Wishram Railyard Sediment Feasibility Study

Ecology Site Name: BNSF Wishram Track Switching Facility
Ecology Facility/ Site ID: 1625461
Cleanup Site ID: 230
Version: Revised Draft

BNSF Railway Company
BNSF Wishram Railyard, Wishram, Washington

Wishram Railyard Sediment Feasibility Study
June 6, 2025

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Client name:	BNSF Railway Company		
Project name:	Wishram Railyard Sediment Feasibility Study		
Date:	June 6, 2025	Project no:	D3819400
Document no:	240507133410_0aaaa1aa	Project manager:	Kris West-Ivarson
Version:	Revised Draft	Prepared by:	Jacobs

Jacobs Engineering Group, Inc.

2020 SW Fourth Avenue
3rd Floor
Portland, OR 97201
United States

T +1.503.235.5000

Executive Summary

This Sediment Feasibility Study (FS) was prepared by Jacobs on behalf of BNSF Railway Company (BNSF) for the BNSF Wishram Railyard (aka BNSF Track Switching Facility, “site”) located in Wishram, Washington (Figure ES-1). Initial investigations were conducted in 2018 to investigate the potential presence of nonaqueous phase liquid (NAPL) in sediment in the nearshore area, characterize the nature and extent of NAPL if present, and evaluate nearshore sediment against applicable sediment cleanup standards (CH2M 2018). The Initial Investigation Work Plan was approved by the Washington State Department of Ecology (Ecology) on February 7, 2018, and field work was performed in June and August 2018. Following the initial work, the Sediment Remedial Investigation (RI) Work Plan (RI Work Plan) (Jacobs 2021) was developed to further characterize and delineate the area of impacted sediment. The RI Work Plan was approved by Ecology in 2021, and the RI field effort was conducted in two mobilizations between April and November 2022. A revision to the RI Work Plan was requested by Ecology on October 3, 2022, and BNSF submitted the RI Work Plan Revision 1 (Jacobs 2022) on October 25, which was subsequently approved by Ecology on October 27, 2022.

The area of NAPL impacted sediment was identified during the Sediment RI as having two differing areas. On the eastern portion of the area, NAPL-impacted sediments are located as close as approximately 20 feet from the shoreline and within 140 feet of the shoreline. To the west, the impacts are farther from shore at approximately 90 feet. As shown on Figure ES-2, the western portion of the NAPL-impacted area is characterized by thinner and less impacted zones that are deeper within the sediment column and are not contributing to the observed sheens (Jacobs 2024). The NAPL that is resulting in intermittent sheens is limited to the eastern portion of the impacted area and is shown as the teal-colored area on Figure ES-2. To the south, the NAPL-impacted interval thins and is closer to the sediment surface as the sediment surface slopes downward. When the sediment bathymetry drops below the base of the impacted interval to the south (approximately141 feet above mean sea level), NAPL is no longer found. This is consistent with a historical surface release from the uplands that was controlled by the site topography before Lake Celilo was filled (Jacobs 2024).

NAPL impacts diminish to the north and east toward the shoreline and are found at lesser thickness and relatively lower peak and average Tar-specific Green Optical Screening Tool (TarGOST) responses. To the west, NAPL impacts are well below the biologically active zone and are generally found below 5 feet below sediment surface (bss). These impacts are not contributing to the sheens observed at the site. Peak and average TarGOST responses decline with distance to the west, and the impacted intervals are 2 feet thick or less, and often less than 1 foot thick. These thinner impacted zones continue to deepen to the west to a depth of between 7 and 8 feet bss. Unimpacted TarGOST profiles collected during the 2022 Sediment RI bound the extent of the NAPL impacts. The analytical data results from the subsurface sediment cores were also used to confirm the lateral and vertical extents of NAPL (Jacobs 2024). West of where sheens had been observed, NAPL impacts are deeper within the sediment column and are at least 4.5 feet bss and typically more than 5 feet bss, extending to a depth of between 7 and 8 feet bss. These impacts are not contributing to the sheens observed at the site. The absence of ebullition-driven sheens in the western portion of the site is consistent with the available literature on ebullition and indicates the ebullition active zone resides above where NAPL impacts are present in this portion of the site.

The RI was completed in 2023 (Jacobs 2024) and identified a zone of NAPL impacts within approximately 140 feet of the shoreline which consisted of localized saturated or coated sediments and NAPL-coated woody debris with odors. No bedding structure was visible, and the abundance of mixed organic debris in the NAPL-impacted intervals suggest that these materials represent a layer of material that was in place before the land was inundated by the filling of Lake Celilo. The extent of the NAPL-impacted sediment is between 30 and 130 feet wide in the north-south direction and approximately 650 feet long in the east-west direction (shown as the hatched area on Figure ES-2).

The RI identified a portion of the NAPL-impacted sediments as the source of the intermittent sheens at the site based on its location (adjacent to historically observed intermittent sheens), depth, peak TarGOST responses, and consistent observations of saturated NAPL conditions. Shown as the teal-colored area on Figure ES-2, the sheen-generating NAPL is estimated to be between approximately 40 and 140 feet south of the shoreline and spans approximately 100- to 170-feet wide in the east-west direction. This is smaller than the total area impacted by NAPL. Within the sheen-generating area, the NAPL-impacted interval intersects the active ebullition zone and thus is subject to ebullition-facilitated transport, which is causing the intermittent sheens.

The sediment cleanup unit has been defined to include the extent of NAPL-impacted sediment and areas where constituent concentrations in sediment are above sediment cleanup objective or cleanup screening level values and includes offsets to accommodate constructability factors (Figure ES-2). The purpose of this FS is to develop and evaluate cleanup action alternatives for the sediment cleanup unit.

Due to the site characteristics including the location of NAPL-generating sheens and overburden sediment (sediment veneer overlying NAPL-impacted sediment), the sediment cleanup unit has been divided into two sediment management areas (SMAs): the eastern SMA (ESMA) and the western SMA (WSMA). Each SMA was evaluated for the suite of cleanup action alternative components (technologies), from which cleanup action alternatives were developed and evaluated for each SMA.

Washington Administrative Code (WAC)173-340-351 and WAC 173-204-550 detail the requirements for the development of cleanup action alternatives. The alternatives were developed to ensure that they met the criteria specified in WAC 173-340-360 and 173-204-550:

- Protects human health and the environment
- Complies with cleanup standards and applicable state and federal laws
- Provides for compliance monitoring
- Completes restoration in a reasonable timeframe

Those cleanup action alternative components that (1) do not meet the criteria and (2) those that are not implementable at the site were not considered further.

Based on the evaluation, six alternatives were developed, including the No Action Alternative as required by the 2021 Ecology Sediment Cleanup User's Manual Section 12.4.4 (Ecology 2021):

- Alternative 1 – No Action
- Alternative 2
  - ESMA – Removal, Backfill, and Offsite Disposal
  - WSMA – Monitored Natural Recovery (MNR) and Institutional Controls (ICs)
- Alternative 3A
  - ESMA – Capping with AquaGate + ORGANOCLAY™ and ICs
  - WSMA – MNR and ICs
- Alternative 3B
  - ESMA – Capping with a Reactive Core Mat (RCM) and ICs

  - WSMA – MNR and ICs
- Alternative 3C
  - ESMA – Capping with RCM and a Marine Armor Mat (MAM) and ICs
  - WSMA – MNR and ICs
- Alternative 4
  - ESMA - In-Situ Stabilization (ISS), Backfill, and ICs
  - WSMA – MNR and ICs

Retained alternatives were then compared using the disproportionate cost analysis (DCA), a Washington State Model Toxics Control Act procedure to evaluate tradeoffs, including costs, among technologies. As part of the DCA, the following relative benefits criteria were considered:

- **Protectiveness:** The overall protectiveness of human health and the environment.
- **Permanence:** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances. The criteria also considers treatment capability, reduction of releases, management of the sources of release, degree of irreversibility of treatment, and the quantity and quality of treatment wastes.
- **Effectiveness Over the Long Term:** The degree of certainty for cleanup success, long-term reliability, magnitude of residual risk, management of treatment wastes, and management of wastes left untreated. The criteria also considers the potential impacts to vulnerable populations and overburdened communities, including tribal nations.
- **Management of Implementation Risks:** The risk to human health and the environment associated with the alternative during construction and implementation.
- **Technical and Administrative Implementability:** The ability to be implemented including consideration of whether the alternative is technically and administratively possible.
- **Cost:** The cost to implement the alternative, including construction and post-construction costs. These costs include present capital costs, future capital costs, indirect costs, and operation and maintenance costs. Cost is not a ranked criteria.

The relative benefits and costs of each alternative were compared to Alternative 2 (removal) in the DCA. Alternative 2 represents the most permanent cleanup action alternative (baseline alternative) against which the other alternatives are evaluated for the purpose of determining whether the cleanup action selected is permanent to the maximum extent practicable. It therefore provides the benchmark against which the relationship between incremental remedy benefits and incremental costs of other cleanup action alternatives are evaluated. This analysis was used to determine whether the proposed cleanup actions are permanent to the maximum extent practicable.

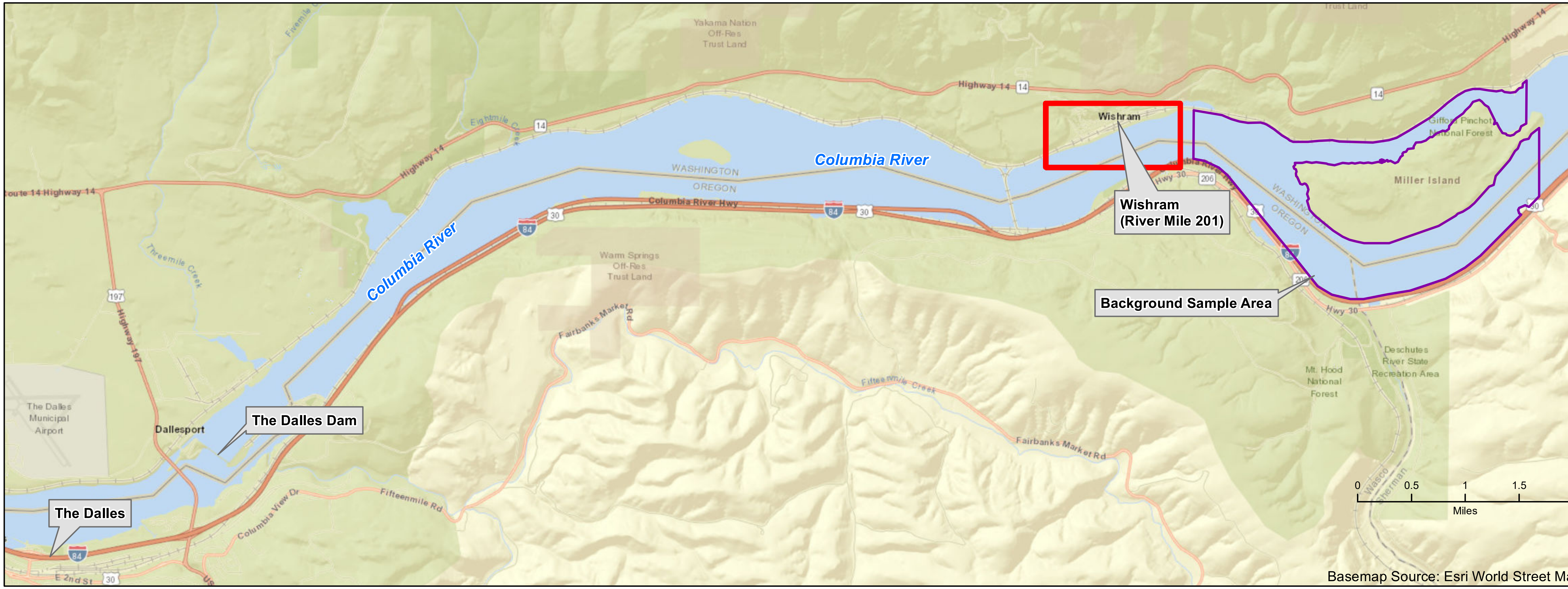
Based on the DCA ranking for each cleanup action alternative, which includes the weighting assigned to each benefits criterium and ranking, the total overall benefits for the cleanup action alternatives range from 7.6 to 8.3. Present-worth costs range from $3.7 million to $9.7 million. The following conclusions were drawn from the DCA:

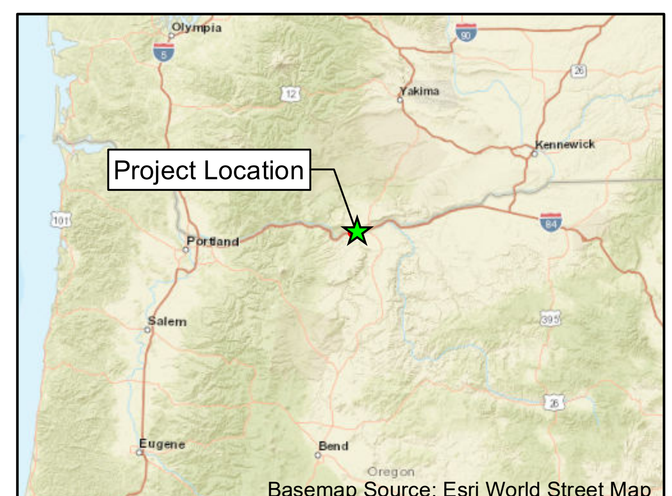
- Higher cost alternatives show incremental cost increases disproportionately to the relative benefit, especially when comparing capping alternatives (Alternatives 3A, 3B, and 3C) against Alternatives 2 and 4.

- The total benefit scores indicate that capping with a layer of AquaGate and ORGANOCLAY (Alternative 3A) results in a higher overall score of 8.3, with scores highest in the effectiveness over the long term, management of short-term risks, and technical and administrative implementability criteria. Protectiveness was the same across the alternatives. The lowest overall score is for Alternative 4 (ISS) due to the low scores for the effectiveness over the long term (which considers impacts to vulnerable populations and overburdened communities, including tribal nations), management of short-term risks, and technical and administrative implementability criteria.
- Costs for the cleanup action alternatives – Alternatives 2 and 3A - range from $3.7 million (Alternative 3A) to $9.7 million (Alternative 2). Alternative 3A has the lowest cost of $0.45 million per benefit gained and Alternative 2 has the highest cost of $1.18 million per benefit gained. This difference is driven primarily by the costs associated with moving the dredged material from a barge to shore, controlling the hazards to site workers, and the duration of activities associated with Alternative 2.
- Of the three capping alternatives – Alternatives 3A, 3B, and 3C – Alternative 3A scored highest. Alternative 3A includes a layer of AquaGate and ORGANOCLAY at an assumed thickness of 3 inches which equates to a mass ORGANOCLAY loading of 6.0 pounds per square foot with an oil adsorption capacity of 0.5 pound of oil per pound of ORGANOCLAY. This results in a much higher mass loading capacity than Alternatives 3B and 3C, which ranked similarly.
- Alternatives 3B and 3C ranked similarly, with Alternative 3B providing a slightly higher ranking for technical and administrative implementability and Alternative 3C providing a slightly higher rating for long-term benefits by using a more aggressive approach to prevent erosion by installing the MAM (which is not considered necessary due to the nature of the river in that area).
- Capping (Alternatives 3A, 3B, and 3C) has benefits that result in higher or similar scores than removal (Alternative 2), especially for management of short-term risk and technical and administrative implementability. For example, based on the RI, a significant number of artifacts are anticipated to be encountered during removal activities under Alternative 2. Capping reduces negative impacts to the environment and potential for tribal and/or related artifact removal or disturbances as well as having a significant reduction in the potential risks to human health during cleanup actions.
- Because the cost of Alternative 2 ($9.7 million) is substantially higher than that of Alternative 3A ($3. million), the incremental cost of Alternative 2 is considered disproportionate, even though it has a high overall score (8.3 for Alternative 2 versus 8.3 for Alternative 3.A).
- The level of benefits for Alternative 4 is substantially lower than that of Alternative 3A (7.6 versus 8.3, respectively), and the ratio of cost to benefits is considerably higher ($1.00 million versus $0.45 million). Therefore, the incremental cost of Alternative 4 is considered disproportionate.

The results of the DCA indicate that, at a minimum, Alternative 2 and Alternative 4 are disproportionately costly than their respective benefits in relation to Alternatives 3A, 3B, and 3C. Among the three capping alternatives, Alternative 3A has the lowest cost of $0.47 million per benefit gained, compared to Alternatives 3B and 3C ($0.58 million and $0.64 million, respectively), Figure ES-3. Thus, Alternative 3A was identified as the most appropriate alternative for the sediment cleanup unit.

The final identification of the cleanup action alternative will be stipulated in the cleanup action plan, which documents the selected cleanup action and specifies the cleanup standards and other requirements that the cleanup action must meet.





N

0 375 750 1,500
Feet

Notes:
Lake Celilo extends from The Dalles Dam 24 miles upstream

Figure ES-1. Site Location Map
BNSF Track Switching Facility
Wishram, Washington

Jacobs

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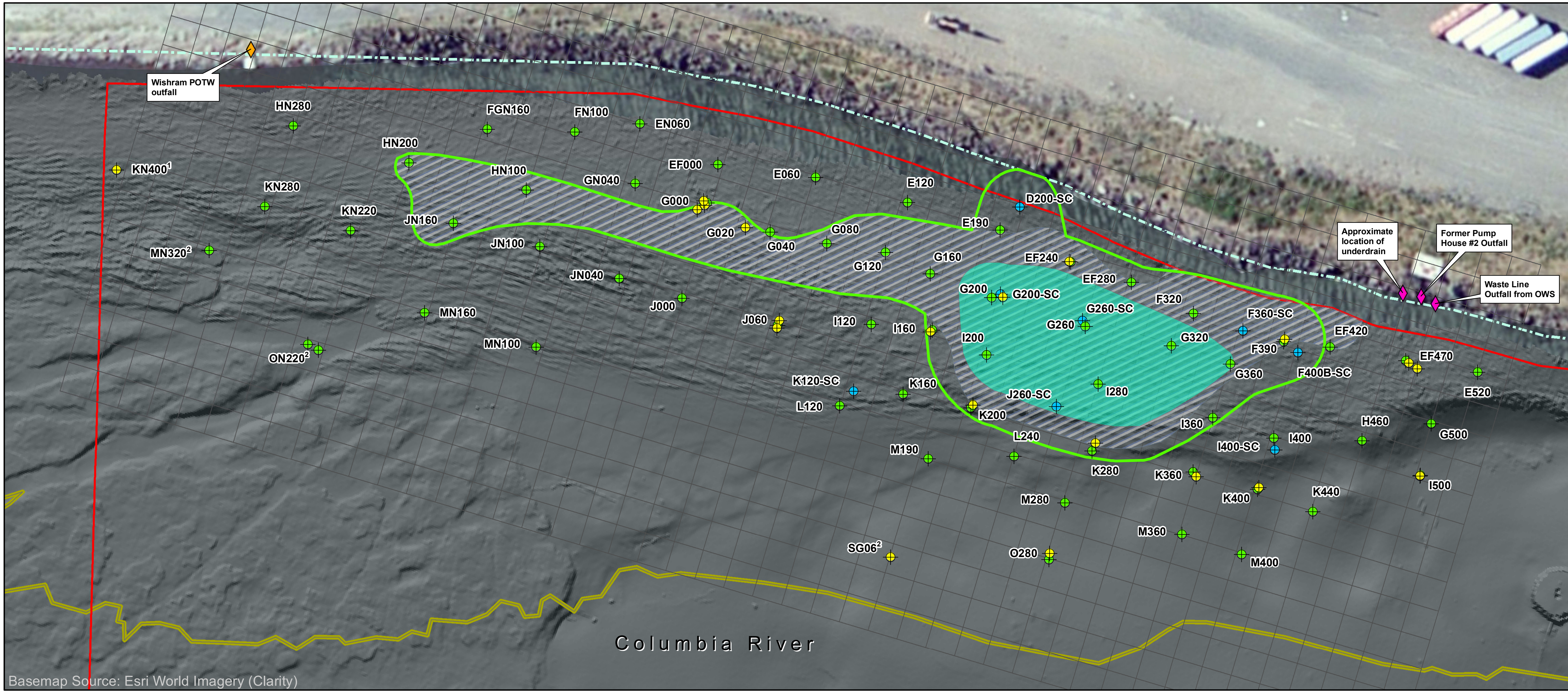

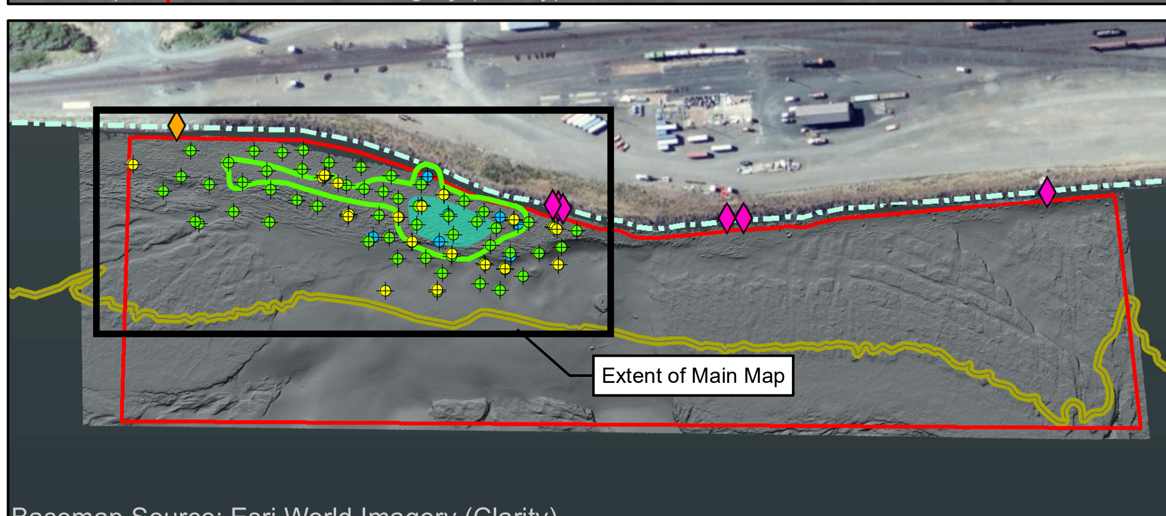

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LEGEND

- Sediment Cleanup Unit Boundary
- Extent of NAPL-affected Area
- Approximate Extent of Sheen-Generating NAPL Impacts
- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

0 25 50 100
Feet

Note: Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.

Figure ES-2. Sediment Cleanup Unit
BNSF Track Switching Facility
Wishram, Washington

Jacobs

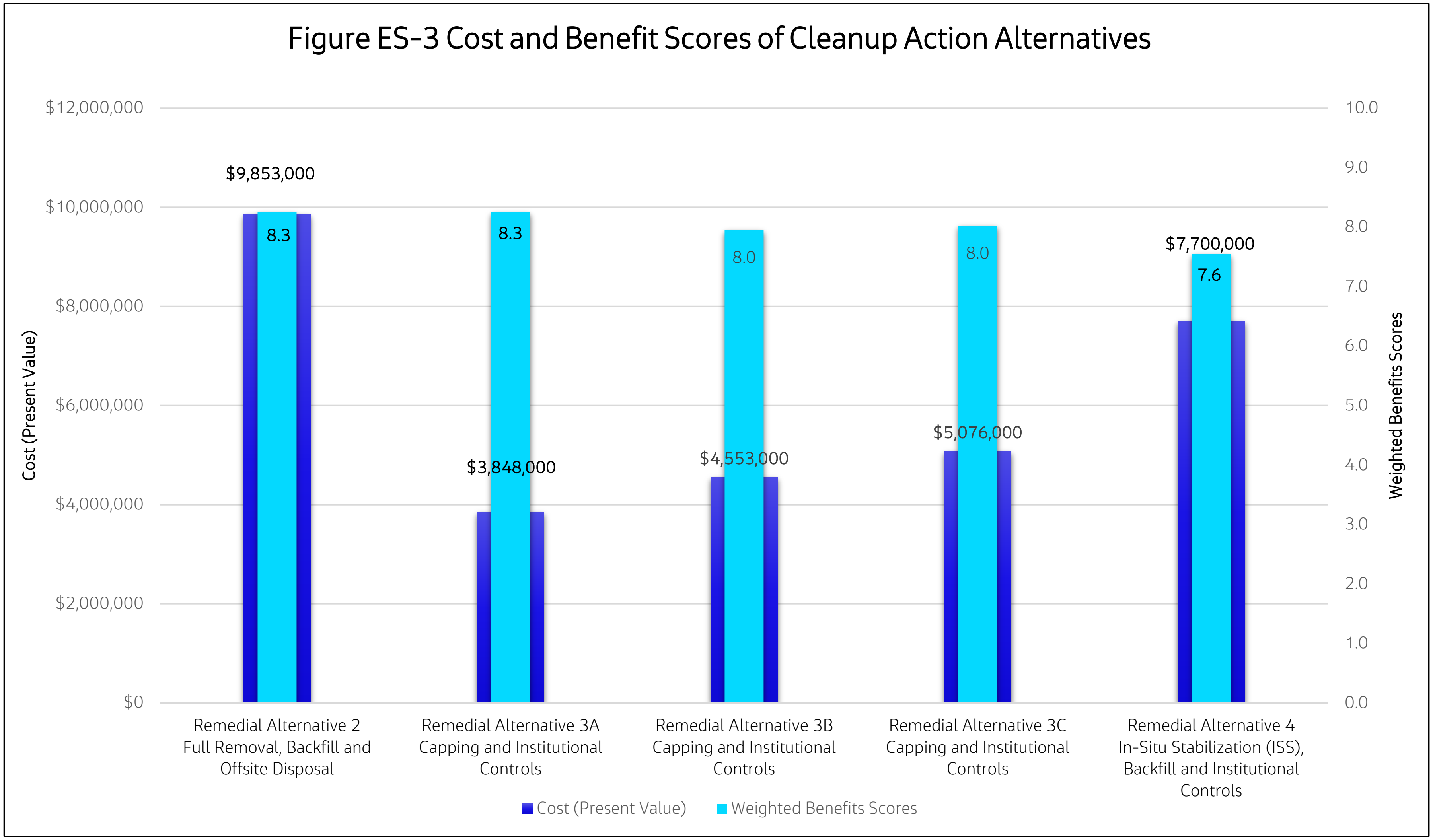
Figure ES-3 Cost and Benefit Scores of Cleanup Action Alternatives
$12,000,000
$10,000,000
$8,000,000
$6,000,000
$4,000,000
$2,000,000
$0
Cost (Present Value)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Weighted Benefits Scores
$9,853,000
8.3
$3,848,000
8.3
$4,553,000
8.0
$5,076,000
8.0
$7,700,000
7.6
Remedial Alternative 2 Full Removal, Backfill and Offsite Disposal
Remedial Alternative 3A Capping and Institutional Controls
Remedial Alternative 3B Capping and Institutional Controls
Remedial Alternative 3C Capping and Institutional Controls
Remedial Alternative 4 In-Situ Stabilization (ISS), Backfill and Institutional Controls
Cost (Present Value)
Weighted Benefits Scores

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Acronyms and Abbreviations

AO	Agreed Order
ARAR	applicable or relevant and appropriate requirement
BAZ	biologically active zone
BMP	best management practice
BNSF	BNSF Railway Company
bss	below sediment surface
CAP	cleanup action plan
cfs	cubic foot (feet) per second
COC	constituent of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
CSM	conceptual site model
CUL	cleanup level
DAHP	Department of Archaeology and Historic Preservation
DCA	disproportionate cost analysis
Ecology	Washington State Department of Ecology
EPC	exposure point concentration
ESMA	eastern sediment management area
FEMA	Federal Emergency Management Agency
FS	feasibility study
GAC	granular activated carbon
IC	institutional control
ISS	in-situ stabilization
lb/ft^2	pound(s) per square foot
LIF	laser-induced fluorescence
LTM	long-term monitoring
MAM	marine armor mat
mg/kg	milligram(s) per kilogram

MNR	monitored natural recovery
MTCA	Model Toxics Control Act
NAPL	nonaqueous phase liquid
NAVD88	North American Vertical Datum of 1988
ng/kg	nanogram(s) per kilogram
OM&M	long-term operation, monitoring and maintenance
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RCM	reactive core mat
RI	remedial investigation
RM	River Mile
RML	residual management layer
SCO	sediment cleanup objective
SCUM	Sediment Cleanup User's Manual
SMA	sediment management area
SMS	Sediment Management Standards
SP&S	Spokane, Portland, and Seattle Railway
SWAC	surface weighted average concentration
SPA	sediment processing area
TarGOST	Tar-specific Green Optical Screening Tool
TCDD	tetrachlorodibenzo-p-dioxin
TEQ	toxicity equivalence quotient
TPH	total petroleum hydrocarbons
TPH-DRO	total petroleum hydrocarbons as diesel range organics
TPH-RRO	total petroleum hydrocarbons as residual range organics
USACE	U.S. Army Corps of Engineers
WAC	Washington Administrative Code
WSMA	western sediment management area
WTS	water treatment system
yd^3	cubic yard(s)

yd^3/day	cubic yard(s) per day
YNF	Yakama Nation Fisheries

1. Introduction

This Sediment Feasibility Study (FS) was prepared by Jacobs on behalf of BNSF Railway Company (BNSF) for the BNSF Wishram Track Switching Facility (Wishram Railyard) in Wishram, Washington (Figure 1-1). This FS is based on historical data collected during the 2018 Initial Investigation and the 2022 Sediment Remedial Investigation (RI) Report. The in-water area investigated during the RI is referred to herein as "the site" for the purposes of this FS.

Petroleum sheening and nonaqueous phase liquid (NAPL) droplets have been observed on occasion along an approximately 350-foot-long stretch of the Columbia River adjacent to the BNSF Wishram Railyard (Ecology 2017). This stretch of the Columbia River is separated from the uplands area by a berm armored with riprap. The area where the sheening has been observed was inundated in 1957 when the area behind The Dalles Dam was flooded, creating Lake Celilo. Initial investigation activities conducted in 2018 in the vicinity of the observed sheen identified a NAPL-impacted organic-rich fill layer approximately 0.5 foot to 2.5 feet below sediment surface (bss) between 40 and 140 feet south (offshore) of the current riprap shoreline. The sheen intermittently observed along the shoreline is the result of ebullition-driven transport of NAPL (bubbles) from portions of the NAPL body to the water column, as described in the Initial Investigation Report (Jacobs 2019). Initial investigation sample results from the surface sediment overlying the NAPL body were found to exceed the Sediment Management Standards (SMS) sediment cleanup objectives (SCOs) for sulfides in one surface sample, and results exceed the cleanup screening levels (CSLs) for total petroleum hydrocarbons (TPH) as diesel range organics (TPH-DRO) and TPH as residual range organics (TPH-RRO) in two surface sediment samples (Washington Administrative Code [WAC] 173-204-563). The RI results show that sediment concentrations that exceed SMS criteria do not exist outside of the NAPL-impacted area.

As required by Washington State Department of Ecology (Ecology) in its letter dated August 13, 2020, BNSF collected additional data to meet the requirements of an RI during 2022. Figure 1-2 shows the area of the 2018 Initial Investigation, the railyard features, current and former shorelines, and the area investigated during the 2022 Sediment RI. Activities conducted during the sediment RI included collecting 16 sediment cores (of which select intervals from 13 cores were submitted for analysis) and 60 Tar-specific Green Optical Screening Tool (TarGOST) locations. These activities are described in the Sediment RI Report (Jacobs 2024).

The RI results identified an area adjacent to the BNSF Wishram Railyard within the Columbia River where NAPL is present in sediments. A portion of the NAPL-impacted area is subject to ebullition that results in periodic sheens (Figure 1-3). This area of NAPL-impacted sediment is found at depths ranging from 0.5-foot bss to the south and 9.5 feet bss to the north (Figures 1-4 and 1-5) (Jacobs 2024). The NAPL is non-mobile based on data collected during the Initial Investigation and the Sediment RI, but occasional visible sheens on the water's surface are generated as a result of ebullition. To the west of the sheen-generating area, lesser thicknesses of NAPL impacts have been identified. NAPL impacts identified in this western zone are not affecting surface sediment and are not known to produce sheen because they are buried by a minimum of 4.5 feet of sediment. The sheen-generating NAPL area, shown on Figure 1-3, represents the majority of the NAPL impacts at the site and is the area targeted for active cleanup actions.

The ecological risk screening evaluated potential risk based on benthic criteria and bioaccumulative criteria as recommended by the Sediment Cleanup User's Manual (SCUM) (Ecology 2021). The results of the ecological risk screening evaluation indicated that constituents found in site surface sediment (driven by two 2018 samples with TPH-DRO exceedances) pose risk to the benthic community. The evaluation of potential risk from bioaccumulative compounds indicated that low concentrations of polycyclic aromatic hydrocarbons (PAHs) and TPH-DRO in a limited number of surface samples exceeded preliminary natural background values. However, when considering the concentration and detection frequency of PAHs and TPH-DRO in site sediment and the low potential for bioaccumulation, further ecological risk evaluation of these compounds is not warranted and are not evaluated in this FS. Human health screening results were similar to ecological screening, with some exceedances of risk criteria at a few sampling stations associated with the shellfish/fish consumption exposure scenario. Additional details on the risk screening are presented in the Sediment RI Report (Jacobs 2024).

1.1 Purpose and Organization

The purpose of this FS is to establish cleanup action objectives, identify and screen remedial technologies, compile retained technologies into cleanup action alternatives, and evaluate cleanup action alternatives for the Wishram Railyard sediment cleanup unit (Section 2.2).

This FS has been prepared in accordance with the Ecology Model Toxics Control Ac*t* (MTCA) regulation WAC 173-340-351, WAC 173-340-730(5)(d), the applicable requirements of WAC 173-204-550, and the SCUM (Ecology 2021). The FS was also prepared following the FS Checklist, which is FS guidance published by the Ecology Toxic Cleanup Program (Ecology 2016).

The report is organized into the following sections:

1. Introduction: Describes the FS purpose and organization, regulatory framework and chronology, site history, and use.

2. Conceptual Site Model (CSM): Presents the site setting, summarizes the results of the RI, and presents a CSM.

3. Sediment Cleanup Unit Boundary and Cleanup Action Objectives: Describes the sediment cleanup unit boundary, sediment management areas (SMAs), and cleanup action objectives. This section also summarizes the other regulatory requirements not covered under MTCA, the potential applicable or relevant and appropriate requirements (ARARs). Details for ARARs are presented in Appendix A.

4. Identification of Cleanup Action Alternatives: Presents the cleanup action objectives and cleanup standards, identifies the preliminary cleanup standards and cleanup actions, and identifies the area and depth of the sediment to be targeted by remediation.

5. Detailed Evaluation and Selection of Cleanup Action Alternatives: Identifies and describes a range of remedial approaches, technologies, and process options that could be used to address the sheens, and screens them based on effectiveness, implementability, and cost. This section presents the development of the cleanup action alternatives for addressing the sheens by combining the cleanup components (technologies), and process options that were retained after the screening described in Section 4. The section also includes evaluation of assembled cleanup action alternatives based on the criteria and disproportionate cost analysis (DCA) ranking criteria (WAC 173-340-360). The degree to which alternatives reduce risk, the amount of time needed to meet cleanup standards, and risks associated with implementing the cleanup are considered. Costs associated with each alternative are detailed in Appendix B.

6. Remedy Selection: Details the rationale behind the selection of the preferred alternative, includes description of how the alternative meets the expectations in WAC 173-340-370, and addresses public concerns.

7. References: Provides the references cited in this report.

1.2 General Site Information

The BNSF Wishram Railyard is in the town of Wishram in Klickitat County, Washington, approximately 13 miles northeast of The Dalles, Oregon, and 0.75 mile south of Washington State Route 14, within the southwestern quarter of Section 17, Township 2 north, Range 15, east of the Willamette Meridian (Figure 1-1).

The railyard occupies a flat bench along the northern side of the Columbia River at the eastern edge of the Columbia River Gorge. The railyard is approximately 5,000 feet long (from northeast to southwest) and ranges from 150 to 720 feet wide (from northwest to southeast). The portion of the railyard where historical industrial activities (e.g., fuel storage, engine refueling, and engine maintenance) occurred and the focus of the upland investigation is at the western end (approximately 1,100 feet) of the yard, covering an area of approximately 6 to 10 acres (KJ 2020). Existing structures on the railyard include storage buildings, a maintenance shop (office and tool storage), two mainline tracks, and active yard tracks (Figure 1-6). Current railyard operations on the uplands include an Amtrak passenger service depot and a railcar switching track spur located just south of the depot. Railcar fueling and maintenance activities are no longer performed at the railyard.

The railyard is located on the shore of the Columbia River within a treaty and accustomed fishing area of the Confederated Tribes and Bands of the Yakama Nation. Tribal members still exercise treaty reserved fishing rights on the shores of, and in the Columbia River, in the vicinity of the railyard. This fishing activity is regulated under tribal laws through off-reservation enforcement authority. The Celilo Treaty Fishing Access Site, a tribal fishing boat launch area regulated by the Bureau of Indian Affairs, is situated across the Columbia River on the Oregon shore. The Columbia River adjacent to the railyard is also used for vessel traffic, sailing, fishing, and various recreational uses.

1.3 Regulatory Framework and Chronology

Corrective action activities on the uplands portion of the railyard are being performed pursuant to an Agreed Order (AO) (No. DE 12897) between Ecology and BNSF, dated October 7, 2015 (BNSF 2017). The scope of work in the AO includes an upland RI, an FS, and a Draft Cleanup Action Plan, and is mainly focused on the upland area, with limited requirements related to shoreline conditions.

On March 3, 2017, Ecology directed BNSF to complete an investigation of the inundated lands area. In response to Ecology's 2017 letter, BNSF developed an Initial Investigation Work Plan to investigate the potential presence of NAPL in the identified nearshore area, characterize the nature and extent of NAPL if present, and evaluate nearshore sediment against applicable sediment cleanup standards (CH2M 2018). The Initial Investigation Work Plan was approved by Ecology on February 7, 2018, and field work was performed in June and August 2018.

Subsequent work at the site included development of a Sediment RI Work Plan (RI Work Plan), which included a phased approach to the investigation. The final RI Work Plan (Jacobs 2021) was submitted to Ecology on November 19, 2021, incorporating Ecology comments on the draft RI Work Plan. On November 30, 2021, Ecology's letter approving the RI Work Plan (dated November 19, 2021) was received by BNSF.

Field work for Step 1, consisting of determining the biologically active zone and surface sediment sampling, was conducted in April 2022, and the results were discussed with Ecology and presented to Ecology and Yakama Nation Fisheries (YNF) in September 2022. Ecology and YNF requested modification to the approved RI Work Plan related to Step 2 field activities on October 3, 2022. In response, the RI Work Plan was revised on October 25, 2022, and the revision (RI Work Plan Revision 1) was approved by Ecology via email on October 27, 2022 (Jacobs 2022). The Step 2 work, consisting of the TarGOST investigation and subsurface coring was conducted in November 2022.

Following completion of the RI, the Draft Sediment RI Report (Draft Sediment RI Report) was submitted to Ecology on May 30, 2023. On July 14, 2023, BNSF received comments from Ecology. In response, the comments were discussed with Ecology and YNF on August 16, 2023, and a revised Draft Sediment RI Report was prepared and submitted to Ecology on October 16, 2023. Subsequent comments on the revised Draft Sediment RI Report were received from Ecology on November 28, 2023, and from YNF on December 8, 2023. Revision 2 of the Draft Sediment RI Report addressing comments from both Ecology and YNF was prepared and submitted to Ecology on January 8, 2024, with a revision 3 submitted on April 22, 2024. Ecology approved the Draft Sediment RI Report via email on May 30, 2024, and the Final Sediment RI Report was submitted on June 10, 2024 (Jacobs 2024).

1.4 Site History and Use

The railyard was developed by the Spokane, Portland, and Seattle Railway (SP&S) between 1910 and 1912. SP&S merged with other railroads in 1970 to become the Burlington Northern Railroad, which merged with the Santa Fe Railroad in 1995 to become what is now BNSF. Historically, locomotive operations involving fueling/watering and repairs also occurred within the western portion of the Wishram Railyard. Oil and diesel were the primary fuels historically used to fuel locomotives at this yard. Most track spurs, early structures, and infrastructure no longer remain.

Prominent historical railyard features present during some portion of the time between 1910 and the present include a pump house and infrastructure (including a 24-foot-diameter structure) to obtain water from the Columbia River for railyard processes and drinking water from the Columbia River, various storage tanks (above and below ground), and an oil water separator (Figure 1-7). Water use from the Columbia River was discontinued after water supply wells were installed within the railyard. The river water supply piping, which extended from a pump shaft on the railyard to the pump house, well, and river intake lines, was removed or abandoned in place in 1920. Historical features were identified using past reports, historical maps, aerial photographs, and historical documents (e.g., NWOR 2014), and correspondences between SP&S personnel, including design plans and drawings for former railyard features (BNSF 2017).

At the time the railyard was constructed, the Columbia River was free-flowing and occupied a channel approximately 300 feet south of and 40 to 50 feet lower than the current railyard. Construction of The Dalles Dam in 1957 impounded the Columbia River to create Lake Celilo. The southern portion of the railyard, now underwater, was inundated during the filling of Lake Celilo in 1957. Areas south of the current railyard that are now underwater consisted of vegetated areas and bedrock outcrops with some areas of sandy beachfront. According to correspondence between SP&S personnel in the 1950s, numerous small shacks occupied by employees of SP&S were also located south of the current railyard (SP&S 1950).

2. Conceptual Site Model

This section describes the CSM based on the SCUM and includes the following information:

- Physical characteristics of the inundated lands with the potential to affect distribution and transport of constituents of concern (COCs). This includes the historical uplands use of the facility including associated outfalls and drainage patterns from railyard operations documented in the Ecology-approved Uplands RI Report (KJ 2020).
- Potential release and transport mechanisms (e.g., erosion and stormwater runoff and direct discharges) going from the uplands to the sediment. Thus, the Uplands RI results help inform the sediment CSM.
- Historical photos and drawings of the railyard before the formation of Lake Celilo, and bathymetry data collected by the U.S. Army Corps of Engineers (USACE) in 2008, by Solmar Hydro, Inc. in 2017 (CH2M 2018), and across a larger area by Solmar Hydro, Inc. in 2022 (Jacobs 2024). Combining the historical aerial photographs with bathymetry shows the current bathymetry aligns closely with the shoreline before inundation and identifies historical drainage pathways and low-lying areas.
- Investigation results including NAPL screening, coring, and surface sediment analytical data from the portion of the inundated lands near where sheens have been observed, both before and during the Initial Investigation and during the RI. The investigations identified the presence of submerged NAPL within the inundated lands and informed the NAPL transport mechanisms.

2.1 Site Setting and Physical Characteristics

The site is approximately 1,850 feet by 500 feet and located at River Mile (RM) 201 along the Washington side of Lake Celilo (Figure 1-1). Lake Celilo is 24 miles long with primary tributaries including the Deschutes River and Fifteen Mile Creek. Background samples were collected between RM 202 and RM 206, upstream of the site near Miller Island, and the confluence of the Columbia and Deschutes Rivers (Figure 1-1). This portion of the river is noted to be one of the driest and warmest portions within the Columbia River basin (USACE et.al. 2020). No changes are anticipated to the future use of the Columbia River.

2.1.1 General Hydrology

The Columbia River basin is 258,000 square miles (670,000 square kilometers) in size. The river itself originates in Canada, entering the United States near the northeastern corner of Washington State and discharging at the Pacific Ocean near Astoria, Oregon, approximately 1,243 miles (2,000 kilometers) from its origin. With an average flow at the mouth of about 265,000 cubic feet per second (cfs), the Columbia River is the fourth largest river in the United States by volume, and it has the largest discharge of any river in North America to the Pacific Ocean. The Deschutes River, with an average discharge of 5,824 cfs, joins the Columbia River just upstream of Wishram. Overall river flows along this reach of the Columbia River are controlled by operations of The Dalles Dam, located approximately 9 river miles downstream of the site, and the John Day Dam approximately 14 river miles upstream, resulting in daily and seasonal fluctuations in surface water elevations.

2.1.2 Geologic and Hydrogeologic Conditions

The local geology at the site, determined by soil borings completed in the uplands area, consists of varying thickness of surface fill (sand and gravel reportedly sourced from nearby sand dunes and river deposits), followed by 10- to 95-foot-thick sequences of glaciofluvial sediment (and silt) deposited on eroded Columbia River Basalt Group bedrock during ice-age floods.

The uppermost hydrogeologic unit at the railyard is the glaciofluvial unconfined aquifer, consisting of unconsolidated sand and silt with gravel lenses deposited during the Missoula Floods. Numerous monitoring wells have been installed at the railyard and screened in the sand/silt deposits. These sand and silt deposits can be up to 95 feet thick in the western section of the railyard where locomotive operations involving fueling/watering and repairs occurred and a glaciofluvial sediment-filled erosional feature in the basalt bedrock is believed to be present. The glaciofluvial deposits are generally homogeneous, and in some areas the sand and silt overlie a thin layer of gravel just above bedrock (KJ 2016). Given the presence of exposed bedrock surfaces east and west of the initial 2018 sediment study, the glaciofluvial aquifer likely pinches out to the south just beyond the former shoreline of the Columbia River, approximately 350 feet from the current shoreline (CH2M 2018; Jacobs 2024).

Local topography and historical aerial photographs taken before the creation of Lake Celilo show exposed bedrock along some portions of the historical Columbia River shoreline adjacent to the railyard. Sampling conducted during the sediment RI confirmed a limited area with sediment adjacent to the railyard. Bedrock was encountered at the surface in the area west of the planned Sediment RI (Jacobs 2024).

Groundwater occurs in the unconfined sand/silt alluvial aquifer at 10 to 12 feet below ground surface at the railyard. Before construction of the dam and creation of Lake Celilo, the unconfined water table was at least 30 to 40 feet deeper. Groundwater flow beneath the central portion of the railyard is generally south toward the lake at a very shallow gradient. However, during 10 months of the year, Lake Celilo in the vicinity of the railyard is a losing water body where flow direction is to the north, toward the railyard (KJ 2020). Daily oscillations in the Columbia River stage (typically 1 to 2 feet) occur because of variable discharge rates from The Dalles Dam (KJ 2020; USACE 2023; USGS 2023).

Historical aerial photographs indicate the former shoreline of the river was approximately 300 feet south of where it is today and consisted primarily of bedrock, with the exception of an 800-foot sandy section where the bedrock erosional feature is believed to extend. Overlying the glaciofluvial deposits within the river and beyond the toe of the riprap embankment, are surface sediment consisting of micaceous fine sand to silty fine sand with varying amounts of organics that have been observed at thicknesses of up to approximately 5 feet. In select locations farther from the current shoreline, a 2- to 3.5-foot interval of highly plastic silty sand fill containing wood, roots, and limited amounts of miscellaneous litter is present (Jacobs 2024).

2.1.3 Bathymetry

A detailed bathymetric survey of the inundated lands adjacent to the railyard and around the Initial Investigation area was completed in 2017 and a second survey was conducted in 2022 in preparation for the Sediment RI (Jacobs 2024). The bathymetric survey indicates that within approximately 100 feet of the current shoreline, surface water depths are up to 15 feet as the riverbed dips to the south at a slope of approximately 8% (Figure 2-1). As shown on Cross Section BB-BB' on Figure 2-1, water depths of up to 20 feet are present in that area with a steep drop off near 100 feet from shore at a 52% slope that levels off abruptly. Water depths in the eastern and western portions of the site increase more gradually, reaching about 25 feet deep at 250 feet from shore in the east (Cross Section CC-CC' on Figure 2-1) and 30 to 35 feet at a distance of 500 feet from shore in the west (Cross Section AA-AA' on Figure 2-1). Slopes in Cross Section AA-AA' are generally at less than 10%, with slopes in Cross Section CC-CC' ranging from 19 to 2%.

Elevation of the sediment surface ranged from approximately 150 feet North American Vertical Datum of 1988 (NAVD88) to 120 feet NAVD88 within the study area. The elevation of The Dalles Dam forebay ranged from 157.74 to 158.72 feet NAVD88 during Step 1 (USACE 2022a) and ranged from 157.76 to

159.67 feet NAVD88 during Step 2 (USACD 2022b). The survey confirmed the conditions on the surface identified from the historic aerial photographs of the area, with rocky outcrops present in several areas as shown by a jagged contour line. No unexpected features were identified.

Bathymetry and sediment coring data indicate that, in general, the portions of the inundated lands impacted by the NAPL represents a depositional environment, with deposition being limited to areas with gentle slopes. This is consistent with the work done by Moody et al. 2003, which found that hydrologic dam alterations trapped sediment, therefore filling riverbeds and sand bars and causing riffles to disappear. The bathymetry in this area shows a steep drop off to the south and the absence of sediment was noted during Sediment Profile Imaging camera and sediment coring field activities.

2.2 Nature and Extent of Impacts

This subsection describes the nature and extent of impacts to sediment identified in the RI.

2.2.1 Estimated Extent of NAPL

The extent of NAPL at the site was delineated using multiple lines of evidence including TarGOST locations/intervals where NAPL-related waveforms were observed and where NAPL impacts in sediment cores advanced in 2018 and 2022 were observed. The estimated lateral and vertical extent of NAPL across the site is shown on Figures 1-3, 1-4, and 1-5. Cross section Figures 1-4 and 1-5 plot the TarGOST responses and the intervals of observed NAPL from the sediment cores and subsurface sediment analytical data.

The extent of NAPL-impacted sediment is between 30 and 130 feet wide in the north-south direction and approximately 650 feet long in the east-west direction. In the eastern portion, impacted sediments are located as close as approximately 20 feet from the shoreline. To the west, the impacts are farther from shore, approximately 90 feet. As shown on Figures 1-3, 1-4, and 1-5, the western portion of the NAPL-impacted area is characterized by thinner and less impacted zones that are deeper within the sediment column and are not contributing to the observed sheens (Jacobs 2024). As described in Section 2.3, the NAPL resulting in intermittent sheens is contained to the eastern portion of the impacted area and is shown as the teal-colored area on Figure 1-3. To the south, the NAPL-impacted interval thins and is closer to the sediment surface as the sediment surface slopes downward (Figure 1-5). When the sediment bathymetry drops below the base of the impacted interval to the south (approximately 141 feet above mean sea level) (Figure 1-5), NAPL is no longer found. This is consistent with a historical surface release from the uplands that was controlled by the site topography before Lake Celilo was filled (Jacobs 2024).

NAPL impacts diminish to the north and east toward the shoreline and are found at lesser thicknesses and relatively lower peak and average TarGOST responses. To the west, NAPL impacts are well below the biologically active zone and are generally found below 5 feet bss. As described in Section 2.3, these impacts are not contributing to the sheens that have been observed at the site. As shown on Figure 1-4, peak and average TarGOST responses decline with distance to the west, and the impacted intervals are 2 feet thick or less, and often less than 1 foot thick. These thinner impacted zones continue to deepen to the west to a depth of between 7 and 8 feet bss (Figure 1-4). Unimpacted TarGOST profiles collected during the 2022 Sediment RI bound the extent of the NAPL impacts (Jacobs 2024). The analytical data results from the subsurface sediment cores were also used to confirm the lateral and vertical extents of NAPL, as illustrated on Figures 1-3 through 1-5 (Jacobs 2024).

2.2.2 Surface Sediment Conditions

The biologically active zone (BAZ) was established by Ecology as the top 10 centimeters of sediment (Ecology 2022) and was targeted during the surface sediment sampling performed as part of the RI. Analytical results from the Sediment RI indicated the presence of total sulfides above the Freshwater Benthic dry weight SCO in both site and background surface sediment samples. During the RI, a single compound, 3 & 4-Methylphenol (m- & p-Cresols), was identified above the SCO in one background sample (BG17). In general, the presence of NAPL-related constituents within the surface sediment of the site is limited as NAPL-impacted intervals are generally buried by at least several feet of unimpacted sediment. TPH-DRO and TPH-RRO were not reported above their respective SCOs in site surface sediment samples collected during the 2022 Sediment RI (Jacobs 2024). Results of the 2018 Initial Investigation (Jacobs 2019) indicated exceedances of TPH-DRO and/or TPH-RRO in surface sediment at locations D200 and J260 (Figure 2-2). To the west of the sheen generating area, NAPL-impacted sediments are deeper. As a result, the surface sediment in that area has concentrations below the SCOs for TPH-DRO and TPH-RRO. The deeper sediment samples in the western area have also been below the SCOs for TPH-DRO and TPH-RRO (Figure 1-4).

Surface weighted average concentrations (SWACs) were calculated for bioaccumulative chemicals, including carcinogenic PAHs (cPAHs), and polychlorinated biphenyls (PCBs). Figure 2-3 shows the resulting Thiessen polygons. Tables 2-1 and 2-2 show the calculations for cPAHs and PCBs, respectively. Due to the low levels of detected concentrations for cPAHs and PCBs, the pre-remedy SWAC results are below the SCOs.

2.3 Fate and Transport

As discussed in the Sediment RI Report (Jacobs 2024), NAPL at the site is not advectively mobile or migrating. The intermittent sheens are the result of gas ebullition-facilitated transport of NAPL from sediment to surface water. Ebullition is a dynamic process fueled by the degradation of organic carbon and influenced by water depth, temperature, depth within the sediment column, and sediment strength, such that no one parameter will control gas bubble generation (McLinn 2009). Where NAPL is coincident with active ebullition, it preferentially sorbs to the hydrophobic bubble surface. NAPL that attaches to a gas bubble is transported to the surface of the water, often spreading when the gas bubble breaks at the water surface and forming a sheen blossom (ASTM E-3282-22 NAPL Mobility and Migration in Sediment – Evaluating Ebullition and Associated NAPL/Contaminant Transport 2022).

Ebullition occurs throughout the inundated lands as gases develop from the decaying organic matter associated with the former upland areas as well as from other aquatic and terrestrial sources. Gas ebullition potential in sediment samples collected from across the study area was evaluated in the 2018 Initial Investigation. Ebullition rates estimated at the site ranged between 6.5 and 6.8 liters per square meter per day with little spatial variability (Jacobs 2019). These rates are indicative of high gas production resulting from the abundance of total organic carbon observed in deeper sediment (2 to 4 feet) and variable carbon substrate observed at shallow depths.

Ebullition can occur at various depths bss but is generally more common closer to the surface with studies showing the active ebullition zone is generally in the top 3.2 feet of the sediment column (Costello and Talsma 2003; DelSontro et al. 2016; Viana et al. 2012). Gas production rates generally decrease rapidly and near exponentially with sediment depth (Popp et al. 2000; Wilkinson et al. 2015; Zepp Falz et al. 1999) with the bulk of ebullition bubbling occurring at depths of less than 5 feet bss (McLinn 2009).

Consistent with the ebullition process, gas bubble generation and the presence of sheens has only been observed at the site during the warmer months. In addition, direct observations at the site are consistent with Harrison et. al. 2017 in that the ebullition observed appears to be controlled, in part, by hydrostatic pressure. Ebullition events and sheens are observed during the summer months and when Dalles Dam-controlled levels in Lake Celilo were at or below an elevation of approximately 161 feet NAVD88. Such an event was observed on August 7, 2018, when the origin of the sheens, which had only been observed along the shoreline prior to that time, was discovered. Lake levels dropped to a minimum of 160.02 feet and wind conditions were favorable for sheen observation (3 to 8 miles per hour). The sheens were seen emerging as far as approximately 130 feet from the shoreline, then moving on the surface of the water from southwest to northeast toward the shoreline, where they had been documented to be present previously. This movement appeared to be driven by a combination of the river current and light winds coming from the west and northwest. At this time, the outboard (southwest and upwind) extent of the NAPL sheens was mapped as shown on Figure 1-3.

Subsequent investigations performed as part of the Sediment RI in 2022 have shown that the southwestern extent of sheens as mapped in August 2018 corresponds to the lateral extent of the shallowest NAPL impacts between the "J" & "K" grid lines (Figure 1-3) that are present between 0.5 foot and 3.5 feet bss. Conversely, beyond (west of) where sheens had been observed, NAPL impacts are deeper within the sediment column and are at least 4.5 feet bss and typically more than 5 feet bss. The absence of ebullition-driven sheens in the western portion of the site is consistent with the available literature on ebullition cited above and indicates the ebullition active zone resides above where NAPL impacts are present in this portion of the site. The extent of sheen-generating NAPL impacts at the site are shown on Figure 1-3. Within this area, the NAPL-impacted interval intersects the active ebullition zone and thus is subject to ebullition-facilitated transport. In addition to being shallower, the impacts that are generating the sheen at the site are thicker, exhibit consistently higher TarGOST responses, and are markedly more visually impacted (saturated with NAPL as opposed to blebs, staining, and odors only).

The buried NAPL in the inundated lands subject to ebullition-facilitated transport is estimated to be between approximately 40 and 140 feet south of the shoreline and spans a distance of approximately 100 to 170 feet wide in the east-west direction (Figure 1-3). Farther south, the extent of NAPL-impacted sediment is limited by a break in the sediment slope. Under current submerged conditions, there is no evidence of erosion of NAPL-impacted sediment via scouring. The NAPL impacts diminish to the north and east toward the shoreline and are found at lesser thicknesses and relatively lower peak and average TarGOST responses.

Figure 2-4 shows both the lateral and vertical distribution of NAPL and the role of ebullition-controlled sheens within the eastern portion of the impacted area.

2.4 Risk Assessment Summary

Human health and ecological screening risk evaluations were conducted in accordance with SCUM guidance (Ecology 2021) and presented in the Sediment RI Report (Jacobs 2024). The ecological risk screening evaluated potential risk based on benthic criteria and bioaccumulative criteria using stepwise processes and the SMS rule recommended by the SCUM (Ecology 2021). The SMS rule process for identifying a cleanup site based on benthic criteria is if the average of three stations exceeds the CSL benthic criteria, which is not limited to "surface" sediment samples. The following exceedances are noted:

- Average of stations J260, D200, and D240:
  - Greater than 8 times the benthic CSL for TPH-DRO
  - Approximately 2.5 times the benthic CSL for TPH-RRO
- The 2022 investigation showed one station exceeded the SCO benthic criteria for sulfides

These results show potential toxicity to the benthic community from surface sediment exceedances and the NAPL at depth to be a potential source of toxicity to the benthic community and impairment of surface water quality.

The evaluation based on bioaccumulative criteria defaulted to screening site sediment results against preliminary natural background values as the presumed SCO for bioaccumulative chemicals. Based on both the 2018 and 2022 investigations, the presence of PAHs and TPH-DRO is localized and generally corresponds to the NAPL footprint. TPH-DRO is known to be subject to weathering and biodegradation in the aquatic environment and its components are not considered bioaccumulative. Evaluating risks from PAHs to higher trophic receptors (i.e., food web exposures) is uncertain because PAHs are not expected to significantly bioaccumulate in the tissues of fish or crustaceans. Therefore, further ecological risk evaluation of TPH-DRO or total PAHs is not warranted, and the presumed SCO set at preliminary natural background is considered protective.

The human health risk screening conducted in the Sediment RI Report (Jacobs 2024) evaluated the following potential exposure scenarios using exposure parameters, toxicity values, and calculated exposure point concentrations (EPCs) recommended in SCUM guidance. The results of the risk screening are summarized as follows:

- **Shellfish Consumption.** With the exception of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxicity equivalence quotient (TEQ) and benzo(g,h,i)perylene, the EPCs of constituents detected in sediment are below the preliminary natural background values used to evaluate the fish/shellfish consumption exposure scenario. The following summarizes the EPCs for these two constituents:
    - The EPC of 2,3,7,8-TCDD TEQ (0.78 nanogram per kilogram [ng/kg]) exceeds the preliminary background concentration (0.532 ng/kg). Three of the 13 samples analyzed for dioxin-like substances had 2,3,7,8-TCDD TEQ concentrations exceeding background. Because the majority of dioxin-like compounds included in the EPC calculation were not detected in sediment samples, the EPC may be biased high.
    - The EPC of benzo(g,h,i)perylene (0.24 milligram per kilogram [mg/kg]) exceeds the preliminary natural background value (0.22 mg/kg). Because there were only 2 samples with detectable concentrations out of 21 samples collected, the EPC is the maximum detected concentration which is biased high. Because the mean of the two detected concentrations (0.13 mg/kg) is less than the preliminary natural background value and the 19 non-detected values range from 0.0076 mg/kg to 0.086 mg/kg, benzo(g,h,i)perylene concentrations are below or similar to the preliminary natural background value.
- **Beach Play**. Risks from exposure to sediment through the beach play exposure scenario meet the SMS and SCUM guidance human health criteria.
- **Clam Digging**. Risks from exposure to sediment through the clam digging exposure scenario meet the SMS and SCUM guidance human health criteria.
- **Net Fishing**. Risks from exposure to sediment through the net fishing exposure scenario meet the SMS and SCUM guidance human health criteria.

3. Sediment Cleanup Unit Boundary and Cleanup Action Objectives

This section presents the sediment cleanup unit boundary, associated SMAs, and applicable cleanup action objectives.

3.1 Sediment Cleanup Unit Boundary

A sediment cleanup unit is defined in WAC 173-204-505(20) as a discrete subdivision of a sediment site established based on unique chemical concentrations or parameters, regional background, environmental, spatial, contaminant source characteristics, future site use needs (such as increased draft depth), or other characteristics determined appropriate. The sediment cleanup unit boundary for the site is presented on Figure 3-1 and includes the following:

- The extent of NAPL-impacted sediment (including the extent of the sheen-generating NAPL) based on TarGOST and sediment sampling conducted in the RI.
- Areas where SCO or CSL values are exceeded within the surface sediment and thus have the potential to result in an ecological and human health exposure risk.
  - TPH-DRO and TPH-RRO, Stations J260, D200, and D240 are within the sediment cleanup unit (Section 2.2)
  - Station E320 for sulfide; however, sulfide is not contributing to risk

The sediment cleanup unit also includes offsets for each cleanup action alternative (further detailed in Sections 4.3.3, 4.3.4, and 4.3.5), which are intended to accommodate constructability factors such as slope stability, proximity to shorelines, bedrock outcroppings, and means and methods of construction.

3.2 Sediment Management Areas

SMAs are a common method of subdividing the sediment cleanup unit and are usually defined based on differing physical conditions (site or sediment), chemical characteristics, water depths, current or wave regimes, required thicknesses of cuts, COCs, or hot spot concentrations of COCs. As a result of the differing conditions in the western and eastern portions of the sediment cleanup unit as identified in the RI, which includes the 2018 data set, the sediment cleanup unit was divided into two SMAs – eastern SMA (ESMA) and western SMA (WSMA) (Figure 3-2).

3.2.1 Eastern SMA

The ESMA) constitutes approximately 0.7 acre (Figure 3-2). The ESMA incorporates the impacted areas where SMS are not currently being met, either as a result of observed intermittent sheens or surface sediment concentrations that are in excess of SCOs. Characteristics of the ESMA include:

- The shallowest NAPL impacts; particularly those located between lines J & K where the top of the NAPL impacts are present between 0.5 foot and 3.5 feet bss
- The thickest and most visually impacted NAPL intervals with highest laser-induced fluorescence (LIF) responses; on average NAPL within the ESMA is located between 3.4 feet and 7.2 feet bss with an average thickness of 3.8 feet
- The NAPL-impacted intervals that are the source of the intermittent sheens observed at the site (sheen-generating NAPL)

- SCO exceedances of TPH-DRO and/or TPH-RRO in surface sediment at locations D200 and J260

The ESMA includes the bulk of the NAPL impacts associated with the site.

3.2.2 Western SMA

The western SMA (WSMA) is shown on Figure 3-2 and constitutes approximately 0.3 acre. This area has been designated as a separate SMA as the conditions here already meet the SMS. Characteristics of the WSMA include:

- No SMS criteria exceedances
- Deeper NAPL impacts that begin between 4.5 and 7.8 feet bss
- The thinnest (ranging from 0.1 foot to 2.5 feet thick) and least visually impacted NAPL intervals with lower LIF responses
- NAPL-impacted intervals that are below the active zone of ebullition and thus do not contribute to the intermittent sheens observed at the site.

3.3 Cleanup Action Objectives

Cleanup action objectives provide a general description of what the remedy is expected to accomplish. They are site-specific and serve as the design basis for the cleanup action alternatives considered for the sediment cleanup unit. Cleanup action objectives are influenced by the nature and extent of chemical exceedances, ARARs, and potential human and environmental exposure. The cleanup action objectives for the site are:

- Compliance with SMS
  - Protect benthic organisms from direct contact with and ingestion of COCs in sediment
  - Protect higher trophic levels (e.g., fish) from exposure to COCs through ingestion of impacted prey or surface water
  - Protect human health from exposure to COCs from direct contact with impacted sediment, incidental ingestion of impacted sediment, and consumption of impacted fish/shellfish
- Prevent the generation of sheen emanating from known areas of buried NAPL-impacted sediment on the site through the ebullition pathway
- Protect cultural resources at the site

3.4 Other Applicable Regulatory Requirements

Applicable laws are defined in WAC 173-204-505(2) as “all legally applicable requirements specified in WAC 173-340-710(3) and those requirements that the department determines, based on the criteria in WAC 173-340-710(4), are relevant and appropriate requirements.”

Other relevant and appropriate requirements may include state, federal, local, or tribal laws that meet the criteria in WAC 173-340-710(4). These are regulatory requirements that may not be legally applicable but address problems or situations sufficiently similar to those encountered at a particular site and are therefore well suited to use at the site. These relevant and appropriate requirements must be considered when selecting and implementing cleanup actions to meet the minimum requirements of WAC 173-204-570(3). Once a requirement is determined to be relevant and appropriate, it must be complied with as an applicable law.

The requirements determined to be applicable or "relevant and appropriate" are commonly referred to as ARARs. ARARs are identified based on site-specific factors, including the chemicals at the site that are being addressed in the cleanup action alternative, the physical characteristics of the site, and the cleanup action alternatives being evaluated. ARARs are usually divided into three categories as follows:

- Chemical-specific ARARs include state and federal requirements that regulate constituent levels in various media, including the presence of sheen. These ARARs are usually health- or risk-based numerical values or methodologies used to determine the acceptable amount or concentrations of chemicals that may remain in the environment.
- Location-specific ARARs are requirements for constituent concentrations or remedial activities that apply based on a site's physical location.
- Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes, or requirements to conduct certain actions to address particular circumstances at a site.

Appendix A presents the ARARs for the site by type.

4. Identification of Cleanup Action Alternatives

This section describes the process used to develop a reasonable number of cleanup action alternatives in accordance with WAC 173-204-550(7)(c)(d). The process begins with the identification of potentially applicable cleanup action alternative components (technologies) based on the available site characterization data and known physical site conditions. In accordance with WAC 173-340-351(6)(c), only technologies that would meet the applicable requirements for a cleanup action set forth in WAC 173-340-360 were considered. These technologies and various process options associated with each were then screened for effectiveness and implementability as described in Section 4.1.

The technologies retained for further consideration were then assembled into a reasonable range of viable cleanup action alternatives for each SMA to address the site-specific cleanup action objectives. Cleanup action alternatives are identified and described in Sections 4.2 and 4.3. A detailed evaluation of the alternatives, as required by WAC 173-340-351(6)(d), is provided in Section 5. Although specific technologies have been identified as part of each alternative, there may be refinements to the identified technologies during the design and implementation phases due to engineering considerations and/or local conditions. The modifications would be made to improve the implementability, effectiveness, or cost of the selected approach, without changing the outcome of the evaluation of the alternatives.

4.1 Identification of Alternative Components

Potential remedial technologies and process options were identified and initially screened in accordance with WAC 173-340-351(6)(c) to determine the most promising and feasible remedial technologies. Major categories of response actions (such as institutional controls [ICs] and monitored natural recovery [MNR]), general categories of technologies (such as sediment capping/vertical containment and dredging), and mechanical or hydraulic dredging were considered in the screening process.

The No Action Alternative is included as required by SCUM Section 12.4.4 (Ecology 2021), and, as the most permanent cleanup action, will serve as a baseline alternative against which other alternatives are compared. Table 4-1 provides identified potentially applicable technologies that meet the requirements in WAC 173-340-360, which includes:

- No Action
- ICs
- Natural Recovery
- Removal
- Containment
- Treatment
- Dewatering
- Transportation
- Disposal

The preliminary screening of these potential cleanup action components is detailed in Table 4-2, which also identifies the basis for eliminating any cleanup alternative components from further evaluation.

4.1.1 Effectiveness and Implementability

Evaluation of the alternative components that meet the requirements for a cleanup action laid out in WAC 173-340-360 includes determining the technical effectiveness of each technology and, in general, the ability to achieve the following:

- Reduce the toxicity or mobility of the COCs
- Comply with applicable laws and meet cleanup action objectives
- Limit potential impacts to human health and the environment during construction and implementation
- Determine whether the process is proven and reliable with respect to the COCs and conditions at the site

Technologies that offer significantly less effectiveness than other proposed technologies may be eliminated from the alternative development process. Likewise, options that do not provide adequate protection of human health and the environment are eliminated from further consideration.

Per WAC 173-340-360, alternative components that are not technically feasible (not realistically possible to conduct) are not carried forward into the detailed evaluation. Table 4-2 presents the screening of alternative components for implementability, which is a measure of the technical or administrative feasibility of implementing a technology at the site. Options that are technically or administratively infeasible, are not compatible with site-specific conditions, or are difficult to construct may be eliminated from further consideration. Administrative feasibility includes consideration of the ease of obtaining land permits and agreements with various property owners and agencies.

4.1.2 Retained Technologies

Individual cleanup action alternative components and their associated process options were screened based on considerations of meeting SMS and technical feasibility. The screening step is designed to narrow the list of alternative components to identify the most viable candidates for use in assembling cleanup action alternatives. Table 4-2 provides a summary of the screening and results. Where appropriate, the alternative components screening also provides the justification for retaining or not retaining a component for further consideration. The overall goal is to retain representative process options within the general alternative component categories to form cleanup action alternatives. The cleanup action alternative components and process options eliminated from further consideration based on lack of effectiveness in meeting SMS and/or technical feasibility are highlighted in gray shading in Table 4-2.

4.2 Development of Alternatives

WAC 173-340-351 and WAC 173-204-550 detail the requirements for the development of cleanup action alternatives. The regulations recommend a range of alternatives, with the number and types of alternatives based on the characteristics and complexity of the facility, including current site conditions and physical constraints and the threats posed by the site to ecological receptors, human health, and the environment (SCUM Section 12.4 [Ecology 2021]). At least one permanent alternative and a no action alternative, should be included for sediment sites. Alternatives that clearly do not meet the minimum requirements in WAC 173-204-570(3) should not be included.

Several cleanup action alternatives have been developed for the sediment cleanup unit, including the No Action Alternative as required by SCUM Section 12.4.4 (Ecology 2021). These cleanup action alternatives differ between the ESMA and the WSMA. The differences are based on the conditions identified within each SMA, as discussed in Sections 3.2.1 and 3.2.2. While NAPL-impacted sediment has been identified to a limited extent in the WSMA, the area meets the SMS requirements with no additional action. MNR was identified for the WSMA to ensure the effectiveness of the natural cap in this area over the long term. For the ESMA, multiple alternative components were retained (Table 4-2). These components were combined to develop the following cleanup action alternatives:

- Alternative 1 – No Action
- Alternative 2
  - ESMA – Removal, Backfill, and Offsite Disposal
  - WSMA –MNR and ICs
- Alternative 3A
  - ESMA – Capping with AquaGate + ORGANOCLAY™ and ICs
  - WSMA – MNR and ICs
- Alternative 3B
  - ESMA – Capping with a Reactive Core Mat (RCM) and ICs
  - WSMA – MNR and ICs
- Alternative 3C
  - ESMA – Capping with RCM and a Marine Armor Mat (MAM), and ICs
  - WSMA – MNR and ICs
- Alternative 4
  - ESMA - In-Situ Stabilization (ISS), Backfill, and ICs
  - WSMA – MNR and ICs

4.3 Description of Cleanup Action Alternatives

This subsection includes a description of each cleanup action alternative including the location and estimated amount of material to be removed or treated (which includes capping) for each alternative, consistent with WAC 173-204-550. The primary components of each cleanup action alternative are summarized in Table 4-3 including the volumes, areas, and other pertinent information used in the descriptions in the following subsections. Figure 4-1 depicts the location of the proposed staging area for the alternatives. Figures 4-2 through 4-4 depict the SMAs and primary remedy component for each cleanup action alternative.

4.3.1 Common Elements

Several elements and assumptions are common to each alternative. Common elements for the ESMA include preconstruction activities, site preparation debris removal, backfill, site restoration, and long-term operation, monitoring, and maintenance (OM&M). MNR and ICs in the WSMA are included in the discussion in Sections 4.3.1.3 and 4.3.1.7. Table 4-4 shows these common elements for the alternatives by SMA.

4.3.1.1 Preconstruction Activities

The following common elements are associated with Alternatives 2, 3A, 3B, 3C, and 4 and include the following activities:

- Pre-design Investigation – These data may be necessary to refine specific aspects of the selected cleanup action alternative. Data needs will be evaluated prior to the outset of the design phase.
- Remedial Design – The remedial design would be developed in a phased approach incorporating a design report, associated calculations, specifications, and drawings. The final specifications and

drawings would be a component of the request for proposal to select a contractor to perform the construction work. For the purposes of this FS, Alternatives 2, 3A, 3B, 3C, and 4 assume active remediation in the ESMA portion of the sediment cleanup unit. Additionally, an evaluation would be performed to identify a list of applicable permits that would be required for construction. Coordination and consultations would be performed with the governing agencies and Tribes. The parties responsible for permit acquisition would be determined after remedy selection.

- Contractor Work Plans - The contractor would be required to prepare work plans detailing means and methods, operational parameters for equipment to be used, quality assurance and quality control procedures, construction schedules, health and safety procedures, work schedules, and other items.
- Mobilization and Demobilization – Prior to commencement and following completion of work, equipment, labor, and materials would be moved to and from the staging area and site.
- Site Preparation – Preparing the site and conducting a property survey.

These details on approach and implementation for the common elements are assumptions for FS purposes only. Although preliminary details on approach and implementation for the common elements are provided, the specifications for implementation and construction of the selected remedy would be identified during design and means and methods for implementation identified by the selected contractor following approval of the design.

4.3.1.2 Site Preparation

Site preparation activities would be conducted before implementation of remedial work associated with Alternatives 2, 3A, 3B, 3C, and 4. Such activities include the construction of material and equipment staging and handling areas (staging areas, approximately 1 acre), infrastructure installation and improvement, security measures, and potentially clearing of vegetation and riprap along the shoreline to provide equipment and personnel access to the river and offloading/onloading facilities. Construction of the sediment processing area (SPA) will be needed for Alternative 2 and will include an area for debris processing. A much smaller area to process debris will be needed for Alternatives 3A, 3B, 3C and 4 with no SPA needed, Erosion, sediment, and stormwater controls would be installed around the upland support areas. Perimeter and in-water monitoring stations (e.g., water quality and dust) would be installed at pre-determined locations. Siting of remedy elements would be assessed and approved by Ecology prior to the cleanup action alternative.

Resuspension control systems (e.g., silt curtains) would be required and installed prior to commencement of remedial activities to minimize potential migration of suspended material to surrounding areas during operations. Design of the resuspension control system would be completed during the design phase of the project upon further evaluation of site characteristics. However, for purposes of this evaluation, turbidity curtains are assumed to be installed around the perimeter where remedial activities would be conducted.

Monitoring would be performed to verify compliance with applicable regulations and permits. Water quality monitoring data (e.g., turbidity) would be collected from fixed locations near the active work area. Ambient air monitoring for dust and noise monitoring would be conducted at upland areas during remedial operations. Mitigation for action level exceedances would be implemented, as appropriate. The monitoring program would be developed during the design phase.

4.3.1.3 Monitored Natural Recovery

MNR is associated with Alternatives 2, 3A, 3B, 3C, and 4 and includes monitoring in the WSMA to verify continued compliance with the cleanup action objectives. The FS assumes MNR for 30 years. Subsequent MNR beyond year 30 will be based on periodic reviews. For costing purposes, monitoring has been assumed for a duration of 100 years. However, this may be reduced based on the periodic review of monitoring data. MNR is assumed to incorporate the following:

- Bathymetric surveys (to occur at year 5 and every 5 years until year 30. Subsequent bathymetric surveys may be conducted on an as-needed basis per the finding of periodic reviews.
- Periodic reviews of monitoring data and summary reports by Ecology starting in year 5 until year 30 and then as needed thereafter.

4.3.1.4 Debris Removal

Debris such as metallic material, logs, roots, concrete, and subaquatic vegetation may be present in the ESMA where active remediation will be conducted. It is anticipated that debris would be removed prior to or concurrently with dredging operations (Alternative 2) and prior to capping (Alternatives 3A, 3B, and 3C) and ISS (Alternative 4). Means and methods of debris removal would be selected by the contractor. However, these may consist of excavator's equipment with an appropriately sized bucket (e.g., clamshell or heavy digging buckets) or rakes or underwater shears. Debris removal is not anticipated to result in alternative implementability concerns. Material would be removed, transported to the upland staging area, processed appropriately (i.e., segregated based on type and size, power washed [if necessary], and stockpiled), to the extent practicable, to facilitate transport and disposal operations to a local landfill or recycling center. For Alternative 2, the debris processing area will be included in the SPA. In Alternatives 3A, 3B, 3C, and 4, there will only be a debris processing area, which will be much smaller than the SPA. There may be a de minimis quantity of sediment removed from the ESMA associated with debris. However, debris processing would separate the sediment, which would then be handled accordingly. Additional investigations (e.g., magnetometer, side scan sonar, or sub-bottom profiling) and evaluations would be performed to further refine the estimated debris quantity and final disposal locations as a component of future design evaluations and based on additional debris surveys.

4.3.1.5 Backfill

Following acceptance of the post-dredge survey (Alternative 2) and ISS (Alternative 4), backfill would be placed in the ESMA to manage residual impacts and to provide suitable substrate for fish habitat and benthic restoration. Backfill assumes the placement of a 6-inch-thick layer, plus a 25% over placement allowance and 25% material loss factor. The over placement allowance provides for the potential loss in thickness due to consolidation, provides a placement tolerance for the contractor, and accounts for the accuracy of verification methods (e.g., bathymetric surveys). Additionally, loss factors are included to account for material that is misplaced or lost due to site characteristics (e.g., river hydrodynamics and water depths). As a basis for this FS, it is assumed that the backfill would be amended with a combination of ORGANOCLAY (5% by weight) and granular activated carbon (GAC) (3% by weight) to address dredge residuals that may have the potential to generate sheen. This component would be assessed during design activities. Backfill would be placed using barge-based mechanical means. Following backfill placement, hydrographic surveys would be performed to verify the desired footprint and thickness have been achieved. Table 4-3 includes approximate backfill volumes.

4.3.1.6 Site Restoration

Site restoration activities would be performed for Alternatives 2, 3A, 3B, 3C, and 4, and coordinated with applicable regulatory agencies. Restoration would be conducted where disturbances to the existing environment and natural habitats occurred within the upland and river bank areas due to the construction of support facilities and implementation of remedial activities.

Following construction, temporary facilities and controls would be removed and placement of backfill would provide suitable aquatic habitat under the current riverine/dam impoundment conditions of Lake Celilo. Specifically, infrastructure (including staging areas, SPA, utilities, water treatment system [WTS] equipment (Alternative 2), temporary security fencing, office trailers, and flood containment structures) would be removed. The upland areas would be restored to original grade.

4.3.1.7 Institutional Controls

ICs may include physical access restrictions and covenants, with signage (such as “limit vessel wake” or “no anchorage”) limiting potential disruption of constructed remedial facilities (e.g., caps). ICs would be implemented following construction, determined during design and in coordination with applicable agencies. The ICs would be applicable in the WSMA for Alternatives 2, 3A, 3B, 3C, and 4, and in the ESMA for Alternatives 3A, 3B, 3C and 4.

4.3.1.8 Long-term Operation, Monitoring, and Maintenance

Following implementation of each alternative, an OM&M plan would be developed. Monitoring would be performed to assess attainment of short-term (1 to 5 years) metrics focusing on remedy implementation success and confirmation of the CSM through collection and analysis of data. Long-term (5 or more years) metrics would be informed by the results of the short-term evaluations.

As a basis for this FS, long-term monitoring (LTM) at the ESMA will consist of visual assessments for sheen generation (Alternative 2 at years 1 through 3) and bathymetric surveys (Alternative 2 at years 1 and 5; Alternatives 3A, 3B, 3C, and 4 at year 5 and every 5 years until year 30). The frequency of future monitoring may be modified and will be based on the results of the periodic reviews. The LTM will be used for comparisons and other metrics similar to the short-term data collection efforts that consider long-term sustainable conditions at the site. The exact components of the LTM would be developed during the design phase. For costing purposes, cap maintenance is included as a contingency for Alternatives 3A, 3B, and 3C in the ESMA in years 15, 30, 50 and 75. However, based on cap maintenance experience with other caps in the Columbia River, such as the Union Pacific Railroad cap located in the high-flow regime area downstream of The Dalles Dam installed in 1990 (EPA Site ID ORD 009049412), where no cap maintenance has been required thus far, cap maintenance is not expected. The maintenance program will be based on the results of the LTM activities and periodic reviews and may consist of repairing or replacing AquaGate + ORGANOCLAY RCM or erosion protection material. OM&M also includes periodic reviews of monitoring data and summary reports by Ecology starting in year 5 until year 30. Periodic reviews would continue to be conducted until cessation of LTM activities. LTM in the WSMA is included in the MNR program detailed in Section 4.3.1.3.

4.3.2 Alternative 1 – No Action

As required by SCUM Section 12.4.4 (Ecology 2021), the No Action Alternative is required to be included unless the permanent alternative is chosen. The No Action Alternative is not being considered for implementation at the site. Under No Action, no cleanup action alternative is implemented and therefore the existing conditions at the site would not change, except for those undergoing natural processes, if present. The No Action Alternative is generally appropriate in situations where impacts at a site present no current or potential threat to human health or the environment, where the State does not provide the authority to take cleanup action, or where a previous response action has eliminated the need for additional cleanup action at a site. COCs would remain in place and be subject to environmental influences.

4.3.3 Alternative 2 – Removal, Backfill, Offsite Disposal, MNR, and Institutional Controls

Alternative 2 includes the common elements detailed in Section 4.3.1, removal of sediment with NAPL impacts, placement of backfill (amended with ORGANOCLAY and GAC to manage residual impacts) in the ESMA and transport and disposal of processed dredge material. MNR and ICs will be conducted in the WSMA as detailed in Sections 4.3.1.3 and 4.3.1.7, respectively. Figure 4-2 depicts the SMAs and remedy components for Alternative 2. The ESMA includes offsets of approximately 21 feet on each side to account for 3 to 1 (3:1) side-slopes based on an approximate dredge depth of 7.1 feet. The WSMA does not include offsets because no active cleanup action alternative will be conducted.

Table 4-3 shows the approximate removal volumes, areas, and primary alternative components associated with Alternative 2. The removal volumes include the following:

- Neatline prism (defined as an three-dimensional geometric shape corresponding to the volume of sediment targeted for removal; the estimated volume of impacted material with no other factors incorporated)
- A 0.5-foot overdredge allowance (typical of dredge projects to ensure depths or bathymetric targets are reached with a certain level of confidence)
- Five percent bulking by volume (to account for density changes of the material when it is disturbed and removed, also referred to sometimes as “fluff factor”)
- Side-slopes of 3:1 (a typical assumption for slope stability for dredge projects at this level of project definition)
- Thirty percent volume contingency factor (to account for potential underestimates of volume given the level of project definition at the FS stage)

Alternative 2 permanently removes NAPL from the river environment (transferring the impacted material to a permitted landfill), achieving the SCO via dredging of approximately 8,200 cubic yards (yd^3). The estimated production rate for dredging is 350 yd^3 per day (yd^3/day). The sheen producing NAPL is located at depth below an overlying sediment veneer and, therefore, the dredge prism has been divided into two distinct zones–the overlying sediment and the NAPL-impacted sediment. The overlying sediment would be removed first to access the NAPL-impacted sediment. The overlying sediment has an average dredge cut depth of 3.4 feet bss and an estimated volume of 4,150 yd^3. The NAPL-impacted sediment has an average dredge cut thickness of 3.8 feet and ranges from 3.4 to 7.1 feet bss with an estimated volume of 4,050 yd^3. Dredge volume estimates would be revised during the design phase to account for constructability considerations including stable sidewall cuts, overdredge, and dredge prism configuration.

Alternative 2 permanently removes NAPL from the ESMA footprint. However, there is potential for resuspension and release during the remedial action. Resuspension is the process by which dredging operations dislodge bedded sediment particles, disperse them into the water column, and are not captured by the dredging operations. Resuspension also occurs from ancillary activities such as spillage (such as scow overflow and misplaced material), spuds, and support vessels, among others. Once material has been resuspended, it has the ability to be released to the water column. Release is defined as the process by which the dredging operations result in the transfer of the COCs from sediment porewater and sediment particles into the water column in the particulate and dissolved phase. The release has the potential for the resuspended particulate to be deposited locally or transported in the particulate or dissolved phase downstream from the location of remediation resulting in residuals (further discussed below).

Floating oils (NAPL – as is the case for this project) are another form of release to the water column during the dredging process providing another mechanism of COC transport (Bridges et al. 2008). The inherent effects of resuspension and release can impact the overall effectiveness and permanence of remedial action. However, these impacts can be minimized through the implementation of administration and engineering controls such as the reduction in cycle times, use of specialty dredging equipment, and installation of resuspension control systems (such as turbidity curtains, baffles, and oil adsorbent booms). Site-specific evaluations are necessary to manage resuspension and release and are conducted during the design phase. For the purposes of this FS, it is assumed that the resuspension and release of NAPL during dredging operations can be minimized, however, must be considered in the assessment. Figure 4-2 depicts the SMAs and total remedial footprint of Alternative 2. For purposes of this FS, and based on sediment removals performed at other similar sites, removal would be conducted using barge-mounted mechanical means (such as an excavator equipped with a clamshell bucket). Excavation from the shoreline and hydraulic dredging were eliminated from consideration as detailed in Table 4-2.

Real-time kinematic digital global positioning system mounted on the dredge equipment would be used to verify the specified removal depths and spatial locations are achieved. Bathymetric surveys would be conducted before and after removal activities to confirm achievement of the horizontal and vertical (required dredge depth) limits of dredging.

Dredged sediment would require management and disposal following removal. The proposed approach involves transporting the dredged sediment in scows to an offloading facility at the shoreline. Spill plates would be constructed to support offloading and to mitigate releases of dredged material. Construction of an offloading facility increases the difficulty associated this alternative when compared to the other alternatives. However, this is a common element associated with dredging. The dredged material would be offloaded from scows and placed directly into a lined and bermed SPA. Sediment processing operations would be performed, as necessary, following offloading to meet transport and disposal requirements. For purposes of this FS, it has been assumed that dredged sediment would require processing and inspection by trained archaeologists at the SPA following dredging and prior to transfer of dredged materials to the landfill. Initial dredged material processing would be conducted through a series of size separation equipment to separate debris (not removed during the debris removal process) and various sediment gradations. Size separation will facilitate transport and disposal operations as well as to evaluate cultural resources. Screening for cultural resources would be conducted by a registered professional archaeologist and is assumed to consist of manually sorting through dredging material to identify and separate cultural resources, consistent with previous Department of Archaeology and Historic Preservation (DAHP) requirements at the site during in-water investigation work. Requirements for sorting of dredged material will be consistent with the recommendations provided following consultation between Ecology, DAHP, and local Tribes. Cultural resource screening is anticipated to be a physically demanding, laborious, and time-consuming process. Additionally, worker health and safety concerns are elevated for this alternative because the screening process will involve handling large quantities of NAPL-laden sediment. To aid in separating NAPL from dredging material, solutions or surfactants are assumed to be required.

Production estimates for screening are assumed at 50 yd^3/day, resulting in total durations of 164 days to process the dredged material, which is significantly longer than the anticipated dredge schedule of 23 days (production rate of 350 yd^3/day). As a result, the majority of dredged sediment targeted for removal will need to be stockpiled at the SPA for extended periods of time resulting in additional maintenance such as odor control and water treatment. Following the cultural screening process, the dredged material will undergo a combination of passive (e.g., gravity drainage) and active (e.g., mechanical mixing) processing. The active processing component is assumed to incorporate a solidification agent (Portland cement) as needed, to solidify the material to meet transport and disposal requirements. As a basis, it is assumed that 50% of the overlying sediment and 100% of the NAPL-impacted sediment would require active processing. The processed dredged material would then be loaded into railcars for transport to the disposal facility. Additional infrastructure (such as loading platforms, decontamination stations, and spill plates) may be required to facilitate the loading of railcars.

Treatability testing would be performed to determine the amendment and dosage required to pass paint filter testing and disposal facility requirements (e.g., a minimum strength may be required by the receiving facility). Management of dredged material would require that the SPA be appropriately sloped to collect stormwater and water that drains from dredged materials (supernatant), which would then be conveyed to an onsite WTS. Treated water would be discharged back to the Columbia River or to a publicly owned treatment works in accordance with regulatory requirements (Clean Water Act) (Appendix A).

Following confirmation of dredging operations, an amended backfill layer would be placed in the ESMA to manage residual impacts. Residual impacts are defined as impacted sediments remaining in or adjacent to the dredging footprint after completion of dredging operations (Palermo et al. 2008). Residuals are classified into two categories – undisturbed and generated. Undisturbed residuals are impacted sediments found at the post-dredging surface that have been uncovered by dredging but not removed. Generated residuals are impacted post-dredging surface sediments that are dislodged or resuspended and released by the dredging operation and are subsequently redeposited. An amended backfill layer, also known as a "residual management layer" (RML) can be placed to manage undisturbed residuals and provide suitable substrate for benthic repopulation and fish habitat restoration, immediately restoring the BAZ for benthic repopulation. Section 4.3.1.5 contains additional details. Table 4-3 contains approximate backfill volumes.

Debris is expected to be encountered and would be removed prior to or concurrently with dredging operations. Section 4.3.1.4 contains additional details.

The total duration of construction is estimated at 8 months. During implementation of Alternative 2, monitoring would be conducted to verify compliance with applicable regulations and permits. Turbidity data would be collected from fixed locations upstream and downstream of the active work area. Ambient air monitoring for dust would be conducted at upland areas during construction. Mitigation for turbidity, sheen, and NAPL releases to surface water, as well as dust releases to air, would be implemented as necessary.

MNR would be conducted as detailed in Section 4.3.1.3 for the WSMA and an OM&M plan would be developed to detail LTM in the ESMA as specified in Section 4.3.1.8. The OM&M plan would be further evaluated with regulatory agencies and refined during the design phase.

4.3.4 Alternative 3 – Capping, MNR, and Institutional Controls

Alternative 3 includes the installation of a reactive cap over the ESMA and the common elements detailed in Section 4.3.1. MNR and ICs will be conducted in the WSMA as detailed in Sections 4.3.1.3 and 4.3.1.7, respectively. Figure 4-3 shows the footprint of the alternative. Table 4-3 includes the quantities of materials and areas to be treated. Impacted sediments would remain on the site. Alternative 3 has been subdivided into three distinct capping alternatives: Alternatives 3A, 3B, and 3C. The differences between the alternatives, specifically the variations of the capping layers, are depicted in Exhibit 4-1 and are based on the reactive and armoring components of the caps, as further detailed below.

In general, cap thickness can vary significantly from as little as 12 inches up to several feet or more for different sites depending on the constituents, their concentrations, remedial objectives, and erosion potential, among other factors. Even at a single site, varying cap configurations can be appropriate due to variable site conditions.

Prior to the placement of cap materials, debris removal (Section 4.3.1.4) would be conducted to prepare the subgrade. Note that debris removal is not considered pre-dredging. Following debris removal, a leveling layer typically composed of granular material, such as sand, is placed and provides a more stable and even surface for placement of the first layer of cap materials, which need to be placed within required thickness tolerances.

In some capping projects, pre-dredging must first be completed to accommodate the thickness of the cap so that upon completion, there is no net elevation gain of the bathymetry. This is often required to comply with Federal Emergency Management Agency (FEMA) and USACE permitting requirements to reduce the potential for flooding or to maintain draft for vessels, among other possible reasons. The site is not within the navigational channel and therefore not regulated by USACE. The area within the Columbia River that would be capped is 0.7 acre in size, located within the dam-controlled area of Lake Celilo and within FEMA Zone A (FEMA FIRMette Map 5300990550B). For Flood Zone A, up to 1 foot of elevation change is allowed under FEMA (44 Code of Federal Regulations 60.3(b)). The volume of Lake Celilo, which is 277,000 acre-feet (Ecology 2023), compared to the volume of material for the cap (based on 2 feet over 0.7 acre) of 2.86 acre-feet is 0.001%. Therefore, no measurable increase in water level is expected and cap layers for the proposed options in this FS are assumed to be placed on the existing sediment surface.

Next, the base layer (i.e., chemical isolation layer) would be placed overlying and in contact with the leveling layer. The base layer would include a reactive material, such as organic carbon, ORGANOCLAY, and GAC, among other amendments, mixed into the granular capping materials (e.g., sand) or incorporated into a prefabricated manufactured cap system (e.g., a RCM) to isolate and prevent migration of NAPL and sheens. The conceptual approach, granular materials, amendments, and prefabricated systems are available in today's market, and are widely accepted and proven applications in the remediation industry. The adsorption capacity of amendments will vary between selected materials and loading, which will be determined during the design phase. The capping alternatives are meant to provide a range of potentially applicable amendments and approaches to reactive capping while complying with regulatory requirements and achieving the cleanup objectives.

The third layer of the cap (armor layer) prevents erosion of the middle and base cap layers. The armor layer may include stone or a prefabricated system such as a MAM. Above the armor layer, a habitat restoration layer (typically sand) would be placed to facilitate the reestablishment of the benthic community, provide fish habitat, and immediately restore the BAZ. In capping applications where erosion potential due to water flow is low and/or propellor wash is not a concern (commensurate with conditions that exist at this site), the armor layer is not needed.

In some capping applications, a filter stone or material is needed between different capping layers. The filter layer serves as a stable base for materials such as armor stone placed above the reactive layers and to provide a transition between layers of significantly different grain sizes to prevent mixing and consolidation between the layers. The need for filter layers would be addressed during the design stage of the project.

For purposes of this FS, as depicted on Exhibit 4-1, the cap components for Alternatives 3A, 3B, and 3C are assumed to consist of the following (from bottom to top):

- An initial 6-inch-thick layer of leveling sand (Alternatives 3A, 3B, and 3C) placed on top of the existing sediment surface
- A reactive layer:
  - 3A: a 3-inch layer of AquaGate plus ORGANOCLAY
  - 3B: a 0.25- to 0.5-inch nominally thick RCM
  - 3C: a 0.25-inch nominally thick RCM
- An erosion protection layer: a 6-inch-thick MAM (Alternative 3C only)

- Benthic restoration layer (12 inches for Alternatives 3A and 3B and 6 inches for Alternative 3C) to restore the BAZ

For Alternatives 3A and 3B, the thickness of the benthic restoration layer has been increased relative to Alternative 3C to provide a suitable option without the installation of a MAM.

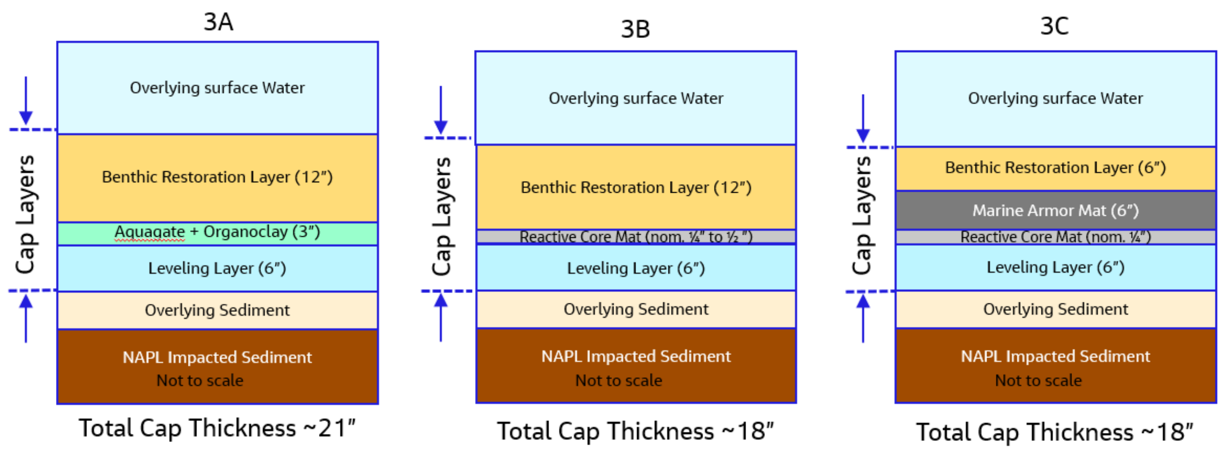

Exhibit 4-1. Typical Cross Section of Caps for Alternatives 3A, 3B, and 3C

The initial 6-inch-thick layer of sand would be placed to facilitate "leveling" of the current bathymetric surface to provide initial stability to prevent lateral movement of the cap and provide an even surface for placement of reactive elements.

Alternatives 3A, 3B, and 3C provide three different configurations for the reactive and erosion protection layers of the cap. The following describes the differences in more detail:

- Alternative 3A: A layer of AquaGate and ORGANOCLAY (assumed thickness of 3 inches) would be placed above the leveling layer in an even thickness. Based on the remedial footprint of the ESMA, a 3-inch-thick layer of AquaGate and ORGANOCLAY equates to a to a mass ORGANOCLAY placement of 6.0 pounds per square foot (lb/ft^2) with an oil adsorption capacity of 0.5 pounds of oil per pound of ORGANOCLAY. This is equivalent to 3.0 lb/ft^2 of oil adsorption capacity. A separate erosion protection layer would not be included. However, an enhanced thickness of 12 inches is assumed for the benthic restoration layer.
- Alternative 3B: An RCM, with a nominal thickness of ¼ to ½ inch would be placed above the leveling layer, and similar to Alternative 3A, a 12-inch layer of benthic restoration material would be placed over the RCM. Based on technical data sheets from CETCO, a single panel of RCM has a mass loading of 0.8 lb/ft^2 ORGANOCLAY with an oil adsorption capacity of 0.5 pounds of oil per pound of ORGANOCLAY. This is equivalent to 0.4 lb/ft^2 of oil adsorption capacity. Multiple layered RCM panels would equate to an increase in mass loading.
- Alternative 3C: An RCM with a nominal thickness of ¼inch would be placed above the leveling layer following by the installation of a MAM and a 6-inch-thick layer of benthic restoration material over the MAM. The RCM ORGANOCLAY mass loading would be the same as Alternative 3B.

Alternatives 3B and 3C have assumed an RCM in lieu of a granular chemical isolation layer to account for potential constructability considerations related to the steeply sloped site bathymetry. The RCM would provide a continuous thickness and layer that would avoid differential settlement common to granular materials. For Alternative 3C, the RCM could be attached directly to the MAM and placed in a single lift as opposed to two separate lifts, simplifying constructability.

A filter layer is not included in the current cap configurations because the typical grain size distributions for the leveling layer, the AquaGate + ORGANOCLAY layer, and the benthic restoration layer are similar enough in grain size such that a filter layer is likely not necessary (Alternative 3A and 3B). For Alternative 3C, the MAM will distribute the load of the armor layer and the armor stone is contained within the geosynthetic meshing of the MAM. Therefore, the filter layer (typically needed between layers of a cap when the grain size distributions differ substantially) would not be necessary.

The benthic restoration layer would be placed as a final layer above the reactive layers or MAM to promote benthic recolonization, provide suitable fish habitat, and immediately restore the BAZ.

The selected materials and cap configurations for Alternatives 3A, 3B, and 3C are permeable allowing the cap to "breathe." Ebullition migrating from the NAPL-impacted sediment layer that causes sheens in the ESMA would pass through the reactive layers of the caps. However, NAPL and dissolved-phased constituents would be adsorbed by the reactive layer, allowing the gases to continue to migrate upward through the sediment and water column. Lateral migration of NAPL is not anticipated because the cap components will be permeable and the materials to construct the cap will be selected to be comparable to those existing at the site. The design of individual layers of the cap will be conducted during the design phase and will incorporate: calculations associated with the volume of NAPL; migration potential and pathways; quantification of ebullition; and hydrodynamic and geotechnical analysis to design the layers (i.e., leveling layer, chemical isolation layer, and erosion control layer); thickness of each layer; and amendments to achieve an increased degree of long-term reliability associated with capping alternatives

Figure 4-3 depicts the SMAs, primary remedy components, and total remedial footprint of Alternative 3 (3A, 3B, and 3C are the same). The ESMA where caps would be placed assumes offsets of approximately 21 feet (similar to Alternatives 2 and 4), to account for inherent uncertainties in the location of the sheen producing NAPL-impacted sediment and likely subsurface irregularities that affect ebullition as well as constructability factors. Table 4-3 provides estimated volumes for each cap component. The AquaGate + ORGANOCLAY and leveling and restoration layer include a 25% overplacement allowance and a 25% material loss factor, which are commonly included for subaqueous cap installations at the FS stage. The RCM and MAM include an additional 15% for overlap. Additionally, it should also be noted that the cost estimates include a 30% contingency factor to account for unforeseen circumstances or variability. For purposes of this FS and based on sediment capping remedies performed at other similar sites, capping would be conducted using barge-mounted mechanical means (such as an excavator/crane equipped with a clamshell bucket).

Active cap simulations and modeling have not been conducted to evaluate the efficacy of various cap configurations and compositions. Modeling will be conducted as part of design to minimize the transport of NAPL-impacted sediment or sheens into the overlying water column as well as addressing the physical conditions that correlate to overall erosive forces present at the site (e.g., wind, waves, velocity, seismic activity). These evaluations would be conducted during the design phase and would simulate cap longevity over the life of the cap. Additionally, hydraulic assessments would be performed to determine whether the cap placement over the existing sediment bed would affect flooding elevations and be compliant with ARARs.

The estimated duration of construction for each capping alternative is as follows:

- Alternative 3A: 2.0 months
- Alternative 3B: 2.0 months
- Alternative 3C: 2.5 months

An OM&M plan would be developed to detail LTM to verify the caps remain in place over time, and to detail periodic monitoring (surveying) and maintenance to verify it is functioning as designed. Section

4.3.1.8 contains additional details. The LTM would be further evaluated with regulatory agencies and refined during the design phase. In addition, ICs would be conducted in the ESMA because NAPL-laden sediment would remain under the caps and in the WSMA to verify MNR.

4.3.5 Alternative 4 – In-Situ Stabilization, Backfill, MNR, and Institutional Controls

Alternative 4 includes the ISS of NAPL-impacted sediment in the ESMA and the common elements detailed in Section 4.3.1. MNR and ICs will be conducted in the WSMA as detailed in Sections 4.3.1.3 and 4.3.1.7, respectively. For this alternative, the ISS would be conducted over an approximate area of 0.7 acre as detailed in Table 4-3. Impacted materials would not be removed from the site under Alternative 4.

Under Alternative 4, NAPL-impacted sediment in the ESMA would be treated in situ by immobilizing the NAPL in a cement-type matrix. Figure 4-4 depicts the SMAs, the primary remedy components, and total remedial footprint of Alternative 4. The ESMA where ISS would be conducted assumes offsets where additional ISS would be performed by a distance of approximately 21 feet (three diameter widths of the auger with overlap) to account for additional ISS around the perimeter of the ESMA due to the inherent uncertainties in the location of the sheen producing NAPL-impacted sediment.

In the remedial footprint, the ISS auger rigs (e.g., crane mounted or hydraulic drill operating from a barge) would mechanically mix reagent into the overlying sediment and the NAPL-impacted sediment, creating an array of overlapping, cement-like columns extending from the surface to below the bottom of the NAPL-impacted sediment. For the purposes of this FS, ISS is assumed to a depth of 10 feet bss based on an average impacted depth of 7.1 feet plus a buffer below to account for dragdown and uncertainties in the impacted depth. Reagent for the ISS would be delivered to the site by truck and mixed onsite in a batch plant. Based on experience at other similar sites, the mix design for Alternative 4 is assumed to be 10% Portland cement. Conducting ISS will cause disturbance and will result in cultural artifacts being solidified in the resulting cement monolith.

ISS implementation typically causes "swell" of the target material, which occurs when reagents are added and mixed due to the volume increase of the material, the mixing process itself, and the curing process. Swell can vary significantly from site to site based on various factors including the target material itself. For purposes of the FS, it has been assumed that swell would be approximately 20%, or given the target depth of 10 feet, a 2-foot increase in sediment surface could be anticipated (similar to the resulting increase in the sediment surface for Alternative 3). Pre-dredging or post-treatment swell removal is sometimes implemented to maintain bathymetric elevations. However, for this FS, it has been assumed that swell removal or pre-dredging to accommodate swell is not necessary because it has been assumed there would be no net rise in surface water elevation. Near the edge of the bench, some buildup of material may be needed to ensure treatment materials are contained.

Following confirmation of ISS operations, a 6-inch-thick backfill layer would be placed in the ESMA above the treated material to provide suitable substrate for benthic repopulation, fish habitat, and immediately restore the BAZ. Section 4.3.1.5 contains additional detail. Table 4-3 details the approximate backfill volumes.

Debris is expected to be encountered and would be removed prior to ISS operations. Section 4.3.1.4 contains additional detail. Note that this is not considered pre-dredging.

Bench-scale testing would be performed during remedial design to determine the optimum reagents, mix ratios, and reagent addition rates. The mix design would be evaluated by measuring and optimizing the hydraulic conductivity, unconfined compressive strength, and leaching reduction in a series of tests prepared using NAPL-impacted sediment obtained from the site.

A field demonstration test would also be performed to verify the bench-scale results, evaluate full-scale equipment options, establish productivity rates, and identify sitewide implementation considerations. Due to logistical limitations associated with mobilizing ISS equipment to the site for a field scale pilot test, a demonstration test would occur at the start of full-scale remediation.

The duration of construction is estimated at 3.5 months. An OM&M plan would be developed to detail LTM to verify the remedy is functioning as designed as detailed in Section 4.3.1.8. Periodic bathymetric surveying is assumed as a basis for this FS. The LTM would be further evaluated with regulatory agencies and refined during the design phase. In addition, ICs would be implemented and maintained following construction.

5. Detailed Evaluation and Selection of Cleanup Action Alternatives

This section provides a description of the evaluation criteria, analysis of each cleanup action alternative against the criteria and a comparative analysis.

5.1 Description of MTCA Evaluation Criteria

This subsection provides an evaluation of the cleanup action alternatives under the MTCA requirements for conducting a FS. As stated in WAC 173-340-351, the purpose of the FS is to develop and evaluate cleanup action alternatives for the site that meet the requirements in WAC 173-340-360 and conform, as appropriate, to the expectations in WAC 173-340-370. Under MTCA, cleanup action alternatives are evaluated within the framework of minimum requirements, including relative benefits criteria and DCA ranking criteria, as specified in WAC 173-340-360 and as presented in the FS Checklist (Ecology 2016). The cleanup action alternatives are screened against minimum requirements and then compared using a DCA.

The requirements, as per WAC 173-340-360(3) and WAC 173-240-570(3), must be met by a cleanup action alternative to be considered further in the evaluations. For sediment sites, threshold requirements also address applicable requirements in WAC 173-204-570 (Section 4.3.7). In addition, these cleanup action alternatives should consider permanent solutions to the maximum extent practicable (WAC 173-340-360[3][a][x] and WAC 173-204-570[3][d]). If an alternative does not meet these criteria, it should be eliminated from further consideration. At a minimum, a sediment cleanup action must meet the following:

- **Protect human health and the environment**. This criterion considers to what degree the alternative is protective of human health and the environment, including vulnerable population and overburdened communities. It considers how much the alternative reduces risk, how much time it will take to meet cleanup standards, and any onsite or offsite risks related to implementing the cleanup (WAC 173-340-360[3][a][i] and WAC 173-204-570[3][a]).
- **Comply with applicable state and federal laws**. For cleanup action alternatives to be considered viable, the alternatives must comply with applicable state and federal laws (WAC 173-340-360[3][a][iii] and WAC 173-204-570[3][b]). This includes those outside the immediate purview of the MTCA that must be met (applicable) or should be met (relevant and appropriate) when cleaning up a site (as presented in the ARARs in Appendix A).
- **Comply with the sediment cleanup standards**. For cleanup action alternatives to be considered viable, the alternatives must comply with cleanup standards specified in WAC 173-204-560 through 173-204-564. Cleanup standards in MTCA have three components: cleanup levels (CULs), points of compliance, and ARARs (WAC 173-340-360[3][a][ii] and WAC 173-204-570[3][c]). Cleanup standards are finalized in the cleanup action plan (CAP).
- **Prevent or minimize present and future releases and migration of hazardous substances in the environment.**
- **Provide resilience to climate change impacts that have a high likelihood of occurring and severely compromising their long-term effectiveness.**
- **Provide for compliance monitoring**. Compliance monitoring is required for the cleanup actions and unless otherwise directed by Ecology, a compliance monitoring plan must be prepared. MTCA specifies

three types of monitoring requirements for site cleanup and monitoring: protection, performance, and confirmation (Section 4.2.4) (WAC 173-340-360[3][a][vi] and WAC 173-204-570[3][j]).

- **Not rely primarily on ICs and monitoring** at a site, or portion thereof, if it is technically possible to implement a more permanent cleanup action.
- **Not rely primarily on dilution and dispersion** unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures over the benefits of dilution and dispersion. The benefits and costs are discussed in Section 5.2, as part of the DCA.
- **Reasonable restoration time frame**. Describe the estimated restoration time frame for each alternative and the basis for this estimate. Discuss the reasonableness of this time frame using the evaluation factors in WAC 173-340-360(4) and WAC 173-204-570(5). The evaluation also considers public concerns identified under WAC 173-340-600(13) and (14) and Tribal rights and interests identified under WAC 173-340-620.
- **Use permanent solutions to the maximum extent practicable**.

5.2 Disproportionate Cost Analysis Ranking Criteria

MTCA requires that cleanup action alternatives use permanent solutions to the maximum extent practicable. For example, alternatives that include dredging to remove sediment with NAPL impacts from the site, which provide a more permanent solution than alternatives that would not remove sediment with NAPL impacts, such as capping or ISS. However, dredging, in general, is more expensive than capping or ISS. The analysis of the disproportionate cost (i.e., DCA) is a MTCA procedure to evaluate tradeoffs, including costs, among technologies. It was specifically created to weigh incremental environmental benefits against the incremental cost of such benefits. This determination is made based on the DCA process in which:

- The most practicable, permanent cleanup action alternative serves as the baseline.
- The benefits of the cleanup action alternatives to human health and the environment are evaluated and compared to the costs.

As required under MTCA, this analysis compares and contrasts each cleanup action alternative for each of the following criteria in accordance with WAC 173-340-360(5)(d) and the FS Checklist (Ecology 2016). Both quantitative measures and more qualitative best professional judgments are used in assessing benefits.

- **Protectiveness.** Overall protectiveness of human health and the environment.
- **Permanence.** The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances. Consider treatment capability, reduction of releases, management of the sources of release, degree of irreversibility of treatment, and the quantity and quality of treatment wastes.
- **Effectiveness Over the Long Term.** Consider the degree of certainty for cleanup success, long-term reliability, magnitude of residual risk, management of treatment wastes, and management of wastes left untreated. In addition, long-term effectiveness considers impacts to vulnerable populations and overburdened communities, including tribal nations.
- **Management of Implementation Risks.** Assess the risk to human health and the environment associated with the alternative during construction and implementation.

- **Technical and Administrative Implementability.** Ability to be implemented including consideration of whether the alternative is technically and administratively possible.
- **Cost.** The cost to implement the alternative, including present capital costs, future capital costs, indirect costs, and operation and maintenance costs.

5.3 Evaluation of Cleanup Action Alternatives against Relative Benefits Criteria

This subsection evaluates each cleanup action alternative with respect to the relative benefits criteria noted in Section 5.2. For any cleanup action alternative, the five threshold requirements must be achieved to be considered viable as a cleanup action alternative for the site and be carried forward in the evaluation. Ultimately, Cleanup Action Alternatives 2, 3A, 3B, 3C, and 4 are designed to satisfy the five threshold requirements with critical differences in degree of certainty, reliance on ICs, and remediation time frames.

Alternative 1 (No Action) would not mitigate the occurrence of sheen on the water surface caused by ebullition from NAPL containing sediments or mitigate exposure risk to the benthic community or human health. This alternative fails to achieve cleanup goal 1 (reduce risk to benthic organisms), cleanup goal 2 (reduce risk to humans), and cleanup goal 3 (prevent the generation of sheen emanating from known areas of buried NAPL-impacted sediments through ebullition) in a reasonable time frame but would achieve cleanup goal 4 (protect cultural resources) because no further action is taken. In addition, this alternative fails to comply with cleanup standards and chemical-specific state and federal laws. Alternative 1 (No Action) does not meet or fully satisfy the criteria, thus it is eliminated from further consideration.

5.3.1 Protect Human Health and the Environment

Protection of human health and the environment is measured by each alternative's ability to achieve SMS cleanup standards while considering factors such as:

- The degree to which the alternative reduces existing risks
- The time required for the alternative to reduce risks at the site and attain cleanup standards
- The onsite and offsite risks remaining after implementing the alternative
- Improvement of the overall environmental quality

As described in Section 1, the Sediment RI indicates human health screening results are similar to ecological screening with some exceedances of risk criteria at a few sampling stations associated with the shellfish/fish consumption exposure scenario, thus the site presents potential threat to human health or the environment. As identified in the FS, sediments with NAPL impacts are non-mobile and are identified between approximately 3.4 and 7.1 feet bss. This area or the extent of sediments with NAPL impacts are identified as a sediment cleanup unit, as defined in Section 3.1. The sediments with NAPL impacts that produce occasionally visible sheens on the water surface through ebullition are found in the ESMA (Section 3.2.1). While there is no current evidence of NAPL-impacted sediment erosion occurring at the site, the potential for future near-surface sediment erosion does exist (Jacobs 2024).

Alternatives 2, 3A, 3B, 3C, and 4 are expected to eliminate the occurrence of sheen on the water surface through ebullition. Cleanup Action Alternatives 3 (3A, 3B, and 3C) and 4 include implementation of ICs to support the long-term protectiveness of the remedy. ICs for these alternatives are limited to restrictions on the use of spuds within the footprint of the ESMA (0.7 acre). ICs are not required for Alternative 2 because the sheen-generating areas would be addressed through removal. ICs should be relied upon to the minimum extent practicable, thus the less reliant an alternative is on ICs, the more protective the alternative.

Other considerations for protectiveness that vary among alternatives include the risk remaining after implementation. Residual NAPL would remain onsite, below the RML, following removal (Alternative 2) because dredging is not 100% effective. In contrast, the onsite risk associated with Alternatives 3A, 3B, 3C, and 4 would be reduced considerably and residual impacted sediment would be isolated from receptors.

Remedy construction can result in elevated short-term environmental risks (e.g., adverse impacts to water quality) from dredging activities that remove sediments with NAPL impacts from the site while providing greater long-term protectiveness and permanence. It is anticipated that in situ mixing of reagents for ISS using auger rigs would have higher short-term impacts on the water quality than dredging or capping due to the degree of mixing and likely disturbance. Some short-term risks can be reduced through prudent design practices and best management practices (BMPs) during construction.

Alternatives 2, 3A, 3B, 3C, and 4 would be protective of human health and the environment and would achieve cleanup action objective 1 (meet CULs to protect human health and the benthic community) and cleanup action objective 2 (reduce risk to humans), through removal and offsite disposal, capping or in-place containment, and ISS of sediments with NAPL impacts. However, handling of dredged material associated with Alternative 2 would cause exposure and risk to human health, especially during potential artifact recovery. Such risks to human health are not present for Alternatives 3A, 3B, 3C, or 4.

Each alternative would achieve cleanup action objective 3 (prevent the generation of sheen through ebullition of NAPL) in a reasonable time frame through the removal of sediments with NAPL impacts (Alternative 2) or the isolation of impacted sediment (Alternatives 3A, 3B, 3C, and 4). Cleanup action objective 4 (protect cultural resources) would be achieved through differing processes for each alternative. Alternative 2 would rely on intensive handling of dredged material, including using surfactants to separate the oil residue from the sediment and/or artifacts that are anticipated. Alternative 3 would leave artifacts in place, to be recovered should the dam be removed, resulting in no change from existing conditions. Alternative 4 will result in a solid subsurface material that may include cultural resources. While the cultural resources would not be removed, the process may cause disturbance and will result in any such resources being solidified.

Alternatives 2, 3A, 3B, 3C, and 4 achieve the criteria of protecting human health and the environment although the alternatives accomplish protectiveness by different means. Long-term risks and short-term (i.e., construction-related) risks are further evaluated in Table 5-1.

5.3.2 Comply with Cleanup Standards

For cleanup action alternatives to be considered viable, the alternatives must comply with cleanup standards. Cleanup standards in MTCA have three components: CULs, points of compliance, and ARARs. Cleanup standards are finalized in the CAP. The cleanup action objectives for this site are described in Section 3.3. Cleanup action objectives are generally concentration-based goals for individual chemicals for a specific medium and are typically based on cleanup goals, the current and reasonably anticipated future land uses, and the potential ARARs in consideration of background concentrations of the COCs. The cleanup action objectives for this site are to prevent potential threat/risk to human health or the environment (cleanup objective 1 and cleanup objective 2) and to prevent the ebullition of NAPL resulting in a visible sheen on the water surface (cleanup objective 3).

WAC 173-340-730(5)(d) (*adjustments to cleanup levels for nonaqueous phase liquid limitation*) states that, "for organic hazardous substances and petroleum hydrocarbons, the cleanup level shall not exceed a concentration that would result in nonaqueous phase liquid being present in or on the surface water.

Physical observations of surface water at or above the cleanup level, such as the lack of a film, sheen, discoloration, sludge or emulsion in the surface water or adjoining shoreline, may be used to determine compliance with this requirement."

Thus, for Alternatives 2, 3A, 3B, 3C, and 4, the cleanup action objectives of preventing the ebullition of NAPL resulting in a visible sheen on the water surface is predicted to be achieved upon completion of remedial construction.

5.3.3 Comply with Applicable State and Federal Laws

Alternatives 2, 3A, 3B, 3C, and 4 would comply with or meet the applicable chemical-, location-, and action-specific state and federal laws identified for the site.

Chemical-specific state and federal laws mainly pertain to the protection of surface water quality. Sediments with NAPL-impact could be released to the Columbia River during in-water construction activities such as during sediment dredging, ISS, and/or capping activities. Compliance with chemical-specific state and federal laws could be attained through the implementation of monitoring programs, BMPs, and engineering controls including silt and erosion control measures installed during construction.

Location-specific state and federal laws for the cleanup action alternatives would be addressed during the implementation of the alternative. These primarily relate to work affecting threatened or endangered species, fish and wildlife habitat, national historic preservation, archaeological and Native American grave protection, and work performed within or adjacent to floodplains and shorelines. Consultation with respective agencies would be performed before implementing any cleanup action alternative. In addition, substantive requirements of various acts and implementing regulations identified would be met and addressed including measures to minimize disturbances on a location-specific basis.

Action-specific state and federal laws for Alternatives 2, 3A, 3B, 3C, and 4 would be addressed during the implementation of the cleanup action alternative. Activities under each alternative would be conducted in a manner that would comply with the substantive requirements of various acts and implementing regulations identified.

5.3.4 Provide for Compliance Monitoring

Compliance monitoring is a key criterion and a key assessment technology for sediment remediation. MTCA (WAC 173-340-410) specifies three types of monitoring requirements for site cleanup:

- **Protection Monitoring.** This confirms that human health and the environment are adequately protected during the construction phase of the cleanup action alternative.
- **Performance Monitoring.** Performance monitoring or post-construction performance monitoring is used to confirm that cleanup action alternatives have achieved the cleanup standards or other performance standards.
- **Confirmational Monitoring.** Confirmational monitoring or OM&M is used to confirm the long-term effectiveness of a cleanup action alternative after the performance standards or remediation levels have been achieved. This would include monitoring of disposal, isolation, or containment sites to ensure long-term protection.

The monitoring program(s) are included as part of Alternatives 2, 3A, 3B, 3C, and 4 allow progress toward achieving cleanup standards to be assessed periodically. Alternatives 2, 3A, 3B, 3C, and 4 would include compliance monitoring through the implementation of a site-specific monitoring plan/program, which would be developed during the design phase. The site-specific monitoring plan/program would include protective measures and monitoring to ensure the protection of human health and the environment during remedy construction. Monitoring would also be performed to evaluate the post-construction performance of the remedy and as part of the LTM. Because Alternative 2 includes removal of NAPL-impacted sediments causing ebullition, its monitoring period is assumed to be of a short duration.

5.3.5 Reasonable Restoration Time Frame

WAC 173-340-360(4) and WAC 173-204-570(5) specify several “factors” to consider when determining whether a cleanup action alternative has a reasonable restoration time frame. The values for the restoration time frame are identical to the values for time to achieve cleanup objectives or cleanup goals.

Alternatives 2, 3A, 3B, 3C, and 4 are predicted to achieve cleanup action objectives as soon as the cleanup action alternative is completed (i.e., preventing the ebullition of NAPL resulting in a visible sheen on the water surface is predicted to be achieved at the end of remedial construction). Based on cleanup action alternative cost estimates, the restoration time frames are estimated to be approximately:

- Alternative 2: 5 months
- Alternatives 3A and 3B: 2 months
- Alternative 3C: 2.5 months
- Alternative 4: 3 months

For Alternative 2, the timeframe includes approximately 3 to 4 months of required time to complete the process of cultural screening of the dredged material at the onsite staging area prior to offsite disposal.

Alternatives 2, 3A, 3B, 3C, and 4 are assumed to provide for reasonable restoration time frames based on the ten factors in WAC 173-204-570(5)(c). However, long-term effectiveness and permanence of Alternatives 3 and 4 would rely on monitoring, and maintenance would be required until the site no longer poses potential risks of non-compliance to address the long-term integrity of the remedy.

5.3.6 Cleanup Action Requirements Summary

Based on the evaluation, Alternatives 2, 3A, 3B, 3C, and 4 comply with the MTCA requirements:

- Protection of human health and the environment
- Compliance with applicable state and federal laws
- Compliance with sediment cleanup standards
- Reasonable restoration time frame

Therefore, these three cleanup action alternatives are carried forward to the next stage of further evaluation. In addition, based on the above evaluation, Alternative 2 presents a more permanent solution than Alternatives 3A, 3B, 3C, and 4. Thus, Alternative 2 is the baseline alternative against which the other alternatives are evaluated for the purpose of determining whether the cleanup action alternative selected is permanent to the maximum extent practicable.

5.3.7 Minimum Requirements for Sediment Cleanup Actions

In addition to the noted requirements, WAC 173-204-570(3) or it will not be further evaluated in the DCA. The minimum requirements and screening of cleanup action alternatives against minimum requirements are as follows:

- Use of permanent solutions to the maximum extent practicable
- Source control measures, if applicable
- Issuance of a sediment recovery zone, if applicable
- Compliance with ICs
- Public review and comment provided
- Compliance monitoring
- Periodic review, if applicable

Exhibit 5-1 shows the alternatives compared to the minimum requirements.

Exhibit 5-1. Cleanup Action Alternatives Against Minimum Requirements

Minimum Requirements	Alternative 2	Alternatives 3A, 3B, 3C	Alternative 4
Protection of human health and the environment	Yes. Following completion of the remedy, the alternative will protect human health and the environment without site use restrictions. See Section 5.3.1.	Yes. Following completion of the remedy, the alternative will protect human health and the environment with minimal site use restrictions. See Section 5.3.1.	
Compliance with applicable laws	Yes. Alternative complies with applicable state and federal regulations. See Section 5.3.3.		
Compliance with sediment cleanup standards	Yes. Alternative is expected to comply with cleanup standards to be selected by Ecology. See Section 5.3.2.		
Use of permanent solutions to the maximum extent practicable	Yes. See Section 5.4.	Yes. See Section 5.4.	Yes. See Section 5.4.
Reasonable restoration time frame	Yes. See Section 5.3.5.	Yes. See Section 5.3.5.	Yes. See Section 5.3.5.
Source control measures, if applicable	Yes. Alternative includes most effective source control measures necessary.		
Issuance of a sediment recovery zone, if applicable	Not necessary. Cleanup standards will be met within a reasonable restoration timeframe.		
Compliance with ICs	Yes	Yes	Yes
Public review and comment provided	Yes[b]	Yes	Yes[a]
Compliance monitoring	Yes. Alternative includes provisions for compliance monitoring. See Section 5.3.4.		
Periodic review, if applicable	Yes	Yes	Yes

[a] Cultural resources would be disturbed but would remain in place.

[b] Cultural resources have a high potential for damage and for some to be transported to an offsite disposal facility.

Alternatives 2, 3A, 3B, 3C, and 4 met these minimum requirements and are further evaluated for: (1) permanent solutions to the maximum extent practicable, (2) relative benefit ranking, and (3) scoring, as presented in the following subsections.

5.4 Evaluation of Cleanup Action Alternatives using DCA Ranking Criteria

The DCA is a MTCA procedure to evaluate tradeoffs, including costs, among technologies. It was specifically created to weigh incremental environmental benefits against the incremental cost of such benefits. Cleanup action alternatives that meet the minimum requirements are further evaluated for permanent solutions to the maximum extent practicable, relative benefit ranking, and scoring.

For this FS, weighted numeric scores are used to quantify the benefits of the cleanup action alternatives. The following benefits criteria are used for this evaluation, per WAC 173-340-360(5)(d) and WAC 173-204-570(4):

- Protectiveness
- Permanence
- Effectiveness Over the Long Term
- Management of Implementation Risks
- Technical and Administrative Implementability
- Cost (cost is not scored nor is it a weighted benefit, but is used in the DCA to evaluate the benefit of each alternative relative to its present value)

Table 5-1 provides an evaluation of the cleanup action alternatives relative to the five ranked criteria. The evaluation is used to rank the cleanup action alternatives on a scale from 1 to 10 for each MTCA criterion and is used as a basis to calculate the numerical ratings in the DCA. These ratings are then weighted and summed for an overall measure of the benefits achieved by the cleanup action alternatives, presented in Table 5-2, along with the cost estimates (as net present value) for each alternative. In general, a score of 1 represents a poorly-performing cleanup action alternative for that criterion, and a score of 10 represents an optimally-performing cleanup action alternative for that criterion or indicates the cleanup action alternative substantially meets the criterion. It should be noted that each aspect of the DCA scoring and weighting factors requires a degree of best professional judgment. Quantitative measures were used where possible.

5.4.1 Weighting Evaluation of Benefits Criteria

The evaluation criteria presented in WAC 173-204-570(4) and WAC 173-340-360(5) are weighted using the following considerations and are presented in Tables 5-1 and 5-2. The weightings emphasize the core purpose of protecting human health and the environment and reflect site-specific considerations, such as the size, complexity, uncertainty, and potential restoration time frames involved in the cleanup action alternatives. Weighting factors for each benefit criterion reflect site-specific conditions and remedial objectives, however, protectiveness, permanence, and long-term effectiveness benefits criteria are typically weighted more because they are core to protecting human health and the environment. The weightings, which add up to 100%, for each criteria are as follows:

- “Protectiveness” criterion is weighted at 25%. It represents the ultimate objective of implementing a cleanup action alternative. Ranking considers the degree to which the alternative reduces existing risks, time required for the alternative to reduce risks at the site and attain cleanup standards, the onsite and offsite risks remaining after implementing the alternative, and improvement of the overall environmental quality.

- "Permanence" criterion is weighted at 25%. In evaluating the alternatives under this criterion, the focus is on the degree to which the toxicity, mobility, or volume of hazardous substances is reduced, and considers the extent to which sediments with NAPL impacts are destroyed. A high level of certainty must accompany the final environmental cleanup so that future actions will not be necessary. The criterion ranking also considers the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.
- "Effectiveness over the long term" criterion is weighted at 25%. This weighting factor is associated with a measure of certainty related to the robustness of the action, as well as confidence in the technology used for the protection of human health and the environment. The criterion also considers the potential impacts to vulnerable populations and overburdened communities, including tribal nations. It is an important requirement because it addresses how well the remedy reduces risks (e.g., whether sediments with NAPL impacts are removed or left in place to be managed over the long term) and whether controls are adequate to maintain protection against potential ebullition of NAPL in the long term. The criterion ranking considers the reliability of the alternative during the time that hazardous substances are expected to remain onsite, resilience to climate change (including recovery from impacts), the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes.
- "Management of implementation risks" criterion is weighted at 15%. This lower weighting is based upon the limited temporal aspect associated with the short-term risks at this site. Each cleanup action alternative is anticipated to have relatively shorter time frames with a smaller active remediation footprint, thus reducing the overall short-term risks to workers, the community, and the environment. At this site, short-term risks can be effectively managed through proper implementation of BMPs and engineering and administrative controls. Short-term risks are actively monitored (i.e., Protectiveness Monitoring) during the period of implementation. The length of active exposure during implementation can, however, vary considerably and this was considered in the ranking.
- "Technical and administrative implementability" criterion is weighted at 10%. This weighting reflects the fact that implementability is less associated with environmental concerns than with the relative difficulty and uncertainty of implementing the project. It includes both technical factors and administrative factors associated with permitting and completing the cleanup.
- "Cost" is not a weighted benefit but is used in the DCA to evaluate the benefit of each alternative relative to its cost (i.e., costs are evaluated against remedy benefits to assess cost-effectiveness and remedy practicability).

5.4.2 Disproportionate Cost Analysis and Discussion

The costs and benefits are summarized on Exhibit 5-2 and on Figure 5-1. The overall benefits associated with each alternative are summarized using a composite "benefits score." This score includes the rankings for individual evaluation criterion, which are multiplied by the weighting within that category and summed to reach the "total benefits score." The estimated costs are expressed in the total present worth which is adjusted for future costs (Appendix B). Cost estimates for each cleanup action alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the assumed scope and project definition at the FS stage. They are prepared solely to facilitate relative comparisons among alternatives for FS evaluation purposes. Exhibit 5-2 shows the DCA summary.

Exhibit 5-2. Summary of Disproportionate Cost Analysis

Cleanup Action Alternative	Total Benefits Score	Estimated Present-Worth Cost [a] (millions)	Ratio of Cost to Benefits[b] (millions)
Alternative 2 – Removal, Backfill, Offsite Disposal, MNR, and ICs	8.3	$9.7	$1.18 per benefit
Alternative 3A – Capping with AquaGate + ORGANOCLAY, ICs, and MNR	8.3	$3.7	$0.45 per benefit
Alternative 3B - Capping with RCM, ICs, and MNR	8.0	$4.4	$0.56 per benefit
Alternative 3C – Capping with RCM, MAM, ICs, and MNR	8.0	$4.9	$0.62 per benefit
Alternative 4 – ISS, Backfill ICs, and MNR	7.6	$7.5	$1.00 per benefit

[a] Cleanup action alternative cost estimates are presented in Appendix B.
[b] Ratio of cost to benefits, example for Alternative 2 = $9.7 million/8.3 = $1.18 million per benefit

The relative benefits and costs of each alternative are compared to Alternative 2, which represents the most permanent cleanup action alternative (the baseline alternative). The baseline alternative therefore provides the benchmark against which the relationship between incremental remedy benefits and incremental costs of each of the other cleanup action alternatives are evaluated. This analysis is used to determine whether the proposed cleanup actions are permanent to the maximum extent practicable.

The total benefits for the cleanup action alternatives range from 7.6 to 8.3, and present-worth costs range from $3.7 million to $9.7 million (Appendix B contains cost details). Figure 5-1 details the weighted benefits score for each alternative with an overlay of cost in graphical format. The following conclusions are drawn from the DCA:

- Higher cost alternatives do not necessarily show proportional increases in overall benefit, especially when comparing capping alternatives (Alternatives 3A, 3B, and 3C) against Alternatives 2 and 4.
- The WSMA is treated the same for each alternative and, therefore, does not result in a differentiation of the alternatives.
- The total benefit scores indicate that capping with a layer of AquaGate and ORGANOCLAY (Alternative 3A) results in the highest overall score of 8.3 along with Alternative 2. Alternative 3A scores highest in effectiveness over the long term, management of short-term risks, and the technical and administrative implementability criteria. Protectiveness was the same for Alternatives 3A, 3B, 3C, and 4. The lowest overall score is for Alternative 4 due to the low scores for effectiveness over the long term (which considers impacts to vulnerable populations and overburdened communities, including tribal nations), management of short-term risks, and the technical and administrative implementability criteria.
- Costs range from $3.7 million (Alternative 3A) to $9.7 million (Alternative 2) while the cost per benefit ranges from $0.45 million to $1.18 million for Alternatives 3A and 2, respectively. Alternative 3A has the lowest cost of $0.45 million per benefit gained and Alternative 2 has the highest cost of $1.18 million per benefit gained. This difference is driven primarily by the costs associated with moving the dredged material from a barge to shore, controlling the hazards to site workers during the lengthy processing period, and the labor intensive nature of removing cultural artifacts from the dredged material associated with Alternative 2.

- Of the three capping alternatives – Alternatives 3A, 3B, and 3C – Alternative 3A scored highest. Alternative 3A includes a layer of AquaGate and ORGANOCLAY at an assumed thickness of 3 inches, which equates to a mass ORGANOCLAY loading of 6.0 pounds per square foot (lb/ft^2) with an oil adsorption capacity of 0.5 pound of oil per pound of ORGANOCLAY. This results in a much higher mass loading capacity in Alternative 3A (3.0 pounds of oil absorption capacity per square foot) compared to Alternatives 3B and 3C (0.4 pound of oil absorption capacity per square foot), which ranked similarly.
- Alternatives 3B and 3C ranked similarly, with Alternative 3B providing a slightly higher ranking for technical and administrative implementability and Alternative 3C providing a slightly higher rating for long-term benefits by using a more aggressive approach to prevent erosion by installing the MAM (which, due to the nature of the river in that area, is not considered necessary).
- Capping (Alternatives 3A, 3B, and 3C) has other benefits that result in higher or similar scores with respect to Alternative 2 (Removal), especially for management of short-term risk and technical and administrative implementability. For example, based on the RI, a significant number of artifacts are anticipated to be encountered during removal activities under Alternative 2. Capping reduces negative impacts to the environment and potential for tribal and/or related artifact removal or disturbances as well as having a significant reduction in the potential risks to human health during cleanup actions.
- Because the cost of Alternative 2 ($9.7 million) is substantially higher than that of Alternative 3A ($3.7 million), and the level of benefit is the same for Alternative 3A (8.3) and for Alternative 2 (8.3), the incremental cost of Alternative 2 is disproportionate.
- The level of benefits for Alternative 4 is lower than that of Alternative 3A (7.6 versus 8.3, respectively), and the ratio of cost to benefits is considerably higher ($1.00 million versus $0.45 million). Therefore, the incremental cost of Alternative 4 is disproportionate.

The results of the DCA indicate that, at a minimum, Alternative 2 and Alternative 4 are disproportionately costly compared to their respective benefits in relation to Alternatives 3A, 3B, and 3C. Among the three capping alternatives, Alternative 3A has the lowest cost of $0.45 million per benefit gained compared to Alternatives 3B and 3C ($0.56 million and $0.62 million, respectively). Thus, Alternative 3A was identified as the most appropriate alternative for the site.

The analysis presented in this section is intended to support participating parties in their evaluations of the cleanup action alternatives relative to MTCA. The final identification of the cleanup action alternative that includes a “permanent solution to the maximum extent practicable” would be stipulated in the CAP. The purpose of a CAP is to document the selected cleanup action and to specify the cleanup standards and other requirements the cleanup action must meet.

The final identification of the cleanup action alternative will be stipulated in the CAP, which documents the selected cleanup action and specifies the cleanup standards and other requirements that the cleanup action must meet.

6. Remedy Selection

Alternative 3A (Capping with AquaGate and ORGANOCLAY, ICs, and MNR) has been identified as the recommended permanent solution to the maximum extent practicable under MTCA based upon its highest overall ranking in the DCA (Table 5-1). This alternative makes the greatest use of high-preference technologies, minimizes short-term impacts to the environment and cultural resources while remaining practicable and protective, and has the lowest cost per benefit gained compared to other cleanup action alternatives. Alternatives 3B and 3C (alternate capping configurations) also scored well in the DCA, having the next lowest cost per benefit and providing similar levels of permanence.

Alternative 2 ranked highest for permanence and Alternative 4 also ranked higher than Alternative 3A. However, based on the total benefits scores, both Alternative 2 and 4 were determined to have a disproportionate cost compared to Alternative 3A.

Alternative 2 received a total benefits score comparable to Alternatives 3B and 3C, slightly lower than Alternative 3A. The proportion of costs for Alternative 2 compared to the benefits gained is higher when compared to Alternative 3A ($1.18 million per benefit versus $0.45 million per benefit, respectively) and compared to Alternative 4 ($1.18 million per benefit versus $1.00 million per benefit, respectively); therefore, it is disproportionate.

Alternative 4 received the lowest total benefits score, which is significantly lower than Alternatives 2, 3A, 3B, and 3C. The proportion of costs for Alternative 4 compared to the benefits gained is higher than Alternative 3A ($1.00 million per benefit versus $0.45 million per benefit, respectively) and is lower than Alternative 2 ($1.00 million per benefit versus $1.18 million per benefit, respectively). Therefore, it is considered disproportionate.

Alternative 3A received the highest total benefits score. In addition, the proportion of costs compared to the benefits gained ($0.45 million per benefit) is the lowest compared to other cleanup action alternatives and therefore was identified as the most appropriate alternative for the site, as presented in Table 5-2.

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Tables

Table 2-1. Estimated Pre-Remedy Surface Weighted Average Concentrations of cPAHs

Station Identifier	Total cPAH (mg/kg)	Polygon Area (square feet)	Area Percentage of Total	Existing Condition Area Adjusted Concentration (mg/kg)	Notes
D160	0.34985	10,197	3.54%	0.0124	
E320	0.40250	5,408	1.88%	0.0076	
E380	0.03279	8,368	2.91%	0.0010	
E460	0.34755	13,742	4.77%	0.0166	
H360	0.03184	20,130	6.99%	0.0022	
I120	0.03306	10,116	3.51%	0.0012	
L320	0.06165	29,440	10.23%	0.0063	
SG01	0.05521	21,515	7.48%	0.0041	
SG02	0.09800	24,941	8.67%	0.0085	
SG03	2.15380	29,183	10.14%	0.2184	
SG11	0.03791	20,554	7.14%	0.0027	
SG13	0.03109	46,085	16.01%	0.0050	
SG23	0.03127	48,136	16.72%	0.0052	
	Totals	287,814			
			SWAC	0.2911	

cPAH = carcinogenic polycyclic aromatic hydrocarbon

mg/kg = milligram(s) per kilogram

SWAC = surface weighted average concentration

Table 2-2. Estimated Pre-Remedy Surface Weighted Average Concentrations of PCBs

Station Identifier	Total PCBs (µg/kg)	Polygon Area (square feet)	Area Percentage of Total	Existing Condition Area Adjusted Concentration (µg/kg)	Notes
D160	0.04647	10,197	3.54%	0.00165	
E320	0.05102	5,408	1.88%	0.00096	
E380	0.01012	8,368	2.91%	0.00029	
E460	0.02503	13,742	4.77%	0.00120	
H360	0.07036	20,130	6.99%	0.00492	
I120	0.02339	10,116	3.51%	0.00082	
L320	0.01571	29,440	10.23%	0.00161	
SG01	0.01970	21,515	7.48%	0.00147	
SG02	0.09530	24,941	8.67%	0.00826	
SG03	0.01444	29,183	10.14%	0.00146	
SG11	0.01725	20,554	7.14%	0.00123	
SG13	0.01415	46,085	16.01%	0.00227	
SG23	0.03163	48,136	16.72%	0.00529	
	Totals	287,814			
			SWAC	**0.0314**	

µg/kg = microgram(s) per kilogram

PCB = polychlorinated biphenyl

SWAC = surface weighted average concentration

Table 4-1. Description of Potentially Applicable Alternative Components (Technologies)

General Response Action	Technology	Process Options	Description
No Action	None	N/A	No remedial measures or monitoring conducted. Required by Sediment Cleanup User's Manual Section 12.4.4
Institutional Controls	Institutional Controls	Institutional Controls	ICs are non-engineered instruments, such as administrative and legal controls, that minimize the potential for human health or ecological exposure to contamination and ensure the long-term integrity of the remedy (EPA 2005). ICs may include land use restrictions, natural resource use restrictions, groundwater use restrictions or management areas, property deed notices, declaration of environmental restrictions, access controls (digging and/or drilling permits), surveillance, information posting or distribution, restrictive covenants, and federal, state, county, and/or local registries.
Natural Recovery	Monitored Natural Recovery	Long-term Monitoring	No treatment actions are taken, but this option considers the natural processes that may reduce or degrade chemical constituents: dispersion, dilution, transformation, sorption, and deposition of cleaner sediment, resulting in a reduction in mass, toxicity, mobility, volume, or concentration of COCs. Long-term monitoring would be required.
	Enhanced Natural Recovery	Thin-layer Placement	Enhanced natural recovery involves placing a thin layer (a few inches) of clean sediment material (with the potential to include amendments) over the impacted sediment to provide a reduction of COC concentrations in the biologically active zone and to accelerate natural recovery. Long-term monitoring would be required.
Removal	Dredging	Mechanical Dredging	Mechanical dredging involves excavating sediment using conventional earthmoving equipment (e.g., excavators and cranes) from a barge. This involves working on the water and moving the barge as needed to remove the contaminated material.
		Hydraulic Dredging	Hydraulic dredging involves removal and transport in a slurry form. The hydraulic dredges typically have a suction device fixed to a movable arm (or ladder) that is raised or lowered to facilitate sediment removal. Hydraulically dredged materials are transported via piping directly to a staging/processing area. Booster pumps may be required to transport the materials as the distance and elevation increase between the dredge and processing areas. The suction end of the dredge is often equipped with a mechanical or hydraulic device to loosen the sediment before being drawn into the dredge suction line. Common hydraulic dredges include plain suction, conventional round cutterhead, horizontal auger, open suction, dustpan, high-solids pumps, and diver-assisted suction dredges.
		Specialty Dredging	Specialty dredging includes vacuum dredging, pneumatic dredging, and other mechanical and hydraulic equipment/approach combinations. Vacuum dredging removes material via the use of vacuum trucks and requires carriage water to transport the dredged material. Dry dredges typically use a clamshell bucket on a fixed boom and use a pump to transport the dredged material. Pneumatic dredges use an air-operated submersible pump and a pipeline for transport of dredged material.
	Excavation (in the dry)	Excavation (in the dry)	This involves excavating sediment using conventional earthmoving equipment (e.g., excavators and cranes) from the shore (removal in the wet) or isolating the target dredge material from the overlying water body by pumping or diverting water from the area (e.g., sheet piling) (removal in dewatered conditions).
Containment	Capping	Engineered Capping	An engineered cap is composed of a single or layered materials (e.g., sand, gravel, cobbles, and geotextile) placed over in situ sediment to physically isolate and protect contaminated sediment from erosion and to mitigate the transport of dissolved and colloidally bound contaminants into the water column. An engineered cap can be composed of multiple materials, each with a specific purpose (e.g., cobble for erosion protection overlying sand for chemical isolation) or the same material that can function as both erosion protection and chemical isolation. Where necessary, materials may include physical barriers such as engineered clay aggregate materials (e.g., bentonite pellets and AquaBlok™). Geosynthetics are also commercially available and may be used to contain chemical isolation barrier material or erosion control material (e.g., marine armor mat). Engineering/capping can be combined with another GRA (e.g., removal) to increase the effectiveness of the alternative.
		Active Capping	An active cap is similar in design to an engineered cap (i.e., physically isolates sediments and protects from erosion). However, it reduces the flux of contaminants from underlying sediment to the water column through the adsorption of contaminants onto the cap material. Reactive materials can be placed within the contaminant isolation layer of the cap (an "active" cap) to supplement this adsorption process or to provide some other physical/containment processes that reduce the mobility of the contaminants. Use of reactive materials may be warranted where evaluations of engineered capping show that a sufficiently thick cap cannot be created to adequately reduce the flux of contaminants over time. This condition may be due to a variety of reasons singly or in combination, such as the presence of highly mobile contaminants, high rates of groundwater advection, and/or the need to maintain certain water depths for navigation or habitat purposes. As described in EPA (2005), examples of materials used in active caps include reactive/adsorptive materials such as activated carbon, apatite, coke, ORGANOCLAY™, zero-valent iron, and zeolite. Composite geotextile mats containing one or more of these materials (e.g., reactive core mats) and geosynthetics (e.g., marine armor mat) are available commercially. Active capping can be combined with another GRA (e.g., removal) to increase the effectiveness of the alternative.
Treatment	In Situ Treatment	Stabilization	In situ treatment stabilization includes mixing and fixating reactive admixtures into the sediment using amendments such as cement and slag to fixate or entrain contaminants. The process would be combined with a destructive approach when using chemical amendments to oxidize or reduce contaminant concentrations.
		Thermal Destruction	Thermal treatment involves the application of steam or hot air injection, or the use of electrical resistance, conductive, electromagnetic, or radio frequency heating. The processes increase the volatility of contaminants such that they can be removed (separated) from the solid matrix. The volatilized contaminants are then either collected or thermally destroyed.

Table 4-1. Description of Potentially Applicable Alternative Components (Technologies)

General Response Action	Technology	Process Options	Description
		Chemical Destruction	Chemical oxidants are injected into the subsurface sediments to oxidize organic contaminants.
		Biological Degradation	Biological degradation uses natural microbiological processes to degrade or transform organic chemicals in the sediment environment. Nutrients and potential electron donors/acceptors are provided while controlling temperature and pH to stimulate existing microorganisms to grow and use chemicals as a source of food and energy.
	Ex Situ Treatment	Stabilization	Ex situ treatment stabilization includes mixing the removed materials ex situ with Portland cement, fly ash, lime, kiln dust, or other stabilization agents. This process may be used for active dewatering only to reduce the leachability (i.e., mobility) of the COCs or modifying the material's structural properties.
		Soil Washing	In soil washing, soil or sediment is put in contact with an aqueous solution to remove contaminants from the soil particles. The suspension is often also used to separate fine particles from coarser particles, allowing beneficial use of the coarser fraction (if sufficiently clean) at the site.
Dewatering	Active Dewatering	Plate and Frame Filter Press	Sediment slurry is pumped into cavities formed by a series of plates covered by a filter cloth. Liquids are forced through filter cloth and dewatered solids are collected in the filter cavities.
		Belt Filter Press	Sediment slurry drops onto a perforated belt where gravity drainage takes place. Thickened solids are pressed between a series of rollers to dewater solids further.
		Hydrocyclone	Sediment slurry is fed tangentially into a funnel-shaped unit to facilitate the centrifugal forces necessary to separate solids from liquids. Dewatered solids are collected, and overflow liquid is discharged.
		Stabilization	See Treatment, Ex Situ Treatment, Stabilization.
	Passive Dewatering	Geotextile Tubes	Hydraulically dredged or rehandled sediments are pumped into the geotextile tubes and excess water flows through the pores in the geotextiles, resulting in effective dewatering and volume reduction of the contaminated materials.
		Gravity Settling and Drainage	Mechanically dredged materials are placed on a lined pad and allowed to drain and air dry. Hydraulic sediment slurry enters a settling basin and is allowed to settle, drain, and consolidate in the bottom of a basin. Pretreatment with chemical addition may be used to enhance settling.
Transportation	Barge	Barge	Sediment is removed and transported to the appropriate treatment/disposal facility via barge. Barge may require stabilization or dewatering before transportation and requires an offloading facility to transfer material from water-based operations to land-based operations.
	Truck	Truck	Sediment is removed and transported to the appropriate treatment/disposal facility via truck. Truck may require stabilization or dewatering before transportation. Additional infrastructure, such as upgrading transport routes, loading docks and stockpile areas, and spill plates for loading, among others, may be required for transportation.
	Pipeline	Pipeline	Hydraulically dredged sediment is transported to the appropriate treatment/disposal facility via pipeline. Additional infrastructure, such as booster pumps and pipe racks, and site upgrades may be required for transportation.
	Rail	Rail	Sediment is removed and transported to the appropriate treatment/disposal facility via rail. Sediment placed in the rail cars (e.g., gondolas) may require stabilization or dewatering before transportation. Existing rail facilities are present at the site, however, may require additional infrastructure, such as loading docks and stockpile areas, and spill plates for loading, among others.
Disposal	Onsite Disposal	Confined Disposal Facility	Sediment is placed in a disposal facility constructed onsite consisting of sheet piling and/or earthen dikes or caissons adjacent to or within a waterbody.
		Confined Aquatic Disposal	Sediment is placed through the water column into a bathymetric low area to form a confined aquatic disposal cell. Bathymetric low areas may be naturally occurring or may be constructed by dredging sediment to create low bathymetry artificially. After the placement of dredged material, the area is capped. Cap material may include the material dredged to create the low bathymetry.
	Offsite Disposal	Permitted Landfill	Sediment is disposed of in existing offsite permitted solid waste landfill.

U.S. Environmental Protection Agency (EPA). 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. EPA-540-R-05-012. Office of Solid Waste and Emergency Response (OSWER) 9355.0-69 PB97-963301. August.

COC = constituent of concern

EPA = U.S. Environmental Protection Agency

GRA = general response action

IC = institutional control

N/A = not applicable

Table 4-2. Screening of Potential Cleanup Action Components

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
No Action	None	N/A	Current and future risks would remain the same. Does not provide controls for reduction of exposure, long-term management, or monitoring measures. Does not meet cleanup action objectives.	N/A	None	Retained; Required by Sediment Cleanup User's Manual Section 12.4.4
Institutional Controls	Institutional Controls	Covenants	Minimizes potential human exposure to COCs in sediment. The site-specific ICs will be determined at a future date and may include land use restrictions, natural resource use restrictions, property deed notices, declaration of environmental restrictions, access controls (digging and/or drilling permits), surveillance, information posting or distribution, restrictive covenants, and federal, state, county, and/or local registries.	Technically and administratively implementable.	Low	Retained for both ESMA and WSMA
Natural Recovery	Monitored Natural Recovery	None	No active remedial activities would be performed. NAPL-impacted sediment generating sheens would not be remediated. Ongoing deposition may provide a natural mechanism to mitigate the potential for sheens in the short and long term. Does not pose any additional risk to the community, workers, or the environment. Requires long-term monitoring. Does not meet cleanup action objectives in the ESMA. Meets SMS in the WSMA.	Readily implementable and minimally intrusive. Activities would be limited to long-term monitoring and sampling from a boat and/or shoreline. Access, materials, personnel, and equipment are readily available.	Low	Retained for WSMA. Not retained for ESMA – does not meet cleanup action objectives
	Enhanced Natural Recovery	Placement of Thin Layer of Clean Material	Reduces potential for sheens in sediment over time. Effectiveness depends on hydraulic conditions created, loading rates, and the quality of sediment deposited. Effective in low-energy aquatic environments. Requires long-term monitoring. Meets cleanup action objectives.	Technically implementable but could alter local habitat. Implementability considerations for specific areas would include impacts on surface water elevations, impacts on channel depth, and stability of added sediment layers. Activities would be limited to long-term monitoring and sampling from a boat and/or shoreline. Access, materials, personnel, and equipment are readily available.	Low	Retained for both ESMA and WSMA
Removal	Dredging	Mechanical Dredging	Reduces potential long-term generation of sheens through the removal of NAPL-containing sediments. This may increase short-term exposure due to resuspension or release of COCs during dredging. Due to dredging technology limitations, management of post-dredging residuals may be necessary (e.g., through the placement of post-dredging cover materials). Cultural resources may be dredged during remedial activities. Additional processing and resources would need to be implemented to ensure the preservation of cultural resources. Meets cleanup action objectives.	Technically and administratively implementable at the site and proven technology that has been implemented at other similar sites. Equipment, materials, and personnel are readily available. Would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats is expected, however, the placement of a habitat layer as part of backfill would provide an environment conducive to benthic recolonization. This may occur where dredging would impact shoreline areas significantly.	Medium	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
		Hydraulic Dredging	Reduces potential long-term generation of sheens through the removal of NAPL-containing sediments. This may increase short-term exposure due to resuspension or release of COCs during dredging. Effectiveness could be limited by the presence of debris and other coarse material. Thus, mechanical removal of debris prior to hydraulic dredging would be required as an initial step. Due to dredging technology limitations, management of post-dredging residuals may be necessary (e.g., through the placement of post-dredging cover materials). Cultural resources may be dredged during remedial activities. Additional processing and resources would need to be implemented to ensure the preservation of cultural resources to meet cleanup action objective SMS 3. Meets cleanup action objectives.	Technically and administratively implementable at the site and proven technology that has been implemented at other similar sites. There are challenges based on the nature of COCs (NAPL) and bedrock outcroppings. NAPL has the potential to impact equipment (cutterheads) and transport (pipelines). Equipment, materials, and personnel are readily available. Conditions, such as the presence of boulders or debris, may cause implementability concerns. Would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats is expected. However, the placement of a habitat layer as part of backfill would provide an environment conducive to benthic recolonization. Not suitable for small projects because the cost of removing sediment is more than mechanical. An open area is needed to build a settling basin, stage geotextile tubes, or set up mechanical equipment for dewatering of material. Mobilization costs lend hydraulic dredging to projects with a larger scope.	High	Not Retained for ESMA or WSMA Implementability and Cost

Table 4-2. Screening of Potential Cleanup Action Components

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
Removal (continued)	Dredging (continued)	Specialty Dredging	Reduces potential long-term generation of sheens through the removal of NAPL-containing sediments. This may increase short-term exposure due to resuspension or release of COCs during dredging. Effectiveness could be limited by the presence of debris and other coarse material. Thus, mechanical removal of debris prior to specialty dredging would be required as an initial step. Due to dredging technology limitations, management of post-dredging residuals may be necessary (e.g., through the placement of post-dredging cover materials). Cultural resources may be dredged during remedial activities. Additional processing and resources would need to be implemented to ensure the preservation of cultural resources to meet cleanup action objective 3. Meets cleanup action objectives.	Administratively implementable at the site and proven technology that has been implemented at other sediment remediation sites. Site characteristics such as water depths, debris, cultural resources, and depth of dredge cuts pose technical challenges. NAPL has the potential to impact equipment and transport pipelines. Equipment, materials, and personnel are readily available. Would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats is expected, however, the placement of a habitat layer as part of backfill would provide an environment conducive to benthic recolonization.	High	Not Retained for ESMA or WSMA Effectiveness, Implementability, and Cost
	Excavation	Excavation (from shoreline or in dewatered conditions)	Reduces potential long-term general of sheens through the removal of NAPL-containing sediments. If conducted in dewatered conditions, provides greater removal precision than dredging through the water column and less potential for resuspension and offsite release of COCs. If conducted from the shoreline in the wet, may increase short-term exposure due to resuspension or release of COCs during excavation. Due to excavation technology limitations, management of post-excavation residuals may be necessary (e.g., through the placement of post-dredging cover materials). Cultural resources may be excavated during remedial activities. Additional processing and resources would need to be implemented to ensure the preservation of cultural resources to meet cleanup action objective 3. Meets cleanup action objectives.	Technically and administratively implementable in areas where site conditions are favorable (e.g., the excavation area can be contained or dewatered and access to sediments is feasible using land-based equipment or equipment in dewatered area). Facilitating dewater conditions (e.g., installing sheetpile cofferdams) presents implementability challenges. Equipment, materials, and personnel are readily available. Would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats is expected. However, the placement of backfill will provide an environment conducive to benthic recolonization.	High	Not Retained for ESMA or WSMA Effectiveness, Implementability, and Cost
Containment	Capping	Active Capping	Reduces long-term potential for sheen generation by containment and providing a cover over the NAPL-containing sediments. Requires post-construction maintenance and monitoring. Meets cleanup action objectives 1 and 2 through containment and provides for treatment of the impacted surface material if a sorptive media (e.g., organic carbon, organoclay, or biochar) is included. Meets cleanup action objective 3 because no intrusive remediation would be performed. Can be combined with another GRA (e.g., removal) to increase the effectiveness of the alternative.	Technically and administratively implementable. Capping by itself is most readily implementable in deeper, lower-energy environments. Implementation in shallower, higher-energy environments may require some sediment removal before capping to address flood storage and navigation concerns. Equipment, materials, and qualified personnel are available. Debris (e.g., metallic material, wood, concrete, and subaquatic vegetation) removal would be required prior to cap placement. Would need to meet substantive requirements of applicable regulations. In situ caps have been successfully placed at other sites, but consideration must be given to the geotechnical characteristics (slope stability and seismic activity) of existing sediments to support the cap during design and construction.	Medium	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
		Isolation Capping	Reduces long-term potential for sheen generation through isolation of NAPL-impacted material achieving cleanup action objectives 1 and 2. May include a physical barrier (e.g., an impermeable geofabric, clay, or AquaBlok) sufficient to isolate and reduce sheens to the water column. Meets cleanup action objective 3 because no intrusive remediation would be performed. Requires post-construction maintenance and monitoring. Meets cleanup action objectives. Can be combined with another GRA (e.g., removal) to increase the effectiveness of the alternative.	Technically and administratively implementable. Capping by itself is most readily implementable in deeper, lower-energy environments. Implementation in shallower, higher-energy environments may require some sediment removal before capping to address flood storage and navigation concerns. Equipment, materials, and qualified personnel are available. Debris (e.g., metallic material, wood, concrete, and subaquatic vegetation) removal would be required prior to cap placement. Would need to meet substantive requirements of applicable regulations. In situ caps have been successfully placed at other sites, but consideration must be given to the geotechnical characteristics (slope stability and seismic activity) of existing sediments to support the cap during design and construction.	Medium	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives

Table 4-2. Screening of Potential Cleanup Action Components

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
Treatment	In Situ Treatment	Stabilization	Meets cleanup action objectives1 and 2 by immobilizing NAPL impacts mitigating long-term potential for sheen generation. The process yields a solidified stable mass with high structural strength and low leaching potential. Does not meet cleanup action objective 3 because cultural resources would be solidified in place. Can be combined with another GRA (e.g., removal) to increase effectiveness.	Technically and administratively implementable. The application is a proven technology that has been implemented at other similar sites. Specialized equipment, materials, and personnel are available. Specialty mixing equipment (augers) can be impeded at sites with debris or coarse granular material (cobbles). Implementation difficulty increases with depth. Implementation would also need to consider the anticipated swell of surface sediments often resulting during ISS and whether that might reduce water depths and inhibit future navigation and therefore swell removal may be required. Would need to meet substantive requirements of applicable regulations.	Medium	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
		Chemical Destruction	The injection of chemical oxidants into the NAPL-impacted sediment would treat contaminants mitigating the generation of sheens. However, the added reagent would remain in-situ. NAPL may be mobilized due to the large quantities of reagents that may be required. May impact cultural resources through chemical interactions. Does not meet cleanup action objectives.	Administratively implementable. Would encounter technical implementability issues due to limited site precedence with NAPL impacts. Chemical destruction/oxidation would require the injection of significant quantities of oxidants to reduce concentrations and the mass of NAPL. It would be difficult to inject these large quantities to the depths where contamination is found. An increase in NAPL mobility may also occur during implementation of this process. May require additional study (both bench-scale to assess project-specifics regarding COCs, appropriate delivery systems, among others; and a pilot scale phase to demonstrate implementability in this setting) including an in-depth understanding of bedrock outcropping characteristics (e.g., bedding planes and fractures). The availability of qualified personnel, materials, and equipment would likely be limited. May be difficult to meet the substantive permit requirements.	High	Not Retained for ESMA or WSMA Implementability, Cost
		Biological Degradation	Bioremediation has not been proven to be effective in the treatment of NAPL-impacted sediment. This technology has not been shown to be effective under the conditions observed at the site. Does not meet cleanup action objectives.	Administratively implementable. Would encounter technical implementability issues due to limited site precedence with NAPL impacts. May require additional study (both bench-scale to assess project-specifics regarding COCs, appropriate delivery systems, among others; and a pilot scale to demonstrate implementability in this setting) including an in-depth understanding of bedrock outcropping characteristics (e.g., bedding planes and fractures). The availability of qualified personnel, materials, and equipment would likely be limited. May be difficult to meet the substantive permit requirements.	Medium	Not Retained for ESMA or WSMA Effectiveness, Implementability
		Thermal Destruction	Thermal treatment may be used to heat NAPL into a less viscous state where it can be recovered via active extraction wells or trenches. Thermal treatment above the boiling point of water would decrease the viscosity of coal tar NAPL, which may be combined with another technology to remove or extract the NAPL. Increases in temperature have been shown to increase the solubility of site COCs. Increased subsurface temperatures increase the concentration of COCs in the dissolved phase and increase the availability of these compounds, thereby having a short-term effect on the benthic community and damage or loss of habitat in the target area. The dissolution of site COCs increases the viability of COCs to migrate outside of the target area. Does not meet cleanup action objectives.	Administratively implementable. Not technically implementable due to the location of NAPL impacts (sediment at depth) and hydrodynamic conditions. Limited site precedence and few methods are currently commercially available. May require additional study (both bench-scale to assess project-specific thermodynamics regarding COCs, appropriate delivery and extraction systems, among others; and a pilot scale to demonstrate implementability in this setting) including an in-depth understanding of bedrock outcropping characteristics (e.g., bedding planes and fractures). The availability of qualified personnel, materials, and equipment would likely be limited. Energy consumption and cost would be expected to be high relative to the expected implementation outcome. There may be implementability concerns with potential air emissions. May be difficult to meet the substantive permit requirements.	High	Not Retained for ESMA or WSMA Effectiveness, Implementability, and Cost

Table 4-2. Screening of Potential Cleanup Action Components

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
Treatment (continued)	Ex Situ Treatment	Stabilization	Effective at dewatering sediment to meet transport and disposal requirements. Meets cleanup action objectives. Can be combined with another GRA (e.g., removal) to increase effectiveness.	Readily implementable and proven at other similar sediment sites. Equipment, materials, and personnel are readily available.	High	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
		Soil Washing	In general, effective on coarse sand and gravel but effectiveness decreases when clay and silt are present. The presence of NAPL decreases the overall effectiveness and may require additional processing. Would need to be combined with a removal technology. Meets cleanup action objectives.	Administratively implementable. Comprises technical implementability due to limited site precedence and few methods are currently commercially available. May require additional study (both bench-scale and a pilot scale to demonstrate implementability in this setting). The availability of qualified personnel, materials, and equipment would likely be limited. Produces a large amount of wastewater that requires treatment and requires large energy consumption. There may be implementability concerns with potential air emissions. May be difficult to meet the substantive permit requirements.	High	Not Retained for ESMA or WSMA. Implementability, and Cost
Dewatering	Active Dewatering	Plate and Frame Filter Press	Effective at dewatering sediment to meet transport and disposal requirements and proven at other sediment sites. Meets cleanup action objectives if combined with another GRA.	Difficult to implement because of infrastructure requirements and the presence of NAPL. May require a large upland area to accommodate equipment. Equipment, materials, and personnel are readily available. May require monitoring and engineering controls for dust.	High	Not Retained for ESMA or WSMA Implementability and Cost
		Belt Filter Press	Effective at dewatering sediment to meet transport and disposal requirements and proven at other sediment sites. Meets cleanup action objectives if combined with another GRA.	Difficult to implement because of infrastructure requirements and the presence of NAPL. May require a large upland area to accommodate equipment. Equipment, materials, and personnel are readily available. May require monitoring and engineering controls for dust.	High	Not Retained for ESMA or WSMA Implementability and Cost
		Hydrocyclone	Effective at dewatering sediment to meet transport and disposal requirements. Meets cleanup action objectives if combined with another GRA.	Difficult to implement because of infrastructure requirements and the presence of NAPL. May require a large upland area to accommodate equipment. Equipment, materials, and personnel are readily available. May require monitoring and engineering controls for dust.	High	Not Retained for ESMA or WSMA Implementability and Cost
	Passive Dewatering	Geotextile Tubes	Effective at dewatering sediment to meet transport and disposal requirements and proven at other sediment sites. Meets cleanup action objectives if combined with another GRA (e.g., removal).	Administratively and technically implementable and no additional infrastructure is needed to implement. Equipment, materials, and personnel are readily available.	Medium	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
		Gravity Settling and Drainage	Effective at dewatering sediment to meet transport and disposal requirements and proven at other sediment sites. Meets cleanup action objectives if combined with another GRA (e.g., removal).	Administratively and technically implementable and no additional infrastructure is needed to implement. Equipment, materials, and personnel are readily available.	Low	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
Disposal	Onsite Repository	Confined Disposal Facility	Meets cleanup action objectives if combined with other GRAs (e.g., removal and ex-situ treatment).	Administratively and technically implementable, however, additional infrastructure would be required depending on the location of the repository. May require a large area to accommodate dredged material based on volume. Equipment, materials, and personnel are readily available.	High	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives
		Confined Aquatic Disposal	Meets cleanup action objectives if combined with other GRAs (e.g., removal and ex-situ treatment).	Implementability concerns because of potential future sheen generation and meeting substantive permit requirements. May require a large area to accommodate dredged material based on volume. Equipment, materials, and personnel are readily available.	High	Not Retained for ESMA or WSMA Implementability and Cost

Table 4-2. Screening of Potential Cleanup Action Components

General Response Action	Technology	Process Option	Effectiveness	Implementability	Cost	Status
	Offsite Disposal	Permitted Landfill	Meets cleanup action objectives if combined with another GRA (e.g., removal)	Requires an upland area to accommodate dredged material staging and processing. Equipment, materials, and personnel are readily available.	High	Retained for ESMA Not Retained for WSMA – area currently meets cleanup action objectives

Shading indicates remedial technologies/process options have been eliminated from further consideration based on lack of effectiveness, implementability, and/or cost. Remaining (unshaded) remedial technologies/process options have been retained for consideration in remedial action alternatives.

COC = constituent of concern

ESMA = eastern sediment management area

ISS = in-situ stabilization

GRA = general response action

IC = institutional control

N/A = not applicable

NAPL = nonaqueous phase liquid

SMS = sediment management standards

WSMA = western sediment management area

Table 4-3. Cleanup Action Alternative Quantities

Cleanup Action Alternative	Description	Remedial Footprint[a] (acre)	Removal or Treatment Depth (feet bss)	Total Removal or Treatment Volume (yd^3)	Total Backfill or Benthic Restoration Layer Volume (yd^3)[b, c, d,]	Capping Leveling Layer (yd^3)[d]	Capping RCM[d] (ft^2)/CIL[e] (yd^3)	Capping MAM[f] (ft^2)
1	No Action	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2	Removal, Backfill, Offsite Disposal, MNR, and Institutional Controls	ESMA - 0.70 WSMA – 0.33	7.1 (neat)/ 7.6 (OD)	8,200[g]removed	1,050	N/A	N/A	N/A
3A	Capping – AquaGate + ORGANOCLAY, Institutional Controls, and MNR	ESMA - 0.70 WSMA – 0.33	N/A	N/A	1,770	890	440 (CIL)	N/A
3B	Capping – RCM, Institutional Controls, and MNR	ESMA - 0.70 WSMA – 0.33	NA	NA	1,770	890	35,220	N/A
3C	Capping – RCM, MAM, Institutional Controls, and MNR	ESMA - 0.70 WSMA – 0.33	N/A	N/A	890	890	35,220	35,220
4	In-Situ Stabilization, Backfill, Institutional Controls, and MNR	ESMA - 0.70 WSMA – 0.33	10[b]	11,340 treated in situ[g]	1,050	N/A	N/A	N/A

[a] Alternative footprints include the ESMA and WSMA. Footprints are the same for all alternatives.
[b] Backfill will be placed as a component of Alternatives 2 and 4 to serve as a residual management layer and benthic restoration layer. Volumes include 710 yd^3 (0.5 foot and 25% overplacement), 180 yd^3 (25% material loss), 78 yd^3 ORGANOCLAY (5% by weight), and 82 yd^3 GAC (3% by weight).
[c] A benthic restoration layer will be placed as a component of Alternatives 3A, 3B, and 3C. Alternative 3A and 3B volumes include 1,420 yd^3 (1.0 foot and 25% overplacement) and 350 yd^3 (25% material loss). Alternative 3C volumes include 710 yd^3 (0.5 foot and 25% overplacement) and 180 yd^3 (25% material loss).
[d] Capping quantities for Alternatives 3A, 3B, and 3C include a 20-foot offset. These offsets are included in the total area of the ESMA.
[e] The CIL is only relevant to Alternative 3A.
[f] RCM and MAM quantities include a 15% overplacement.
[g] Alternative 2 dredge quantities include a 3 horizontal to 1 vertical (3:1) side slope. Alternatives 4 includes an offset of approximately 10 feet to accommodate the auger diameter (5 feet) of two additional ISS monoliths at the perimeter of the remedial footprint. These offsets are included in the total area of the ESMA. The total depth of material for treatment for Alternative 4 includes an average of 2.9-foot treatment zone beneath the target material (7.1 feet bss), which, for constructability purposes, is assumed to result in a total depth of treatment of 10 feet. This will ensure overlap of assumed non-impacted material beneath the target zone, and accounts for auger size and sloped bathymetry and dragdown. No dredging is assumed, and swell can express above existing sediment surface.

The actual areas and volumes of contaminated sediment removal, backfill, and capping will be refined during the design phase. Quantities shown are conservative estimates based on spatial analysis of previously collected samples.
bss = below sediment surface
CIL = chemical isolation layer
ESMA = eastern sediment management area
ft^2 = square foot (feet)
GAC = granular activated carbon
ISS = in-situ stabilization
MAM = marine armor mat
MNR = monitored natural recovery
N/A = not applicable
OD = over dredge
RCM = reactive core mat
WSMA = western sediment management area
yd^3 = cubic yard(s)

Table 4-4. Common Elements of Cleanup Action Alternatives

Element	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs		Alternatives 3A/3B/3C Capping, ICs, and MNR		Alternative 4 In-Situ Stabilization, Backfill, ICs, and MNR	
	ESMA	WSMA	ESMA	WSMA	ESMA	WSMA
Pre-Construction Activities	X		X		X	
Site Preparation	X		X		X	
Debris Removal	X		X		X	
Backfill	X		X		X	
ICs		X	X	X	X	X
Long-term Monitoring	X	X	X	X	X	X
MNR		X		X		X

ESMA = eastern sediment management area

IC = institutional control

MNR = Monitored Natural Recovery

WSMA = western sediment management area

Table 5-1. Relative Benefits Criteria Ranking

Benefit Criteria and Weighting	Evaluation Factors	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs	Alternative 3A/3B/3C Capping, ICs, and MNR	Alternative 4 ISS, Backfill, ICs, and MNR
Protectiveness **25%**	• Degree to which the alternative reduces existing risks. • Time required for the alternative to reduce risks at the site and attain cleanup standards. • The onsite and offsite risks remaining after implementing the alternative. • Improvement of the overall environmental quality.	• Effective at reducing risks • Timeframe to reduce risk and achieve cleanup standards is limited to the construction period in the ESMA and placement of the habitat layer immediately restoring the BAZ. Residual hydrocarbons will remain at depth in the WSMA, isolated from receptors and unable to result in sheen. • Some onsite risk (residuals) would remain following removal because dredging is not 100% effective. The dredged sediments with NAPL impacts would be disposed of at an offsite permitted facility. • Handling of dredged material would cause exposure and risk to human health, especially during potential artifact recovery, and active handling during transportation and disposal at the offsite landfill. • High level of improvement to the overall environmental quality. Benthic community is restored following completion of the remedy. The main area of NAPL would be removed, but residuals would remain.	• Effective at reducing risks. • Timeframe to reduce risk and to achieve cleanup standards at the surface is limited to the construction period and placement of the habitat layer in the ESMA immediately restoring the BAZ. Residual hydrocarbons will remain at depth in the WSMA, isolated from receptors and unable to result in sheen. • Onsite risk would be reduced considerably, and residual hydrocarbon Impacts are isolated from receptors. No offsite disposal of impacted sediment is anticipated other than a de minimis quantity associated with debris removal. Debris processing (i.e., size separation and power-washing) would separate sediment from debris that would be manually stockpiled or captured during filtration associated with water treatment. As such, there is little to no risk to human health during or after implementation. • High level of improvement to the overall environmental quality. Benthic community is restored following installation of the cap/remedy. Impacts at depth are isolated and unable to impact the BAZ.	• Effective at reducing risks. • Timeframe to reduce risk and to achieve cleanup standards at the surface is limited to the construction period, curing time of ISS reagents, and placement of backfill in the ESMA, which also serves as the habitat layer immediately restoring the BAZ. Residual hydrocarbons will remain at depth in the WSMA, isolated from receptors and unable to result in sheen. • Onsite risk would be reduced considerably, however, stabilized sediments with NAPL impacts will remain as part of the monolith, isolated from receptors. ISS is not 100% effective because the potential for small untreated areas to remain after implementation exists. No offsite disposal of impacted sediment is anticipated other than a de minimis quantity associated with debris removal. Debris processing (i.e., size separation and power-washing) would separate sediment from debris that would be manually stockpiled or captured during filtration associated with water treatment. As such, there is little to no risk to human health during or after implementation. • No offsite disposal of impacted sediment is anticipated under this alternative, therefore, no risk to human health during or after implementation. • High level of improvement to the overall environmental quality following a period of higher pH immediately following construction. Benthic community is restored following completion of the remedy and placement of a habitat layer.
	Relative Rating	9	8 / 8 / 8	8

Table 5-1. Relative Benefits Criteria Ranking

Benefit Criteria and Weighting	Evaluation Factors	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs	Alternative 3A/3B/3C Capping, ICs, and MNR	Alternative 4 ISS, Backfill, ICs, and MNR
Permanence **25%**	• The adequacy of the alternative in destroying the hazardous substances. • The reduction or elimination of hazardous substance releases and sources of releases. • The degree of irreversibility of waste treatment process. • The characteristics and quantity of treatment residuals generated.	• Provides the greatest degree of permanence because most sediments with NAPL impacts would be removed (not destroyed), thus eliminating the production of sheen and the mass/volume of the contaminants. Residual hydrocarbons in the WSMA would remain isolated. • Sediments with NAPL impacts would be removed, processed, and transported for disposal at an offsite repository/facility. Note, some amount of residual NAPL impacts would likely remain onsite (dredge residuals). Residual hydrocarbons in the WSMA will remain isolated, unable to impact the BAZ. • Effective reduction or elimination of sources of releases. Removal of sediments with NAPL impacts and disposal at an offsite repository/facility would be irreversible, including any artifacts. There is a high potential for artifacts to be destroyed and for some to be transported offsite to a disposal facility. • Dredging technology does not remove 100% of contamination and residuals will be present following remedial action in the ESMA. Backfill will be placed to manage residuals and may be amended (e.g., ORGANOCLAY and GAC) to provide for a residuals management layer. No active remediation is proposed for the WSMA and therefore hydrocarbons would remain at depth. • No treatment residuals are generated, other than the material disposed of offsite.	• Capping would eliminate the production of sheen and the NAPL mass would remain under the cap and be unable to impact the BAZ. Residual hydrocarbons in the WSMA would remain isolated. • The entire ESMA would be capped, resulting in the elimination of the NAPL's ability to impact the BAZ and be released to surface water. Residual hydrocarbons in the WSMA will remain, unable to impact the BAZ. • Treatment provided by the chemical isolation layer of the cap is irreversible in the post-construction environment. • No treatment residuals are generated, other than debris removed and disposed of offsite.	• Impacted sediment would be stabilized in-situ through auger mixing using stabilization reagents that encapsulate the NAPL into a solidified monolith. However, NAPL mass would remain. Residual hydrocarbons in the WSMA would remain isolated. • ISS would be conducted over the entire ESMA, resulting in the elimination of NAPL mobility and any related hazardous substance releases. Residual hydrocarbons in the WSMA will remain isolated, unable to impact the BAZ. • Stabilization amendments used are considered irreversible. • No treatment residuals are generated other than debris removed and disposed of offsite.
	Relative Rating	**9**	**7 / 7 / 7**	**8**

Table 5-1. Relative Benefits Criteria Ranking

Benefit Criteria and Weighting	Evaluation Factors	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs	Alternatives 3A/3B/3C Capping, ICs, and MNR	Alternative 4 ISS, Backfill, ICs, and MNR
Long-Term Effectiveness **25%**	• The degree of certainty that the alternative will be successful. • The reliability of the alternative during the period of time hazardous substances are expected to remain onsite at concentrations that exceed cleanup levels. • The resilience of the alternative to climate change impacts. • The ability to resist and recover from climate change impacts should be considered explicitly and documented in the FS (WAC 173-340-360(5)(d)(iii)(A)(III) and 173-340-351(6)(f)(vii)). This includes likely climate-induced resistance to effective treatment or changes in sequestration effectiveness. This is particularly important for cleanups using contaminant mobility sequestration or capping technologies at sites affecting sediment. • The magnitude of residual risk with the alternative in place. • The effectiveness of controls required to manage treatment residues or remaining wastes.	• Removal is known to be an effective long-term remedy with a high degree of certainty. • Removed impacted sediments would be disposed of at an offsite existing permitted facility, resulting in high reliability. • The alternative has a high level of resiliency to climate change impacts. • Removal and backfill do not modify the existing ability of the site to resist and recover from climate change impacts. • Residual impacted sediment will remain in place and be managed via backfill placement in the ESMA. The location and amount of residual material is unknown. In the WSMA, the natural cover eliminates exposure to the residual hydrocarbons, therefore there is no residual risk. • Monitoring program will be designed to confirm establishment of the benthic community in the ESMA, and long-term effectiveness for the WSMA.	• Capping is known to be an effective long-term remedy with a high degree of certainty. Alternative 3A includes a layer of AquaGate and ORGANOCLAY™ at an assumed thickness of 3 inches, which equates to a mass ORGANOCLAY loading of 6.0 pounds per square foot with an oil adsorption capacity of 0.5 pound of oil per pound of ORGANOCLAY. Alternatives 3B and 3C includes placement of an RCM with a mass ORGANOCLAY loading of 0.8 pound per square foot with an oil adsorption capacity of 0.5 pounds of oil per pound of ORGANOCLAY. Multiple layered RCM panels would result in an increase in mass loading. However, Alternative 3A has a much higher ORGANOCLAY mass loading capacity than Alternatives 3B and 3C. • A cap would be designed for long-term reliability to ensure impacted sediments remain isolated. Alternative 3C includes placement of a prefabricated MAM system to protect cap layers, thus providing a relatively higher degree of long-term effectiveness than Alternatives 3A and 3B. • Design evaluations would be conducted to understand the overall site-specific erosive forces present at the site (e.g., wind, waves, velocity, and seismic activity) that would be required for a long-term successful remedial action. The design would also incorporate the effects of climate change and evaluate the potential impacts to flood elevations (expected to be de minimis). Therefore, these alternatives have a high degree of resiliency. The cap will be designed to ensure that the NAPL remains isolated from receptors. • The magnitude of residual risk would be minimal because the cap would be designed for a long-term reliability and effectively isolate impacts while allowing ebullition gases to vent as needed. In the WSMA, the natural cover eliminates exposure to the residual hydrocarbons, therefore there is no residual risk. • Monitoring and maintenance will be designed to confirm establishment of the benthic community in the ESMA and long-term effectiveness in both the ESMA and WSMA.	• ISS is a relatively new technology for sediment remediation. In general, it is known to be an effective long-term remedy with a moderate degree of certainty. Mixing conditions and curing temperatures will influence solidified sediment strength. Mixing is difficult to control in a subaqueous environment. Curing temperature can be modeled but not controlled. • Long-term effectiveness and reliability is dependent on bench-scale testing and field demonstrations of ISS technology. • Design evaluation would be conducted to understand the overall site-specific erosive forces present at the site (e.g., wind, waves, velocity, and seismic activity) for a long-term successful cleanup action. The design would also incorporate the effects of climate change and evaluate the potential impacts to flood elevations (expected to be de minimis). Therefore, this alternative is expected to have a high degree of resiliency. • Due to a possible increase in the overall volume of stabilized sediments, a detailed hydraulic assessment would be required to determine the effect of flooding elevations and be compliant with MTCA and any federal or state legal standards outside of the immediate purview of MTCA that must be met (applicable) or should be met (relevant and appropriate), and to evaluate the ability of the remedy to resist and recover from climate change impacts. • ISS will not change the toxicity of the NAPL but will eliminate migration. The benthic restoration material placed on top of the ISS will provide separation between the benthic community and the solidified NAPL. Monitoring and maintenance will be designed to confirm long-term effectiveness. • ISS would be effective in controlling ebullition because impacted sediment would be stabilized in-situ through auger mixing using stabilization reagents that encapsulates NAPL in a solidified monolith.
	Relative Rating	**9**	**9 / 8 / 8.5**	**8**

Table 5-1. Relative Benefits Criteria Ranking

Benefit Criteria and Weighting	Evaluation Factors	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs	Alternative 3A/3B/3C Capping, ICs, and MNR	Alternative 4 ISS, Backfill, ICs, and MNR
Management of Implementation Risk **15%**	• The risks to human health and the environment posed by the alternative during construction and implementation. • The measures the alternative uses to manage the risks posed by the alternative. • The degree to which those measures will effectively manage the risks posed by alternative.	• High potential for risk to human health and the environment is posed by construction and implementation. The handling of sediment to sort material to remove archaeological artifacts from the dredged material will require hand sifting and the use of surfactants to remove NAPL prior to sorting. Additional potential impacts to workers will be related to activities performed on a barge in a river environment such as working on a vessel, near heavy and mobile equipment in and around working docks and disposal facility workers. Risks to the environment include temporary loss of benthos and habitat for the ecological community in remedial areas and low water quality during construction. • Workers handling impacted material would be required to have level C (minimum) appropriate PPE to isolate them physically from direct contact and vapor inhalation. Due to the potential for overheating, workers would have shorter shifts and shade tents. • Turbidity curtains would be used to try and reduce risk to water quality impacts. However, resuspension of NAPL into the water column is highly likely to occur during dredging activities and NAPL may remain suspended in the water column due to the weathering and age of the product, resulting in redeposition in a downstream area. A sheen management team will be mobilized during dredging to monitor, contain, and reduce the migration of sheens. • Risks to workers would be effectively managed, however, they would be reliant on PPE. Management of risks to workers are anticipated to have moderately low effectiveness due to the long duration of exposure and use of PPE. High potential for damage to archaeological artifacts. Some risk to the environment would remain due to residual NAPL.	• Low risk to human health and the environment due to placement of a cap. Potential impacts to workers would be related to activities performed on a barge in a river environment such as working on a vessel, near heavy and mobile equipment in and around working docks. Risks to the environment include temporary loss of benthos and habitat for the ecological community in remedial areas and lower water quality during placement of the cap materials. • Safety measures and BMPs would be used to minimize the impacts. Turbidity curtains would be used to reduce risk to water quality impacts. • Management of risks to human health are anticipated to be highly effective. Management of risks to the environment are anticipated to be highly effective. • No damage to archaeological artifacts, except those that may be located in the upper/shallow sediment layer where surface debris may need to be removed prior to placement of the cap. Debris processing (i.e., size separation and power-washing) would separate sediment from debris. Sediment removed would be de minimis.	• Low to moderate risk to human health and the environment due to ISS. Potential impacts to workers would be related to activities performed on a barge in a river environment such as working on a vessel, near heavy and mobile equipment in and around working docks. Risks to the environment include temporary loss of benthos and habitat for the ecological community in remedial areas, low water quality during construction, and potential release of reagents to the water column. It is anticipated that in-situ mixing of reagents for ISS using auger rigs would have much higher short-term impacts on the water quality than dredging and capping. • Safety measures and BMPs would be used to minimize the impacts. Turbidity curtains would be used to reduce risk to water quality impacts. • Management of risks to human health are anticipated to be highly effective. Management of risks to the environment are anticipated to be moderately effective. • The ISS process would result in damage to archaeological artifacts.
	Relative Rating	**6**	**9 / 9 / 9**	**7**

Table 5-1. Relative Benefits Criteria Ranking

Benefit Criteria and Weighting	Evaluation Factors	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs	Alternative 3A/3B/3C Capping, ICs, and MNR	Alternative 4 ISS, Backfill, ICs, and MNR
Technical and Administrative Implementability **10%**	• The technical difficulty of designing, constructing, and otherwise implementing the alternative in a reliable and effective manner, regardless of cost. • The availability of necessary offsite facilities, services, and materials. • Administrative and regulatory requirements. • Scheduling, size, and complexity. • Monitoring requirements. • Access for construction operations and monitoring. This may require cooperation of property owners other than the person conducting the cleanup. • Integration with existing facility operations and other current or potential remedial actions.	• Moderate level of difficulty in design and high level of difficulty for construction. Site is adjacent to steep riprap banks and bedrock outcroppings. Will be managed with layback offsets for construction extending to nearshore areas. Shallow bedrock increases difficulty in sediment removal, resulting in an increased potential for residuals in some areas. Debris is anticipated based on site characteristics and can be managed with appropriate means and methods. A barge-to-shore materials processing facility would need to be constructed to bridge the riprap berm where sediment can be dewatered and processed for disposal. • Construction resources are readily available. Waste management will require construction and operation of a sediment processing area; use of chemicals (surfactants), and screening of NAPL-impacted sediment for artifacts prior to transportation to offsite disposal facility. • Coordination with Ecology, Yakama Nation, YNF, NMFS, and USFWS needs to be conducted during construction to protect migratory fish in the Columbia River. Coordination with BNSF and/or other property owners would need to be conducted to manage impacted sediments during multiple months of material screening activities. This may require implementation of temporary land use restrictions while impacted sediment remains onsite during screening activities. • Dredging sediments with NAPL impacts is a proven technology that has been implemented at other sites. The size of the remedial action is relatively small, and that smaller footprint means smaller volumes of dredging. The scheduling and the complexity of implementing remedial action are not anticipated to cause additional implementability concerns. • Monitoring of surface water and air quality (for offsite disposal activities) will be required during implementation. Administrative and engineering controls will be applied to manage environmental quality. • Access is anticipated from the BNSF property and is not anticipated to cause implementability concerns. Access for in-water construction will be required and should be obtainable. • For the duration of remedy implementation, upland staging, equipment operations, material processing, and the related unit processes will be integrated with upland BNSF operations. These remedial action activities are not anticipated to cause high degree of implementability concerns. However, construction of an offloading facility has a high impact on constructability. Dredged material will require stockpiling for an extended period for cultural resource screening, which has a moderate potential to impact facility operations.	• Low level of difficulty in design and construction. Cap area is far enough from shore to limit issues with access. The sediment surface has a steep slope in the southern portion that may complicate construction in that area to a small degree. Alternatives 3B and 3C have slightly higher relative complexity due to the placement of the RCM and/or MAM, which may require diver assistance. However, the RCM/MAM would provide a continuous thickness and layer to avoid differential settlement common to granular materials. In addition, the RCM could be attached directly to the MAM (Alternative 3C) and placed in a single lift as opposed to two separate lifts, thus simplifying construction. • Construction resources are readily available. No waste management would be needed other than for debris for offsite removal. • Coordination with Ecology, Yakama Nation, YNF, NMFS, and USFWS needs to be conducted during construction to protect migratory fish in the Columbia River. Coordination with BNSF and/or other property owners would need to be conducted for temporary use of facilities, to implement land use restrictions and ICs, if needed. • Capping impacted sediments is a proven technology that has been implemented at other similar sites, including the Union Pacific Railroad site located below The Dalles Dam. The size of the remedial action is relatively small, and that smaller footprint means smaller volume of cap material needed. The scheduling and the complexity of implementing remedial action are not anticipated to cause implementability concerns. • Monitoring of surface water will be required during implementation. Maintenance and a long-term monitoring program will be implemented to confirm that the in-place containment system remains effective over time. In addition, administrative controls will be implemented to further eliminate risks. • Access is anticipated from the BNSF property and is not anticipated to cause implementability concerns. Access for in-water construction will be required and should be obtainable. • For the duration of remedy implementation, upland staging, equipment operations, debris processing, and the related unit processes will be integrated with upland BNSF operations. Debris processing will be managed using a crane from the barge, and, therefore, no special processing facility would be needed. These remedial action activities are not anticipated to cause implementability concerns.	• Moderate level of difficulty in design and a high level of difficulty in construction. ISS area is far enough from shore to limit issues with access. The steep drop-off of the sediment surface may complicate construction in the southern areas of the ESMA. Shallow bedrock increases difficulty in ISS process in some areas. Debris is anticipated based on site characteristics, which will need removal prior to implementation. • Construction resources are readily available. No waste management would be needed other than for debris for offsite disposal. • Coordination with Ecology, Yakama Nation, YNF, NMFS, and USFWS needs to be conducted during construction to protect migratory fish in the Columbia River. Coordination with BNSF and/or other property owners would need to be conducted for temporary use of facilities, to implement land use restrictions and ICs, if needed. • ISS with NAPL impact is a relatively new technology for sediments. Unlike upland sites, the dynamic nature of subaqueous sediment introduces challenges to the design and implementation of the remedy even over a small remedial footprint. • Monitoring of surface water will be required during implementation. Maintenance and long-term monitoring program will be implemented to confirm that the stabilized sediment remains effective over time. In addition, administrative controls will be implemented to further eliminate risks. • Access is anticipated from the BNSF property and is not anticipated to cause implementability concerns. Access for in-water construction will be required and should be obtainable. • For the duration of remedy implementation, upland staging, equipment operations, material processing, and the related unit processes will be integrated with upland BNSF operations. These remedial action activities are not anticipated to cause implementability concerns.
	Relative Rating	**6**	**9 / 8.5 / 8**	**5**

Table 5-1. Relative Benefits Criteria Ranking

Benefit Criteria and Weighting	Evaluation Factors	Alternative 2 Removal, Backfill, Offsite Disposal, MNR, and ICs	Alternative 3A/3B/3C Capping, ICs, and MNR	Alternative 4 ISS, Backfill, ICs, and MNR
Total Weighted Benefits		**8.3**	**8.3 / 8.0 / 8.0**	**7.6**
Costs		**$9,705,000**	**$3,706,000 / $4,411,000 / $4,906,000**	**$7,530,000**
Ratio of Cost to Benefits ($ million per Benefit)		**$1.18**	**$0.45 / $0.56 / $0.62**	**$1.00**

BAZ = biologically active zone
BMP = best management practice
BNSF = BNSF Railway Company
Ecology = Washington State Department of Ecology
ESMA = eastern sediment management area
FS = feasibility study
IC = institutional control
ISS = in-situ stabilization
MAM = marine armor mat
MNR = monitored natural recovery
MTCA = Model Toxics Control Act
NAPL = nonaqueous phase liquid
NMFS = National Marine Fisheries Service
PPE = personal protective equipment
RCM = reactive core mat
USFWS = U.S. Fish and Wildlife Service
WAC = Washington Administrative Code
WSMA = western sediment management area
YNF = Yakama Nation Fisheries

Table 5-2. Summary of Disproportionate Cost Analysis – Alternative Benefits Metrics and Scores

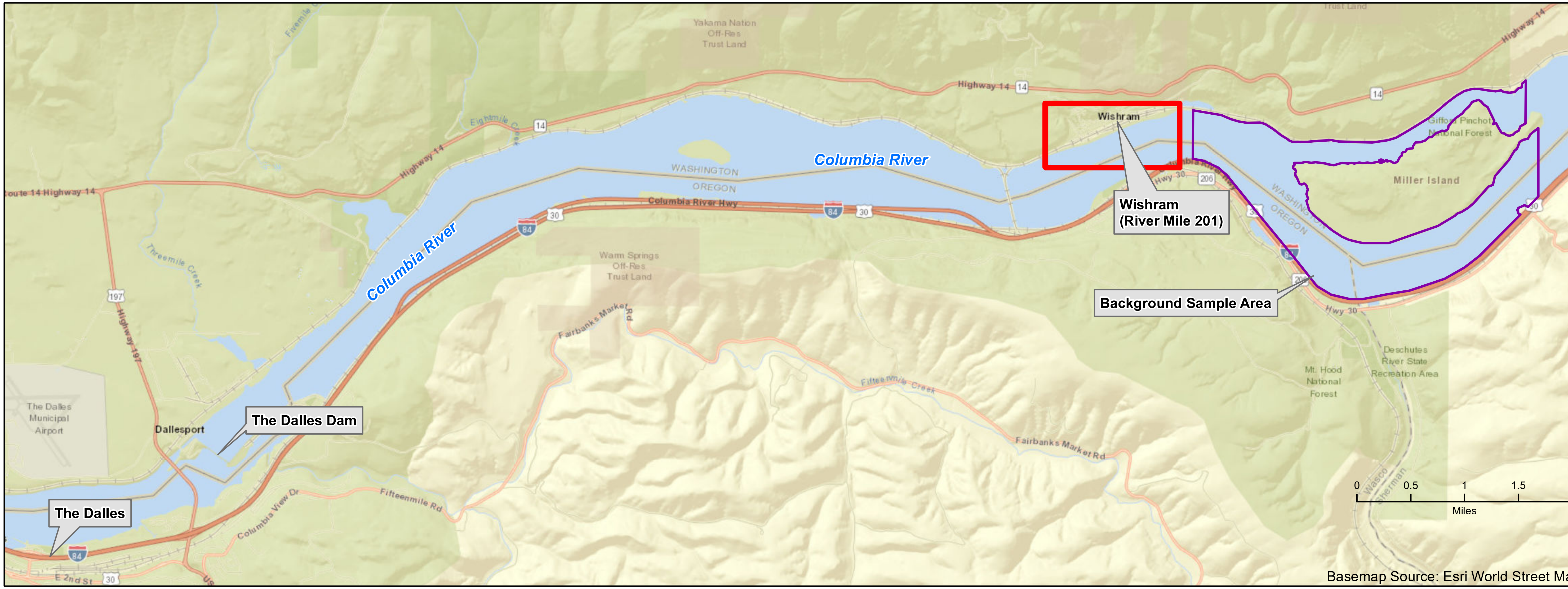
DCA Evaluation Criteria[a]	Cleanup Action Alternative - Benefits Scores[b]					Weighting Factor (Total 100%)	Cleanup Action Alternative - Weighted Benefits Scores[c]				
	Alternative 2	Alternative 3A	Alternative 3B	Alternative 3C	Alternative 4		Alternative 2	Alternative 3A	Alternative 3B	Alternative 3C	Alternative 4
Satisfy MTCA Criteria[d]	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	–	–			–	–
Protectiveness	9	8	8	8	8	25%	2.3	2.0	2.0	2.0	2.0
Permanence	9	7	7	7	8	25%	2.3	1.8	1.8	1.8	2.0
Effectiveness Over the Long Term	9	9	8	8.5	8	25%	2.3	2.3	2.0	2.1	2.0
Management of Implementation Risks	6	9	9	9	7	15%	0.9	1.4	1.4	1.4	1.1
Technical and Administrative Implementability	6	9	8.5	8	5	10%	0.6	0.9	0.9	0.8	0.5
						Total Benefits Score	**8.3**	**8.3**	**8.0**	**8.0**	**7.6**
						Estimated Cost ($M Net Present Value)[e]	$9.71	$3.71	$4.41	$4.91	$7.53
						Ratio of Cost to Benefits ($M per Benefit)[f]	**$1.18 M per Benefit**	**$0.45 M per Benefit**	**$0.56 M per Benefit**	**$0.62 M per Benefit**	**$1.00 M per Benefit**
						Cost Disproportionate to Incremental Benefits	**Yes**	**No**	**No**	**No**	**Yes**
						Alternative Permanence (Maximum Extent Practicable)	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
						Practicability of Remedy	**Yes**	**Yes**	**Yes**	**Yes**	**No**
						Overall Cleanup Action Alternative Ranking	**5th**	**1st**	**2nd**	**3rd**	**4th**

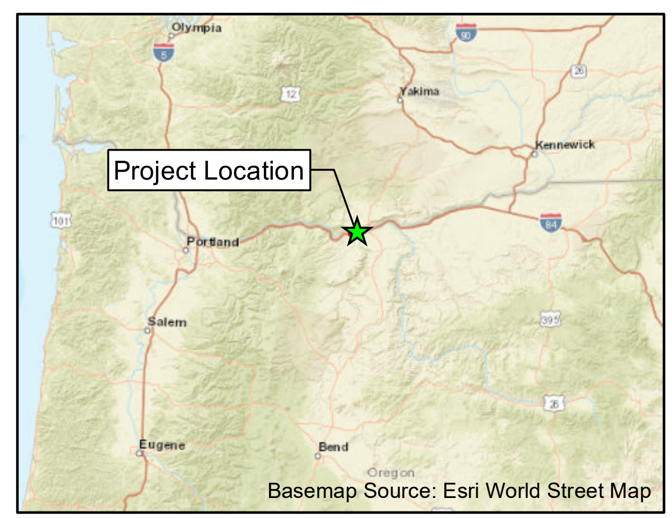
[a] Evaluation of remedial alternatives using disproportionate cost analysis ranking criteria are presented in Section 4.3 and Table 4-1.
[b] A score of 1 represents a poor-performing alternative for that criterion, and a score of 10 represents an optimal-performing alternative for that criterion or indicates the alternative meets the criterion significantly well. It should be noted that each aspect of the DCA scoring and weighting factors requires a degree of best professional judgment.
[c] For Alternative 2, Protectiveness Score = 9 X 25% (weighting factor) = 2.3
[d] The criteria are presented in Sections 4 and 5.
[e] Cleanup action alternative cost estimates are presented in Appendix B.
[f.] Ratio of cost to benefits for Alternative 2 = $9.7M / 8.3 = $1.18M per benefit

Alternative 2: Removal, Backfill, Offsite Disposal, MNR, and ICs
Alternative 3A: Capping with AquaGate + ORGANOCLAY, ICs, and MNR
Alternative 3B: Capping with RCM, ICs, and MNR
Alternative 3C: Capping with RCM and marine armor mat, ICs, and MNR
Alternative 4: In-Situ Stabilization, Backfill, ICs, and MNR

$M = dollars in millions
DCA = disproportionate cost analysis
IC = institutional control
MNR = monitored natural recovery
MTCA = Model Toxics Control Act
RCM = reactive core mat

Figures





N

0 375 750 1,500

Feet

Notes:

Lake Celilo extends from The Dalles Dam 24 miles upstream

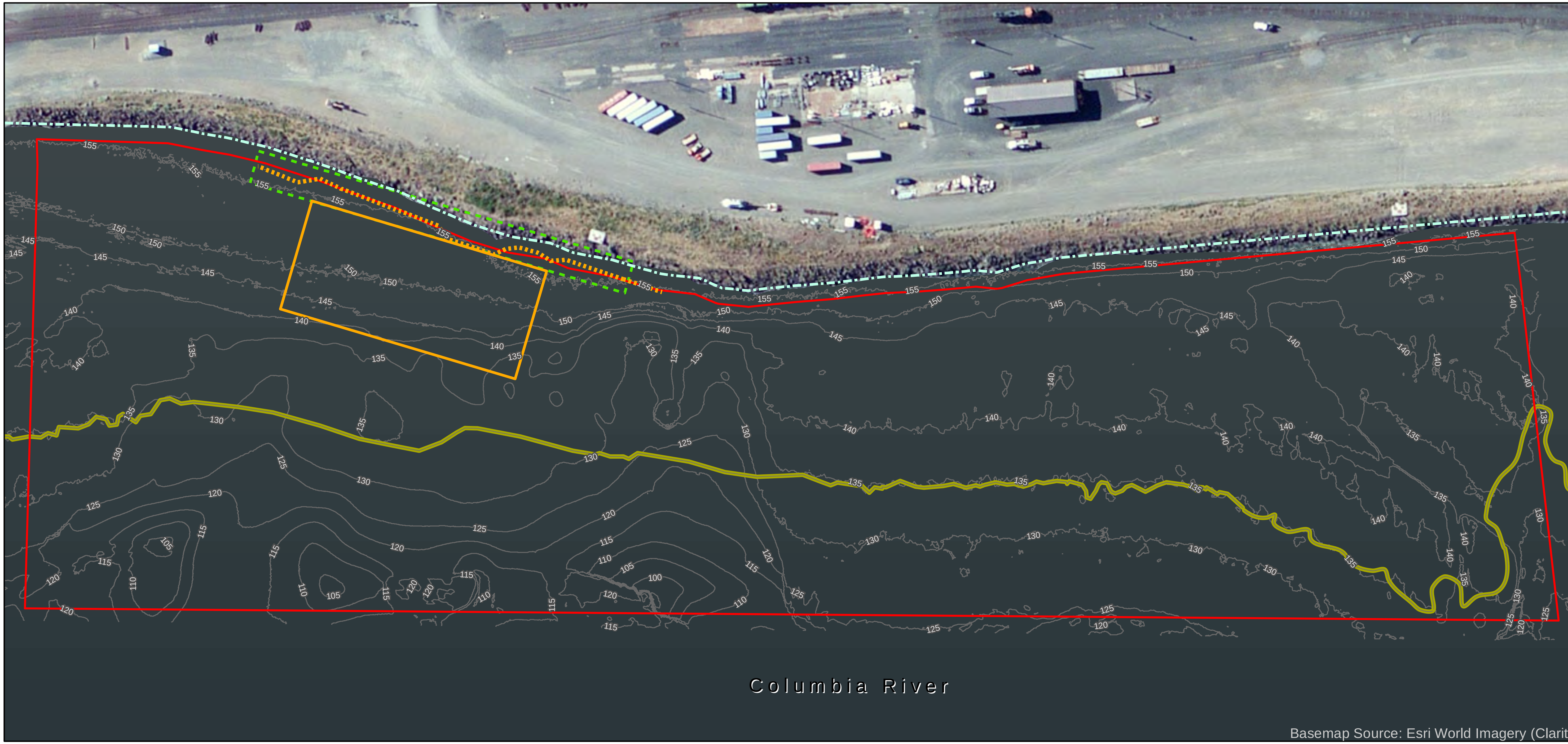
Figure 1-1. Site Location Map

BNSF Track Switching Facility

Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE1-1_SITEMAP.MXD STOLZRC 5/7/2024 16:04:33



LEGEND

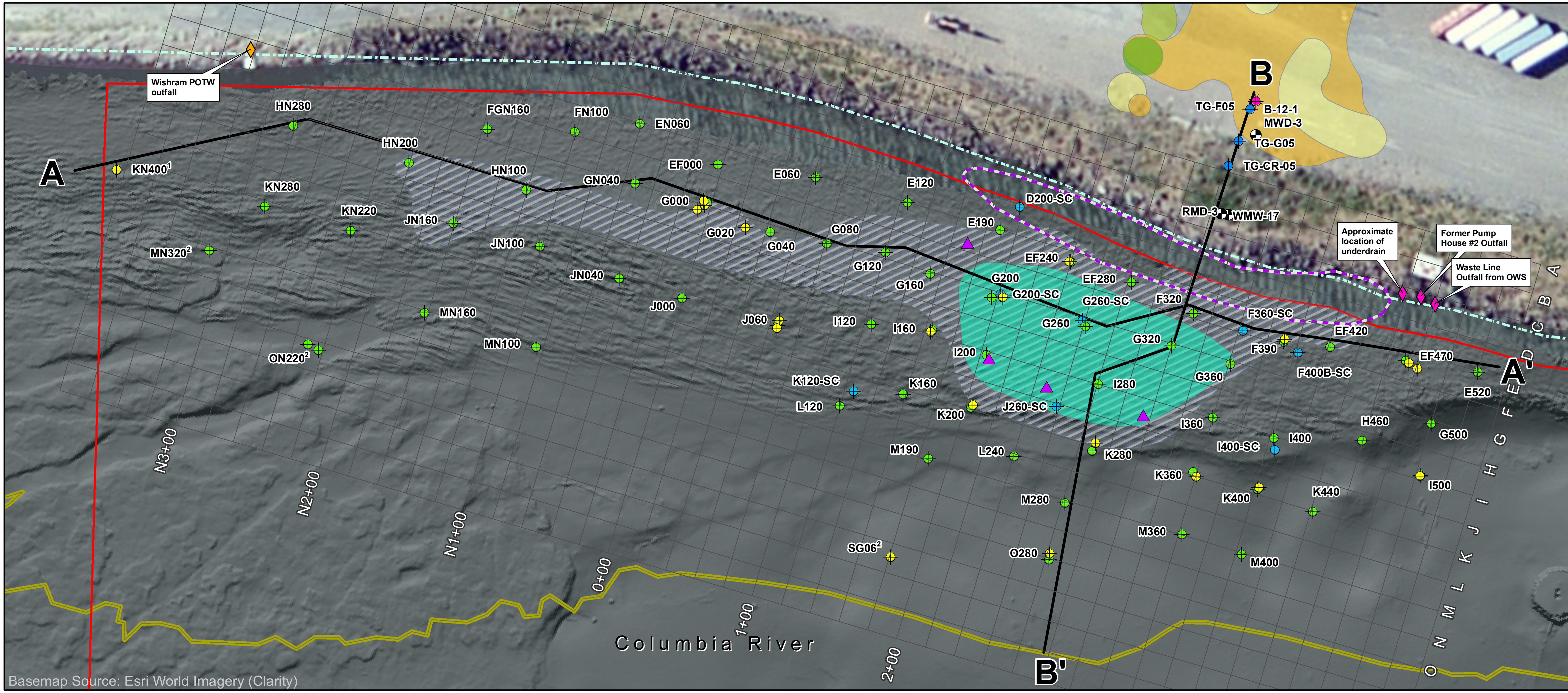
- Remedial Investigation Area
- WA Ecology Initial Investigation Area
- 2018 Initial Investigation Area
- Current Shoreline
- Former Shoreline
- Toe of Exposed Riprap observed within 2018 Sampling Investigation Area
- 2022 Bathymetric Contour (ft NAVD88, 5 ft Contour Interval)

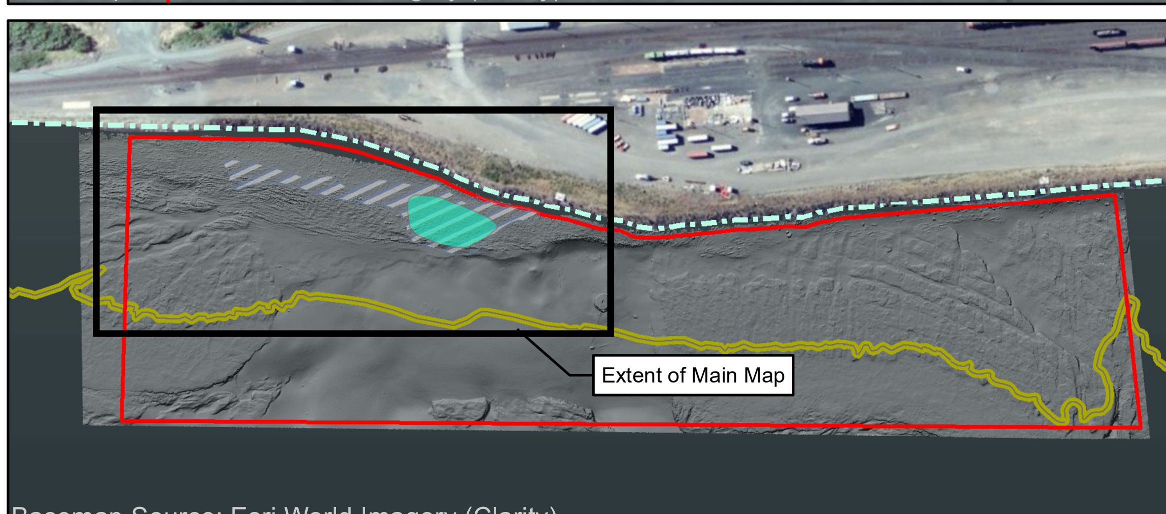
N

0 100 200 400
Feet

Figure 1-2. Area Features
BNSF Track Switching Facility
Wishram, Washington

Jacobs





\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE1-3_NAPLIMPACTS.MXD GGEE 5/27/2025 13:08:13

LEGEND

- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Upland RI TarGOST Location
- Upland Boring
- Groundwater Monitoring Well
- Extent of NAPL-affected Area
- Approximate Extent of Sheen-Generating NAPL Impacts
- Location of Farthest Offshore Sheens Observed (August 7, 2018)
- Small-extent NAPL Sheens Observed (Ecology, 2017)
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline
- Cross Section Location
- Inferred Lateral Extent of Smear Zone Diesel Impacts
- Inferred Lateral Extent of Submerged Diesel Impacts
- Inferred Lateral Extent of Smear Zone Oil Impacts
- Inferred Lateral Extent of Submerged Oil Impacts

0 25 50 100
Feet

Notes:
OWS = oil/water separator; POTW = publicly owned treatment works
[1]Changed station name from HN300 to KN400 post sample collection based on actual X,Y. (No target X,Y available at the time of collection. Station was estimated.)
[2]Refusal at surface.

Figure 1-3. Extent of NAPL Impacts
BNSF Track Switching Facility
Wishram, Washington

Jacobs

Cross-Section A-A'

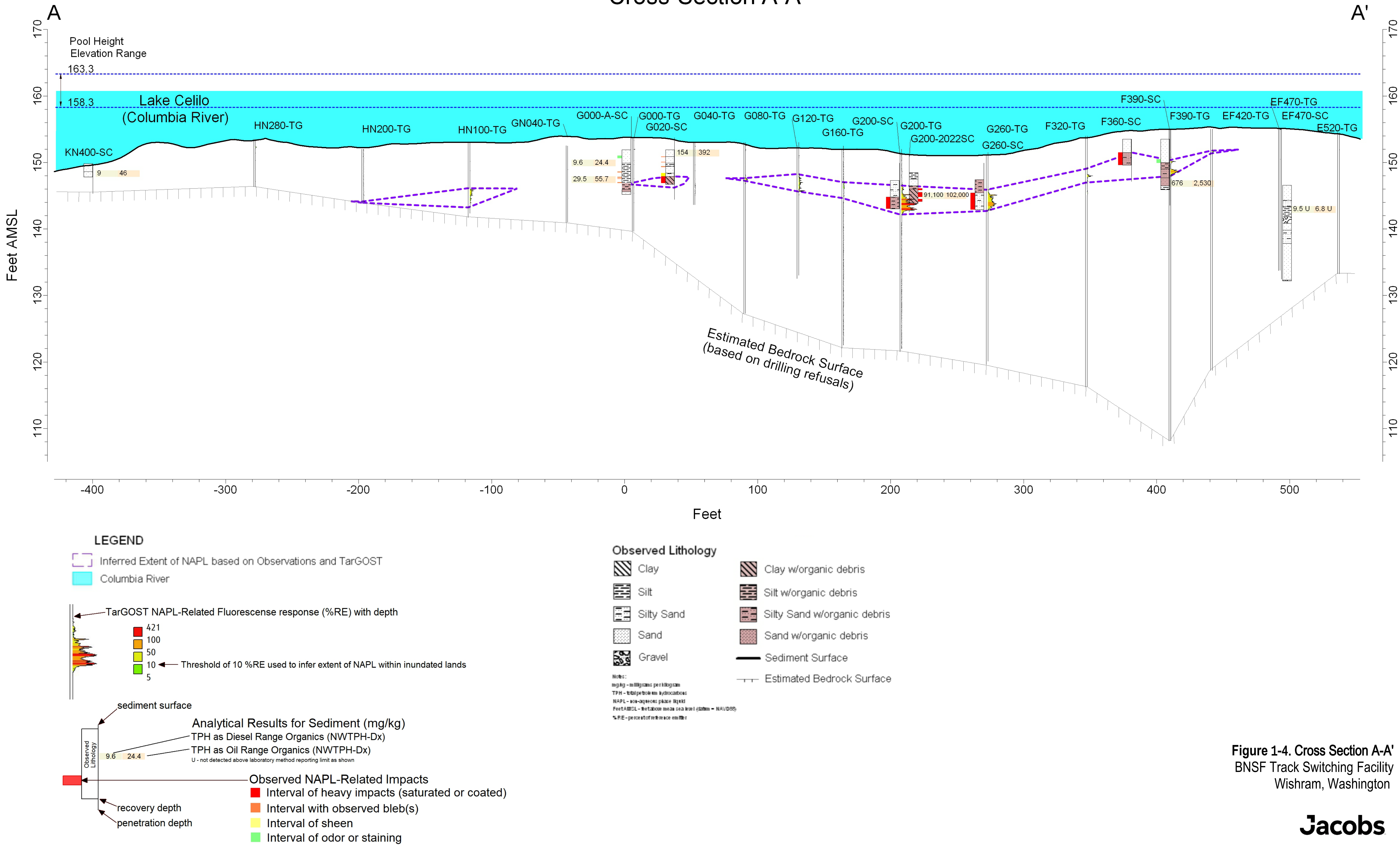


Figure 1-4. Cross Section A-A'
BNSF Track Switching Facility
Wishram, Washington

Jacobs

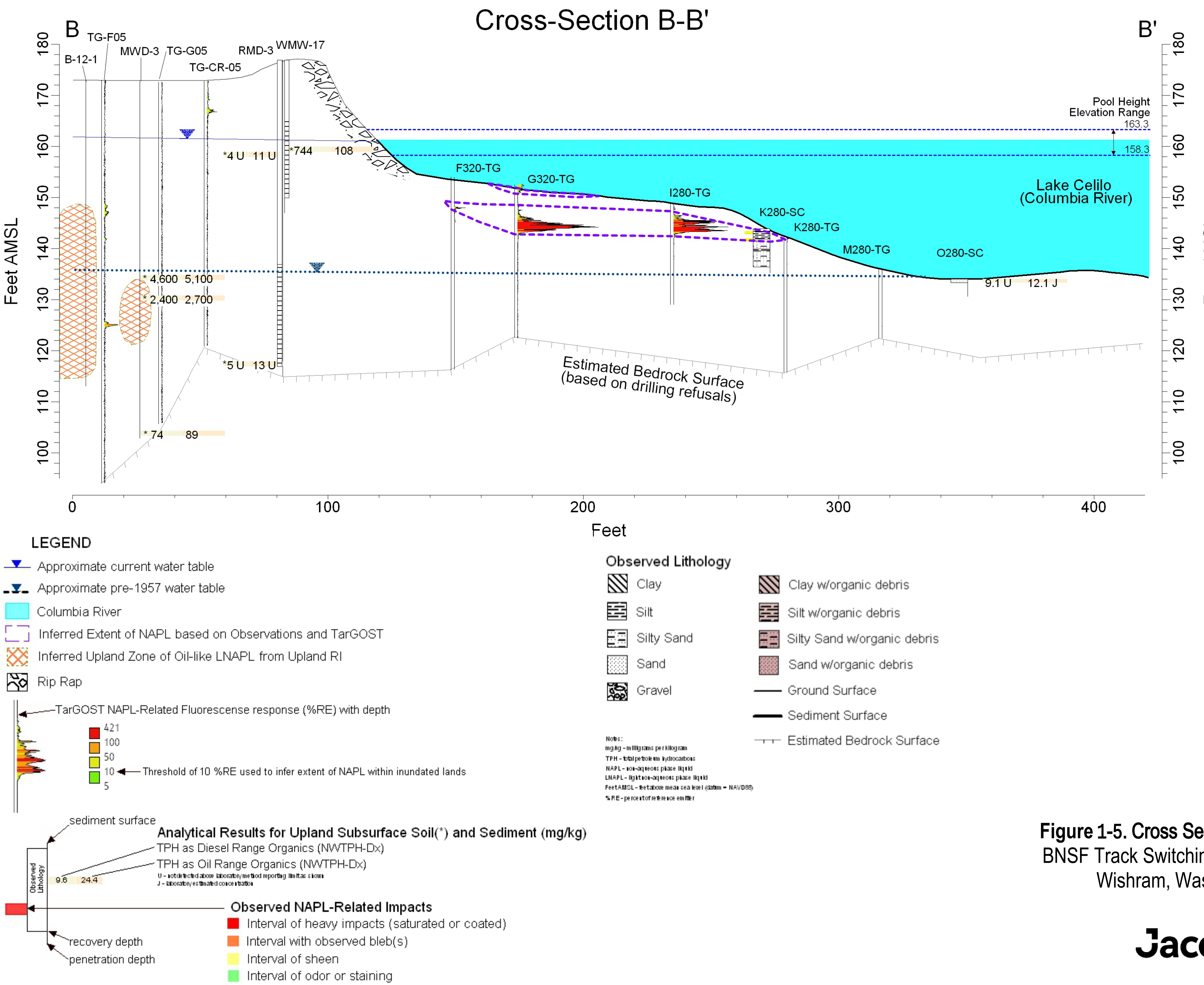
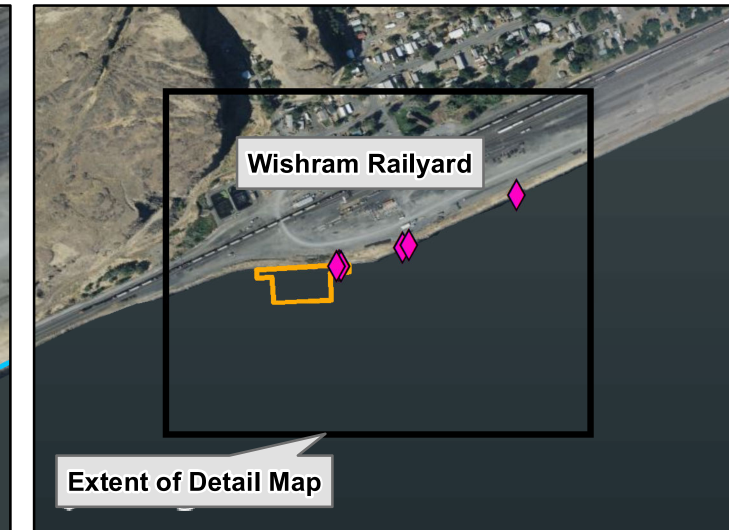


Figure 1-5. Cross Section B-B'
BNSF Track Switching Facility
Wishram, Washington

Jacobs



LEGEND

- Former Outfall Location
- Stormwater Underdrain (A portion removed from service circa 1960)
- Stormwater Underdrain (Rerouted portion circa 1960)
- Current Shoreline
- WA Ecology Initial Investigation Area
- Initial Investigation Area (Jacobs. 2019. Inundated Lands Initial Investigation Report Draft. BNSF Wishram Railyard, Wishram, Washington. May.)

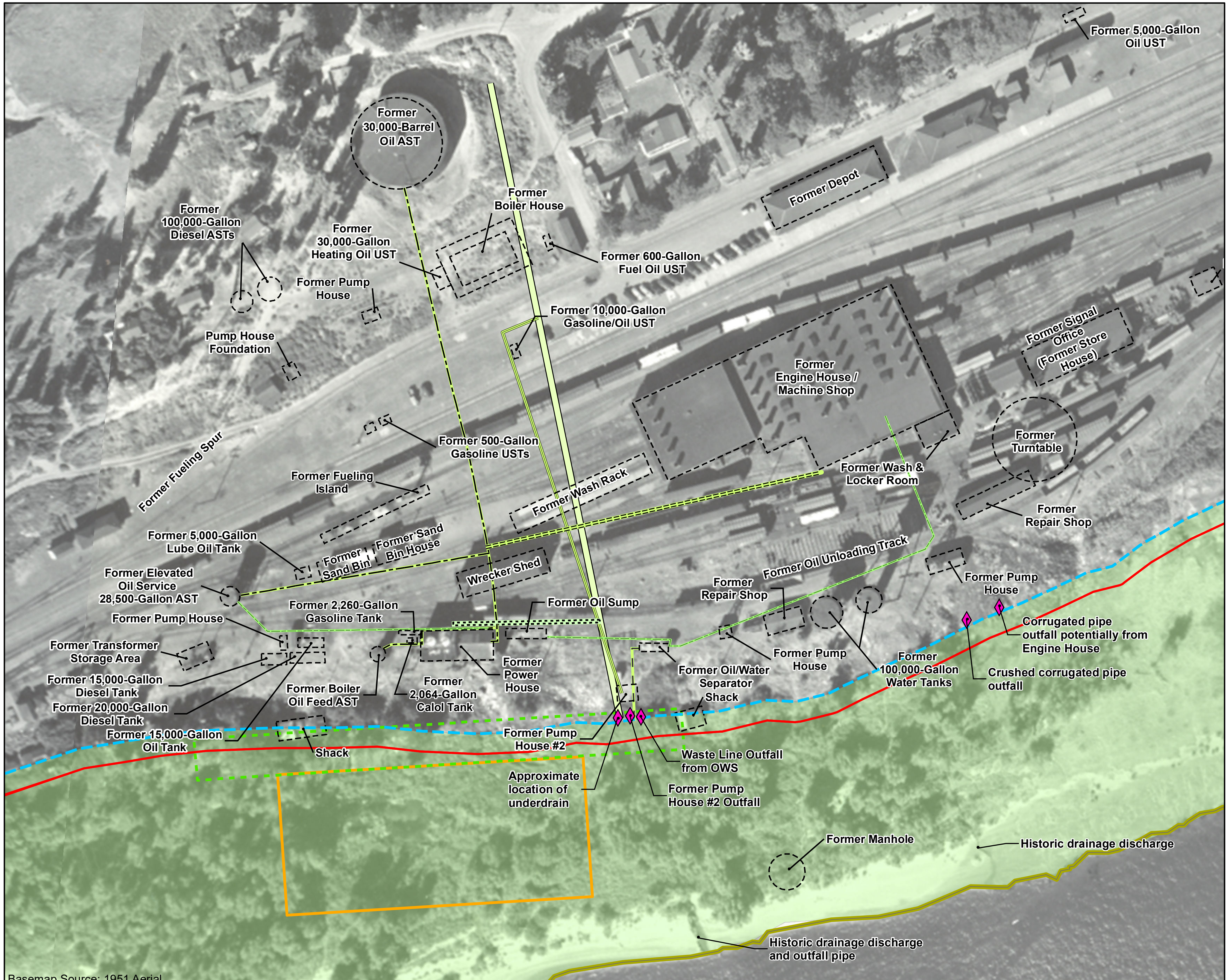
Notes:
OWS = oil/water separator

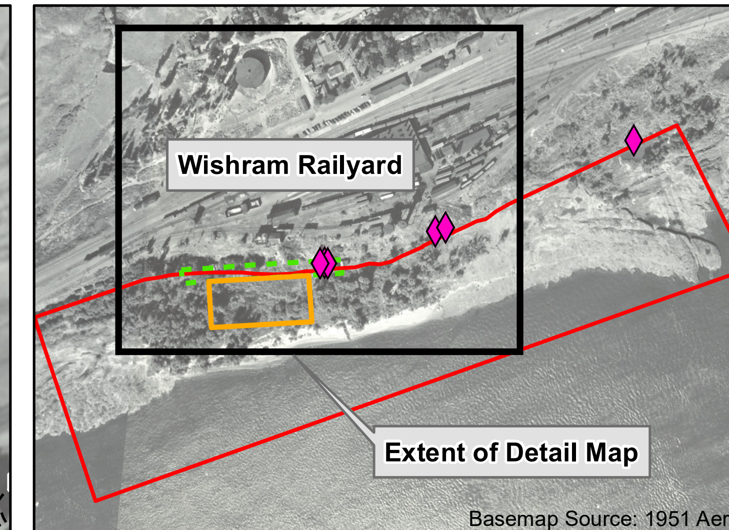
N
0 150 300 600
Feet

Figure 1-6. Current Site Features
BNSF Track Switching Facility
Wishram, Washington

Jacobs

SLC \\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE1-6_CURRENT_SITE_FEATURES.MXD GGEE 5/27/2025 12:59:07





LEGEND

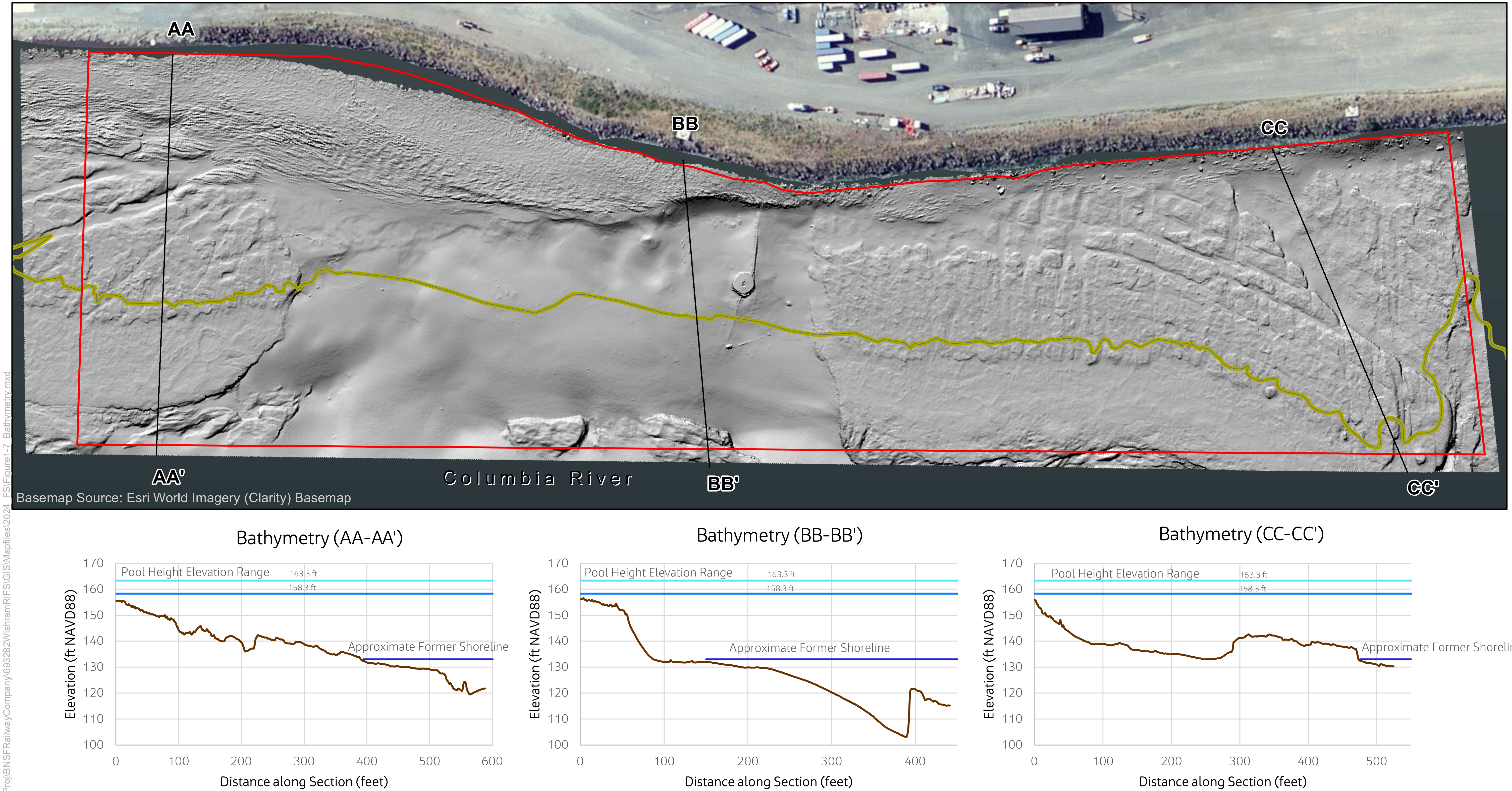
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Steam Line
- Former Bunker Fuel / Oil Pipeline
- Former Oil Drain
- Former Oil Trough
- Former Sewer Line (Potential)
- Stormwater Underdrain (A portion removed from service circa 1960)
- Stormwater Underdrain (Rerouted portion circa 1960)
- WA Ecology Initial Investigation Area
- Initial Investigation Area (Jacobs. 2019. Inundated Lands Initial Investigation Report Draft. BNSF Wishram Railyard, Wishram, Washington. May.)
- Former Shoreline
- Inundated Lands

0 75 150 300
Feet

Figure 1-7. Former Site Features Shown on 1951 Aerial
BNSF Track Switching Facility
Wishram, Washington

Jacobs

SLC \\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE1-7_HISTORICAL_SITE_FEATURES.MXD GGEE 5/27/2025 13:12:06



LEGEND

Remedial Investigation Area

Former Shoreline

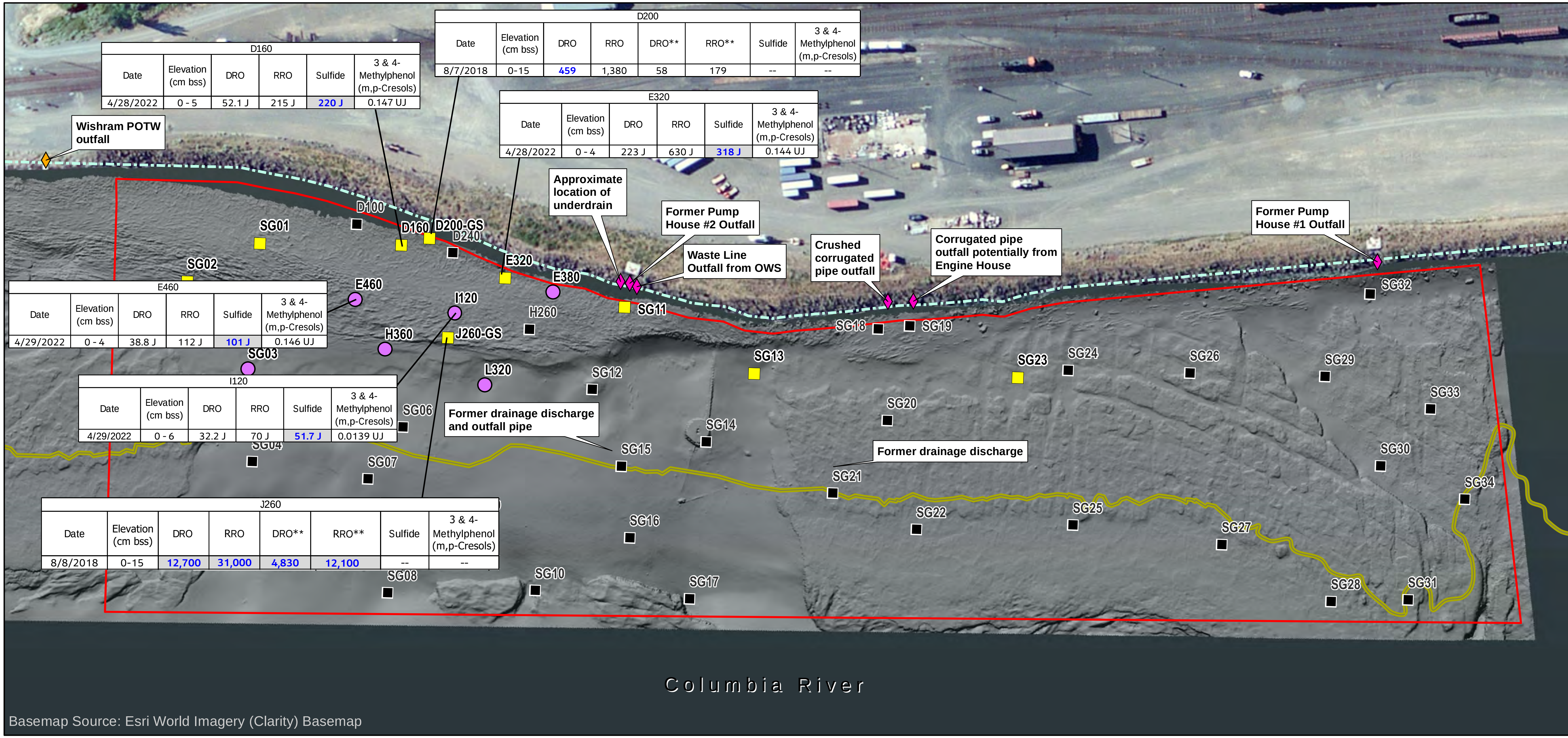
Note: Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.

N

0 100 200 Feet

Figure 2-1. Site Bathymetry with Cross Sections
BNSF Track Switching Facility
Wishram, Washington

Jacobs



D160

Date	Elevation (cm bss)	DRO	RRO	Sulfide	3 & 4-Methylphenol (m,p-Cresols)
4/28/2022	0 - 5	52.1 J	215 J	**220 J**	0.147 UJ

D200

Date	Elevation (cm bss)	DRO	RRO	DRO**	RRO**	Sulfide	3 & 4-Methylphenol (m,p-Cresols)
8/7/2018	0-15	**459**	1,380	58	179	--	--

E320

Date	Elevation (cm bss)	DRO	RRO	Sulfide	3 & 4-Methylphenol (m,p-Cresols)
4/28/2022	0 - 4	223 J	630 J	**318 J**	0.144 UJ

E460

Date	Elevation (cm bss)	DRO	RRO	Sulfide	3 & 4-Methylphenol (m,p-Cresols)
4/29/2022	0 - 4	38.8 J	112 J	**101 J**	0.146 UJ

I120

Date	Elevation (cm bss)	DRO	RRO	Sulfide	3 & 4-Methylphenol (m,p-Cresols)
4/29/2022	0 - 6	32.2 J	70 J	**51.7 J**	0.0139 UJ

J260

Date	Elevation (cm bss)	DRO	RRO	DRO**	RRO**	Sulfide	3 & 4-Methylphenol (m,p-Cresols)
8/8/2018	0-15	**12,700**	**31,000**	**4,830**	**12,100**	--	--

LEGEND

- Composite Grab Sample (6 locations)
- Grab Sample (9 locations)
- No Sample* (31 locations)
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

Notes:
*No recovery due to the presence of bedrock, cobbles, boulders, grass, or shells.
OWS = oil/water separator
POTW = publicly owned treatment works

Note: Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.

Sample locations portrayed at centroid of locations with multiple attempts.

Analyte	Units	SCO[1]	CSL[2]
Sulfide	mg/kg	39	61
3 & 4-Methylphenol (m,p-Cresols)[3]	mg/kg	0.26	2
DRO	mg/kg	340	510
RRO	mg/kg	3600	4400

Table Notes:
[1] Washington Freshwater Sediment Cleanup Objectives (SCO)
[2] Washington Freshwater Sediment Cleanup Screening Levels (CSL)
[3] 3-methylphenol and 4-methylphenol may not be able to be separated. In this case 4-methylphenol may be reported as the sum of the 3- and 4-methylphenol isomers

** - Analyzed with silica gel cleanup. Limited to samples collected during the 2018 Initial Investigation.
Values in blue bold are in excess of the SCO
Shaded values are in excess of the CSL
Results are presented in mg/kg
bss – below sediment surface
cm – centimeters
DRO – Diesel range organics
J – Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value. mg/kg – milligram per kilogram
RRO – Residual range organics
U - not detected above the practical quantitation limit

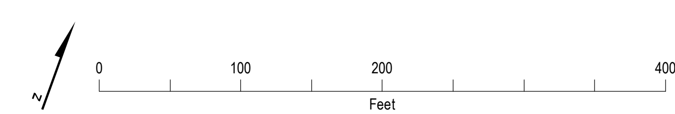
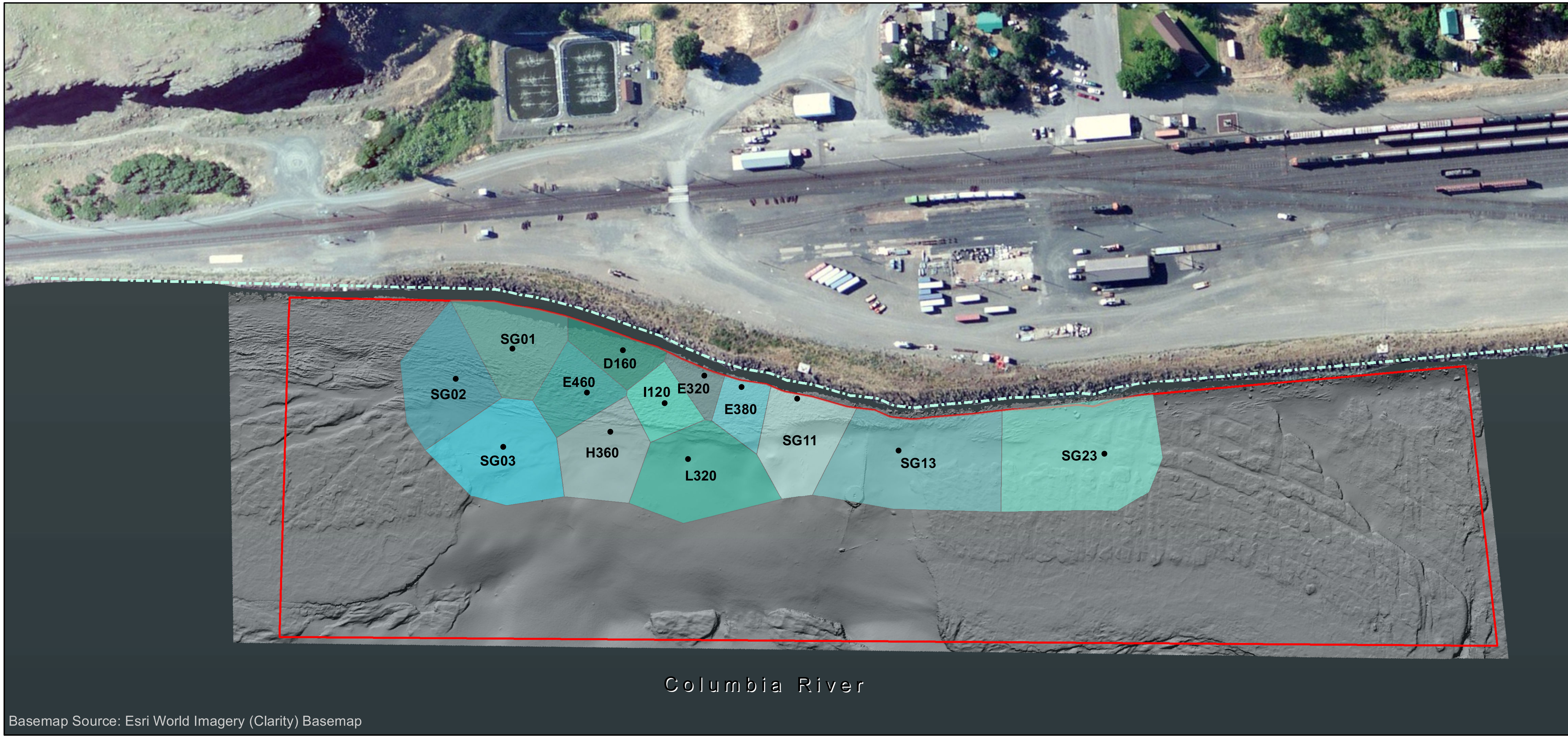


Figure 2.2. Grab Sample Locations with Analytical Results Exceeding one or more Screening Levels or Cleanup Objectives - Surface
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2022_REMEDIALINVESTIGATION\RI REPORT 2023\FIGURE2-2_GRABLOCATIONS.MXD GGEE 4/14/2023 14:40:16



LEGEND

- Sample Location
- Remedial Investigation Area

note - coloring of polygons is for visualization only

Figure 2-3. Thiessen Polygons for Sample Locations with Analytical Data - For Surface Weighted Average Concentration Calculation
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\THIESSENPOLYS.MXD GGEE 6/21/2024 15:00:06

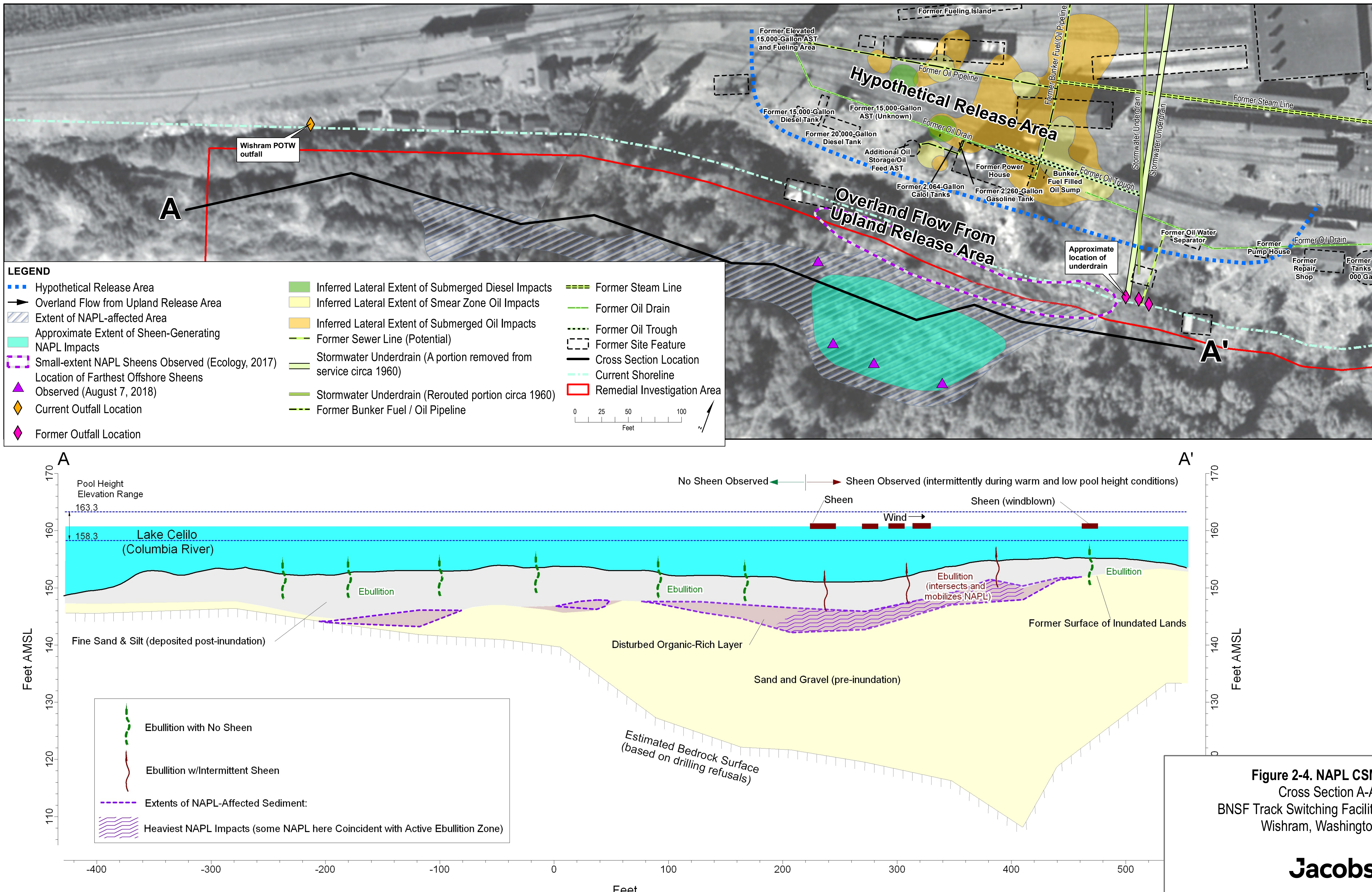
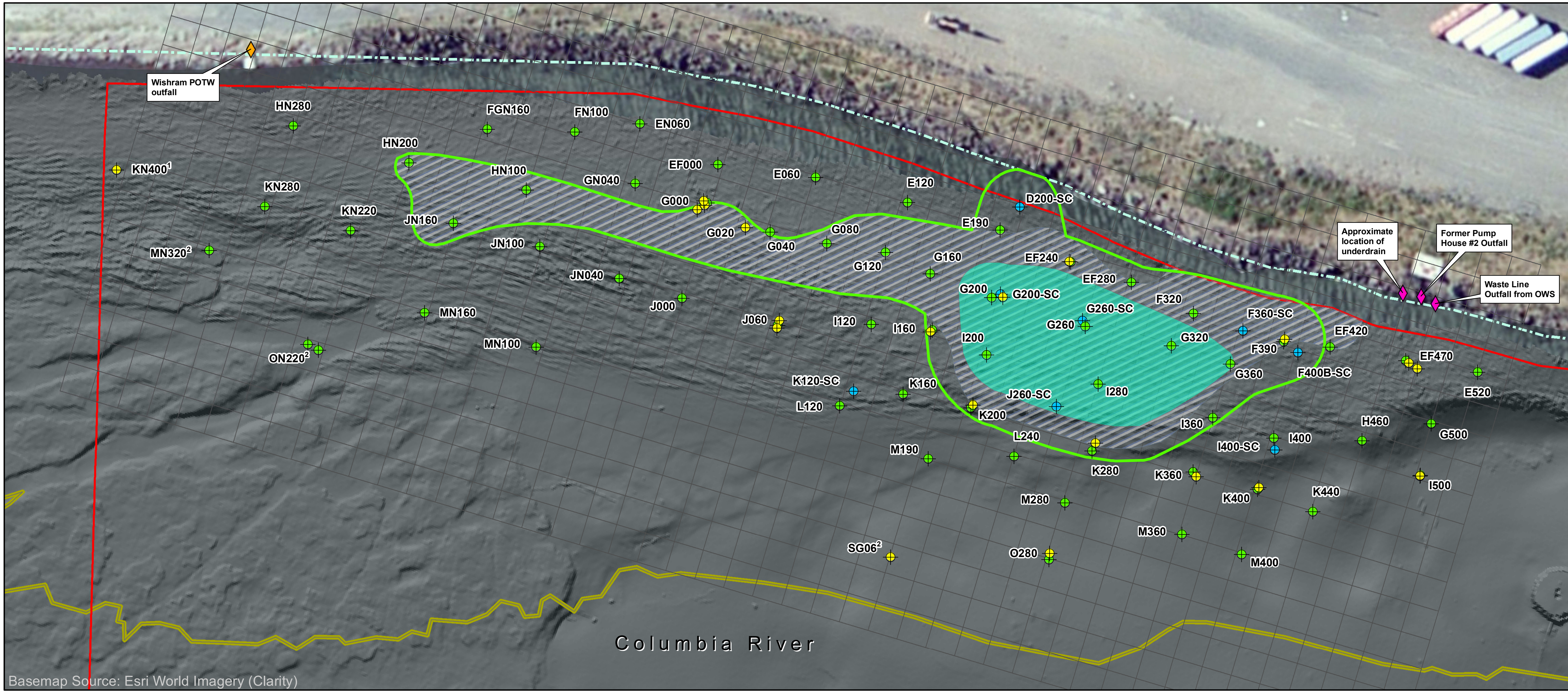
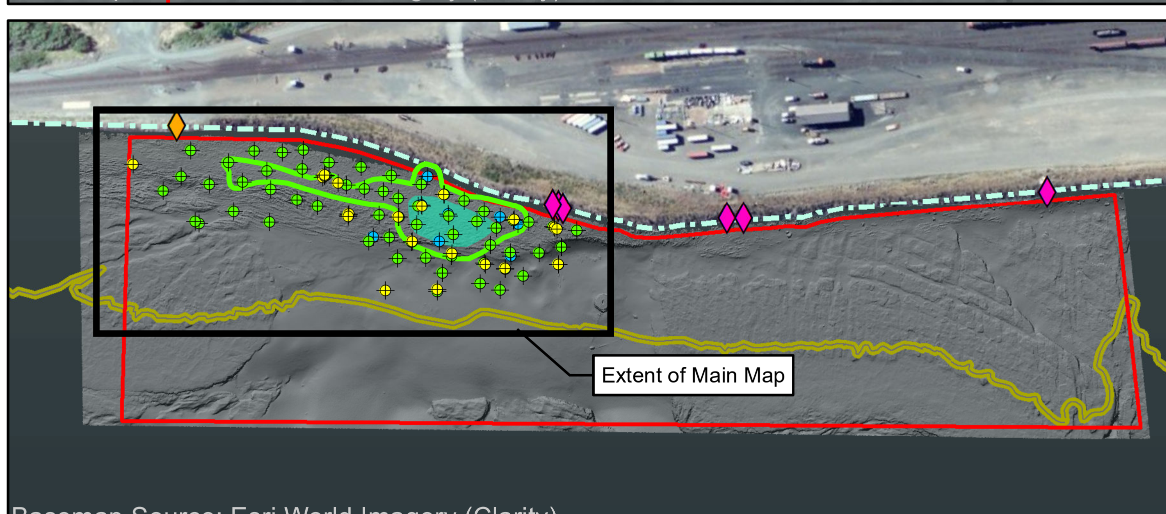


Figure 2-4. NAPL CSM
Cross Section A-A'
BNSF Track Switching Facility
Wishram, Washington

Jacobs





\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE3-1_SEDIMENT CLEANUP UNIT.MXD GGEE 5/9/2025 10:16:16

LEGEND

- Sediment Cleanup Unit Boundary
- Extent of NAPL-affected Area
- Approximate Extent of Sheen-Generating NAPL Impacts
- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

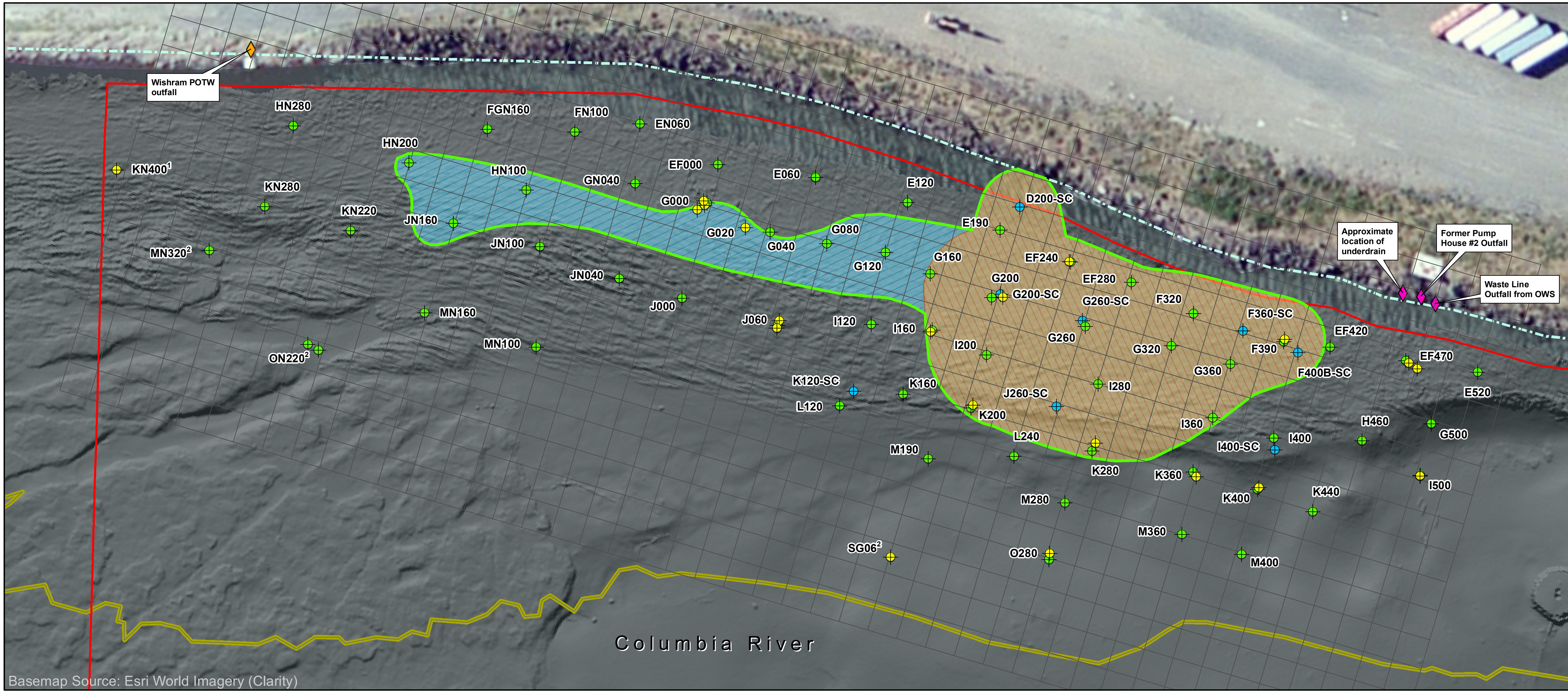
0 25 50 100
Feet

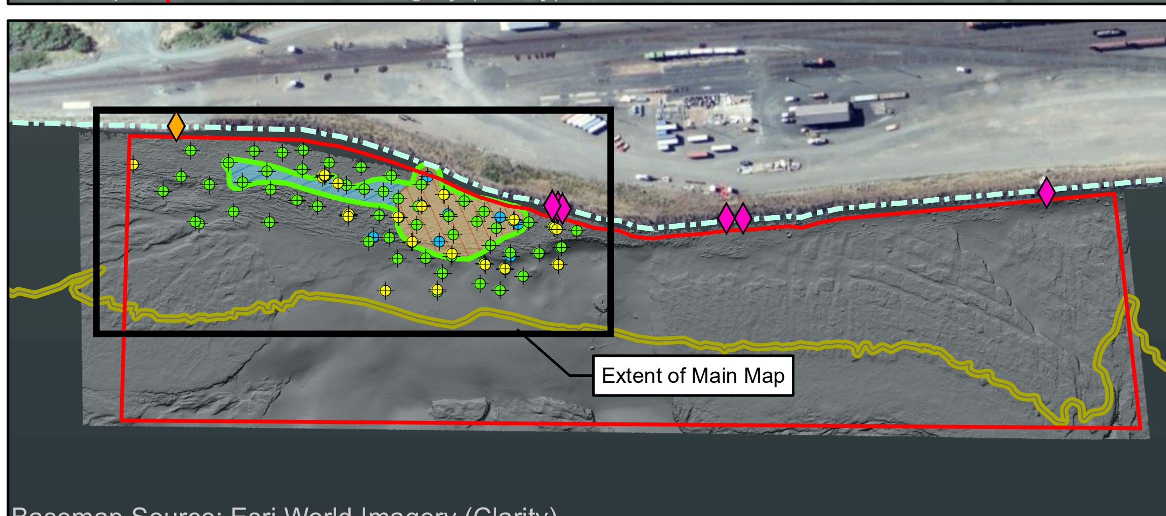
N

Note: Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.

Figure 3-1. Sediment Cleanup Unit
BNSF Track Switching Facility
Wishram, Washington

Jacobs





LEGEND

- Sediment Cleanup Unit Boundary
- SMA East
- SMA West
- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

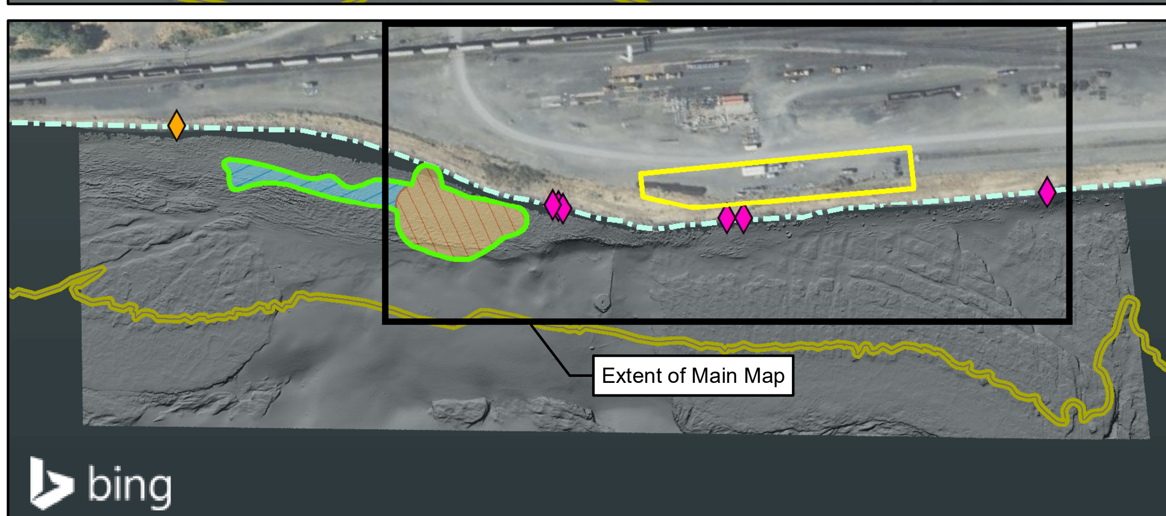
0 25 50 100
Feet

Note: Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.

Figure 3-2. Sediment Management Areas
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE3-2_SEDIMENT MANAGEMENT AREAS.MXD GGEE 5/27/2025 13:21:56



LEGEND

- Proposed Staging Area
- Sediment Cleanup Unit Boundary
- SMA East
- SMA West
- Current Outfall Location
- Former Outfall Location
- Current Shoreline
- Former Shoreline

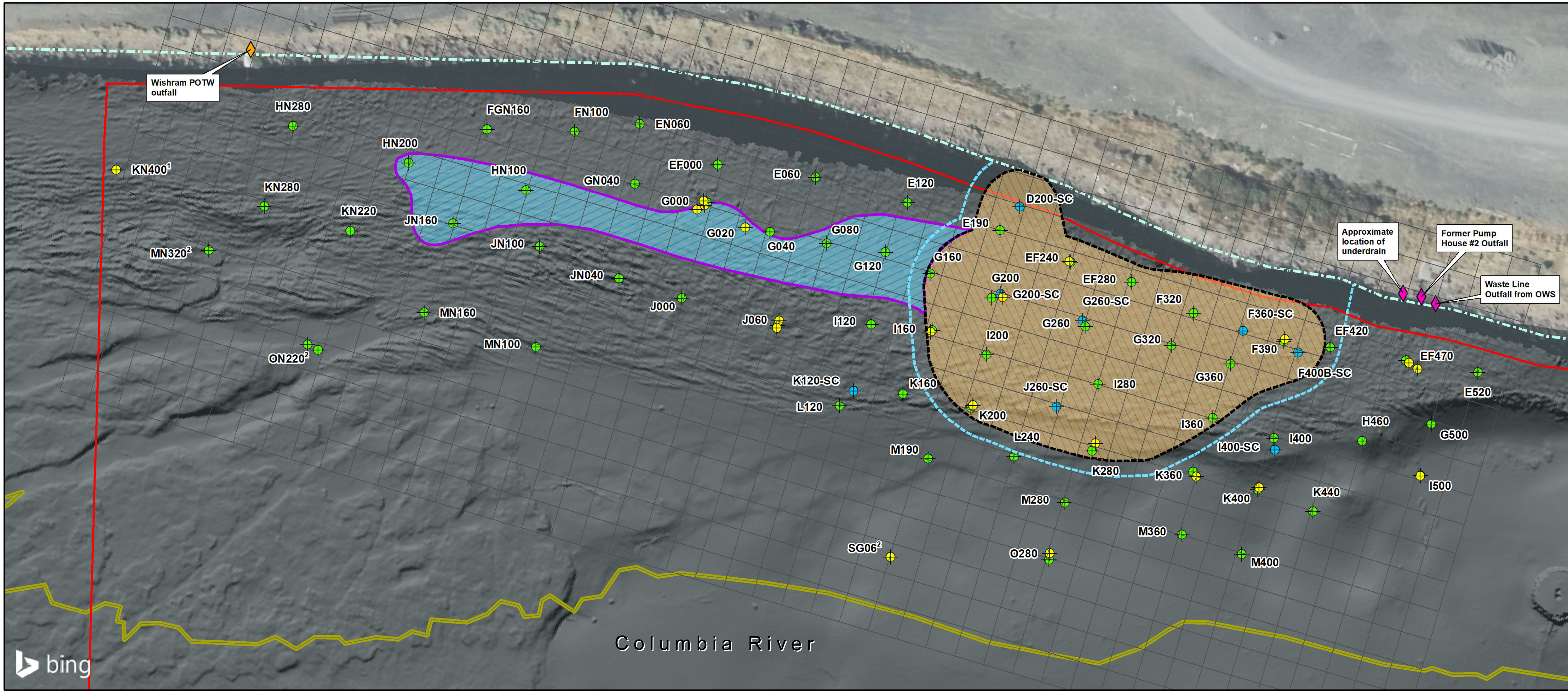
0 25 50 100
Feet

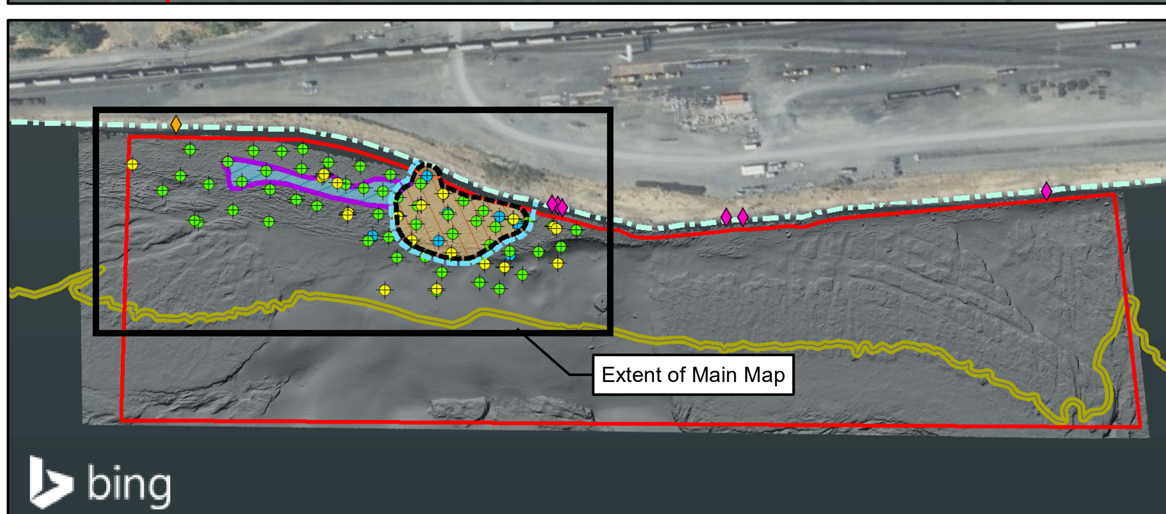
Notes:
1. Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.
2. Aerial Imagery Source: Bing Maps Aerial. Accessed 5/27/2025

Figure 4-1. Proposed Staging Area
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE4-1_PROPOSEDSTAGINGAREA.MXD GGEE 5/27/2025 13:46:32





LEGEND

- Removal and Backfill Remedial Footprint (0.70 acres)
- Silt Curtain
- MNR
- SMA East
- SMA West
- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

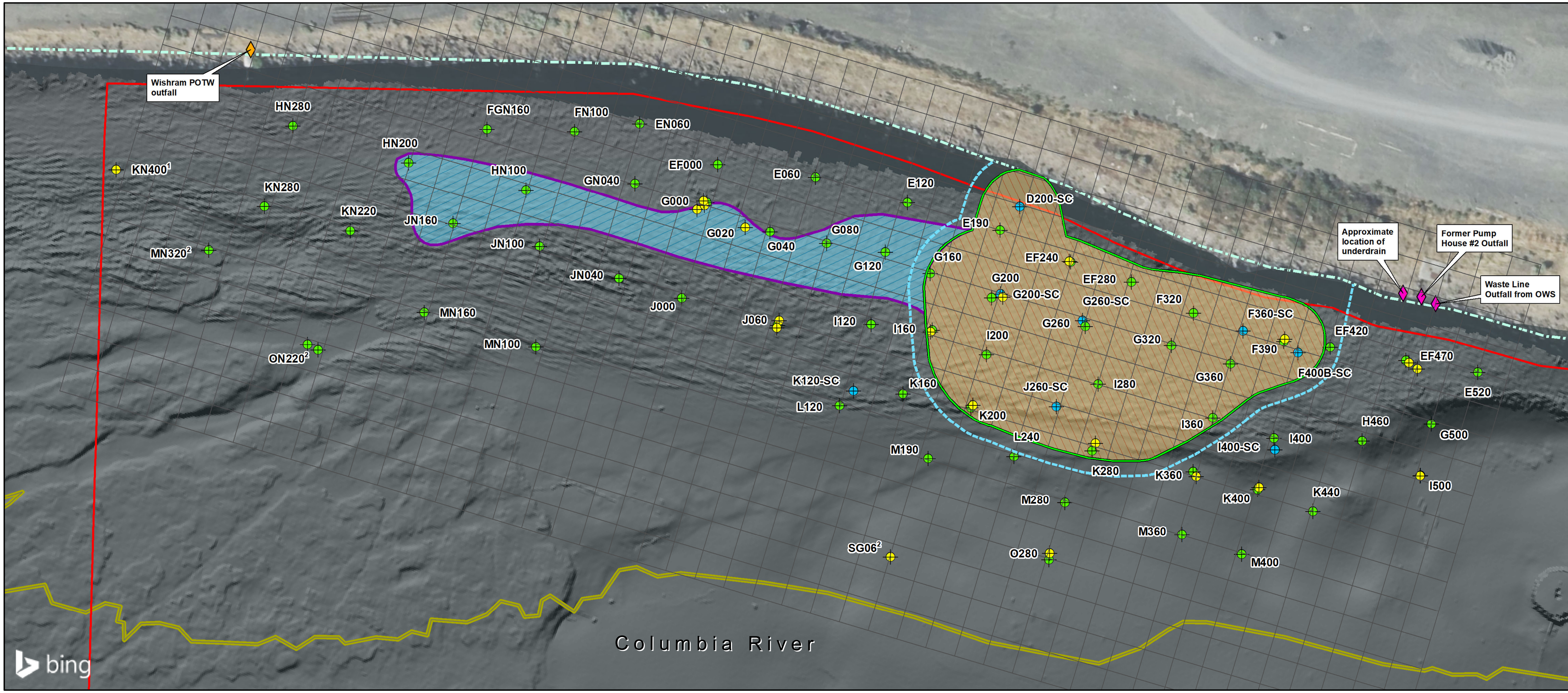
0 25 50 100
Feet

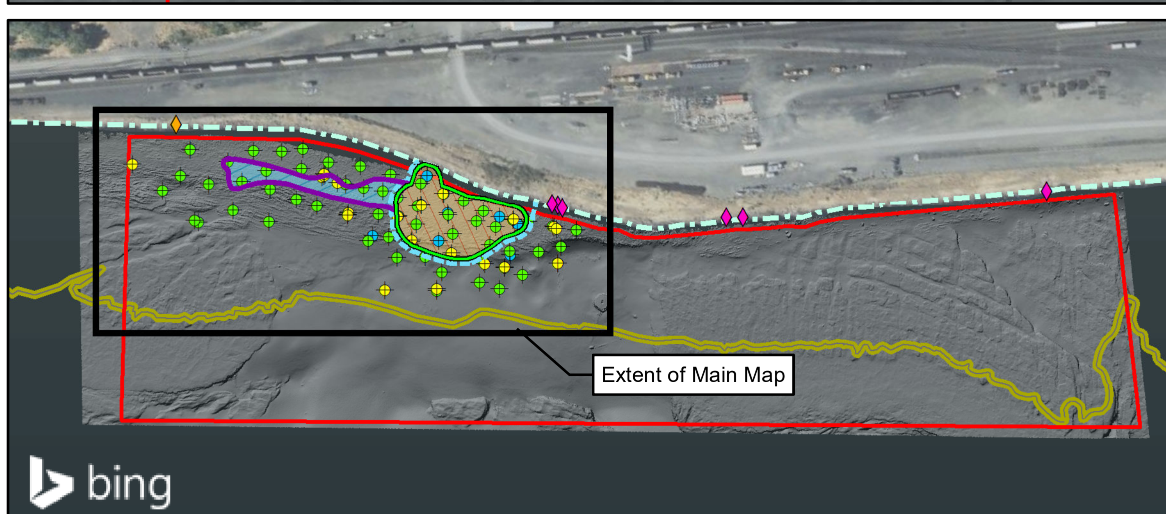
Notes:
1. Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.
2. Aerial Imagery Source: Bing Maps Aerial. Accessed 6/2/2025

Figure 4-2. Alternative 2 – Removal, Backfill, Offsite Disposal, MNR, and Institutional Controls
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE4-2_ALT2.MXD GGEE 6/2/2025 13:14:42





LEGEND

- Capping Remedial Footprint (0.70 acres)
- Silt Curtain
- MNR
- SMA East
- SMA West
- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

0 25 50 100
Feet

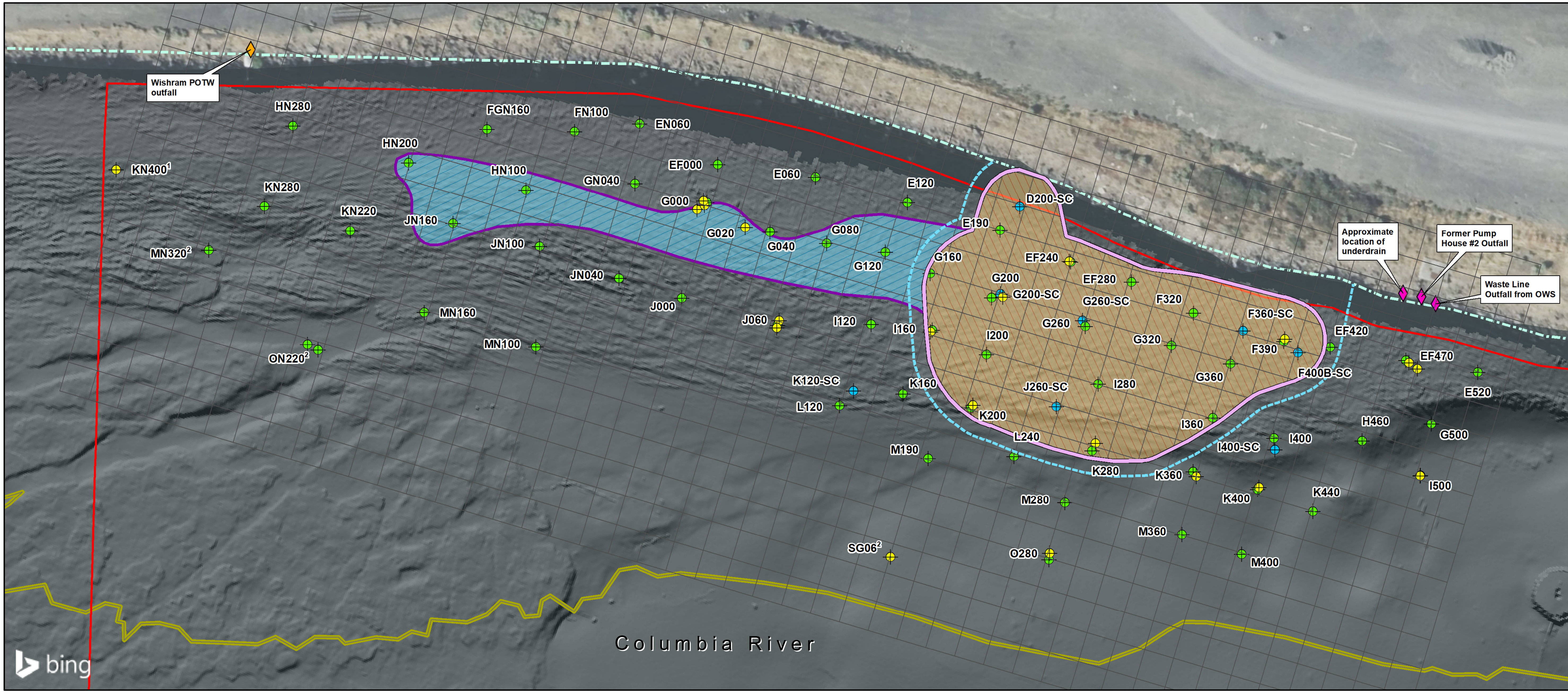
N

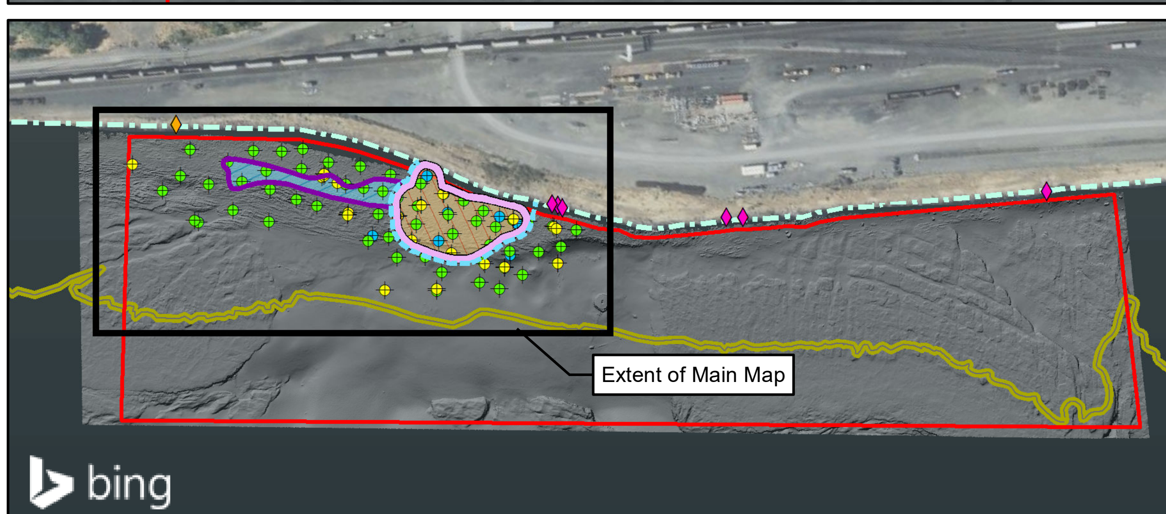
Notes:
1. Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.
2. Aerial Imagery Source: Bing Maps Aerial. Accessed 6/2/2025

Figure 4-3. Alternatives 3A, 3B and 3C – Capping, Institutional Controls, and MNR
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE4-3_ALT3.MXD GGEE 6/2/2025 13:16:08





LEGEND

- In-Situ Stabilization Remedial Footprint (0.70 acres)
- Silt Curtain
- MNR
- SMA East
- SMA West
- 2022 TarGOST Location
- 2022 Sediment Core
- 2018 Sediment Core
- Current Outfall Location
- Former Outfall Location
- Remedial Investigation Area
- Current Shoreline
- Former Shoreline

0 25 50 100
Feet

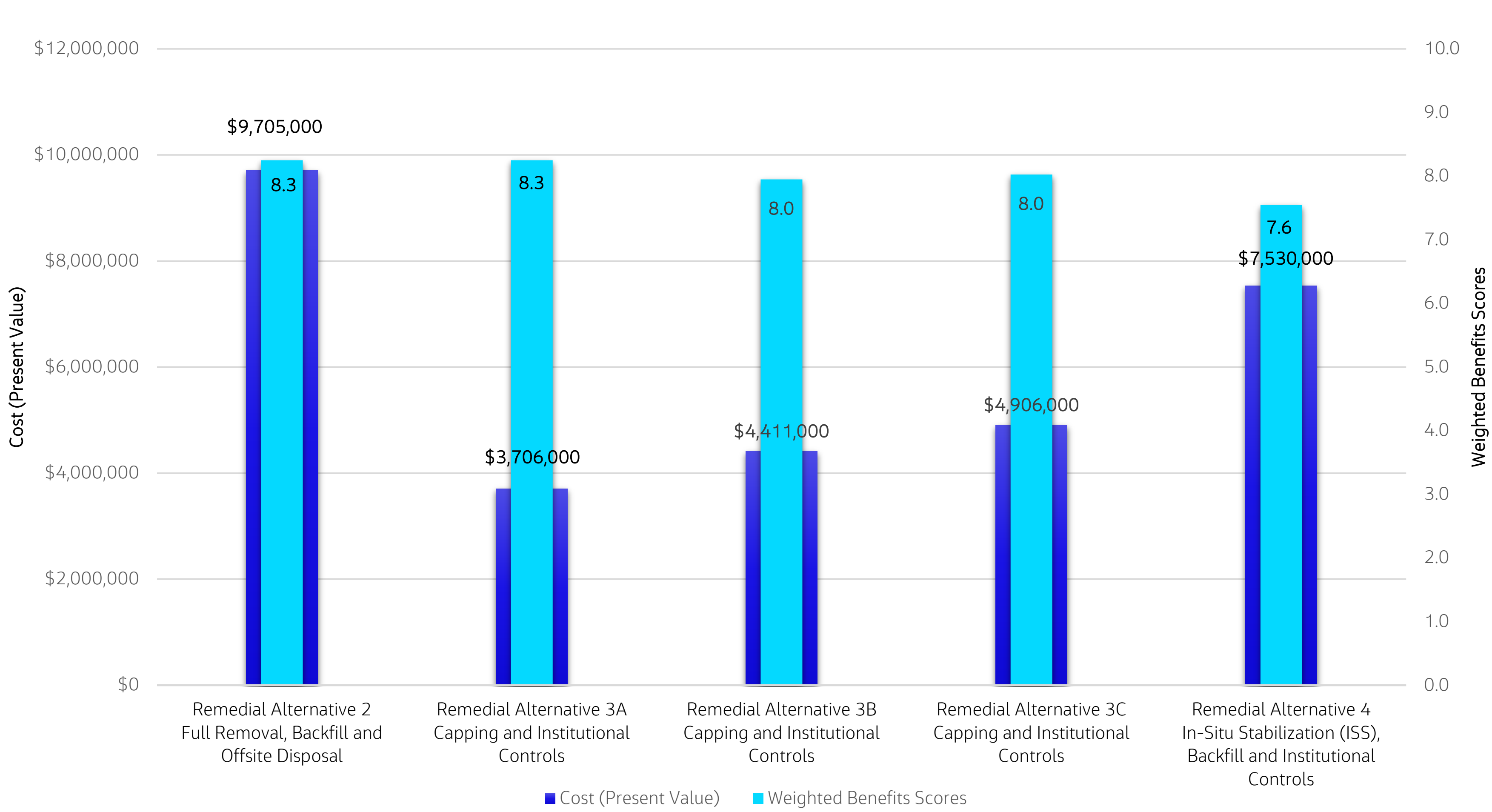
Notes:
1. Bathymetry shown presents results of a multibeam bathymetric survey conducted by Solmar Hydro, Inc.on January 12, 2022. Bathymetric data were collected in accordance with the U.S. Army Corps of Engineers hydrographic manual EM-1110-02-1003 (November 2013). Survey data are represented at a 1-foot grid resolution.
2. Aerial Imagery Source: Bing Maps Aerial. Accessed 6/2/2025

Figure 4-4. Alternative 4 – In-Situ Stabilization, Backfill, Institutional Controls, and MNR
BNSF Track Switching Facility
Wishram, Washington

Jacobs

\\PDXFPP01\PROJ\BNSFRAILWAYCOMPANY\693282WISHRAMRIFS\GIS\MAPFILES\2024_FS\FIGURE4-4_ALT4.MXD GGEE 6/2/2025 13:17:49

Figure 5-1 Cost and Benefit Scores of Cleanup Action Alternatives



Appendix A
Applicable or Relevant and Appropriate Requirement

Table A-1. Chemical-Specific ARARs for Remedial Action at the BNSF Wishram Track Switching Facility

Medium	Regulation/Citation	Criterion/Standard	Rationale for Including	Action to Comply/Permit
Protection of surface water	Clean Water Act, 33 USC 1313 and 1314 (Sections 303 and 304). Most recent 304(a) list of recommended water quality criteria, as updated	Under CWA Section 304(a), EPA develops recommended water quality criteria for water quality programs established by states. Two kinds of water quality criteria are developed: one for protection of human health, and one for protection of aquatic life. CWA §303 requires States to develop water quality standards based on Federal water quality criteria to protect existing and attainable use or uses (e.g., recreation, public water supply) of the receiving waters.	The most recent 304(a) recommended water quality criteria are **Relevant and Appropriate** as criterion to apply to short-term impacts from dredging, in-situ stabilization, and/or capping if more stringent than promulgated state criteria. Contaminants could be released to the Columbia River during in-water construction activities such as during the sediment dredging, in-situ stabilization, and/or capping activities.	401 Water Quality Certification
Protection of surface water	Water Quality Standards for Surface Waters of the State of Washington, WAC 173-201A-240(5)	Establishes chemical water quality standards for surface waters of the State of Washington for protection of aquatic life.	State standards that are more stringent than federal standards are **Relevant and Appropriate** as criterion to short-term impacts during construction that may occur in implementing the remedy. Contaminants could be released to the Columbia River during in-water construction activities such as during the sediment dredging, in-situ stabilization, and/or capping activities.	401 Water Quality Certification
Protection of surface water	40 CFR 131.36(b)(1) Toxics Criteria for Those States Not Complying with Clean Water Act as applied to Washington, 40 CFR 131.45, Revision of certain Federal water quality criteria applicable to Washington	Establishes numeric water quality criteria for priority toxic pollutants for the protection of human health and aquatic organisms which supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	**Applicable** requirement for any discharge of water generated during construction. Would apply to any discharges of water during construction. For example, if porewater drained from dredged sediments is discharged to the Columbia River.	401 Water Quality Certification

Table A-2. Action-Specific ARARs for Remedial Action at the BNSF Wishram Track Switching Facility

Action	Regulation/Citation	Description of Regulatory Requirement	Rational for Including	Action to Comply/Permit
Actions that discharge dredged or fill material into navigable waters	Clean Water Act, Section 404, 33 USC 1344 and Section 404(b)(1) Guidelines, 40 CFR Part 230 (Guidelines for Specification of Disposal Sites for Dredged or Fill Material)	CWA Section 404 regulates the discharge of dredged or fill material into waters of the U.S, including return flows from such activity. This program is implemented through regulations set forth in the 404(b)(1) guidelines, 40 CFR Part 230. The guidelines specify: - the restrictions on discharge (40 CFR 230.10); - the factual determinations on short-term and long-term effects of a proposed discharge of dredged or fill material on the physical, chemical, and biological components of the aquatic environment (40 CFR 230.11) in light of Subparts C through F of the guidelines; and - the findings of compliance on the restrictions (40 CFR 230.12). Subpart J of the guidelines provide the standards and criteria for the use of compensatory mitigation when the response action will result in unavoidable impacts to the aquatic environment.	CWA Section 404 requirements are Applicable. Provides criteria and guidelines for evaluating impacts to the aquatic environment from dredging contaminated sediment, placement of capping material and enhanced monitored natural recovery material, and in-situ treatment of sediments that may occur in implementing the remedy.	Section 404 Permit, USACE Portland District More detailed remedial design information will be required to assess impacts and specify the requirements and controls to be placed on dredging and placement of capping or other materials in the river to minimize impacts. Compensatory mitigation for unavoidable loss of aquatic habitat will be determined and mitigation plans developed if necessary.
Actions that discharge pollutants to waters of U.S.	Clean Water Act, 33 USC 1341, (Section 401), 40 CFR Section, 121.2(a)(3), (4) and (5) See also WAC 173-225 Federal Water Pollution Control Act – Establishment of Implementation Procedures of Application of Certification.	Any activity which may result in any discharge into navigable waters requires reasonable assurances that the activity will be conducted in a manner which will not violate applicable water quality standards by the imposing effluent limitations, other limitations, and monitoring requirements needed so that the discharge will meet the applicable provisions of sections 1311, 1312, 1313, 1316, and 1317 of the Clean Water Act.	Relevant and Appropriate CWA 401 requirement, if more stringent than state implementation regulations, that in-water response actions that result in a discharge of pollutants comply with water quality standards through the placement of water quality-based conditions and other requirements on the discharge as needed. The Applicable state regulations require reasonable assurance that discharge to state waters will comply with state water quality standards. Actions to implement the remedial action that may result in discharges to state waters include, but may not be limited to, dredging, capping, riverbank remediation, or de-watering sediments.	401 Water Quality Certification Conditions and other requirements as needed so that state water quality standards are not violated will be placed on any such discharge.
Actions resulting in discharges to waters of the State of Washington	WAC-173-201A-510 and 520, Implementation of Water Quality Standards for Surface Waters of the State of Washington	Establishes water quality standards for the state of Washington, consistent with public health and enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife. For non-point sources and stormwater pollution, requires Best Management Practices to prevent quarter quality violations caused by stormwater.	All state-wide water quality standards, including numeric, narrative, and designated uses, are Applicable for any discharges to surface water from remedial activities that may result in discharges to waters of the state, such as, dredge and fill, capping, riverbank remediation, and or dewatering sediments. These regulations are Relevant and Appropriate for managing stormwater generated during construction, if the area disturbed is less than 1 acre.	401 Water Quality Certification NPDES and State Waste Discharge General Permit for Stormwater Discharges Associated with Construction Activity requirements are relevant and appropriate for remedies that include use of a concrete batch plant.
Actions involving sediment cleanup	WAC 173-204-570, Selection of Cleanup Actions	Sediment cleanup actions must comply with the sediment cleanup standards, use permanent solutions to the maximum extent practicable, provide for a reasonable restoration time frame, and shall not rely exclusively on MNR or ICs and monitoring where implementing a more permanent cleanup action is possible.	Washington Sediment Management Standards (SMS) are Applicable.	The proposed remedies include full removal and backfill, capping or in-situ stabilization but some proposed remedies rely on institutional controls to achieve remedial goals.
Actions involving sediment cleanup	WAC-220-660 Hydraulic Code Rules Subsections 220-660-110 Authorized work times in freshwater areas, 220-660-120 Common freshwater construction provisions, 220-660-130 Stream bank protection and lake shoreline stabilization, and 220-660-170 Dredging in freshwater areas	Places restrictions on construction projects in marine and freshwater environments to protect and restore fish habitat	Applicable to cleanup actions in sediments. The selected remedy will comply to the extent feasible and will include measures to mitigate unavoidable impacts to freshwater habitat as necessary.	Hydraulic Project Authorization (HPA) issued by the Washington Department of Fisheries (WDFW) Construction activities will avoid where feasible unnecessary disturbance to fish, shellfish, and wildlife.
Actions in federal navigation channels	River and Harbors Act of 1899, Section 10, 33 USC Section 403 and implementing regulations at 33 CFR Sections 322(e), 323.3, 323.4(b)-(c) and 329	The creation of any obstruction not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States is prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any port, roadstead, haven, harbor, canal, navigable	Applicable requirement for construction in the navigation channel so as not to create an obstruction to the navigable capacity. Applicable to the use of aids to navigation as institutional controls for maintaining the integrity of the cap. Applicable to the discharge of dredged	Section 404 Permit, USACE Portland District

Table A-2. Action-Specific ARARs for Remedial Action at the BNSF Wishram Track Switching Facility

Action	Regulation/Citation	Description of Regulatory Requirement	Rational for Including	Action to Comply/Permit
		river, or other water of the United States, outside established harbor lines. 33 CFR 322.5(e) addresses placing of aids to navigation in navigable water is under the purview of Section 10 and must meet requirements of the U.S. Coast Guard (33 CFR 330.5(a)(l)). 33 CFR Section 323.4(b) and (c) provide if any discharge of dredged or fill material contains any toxic pollutant listed under section 307 of the CWA such discharge shall require compliance with Section 404 of the CWA. Placement of pilings, or discharge of dredged material that where the flow or circulation of waters of the United States may be impaired or the reach of such waters reduced must comply with Section 10. 33 CFR 329.4 defines the terms "navigable water of the United States" for purposes of the USACE regulations, including those addressing the discharge of dredged or fill material.	material that may impair the flow or circulation of waters or reach of waters the United States.	
Actions generating air emissions	General Standards for Maximum Emissions, WAC-173-400-040	All sources and emissions units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, fallout, fugitive emissions, odors, emissions detrimental to persons and property, sulfur dioxide, concealment and masking, and fugitive dust	State regulations defining methods of control to be employed to minimize the release of contaminants associated with fugitive emissions are Applicable to remedial actions that may generate fugitive emissions. For example, if an on-site concrete batch plant is used for in-situ stabilization. These regulations could apply to earth-moving equipment, dust from vehicle traffic, and mobile-source exhaust.	Ecology General Order Permit for the potential on-site concrete batch plant Remedial actions that have the potential to release air emissions will meet standards
Actions generating noise	Maximum environmental noise levels, WAC 173-60 Incorporated by reference in Klickitat County Municipal Code 9.15.050 – Noise Level	Regulations contain specific requirements that pertain to noise levels and limitations	These regulations are Applicable to noise generated during remedial action.	Noise levels will need to be controlled if noise reaches nuisance levels.
Actions that involve generating, handling, and disposal of waste	Identifying Solid Waste, WAC-173-303-016	This regulation identifies those materials that are and are not solid wastes when recycled.	Solid waste identification requirements are Applicable to solid wastes generated during remedial actions.	Standards will be met for remediation activities.
Actions generating wastes for off-site disposal	Designation of Dangerous Waste, WAC 173-303-070	This regulation establishes the requirements for determining if a solid waste is a dangerous waste.	Dangerous waste characterization and determination is Applicable to wastes generated during remedial actions that will be disposed offsite.	A waste determination will be made for wastes prior to offsite disposal.
Actions generating a dangerous waste	Requirements for Generators of Dangerous Waste, WAC 173-303-170	This regulation establishes the requirements for dangerous waste generators.	This regulation is Applicable to remedial actions that may generate dangerous wastes.	Management of remediation wastes that are dangerous waste will comply with these requirements.
Actions generating a dangerous waste	Accumulating Dangerous Waste On Site, WAC 173-303-200	This regulation establishes the requirements for accumulating dangerous wastes on site.	State rules establishing requirements for accumulating dangerous waste on site are Applicable for managing dangerous wastes generated at the site, such as contaminated debris, personal protective equipment, and treatment chemicals.	If dangerous waste is found, then the waste will be managed to meet these requirements.
Actions generating a dangerous waste	Use and Management of Containers, WAC 173-303-630, General Requirements, WAC 173-303-280(6), and Closure, WAC 173-303-610(2), (4), and (5)	This regulation establishes requirements for management of dangerous waste in containers	This standard is Applicable to remedial actions that involve management of dangerous waste in containers that are subject to this standard.	Remedial actions that produce or manage containers of dangerous waste will be managed to meet standards.
Actions managing remediation wastes in staging piles	Staging Piles, WAC-173-303-64690	This regulation establishes the requirements for temporary storage of nonflowing remediation waste during remedial operations (incorporates 40 CFR 264.544 by reference)	This rule is Relevant and Appropriate for management of remediation wastes including contaminated soil/sediment piles that may be generated and accumulated during construction.	Standards will be met for remediation waste.
Actions cleaning up dangerous waste	General requirements for cleanup-only dangerous waste facilities, WAC 173-303-280(6)	This regulation establishes requirements for the protection of public safety and worker safety at dangerous waste cleanup sites, including measures to prevent exposure to members of the public, worker safety training, accident prevention, management of surface impoundments and waste piles, and construction quality assurance planning.	This rule is Relevant and Appropriate to construction activities including sediment dredging, capping, and in-situ stabilization and to handling prior to offsite transport.	Cleanup activities will comply with these standards.
Actions generating, handling, and disposal of solid waste	Owner Responsibilities for Solid Waste, WAC 173-350-025, Performance Standards, WAC 173-350-040, On-Site Storage,	This regulation establishes minimum functional performance standards for the proper handling and disposal of solid waste, not otherwise excluded. Provides requirements for the proper handling of solid waste ,	Requirements are Applicable for solid waste generated during implementation of remedial actions.	Remedial actions that generate solid waste will meet standards.

Table A-2. Action-Specific ARARs for Remedial Action at the BNSF Wishram Track Switching Facility

Action	Regulation/Citation	Description of Regulatory Requirement	Rational for Including	Action to Comply/Permit
	Collection and Transportation Standards, WAC 173-350-300, and Remedial Action, WAC 173-350-900	and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.		
Actions generating dredged material dangerous waste	Excluded Categories of Waste, WAC 173-303-071(3)(ll)(i)	Dredged material that is subject to the requirements of Section 404 of the CWA is excluded as a dangerous waste.	The exemption is Applicable to the dredging, in-situ treatment, handling, storage, or other on-site activities of dredged materials that are being managed in accordance with Section 404 analysis and approvals.	Section 404 Permit, USACE Portland District

Table A-3. Location-Specific ARARs for Remedial Action at the BNSF Wishram Track Switching Facility

Location	Regulation/Citation	Criterion/Standard	Rationale for Including	Permit/Action
Presence of archaeologically or historically sensitive area	Native American Graves Protection and Reparation Act, 25 USC 3001-3013, 43 CFR 10 See also Protection of Indiana Graves - Penalty, RCW 22.44.040 and Skeletal Human Remains, Duty to Notify – Ground Disturbing Activities- Coroner Determination – Definitions, RCW 27.44.055	Requires Federal agencies and museums which have possession of or control over Native American cultural items (including human remains, associated and unassociated funerary items, sacred objects and objects of cultural patrimony) to compile an inventory of such items. Prescribes when such Federal agencies and museums must return Native American cultural items. "Museums" are defined as any institution or State or local government agency that receives Federal funds and has possession of, or control over, Native American cultural items.	If Native American human remains or cultural items associated with human remains are present and discovered during the course of remedial construction, this requirement is Relevant and Appropriate. Such a discovery at the BNSF Wishram Track Switching Facility is unlikely but possible given the long use of the area by the by the Confederated Tribes and Bands of the Yakama Nation.	BNSF will coordinate with DAHP (Department of Archaeology and Historic Preservation) and local tribal nations regarding the level of training or oversight needed during different phases of construction. This consultation is typically triggered by applying for a CWA Section 404 permit.
Presence of archaeologically or historically sensitive area	Archaeological and Historic Preservation Act. 16 USC 469a-1	Provides for the preservation of historical and archaeological data that may be irreparably lost due to a federally-approved project and mandates only preservation of the data.	Relevant and Appropriate if historical and archaeological data may be irreparably lost by implementation of the remedial activities.	BNSF will consult with the DAHP, and the local tribal nations prior to the start of remedial construction and will work to avoid, minimize, or mitigate the impacts of construction. This consultation is typically triggered by applying for a CWA Section 404 permit.
Presence of a floodplain	Requirements for Flood Plain Management Regulations, 44 CFR 60.3(a) Floodplain management, WAC-173-158	Prohibits encroachments that would result in any increase in flood levels during occurrence of base flood discharge.	FEMA flood rise requirements are considered Relevant and Appropriate requirements for remedial actions that involve capping or other placement of material in the river or on riverbanks that may increase flood levels.	Capping or other placement of material in the Columbia River or on riverbanks will not increase flood levels.
Presence of federally or state-listed endangered or threatened species	Interagency Cooperation for the Endangered Species Act, 50 CFR 402 Subpart B, Consultation Procedures Wildlife Classified as Protected Shall Not be Hunted or Fished, WAC 220-200-100 Wildlife Classified as Endangered Species, WAC 220-610-010	Actions authorized, funded, or carried out by federal agencies may not jeopardize the continued existence of endangered or threatened species or result in the adverse modification of species' critical habitat. Agencies are to avoid jeopardy or take appropriate mitigation measures to avoid jeopardy.	Applicable to remedial actions that may impact endangered or threatened species that are present at the site. Listed species, such as salmonids, may be present at the Site.	BNSF will consult with the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) regarding actions to be taken, their impacts on listed species, and measures (applicable mitigation and/or best management practices) that will be taken to reduce, minimize, or avoid such impacts so as not to jeopardize the continued existence or adversely modify critical habitat. If take cannot be avoided, take permission from the Services will be obtained prior to construction and mitigation measures identified. Consultation with NMFS and USFWS, typically triggered by application CWA Section 404 Permit
Presence of essential fish habitat	Magnuson-Stevens Fishery Conservation and Management Act. 50 CFR Part.600.920	Requires consultation with NMFS on actions that may adversely affect Essential Fish Habitat (EFH), defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."	Applicable because the NMFS has designated the Middle Columbia-Hood Watershed as EFH for Coho and Chinook Salmon.	BNSF will consult with the NMFS regarding actions to be taken, their impact on EFH, and measures that will be implemented to minimize impacts on essential habitat. Consultation with NMFS and USFWS is typically triggered by an application for a Section 404 Permit.
Presence of fish and wildlife habitat	Fish and Wildlife Coordination Act. 16 USC 662 and 663, 50 CFR 6.302(g)	Requires federal agencies to consider effects on fish and wildlife from projects that may alter a body of water and mitigate or compensate for project-related losses, which includes discharges of pollutants to water bodies.	Relevant and Appropriate to determining impacts and appropriate mitigation, if necessary, for effects on fish and wildlife from filling activities, in-situ stabilization, or discharges from point sources.	BNSF will consult with the NMFS and USFWS regarding actions to be taken and measures that will be implemented to minimize impacts on essential habitat. Consultation with NMFS and USFWS is typically triggered by an application for a Section 404 Permit.
Presence of migratory birds	Migratory Bird Treaty Act. 16 USC §703 SO CFR §10.12	Makes it unlawful to take any migratory bird. "Take" is defined as pursuing, hunting, wounding, killing, capturing, trapping and collecting.	Applicable to response actions that could harm migratory birds using the Columbia River and may require use of best management practices for observing and avoiding contact with such species during construction of the remedy.	BNSF will consult with USFWS regarding actions to be taken and measures that will be implemented to avoid take of any migratory bird. If a take is unavoidable, a migratory bird permit is required.
Presence of Bald and Golden Eagles	Bald and Golden Eagle Protection Act. 16 USC 668, 50 CFR Part 22	Protects bald and golden eagles from take, possession, or transportation without a permit.	Applicable to remedial actions that would disturb bald or golden eagles, if present.	BNSF will consult with USFWS regarding actions to be taken and measures that will be implemented to avoid disturbance of bald and golden eagles, if present. If needed, remedial action work plans will include measures to minimize disturbances to bald or golden eagles. If a take is unavoidable, a permit is required.

Table A-3. Location-Specific ARARs for Remedial Action at the BNSF Wishram Track Switching Facility

Location	Regulation/Citation	Criterion/Standard	Rationale for Including	Permit/Action
Presence of Bald Eagles	Bald Eagle Protection Rules, WAC 220-610-100	Protects eagle habitat to maintain eagle populations so the species are not classified as threatened, endangered, or sensitive in Washington State	**Applicable** to remedial actions that would impact eagle habitat if present.	BNSF will consult with WDFW regarding bald eagles and their habitat, if present. If needed, remedial action work plans will include measures to protect bald eagle habitat.
Presence of shorelines	Shoreline Management Act of 1971, RCW 90.58 and WAC 173-24 Klickitat County Shorelines Master Program	Establishes regulations, enforcement procedures, and policies for protecting and developing Klickitat County shorelines areas. The Klickitat County SMP was approved by Ecology on August 7, 1998, and amended in 2007.	Policies and regulations for the shorelines of Klickitat County are **Relevant and Appropriate** for construction within 200 feet of the river shoreline and for dredging.	Design and construction will comply with the Shoreline Master Program requirements and will include mitigation for unavoidable impacts to shoreline resources. BNSF will consult with the Klickitat County Planning Department and apply for a Shoreline Development Permit via the Joint Aquatic Resources Permit Application (JARPA) as needed.

Appendix B
Costs

Basis of Estimate, Wishram Railyard Sediment Feasibility Study, BNSF Wishram Railyard, Wishram, Washington

1. Introduction

Jacobs prepared detailed analysis cost estimates for remedial alternatives as part of the feasibility study (FS) for the BNSF Wishram Track Switching Facility (BNSF Wishram Railyard) in Wishram, Washington. Detailed cost estimates were prepared for each remedial alternative addressing impacted sediments in the Columbia River adjacent to the site.

This basis of estimate (BoE) focuses on the approach used specifically for the detailed analysis cost estimates for remedial alternatives in the FS.

2. Purpose and Intended Uses

This BoE constitutes the estimated construction costs to execute the activities as described in the FS. The purpose of this BoE is to establish a rough order of magnitude (ROM) opinion of probable costs (Table 1) for implementation of the remedial alternatives and long-term operation, monitoring, and maintenance (OM&M) for the purpose of comparing remedial alternatives to inform the remedy selection process. The ROM opinion of probable costs is not intended to be used as a forecasting tool to establish project budgets or negotiating enforcement settlements. The FS remedial alternative cost estimates are subject to change due to fluctuations in general economic and business conditions; rates of escalation and inflation; potential supply chain disruptions and market volatility with respect to labor, equipment, and materials; future changes in site conditions; regulatory or enforcement policy changes; scope changes; and delays in performance, among other factors. As such, the ROM opinion of probable costs is subject to change and may need to be revised.

Table 1. Estimate Information

Estimate Classification	Class 4
Estimate Use	Feasibility Study Comparative Evaluation
Requested By	BNSF
Estimated By	Jacobs
Estimate Date	June 2025

3. Cost Guidance and Estimate Methodology

The approach to the development of the cost estimates is based on the methodology as described in the following cost guidance documents, as applicable:

- AACE International 2021 - *Recommended Practice No.107R-19: Cost Estimate Classification System As Applied in Engineering, Procurement, and Construction for the Environmental Remediation Industries*. October 5.
- U.S. Army Corps of Engineers (USACE) 2016 - *Engineering and Design Environmental Remediation and Removal Programs Cost Engineering*. USACE Engineer Regulation 1110-3-1301. December 30.
- U.S. Environmental Protection Agency (EPA) 2000 - *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study.* EPA 540-R-00-002. July.

The estimate was developed using HCSS Heavy Bid (HCSS) software and the cost estimate is considered a bottom rolled up type estimate with individual cost items developed using labor, materials, subcontractors, and equipment. No binding quotations were obtained for contractors or materials at this stage. However, vendor quotes were obtained for project critical contractors and equipment for estimating purposes only.

Unit costs for various remedial activities were developed for the detailed analysis cost estimates for each remedial alternative, as presented in Section 5 of the FS. Unit costs generated from the HCSS software were used to present cost estimate summary and present value analysis in Microsoft Excel for each remedial alternative. Detailed, unit-cost, or activity-based, cost estimates are the most definitive of the estimating techniques and use information down to the lowest level of detail available at the time the estimates were generated.

4. Remedial Alternatives and Overall Costs

The following are the remedial alternatives for detailed analysis as presented in Section 4 of the FS:

- Alternative 1 – No Action
- Alternative 2
  - Eastern sediment management area (ESMA) – Removal, Backfill, and Offsite Disposal
  - Western sediment management area (WSMA) – Monitored Natural Recovery (MNR) and Institutional Controls (ICs)
- Alternative 3A
  - ESMA – Capping with AquaGate + ORGANOCLAY™ and ICs
  - WSMA – MNR and ICs
- Alternative 3B
  - ESMA – Capping with a Reactive Core Mat (RCM) and ICs
  - WSMA – MNR and ICs
- Alternative 3C
  - ESMA – Capping with RCM and a Marine Armor Mat, and ICs
  - WSMA – MNR and ICs
- Alternative 4
  - ESMA - In-Situ Stabilization, Backfill, and ICs
  - WSMA – MNR and ICs

Table CS-1 in Attachment 1 summarizes the overall costs associated with the remedial alternatives. The estimated total cost represents the total costs for construction and 100 years of long-term OM&M for each remedial alternative. The estimated total present worth presents the net present value of each remedial alternative. The total costs and total present worth costs were developed in 2024 U.S. dollars and do not include escalation.

5. Key Assumptions – HCSS Heavy Bid Cost Estimate Preparation

The basis for the cost estimates includes the following:

- Unit costs for various remedial activities were developed for the detailed analysis cost estimates for each remedial alternative using the HCSS software.
- The cost estimate assumes specialized and heavy equipment such as dredging equipment, long-reach excavators, barges, and screening plants, that would require mobilization to the site.

- It is assumed that project-dedicated supervisory staff and specialty laborers/equipment operators will be hired from outside the local labor market and will receive per diem for the duration of the remedial action.
- The estimate was prepared using local market conditions to the degree practicable:
  - Wage rates based on January 2024 Davis-Bacon Act wage determinations from Klickitat County, Washington for craft laborers and equipment operators.
  - Equipment rates are based on 80% of Blue Book value.

Material costs were obtained primarily via current vendor quotes, internet vendor searches, and Jacobs' estimator experience and are representative of current pricing.

- The provided labor rate database also includes the contractor and subcontractor burden markups for labor:
  - Federal/State Unemployment Taxes: 4.5% (0.8% federal/3.7% state)
  - Social Security Taxes: 7.65%
  - Workmen's Compensation: Varies by contractor class (as applied in the HCSS software)
- The following prime contractor overhead and profit were assumed:
  - General and Administrative Expense (G&A) = 5%
  - General Conditions = 15%
  - Profit = 10%
- The prime contractor also applies their markups on work performed by subcontractors. The following prime contractor markups on subcontractors are assumed:
  - G&A = 5%
  - Profit = 10%
- Escalation is not assumed for this cost estimate per EPA cost guidance *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000).

6. Key Assumptions - Backup Calculations

- The quantities used in the detailed analysis cost estimates and descriptions for each remedial alternative were determined from the FS. Engineering judgment or assumptions were also used as necessary in developing unit costs.
- Productivity determination for activities such as dredging, excavation, in-situ stabilization, loading, and hauling, were calculated based on engineer experience or vendor information, and adjusted to site-specific conditions or equipment driving the productivity for an activity.
- Quantities used for calculating the unit costs for the detailed analysis cost estimates for each remedial alternative are presented in Table 3-1 of the FS.
- The estimated duration of each remedial alternative is calculated based on major work activities such as site preparation, dredging/excavation, cultural resource screening, backfill, capping, in-situ stabilization, and site restoration as follows:
  - Alternative 2 – 8 Months
  - Alternative 3A – 2 Months
  - Alternative 3B – 2 Months
  - Alternative 3C – 2.5 Months
  - Alternative 4 – 3.5 Months

7. Key Assumptions – Cost Summary and Present Value Analyses for FS Alternative Cost Estimates

- The contingency includes a combined scope (10%) and bid (10%) contingency of 20%. The contingency was applied and is presented on Detailed Cost Estimate Summary sheets per EPA's 2000 cost guidance (Attachment 1). Scope contingency covers unknown costs that may occur during remedial design. Bid contingency represents costs, unforeseeable at the time of estimate preparation, which are likely to become known as the remedial action construction or as OM&M proceeds.
- Professional/technical services costs (i.e., project management, remedial design, construction management, and technical support) were included as a percentage of the capital cost and/or annual OM&M/periodic costs as recommended in Section 5.5 of EPA's cost guidance (EPA 2000).
- Types of costs (capital costs, annual OM&M costs, periodic costs, and present value of capital) assessed during the detailed analysis of each retained alternative and assumptions regarding discount rate and period of analysis are presented in Section 5 of the FS.

8. Estimate Accuracy

This cost estimate, as prepared, is considered Class 4, as defined by Recommended Practice No.107R-19: Cost Estimate Classification System (AACE International 2021). This Class 4 cost estimate is assumed to represent the actual total installed cost within the range of -30% to +50% of the cost indicated. These are prepared solely to facilitate relative comparisons between remedial alternatives for FS evaluation purposes. The information in these cost estimates is based on the best available information regarding the anticipated scope of the remedial alternative at the time of development. Future changes in the cost estimates are likely to occur. This cost estimate is not an offer for either construction or project execution and should be evaluated for market changes after 90 days of the issue date.

9. References

AACE International. 2021. *Recommended Practice No. 107R-19: Cost Estimate Classification System As Applied in Engineering, Procurement, and Construction for the Environmental Remediation Industries*. October 5.

U.S. Army Corps of Engineers (USACE). 2016. *Engineering and Design Environmental Remediation and Removal Programs Cost Engineering*. USACE Engineer Regulation 1110-3-1301. December 30.

U.S. Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. EPA 540R00-002. July.

Attachment 1
Cost Estimate Summary Worksheets

TABLE CS-1

ALTERNATIVE COST SUMMARY

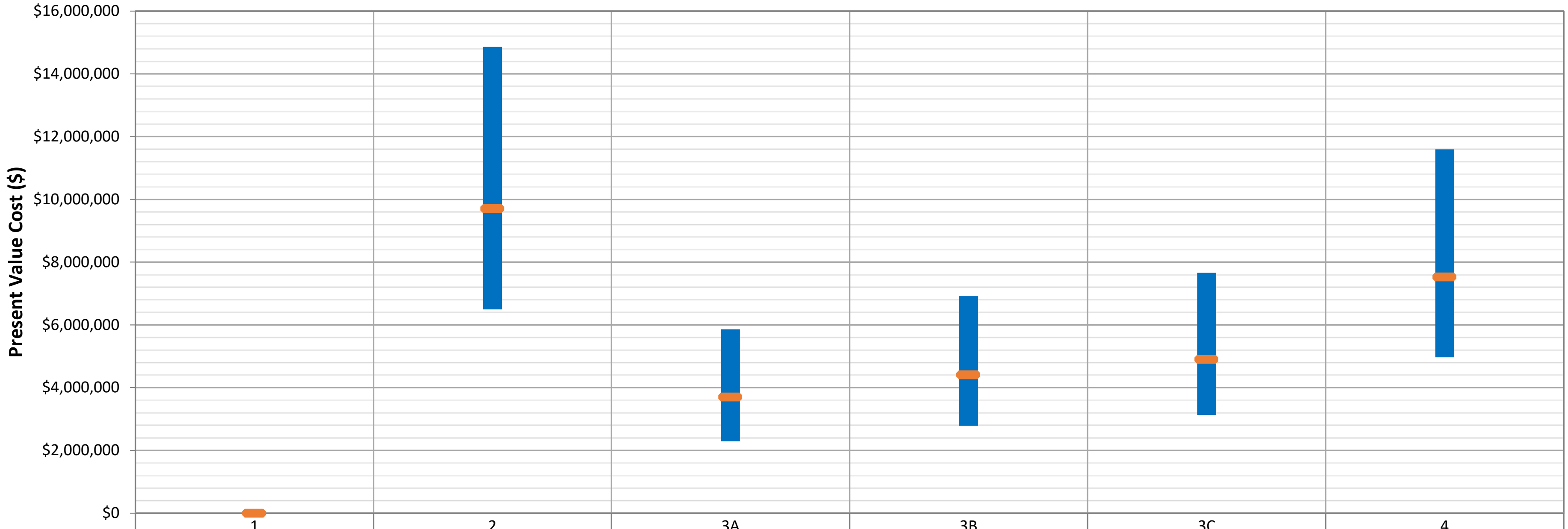
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Phase: Feasibility Study
Base Year: 2025

Alternative	Total Capital Cost	Total Annual Cost	Total Periodic Cost	Total Non-Discounted Cost	Present Value Cost
1	$0	$0	$0	$0	**$0**
2	$9,169,000	$0	$1,037,000	$10,206,000	**$9,705,000**
3A	$2,902,000	$0	$1,692,334	$4,594,334	**$3,706,000**
3B	$3,504,000	$0	$1,910,172	$5,414,172	**$4,411,000**
3C	$3,928,000	$0	$2,059,741	$5,987,741	**$4,906,000**
4	$7,077,000	$0	$950,029	$8,027,029	**$7,530,000**

General Notes

1. Capital costs, annual costs, and periodic costs are presented on Tables CS-2 through CS-4.
2. Estimated remedial timeframes and associated present value analysis for each remedial alternative are provided on Tables PV-2 through PV-4.
3. The non-discounted total cost demonstrates the impact of a discount rate on the total present value cost and the relative amount of future annual expenditures. Non-discounted costs are presented for comparison purposes only and should not be used in place of present value costs in the remedy selection process in accordance with feasibility study guidance.
4. Costs presented for these alternatives are considered to have an accuracy between -30% to +50% of actual costs, based on the scope presented. Costs are prepared solely to facilitate relative comparisons between these alternatives for feasibility study level evaluation purposes.

Alternative Cost Estimate Accuracy Ranges



	1	2	3A	3B	3C	4
PV (+50%)	$0	$14,558,000	$5,559,000	$6,617,000	$7,359,000	$11,295,000
PV	$0	$9,705,000	$3,706,000	$4,411,000	$4,906,000	$7,530,000
PV (-30%)	$0	$6,794,000	$2,595,000	$3,088,000	$3,435,000	$5,271,000

Remedial Alternative

TABLE PV-2						
PRESENT VALUE ANALYSIS						
Alternative	**2**					
ESMA – Removal, Backfill, and Offsite Disposal						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
0	$9,169,000	$0	$0	$9,169,000	1.0000	$9,169,000
1	$0	$0	$29,040	$29,040	0.9804	$28,471
2	$0	$0	$29,040	$29,040	0.9612	$27,912
3	$0	$0	$29,040	$29,040	0.9423	$27,365
4	$0	$0	$0	$0	0.9238	$0
5	$0	$0	$73,079	$73,079	0.9057	$66,190
6	$0	$0	$0	$0	0.8880	$0
7	$0	$0	$0	$0	0.8706	$0
8	$0	$0	$0	$0	0.8535	$0
9	$0	$0	$0	$0	0.8368	$0
10	$0	$0	$73,079	$73,079	0.8203	$59,950
11	$0	$0	$0	$0	0.8043	$0
12	$0	$0	$0	$0	0.7885	$0
13	$0	$0	$0	$0	0.7730	$0
14	$0	$0	$0	$0	0.7579	$0
15	$0	$0	$73,079	$73,079	0.7430	$54,299
16	$0	$0	$0	$0	0.7284	$0
17	$0	$0	$0	$0	0.7142	$0
18	$0	$0	$0	$0	0.7002	$0
19	$0	$0	$0	$0	0.6864	$0
20	$0	$0	$73,079	$73,079	0.6730	$49,180
21	$0	$0	$0	$0	0.6598	$0
22	$0	$0	$0	$0	0.6468	$0
23	$0	$0	$0	$0	0.6342	$0
24	$0	$0	$0	$0	0.6217	$0
25	$0	$0	$73,079	$73,079	0.6095	$44,544
26	$0	$0	$0	$0	0.5976	$0
27	$0	$0	$0	$0	0.5859	$0
28	$0	$0	$0	$0	0.5744	$0
29	$0	$0	$0	$0	0.5631	$0
30	$0	$0	$73,079	$73,079	0.5521	$40,345
31	$0	$0	$0	$0	0.5412	$0
32	$0	$0	$0	$0	0.5306	$0
33	$0	$0	$0	$0	0.5202	$0
34	$0	$0	$0	$0	0.5100	$0

TABLE PV-2						
PRESENT VALUE ANALYSIS						
Alternative	**2**					
ESMA – Removal, Backfill, and Offsite Disposal						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
35	$0	$0	$0	$0	0.5000	$0
36	$0	$0	$0	$0	0.4902	$0
37	$0	$0	$0	$0	0.4806	$0
38	$0	$0	$0	$0	0.4712	$0
39	$0	$0	$0	$0	0.4619	$0
40	$0	$0	$73,079	$73,079	0.4529	$33,097
41	$0	$0	$0	$0	0.4440	$0
42	$0	$0	$0	$0	0.4353	$0
43	$0	$0	$0	$0	0.4268	$0
44	$0	$0	$0	$0	0.4184	$0
45	$0	$0	$0	$0	0.4102	$0
46	$0	$0	$0	$0	0.4022	$0
47	$0	$0	$0	$0	0.3943	$0
48	$0	$0	$0	$0	0.3865	$0
49	$0	$0	$0	$0	0.3790	$0
50	$0	$0	$73,079	$73,079	0.3715	$27,151
51	$0	$0	$0	$0	0.3642	$0
52	$0	$0	$0	$0	0.3571	$0
53	$0	$0	$0	$0	0.3501	$0
54	$0	$0	$0	$0	0.3432	$0
55	$0	$0	$0	$0	0.3365	$0
56	$0	$0	$0	$0	0.3299	$0
57	$0	$0	$0	$0	0.3234	$0
58	$0	$0	$0	$0	0.3171	$0
59	$0	$0	$0	$0	0.3109	$0
60	$0	$0	$73,079	$73,079	0.3048	$22,273
61	$0	$0	$0	$0	0.2988	$0
62	$0	$0	$0	$0	0.2929	$0
63	$0	$0	$0	$0	0.2872	$0
64	$0	$0	$0	$0	0.2816	$0
65	$0	$0	$0	$0	0.2761	$0
66	$0	$0	$0	$0	0.2706	$0
67	$0	$0	$0	$0	0.2653	$0
68	$0	$0	$0	$0	0.2601	$0
69	$0	$0	$0	$0	0.2550	$0

TABLE PV-2						
PRESENT VALUE ANALYSIS						
Alternative	**2**					
ESMA – Removal, Backfill, and Offsite Disposal						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
70	$0	$0	$73,079	$73,079	0.2500	$18,272
71	$0	$0	$0	$0	0.2451	$0
72	$0	$0	$0	$0	0.2403	$0
73	$0	$0	$0	$0	0.2356	$0
74	$0	$0	$0	$0	0.2310	$0
75	$0	$0	$0	$0	0.2265	$0
76	$0	$0	$0	$0	0.2220	$0
77	$0	$0	$0	$0	0.2177	$0
78	$0	$0	$0	$0	0.2134	$0
79	$0	$0	$0	$0	0.2092	$0
80	$0	$0	$73,079	$73,079	0.2051	$14,989
81	$0	$0	$0	$0	0.2011	$0
82	$0	$0	$0	$0	0.1971	$0
83	$0	$0	$0	$0	0.1933	$0
84	$0	$0	$0	$0	0.1895	$0
85	$0	$0	$0	$0	0.1858	$0
86	$0	$0	$0	$0	0.1821	$0
87	$0	$0	$0	$0	0.1786	$0
88	$0	$0	$0	$0	0.1751	$0
89	$0	$0	$0	$0	0.1716	$0
90	$0	$0	$73,079	$73,079	0.1683	$12,296
91	$0	$0	$0	$0	0.1650	$0
92	$0	$0	$0	$0	0.1617	$0
93	$0	$0	$0	$0	0.1586	$0
94	$0	$0	$0	$0	0.1554	$0
95	$0	$0	$0	$0	0.1524	$0
96	$0	$0	$0	$0	0.1494	$0
97	$0	$0	$0	$0	0.1465	$0
98	$0	$0	$0	$0	0.1436	$0
99	$0	$0	$0	$0	0.1408	$0
100	$0	$0	$73,079	$73,079	0.1380	$10,087
TOTALS:	$9,169,000	$0	$1,037,149	$10,206,149		$9,705,421
TOTAL PRESENT VALUE OF ALTERNATIVE 2[5]						**$9,705,000**

TABLE PV-2						
PRESENT VALUE ANALYSIS						
Alternative	**2**					
ESMA – Removal, Backfill, and Offsite Disposal						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**

1. Period of analysis and long-term monitoring was assumed to be 3 years beyond the construction in Year 0.
2. Capital costs, for purposes of this analysis are assumed to occur in "year zero" of the project.
3. Total annual expenditure is the total cost per year with no discounting.
4. Present value is the total cost per year including a 2.0% discount factor for that year.
5. Total present value is rounded to the nearest $10,000. Inflation and depreciation are excluded from the present value cost.
6. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented.
7. Costs are prepared solely to facilitate relative comparisons between alternatives for feasibility study evaluation purposes.
8. For federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of Office of Management & Budget Circular A-94 (2023). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment.

ESMA = eastern sediment management area
O&M = operations and maintenance
WSMA = western sediment management area

TABLE CS-2

Alternative 2
ESMA – Removal, Backfill, and Offsite Disposal
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal of debris and overlying and NAPL-impacted sediment in the ESMA followed by placement of backfill (amended with ORGANOCLAY and GAC), water treatment and transport and disposal of processed debris and dredged material. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Capital Costs (Assumed to be Incurred During Year 0)						
1	**Mobilization**	LS	1	$286,000	$286,000	Includes mobilization of labor, equipment, and materials, which were assumed to be approximately 5 percent of the total direct construction costs.
2	**Site Preparation**					
2.1	Staging Area Development	LS	1	$411,000	$411,000	Includes the construction of a 1.0-acre staging area including the placement of a 4-inch layer of gravel/DGA, installation of geotextile, geogrid and a high-density polyethylene liner, 4 inches of asphalt over 0.5 acre, bin blocks (around the perimeter for secondary containment), decontamination station, personnel river access/docking and spill plates (2 total) for river offloading facility and for loading of dump trucks.
2.2	Erosion and Sediment Control	LF	960	$10	$9,601	Includes the installation and maintenance of upland erosion and sediment controls around the staging area during construction.
2.3	Resuspension Control System	LF	1,019	$130	$132,450	Includes the installation of turbidity curtains, oil booms, and anchors. Quantities assume the placement encompassing the perimeter of the remedial footprint with anchors installed every 50 feet and attached to the shoreline.
3	**Temporary Facilities and Utilities**	MO	7.9	$9,900	$78,499	Includes temporary facilities and utilities including on-site office trailers and supplies, jobsite sanitation, portable power, and potable water.
4	**Debris Removal, Management and Disposal**					
4.1	Debris Removal and Processing	AC	0.70	$72,000	$50,623	Includes the mechanical removal of surface debris, transport via tugs and scows to the offloading facility and debris offloading into the staging area for processing. Debris removal is assumed to be conducted using in-water mechanical methods utilizing a single barge platform. Debris removal operations are assumed to occur concurrently with dredging operations. Water generated from debris processing operations will be processed at the temporary onsite water treatment system. Estimated quantities assume 5 tons per acre. Engineering and administrative best management practices will be employed to control turbidity during debris removal activities.
5	**Dredging**					
5.1	Mechanical Dredging	CY	8,195	$96	$786,695	Includes mechanical dredging, sediment transport via tugs and scows to the offloading facility, and sediment offloading into the sediment processing area for processing. Dredging is assumed to be conducted using in-water mechanical methods utilizing a single barge platform. Dredging is assumed at a production rate of 350 CY per day. Estimated dredge quantities include the target area, 3:1 side slopes, a 0.5-foot allowable overdredge and 0.5 percent bulking factor. Water generated from sediment processing operations will be processed at the temporary onsite water treatment system. Engineering and administrative best management practices will be employed to control turbidity during all dredging activities.
5.2	Solidification Agent Procurement and Transport	TON	925	$190	$175,686	Includes the procurement, transport, and delivery of Portland cement to the Site.
5.3	Solidification of Dredged Material	TON	10,171	$36	$366,166	Includes the mixing of Portland cement and dredged sediments using mechanical means to reduce water content to meet transport and disposal requirements. Solidification of sediment is assumed with 10 percent Portland cement by weight. Solidification of dredged material is assumed at a production rate of 350 CY per day.
5.4	Solidified Dredged Material Loading	CY	6,892	$6	$41,355	Includes the loading of processed dredged material for transport to the disposal facility.
5.5	Cultural Resource Screening	DAY	164	$11,006	$1,803,776	Includes an initial mechanical separation of dredged material using a shaker and spray system, and manual power washing using surfactants followed by the manual screening of dredged material for cultural resources. Screening is assumed at a production of 50 CY per day.

TABLE CS-2

Alternative 2
ESMA – Removal, Backfill, and Offsite Disposal
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal of debris and overlying and NAPL-impacted sediment in the ESMA followed by placement of backfill (amended with ORGANOCLAY and GAC), water treatment and transport and disposal of processed debris and dredged material. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
6	**Water Treatment**					
6.1	Water Treatment System	MTH	6.3	$73,000	$460,520	Assumes the installation and operation of a temporary water treatment system for the treatment of water resulting from scow dewatering and sediment processing. Costs include water treatment system rental and labor for operations. Water treatment system is assumed for the duration of dredged material processing and includes all appurtenances, controls and sensors, an oil-water separator, sand filters and GAC filtration. Water treatment system size was developed based on assumptions of approximately 50 gallons of water per in-situ CY of sediment. Treated effluent is assumed to be discharged back to the Columbia River in accordance with applicable discharge requirements.
7	**Transportation and Disposal (T&D)**					
7.1	Dredged Material Offsite Transport and Disposal (NAPL Impacted Sediment)	TONS	6,821	$45	$306,955	Includes T&D of processed dredged sediment via dump trucks to the Republic facility located in Roosevelt, WA.
7.2	Dredged Material Offsite Transport and Disposal (Overlying Sediment)	TONS	3,350	$45	$150,752	Includes T&D of processed dredged sediment via dump trucks to the Republic facility located in Roosevelt, WA. Assume 50% qualifies as daily cover (no disposal cost).
7.3	Debris and Construction Material, and General Refuse	TON	1,643	$45	$73,921	Includes T&D of debris and construction material, and general refuse via dump trucks to the Republic facility located in Roosevelt, WA.
8	**Backfill**					
8.1	Sand Procurement and Transport	TON	1,241	$41	$50,868	Includes the procurement, transport, and delivery of sand to the Site.
8.2	Organoclay Procurement and Transport	TON	62	$7,400	$459,050	Includes procurement, transport, and delivery of ORGANOCLAY to the Site.
8.3	GAC Procurement and Transport	TON	37	$3,000	$111,661	Includes procurement, transport, and delivery of GAC to the Site.
8.4	Backfill Blending Operations	CY	1,046	$30	$31,366	Includes the on-site blending of sand, ORGANOCLAY and GAC in the staging area.
8.5	Backfill Placement	CY	1,046	$120	$125,465	Includes the transfer of backfill material from the staging area to on-water scows, transport of the backfill material to the location of placement and placement of the backfill. Placement operations would be conducted following the successful confirmation of dredging activities. Backfill placement is assumed to be conducted using in-water mechanical methods utilizing from a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a minimum 6-inch-thick layer of sand/GAC/ORGANOCLAY with 25 percent allowable overplacement with an assumed 25 percent material loss factor. Backfill amendment assumes a combination of ORGANOCLAY (5 percent by weight) and GAC (3 percent by weight) to address residual remaining concerns of sheen generating NAPL.
9	**Site Surveying**	DY	5	$6,300	$31,500	Includes pre-construction and post-construction upland topographic and bathymetric surveys and reporting. Confirmation surveying will be conducted prior to and during dredging and backfill placement. Pre- and post-processed survey data will be compared to evaluate the successful completion of remedial activities.
10	**Site Restoration**	LS	1	$60,000	$60,000	Includes removal of upland staging area and restoration of the area to pre-construction conditions.
11	**Site Institutional Controls (ICs)**	LS	1	$15,810	$15,810	Includes development and maintenance of institutional controls and community awareness activities in the WSMA.
12	**Demobilization**	LS	1	$286,000	$286,000	Includes demobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
				Subtotal:	**$6,307,418**	

TABLE CS-2

Alternative 2
ESMA – Removal, Backfill, and Offsite Disposal
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal of debris and overlying and NAPL-impacted sediment in the ESMA followed by placement of backfill (amended with ORGANOCLAY and GAC), water treatment and transport and disposal of processed debris and dredged material. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
	Contingency (Scope [10%] and Bid [10%]):			20%	$1,261,484	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				Subtotal:	**$7,568,901**	
13	Project Management:			5%	$378,445	Project Management includes planning and reporting, community relations support during construction, bid or contract administration, and legal services. Percentage based multiplier were used from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
14	Remedial Design:			8%	$605,512	Remedial design includes services to design the remedial action. Activities that are part of remedial design include pre-design collection and analysis of field data, engineering survey for design, treatability study (e.g., pilot-scale), and the various design components such as design analysis, plans, specifications, cost estimate, and schedule at the preliminary, intermediate, and final design phases. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
15	Construction Management:			6%	$454,134	Construction management includes services to manage construction or installation of the remedial action from mobilization through to demobilization. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of O&M manual, documentation of quality control/quality assurance, and record drawings. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				TOTAL:	**$9,006,993**	
	Washington State Gross Receipts Tax (1.8%):				**$162,126**	
	TOTAL DIRECT AND INDIRECT CAPITAL COSTS:				**$9,169,000**	

TABLE CS-2

Alternative 2
ESMA – Removal, Backfill, and Offsite Disposal
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal of debris and overlying and NAPL-impacted sediment in the ESMA followed by placement of backfill (amended with ORGANOCLAY and GAC), water treatment and transport and disposal of processed debris and dredged material. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Long-term operation, monitoring and maintenance (OM&M) - Periodic Costs						
16	**Long-Term Monitoring - Visual Monitoring (Years 1, 2 and 3)**	EA	3	$20,000	$60,000	Assumes post-construction visual monitoring and installation of time-lapse cameras to evaluate the presence of sheen following construction in the ESMA. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
17	**Long-Term Monitoring - Survey (Years 1, 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	14	$30,330	$424,620	Assumes bathymetric surveying in the ESMA in Years 1 and 5 and WSMA every 5 years for a duration of 30 years and then every 10 years for a duration of 100 years using multi-beam bathymetric survey techniques. Data will be evaluated, and the results will be included in a report. The estimated cost was calculated using the present worth analysis process outlined by EPA(July 2000) using a discount rate of 2.0 percent.
19	**Periodic Agency Reviews ((Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$20,000	$260,000	Period agency reviews will be performed every 5 years starting in year 5 through 30 and then every 10 years through 100. This includes review of O&M and MNR monitoring data. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
				Subtotal:	**$744,620**	
	Contingency (Scope [10%] and Bid [10%]):			20%	$148,924	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				Subtotal:	**$893,544**	
20	Project Management:			6%	$53,613	Project Management includes planning and reporting, community relations support during O&M. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
21	Technical Support:			15%	$134,032	Technical support during O&M includes services to monitor, evaluate, and report progress of the remedial action. This includes oversight of O&M activities, update of O&M manual, and progress reporting. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July. Middle value of the recommended range in EPA 540-R-00-002 was used.
				TOTAL:	**$1,081,188**	
				TOTAL NON-DISCOUNTED PERIODIC COST:	**$1,081,000**	
				TOTAL NON-DISCOUNTED PROJECT COST:	**$10,206,149**	
				TOTAL DISCOUNTED PROJECT COST:	**$9,705,000**	

TABLE CS-2						
Alternative	**2**					
ESMA – Removal, Backfill, and Offsite Disposal						
WSMA – Monitored Natural Recovery and Institutional Controls						
Description:	Removal of debris and overlying and NAPL-impacted sediment in the ESMA followed by placement of backfill (amended with ORGANOCLAY and GAC), water treatment and transport and disposal of processed debris and dredged material. MNR and institutional controls in the WSMA.					**FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY**
Site:	BNSF Wishram Railyard					
Location:	Wishram, Washington					
Base Year:	2025					
Date:	May-25					
ITEM NO.	**DESCRIPTION**	**UNIT**	**NO. OF UNITS**	**UNIT COST**	**ESTIMATED COST**	**NOTES**

General Notes:

1. Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," EPA 2000.
2. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
3. Cost details provided in this estimate are based on professional judgment, similar project experience, knowledge of the existing conditions at the site, and costs from similar project estimates. Costs were not developed from the ground up and are instead estimated through unit costs, production and schedule assumptions, and associated project durations.
4. All assumptions, quantities, and unit prices used in this cost estimate are preliminary for the purposes of the FS and cost estimate. Cost estimates will be refined during future remedial design development efforts.
5. Remedial operations are assumed 12 hours per day, 6 days per week.
6. All costs include labor, equipment and materials, overhead and profit, and general and administrative expenses and are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.
7. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, and potential debris, physical properties of the existing sediment at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.
8. These estimates are developed using current and generally accepted engineering cost estimation methods. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material. Jacobs is not licensed as an accountant or securities attorney and, therefore, makes no representations that these costs form an appropriate basis for complying with financial reporting requirements for such costs.

CY = cubic yard(s)
DGA = dense graded aggregate
EA = each
EPA = U.S. Environmental Protection Agency
ESMA = eastern sediment management unit
FS = feasibility study
GAC = granular activated carbon
LF = linear foot (feet)
LS = lump sum
MNR = Monitored Natural Recovery
NAPL = nonaqueous phase liquid
O&M = operations and maintenance
POWT = publicly owned treatment works
SF = square foot (feet)
T&D = transportation and disposal
TON = ton(s)
WSMA = western sediment management area

TABLE PV-3A

PRESENT VALUE ANALYSIS

Alternative **3A**

ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Site: **BNSF Wishram Railyard**
Location: **Wishram, Washington**
Phase: **Feasibility Study**
Base Year: **2025** **Discount Rate[6]** 2.0%

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (2.0%)	Present Value[4]
0	$2,902,000	$0	$0	$2,902,000	1.0000	$2,902,000
1	$0	$0	$0	$0	0.9804	$0
2	$0	$0	$0	$0	0.9612	$0
3	$0	$0	$0	$0	0.9423	$0
4	$0	$0	$0	$0	0.9238	$0
5	$0	$0	$73,079	$73,079	0.9057	$66,190
6	$0	$0	$0	$0	0.8880	$0
7	$0	$0	$0	$0	0.8706	$0
8	$0	$0	$0	$0	0.8535	$0
9	$0	$0	$0	$0	0.8368	$0
10	$0	$0	$73,079	$73,079	0.8203	$59,950
11	$0	$0	$0	$0	0.8043	$0
12	$0	$0	$0	$0	0.7885	$0
13	$0	$0	$0	$0	0.7730	$0
14	$0	$0	$0	$0	0.7579	$0
15	$0	$0	$258,655	$258,655	0.7430	$192,185
16	$0	$0	$0	$0	0.7284	$0
17	$0	$0	$0	$0	0.7142	$0
18	$0	$0	$0	$0	0.7002	$0
19	$0	$0	$0	$0	0.6864	$0
20	$0	$0	$73,079	$73,079	0.6730	$49,180
21	$0	$0	$0	$0	0.6598	$0
22	$0	$0	$0	$0	0.6468	$0
23	$0	$0	$0	$0	0.6342	$0
24	$0	$0	$0	$0	0.6217	$0
25	$0	$0	$73,079	$73,079	0.6095	$44,544
26	$0	$0	$0	$0	0.5976	$0
27	$0	$0	$0	$0	0.5859	$0
28	$0	$0	$0	$0	0.5744	$0
29	$0	$0	$0	$0	0.5631	$0
30	$0	$0	$258,655	$258,655	0.5521	$142,796
31	$0	$0	$0	$0	0.5412	$0
32	$0	$0	$0	$0	0.5306	$0
33	$0	$0	$0	$0	0.5202	$0
34	$0	$0	$0	$0	0.5100	$0

TABLE PV-3A						
PRESENT VALUE ANALYSIS						
Alternative	**3A**					
ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
35	$0	$0	$0	$0	0.5000	$0
36	$0	$0	$0	$0	0.4902	$0
37	$0	$0	$0	$0	0.4806	$0
38	$0	$0	$0	$0	0.4712	$0
39	$0	$0	$0	$0	0.4619	$0
40	$0	$0	$73,079	$73,079	0.4529	$33,097
41	$0	$0	$0	$0	0.4440	$0
42	$0	$0	$0	$0	0.4353	$0
43	$0	$0	$0	$0	0.4268	$0
44	$0	$0	$0	$0	0.4184	$0
45	$0	$0	$0	$0	0.4102	$0
46	$0	$0	$0	$0	0.4022	$0
47	$0	$0	$0	$0	0.3943	$0
48	$0	$0	$0	$0	0.3865	$0
49	$0	$0	$0	$0	0.3790	$0
50	$0	$0	$258,655	$258,655	0.3715	$96,098
51	$0	$0	$0	$0	0.3642	$0
52	$0	$0	$0	$0	0.3571	$0
53	$0	$0	$0	$0	0.3501	$0
54	$0	$0	$0	$0	0.3432	$0
55	$0	$0	$0	$0	0.3365	$0
56	$0	$0	$0	$0	0.3299	$0
57	$0	$0	$0	$0	0.3234	$0
58	$0	$0	$0	$0	0.3171	$0
59	$0	$0	$0	$0	0.3109	$0
60	$0	$0	$73,079	$73,079	0.3048	$22,273
61	$0	$0	$0	$0	0.2988	$0
62	$0	$0	$0	$0	0.2929	$0
63	$0	$0	$0	$0	0.2872	$0
64	$0	$0	$0	$0	0.2816	$0
65	$0	$0	$0	$0	0.2761	$0
66	$0	$0	$0	$0	0.2706	$0
67	$0	$0	$0	$0	0.2653	$0
68	$0	$0	$0	$0	0.2601	$0
69	$0	$0	$0	$0	0.2550	$0

TABLE PV-3A

PRESENT VALUE ANALYSIS

Alternative **3A**

ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Site: **BNSF Wishram Railyard**
Location: **Wishram, Washington**
Phase: **Feasibility Study**
Base Year: **2025** **Discount Rate[6]** 2.0%

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (2.0%)	Present Value[4]
70	$0	$0	$73,079	$73,079	0.2500	$18,272
71	$0	$0	$0	$0	0.2451	$0
72	$0	$0	$0	$0	0.2403	$0
73	$0	$0	$0	$0	0.2356	$0
74	$0	$0	$0	$0	0.2310	$0
75	$0	$0	$185,576	$185,576	0.2265	$42,025
76	$0	$0	$0	$0	0.2220	$0
77	$0	$0	$0	$0	0.2177	$0
78	$0	$0	$0	$0	0.2134	$0
79	$0	$0	$0	$0	0.2092	$0
80	$0	$0	$73,079	$73,079	0.2051	$14,989
81	$0	$0	$0	$0	0.2011	$0
82	$0	$0	$0	$0	0.1971	$0
83	$0	$0	$0	$0	0.1933	$0
84	$0	$0	$0	$0	0.1895	$0
85	$0	$0	$0	$0	0.1858	$0
86	$0	$0	$0	$0	0.1821	$0
87	$0	$0	$0	$0	0.1786	$0
88	$0	$0	$0	$0	0.1751	$0
89	$0	$0	$0	$0	0.1716	$0
90	$0	$0	$73,079	$73,079	0.1683	$12,296
91	$0	$0	$0	$0	0.1650	$0
92	$0	$0	$0	$0	0.1617	$0
93	$0	$0	$0	$0	0.1586	$0
94	$0	$0	$0	$0	0.1554	$0
95	$0	$0	$0	$0	0.1524	$0
96	$0	$0	$0	$0	0.1494	$0
97	$0	$0	$0	$0	0.1465	$0
98	$0	$0	$0	$0	0.1436	$0
99	$0	$0	$0	$0	0.1408	$0
100	$0	$0	$73,079	$73,079	0.1380	$10,087
TOTALS:	$2,902,000	$0	$1,692,334	$4,594,334		$3,705,982
TOTAL PRESENT VALUE OF ALTERNATIVE 3[5]						**$3,706,000**

TABLE PV-3A						
PRESENT VALUE ANALYSIS						
Alternative	**3A**					
ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**

1. Period of analysis and long-term monitoring was assumed to be 30 years beyond the construction in Year 0.
2. Capital costs, for purposes of this analysis are assumed to occur in "year zero" of the project.
3. Total annual expenditure is the total cost per year with no discounting.
4. Present value is the total cost per year including a 2.0% discount factor for that year.
5. Total present value is rounded to the nearest $10,000. Inflation and depreciation are excluded from the present value cost.
6. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented.
7. Costs are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
8. For federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of Office of Management & Budget Circular A-94 (OMB 2023). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment.

ESMA = eastern sediment management area
O&M = operations and maintenance
WSMA = western sediment management area

TABLE CS-3A

Alternative 3A
ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap and institutional controls in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 3 -inch layer of AquaGate+ORGANOCLAY and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Capital Costs (Assumed to be Incurred During Year 0)						
1	**Mobilization**	LS	1	$91,000	$91,000	Includes mobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
2	**Site Preparation**					
2.1	Staging Area Development and Water Access	LS	1	$203,000	$203,000	Includes the construction of a 1.0-acre staging area including the placement of a 4-inch layer of gravel/DGA and a geogrid and personnel river access/docking.
2.2	Erosion and Sediment (E&S) Control	LF	960	$10.00	$9,601	Includes the installation and maintenance of upland erosion and sediment controls around the staging area during construction.
2.3	Resuspension Control System	LF	1,019	$130	$132,450	Includes the installation of turbidity curtains, oil booms, and anchors. Quantities assume the placement encompassing the perimeter of the remedial footprint with anchors installed every 50 feet and attached to the shoreline.
3	**Temporary Facilities and Utilities**	MO	1.5	$9,900	$14,861	Includes temporary facilities and utilities including on-site office trailers and supplies, jobsite sanitation, portable power, and potable water.
4	**Debris Removal, Management and Disposal**					
4.1	Debris Removal and Processing	AC	0.70	$72,000	$50,623	Includes the mechanical removal of surface debris and transport via tugs and scows to the offloading facility and debris offloading into the staging area for processing . Debris removal is assumed to be conducted using in-water mechanical methods utilizing a single barge platform. Debris removal operations are assumed to occur prior to cap placement. Water generated from debris processing operations is expected to be minimal and will be containerized and transported to the local POTW. Estimated quantities assume 5 tons per acre. Engineering and administrative best management practices will be employed to control turbidity during debris removal activities.
5	**Cap Installation**					
5.1	Sand Leveling Layer Procurement and Transport	TON	1,241	$41	$50,868	Includes procurement, transport, and delivery of sand to the Site.
5.2	Sand Leveling Layer Placement	CY	886	$94	$83,302	Includes the placement of a sand leveling layer to provide initial stability to prevent lateral movement of the cap. Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods utilizing a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target Area, placement of 6 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
5.3	AquaGate + ORGANOCLAY Procurement and Transport	TON	479	$1,650	$789,601	Includes procurement, transport, and delivery of AquaGate + ORGANOCLAY to the Site.
5.4	AquaGate + ORGANOCLAY Layer Installation	CY	443	$94	$41,651	Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods utilizing a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target, placement of 3 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
5.5	Benthic Restoration Layer Procurement and Transport	TON	2,481	$41	$101,735	Includes procurement, transport, and delivery of sand to the Site.

TABLE CS-3A

Alternative 3A
ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

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Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
5.6	Benthic Restoration Layer Placement	CY	1,772	$119	$210,915	Includes the placement of a benthic restoration layer (sand) to promote benthic recolonization. Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods using general construction equipment from a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target Area, placement of 12 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
6	**Transportation and Disposal**					
6.1	Debris and Construction Material, and General Refuse	TON	891	$45	$40,078	Includes T&D of debris and construction material, and general refuse via dump trucks to the Republic facility located in Roosevelt, WA.
7	**Site Surveying**	DY	6	$6,300	$37,800	Includes pre-construction and post-construction upland topographic and bathymetric surveys and reporting. Confirmation surveying will be conducted prior to and during capping placement. Pre- and post-processed survey data will be compared to evaluate the successful completion of remedial activities.
8	**Site Restoration**	LS	1	$30,000	$30,000	Includes removal of upland staging area and restoration of the area to pre-construction conditions.
9	**Site Institutional Controls (ICs)**	LS	1	$15,810	$15,810	Includes development and maintenance of institutional controls and community awareness activities in the ESMA and WSMA.
10	**Demobilization**	LS	1	$91,000	$91,000	Includes demobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
				Subtotal:	**$1,995,996**	

Contingency (Scope [10%] and Bid [10%]):	20%	$399,199	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
	Subtotal:	**$2,395,196**	

TABLE CS-3A

Alternative 3A

ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls

WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap and institutional controls in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 3 -inch layer of AquaGate+ORGANOCLAY and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard

Location: Wishram, Washington

Base Year: 2025

Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
11	Project Management:			5%	$119,760	Project Management includes planning and reporting, community relations support during construction, bid or contract administration, and legal services. Percentage based multiplier were used from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
12	Remedial Design:			8%	$191,616	Remedial design includes services to design the remedial action. Activities that are part of remedial design include pre-design collection and analysis of field data, engineering survey for design, treatability study (e.g., pilot-scale), and the various design components such as design analysis, plans, specifications, cost estimate, and schedule at the preliminary, intermediate, and final design phases. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
13	Construction Management:			6%	$143,712	Construction management includes services to manage construction or installation of the remedial action from mobilization through to demobilization. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of O&M manual, documentation of quality control/quality assurance, and record drawings. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				TOTAL:	**$2,850,283**	

Washington State Gross Receipts Tax (1.8%):	**$51,305**
TOTAL DIRECT AND INDIRECT CAPITAL COSTS:	**$2,902,000**

TABLE CS-3A

Alternative **3A**
ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

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Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Long-term operation, monitoring and maintenance (OM&M) - Periodic Costs						
14	**Long-Term Monitoring - Survey (Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$30,330	$394,290	Assumes bathymetric surveying in the ESMA and WSMA will be conducted every 5 years for a duration of 30 years and then every 10 years for a duration of 100 years using multi-beam bathymetric survey techniques. Data will be evaluated, and the results will be included in a report. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
16	**Maintenance Program (Year 15, 30, 50, 75)**	EA	4	$127,807	$511,229	The cap maintenance program will be conducted in the ESMA and is assumed to include cap maintenance activities at years 15, 30, 50 and 75. The cap maintenance program was calculated assuming a 10 percent multiplier of cap total direct construction costs for each maintenance event. The estimated cost for the long-term cap maintenance program was calculated and using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
17	**Periodic Agency Reviews ((Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$20,000	$260,000	Period agency reviews will be performed every 5 years starting in year 5 through 30 and then every 10 years through 100. This includes review of O&M and MNR monitoring data. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
				Subtotal:	**$1,165,519**	
			Contingency (Scope [10%] and Bid [10%]):	20%	$233,104	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				Subtotal:	**$1,398,623**	
18			Project Management:	6%	$83,917	Project Management includes planning and reporting, community relations support during O&M. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
19			Technical Support:	15%	$209,793	Technical support during O&M includes services to monitor, evaluate, and report progress of the remedial action. This includes oversight of O&M activities, update of O&M manual, and progress reporting. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July. Middle value of the recommended range in EPA 540-R-00-002 was used.
				TOTAL:	**$1,692,334**	
				TOTAL NON-DISCOUNTED PERIODIC COST:	**$1,692,000**	
				TOTAL NON-DISCOUNTED PROJECT COST:	**$4,594,334**	
				TOTAL DISCOUNTED PROJECT COST:	**$3,706,000**	

TABLE CS-3A

Alternative 3A
ESMA – Capping with AquaGate + ORGANOCLAY™ and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap and institutional controls in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 3 -inch layer of AquaGate+ORGANOCLAY and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES

General Notes:

1. Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," EPA 2000.
2. 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 FS evaluation purposes.
3. Cost details provided in this estimate are based on professional judgment, similar project experience, knowledge of the existing conditions at the site, and costs from similar project estimates. Costs were not developed from the ground up and are instead estimated through unit costs, production and schedule assumptions, and associated project durations.
4. All assumptions, quantities, and unit prices used in this cost estimate are preliminary for the purposes of the FS and cost estimate. Cost estimates will be refined during future remedial design development efforts.
5. Remedial operations are assumed 12 hours per day, 6 days per week.
6. All costs include labor, equipment and materials, overhead and profit, general and administrative expenses and are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.
7. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.
8. These estimates are developed using current and generally accepted engineering cost estimation methods. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material. Jacobs is not licensed as an accountant or securities attorney and, therefore, makes no representations that these costs form an appropriate basis for complying with financial reporting requirements for such costs.

CY = cubic yard(s)
DGA = dense graded aggregate
EA = each
EPA = U.S. Environmental Protection Agency
ESMA = eastern sediment management unit
FS = feasibility study
GAC = granular activated carbon
LF = linear foot (feet)
LS = lump sum
MNR = Monitored Natural Recovery
NAPL = nonaqueous phase liquid
O&M = operations and maintenance
POWT = publicly owned treatment works
RCM = reactive core mat
SF = square foot (feet)
T&D = transportation and disposal
TON = ton(s)
WSMA = western sediment management area

TABLE PV-3B

PRESENT VALUE ANALYSIS

Alternative **3B**

ESMA – Capping with a Reactive Core Mat and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Site: **BNSF Wishram Railyard**
Location: **Wishram, Washington**
Phase: **Feasibility Study**
Base Year: **2025** **Discount Rate[6]** 2.0%

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (2.0%)	Present Value[4]
0	$3,504,000	$0	$0	$3,504,000	1.0000	$3,504,000
1	$0	$0	$0	$0	0.9804	$0
2	$0	$0	$0	$0	0.9612	$0
3	$0	$0	$0	$0	0.9423	$0
4	$0	$0	$0	$0	0.9238	$0
5	$0	$0	$73,079	$73,079	0.9057	$66,190
6	$0	$0	$0	$0	0.8880	$0
7	$0	$0	$0	$0	0.8706	$0
8	$0	$0	$0	$0	0.8535	$0
9	$0	$0	$0	$0	0.8368	$0
10	$0	$0	$73,079	$73,079	0.8203	$59,950
11	$0	$0	$0	$0	0.8043	$0
12	$0	$0	$0	$0	0.7885	$0
13	$0	$0	$0	$0	0.7730	$0
14	$0	$0	$0	$0	0.7579	$0
15	$0	$0	$313,115	$313,115	0.7430	$232,649
16	$0	$0	$0	$0	0.7284	$0
17	$0	$0	$0	$0	0.7142	$0
18	$0	$0	$0	$0	0.7002	$0
19	$0	$0	$0	$0	0.6864	$0
20	$0	$0	$73,079	$73,079	0.6730	$49,180
21	$0	$0	$0	$0	0.6598	$0
22	$0	$0	$0	$0	0.6468	$0
23	$0	$0	$0	$0	0.6342	$0
24	$0	$0	$0	$0	0.6217	$0
25	$0	$0	$73,079	$73,079	0.6095	$44,544
26	$0	$0	$0	$0	0.5976	$0
27	$0	$0	$0	$0	0.5859	$0
28	$0	$0	$0	$0	0.5744	$0
29	$0	$0	$0	$0	0.5631	$0
30	$0	$0	$313,115	$313,115	0.5521	$172,862
31	$0	$0	$0	$0	0.5412	$0
32	$0	$0	$0	$0	0.5306	$0
33	$0	$0	$0	$0	0.5202	$0
34	$0	$0	$0	$0	0.5100	$0

TABLE PV-3B						
PRESENT VALUE ANALYSIS						
Alternative	**3B**					
ESMA – Capping with a Reactive Core Mat and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
35	$0	$0	$0	$0	0.5000	$0
36	$0	$0	$0	$0	0.4902	$0
37	$0	$0	$0	$0	0.4806	$0
38	$0	$0	$0	$0	0.4712	$0
39	$0	$0	$0	$0	0.4619	$0
40	$0	$0	$73,079	$73,079	0.4529	$33,097
41	$0	$0	$0	$0	0.4440	$0
42	$0	$0	$0	$0	0.4353	$0
43	$0	$0	$0	$0	0.4268	$0
44	$0	$0	$0	$0	0.4184	$0
45	$0	$0	$0	$0	0.4102	$0
46	$0	$0	$0	$0	0.4022	$0
47	$0	$0	$0	$0	0.3943	$0
48	$0	$0	$0	$0	0.3865	$0
49	$0	$0	$0	$0	0.3790	$0
50	$0	$0	$313,115	$313,115	0.3715	$116,331
51	$0	$0	$0	$0	0.3642	$0
52	$0	$0	$0	$0	0.3571	$0
53	$0	$0	$0	$0	0.3501	$0
54	$0	$0	$0	$0	0.3432	$0
55	$0	$0	$0	$0	0.3365	$0
56	$0	$0	$0	$0	0.3299	$0
57	$0	$0	$0	$0	0.3234	$0
58	$0	$0	$0	$0	0.3171	$0
59	$0	$0	$0	$0	0.3109	$0
60	$0	$0	$73,079	$73,079	0.3048	$22,273
61	$0	$0	$0	$0	0.2988	$0
62	$0	$0	$0	$0	0.2929	$0
63	$0	$0	$0	$0	0.2872	$0
64	$0	$0	$0	$0	0.2816	$0
65	$0	$0	$0	$0	0.2761	$0
66	$0	$0	$0	$0	0.2706	$0
67	$0	$0	$0	$0	0.2653	$0
68	$0	$0	$0	$0	0.2601	$0
69	$0	$0	$0	$0	0.2550	$0

TABLE PV-3B						
PRESENT VALUE ANALYSIS						
Alternative	**3B**					
ESMA – Capping with a Reactive Core Mat and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
70	$0	$0	$73,079	$73,079	0.2500	$18,272
71	$0	$0	$0	$0	0.2451	$0
72	$0	$0	$0	$0	0.2403	$0
73	$0	$0	$0	$0	0.2356	$0
74	$0	$0	$0	$0	0.2310	$0
75	$0	$0	$240,036	$240,036	0.2265	$54,358
76	$0	$0	$0	$0	0.2220	$0
77	$0	$0	$0	$0	0.2177	$0
78	$0	$0	$0	$0	0.2134	$0
79	$0	$0	$0	$0	0.2092	$0
80	$0	$0	$73,079	$73,079	0.2051	$14,989
81	$0	$0	$0	$0	0.2011	$0
82	$0	$0	$0	$0	0.1971	$0
83	$0	$0	$0	$0	0.1933	$0
84	$0	$0	$0	$0	0.1895	$0
85	$0	$0	$0	$0	0.1858	$0
86	$0	$0	$0	$0	0.1821	$0
87	$0	$0	$0	$0	0.1786	$0
88	$0	$0	$0	$0	0.1751	$0
89	$0	$0	$0	$0	0.1716	$0
90	$0	$0	$73,079	$73,079	0.1683	$12,296
91	$0	$0	$0	$0	0.1650	$0
92	$0	$0	$0	$0	0.1617	$0
93	$0	$0	$0	$0	0.1586	$0
94	$0	$0	$0	$0	0.1554	$0
95	$0	$0	$0	$0	0.1524	$0
96	$0	$0	$0	$0	0.1494	$0
97	$0	$0	$0	$0	0.1465	$0
98	$0	$0	$0	$0	0.1436	$0
99	$0	$0	$0	$0	0.1408	$0
100	$0	$0	$73,079	$73,079	0.1380	$10,087
TOTALS:	$3,504,000	$0	$1,910,172	$5,414,172		$4,411,078
TOTAL PRESENT VALUE OF ALTERNATIVE 3[5]						**$4,411,000**

TABLE PV-3B						
PRESENT VALUE ANALYSIS						
Alternative	**3B**					
ESMA – Capping with a Reactive Core Mat and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**

1. Period of analysis and long-term monitoring was assumed to be 30 years beyond the construction in Year 0.
2. Capital costs, for purposes of this analysis are assumed to occur in "year zero" of the project.
3. Total annual expenditure is the total cost per year with no discounting.
4. Present value is the total cost per year including a 2.0% discount factor for that year.
5. Total present value is rounded to the nearest $10,000. Inflation and depreciation are excluded from the present value cost.
6. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented.
7. Costs are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
8. For federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of Office of Management & Budget Circular A-94 (OMB 2023). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment.

ESMA = eastern sediment management area
O&M = operations and maintenance
WSMA = western sediment management area

TABLE CS-3B

Alternative **3B**
ESMA – Capping with a Reactive Core Mat and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap over in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25 to 0.5-inch RCM, and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Capital Costs (Assumed to be Incurred During Year 0)						
1	**Mobilization**	LS	1	$110,000	$110,000	Includes mobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
2	**Site Preparation**					
2.1	Staging Area Development and Water Access	LS	1	$203,000	$203,000	Includes the construction of a 1.0-acre staging area including the placement of a 4-inch layer of gravel/DGA and a geogrid and personnel river access/docking.
2.2	Erosion and Sediment (E&S) Control	LF	960	$10.00	$9,601	Includes the installation and maintenance of upland erosion and sediment controls around the staging area during construction.
2.3	Resuspension Control System	LF	1,019	$130	$132,450	Includes the installation of turbidity curtains, oil booms, and anchors. Quantities assume the placement encompassing the perimeter of the remedial footprint with anchors installed every 50 feet and attached to the shoreline.
3	**Temporary Facilities and Utilities**	MO	1.6	$9,900	$16,005	Includes temporary facilities and utilities including on-site office trailers and supplies, jobsite sanitation, portable power, and potable water.
4	**Debris Removal, Management and Disposal**					
4.1	Debris Removal and Processing	AC	0.70	$72,000	$50,623	Includes the mechanical removal of surface debris and transport via tugs and scows to the offloading facility and debris offloading into the staging area for processing . Debris removal is assumed to be conducted using in-water mechanical methods utilizing a single barge platform. Debris removal operations are assumed to occur prior to cap placement. Water generated from debris processing operations is expected to be minimal and will be containerized and transported to the local POTW. Estimated quantities assume 5 tons per acre. Engineering and administrative best management practices will be employed to control turbidity during debris removal activities.
5	**Cap Installation**					
5.1	Sand Leveling Layer Procurement and Transport	TON	1,241	$41	$50,868	Includes procurement, transport, and delivery of sand to the Site.
5.2	Sand Leveling Layer Placement	CY	886	$94	$83,302	Includes the placement of a sand leveling layer to provide initial stability to prevent lateral movement of the cap. Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods utilizing a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target Area, placement of 6 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
5.3	Organoclay RCM Procurement and Transport	SF	35,221	$26	$924,551	Includes procurement, transport and delivery of prefabricated RCM containing organoclay at a thickness of 3 to 6 inches. The final thickness will be determined during the design phase.
5.4	Organoclay RCM Installation	SF	35,221	$8	$281,768	Includes the transfer of the RCM from the staging area to on-water barge platform, transport of the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods with general construction equipment using roll bars from two platforms assisted by divers with an assumed 20-foot offset from the Target Area and production rate of approximately 8,500 SF per day.
5.5	Benthic Restoration Layer Procurement and Transport	TON	2,481	$41	$101,735	Includes procurement, transport, and delivery of sand to the Site.

TABLE CS-3B

Alternative 3B
ESMA – Capping with a Reactive Core Mat and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap over in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25 to 0.5-inch RCM, and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
5.6	Benthic Restoration Layer Placement	CY	1,772	$119	$210,915	Includes the placement of a benthic restoration layer (sand) to promote benthic recolonization. Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods using general construction equipment from a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target Area, placement of 12 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
6	**Transportation and Disposal**					
6.1	Debris and Construction Material, and General Refuse	TON	891	$45	$40,078	Includes T&D of debris and construction material, and general refuse via dump trucks to the Republic facility located in Roosevelt, WA.
7	**Site Surveying**	DY	6	$6,300	$37,800	Includes pre-construction and post-construction upland topographic and bathymetric surveys and reporting. Confirmation surveying will be conducted prior to and during capping placement. Pre- and post-processed survey data will be compared to evaluate the successful completion of remedial activities.
8	**Site Restoration**	LS	1	$30,000	$30,000	Includes removal of upland staging area and restoration of the area to pre-construction conditions.
9	**Site Institutional Controls (ICs)**	LS	1	$15,810	$15,810	Includes development and maintenance of institutional controls and community awareness activities in the ESMA and WSMA.
10	**Demobilization**	LS	1	$110,000	$110,000	Includes demobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
				Subtotal:	**$2,410,206**	

Contingency (Scope [10%] and Bid [10%]):	20%	$482,041	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
	Subtotal:	**$2,892,248**	

TABLE CS-3B

Alternative 3B
ESMA – Capping with a Reactive Core Mat and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap over in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25 to 0.5-inch RCM, and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
11			Project Management:	5%	$144,612	Project Management includes planning and reporting, community relations support during construction, bid or contract administration, and legal services. Percentage based multiplier were used from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
12			Remedial Design:	8%	$231,380	Remedial design includes services to design the remedial action. Activities that are part of remedial design include pre-design collection and analysis of field data, engineering survey for design, treatability study (e.g., pilot-scale), and the various design components such as design analysis, plans, specifications, cost estimate, and schedule at the preliminary, intermediate, and final design phases. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
13			Construction Management:	6%	$173,535	Construction management includes services to manage construction or installation of the remedial action from mobilization through to demobilization. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of O&M manual, documentation of quality control/quality assurance, and record drawings. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				TOTAL:	**$3,441,775**	
				Washington State Gross Receipts Tax (1.8%):	**$61,952**	
				TOTAL DIRECT AND INDIRECT CAPITAL COSTS:	**$3,504,000**	

TABLE CS-3B

Alternative 3B
ESMA – Capping with a Reactive Core Mat and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap over in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25 to 0.5-inch RCM, and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Long-term operation, monitoring and maintenance (OM&M) - Periodic Costs						
14	**Long-Term Monitoring - Survey (Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$30,330	$394,290	Assumes bathymetric surveying in the ESMA and WSMA will be conducted every 5 years for a duration of 30 years and then every 10 years for a duration of 100 years using multi-beam bathymetric survey techniques. Data will be evaluated, and the results will be included in a report. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
16	**Maintenance Program (Year 15, 30, 50, 75)**	EA	4	$165,314	$661,256	The cap maintenance program will be conducted in the ESMA and is assumed to include cap maintenance activities at years 15, 30, 50 and 75. The cap maintenance program was calculated assuming a 10 percent multiplier of cap total direct construction costs for each maintenance event. The estimated cost for the long-term cap maintenance program was calculated and using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
17	**Periodic Agency Reviews ((Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$20,000	$260,000	Period agency reviews will be performed every 5 years starting in year 5 through 30 and then every 10 years through 100. This includes review of O&M and MNR monitoring data. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
				Subtotal:	**$1,315,546**	
	Contingency (Scope [10%] and Bid [10%]):			20%	$263,109	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				Subtotal:	**$1,578,655**	
18	Project Management:			6%	$94,719	Project Management includes planning and reporting, community relations support during O&M. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
19	Technical Support:			15%	$236,798	Technical support during O&M includes services to monitor, evaluate, and report progress of the remedial action. This includes oversight of O&M activities, update of O&M manual, and progress reporting. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July. Middle value of the recommended range in EPA 540-R-00-002 was used.
				TOTAL:	**$1,910,172**	
				TOTAL NON-DISCOUNTED PERIODIC COST:	**$1,910,000**	
				TOTAL NON-DISCOUNTED PROJECT COST:	**$5,414,172**	
				TOTAL DISCOUNTED PROJECT COST:	**$4,411,000**	

TABLE CS-3B	
Alternative	**3B**
ESMA – Capping with a Reactive Core Mat and Institutional Controls	
WSMA – Monitored Natural Recovery and Institutional Controls	
Description:	Removal and transport and disposal of debris, and Installation of an active cap over in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25 to 0.5-inch RCM, and a 12-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.
Site:	BNSF Wishram Railyard
Location:	Wishram, Washington
Base Year:	2025
Date:	May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES

General Notes:

1. Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," EPA 2000.
2. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
3. Cost details provided in this estimate are based on professional judgment, similar project experience, knowledge of the existing conditions at the site, and costs from similar project estimates. Costs were not developed from the ground up and are instead estimated through unit costs, production and schedule assumptions, and associated project durations.
4. All assumptions, quantities, and unit prices used in this cost estimate are preliminary for the purposes of the FS and cost estimate. Cost estimates will be refined during future remedial design development efforts.
5. Remedial operations are assumed 12 hours per day, 6 days per week.
6. All costs include labor, equipment and materials, overhead and profit, general and administrative expenses and are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.
7. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.
8. These estimates are developed using current and generally accepted engineering cost estimation methods. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material. Jacobs is not licensed as an accountant or securities attorney and, therefore, makes no representations that these costs form an appropriate basis for complying with financial reporting requirements for such costs.

CY = cubic yard(s)
DGA = dense graded aggregate
EA = each
EPA = U.S. Environmental Protection Agency
ESMA = eastern sediment management unit
FS = feasibility study
GAC = granular activated carbon
LF = linear foot (feet)
LS = lump sum
MNR = Monitored Natural Recovery
NAPL = nonaqueous phase liquid
O&M = operations and maintenance
POWT = publicly owned treatment works
RCM = reactive core mat
SF = square foot (feet)
T&D = transportation and disposal
TON = ton(s)
WSMA = western sediment management area

TABLE PV-3C						

PRESENT VALUE ANALYSIS

Alternative 3C

ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Site: BNSF Wishram Railyard
Location: Wishram, Washington
Phase: Feasibility Study
Base Year: 2025 **Discount Rate[6]** 2.0%

Year[1]	Capital Costs[2]	Annual O&M Costs	Periodic Costs	Total Annual Expenditure[3]	Discount Factor (2.0%)	Present Value[4]
0	$3,928,000	$0	$0	$3,928,000	1.0000	$3,928,000
1	$0	$0	$0	$0	0.9804	$0
2	$0	$0	$0	$0	0.9612	$0
3	$0	$0	$0	$0	0.9423	$0
4	$0	$0	$0	$0	0.9238	$0
5	$0	$0	$73,079	$73,079	0.9057	$66,190
6	$0	$0	$0	$0	0.8880	$0
7	$0	$0	$0	$0	0.8706	$0
8	$0	$0	$0	$0	0.8535	$0
9	$0	$0	$0	$0	0.8368	$0
10	$0	$0	$73,079	$73,079	0.8203	$59,950
11	$0	$0	$0	$0	0.8043	$0
12	$0	$0	$0	$0	0.7885	$0
13	$0	$0	$0	$0	0.7730	$0
14	$0	$0	$0	$0	0.7579	$0
15	$0	$0	$350,507	$350,507	0.7430	$260,432
16	$0	$0	$0	$0	0.7284	$0
17	$0	$0	$0	$0	0.7142	$0
18	$0	$0	$0	$0	0.7002	$0
19	$0	$0	$0	$0	0.6864	$0
20	$0	$0	$73,079	$73,079	0.6730	$49,180
21	$0	$0	$0	$0	0.6598	$0
22	$0	$0	$0	$0	0.6468	$0
23	$0	$0	$0	$0	0.6342	$0
24	$0	$0	$0	$0	0.6217	$0
25	$0	$0	$73,079	$73,079	0.6095	$44,544
26	$0	$0	$0	$0	0.5976	$0
27	$0	$0	$0	$0	0.5859	$0
28	$0	$0	$0	$0	0.5744	$0
29	$0	$0	$0	$0	0.5631	$0
30	$0	$0	$350,507	$350,507	0.5521	$193,505
31	$0	$0	$0	$0	0.5412	$0
32	$0	$0	$0	$0	0.5306	$0
33	$0	$0	$0	$0	0.5202	$0
34	$0	$0	$0	$0	0.5100	$0

TABLE PV-3C						
PRESENT VALUE ANALYSIS						
Alternative	**3C**					
ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
35	$0	$0	$0	$0	0.5000	$0
36	$0	$0	$0	$0	0.4902	$0
37	$0	$0	$0	$0	0.4806	$0
38	$0	$0	$0	$0	0.4712	$0
39	$0	$0	$0	$0	0.4619	$0
40	$0	$0	$73,079	$73,079	0.4529	$33,097
41	$0	$0	$0	$0	0.4440	$0
42	$0	$0	$0	$0	0.4353	$0
43	$0	$0	$0	$0	0.4268	$0
44	$0	$0	$0	$0	0.4184	$0
45	$0	$0	$0	$0	0.4102	$0
46	$0	$0	$0	$0	0.4022	$0
47	$0	$0	$0	$0	0.3943	$0
48	$0	$0	$0	$0	0.3865	$0
49	$0	$0	$0	$0	0.3790	$0
50	$0	$0	$350,507	$350,507	0.3715	$130,223
51	$0	$0	$0	$0	0.3642	$0
52	$0	$0	$0	$0	0.3571	$0
53	$0	$0	$0	$0	0.3501	$0
54	$0	$0	$0	$0	0.3432	$0
55	$0	$0	$0	$0	0.3365	$0
56	$0	$0	$0	$0	0.3299	$0
57	$0	$0	$0	$0	0.3234	$0
58	$0	$0	$0	$0	0.3171	$0
59	$0	$0	$0	$0	0.3109	$0
60	$0	$0	$73,079	$73,079	0.3048	$22,273
61	$0	$0	$0	$0	0.2988	$0
62	$0	$0	$0	$0	0.2929	$0
63	$0	$0	$0	$0	0.2872	$0
64	$0	$0	$0	$0	0.2816	$0
65	$0	$0	$0	$0	0.2761	$0
66	$0	$0	$0	$0	0.2706	$0
67	$0	$0	$0	$0	0.2653	$0
68	$0	$0	$0	$0	0.2601	$0
69	$0	$0	$0	$0	0.2550	$0

TABLE PV-3C						
PRESENT VALUE ANALYSIS						
Alternative	**3C**					
ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
70	$0	$0	$73,079	$73,079	0.2500	$18,272
71	$0	$0	$0	$0	0.2451	$0
72	$0	$0	$0	$0	0.2403	$0
73	$0	$0	$0	$0	0.2356	$0
74	$0	$0	$0	$0	0.2310	$0
75	$0	$0	$277,428	$277,428	0.2265	$62,826
76	$0	$0	$0	$0	0.2220	$0
77	$0	$0	$0	$0	0.2177	$0
78	$0	$0	$0	$0	0.2134	$0
79	$0	$0	$0	$0	0.2092	$0
80	$0	$0	$73,079	$73,079	0.2051	$14,989
81	$0	$0	$0	$0	0.2011	$0
82	$0	$0	$0	$0	0.1971	$0
83	$0	$0	$0	$0	0.1933	$0
84	$0	$0	$0	$0	0.1895	$0
85	$0	$0	$0	$0	0.1858	$0
86	$0	$0	$0	$0	0.1821	$0
87	$0	$0	$0	$0	0.1786	$0
88	$0	$0	$0	$0	0.1751	$0
89	$0	$0	$0	$0	0.1716	$0
90	$0	$0	$73,079	$73,079	0.1683	$12,296
91	$0	$0	$0	$0	0.1650	$0
92	$0	$0	$0	$0	0.1617	$0
93	$0	$0	$0	$0	0.1586	$0
94	$0	$0	$0	$0	0.1554	$0
95	$0	$0	$0	$0	0.1524	$0
96	$0	$0	$0	$0	0.1494	$0
97	$0	$0	$0	$0	0.1465	$0
98	$0	$0	$0	$0	0.1436	$0
99	$0	$0	$0	$0	0.1408	$0
100	$0	$0	$73,079	$73,079	0.1380	$10,087
TOTALS:	$3,928,000	$0	$2,059,741	$5,987,741		$4,905,864
TOTAL PRESENT VALUE OF ALTERNATIVE 3[5]						**$4,906,000**

TABLE PV-3C						
PRESENT VALUE ANALYSIS						
Alternative	**3C**					
ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**

1. Period of analysis and long-term monitoring was assumed to be 30 years beyond the construction in Year 0.
2. Capital costs, for purposes of this analysis are assumed to occur in "year zero" of the project.
3. Total annual expenditure is the total cost per year with no discounting.
4. Present value is the total cost per year including a 2.0% discount factor for that year.
5. Total present value is rounded to the nearest $10,000. Inflation and depreciation are excluded from the present value cost.
6. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented.
7. Costs are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
8. For federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of Office of Management & Budget Circular A-94 (OMB 2023). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment.

ESMA = eastern sediment management area
O&M = operations and maintenance
WSMA = western sediment management area

TABLE CS-3C

Alternative **3C**
ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25-inch RCM, 6-inch-thick MAM and a 6-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Capital Costs (Assumed to be Incurred During Year 0)						
1	**Mobilization**	LS	1	$123,000	$123,000	Includes mobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
2	**Site Preparation**					
2.1	Staging Area Development and Water Access	LS	1	$203,000	$203,000	Includes the construction of a 1.0-acre staging area including the placement of a 4-inch layer of gravel/DGA and a geogrid and personnel river access/docking.
2.2	Erosion and Sediment (E&S) Control	LF	960	$10.00	$9,601	Includes the installation and maintenance of upland erosion and sediment controls around the staging area during construction.
2.3	Resuspension Control System	LF	1,019	$130	$132,450	Includes the installation of turbidity curtains, oil booms, and anchors. Quantities assume the placement encompassing the perimeter of the remedial footprint with anchors installed every 50 feet and attached to the shoreline.
3	**Temporary Facilities and Utilities**	MO	2.4	$9,900	$24,007	Includes temporary facilities and utilities including on-site office trailers and supplies, jobsite sanitation, portable power, and potable water.
4	**Debris Removal, Management and Disposal**					
4.1	Debris Removal and Processing	AC	0.70	$72,000	$50,623	Includes the mechanical removal of surface debris and transport via tugs and scows to the offloading facility and debris offloading into the staging area for processing. Debris removal is assumed to be conducted using in-water mechanical methods utilizing a single barge platform. Debris removal operations are assumed to occur prior to cap placement. Water generated from debris processing operations is expected to be minimal and will be containerized and transported to the local POTW. Estimated quantities assume 5 tons per acre. Engineering and administrative best management practices will be employed to control turbidity during debris removal activities.
5	**Cap Installation**					
5.1	Sand Leveling Layer Procurement and Transport	TON	1,241	$41	$50,868	Includes procurement, transport, and delivery of sand to the Site.
5.2	Sand Leveling Layer Placement	CY	886	$94	$83,302	Includes the placement of a sand leveling layer to provide initial stability to prevent lateral movement of the cap. Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods utilizing a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target Area, placement of 6 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
5.3	Organoclay RCM Procurement and Transport	SF	35,221	$15	$528,315	Includes procurement, transport and delivery of prefabricated RCM containing organoclay at a thickness of 3 inches. The final thickness will be determined during the design phase.
5.4	Organoclay RCM Installation	SF	35,221	$8	$281,768	Includes the transfer of the RCM from the staging area to on-water barge platform, transport of the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods with general construction equipment using roll bars from two platforms assisted by divers with an assumed 20-foot offset from the Target Area and production rate of approximately 8,500 SF per day.
5.5	6-inch MAM Procurement and Transport	SF	35,221	$15	$528,315	Includes procurement, transport, and delivery of 6-inch MAM and onsite installation of armor stone into MAMs.

TABLE CS-3C

Alternative 3C
ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25-inch RCM, 6-inch-thick MAM and a 6-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
5.6	6-inch MAM Installation	SF	35,221	$8	$281,768	Includes the transfer of the MAM from the staging area to on-water barge platform, transport of the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods with a crane from a single platform assisted by divers with an assumed 20-foot offset from the Target Area and production rate of approximately 1,500 SF per day.
5.7	Benthic Restoration Layer Procurement and Transport	TON	1,241	$41	$50,868	Includes procurement, transport, and delivery of sand to the Site.
5.8	Benthic Restoration Layer Placement	CY	886	$119	$105,457	Includes the placement of a benthic restoration layer (sand) to promote benthic recolonization. Includes the transfer of material from the staging area to on-water scows, transport of the material to the location of placement and in-water placement. Placement is expected to be conducted using in-water mechanical methods using general construction equipment from a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a 20-foot offset from the Target Area, placement of 6 inches of sand with a 25 percent allowable overplacement with an assumed 25 percent material loss factor.
6	**Transportation and Disposal**					
6.1	Debris and Construction Material, and General Refuse	TON	891	$45	$40,078	Includes T&D of debris and construction material, and general refuse via dump trucks to the Republic facility located in Roosevelt, WA.
7	**Site Surveying**	DY	6	$6,300	$37,800	Includes pre-construction and post-construction upland topographic and bathymetric surveys and reporting. Confirmation surveying will be conducted prior to and during capping placement. Pre- and post-processed survey data will be compared to evaluate the successful completion of remedial activities.
8	**Site Restoration**	LS	1	$30,000	$30,000	Includes removal of upland staging area and restoration of the area to pre-construction conditions.
9	**Site Institutional Controls (ICs)**	LS	1	$15,810	$15,810	Includes development and maintenance of institutional controls and community awareness activities in the ESMA and WSMA.
10	**Demobilization**	LS	1	$123,000	$123,000	Includes demobilization of labor, equipment, and materials, which were assumed to be 5 percent of the total direct construction costs.
				Subtotal:	**$2,701,730**	

Contingency (Scope [10%] and Bid [10%]):	20%	$540,346	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
	Subtotal:	**$3,242,076**	

TABLE CS-3C

Alternative **3C**

ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls

WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25-inch RCM, 6-inch-thick MAM and a 6-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard

Location: Wishram, Washington

Base Year: 2025

Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
11			Project Management:	5%	$162,104	Project Management includes planning and reporting, community relations support during construction, bid or contract administration, and legal services. Percentage based multiplier were used from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
12			Remedial Design:	8%	$259,366	Remedial design includes services to design the remedial action. Activities that are part of remedial design include pre-design collection and analysis of field data, engineering survey for design, treatability study (e.g., pilot-scale), and the various design components such as design analysis, plans, specifications, cost estimate, and schedule at the preliminary, intermediate, and final design phases. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
13			Construction Management:	6%	$194,525	Construction management includes services to manage construction or installation of the remedial action from mobilization through to demobilization. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of O&M manual, documentation of quality control/quality assurance, and record drawings. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				TOTAL:	**$3,858,071**	
				Washington State Gross Receipts Tax (1.8%):	**$69,445**	
				TOTAL DIRECT AND INDIRECT CAPITAL COSTS:	**$3,928,000**	

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Long-term operation, monitoring and maintenance (OM&M) - Periodic Costs						
14	**Long-Term Monitoring - Survey (Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$30,330	$394,290	Assumes bathymetric surveying in the ESMA and WSMA will be conducted every 5 years for a duration of 30 years and then every 10 years for a duration of 100 years using multi-beam bathymetric survey techniques. Data will be evaluated, and the results will be included in a report. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
16	**Maintenance Program (Year 15, 30, 50, 75)**	EA	4	$191,066	$764,264	The cap maintenance program will be conducted in the ESMA and is assumed to include cap maintenance activities at years 15, 30, 50 and 75. The cap maintenance program was calculated assuming a 10 percent multiplier of cap total direct construction costs for each maintenance event. The estimated cost for the long-term cap maintenance program was calculated and using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
17	**Periodic Agency Reviews ((Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$20,000	$260,000	Period agency reviews will be performed every 5 years starting in year 5 through 30 and then every 10 years through 100. This includes review of O&M and MNR monitoring data. The estimated cost was calculated using the present worth analysis process outlined by EPA (July 2000) using a discount rate of 2.0 percent.
				Subtotal:	**$1,418,554**	

TABLE CS-3C

Alternative 3C

ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls

WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25-inch RCM, 6-inch-thick MAM and a 6-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard

Location: Wishram, Washington

Base Year: 2025

Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
	Contingency (Scope [10%] and Bid [10%]):			20%	$283,711	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				Subtotal:	**$1,702,265**	
18	Project Management:			6%	$102,136	Project Management includes planning and reporting, community relations support during O&M. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
19	Technical Support:			15%	$255,340	Technical support during O&M includes services to monitor, evaluate, and report progress of the remedial action. This includes oversight of O&M activities, update of O&M manual, and progress reporting. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July. Middle value of the recommended range in EPA 540-R-00-002 was used.
				TOTAL:	**$2,059,741**	

TOTAL NON-DISCOUNTED PERIODIC COST:	**$2,060,000**
TOTAL NON-DISCOUNTED PROJECT COST:	**$5,987,741**
TOTAL DISCOUNTED PROJECT COST:	**$4,906,000**

TABLE CS-3C

Alternative 3C

ESMA – Capping with Reactive Core Mat and a Marine Armor Mat, and Institutional Controls

WSMA – Monitored Natural Recovery and Institutional Controls

Description: Removal and transport and disposal of debris, and Installation of an active cap in the ESMA. The cap consists of the following (from bottom to top): an initial 6-inch-thick layer of sand, 0.25-inch RCM, 6-inch-thick MAM and a 6-inch thick benthic restoration layer. MNR and institutional controls in the WSMA.

Site: BNSF Wishram Railyard

Location: Wishram, Washington

Base Year: 2025

Date: May-25

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES

General Notes:

1. Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," EPA 2000.
2. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
3. Cost details provided in this estimate are based on professional judgment, similar project experience, knowledge of the existing conditions at the site, and costs from similar project estimates. Costs were not developed from the ground up and are instead estimated through unit costs, production and schedule assumptions, and associated project durations.
4. All assumptions, quantities, and unit prices used in this cost estimate are preliminary for the purposes of the FS and cost estimate. Cost estimates will be refined during future remedial design development efforts.
5. Remedial operations are assumed 12 hours per day, 6 days per week.
6. All costs include labor, equipment and materials, overhead and profit, general and administrative expenses and are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.
7. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.
8. These estimates are developed using current and generally accepted engineering cost estimation methods. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material. Jacobs is not licensed as an accountant or securities attorney and, therefore, makes no representations that these costs form an appropriate basis for complying with financial reporting requirements for such costs.

CY = cubic yard(s)
DGA = dense graded aggregate
EA = each
EPA = U.S. Environmental Protection Agency
ESMA = eastern sediment management unit
FS = feasibility study
GAC = granular activated carbon
LF = linear foot (feet)
LS = lump sum
MAM = marine armor mat
MNR = Monitored Natural Recovery
NAPL = nonaqueous phase liquid
O&M = operations and maintenance
POWT = publicly owned treatment works
RCM = reactive core mat
SF = square foot (feet)
T&D = transportation and disposal
TON = ton(s)
WSMA = western sediment management area

TABLE PV-4						
PRESENT VALUE ANALYSIS						
Alternative	**4**					
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
0	$7,077,000	$0	$0	$7,077,000	1.0000	$7,077,000
1	$0	$0	$0	$0	0.9804	$0
2	$0	$0	$0	$0	0.9612	$0
3	$0	$0	$0	$0	0.9423	$0
4	$0	$0	$0	$0	0.9238	$0
5	$0	$0	$73,079	$73,079	0.9057	$66,190
6	$0	$0	$0	$0	0.8880	$0
7	$0	$0	$0	$0	0.8706	$0
8	$0	$0	$0	$0	0.8535	$0
9	$0	$0	$0	$0	0.8368	$0
10	$0	$0	$73,079	$73,079	0.8203	$59,950
11	$0	$0	$0	$0	0.8043	$0
12	$0	$0	$0	$0	0.7885	$0
13	$0	$0	$0	$0	0.7730	$0
14	$0	$0	$0	$0	0.7579	$0
15	$0	$0	$73,079	$73,079	0.7430	$54,299
16	$0	$0	$0	$0	0.7284	$0
17	$0	$0	$0	$0	0.7142	$0
18	$0	$0	$0	$0	0.7002	$0
19	$0	$0	$0	$0	0.6864	$0
20	$0	$0	$73,079	$73,079	0.6730	$49,180
21	$0	$0	$0	$0	0.6598	$0
22	$0	$0	$0	$0	0.6468	$0
23	$0	$0	$0	$0	0.6342	$0
24	$0	$0	$0	$0	0.6217	$0
25	$0	$0	$73,079	$73,079	0.6095	$44,544
26	$0	$0	$0	$0	0.5976	$0
27	$0	$0	$0	$0	0.5859	$0
28	$0	$0	$0	$0	0.5744	$0
29	$0	$0	$0	$0	0.5631	$0
30	$0	$0	$73,079	$73,079	0.5521	$40,345
31	$0	$0	$0	$0	0.5412	$0
32	$0	$0	$0	$0	0.5306	$0
33	$0	$0	$0	$0	0.5202	$0
34	$0	$0	$0	$0	0.5100	$0

TABLE PV-4						
PRESENT VALUE ANALYSIS						
Alternative	**4**					
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
35	$0	$0	$0	$0	0.5000	$0
36	$0	$0	$0	$0	0.4902	$0
37	$0	$0	$0	$0	0.4806	$0
38	$0	$0	$0	$0	0.4712	$0
39	$0	$0	$0	$0	0.4619	$0
40	$0	$0	$73,079	$73,079	0.4529	$33,097
41	$0	$0	$0	$0	0.4440	$0
42	$0	$0	$0	$0	0.4353	$0
43	$0	$0	$0	$0	0.4268	$0
44	$0	$0	$0	$0	0.4184	$0
45	$0	$0	$0	$0	0.4102	$0
46	$0	$0	$0	$0	0.4022	$0
47	$0	$0	$0	$0	0.3943	$0
48	$0	$0	$0	$0	0.3865	$0
49	$0	$0	$0	$0	0.3790	$0
50	$0	$0	$73,079	$73,079	0.3715	$27,151
51	$0	$0	$0	$0	0.3642	$0
52	$0	$0	$0	$0	0.3571	$0
53	$0	$0	$0	$0	0.3501	$0
54	$0	$0	$0	$0	0.3432	$0
55	$0	$0	$0	$0	0.3365	$0
56	$0	$0	$0	$0	0.3299	$0
57	$0	$0	$0	$0	0.3234	$0
58	$0	$0	$0	$0	0.3171	$0
59	$0	$0	$0	$0	0.3109	$0
60	$0	$0	$73,079	$73,079	0.3048	$22,273
61	$0	$0	$0	$0	0.2988	$0
62	$0	$0	$0	$0	0.2929	$0
63	$0	$0	$0	$0	0.2872	$0
64	$0	$0	$0	$0	0.2816	$0
65	$0	$0	$0	$0	0.2761	$0
66	$0	$0	$0	$0	0.2706	$0
67	$0	$0	$0	$0	0.2653	$0
68	$0	$0	$0	$0	0.2601	$0
69	$0	$0	$0	$0	0.2550	$0

TABLE PV-4						
PRESENT VALUE ANALYSIS						
Alternative	**4**					
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**
70	$0	$0	$73,079	$73,079	0.2500	$18,272
71	$0	$0	$0	$0	0.2451	$0
72	$0	$0	$0	$0	0.2403	$0
73	$0	$0	$0	$0	0.2356	$0
74	$0	$0	$0	$0	0.2310	$0
75	$0	$0	$0	$0	0.2265	$0
76	$0	$0	$0	$0	0.2220	$0
77	$0	$0	$0	$0	0.2177	$0
78	$0	$0	$0	$0	0.2134	$0
79	$0	$0	$0	$0	0.2092	$0
80	$0	$0	$73,079	$73,079	0.2051	$14,989
81	$0	$0	$0	$0	0.2011	$0
82	$0	$0	$0	$0	0.1971	$0
83	$0	$0	$0	$0	0.1933	$0
84	$0	$0	$0	$0	0.1895	$0
85	$0	$0	$0	$0	0.1858	$0
86	$0	$0	$0	$0	0.1821	$0
87	$0	$0	$0	$0	0.1786	$0
88	$0	$0	$0	$0	0.1751	$0
89	$0	$0	$0	$0	0.1716	$0
90	$0	$0	$73,079	$73,079	0.1683	$12,296
91	$0	$0	$0	$0	0.1650	$0
92	$0	$0	$0	$0	0.1617	$0
93	$0	$0	$0	$0	0.1586	$0
94	$0	$0	$0	$0	0.1554	$0
95	$0	$0	$0	$0	0.1524	$0
96	$0	$0	$0	$0	0.1494	$0
97	$0	$0	$0	$0	0.1465	$0
98	$0	$0	$0	$0	0.1436	$0
99	$0	$0	$0	$0	0.1408	$0
100	$0	$0	$73,079	$73,079	0.1380	$10,087
TOTALS:	$7,077,000	$0	$950,029	$8,027,029		$7,529,673
TOTAL PRESENT VALUE OF ALTERNATIVE 4 [5]						**$7,530,000**

TABLE PV-4						
PRESENT VALUE ANALYSIS						
Alternative	**4**					
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls						
WSMA – Monitored Natural Recovery and Institutional Controls						
Site:	**BNSF Wishram Railyard**					
Location:	**Wishram, Washington**					
Phase:	**Feasibility Study**					
Base Year:	**2025**	**Discount Rate[6]**	2.0%			
Year[1]	**Capital Costs[2]**	**Annual O&M Costs**	**Periodic Costs**	**Total Annual Expenditure[3]**	**Discount Factor (2.0%)**	**Present Value[4]**

1. Period of analysis and long-term monitoring was assumed to be 30 years beyond the construction in Year 0.
2. Capital costs, for purposes of this analysis are assumed to occur in "year zero" of the project.
3. Total annual expenditure is the total cost per year with no discounting.
4. Present value is the total cost per year including a 2.0% discount factor for that year.
5. Total present value is rounded to the nearest $10,000. Inflation and depreciation are excluded from the present value cost.
6. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented.
7. Costs are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
8. For federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of Office of Management & Budget Circular A-94 (OMB 2023). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment.

ESMA = eastern sediment management area
O&M = operations and maintenance
WSMA = western sediment management area

TABLE CS-4

Alternative 4
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

Description: Removal and transport and disposal of debris in the ESMA followed by in-situ stabilization and placement of backfill (amended with organoclay and GAC). MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
Capital Costs (Assumed to be Incurred During Year 0)						
1	**Mobilization**	LS	1	$406,000	$406,000	Includes mobilization of labor, equipment, and materials, which were assumed to be 10 percent of the total direct construction costs.
2	**Site Preparation**					
2.1	Staging Area Development	LS	1	$201,750	$201,750	Includes the construction of a 1.0-acre staging area including the placement of a 4-inch layer of gravel/DGA and a geogrid and personnel river access/docking.
2.2	Erosion and Sediment (E&S) Control	LF	960	$10	$9,601	Includes the installation and maintenance of upland erosion and sediment controls around the staging area during construction.
2.3	Resuspension Control System	LF	1,019	$130	$132,450	Includes the installation of turbidity curtains, oil booms, and anchors. Quantities assume the placement encompassing the perimeter of the remedial footprint with anchors installed every 50 feet and attached to the shoreline.
3	**Temporary Facilities and Utilities**	MO	3.4	$9,900	$33,533	Includes temporary facilities and utilities including on-site office trailers and supplies, jobsite sanitation, portable power, and potable water.
4	**Debris Removal, Management and Disposal**					
4.1	Debris Removal and Processing	AC	0.70	$72,000	$50,623	Includes the mechanical removal of surface and subsurface debris, transport via tugs and scows to the offloading facility and debris offloading into the staging area for processing. Debris removal is assumed to be conducted using in-water mechanical methods utilizing a single barge platform. Debris removal operations are assumed to occur prior to in-situ stabilization operations. Water generated from debris processing operations will be containerized and transported to the local POTW. Estimated quantities assume 5 tons per acre. Engineering and administrative best management practices will be employed to control turbidity during debris removal activities.
5	**In-Situ Stabilization**					
5.1	Field Demonstration Stabilization Agent Procurement and Tra	TON	313	$192	$60,000	Includes procurement, transport, and delivery of Portland cement to the Site to conduct the field demonstration. Quantity assumes a footprint of 5,625 SF with an in-situ sediment stabilization volume of 2,100 CY. Portland cement is assumed at 10 percent by weight of the in-situ stabilization volume.
5.2	Field Demonstration In-situ Stabilization Operations	CY	2,329	$188	$437,927	Includes In-situ stabilization using auger rigs on a single barge platform to mechanically mix reagent into the overlying sediment and the NAPL impacted sediment, creating an array of overlapping, cement-like columns extending from the surface to 10 feet bss.
5.3	Full-Scale Stabilization Agent Procurement and Transport	TON	1,389	$192	$266,687	Includes procurement, transport, and delivery of Portland cement to the Site to conduct the full scale in-situ stabilization. Quantity assumes a footprint of approximately 13,590 SF with an in-situ sediment stabilization volume of 5,050 CY. Portland cement is assumed at 10 percent by weight of the in-situ stabilization volume.
5.4	Full-Scale In-situ Stabilization Operations	CY	10,354	$188	$1,946,492	Includes In-situ stabilization using auger rigs on a single barge platform to mechanically mix reagent into the overlying sediment and the NAPL impacted sediment, creating an array of overlapping, cement-like columns extending from the surface to 10 feet bss. Grout plants and mixing equipment is assumed on the platform.
6	**Transportation and Disposal (T&D)**					
6.1	Debris and Construction Material, and General Refuse	TON	891	$45	$40,078	Includes T&D of debris and construction material, and general refuse via dump trucks to the Republic facility located in Roosevelt, WA.

TABLE CS-4

Alternative 4
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

Description: Removal and transport and disposal of debris in the ESMA followed by in-situ stabilization and placement of backfill (amended with organoclay and GAC). MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
7	**Backfill**					
7.1	Sand Procurement and Transport	TON	1,241	$41	$50,868	Includes the procurement, transport, and delivery of sand to the Site.
7.2	Organoclay Procurement and Transport	TON	62	$7,400	$459,050	Includes procurement, transport, and delivery of organoclay to the Site.
7.3	GAC Procurement and Transport	TON	37	$3,000	$111,661	Includes procurement, transport, and delivery of GAC to the Site.
7.4	Backfill Blending Operations	CY	1,046	$30	$31,366	Includes the on-site blending of sand, organoclay and GAC in the staging area.
7.5	Backfill Placement	CY	1,046	$120	$125,465	Includes the transfer of backfill material from the staging area to on-water scows, transport of the backfill material to the location of placement and placement of the backfill. Placement operations would be conducted following the successful confirmation of in-situ stabilization operation. Backfill placement is assumed to be conducted using in-water mechanical methods utilizing from a single platform with an assumed production rate of approximately 250 CY per day. Estimated quantities assume a minimum 6-inch-thick layer of sand/GAC/organoclay with 25 percent allowable overplacement with an assumed 25 percent material loss factor. Backfill amendment assumes a combination of organoclay (5 percent by weight) and GAC (3 percent by weight) to address residual remaining concerns of sheen generating NAPL.
8	**Site Surveying**	DY	5	$6,300	$31,500	Includes pre-construction and post-construction upland topographic and bathymetric surveys and reporting. Pre- and post-processed survey data will be compared to evaluate the successful completion of remedial activities.
9	**Site Restoration**	LS	1	$50,000	$50,000	Includes removal of upland staging area and restoration of the area to pre-construction conditions.
10	**Site Institutional Controls (ICs)**	LS	1	$15,810	$15,810	Includes development and maintenance of institutional controls and community awareness activities in the ESMA and WSMA.
11	**Demobilization**	LS	1	$406,000	$406,000	Includes demobilization of labor, equipment, and materials, which were assumed to be 10 percent of the total direct construction costs.
				Subtotal:	**$4,868,561**	

Contingency (Scope [10%] and Bid [10%]):	20%	$973,712	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
	Subtotal:	**$5,842,273**	

TABLE CS-4

Alternative 4
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls
WSMA – Monitored Natural Recovery and Institutional Controls

FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

Description: Removal and transport and disposal of debris in the ESMA followed by in-situ stabilization and placement of backfill (amended with organoclay and GAC). MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
12			Project Management:	5%	$292,114	Project Management includes planning and reporting, community relations support during construction, bid or contract administration, and legal services. Percentage based multiplier were used from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
13			Remedial Design:	8%	$467,382	Remedial design includes services to design the remedial action. Activities that are part of remedial design include pre-design collection and analysis of field data, engineering survey for design, treatability study (e.g., pilot-scale), and the various design components such as design analysis, plans, specifications, cost estimate, and schedule at the preliminary, intermediate, and final design phases. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
14			Construction Management:	6%	$350,536	Construction management includes services to manage construction or installation of the remedial action from mobilization through to demobilization. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of O&M manual, documentation of quality control/quality assurance, and record drawings. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				TOTAL:	**$6,952,305**	
	Washington State Gross Receipts Tax (1.8%):				**$125,141**	
	TOTAL DIRECT AND INDIRECT CAPITAL COSTS:				**$7,077,000**	
Long-term operation, monitoring and maintenance (OM&M) - Periodic Costs						
15	**Long-Term Monitoring - Survey (Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$30,330	$394,290	Assumes bathymetric surveying in the ESMA and WSMA will be conducted every 5 years for a duration of 30 years and then every 10 years for a duration of 100 years using multi-beam bathymetric survey techniques. Data will be evaluated, and the results will be included in a report. The estimated cost was calculated using the present worth analysis process outlined by the U.S. Environmental Protection Agency (USEPA, July 2000) using a discount rate of 2.0 percent.
17	**Periodic Agency Reviews ((Years 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100)**	EA	13	$20,000	$260,000	Period agency reviews will be performed every 5 years starting in year 5 through 30 and then every 10 years through 100. This includes review of O&M and MNR monitoring data. The estimated cost was calculated using the present worth analysis process outlined by the U.S. Environmental Protection Agency (USEPA, July 2000) using a discount rate of 2.0 percent.
				Subtotal:	**$654,290**	

TABLE CS-4

Alternative 4
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FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

Description: Removal and transport and disposal of debris in the ESMA followed by in-situ stabilization and placement of backfill (amended with organoclay and GAC). MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES
			Contingency (Scope [10%] and Bid [10%]):	20%	$130,858	A contingency allowance has been included to account for unforeseen circumstances or variability such as quantities, labor, material costs, construction modifications, change orders and claims to cover bid and scope contingency. Due to the high levels of uncertainty at the feasibility stage, a 20 percent multiplier has been assumed on total project costs. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
				Subtotal:	**$785,148**	
18			Project Management:	6%	$47,109	Project Management includes planning and reporting, community relations support during O&M. Percentage based multiplier from Exhibit 5-8 detailed in the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July.
19			Technical Support:	15%	$117,772	Technical support during O&M includes services to monitor, evaluate, and report progress of the remedial action. This includes oversight of O&M activities, update of O&M manual, and progress reporting. Percentage based multiplier from the following reference: EPA 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, EPA 540-R-00-002. July. Middle value of the recommended range in EPA 540-R-00-002 was used.
				TOTAL:	**$950,029**	

TOTAL NON-DISCOUNTED PERIODIC COST:	**$950,000**
TOTAL NON-DISCOUNTED PROJECT COST:	**$8,027,029**
TOTAL DISCOUNTED PROJECT COST:	**$7,530,000**

TABLE CS-4

Alternative 4
ESMA – In-Situ Stabilization, Backfill, and Institutional Controls
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FEASIBILITY STUDY DETAILED COST ESTIMATE SUMMARY

Description: Removal and transport and disposal of debris in the ESMA followed by in-situ stabilization and placement of backfill (amended with organoclay and GAC). MNR and institutional controls in the WSMA.
Site: BNSF Wishram Railyard
Location: Wishram, Washington
Base Year: 2025
Date: May-25

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST	NOTES

General Notes:

1. Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study," EPA 2000.
2. Costs presented for this alternative are expected to have an accuracy between -30% and +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.
3. Cost details provided in this estimate are based on professional judgment, similar project experience, knowledge of the existing conditions at the site, and costs from similar project estimates. Costs were not developed from the ground up and are instead estimated through unit costs, production and schedule assumptions, and associated project durations.
4. All assumptions, quantities, and unit prices used in this cost estimate are preliminary for the purposes of the FS and cost estimate. Cost estimates will be refined during future remedial design development efforts.
5. Remedial operations are assumed 12 hours per day, 6 days per week.
6. All costs include labor, equipment and materials, overhead and profit, general and administrative expenses and are provided in present day dollars and all cost expenditures are assumed to occur at the start of construction.
7. These costs have been developed using currently available information regarding site characteristics such as site bathymetry, potential debris, physical properties of the existing sediment at the site. As information regarding these site characteristics changes or new information becomes available, these costs will be subject to change.
8. These estimates are developed using current and generally accepted engineering cost estimation methods. Note that these estimates are based on assumptions concerning future events and actual costs may be affected by known and unknown risks including, but not limited to, changes in general economic and business conditions, site conditions that were unknown at the time the estimates were performed, future changes in site conditions, regulatory or enforcement policy changes, and delays in performance. Actual costs may vary from these estimates and such variations may be material. Jacobs is not licensed as an accountant or securities attorney and, therefore, makes no representations that these costs form an appropriate basis for complying with financial reporting requirements for such costs.

bss = below sediment surface
CY = cubic yard(s)
DGA = dense graded aggregate
EA = each
EPA = U.S. Environmental Protection Agency
ESMA = eastern sediment management unit
FS = feasibility study
GAC = granular activated carbon
LF = linear foot (feet)
LS = lump sum
MAM = marine armor mat
MNR = Monitored Natural Recovery
NAPL = nonaqueous phase liquid
O&M = operations and maintenance
POWT = publicly owned treatment works
RCM = reactive core mat
SF = square foot (feet)
T&D = transportation and disposal
TON = ton(s)
WSMA = western sediment management area