Appendix B
Preferred Alternative Report

October 31, 2022
Gasco Sediments Cleanup Action

Preferred Alternative Report

Prepared for U.S. Environmental Protection Agency, Region 10

GASCO0066611

October 2022
Gasco Sediments Cleanup Action

Preferred Alternative Report

Prepared for
U.S. Environmental Protection Agency
Region 10
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ABBREVIATIONS

BANCS	Bank Assessment of Non-Point Source Consequences of Sediment
bgs	below ground surface
BMP	best management practice
Combined BOD-PDR	*Combined Sediment Remedy Basis of Design and Preliminary Design Report*
COP	City of Portland datum
CRD	Columbia River Datum
cy	cubic yard
DEQ	Oregon Department of Environmental Quality
Design Team	Anchor QEA, Sevenson Environmental Services, and Hahn and Associates
DGWP	*Revised Pre-Remedial Design Data Gaps Work Plan*
DMU	dredge management unit
DNAPL	dense nonaqueous phase liquid
DOC	depth of contamination
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
H:V	horizontal to vertical
HC&C	hydraulic control and containment
ISS	in situ stabilization and solidification
KPFF	KPFF Consulting Engineers
LPS Work Plan	*In Situ Stabilization and Solidification Laboratory Pilot Study Work Plan*
NAPL	nonaqueous phase liquid
NCP	*National Contingency Plan*
NRC	not reliably contained
PAR	*Preferred Alternative Report*
Project Area	Gasco Sediments Site Project Area
psi	pound per square inch
PTW	principal threat waste
RAL	remedial action level
ROD	*Record of Decision – Portland Harbor Superfund Site, Portland, Oregon*
SES	Sevenson Environmental Services
Siltronic	Siltronic Corporation
TEWP	*Final Pre-Remedial Basis of Design Technical Evaluations Work Plan*
USACE	U.S. Army Corps of Engineers
WBZ	water-bearing zone

1 Introduction

NW Natural submitted a *Combined Sediment Remedy Basis of Design and Preliminary Design Report* (Combined BOD-PDR; Anchor QEA 2021a) to the U.S. Environmental Protection Agency (EPA) on April 30, 2021, for the Gasco Sediments Site Project Area (Project Area). EPA's comments on the Combined BOD-PDR (EPA 2021a) required additional evaluations of multiple technical issues and reevaluation of remedial technology assignments throughout the Project Area.

NW Natural's Design Team initially focused on revising the dredge and cap technology assignments throughout the Project Area to address all of the EPA objectives identified in the comments. That effort identified several significant design challenges to the feasibility and implementability of extensive dredge and cap technologies. For that reason, NW Natural requested that its design-build team, consisting of Anchor QEA, Sevenson Environmental Services (SES), and Hahn and Associates (collectively, the Design Team), determine whether another accepted technology in the *Record of Decision – Portland Harbor Superfund Site, Portland, Oregon* (ROD; EPA 2017), or a combination of ROD technologies, could better address EPA's objectives for the ROD-identified Intermediate, Shallow, and Riverbank Regions of the Project Area.

Several different technology configurations were considered (see Appendix A). These evaluations included replacement of the cap on grade technology in the Shallow Region with partial dredge and cap and increased removal of principal threat waste-nonaqueous phase liquids/not reliably contained (PTW-NAPL/NRC) to the extent feasible in the Shallow and Intermediate Regions.[1]

Only one design alternative fully achieves all of EPA's design objectives and prevents sediment recontamination. That design combines full dredging to the depth of contamination (DOC) based on ROD Table 21 remedial action level (RAL) exceedances and the presence of PTW in the Navigation Channel Region, combined with in situ stabilization and solidification (ISS) treatment throughout the Intermediate, Shallow, and Riverbank Regions of the Project Area, and an integrated deep ISS treatment barrier wall at the top of riverbank.[2] An integrated deep ISS treatment barrier wall along the shared US Moorings and Gasco property line is also an important component of the design included to ensure long-term remedial effectiveness and structural stability. This design alternative is

[1] The Revised Dredge and Cap Design was not limited by the assumed excavation depth of 5 feet (followed by placement of a cap) discussed in Section 14.2.4 of the ROD.

[2] Both EPA's *Portland Harbor RI/FS – Feasibility Study* (EPA 2016) (see Section 3.2.2.1 and Table 2.4-2) and the ROD (see Section 10.1.1.2) included an evaluation of ISS for sediment cleanup and concluded it is an appropriate harborwide technology. The *National Contingency Plan* (NCP; EPA 1994) expressly includes ISS as a physical method for remediating contaminated sediments (see Appendix D, Paragraph (b)(2)). ISS has been effectively used for decades at hundreds of sites around the country, many of which are manufactured gas plant sites like Gasco that are contaminated with free-phase and residual-phase NAPL. ISS is nationally established as an effective remedial technology to address contaminated sediments, specifically identified in the NCP, and selected for remedial action at large sediment cleanup Superfund sites such as the Gowanus Canal in New York. ISS is currently being implemented within EPA Region 10 at the Wyckoff Co./Eagle Harbor Superfund Site in Washington State.

fully consistent with EPA's selected "F Mod" remedy and is not a modification or change to EPA's ROD.

The Full Dredge and ISS Design alternative removes or directly treats 100% of PTW-NAPL/NRC, 100% of PTW-highly toxic sediment concentration exceedances, and 100% of the remaining ROD Table 21[3] RAL exceedances throughout the entirety of the Project Area. It also eliminates the ebullition-facilitated transport of dense DNAPL (DNAPL), eliminates contaminant transport via advective flux, and ensures there will be no recontamination of the Project Area from the Gasco OU uplands because all contaminant migration pathways to the river (including groundwater and DNAPL) are fully controlled. This design configuration also protects functional structures, provides complete control of final slope configuration to improve habitat, eliminates potential future risks associated with sea level rise, provides a higher factor of safety during seismic events, and minimizes sediment disturbance and associated water quality impacts during construction. The Full Dredge and ISS Design thus meets all of the objectives in EPA's comments, better ensures long-term effectiveness, is cost-effective, and has several other desirable remedial action attributes as compared to the Revised Dredge and Cap Design. As detailed in Appendix A, other technology configurations were considered and discarded because they did not fully meet the design objectives described in EPA's comments.

NW Natural presented the results of these detailed remedial technology evaluation findings to EPA, the Oregon Department of Environmental Quality (DEQ), and the Portland Harbor Superfund Site Technical Coordination Team during a series of meetings between June and August 2022. EPA requested that NW Natural prepare a Preferred Alternative Report to formally submit the results and document how the preferred Full Dredge and ISS Design provides the most protective, effective, and constructable configuration of remedial technology assignments. This *Preferred Alternative Report* provides the requested detailed design alternatives analysis and comparison for the Revised Dredge and Cap Design and Full Dredge and ISS Design, as shown in Section 2.

1.1 EPA Comments on the Combined BOD-PDR

NW Natural submitted the Combined BOD-PDR (Anchor QEA 2021a) to EPA on April 30, 2021, for the Project Area. The technology assignments in the preliminary design included dredging to the bottom DOC based on RAL exceedances and the presence of PTW (including PTW-NAPL, PTW-NRC, and PTW-highly toxic threshold exceedances) with cover placement in the Navigation Channel Region and a combination of excavation/dredging, capping, and monitoring in the Intermediate, Shallow, and Riverbank Regions of the Project Area. The technical evaluations presented in the Combined BOD-PDR were performed in accordance with the EPA-approved *Final Pre-Remedial Basis*

[3] The ROD RAL and PTW thresholds were updated to include revisions from the ROD *Explanation of Significant Differences – Portland Harbor Superfund Site, Portland, Oregon* (EPA 2019a) and Errata #3, dated September 7, 2022 (EPA 2022).

of Design Technical Evaluations Work Plan (TEWP; Anchor QEA 2019a). On August 17, 2021, EPA provided its comments on the Combined BOD-PDR (EPA 2021a).

EPA provided the following four major comments that led NW Natural to reconsider remedial technology assignments throughout the Project Area:

- Revise the design to focus on removal of PTW-NAPL/NRC materials to the extent feasible[4]
- Eliminate or minimize cap on grade and maintain current elevations to minimize habitat impacts[5]
- Better integrate upland source control measures into the sediment remedy[6]
- Evaluate and assign appropriate active remedial technologies at the Siltronic Corporation (Siltronic) riverbank[7]

In response to these comments, the Design Team considered several different technology configurations. Two designs, the Revised Dredge and Cap Design and the Full Dredge and ISS Design, emerged as best meeting the objectives outlined in EPA's comments and are evaluated and compared in this *Preferred Alternative Report*.

1.2 Document Organization

The remainder of this PAR presents the following information:

- **Section 2** summarizes the remedial technology configurations for the Revised Dredge and Cap Design and Full Dredge and ISS Design.
- **Section 3** presents the technical evaluations conducted by the Design Team to address EPA's comments on the Preliminary Design and to develop technology assignments for the Revised Dredge and Cap Design and the Full Dredge and ISS Design.
- **Section 4** summarizes the results of the detailed designs evaluation and documents that the Full Dredge and ISS Design outperforms the Revised Dredge and Cap Design.
- **Section 5** presents the recommended next steps to proceed with remedial design for the Project Area.
- **Section 6** includes the references supporting the technical evaluations.

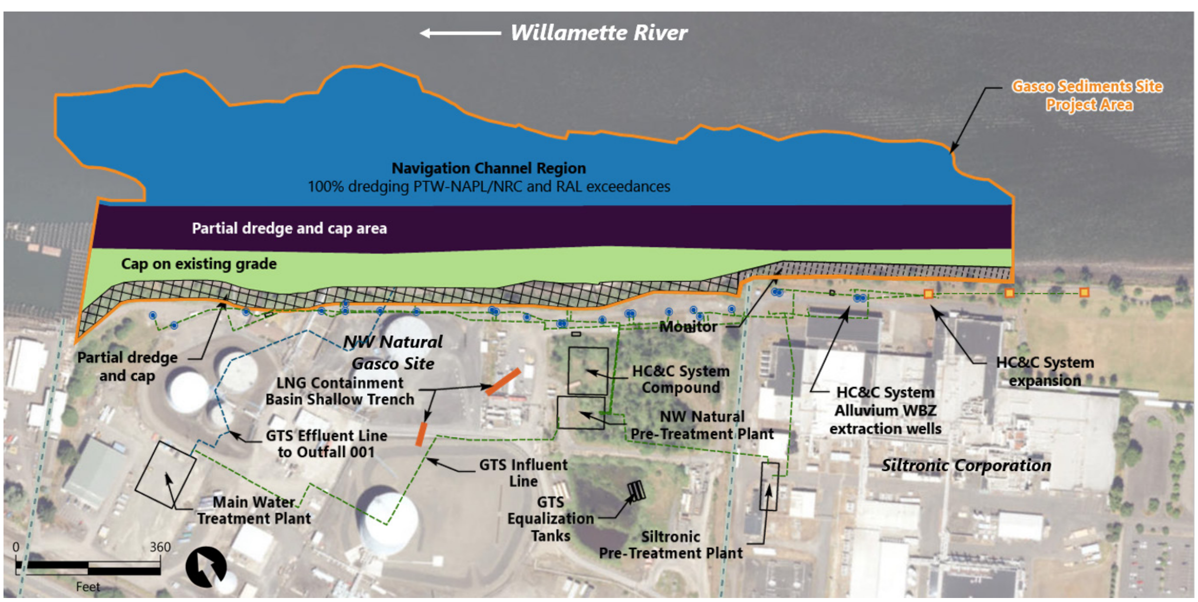
[4] EPA General Comments 1, 3, 5, and 16 and Specific Comments 60, 61, and 89.
[5] EPA General Comments 2 and 24 and Specific Comments 14, 97, and 114.
[6] EPA General Comment 3.
[7] EPA Specific Comments 58 and 89.

2 Summary of Remedial Technology Assignments Developed for the PAR

The Design Team evaluated several revised remedial technology configurations throughout the Project Area. Two designs were retained: a Revised Dredge and Cap Design and a Full Dredge and ISS Design. Other designs that were considered and screened out are discussed in Appendix A.

Revised Dredge and Cap Design: This design includes the following: 1) full dredging to the DOC based on RAL exceedances and PTW (including PTW-NAPL, PTW-NRC, and PTW-highly toxic threshold exceedances) in the Navigation Channel Region and placement of cover materials for dredge residual management; and 2) revised dredge and cap technologies in the Intermediate, Shallow, and Riverbank Regions to maximize the additional feasible dredging of PTW-NAPL/NRC and minimize cap on grade and net mudline elevation increases. To facilitate additional dredging while maintaining structural and long-term slope stability of the capped post-construction surface, two sheetpile walls are included adjacent to the Gasco dock and within the Intermediate Region adjacent to the Siltronic riverbank. To protect the sediment remedy from recontamination from the upland groundwater migration pathway to the river, this design includes the following: 1) continued operation of the Lower Alluvium water-bearing zone (WBZ) hydraulic control and containment (HC&C) system wells; 2) replacement of the existing Upper Alluvium WBZ HC&C system wells with a deep groundwater extraction trench that controls groundwater discharge in both the Fill and Upper Alluvium WBZs; and 3) expansion of these source controls farther south on the Siltronic property to ensure sources are controlled to the southern/upriver portion of the Project Area. A schematic showing the elements of this design is provided in Figure 2-1.

Figure 2-1
Revised Dredge and Cap Design Remedial Technology Assignments



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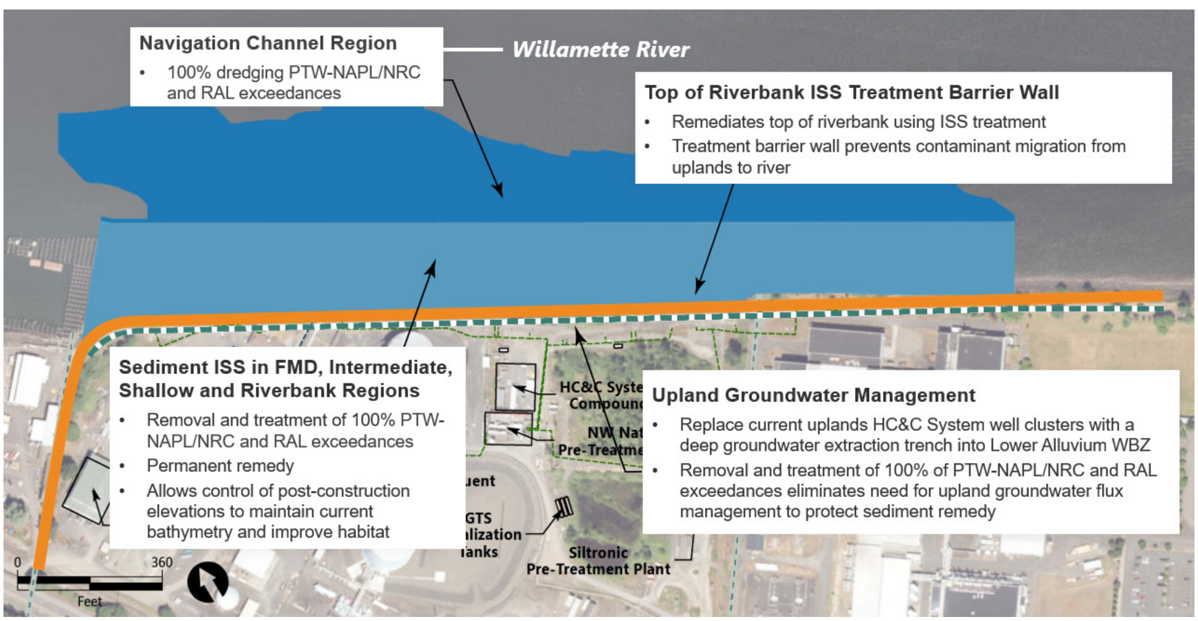
Full Dredge and ISS Design: This design includes full dredging to the DOC based on RAL exceedances and PTW (including PTW-NAPL, PTW-NRC, and PTW-highly toxic threshold exceedances) in the Navigation Channel Region followed by placement of cover materials for dredge residual management. ISS is applied to the DOC throughout the Intermediate, Shallow, and Riverbank Regions to treat 100% of the RAL exceedances and PTW in situ, as well as a top of riverbank deep ISS treatment barrier wall. This design eliminates the need for the structural support sheetpile wall installation required in the Revised Dredge and Cap Design. It also eliminates the need to address ebullition-facilitated transport of DNAPL because ebullition does not occur in sediments that are directly treated with ISS, as well as the need for reactive caps. The deep ISS treatment barrier wall is an integral and critical component of the design because it eliminates advective flux, provides seismic structural resiliency, fully controls potential future upland DNAPL migration, and ensures no recontamination from upland contaminant migration pathways, including contaminated groundwater. A schematic showing the elements of this design is provided in Figure 2-2. Unlike the Revised Dredge and Cap Design, the post-construction riverbank elevation profile using ISS is flexible and would be designed and constructed to ensure habitat improvements are optimally designed as well as meeting the Federal Emergency Management Agency (FEMA) no-rise threshold criteria.

Figure 2-2
Full Dredge and ISS Design Remedial Technology Assignments



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3 Technical Evaluations Based on EPA's Comments

This section summarizes the technical evaluations performed by the Design Team in response to EPA's comments. Appendix B documents that the two designs carried forward are protective and meet applicable or relevant and appropriate requirements. Appendix B also compares the long-term effectiveness, implementability, reduction of toxicity, mobility and volume through treatment, short-term effectiveness, and cost of the designs.

3.1 EPA Comment: Revise Design to Focus on Removal of PTW-NAPL/NRC to the Extent Feasible

Revised Dredge and Cap Design

The Design Team attempted to address this EPA comment by revising the dredge and cap design to include additional dredging to the feasible bottom depth of PTW-NAPL/NRC. As requested, the ROD assumption of a 5-foot dredge depth was discarded. To evaluate the objective of the comment, the following technical issues were considered: 1) maintain long-term slope stability for post-dredge cap and habitat material placement; 2) minimize potential impacts to the Gasco Dock; 3) minimize potential impacts to the upland and source control infrastructure; 4) minimize potential impacts to the Gasco Dock berthing elevations; 5) minimize water quality impacts during dredging; 6) control advective flux; and 7) control the ebullition-facilitated transport of DNAPL. The Design Team reviewed the three-dimensional extent of PTW-NAPL/NRC shown in Figures 3-1 and 3-2 and evaluated the additional feasible depth of removal while accounting for each identified technical issue. Based on evaluation of these technical issues and SES's dredging experience during the Gasco Early Action in 2005 and recent visits to the Project Area, it is not possible to remove 100% of the PTW-NAPL/NRC in the Intermediate, Shallow, and Riverbank Regions. The maximum amount of PTW-NAPL and PTW-NRC that could be removed is approximately 70% and 50%, respectively (an estimated 25,000 cubic yards [cy] of combined PTW left in place), and even that would require extraordinary effort, including the use of specialized equipment and some form of in situ treatment of the sediments containing PTW within established offsets from in-water functional structures.

Specifically, removing additional PTW-NAPL/NRC was found to present the following significant design and implementability challenges for each of the seven technical issues identified above:

1. **Maintain long-term slope stability for post-dredge cap and habitat material placement:** Section 6.2.5 of the Combined BOD-PDR presented the Preliminary Design findings regarding short- and long-term slope stability for caps in the Intermediate, Shallow, and Riverbank Regions for a range of potential constructed slopes for both short-term (undrained) and long-term (drained) conditions. These findings identified a slope of 3 horizontal: 1 vertical (3H:1V) or flatter from the top of bank to elevation 0 feet City of Portland datum (COP) and a slope of

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2.5H:1V or flatter for underwater slopes deeper than elevation 0 feet COP to achieve long-term target static factors of safety greater than 1.5. However, the Design Team's additional evaluations of the Project Area conditions and equipment accessibility identified the submerged slopes should also be constructed at 3H:1V or shallower, wherever feasible. Existing slopes within the Project Area throughout the Intermediate Region, deeper portions of the Shallow Region, and throughout the Riverbank Region are steeper than 3H:1V. In addition, as shown in Figures 3-3 and 3-4a, PTW-NAPL/NRC are present at significant depths below mudline throughout large portions of the Intermediate and Shallow Regions, including adjacent to the Gasco dock and the toe of the Gasco and Siltronic riverbanks. Dredging the full extents of PTW-NAPL/NRC while maintaining these target shallower slopes leads to a host of significant design challenges due to the confined nature of the Project Area coupled with the presence of both in-water and upland functional structures. These challenges are further discussed in the remainder of this section.

2. **Minimize Potential Impacts to the Gasco Dock:** As discussed in Appendix F of the Combined BOD-PDR, NW Natural engaged KPFF Consulting Engineers (KPFF) to develop a Structural Inspection Report that presented a determination of estimated remaining service life for each of the overwater functional structures in and directly adjacent to the Project Area. The Gasco dock was designated a functional structure, and photographs of the dock are shown in Figure 3-5. Based on the design and condition of the Gasco dock, KPFF estimated that partial dredging followed by placement of cap material should be limited to a maximum 10-foot depth in the vicinity of the Gasco dock to minimize potential structural impacts. As shown in Figure 3-3, the full extents of PTW-NAPL and PTW-NRC cannot be removed with this maximum removal depth. In addition, due to the steeper than 2H:1V existing mudline slope under the dock, construction of the required minimum long-term stable 3H:1V slope for cap and habitat material placement would lead to mudline elevation increases within the vessel berthing area adjacent to the dock (see more detailed summary below) and cap material placement within the 10-foot offset from the navigation channel line shown in Figure 3-3. The U.S. Army Corps of Engineers (USACE) commented on the Combined BOD-PDR that increases in this offset are prohibited to prevent impacts on its future maintenance dredging operations. These cascading design challenges require the installation of a vertical sheetpile wall just channelward of the face of the dock and the associated placement of a rock toe berm at the channelward face of the wall to protect it from river and propeller wash erosive forces (Figure 3-3). At some point in the future, the steel will erode, at which time the rock toe berm will solely serve to retain the upgradient sediments at the post-construction grades.

   SES has considerable experience performing dredging directly adjacent to structures like the Gasco dock, including the Gasco Early Action cleanup in 2005. Based on this experience and recent visits to the Project Area, SES determined that specialized dredging equipment would be required in the vicinity of the Gasco dock, and appropriate dredging offsets from the dock would need to be determined during remedial design to minimize the potential for structural impacts. Some form of in situ treatment of sediments containing PTW-NAPL/NRC would then be required within the offsets, which would require additional specialized equipment and design to ensure continuous post-construction grades surrounding the structure. This spatially confined work would take considerable time within the short 4-month in-water work window to address a relatively small fraction of PTW-NAPL/NRC.

3. **Minimize Potential Impacts to the Uplands and Source Control Infrastructure:** As shown in Figures 3-1 and 3-2, PTW-NAPL/NRC is located at deep depths along the toe of the riverbank adjacent to both the Gasco and Siltronic properties, which spans approximately 2,500 linear feet of shoreline and 1.7 acres. Removal of this PTW-NAPL/NRC would require layback of the riverbank and associated encroachment into the uplands to support the 3H:1V stable long-term slope for placement of cap materials and overlying habitat materials. In some areas of the shoreline, this removal of PTW-NAPL/NRC and associated post-dredge 3H:1V slope layback would lead to destructive impacts to upland roads, utilities, pumping wells, conveyance systems, and other key components of the HC&C system infrastructure and, potentially, buildings or other upland structures. These impacts are evident along the Siltronic riverbank where large portions of both the riverbank and sediment slope are steeper than 3H:1V from the top of riverbank out to the navigation channel line.

   As depicted in Figure 3-4a, removal of the full extent of PTW-NAPL/NRC would lead to significant excavation of the riverbank slope into the uplands, as well as the unnecessary dredging of unimpacted sediments below the DOC. In addition, a vertical sheetpile wall is required to facilitate capping at the long-term stable 3H:1V slope and avoid placement of cap material within the 10-foot offset from the navigation channel line to not impact future maintenance dredging operations by USACE. At some point in the future, the steel will erode, at which time the rock toe berm will solely serve to retain the upgradient sediments at the post-construction grades. To eliminate these upland infrastructure impacts, the dredge prism was reduced as depicted in Figure 3-4b, with disproportionately more costly to remove PTW-NAPL/NRC left in place.

4. **Minimize Potential Impacts to the Gasco Dock Berthing Elevations:** As mentioned above in the description of the Gasco dock structural impacts and shown in Figures 3-1, 3-2, and 3-3, additional dredging of the PTW-NAPL/NRC around the Gasco dock would subsequently require mudline elevation increases within the vessel berthing area adjacent to the dock to achieve the required long-term stable 3H:1V slope for cap and habitat material placement along the existing steep slope under the dock. In addition, extension of this 3H:1V slope further into the navigation channel would lead to capping in the 10-foot offset from the navigation channel, which is prohibited by USACE. Therefore, a sheetpile wall is required just channelward of the face of the

dock. As shown in Figure 3-3, the elevation of the upper portion of the sheetpile wall and cap elevations on the land side of the wall are above the existing mudline elevations, impacting NW Natural's tenant's frequent vessel operations at the dock. Additional coordination with the tenant and flood and habitat impact evaluations would be required to attempt to minimize these net elevation increases.

5. **Minimize Water Quality Impacts During Dredging:** Dredging operations are well documented to result in sediment resuspension, contaminant releases from bedded sediment, and residuals generation and, therefore, short-term water quality impacts (Bridges et al. 2010). These adverse construction impacts can be mitigated by the implementation of best management practice (BMP) controls, which are intended to minimize, to the extent practical, these releases and associated contaminant residuals generation and water quality impacts. Section 16 of the Combined BOD-PDR presents a Project Area-specific evaluation of water quality barrier controls, and mobile moon pool silt curtains and full- and partial-depth silt curtains were retained for further evaluation during remedial design. Although these BMPs have been proven effective, the potential for water quality impacts for untreated sediments containing liquid NAPL exists and will need to be closely managed. These BMPs often include the use of moon pool and perimeter silt curtains in compliance with the water quality permit.
6. **Control Advective Flux:** The capping component of the Revised Dredge and Cap Design is required to address advective flux. Contaminants presenting potential risk from this pathway to receptors in sediments and surface water are mobilized in advective flux from existing buried sediment impacts as well as upland groundwater. For capping to be effective, the hydraulic head driving advective flux must be controlled. These controls reduce the contaminant loading from both sources (groundwater and buried sediments); however, caps are still required because those contaminant loads will continue as long as buried sediment sources are present. As detailed in Section 6 of the Combined BOD-PDR, use of these measured fluxes and sediment concentrations in Project Area-specific chemical isolation modeling identified that a robust chemical isolation cap would be required for the Revised Dredge and Cap Design to be protective of this advective flux. Cap integrity and performance would need to be monitored over the long term and any necessary maintenance performed based on the monitoring results. Long-term cap integrity is also a consideration with regard to EPA's requested evaluation of climate change, specifically in the context of increased flooding and sea level rise.
7. **Control the Ebullition-Facilitated Transport of DNAPL:** As discussed in Section 6.2.1.3.2 of the Combined BOD-PDR, Project Area-specific visual monitoring documented that ebullition occurs in portions of the Project Area due to the anerobic generation of methane (i.e., methanogenesis). This methanogenesis leads to ebullition-facilitated transport of DNAPL to surface sediments and surface water. A detailed evaluation of this contaminant transport pathway is provided in Appendix I of the Combined BOD-PDR. In addition, Appendix J of the

Combined BOD-PDR presents site-specific ebullition laboratory studies and biogeochemical reactive transport modeling performed by Anchor QEA to simulate relative rates of ebullition and how they vary as a function of the parameters that influence the microbial activities responsible for gas bubble generation in sediment. During remedial design, similar simulations would need to be developed and used to estimate the change in ebullition rates that may occur in various portions of the Project Area due to remediation and to assess how those changes may alter the annual average DNAPL mass fluxes related to ebullition. The Revised Dredge and Cap Design must be designed to fully address this documented DNAPL transport pathway.

Full Dredge and ISS Design

The Design Team reviewed the three-dimensional extent of PTW-NAPL/NRC shown in Figures 3-1 and 3-2 and DOC[8] based on RAL exceedances and PTW (including PTW-NAPL, PTW-NRC, and PTW-highly toxic threshold exceedances) in Figure 3-6. Unlike the Revised Dredge and Cap Design, the Design Team determined this design can remove or directly treat the full lateral and vertical extent of DOC. A schematic showing the conceptual ISS design to achieve the DOC is shown in Figure 3-7. The remainder of this section summarizes the ability of this design to achieve full removal and treatment to the DOC while addressing each of the seven technical issues.

1. **Maintain Long-Term Slope Stability for Post-Dredge Cap and Habitat Material Placement:** The full depth of the ISS treatment layer would be designed to achieve a target design strength (i.e., equal to or greater than 50 pounds per square inch [psi]), which is significantly higher than the existing in situ sediment strength. This additional strength allows much greater flexibility compared to the Revised Dredge and Cap Design to design the post-treated surface to a wider range of slope configurations that maintain long-term slope stability and, when integrated with the deep ISS treatment barrier wall, higher seismic stability factors of safety. In turn, this wider range of slope configurations provides additional flexibility for optimizing habitat conditions compared to the Revised Dredge and Cap Design. As discussed below, the treated sediments can be dredged using commonly available equipment to achieve the optimized design slope.
2. **Minimize Potential Impacts to the Gasco Dock:** Application of ISS adjacent to and under the dock eliminates the structural stability issues associated with dredging and capping identified by KPFF and discussed in Section 3.1. ISS is commonly used in and around structures where it is often difficult or infeasible to perform dredging and capping, consistent with the following statement in Section 10.1.1.2 of the ROD: "Treatment options considered include in-situ solidification/stabilization and sequestration, which may be used to address PTW underneath and around pilings, docks, berthing or mooring dolphins, and other structures servicing active

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[8] Figure 3-6 shows the DOC based on RAL and PTW-highly toxic threshold exceedances and is a copy of Figure 7-1 from the Combined BOD-PDR. This figure shows there are sediment cores that are vertically unbounded. A field work plan will be developed to determine the DOC at these locations, and this information will be used to revise the interpolation of the DOC during a future design deliverable.

wharfs or shore-based facilities that remain intact" (EPA 2017). The Design Team has conducted site visits, talked with equipment vendors, and has identified ISS technologies and associated equipment that can access and achieve the DOC in the vicinity of the dock.

3. **Minimize Potential Impacts to the Uplands and Source Control Infrastructure:** The flexibility to design the post-treated surface to a wider range of slope configurations eliminates impacts to the upland and source control infrastructure identified for the Revised Dredge and Cap Design, as shown in Figure 3-7.

4. **Minimize Potential Impacts to the Gasco Dock Berthing Elevations:** Following ISS treatment, excess treated materials (swell) that rise above the existing mudline can be subsequently dredged to any targeted post-construction slope. Post-constructions elevations can be configured to optimize habitat goals and ensure long-term slope stability. Unlike the Revised Dredge and Cap Design, this approach provides flexibility for design of the post-construction slope to prevent: 1) increases in the existing mudline elevations along the face of the dock in the berthing area adjacent to the dock; and 2) encroachment of materials within the 10-foot offset from the navigation channel line shown in Figure 3-3. This, in turn, prevents impacts to NW Natural's tenant vessel operations and eliminates the need to install the limited lifespan sheetpile wall and rock toe berm required by the Revised Dredge and Cap Design.

5. **Minimize Water Quality Impacts During Dredging:** As noted in the ROD and *National Contingency Plan* (NCP; EPA 1994), ISS is a proven treatment technology that directly treats contaminants within environmental media, such as soil and sediment, through a physical modification and chemical reaction to bind the target compounds (i.e., solidification) and transform them into a less mobile form. Through the physical process of solidification, the contaminated material is encapsulated, and the physical properties of the environmental media are transformed by the addition of grout to modify the permeability and meet the specified performance standards. Stabilization is a chemical process where grout reacts with the contaminated media to significantly reduce leachability to specific remedial design targets. The ISS materials are mixed into the sediment and riverbank column using a rotating auger that is advanced in a single location from the mudline to the target DOC. The only exposure of the untreated contaminated sediments to the water column during the ISS process is during initial treatment at the mudline. All deeper subsurface sediment contamination is mixed in situ with no exposure to the water column. This significantly minimizes the risks for water quality impacts relative to the Revised Dredge and Cap Design, where dredge buckets containing untreated liquid NAPL are continuously raised vertically through the water column and, therefore, have a greater potential for release from the mudline and dredge budget. The ISS mixing would be performed within a fully enclosed moon pool as a BMP (identical design to the Revised Dredge and Cap Design moon pool) to further minimize the potential for water quality impacts. This

BMP proved highly effective at NW Natural's Portland Gas Manufacturing Site sediment cleanup just upriver from the Portland Harbor Superfund Site in 2020.

6. **Control Advective Flux:** The Full Dredge and ISS Design approach eliminates advective flux as a contaminant transport pathway. All sediments containing RAL exceedances and PTW are removed or directly treated so buried sediments are no longer a potential source of elevated contamination concentrations. In addition, the integrated deep ISS treatment barrier wall that ensures structural integrity also prevents any potential future upland DNAPL migration and, in conjunction with the upland HC&C system, ensures remedy effectiveness by preventing recontamination from upland groundwater. As detailed in Section 3.3, the advective flux condition is created by groundwater migrating from the uplands through the sediments to the river surface water. Unless controlled, this advective flux contains contaminated groundwater discharging from the Fill WBZ and Upper and Lower Alluvium WBZs. It also contains groundwater from the Deep Lower Alluvium WBZ that does not pose a current or future risk; however, that groundwater can become contaminated as it flows through contaminated sediments. The Full Dredge and ISS Design eliminates this advective flux through the contaminated sediments by directly treating 100% of the RAL exceedances and PTW in situ and creating a treated layer designed equal to or less than 10^{-6} centimeters per second permeability prohibiting advective flux. The specific target design permeability will be determined based on the laboratory pilot study results proposed to be performed by NW Natural in early 2023.
7. **Control Ebullition-Facilitated Transport of DNAPL:** The Full Dredge and ISS Design includes ISS treatment of the entirety of the Intermediate, Shallow, and Riverbank Regions where ebullition-facilitated transport of DNAPL has been documented. As discussed above in technical issue Nos. 5 and 6 for the Full Dredge and ISS Design, the treated contaminated sediments are encapsulated and stabilized by the addition of grout, transforming the physical properties of the environmental media to significantly reduce the permeability and leachability. This treatment eliminates the ebullition-facilitated transport of DNAPL because methane release through the treatment layer is prevented.

3.2 EPA Comment: Revise Design to Eliminate or Minimize Cap on Grade and Maintain Current Elevations to Minimize Habitat Impacts

Revised Dredge and Cap Design

The Design Team attempted to address this EPA comment by revising the dredge and cap design to include additional dredging to feasibly eliminate or minimize the extent of cap on grade and minimize net mudline elevation increases in areas shallower than -15 feet Columbia River Datum (CRD). After receiving EPA's comments, the Design Team developed a revised partial dredge and cap approach in regions that were previously cap on grade. This change attempts to address the ROD's assumed no net elevation increase for a self-mitigating sediment remedy but was not limited by an excavation depth of 5 feet (followed by placement of a cap) that is discussed in Section 14.2.4 of the ROD. The Design Team could not achieve this no net increase assumption in some portions of the Project Area due to the necessary increases in mudline elevations in portions of the Intermediate, Shallow, and Riverbank Regions required to limit impacts to in-water and upland structures and maintain long-term slope stability associated with the post-dredge cap and habitat material placement discussed in Section 3.1. Preliminary flood rise evaluations for the Revised Dredge and Cap Design, including these isolated elevation increases, indicate minimal potential for flood rise impacts; however, additional Project Area-specific modeling would be required to confirm the no net rise threshold can be met with sheetpile wall structures in place and incorporation of additional remedial design details. In addition, habitat mitigation analysis (performed using habitat equivalency assessment calculations) would need to be performed to determine the need for compensatory mitigation.

Full Dredge and ISS Design

The Design Team found that the Full Dredge and ISS Design allows full control of post-construction mudline elevations. Net mudline elevation increases in areas shallower than -15 feet CRD can, therefore, be eliminated or managed as needed based on habitat objectives. The addition of ISS treatment materials into the contaminated sediments increases the total volume of material present (swell). As discussed in Section 3.1, swell can be dredged to the extent needed to ensure no net mudline increases and to optimize habitat configurations. The amount of swell generated by the ISS process is dependent on several factors, including the amount and type of ISS treatment materials used, the physical and chemical characteristics of the in situ sediments, and water-to-treatment material ratio used. The strength of this treated swell material is much higher than the existing in situ sediments or cap materials, allowing more flexibility to eliminate or minimize cap on grade and maintain current elevations. This flexibility will help optimize habitat objectives compared with the Revised Dredge and Cap Design.

3.3 EPA Comment: Revise Design to Better Integrate Upland Source Control Measures into the Sediment Remedy

As discussed in Section 1, the Design Team considered information from in-water pre-design studies along with upland data collected subsequent to implementation of existing source control measures to evaluate what design measures were required to ensure sediment remedy protectiveness.

As detailed in the *Interim Feasibility Study* (Anchor QEA 2018), the following geologic units are present in the Gasco OU: Fill WBZ, Upper Alluvium WBZ, Lower Alluvium WBZ, Deep Lower Alluvium WBZ, and bedrock. A lower conductivity upper silt unit that extends across the upland and to the river mudline limits the hydraulic connection between the Fill WBZ and Upper Alluvium WBZ.

Similarly, a lower silt unit that extends a short distance under the riverbank limits the hydraulic connection between the Lower Alluvium WBZ and the Deep Lower Alluvium WBZ. A schematic illustration of these geologic units relative to the Riverbank, Shallow, Intermediate, and Navigation Channel Regions and associated DOC is shown in Figure 3-8. Elevated chemical concentrations in soil and/or groundwater have been identified in the Fill, Upper Alluvium, and Lower Alluvium WBZs. With respect to the Deep Lower Alluvium, "DEQ does not require the HC&C system to fully capture groundwater from the Deep Lower Alluvium WBZ in order to achieve groundwater source control RAOs." (DEQ 2022). A schematic illustration of the groundwater migration pathways in each of these WBZs in the absence of source controls is provided in Figure 3-9, where the red and blue arrows represent groundwater that does and does not pose a risk of current or future sediment recontamination, respectively. As shown in the figure, the contaminated Fill, Upper Alluvium, and Lower Alluvium WBZs groundwater migrates to the sediments and surface water; the underlying Deep Lower Alluvium WBZ groundwater that does not pose a current of future risk of sediment recontamination upon entering the riverbank flows through the contaminated sediments, becomes contaminated at levels that exceed ROD Table 17 cleanup levels, and transports this contamination to the surface sediments and surface water.

To ensure sediment remedy protectiveness in the design, all contaminated groundwater migration pathways from the Upper and Lower Alluvium WBZs to the river must be controlled. NW Natural installed the state-of-the-art HC&C system that initiated full-scale operation in 2013. This system consists of 26 shoreline extraction wells that pump groundwater from the Upper and Lower Alluvium WBZs to reverse the groundwater flow direction from the Project Area toward the Gasco OU. DEQ has determined the system is achieving the Alluvium WBZ source control objectives (DEQ 2022). The system is fully automated, with pressure transducers that monitor hydraulic heads continuously at 25 non-pumped control wells and 2 river gauges, and pumping rates adjust automatically to maintain hydraulic heads in the upland below the elevation of the river.

The HC&C system was not designed to control contaminated groundwater that discharges to the river from the Fill WBZ. However, in November 2020, NW Natural constructed a DEQ-approved interim trench system as a removal action to intercept contaminated groundwater within the Fill WBZ at the central (LNG Tank Basin) portion of the Gasco property before it reaches the river. Water collected from the two trenches is conveyed to the HC&C system groundwater treatment plant. As discussed in Section 2.10 of the Combined BOD-PDR, NW Natural has committed to fully address source control for the Fill WBZ groundwater pathway to the river either prior to or concurrent with the sediment remedy. A schematic illustration of the groundwater flow directions with the current HC&C system operating is provided in Figure 3-10.

To ensure the sediment remedial design will be protective, the Design Team evaluated the following design and implementability considerations and associated challenges. These are crucial because the

Revised Dredge and Cap Design manages advective flux and ebullition in an entirely different way than the Full Dredge and ISS Design.

- As shown in Figure 3-11, measured offshore groundwater seepage rates through the surface sediments during HC&C system operations with a range of groundwater and river water elevations indicated that the system significantly decreases seepage relative to pre-HC&C system operations. However, some of the seepage measurements are still slightly positive (i.e., groundwater migration from sediments to surface water) with the HC&C system operating, ranging from 0.06 to 0.98 centimeters per day. Consistent with the EPA-approved TEWP (Anchor QEA 2019a), these post-HC&C seepage meter data were used to develop Project Area-specific inputs to the chemical isolation cap modeling presented in Appendix G of the Combined BOD-PDR to determine the chemical isolation layer thickness and sorptive amendment content necessary to reliably contain contaminants. The slightly positive seepage still requires significant sorptive amendments for chemical isolation in the sediment cap design and full-time operation of the HC&C system for perpetuity.
- HC&C system operation does not eliminate ebullition, so the cap design also needs to incorporate additional amendments to eliminate this documented chemical migration pathway discussed in Section 6 of the Combined BOD-PDR.
- As shown in Figure 3-10, some of the groundwater pumped by the existing HC&C system originates from the Deep Lower Alluvium WBZ, which does not pose current or future potential risk. This additional pumping increases pumping volumes, operations and maintenance requirements, treated solids management and disposal, greenhouse gas emissions, and costs with no additional risk reduction.

The HC&C system is not designed to control DNAPL migration toward the river. Multiple investigations over more than two decades have not identified an existing complete pathway for subsurface DNAPL to the river. EPA recently commented, "The presence of NAPL in Gasco sediments is due to historical overland discharges or upland runoff and not due to subsurface advection from the uplands" (EPA 2021b). However, the potential for future DNAPL migration in the uplands must be considered in designing a sediment remedy for optimal performance in perpetuity.

Revised Dredge and Cap Design

The Revised Dredge and Cap Design requires capping to address ongoing advective flux and ebullition-facilitated transport of DNAPL for the entire life of the remedy. Robust caps are required to ensure sediment remedy protectiveness and need to be monitored and maintained over time. Based on these design concerns, along with a detailed review of HC&C system performance monitoring since system startup in 2013 (including operations and maintenance data), the Revised Dredge and Cap Design will also require optimizing and expanding the HC&C system. HC&C system operations and maintenance data indicated that the Upper Alluvium WBZ extraction wells are more prone to fouling due to a variety of issues and require more frequent maintenance and replacement. The Design Team believes that a deep trench installed into the upper portion of the Upper Alluvium WBZ would substantially reduce maintenance relative to the existing system of extraction wells, provide additional protectiveness as a physical and hydraulic barrier, and facilitate collection/removal of shallow DNAPL within the Fill and Upper Alluvium WBZs along the shoreline area, as shown in Figure 3-12. Modeling of groundwater capture in the Upper and Lower Alluvium WBZs shows that capture is not fully achieved in the southern/upriver portion of the Project Area. Therefore, the HC&C system would be expanded to include three additional Lower Alluvium WBZ extraction wells in the southern portion of the Gasco OU on the Siltronic property, as well as construction of the deep trench in this same area. The approximate expansion locations are discussed and depicted in Section 4.1.

Full Dredge and ISS Design

The Full Dredge and ISS Design eliminates the advective flux and ebullition-facilitated transport of DNAPL migration pathways. This is because the integrated top of riverbank deep ISS treatment barrier wall eliminates all pathways for upland contaminated groundwater (including the currently uncontrolled Fill WBZ) and potential future DNAPL migration to the river, and the in-water ISS eliminates the ebullition pathway. The ISS'd sediments and riverbank soils will have extremely low permeability, so groundwater will not migrate through it. In addition, because the ISS treatment approach will directly remediate all sediments containing RAL exceedances and PTW, groundwater migrating from the Deep Lower Alluvium WBZ will not become contaminated and a risk pathway for surrounding areas.

The Design Team found that a deep ISS treatment barrier wall along the top of riverbank adjacent to the entirety of the Project Area is required to ensure the performance of the Full Dredge and ISS Design.[9] Based on site visits and review of the HC&C system infrastructure locations, the Design Team estimates that there is sufficient space along the top of riverbank to construct the barrier wall on the riverside of the existing HC&C system infrastructure. The preliminary alignment of the barrier wall is shown in Figure 3-13a. The Design Team evaluated the nature and extent of the geologic units along the alignment in addition to the presence of elevated chemical concentrations and potentially mobile DNAPL (as determined in the *Interim Feasibility Study* [Anchor QEA 2018]). The bedrock depth below ground surface (bgs) near the northwest corner of the Gasco OU along the US Moorings property line boundary ranges from approximately 85 to 95 feet. This bedrock depth remains

[9] EPA and DEQ have long considered a vertical barrier wall an integral component of the in-water remedy. The *Statement of Work – Gasco Sediments Site* states that "*upland source controls will include a vertical barrier to NAPL migration and a groundwater extraction and treatment system*" (EPA 2009). DEQ initially directed NW Natural to construct a vertical barrier wall in conjunction with installation of the HC&C system but ultimately agreed to defer evaluation of vertical barriers to the final upland feasibility study based on additional DNAPL investigations performed during source control measure design.

generally constant until approximately 350 feet south (upriver) from the property line, where it increases significantly throughout the remainder of the Gasco OU shoreline. There is an upward hydraulic gradient between the Lower Alluvium and Deep Lower Alluvium WBZs that are separated by a silt unit. This unit intersects the bedrock at approximately 135 feet bgs in the central portion of the Gasco OU on the Gasco property and is between 125 to 135 feet bgs for the remaining southern portion of the Gasco OU shoreline. The barrier wall alignment is shown in Figure 3-13a (black horizontal line), and multiple cross-section views along the alignment showing the bedrock and lower silt unit depths are depicted in Figures 3-13b through 3-13f.

Installing the barrier wall to bedrock along the northern portion of the Gasco OU and the lower silt confining unit for the remainder of the Gasco OU shoreline would hydraulically and physically contain contaminated groundwater in the Fill, Upper, and Lower Alluvium WBZs. This configuration is of particular importance for the Full Dredge and ISS Design because it allows the Deep Lower Alluvium WBZ groundwater that does not pose a current or future potential risk to discharge to the river instead of being pumped, unnecessarily treated, and then discharged to the river. In addition, the barrier wall would eliminate any potential for future migration of DNAPL from the uplands to the river.

The Full Dredge and ISS Design also includes construction of a deep groundwater extraction trench on the upland side of the top-of-riverbank ISS treatment barrier wall, extending into the upper portion of the Upper Alluvium WBZ (same bottom depth as in the Revised Dredge and Cap Design) along the entire length of the Gasco OU. The deep trench would optimize the groundwater capture system and replace all existing HC&C system extraction wells, preventing groundwater mounding upgradient of the wall. Extracted groundwater would be conveyed via underground piping to the existing groundwater treatment system where it would be treated to remove contaminants prior to discharge. As shown in the cross-sections on Figures 3-13b through 3-13f, the deep trench (dark blue horizontal line) would generally range from 35 to 45 feet bgs. However, as shown in Figure 3-13c, along the shoreline near the northern portion of the Former Tar Pond Area, the trench would extend down to 65 feet bgs. This deeper portion of the trench is in an area where DNAPL has been identified in the Upper Alluvium WBZ and may facilitate nearby DNAPL collection and removal over time.

The Design Team evaluated barrier wall design options in terms of effectiveness and protectiveness. These evaluations accounted for the top of riverbank physical and chemical characteristics, the range of target depths for the wall across the entire alignment, equipment access to the wall alignment, the ability to seamlessly integrate with the treated ISS materials in the directly adjacent riverbank, and potential to include a treatment element. Based on these evaluations and discussions with equipment vendors, the Design Team proposes that the barrier wall would be composed of two side-by-side rows of ISS columns that will overlap/integrate with the riverbank columns. The remainder of this PAR identifies the wall as the "deep ISS treatment barrier wall."

A schematic illustration of the groundwater migration pathways in each of the WBZs with the deep ISS treatment barrier wall and deep trench is provided in Figure 3-14.

Integration of the deep ISS treatment barrier wall also provides the following benefits:

- Eliminate the unnecessary pumping and treatment of the groundwater in the Deep Lower Alluvium WBZ that does not pose current or future risk.
- Section 5.7.1 of the *Final Gasco Sediments Site Sufficiency Assessment* (Anchor QEA 2021b) identified groundwater discharges from the US Moorings property to offshore sediments as a potential source of sediment recontamination in the Project Area. The design, therefore, includes an ISS treatment barrier wall along the Gasco/US Moorings shared property line down to with the top of bedrock. Any groundwater flow encountering the wall will be managed by the top of riverbank deep trench.
- Greatly improved seismic structural stability of the ISS treatment area.
- Barrier to potential future DNAPL migration.

3.4 Revise Design to Evaluate/Perform Active Remediation at Siltronic Riverbank

ROD Figure 28 assigns monitoring to hardened, non-erosive riverbanks. EPA's comments require further evaluation of whether active remedies should be performed at the Siltronic riverbank because of the identification of PTW-NAPL within the riverbank and ROD Table 17 and Table 21 exceedances at a single angled Siltronic riverbank boring.

Revised Dredge and Cap Design

The Revised Dredge and Cap Design retains monitoring of the Siltronic Riverbank. EPA's comment requesting active remediation in this area is not feasible using dredge and cap technologies for the following reasons:

- As stated in Section 3.3 of the EPA-approved *Revised Pre-Remedial Design Data Gaps Work Plan* (DGWP; Anchor QEA 2019b), "Per ROD Figure 28, monitoring is a suitable remedy in areas without PTW-NAPL/NRC, where existing erosion protection is shown to be adequate." Contrary to the EPA comment, no PTW-NAPL was identified in all three of the angled riverbank borings (PDI-142, PDI-143, and PDI-144) that were specifically collected in accordance with the DGWP to evaluate the presence of PTW-NAPL underneath the Siltronic riverbank. Section 2.5 of the Combined BOD-PDR documents the highly armored nature of

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the Siltronic riverbank and the results of the Siltronic Bank Assessment of Non-Point Source Consequences of Sediment (BANCS) that identifies the bank is not erosive.

- Dredging and capping the Siltronic riverbank would lead to the following:
  - Spatially extensive excavation of the riverbank slope and uplands with associated destructive impacts to upland roads, utilities, pumping wells, conveyance systems and other key components of the HC&C system infrastructure, and buildings or other upland structures. These impacts can be observed in Figure 3-4a, which depicts the Siltronic riverbank where both the riverbank and sediment slope are steeper than 3H:1V from the top of riverbank out to the navigation channel line.
  - Unnecessary removal of clean sediment below the DOC (Figure 3-4a).
  - Require an offshore vertical sheetpile wall to support capping at a long-term stable 3H:1V slope and to avoid placement of cap material within the 10-foot offset from the navigation channel line to not impact future maintenance dredging operations by USACE (Figure 3-4a).

EPA commented that the basis of design for the Siltronic riverbank should include discussion of transport of contamination from riverbank soil via non-erosion processes. Photographs of the Siltronic Riverbank are presented in Figure 3-15. Visual observations over the past 15 years have not identified visible soils through the riverbank armor. Due to the thick layer of large armor material, it is infeasible to collect soil augers/borings under the armor or surface water at the base of the armor. Precipitation that falls on armored slope above the river level will seep vertically through the armor and into the underlying soil, and then stagnate because the lateral groundwater advection from the uplands will be controlled prior to or during sediment remedy construction. Operation of the HC&C system with the deep trench will lead to net groundwater/porewater shoreward hydraulic gradient eliminating the soil to surface water pathway.

Full Dredge and ISS Design

If required by EPA, active remediation of the Siltronic riverbank is feasible with ISS treatment, including an ISS barrier wall along the top of the Siltronic riverbank (described in Section 3.3.2). The Design Team determined that the most effective and protective means to integrate these abutting remediation areas would be to remove the existing thick armor layer and underlying geotextile and complete ISS across the entire riverbank. This approach would not result in extensive encroachment into the uplands or threaten the integrity of any structures and would eliminate potential erosion or any other contaminant migration pathways to the river from the portion of the Siltronic property adjacent to the Project Area, provide more flexibility for incorporating habitat improvements on the post-ISS surface, and provide more seismic stability along the riverbank.

The post-construction riverbank elevations would be designed and constructed to meet the FEMA no-rise threshold criteria and to target elevations that maximize habitat improvements.

3.5 Additional Design Performance Considerations

Other important design considerations were evaluated as part of the remedial technology comparative analysis that have impacts on both short- and long-term protectiveness and effectiveness. These considerations included seismic stability, potential for water quality impacts during construction, post-dredge residuals management, potential for long-term sediment recontamination caused by contaminated sediments left in place, potential for riverbank and cap integrity impacts by climate change, and green remediation. The evaluation findings for each consideration are provided below for the Revised Dredge and Cap Design relative to the Full Dredge and ISS Design.

Seismic Stability

The Design Team performed some preliminary analysis to evaluate and compare the factors of safety associated with slope failures during a range of seismic events for the Revised Dredge and Cap Design versus Full Dredge and ISS Design. As discussed in Sections 6.2.5 and 6.2.6 of the Combined BOD-PDR, the dredge and cap remedy does not meet the target seismic factor of safety of 1.1 for slope stability. Additional seismic evaluations were not completed for the minor revisions to the Revised Dredge and Cap Design post-construction grades, but the factor of safety is anticipated to be similar. In addition, due to the nature of the sediments (i.e., soft, compressible silt and saturated sand deposits), the Revised Dredge and Cap Design is susceptible to liquefaction-induced settlement and deformation during larger seismic events.

The Full Dredge and ISS Design includes an integrated top of riverbank ISS treatment barrier wall that would be structurally connected to the riverbank and in-water ISS treatment zone. This wall would act as a key into the upland soils at depths up to approximately 155 feet bgs. In addition, the ISS treatment layer would be designed to achieve a target strength of a minimum 50 psi, which is significantly greater than the untreated in situ sediments. Therefore, the treated sediments would be less likely to experience liquefaction-induced settlement and deformation during larger seismic events as compared to untreated sediments.

The Full Dredge and ISS Design would, therefore, achieve a much higher factor of safety for slope failure compared to the Revised Dredge and Cap Design.

Potential for Water Quality Impacts During Construction

As discussed in Section 3.1.1, dredging operations are well-documented to result in sediment resuspension, contaminant releases from bedded sediment, and residuals generation and, therefore, short-term water quality impacts (Bridges et al. 2010). These adverse construction impacts can be

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mitigated by the implementation of BMP controls, which are intended to minimize, to the extent practical, these releases and associated contaminant residuals generation and water quality impacts. Section 16 of the Combined BOD-PDR presents a Project Area-specific evaluation of water quality barrier controls, and mobile moon pool silt curtains and full- and partial-depth silt curtains were retained for further evaluation during remedial design.

The Revised Dredge and Cap Design includes the exposure of contaminated sediments containing PTW-NAPL with the water column with each dredge bucket pass. Although this design would include the use of water quality BMPs, including the moonpool successfully applied at the NW Natural PGM Site sediment cleanup, the potential for water quality impacts during the dredging of sediments containing liquid NAPL and significantly elevated chemical concentrations remains.

Alternatively, in areas treated by ISS, the Full Dredge and ISS Design minimizes the exposure of untreated contaminated sediments to the water column to only occur during the surficial ISS treatment. The subsequent ISS treatment in deeper sediments is performed without exposure to the water column, significantly reducing the potential for water quality impacts. Those potential impacts would be further reduced by the use of the same moonpool system during ISS treatment that would be used for the Revised Dredge and Cap Design. As discussed in Section 3.2, dredging of the post-treatment swell will be required to minimize increases in elevations to meet the net cut and fill requirements and to optimize habitat configurations. Removal of swell will have minimal water quality impacts because any NAPL and elevated chemical concentrations in sediments have been treated. In addition, this dredging would be performed in the same moonpool system to further minimize the potential for water quality impacts.

The Full Dredge and ISS Design would, therefore, significantly reduce the risks of water quality impacts during construction compared to the Revised Dredge and Cap Design.

Post-Dredge Residuals Management

Appendix M of the Combined BOD-PDR describes the post-dredge verification, confirmatory sampling, and residuals management approach that NW Natural developed in close coordination between EPA and EPA's partners during several meetings in 2018. Although this approach was developed primarily for portions of the Project Area where dredging will be performed to the full DOC (i.e., the Navigation Channel Region for both the Revised Dredge and Cap Design and the Full Dredge and ISS Design), NW Natural may also elect to apply elements of this approach to the dredge and cap areas in the Intermediate, Shallow, and submerged portions of the Riverbank Regions depending on the construction sequencing. For example, during remedial design, site-specific factors may be used to divide the three-dimensional dredge prism into smaller operational dredge management units (DMUs) to balance an efficient pace of dredge work against short-term risks associated with generated dredge residuals that may include the presence of PTW-NAPL. The

DMU boundaries and sizes will be developed based on the evaluation of multiple lines of evidence during the remedial design process. Depending on the amount of time it takes to dredge each DMU and the subsequent amount of time prior to placement of overlying cap material, NW Natural may elect to place a thin layer of residuals management cover in post-dredge DMUs prior to cap placement to minimize the potential for generated residual migration outside of the work area. Performing concurrent dredging and residual management cover placement complicates the design, requires significant additional equipment to be staged within a relatively small work area, and presents logistical sequencing challenges that can significantly reduce production rates and increase the total construction duration (and associated potential water quality impacts for a longer period). Similarly, depending on the construction sequencing, NW Natural may elect to place residuals management cover in some DMUs between each construction season to further reduce the potential for residuals migration from the work area during extended non-work periods. This would also reduce seasonal production rates and increase the total construction duration.

Alternatively, the Full Dredge and ISS Design would not require generated residuals management. The entirety of PTW-NAPL/NRC and RAL and PTW-highly toxic threshold exceedances will be treated prior to dredging of the ISS swell. This swell will have a design strength of 50 psi or greater, so any generated dredge particulates will be significantly reduced and will comprise treated materials. This simplifies the design and, unlike the Revised Dredge and Cap Design, eliminates dredge residuals potentially containing PTW-NAPL and the associated risk for off-site migration. It also reduces equipment needs and associated staging challenges, significantly simplifies construction sequencing, and does not impact the ISS production rates and total construction duration.

The Full Dredge and ISS Design would, therefore, significantly reduce the risks, design complexity, equipment needs, and construction durations compared to the Revised Dredge and Cap Design.

Potential for Long-Term Sediment Recontamination Caused by Contaminated Sediments Left in Place

The Revised Dredge and Cap Design is limited to remove 70% of PTW-NAPL and 50% of PTW-NRC, is reliant on long-term cap chemical isolation and the HC&C system to be protective of continued groundwater advective flux through the contaminated sediments left in place, and does not eliminate the ebullition-facilitated transport of DNAPL pathway. Although a robust engineered cap can be designed to control these long-term contaminant migration pathways, there exists some potential for long-term releases (e.g., if the cap integrity were compromised due to physical impacts, dramatic changes in river dynamics, the HC&C system experienced equipment or long-term power failures, etc.).

Alternatively, the Full Dredge and ISS Design directly treats 100% of sediments containing RAL exceedances and PTW, is not reliant on the HC&C system to control advective flux, and eliminates the ebullition-facilitated transport of DNAPL pathway.

The Full Dredge and ISS Design would, therefore, be significantly more effective at preventing long-term sediment recontamination caused by contaminated sediments left in place compared to the Revised Dredge and Cap Design.

Potential for Riverbank Impacts and Cap Integrity by Climate Change

EPA has expressed that flooding and sea level rise are currently the forerunning sediment remedy concerns due to climate change. If climate change results in dramatic changes in river dynamics, particularly flood events, cap integrity could become an issue. The Revised Dredge and Cap Design would include capping of the entire Gasco property riverbank along with the Shallow and Intermediate Regions. The cap design would be based on assumptions regarding climate change that cannot currently be accurately predicted, which creates an uncertainty and potential long-term risk for riverbank impacts over time.

In contrast, the Full Dredge and ISS Design includes treatment of the entirety of the riverbank to a design strength of a minimum 50 psi. Therefore, the riverbank will not be subject to damage or failure during floods or sea level rise over time.

The Full Dredge and ISS Design would, therefore, significantly reduce the risk of riverbank impacts by climate change relative to the Revised Dredge and Cap Design.

Green Remediation

Green remediation practices would be followed during implementation of the Revised Dredge and Cap Design to the extent practicable. In the short term, this design includes a high volume of contaminated material transported for off-site disposal, resulting in high vehicle and equipment emissions. Over the long term (e.g., 100 years), this design would result in increased material and energy consumption compared to Full Dredge and ISS Design due to the extensive operations, monitoring, and maintenance associated with the HC&C system capture and treatment of significant volumes of groundwater not posing current or future risk from the Deep Lower Alluvium WBZ.

Similarly, green remediation practices would be followed during implementation of the Full Dredge and ISS Design to the extent practicable. In the short term, this design will reduce the volume of contaminated material transported for off-site disposal, resulting in lower vehicle and equipment emissions. Over the long term (e.g., 100 years), this design would result in less material and energy consumption due the elimination of unnecessary capture and treatment of significant volumes of groundwater from the Deep Lower Alluvium WBZ that does not pose a current or future risk.

The Full Dredge and ISS Design would, therefore, result in a greener approach over the remedy lifespan compared to the Revised Dredge and Cap Design due to less material and energy consumption.

4 Summary of Preferred Design

The following Table 4-1 summarizes the results of the technical evaluations performed to address EPA's comments and demonstrates that the Full Dredge and ISS Design outperforms the Revised Dredge and Cap Design for each consideration. A more detailed design comparison is presented in Table 4-2.

Table 4-1
Summary of Revised Remedial Design Technical Evaluations

Technical Considerations	Revised Dredge and Cap Design	Full Dredge and ISS Design
Percent of PTW-NAPL/NRC and RAL and PTW-highly toxic threshold exceedances removed from Navigation Channel Region	100%	100%
Percent of Intermediate, Shallow and Riverbank Regions, and top of riverbank PTW-NAPL/NRC directly treated or removed	50%	100%
Estimated volume of PTW-NAPL/NRC directly treated in situ	0%	100% (>45,000 cy)
Estimated volume of PTW-NAPL/NRC remaining in place without direct treatment	>20,000 cy	0
Capping required to manage groundwater flux and ebullition-facilitated transport of DNAPL for long-term protectiveness of sediment remedy	Yes	No
Eliminates need for managing groundwater flux using HC&C System and includes ISS treatment of the upland top of riverbank alignment at Gasco and Siltronic	No	Yes
Active remediation of Siltronic riverbank possible	No	Yes
Desired slope profile can be any shape: removal of swell ensures no net flood rise and provides full control of slope configuration for improved habitat conditions	No	Yes
May require dredge residual management and multi season cover placement outside the Navigation Channel Region	Yes	No

In summary, the Full Dredge and ISS Design is preferred because it offers the following additional primary effectiveness and protectiveness compared to the Revised Dredge and Cap Design:

- Removes and directly treats 100% of PTW-NAPL, 100% of PTW-NRC threshold exceedances, and 100% of RAL and PTW-highly toxic threshold exceedances
- Eliminates the groundwater advective flux pathway
- Eliminates the ebullition-facilitated transport of DNAPL pathway
- Eliminates cap on grade and maintain current elevations to minimize habitat impacts
- Allows flexible and stable post-construction elevations and slopes for habitat improvements
- Can actively remediate the Siltronic riverbank

- Provides enhanced seismic stability, lower risk of short-term water quality impacts, and reduced overall environmental impacts from construction

The preferred design was assembled from technologies supported by the ROD and the *Statement of Work – Gasco Sediments Site* (EPA 2009). Although a ROD has been issued for the site, including the Project Area, Appendix B provides an additional technical analysis of the two designs using the NCP's Threshold Criteria and Primary Balancing Criteria, as requested by EPA. The Modifying Criteria are not included because these designs are each consistent with ROD technology assignments for the selected Portland Harbor Alternative (F Mod) and have, therefore, already been met.

5 Recommended Next Steps

EPA selection of the preferred design approach is the first step. NW Natural is committed to expeditiously proceeding with pilot testing and remedial design of the preferred Full Dredge and ISS Design, but that work cannot proceed until the preferred design approach is determined.

If EPA selects the Full Dredge and ISS Design, NW Natural would proceed with the testing program discussed with EPA during the meeting on June 21, 2022, and presented in the *In Situ Stabilization and Solidification Laboratory Pilot Study Work Plan* (LPS Work Plan; Anchor QEA 2022) submitted to EPA on October 31, 2022. That program includes both a laboratory pilot study and field pilot study as soon as possible to: 1) incorporate more detailed design information earlier in the remedial design process to support EPA's review and minimize the potential for substantive design changes during development of the Final Design; and 2) field verify and incorporate optimized construction means and methods in the Final Design.

The field pilot study must be completed during the in-water construction window between July through October. For NW Natural to be able to conduct a field pilot study in 2023, EPA selection of the preferred design approach must be received before the end of 2022. If the required studies are pushed back a year, that would have an equivalent effect on the overall design schedule. In summary, the critical next steps are as follows:

1. EPA selection of a preferred design approach by the end of 2022.
2. EPA review and approval of the LPS Work Plan by late January 2023.
3. If both EPA approvals are received in that timeframe:
    a. The LPS Work Plan (Anchor QEA 2022) field sampling could begin in January/February 2023 with Phase I laboratory analysis continuing through June 2023. Additional phases of testing and associated timing will be described in the LPS Work Plan.
    b. NW Natural would work to implement the field pilot study in 2023, including development and submittal of a *In Situ Stabilization and Solidification Field Pilot Study Work Plan* to EPA in early 2023.
    c. NW Natural would target submittal of an initial draft of the *Revised Sediments Remedy Basis of Design Report* for the Full Dredge and ISS Design and comprehensive responses to EPA's comments on the Combined BOD-PDR in February 2023.

6 References

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Tables

Table 4-1
Summary of Revised Remedial Design Technical Evaluations

Technical Considerations	Revised Dredge and Cap Design	Full Dredge and ISS Design
Percent of PTW-NAPL/NRC and RAL and PTW-highly toxic threshold exceedances removed from Navigation Channel Region	100%	100%
Percent of Intermediate, Shallow and Riverbank Regions, and top of riverbank PTW-NAPL/NRC directly treated or removed	50%	100%
Estimated volume of PTW-NAPL/NRC directly treated in situ	0%	100% (>45,000 cubic yards)
Estimated volume of PTW-NAPL/NRC remaining in place without direct treatment	>20,000 cubic yards	0
Capping required to manage groundwater flux and ebullition-facilitated transport of DNAPL for long-term protectiveness of sediment remedy	Yes	No
Eliminates need for managing groundwater flux using HC&C System and includes ISS treatment of the upland top of riverbank alignment at Gasco and Siltronic	No	Yes
Active remediation of Siltronic riverbank possible	No	Yes
Desired slope profile can be any shape: removal of swell ensures no net flood rise and provides full control of slope configuration for improved habitat conditions	No	Yes
May require dredge residual management and multi season cover placement outside the Navigation Channel Region	Yes	No

Notes:
DNAPL: dense nonaqueous phase liquid
HC&C: hydraulic control and containment
ISS: in situ stabilization and solidification
NAPL: nonaqueous phase liquid
NRC: not reliably contained
PTW: principal threat waste
RAL: remedial action level
Siltronic: Siltronic Corporation

Table 4-2
Comparison of Dredge and Cap and Full Dredge and ISS Designs to Address EPA Comments

Technical Issue	Revised Dredge and Cap Design[1]	Full Dredge and ISS Design[1]	Preferred Option for Each Technical Issue
Addressing EPA Comments on the Combined BOD-PDR			
Revise Design to Focus on Removal of PTW-NAPL/NRC to the Extent Feasible (Section 3.1)	The Revised Dredge and Cap Design provides for the maximum amount of combined PTW-NAPL/NRC removal of approximately 50% (an estimated 25,000 cubic yards left in place) and requires the use of specialized equipment and some form of in situ treatment of the sediments containing PTW within established offsets from in-water functional structures. Removing additional PTW-NAPL/NRC was found to present significant design and implementability challenges for each of the seven technical issues identified in Section 3.1.	The Full Dredge and ISS Design removes or directly treats the full lateral and vertical extent of PTW-NAPL/NRC and RAL and PTW-highly toxic threshold exceedances, while fully addressing each of the seven technical issues discussed in Section 3.1.	**Full Dredge and ISS Design** treats 100% of the PTW-NAPL/NRC and RAL and PTW-highly toxic threshold exceedances and fully addresses all seven technical issues.
Revise Design to Eliminate or Minimize Cap on Grade and Maintain Current Elevations to Minimize Habitat Impacts (Section 3.2)	The Revised Dredge and Cap Design minimizes capping on grade and maintains current elevations to the extent practicable. However, there are localized areas with net elevation increase to facilitate long-term stable cap slopes associated with the sheetpile wall at the face of the Gasco dock. Additional modeling is required to confirm the no net rise threshold is met with sheetpile wall structures in place and incorporation of additional design details. In addition, habitat mitigation analysis (performed using HEA calculations) needs to be performed to determine the need for compensatory mitigation.	The Full Dredge and ISS Design eliminates net mudline elevation increases in areas shallower than -15 feet CRD. The post-treatment ISS swell can be dredged to the extent needed to assure no net mudline increases and to optimize habitat configurations. The strength of the swell material is much higher than the existing in situ sediments or cap materials, allowing more flexibility to maintain current elevations. This flexibility helps minimize habitat impacts relative to the untreated capped sediments in the Revised Dredge and Cap Design.	**Full Dredge and ISS Design** eliminates the need to cap on grade and more effectively minimizes the potential need for mudline elevation increases to support habitat improvements.
Revise Design to Better Integrate Upland Source Control Measures into the Sediment Remedy (Section 3.3)	The Revised Dredge and Cap Design remedy performance is reliant on upland groundwater controls to manage groundwater seepage to the sediment using the upland HC&C system, so protection of this system is critical for short- and long-term sediment remedy success. This design requires capping to address advective flux from upland chemical migration pathways and ebullition-facilitated transport of DNAPL. This design will expand the system onto the Siltronic property and optimize the existing system by replacing the Fill WBZ extraction wells with a deep trench.	The Full Dredge and ISS Design eliminates remedy performance reliance on upland groundwater controls by eliminating all upland contaminant risk migration pathways (both groundwater and DNAPL) to the river. This design also eliminates unnecessary pumping of the Deep Lower Alluvium WBZ that does not present a current or future potential risk. This design replaces the existing Fill and Lower Alluvium WBZ extraction wells with a vertical deep ISS treatment barrier wall coupled with a deep groundwater recovery trench to manage mounding of groundwater that encounters the wall.	**Full Dredge and ISS Design** eliminates all upland contaminant migration pathways to the river and the associated potential for short- and long-term sediment remedy recontamination, as well as unnecessary pumping of the Deep Lower Alluvium WBZ groundwater.
Revise Design to Evaluate/Perform Active Remediation at Siltronic Riverbank (Section 3.4)	The Revised Dredge and Cap Design maintains a monitoring remedy for the Siltronic riverbank consistent with the ROD Figure 28 technology application decision tree and Figure 4 of EPA's Riverbank Guidance (EPA 2019b). Active remediation of the riverbank is not practicable using dredge and cap technologies due to significant excavation of the riverbank slope into the uplands and associated destructive impacts to upland roads, utilities, pumping wells, conveyance systems and other key components of the HC&C system infrastructure. Active remediation using dredge and cap technologies also leads to removal of clean sediment below the DOC and requires installation of an offshore vertical sheetpile wall.	Active remediation of the Siltronic riverbank is feasible with ISS treatment, if required by EPA, and can be integrated with the abutting vertical deep ISS treatment barrier wall.	**Full Dredge and ISS Design** allows for active remediation of the entirety of the Siltronic riverbank, if required by EPA.
Additional Design Performance Considerations (Section 3.5)			
Seismic Stability	The Revised Dredge and Cap Design does not meet the target seismic factor of safety of 1.1 for slope stability. Additional seismic evaluations were not completed for the minor revisions to the Revised Dredge and Cap Design post-construction grades, but the factor of safety is anticipated to be similar due to consistent slope stability conditions. In addition, due to the nature of the sediments (i.e., soft, compressible silt and saturated sand deposits), this design is susceptible to liquefaction-induced settlement and deformation during larger seismic events.	The Full Dredge and ISS Design includes an integrated top of riverbank ISS vertical deep treatment barrier wall that would be structurally connected to the riverbank (including the Siltronic riverbank if required by EPA) and in-water ISS treatment zone. This integrated ISS treatment will significantly improve the seismic stability of the remedy. In addition, the ISS treatment layer would be less likely to experience liquefaction-induced settlement and deformation during larger seismic events as compared to untreated sediments.	**Full Dredge and ISS Design** reduces the potential for liquefaction-induced settlement and deformation.
Potential for long-term sediment recontamination caused by contaminated sediments left in place	The Revised Dredge and Cap Design leaves 30% of PTW-NAPL and 50% of PTW-NCR in place, is reliant on cap performance and the HC&C system to maintain low groundwater advective flux, and does not eliminate the ebullition contaminant transport pathway. Although this contamination and these contaminant migration pathways can be controlled by a robust engineered cap, there exists some potential for long-term releases if the cap integrity were compromised due to physical impacts or issues with the HC&C system.	The Full Dredge and ISS Design directly treats the full lateral and vertical extent of PTW-NAPL/NRC and RAL and PTW-highly toxic threshold exceedances, is not reliant on the HC&C system, and eliminates the ebullition contaminant transport pathway.	**Full Dredge and ISS Design** eliminates the potential for long-term sediment recontamination caused by contaminated sediments left in place.

Table 4-2
Comparison of Dredge and Cap and Full Dredge and ISS Designs to Address EPA Comments

Technical Issue	Revised Dredge and Cap Design[1]	Full Dredge and ISS Design[1]	Preferred Option for Each Technical Issue
Potential for water quality impacts during dredging	The Revised Dredge and Cap Design includes a significantly increased potential for water quality impacts caused by the continuous exposure of sediments containing untreated PTW-NAPL and elevated chemical concentrations throughout the full dredge depth. Although robust water quality BMPs will be implemented to minimize the potential for water quality impacts, the potential for impacts remains.	The Full Dredge and ISS Design significantly reduces the potential for water quality impacts by minimizing the exposure of untreated contaminated sediments to the water column to only occur during the surficial ISS treatment and preventing the exposure of untreated sediments to the water column during swell removal. The same robust water quality BMPs used for the Revised Dredge and Cap Design will further reduce the potential risk of water quality impacts.	**Full Dredge and ISS Design** reduces the overall amount of dredging and thereby reduces the potential risks for water quality impacts.
Climate change	The Revised Dredge and Cap Design would need to rely on assumptions regarding climate change that cannot currently be accurately predicted. Potential concerns for this remedy due to the factors of climate change identified by EPA (i.e., increased flood and sea rise conditions) include cap integrity. This uncertainty may impact the design and performance of the remedy.	The Full Dredge and ISS Design strengthens riverbanks and the treated riverbed against flood and sea rise conditions, eliminating the design and performance impacts identified for the Revised Dredge and Cap Design.	**Full Dredge and ISS Design** provides a flood resistant and stable remedy that addresses EPA's concern about future flood and sea rise conditions associated with climate change.
Green remediation	The Revised Dredge and Cap Design would result in increased long term (e.g., 100 years) material and energy consumption due to the extensive operations, monitoring, and maintenance associated with HC&C system capture to reduce advective flux in sediments and treatment of significant volumes of uncontaminated groundwater from the Deep Lower Alluvium WBZ.	The Full Dredge and ISS Design would result in less long term (e.g., 100 years) material and energy consumption due to the elimination of advective flux and no longer needing to capture and treat significant volumes of uncontaminated groundwater from the Deep Lower Alluvium WBZ.	**Full Dredge and ISS Design** is a greener approach over the remedy lifespan (i.e., 100 years).

Notes:

1. Additional details about the remedial technologies included in Revised Dredge and Cap Design and Full Dredge and ISS Design are presented in Sections 2 and 3 of the PAR, and Section 4 summarizes the preferred design.

BMP: best management practice
Combined BOD-PDR: *Combined Sediment Remedy Basis of Design and Preliminary Design Report* (Anchor QEA 2021a)
CRD: Columbia River Datum
DNAPL: dense nonaqueous phase liquid
DOC: depth of contamination
EPA: U.S. Environmental Protection Agency
HC&C: hydraulic control and containment
ISS: in situ stabilization and solidification
NAPL: nonaqueous phase liquid
NRC: not reliably contained
PAR: *Preferred Alternative Report*
PTW: principal threat waste
RAL: remedial action level
ROD: *Record of Decision – Portland Harbor Superfund Site, Portland, Oregon* (EPA 2017)
Siltronic: Siltronic Corporation
WBZ: water-bearing zone

Figures

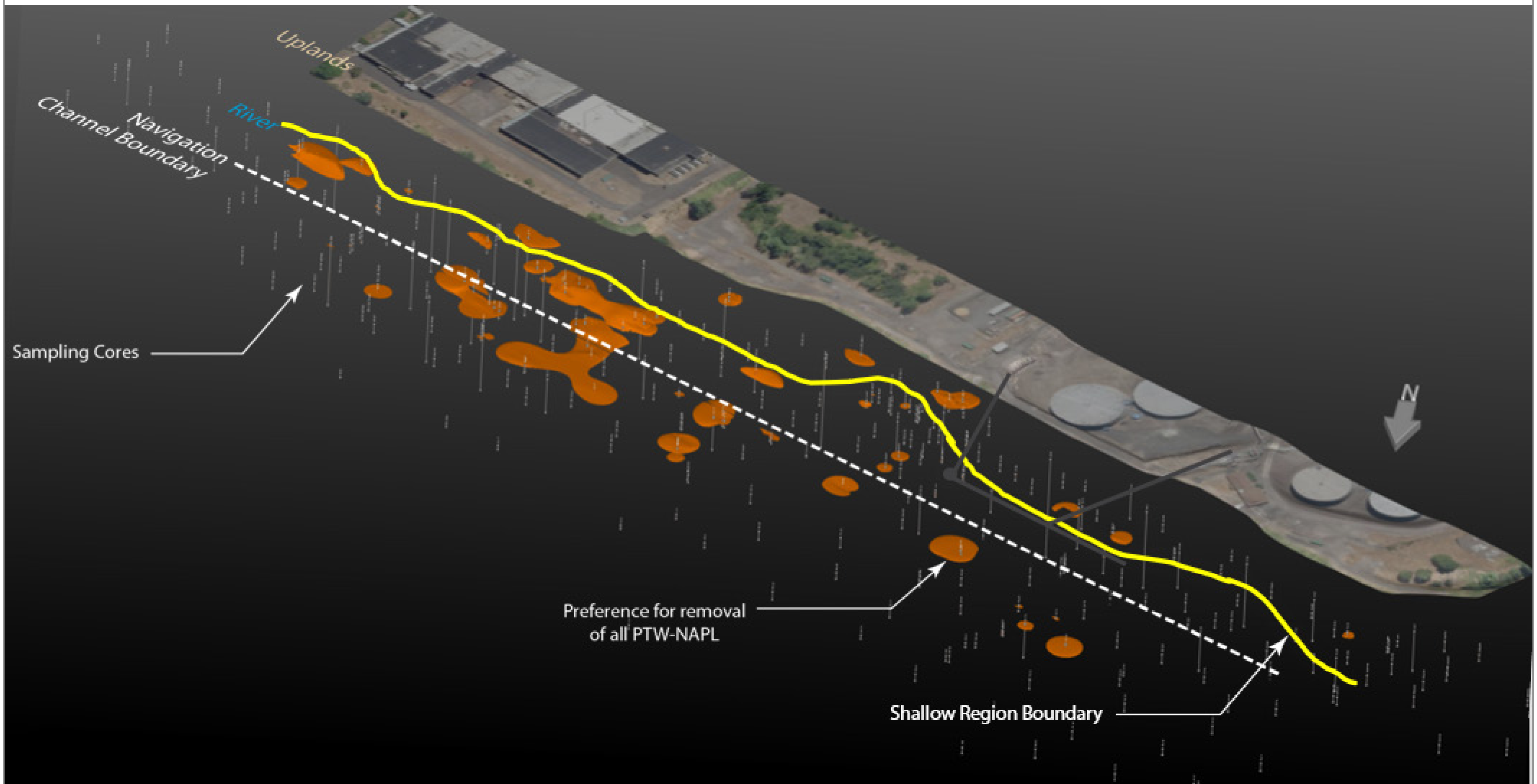

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Figure 3-1
Project Area PTW-NAPL Distribution
Preferred Alternative Report
Gasco Sediments Cleanup Action

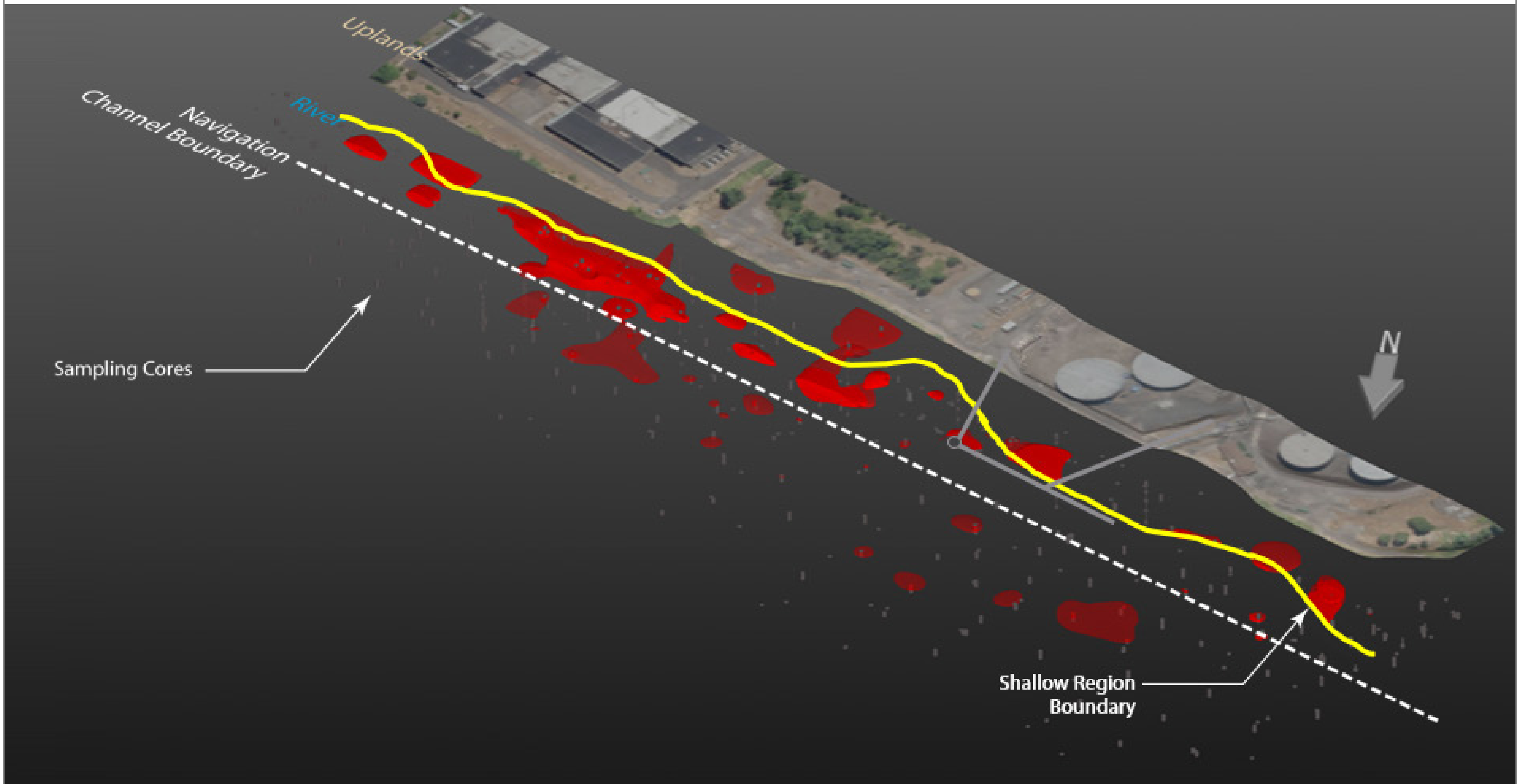

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Figure 3-2
Project Area PTW-NRC Distribution
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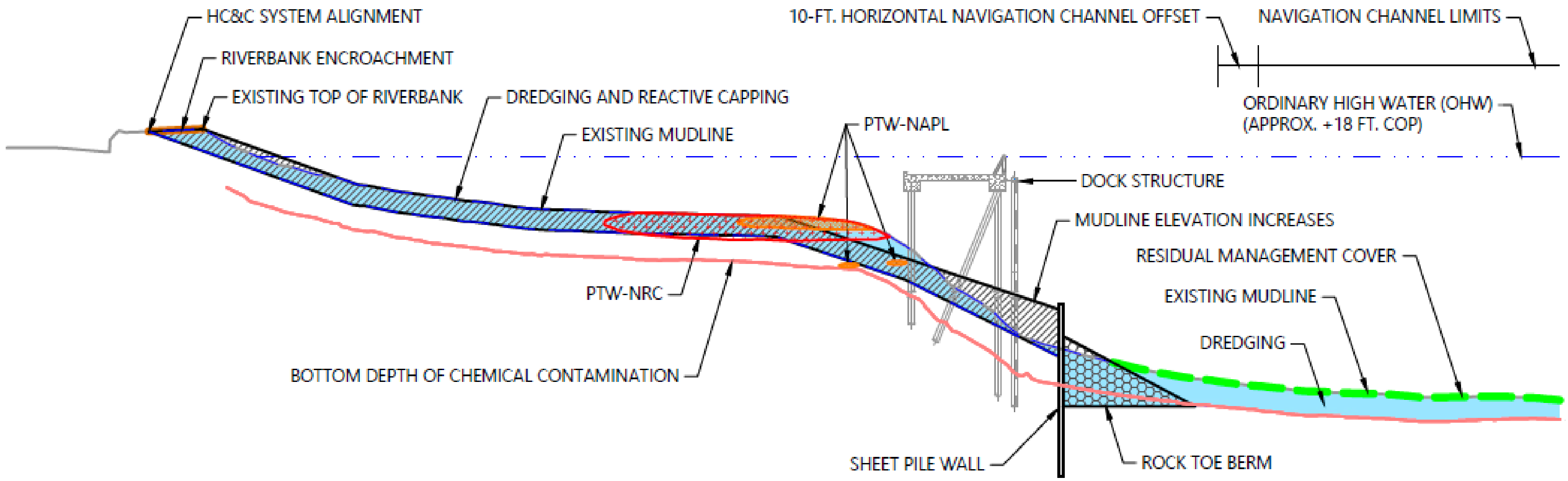
Gasco Sediments Cleanup Action



NOTE: PTW-NAPL/NRC extents are conceptual for representative cross section presentation purposes.

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Figure 3-3
Lateral and Vertical Extents of PTW-NAPL and PTW-NRC Adjacent to the Gasco Dock Structure

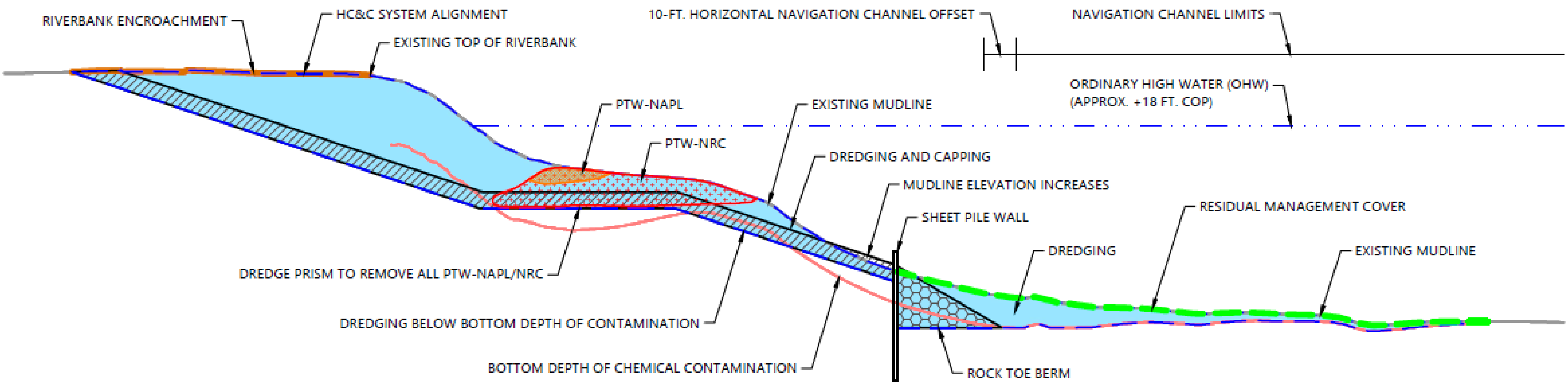

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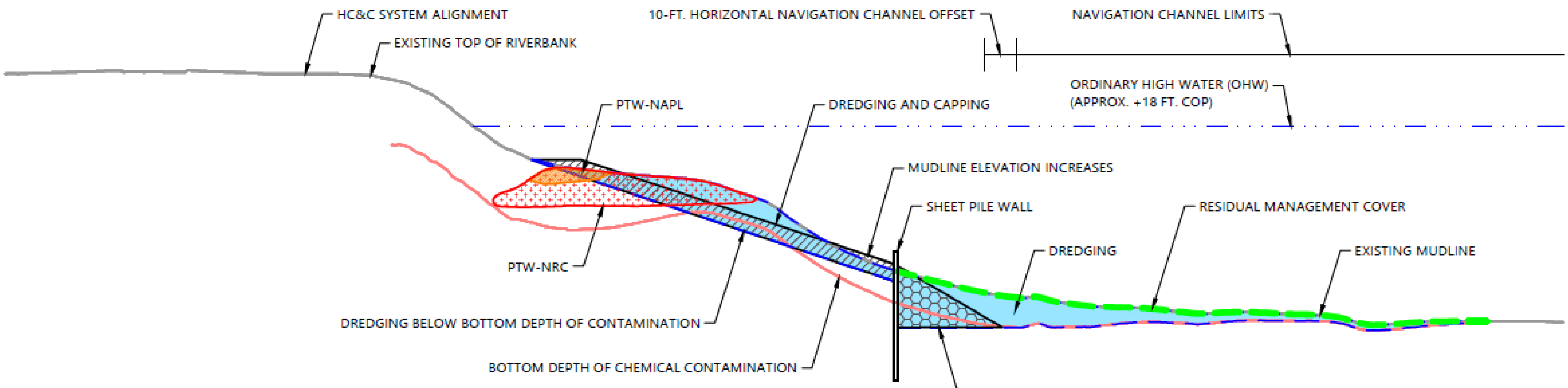
Figure 3-4a

Lateral and Vertical Extents of PTW-NAPL and PTW-NRC with Full Removal Adjacent to the Siltronic Riverbank



NOTE: PTW-NAPL/NRC extents are conceptual for representative cross section presentation purposes.

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Figure 3-4b
Lateral and Vertical Extents of PTW-NAPL and PTW-NRC with Revised Dredge Prism Adjacent to the Siltronic Riverbank

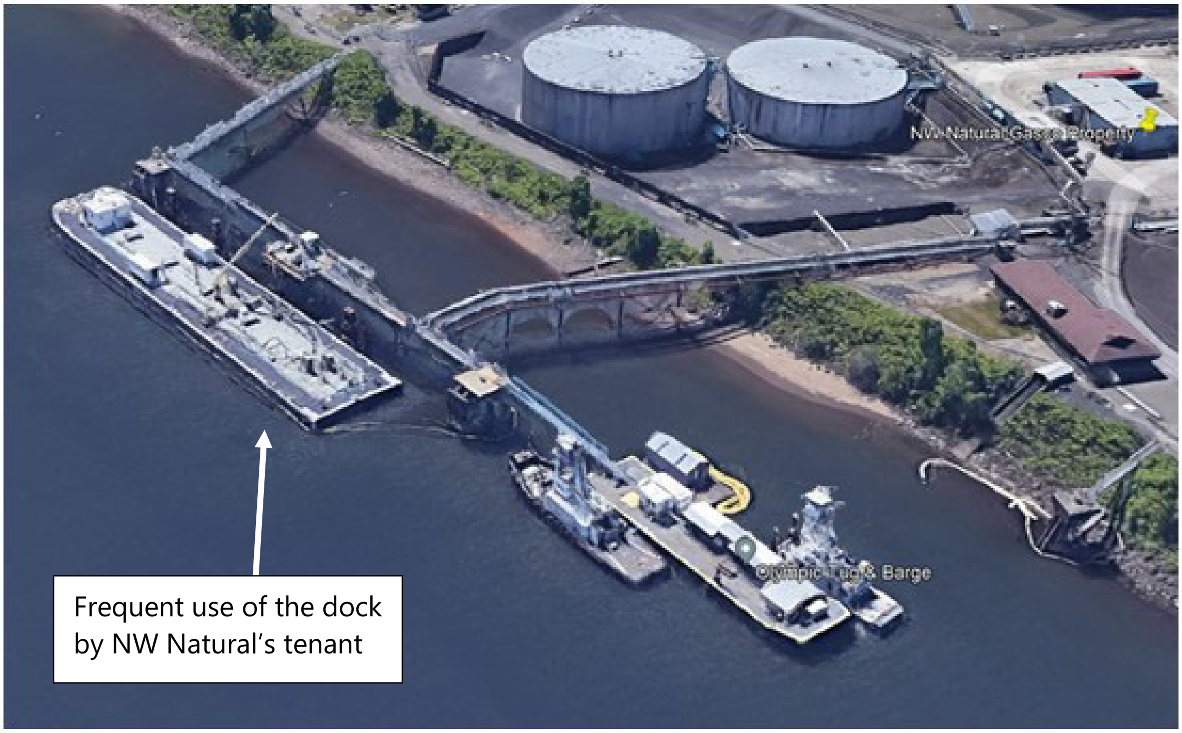

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Figure 3-5
Photographs of the Gasco Dock Structure
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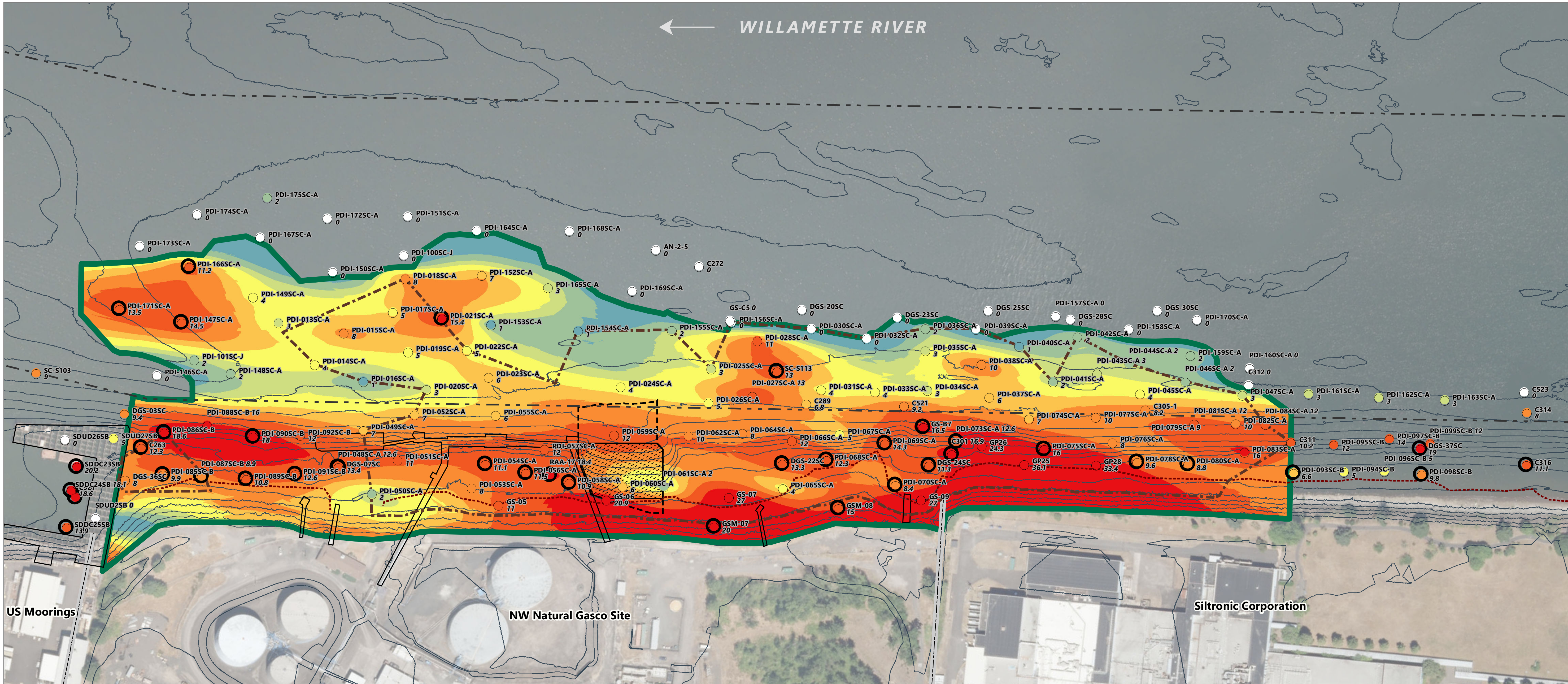
Gasco Sediments Cleanup Action



- Gasco Sediments Site Final Project Area
- Navigation Channel
- Structures
- Property Line
- Gasco Early Action Removal Action Area (Anchor Environmental 2006)
- Gasco Early Action Removal Action Pilot Cap
- Refined PTW-NAPL Boundary
- Approximate Riprap Boundary
- DOC Vertically Unbounded

DOC in Feet

- 0
- 0.1 - 1
- 1.1 - 2
- 2.1 - 3
- 3.1 - 5
- 5.1 - 7
- 7.1 - 10
- 10.1 - 15
- > 15

NOTES:

1. Depth of contamination shown on this figure is from Figure 7-1 of the Combined Sediment Remedy Basis of Design and Preliminary Design Report (Combined BOD-PDR; Anchor QEA 2021).
2. Bathymetry surveyed by eTrac 2019. Topography surveyed by Geometrix 2011.
3. Arrow indicates direction of flow of river.
4. Horizontal datum is NAD83 (HARN 91) Oregon State Plane North, International Feet.
5. Vertical datum is City of Portland (COP), Feet.
6. Aerial imagery from City of Portland 2018.

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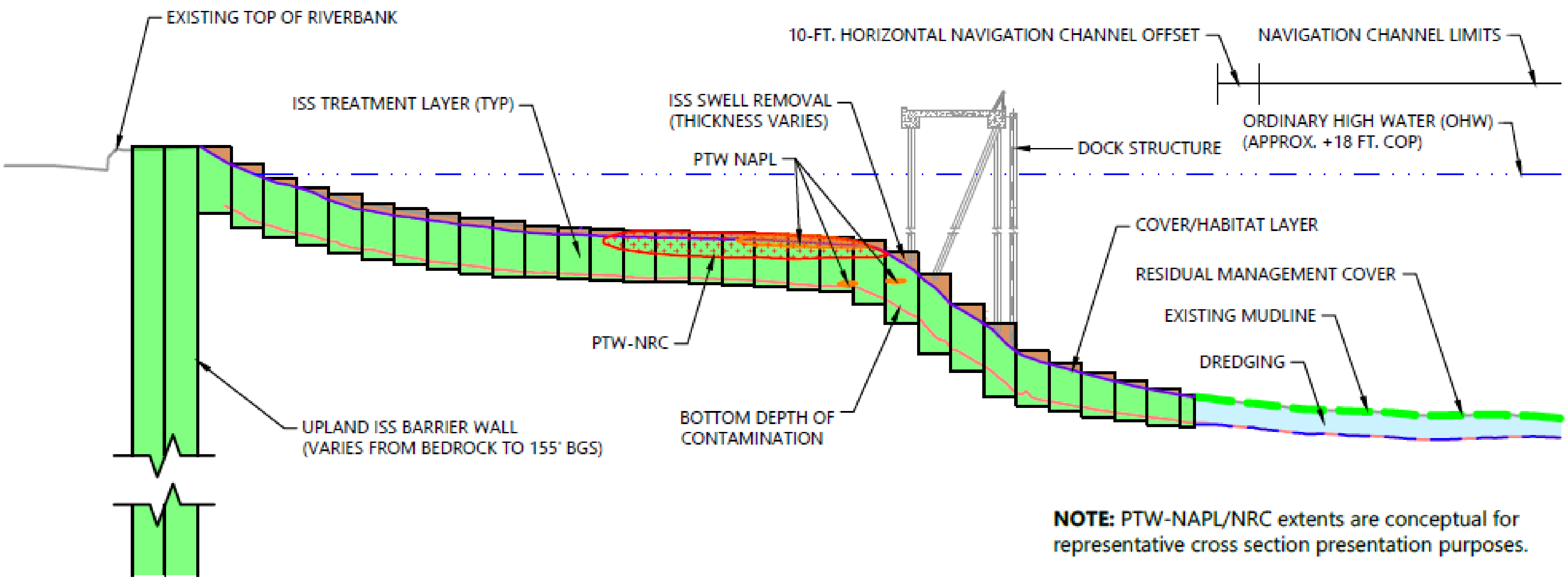
Figure 3-6
Depth of Contamination Based on RAL and PTW-Highly Toxic Threshold Exceedances Presented in the Combined BOD-PDR
Preferred Alternative Report
Gasco Sediments Cleanup Action



NOTE: PTW-NAPL/NRC extents are conceptual for representative cross section presentation purposes.

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Figure 3-7
Lateral and Vertical Extents of PTW-NAPL and PTW-NRC with ISS Adjacent to the Gasco Dock Structure

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Gasco Sediments Cleanup Action

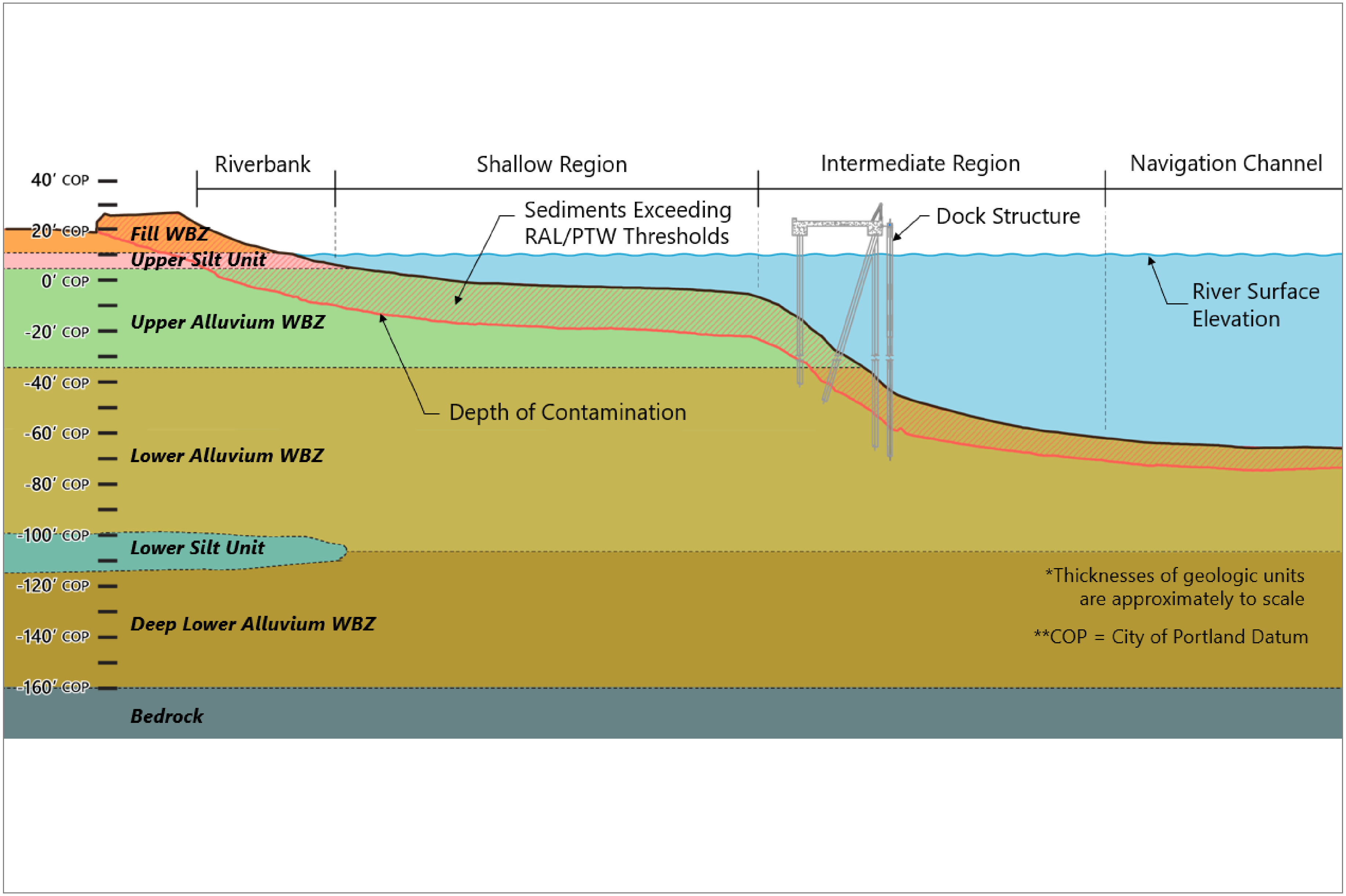

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Figure 3-8
Summary of Hydrogeologic Units
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Gasco Sediments Cleanup Action

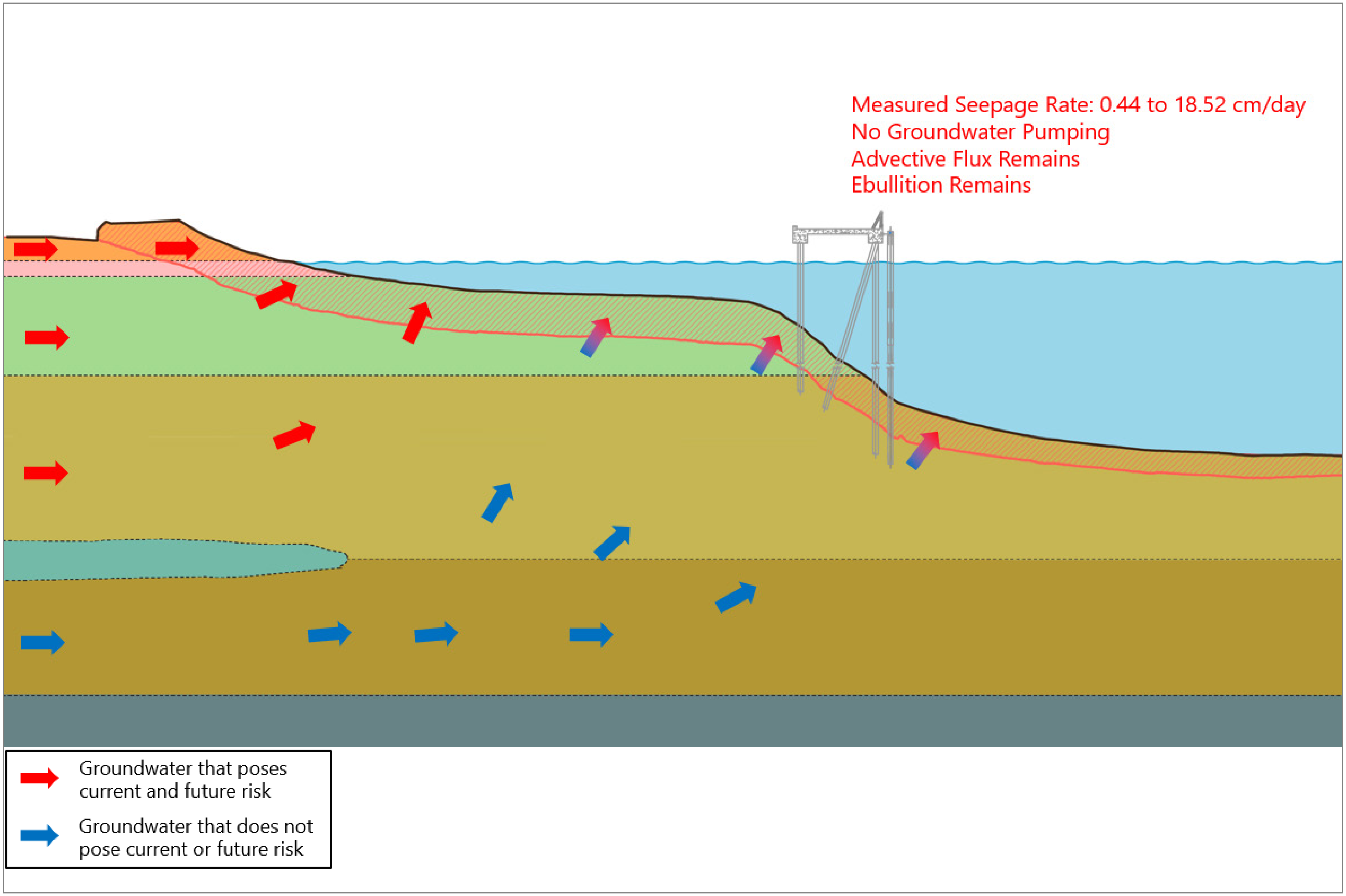

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Figure 3-9
Upland Groundwater Migration Pathways Without Source Control Integration

Preferred Alternative Report
Gasco Sediments Cleanup Action

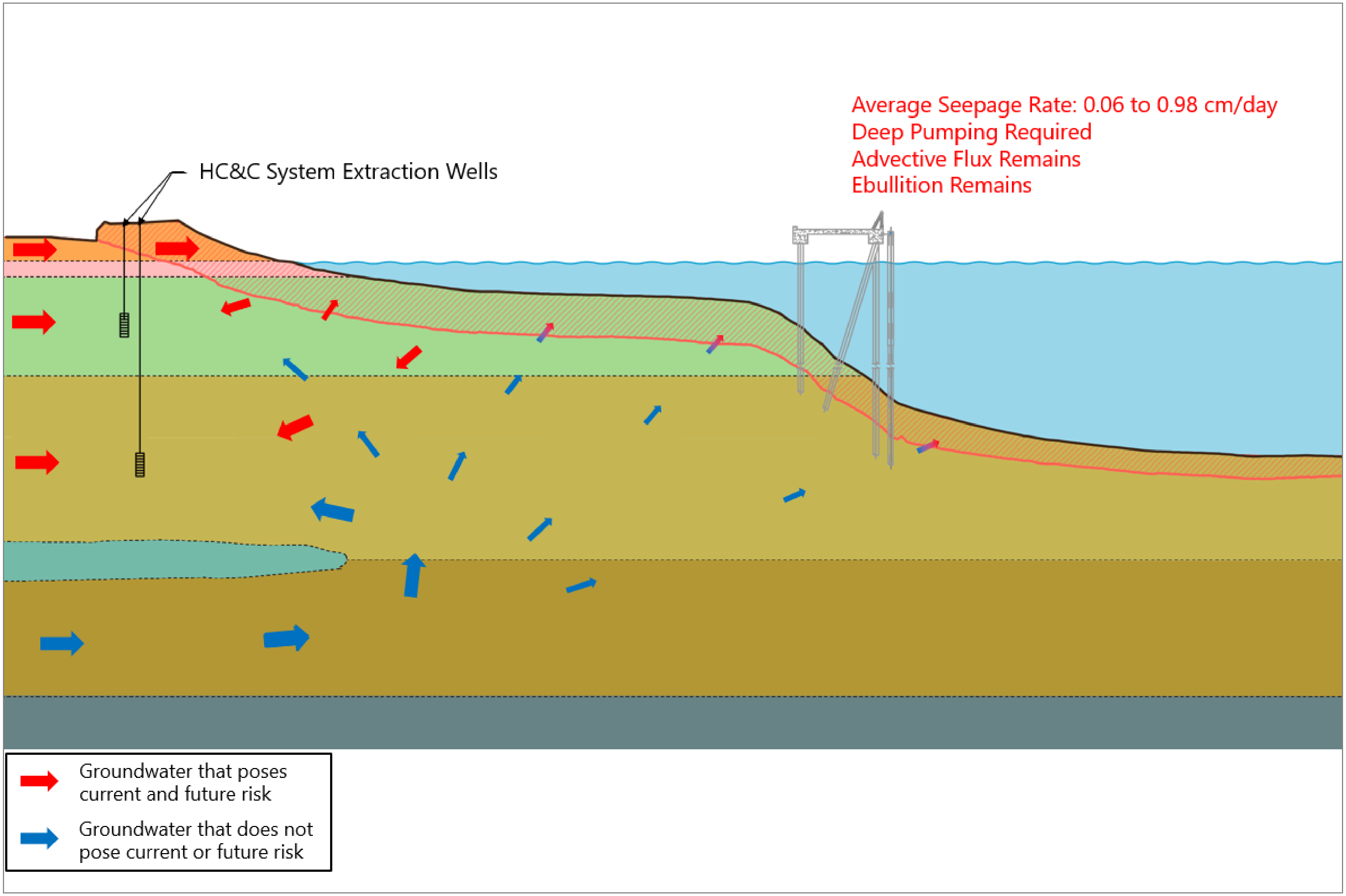

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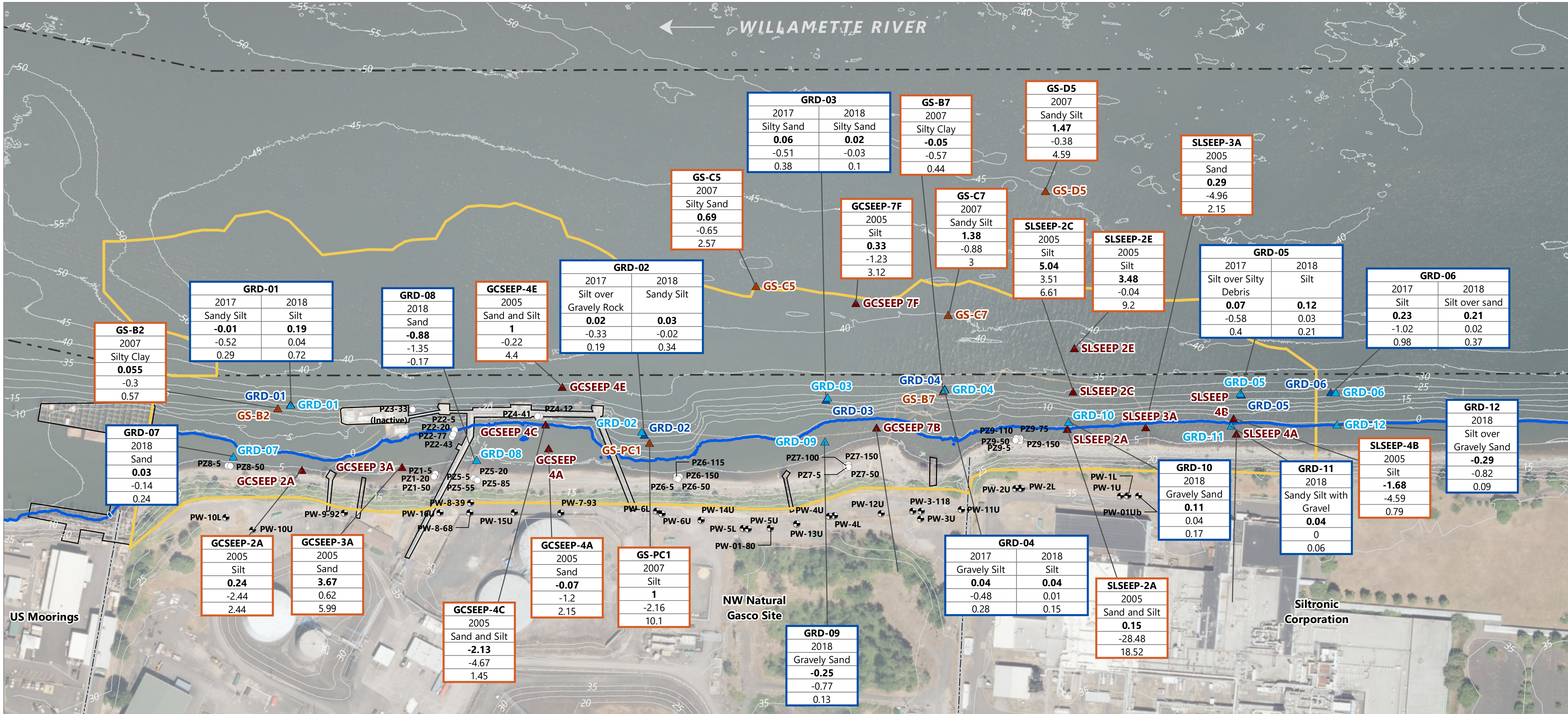
Figure 3-10
Upland Groundwater Migration Pathways with the Current HC&C System
Preferred Alternative Report
Gasco Sediments Cleanup Action



LEGEND:

- Navigation Channel
- Structures
- Property Line
- Gasco Sediments Site Final Project Area
- Approximate ROD Shallow Region/Intermediate Region Boundary
- NW Natural Gasco Seepage Meter (2018)
- NW Natural Gasco Seepage Meter (2017)
- NW Natural Gasco Seepage Meter (2007)
- LWG Seepage Meter (2005)
- HC&C System Extraction Well
- Existing Piezometer Location
- Elevation (feet COP)

GRD-09	Seepage Meter ID
2018	Year Measured
Gravely Sand	Substrate Material
-0.25	Mean Seepage
-0.77	Minimum Seepage
0.13	Maximum Seepage

- Post-HC&C Operation Data (2017 and 2018)
- Pre-HC&C Operation Data (2005 and 2007)

NOTES:

1. Seepage rates in cm/day, >0 indicates flow upward, <0 indicates flow downward. UltraSeep meter uncertainty: 0.1 cm/day.
2. HC&C = Hydraulic control and containment.
3. Arrow indicates direction of flow of river.
4. Bathymetry surveyed by eTrac in 2019. Topography surveyed by Geometrix 2011.
5. Horizontal datum is NAD83 Oregon State Plane North, International Feet.
6. Vertical datum is City of Portland, Feet.
7. Aerial imagery from City of Portland 2018.

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Figure 3-11
Summary of Measured Offshore Groundwater Seepage Fluxes
Preferred Alternative Report
Gasco Sediments Cleanup Action

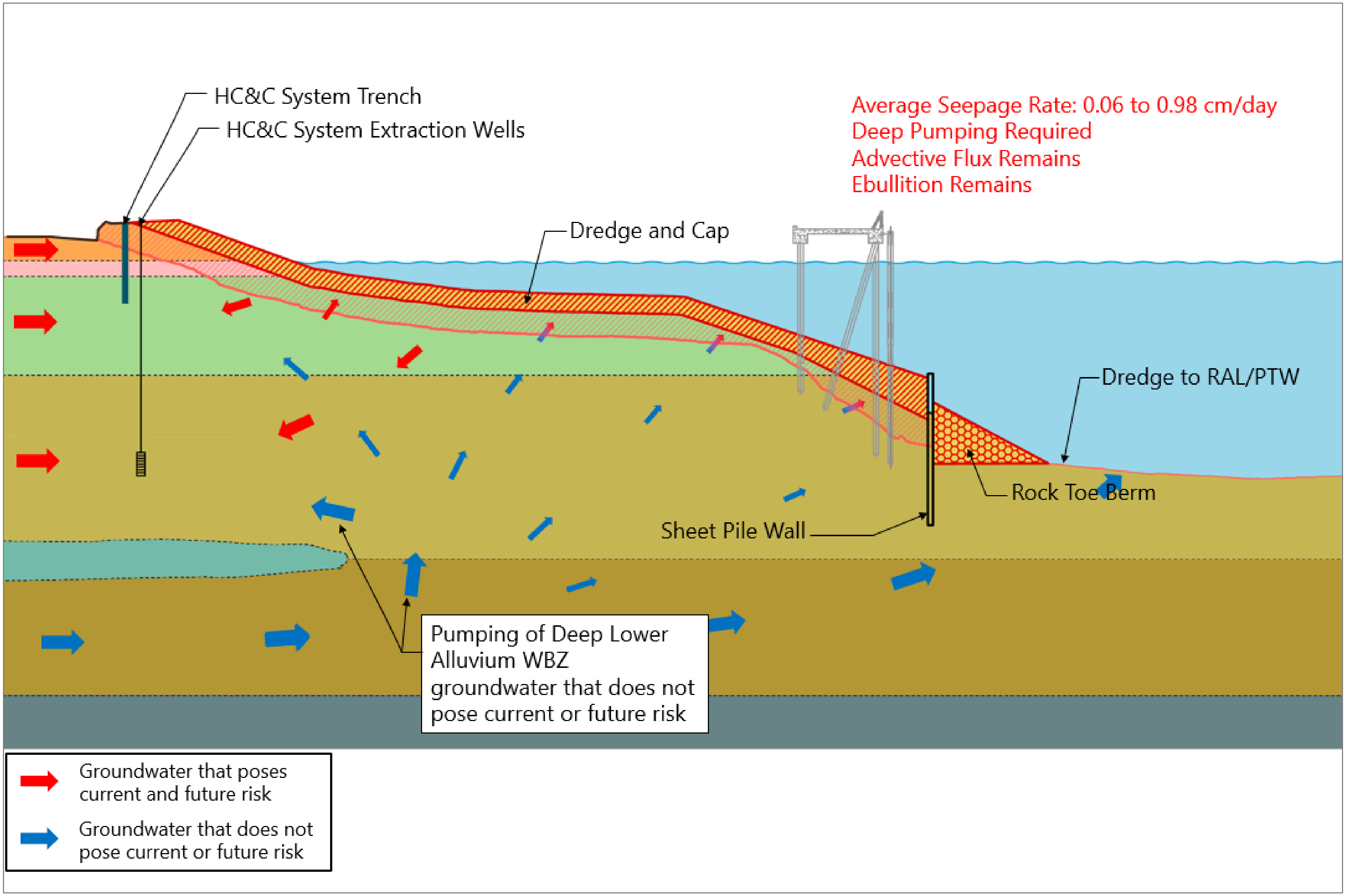

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Figure 3-12
Revised Dredge and Cap Design Upland Groundwater Migration Pathways with Modified HC&C System
Preferred Alternative Report
Gasco Sediments Cleanup Action

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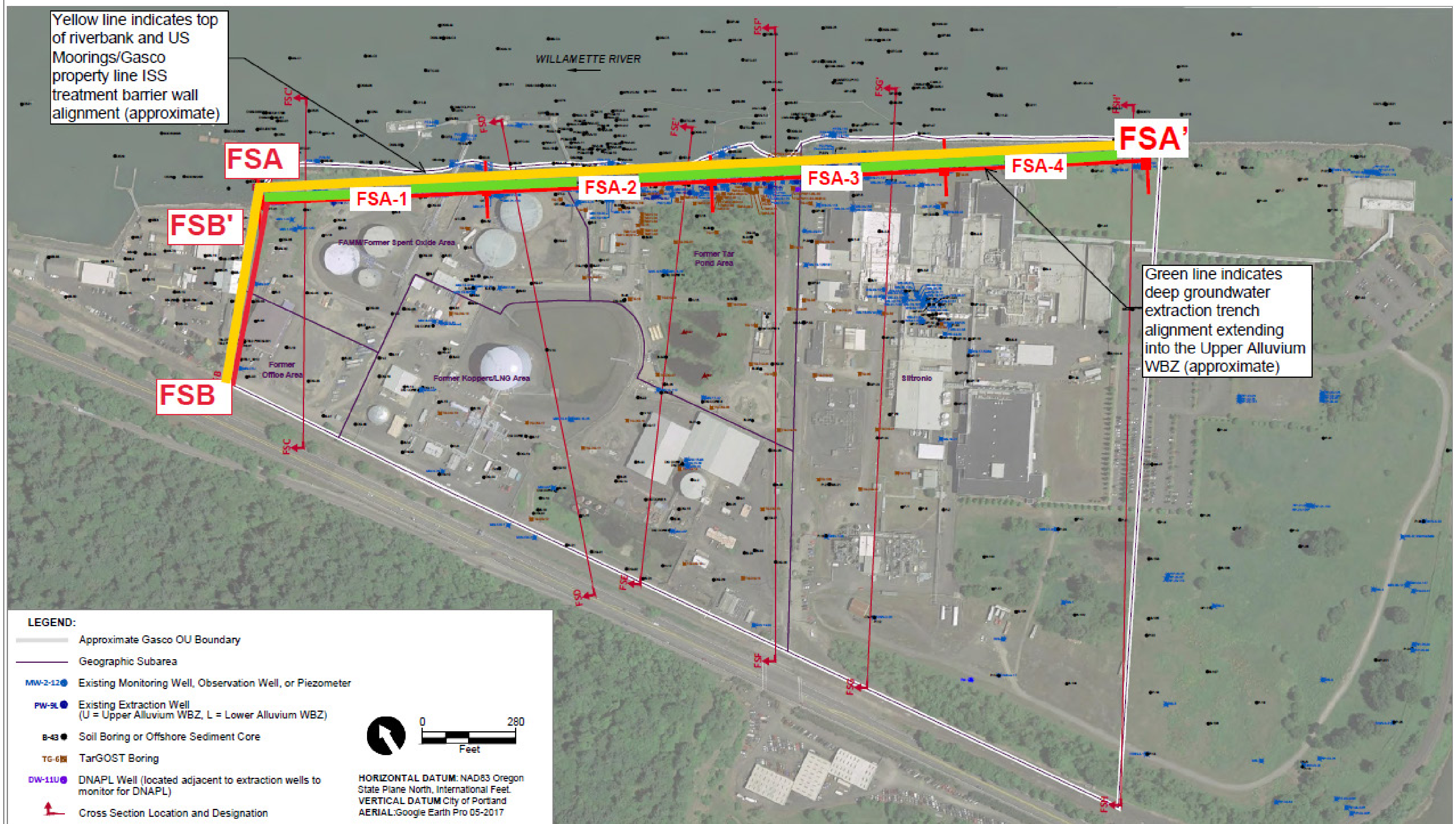

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Figure 3-13a

Upland ISS Treatment Barrier Wall and Deep Groundwater Trench Alignments

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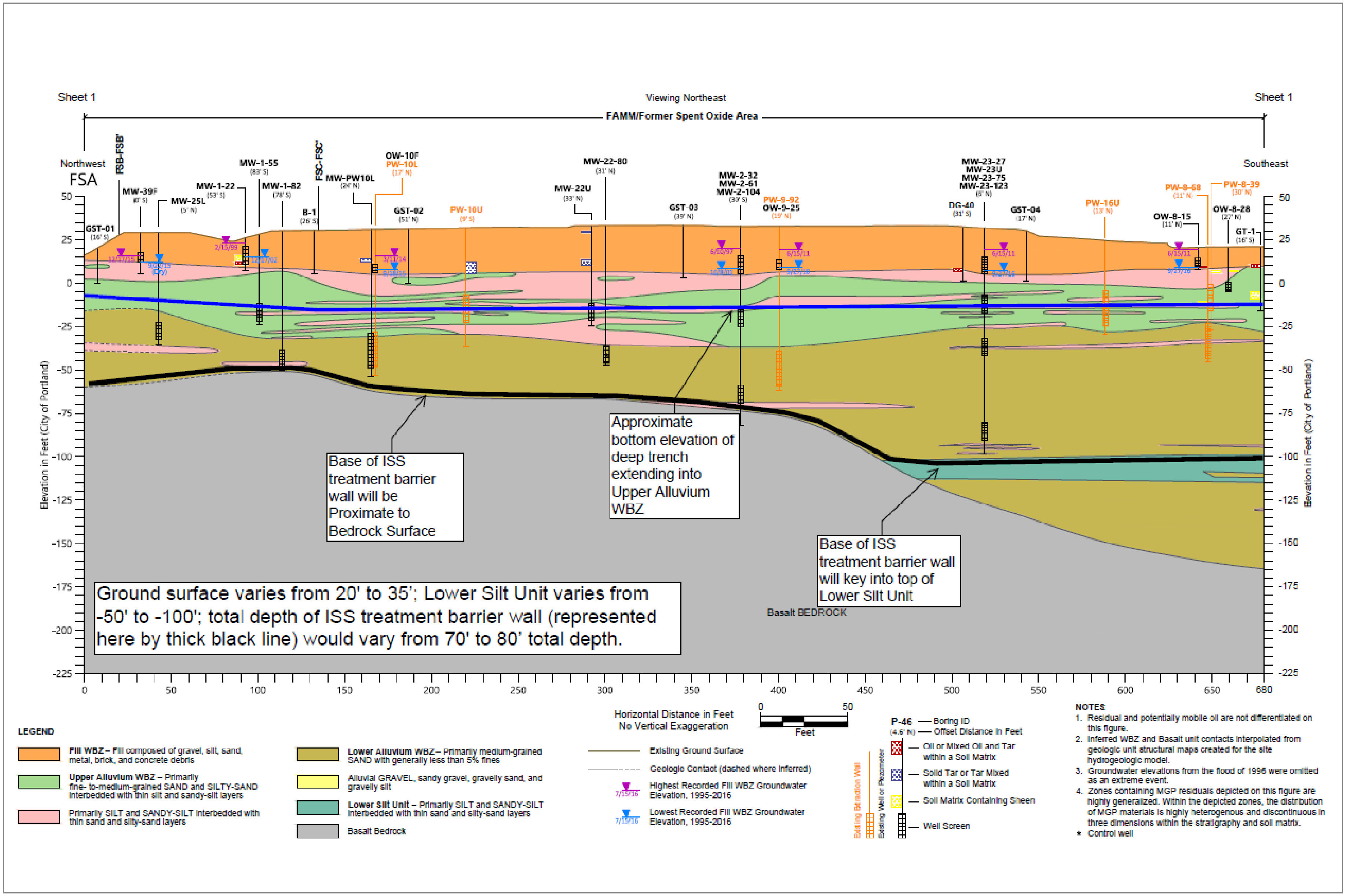

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Figure 3-13b
Cross-Section FSA-FSA'– Sheet 1 of 4
Preferred Alternative Report
Gasco Sediments Cleanup Action

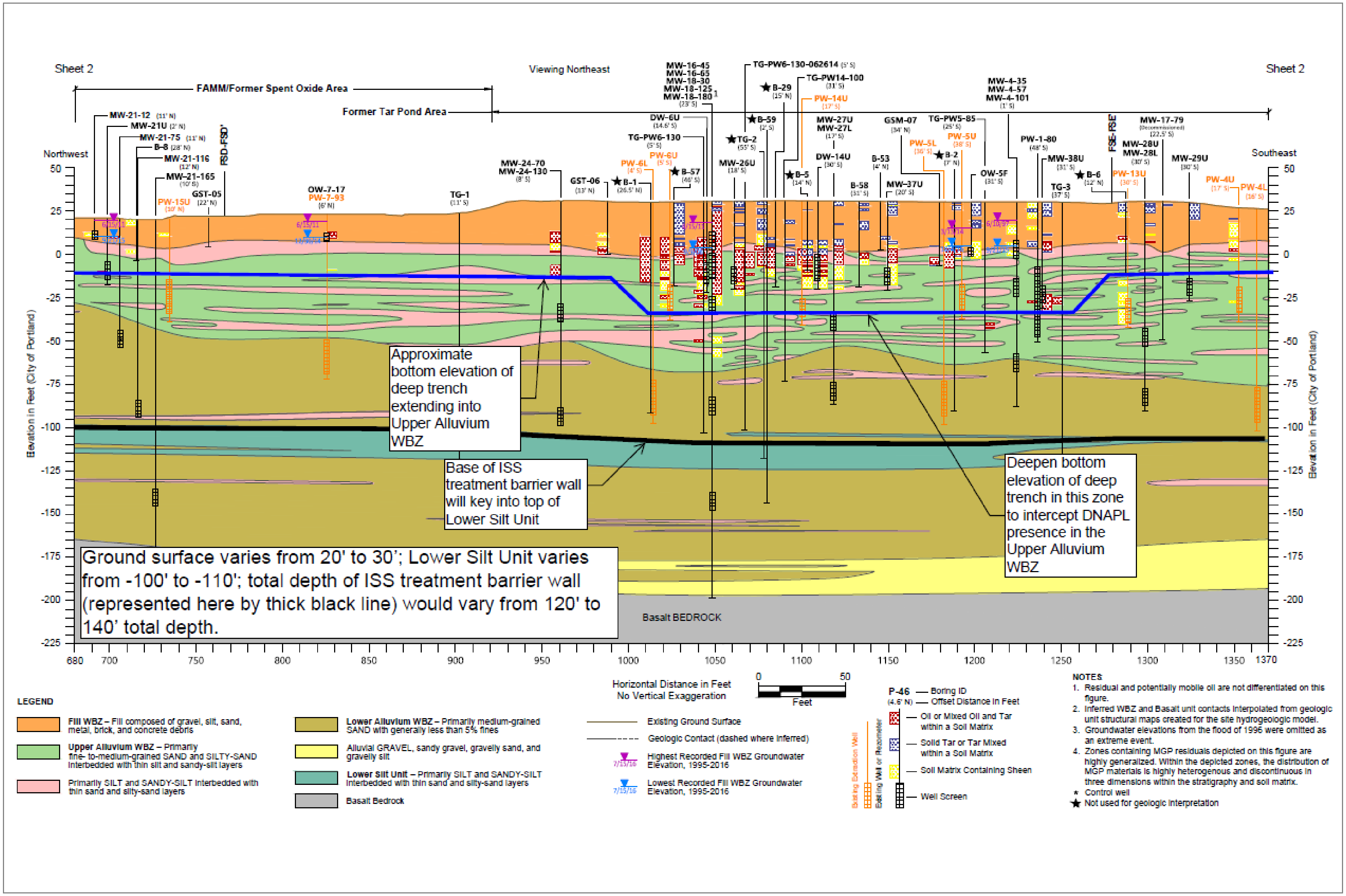

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Figure 3-13c
Cross Section FSA-FSA'– Sheet 2 of 4
Preferred Alternative Report
Gasco Sediments Cleanup Action

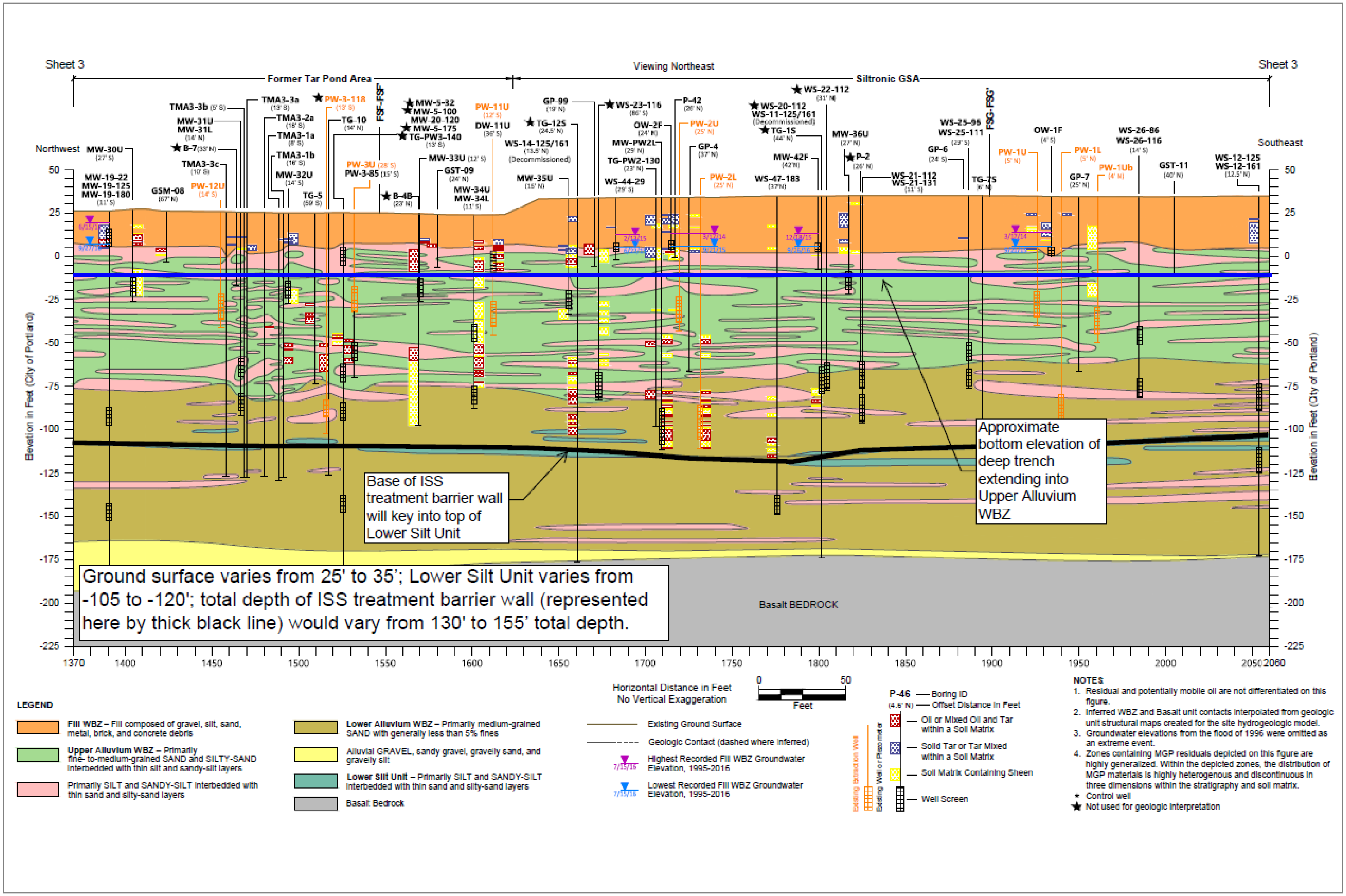

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Figure 3-13d
Cross Section FSA-FSA'– Sheet 3 of 4
Preferred Alternative Report
Gasco Sediments Cleanup Action

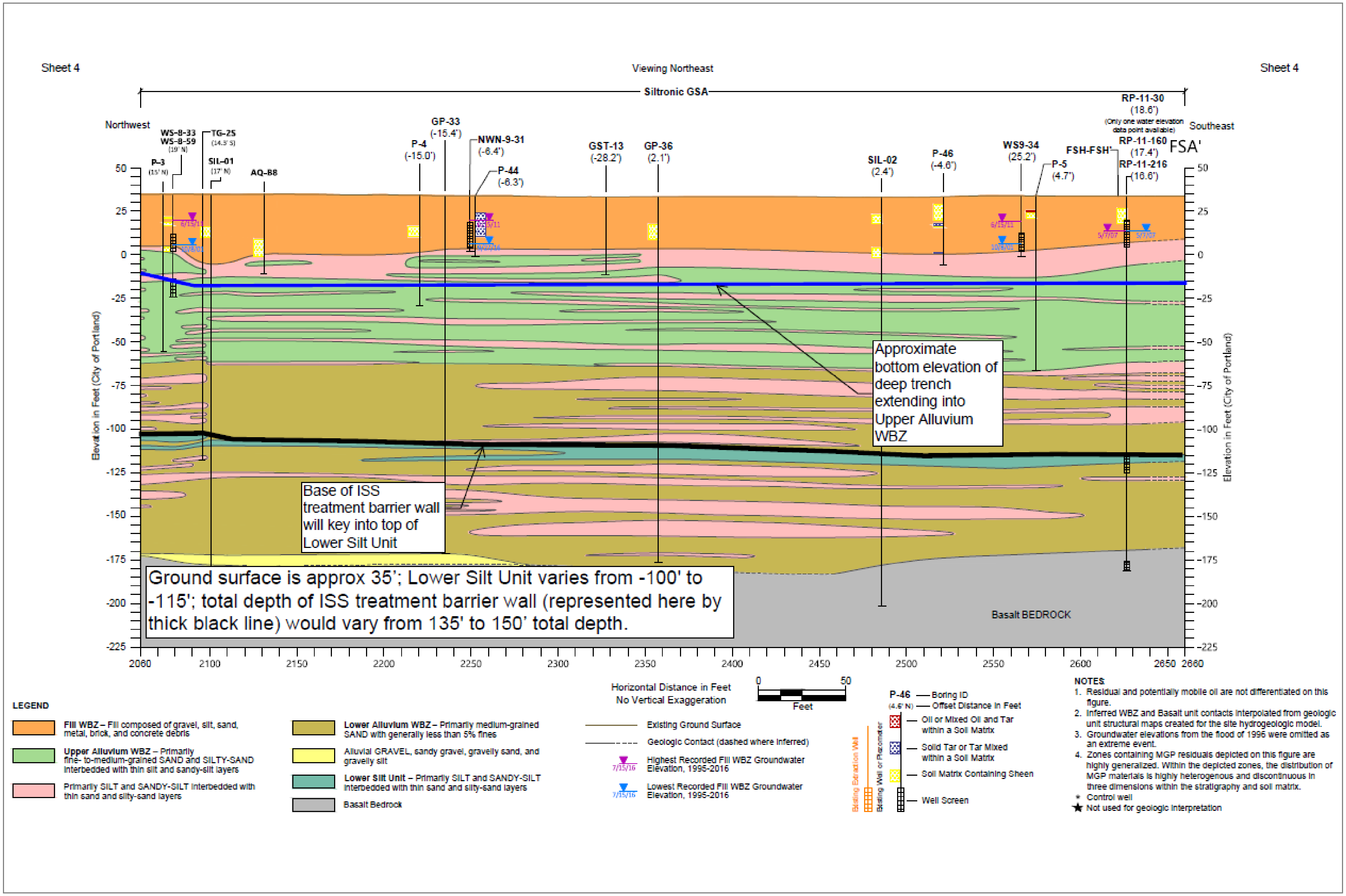

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Figure 3-13e
Cross Section FSA-FSA'– Sheet 4 of 4
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Gasco Sediments Cleanup Action

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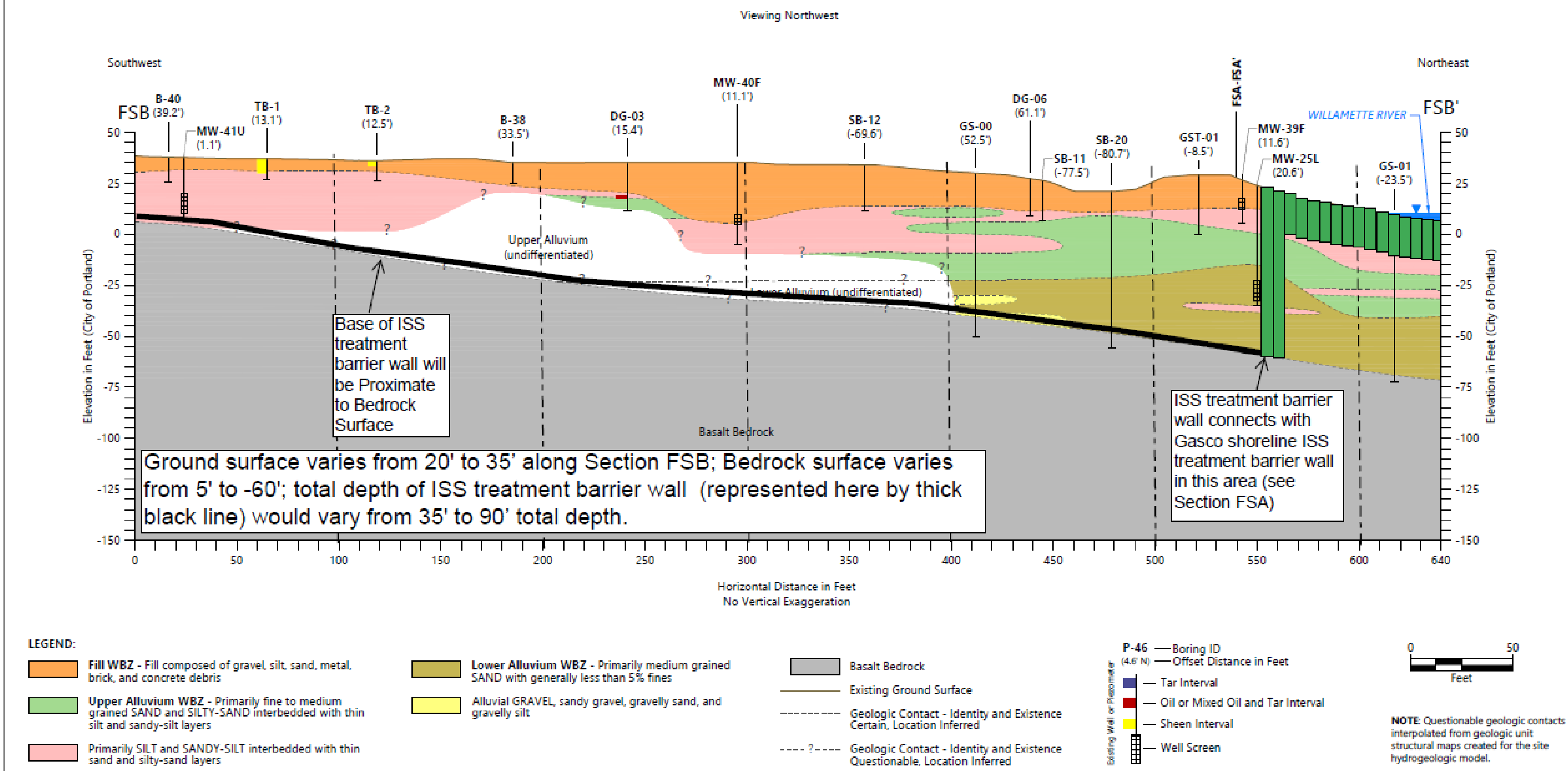

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Figure 3-13f
Cross Section FSB-FSB′
Preferred Alternative Report
Gasco Sediments Cleanup Action

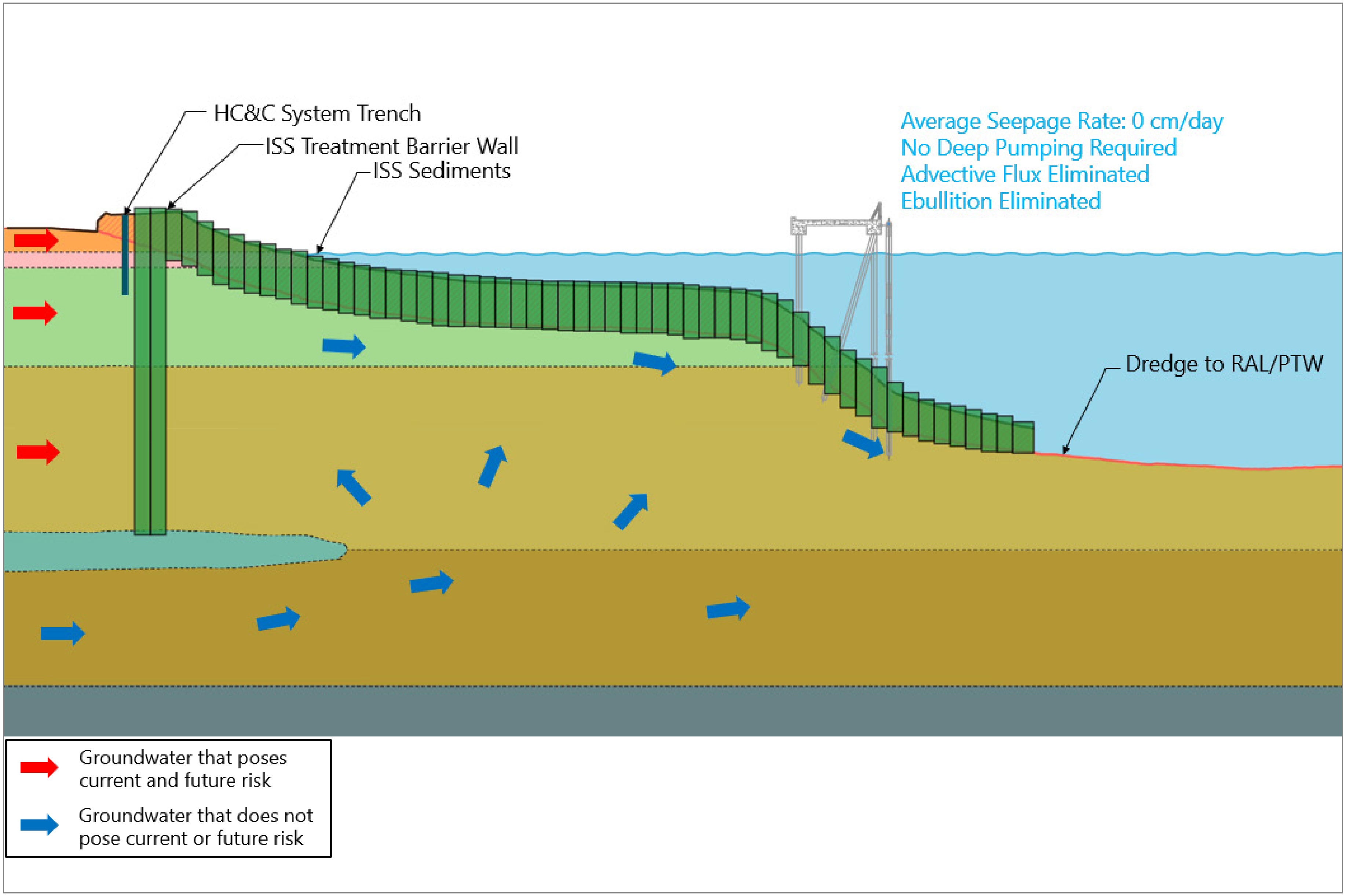

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Figure 3-14
Full Dredge and ISS Design Upland Migration Pathways with ISS Treatment Barrier Walls and Modified HC&C System
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Gasco Sediments Cleanup Action

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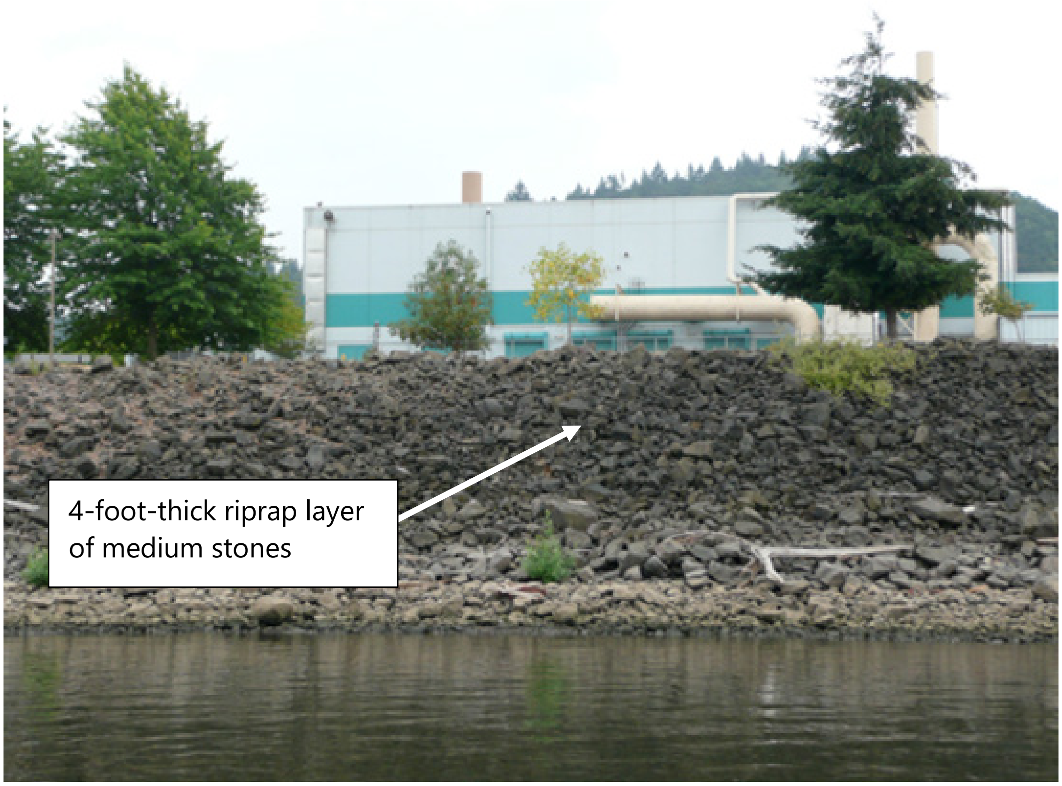

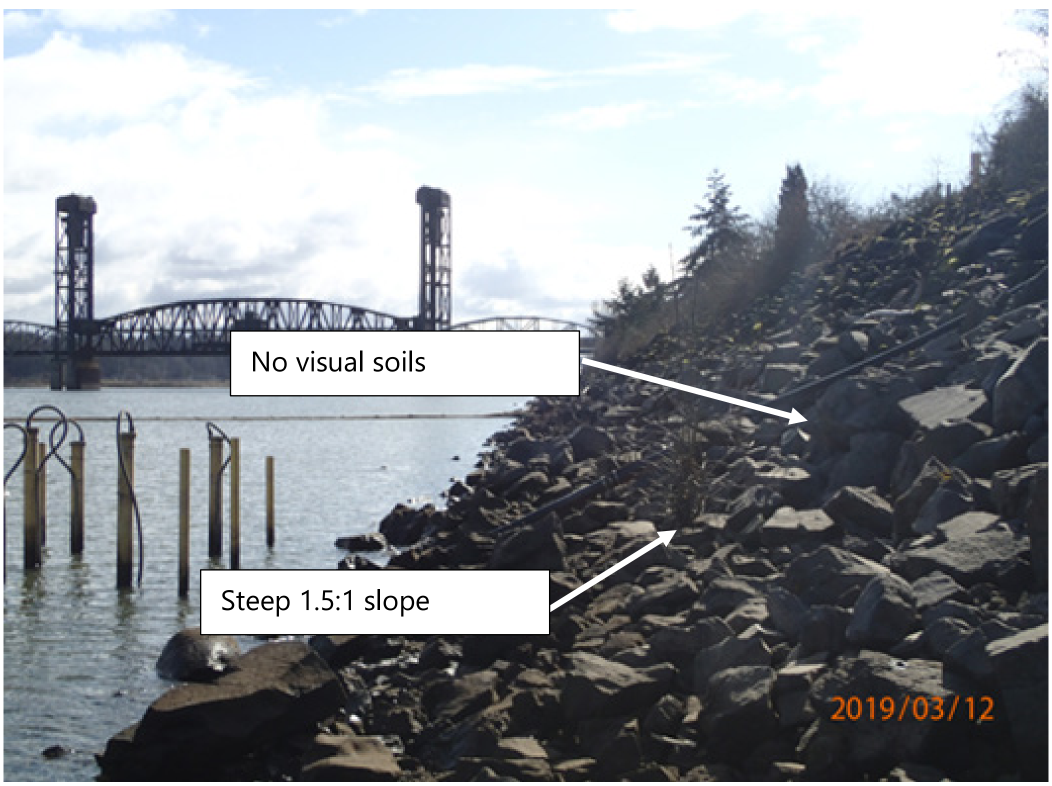

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Figure 3-15
Photographs of the Siltronic Riverbank
Preferred Alternative Report
Gasco Sediments Cleanup Action

Appendix A
Summary of Screened Out Revised Remedial Technologies

October 31, 2022
Gasco Sediments Cleanup Action

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Summary of Screened Out Revised Remedial Technologies

Prepared for U.S. Environmental Protection Agency, Region 10

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October 2022
Gasco Sediments Cleanup Action

Summary of Screened Out Revised Remedial Technologies

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Project Number: 000029-02.79

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FIGURE

ABBREVIATIONS

Combined BOD-PDR	*Combined Sediment Remedy Basis of Design and Preliminary Design Report*
DOC	depth of contamination
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
HC&C	hydraulic control and containment
ISS	in situ stabilization and solidification
NAPL	nonaqueous phase liquid
PAR	*Preferred Alternative Report*
PDI	pre-design investigation
Project Area	Gasco Sediments Site Project Area
PTW	principal threat waste
RAL	remedial action level
RAO	remedial action objective
ROD	*Record of Decision – Portland Harbor Superfund Site, Portland, Oregon*
WBZ	water-bearing zone

1 Introduction

This *Summary of Screened Out Revised Remedial Technologies* is Appendix A of the *Preferred Alternative Report* (PAR) for the Gasco Sediments Site Project Area (Project Area). The PAR summarizes and technically evaluates two revised sediment cleanup designs for the selected *Record of Decision – Portland Harbor Superfund Site, Portland, Oregon* (ROD; EPA 2017) remedy (Alternative F Mod) containing different combinations of remedial technologies developed by NW Natural to address U.S. Environmental Protection Agency (EPA) comments (EPA 2021) on the *Combined Sediment Remedy Basis of Design and Preliminary Design Report* (Combined BOD-PDR; Anchor QEA 2021) dated April 30, 2021. During development of the PAR, several other combinations of remedial technologies were evaluated and screened out from further consideration. This appendix describes these other designs and presents the rationale for why they were screened out.

2 Summary of Screened Out Remedial Technologies

This section summarizes the remedial technologies that were evaluated and ultimately screened out from further consideration during development of the revised remedial designs for the Project Area to address EPA comments on the Combined BOD-PDR (Anchor QEA 2021).

2.1 Revised Dredge and Cap Design with Full Removal of PTW-NAPL

EPA General Comments 1 and 16 and Specific Comments 60, 61, and 89 on the Combined BOD-PDR are associated with the preference for removal of principal threat waste-nonaqueous phase liquids (PTW-NAPL) to the maximum extent feasible throughout the entire Project Area. These comments are consistent with Remedial Action Objective (RAO) 1 in the *Statement of Work – Gasco Sediments Site* (SOW; EPA 2009), which states, "Removal of sediments containing substantial amounts of product (e.g., solid "tar" and/or NAPL) that may serve as potential future source of risk material, unless it can be shown that the costs of such removal are clearly disproportionate to the degree of risk reduction to be attained through physical removal as compared to other remedial options for the same material."

NW Natural previously evaluated the removal of the full vertical and lateral extents of PTW-NAPL throughout the Project Area in Alternative 5 of the *Draft Engineering Evaluation/Cost Analysis* (EE/CA) (Anchor QEA 2012) (Figure A-1). The Draft EE/CA concluded that Alternative 5 "do[es] not provide additional long-term risk reduction and [is] cost disproportionate relative to" alternatives that do not fully remove PTW-NAPL. To address EPA's comments on the Combined BOD-PDR, NW Natural reevaluated this Draft EE/CA finding, using the results of the comprehensive pre-design investigation (PDI) data gaps sampling performed in 2019 and 2020. This PDI included the collection of an additional 175 subsurface sediment cores within and along the perimeter of the Project Area that refined the lateral and vertical extents of PTW-NAPL, as shown in Figure 4-1 of the Combined BOD-PDR.

Evaluation of this more comprehensive dataset confirmed the Draft EE/CA findings that long-term risk reduction from removal of all PTW-NAPL would be cost disproportionate. The additional dredging in the Revised Dredge and Cap Design presented in the PAR would remove approximately 70% of the PTW-NAPL in the Intermediate, Shallow, and Riverbank Regions. Expanding dredging even further to include full removal of PTW-NAPL would require dredging the final 30% of the remaining PTW-NAPL, which is estimated at 2,000 cubic yards. This additional remaining PTW-NAPL is frequently located at significantly deep elevations below the mudline in very thin intervals and often overlain by feet of sediments containing no PTW-NAPL. Therefore, significant additional dredging of non-PTW-NAPL sediments would be required to remove these thin layers of deeper PTW-NAPL. The feasibility of this additional dredging is very low given slope stability and structural factors discussed in both the Draft EE/CA and the PAR. In addition, this additional dredge volume

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would need to be treated ex situ to sufficiently dewater the sediments to allow upland transport, transported via barge or rail, and disposal at the landfill. As demonstrated in the Draft EE/CA Alternative 5 and the ROD (EPA 2017), these dredging-related construction elements are significantly more costly than the placement of active cap layers. In addition, Section 6 and Appendix G of the Combined BOD-PDR (Anchor QEA 2021) demonstrate using Project Area-specific data that this additional PTW-NAPL can be protectively isolated in situ with an active cap, so dredging does not provide additional risk reduction.

As discussed in Section 3.1 of the PAR and consistent with the Draft EE/CA findings, expanding dredging to address the full extent of PTW-NAPL also presents the following significant design and implementability challenges, which would further increase the cost disproportionality with no additional risk reduction:

- **Disproportionate costs associated with Gasco Dock structure removal and replacement:** Based on the design and condition of the Gasco Dock, KPFF Consulting Engineers estimated that dredging should be limited to a maximum 10-foot depth in the vicinity of the Gasco Dock to minimize potential structural impacts. As depicted in Figure A-2, full removal of PTW-NAPL would require dredging deeper than 10 feet near the Gasco Dock, so the dock would need to be removed and replaced during remedy implementation. Cost estimates presented in Appendix J of the Draft EE/CA identified that full removal and replacement of the Gasco Dock would cost more than $10 million in 2012 dollars.
- **Disproportionate costs associated with extensive uplands encroachment, impacts to upland structures, and source control infrastructure:** PTW-NAPL is located at deep depths along the toe of the riverbank adjacent to both the Gasco and Siltronic properties. As depicted in Figure A-3, full removal of PTW-NAPL in these areas would result in significant excavation of the riverbank slope and extensive encroachment into the uplands due to the associated post-dredge 3 horizontal to 1 vertical (3H:1V) slope layback necessary to achieve long-term slope stability for capping. This significant upland encroachment would lead to the impacts to roadways, subsurface utilities, upland structures, and important source control infrastructure that is necessary to control offshore migration of contaminated groundwater. No specific cost estimates have been developed for these impacts, but the approximate extent of removal in the uplands shown in Figure A-1 shows the extensive encroachment on uplands structures that would result in significant costs for removal and replacement of these structures as well as business disruption for the duration of construction.

2.2 Hybrid Dredge and ISS Design

As discussed in the PAR, in situ stabilization and solidification (ISS) treatment was evaluated as a revised remedial technology to address EPA comments on the Combined BOD-PDR. The preferred Full Dredge and ISS Design in the PAR includes ISS treatment throughout the Intermediate, Shallow, and Riverbank Regions of the Project Area down to the full depth of contamination (DOC) defined by remedial action level (RAL) exceedances and the presence of PTW. During development of that design, the Design Team was asked to evaluate a hybrid design. The following hybrid configurations were evaluated:

- Dredge and cap in areas with substantial amounts of PTW-NAPL and ISS in the remaining areas.
- Dredge and cap in areas removed from structures and/or limited access and ISS in areas near structures and/or limited access.
- Dredge PTW-NAPL in shallow depth intervals (i.e., less than 5 feet) prior to ISS treatment of the remaining underlying sediments containing the remainder of RAL exceedances and the presence of PTW.

In each of these hybrid dredge and cap configurations, advective flux though contaminated sediments remained, driving the requirement for long-term management of caps and ebullition-facilitated transport of dense NAPL. In the third configuration, only a small amount of the total PTW-NAPL was present in the shallow depth intervals, and removal of this small volume would be disproportionately costly without providing additional risk reduction. This approach also results in the loss of an ISS layer above the deeper sediments with higher contaminant concentrations. This not only increases the risk of exposing sediments with higher contaminant concentrations during dredging, but it also means reduced sequestration of deeper sediments during treatment.

Effectively, the benefits of the Full Dredge and ISS Design approach were lost in the hybrid dredge and cap configurations, and these approaches offered no additional environmental benefit than the Revised Dredge and Cap Design that was carried forward. Further, these configurations would also complicate the design (e.g., potentially trigger additional dredge residual management and require additional equipment that would need to be staged and sequenced in a very small footprint) and lead to an increased potential for water quality impacts during dredging relative to ISS treatment of the full depth of RAL exceedances and the presence of PTW. Therefore, the hybrid configurations were screened out.

2.3 Full Dredge and ISS Design Without ISS Barrier Wall

The Design Team initially evaluated the Full Dredge and ISS Design without the top of riverbank ISS treatment barrier wall and with continued operation of the existing hydraulic control and containment (HC&C) system. However, as described below, evaluation of the upland groundwater migration pathways to the Project Area identified that this design would not be protective and would result in unnecessary impacts to and subsequent removal and treatment of upland groundwater that does not pose a current or future risk of sediment remedy recontamination.

A schematic illustration of the upland geologic units relative to the Navigation Channel, Intermediate, Shallow, and Riverbank Regions and associated DOC is shown in Figure A-4. The Full Dredge and ISS Design without an ISS treatment barrier wall was screened out for two significant reasons. First, the preferred design includes control for the Fill water-bearing zone (WBZ), which is currently uncontrolled by the existing HC&C system. Discharge from this WBZ would encounter the Riverbank Region ISS treated materials and mound to the top of riverbank area as shown in Figure A-5. Second, this configuration results in the unnecessary pumping and treatment of the Deep Lower Alluvium WBZ groundwater that does not pose a current or future risk of sediment remedy recontamination. Long-term operation of this configuration would result in unnecessary pumping and associated treatment of significant volumes of water that would not otherwise pose risk. To attempt to address these issues, the Design Team evaluated incorporation of the same deep trench design included in the Revised Dredge and Cap Design. However, this design modification did not address the second issue, as shown in Figure A-6. The Design Team then performed additional evaluations and determined that a deep ISS treatment barrier wall along the top of riverbank adjacent to the entirety of the Project Area would address both of these design issues and maintain consistency with the past EPA decisions described in the PAR. It should be noted that the ISS treatment barrier wall is required for other important design considerations unrelated to groundwater source control (see Section 3.3. of the PAR).

3 References

Anchor QEA, 2012. *Draft Engineering Evaluation/Cost Analysis*. Prepared for NW Natural. March 2012.

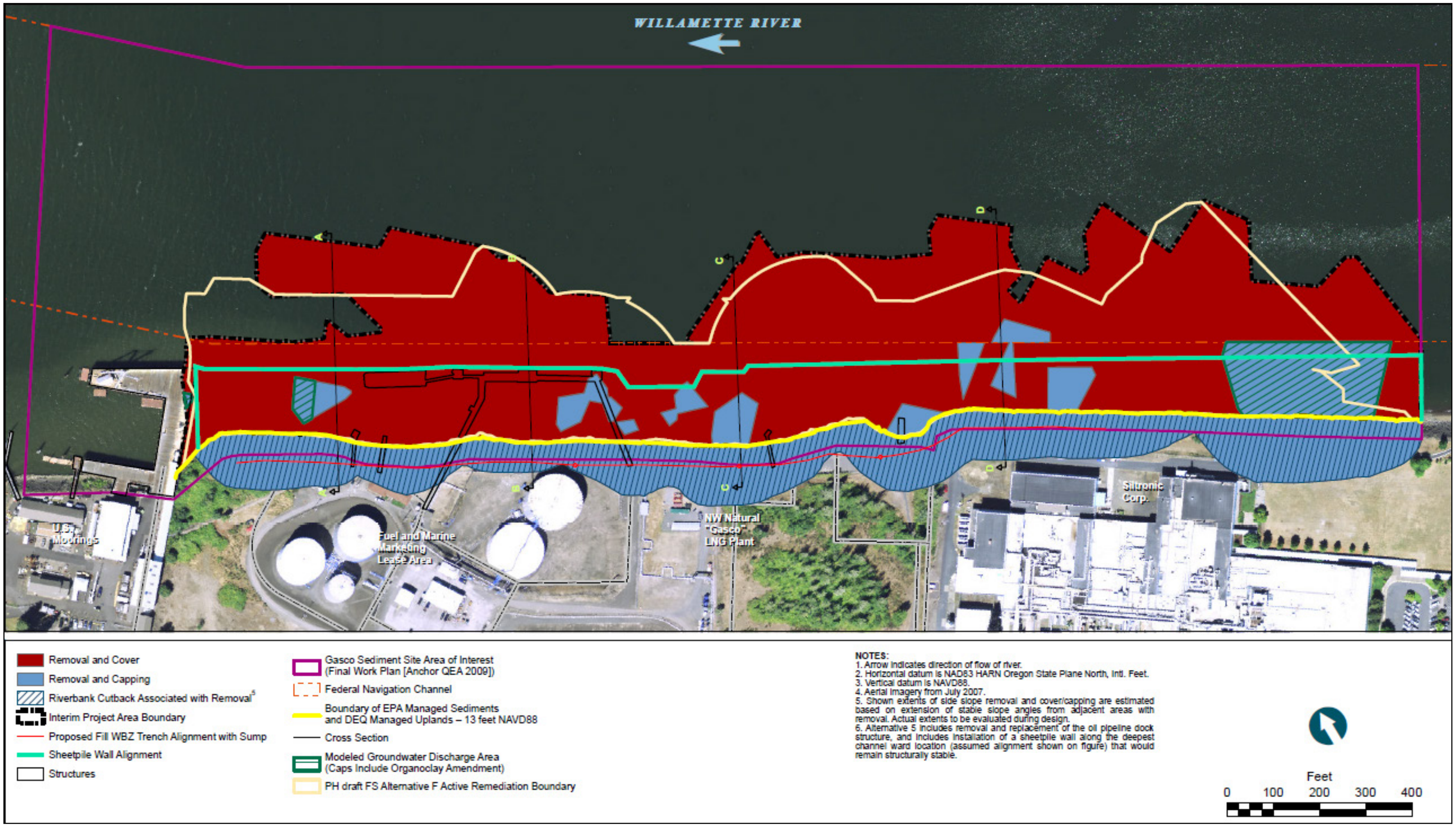
Anchor QEA, 2021. *Combined Sediment Remedy Basis of Design and Preliminary Design Report*. Gasco Sediments Cleanup Action. Prepared on behalf of NW Natural. April 30, 2021.

EPA (U.S. Environmental Protection Agency), 2009. *Statement of Work – Gasco Sediments Site*. U.S. Environmental Protection Agency Region 10. September 9, 2009.

EPA, 2017. *Record of Decision – Portland Harbor Superfund Site*. U.S. Environmental Protection Agency Region 10. January 2017.

EPA, 2021. *Comments on Combined Sediment Remedy Basis of Design and Preliminary Design Report*. Gasco Sediments Cleanup Action. August 17, 2021.

Figures



Note: This figure is a copy of Figure 6.1-5 of the EE/CA Report (Anchor QEA 2012).

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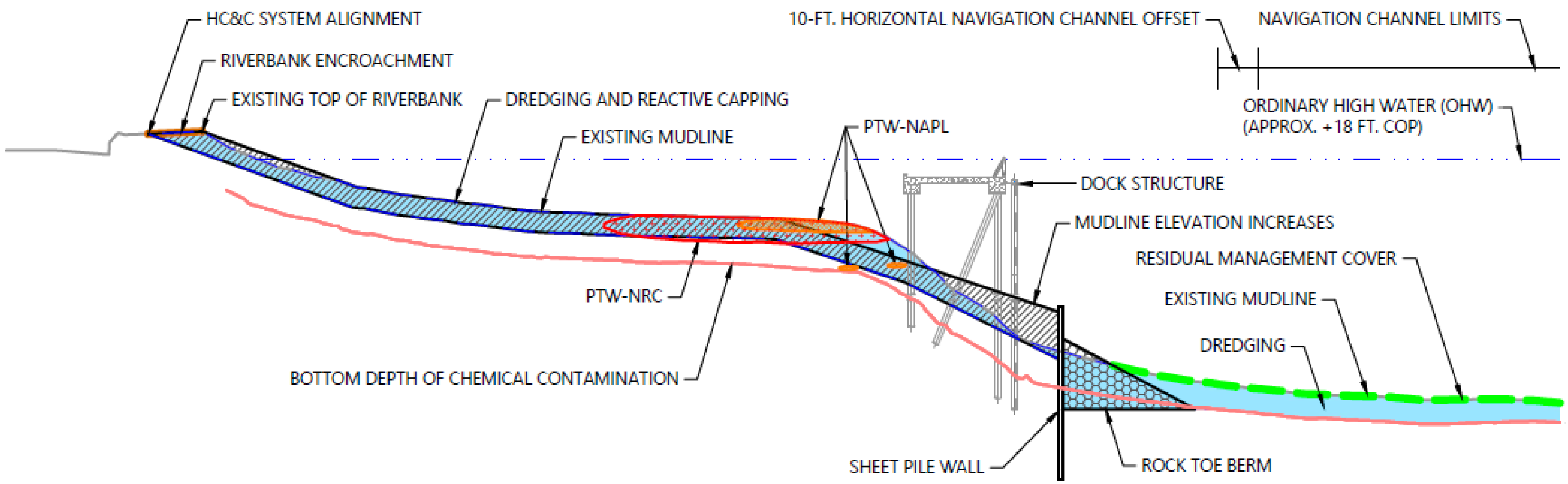
Figure A-1
Alternative 5 Remedial Footprint and Technology Assignments as Presented in the 2012 Draft Engineering Evaluation/Cost Analysis Report



NOTE: PTW-NAPL/NRC extents are conceptual for representative cross section presentation purposes.

Filepath: K:\Projects\0029-NW Natural Gas Co\Gasco Sediments_Pre-Remedial Design_Report Drafting\0029-WK-004b.2 (PTW-NAPL-EXTRA-Sections-PRESENTATION-Dredge Design).dwg Figure 2

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Figure A-2
Lateral and Vertical Extents of PTW-NAPL and PTW-NRC Adjacent to the Gasco Dock Structure

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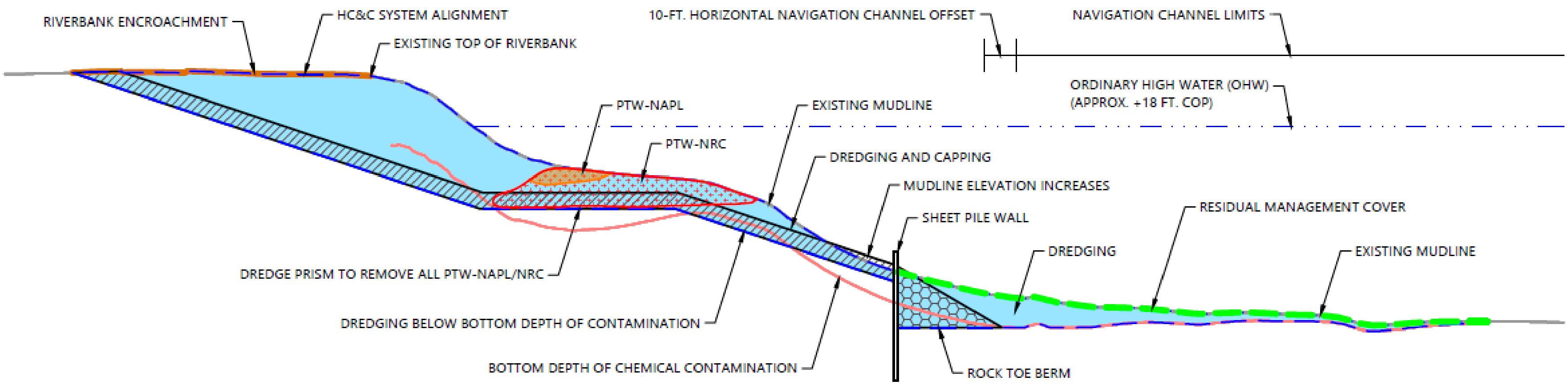
Gasco Sediments Cleanup Action



NOTE: PTW-NAPL/NRC extents are conceptual for representative cross section presentation purposes.

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Figure A-3

Lateral and Vertical Extents of PTW-NAPL and PTW-NRC with Full Removal Adjacent to the Siltronic Riverbank

Preferred Alternative Report
Gasco Sediments Cleanup Action

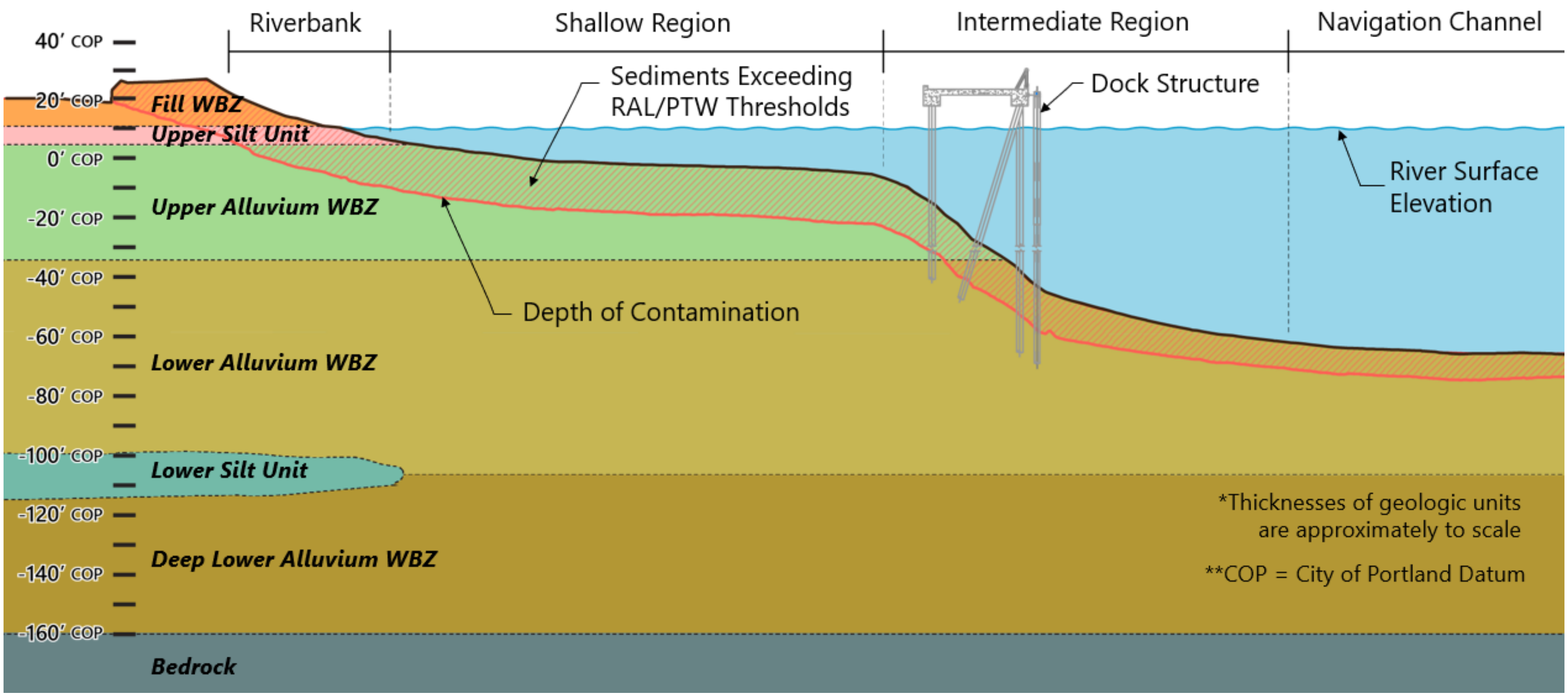

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Figure A-4
Summary of Hydrogeologic Units
Preferred Alternative Report
Gasco Sediments Cleanup Action

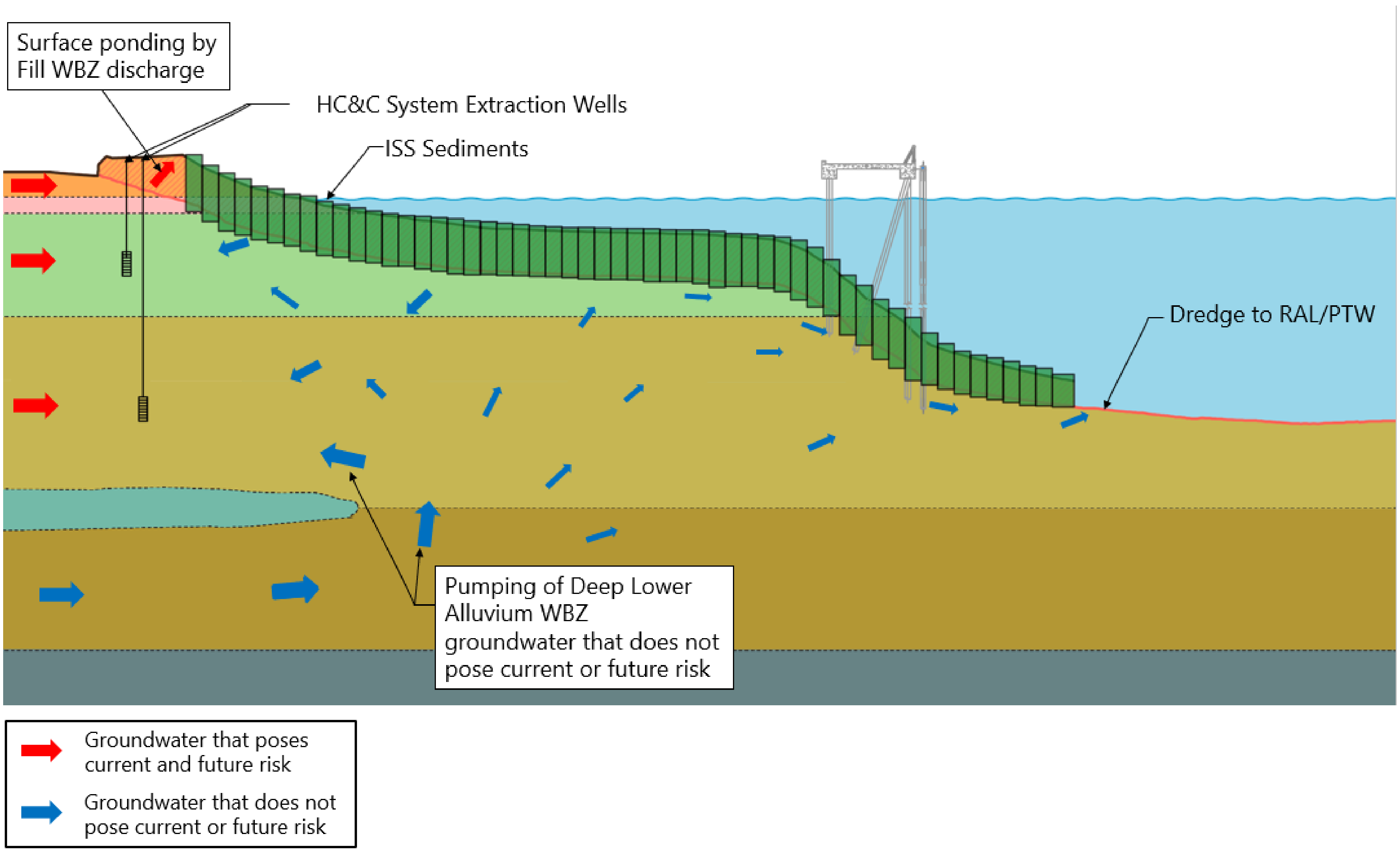

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Figure A-5

Full Dredge and ISS Design Upland Migration Pathways with Current HC&C System

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Gasco Sediments Cleanup Action

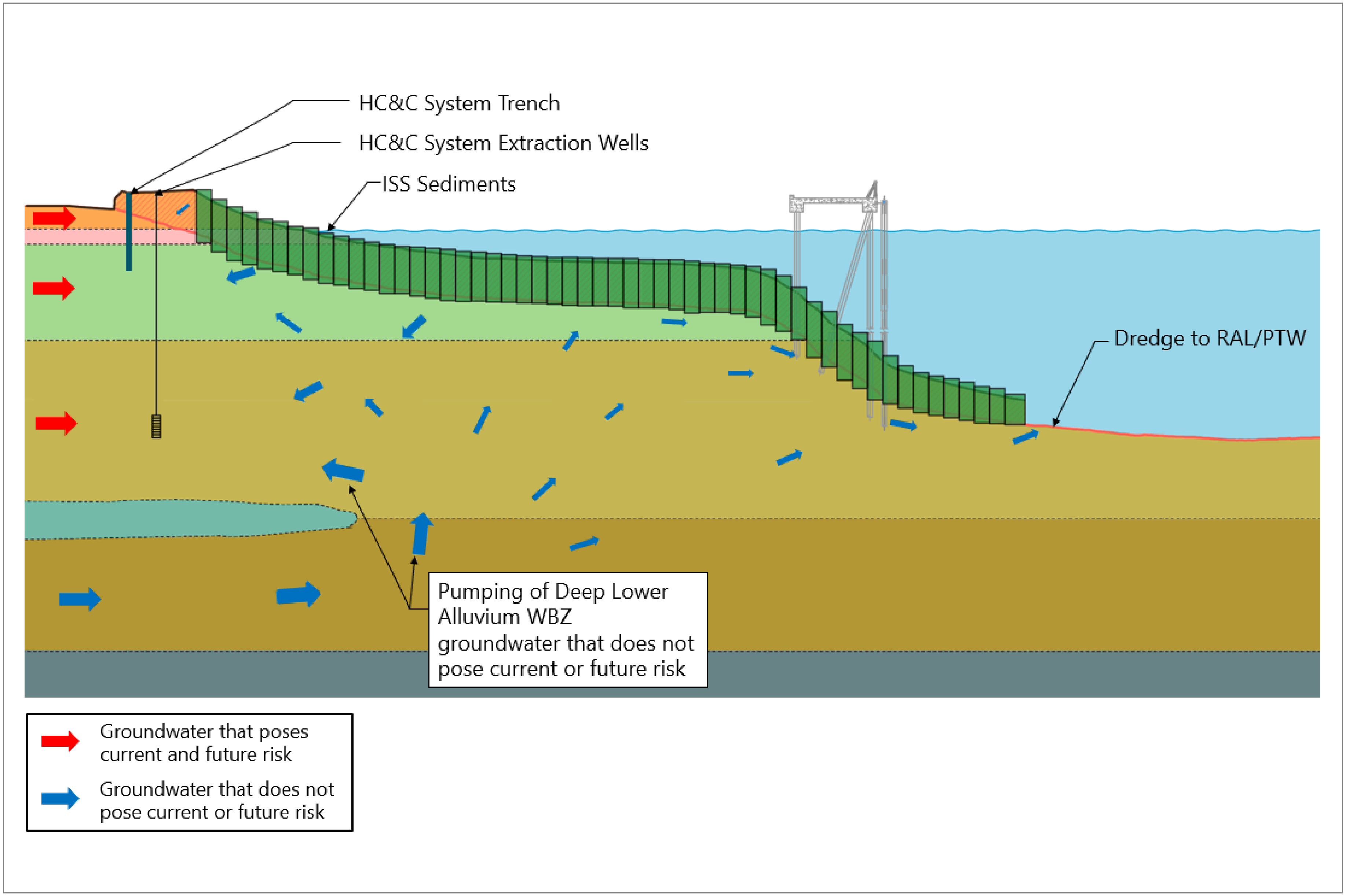

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Figure A-6
Full Dredge and ISS Design Upland Migration Pathways with Modified HC&C System

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Appendix B
Detailed Analysis of Remedial Designs

October 31, 2022
Gasco Sediments Cleanup Action

Detailed Analysis of Remedial Designs

Prepared for U.S. Environmental Protection Agency, Region 10

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October 2022
Gasco Sediments Cleanup Action

Detailed Analysis of Remedial Designs

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TABLE

ABBREVIATIONS

ARAR	Applicable or Relevant and Appropriate Requirement
BMP	best management practice
Combined BOD-PDR	*Combined Sediment Remedy Basis of Design and Preliminary Design Report*
DARD	*Detailed Analysis of Remedial Designs Report*
DMU	dredge management unit
DNAPL	dense nonaqueous phase liquid
DOC	depth of contamination
EPA	U.S. Environmental Protection Agency
FS	*Portland Harbor RI/FS Feasibility Study*
H:V	horizontal to vertical
HC&C	hydraulic control and containment
ISS	in situ stabilization and solidification
NAPL	nonaqueous phase liquid
NCP	National Contingency Plan
NRC	not reliably contained
PAR	*Preferred Alternative Report*
PGM	Portland Gas Manufacturing
Project Area	Gasco Sediments Site Project Area
psi	pounds per square inch
PTW	principal threat waste
RAL	remedial action level
RAO	remedial action objective
ROD	*Record of Decision – Portland Harbor Superfund Site, Portland, Oregon*
SES	Sevenson Environmental Services, Inc.
Siltronic	Siltronic Corporation
Site	Portland Harbor Superfund Site
USACE	U.S. Army Corps of Engineers
WBZ	water-bearing zone

1 Introduction

This *Detailed Analysis of Remedial Designs* (DARD) is Appendix B of the *Preferred Alternative Report* (PAR) for the Gasco Sediments Site Project Area (Project Area). The PAR summarizes and technically evaluates two revised sediment cleanup designs containing different combinations of remedial technologies that were developed by NW Natural to address the U.S. Environmental Protection Agency (EPA) comments on the *Combined Sediment Remedy Basis of Design and Preliminary Design Report* (Combined BOD-PDR; Anchor QEA 2021) dated April 30, 2021.

The *Record of Decision – Portland Harbor Superfund Site, Portland, Oregon* (ROD; EPA 2017) selected Alternative F Mod as the remedy for the Portland Harbor Superfund Site (Site). At EPA's request, NW Natural performed a comparative analysis of the two designs carried forward into the PAR using the National Contingency Plan (NCP; EPA 1994) Threshold Criteria and Primary Balancing Criteria. Modifying Criteria were considered by EPA in development of the ROD and are not included in this analysis, which simply compares two technology assignment designs developed pursuant to the ROD.

The primary difference between the two revised sediment cleanup designs is the treatment method. The Revised Dredge and Cap Design presented in the PAR uses amended capping (i.e., reactive capping). This technology indirectly treats buried sediments with contaminant concentrations that exceed the ROD remedial action levels (RALs) and contain principal threat waste (PTW) that cannot be feasibly dredged without highly disproportionate impacts to existing upland and in-water structures, geotechnical risk to slope stability, and other costs relative to the degree of risk reduction that would be attained through physical removal of the buried contamination. Reactive capping is required to prevent contaminant migration to the river via the advective flux and ebullition pathways and relies on ongoing upland hydraulic controls to reduce groundwater flux through the sediment column for effectiveness.

The Full Dredge and In Situ Stabilization and Solidification (ISS) Design replaces the nearshore dredging and reactive caps with ISS. ISS is acknowledged in both the ROD and the NCP as an effective treatment technology, and it was identified as a representative process option in EPA's *Portland Harbor RI/FS Feasibility Study* (FS; EPA 2016). The application of ISS in the Project Area allows the design to fully treat all sediment contamination that exceeds RALs and contains PTW. Upland hydraulic controls are not required to reduce advective flux through the treated sediments, but a top of riverbank ISS treatment barrier wall is included that provides seismic structural stability, a physical barrier to any potential future dense nonaqueous phase liquid (DNAPL) migration from the uplands toward the river, and a physical system that isolates contaminated upland groundwater from the sediment remedy and surrounding areas. It also prevents deeper groundwater that does not pose a current or future potential risk.

Technical details for the two revised designs are presented in the PAR. In summary, the key elements of the two revised designs are described as follows:

- **Revised Dredge and Cap Design:** This design includes the following: 1) full dredging to the depth of contamination (DOC) based on the bottom depth of RAL exceedances and PTW (including PTW-nonaqueous phase liquids [NAPL], PTW-not reliably contained [NRC], and PTW-highly toxic threshold exceedances) in the Navigation Channel Region and placement of cover materials for dredge residual management; 2) revised dredge and active cap technologies that maximize the additional feasible dredging of PTW-NAPL/NRC, indirectly treat contamination left in place, and minimize cap on grade and net mudline elevation increases; and 3) modifications to the existing upland hydraulic control and containment (HC&C) system to minimize the potential for long-term sediment recontamination in the Project Area via upland contaminant migration pathways and optimize the long-term operations and maintenance of the system.
- **Full Dredge and ISS Design:** This design includes the following: 1) consistent with the Revised Dredge and Cap Design, full dredging to the DOC in the Navigation Channel Region followed by placement of cover materials for dredge residual management; 2) ISS to the DOC throughout the Intermediate, Shallow, and Riverbank Regions to directly treat 100% of the RAL exceedances and PTW in situ within the Project Area and eliminate the advective flux and ebullition-facilitated DNAPL transport pathways; and 3) a top of riverbank deep ISS treatment barrier wall to isolate contaminated upland groundwater and DNAPL from the river, provide seismic structural stability, and prevent deep groundwater that does not present a current or future potential risk from becoming contaminated.

The remainder of this DARD provides a detailed analysis of these two revised designs against the two Threshold Criteria and five Primary Balancing Criteria required by the NCP and includes a comparison of the relative performance of each design against those criteria. These analyses are presented as updates to the ROD Section 12 summary of comparative analysis findings for the EPA-selected Alternative F Mod remedy. A summary of the comparative analysis findings for each design and criterion is presented in Table B-1. This summary demonstrates that the Full Dredge and ISS Design has a superior performance for each of the balancing criteria compared to the Revised Dredge and Cap Design.

2 Detailed Analysis of Designs

This section provides a detailed comparison of the two revised designs that apply different combinations of treatment technologies against the NCP Threshold and Primary Balancing Criteria. Both of these designs are consistent with EPA's ROD and selected Alternative F Mod remedy[1] and only differ in that one design applies indirect treatment of contamination left in place via reactive capping in the Nearshore, Shallow, and Riverbank Regions, whereas the other applies ISS to directly treat 100% of the contamination. Both of these treatment technologies were screened and retained by EPA as representative process options in the ROD. To maintain consistency with the ROD, the detailed analysis of the two revised designs is presented for each of the expected outcomes at construction completion for each Threshold and Primary Balancing Criterion presented in the ROD Table 22 detailed comparative analysis of remedial alternatives.

2.1 Threshold Criteria

The first two NCP criteria are known as "Threshold Criteria" because they are the minimum requirements that each response measure must meet to be eligible for selection as a remedy. As documented in the following paragraphs, the ROD determined that Alternative F Mod achieved both threshold criteria. The Revised Dredge and Cap Design and Full Dredge and ISS Design are both configured using technologies and process options that EPA retained in the ROD and offer the same level of protectiveness over similar area and scope and compliance with Applicable or Relevant and Appropriate Requirements (ARARs) as the technologies and process options assumed for Alternative F Mod. Therefore, both designs achieve the Threshold Criteria. A short description of the Threshold Criteria is presented in the following paragraphs. This conclusion is also supported by the results of the comparison of the Primary Balancing Criteria presented in Section 2.2.

Overall Protection of Human Health and the Environment

ROD Section 12.1 defines this criterion as follows:

> "Overall protection of human health and the environment addresses whether each design provides adequate protection of human health and the environment and

[1] EPA's ROD evaluated the remedial technologies and process options included in the Revised Dredge and Cap Alternative and Full Dredge and ISS Alternative (i.e., dredging [mechanical dredging process option], capping [reactive capping process option, which is a form of in situ treatment (see FS Section 3.2.2.1; EPA 2016)], and solidification and stabilization [ISS in situ treatment process option]) against the effectiveness, implementability, and cost criteria in Section 2.4 of the EPA FS (EPA 2016), and all were designated as representative process options for cleanup areas containing conditions prevalent in the Project Area. The ROD used these retained technologies and selected representative process options to develop the FS-level remedial technology assignments throughout the Site, including the Project Area. As stated in Section 10.1.1.2 of the ROD, "Given the NCP's expectation for treatment of PTW, in-situ treatment technologies were considered for areas containing PTW [principal threat waste]" (EPA 2017). Treatment options considered included ISS, which was specifically identified as a feasible technology to "address PTW underneath and around pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities that remain intact" (EPA 2017). Further, ROD Section 10.1.1.5 specifically states, "Solidification/stabilization has been effectively used for Gasco wastes and is effective at reducing the mobility of contaminants" (EPA 2017).

> describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls […] All remaining alternatives [except the Alternative A – No Action Alternative] are expected to be protective of human health by eliminating, reducing, or controlling risks from direct contact or ingestion of contaminated media and fish/shellfish through dredging, capping, treatment of contaminated groundwater and PTW, ENR, MNR and ICs […] Additionally, Alternatives I, E, F Mod, F, and G, in order with less reliance on MNR, would be expected to be protective of the environment and ecological receptors by eliminating, reducing, or controlling risks from direct contact or ingestion of contaminated media and fish/shellfish through dredging, capping, treatment of contaminated groundwater and PTW, ENR, and MNR." (EPA 2017)

Because the entire Project Area will be actively remediated for both revised designs, either design will attain the ROD cleanup levels at construction completion without reliance on enhanced natural recovery or monitored natural recovery. Either design will therefore exceed the interim target for overall protectiveness set in the ROD and be overall protective of each risk exposure pathway factor for removal action objectives (RAOs) 1 through 9 identified in ROD Table 22.

Compliance with ARARs

ROD Section 12.2 defines this criterion as follows:

> "Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other federal and state environmental statutes or provides a basis for invoking a waiver" (EPA 2017).

Alternatives B through I, including Alternative F Mod, had common ARARs associated with the construction of the alternative because they all use essentially the same remedial technologies with varying degrees of area and scope. Because Alternative F Mod complies with each of the chemical-specific, location-specific, and action-specific ARARs, and the two revised designs include implementation of best management practices (BMPs) for water quality protection in the same areas of the Project Area using ROD-retained technologies and process options, both designs also meet this criterion. However, the Full Dredge and ISS Design is more likely to avoid potential water quality impacts than the Revised Dredge and Cap Design. As discussed in Section 3.5 of the PAR, the Full Dredge and ISS Design minimizes the exposure of untreated contaminated sediments to the water column during construction so that they only occur during the ISS treatment of surface sediments. Deeper sediments will be sequestered from the water column as treatment is extended to the DOC. Alternatively, the Revised Dredge and Cap Design includes the exposure of contaminated sediments containing PTW-NAPL to the water column with each dredge bucket pass.

The Full Dredge and ISS Design will employ the same BMPs during construction but rely on them less to maintain compliance and is therefore determined to be significantly more effective at complying with this criterion.

2.2 Primary Balancing Criteria

The five Primary Balancing Criteria are used to identify major trade-offs between remedial designs, and these trade-offs are ultimately balanced to identify the preferred design. This section summarizes the analysis findings for each of these five criteria for the expected outcomes at construction completion identified in ROD Table 22.

Long-Term Effectiveness and Permanence

Section 12.3 of the ROD defines this criterion as follows:

> "Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls." (EPA 2017)

An analysis of the expected outcomes at construction completion identified in ROD Table 22 affecting the long-term effectiveness and permanence for the Revised Dredge and Cap Design and the Full Dredge and ISS Design includes the following:

- **Magnitude of Residual Risk (Post-Construction Risk) and Migration of Groundwater to Sediment/Surface Water – RAOs 4 and 8 (Contaminated Groundwater Plumes not Addressed):** As discussed in Sections 3.1 and 3.5 of the PAR, the Revised Dredge and Cap Design does not eliminate contaminated groundwater advective flux through the capped contaminated sediments. Although a robust active cap can be designed to control these long-term contaminant migration pathways (as detailed in Section 6 of the Combined BOD-PDR), there exists some potential risk of long-term releases (e.g., compromised cap integrity due to seismic events, physical disturbance, or chemical isolation breakthrough). Any disruption of the HC&C system, including equipment or long-term power failures, has the potential to impact the long-term groundwater advective flux pathway.

  Alternatively, the Full Dredge and ISS Design eliminates the advective flux through the directly treated sediments and eliminates the contaminant migration pathways from the uplands to sediments in the Project Area.

- **Direct Contact with Sediments – RAO 1; Allowable Fish Meals at Construction Completion – RAO 2; Direct Contact Surface Water – RAO 3 (Risk at Construction Completion vs. Risk at Cleanup Level for each Contaminant of Concern); Benthic Organisms – RAO 5 (Benthic Areas not Addressed); Consumption of Prey – RAO 6; and Direct Contact Surface Water – RAO 7:** Both revised designs will result in active remediation over the same footprint throughout the Project Area that will lead to a newly constructed, clean surface sediment layer immediately following post-construction. Therefore, both designs equally achieve these expected outcomes at construction completion.
- **Adequacy and Reliability of Controls:**
  - **Advective Flux and Ebullition-Facilitated DNAPL Contaminant Migration Pathways:** As discussed in Sections 3.1 and 3.5 of the PAR, the Revised Dredge and Cap Design is reliant on long-term cap chemical isolation and operation of the HC&C system to be protective of continued upland groundwater advective flux through contaminated sediments left in place and does not eliminate the ebullition-facilitated transport of DNAPL pathway. Although a robust active cap can be designed to control these long-term contaminant migration pathways (as detailed in Section 6 of the Combined BOD-PDR), there exists some potential risk of long-term releases (e.g., compromised cap integrity due to seismic events, physical disturbance, or chemical isolation breakthrough). Any disruption of the HC&C system, including equipment or long-term power failures, has the potential to affect cap performance.

    Alternatively, the Full Dredge and ISS Design treats 100% of sediments exceeding the RALs and containing PTW, is not reliant on the HC&C system to control advective flux within the sediments, eliminates the ebullition-facilitated transport of DNAPL pathway, and prevents long-term sediment recontamination associated with these contaminant migration pathways.
  - **Seismic-Induced Remedy Failure:** As discussed in Section 3.5 of the PAR, the Revised Dredge and Cap Design does not meet the target seismic factor of safety of 1.1 for slope stability and would be susceptible to liquefaction-induced settlement and deformation during larger seismic events. If cap failure were to occur, contaminated sediments that are capped in place could become exposed during large seismic events. Due to multiple constraints, the current Project Area mudline elevations cannot be reconfigured to establish a target seismic factor of safety of 1.1, but the revised Dredge and Cap Design does present the most stable slope configuration feasible for its technology assignments.

    Alternatively, the Full Dredge and ISS Design includes an integrated top of riverbank ISS treatment barrier wall that would be structurally connected to the riverbank and in-water sediment ISS treatment zone extending further offshore. This wall would act as a key into the upland soils at depths up to approximately 155 feet below ground surface. In addition, the ISS treatment layer would be designed to achieve a target strength of a minimum 50 pounds per square inch (psi), which is significantly greater than the untreated in situ sediments. Therefore, this design would be less likely to experience liquefaction-induced settlement and deformation during larger seismic events as compared to Revised Dredge and Cap Design.

– **Potential for Riverbank Impacts Due to Climate Change:** As discussed in Section 3.5 of the PAR, EPA has expressed that flooding and sea level rise are currently the forerunning sediment remedy concerns due to climate change. The potential for cap disturbances or failure during flood conditions is therefore a climate change consideration for the Revised Dredge and Cap Design.

  Alternatively, the Full Dredge and ISS Design includes treatment of the entirety of the riverbank to a design strength of a minimum 50 psi. Therefore, the riverbank will not be subject to damage or failure during floods or sea level rise over time.

– **Potential for Long-Term Recontamination from Upland Sources:** As discussed in Section 3.3 of the PAR, the Revised Dredge and Cap Design relies on the continued operation of the upland HC&C system to prevent migration of Upper and Lower Alluvium Water-Bearing Zone (WBZ) groundwater posing risk to the river and also reduces the magnitude of advective flux to support cap effectiveness. This system would need to be expanded to address Fill WBZ groundwater impacts. The protectiveness of this design relies on continuous long-term operation of an expanded HC&C system to prevent long-term recontamination from upland groundwater via advective flux. The HC&C system does not address the potential for DNAPL migration. The HC&C system also pumps groundwater that does not pose current or future potential risk from the upland Deep Lower Alluvium WBZ, which is hydraulically separated from the Upper and Lower Alluvium WBZs by the lower silt unit, to reduce advective flux of groundwater through the contaminated sediments.

  Alternatively, the Full Dredge and ISS Design includes a top of riverbank ISS treatment barrier wall as an integral and critical component of the design. This eliminates the potential for sediment remedy recontamination from all upland contaminant migration pathways, including both contaminated groundwater and potentially mobile DNAPL.

– **Green Remediation:** As discussed in Section 3.5 of the PAR, the Revised Dredge and Cap Design requires extensive operations, monitoring, and maintenance associated with HC&C system capture and treatment of significant volumes of groundwater not posing present or future potential risk that become impacted when pumped from the Deep

Lower Alluvium WBZ. These activities would result in significant material and energy consumption over the life of the project.

Alternatively, the Full Dredge and ISS Design minimizes the volume of water that is recovered and treated by the HC&C system by eliminating the unnecessary capture and treatment of significant volumes of groundwater from the Deep Lower Alluvium WBZ.

Reduction of Toxicity, Mobility, or Volume through Treatment

Section 12.4 of the ROD defines this criterion as follows:

> "Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy." (EPA 2017)

This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and/or significantly reduce the toxicity, mobility, or volume of hazardous substances as their principal element.

An analysis of the expected outcomes at construction completion identified in ROD Table 22 affecting the reduction of toxicity, mobility, or volume through treatment for the Revised Dredge and Cap Design and the Full Dredge and ISS Design includes the following:

- **Treatment Process Used and Irreversible Treatment:** The Revised Dredge and Cap Design indirectly treats the remaining contaminated sediments using amendments such as activated carbon or similar to address chemical isolation requirements associated with advective flux and organophilic clay or similar to address ebullition-facilitated transport of DNAPL.

  Alternatively, the Full Dredge and ISS Design directly treats the full lateral and vertical extents of contaminated sediments using ISS.

- **Amount Destroyed or Treated, Reduction in Toxicity, Mobility and Volume, and Type and Quantity of Residuals Remaining after Treatment:** The Revised Dredge and Cap Design indirectly treats the remaining PTW-NAPL (30%), combined PTW-NAPL/NRC (50%; volume remaining is estimated to be greater than 20,000 cubic yards), and RAL exceedances in place with overlying reactive caps. As discussed in the preceding analysis of long-term effectiveness and permanence, there exists some potential risk of long-term releases from these caps caused by the advective flux and ebullition-facilitated DNAPL transport pathways. In addition, this design does not treat the Siltronic Corporation (Siltronic) riverbank, based on the rationale provided in Section 3.4 of the PAR.

  Alternatively, the Full Dredge and ISS Design ISS directly (in situ) treats 100% of sediments exceeding the RALs and containing PTW, which significantly reduces the mobility of all treated sediments left in place due to the stabilization and solidification processes. In addition, as discussed in Section 3.1 of the PAR, the Full Dredge and ISS Design eliminates advective flux and ebullition-facilitated DNAPL transport as contaminant transport pathways, further reducing the potential contaminant mobility. Lastly, as requested by EPA's comments, this design can actively remediate the entirety of the Siltronic riverbank using ISS and includes an integrated ISS treatment barrier wall along the top of the Siltronic riverbank (described in Section 3.4 of the PAR).

Short-Term Effectiveness

Section 12.5 of the ROD defines this criterion as follows:

> "Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to the community, workers, and the environment during construction and operation of the remedy until cleanup levels are achieved." (EPA 2017)

An analysis of the expected outcomes at construction completion identified in ROD Table 22 affecting the short-term effectiveness for the Revised Dredge and Cap Design and the Full Dredge and ISS Design includes the following:

- **Time Until Action Is Complete:** Both the Revised Dredge and Cap Design and the Full Dredge and ISS Design would be implemented over the entire Project Area footprint (i.e., they would have identical footprints). Although a formal design configuration has not been finalized for detailed estimates of duration, based on the Design Team's extensive construction experience in the Project Area using consistent technology assignments and the technologies applied in the two revised designs, the anticipated construction durations are expected to be similar. Therefore, the short-term impacts associated with construction duration are expected to be similar for both designs.
- **Community Protection:** Based on the identical active remediation footprint and the estimated equipment and associated means and methods to be used in the revised designs, both designs are estimated to cause the same relative short-term impacts associated with temporary noise, light (if applicable), disruptions to river use, and potential for waterborne accidents during construction. However, the potential for odors and air quality impacts are increased for the Revised Dredge and Cap Design because the dredging and ex situ (i.e., following dredging) addition and mixing of dewatering amendments into the dredge materials will be performed on untreated sediments that will contain PTW-NAPL and significantly elevated chemical concentrations commonly associated with the potential for odor and air quality impacts (e.g., benzene and naphthalene). Monitoring and BMPs will be performed to minimize the potential for these short-term impacts, but the risk for impacts

cannot be eliminated. In addition, the Revised Dredge and Cap Design will generate a significantly greater volume of contaminated waste that must be barged downriver, offloaded, and transported by truck through neighborhoods.

Alternatively, the Full Dredge and ISS Design includes dredging of 100% solidified and stabilized sediments that do not require the ex situ addition and mixing and dewatering amendments to facilitate subsequent transport and disposal at the disposal facility, which reduces or eliminates the potential for odors and air quality impacts. In addition, the volume of ISS swell that will need to be disposed is estimated to be significantly less than the Revised Dredge and Cap Design, so the amount of associated truck traffic for this design would be relatively less.

- **Worker Protection:** The risks to workers are estimated to be relatively similar for both revised designs.
- **Environmental Impacts (Impacts of Construction Activities):** The primary factor identified for this criterion is the potential for water quality impacts during construction. As discussed in Section 3.5 of the PAR, dredging operations are well documented to result in sediment resuspension, contaminant releases from bedded sediment, and residuals generation and, therefore, short-term water quality impacts (Bridges et al. 2010). These adverse construction impacts can be mitigated by the implementation of BMP controls, which are intended to minimize, to the extent practicable, these releases and associated contaminant residuals generation and water quality impacts. Section 16 of the Combined BOD-PDR presents a Project Area-specific evaluation of water quality barrier controls, and mobile moon pool silt curtains and full- and partial-depth silt curtains were retained for further evaluation during remedial design.

The Revised Dredge and Cap Design includes the exposure of contaminated sediments containing PTW-NAPL throughout the water column with each dredge bucket pass. Although this design would include the use of water quality BMPs such as the moon pool successfully applied at the NW Natural Portland Gas Manufacturing (PGM) Site sediment cleanup, the risk of water quality impacts during the dredging of sediments containing liquid NAPL and significantly elevated chemical concentrations remains.

Alternatively, in areas treated by ISS, the Full Dredge and ISS Design minimizes the exposure of untreated contaminated sediments to the water column to only occur during the surficial ISS treatment. The subsequent ISS treatment in deeper sediments is performed without exposure to the water column, significantly reducing the potential for water quality impacts. Consistent with the Revised Dredge and Cap Design, those potential impacts (along with any potential impacts from dredging in the navigation channel) would be further reduced by the use of water quality BMPs such as the moon pool successfully applied at the NW Natural PGM Site. As discussed in Section 3.2 of the PAR, dredging of the post-treatment swell material will be required to minimize increases in elevations to achieve the Federal Emergency Management Act no-rise requirements and to optimize post-construction habitat configurations. Removal of swell material will significantly reduce the potential for water quality impacts relative to the Revised Dredge and Cap Design because all NAPL and elevated chemical concentrations in sediments will have been treated.

In addition, as discussed previously for community protection, the Revised Dredge and Cap Design includes a considerably greater volume of contaminated waste removed from the Project Area than the Full Dredge and ISS Design, resulting in significant additional truck traffic through neighborhoods over the length of the multiyear project.

Implementability

Section 12.6 of the ROD states the following:

> "Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered." (EPA 2017)

An analysis of the expected outcomes at construction completion identified in ROD Table 22 affecting implementability for the Revised Dredge and Cap Design and the Full Dredge and ISS Design includes the following:

- **Ability to Construct and Operate:** The dredging, active capping, and ISS remedial technologies have been successfully implemented at other Superfund sediment cleanup sites. However, the following design elements increase the difficulty of construction of the Revised Dredge and Cap Design relative to the Full Dredge and ISS Design:
  - **Construction Challenges Associated with the Gasco Dock:** Sevenson Environmental Services, Inc. (SES), has considerable experience performing dredging directly adjacent to structures like the Gasco dock, including the Gasco Early Action cleanup in 2005. Based on this experience and recent visits to the Project Area, SES determined that specialized dredging equipment would be required in the vicinity of the Gasco dock for the Revised Dredge and Cap Design, and appropriate dredging offsets from the dock would need to be determined during remedial design to minimize the potential for structural impacts. Some form of in situ treatment of sediments containing PTW-NAPL/NRC would then be required within the offsets, which would require additional specialized equipment and design to ensure continuous post-construction grades surrounding the structure. This spatially confined work would take considerable time within the short 4-month in-water work window to address a relatively small area of contamination without undermining the structural stability of the dock and channel

side slopes. In addition, due to the steeper than 2 horizontal to 1 vertical (2H:1V) existing mudline slope under the dock, construction of the required minimum long-term stable 3H:1V slope for cap and habitat material placement would increase mudline elevations within the dock vessel berthing area and cap material placement within the 10-foot offset from the navigation channel line deemed necessary by the U.S. Army Corps of Engineers (USACE) to prevent impacts on its future maintenance dredging operations. These cascading design challenges require the installation of a vertical sheetpile wall just channelward of the face of the dock and the associated placement of a rock toe berm at the channelward face of the wall to protect it from river and propeller wash erosive forces. Installation of this engineering control is suboptimal because the steel will erode at some time in the future, at which time the rock toe berm will solely serve to retain the upgradient sediments at the post-construction grades.

Alternatively, the Full Dredge and ISS Design includes ISS treatment adjacent to and under the dock, which eliminates the Gasco dock structural stability issues associated with dredging and capping and the need for a sheetpile wall. ISS is commonly used in and around structures where it is often difficult or infeasible to perform dredging and capping, consistent with the following statement in Section 10.1.1.2 of the ROD:

> "Treatment options considered include in-situ solidification/ stabilization and sequestration, which may be used to address PTW underneath and around pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities that remain intact." (EPA 2017)

The Design Team has conducted site visits and consulted with equipment vendors and has identified ISS technologies and associated equipment that can access and achieve the DOC in the vicinity of the dock.

- **Impacts to Upland Structures and Critical Infrastructure:** As discussed in Section 3.1 of the PAR, to mitigate for potential impacts to upland structures and critical infrastructure, a vertical sheetpile wall is required to facilitate capping at the long-term stable 3H:1V slope and avoid placement of cap material within the 10-foot offset from the navigation channel line to avoid impacting future maintenance dredging operations by USACE.

  Alternatively, the Full Dredge and ISS Design does not require installation of a sheetpile wall to mitigate for potential impacts to upland structures and critical infrastructure.

- **Dredge Residual Management:** As discussed in Section 3.5 of the PAR, NW Natural may elect to place a thin layer of residuals management cover in post-dredge dredge management units (DMUs) in the Intermediate and Shallow Regions prior to cap placement to minimize the potential for generated residual migration outside of the work area. Performing concurrent dredging and residual management cover placement would require significant additional equipment to be staged within a relatively small work area and presents logistical sequencing challenges that can significantly reduce production rates and increase the total construction duration. Similarly, depending on the construction sequencing, NW Natural may elect to place residuals management cover in some DMUs between each construction season to further reduce the potential for residuals migration from the work area during extended non-work periods. This would also reduce seasonal production rates and increase the total construction duration.

  Alternatively, the Full Dredge and ISS Design would not require generated residuals management in the Intermediate and Shallow Regions. The entirety of RAL exceedances and PTW will be treated prior to dredging of the ISS swell. This swell will have a design strength of 50 psi or greater, so any generated dredge particulates will be significantly reduced and will be composed of treated materials. This reduces equipment needs and associated staging challenges, significantly simplifies construction sequencing, and does not impact the ISS production rates and total construction duration.

- **Ease of Doing More Action:** Both revised designs are assumed to provide the same level of ease of doing more action in the future, if needed.
- **Ability to Monitor Effectiveness:** The Dredge and Cap Design will require long-term monitoring and maintenance of caps. Monitoring results will be used to assess cap condition and effectiveness and any disruption to a cap will require resources to implement corrective action. The post-construction monitoring would be performed consistent with the "Summary of Final Cap Modeling and Long-Term Cap Monitoring Approach – Gasco Sediments Site" memorandum, submitted to EPA on June 25, 2019 (Anchor QEA 2019), which is summarized in Section 6.3.1 of the Combined BOD-PDR and included as the associated Appendix K of that report (Anchor QEA 2021). This approach requires sampling and analysis of porewater from specialized manhole ports install during remedy implementation and the performance of bathymetry surveys.

  Alternatively, the Full Dredge and ISS Design includes permanent ISS of 100% of the RAL exceedances and PTW, so any required long-term monitoring of the post-ISS treated materials by EPA to evaluate long-term performance of the remedy would be reduced and developed with EPA during remedial design.

Cost

In ROD Appendix IV, EPA determined the total capital cost for Site-wide Alternative F Mod. EPA did not present a cost estimate for cleanup within the Project Area. Although a formal design configuration has not been finalized for detailed cost estimating of the two revised designs by NW Natural, based on SES's construction experience in the Project Area and other sites for the technology assignments and process options included in each of the two revised designs, the anticipated construction cost for each design is expected to be comparable in accordance with ROD parameters.[2] This is largely because the area of active remedy is identical, the technology assignment for a large portion of the Project Area is identical (full dredge in the navigation channel), and the primary difference between technologies in the other areas of the Study Area is the treatment method used. In addition, the overall construction duration for both designs is anticipated to be similar.

[2] Appendix IV of the ROD states, "Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for feasibility study level evaluation purposes" (EPA 2017).

3 Summary of Findings and Conclusion

ROD Table 23 was used as a template for summarizing the detailed designs analysis. The findings and conclusions of this evaluation using that format is presented in Table B-1. As shown on the table, both remedial designs meet the two NCP Threshold Criteria. Table B-1 also shows that for a similar expected cost with significant additional risk reduction, the Full Dredge and ISS Design outperforms the Revised Dredge and Cap Design for each of the NCP Primary Balancing Criteria. The Modifying Criteria are not included because these design designs are each consistent with ROD selected Site-wide Alternative F Mod and have therefore already been met.

4 References

Anchor QEA (Anchor QEA, LLC), 2019. Memorandum to: Sean Sheldrake and Karl Gustavson, U.S. Environmental Protection Agency. Regarding: Summary of Final Cap Modeling and Long-Term Cap Monitoring Approach – Gasco Sediments Site. June 25, 2019.

Anchor QEA, 2021. *Combined Sediment Remedy Basis of Design and Preliminary Design Report*. Gasco Sediments Cleanup Action. Prepared on behalf of NW Natural. April 30, 2021.

Bridges, T., K. Gustavson, P. Schroeder, S. Ells, D. Hayes, S. Nadeau, M. Palermo, and C. Patmont, 2010. "Dredging Processes and Remedy Effectiveness: Relationship to the 4 Rs of Environmental Dredging." *Integrated Environmental Assessment and Management*, Volume 6, Number 4. SETAC 2010. February 10, 2010.

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EPA, 2016. *Portland Harbor RI/FS – Feasibility Study*. U.S. Environmental Protection Agency Region 10. June 2016.

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EPA, 2021. *Comments on Combined Sediment Remedy Basis of Design and Preliminary Design Report*. Gasco Sediments Cleanup Action. August 17, 2021.

Table

Table B-1
Summary of Comparative Analysis of Remedial Designs

Remedial Alternative	Description (ROD technologies applied at the Gasco Sediments Site Project Area)	Threshold Criteria		Balancing Criteria				
		Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present Value Cost (dollars)
F Mod Revised Dredge and Cap Technology Assigments	**Revised technology assignments based on ROD** Full dredge 11.4 acres[1]; partial dredge and indirect cap 11.2 acres; 0.5 acre of riverbank monitoring	+	+	Better	Better	Moderate	Moderate	$$$
F Mod Full Dredge and ISS Technology Assignments	**Revised technology assignments based on ROD** Full dredge 11.4 acres[1]; direct ISS treatment 11.7 acres	+	+	Best	Best	Better	Better	$$$

Legend for Qualitative Ratings System:

Threshold Criteria
- Unacceptable
+ Acceptable

Balancing Criteria (relative performance of criterion)
Least
Low
Moderate
Better
Best

Notes:
1. The presented acreages are based on the Final Project Area footprint presented in the Combined BOD-PDR (Anchor QEA 2021). Any revisions to the Final Project Area, as required to address EPA's comments on the Combined BOD-PDR (EPA 2021), will be included in the forthcoming *Revised Sediments Remedy Basis of Design Report.*

ARAR: Applicable or Relevant and Appropriate Requirement
Combined BOD-PDR: *Combined Sediment Remedy Basis of Design and Preliminary Design Report*
cy: cubic yard
EPA: U.S. Environmental Protection Agency
ISS: in situ stabilization and solidification
ROD: *Record of Decision – Portland Harbor Superfund Site, Portland, Oregon*