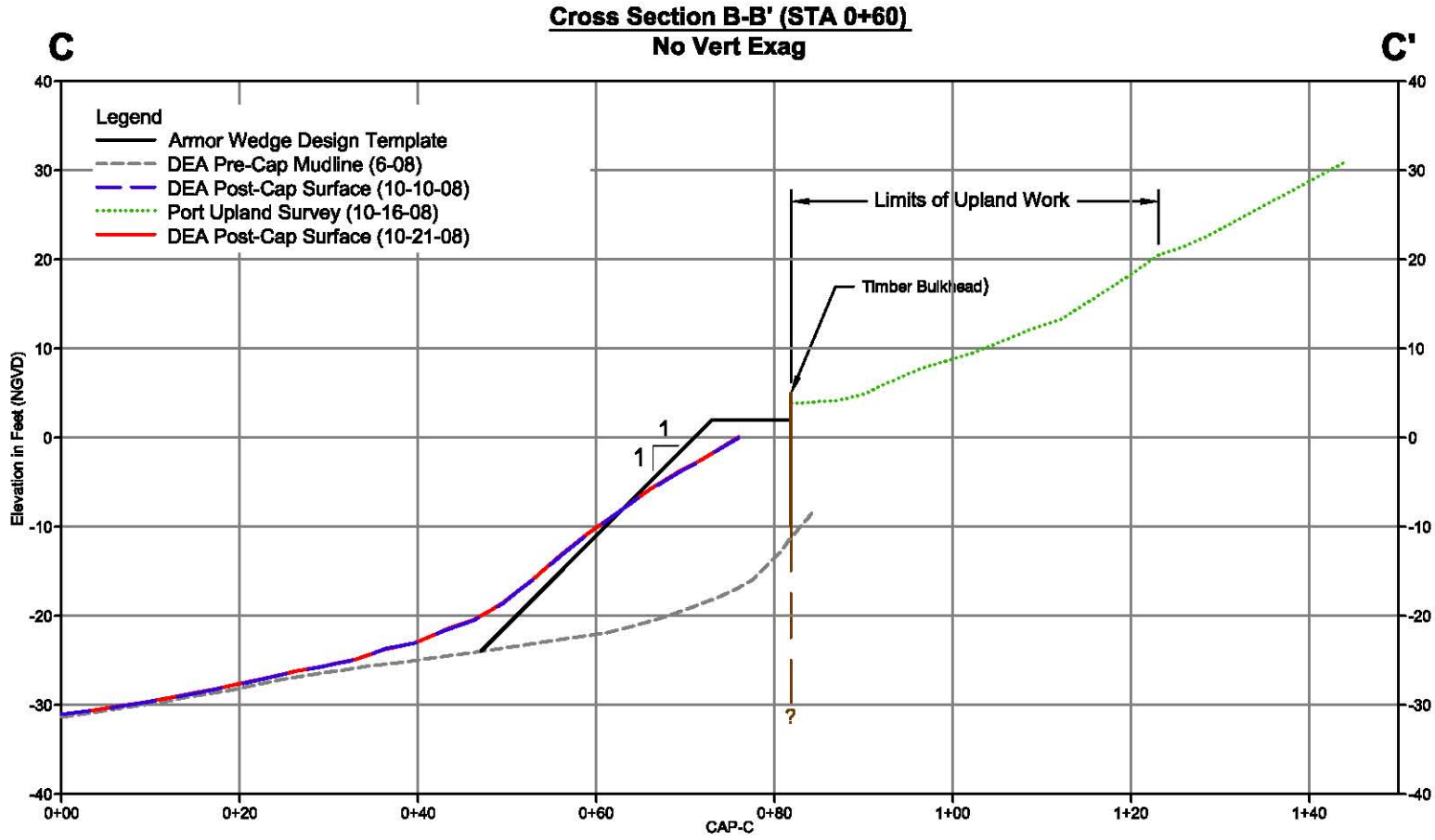
Figure 1
Post-Cap Survey (October 10, 2008)
Terminal 4 Phase 1 Removal Action
Port of Portland



Cross Section A-A' (STA 0+30)
No Vert Exag



Cross Section B-B' (STA 0+60)
No Vert Exag



Cross Section C-C' (STA 1+00)
No Vert Exag

NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET) VERTICAL DATUM: NGVD 29-47 CONTOUR INTERVAL = 1 FT
2. POST-CAP SURVEY BY DAVID EVANS AND ASSOCIATES, INC. DATED SEPTEMBER 21, 2008
3. UPLAND SURVEY DATED OCTOBER 16, 2008

0 10 20
SCALE IN FEET
(HORIZ AND VERT)

K:\Jobs\050332-PORT_OF_PORTLAND\05033201 TERMINAL 4_Phase 1\RACR_PH-1-FIG 2a_2b.dwg RACR Add O FIG 2a

Dec 11, 2008 4:02pm tgriga

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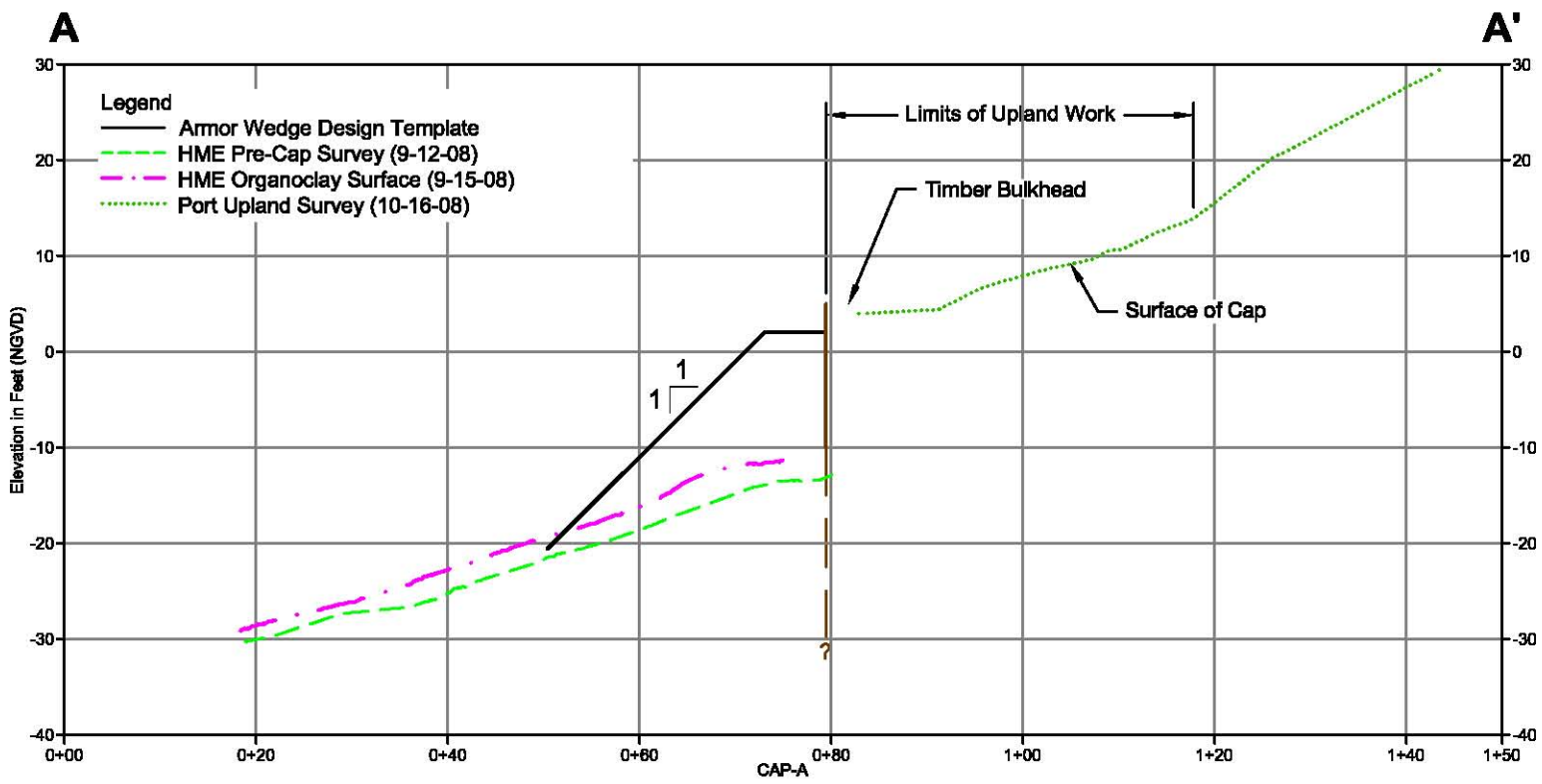
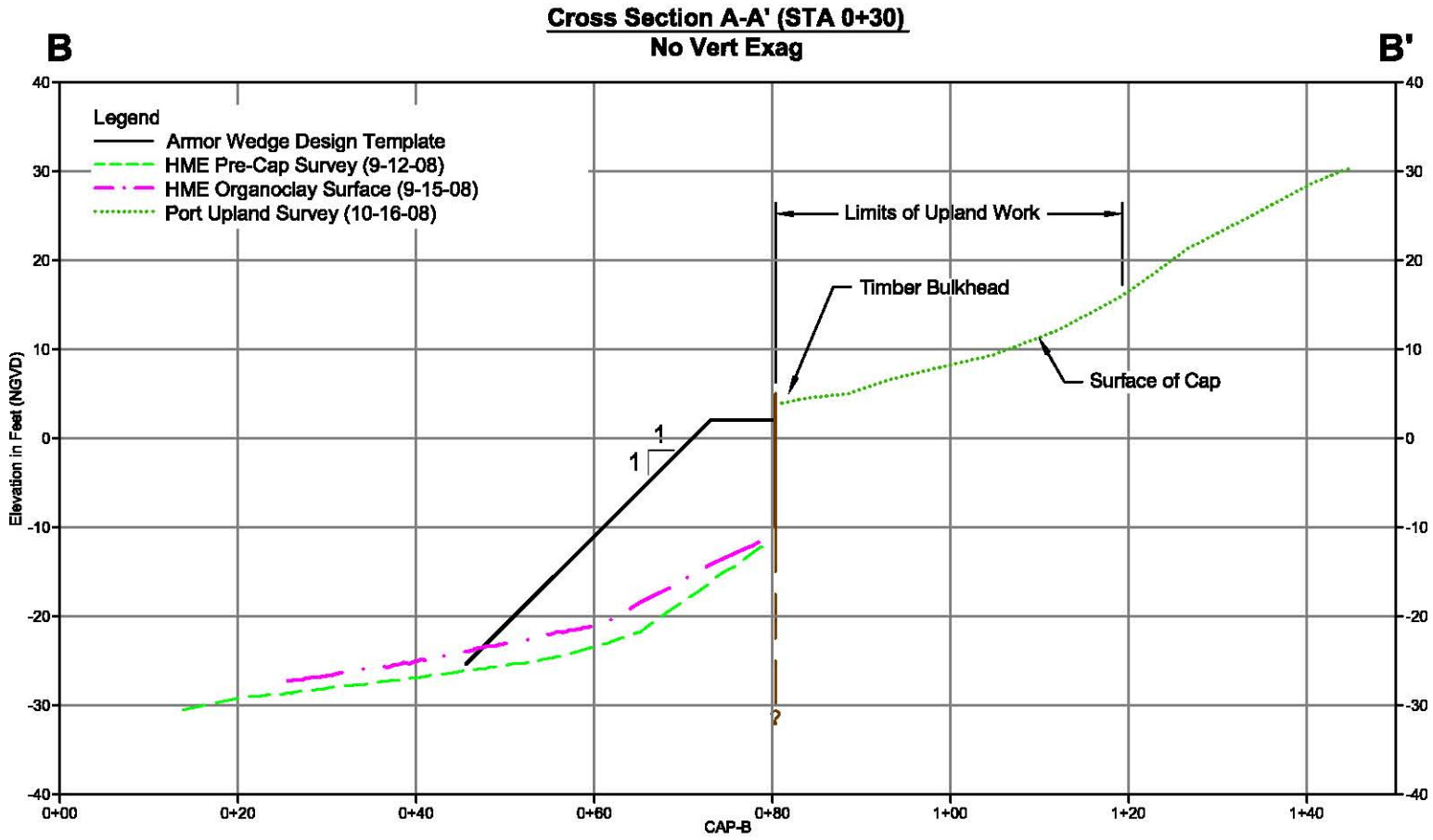
Figure 2a
Cross Sections A-A', B-B' and C-C' (DEA Surveys)
Terminal 4 Phase I Removal Action
Portland, Oregon



Cross Section A-A' (STA 0+30)
No Vert Exag



Cross Section B-B' (STA 0+60)
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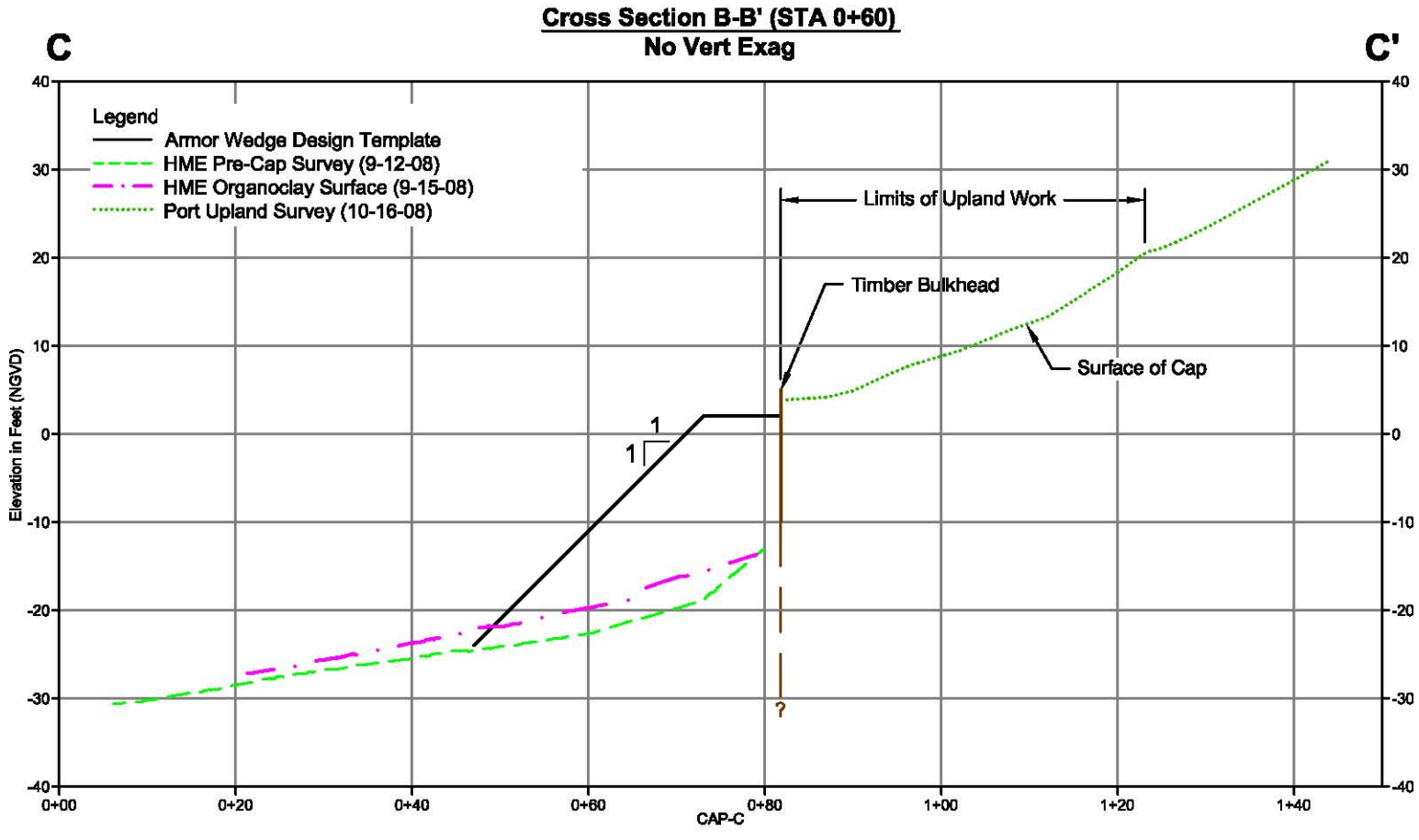

Cross Section C-C' (STA 1+00)
No Vert Exag

NOTES:

1. HORIZONTAL DATUM: PORT OF PORTLAND LOCAL PROJECTION (INTERNATIONAL FEET) VERTICAL DATUM: NGVD 29-47 CONTOUR INTERVAL = 1 FT
2. POST-CAP SURVEY BY DAVID EVANS AND ASSOCIATES, INC. DATED SEPTEMBER 21, 2008
3. UPLAND SURVEY DATED OCTOBER 16, 2008

0 10 20
SCALE IN FEET
(HORIZ AND VERT)

Dec 11, 2008 4:06pm tgrigg

Figure 2b
Cross Sections A-A', B-B' and C-C' (Type 3 Cap Survey)
Terminal 4 Phase I Removal Action
Portland, Oregon

ANCHOR ENVIRONMENTAL, L.L.C.

Oct 17, 2008 3:09pm dholmer K:\Jobs\050332-PORT OF PORTLAND\05033201 TERMINAL 4\ Phase 1\COLOR-T4-DEA-SRVY-RP1.dwg Figure 3

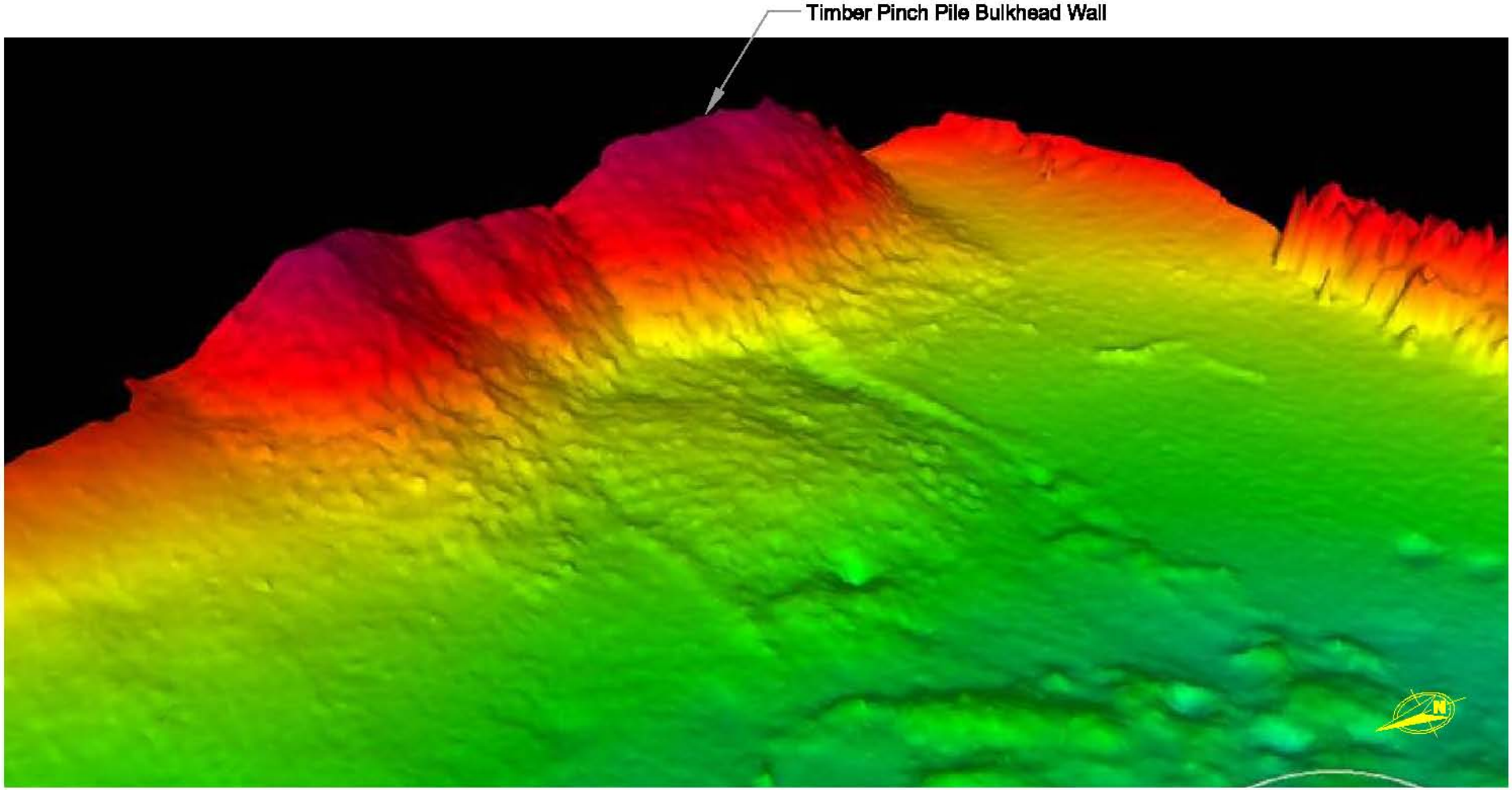

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Figure 3
DEA Survey (10-10-08)
Terminal 4 Phase 1 Removal Action
Port of Portland