



BNSF Railway Company &
Husky Oil Operations Limited

Engineering Design Report

BNSF Railway Black Tank Property

November 2021

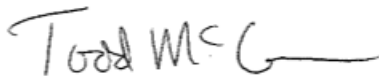
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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
amsl	above mean sea level
AO	Agreed Order
ARAR	applicable or relevant and appropriate requirements
bgs	below ground surface
BNSF	BNSF Railway
BS	biosparging
BSI	biosparging injection
BV	bioventing
CAP	Cleanup Action Plan
CD	Consent Decree
CMP	Compliance Monitoring Plan
CO ₂	carbon dioxide
cPAH	carcinogenic polycyclic aromatic hydrocarbon
cSt	centistoke

CUL	cleanup level
DO	dissolved oxygen
DPWP	Deep Contamination Cleanup Action Design Parameters Work Plan
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
ERM	ERM-West, Inc.
FS	Feasibility Study
gal HC/acre-yr	gallons of hydrocarbons per acre per year
HASP	Health and Safety Plan
Husky	Husky Oil Operations Limited
IAWP	Interim Action Work Plan for Shallow Soil Removal
ITRC	Interstate Technology and Regulatory Council
LNAPL	light non-aqueous phase liquid
MDPE	medium-density polyethylene
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MTCA	Model Toxics Control Act
MW	monitoring well
NAVD 88	North America Vertical Datum of 1988
NOI	Notice of Intent
NPS	nominal pipe size
NSC	North Spokane Corridor
NSZD	natural source zone depletion
OMP	Operations and Maintenance Plan
P&ID	pipng and instrumentation diagram
PLC	programmable logic controller
PLP	potentially liable person
psi	pound per square inch
psig	pounds per square inch-gauge
PVC	polyvinyl chloride
RCW	Revised Code of Washington
RI	Remedial Investigation
ROI	radius of influence
RTF	restoration timeframe
scfm	standard cubic feet per minute
SD	standard deviation
SEE	steam-enhanced extraction
SF ₆	sulfur hexafluoride
SGC	silica gel cleanup
Site	BNSF Railway Black Tank Property
SOP	standard operating procedure
SOW	Scope of Work
SPT	Steam Propagation Test
SSA	surface soil area
SVRP	Spokane-Valley Rathdrum-Prairie
TPH-D/HO	total petroleum hydrocarbon-diesel and heavy oil
VFD	variable frequency drive
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

This Engineering Design Report (EDR) was prepared by ERM-West, Inc. (ERM) on behalf of BNSF Railway (BNSF) and Husky Oil Operations Limited (Husky) for the BNSF Railway Black Tank Property (Site) (Facility Site #98615712, Cleanup Site #3243), generally located at 3202 East Wellesley Avenue in Spokane, Spokane County, Washington (Figure 1-1). This EDR is required as part of the cleanup process under the Model Toxics Control Act (MTCA), Ch. 70.105D Revised Code of Washington (RCW), implemented by the Washington State Department of Ecology (Ecology). The EDR was prepared in accordance with the requirements of Washington Administrative Code (WAC) 173-340-400.

Ecology selected the remedy and documented it in the final *Cleanup Action Plan* (CAP; Ecology 2018a). Ecology based its selection on information presented in the *Remedial Investigation / Feasibility Study* (RI/FS; ERM 2013) and other relevant documents in the administrative record. Ecology named BNSF and Marathon Oil Company as the potentially liable persons (PLPs), with Husky performing Marathon Oil Company's obligations for this project. Site investigation activities were completed under Agreed Order No. 9188 and the CAP is being implemented under Consent Decree (CD) No. 19203114-32 (Ecology 2019). The selected remedy includes, but is not limited to the following activities:

- Excavation of shallow impacted soil (less than 15 feet below ground surface [bgs]) and transportation of the soil to an appropriate off-Site disposal facility. A substantial portion of this work was completed as an Interim Action under Amendment No. 1 to Agreed Order No. 9188. The remainder of the excavation will be completed by WSDOT during the NSC project and track realignment with confirmation sampling and documentation performed by the PLPs.
- Installation and operation of a bioventing/biosparging (BV/BS) system to address mobile¹ light non-aqueous phase liquid (LNAPL) petroleum hydrocarbons. Optimization and expansion of the BV/BS system will occur, if needed, to meet performance criteria established in the CAP. If the BV/BS system does not meet the performance criteria specified in the CAP, a contingent remedy (steam-enhanced extraction [SEE]) may be initiated if SEE is determined to be technically feasible based on steam propagation testing, pilot testing, and other criteria as specified in the CAP.

The remedy described in the CAP (Exhibit B of the CD) is required to be completed in accordance with the scope of work (SOW) and schedule (Exhibit C) included in the CD. The work plan for pre-design field investigations was completed in August 2020 and the pre-design field investigation was completed in November 2020 (CD SOW Task B1). This EDR and its companion documents, the Compliance Monitoring Plan (CMP), Health and Safety Plan (HASP) and Operations and Maintenance Plan (OMP), fulfill the requirements of CD SOW Tasks B3, B5, and B6. Following Ecology's approval of the EDR, the detailed plans and specifications needed to construct and operate the BV/BS system will be prepared, fulfilling the requirements of CD SOW Task B4. The EDR, CMP, HASP, and OMP are supplements to the construction plans and specifications. All personnel involved with the execution of the remedy will review the EDR, CMP, HASP, and OMP with the construction plans and specifications.

¹ Per ITRC (2019), measurable LNAPL in a well is evidence of mobile LNAPL. Concentrations exceeding residual saturation can, but do not always, indicate mobile LNAPL. Per Section 4.4.2.2 of the CAP, "Ecology's residual saturation-based CUL for TPH-D/HO in subsurface soils (i.e., below 15 feet bgs) is 5,630 mg/kg. It is, however, understood that residual saturation varies at the Site. Therefore, the TPH-D/HO CUL for subsurface soil is used to identify areas requiring cleanup action, but compliance with the cleanup standards will be based on the absence of LNAPL in monitoring wells (and not on TPH-D/HO concentrations in subsurface soils)." Therefore, the area of mobile LNAPL at the Site requiring cleanup action includes intermediate soils exceeding the TPH-D/HO CUL of 5,630 and the area of measurable LNAPL in wells.

1.1 Purpose of the EDR

Per WAC 173-340-400(4)(a), the purpose of the EDR is to provide sufficient information for the development and review of the construction plans and specifications for the remedy. The specific information requirements of WAC 173-340-400(4) for the EDR are listed in Table 1-1 with the corresponding section of this EDR where the required information is provided.

2. SITE BACKGROUND

This section describes the historical, physical, and environmental conditions that are relevant to the design of the remedy. The information is from the RI/FS (ERM 2017), subsequent groundwater monitoring reports, the *Interim Action Completion Report* (ERM 2019a), and publicly available information from the Washington State Department of Transportation (WSDOT).

2.1 Site Description

The Black Tank Property is situated within an industrial and transportation corridor in the Hillyard neighborhood of northeast Spokane. Its specific location is in the northwest quarter of Section 3, Township 25 North, Range 43 East of the Willamette Meridian, along a main north-south BNSF rail line (Figure 1-1). Currently, operations include active rail traffic and WSDOT's construction of the North Spokane Corridor (NSC) freeway project. All structures associated with historic operations have been removed.

Based on the information currently known, the Site is generally congruent with the property shown on Figure 1-1. It consists of approximately 18 acres, and is generally bounded by Market Street to the west, Wellesley Avenue to the north, the former Aluminum Recycling Corporation site to the east, and the Sem Materials cleanup site (currently Western States Asphalt Inc.), and undeveloped land to the south (Figure 2-1). BNSF and WSDOT own the property. BNSF's property is zoned Light Industrial, and WSDOT's property is zoned Center and Corridor Core; this zoning allows for many types of uses including commercial, office, residential, and parks.

2.2 Site History

BNSF and its predecessors have owned most of the property since at least 1910. BNSF provided WSDOT with an easement through a portion of the property for the NSC freeway project. BNSF and its predecessors historically leased portions of the property and infrastructure to other operators, including Blackline Asphalt Sales, Husky, Intermountain Asphalt Company, and Koch Materials.

Based on historical documents, the area was developed as early as 1913. Historical operations included railroad transport, the Black Tank fueling and maintenance system, the Red Tank fueling and maintenance system, the Chemical Solution Pipeline, and an asphalt storage and transfer system (the Liquid Asphalt Pipeline). The Black Tank was a 50-foot-diameter, 420,000-gallon, aboveground storage tank used to store Bunker C oil for the purpose of refueling locomotives from circa 1913 until at least 1956. The Black Tank was subsequently leased to other operators, who stored oil for asphalt and other petroleum products until its removal in 2006. The Red Tank was a 420,000-gallon, aboveground storage tank used to store diesel in support of locomotive refueling until its removal sometime between 1990 and 1997. At some point or points in time, operations resulted in infrastructure leaks and/or fuel releases.

2.2.1 Previous Investigations

Characterization activities began in 2006, and culminated with completion of the RI in 2017. The final RI/FS report describes the investigation activities and results obtained through March 2016 (ERM 2017). It documents the nature and extent of hazardous substances in soil and groundwater based on the data available at that time. Post-RI/FS groundwater monitoring continued on a quarterly basis from 2016 through 2018 and semi-annually from 2019 through 2020.

The RI characterized the physical, chemical, and biological conditions needed to select a remedy. It defined the nature, magnitude, and extent of impacts that pose a potential risk to human health and/or the environment by identifying the contaminants of concern (COCs) and the media and areas having

concentrations of COCs that exceed MTCA cleanup levels (CULs). It determined petroleum hydrocarbons and constituents thereof as the only COCs. Specifically, petroleum hydrocarbons (total, diesel, heavy oil, and free product), naphthalene, and carcinogenic polycyclic aromatic hydrocarbons (cPAHs) are the COCs that exceed MTCA CULs in the soil and groundwater. Analytical testing demonstrates that the petroleum hydrocarbons are a mix of Bunker C, asphaltic oils, and diesel that is weathered and viscous.

Soil and/or groundwater with LNAPL and/or total petroleum hydrocarbon-diesel and heavy oil (TPH-D/HO) concentrations exceeding the applicable CULs define the areas of impact requiring cleanup. Media with CUL exceedances include surface soil (≤ 15 feet bgs), intermediate soil (greater than 15 feet to top of the smear zone at 156 feet bgs), LNAPL in smear zone soil (156 to 185 feet bgs or 1,854 to 1,883 feet above mean sea level [amsl]), and groundwater. Section 2.4 details the nature and extent of impacts, and Figure 2-1 illustrates the areas of impact requiring cleanup.

2.2.2 Previous Remediation

Through previous or ongoing remediation work, all accessible primary sources of COCs have been removed. Accessible refers to not being beneath or within the setback areas of the active rail lines. In 2006, the Black Tank was decommissioned and removed along with 10,270 tons of petroleum-impacted soil from the area around and beneath the tank (Figure 2-2). Additional structures and appurtenances were also removed including the Red Tank pipeline, a water pipeline, and portions of the Liquid Asphalt Pipeline and Black Tank pipeline encountered in the Black Tank excavation. The impacted soil and other waste materials were transported to a permitted landfill for disposal.

In late 2018, the first phase of a surface soil interim action was completed. The work was performed in accordance with Amendment No. 1 to AO No. 9188 (Ecology 2018b) and the final *Interim Action Work Plan for Shallow Soil Removal* (IAWP; ERM 2018). Section 7.1 of the CAP and Exhibit C of the CD also describe the work requirements. The *Interim Action Cleanup Report* (ERM 2019a) describes the first phase interim action work and confirmation sampling results. This work included removal of the remaining accessible underground piping, concrete infrastructure, and petroleum-impacted surface soil exceeding CULs. In addition to soils, infrastructure removed included 402 linear feet of asbestos-containing piping, 1,680 linear feet of non-asbestos-containing piping, 510 tons of concrete debris (including the Black Tank sump), and 660 gallons of oily liquid from within the piping and sump (Figure 2-2). Approximately 7,994 tons of petroleum-impacted surface soil were removed from SSA-1, SSA-4, SSA-5, and the eastern half of SSA-2 (Figure 2-2). Confirmation sampling results demonstrated that the CULs were met down to 15 feet bgs in all areas except the western sidewall of SSA-2, which will be addressed during the second phase of the interim action. Excavated soil and other waste materials were transported to Waste Management's Graham Road landfill for disposal.

Manual LNAPL removal began with LNAPL skimming tests in the first quarter of 2016 and continued quarterly during monitoring events from the fourth quarter of 2016 through 2018, and then semi-annually through 2020. Fourteen LNAPL removal events occurred between the first quarter 2016 and third quarter 2020, and each event included 8 to 15 monitoring wells. Removal rates have ranged from 1.1 to 8 gallons per event, and the total volume of LNAPL removed is approximately 30 gallons. The waste LNAPL is transported to an appropriately permitted treatment facility, where it is treated and recycled or disposed.

2.3 Physical Site Characteristics

2.3.1 Topography and Climate

The Hillyard area is generally level with an approximate elevation of 2,035 feet NAVD 88;² however, the rail lines running north-south through the Site are located in an excavated area approximately 100 feet wide and 5 to 10 feet below the surrounding grade. The region is semi-arid, receiving around 18 inches of precipitation annually with warm and dry summers. Most of the precipitation occurs in late fall through early spring; winter precipitation is usually in the form of snow. The annual mean temperature is about 50 degrees Fahrenheit (°F).

2.3.2 Regional Geology

The regional geology is primarily basalt flows of the Columbia Plateau overlain by Quaternary glacial flood deposits. The flood deposits are composed of thickly bedded, poorly sorted boulders, cobbles, gravel, sand, and silt, and are approximately 300 feet thick in the immediate vicinity. Depth to bedrock is believed to be 500 to 600 feet bgs. The coarse nature of the glacial flood deposits results in very high permeability. Intermittent layers of sand, silty sand, and silt/clay are present within the coarse deposits. The RI encountered fine-grained deposits at depths of 1,855 to 1,879 feet NAVD 88.

2.3.3 Site Geology

Glacial flood deposits composed of thickly bedded, poorly sorted boulders, cobbles, gravel, sand, and silt with intermittent layers of silty sand and silt/clay typify the substrate to a maximum drilled depth of 197 feet bgs (approximately 1,838 feet NAVD 88). As summarized in the RI/FS report (ERM 2017), the substrate consists of two grain-size-based facies:

- Sand and gravel facies—poorly sorted; gravel; coarse-, medium-, and fine-grained sand; and interbedded zones of these materials, with generally less than 10 percent silt and clay; and
- Silt and silty sand facies—lenses and beds of silt, silty sand, sand with silt, and interbedded zones of these materials with generally 20 to 40 percent silt and clay, but may have as much as 85 percent silt and clay.

The substrate predominantly consists of the sand and gravel facies, and contains more gravel at shallow depths. Discontinuous lenses of the silt and silty sand facies are scattered throughout the sand and gravel facies, and a relatively thin layer of the silt and silty sand facies is reported near the groundwater table, between the depths of 156 and 180 feet bgs (i.e., 1,855 to 1,879 feet NAVD 88) on the geologic logs of most of the monitoring wells. The consistency in occurrence of the silt and silty sand facies at the same horizon suggests that it may be a laterally continuous layer. Alternatively, it may be a series of discontinuous lenses of silt and silty sand facies at the same horizon.

2.3.4 Regional Hydrogeology

The primary underlying aquifer is the Spokane-Valley Rathdrum-Prairie (SVRP) aquifer. The aquifer flows from northern Idaho to the west and southwest down the Spokane Valley and, in some areas, at rates of over 100 feet per day. Once reaching the greater downtown Spokane area, groundwater flow in the aquifer turns north, where it flows through the Hillyard Trough area, which extends north from the Spokane River area to the Little Spokane River. In the Hillyard Trough, the average transmissivity is 3.9 million square feet per day, which translates to a horizontal hydraulic conductivity of 12,000 feet/day and velocities ranging from 41 to 47 feet/day (Drost and Seitz 1977).

² North America Vertical Datum of 1988

2.3.5 Site Hydrogeology

The SVRP aquifer is generally unconfined, and the groundwater table occurs at depths ranging from approximately 158 to 179 feet bgs as measured in monitoring wells. Groundwater levels fluctuate from 4 to 7 feet annually. Groundwater flow is to the north-northwest with a horizontal hydraulic gradient of approximately 0.0013 to 0.0014 (Figure 2-3). Assuming the hydraulic conductivity of the sand and gravel facies is 12,000 feet/day, the porosity ranges from 25 to 35 percent, and the flow gradient is 0.0014, groundwater flow velocities in the sand and gravel facies range from 48 to 67 feet/day. However, hydraulic conductivity testing of samples of the silt and silty sand facies near the groundwater table indicate much lower groundwater velocities in that portion of the aquifer. With hydraulic conductivities ranging from 0.006 to 38.5 feet/day, porosities ranging from 25 to 50 percent and a flow gradient of 0.0014, groundwater flow velocities in the silt and silty sand facies range from 0.000017 to 0.2 foot/day.

2.4 Site Impacts

In most areas of the Site, the impacts were limited to surface soils and did not migrate to groundwater. However, in the area of the Black Tank, Black Tank Sump, and the Chemical Solution Pipelines and Dispensers, the COCs migrated in narrow vertical columns through the surface soil and the intermediate soil to the groundwater table where it formed LNAPL in the smear zone soil and an intermittent dissolved-phase plume. Figure 2-4 is a north-south cross-sectional view showing the vertical and horizontal extent of impacts. Figure 2-5 shows a plan view of current soil and groundwater LNAPL and TPH-D/HO impacts. The following subsections describe the media (i.e., surface soil, intermediate soil, LNAPL, and groundwater) having COCs exceeding CULs.

2.4.1 Surface Soil

Surface soil (0 to 15 feet bgs) samples defined five areas where COCs (TPH-D/HO, cPAHs, and naphthalenes) exceeded CULs. These areas are defined as SSA-1 through SSA-5 (Figure 2-2). SSA-1, SSA-4, and SSA-5 and a portion of SSA-2 were excavated as part of the first phase of the surface soil interim action (see Section 2.2.2 and Figure 2-2). The western part of SSA-2 and all of SSA-3 remain as they are beneath or within the setback areas of active rail lines (Figure 2-2) and will be excavated once rail realignment is complete.

2.4.2 Intermediate Soil and Mobile LNAPL

Intermediate soils are defined as vadose zone soils that extend from below the surface soils (i.e., greater than 15 feet bgs) to the top of the smear zone (approximately 156 feet bgs; 1,883 feet amsl). Analytical data from intermediate soil samples demonstrates that concentrations of COCs (i.e., TPH-D/HO) exceed the residual-saturation-based CUL (5,630 mg/kg)¹ applicable to intermediate soil. Figure 2-1 shows a plan view of intermediate soils exceeding the CULs; it encompasses the former area of the Black Tank, Black Tank Sump, and Chemical Solution Pipelines operations. Figure 2-4 illustrates the vertical extent of the intermediate soils exceeding the CULs.

2.4.3 Smear Zone Soil and Mobile LNAPL

The smear zone soil extends from 156 to 185 feet bgs (i.e., 1,883 to 1,854 feet amsl) and straddles the high and low groundwater elevations (Figure 2-4). Analytical data from the smear zone soil samples demonstrate TPH-D/HO impact above CULs. Measurable LNAPL is present in some groundwater monitoring wells having screens that straddle the smear zone.

The Interstate Technology and Regulatory Council defines mobile LNAPL as LNAPL that will accumulate in a well; therefore, the basis of the areal extent of mobile LNAPL at the Site is the presence or absence

of measurable LNAPL in monitoring wells. As illustrated on Figure 2-1, there are two areas of mobile LNAPL; the main mobile LNAPL area covers approximately 5.8 acres and the small mobile LNAPL area covers approximately 0.2 acre. The lateral extent of the mobile LNAPL areas (based on the presence/absence of LNAPL in monitoring wells) has not increased since thickness gauging began in 2014.

The main mobile LNAPL area is divided into three subareas to reflect the relative time needed to remediate each area. The mobile LNAPL area encompassing the historically thickest accumulations of LNAPL is expected to take the longest time to achieve remediation goals, and is identified as the high restoration timeframe (RTF) area. The mobile LNAPL area having greater than 1 foot of measureable LNAPL, but excluding the high RTF area, is the medium RTF area, and the area having less than 1 foot of measureable LNAPL is the low RTF area (Figure 2-5). Estimates of the volume of mobile LNAPL in each RTF area based on the size of each area, the gauged LNAPL thicknesses measured in monitoring wells in March 2016, and estimates of the porosity and percent mobile LNAPL saturation were presented in the RI/FS report (ERM 2017) and are summarized in Table 2-1.

Since completion of the RI, additional LNAPL thickness gauging data has been collected and a more rigorous evaluation of the data has been performed as follows:

- LNAPL thicknesses were gauged in monitoring wells quarterly from 2016 through 2018 and semi-annually from 2019 through 2020, and seasonal and long-term trends in gauged LNAPL thicknesses were evaluated.
- Three additional water table monitoring wells (MW-22R, MW-23R, and MW-31) were constructed in the mobile LNAPL area and LNAPL thicknesses were gauged in those wells in September 2020.
- Hydrostratigraphic and gauged LNAPL thickness data from monitoring wells were evaluated to assess whether the LNAPL at each monitoring well is under unconfined, confined, and/or perched conditions, and whether those hydrostratigraphic conditions exaggerate the gauged LNAPL thickness in the well relative to the actual thickness of mobile LNAPL in the formation.
- The estimated volume of mobile LNAPL in each RTF area was updated based on the updated size of each area and the gauged LNAPL thicknesses measured in monitoring wells in September 2019.

Post-RI LNAPL gauging data is presented in Table 2-2. Figures 2-6 and 2-7 show changes in gauged LNAPL thicknesses over time and seasonally for monitoring wells having LNAPL thicknesses greater than, and less than, 1 foot of LNAPL, respectively. Appendix A presents an evaluation of the hydrostratigraphic data from the monitoring wells with measurable LNAPL.

Since March 2016, when the improved LNAPL thickness gauging procedure and LNAPL recovery from the wells was first instituted, gauged LNAPL thickness has generally decreased at monitoring wells having LNAPL thicknesses greater than 1 foot (Figure 2-6). As of September 2019—the last monitoring event that included all of the monitoring wells—four of the wells historically having LNAPL thicknesses greater than 1 foot (MW-03, MW-04, MW-17, and MW-20) had lower gauged LNAPL thicknesses than in March 2016. Only MW-07 had a higher gauged LNAPL thickness in September 2019 than in March 2016. As of September 2020, MW-03, MW-04, MW-07, and MW-17 have LNAPL thicknesses less than 1 foot (Figure 2-6). MW-20 was decommissioned following the September 2019 monitoring event. MW-20 and MW-03 demonstrated the largest decreases in gauged LNAPL thickness between March 2016 and September 2019. The gauged LNAPL thickness at MW-20 decreased from 9.34 feet to 3.36 feet from March 2016 to September 2019, and the gauged LNAPL thickness at MW-03 decreased from 8.55 feet to 0.11 foot from June 2016 to September 2020 (Figure 2-6).

Figure 2-7 shows gauged LNAPL thickness at monitoring wells having LNAPL thicknesses less than 1 foot have been generally stable since March 2016. Notable exceptions are:

- MW-19 decreased from 1.27 feet to 0.02 foot from March 2016 to September 2019. The well was decommissioned following the September 2019 monitoring event, and
- MW-01 increased from 0.03 foot to 1.2 feet from March 2016 to September 2020.

Overall, data indicate a decrease in gauged LNAPL thickness since March 2016. This decrease is attributable to the revised LNAPL gauging method yielding more accurate and verified LNAPL thickness data, natural source zone depletion (NSZD), and LNAPL recovery.

Post-RI data was used to update the lateral extent of the RTF areas. The updates include:

- Extending the medium RTF area to the southeast to include MW-01 because recent gauging of that well consistently showed LNAPL thicknesses greater than 1 foot, and
- Identifying a potential future contracting of the northwestern extent of the low RTF area to exclude new monitoring well MW-22R since there was no measurable LNAPL at that well. However, the well has only been gauged once and additional gauging is needed to verify the presence or absence of mobile LNAPL at that location, before making any adjustment to the low RTF area.

The updated RTF areas are shown on Figure 2-5. The only update considered for designing the remedial action is expanding the medium RTF area to include MW-01.

The hydrostratigraphic evaluation (Appendix A) demonstrates that the LNAPL is generally under unconfined conditions.³ Therefore, the gauged thicknesses measured in monitoring wells or determined from the volume of LNAPL removed from the wells is generally representative of the formation thickness of mobile LNAPL. However, five of the monitoring wells (MW-2, MW-3, MW-7, MW-18, and MW-20) occasionally exhibited perched LNAPL conditions. Research by Kirkman et al. (2013) and Reyenga and Hawthorne (2015) demonstrated that perched LNAPL conditions can result in exaggerated gauged LNAPL thicknesses. Appendix A describes the LNAPL conditions identified at each of the monitoring wells and the data used to identify those conditions.

MW-2, MW-3, MW-7, and MW-18 exhibit perched LNAPL conditions when the groundwater table drops below the top of a confining layer situated near the bottom of their normal groundwater fluctuation intervals. These low groundwater conditions only occur in the late summer and fall of dry years; thus, the perched conditions are an occasional seasonal condition and not the norm (Appendix A). The wells exhibit unconfined conditions during most seasons, and the gauged LNAPL thickness data from those seasons are not exaggerated. However, the occasional spike in gauged LNAPL thickness observed at these wells is likely the result of seasonal perched LNAPL conditions.

MW-20 has three silt confining layers, one of which is 2.5 feet thick, within its normal groundwater fluctuation interval (Appendix A; Figure A-11). Based on staining and fluorescence data from the MW-20 soil core samples, LNAPL is present above, between, and within these potential confining layers (Appendix A). The top of the LNAPL layer is consistently above these potential confining layers. However, the LNAPL/groundwater interface was below the top of the 2.5-foot-thick potential confining layer from March 2016 through March 2018 and above it from June 2018 through September 2019. These data indicate MW-20 had perched LNAPL conditions and exaggerated gauged LNAPL thicknesses from March 2016 through March 2018 and unconfined LNAPL conditions with no exaggerated gauged LNAPL thicknesses from June 2018 through September 2019 (Appendix A: Table A-1 and Figure A-11).

³ The site data show that the aquifer is generally unconfined with respect to both groundwater and LNAPL. However, it exhibits perched LNAPL conditions in localized areas during certain groundwater level conditions. In the same aquifer materials, groundwater may migrate vertically with little or no restriction, displaying unconfined conditions; whereas, the presence of residual LNAPL in the pore space of the aquifer materials and the higher viscosity and capillary limitations of LNAPL may restrict its vertical migration, resulting in perched LNAPL conditions.

Although occasional perched LNAPL conditions at MW-2, MW-3, MW-7, and MW-18 exaggerate some of the gauged LNAPL thicknesses at those wells, most of the gauged LNAPL data from those wells are not exaggerated. Correcting the exaggerated data results in relatively modest changes in the reported LNAPL thicknesses for those wells, and the changes do not affect the footprint of the LNAPL RTF areas. Similarly, the perched LNAPL conditions at MW-20 from March 2016 through March 2018 exaggerate the gauged LNAPL thicknesses from that period, but the unconfined LNAPL conditions from June 2018 through September 2019 yield gauged LNAPL data for MW-20 that are not exaggerated. The actual formation thickness of LNAPL at MW-20 can be determined from the June 2018 through September 2019 well data (1.87 to 2.46 feet). Correcting the exaggerated LNAPL thicknesses reported at MW-20 does not affect the footprint of the LNAPL RTF areas, but it does reduce the estimated volume of mobile LNAPL in that general area.

Updated baseline LNAPL viscosity and transmissivity were collected during the pre-design investigation. Those data and an updated estimate of the volume of mobile LNAPL are described in Section 4.

2.4.4 TPH-D/HO Groundwater Plume

TPH-D/HO concentrations exceeding the CULs are occasionally detected in groundwater samples from monitoring wells immediately cross-gradient (MW-15 and MW-24) and/or downgradient (MW-11, MW-16, and MW-22) of the mobile LNAPL area (Figures 2-1 and 2-5). The TPH-D/HO in groundwater is a combination of petroleum hydrocarbons released from the LNAPL and petroleum metabolites generated from biodegradation of the LNAPL. Analyses with and without silica gel cleanup (SGC) demonstrates that the TPH-D/HO concentrations in groundwater include petroleum metabolites from LNAPL biodegradation. It appears that groundwater TPH-D/HO concentrations mostly appear in the spring and early summer, possibly the result of groundwater rise and liberation of metabolites generated from biodegradation of LNAPL in the upper portion of the smear zone. This typically results in the TPH-D/HO plume expanding in downgradient (and occasionally cross-gradient) directions during the spring and summer, and generally contracting in the fall and winter. Petroleum metabolites are highly degradable (Zemo et al. 2016); therefore, it is unlikely that they will extend north past Wellesley Avenue at concentrations exceeding the CUL.

2.5 Natural Source Zone Depletion

To estimate baseline NSZD rates carbon dioxide (CO₂) soil flux monitoring (carbon traps and carbon flux chambers), metabolic gas monitoring, and groundwater NSZD parameter data were collected during the RI. The NSZD data and evaluation are presented in the RI/FS report (ERM 2017). The evaluation concludes that the NSZD rates for: (1) the vadose zone soil ranges from 229 to 1,681 gallons of hydrocarbons per acre per year (gal HC/acre-yr) with an average of 791 gal HC/acre-yr, and (2) the saturated zone ranges from 6.4 to 73 gal HC/acre-yr with an average of 43 gal HC/acre-yr. No post-RI NSZD data have been collected; therefore, the baseline NSZD rates have not been updated.

2.6 North Spokane Corridor Project

The NSC project involves construction of the remaining 5 miles of a 10.5-mile-long freeway (U.S. Route 395) running north-south along the eastern border of Spokane. WSDOT's alignment for the freeway places part of it over the Site's western portion. WSDOT, BNSF, and Ecology coordinated plans to allow freeway construction and remediation to proceed with minimal interference. The part of the NSC project that affects the timing of the remedy construction includes:

- Rerouting existing active rail lines to areas east and west of the planned freeway corridor;

- Rerouting the access road that currently accesses the Site and Western States Asphalt, Inc. from the north (Wellesley Ave) to access the east via E. Rich Avenue and N. Ferrall Street;
- Constructing a new interchange for Wellesley Avenue immediately north of the Site;
- Constructing the freeway through the Site's west-central portion and a bike and pedestrian path west of the rail realignment;
- Constructing sound barriers or fences along the eastern and western boundaries of the NSC corridor; and
- Restricting access to the NSC corridor during, and following completion of, the project.

WSDOT's final alignment for the NSC covers slightly more than the Site's western half; however, it avoids most of the area having the highest mass of COCs (i.e., the high RTF LNAPL and intermediate soil areas). Figure 2-8 shows the currently proposed NSC alignment relative to the impacted areas.

WSDOT initiated construction of the on-Site portion of the NSC project in early 2020. Their current forecast for completion is 2024.

The NSC project constrains the remedy as follows:

- Phase 2 of the Shallow Soil Interim Action cannot be performed until rail realignment is completed, which will allow access to the remaining impacted soil and infrastructure.
- Existing monitoring wells located in or near NSC construction elements (freeway, rail lines, etc.) were decommissioned and some replacement wells were constructed. Additional replacement wells are proposed in the CMP for construction in the accessible areas.
- Accessibility for installation, operation, maintenance, and monitoring of active remediation systems is limited because of access restrictions in the NSC corridor.
- Installation of active remediation systems cannot be initiated until after WSDOT completes the on-Site portion of the NSC project.

Phase 2 of the Shallow Soil Interim Action involves removing and disposing of the remaining impacted surface soil and associated underground piping and concrete infrastructure at SSA-2 and SSA-3. As illustrated on Figure 2-2, the western part of SSA-2 and all of SSA-3 were not excavated during Phase I of the Shallow Soil Interim Action because they are beneath or within the setback areas of active rail lines. Removal of this soil and infrastructure will be performed after rail realignment is complete, and the soil and infrastructure beneath the former rail lines is accessible. Based on the NSC project schedule for rail relocation, the area for Phase 2 of the Surface Soil Interim Action will be accessible in mid to late 2021.

In June 2020, WSDOT and BNSF determined that 14 existing monitoring wells required decommissioning to accommodate construction of the NSC project. Wells were decommissioned in September 2019 (ERM 2019b). Table 2-3 summarizes the decommissioned wells and Figure 2-8 shows their locations.

Ecology, WSDOT, and the PLPs previously agreed that no wells or other remediation infrastructure would be installed if that infrastructure would potentially require removal or relocation to accommodate WSDOT access and work for the NSC. Accordingly, the fences depicted in the drawings of the NSC project are located on the edge of their permanent easement for the NSC project. Placement of remediation system infrastructure outside the fence is acceptable without WSDOT involvement.

2.7 Active BNSF Rail Lines

The NSC includes active BNSF rail lines on the east and west sides of the freeway. The presence of these active rail lines poses safety hazards that restrict work on or near the rail lines. The requirements for work on BNSF property are presented in BNSF's General Safety Requirements (Appendix G of the HASP). All remediation system infrastructure should be located more than 25 feet from the nearest rail.

3. CLEANUP ACTION PLAN

3.1 Goals of the Remedy

The selected remedy will protect human health and the environment from indicator hazardous substances (referred to previously in this document as COCs) exceeding CULs at the Site. As part of a cleanup action plan cleanup levels are set for indicator hazardous substances rather than COCs. The remedy will be conducted in accordance with MTCA regulations (WAC 173-340).

Ecology has established an overall RTF of 20 years. However, it is generally agreed that cleanup standards should be attained as quickly as practicable. The initiation of the RTF starts following construction, start-up, and an initial period of shakedown for the selected remedy. The 20-year RTF is intended to be the measure by which Ecology will evaluate performance of the selected remedy alternatives.

3.2 Cleanup Standards

Per MTCA, the components of cleanup standards are CULs, points of compliance, and all applicable or relevant and appropriate requirements (ARARs) based on local, state, and federal laws and associated regulations.

3.2.1 Cleanup Levels

A CUL is the concentration at which a substance does not threaten human health or the environment. The process for establishing CULs for the impacted media is presented in the CAP (Ecology 2018a). Tables 3-1 and 3-2 present the final CULs for groundwater and soil, respectively.

Ecology's residual saturation-based CUL for TPH-D/HO in subsurface soils (i.e., below 15 feet bgs) is 5,630 milligrams per kilogram. It is, however, understood that residual saturation varies. Therefore, the TPH-D/HO CUL for subsurface soil is used to identify areas requiring remedial action, but compliance with the cleanup standards will be based on the absence of LNAPL in monitoring wells (and not on TPH-D/HO concentrations in subsurface soils).

A mobile LNAPL thickness of 1 foot or greater has been established as a screening level for where active cleanup technologies will be used for mobile LNAPL. This screening level is not the LNAPL CUL. The screening level is set higher than the CUL and is used to focus more aggressive cleanup technologies (and/or a contingent cleanup technology) on areas having the highest accumulations of mobile LNAPL.

3.2.2 Points of Compliance

Points of compliance are the locations where CULs must be met. Standard points of compliance are applicable. The standard point of compliance for groundwater CULs will be all groundwater beneath the Site from the top of the saturated zone to the lowest depth that could be affected by the Site. The standard point of compliance for surface soil (based on protection of the direct contact pathway) is all soil from ground surface to a depth of 15 feet. The standard point of compliance for soil CULs based on protection of groundwater is the entire soil column beneath the Site.

3.2.3 Applicable or Relevant and Appropriate Requirements

MTCA requires that all remedies comply with local, state, and federal ARARs. Table 3-3 presents the final Site ARARs. The CAP provides detail regarding compliance with the ARARs and an exemption from procedural requirements for remedies conducted under a consent decree.

3.3 Who Will Own, Operate, and Maintain the Remedy

As the identified PLPs, BNSF and Husky will own the remedy and will be responsible for operation and maintenance during and following construction. BNSF and Husky will procure contractors to implement the remedy, including operating, maintaining, and monitoring any remediation systems, on their behalf.

3.4 Description of Selected Remedy

Ecology selected the remedy described in the CAP because it will be protective of human health and the environment and is consistent with the preference for permanent solutions stated in RCW 70.105D.030(1)(b). The components of the selected remedy are described in the CAP and summarized in the following subsections.

3.4.1 Excavation of Impacted Surface Soil

The selected remedy for surface soil is excavation of impacted soil exceeding CULs to depths of 15 feet bgs. Excavation will occur in the five impacted surface soil areas (SSA-1 through SSA-5) identified in the RI and shown on Figure 2-2. A substantial portion of this work (i.e., excavation of SSA-1, SSA-4, SSA-5, and the eastern half of SSA-2) was completed as Phase 1 of the Surface Soil Interim Action. That work is described in Section 2.2.2 and illustrated on Figure 2-2. Phase 2 of the Surface Soil Interim Action will involve removing and disposing of the impacted surface soil and associated underground piping and concrete infrastructure that was not addressed during Phase I (i.e., the western part of SSA-2 and all of SSA-3).

3.4.2 Bioventing/Biosparging in High and Medium Restoration Timeframe Areas

The selected remedy for deep impacts in the high and medium RTF areas are BV and BS, which involve the injection of air into subsurface soil and groundwater, respectively. These remedial technologies accelerate the natural biodegradation processes normally achieved by NSZD in the unsaturated and saturated zones. A preliminary conceptual layout of the BV/BS system was provided in the FS report and is included herein as Figure 3-1. The preliminary BV/BS system layout as presented in the FS was designed considering:

- WSDOT's 2016 draft NSC alignment available at the time of the FS
- Gauged LNAPL thickness data from March 2016
- Assumed BV and BS radius of influence (ROI)

Figure 3-1 also highlights the difference between the NSC freeway layout during the conceptual layout of the BV/BS system and the layout in WSDOT's current NSC freeway design drawings.

Monitoring in the medium and high RTF areas of respiration rate, LNAPL viscosity, LNAPL transmissivity, gauged LNAPL thickness, mobile LNAPL mass, and TPH-D/HO concentrations in groundwater will be used to:

- Assess performance of the BV/BS systems relative to achieving CULs in the medium and high RTF area within the 20-year RTF and inform system optimization decisions.
- Determine whether portions of the medium and high RTF areas can transition to the low RTF area and from active remediation to NSZD.
- Assess whether achieving CULs in the high RTF area within the 20-year RTF is at material risk, and implementation of the contingent remedy should be considered.
- Determine if CULs have been achieved and active remediation can be terminated.

Per the CAP, the full range of monitoring parameters described above is needed to assess BV/BS performance. Respiration rates will provide the earliest and most consistent indication of BV/BS performance over the course of the remedy. The next monitoring parameters expected to show changes are LNAPL viscosity and transmissivity, resulting from biodegradation changing the composition and physical character of the LNAPL. Increases in TPH-D/HO concentrations (without SGC) in groundwater are also anticipated as enhanced biodegradation of the LNAPL results in increased petroleum metabolite concentrations. Reductions in gauged LNAPL thickness, mobile LNAPL mass and TPH-D/HO concentrations (with SGC) in groundwater may not occur early in the operation of the BV/BS system, but will follow when sufficient biodegradation has occurred to exhibit measurable changes in mobile LNAPL. Because the monitoring parameters have differing response times, a holistic evaluation of the monitoring data, based on the weight of the evidence, is needed to assess BV/BS performance with gauged LNAPL thickness being the current regulatory performance metric.

If monitoring indicates that the 20-year RTF is at risk, optimization of the BV/BS systems will be performed. Optimization techniques could include changing and/or increasing the air flow to existing wells, cycling, combining air injection with extraction in a push-pull configuration, increasing the density of BV and/or BS wells, bioaugmentation, and/or heated bioventing. Optimization, if needed, will be performed in a sequential manner, and each optimization step will be evaluated over a reasonable period of time before moving to the next optimization step.

The BV/BS systems must be operated until mobile LNAPL is no longer present in the high and medium RTF areas, or until no appreciable increase in the destruction of indicator hazardous substances over that of NSZD is attained, so long as cleanup standards for mobile LNAPL and dissolved-phase impacts will be achieved within the 20-year RTF.

Dissolved-phase groundwater treatment may be required if monitoring indicates the dissolved-phase plume poses a material risk of: (1) significantly increasing off-Site size and/or magnitude, or (2) not achieving the dissolved-phase groundwater cleanup standards within the 20-year RTF.

BS wells (or other applicable remedial technologies) may be constructed in other areas of the Site as needed to address the dissolved-phase groundwater plume.

3.4.3 Natural Source Zone Depletion in Low Restoration Timeframe Area

The selected remedy for deep impacts in the low RTF area is NSZD, which are the natural biodegradation processes normally achieved in the unsaturated and saturated zones. Monitoring of NSZD rates will be achieved for the saturated zone using groundwater NSZD parameter data and for the unsaturated zone using discrete vertical intervals of thermal and/or soil vapor data, and/or CO₂ soil flux data from carbon traps and/or carbon flux chambers. These data along with LNAPL viscosity, LNAPL transmissivity, gauged LNAPL thickness, and mobile LNAPL mass data will be used to assess:

- Progress of the remedy
- Whether achieving the CULs in the low RTF area within the 20-year RTF is at material risk

NSZD monitoring is not meaningful in areas where active remediation (e.g., the influence of the BV/BS systems) results in enhanced biodegradation rates. Those areas, which may include all or parts of the low RTF area, will be included in the BV/BS performance monitoring and not in NSZD monitoring. However, when active remediation no longer impacts (i.e., the BV/BS systems are no longer adding oxygen to the subsurface) an area with measureable LNAPL and/or TPH-D/HO concentrations exceeding CULs in groundwater, NSZD monitoring will be implemented in that area.

3.4.4 Institutional Controls and Environmental Covenant

The selected remedy includes institutional controls that may be necessary to limit or prohibit activities that interfere with the integrity of the remedies or result in exposure to hazardous substances, as described in Section 7.5 of the CAP and Section VI.6 of the CD. Institutional controls are measures undertaken to limit or prohibit activities that may interfere with the integrity of a remedy or result in exposure to hazardous substances. Such measures are required to assure both the continued protection of human health and the environment and the integrity of the remedy whenever hazardous substances remain at concentrations exceeding applicable CULs. Institutional controls can include both engineering and administrative controls.

Institutional controls will include an Environmental Covenant prohibiting excavation of impacted soil or the extraction of impacted groundwater for purposes other than remediation, and restricting future activities and uses of the Site as agreed to by Ecology and BNSF. The Environmental Covenants will be prepared consistent with WAC 173-340-440, RCW 64.70 (Uniform Environmental Covenants Act), and any policies or procedures specified by Ecology. The Environmental Covenant for affected properties will be recorded with the office of the Spokane County Auditor. Institutional Controls and an Environmental Covenant are further discussed in Section 6.4.

3.4.5 Contingent Remedy—Steam Enhanced Extraction

Ecology selected SEE as a contingent remedy for the high RTF area. If performance monitoring conducted following optimization efforts in the high RTF area demonstrate that achieving CULs in that area within the 20-year RTF is at material risk, Ecology will consider implementation of the contingent remedy in that area. The tasks to be implemented and the decision-making process for system optimization and contingent remedy implementation are described in Sections 7.3 and 7.3.3 of the CAP. The decision-making process was designed by the PLPs and Ecology to encourage continuous improvement and adaptive management of the remedy to achieve the cleanup standards within the 20-year RTF. If the contingent remedy must be pursued, then a work plan for pilot testing SEE will be prepared and will include a steam propagation test (SPT). In a letter dated 3 August 2020, Ecology approved combining the SPT with the SEE pilot test, if needed. However, those tests will be performed only if work completed per the CD SOW determines that the contingent remedy is necessary. If the SEE pilot test and SPT are performed and the results demonstrate that SEE is technically feasible based on the criteria established in the CAP, the PLPs will prepare a supplemental EDR for the contingent remedy. Therefore, the contingent remedy is not considered further in this EDR.

4. RESULTS OF PRE-DESIGN INVESTIGATIONS

Pre-design investigations were performed to collect: (1) data needed to inform the design of the BV/BS system, and (2) updated critical baseline data. The investigations included BV/BS ROI testing and updated baseline LNAPL parameter testing. The objectives, scope of work, and procedures for the investigations are presented in the final *Deep Contamination Cleanup Action Design Parameters Work Plan* (DPWP; ERM 2020). The following sections summarize the scope of the investigations and present the results and conclusions drawn from those investigations.

4.1 BV/BS Radius of Influence Tests

BV/BS ROI testing was designed to collect data that informs the ROIs that can be achieved by BV in the vadose zone soil and by BS in the saturated zone soil and groundwater. BV ROI testing was performed by injecting air into a BV injection well and monitoring parameters in BV performance monitoring wells situated at various distances from the injection well. BS ROI testing was performed using similar procedures, but with a BS injection well and BS performance monitoring wells. To avoid having the two tests interfere with each other, they were performed at different times and in different areas of the Site.

4.1.1 Bioventing Test

A BV air injection compressor and associated process piping and gauges were used for the BV ROI testing. The well array consisted of MW-08 for air injection, and new monitoring wells MW-22R and MW-23R and existing monitoring wells MW-05, MW-07, and MW-09 for performance monitoring. As shown on Figure 4-1, the performance monitoring wells are situated at distances from the BV injection well of 32 feet (MW-23R), 68 feet (MW-07), 96 feet (MW-22R), 114 feet (MW-09), and 124 feet (MW-05). A cross-sectional view of the BV ROI testing area (Figure 4-2) shows that the BV injection well and all of the performance monitoring wells had exposed screen above the top of the mobile LNAPL layer. Thus, all of the wells were suitable for use in the BV ROI test. The soil boring, well construction, and well development logs for the new wells (MW-22R and MW-23R) are included in Appendix B. Photographs of the BV test equipment are included in Appendix C.

The following two BV ROI tests were performed:

■ Pressure versus Flow Rate Step Test

A step test was conducted at the BV injection well by slowly increasing air pressure and monitoring the injection flow rate. Flow rates were increased by adjusting the pressure and flow control valves on the test manifold in steps of 20, 40, 65, 80, and 110 standard cubic feet per minute (scfm), with each step conducted over approximately 90 minutes. Helium was injected at an approximate concentration of 1 percent by volume for the duration of the step test. Wellhead concentrations of helium, oxygen, CO₂, and methane as well as pressure and flow were collected at the performance monitoring wells.

■ Sustained BV Test

The step test results indicated that 110 scfm was the optimal flow rate for the sustained test (Figure C-1 in Appendix C). A 4-day sustained BV test began immediately following collection of the final step test data. Helium was injected at an approximate concentration of 1 percent by volume for the first 24 hours of the sustained test. After completion of the 4-day test, the flow was increased to 150 scfm and the system was monitored for a little less than a day. Air injection was then stopped. Wellhead concentrations of helium, oxygen, CO₂, and methane as well as pressure and flow were collected at the performance monitoring wells throughout the sustained BV tests and for 2 days after air injection ceased.

4.1.1.1 Performance Monitoring

Monitoring at the performance monitoring wells occurred approximately every 2 to 3 hours during the step and sustained BV tests. Before each round of monitoring, at least one well volume of air was purged from each performance monitoring well. Performance monitoring data from the BV tests is summarized in Table C-1 in Appendix C. Although monitored, pressure and flow changes were not observed at any of the performance monitoring wells during the BV tests.

Notable results from the monitoring of wellhead concentrations of helium, oxygen, CO₂, and methane during the BV tests are summarized as follows:

- Pre-air injection readings from the performance monitoring wells show detectable concentrations of methane (0.3 to 3.2 percent), low concentrations of oxygen (0 to 16.5 percent) relative to atmospheric levels (20.9 percent), and high concentrations of CO₂ (3.1 to 6.2 percent) relative to atmospheric levels (0.04 percent). These data indicating anaerobic conditions indicative of petroleum biodegradation were present in the LNAPL smear zone throughout the test area prior to initiating the BV test.
- Oxygen concentrations increased from 0.7 to 21.5 percent at MW-23R, from 16.5 to 20.2 percent at MW-07, and from 0.2 to 6.4 percent at MW-22R during the 4-day sustained BV test (Table 4-1 and Figure 4-3). The oxygen concentrations at these performance monitoring wells increased further during the subsequent higher flow rate period. No substantive changes in oxygen concentration were observed at MW-9 and MW-5 during the BV testing (Table 4-1).
- CO₂ concentrations decreased from 3.2 to 0.3 percent at MW-23R and from 3.1 to 1.6 percent at MW-07 during the 4-day sustained BV test (Table C-1 in Appendix C). The CO₂ concentrations at these performance monitoring wells decreased further during the subsequent higher flow rate period. No substantive changes in CO₂ concentration were observed at MW-22R, MW-9, and MW-5 during the BV testing (Table C-1 in Appendix C).
- Helium (the tracer gas injected at MW-8) was observed at MW-23R (32 feet from MW-8) approximately 1 day after starting the sustained BV test, and at MW-07 (68 feet from MW-8) approximately 2 days after starting the sustained BV test (Table C-1 in Appendix C). Although helium injection was terminated before the beginning of the second day of the sustained test, helium concentrations increased through part of the second day and into the third day at MW-23R and MW-07, respectively (Table 4-2, Figure 4-4). No helium was detected at MW-22R, MW-9, or MW-5 during the BV testing (Table C-1 in Appendix C).
- Methane concentrations decreased from 3.2 to 0.3 percent at MW-23R, from 3 to 1.8 percent at MW-22R and from 0.4 to 0.3 percent at MW-7 during the 4-day sustained BV test (Table C-1 in Appendix C). No sustained changes in methane concentration were observed at MW-9 and MW-5 during the BV testing (Table C-1 in Appendix C).

The BV test data demonstrate that 4 days of injecting air at a rate of 110 scfm into the vadose portion of the LNAPL smear zone via BV injection well MW-8 produced:

- Increased oxygen concentrations in the LNAPL smear zone out to at least 96 feet (at MW-22R)
- Decreased CO₂ concentrations in the LNAPL smear zone out to at least 68 feet (at MW-07)
- Detectable helium tracer gas in the LNAPL smear zone out to at least 68 feet (at MW-07)
- Decreased methane concentrations in the LNAPL smear zone out to at least 96 feet (at MW-22R)

The test data trends also indicate that impacts of the air injection had not reached steady state and were still expanding outward when the 4-day sustained test was terminated. Moreover, the increased flow rate

tested after the 4-day sustained test indicated that faster outward expansion of the impacts could be achieved under higher flow rates. Lastly, the data demonstrate that only 4 days of air injection were needed to transition the LNAPL smear zone at MW-23R (32 feet from the injection well) from anaerobic to aerobic degradation.

To determine the maximum ROI for a BV injection well operating at a flow rate of 110 scfm, an ROI versus time model was created from equation 2-27 of the U.S. Army Corp of Engineers *Soil Vapor Extraction and Bioventing Manual* (USACE 2002). The equation uses air flow rate, estimated soil porosity, and vertical air distribution thickness to predict ROI. The model was calibrated to fit the pilot test data by adjusting the vertical flow distribution thickness. The model backup is included in Appendix E, and the calibrated results of the model are illustrated on Figure 4-5.

The pilot test data calibrated model demonstrates that the ROI rate of increase starts declining (i.e., stabilizing to a maximum ROI) at approximately 225 feet and 20 days of operation. To determine the design ROI, a 1.5 to 1.8 safety factor was applied to the maximum ROI. Per the calibrated model, design ROIs of 125 and 150 feet would be achieved at 6 and 8 days of operation, respectively (Figure 4-5).

4.1.2 Biosparging Test

The BV air injection compressor and associated process piping and gauges were used for the BS ROI testing. The well array consisted of new BSI-1 for air injection, and new monitoring well MW-31 and existing monitoring wells MW-03, MW-04, and MW-05 for performance monitoring. As shown on Figure 4-6, the performance monitoring wells are situated at distances from the BS injection well of 11 feet (MW-31), 28 feet (MW-03), 60 feet (MW-04), and 133 feet (MW-05). A cross-sectional view of the BS ROI testing area (Figure 4-7) shows that the top of the BS injection well screen is approximately 22 feet below the groundwater/LNAPL interface and all of the performance monitoring well screens straddle the LNAPL layer. Thus, all of the wells were suitable for use in the BS ROI test. The soil boring, well construction, and well development logs for the new wells (BSI-1 and MW-31) are included in Appendix B.

The BS ROI testing included the following four tests:

- **Leak Test**

To confirm structural integrity of the BS injection well (BSI-1), flow was introduced slowly until the pressure reached 5 pounds per square inch (psi) (i.e., air depressing water table without breaking out into formation). Flow value was then shut to confirm air pressure could be maintained inside the casing. Pressure was maintained for the duration of the test (i.e., approximately 10 minutes), which demonstrated the integrity of BSI-1.

- **Breakout Pressure Test**

Breakout pressure was measured by slowly increasing the injection pressure until air began to flow into the formation. The breakout pressure was 9 psi.

- **Pressure versus Flow Rate Step Test**

A step test was conducted at BSI-1 by slowly increasing air pressure and monitoring the injection flow rate. Flow rate steps of 10, 20, 35, 65, and 75 scfm were used, with each step conducted over approximately 90 minutes. Helium was injected at an approximate concentration of 1 percent by volume for the duration of the step test. Wellhead concentrations of helium, oxygen, CO₂, and methane as well as pressure and flow were collected at the performance monitoring wells.

Groundwater quality parameters (e.g., dissolved oxygen (DO), oxidation-reduction potential, temperature, conductivity, pH, and turbidity) were recorded at performance monitoring wells MW-04

and MW-31 using an Aqua troll multi-meter. A transducer was installed in MW-03 instead of an Aqua troll multi-meter because field observations during the LNAPL gauging at MW-03 indicated that its well casing had a thick coating of high viscosity LNAPL that would prevent the Aqua troll from passing through the LNAPL layer to the groundwater. MW-5 had an insufficient thickness of groundwater for either an Aqua troll or a transducer; therefore, no monitoring of groundwater quality parameters was possible at that well.

■ Sustained Biosparging Test

The step test results indicated that 25 scfm was the optimal air flow rate for the sustained test (Figure C-2 in Appendix C). A 4-day sustained BS test began immediately following collection of the final step test data. Helium and sulfur hexafluoride (SF₆) were injected for the first 40 and 60 hours, respectively, of the sustained test. Helium was injected at an approximate concentration of 1 percent by volume and was monitored as a tracer gas in the unsaturated zone. SF₆ was injected at 0.5 liter per minute and was monitored as a tracer gas in groundwater. The performance monitoring wells were monitored for the same parameters as for the step test. Groundwater samples were collected for SF₆ analysis from the performance monitoring wells and the BS injection well approximately 18 hours after completion of the sustained BS test. The system was then restarted at an increased flow rate (approximately 75 scfm) for 4 hours to assess whether measurable oxygen changes would occur at MW-03. A second round of groundwater samples for SF₆ analysis was collected from the performance monitoring wells 2 weeks following completion of the sustained BS test.

4.1.2.1 Performance Monitoring

Vapor monitoring at the performance monitoring wells occurred every 2 to 3 hours during the step test and the sustained BS test. Before each round of sampling, at least one well volume of air was purged from each of the performance monitoring wells. Groundwater quality data collection was continuous at MW-04 and MW-31, and pressure monitoring was continuous at MW-03. Groundwater SF₆ samples were collected twice after completion of the sustained test. Performance monitoring data from the BS tests is presented in Tables C-1 and C-2 of Appendix C. Although monitored, flow and pressure changes were not observed at any of the performance monitoring wells during the BS tests.

Notable results from the vapor and groundwater monitoring during the BS tests are summarized as follows:

- Pre-air-injection readings from the performance monitoring wells demonstrate detectable concentrations of methane (0.2 to 0.5 percent), low concentrations of oxygen (0 to 12.4 percent) relative to atmospheric levels (20.9 percent) and high concentrations of CO₂ (7.0 to 16.9 percent) relative to atmospheric levels (0.04 percent). These data represent anaerobic conditions, indicating petroleum biodegradation was occurring in the LNAPL smear zone throughout the test area prior to initiating the BS test.
- SF₆ was detected in groundwater samples collected from MW-31 (i.e., 11 feet from the injection well) and MW-03 (i.e., 28 feet from the injection well). SF₆ was not detected in groundwater samples collected from any of the other performance monitoring wells. All of the SF₆ data are summarized in Table 4-3, and the detected results from MW-31 and MW-03 are illustrated on Figure 4-8.
- Dissolved oxygen concentrations increased from 0.05 milligrams per liter (mg/L) to 10.08 mg/L at MW-31 as the air injection rate at BSI-01 was increased from 0 to 75 scfm during the step test (Figure 4-9). Dissolved oxygen concentrations varied from 0.49 to 10.25 mg/L at MW-31 while the air injection rate at BSI-01 was maintained at 25 scfm for the 4-day sustained BS test (Figure 4-9). The DO concentration at MW-31 increased to 12.01 mg/L when the air injection rate at BSI-01 was increased to 75 scfm following the sustained BS test (Figure 4-9).

- Dissolved oxygen concentration changes indicative of impacts from the BS injection well were not observed in any of the other performance monitoring wells. However, DO monitoring could not be performed in MW-03 (i.e., 28 feet from the injection well) because the Aqua troll would not fit down the well, past the thick coating of high viscosity LNAPL adjacent to the smear zone.
- Other groundwater quality parameter (e.g., oxidation-reduction potential, temperature, conductivity, pH, and turbidity) results showed no changes indicative of impacts from the BS injection well in any of the performance monitoring wells.
- Vapor constituent (i.e., helium, oxygen, CO₂, and/or methane) results showed no changes indicative of impacts from the BS injection well in any of the performance monitoring wells.
- Groundwater level results showed no changes indicative of impacts from the BS injection well in any of the performance monitoring wells.

The BS test data demonstrate that injecting air at a rate of 25 scfm into BS injection well BV-01 produced:

- Increased DO in the saturated portion of the LNAPL smear zone out to at least 11 feet (at MW-31).
- Detectable SF₆ tracer gas in the saturated portion of the LNAPL smear zone out to at least 28 feet (at MW-03). Dissolved oxygen monitoring was not possible at MW-03; however, the presence of SF₆ at MW-03 is a clear indicator of BS influence.

Thus, a BS ROI can be conservatively estimated at 25 feet. A similar ROI (30 feet) was reported for the sparging system wells in the same aquifer at the North Market Street site (Ecology 2000, 2008). The performance monitoring data do not yield more lines of evidence for this ROI due to the influence of mobile LNAPL and low permeability soils in the saturated portion of the smear zone, on migration of vapors to the vadose zone where monitoring was performed. The increased, but inconsistent DO concentration trends observed at MW-31 during the 4-day sustained BS tests further suggest that air migration in the saturated zone is dynamic.

4.1.3 Updated Baseline LNAPL Parameter Testing

Updated baseline LNAPL parameter data were collected to ensure the design of the BV/BS system is based on data representing current conditions. The testing established baseline estimates of:

- Mobile LNAPL mass: The mass of mobile LNAPL was estimated in the RI/FS report; however, data collected during monitoring events subsequent to the RI/FS report were used to prepare an updated baseline estimate of mobile LNAPL mass. Mobile LNAPL mass is expected to decrease with time as a result of active cleanup and NSZD.
- LNAPL viscosity: LNAPL viscosity is a measure of LNAPL's resistance to flow and is expected to increase with time as a result of active cleanup and NSZD.
- LNAPL transmissivity: LNAPL transmissivity is an indicator of the potential for LNAPL to move through the formation—an indicator of mobility. Transmissivity is expected to decrease with time as a result of active cleanup and NSZD.

The procedures used for obtaining the updated baseline LNAPL data are described in the DPWP (ERM 2020).

4.1.3.1 Mobile LNAPL Mass

The estimate of mobile LNAPL mass was updated using the most current complete set of gauged LNAPL thickness data, which was collected during the September 2019 monitoring event. After that monitoring event, several LNAPL-containing monitoring wells (MW-18, MW-19, MW-20, MW-23, and MW-28) were decommissioned for NSC construction. To account for measurement and seasonal variations, the

standard deviation (SD - normal variation from the average) of LNAPL thickness measurements was calculated and used to estimate the upper 80th percentile (i.e., the mean plus 1 SD) of the updated mobile LNAPL mass estimate. Table 2-2 summarizes the updated mobile LNAPL mass estimate and the upper 80th percentile of the updated mobile LNAPL mass estimate. The backup calculations for these estimates are included in Appendix D.

An isopleth map of the September 2019 gauged LNAPL thickness data (i.e., updated vertical and horizontal extent of the mobile LNAPL) is included as Figure D-1 in Appendix D. The updated mobile LNAPL mass was calculated using the areas of the isopleths, the average LNAPL thickness represented by each isopleth and the formation porosity and percent mobile LNAPL saturation data reported in the RI. The data and the calculations are presented in Table D-1 of Appendix D. Notable updates from the RI estimates are as follows:

- Gauged LNAPL thickness at MW-01 increased to more than 1 foot; therefore, the medium RTF area was extended to the southeast to include that well. The result is that the medium RTF area is approximately 0.1 acre larger than indicated in the RI estimate.
- Gauged LNAPL thicknesses in all of the high RTF area wells (MW-3, MW-4, and MW-17) and the medium RTF well that previously demonstrated the largest gauged LNAPL thickness (MW-20) decreased substantively since the March 2016 monitoring event. This decrease has been documented in groundwater monitoring events from June 2016 through 2020.
- The mobile LNAPL estimate in the RI didn't include the LNAPL in the small low RTF area at MW-2.

The mean and SD of LNAPL thickness measurements for each LNAPL-containing well were calculated using gauging data collected from 2017 through 2020 (Table D-2). The SDs from all the LNAPL-containing wells was then averaged (Table D-2). This average SD was added the average LNAPL thickness in each RTF area (Table D-1) to account for normal thickness variation. The upper 80th percentile of the updated mobile LNAPL volume estimate was recalculated using the average LNAPL thickness plus 1 SD.

The mobile LNAPL volume estimate based on the September 2019 data is 90,000 gallons and the upper 80th percentile estimate is 130,000 gallons (Table 2-1). While this is a reduction of estimated mobile LNAPL volume of 29,000 to 69,000 gallons, most of the decrease is the result of having more accurate and verified gauged LNAPL thickness data in September 2019 than was available in March 2016. Most of the decrease is the result of lower gauged LNAPL thicknesses in the high and medium RTF areas (Table 2-1). By including the small low RTF area, the mobile LNAPL estimate for the low RTF area increased by a few thousand gallons. The remaining decrease in estimated mobile LNAPL volume can be attributed to NSZD and manual LNAPL removal.

4.1.3.2 LNAPL Viscosity

Updated baseline LNAPL viscosity data was established by collecting samples of LNAPL and testing them for viscosity: (1) in the field using a variation of ASTM International Standard D6910-04, *Standard Test Method for Marsh Funnel Viscosity of Clay Construction Slurries* (ASTM 2004), and (2) in the laboratory using ASTM Method D445-19 (ASTM 2019). The LNAPL samples were collected from monitoring wells situated within the mobile LNAPL plume (i.e., MW-01 through MW-05, MW-07, MW-09, MW-17, MW-22R, MW-23R, and MW-31).

For the field testing procedure, a funnel was selected that worked for all of the LNAPL types encountered at the Site and modified the testing procedure as needed to work efficiently for conditions. An updated standard operating procedure (SOP) for field viscosity testing that specifies the selected funnel and incorporates lessons learned from the pre-design testing is included in the CMP for use during future

performance monitoring. The field viscosity testing method allows for frequent and efficient viscosity data collection that can be periodically calibrated using laboratory viscosity testing.

The results of the field and laboratory viscosity tests are summarized in Table 4-4, and the laboratory test report is included in Appendix D. The field data include the temperature of the LNAPL sample and the time required for a set volume of LNAPL to pass through the field funnel (i.e., field sample test duration). The laboratory viscosity measured at 40 degrees Celsius (°C) for each sample was converted to viscosity at the field sample temperature (i.e., estimated field viscosity) using the Bunker C viscosity vs. temperature graph developed by WIN GD (2018). A Bunker C viscosity vs. temperature graph showing the converted viscosity results is included as Figure D-2 in Appendix D. The estimated field viscosity data are summarized in Table 4-4.

The laboratory viscosity tests for the pre-design investigation samples were performed at 40°C, whereas the laboratory viscosity tests for the RI samples were performed at 21°C (Table 4-4). To facilitate comparison, the RI viscosity data measured at 21°C was converted to viscosity at 40°C using the Bunker C viscosity vs. temperature graph developed by WIN GD (2018). A Bunker C viscosity vs. temperature graph showing the converted viscosity results is included as Figure D-3 in Appendix D. The converted viscosity results are summarized in Table 4-4.

The relationship of field sample test duration to estimated field viscosity is illustrated on Figure D-4 in Appendix D. The high correlation coefficient ($R^2 = 0.96$) for these data illustrated on Figure D-4 in Appendix D suggests that field sample test duration measurements can be reliably used to estimate field viscosity values. This relationship will be referenced in the CMP for use during future performance monitoring.

Evaluation of the LNAPL viscosity data demonstrates the following:

- The RI and pre-design investigation results are similar for the two wells from which LNAPL samples were collected and tested during both events (MW-01 and MW-03). The RI viscosities were converted for comparison and should be considered approximations; nonetheless, the results (412 and 500 centistoke (cSt) for MW-01, and 871 and 1,000 cSt for MW-03) are similar (Table 4-4).
- The viscosity at MW-03 is approximately twice the viscosity at MW-01 during both sampling events.
- The LNAPL sample collected from MW-31 exhibited the highest viscosity because the sample was too viscous to yield a laboratory test value.
- LNAPL viscosities are highest in the vicinity of the former Black Tank sump (i.e., MW-03, MW-04, and MW-31), decreasing a short distance from the core of the source area (i.e., MW-01, MW-02, MW-05, and MW-18), and lowest at the downgradient margin of the mobile LNAPL plume (i.e., MW-09 and MW-07). This observation suggests that the less viscous LNAPLs migrated the farthest from the source area.
- LNAPL at MW-17 is an outlier to the trend described above because it exhibited a low viscosity, but the sample location is situated between wells having LNAPL with the highest viscosities (i.e., MW-03, MW-04, and MW-31) and wells having LNAPL with intermediate viscosities (i.e., MW-01, MW-02, and MW-18).

4.1.3.3 LNAPL Transmissivity

LNAPL skimming tests were performed in monitoring wells MW-01 through MW-05, MW-07, MW-17, and MW-31 to update transmissivity estimates. Tests were not performed in new monitoring wells MW-22R and MW-23R because those wells contained little or no LNAPL. The manual skimming tests were performed over the course of 4 weeks and were concluded when at least one of the following conditions was achieved:

- Three consecutive well recharge rates were within 25 percent of each other and no consistently decreasing trend was observed;
- Insignificant LNAPL recovery occurred between removal events; or
- Four removal events had been performed.

The skimming test field data and calculated discharge rates are presented in Table D-3 of Appendix D.

The new skimming test data were used with equations 16 and 17 of ASTM Standard E2856-13 (ASTM 2013) to calculate updated baseline LNAPL transmissivities (Table 4-5). This is the same approach used to develop the baseline LNAPL transmissivities presented in the RI. The updated LNAPL transmissivity data were compared to transmissivity values provided in the RI and in the Interstate Technology & Regulatory Council (ITRC) LNAPL guidance documents (ITRC 2009a and 2009b). Evaluation of the transmissivity data demonstrates the following:

- Transmissivities are below the low end of the ITRC transmissivity range (i.e., 0.1 square foot per day) indicating hydraulic recovery of LNAPL is not practicable.
- MW-04 and MW-07 have updated transmissivities two orders of magnitude less than those observed during the RI.
- MW-03 has an updated transmissivity one order of magnitude less than that observed during the RI.
- MW-17 has an updated transmissivity consistent with that observed during the RI.

The reduction in transmissivities at MW-03, MW-04, and MW-07 are attributed to improved skimming test methods and NSZD in the high RTF area. The recent skimming tests occurred over 15 to 25 days, whereas the RI skimming tests occurred over 3 to 6 days. Additionally, the methods used for LNAPL removal and volume measurement are more consistent and reliable than those used during the RI. The longer test period and improved test methodology resulted in the updated transmissivity data being more reliable. An updated SOP for LNAPL skimming tests that specifies the selected test equipment and incorporates lessons learned from the pre-design testing is included in the CMP for use during future performance monitoring. Future tests will be conducted over a 15 to 25-day period, consistent with the recent testing, so results are representative and comparable.

5. CONCEPTUAL DESIGN OF BIOVENTING/BIOSPARGING SYSTEM

This section presents the 30 percent design for the BV/BS system, which is based on the design criteria and engineering concepts presented in this report. It is sufficient for the development of the next phase of engineering, which is the preparation of construction plans and specifications for the system.

5.1 Basis of Design

The basis of design for the bioventing and biosparging systems is to inject sufficient air into the high and medium RTF zones such that increased oxygen available to naturally occurring in-situ microorganisms stimulates enhanced biodegradation of mobile LNAPL and TPH-D/HO groundwater impacts to below cleanup standards. The remedial design and operations criteria have been established through consideration of multiple factors that influence the effectiveness and constructability of the remedy. The design was completed using industry standard engineering practices and calculation methods as well as local, state, and federal building codes and regulations.

The effectiveness of treatment, as it pertains to the successful stimulation of in-situ microbes and the resulting biodegradation of LNAPL, was considered when reviewing both the Site-specific hydrogeology data and the data collected during the BV and BS ROI tests. Specifically, design parameters such as the BV/BS air injection rates and well ROI were the result of evaluating field measurements (i.e., soil permeability, groundwater flow gradient, direction, and velocity, etc.) as well as the BV and BS ROI test data.

Initial respiration rates presented in the RI/FS (ERM 2016) indicate that the selected remedy will effectively reduce LNAPL mass through stimulated bioremediation to achieve the CULs within a 20-year RTF. However, baseline in-situ respiration tests (i.e., baseline NSZD testing in the saturated and unsaturated zones) will be completed after system construction, but prior to turning on the BV/BS systems and introducing additional oxygen to the unsaturated and saturated zones. The results of the baseline NSZD testing will be compared to the performance NSZD monitoring rates resulting from operation of the BV/BS systems to assess the change in biodegradation resulting from operation of the systems and the effectiveness of the selected remedy. The intent is to compare the baseline NSZD biodegradation rates to the biodegradation rates in the areas impacted by the bioventing and biosparging systems.

The future use and layout of the NSC components (i.e., freeway and rail infrastructure) that will pass through the Site were also considered in the system design. Specifically, the NSC impacted well placement, well design, and placement of system components such as mechanical equipment and conveyance piping. The design intentionally minimizes the need to place equipment and personnel in the NSC right-of-way for maintenance and performance monitoring events, and serves to protect workers from vehicular and rail traffic. Furthermore, future work such as rail and roadway maintenance has been considered in the system design.

Finally, the BV/BS systems have been designed to be flexible throughout the life cycle of the active cleanup, with equipment size and process controls designed to allow for future optimization, varied injection schemes, potential vapor extraction, and implementation of the contingent remedy, if necessary.

5.2 System Design

This section discusses the design considerations for the BV/BS systems.

5.2.1 Operating Criteria

To achieve the remedial action objectives, the designs of the BV/BS systems are based on the run conditions and ROI results from the field tests with consideration of Site-specific permeability and groundwater velocities. Specifically, the BV system has been designed to achieve an injection well ROI of 125 to 150 feet or greater in the medium RTF area smear zone under flow conditions of 100 scfm at 2 psi injection pressure, and the BS system has been designed to achieve an injection ROI of 25 feet or greater in the high RTF area saturated smear zone under flow conditions of 25 scfm at 9 to 12 psi injection pressure.

5.2.2 Bioventing System Components

The bioventing system will include the following primary components:

- Five BV air injection wells (BV-1 through BV-5 shown on Figure 5-1)
- A single air injection blower (B-200)
- Subsurface conveyance piping
- Valves, gauges, and flow measuring devices

5.2.2.1 Bioventing Air Injection Wells

The BV injection well layout shown on Figure 5-1 provides for air injection throughout the high and medium RTF areas with adequate overlap in BV injection well ROIs, assuming a conservative ROI of 125 feet. The BV injection well layout also provides for air injection throughout a significant portion of the low RTF area, particularly if an ROI of 150 feet or greater is achieved (Figure 5-1). For operational efficiency and worker safety reasons, the design places the wellheads for all of the BV injection wells east of the NSC freeway right-of-way, in an area having sufficient room for system construction, operation, and maintenance. To accomplish the objectives of (1) achieving full coverage of the high and medium RTF areas with the BV injection well ROIs, and (2) having all of the well heads on the east side of the NCS freeway, two of the BV injection wells (i.e., BV-04 and BV-05) will be high-angled wells (i.e., approximately 30 degrees from vertical) so that the well heads can be located east of the NSC freeway and their well screens can be located beneath the NSC freeway (Figure 5-1).

Bioventing injection wells BV-02 through BV-05 will be constructed in accordance with the SOP for BV well construction included in the CMP. BV-01, formerly MW-08, has already been constructed (i.e., it is a monitoring well that was screened at too shallow of an interval) and was used successfully during the pilot test. Injection screen intervals will be 20 feet in length for vertical wells and 25 feet for the high-angle wells, with the bottom of the injection screens targeting the seasonally low groundwater table for effective smear zone air distribution (Figure 5-2 and Table 5-1). BV-04 and BV-05 will be high-angled wells constructed as shown on Figure 5-3. The two vertical bioventing wells in the high RTF area (BV-02 and BV-03) will be constructed using carbon steel casing and stainless steel injection screens for potential future use as SEE injection wells if the contingent remedy requires implementation. The other BV injection wells are not located in the target area for the contingent remedy and thus will not be constructed as potential SEE injection wells.

5.2.2.2 Bioventing Air Injection Blower

A piping and instrumentation diagram (P&ID) for both the bioventing and biosparging injection systems is shown on Figure 5-4. The blower (B-200) minimum specification will be a flow of 600 scfm at a discharge pressure of 4 psig. This blower specification will provide a minimum injection rate of 100 scfm to each of the five proposed bioventing injection wells, for a total normal operating flow of 500 scfm. Additional flow

capacity will be available above the normal flow value to allow for (1) operation of some BV injection wells at flow rates as high as 150 scfm, or (2) the addition of another BV injection well, if monitoring data indicate optimization of the BV system is necessary. The expected well-head pressure necessary to achieve the minimum design flow rate is approximately 2 psi, based on observed conditions during the pilot test. Including friction losses between the blower and the injection wells, which will be minimized during final pipe size selection, the expected blower discharge pressure will be approximately 3 to 4 psi. The blower will be equipped with a variable frequency drive (VFD) to allow for flexibility in operating conditions, and will also be furnished with safety control devices, such as pressure relief valves, where necessary, to protect both the equipment and workers.

Based on the expected injection pressure and flow rates, a regenerative air blower is being considered for this application. However, final equipment selection will be made in conjunction with vendor input after detailed specifications have been prepared.

5.2.2.3 Subsurface Bioventing Conveyance Piping

The blower will discharge into a single main subsurface piping header, which is expected to be constructed of nominal pipe size (NPS) 6-inch polyvinyl chloride (PVC) or medium-density polyethylene (MDPE) piping. Branch lines will be constructed of the same material and will connect individual wells to the main header through an expected NPS 3-inch pipe. This design will allow for the addition of a second main header for extraction if during the life cycle of the BV/BS system it is determined that alternating between bioventing injection and vapor extraction is necessary. All conveyance piping will be installed in an approximately 36-inch-deep excavated trench.

Each bioventing wellhead will be completed in a subsurface traffic-rated well vault. Well-head components in each bioventing well vault will consist of air isolation valves, a flow measuring device such as a pitot tube and differential pressure gauge, a sample port, and static pressure gauges. A plan view of the conceptual layout of the BV and BS wells, piping, and mechanical facilities is included as Figure 5-5.

5.2.3 Biosparging System Components

The biosparging system will include the following primary components:

- Nine biosparging air injection wells (BS-01 through BS-09 shown on Figure 5-6)
- A single air injection compressor (AC-100)
- Subsurface conveyance piping
- Valves, gauges, and flow measuring devices

5.2.3.1 Biosparging Air Injection Wells

The BS injection well layout shown on Figure 5-6 focuses on the high RTF area and the immediately adjacent portions of the medium RTF area because this area has historically shown the highest mass of mobile LNAPL, and groundwater samples from this area exhibit DO readings ranging from 0 to 0.35 mg/L, which are below the level needed to sustain biodegradation of petroleum hydrocarbons in the saturated zone. The BS injection well layout provides for increased DO concentrations throughout the saturated portion of the LNAPL smear zone in the high RTF area and the immediately adjacent portions of the medium RTF area, assuming a BS ROI of 25 feet (Figure 5-6). In addition, the LNAPL and hydrogeologic data from MW-20 indicate that the area warrants further consideration because the well contained a thicker layer of mobile LNAPL than other Site wells and the well log suggests the presence of a localized lens of finer-grained deposits in and around which the LNAPL occurs. The atypical LNAPL and hydrogeologic conditions at the MW-20 location warrant placement of a biosparge well (BS-10) at that

location. BS-10 will be angle-drilled under the freeway from the east side of the Site and the well screen will be set slightly lower and upgradient of the lens of LNAPL at MW-20.

The BS injection wells are arranged in three transects oriented perpendicular to the groundwater flow direction. The wells within each transect are spaced approximately 45 feet apart to achieve some overlap in the 25-foot ROI of the BS injection wells, except for BS-10, which is located in the area of MW-20. The transects are spaced 100 feet apart on the basis that elevated DO concentrations from the BS injection wells are expected to extend at least 100 feet downgradient of the BS injection wells. The rationale is that groundwater flow velocities in the sand and gravel facies are 48 to 67 feet per day and the recovery data from the BS pilot test demonstrate that 1.5 to 2 days were required for the DO concentrations to decrease to pre-test levels (Figure 4-9). Therefore, elevated DO levels should extend downgradient at least 72 to 100 feet beyond the 25-foot ROI of the BS injection wells.

Most of the high RTF area is situated east of the NSC freeway right-of-way; however, a portion of the high RTF area and most of the medium RTF area extends beneath the freeway, and a portion of each extends beneath the Blue Knight line (Figure 5-6). For the same reasons described for the BV well layout, the BS well layout places the wellheads for all of the BS injection wells east of the NSC freeway right-of-way and west of the Blue Knight line. To accomplish this, BS-10 will be angle-drilled (i.e., approximately 35 to 40 degrees from vertical) under the freeway from the east side of the Site, and one of the BS injection wells (i.e., BS-06) will be low-angled wells (i.e., approximately 5 degrees from vertical) to reach under the Blue Knight line (Figure 5-6).

Biosparging injection wells BS-02 through BS-10 will be constructed in accordance with the SOP for BS well construction included in the CMP. BS-01, formerly BSI-01, was already constructed for, and used successfully during, the BS ROI test. Injection well screens will be 5 feet in length with the top of the screens 20 feet below the seasonally low groundwater table for effective saturated-zone air distribution (Figure 5-7, Table 5-1). BS-06 will be such low angle well (i.e., approximately 5 degrees from vertical) that its construction will be similar to that shown on Figure 5-7. BS-10 well construction is shown on Figure 5-8.

The CAP states that BS injection wells located in the high RTF area will be constructed of materials for potential future use as SEE injection wells if the contingent remedy requires implementation. However, the BS injection well screens will be set 20 feet below the seasonally low groundwater table to obtain effective saturated-zone air distribution. This screen depth is too deep for effective steam propagation in the saturated zone. Therefore, the BS injection wells located in the high RTF area will not be constructed for potential use as SEE injection wells. Instead, the two BV injection wells located in the high RTF area will be constructed for potential use as SEE injection wells because their well screens will be placed at an appropriate depth for steam propagation near the top of the LNAPL smear zone. Additionally, some of the BV injection wells may be converted to thermal monitoring points if the contingent remedy requires implementation. However, conversion to thermal monitoring points does not require constructing the BS injection wells using different materials.

5.2.3.2 Biosparging Air Compressor

The biosparge air compressor (AC-100) will be sized to provide an injection rate of 25 scfm to each of the 10 wells. The minimum specification for AC-100 will be a flow rate of 250 scfm at a compressor discharge pressure of 15 psi. The expected well head pressure necessary to achieve the design flow rate is 9 to 12 psi. Including friction losses between the compressor and the wells, the expected compressor discharge pressure will be approximately 15 psi. However, a flow rate safety factor of at least 1.2 will be used for selection of the blower allowing for an increased flow rate to some wells if performance monitoring data indicate optimization is necessary. The compressor will be equipped with a VFD to allow for flexibility in

operating conditions and will also be furnished with safety control devices, such as pressure relief valves, where necessary to protect both the equipment and workers.

Based on the expected injection pressure and flow rates, a rotary claw air compressor is being considered for this application. However, final equipment selection will be made in conjunction with vendor input after detailed specifications have been prepared.

5.2.3.3 Subsurface Biosparging Conveyance Piping

The compressor will discharge into an above-grade piping manifold that will include connections for nine individual conveyance pipes, one for each of the nine biosparging wells. Each leg of the piping manifold will include isolation valves, a flow measuring device, pressure gauges, and a motorized ball valve or other similar remote-actuated valve. The remote-actuated valves will be connected to the system programmable logic controller (PLC), where user-defined custom timers will allow for complete and remote customization of the injection network, pulsing operations, and zone cycling.

The nine conveyance pipes are expected to be constructed of NPS 2-inch MDPE pipe, and will be buried in the subsurface trench along with the bioventing piping header. Each conveyance pipe will be routed to an individual biosparging well, which will be installed in a subsurface traffic-rated vault. Well-head components in each biosparging well vault will consist of isolation valves, static pressure gauges, and a sample port. A plan view of the conceptual layout of the BV and BS wells, piping, and mechanical facilities is included as Figure 5-5.

5.2.4 Controls and Telemetry

The BV and BS systems will be furnished with a single PLC and motor control cabinet that will control both systems. The specific components of the system controls and telemetry systems will be designed in conjunction with an equipment vendor and will be provided with the final constructed blower and compressor skid.

In general, the PLC will collect system operational data from numerous pressure and flow transmitters that will be included with each of the injection systems. The PLC will log transmitter data, which will be accessible via secured remote login. Additionally, the VFD run speeds, discharge pressure, and flow setpoints for both the bioventing blower and the biosparging compressor will be adjustable using the remote access provided by the PLC, allowing for changes to system operation without a dedicated Site visit. Furthermore, the PLC will control the remote-actuated valves located on each leg of the biosparging injection manifold to allow for multiple different operational configurations if performance monitoring data indicate optimization of the system is warranted. Finally, the PLC will automatically communicate mechanical alarm conditions and system faults via email callouts to facilitate timely troubleshooting and maintenance response.

The PLC and data will be accessed via cellular modem with an internal secured server and firewall. All data transmissions will be encrypted with industry standard technology and access will be limited to key project operations and data management personnel.

5.2.5 System Security, Protection, and Noise Suppression

All mechanical and electrical equipment will be located inside a lockable and weatherproof enclosure and may be delivered as a constructed skid and enclosure together. Although both the expected pieces of equipment, the regenerating blower and rotary claw compressor, are generally quieter than other types of fans (e.g., rotary lobe blowers), the enclosure will further attenuate the noise generated from the mechanical equipment. The enclosure will be located within a locked fence or other similar visible barrier. The compound will be installed with downward-facing, motion-activated flood lights for night-time visibility.

A security system with remote-access cameras and door alarms may be evaluated and installed at a later date if necessary.

5.2.6 Waste Management

No vapor emissions, or groundwater or LNAPL effluent is expected to be generated through operation of the BV/BS system. This reduces risks that may be presented to workers through handling of potentially impacted media, and eliminates the need for containment structures or hazardous material release control and alarm systems. If future modifications to the system result in generating emissions or effluent streams, then adequate treatment, containment, and/or release control and alarm systems will be considered in the system modifications.

Waste generated during construction of the BV/BS systems (e.g., soil from drilling and excavation, water from well development and equipment decontamination) will be managed in accordance with the operating procedures described in Section 5.3.3 of the CMP.

5.3 System Construction

5.3.1 Construction Testing

Construction testing (e.g., pipe pressure tests, acceptance testing of electrical and process connection) will be used to demonstrate adequate quality control prior to compliance sampling and system start-up. Specific tests will be outlined in the construction plan report.

5.3.2 Compliance Monitoring

Compliance monitoring that will be performed during and after construction is outlined in the CMP.

5.4 Health and Safety

Procedures proposed to assure health and safety during system construction and operation are detailed in the HASP, Appendix A of the CMP.

5.5 Permitting and State Environmental Policy Act Requirements

Permitting required for this project includes:

- A building permit for the building that will house the system equipment
- An electrical permit for the electrical drop
- Notice of Intent to Construct and Decommission an Environmental Investigation Well (Start Card) for each new well
- A grading permit for trench excavation for subsurface piping and grading for Site preparation

The Washington-licensed drilling contractor that constructs the new wells will prepare Start Cards prior to construction of each new well. The PLP's contractor for construction of the BV/BS system will obtain permits for the building, electrical drop, and grading prior to construction.

A construction stormwater permit will not be needed for this project because (1) the area of land disturbance is below the 1-acre permitting threshold and (2) there is an extremely low potential for stormwater discharge to waters of the state. No other permits from Table 3-3 are applicable to this project.

A State Environmental Policy Act (SEPA) Environmental Checklist for the BV/BS system was submitted with the final CAP (Ecology 2018a). A SEPA Environmental Checklist for the Shallow Soil Interim Action Work was provided to Ecology in April 2019. Ecology has approved both checklists. No additional SEPA checklists are required.

6. ADDITIONAL COMPONENTS OF CLEANUP ACTION PLAN

The following sections describe the other components of the selected remedy.

6.1 Excavation of Impacted Surface Soil

As described in Sections 2.2.2 and 3.4.1, surface soil within the western half of SSA-2 and the entire SSA-3 will require excavation during Phase 2 of the Shallow Soil Interim Action (Figure 2-2).

Removal of these areas will be performed by WSDOT after rail realignment is complete and the soil and infrastructure beneath the former rail lines are accessible. If asbestos-containing-material pipe removal is necessary, an NOI permit from the Spokane Regional Clean Air Agency will be obtained prior to removal. Excavation may extend deeper than 15 feet bgs if high-concentration source material is encountered, and it is readily accessible for removal without resorting to shoring or other substantive measures. All excavations will be backfilled (and compacted) with clean imported fill soil. WSDOT's remediation contractor will transport the impacted soil and other waste materials to an appropriately permitted landfill for disposal.

ERM will observe the cleanup activities, collect confirmation and performance soil samples, and report the results of the Phase 2 Surface Soil Interim Action work to Ecology. Compliance sampling in the excavation walls will be performed prior to backfill to ensure the lateral extent of impacted soil exceeding the CULs was removed. Soil samples will be collected in the excavation bottom to document the level of impacts, if any, left in place. Per the IAWP (ERM 2018), an addendum to the *Interim Action Completion Report* (ERM 2019a) will be submitted for Phase 2 of the Surface Soil Interim Action. The Phase 2 work will be performed in accordance with Amendment No. 1 to AO No. 9188 (Ecology 2018b) and the IAWP. Section 7.1 of the CAP and Exhibit C of the CD also describe the requirements of the work. Because Phase 2 of the Surface Soil Interim Action is described in the IAWP, details of the plan for cleanup of these inaccessible soils are not repeated in this EDR.

6.2 Manual LNAPL Removal

LNAPL will be removed manually from a network of monitoring wells in the high and medium RTF areas during groundwater monitoring events. Based on past performance, manual removal of LNAPL from the monitoring well network yields approximately 1.5 gallons of LNAPL per monitoring event. Therefore, this action will result in removal of approximately 6 gallons of LNAPL per year. Although this opportunistic removal of LNAPL is helpful, it is only 0.001 percent of the estimated mobile LNAPL volume in the medium and high RTF areas that will be removed through enhanced NSZD. Details regarding the removal process are presented in the CMP.

6.3 Natural Source Zone Depletion

NSZD will be utilized to address residual LNAPL and any remaining mobile LNAPL in areas not undergoing active remediation (i.e., the low RTF area and sections of the medium and high RTF areas as the BV/BS system is shut down). The rate of LNAPL depletion by NSZD is expected to be sufficient to eliminate the residual mobile LNAPL in these areas within the 20-year RTF. However, monitoring will be performed to verify the occurrence and rate of NSZD in these areas. Because NSZD monitoring is not meaningful in areas where active remediation enhances biodegradation rates, it will only be performed in areas that are not affected by active remediation. As shown on Figure 5-1, the BV system is expected to impact most of the low RTF area; therefore, NSZD monitoring will not be performed until portions of the system are shut down and NSZD alone is responsible for degrading the residual mobile LNAPL in these areas.

To evaluate saturated zone NZSD, groundwater samples will be analyzed for NSZD parameters. Four methods for evaluating vadose zone NSZD may be implemented at the site: thermal monitoring, diffusion gradient, carbon traps, and/or carbon flux chambers. Details of the NSZD monitoring are provided in the CMP.

6.4 Institutional Controls and Environmental Covenant

As described in Section 3.4.4 of this document, institutional controls will be put in place to limit or prohibit activities that may interfere with the integrity of the remedy or result in exposure to hazardous substances. It is expected that cleanup of surface soil to applicable CULs at standard points of compliance cleanup will be achieved prior to implementation of any institutional controls; therefore, institutional controls will not be required to assure continued protection of human health and the environment from the surface soil. However, groundwater is expected to have concentrations of TPH-D/HO exceeding the applicable CULs.

Institutional controls will include an Environmental Covenant prohibiting the extraction of impacted groundwater for purposes other than remediation, and restricting future activities and uses of the Site as agreed to by Ecology and BNSF. An initial draft of an Environmental Covenant for implementation following completion of the surface soil cleanup is included as Appendix F. The Environmental Covenant will be consistent with WAC 173-340-440, RCW 64.70 (Uniform Environmental Covenants Act), and any policies or procedures specified by Ecology. The Environmental Covenant will be finalized, executed, and recorded with the office of the Spokane County Auditor following Ecology's review and approval. BNSF will provide Ecology with the original recorded Environmental Covenant within 30 days of the recording date.

As conditions change (e.g., the footprint of impacted groundwater exceeding applicable CULs decreases or is eliminated), the Environmental Covenant may be amended in accordance with Ecology guidance.

7. SCHEDULE

There has been one modification to the schedule in Exhibit C of the CD. In a letter dated 3 August 2020, Ecology approved a 9 July 2020 request to design and perform Task B2, the SPT, in conjunction with the Steam Enhanced Extraction Pilot Test (Task B9), if triggered.

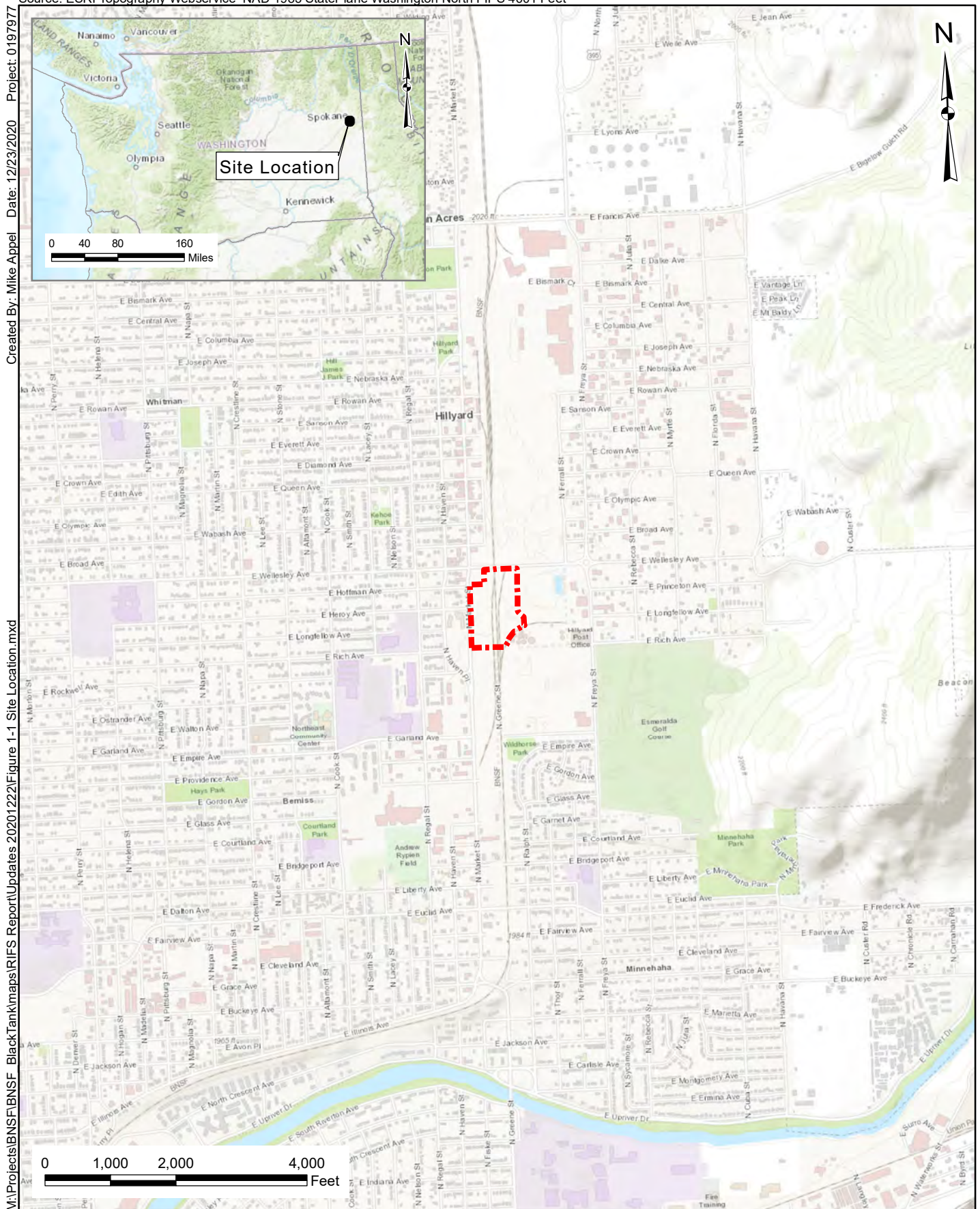
Table 7-1 presents the anticipated task schedule for the engineering design, procurement, and construction of the BV/BS system. The schedule begins with submittal of the draft EDR and extends through start-up and acceptance of the BV/BS system. The schedule is aligned with WSDOT's current anticipated schedule for NSC construction work, but is subject to change based on WSDOT's actual completion of the NSC construction.

8. REFERENCES

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FIGURES



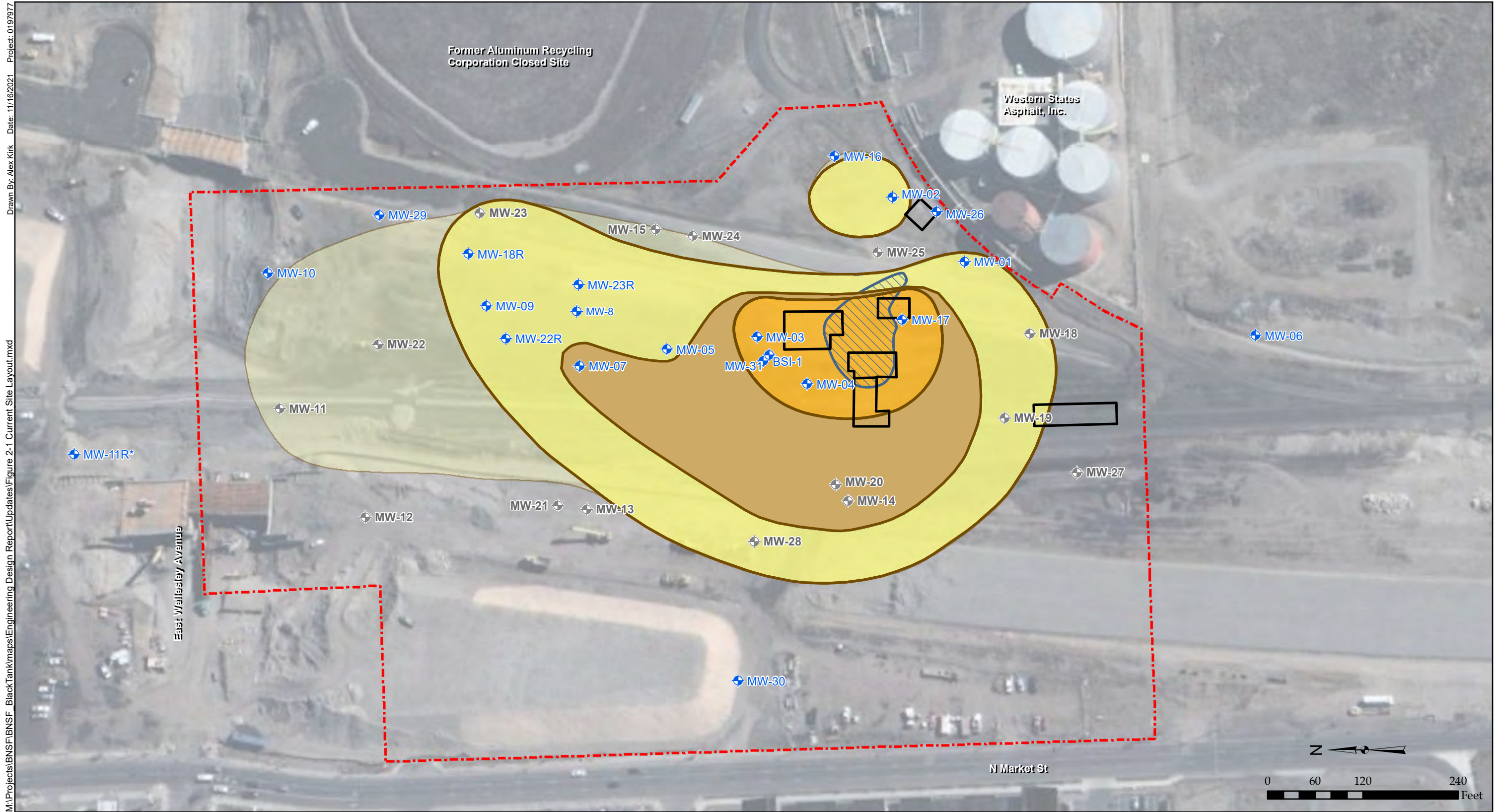
Legend

 Site Boundary



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Figure 1-1
Site Location and Boundary
BNSF Railway Black Tank Property Site
Spokane, Washington

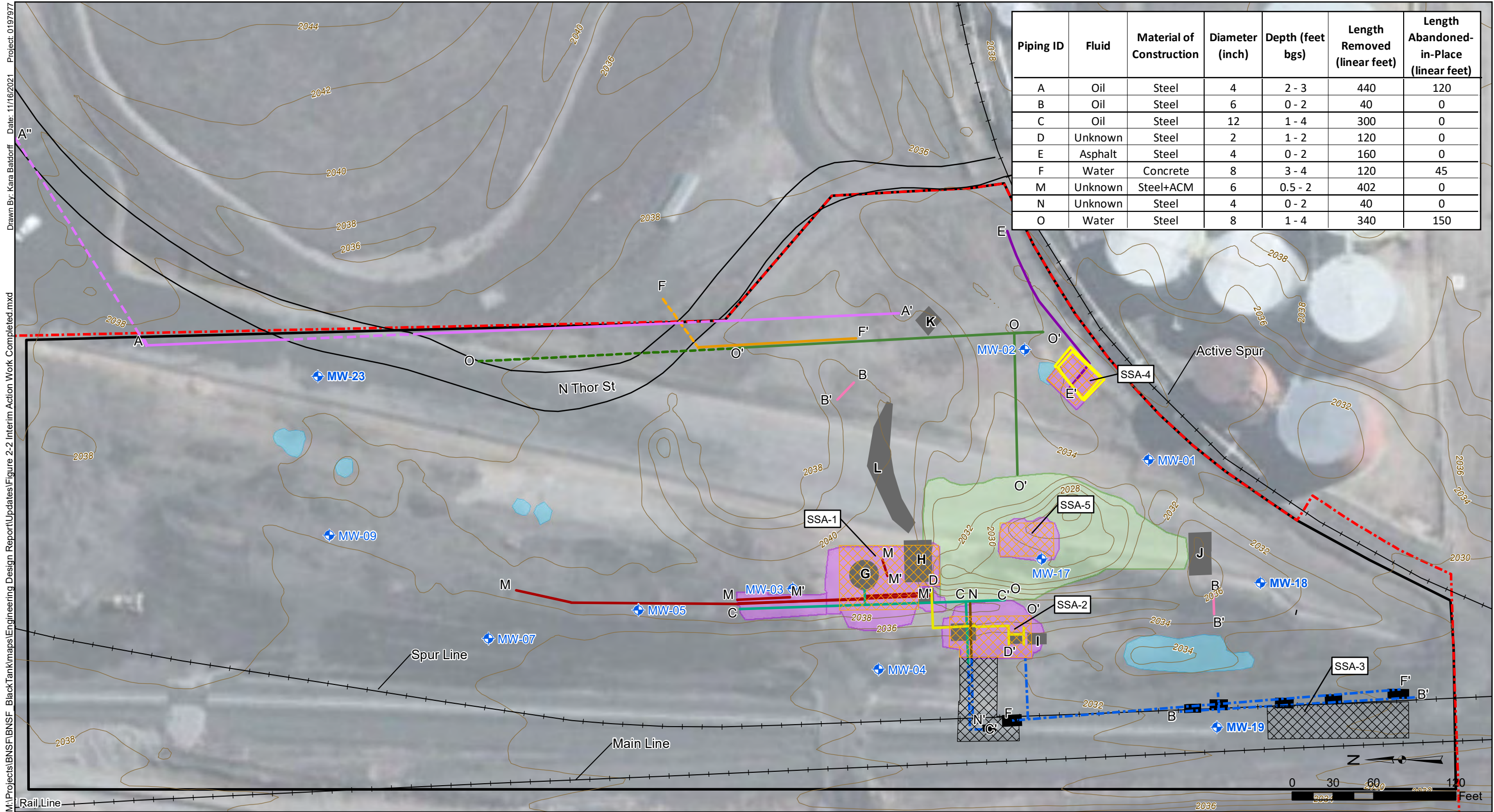


Legend

- Monitoring Well
- Monitoring Well - Abandoned September 2019
- Seasonal Dissolved Phase TPH-D/HO Plume
- Site Boundary
- TPH-D/HO in Intermediate Soil Exceeding the Preliminary CUL
- TPH-D/HO in Surface Soil Exceeding the CUL
- High RTF Area
- Medium RTF Area
- Low RTF Area

Notes:
LNAPL = Light Non-Aqueous Phase Liquid
TPH-D/HO = Total Petroleum Hydrocarbons - Diesel and Heavy Oil Ranges
Image Source = Google Earth 3/2021

Figure 2-1
Current Site Layout and RI-Based Contamination
Engineering Design Report
BNSF Railroad Black Tank Property Site
Spokane, Washington



Legend

Monitoring Well from which LNAPL has been Removed

Former Black Tank Excavation

Excavations to be completed in 2018 (Phase I Excavations)

Excavations to be undertaken following rail realignment (Phase II Excavations)

Shoring Installed

Completed Excavation

Completed IDW Removal

Piping Removed

Piping plugged and abandoned in place

Piping abandoned in place

Piping to be removed following track relocation - Extent not confirmed

Pipeline A

Pipeline B

Pipeline C

Pipeline D

Pipeline E

Pipeline F

Pipeline M

Pipeline N

Pipeline O

Concrete Infrastructure and Debris Removed

Concrete infrastructure removal to be undertaken by WSDOT following track relocation.

Interim Action Project Area

MTCA Site Boundary

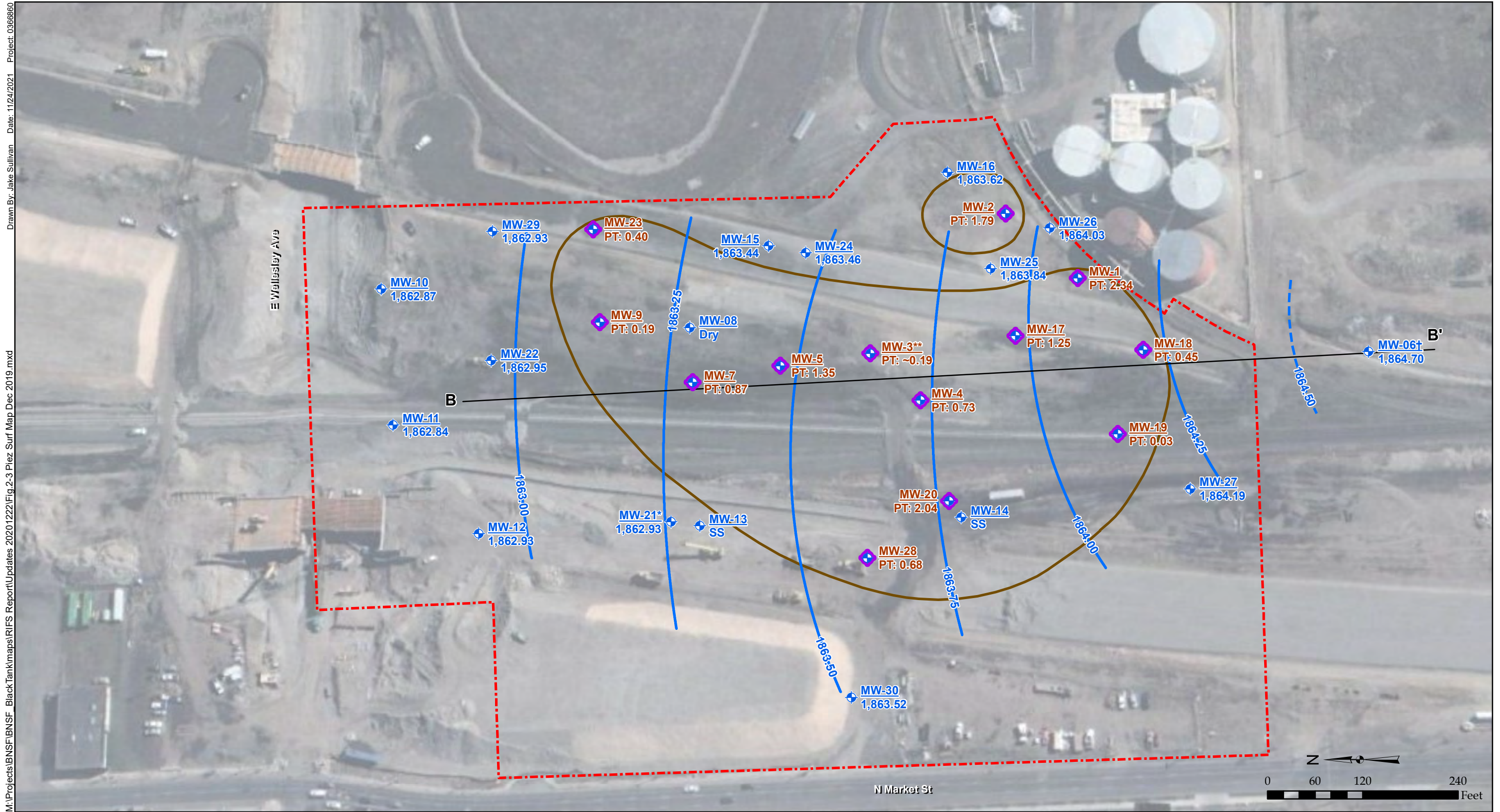
Access Road

Active Railroad

Notes:
Elevation data: WA DNR/PSLC, Spokane 2015
Project
Image Source = Google Earth 3/2021

Figure 2-2
Previous Site Remediation Work
BNSF Railways Black Tank Property Site
Spokane, Washington

Environmental Resources Management
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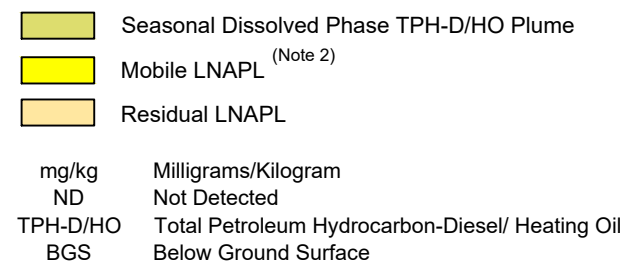
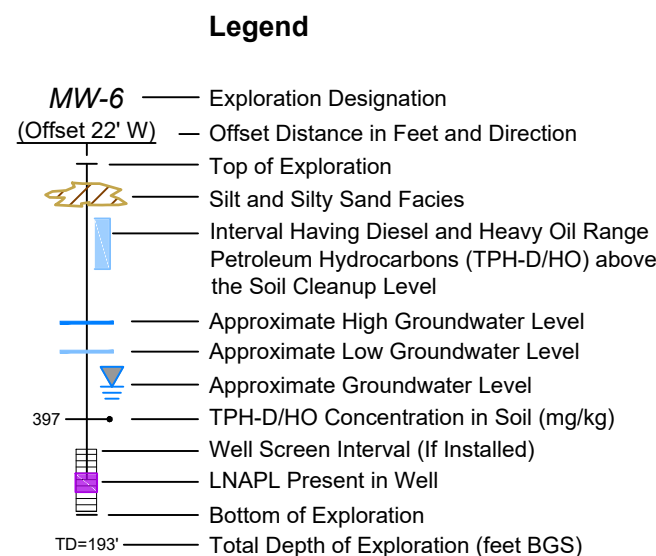
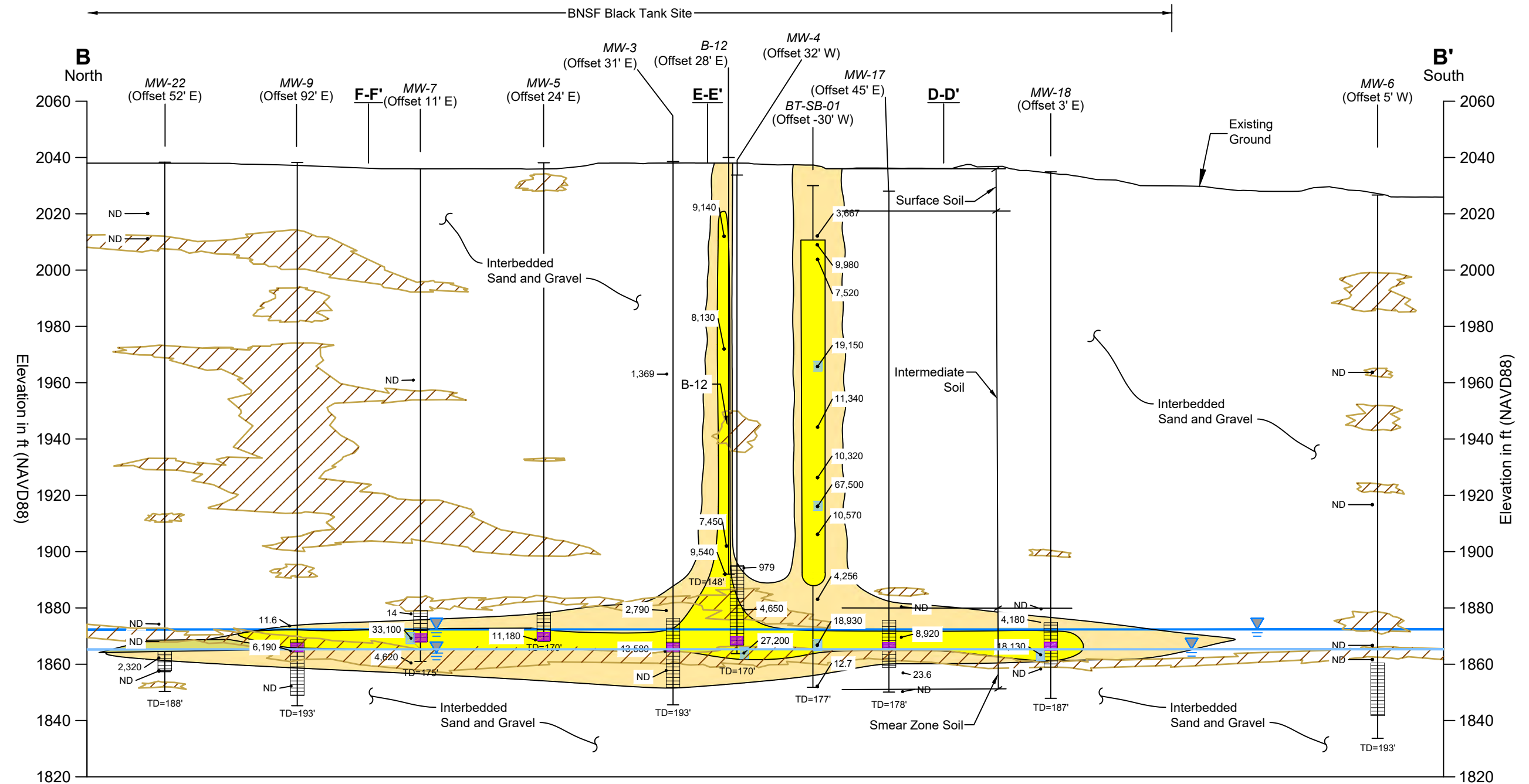


Legend

- Monitoring Well with LNAPL
- Monitoring Well without LNAPL
- Approximate Extent of LNAPL
- Cross Section Line
- Groundwater Contour
- Inferred Groundwater Contour
- BNSF Black Tank Site Boundary

Notes:
* = MW-21 was not used for contouring.
** = Water level not measured due to high viscosity of LNAPL.
† = Biased low due to submerged screen greater than 1 foot.
Dry = No water detected or water level was below screened interval.
LNAPL = Light Non-Aqueous Phase Liquid.
NM = Not Measured.
PT = LNAPL thickness in feet.
SS = Well screened below the water table; screen is submerged. Not used for Contouring.
All elevations in Feet Above Mean Sea Level (ft. AMSL).
Contour Interval = 0.25 feet.
Aerial Photo: Esri World Imagery Webservice, Spokane Image Consortium, 2018.

Figure 2-3
Piezometric Surface Map
Engineering Design Report
December 2019
BNSF Black Tank
Spokane, Washington
Environmental Resources Management
www.erm.com
ERM



Notes:
1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. Subsurface soil (below 15 feet bgs) contains TPH-D/HO concentration exceeding Ecology's Residual-Saturation- Based cleanup level (5,630 mg/kg) or measurable LNAPL is present in a monitoring well.

Drawing Source:
Landau Associates, Figure 6, 1/14/15.

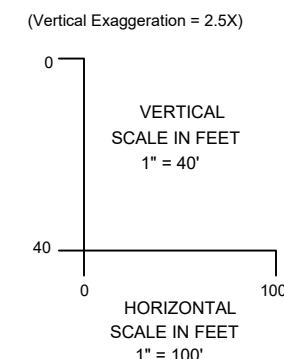
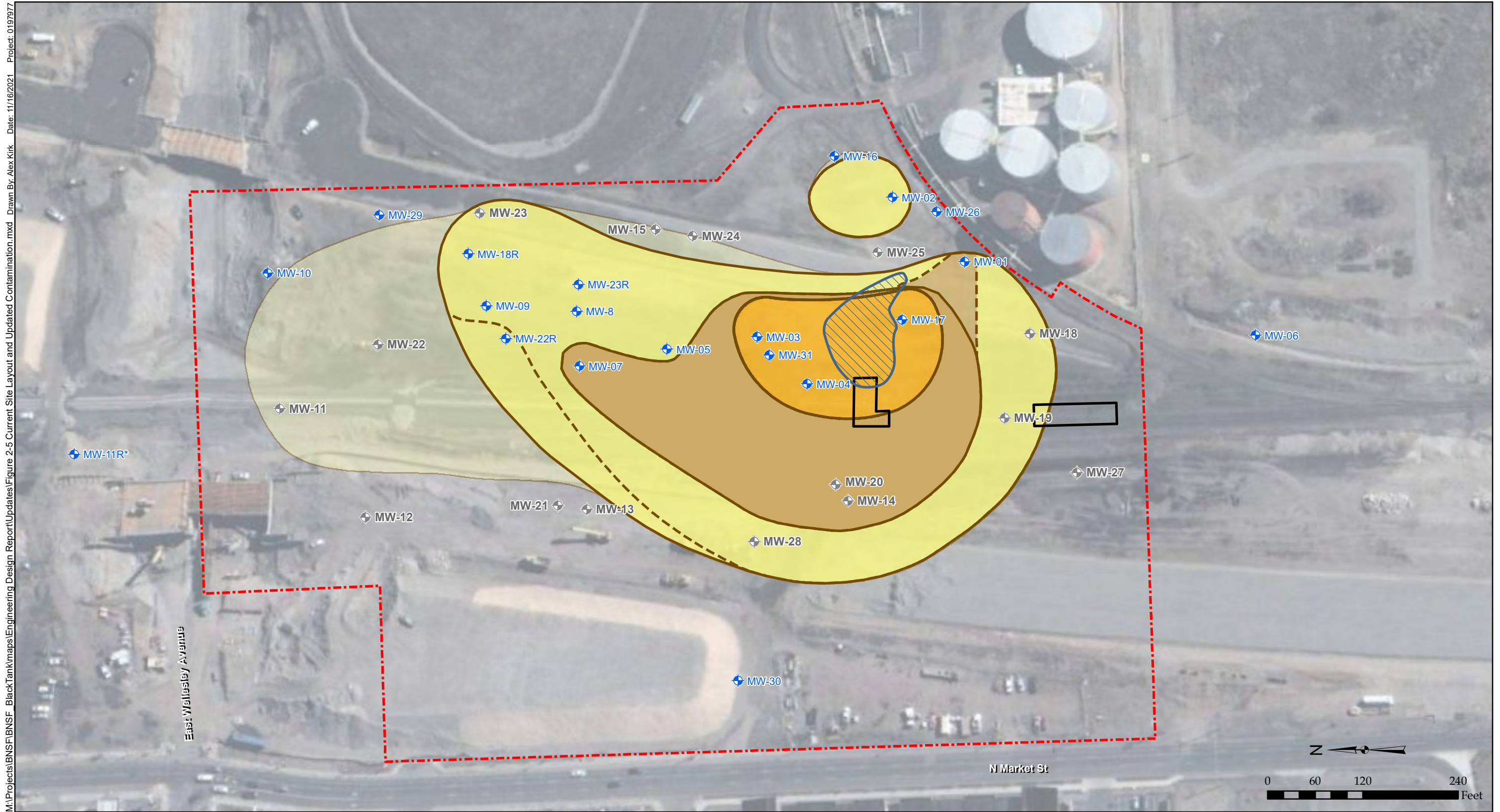


Figure 2-4
Geologic Profile B-B' with LNAPL Overlay
Engineering Design Report
BNSF Black Tank
Spokane, Washington



Legend

- Monitoring Well
- Monitoring Well - Abandoned September 2019
- September 2020 Boundary RTF
- High RTF Area
- Medium RTF Area
- Low RTF Area
- Seasonal Dissolved Phase TPH-D/HO Plume
- Residual TPH-D/HO in Surface Soil Exceeding the CUL
- Site Boundary
- TPH-D/HO in Intermediate Soil Exceeding the Preliminary CUL

Notes:
LNAPL = Light Non-Aqueous Phase Liquid
TPH-D/HO = Total Petroleum Hydrocarbons - Diesel and Heavy Oil Ranges
Image Source = Google Earth 3/2021

Figure 2-5
*Current Site Layout and
Updated Site Contamination
Engineering Design Report
BNSF Black Tank
Spokane, Washington*

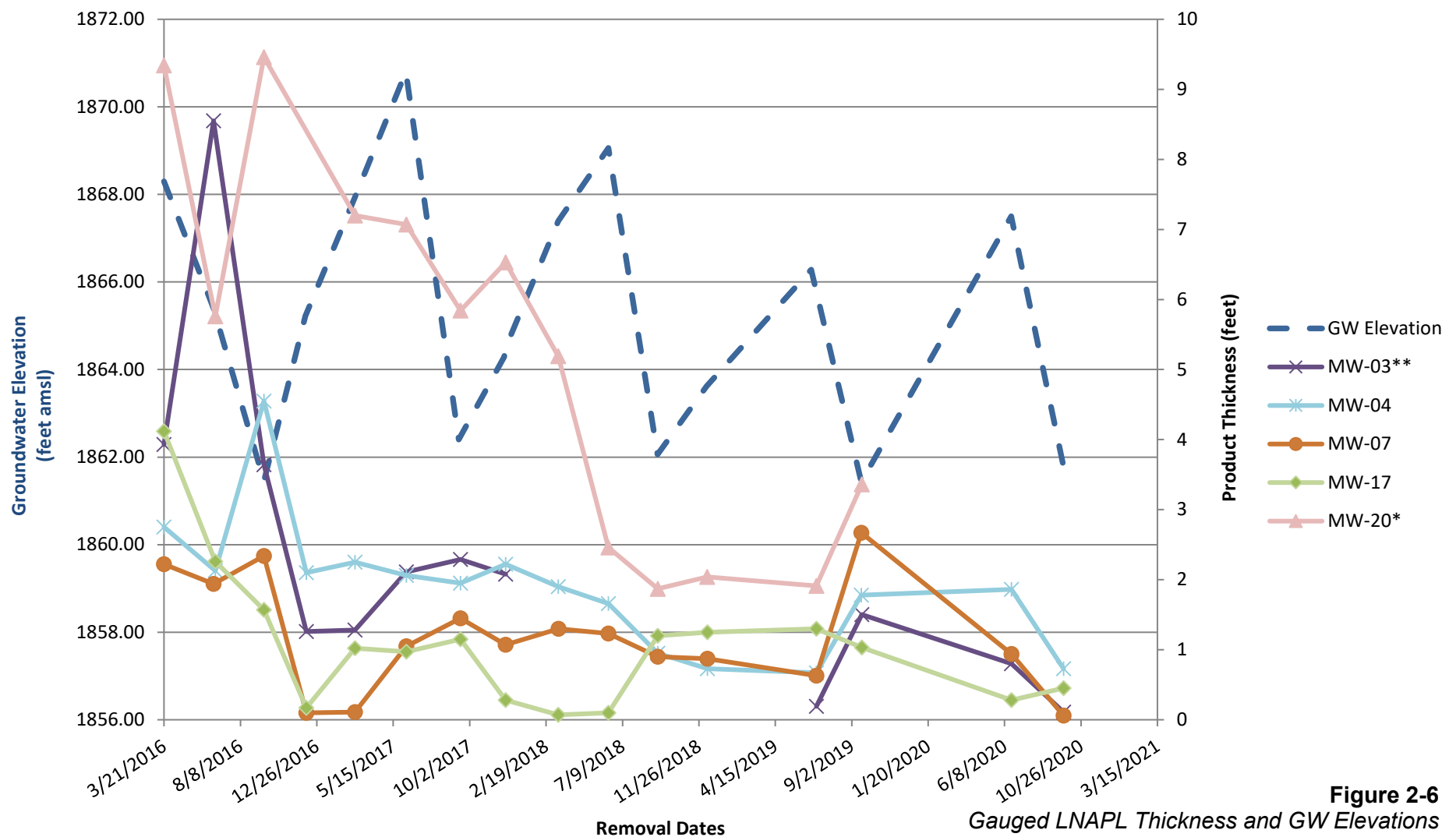
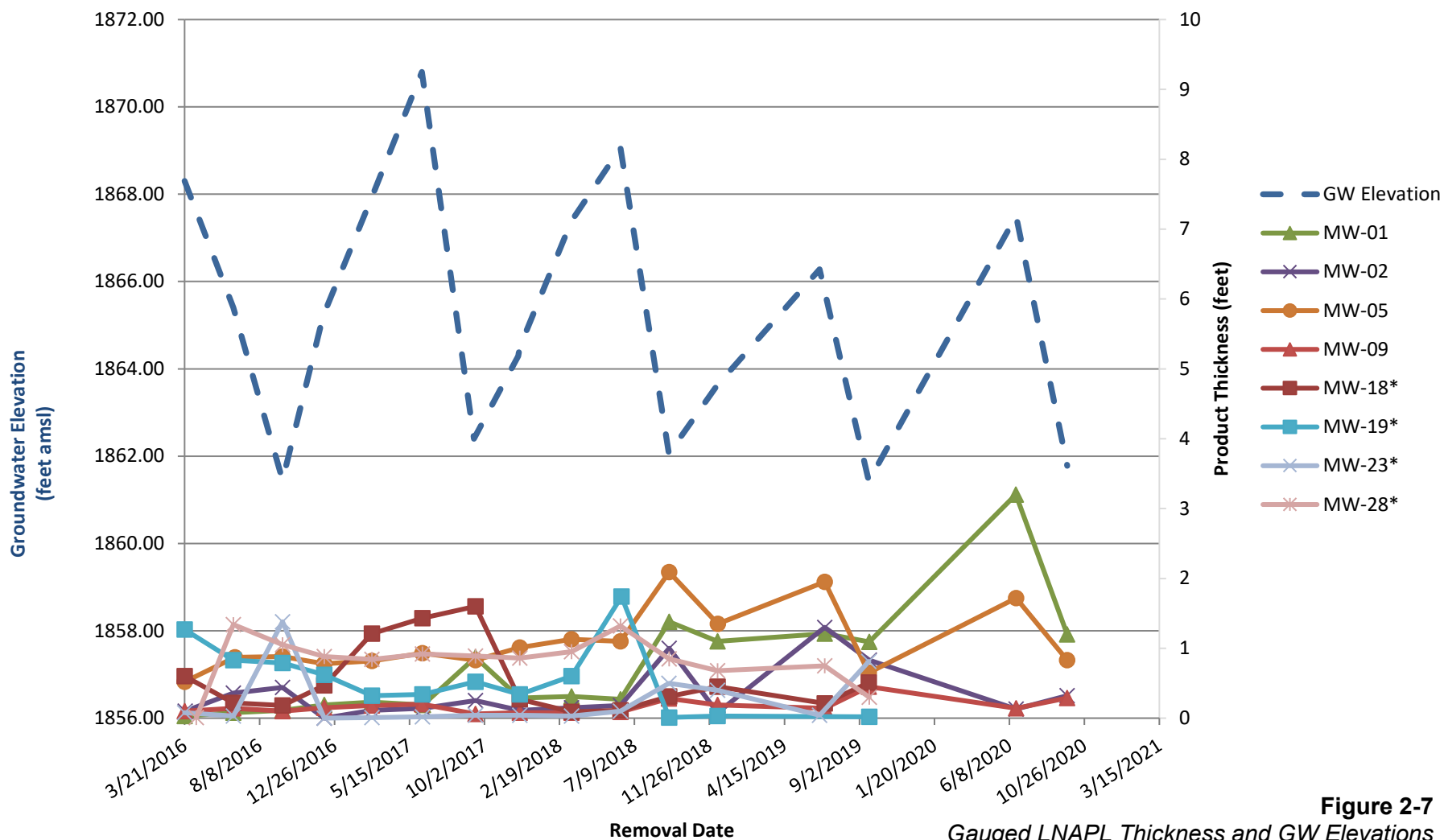


Figure 2-6
Gauged LNAPL Thickness and GW Elevations
 (3/16 through 9/20)
 LNAPL > 1 foot thick
 Engineering Design Report
 BNSF Black Tank Site
 Spokane, Washington



--- NAPL removed on this date.

* MW-18, MW-19, MW-23, and MW-28
abandoned September 2019.

Figure 2-7
Gauged LNAPL Thickness and GW Elevations
(3/16 through 9/20)
LNAPL < 1 Foot Thick
Engineering Design Report
BNSF Black Tank Site
Spokane, Washington

M:\Projects\BNSF\BNSF Black Tank\maps\Engineering Design Report\Figure 2-8 Site Layout.mxd
Drawn By: Kara Baldorff
Date: 23/11/2021
Project: 0197977

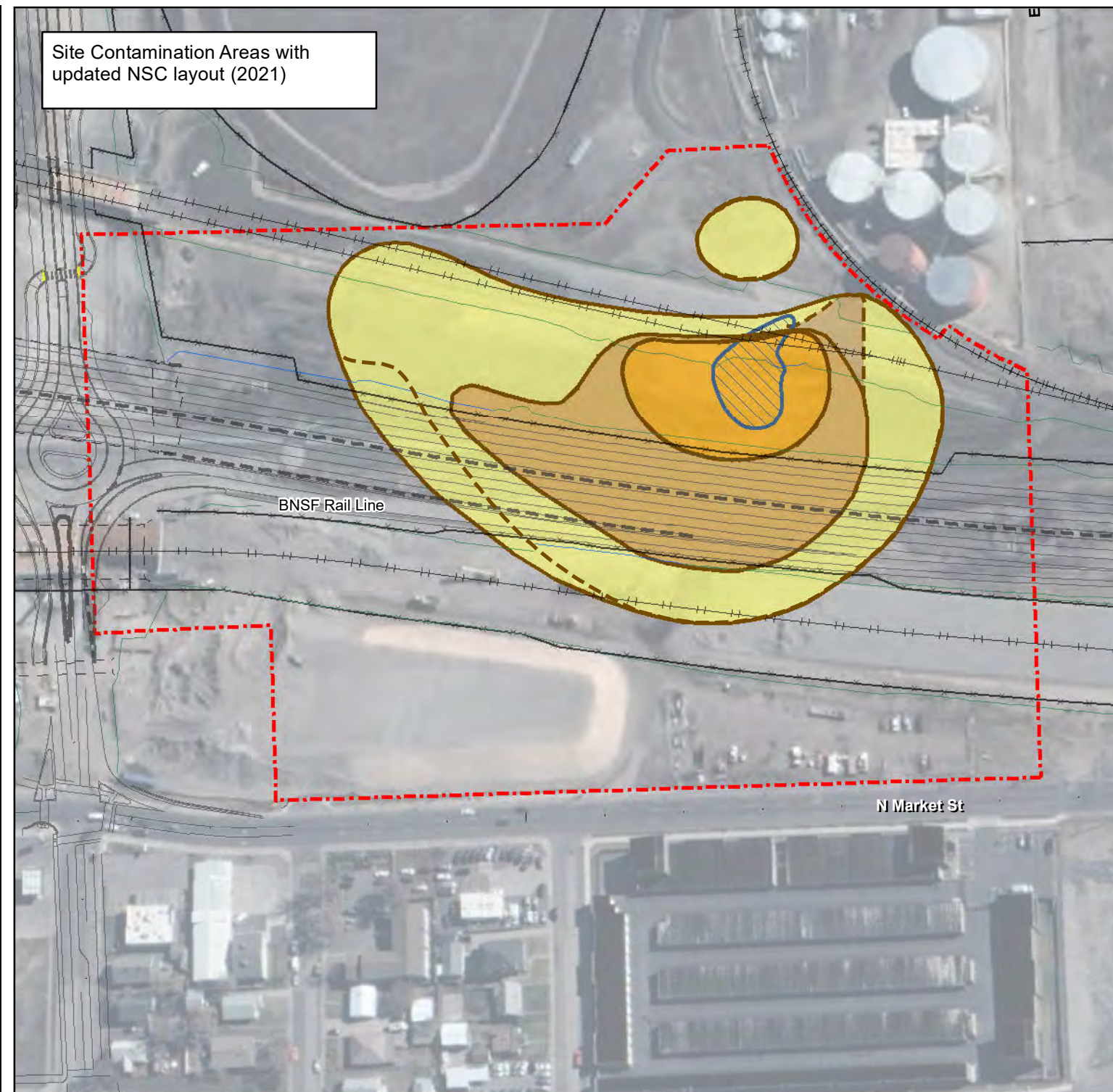
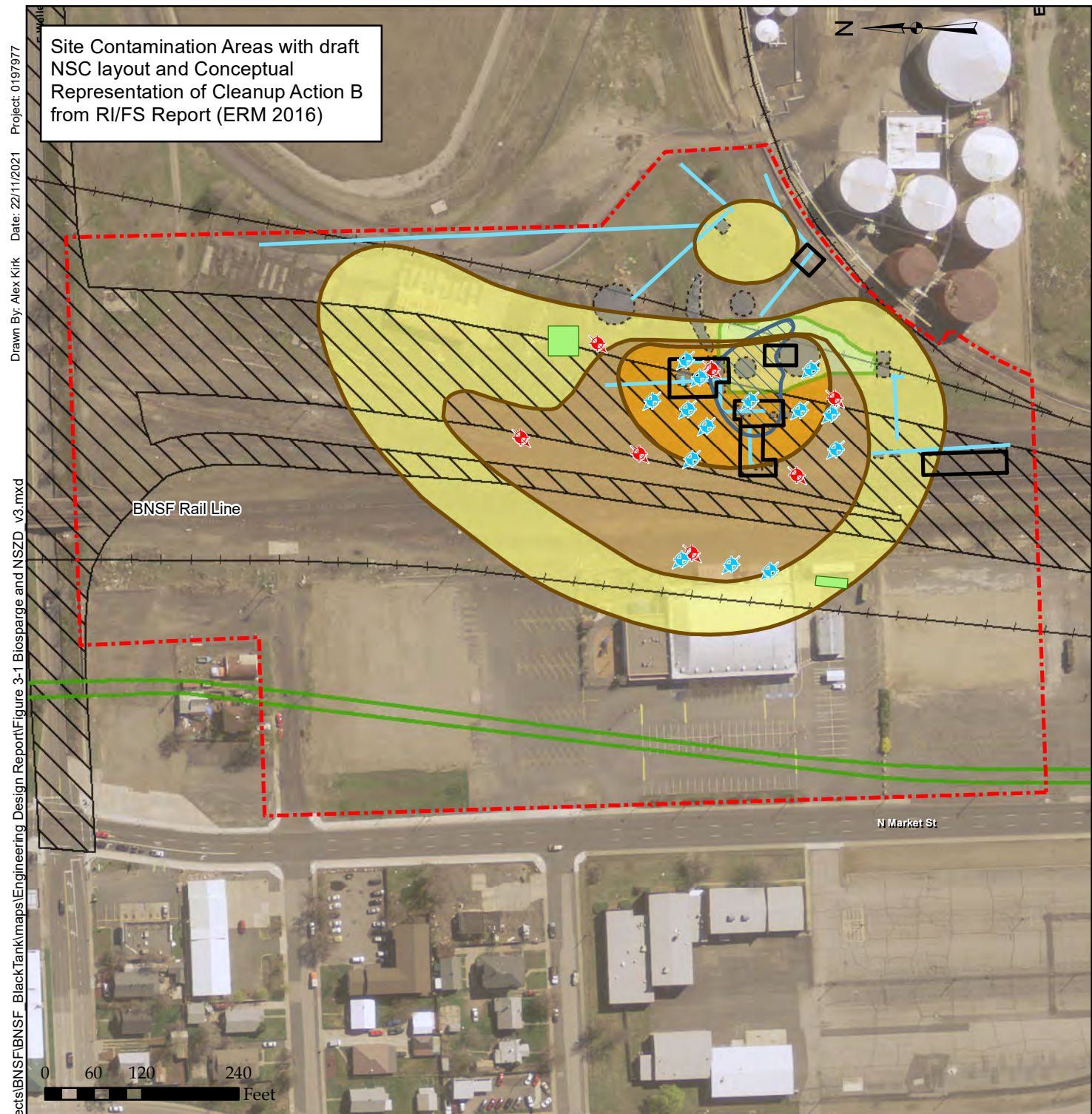


Legend

- | | | | |
|--|---|----------------------------|-----------|
| Monitoring Well | TPH-D/HO in Intermediate Soil Exceeding the CUL | Barrier | Bridge |
| Monitoring Well - Abandoned September 2019 | BNSF Black Tank Site Boundary | Fence | Cut Line |
| September 2020 Boundary RTF | High RTF Area | Guardrail | Fill Line |
| Cut Locations | Medium RTF Area | Curb/Roadway | Railroad |
| | Low RTF Area | Detectable Warning Surface | |

Notes:
Alignment subject to change
CUL = Cleanup Level
LNAPL = Light Non-Aqueous Phase Liquid
RTF: Restoration Timeframe
NSC = North Spokane Corridor
TPH-D/HO = Combined Diesel and Heavy Oil-Range Petroleum Hydrocarbons
CUL = 5,360 milligrams per kilogram
WSDOT = Washington State Department of Transportation
Aerial Photo: Google Earth 3/2021

Figure 2-8
Site Layout with North Spokane Corridor Footprint and Decommissioned Monitoring Wells, Engineering Design Report BNSF Black Tank Spokane, Washington



Legend

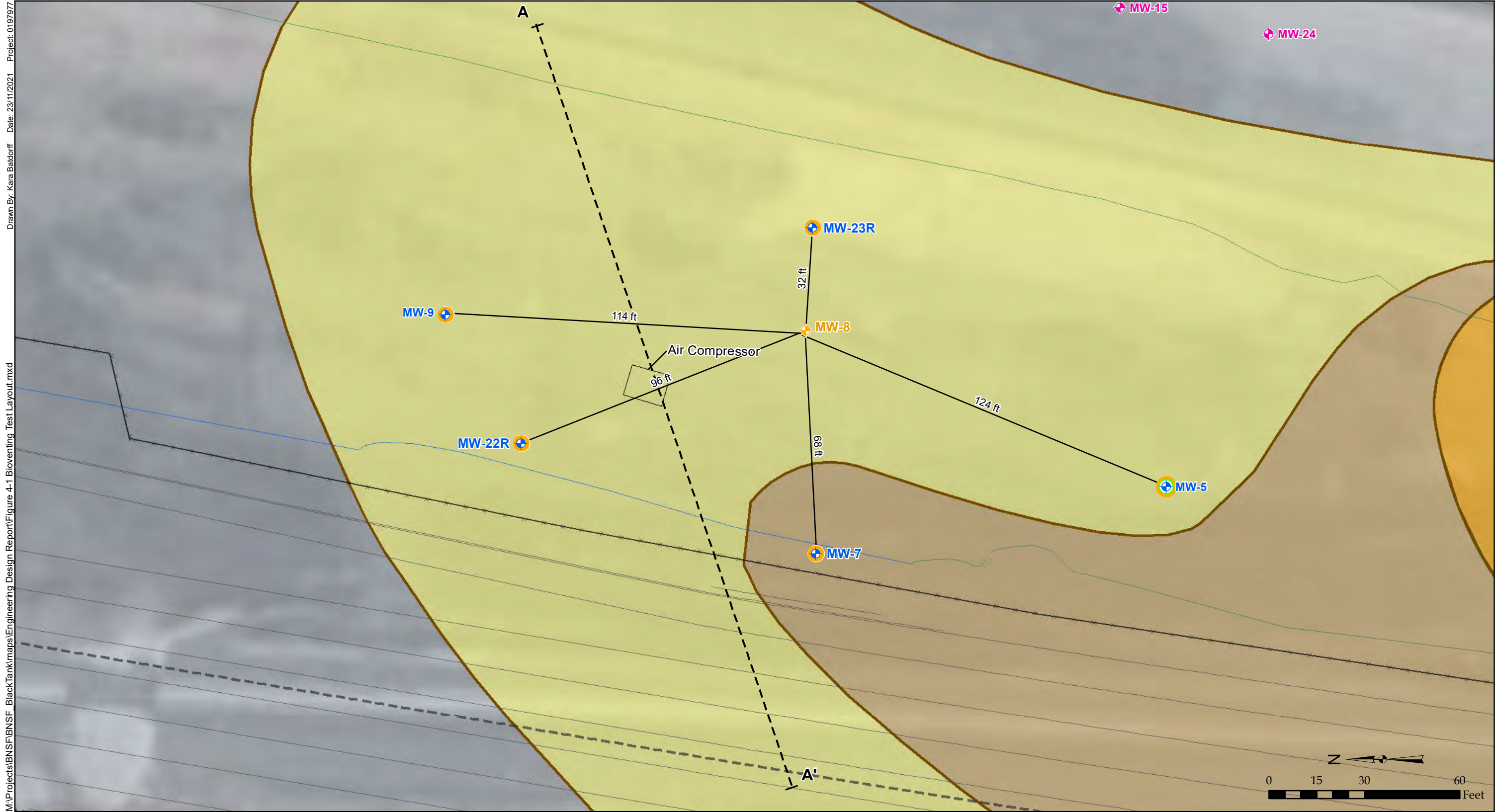
- | | | | |
|---|--|---|--|
| <ul style="list-style-type: none"> Monitoring Well Monitoring Well - Abandoned September 2019 Proposed Biosparge Well Proposed Bioventing Injection Well Proposed Mechanical Equipment Facility September 2020 Boundary RTF | <ul style="list-style-type: none"> High RTF Area Medium RTF Area Low RTF Area Existing Piping (Petroleum and Chemical Solution), June 2016 DOT Proposed Railroad Realignment Option - 2014 | <ul style="list-style-type: none"> Proposed BNSF Black Tank Site Boundary TPH-D/HO in Intermediate Soil Exceeding the Preliminary CUL Approximate Lateral Limits of Surface Soil Cleanup Areas DOT Proposed Highway Alignment Option - 2014 | <ul style="list-style-type: none"> DOT Proposed Pedestrian Pathway - 2014 Former Black Tank Excavation Historical Aboveground Storage Tank, Sump or Pump House |
|---|--|---|--|

Notes:

CUL = Cleanup Level
 DOT = Washington State Department of Transportation
 LNAPL = Light Non-Aqueous Phase Liquid
 NSZD = Natural Source Zone Depletion
 ROI = Radius of Influence
 RTF = Restoration Timeframe
 TPH-D/HO = Combined Diesel and Heavy Oil-Range Petroleum Hydrocarbons
 Preliminary CUL = 13,600 milligrams per kilogram
 Aerial Photo: USGS, April 2012, Google Earth 3/2021

Figure 3-1
Conceptual Representation of Cleanup Action B
And Changes in NSC Layout
(NSZD and Biosparging/Bioventing)
BNSF Black Tank
Spokane, Washington

M:\Projects\BNSF\BNSF Black Tank\maps\Engineering Design Report\Figure 4-1 Bioventing Test Layout.mxd
Drawn By: Kara Baldorff Date: 23/11/2021 Project: 0197977

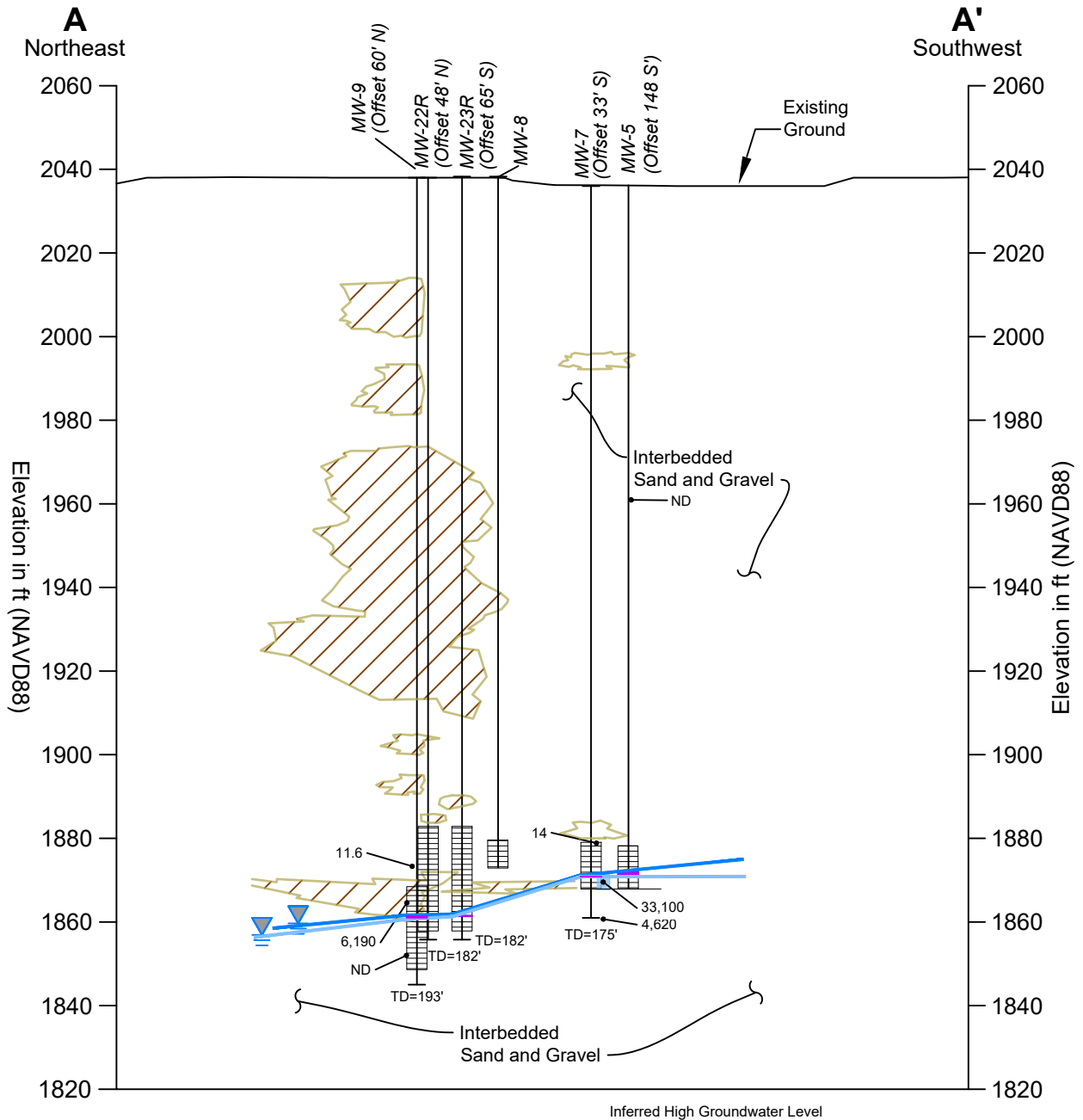


Legend

- | | | | |
|--|--------------------------------|--------------|-----------------|
| Biosparge and Bioventing Performance Monitoring Well | Decommissioned Monitoring Well | Fence | High RTF Area |
| Bioventing Performance Monitoring Well | Cross Section Line | Curb/Roadway | Medium RTF Area |
| Bioventing Injection Well | BNSF Black Tank Site Boundary | Cut Line | Low RTF Area |
| Monitoring Well to be Retained | Barrier | Fill Line | |

Notes:
¹ Alignment subject to change
ROI = Radius of Influence
CUL = Cleanup Level
LNAPL = Light Non-Aqueous Phase Liquid
RTF: Restoration Timeframe
NSC = North Spokane Corridor
TPH-D/HO = Combined Diesel and Heavy Oil-Range Petroleum Hydrocarbons
CUL = 5,360 milligrams per kilogram
WSDOT = Washington State Department of Transportation
Aerial Photo: Google Earth 3/2021.

Figure 4-1
Bioventing ROI Test Layout
Engineering Design Report
BNSF Black Tank
Spokane, Washington



Legend

- MW-6 — Existing Exploration Designation
- (Offset 22' W) — Offset Distance in Feet and Direction
- Top of Exploration
- Silt and Silty Sand Facies
- Interval Having Diesel and Heavy Oil Range Petroleum Hydrocarbons (TPH-D/HO) above the Soil Cleanup Level
- LNAPL Level During Testing
- Groundwater Level During Testing
- Approximate Groundwater Level
- 397 — TPH-D/HO Concentration in Soil (mg/kg)
- Well Screen Interval (If Installed)
- LNAPL Present in Well
- Bottom of Exploration
- TD=193' — Total Depth of Exploration (feet BGS)

mg/kg Milligrams/Kilogram
 ND Not Detected
 TPH-D/HO Total Petroleum Hydrocarbon-Diesel/ Heating Oil
 BGS Below Ground Surface

Note:

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
2. TPH-D/HO Soil Cleanup Level = 13,600 mg/kg

Drawing Source:
 Landau Associates, Figure 6, 1/14/15.

Cross Section location shown on Figure 4

(Vertical Exaggeration = 2.5X)

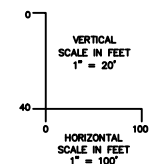
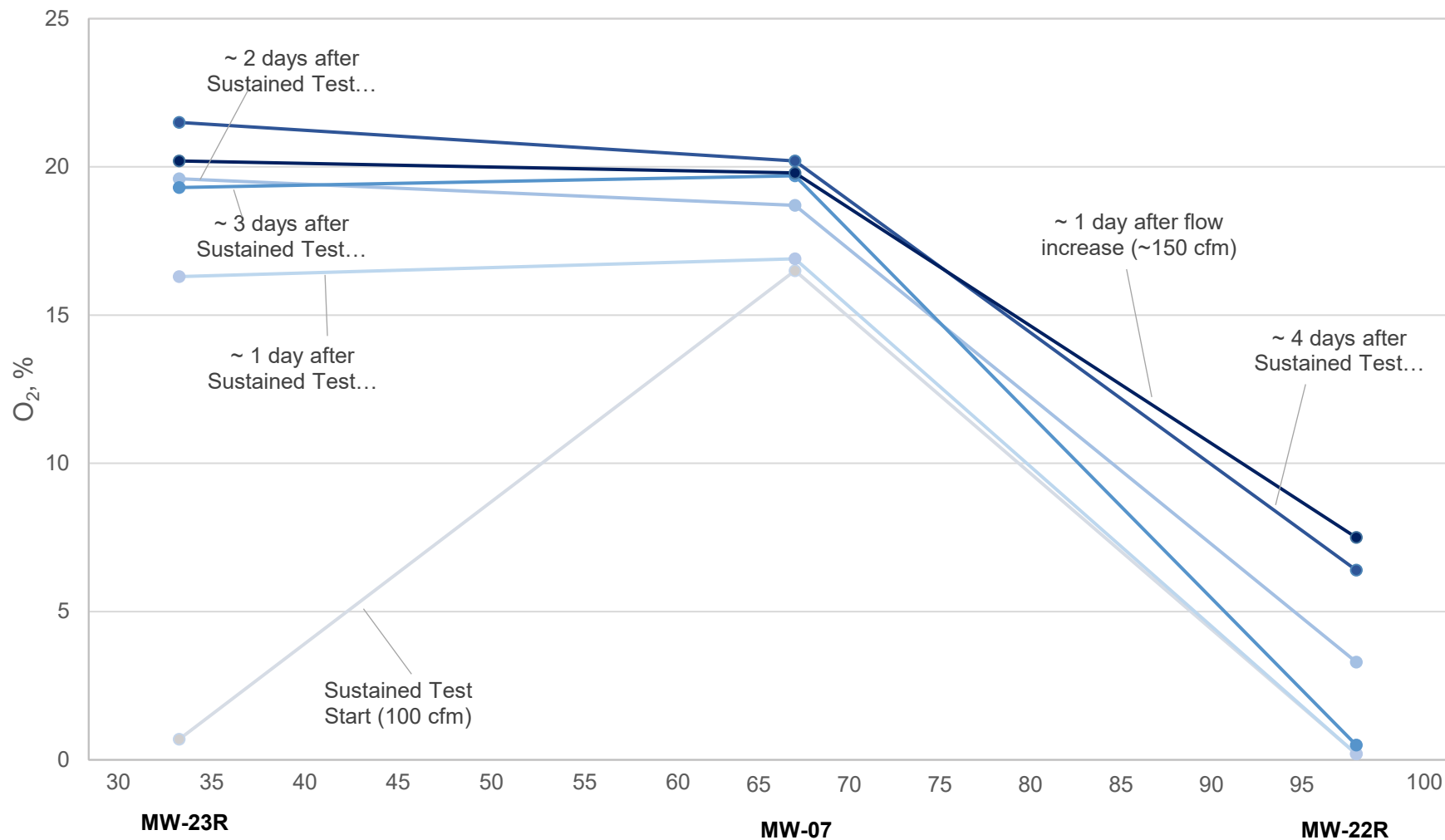


Figure 4-2
Geologic Profile A-A'
Engineering Design Report
BNSF Black Tank
Spokane, Washington

Environmental Resources Management
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Distance from Injection Well, feet

Figure 4-3
 Bioventing ROI O₂ Results
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington

Environmental Resources Management
 www.erm.com



Notes: Initial concentration (i.e., start of sustained test) at MW-07 considered anomalous, concentration increases were observed during test.

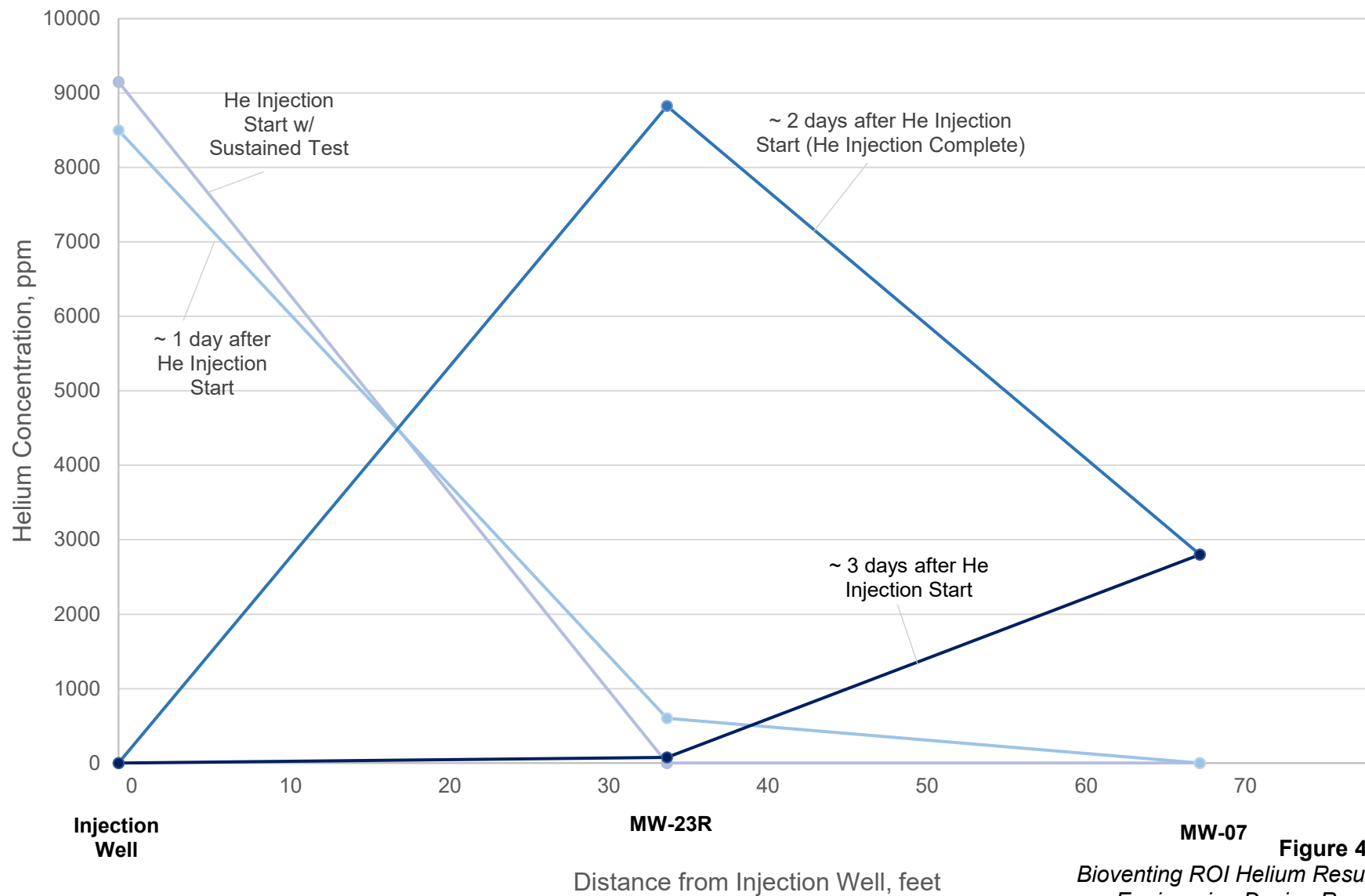


Figure 4-4
 Bioventing ROI Helium Results
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington

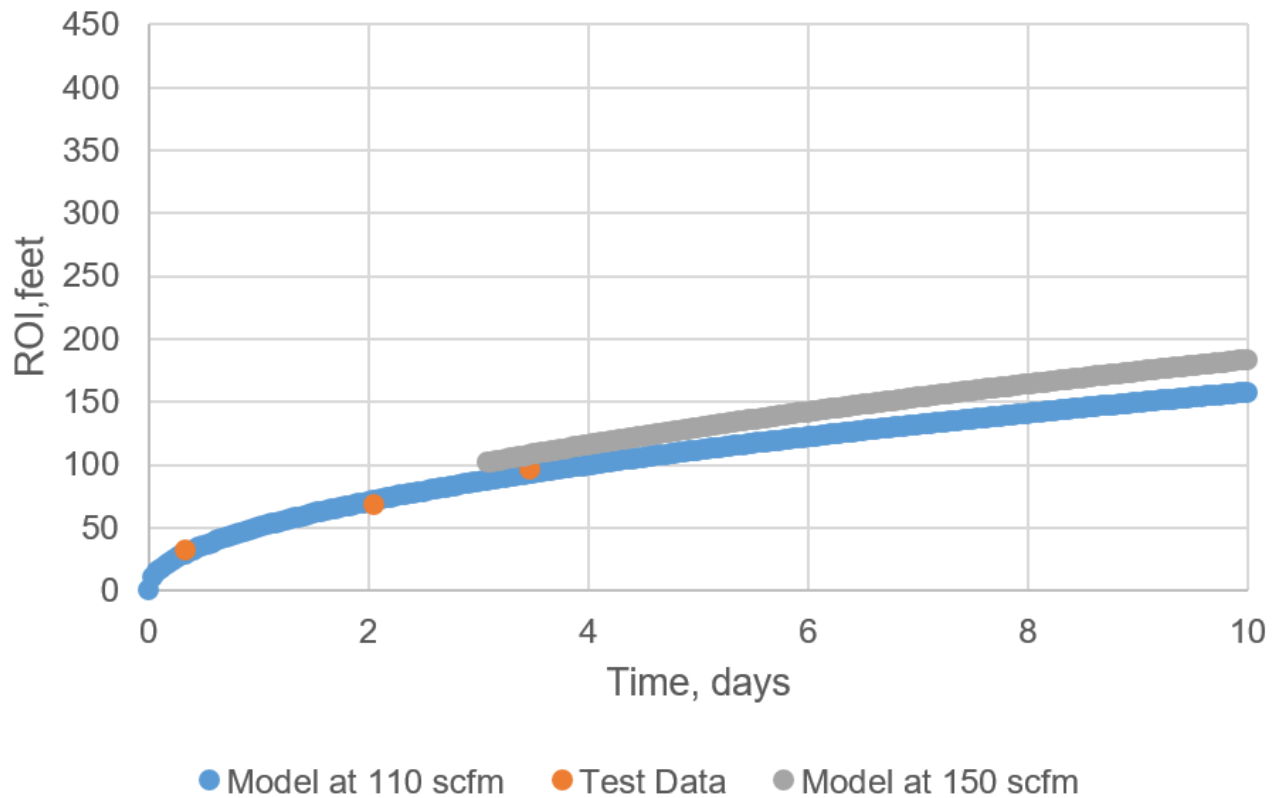
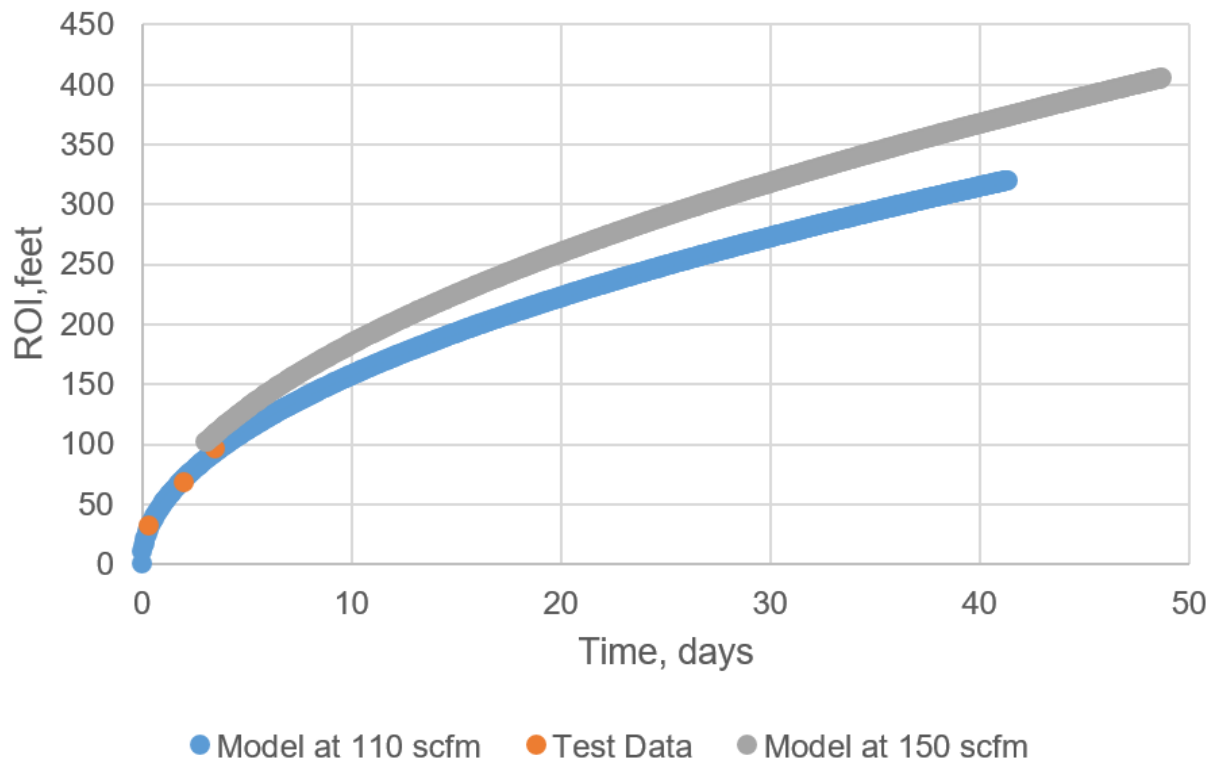
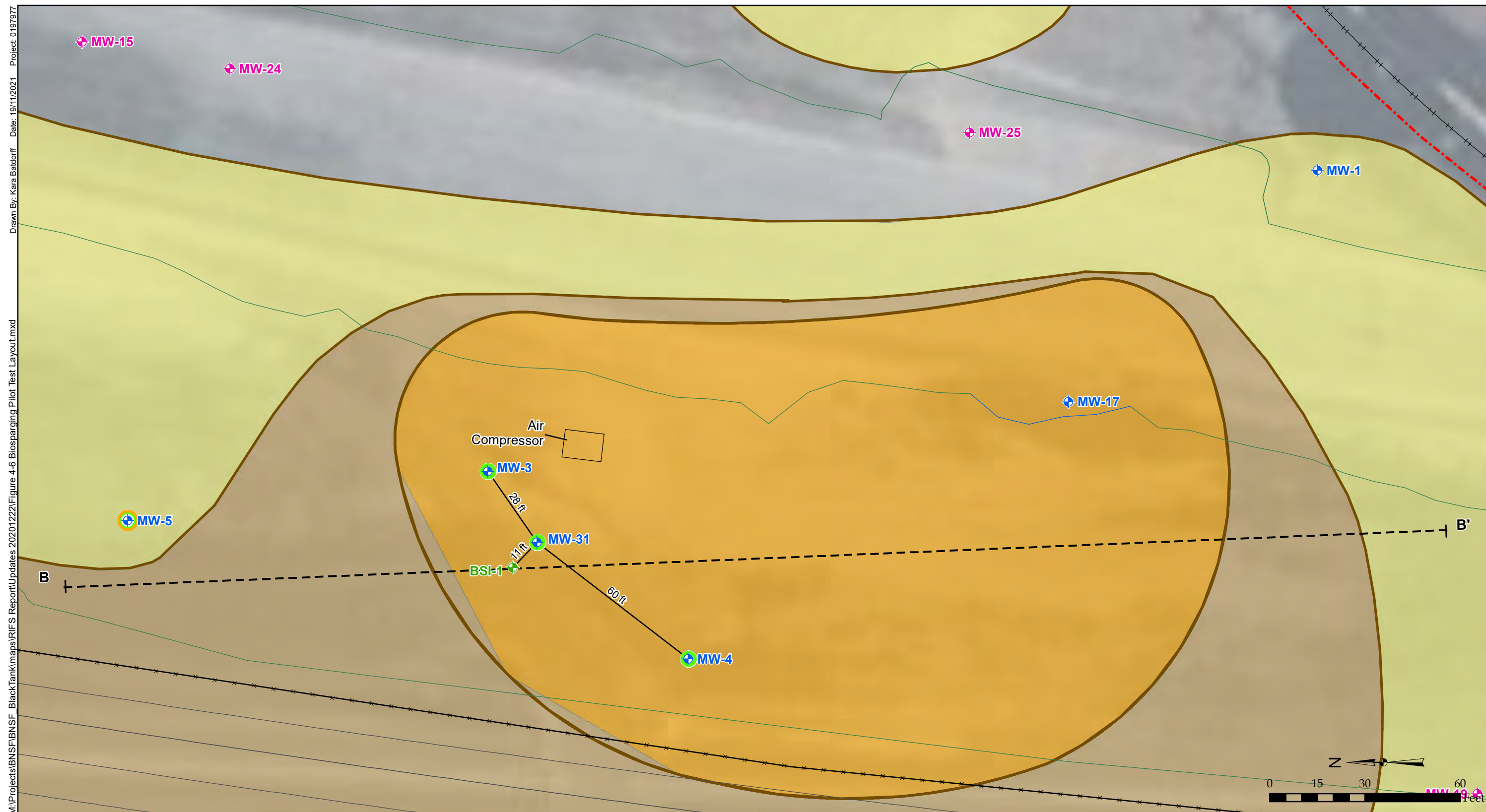


Figure 4-5
Bioventing ROI versus Time Model
Engineering Design Report BNSF
Black Tank
Spokane, Washington



Legend

 Decommissioned Monitoring Well
 Cross Section Line
 BNSF Black Tank Site Boundary
 Fence

- Curb/Roadway
- Cut Line
- Fill Line
- ++ Railroad

 High RTF Area
 Medium RTF Area
 Low RTF Area

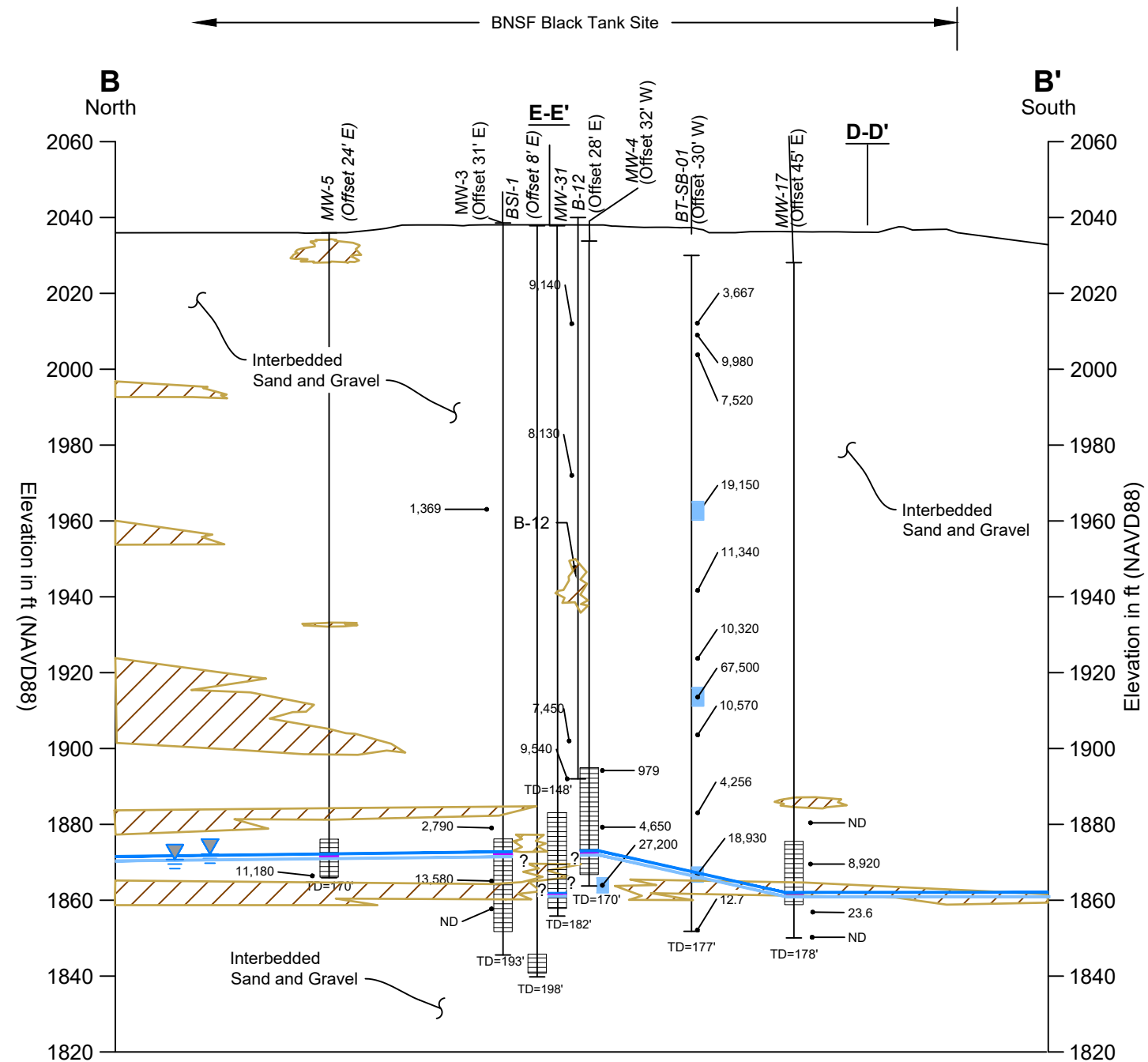
Notes:
¹ Alignment subject to change
 CUL = Cleanup Level
 LNAPL = Light Non-Aqueous Phase Liquid
 RTF: Restoration Timeframe
 NSC = North Spokane Corridor
 TPH-D/HO = Combined Diesel and Heavy
 Oil-Range Petroleum Hydrocarbons
 CUL = 5,360 milligrams per kilogram
 WSDOT = Washington State Department
 of Transportation
 Image Source = Google Earth 3/2021

Figure 4-6
Biosparging ROI Test Layout
Engineering Design Report
BNSF Black Tank
Spokane, Washington

Environmental Resources Management
www.erm.com



R. Olson\jse 1/07/2021 0278173.xxx G:\DWGS\0578173 Black Tank Site\0578173-03.dwg



Legend

- MW-6 Existing Exploration Designation
- (Offset 22' W) Offset Distance in Feet and Direction
- Top of Exploration
- Silt and Silty Sand Facies
- Interval Having Diesel and Heavy Oil Range Petroleum Hydrocarbons (TPH-D/HO) above the Soil Cleanup Level
- LNAPAL Level During Testing
- Groundwater Level During Testing
- Approximate Groundwater Level
- TPH-D/HO Concentration in Soil (mg/kg)
- Well Screen Interval (If Installed)
- LNAPL Present in Well
- Bottom of Exploration
- TD=193' Total Depth of Exploration (feet BGS)

mg/kg Milligrams/Kilogram
ND Not Detected
TPH-D/HO Total Petroleum Hydrocarbon-Diesel/ Heating Oil
BGS Below Ground Surface

Note:

- Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.
- TPH-D/HO Soil Cleanup Level = 13,600 mg/kg

Drawing Source:

Landau Associates, Figure 6, 1/14/15.

Cross Section Location is shown on Figure 7.

? = Groundwater elevation connection not known.

(Vertical Exaggeration = 2.5X)

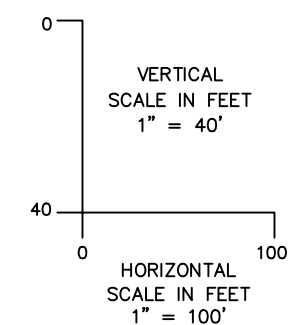


Figure 4-7
Geologic Profile B-B'
Engineering Design Report
BNSF Black Tank
Spokane, Washington

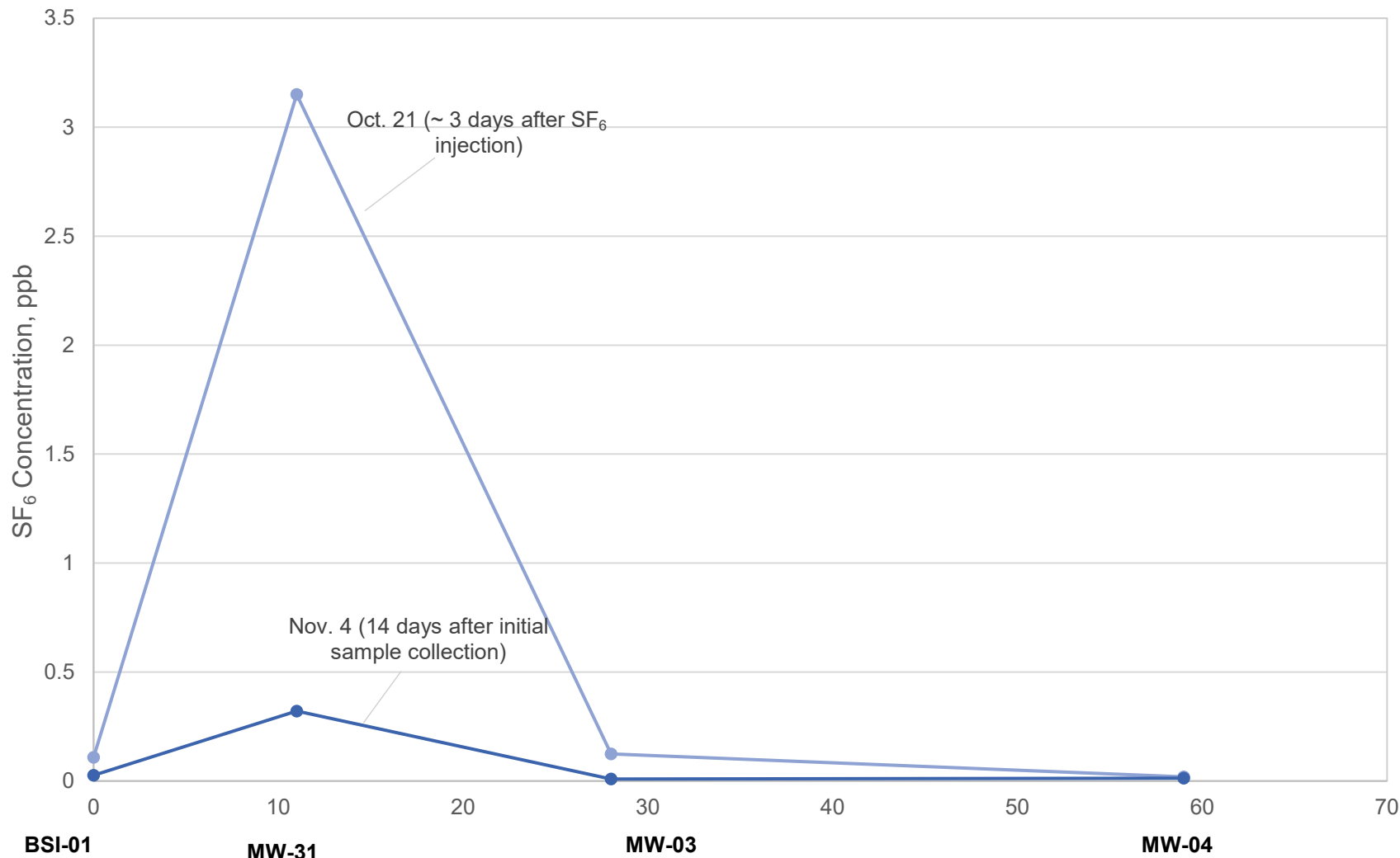


Figure 4-8
Biosparging ROI SF₆ Results
Engineering Design Report
BNSF Black Tank
Spokane, Washington

—●— Oct. 21 (~ 3 days after SF₆ injection)

—●— Nov. 4 (14 days after initial sample collection)

Environmental Resources Management
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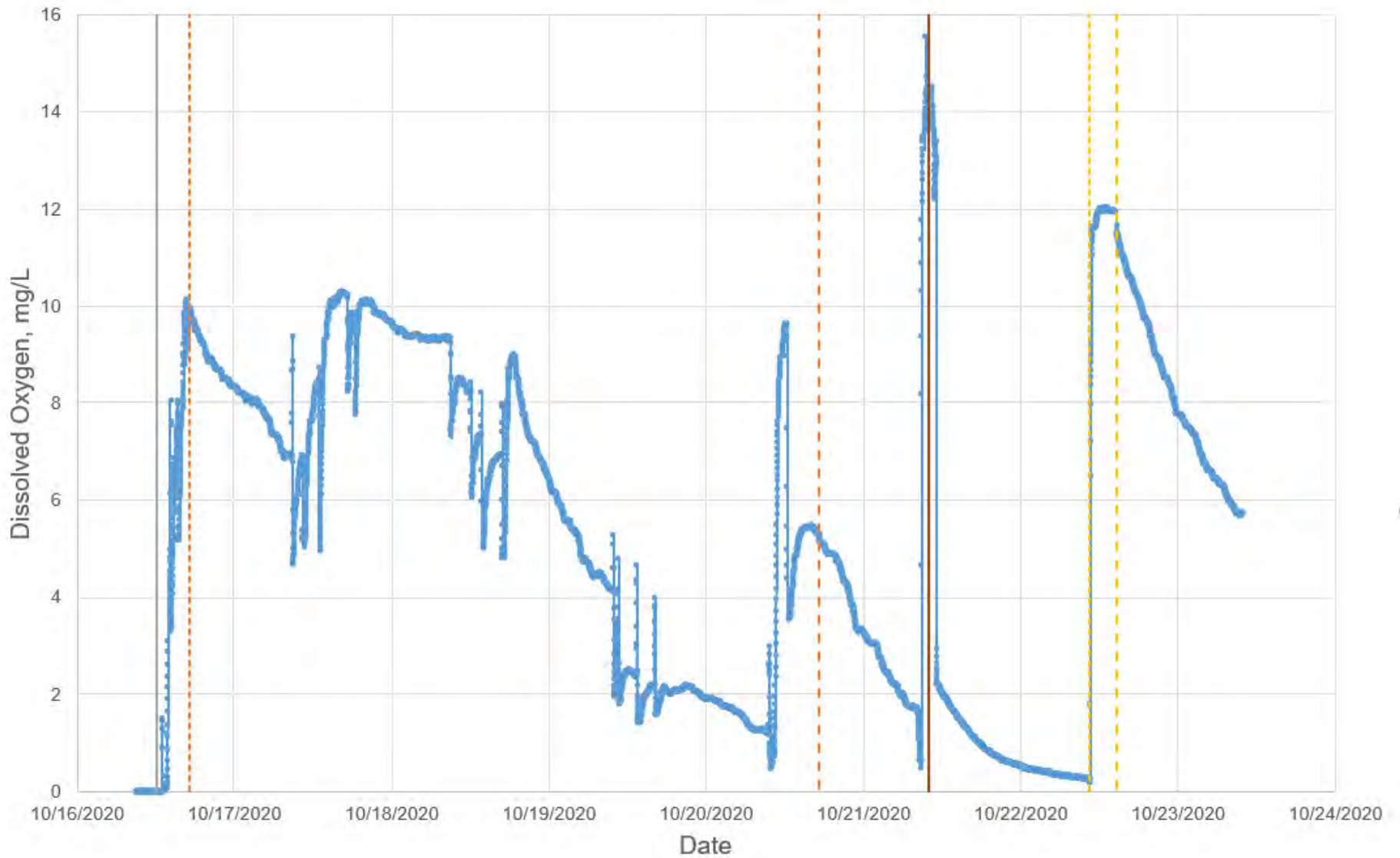
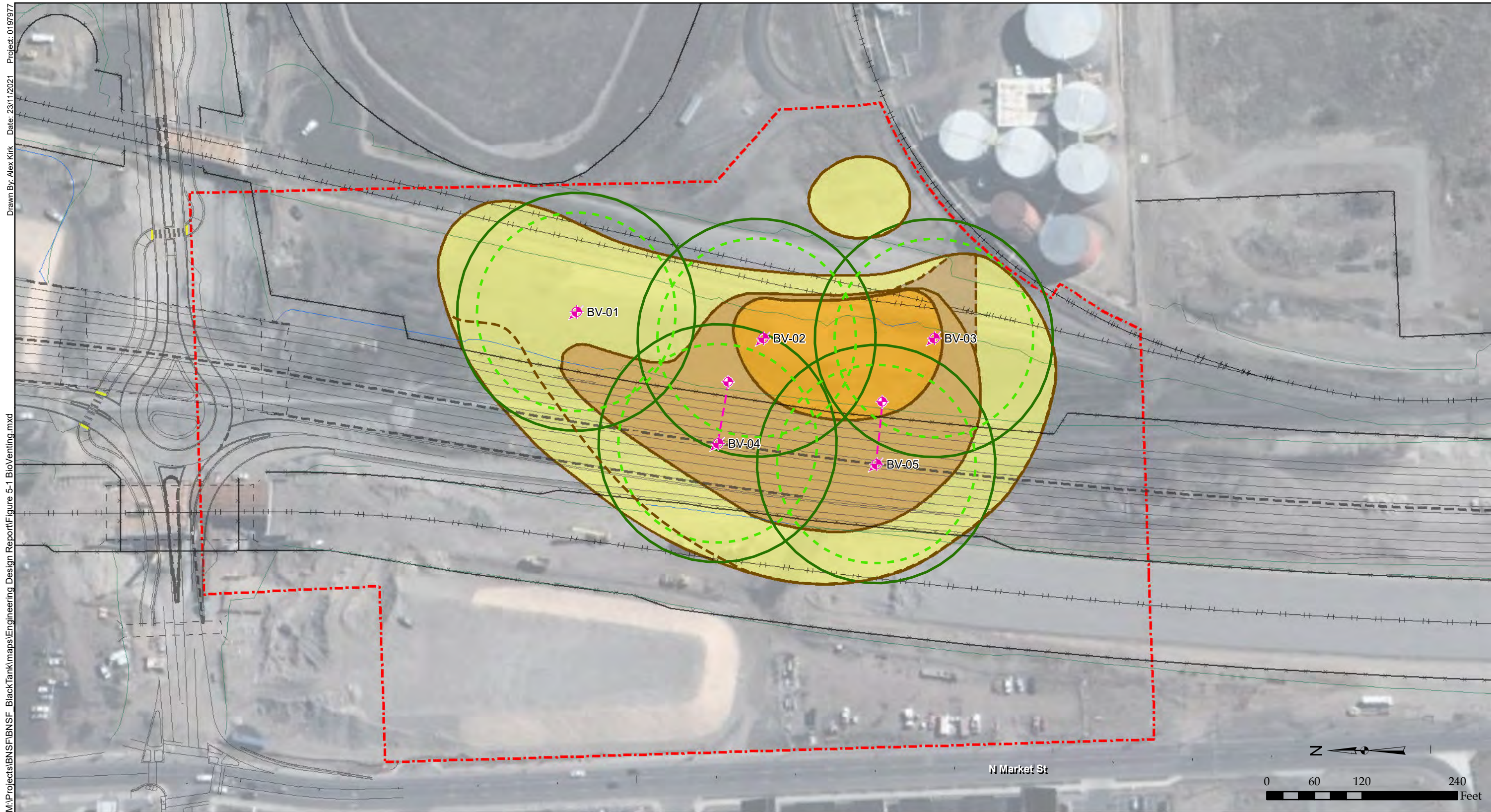


Figure 4-9
Biosparging ROI Dissolved Oxygen Results
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington



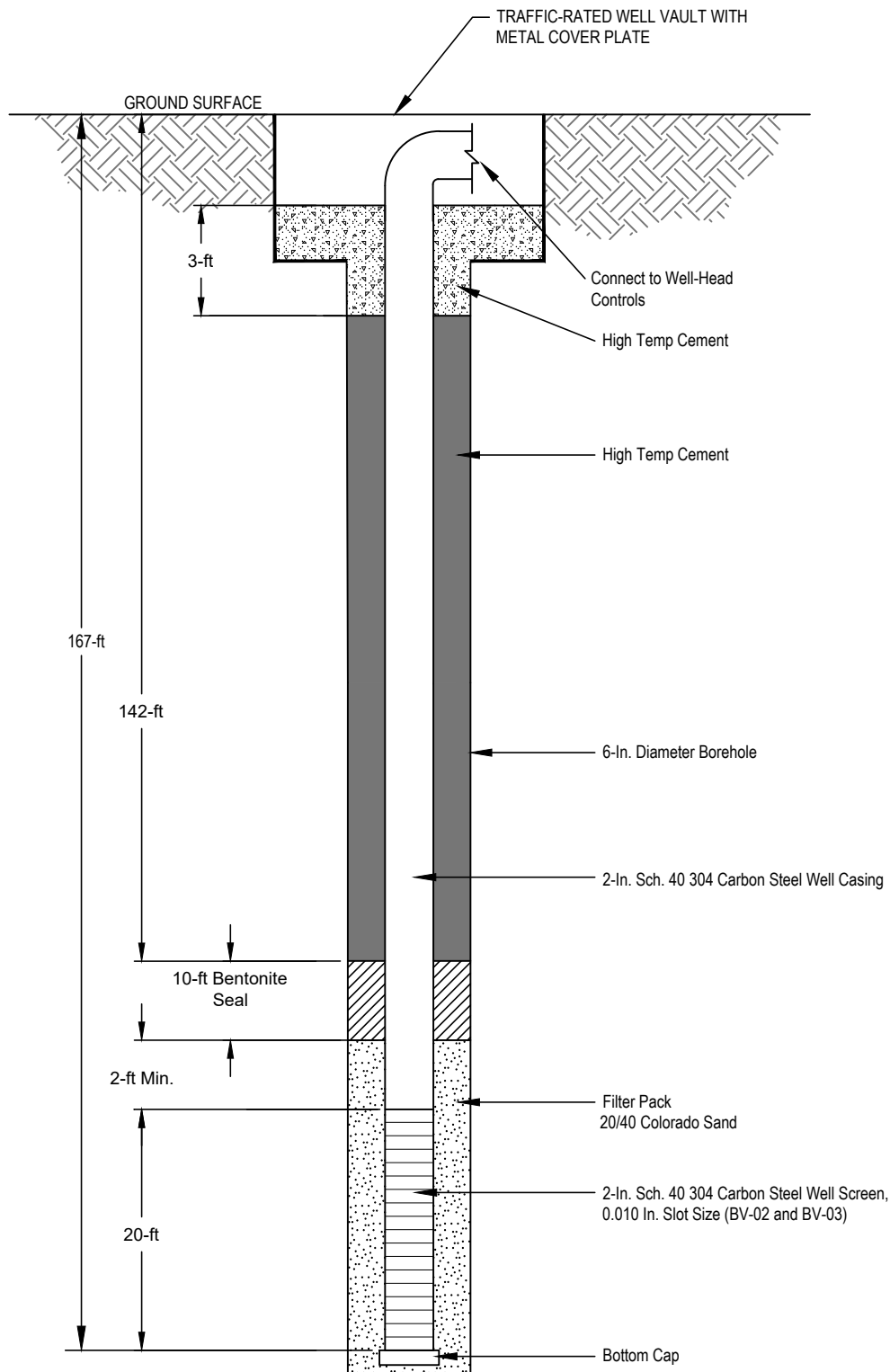
M:\Projects\BNSF\BNSF Black Tank\maps\Engineering Design Report\Figure 5-1 BioVenting.mxd
 Drawn By: Alex Kirk Date: 23/11/2021 Project: 0197977

Legend

- | | | | |
|--|---|--|---|
| <ul style="list-style-type: none"> Bioventing Injection Well Screen Location Well head location for Bioventing Injection Angle Well Bioventing Injection Angle Well 125' ROI 150' ROI | <ul style="list-style-type: none"> September 2020 Boundary RTF High RTF Area Medium RTF Area Low RTF Area BNSF Black Tank Site Boundary Barrier | <ul style="list-style-type: none"> Fence Guardrail Curb/Roadway Detectable Warning Surface Bridge Cut Line | <ul style="list-style-type: none"> Fill Line Railroad |
|--|---|--|---|

Notes:
 LNAPL = Light Non-Aqueous Phase Liquid
 ROI = Radius of Influence
 RTF = Restoration Timeframe

Figure 5-1
 Bioventing System Well Layout
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington



NOTE:

BV-04 and BV-05 - APPROXIMATE WELL DEPTH AND SCREEN INTERVAL. TOTAL DEPTH OF WELL AND SCREEN INTERVAL WILL BE DETERMINED IN THE FIELD.

NOT TO SCALE

Figure 5-2
Vertical Bioventing Well Construction Diagram
Engineering Design Report
Black Tank Site
Spokane, WA

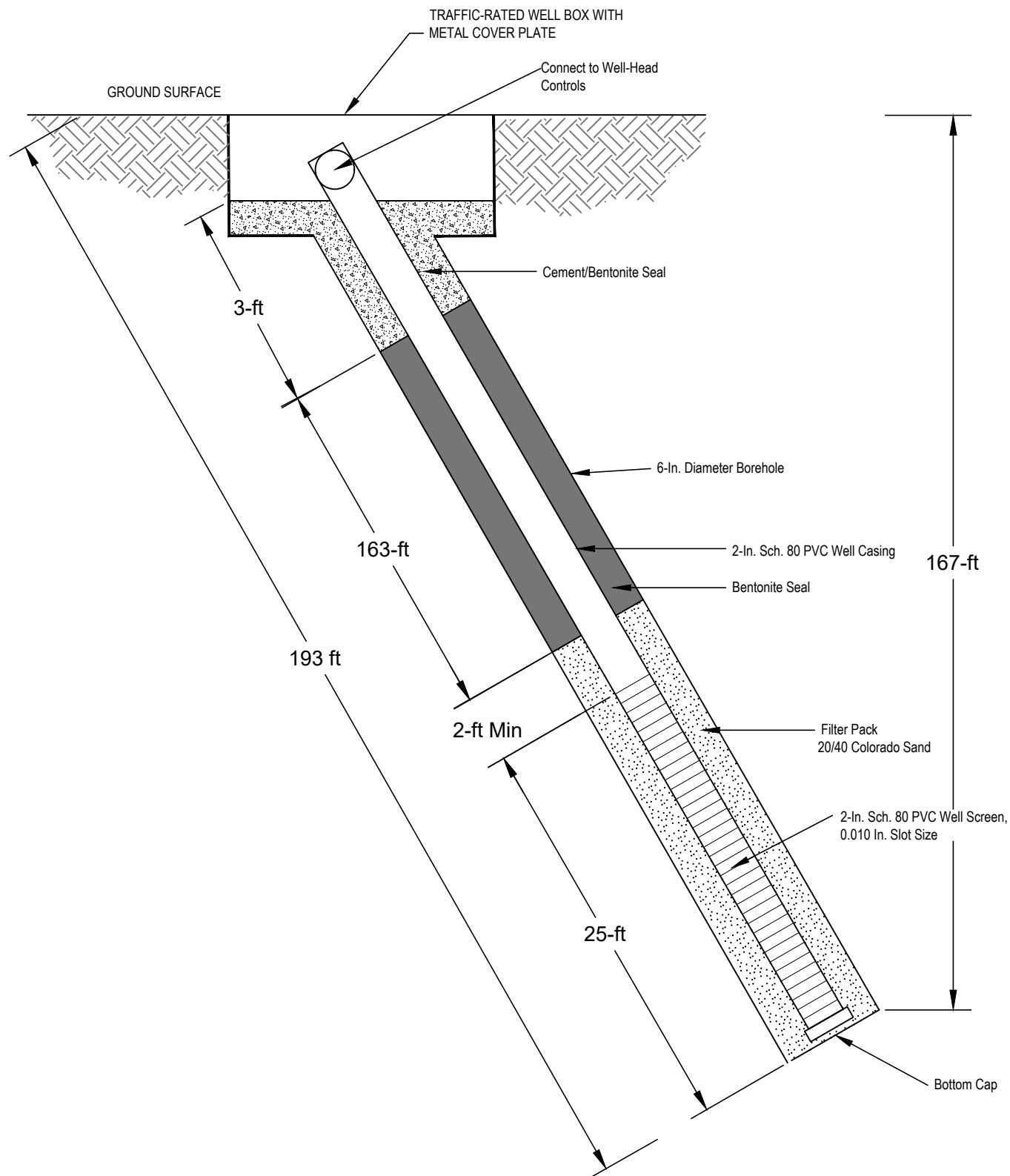


Figure 5-3
Angled Bioventing Well Construction Diagram
Engineering Design Report
Black Tank Site
Spokane, WA

NOTE:
 BV-04 and BV-05 - APPROXIMATE WELL DEPTH AND
 SCREEN INTERVAL. TOTAL DEPTH OF WELL AND
 SCREEN INTERVAL WILL BE DETERMINED IN THE FIELD.

NOT TO SCALE

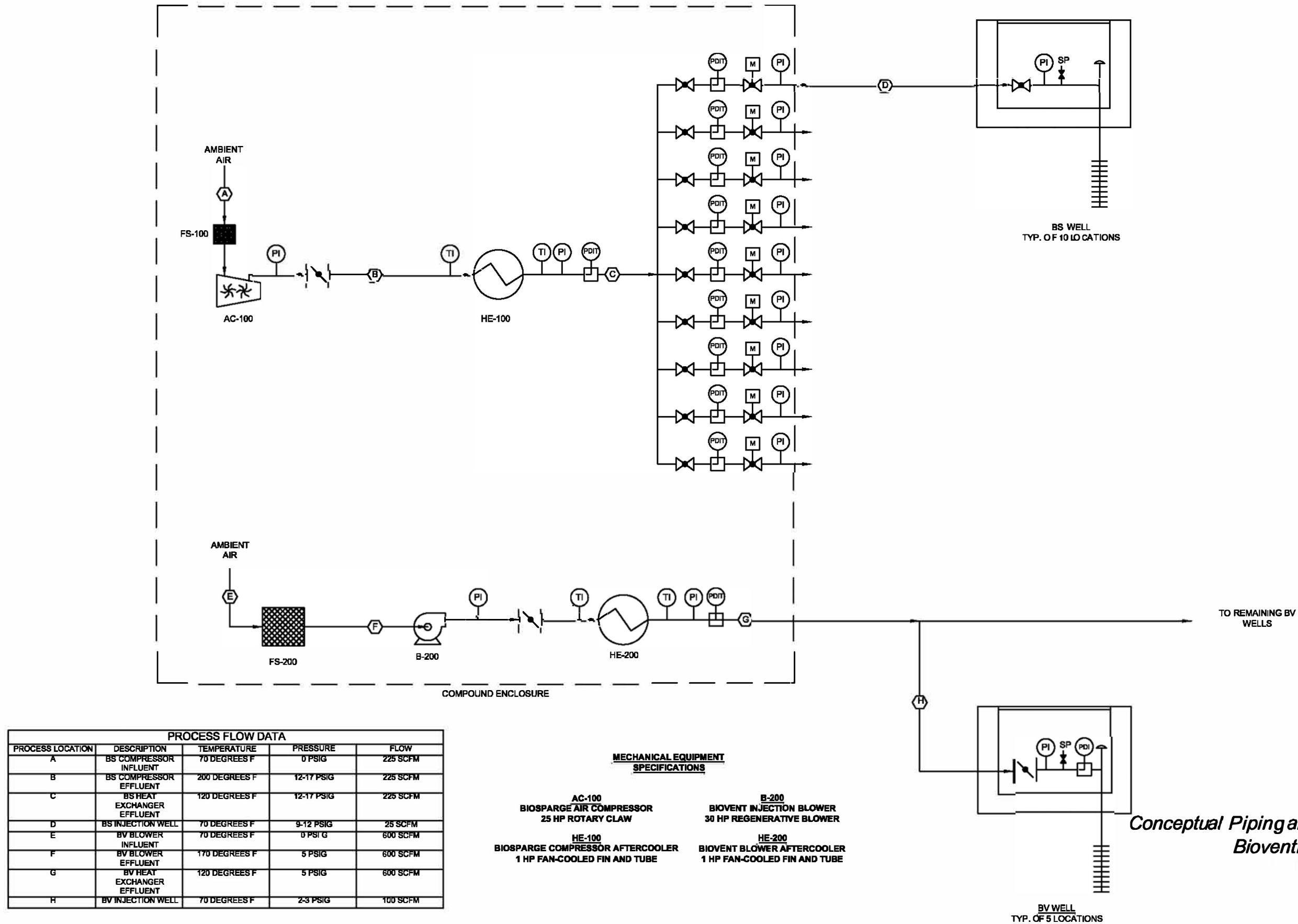
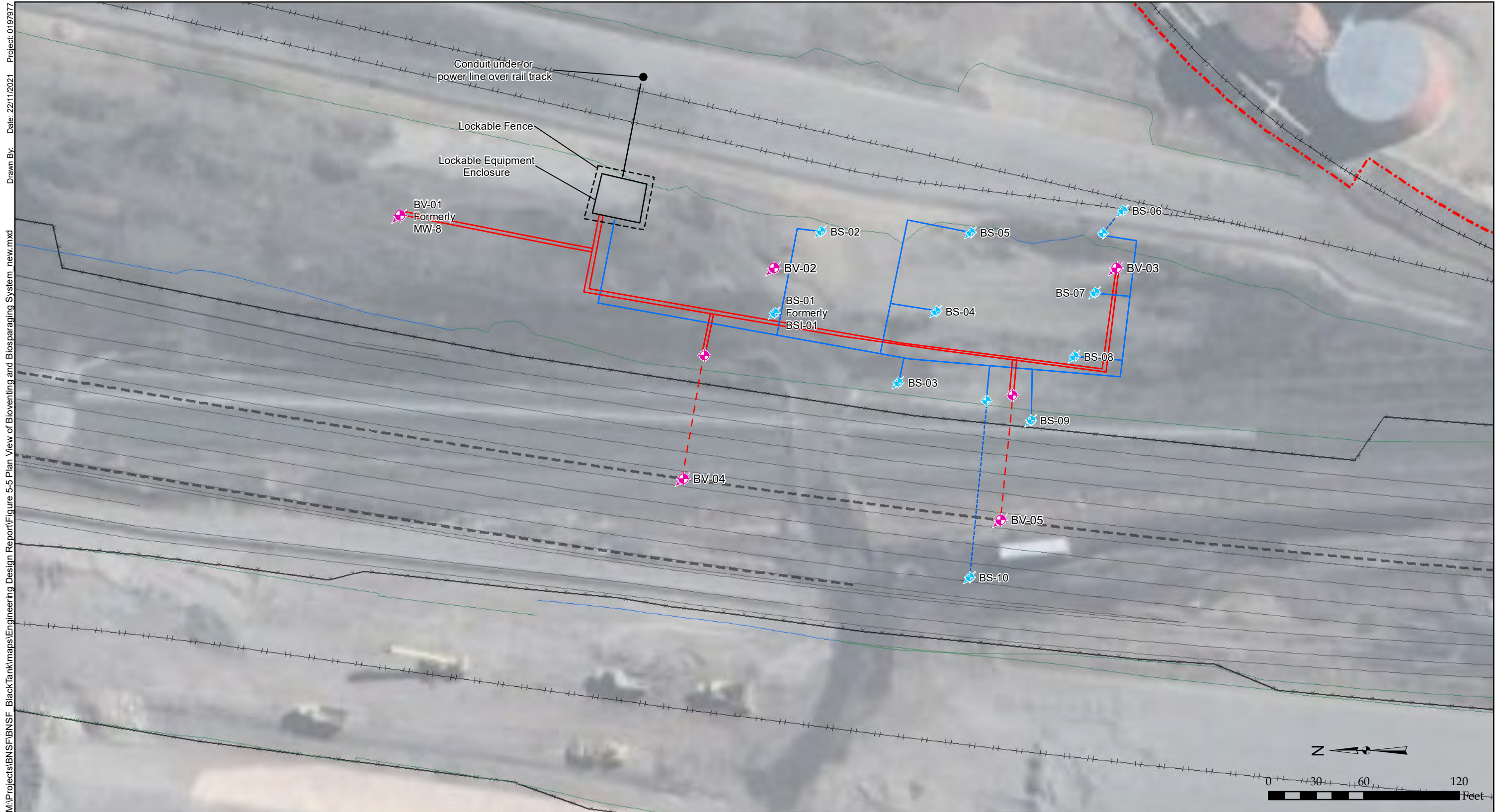


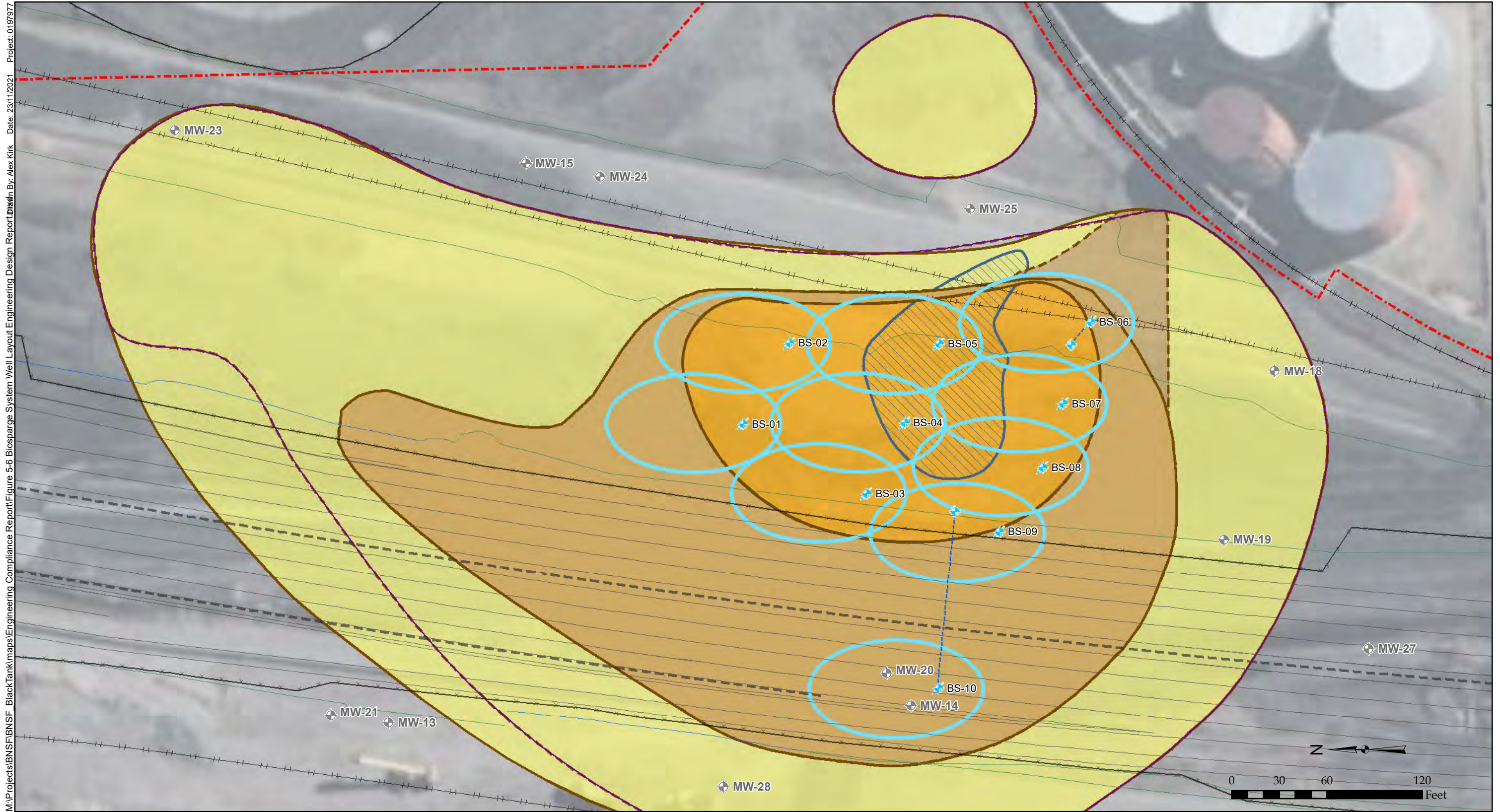
Figure 5-4
*Conceptual Piping and Instrumentation Diagram
Bioventing and Biosparging System
Engineering Design Report
BNSF Black Tank*



M:\Projects\BNSF\BNSF Black Tank\maps\Engineering Design Report\Figure 5-5 Plan View of Bioventing and Biosparging System_new.mxd
 Drawn By: Date: 22/11/2021 Project: 0197977

Legend			
	Bioventing Injection Well Screen Location		Bioventing 30° Angle Well
	Bioventing Injection Well Head Location		Biosparging Air Injection Conveyance Piping
	Biosparging Injection Well Screen Location		Bioventing Air Injection/Extraction Conveyance Piping
	Biosparging Injection Well Head Location		Barrier
	Biosparging Angle Well		Fence
			Guardrail
			Curb/Roadway
			Detectable Warning Surface
			Bridge
			Cut Line
			Fill Line
			Railroad

Figure 5-5
Plan View of Bioventing and Biosparging System
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington



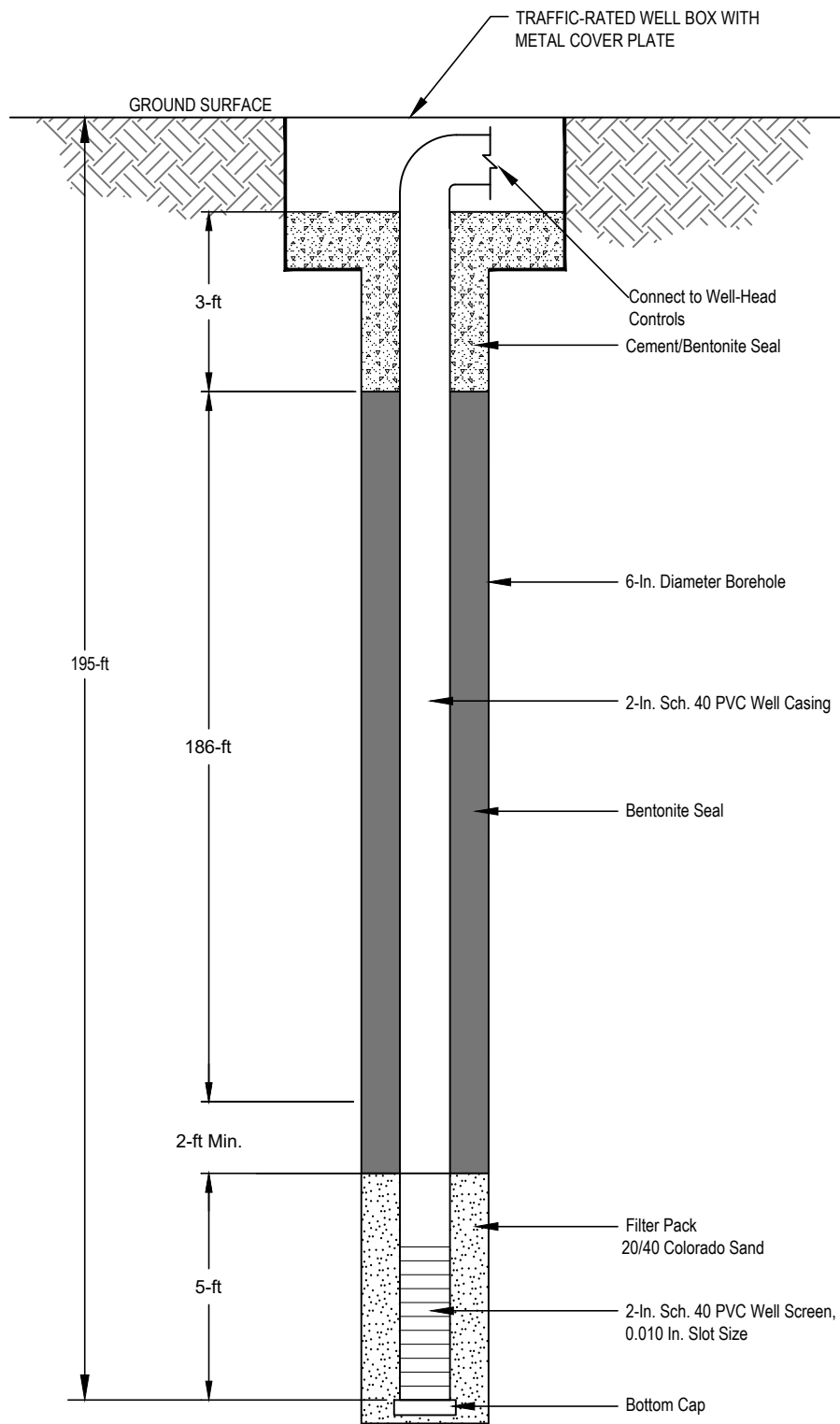
- Legend**
- Proposed Biosparage Well Head Location
 - Proposed Biosparage Well Screen Location
 - Biosparage Angle Well
 - Biosparage Well ROI with Groundwater Gradient Influence
 - September 2020 Boundary RTF
 - High RTF Area

- Medium RTF Area
- Low RTF Area
- Proposed BNSF Black Tank Site Boundary
- TPH-D/HO in Intermediate Soil Exceeding the Preliminary CUL
- Barrier

- Fence
- Curb/Roadway
- Cut Line
- Fill Line
- Railroad

Notes:
 ROI = Radius of Influence
 RTF = Restoration Timeframe

Figure 5-6
 Biosparaging System Well Layout
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington



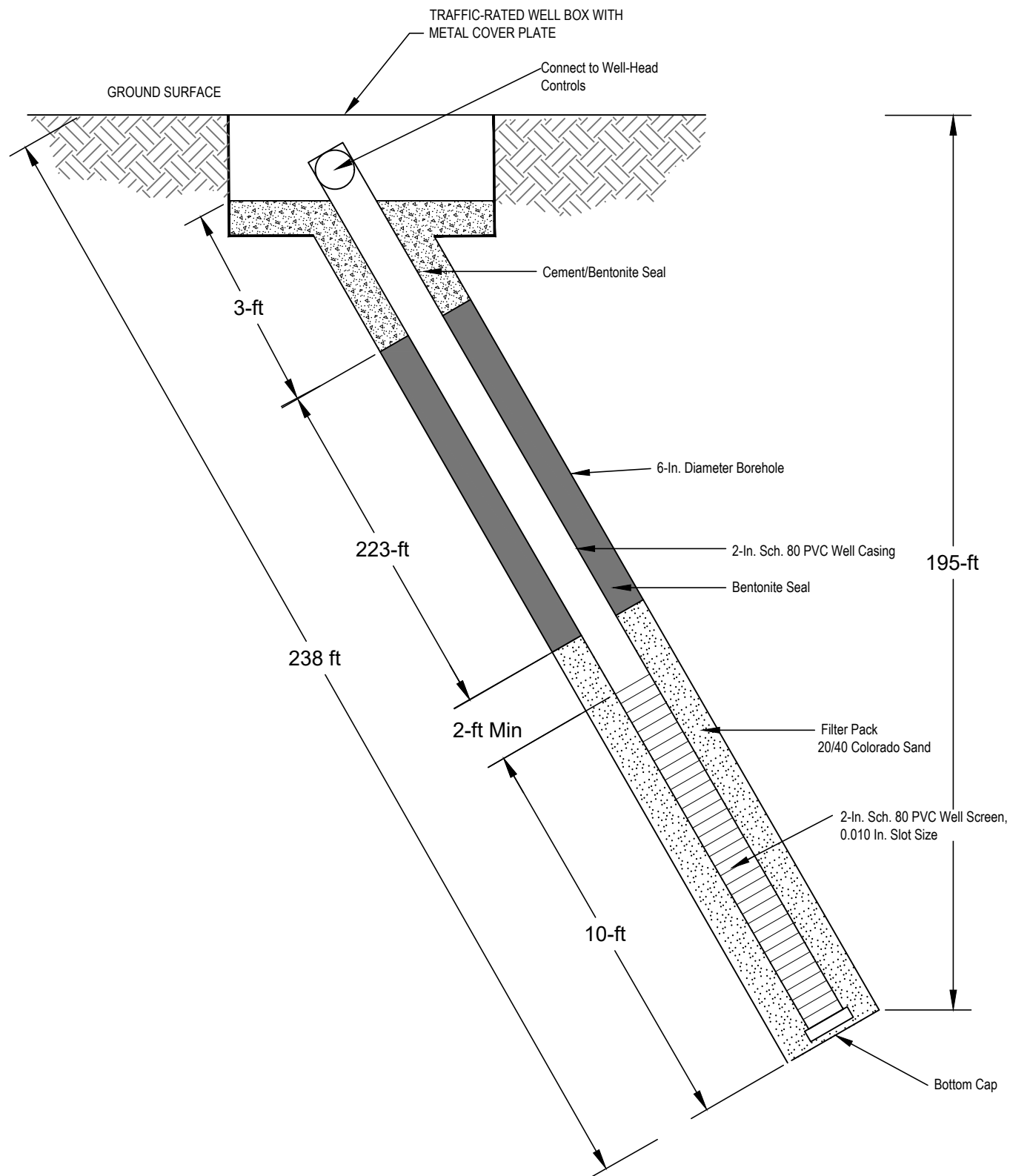
NOTE:

APPLICABLE TO VERTICAL WELLS AND ANGLED WELLS UP TO 7 DEGREES FROM VERTICAL.

APPLICABLE TO BS-02 THROUGH BS-09. LOW ANGLED WELL (BS-06) USE SCH. 80 PVC WELL CASING. APPROXIMATE WELL DEPTH AND SCREEN INTERVAL. TOTAL DEPTH OF WELL AND SCREEN INTERVAL WILL BE DETERMINED IN THE FIELD.

Figure 5-7
Vertical & Low Angled Biosparging Well Construction Diagram

Engineering Design Report
Black Tank Site
Spokane, WA



NOTE:

BV-10 - APPROXIMATE WELL DEPTH AND SCREEN INTERVAL. TOTAL DEPTH OF WELL AND SCREEN INTERVAL WILL BE DETERMINED IN THE FIELD.

NOT TO SCALE

Figure 5-8
Angled Biosparging Well Construction
Diagram Engineering Design Report
Black Tank Site
Spokane, WA

TABLES

Table 1-1
Engineering Design Report Requirements
Engineering Design Report
BNSF Black Tank
Spokane, WA

WAC 173-340-400 4(a) Requirement	Section
(i) Goals of the cleanup action including specific cleanup or performance requirements;	3.1, 3.2
(ii) General information on the facility including a summary of information in the remedial investigation/feasibility study updated as necessary to reflect the current conditions;	2.1, 2.2
(iii) Identification of who will own, operate, and maintain the cleanup action during and following construction;	3.3
(iv) Facility maps showing existing site conditions and proposed location of the cleanup action;	Figures 2-5, 5-1 & 5-6
(v) Characteristics, quantity, and location of materials to be treated or otherwise managed, including groundwater containing hazardous substances;	2.4
(vi) A schedule for final design and construction;	7.0
(vii) A description and conceptual plan of the actions, treatment units, facilities, and processes required to implement the cleanup action including flow diagrams;	3.4, 5.2, 6.1, 6.2, 6.3 & associated figures
(viii) Engineering justification for design and operation parameters, including:	4.1
(A) Design criteria, assumptions and calculations for all components of the cleanup action;	4.1, 5.1, 6.1, 6.2 & 6.3
(B) Expected treatment, destruction, immobilization, or containment efficiencies and documentation on how that degree of effectiveness is determined; and	5.2.2, 5.2.3, 5.3.2 & 6.4
(C) Demonstration that the cleanup action will achieve compliance with cleanup requirements by citing pilot or treatability test data, results from similar operations, or scientific evidence from the literature;	4.1
(ix) Design features for control of hazardous materials spills and accidental discharges (for example, containment structures, leak detection devices, run-on and runoff controls);	5.2.4
(x) Design features to assure long-term safety of workers and local residences (for example, hazardous substances monitoring devices, pressure valves, bypass systems, safety cutoffs);	5.2.4, 5.2.5
(xi) A discussion of methods for management or disposal of any treatment residual and other waste materials containing hazardous substances generated as a result of the cleanup action;	5.2.6
(xii) Facility specific characteristics that may affect design, construction, or operation of the selected cleanup action, including:	2.6, 2.7 & 5.1
(A) Relationship of the proposed cleanup action to existing facility operations;	2.6 & 5.1
(B) Probability of flooding, probability of seismic activity, temperature extremes, local planning and development issues; and	2.6 & 5.1
(C) Soil characteristics and groundwater system characteristics;	2.3.3, 2.3.5 & 5.1
(xiii) A general description of construction testing that will be used to demonstrate adequate quality control;	5.3.1
(xiv) A general description of compliance monitoring that will be performed during and after construction to meet the requirements of WAC 173-340-410;	5.3.2
(xv) A general description of construction procedures proposed to assure that the safety and health requirements of WAC 173-340-810 are met;	5.4
(xvi) Any information not provided in the remedial investigation/feasibility study needed to fulfill the applicable requirements of the State Environmental Policy Act (chapter 43.21C RCW);	5.5
(xvii) Any additional information needed to address the applicable state, federal and local requirements including the substantive requirements for any exempted permits; and property access issues which need to be resolved to implement the cleanup action;	5.5
(xviii) For sites requiring financial assurance and where not already incorporated into the order or decree or other previously submitted document, preliminary cost calculations and financial information describing the basis for the amount and form of financial assurance and, a draft financial assurance document;	NA
(xix) For sites using institutional controls as part of the cleanup action and where not already incorporated into the order or decree or other previously submitted documents, copies of draft restrictive covenants and/or other draft documents establishing these institutional controls; and	6.4
(xx) Other information as required by the department.	NA

Table 2-1
Estimated Mobile LNAPL Volume
Engineering Design Report
BNSF Black Tank Site
Spokane, Washington

Area (acre)	Area - 2016 (acres)	Area - 2019 (acres)	Residual ¹ LNAPL (above smear zone)		Mobile LNAPL - 2016		Mobile LNAPL - 2019 (Using Mean Thickness)		Mobile LNAPL - 2019 (Using Mean + 1SD Thickness)		Change 2016 to 2019 (Using Mean Thickness)		Change 2016 to 2019 (Using Mean + 1SD Thickness)	
			gallons	gal/acre	gallons	gal/acre	gallons	gal/acre	gallons	gal/acre	gallons	gal/acre	gallons	gal/acre
High RTF	0.8	0.8	N/A	N/A	66,000	83,000	21,000	26,000	29,000	36,000	-45,000	-57,000	-37,000	-47,000
Medium RTF	1.7	1.8	N/A	N/A	84,000	49,000	57,000	32,000	74,000	41,000	-27,000	-17,000	-10,000	-8,000
Low RTF	3.5	3.4	21300	6100	9,000	2,600	12,000	3,600	27,000	8,000	3,000	1,000	18,000	5,400
Totals	6.0	6.0			159,000	27,000	90,000	15,000	130,000	22,000	-69,000	-12,000	-29,000	-5,000

Abbreviations:

gal/acre = gallons per acre

LNAPL = Light Non-Aqueous Phase Liquid

Table 2-2
Groundwater and LNAPL Level Measurements
March 2016 through September 2020
Engineering Design Report
BNSF Black Tank Site
Spokane, Washington

Monitoring Well	Measurement Date	Collector	Total Depth feet	TOC Elevation feet amsl	Depth to Product feet	Depth to Groundwater feet	Gauged LNAPL Thickness feet	Corrected Depth to Groundwater feet	LNAPL Elevation feet amsl	Groundwater Elevation feet amsl	Corrected Groundwater Elevation feet amsl	Submerged Screen? Y/N	Comment
MW-01	6/20/2020	ERM	NM	2036.07	168.10	171.30	3.20	168.45	1867.97	1864.77	1867.62	No	
MW-01	9/24/2020	ERM	NM	2036.07	173.78	174.98	1.20	173.91	1862.29	1861.09	1862.16	No	Product thickness & GW depth/elevation corrected because product too viscous to allow accurate measurement. Original LNAPL thickness = 2.32 feet. Corrected thickness is based on product volume removed.
MW-02	6/20/2020	ERM	NM	2037.07	169.45	169.58	0.13	169.46	1867.62	1867.49	1867.61	No	
MW-02	9/24/2020	ERM	NM	2037.07	175.06	175.38	0.32	175.10	1862.01	1861.69	1861.97	No	Product thickness & GW depth/elevation corrected because product too viscous to allow accurate measurement. Original LNAPL thickness = 0.88 feet. Corrected thickness is based on product volume removed.
MW-03	6/20/2020	ERM	NM	2040.89	168.30	169.10	0.80	168.39	1872.59	1871.79	1872.50	No	
MW-03	9/24/2020	ERM	NM	2040.89	168.49	168.60	0.11	168.50	1872.4	1871.79	1872.39	No	
MW-04	6/20/2020	ERM	NM	2033.59	159.24	161.10	1.86	159.44	1874.35	1872.49	1874.15	No	Well interior coated with LNAPL precluded collection of depth to LNAPL using LNAPL interface probe; however, depth to groundwater was collected because groundwater probe is smaller diameter. Product thickness/depth/elevation based on volume product removed and GW elevation.
MW-04	9/24/2020	ERM	NM	2033.59	161.20	161.93	0.73	161.28	1872.39	1871.66	1872.31	No	Product thickness & GW depth/elevation corrected because product too viscous to allow accurate measurement. Original LNAPL thickness = 1.6 feet. Corrected thickness is based on product volume removed.
MW-05	6/20/2020	ERM	NM	2040.87	168.89	ND	1.72	ND	1871.98	ND	ND	NA	Product thickness based on volume product removed because product too viscous (tarry) to allow accurate measurement. No water observed. Original LNAPL thickness could not be measured.
MW-05	9/24/2020	ERM	NM	2040.87	169.01	169.84	0.83	169.10	1871.86	1871.03	1871.77	No	Product thickness & GW depth/elevation corrected because product too viscous to allow accurate measurement. Original LNAPL thickness = 1.7 feet. Corrected thickness is based on product volume removed.
MW-06	6/20/2020	ERM	NM	2029.48	ND	160.98	ND	160.98	ND	1868.50	1868.50	Yes	
MW-06	9/24/2020	ERM	NM	2029.48	ND	166.64	ND	166.64	ND	1863.06	1862.84	Yes	
MW-07	6/20/2020	ERM	NM	2036	165.11	166.05	0.94	165.21	1870.89	1869.95	1870.79	No	
MW-07	9/24/2020	ERM	NM	2036	165.15	165.21	0.06	165.16	1870.85	1870.79	1870.84	No	
MW-09	6/20/2020	ERM	NM	2040.60	173.51	173.65	0.14	173.53	1867.09	1866.95	1867.07	No	
MW-09	9/24/2020	ERM	NM	2040.60	179.28	179.57	0.29	179.31	1861.32	1861.03	1861.29	No	
MW-10	6/20/2020	ERM	NM	2038.07	ND	171.23	ND	171.23	ND	1866.84	1866.84	No	
MW-10	9/24/2020	ERM	NM	2038.07	ND	176.97	ND	176.97	ND	1861.1	1861.10	Yes	
MW-16	6/20/2020	ERM	NM	2036.70	ND	169.20	ND	169.20	ND	1867.50	1867.50	No	
MW-16	9/24/2020	ERM	NM	2036.70	ND	174.92	ND	174.92	ND	1861.78	1861.78	No	
MW-17	6/20/2020	ERM	NM	2030.78	162.83	163.11	0.28	162.86	1867.95	1867.67	1867.92	No	
MW-17	9/24/2020	ERM	NM	2030.78	168.70	169.15	0.45	168.75	1862.08	1861.63	1862.03	No	
MW-22R	9/24/2020	ERM	NM	2039.85	ND	178.56	ND	178.56	ND	1861.285	1861.29	No	
MW-23R	9/24/2020	ERM	NM	2039.94	178.46	178.47	0.01	178.46	1861.479	1861.469	1861.48	No	
MW-26	6/20/2020	ERM	NM	2035.63	ND	167.75	ND	167.75	ND	1867.88	1867.88	Yes	
MW-26	9/24/2020	ERM	NM	2035.63	ND	173.50	ND	173.50	ND	1862.13	1862.13	No	
MW-29	6/20/2020	ERM	NM	2041.05	ND	174.18	ND	174.18	ND	1866.87	1866.87	No	
MW-29	9/24/2020	ERM	NM	2041.05	ND	179.91	ND	179.91	ND	1861.14	1861.14	No	
MW-30	6/20/2020	ERM	NM	2041.25	ND	173.87	ND	173.87	ND	1867.38	1867.38	No	
MW-30	9/24/2020	ERM	NM	2041.25	ND	179.58	ND	179.58	ND	1861.67	1861.67	No	
MW-31	9/24/2020	ERM	NM	2038.21	176.76	176.78	0.02	176.76	1861.45	1861.43	1861.45	No	
BSI-1	9/24/2020	ERM	NM	2038.58	ND	178.33	ND	178.33	ND	1860.249	1860.25	Yes	Well casing not at final elevation; depth to groundwater is approximate.

Notes:

Erroneous measurement revised based on volume of LNAPL removed from the well.

Abbreviations:

amsl = above mean sea level

NA = data not available

ND = not detected

NM = not measured

TOC = top of casing

Corrected product thickness evaluation:

For unconfined observations, no correction to approximate product thickness was performed.

For perched observations, corrected product thicknesses were calculated by calculating the difference between the product elevation and top of silt facies elevation.

For confined observations, corrected product thicknesses were calculated by calculating the difference between bottom of silt facies and groundwater elevation.

Table 2-3
Construction Details of Decommissioned Monitoring Wells to be Decommissioned
Engineering Design Report
BNSF Black Tank Site
Spokane, Washington

Well Identification	Well Completion Date	Washington State Plane Coordinates, North Zone (NAD 83, feet)		Borehole Depth (feet bgs)	Ground Surface Elevation (NAVD 88, feet)	Top of Casing Elevation (NAVD 88, feet)	Screen Interval Depth to		Screen Length (feet)	Screen Slot Size (inches)	Filter Pack Depth to	
		Easting	Northing				Top (feet bgs)	Bottom (feet bgs)			Top (feet bgs)	Bottom (feet bgs)
MW-07	23-Jul-08	274277.4	2494723.7	175.0	2036.46	2036.00	158.5	168.5	10.0	0.020	156.0	169.0
MW-11	29-May-09	274654.5	2494670.0	197.0	2037.98	2037.67	167.0	197.0	30.0	0.010	164.9	197.0
MW-12	9-Jan-06	274546.6	2494533.1	198.0	2038.21	2038.21	167.0	197.0	30.0	0.010	163.5	198.0
MW-13	9-Mar-06	274268.2	2494543.2	197.0	2039.54	2039.21	182.0	197.0	15.0	0.010	180.0	197.0
MW-14	9-Jun-06	273939.3	2494553.9	217.0	2039.26	2038.84	197.0	217.0	20.0	0.010	195.0	217.0
MW-15	28-May-09	274181.6	2494895.5	197.0	2037.66	2037.40	166.0	196.0	30.0	0.010	163.0	196.0
MW-18	17-Oct-13	273710.3	2494764.6	187.0	2034.90	2037.67	161.2	176.2	15.0	0.010	158.2	177.6
MW-19	11-Nov-13	273742.2	2494658.5	178.0	2030.91	2030.43	160.3	175.3	15.0	0.010	157.2	176.6
MW-20	29-Oct-13	273954.7	2494574.2	188.0	2039.48	2039.11	167.5	182.5	15.0	0.010	164.6	183.9
MW-21	1-Nov-13	274304.5	2494547.9	188.0	2039.39	2039.04	176.3	186.3	10.0	0.010	173.4	187.8
MW-22	5-Nov-13	274530.8	2494751.0	188.0	2038.32	2041.20	170.7	180.7	10.0	0.010	167.8	182.1
MW-23	28-Oct-13	274402.7	2494916.3	188.0	2038.68	2041.49	172.0	182.0	10.0	0.010	169.1	183.3
MW-24	12-Nov-13	274135.0	2494887.1	183.4	2037.77	2040.41	168.1	183.1	15.0	0.010	165.2	183.4
MW-25	14-Nov-13	273902.1	2494866.9	178.2	2033.17	2036.14	162.9	177.9	15.0	0.010	160.9	178.2
MW-27	27-Sep-14	273651.14	2494589.65	187.0	2038.36	2038.15	173.5	183.5	10.0	0.010	171.8	184.0
MW-28	7-Apr-16	274057.40	2494502.77	187.0	2040.36	2042.76	165.0	180.0	15.0	0.010	162.0	160.0
MW-29	9-Apr-16	274529.23	2494913.79	183.0	2038.54	2041.05	168.0	183.0	15.0	0.010	183.0	165.0

Notes:
bgs = below ground surface

Table 3-1
Groundwater Cleanup Levels
Engineering Design Report
BNSF Black Tank
Spokane, WA

Analyte	Cleanup Level (ug/L)	Basis for Cleanup Level
TPH-D/HO	500	MTCA Method A
Benzo(a)Pyrene	0.1	MTCA Method A
Benzo(a)Pyrene TEQ	0.1	MTCA Method A
LNAPL	No Detectable LNAPL	WAC 173-340-360(2)(c)(ii)

Notes:

ug/L = micrograms per liter

TPH-D/HO = total petroleum hydrocarbons as diesel/heavy oil

TEQ = toxic equivalency quotient

LNAPL = light, non-aqueous-phase liquid

MTCA = Model Toxics Control Act

Table 3-2
Soil Cleanup Levels
Engineering Design Report
BNSF Black Tank
Spokane, WA

Analyte	Cleanup Level (mg/kg)	Basis for Cleanup Level
Surface Soil (surface to 15 feet bgs)		
TPH-D/HO	2000	MTCA Method A
Benzo(a)Pyrene	0.1	MTCA Method A
Benzo(a)Pyrene TEQ	0.1	MTCA Method A
Naphthalene	5	MTCA Method A
Total Naphthalenes	5	MTCA Method A
Subsurface Soil (below 15 feet bgs)		
TPH-D/HO	5630	Residual Saturation*
LNAPL		
LNAPL	No Detectable LNAPL	WAC 173-340-360(2)(c)(ii)

*Residual Saturation was determined empirically as the lowest median soil TPH value from soil borings that contained soil contamination from the ground surface to groundwater.

Notes:

bgs = below ground surface

LNAPL = light, non-aqueous-phase liquid

mg/kg = milligrams per kilogram

MTCA = Model Toxics Control Act

TPH-D/HO = total petroleum hydrocarbons as diesel/heavy oil

TEQ = toxic equivalency quotient

WAC = Washington Administrative Code

Table 3-3
Applicable or Relevant and Appropriate Requirements For the Cleanup Action
Engineering Design Report
BNSF Black Tank
Spokane, WA

Jurisdiction	Summary of ARARs	
City of Spokane	Municipal Code 10.08D	Nuicances (Noise and Dust)
	Municipal Code 17E.010	Critical Aquifer Recharge Areas - Aquifer Protection
	Municipal Code 17D.060	Stormwater Management Regulations
	Municipal Code 17D.090	Land Disturbing Activities (TESC and Grading)
State of Washington Regulations	Ch. 18.104 RCW	Water Well Construction
	Ch. 173-160 WAC	Minimum Standards for Construction and Maintenance of
	Ch. 173-162 WAC	Rules & Regulations Governing the Licensing of Well
	Ch. 173-303 WAC	Dangerous Waste Management
	Ch. 173-304 WAC	Solid Waste Handling Standards
	Ch. 70.105D RCW	Model Toxics Control Act
	Ch. 173-340 WAC	MTCA Cleanup Regulation
	Ch. 173-350 WAC	Solid Waste Handling Standards
	Ch. 43.21C RCW	State Environmental Policy Act
	Ch. 197-11 WAC	SEPA Rules
	Ch. 70.94 RCW	Washington Clean Air Act
	Ch. 43.21A RCW	General Regulations for Air Pollution
	Ch. 173-400 WAC	General Regulations for Air Pollution
	Ch. 173-460 WAC	Controls for New Sources of Air Pollution
	Ch. 173-470 WAC	Ambient Air Quality Standards for Particulate Matter
Federal Regulations	29 CFR 1910	Occupational Safety and Health Act
	42 USC 7401	Clean Air Act of 1977
	40 CFR 50	National Ambient Air Quality Standards
	40 CFR 141	Drinking Water Regulations
	40 CFR 260-268	Hazardous Waste Regulations (RCRA)

Notes:
ARAR = applicable or relevant and appropriate requirement
CFR = Code of Federal Regulations
MTCA = Model Toxics Control Act
RCRA = Resource Conservation and Recovery Act
RCW = Revised Code of Washington
SEPA = State Environmental Policy Act
TESC = Temporary Erosion and Sediment Control
USC = U.S. Code
WAC = Washington Administrative Code

Table 4-1
Bioventing Pilot Test Oxygen Data
Engineering Design Report
BNSF Black Tank
Spokane, WA

			Distance from Injection (ft)					
			32	68	96	114	124	
Start time	Injection Pressure (psi)	Injection dP (in. w.c.)	MW-23R O2 %	MW-7 O2 %	MW-22R O2 %	MW-9 O2 %	MW-5 O2 %	Notes
10/6/2020 15:50	0	0.1	0.7	16.5	0.2	0	12.2	Sustained Test Start (110 cfm)
10/6/2020 17:11	0	0.46	1.8	16.7	0.5	0	12.4	
10/7/2020 9:32	1	1.1	6.3	17.3	0.4	0	12.3	
10/7/2020 11:51	1.25	1.63	13.8	16.8	0.6	0	12.1	
10/7/2020 13:22	1.5	3	2.9	16.7	0.2	0	12.1	
10/7/2020 16:03	1.5	3	16.3	16.9	0.2	0	12.2	~ 1 day after Sustained Test Start
10/8/2020 9:32	2	3	17.6	17.4	2.3	0	12.3	
10/8/2020 11:49	1.8	3	14.7	17.3	1.2	0	11.9	
10/8/2020 14:45	1.8	3	16.2	17.8	1.6	0	12	
10/8/2020 16:38	1.8	3	19.6	18.7	3.3	0	12.5	~ 2 days after Sustained Test Start
10/9/2020 9:11	1.8	3	19.3	19	11.7	0	11.9	
10/9/2020 14:08	1.8	3	16.1	19.6	1.7	0	12.1	
10/9/2020 15:32	1.8	3	17.8	19.2	1.2	0	11.7	
10/9/2020 16:55	1.8	3	19.3	19.7	0.5	0	12.1	~ 3 days after Sustained Test Start
10/10/2020 9:00	1.8	3	18.8	20.1	1.7	0	12	
10/10/2020 11:10	1.8	3	18.9	20.3	1.4	0	12.2	
10/10/2020 19:30	3	5	21.5	20.2	6.4	0	12.6	~ 4 days after Sustained Test Start (flow increase ~150 cfm)
10/11/2020 8:05	3.2	5.2	21.6	20.8	5.8	0	12.6	
10/11/2020 12:05	3.2	5.2	20.2	19.8	7.5	0	12	~ 1 day after flow increase (~150 cfm)
10/11/2020 18:25	0	0	15.1	20.7	0.7	0	12.3	
10/12/2020 10:40	0	0	16	20.4	6	0	12.3	
10/12/2020 13:35	0	0	8.5	20.4	2.4	0	12.5	
10/12/2020 16:35	0	0	8.4	20.6	2.7	0	12.5	
10/13/2020 7:50	0	0	1.4	20.7	0.2	0	12.3	
10/13/2020 13:00	0	0	0.8	20.2	0.2	0	12.3	

Notes:

CH4 = Methane

CO2 = Carbon dioxide

in. w.c. = inches water column

L/min = Liters per minute

O2 = Oxygen

psi = Pounds per square inch

Table 4-2
Bioventing Pilot Test Helium Data
Engineering Design Report
BNSF Black Tank
Spokane, WA

Start time	Injection Pressure (psi)	Injection dP (in. w.c.)	Distance from Injection (ft)						Notes
			0	32	68	96	114	124	
10/6/2020 15:50	0	0.1	9150	0	0	0	0	0	He Injection Start w/ Sustained Test
10/6/2020 17:11	0	0.46	9500	0	0	0	0	0	
10/7/2020 9:32	1	1.1	9325	0	0	0	0	0	
10/7/2020 11:51	1.25	1.63	6800	0	0	0	0	0	
10/7/2020 13:22	1.5	3	12475	0	0	0	0	0	
10/7/2020 16:03	1.5	3	8500	600	0	0	0	0	~ 1 day after He Injection Start
10/8/2020 9:32	2	3	9725	1625	0	0	0	0	
10/8/2020 11:49	1.8	3	8725	1275	0	0	0	0	
10/8/2020 14:45	1.8	3	0	3950	1450	0	0	0	
10/8/2020 16:38	1.8	3	0	8825	2800	0	0	0	~ 2 days after He Injection Start (He Injection Complete)
10/9/2020 9:11	1.8	3	0	175	3525	0	0	0	
10/9/2020 14:08	1.8	3	0	0	3475	0	0	0	
10/9/2020 15:32	1.8	3	0	0	2525	0	0	0	
10/9/2020 16:55	1.8	3	0	75	2800	0	0	0	~ 3 days after He Injection Start
10/10/2020 9:00	1.8	3	0	125	875	0	0	0	
10/10/2020 11:10	1.8	3	0	0	775	0	0	0	
10/10/2020 19:30	3	5	0	25	150	0	0	0	
10/11/2020 8:05	3.2	5.2	0	0	0	0	0	0	
10/11/2020 12:05	3.2	5.2	0	75	0	0	0	0	
10/11/2020 18:25	0	0	0	0	0	0	0	0	
10/12/2020 10:40	0	0	0	0	100	0	0	0	
10/12/2020 13:35	0	0	0	0	100	0	0	0	
10/12/2020 16:35	0	0	0	0	150	0	0	0	
10/13/2020 7:50	0	0	0	0	25	0	0	0	
10/13/2020 13:00	0	0	0	0	0	0	0	0	

Notes:
 CH4 = Methane
 CO2 = Carbon dioxide
 in. w.c. = inches water column
 L/min = Liters per minute
 O2 = Oxygen
 psi = Pounds per square inch

Table 4-3

Biosparing Pilot SF⁶ Test Data
Engineering Design Report
BNSF Black Tank
Spokane, WA

ID	Distance from Injection	Sample Date	Reported Concentration (ppb)	Measured Concentration (ppb)
BSI-1-CO-DUP-102120	-	16-Oct-20	30.6	30.6
BSI-1-CO-102120	-	16-Oct-20	31.9	31.9
BSI-01-102120	0	21-Oct-20	0.108	0.108
MW-31-102120	11	21-Oct-20	3.15	3.15
MW-03-102120	28	21-Oct-20	0.124	0.124
MW-04-102120	59	21-Oct-20	<LOD	0.019
Field Blank	-	21-Oct-20	0.140	0.14
MW-07-102120	~250	21-Oct-20	<LOD	0.016
MW-22R-102120	~330	21-Oct-20	<LOD	0.023
BSI-1-110420	0	4-Nov-20	0.026	0.026
MW-31-110420	11	4-Nov-20	0.321	0.321
MW-03-110420	28	4-Nov-20	<LOD	0.009
MW-04-110420	59	4-Nov-20	<LOD	0.013
Field Blank	-	4-Nov-20	<LOD	0.012
MW-07-110420	~250	4-Nov-20	<LOD	0.014
MW-22R-110420	~330	4-Nov-20	<LOD	0.014

Notes:

LOD = Limit of detection (25 ppt)

LOQ = Limit of quantitation (40 ppt)

ppb = Parts per million

ppt = Parts per trillion

1. Data validator reviewed results and concluded that the SF₆ detection in the field blank does not indicate cross-contamination in the investigative samples because three of the associated investigative samples are non-detect for SF₆. Therefore, none of the results are qualified as having blank contamination.

2. During sampling of MW-05 for SF₆, the connector on the bailer broke, leaving the bailer in the bottom of the well, where it blocked access to the groundwater in the well. The bailer could not be immediately retrieved so no groundwater samples were collected from MW-05 for SF₆ analysis. Retrieval will be attempted on 11/16/20 and if successful, the well will be sampled for SF₆. Wells immediately downgradient of MW-05 (MW-07 and MW-22R) were sampled and showed no detectable SF₆.

Table 4-4
Viscosity Data - Field and Laboratory
Engineering Design Report
BNSF Black Tank
Spokane, WA

Well ID	Pre-Design Investigation Data				RI Data	
	Field Sample Temperature (°C)	Field Sample Test Duration (sec)	Estimated Field Viscosity (cSt) ¹	Lab Viscosity at 40°C (cSt)	Lab Viscosity at 21°C (cSt)	Converted Lab Viscosity at 40°C (cSt) ⁴
MW-01	12.70	8.32	3,500	412	2,070	500
MW-02	12.00	8.25	4,300	460	-	-
MW-03	17.10	10.54	5,500	871	5,570	1,000
MW-04	17.50	7.97	3,700	655	-	-
MW-05	13.60	4.40	1,800	281	-	-
MW-07	12.80	2.38	750	141	-	-
MW-09	- ²	- ²	- ²	47	-	-
MW-17	13.20	4.12	1,100	192	-	-
MW-18	-	-	-	-	1,660	390
MW-31	20.40	16.59	-	- ³	-	-

Notes:

°C= degrees celsius

sec = seconds

cSt = centistoke

- = Not sampled

1 = Converted lab viscosity to field viscosity at field temperatures using Bunker C viscosity vs. temperature graph (Figure D-2) (WinGD 2018)

2 = Not enough sample to conduct field test.

3 = Viscosity test fails at 40 and 100° C . Sample too thick and fails to flow adequately to fill viscosity cell.

4 = Converted lab viscosity at 21°C to lab viscosity at 40°C using Bunker C viscosity vs. temperature graph (Figure D-3) (WinGD 2018)

Table 4-5
LNAPL Recovery Test Transmissivity
Engineering Design Report
BNSF Black Tank
Spokane, WA

Well ID	$\ln(R_{oi}/r_w)$	b_n (ft)	ρ_r	s_n (ft)	Q_n (ft ³ /day)	2020 Recovery Test T_n (ft ² /day)	2016 Recovery Test T_n (ft ² /day)
MW-01	4.6	1.19	0.96	0.05	2.9E-05	4.5E-04	--
MW-02	4.6	0.32	0.96	0.01	9.8E-06	5.6E-04	--
MW-03	4.6	0.26	0.98	0.01	3.2E-04	4.5E-02	6.2E-04
MW-04	4.6	0.72	0.98	0.01	4.8E-05	2.4E-03	1.5E-02
MW-05	4.6	0.83	0.98	0.02	1.9E-04	8.6E-03	--
MW-07	4.6	2.02	0.98	0.04	2.8E-04	5.1E-03	9.8E-02
MW-09	4.6	0.11	0.98	0.00	3.1E-04	1.0E-01	--
MW-17	4.6	1.00	0.98	0.02	1.5E-03	5.6E-02	3.6E-02
MW-31	4.6	0.21	0.98	0.00	5.8E-05	1.0E-02	--

Notes:

Transmissivity is calculated using Equation 16.

LNAPL drawdown time is calculated using Equation 17.

The value of the term $\ln(R_{oi}/r_w)$ can be assumed to equal 4.6 with the introduction of little additional error.

Abbreviations:

ft³/day = cubic feet per day

ft²/day = square feet per day

ITRC = Interstate Technology and Regulatory Council

ITRC- Low= 0.1 ft²/day = Low end of ITRC transmissivity range that indicates hydraulic recovery of LNAPL is not practicable.

ITRC- High = 0.8 ft²/day High end of ITRC transmissivity range that indicates hydraulic recovery of LNAPL is not practicable.

LNAPL = light non-aqueous phase liquid

Equation 16 - ASTM E2856-11^{ε1}, Manual Skimming Test Transmissivity

$$T_n = \frac{Q_n \ln\left(\frac{R_{oi}}{r_w}\right)}{2\pi s_n}$$

Equation 17 - ASTM E2856-11^{ε1}, Maximum unconfined LNAPL drawdown

$$s_{n_unconfined} = b_n(1 - \rho_r)$$

Equations 16 & 17 Variables

T_n	= LNAPL Transmissivity (ft ² /day)
Q_n	= measured LNAPL recovery rate (ft ³ /day)
R_{oi}	= radius of influence (ft)
r_w	= well radius (ft)
s_n	= LNAPL drawdown at time t (ft)
b_n	= LNAPL thickness (ft)
ρ_r	= LNAPL specific density

Table 5-1
New Well Construction Details
Engineering Design Report
BNSF Black Tank
Spokane, WA

Well Identification	Pre-Clearance Method	Drilling Method	Borehole Diameter (inches)	Soil Sampling Interval For Logging	Borehole Depth (feet bgs)	Screen Interval Depth to		Screen Length (feet)	Screen Slot Size (inches)	Filter Pack Depth to		Well Diameter (inches)	Well Construction Materials		
						Top (feet bgs)	Bottom (feet bgs)			Top (feet bgs)	Bottom (feet bgs)		Screen	Riser	Protective Cover
BV-02 & BV-03	Air Knife	Sonic	6	Continuous	167	147	167	20	0.010	145	167	2	Schedule 40 304 SS	Schedule 40 carbon steel	Well Vault
BV-04 & BV-05*	Air Knife	Sonic	6	Continuous	167	147	167	25 **	0.010	145	167	2	Schedule 80 PVC	Schedule 80 PVC	Well Vault
BS-02 to BS-05, BS-07 to BS-09	Air Knife	Sonic	6	Continuous	195	190	195	5	0.010	188	195	2	Schedule 40 PVC	Schedule 40 PVC	Well Vault
BS-06 & BS-10*	Air Knife	Sonic	6	Continuous	195	190	195	5	0.010	188	195	2	Schedule 80 PVC	Schedule 80 PVC	Well Vault

Notes:

* = borehole length will be longer than depth for the angled wells

** = Screen length of these two angled wells is 25 ft. Because angled well the screen will cover the vertical interval of 147 ft bgs to 167 ft bgs

bgs = below ground surface

N/A = Not Applicable

Table 7-1

Schedule for Engineering Design, Procurement and Construction of BV/BS System
Engineering Design Report
BNSF Black Tank
Spokane, WA

Task	Estimated Duration	Schedule
Submit Revised Draft EDR and accompanying documents to Ecology		2Q 2021
Complete rerouting of active rail lines on the Site		3Q 2021
Complete Phase 2 of the Surface Soil Interim Action	90 days	3Q - 4Q 2021
Submit Addendum to the Surface Soil Interim Action Completion Report	60 days	4Q 2021
Ecology review and approve Draft EDR and accompanying documents		10/27/2021
Submit Final EDR w/ accompanying documents to Ecology		11/26/2021
Ecology approve Final EDR		11/26/2021
Submit Construction Plans & Specifications to Ecology	60 days + 30 days	1Q 2022
Ecology approve Construction Plans & Specifications		2Q 2022
North Spokane Corridor (NSC) project grading complete (1)		3Q 2022
Initiate construction of BV/BS system including verification that BV/BS system is aligned with NSC as-built configuration		3Q - 4Q 2022
Construct BV/BS system including well network and including procure equipment, materials, & services.	240	3Q 2022 – 3Q 2023
Start-up and Acceptance of BV/BS System	60 days	3Q - 4Q 2023

Notes:

(1) *Timeframe based on information provided on the NSC website and in May 2021 conversations with WSDOT.*

NA = *Not applicable*

TBD = *To be determined*

Q = *quarter*

EDR = *Engineering Design Report*

BV/BS = *biovent/biosparge*

NSC = *North Spokane Corridor*

APPENDIX A LNAPL CONDITIONS ASSESSMENT

APPENDIX A: LNAPL CONDITIONS ASSESSMENT

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Acronyms and Abbreviations

ERM	Environmental Resources Management
LNAPL	light non-aqueous phase liquid
MW	Monitoring Well
SM	Silty sands and silt-mixtures
SP	Poorly-graded sands and gravelly sands, little or no fines

1. INTRODUCTION

ERM (ERM-West, Inc.) evaluated hydrostratigraphic and gauged light non-aqueous phase liquid (LNAPL) thickness data from the Black Tank site to determine whether the LNAPL is under confined, unconfined, or perched conditions, and if those conditions have resulted in gauged LNAPL thicknesses that are exaggerated relative to the formation thickness of mobile LNAPL. Research by Kirkman et al. (2013) and Reyenga and Hawthorne (2015) shows that confined and perched conditions can result in exaggerated gauged LNAPL thicknesses. This evaluation was undertaken because lenses or beds of silt and silty sand facies identified at the Site in the depth interval between the seasonal high and low groundwater table could potentially produce confined and/or perched LNAPL (ERM 2017). To assess whether exaggerated gauged LNAPL thicknesses exist at the Site and to make appropriate corrections to those thicknesses, ERM used the techniques presented in Hawthorne (2011) and Kirkman et al. (2013) to evaluate LNAPL and groundwater level data collected from the Site since March 2016.

2. LNAPL EVALUATION APPROACH

ERM prepared hydrostratigraphs showing LNAPL (air/LNAPL interface) elevation, groundwater (LNAPL/water interface) elevation, and gauged LNAPL thickness data for each monitoring well containing measurable LNAPL (MW-01 through MW-05, MW-07, MW-09, MW-17 through MW-20, MW-23, and MW-28). The position of the well screen and any layers of silt and silty sand facies identified in the screened interval are also shown on the hydrostratigraphs. Visually assessing these data on the hydrostratigraph helps identify potential confined, unconfined, and perched LNAPL conditions (Hawthorne 2011; Kirkman et al. 2013). Data collected since March 2016 was used for this evaluation because the data were collected using better field measurement technique and were cross-checked using LNAPL removal data. Data collected prior to March 2016 are suspect because the techniques for: (1) measuring the LNAPL-groundwater interface and (2) identifying and correcting erroneous gauged LNAPL thickness data had not yet been refined. LNAPL recovery from these wells was performed following each monitoring event, except June and September 2016. For this evaluation, it is assumed that gauged LNAPL thicknesses recover to levels representative of the formation thickness of mobile LNAPL between monitoring events. This assumption appears to be valid because the period between monitoring events has ranged from one quarter to more than a year for some wells, yet the hydrostratigraphs show that gauged LNAPL thicknesses are generally stable. Nonetheless, this assumption can be re-evaluated in the future as additional LNAPL thickness data is collected.

Field measurement of the LNAPL/water interface continues to be challenging in wells where the LNAPL is highly viscous, the well interior is coated with LNAPL, and/or the LNAPL thickness exceeds approximately 2 feet because it is difficult to get the water level probe to pass through the LNAPL before the protective ice coating melts and the LNAPL fouls the probe. In some wells (e.g., MW-03, MW-04, and MW-05), the LNAPL has been too viscous to collect LNAPL/water interface data. When possible, ERM determines the LNAPL thickness for these wells based on the volume of LNAPL removed from the well. ERM also cross-checks the gauged LNAPL thicknesses from other wells noted to contain viscous LNAPL or as having measurement problems by comparing the field LNAPL thickness to calculated LNAPL thickness value based on the volume of LNAPL removed from the well. If the field LNAPL thickness exceeds twice the calculated LNAPL thickness, the field LNAPL thickness is considered erroneous and replaced with the calculated LNAPL thickness. The *Addendum for Modified Product Gauging Method, RI/FS Project Plan* (ERM 2016), presents the updated field methodology used to collect gauged LNAPL thickness data, and the groundwater monitoring reports from 2016 through 2020 present the gauged LNAPL thickness data used in this report and the technique for identifying and correcting erroneous gauged LNAPL thickness data.

The silt and silty sand facies may be a potential confining layer for the LNAPL without being a confining layer for groundwater. Soils containing a higher percentage of silt and/or clay have smaller pore sizes and LNAPL movement may be inhibited in these soils because it cannot overcome their pore entry pressure (Kirkman et al. 2013). Because water does not have the same capillary limitations as LNAPL, some fine-grained materials may not be a confining layer for groundwater while being a confining layer for LNAPL (Hawthorne et al. 2011a). Layers of the silt and silty sand facies, as described in the *Work Plan to Determine Deep Contamination Cleanup Action Design Parameters* (ERM 2020), and layers of sand with silt (i.e., SM or SP/SM) are illustrated on the hydrostratigraphs because both may contain a sufficiently high percentage of silt and/or clay to be a potential confining layer for LNAPL.

ERM visually assessed each hydrostratigraph for perched, confined, and unconfined conditions. Perched LNAPL conditions exist when a monitoring well is constructed with its screen above and within a confining layer, LNAPL rests above the confining layer, and the groundwater level is within or below the confining layer. Under these conditions, the well will act as a sump, and LNAPL will accumulate in the well until it equilibrates with the top of the LNAPL interval (Hawthorne et al. 2011b). This results in an exaggerated LNAPL thickness if the bottom of the monitoring well is deeper than the top of the confining layer. Confined LNAPL conditions exist when LNAPL is trapped beneath a confining layer and pressurized. If a monitoring well is constructed with its screen within and below the confining layer, the well will act as a pressure relief valve for the confined LNAPL, and LNAPL will accumulate and rise in the well until it equalizes with atmospheric pressure, resulting in an exaggerated gauged LNAPL thickness (Hawthorne et al. 2011a). Unconfined LNAPL is neither trapped below nor resting above a confining layer. The gauged LNAPL thickness in a well under unconfined conditions is representative of the LNAPL thickness in the formation.

Because groundwater levels at the site fluctuate up to 9.6 feet in a year and layers of the silt and silty sand facies occur partially or wholly within the groundwater fluctuation interval, LNAPL conditions at a well can vary from unconfined to confined or perched as a result of changes in groundwater level. Therefore, ERM assessed the conditions at each monitoring well during each monitoring event and identified LNAPL thickness measurements for correction, as needed, to reflect the conditions during that monitoring event.

The approach used to assess the LNAPL conditions from the hydrostratigraphs and determine an appropriate LNAPL thickness correction, if needed, is summarized below:

- Unconfined LNAPL conditions—Neither the LNAPL level nor the groundwater level are situated within a potential confining layer. No potential for exaggeration exists; therefore, no LNAPL thickness correction is needed.
- Perched LNAPL conditions—The LNAPL level is situated above a potential confining layer and the groundwater level is below the top of the potential confining layer. Acceptable methods for correcting the LNAPL thickness are to use: (1) the difference between the LNAPL elevation and the elevation of the top of the confining layer, or (2) the LNAPL thickness measurement from the most recent monitoring event showing unconfined conditions at the monitoring well (Reyenga and Hawthorne 2015).
- Confined LNAPL conditions—The LNAPL level is within a potential confining layer and the groundwater level is below the same potential confining layer. Acceptable methods for correcting the LNAPL thickness are to use: (1) the difference between the groundwater elevation and the elevation of the bottom of the confining layer, or (2) the LNAPL thickness measurement from the most recent monitoring event showing unconfined conditions at the monitoring well (Reyenga and Hawthorne 2015).

Where both the LNAPL level and the groundwater level are within a potential confining layer, the LNAPL condition may be either perched or confined. The condition cannot be discerned from this information alone, but generally can be discerned using stratigraphic and previous LNAPL condition data for the well. Neither Hawthorne (2011) nor Kirkman et al. (2013) provide a method for directly correcting the gauged LNAPL thickness measurement for this situation. However, comparison to historical LNAPL thickness measurements can be used to develop a corrected LNAPL thickness. Specifically, the corrected LNAPL thickness should be the lesser of: (1) the gauged LNAPL thickness from the monitoring event, (2) the most recent corrected LNAPL thickness based on documented unconfined, confined, or perched LNAPL conditions, or (3) the lowest gauged LNAPL thickness if all monitoring events have shown LNAPL and groundwater levels within the potential confining layer.

This evaluation presents ERM's interpretation of the LNAPL conditions at for each monitoring event at each Site monitoring well based on the data currently available and the evaluation techniques provided by Hawthorne (2011) and Kirkman et al. (2013). However, evaluation of LNAPL conditions at the site is an iterative process that may result in revised interpretations over time. As more LNAPL data are collected and new evaluation techniques are used, our interpretation of the LNAPL conditions at individual monitoring well locations may evolve.

3. RESULTS OF LNAPL EVALUATION AND LNAPL THICKNESS CORRECTION

The LNAPL conditions for each monitoring well containing LNAPL during the March 2016 through September 2020 monitoring events are summarized on Table A-1, and the hydrostratigraphs used to interpret the LNAPL conditions are presented on Figures A-1 through A-13.

Monitoring wells MW-01, MW-04, MW-05, MW-09, MW-17, MW-19, MW-23, and MW-28 show no evidence of exaggerated gauged LNAPL thicknesses. These wells have either no confining layer or only leaky confining layers within their normal groundwater fluctuation intervals. Therefore, they show unconfined or leaky confined conditions throughout all monitoring events (Table A-1). No confining layers are situated within the normal groundwater fluctuation intervals at MW-1 (Figure A-1), MW-5 (Figure A-5), and MW-23 (Figure A-12); therefore, unconfined LNAPL conditions consistently occurred at these wells during all of the monitoring events (Table A-1). Only potential leaky confining layers are situated in the normal groundwater fluctuation intervals at MW-4 (Figure A-4), MW-9 (Figure A-7), MW-17 (Figure A-8), MW-19 (Figure A-9), and MW-28 (Figure A-13); therefore, unconfined or leaky confined LNAPL conditions consistently occurred at these wells during all of the monitoring events (Table A-1).

Monitoring wells MW-2, MW-3, MW-7, and MW-18 have confining layers near the bottom of their normal groundwater fluctuation intervals and LNAPL above the confining layers (Figures A-2, A-3, A-6, and A-9). Occasionally, groundwater levels are below the top of the confining layer, resulting in perched LNAPL conditions and exaggerated gauged LNAPL thicknesses at these wells (Table A-1 and Figures A-2, A-3, A-6, and A-9). This is particularly obvious in MW-07 and MW-18. Monitoring well MW-20 has relatively thick confining layers throughout most of its normal groundwater fluctuation interval and LNAPL between and within the confining layers (Figure A-11). Groundwater levels at this well are generally below the top of the lower confining layer, resulting in mostly perched LNAPL conditions and exaggerated gauged LNAPL thicknesses (Table A-1 and Figure A-11). However, one monitoring event showed a very high water table condition resulting in the LNAPL being trapped below an overlying confining layer. This produced confined LNAPL conditions and exaggerated gauged LNAPL thicknesses (Table A-1 and Figure A-11).

Potential corrected LNAPL thickness values for perched or confined conditions exhibited at MW-2, MW-3, MW-07, MW-18, and MW-20 are displayed on their hydrostratigraphs (Figures A-2, A-3, A-6, A-9, and A-11). For MW-02, MW-03, MW-07, and MW-18, this analysis helps explain some or all of the anomalous spikes in gauged LNAPL thickness in these wells by showing that they correlate with perched LNAPL conditions resulting from low groundwater levels (Figures A-2, A-3, A-6, and A-9). Thus, the gauged LNAPL thickness data obtained from these wells during unconfined conditions is representative of the LNAPL thicknesses in the formation at these wells and the occasional exaggerated thickness observed during perched conditions is not representative (Figures A-2, A-3, A-6 and A-9). For MW-20, this analysis helps explain the anomalously high gauged LNAPL thicknesses reported from a well situated a considerable distance from the LNAPL source. The consistent perched or confined LNAPL conditions resulting from the thick confining layers observed throughout the groundwater fluctuation interval at this well location likely results in consistently exaggerated gauged LNAPL thicknesses. The actual formation thickness of LNAPL at this location cannot be readily determined from the well data; however, we can reasonably say that it is less than the thinnest LNAPL measurement reported for the well (1.87 feet).

ERM believes the potential corrected LNAPL thickness data present a more realistic representation of changes over time in the formation LNAPL thickness at MW-02, MW-03, MW-07, MW-18, and MW-20. The potential corrected data reduces both spatial and temporal anomalies in the LNAPL thickness data by eliminating exaggerated thicknesses. However, correcting the exaggerated thicknesses results in relatively modest changes in the reported LNAPL thicknesses and the changes do not affect the footprint of any of the LNAPL restoration timeframe (RTF) areas.

MW-02, MW-03, and MW-07 are potential performance monitoring wells for the Site, and because they occasionally exhibited perched conditions, the LNAPL conditions at those wells and potential corrections to gauged LNAPL thickness data from those wells should be considered for future evaluation of gauged LNAPL thickness performance monitoring data. The other two wells that exhibited perched and/or confined conditions (MW-18 and MW-20) were decommissioned and are not available for future performance monitoring.

4. REFERENCES

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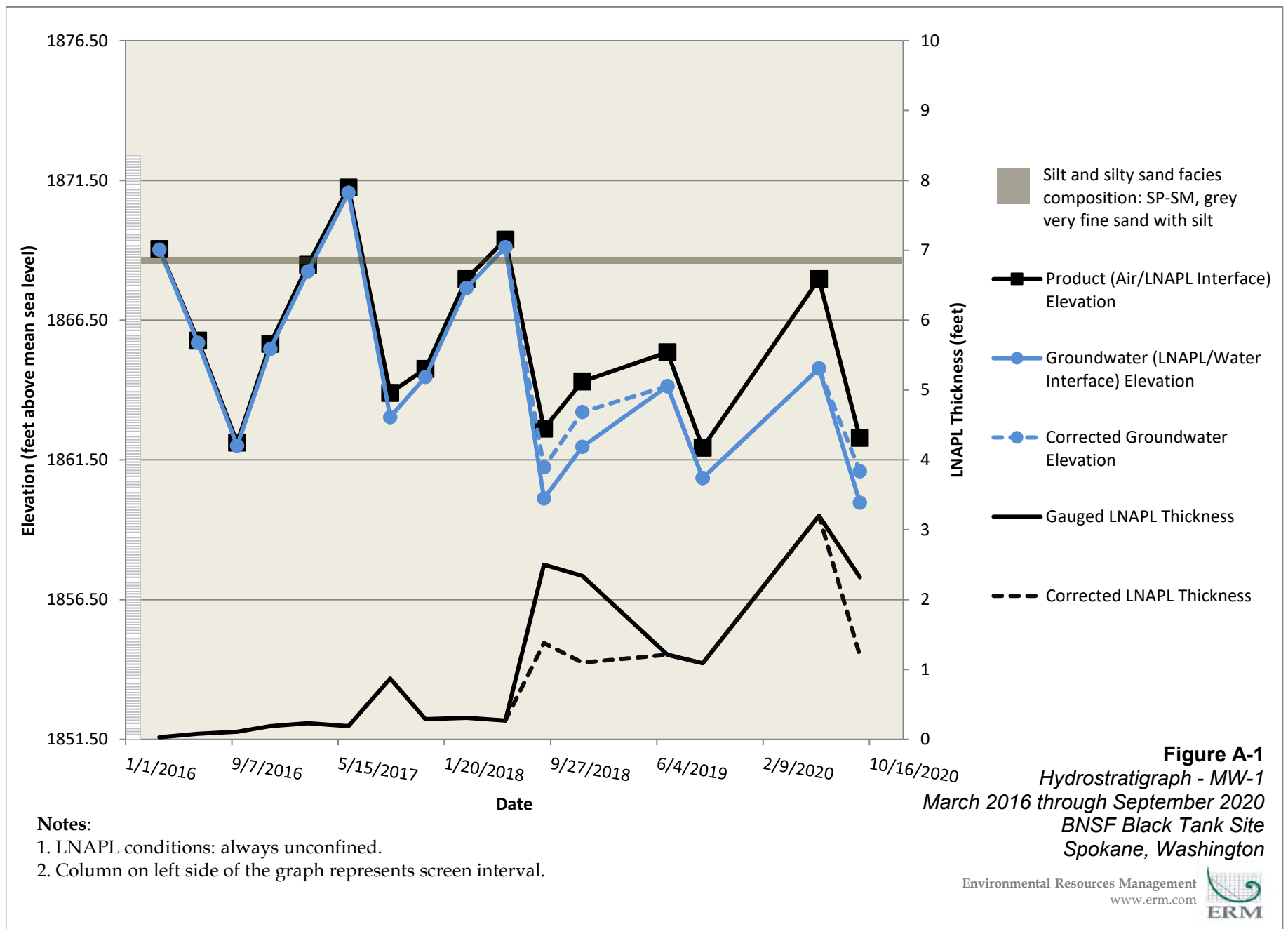
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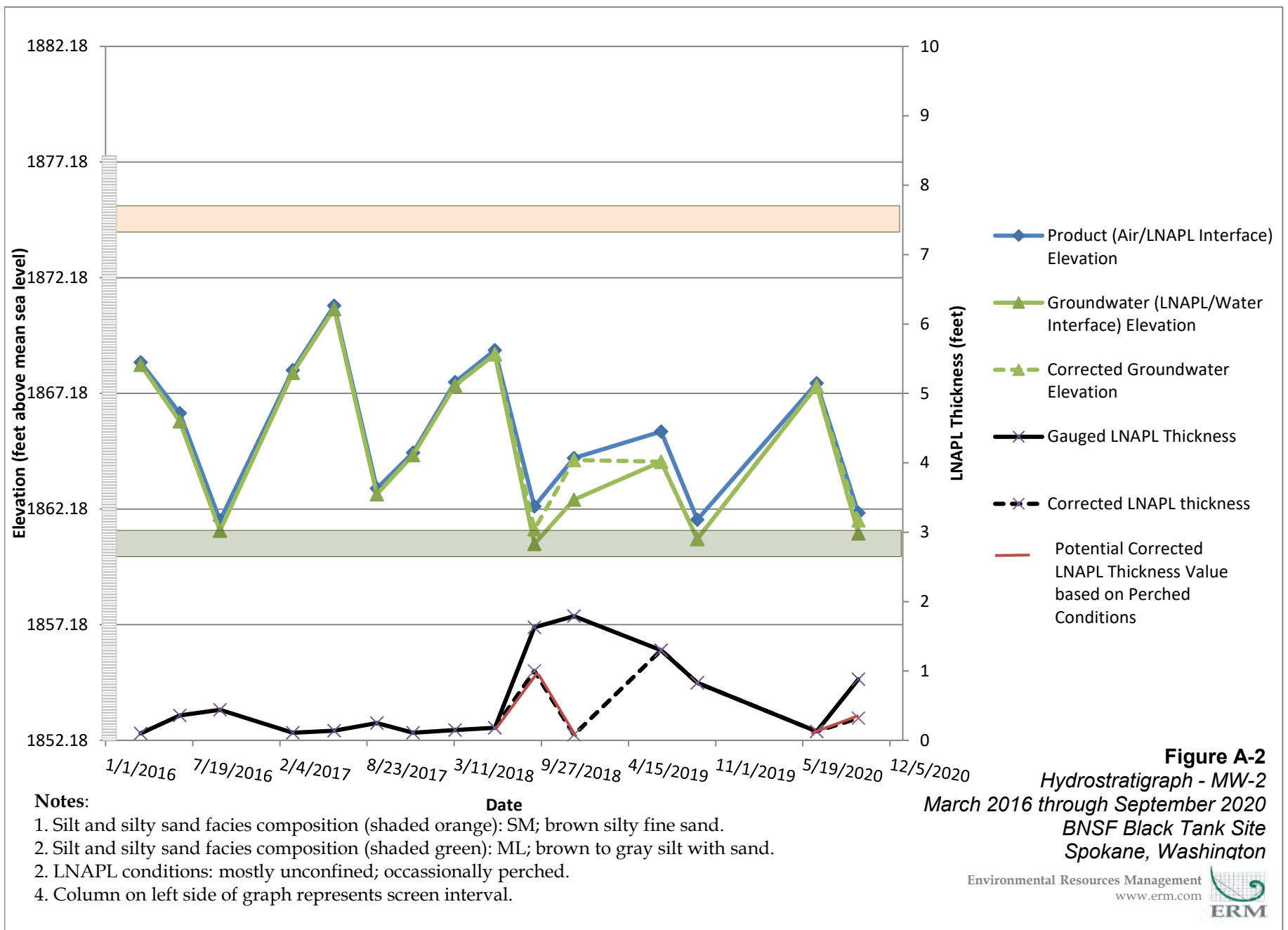
Table A-1
Summary of Hydrostratigraphic Assessment
Engineering Design Report
BNSF Black Tank
Spokane, WA

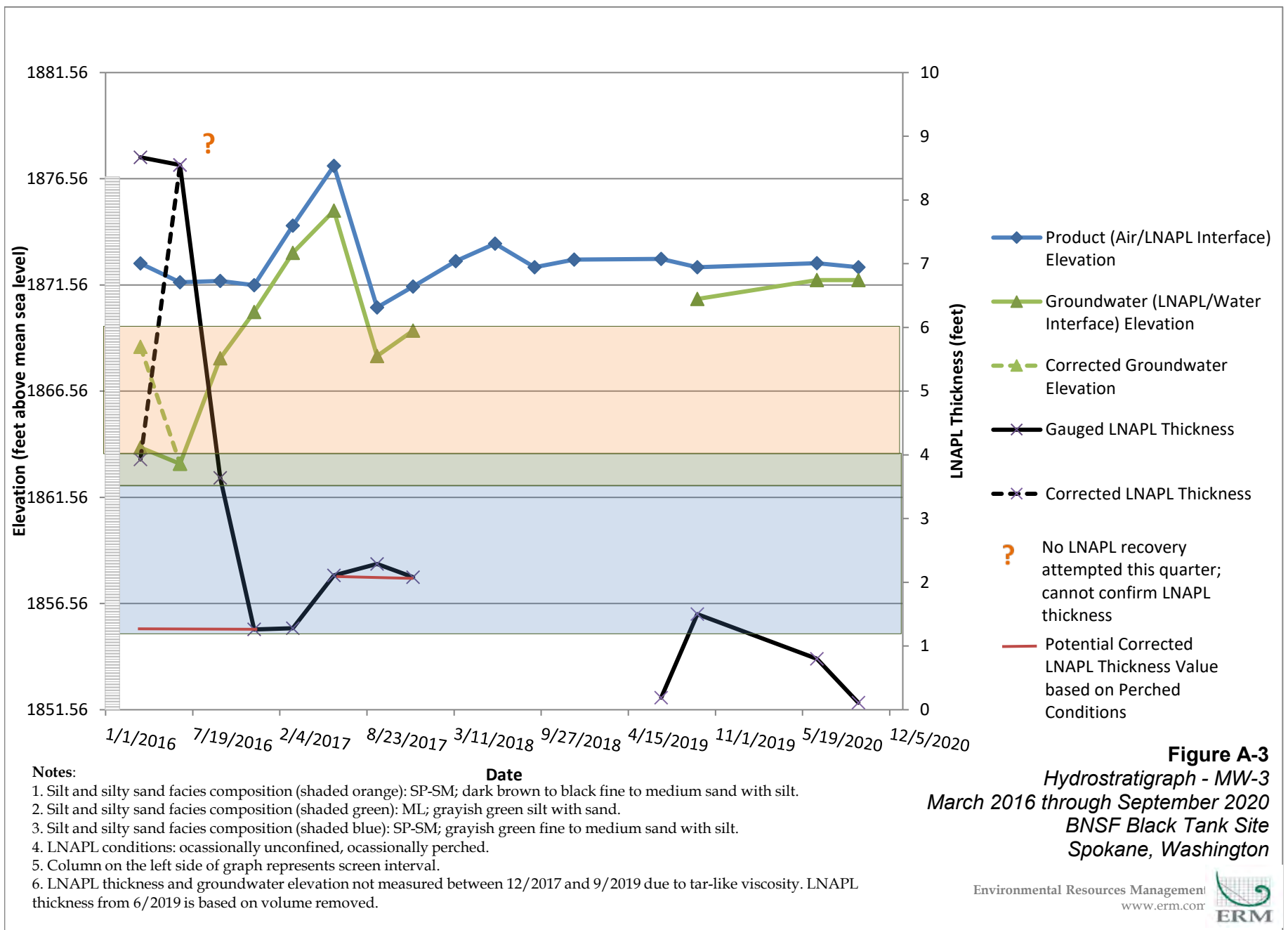
Monitoring Well	LNAPL Condition											
	March-16	June-16	September-16	December-16	March-17	June-17	September-17	December-17	March-18	June-18	September-18	December-18
MW-01	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
MW-02	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Perched	Unconfined
MW-03	Perched	Perched	Perched	Unconfined	Unconfined	Unconfined	Perched	Perched	Not measured	Not measured	Not measured	Not measured
MW-04	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer
MW-05	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
MW-07	Perched	Perched	Perched	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
MW-09	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer
MW-17	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined	Unconfined
MW-18	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Perched	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
MW-19	Unconfined	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined	Unconfined within leaky confined layer	Unconfined	Unconfined	Unconfined within leaky confined layer	Unconfined	Unconfined	Unconfined within leaky confined layer	Unconfined within leaky confined layer
MW-20	Perched	Perched	Perched	Perched	Perched	Perched	Perched	Perched	Perched	Confined	Perched	Perched
MW-23	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined	Unconfined
MW-28	Unconfined within leaky confined layer	Unconfined	Unconfined	Unconfined	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined	Unconfined

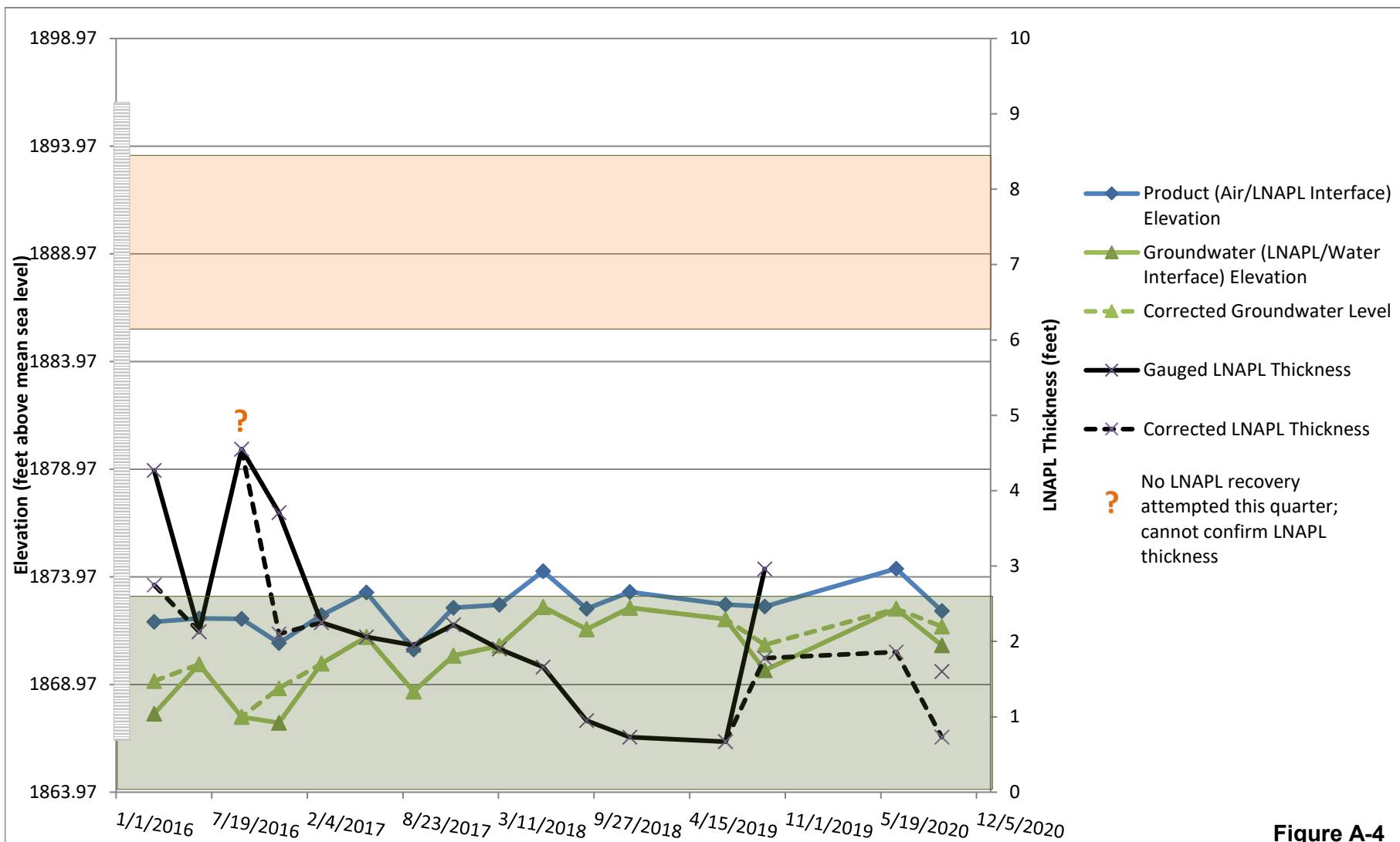
Table A-1 (continued)
Summary of Hydrostratigraphic Assessment
Engineering Design Report
BNSF Black Tank
Spokane, WA

Monitoring Well	LNAPL Condition							Correction Needed	Correction Method
	June-19	September-19	June-20	September-20	Unconfined	Confined	Perched		
MW-01	Unconfined	Unconfined	Unconfined	Unconfined	Always	Not Observed	Not Observed	None	Correction not needed; therefore, gauged product thickness used
MW-02	Unconfined	Perched	Unconfined	Unconfined	Mostly	Not Observed	Occasionally	Occasionally	Lesser of most recent unconfined gauged measurement or corrected measurement taken during perched conditions.
MW-03	Not measured	Unconfined	Unconfined	Unconfined	Occasionally	Not Observed	Occasionally	Occasionally	Lesser of most recent unconfined gauged measurement or corrected measurement taken during perched conditions.
MW-04	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Always	Not Observed	Not Observed	None	Correction not needed as unconfined conditions are observed within the leaky confined layer; therefore, gauged product thickness used.
MW-05	Unconfined	Unconfined	Unconfined	Unconfined	Always	Not Observed	Not Observed	None	Correction not needed; therefore, gauged product thickness used
MW-07	Unconfined	Perched	Unconfined	Perched	Mostly	Not Observed	Occasionally	Occasionally	Lesser of most recent unconfined gauged measurement or corrected measurement taken during perched conditions.
MW-09	Unconfined within leaky confined layer	Unconfined	Unconfined within leaky confined layer	Unconfined	Always	Not Observed	Not Observed	None	Correction not needed as unconfined conditions are observed within the leaky confined layer; therefore, gauged product thickness used.
MW-17	Unconfined within leaky confined layer	Unconfined	Unconfined within leaky confined layer	Unconfined	Always	Not Observed	Not Observed	None	Correction not needed as unconfined conditions are observed within the leaky confined layer; therefore, gauged product thickness used.
MW-18	Unconfined	Unconfined	Not measured	Not measured	Mostly	Not Observed	Occasionally	Occasionally	Lesser of most recent unconfined gauged measurement or corrected measurement taken during perched conditions.
MW-19	Not measured	Unconfined within leaky confined layer	Not measured	Not measured	Always	Not Observed	Not Observed	None	Correction not needed as unconfined conditions are observed within the leaky confined layer; therefore, gauged product thickness used.
MW-20	Perched	Perched	Not measured	Not measured	Never	Occasionally	Mostly	Always	Lesser of most recent unconfined gauged measurement or corrected measurement taken during perched or confined conditions.
MW-23	Unconfined	Unconfined	Not measured	Not measured	Always	Not Observed	Not Observed	None	Correction not needed; therefore, gauged product thickness used
MW-28	Unconfined within leaky confined layer	Unconfined within leaky confined layer	Not measured	Not measured	Always	Not Observed	Not Observed	None	Correction not needed as unconfined conditions are observed within the leaky confined layer; therefore, gauged product thickness used.





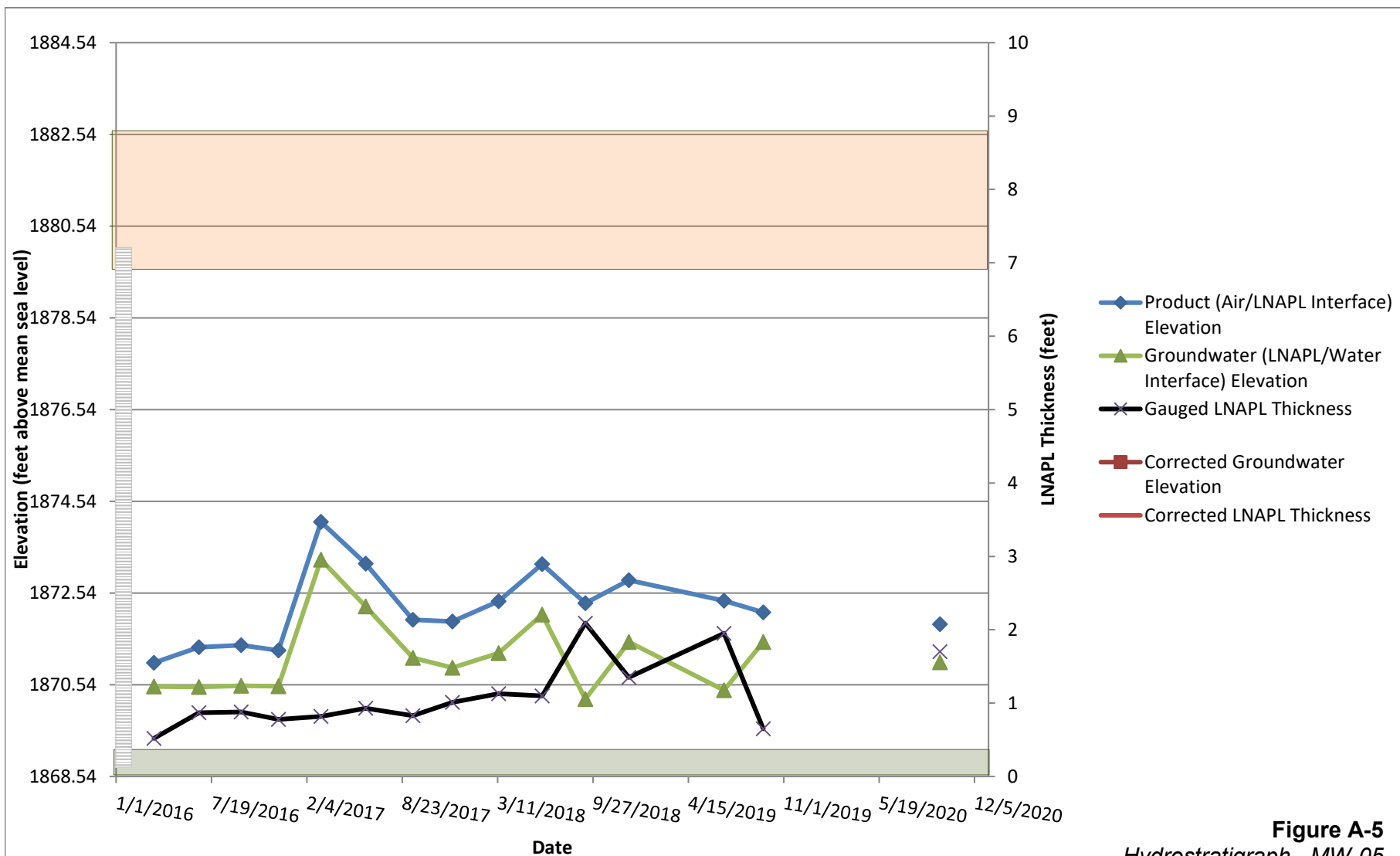




Notes:

1. Silt and silty sand facies composition (shaded orange): SP-SM; dark brown to brown fine to medium sand with trace gravel and silt.
2. Silt and silty sand facies composition (shaded green): SP-SM; dark brown to black fine to medium sand with silt, SM; dark brown to black fine sand, ML; dark brown to black silt with sand.
3. LNAPL conditions: Unconfined within leaky confining layer.
4. Column on the left side of graph represents screen interval.

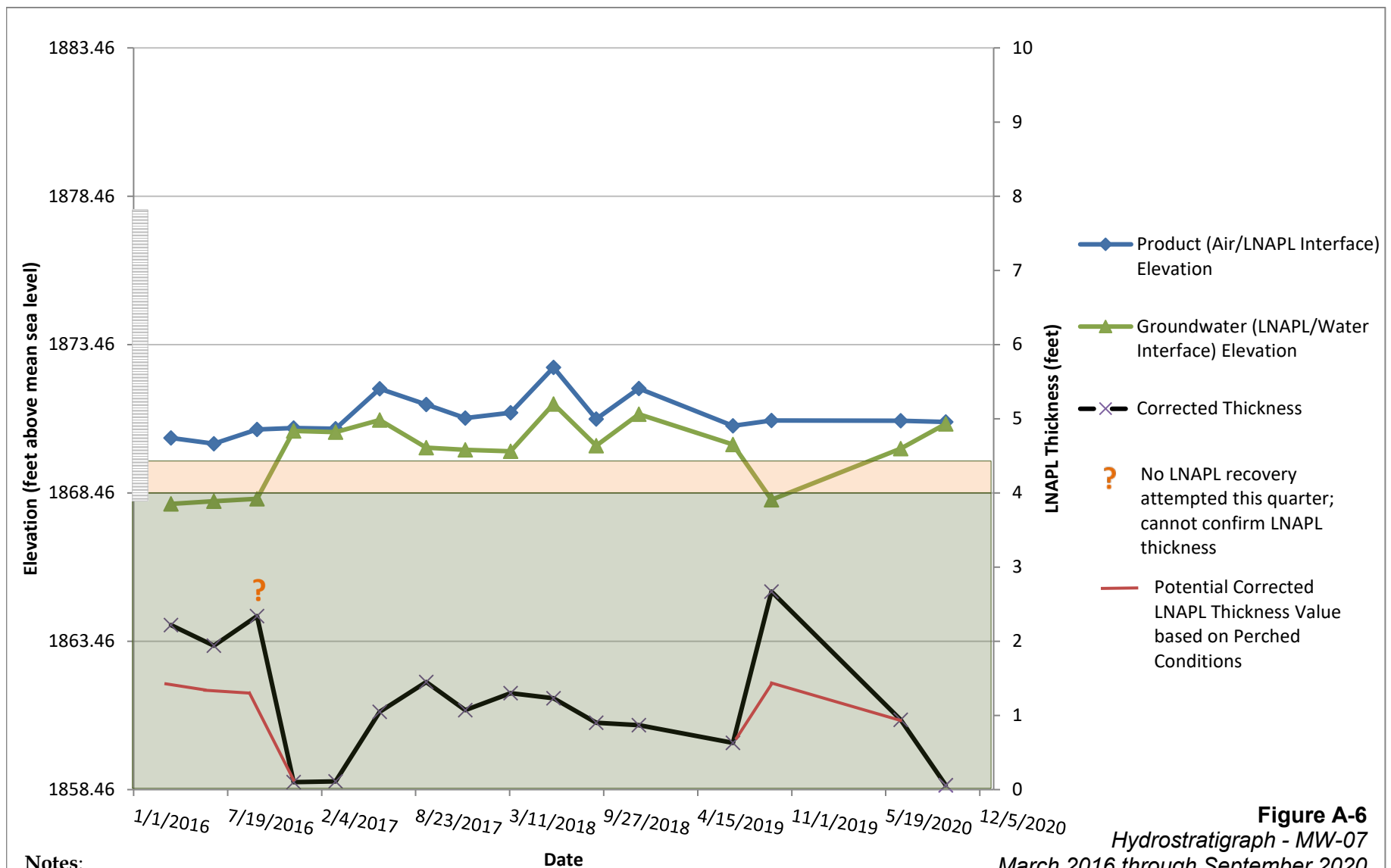
Figure A-4
Hydrostratigraph - MW-4
March 2016 through September 2020
BNSF Black Tank Site
Spokane, Washington



Notes:

1. Silt and silty sand facies composition (shaded orange): SP-SM; Gray fine to medium sand with silt.
2. Silt and silty sand facies composition (shaded green): ML; dark brown silt.
3. LNAPL conditions: always unconfined.
4. Column on left side of graph represents screen interval.

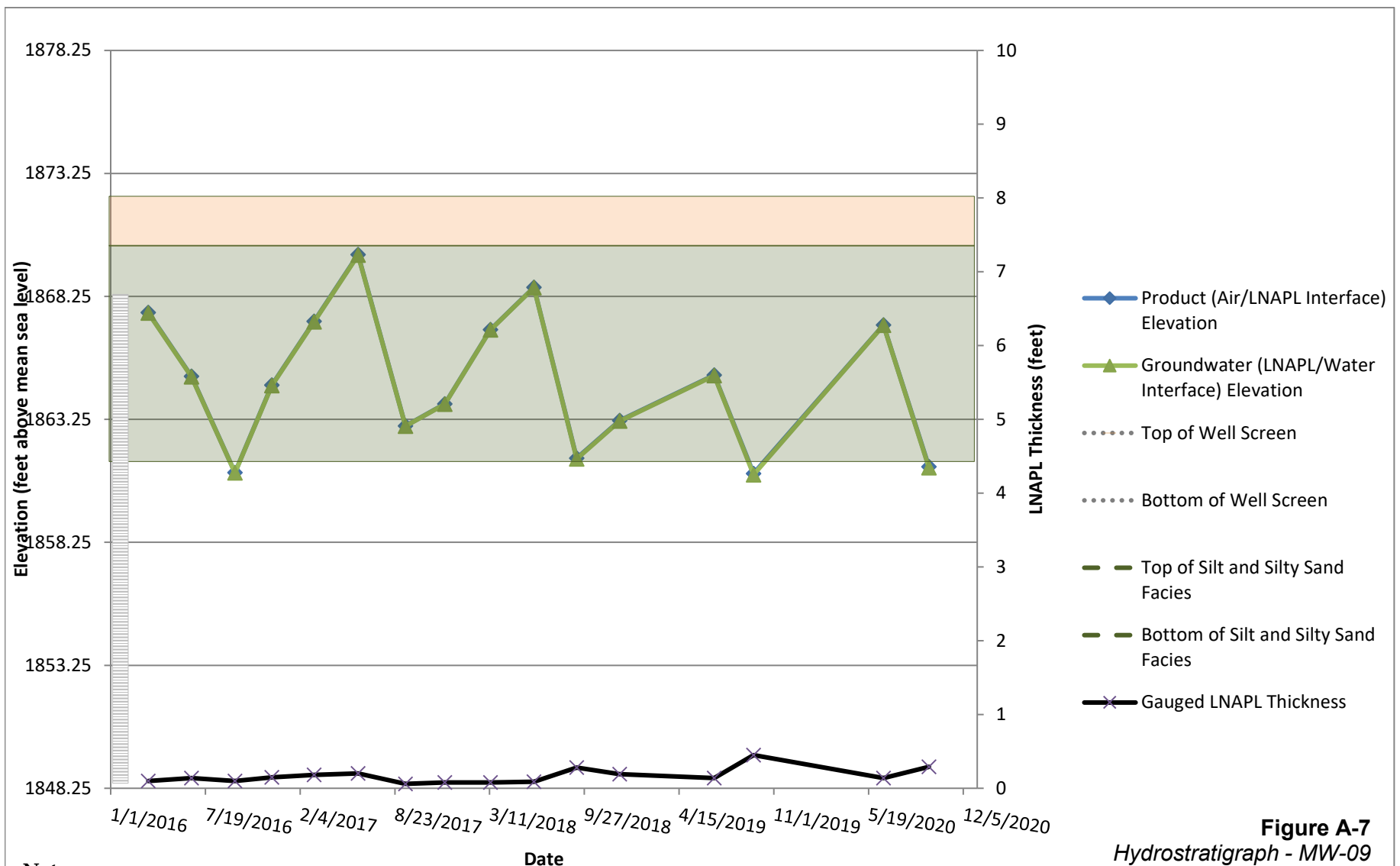
Figure A-5
 Hydrostratigraph - MW-05
 March 2016 through September 2020
 BNSF Black Tank Site
 Spokane, Washington



Notes:

1. Silt and silty sand facies composition (shaded orange): ML: grayish green to black silt with fine sand.
2. Silt and silty sand facies composition (shaded green): SM; grayish green to gray silty fine to coarse sand with trace gravel.
3. LNAPL onditions: mostly unconfined, ocassionally perched.
4. Column on the left side of graph represents screen interval.

Figure A-6
Hydrostratigraph - MW-07
March 2016 through September 2020
BNSF Black Tank Site
Spokane, Washington



Notes:

1. Silt and silty sand facies composition (shaded orange) : ML: brown silt with fine sand.
2. Silt and silty sand facies composition (shaded green): SM; greenish gray to brown silty fine to coarse sand with gravel.
3. LNAPL conditions: Unconfined, generally within leaky confining layer.
4. Column on the left side of graph represents screen interval.

Figure A-7
Hydrostratigraph - MW-09
March 2016 through September 2020
BNSF Black Tank Site
Spokane, Washington

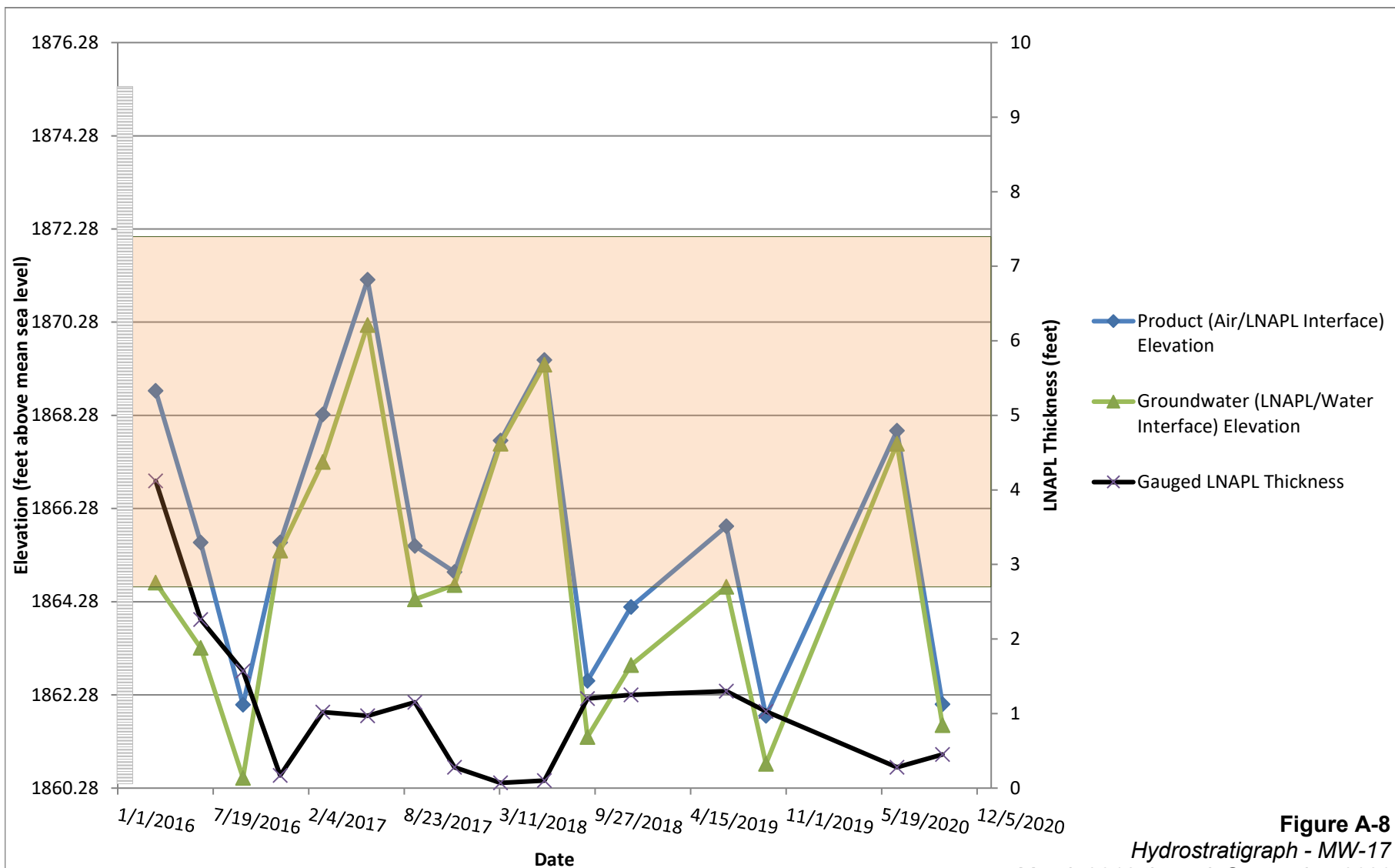
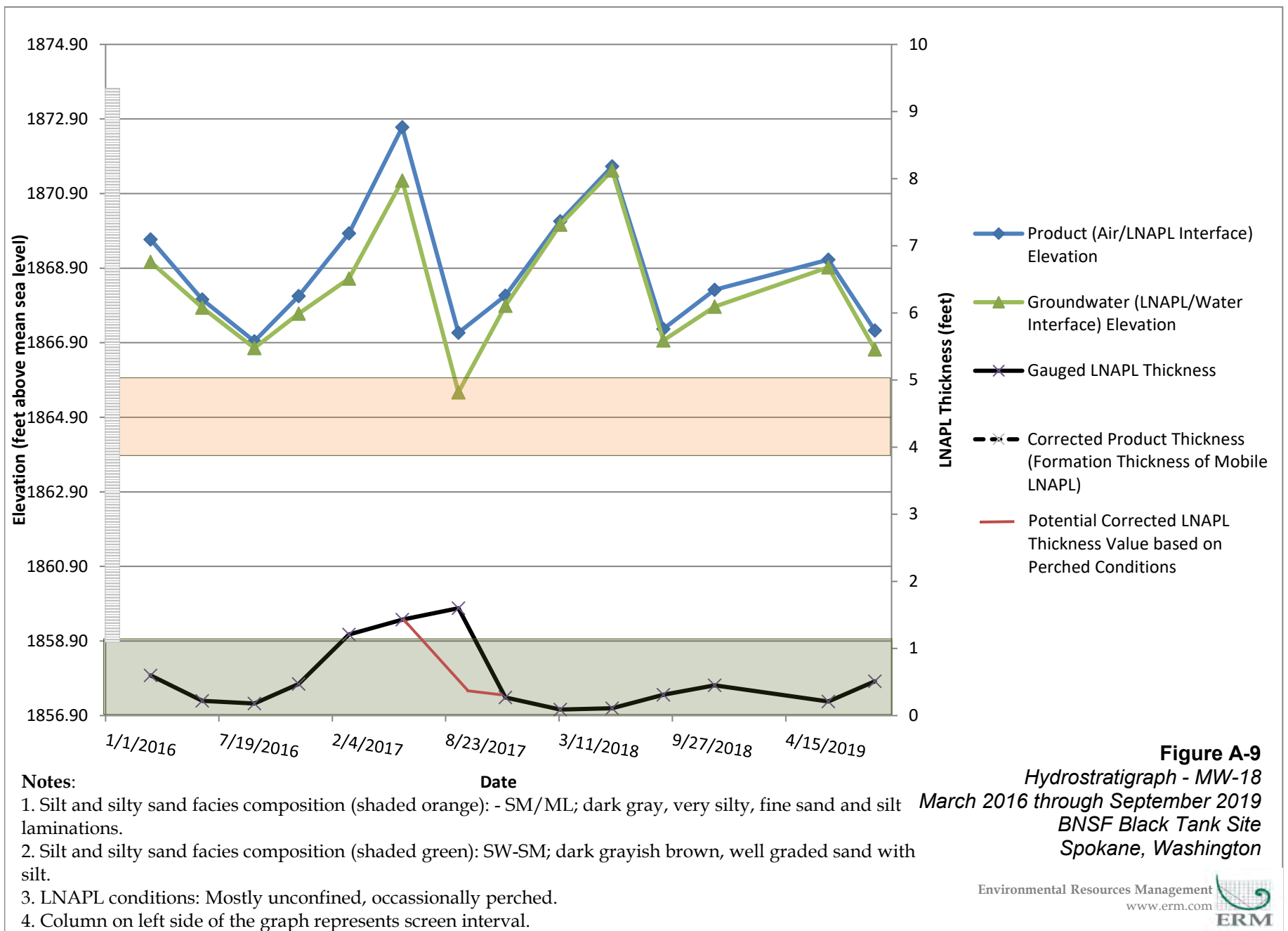
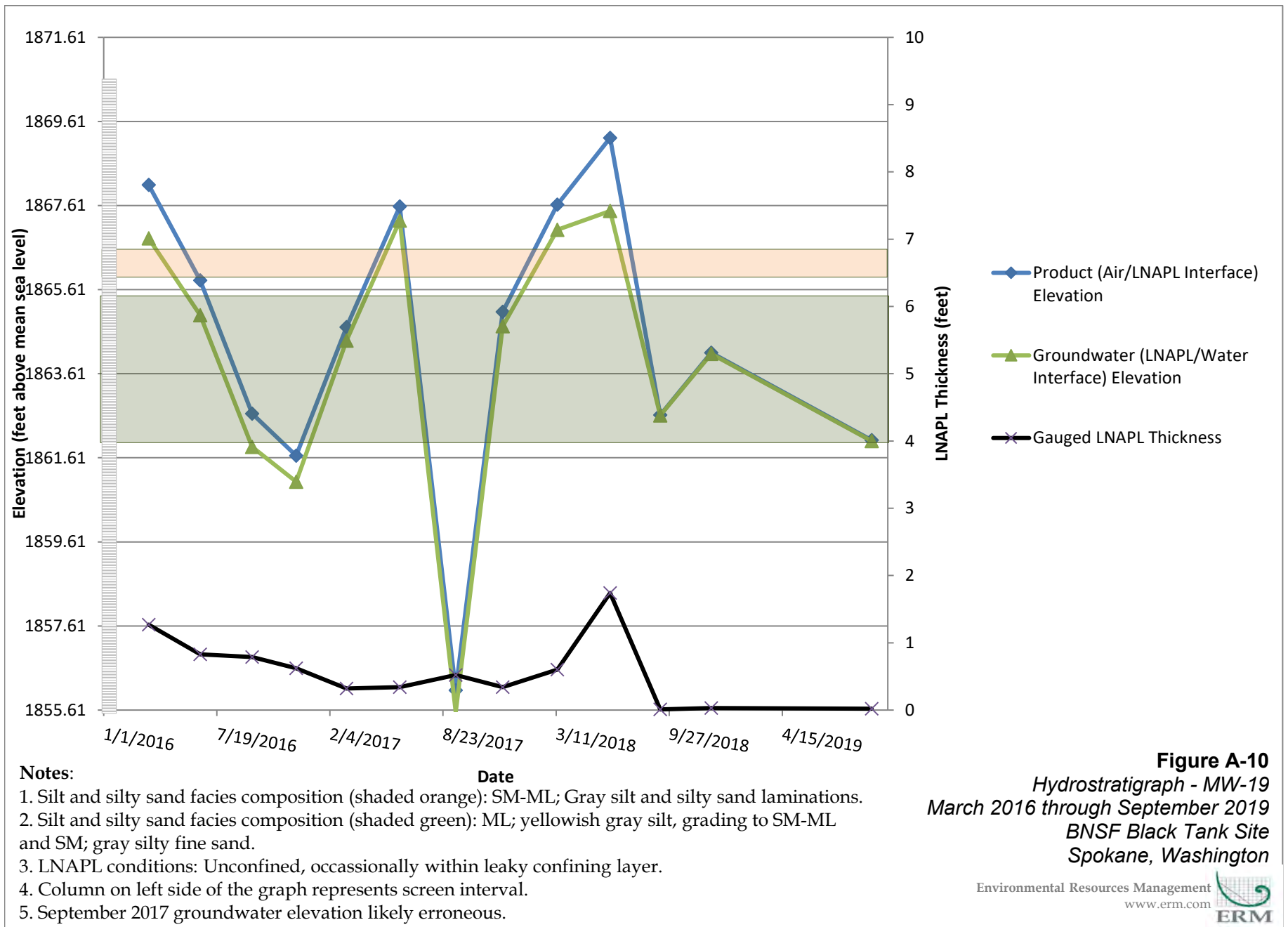


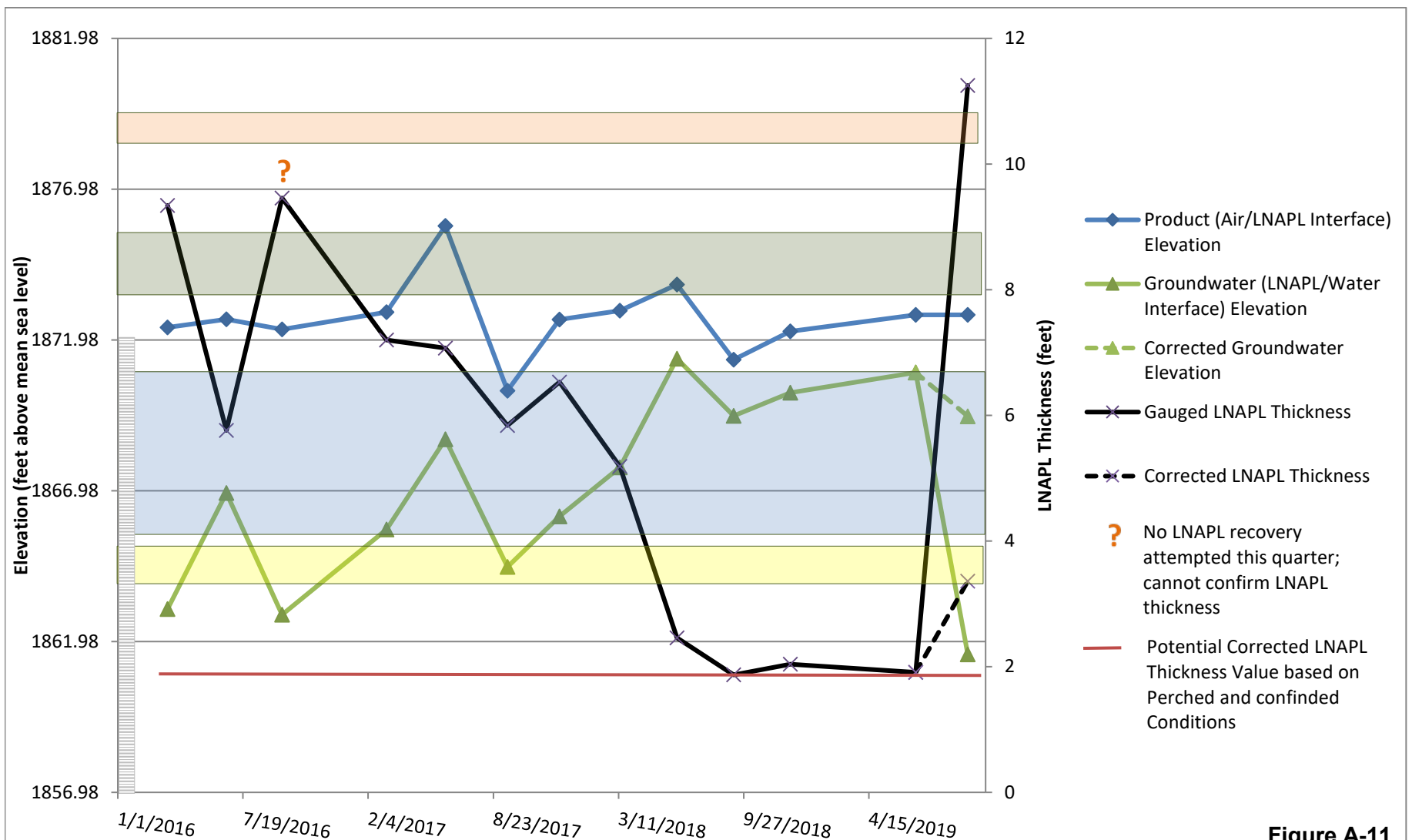
Figure A-8
 Hydrostratigraph - MW-17
 March 2016 through September 2020
 BNSF Black Tank Site
 Spokane, Washington

Notes:

1. Silt and silty sand facies composition (shaded orange): SP/SM; gray silty medium sand with silt.
2. LNAPL conditions: Unconfined, occasionally within leaky confining layer.
3. Column on left side of graph represents screen interval.



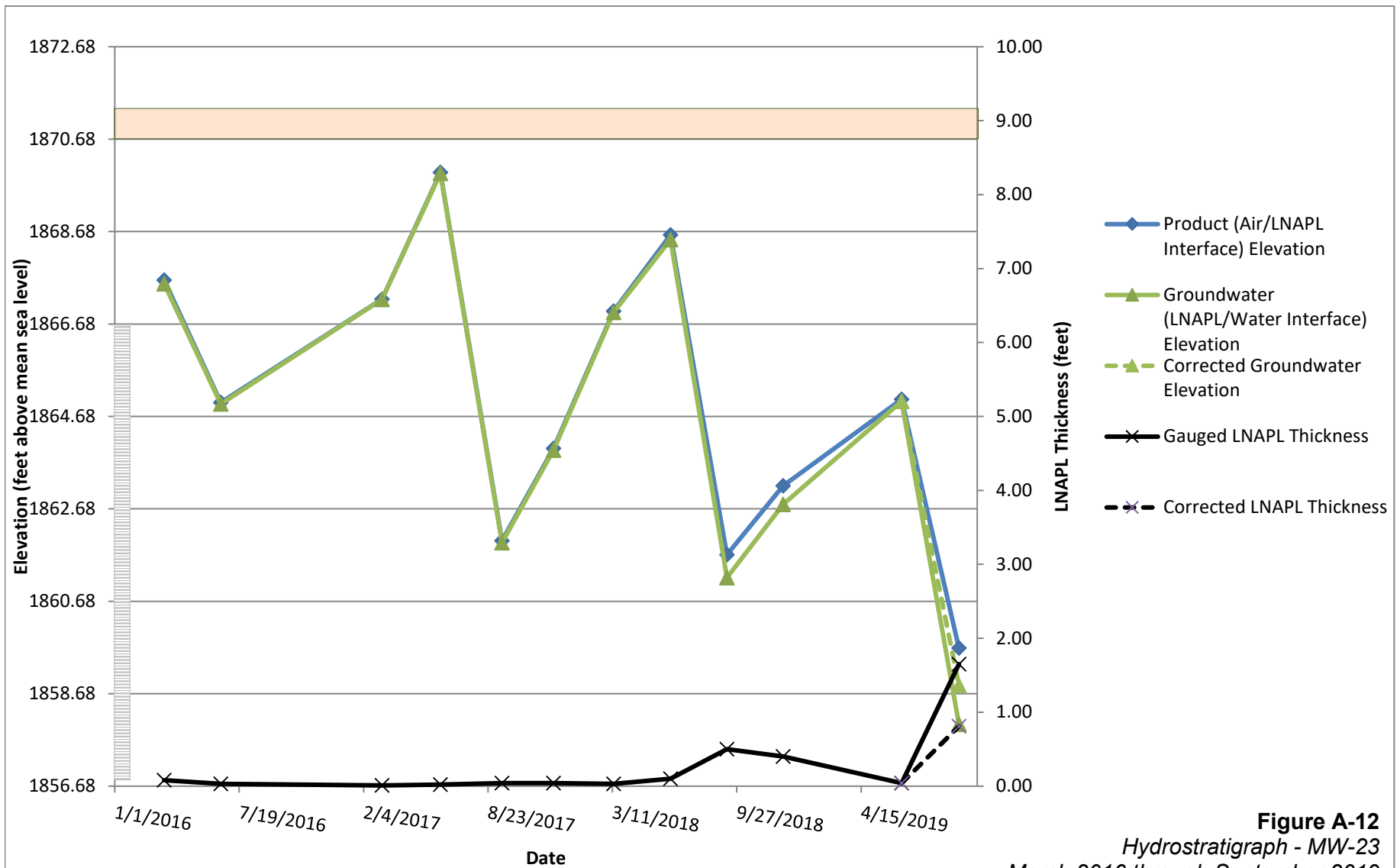




Notes:

1. Silt and silty sand facies composition (shaded orange, green, blue, yellow): Interbedded layers consisting of SM-ML, SM, and ML; gray to black silts and silty fine to medium sands.
2. LNAPL conditions: Perched and occasionally confined.
3. Column on left side of graph represents screen interval.

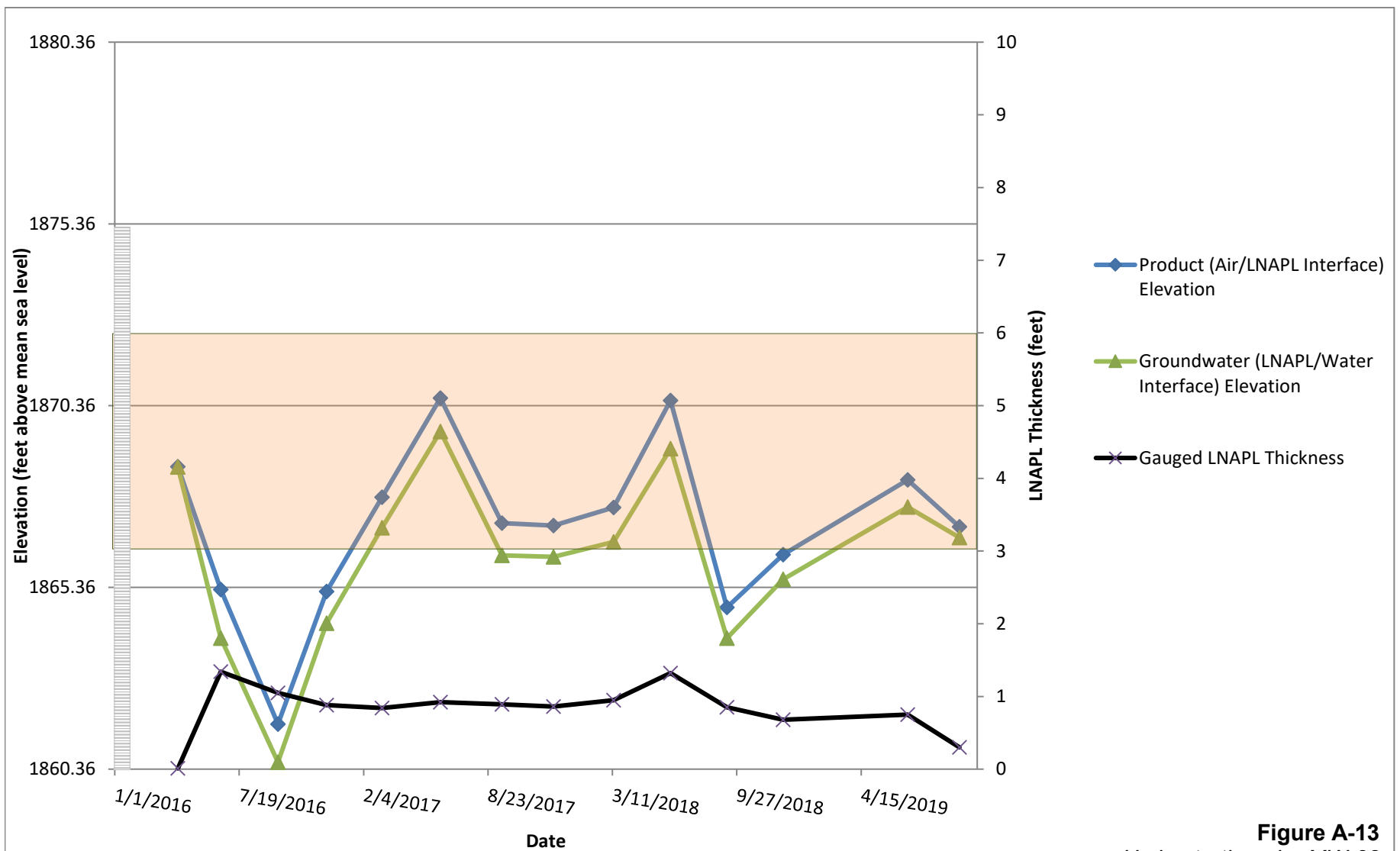
Figure A-11
 Hydrostratigraph - MW-20
 March 2016 through September 2019
 BNSF Black Tank Site
 Spokane, Washington



Notes:

1. Silt and silty sand facies composition (shaded orange): ML; brown silt.
2. LNAPL Conditions: Always unconfined.
3. Column on left side of column represents screen interval.

Figure A-12
 Hydrostratigraph - MW-23
 March 2016 through September 2019
 BNSF Black Tank Site
 Spokane, Washington



Notes:

1. Silt and silty sand facies composition (shaded orange): SM ; brown silt and silty fine sand.
2. LNAPL conditions: Unconfined, occasionally within leaky confining layer.
3. Column on left side of the graph represents screen interval.

Figure A-13
 Hydrostratigraph - MW-28
 March 2016 through September 2019
 BNSF Black Tank Site
 Spokane, Washington

APPENDIX B WELL DEVELOPMENT FORMS AND BORING LOGS

WELL DEVELOPMENT FORMS

WELL DEVELOPMENT/PURGE FORM

WELL NUMBER MW-22R

CLIENT **BNSF, Husky**

PROJECT NAME/NUMBER Black Tank 2020 Well Install

WELL CONSTRUCTION DATA (Y/N)	Y
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DEPTH TO WATER AT START 178.46' bto c

TD @ start 184.15' bto c

LOCATION MW-22R

DEVELOPMENT CONTRACTOR EWE

DEVELOPMENT METHOD	Surge/bail, pump
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FIELD SUPERVISOR MC

DEPTH TO WATER AT END 178.45' b10c

TD @ End 184.15' bto c

DATE 9/9/20 - 9/10/20

AIR TEMPERATURE ~ 80° F

CASING VOLUME (GAL.) 0.98

TOTAL GALS. REMOVED 36

[illegible]

SIGNATURE

MP 09/10/2020

ERM-WEST, INC.

plp/1.00/12.95

$$\frac{0.83 \text{ hr}}{1} \times \frac{60 \text{ min}}{1 \text{ hr}} = 49.8$$

WELL DEVELOPMENT/PURGE FORM

WELL NUMBER MW-23R

CLIENT BNSF, Husky

PROJECT NAME/NUMBER Black Tank 2020 Well Install

WELL CONSTRUCTION DATA (Y/N) **Y**

DEPTH TO WATER AT START 178.37' bto c

TID @ start - 183,17' btoc

LOCATION MW-23R

DEVELOPMENT CONTRACTOR EWE

DEVELOPMENT METHOD	Surge/bail. pump
1. <i>Design</i>	1. <i>Design</i>
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104. <i>Design</i>	104. <i>Design</i>
105. <i>Design</i>	105. <i>Design</i>
106. <i>Design</i>	106. <i>Design</i>
107. <i>Design</i>	107. <i>Design</i>
108. <i>Design</i>	108. <i>Design</i>
109. <i>Design</i>	109. <i>Design</i>
110. <i>Design</i> </	

FIELD SUPERVISOR MC

DEPTH TO WATER AT END 178.40' bto

TD @ End - 183.18' btoc

DATE 9/9-10/2020

AIR TEMPERATURE $\sim 80^{\circ} \text{F}$

CASING VOLUME (GAL.) 0.93

TOTAL GALS. REMOVED 68

[illegible]

SIGNATURE

09/10/2020

ERM-WEST, INC.

plp/1.00/12.95

$$\frac{42}{72}$$

~~$$\begin{array}{r} 37 \\ 20 \\ \hline \end{array}$$~~
$$\begin{array}{r} 20 \\ 33 \\ \hline \end{array}$$

$$8.3x = \frac{0.83}{8.3} = \frac{x}{68}$$

$$8.3x = \frac{(0.83)(68)}{8.3} \quad x =$$

WELL DEVELOPMENT/PURGE FORM

WELL NUMBER MW-31

CLIENT BNSF, Husky

PROJECT NAME/NUMBER Black Tank 2020 Well InstallWELL CONSTRUCTION DATA (Y/N) Y

DEPTH TO WATER AT START 176.62' btoe

LOCATION MW-31

DEVELOPMENT CONTRACTOR EWE

DEVELOPMENT METHOD	Surge/bail, pump
--------------------	------------------

FIELD SUPERVISOR _____ MC _____

DEPTH TO WATER AT END 176.65' bto

DATE 09/10/2020

AIR TEMPERATURE ~80° F

CASING VOLUME (GAL.) 1.16

TOTAL GALS. REMOVED 35

TD @ start - 183,32' bto c

TD @ End - 183.32' bto c

[illegible]

SIGNATURE

MC 9/10/2020

ERM-WEST, INC.

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$$\frac{30}{31}$$

WELL DEVELOPMENT/PURGE FORM

WELL NUMBER BSI-1

CLIENT BNSF, Husky

PROJECT NAME/NUMBER Black Tank 2020 Well Install

WELL CONSTRUCTION DATA (Y/N)	Y
------------------------------	---

DEPTH TO WATER AT START 174.33' btoe

TD @ Start - NC

LOCATION BSI-7

DEVELOPMENT CONTRACTOR EWE

DEVELOPMENT METHOD	Surge/bail. pump
1970-1980	1970-1980
1980-1990	1980-1990
1990-2000	1990-2000
2000-2010	2000-2010
2010-2020	2010-2020
2020-2030	2020-2030
2030-2040	2030-2040
2040-2050	2040-2050
2050-2060	2050-2060
2060-2070	2060-2070
2070-2080	2070-2080
2080-2090	2080-2090
2090-2100	2090-2100

FIELD SUPERVISOR MC

DEPTH TO WATER AT END 174.32' bto c

TD @ End - NC

DATE 9/21/2020

AIR TEMPERATURE $\sim 70^{\circ}$

CASING VOLUME (GAL.) ~ 4.15

TOTAL GALS. REMOVED ~ 55

[illegible]

SIGNATURE THC 9/21/2020

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NC - not collected. TD is $>200'$, only have 200' water level tape

BORING LOGS



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BSI-1
PAGE 1 OF 5

CLIENT BNSF and Husky Oil

PROJECT NAME Black Tank Site

PROJECT NUMBER 0175844

PROJECT LOCATION Spokane, WA

DATE STARTED 9/11/20

COMPLETED 9/29/20

GROUND ELEVATION 2038.579 feet **HOLE SIZE** 6 inches

CONTRACTOR Environmental West

GROUND WATER LEVELS:

EQUIPMENT Sonic

▽ **AT TIME OF DRILLING** 166.00 ft / Elev 1872.58 ft

LOGGED BY Matt Crandell

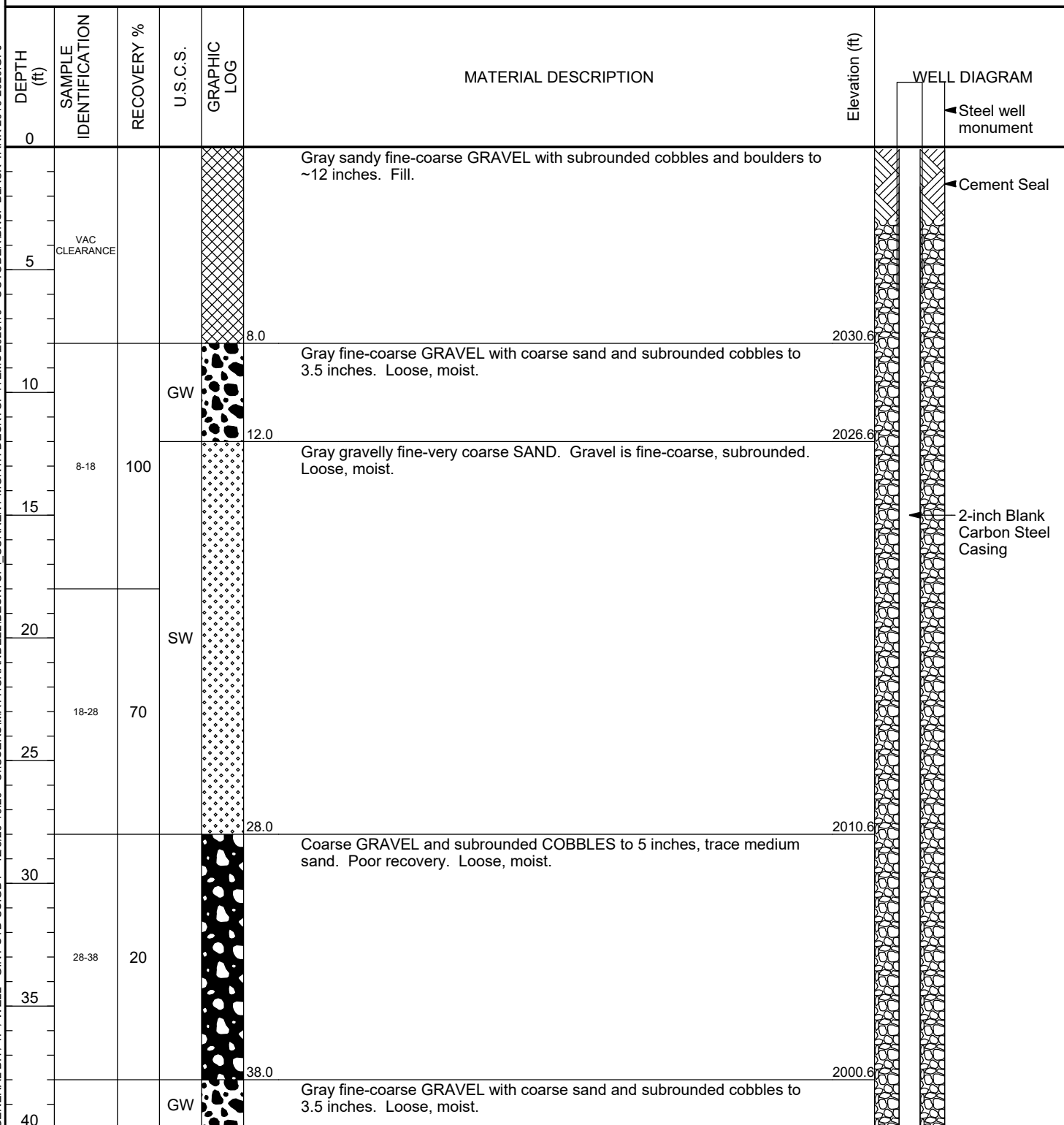
CHECKED BY Dave Edwards

AT END OF DRILLING ---

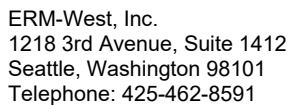
NOTES Pre-cleared to 8 feet bgs

AFTER DRILLING ---

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(Continued Next Page)



PROJECT NAME Black Tank Site

PROJECT LOCATION Spokane, WA

COMPLETED 9/29/20

GROUND ELEVATION 2038.579 feet **HOLE SIZE** 6 inches

CONTRACTOR Environmental West

GROUND WATER LEVELS:

EQUIPMENT Sonic

▽ **AT TIME OF DRILLING** 166.00 ft / Elev 1872.58 ft

LOGGED BY Matt Crandell

CHECKED BY Dave Edwards

AT END OF DRILLING ---

NOTES Pre-cleared to 8 feet bgs

AFTER DRILLING ---

[illegible]

(Continued Next Page)



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CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>9/11/20</u> COMPLETED <u>9/29/20</u>	GROUND ELEVATION <u>2038.579 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	▽ AT TIME OF DRILLING <u>166.00 ft / Elev 1872.58 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Pre-cleared to 8 feet bgs</u>	AFTER DRILLING <u>---</u>

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDALL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\2020\10 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
80							
80	78-88	100	SW		Gray gravelly fine-very coarse SAND with subrounded cobbles to 4 inches. Gravel is fine-coarse, subrounded. Loose, moist. (continued)		
85							
88.0						1950.6	
90			GW		Gray fine-coarse GRAVEL with coarse sand. Loose, moist.		
93.0	88-98	70				1945.6	
94.5					Granitic boulder from 93 to 94.5 feet bgs. Hard drilling.	1944.1	
95			GW		Gray fine-coarse GRAVEL with coarse sand. Loose, moist.		
98.0						1940.6	
100					Grayish brown gravelly fine-very coarse SAND, trace subrounded cobbles to 5 inches. Loose, moist.		
105							
110	98-118	90	SW				
113					No cobbles at 113 feet bgs.		
115							
120							

← Bentonite
Grout Seal

(Continued Next Page)



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CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>9/11/20</u> COMPLETED <u>9/29/20</u>	GROUND ELEVATION <u>2038.579 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	▽ AT TIME OF DRILLING <u>166.00 ft / Elev 1872.58 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Pre-cleared to 8 feet bgs</u>	AFTER DRILLING <u>---</u>

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
120							
			SW		Grayish brown gravelly fine-very coarse SAND, trace subrounded cobbles to 5 inches. Loose, moist. (continued)		
					124.0	1914.6	
125					Grayish brown medium-coarse SAND with fine subrounded gravel. Loose, wet. Moisture from drill head water.		
	118-138	100	SP				
130							
					138.0	1900.6	
135							
			SW		Grayish brown fine-coarse SAND, trace silt. Loose, moist.		
140					140.0	1898.6	
			SP		Grayish brown medium-coarse SAND with fine subrounded gravel. Loose, wet. Moisture from drill head water.		
145							
	138-158	100			Sand grain size change to fine-medium.		
150					152.0	1886.6	
			SW		Grayish brown fine-coarse SAND, trace silt. Loose, moist.		
155					154.0	1884.6	
			SP		Grayish brown medium-coarse SAND with fine subrounded gravel. Loose, wet. Moisture from drill head water.		
160							

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BSI-1

PAGE 5 OF 5

CLIENT BNSF and Husky Oil

PROJECT NAME Black Tank Site

PROJECT NUMBER 0175844

PROJECT LOCATION Spokane, WA

DATE STARTED 9/11/20

COMPLETED 9/29/20

GROUND ELEVATION 2038.579 feet HOLE SIZE 6 inches

CONTRACTOR Environmental West

GROUND WATER LEVELS:

EQUIPMENT Sonic

▽ AT TIME OF DRILLING 166.00 ft / Elev 1872.58 ft

LOGGED BY Matt Crandell

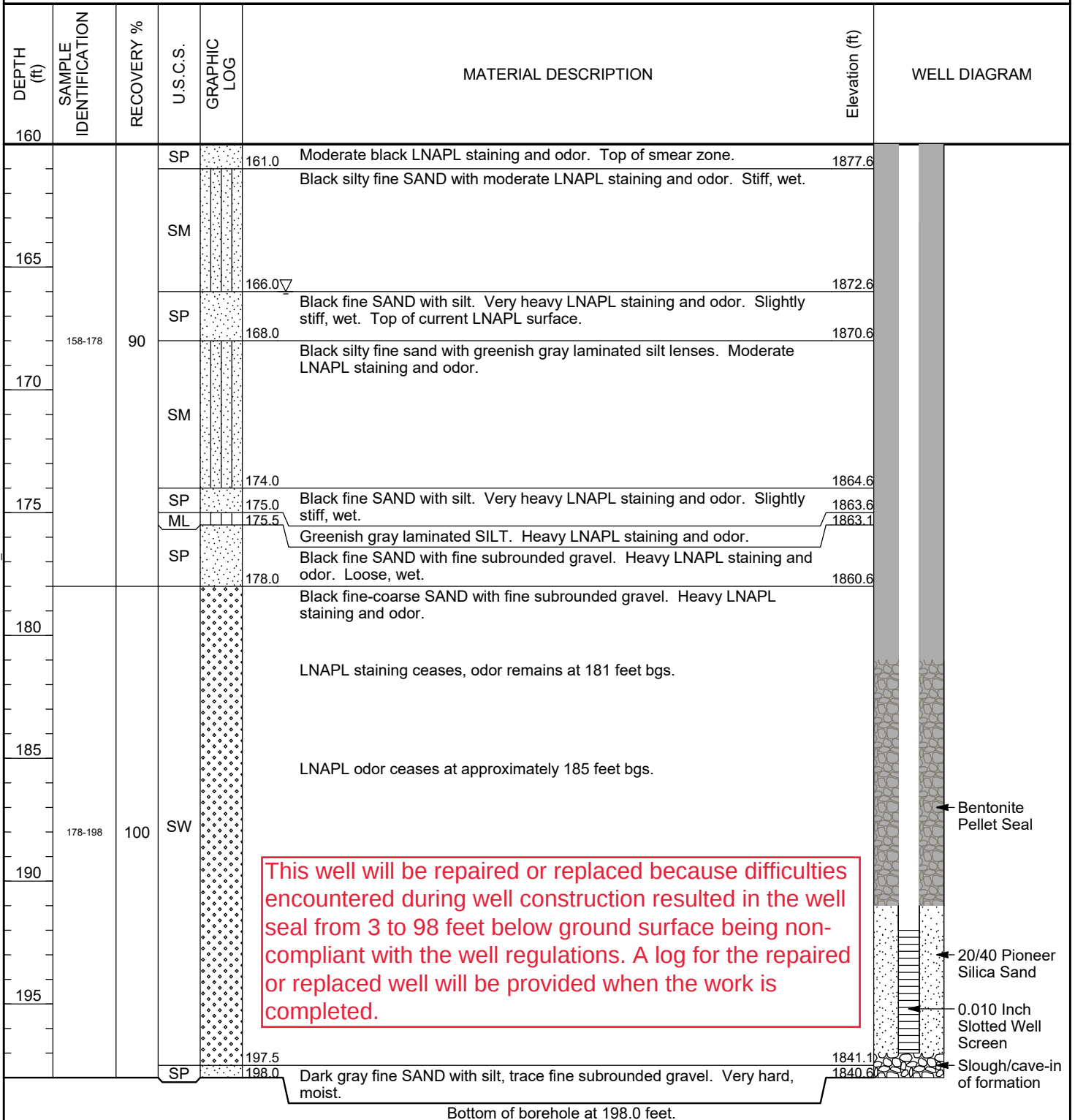
CHECKED BY Dave Edwards

AT END OF DRILLING ---

NOTES Pre-cleared to 8 feet bgs

AFTER DRILLING ---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ



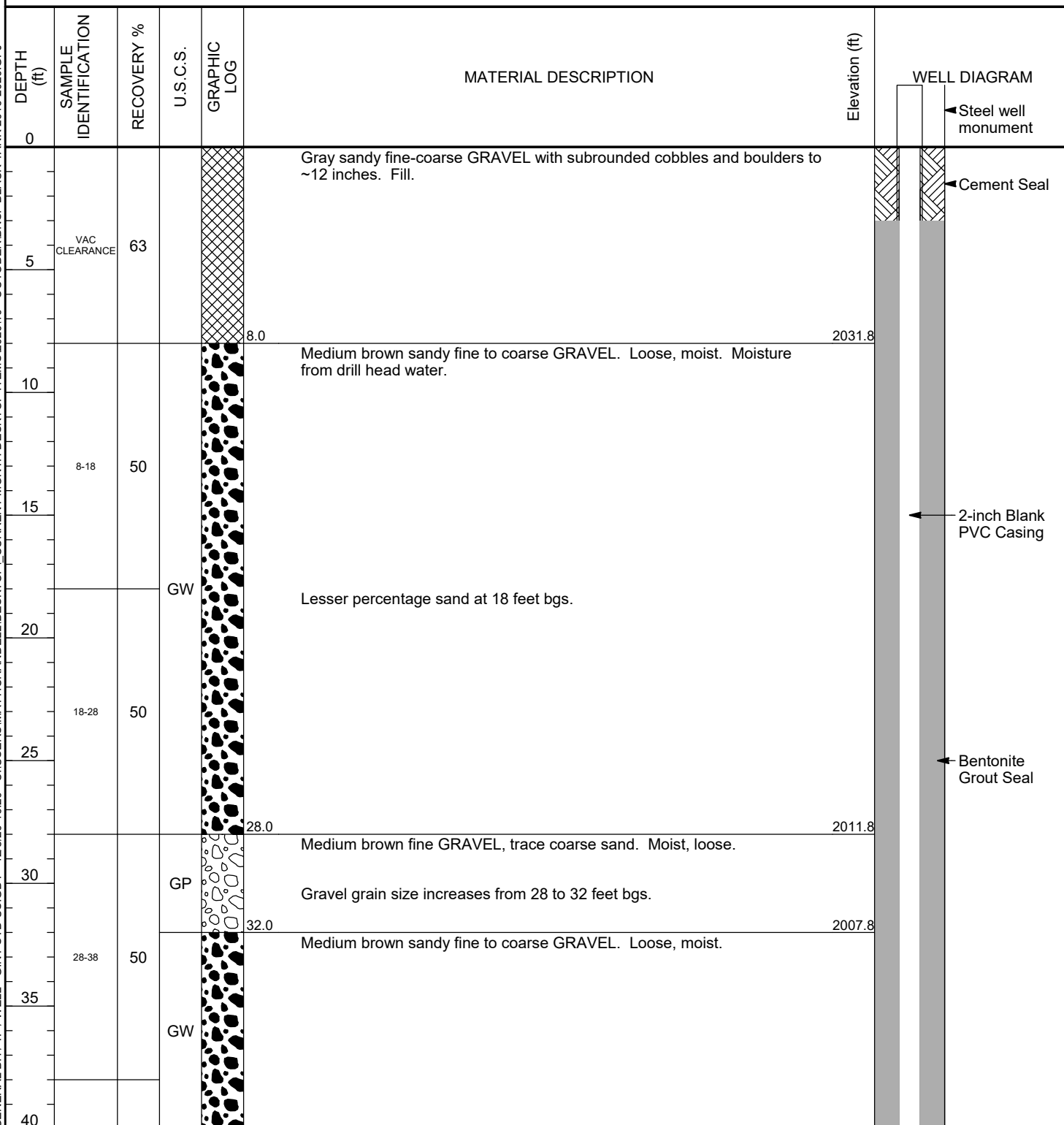


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MW-22R
PAGE 1 OF 5

CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>8/19/20</u> COMPLETED <u>8/21/20</u>	GROUND ELEVATION <u>2039.845 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	▽ AT TIME OF DRILLING <u>175.50 ft / Elev 1864.35 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Pre-cleared to 8 feet bgs</u>	AFTER DRILLING <u>---</u>

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ



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PAGE 2 OF 5

CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	8/19/20	COMPLETED	8/21/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2039.845 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 8 feet bgs		
		GROUND WATER LEVELS:	
		▽ AT TIME OF DRILLING	175.50 ft / Elev 1864.35 ft
		AT END OF DRILLING	---
		AFTER DRILLING	---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\2020\10 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
40							
	38-48	85	GW		Medium brown sandy fine to coarse GRAVEL. Loose, moist. (continued)		
					44.0	1995.8	
45			SW		Medium brown gravelly fine-coarse SAND, trace silt. Gravel is fine-coarse. Loose, moist.		
					48.0	1991.8	
50			GW		Medium brown sandy fine to coarse GRAVEL. Loose, moist.		
	48-58	80			53.0	1986.8	
55			SW		Medium brown gravelly fine-coarse SAND, trace subrounded cobbles to 4 inches. Gravel is fine-coarse. Loose, moist.		
					58.0	1981.8	
60					Brown fine-coarse SAND and fine-coarse GRAVEL. Loose, moist.		
	58-68	100			68.0	1971.8	
65							
					68.0	1971.8	
70			GW		Multi-colored fine-coarse GRAVEL and COBBLES to 5 inches, with medium-coarse sand. Loose, moist.		
	68-78	40			78.0	1961.8	
75							
			SW		Medium brown gravelly fine-coarse SAND, trace silt. Gravel is fine-coarse. Loose, moist.		
80							

(Continued Next Page)



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CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>8/19/20</u> COMPLETED <u>8/21/20</u>	GROUND ELEVATION <u>2039.845 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	▽ AT TIME OF DRILLING <u>175.50 ft / Elev 1864.35 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Pre-cleared to 8 feet bgs</u>	AFTER DRILLING <u>---</u>

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S. GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
80						
	78-88	100	SW	81.0	1958.8	
			SM	81.5	1958.3	
			SW	Medium brown gravelly fine-coarse SAND, trace silt. Gravel is fine-coarse. Loose, moist.		
			ML	84.0	1955.8	
85			ML	84.5	1955.3	
			SW	Brown SILT lens.		
				Medium brown gravelly fine-coarse SAND, trace silt. Gravel is fine-coarse. Loose, moist.		
				88.0	1951.8	
90	88-98	100	GW	Grayish brown fine-coarse GRAVEL with subrounded cobbles to 4 inches, trace silt.		
				Higher percentage of SILT at 90.5 feet bgs, possible small silt lens.		
95						
			GP	98.0	1941.8	
			GP	99.0	1940.8	
100			SP	Brown coarse SAND.		
				101.0	1938.8	
	98-108	100	ML	Brown laminated SILT. Moist, stiff.		
				103.0	1936.8	
105			SP	Brown very coarse SAND.		
				Sand grain size decreases to medium-coarse. Overall fining downwards sequence from 98 to 103 feet bgs.		
				108.0	1931.8	
110			GP	Grayish brown sandy fine GRAVEL, sand is coarse. Loose, wet. Moisture from drill head water.		
	108-118	80		113.0	1926.8	
115			SW	Brown fine-coarse SAND and fine-coarse GRAVEL. Loose, moist.		
				116.0	1923.8	
			SW	Gray gravelly fine-coarse SAND, trace silt. Loose, dry.		
120						

(Continued Next Page)



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MW-22R
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CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	8/19/20	COMPLETED	8/21/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2039.845 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 8 feet bgs		
		GROUND WATER LEVELS:	
		▽ AT TIME OF DRILLING	175.50 ft / Elev 1864.35 ft
		AT END OF DRILLING	---
		AFTER DRILLING	---

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DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
120					Gray gravelly fine-coarse SAND, trace silt. Loose, dry. (continued)		
125	118-128	85	SW				
130							
135	128-138	100	ML		134.0 134.5 Orange-brown SILT lens. Gray fine-coarse SAND, trace fine gravel. Moist, loose.	1905.8 1905.3	
140							
145	138-148	100	SW				
150							
155	148-158	100	SM		153.0 153.5 Grayish brown silty fine SAND. Stiff, moist. Brown fine-medium SAND with silt. Loose, moist.	1886.8 1886.3	
160			SP				
			SW		158.0 Brown fine-coarse SAND, trace silt. Loose, moist.	1881.8	

→ Bentonite
Pellet Seal

(Continued Next Page)



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MW-22R
PAGE 5 OF 5

CLIENT BNSF and Husky Oil **PROJECT NAME** Black Tank Site
PROJECT NUMBER 0175844 **PROJECT LOCATION** Spokane, WA
DATE STARTED 8/19/20 **COMPLETED** 8/21/20 **GROUND ELEVATION** 2039.845 feet **HOLE SIZE** 6 inches
CONTRACTOR Environmental West **GROUND WATER LEVELS:**
EQUIPMENT Sonic **AT TIME OF DRILLING** 175.50 ft / Elev 1864.35 ft
LOGGED BY Matt Crandell **CHECKED BY** Dave Edwards **AT END OF DRILLING** ---
NOTES Pre-cleared to 8 feet bgs **AFTER DRILLING** ---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDALL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
160					Brown fine-coarse SAND, trace silt. Loose, moist. (continued)		
165	158-168	100	SW				
			SP		165.5 166.0 Brown medium SAND	1874.3 1873.8	
			ML		Medium brown SILT. Moist, stiff.		20/40 Pioneer Silica Sand
					168.0	1871.8	
170			SM		Coarsening downwards sequence to 168 feet bgs: Gray silty fine SAND, trace coarse sand. Wet, slightly stiff. LNAPL odor, slight staining. Top of smear zone.		
					170.5	1869.3	
					Black well graded gravelly SAND, trace silt. Wet, loose. Heavy LNAPL staining and odor.		0.010 Inch Slotted Well Screen
175	168-182	100	SW				
					Very heavy black LNAPL staining, wet at 175.5 feet bgs. No gravel, no silt. Top of current LNAPL surface.		
180					LNAPL staining ceases at 179 feet bgs, odor continues to bottom of boring at 182 feet bgs.		
					182.0	1857.8	Slough/cave-in of formation

Bottom of borehole at 182.0 feet.



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MW-23R
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CLIENT BNSF and Husky Oil

PROJECT NAME Black Tank Site

PROJECT NUMBER 0175844

PROJECT LOCATION Spokane, WA

DATE STARTED 8/31/20 COMPLETED 9/2/20

GROUND ELEVATION 2039.908 feet HOLE SIZE 6 inches

CONTRACTOR Environmental West

GROUND WATER LEVELS:

EQUIPMENT Sonic

▽ AT TIME OF DRILLING 173.50 ft / Elev 1866.41 ft

LOGGED BY Matt Crandell

CHECKED BY Dave Edwards

AT END OF DRILLING ---

NOTES Pre-cleared to 9 feet bgs

AFTER DRILLING ---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\2020\10 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
0							Steel well monument
5	VAC CLEARANCE				Gray sandy fine-coarse GRAVEL with subrounded cobbles and boulders to ~18 inches. Fill.		Cement Seal
10	8-18	50	SW		9.0 Brownish-gray gravelly fine-coarse SAND, trace rock flour. Nearly 50% gravel. Gravel is fine-coarse, subrounded to subangular. Dry, loose.	2030.9	
15							2-inch Blank PVC Casing
20	18-28	70			18.0 Brownish-gray sandy fine-coarse GRAVEL with very coarse sand and cobbles to 4 inches, trace silt. Moist, loose.	2021.9	
25							Bentonite Grout Seal
30			GW				
35	28-38	80					
40							

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CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	8/31/20	COMPLETED	9/2/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2039.908 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 9 feet bgs		
		GROUND WATER LEVELS:	
		▽ AT TIME OF DRILLING	173.50 ft / Elev 1866.41 ft
		AT END OF DRILLING	---
		AFTER DRILLING	---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\2020\10 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
40							
45	38-48	50	GW		Brownish-gray sandy fine-coarse GRAVEL with very coarse sand and cobbles to 4 inches, trace silt. Moist, loose. (continued)		
48.0						1991.9	
50	48-58	0			No recovery. Driller reports a boulder likely prevented recovery of the sample; lithology loose enough so the core barrel pushed the boulder down the entire 10 feet of the sample interval.		
55							
58.0						1981.9	
60	58-68	70			Brownish-gray sandy fine-coarse GRAVEL with very coarse sand and cobbles to 4 inches, trace silt. Moist, loose.		
65							
70			GW				
75	68-78	50					
80							

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MW-23R
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CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>8/31/20</u> COMPLETED <u>9/2/20</u>	GROUND ELEVATION <u>2039.908 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	<u>▽ AT TIME OF DRILLING</u> <u>173.50 ft / Elev 1866.41 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	<u>AT END OF DRILLING</u> <u>---</u>
NOTES <u>Pre-cleared to 9 feet bgs</u>	<u>AFTER DRILLING</u> <u>---</u>

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\ CURRENT MONTH DESKTOP ITEMS\2020\10 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
80					Brownish-gray sandy fine-coarse GRAVEL with very coarse sand and cobbles to 4 inches, trace silt. Moist, loose. <i>(continued)</i>		
85	78-88	80					
90			GW				
95	88-98	70					
97.0						1942.9	
98.0			SW		Grayish brown gravelly fine-coarse SAND. Gravel is fine, subrounded. Moist, loose.	1941.9	
100					Brownish-gray sandy fine-coarse GRAVEL with very coarse sand and cobbles to 4 inches, trace silt. Moist, loose.		
105	98-108	70	GW				
108.0						1931.9	
110			GP		Gray fine GRAVEL, trace coarse subrounded gravel, trace medium sand. Wet, loose. Moisture from drill head water.	1929.9	
115	108-118	80	GW		Brownish-gray sandy fine-coarse GRAVEL with very coarse sand and cobbles to 4 inches, trace silt. Moist, loose.		
116.0						1923.9	
			SW		Brownish gray gravelly fine-coarse SAND. Gravel is fine, subrounded. Moist, loose.		
120					Trace subrounded cobbles to 5 inches from 118 to 128 feet bgs.		

(Continued Next Page)



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CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>8/31/20</u> COMPLETED <u>9/2/20</u>	GROUND ELEVATION <u>2039.908 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	▽ AT TIME OF DRILLING <u>173.50 ft / Elev 1866.41 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Pre-cleared to 9 feet bgs</u>	AFTER DRILLING <u>---</u>

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DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
120							
118-128	80	SW			Brownish gray gravelly fine-coarse SAND. Gravel is fine, subrounded. Moist, loose. (continued)		
125							
					128.0	1911.9	
130			SP		Brown fine-medium SAND. Moist, loose		
128-138	80						
135					135.0	1904.9	
			SM		Brown silty fine SAND.		
					137.0	1902.9	
			SP		Brown fine-medium SAND. Moist, loose		
					138.0	1901.9	
140					Brown gravelly fine-coarse SAND, trace fine subrounded gravel and silt. Moist, loose.		
138-148	90	SW					
145							
					149.0	1890.9	
150					Brown fine-medium SAND, trace silt. Moist, loose.		
148-158	90	SP					
155							
160							

← Bentonite
Pellet Seal

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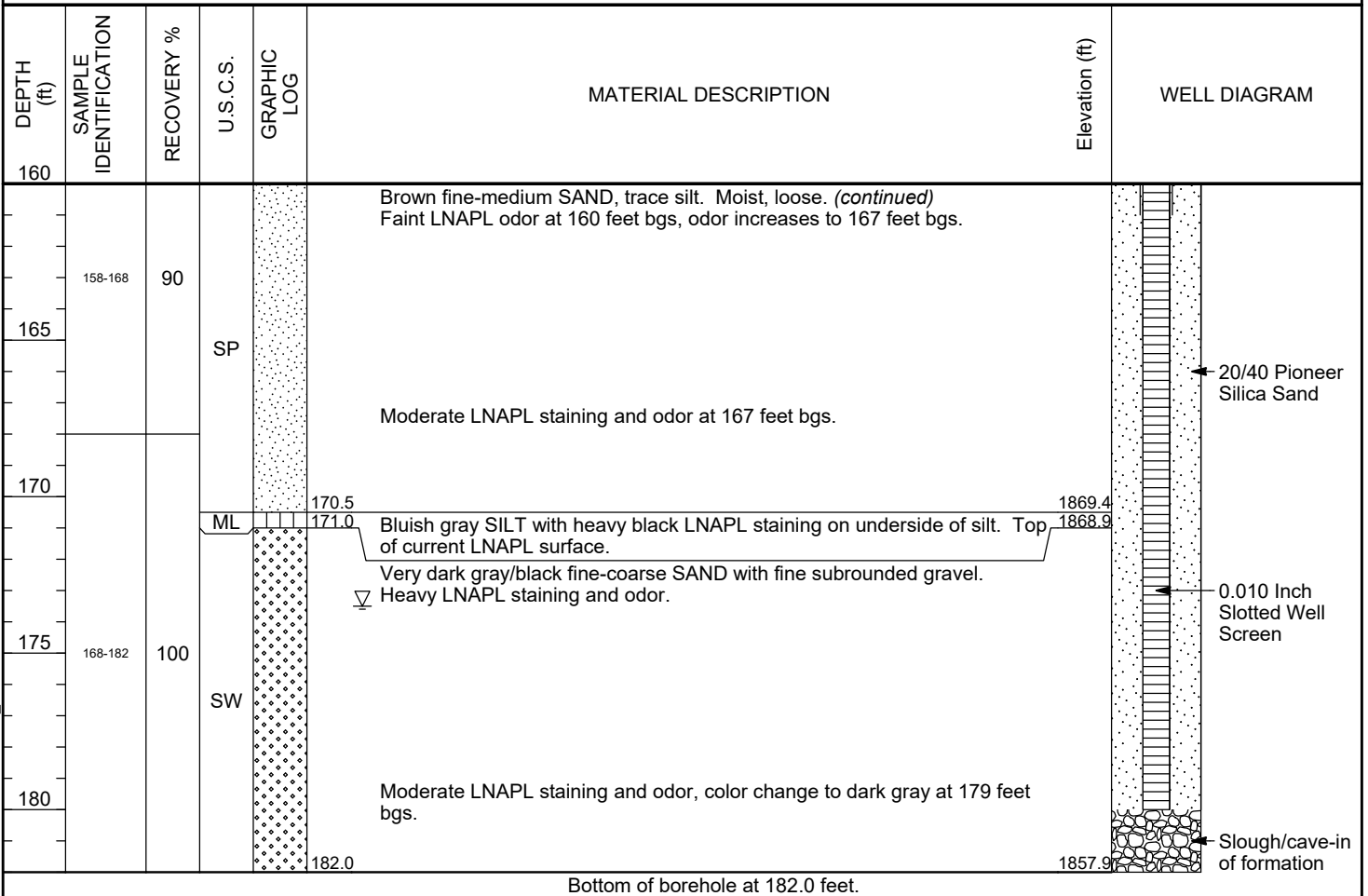


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CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	8/31/20	COMPLETED	9/2/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2039.908 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 9 feet bgs		
GROUND WATER LEVELS:		▽ AT TIME OF DRILLING 173.50 ft / Elev 1866.41 ft	
		AT END OF DRILLING ---	
		AFTER DRILLING ---	

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CLIENT BNSF and Husky Oil **PROJECT NAME** Black Tank Site
PROJECT NUMBER 0175844 **PROJECT LOCATION** Spokane, WA
DATE STARTED 9/2/20 **COMPLETED** 9/8/20 **GROUND ELEVATION** 2038.21 feet **HOLE SIZE** 6 inches
CONTRACTOR Environmental West **GROUND WATER LEVELS:**
EQUIPMENT Sonic **AT TIME OF DRILLING** 163.50 ft / Elev 1874.71 ft
LOGGED BY Matt Crandell **CHECKED BY** Dave Edwards **AT END OF DRILLING** ---
NOTES Pre-cleared to 8 feet bgs **AFTER DRILLING** ---

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DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
0							Steel well monument
5	VAC CLEARANCE				Brown fine-coarse SAND, trace subangular fine gravel and silt. Fill.		Cement Seal
8.0						2030.2	
10	8-18	50			Light brown fine-coarse subrounded GRAVEL with fine-medium sand with subrounded cobbles to 3 inches. Wet, loose.		
15			GW				2-inch Blank PVC Casing
20					Granite boulder at 18 feet bgs.		
25	18-28	40				2013.2	
28.0			SW		Brown gravelly fine-very coarse SAND. Gravel is fine, subrounded.	2010.2	Bentonite Grout Seal
30					Light brown fine-coarse subrounded GRAVEL with fine-medium sand with subrounded cobbles to 3 inches. Wet, loose.		
35	28-38	50	GW				
36.0					Brown coarse GRAVEL with fine gravel, trace coarse sand. Loose, moist.	2002.2	
38.0			GP			2000.2	
40			GW		Light brown fine-coarse subrounded GRAVEL with fine-medium sand with subrounded cobbles to 3 inches. Wet, loose.		

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CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	9/2/20	COMPLETED	9/8/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2038.21 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 8 feet bgs		
		GROUND WATER LEVELS:	
		▽ AT TIME OF DRILLING	163.50 ft / Elev 1874.71 ft
		AT END OF DRILLING	---
		AFTER DRILLING	---

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DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
40							
45	38-48	50			Light brown fine-coarse subrounded GRAVEL with fine-medium sand with subrounded cobbles to 3 inches. Wet, loose. (continued)		
50							
55	48-58	60					
60			GW				
65	58-68	60			Reddish brown 1 inch lens of oxidized coarse sand at 64 feet bgs.		
70							
75	68-78	90					
80							

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CLIENT <u>BNSF and Husky Oil</u>	PROJECT NAME <u>Black Tank Site</u>
PROJECT NUMBER <u>0175844</u>	PROJECT LOCATION <u>Spokane, WA</u>
DATE STARTED <u>9/2/20</u> COMPLETED <u>9/8/20</u>	GROUND ELEVATION <u>2038.21 feet</u> HOLE SIZE <u>6 inches</u>
CONTRACTOR <u>Environmental West</u>	GROUND WATER LEVELS:
EQUIPMENT <u>Sonic</u>	<u>▽ AT TIME OF DRILLING</u> <u>163.50 ft / Elev 1874.71 ft</u>
LOGGED BY <u>Matt Crandell</u> CHECKED BY <u>Dave Edwards</u>	AT END OF DRILLING <u>---</u>
NOTES <u>Pre-cleared to 8 feet bgs</u>	AFTER DRILLING <u>---</u>

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ

DEPTH (ft)	SAMPLE IDENTIFICATION	RECOVERY %	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	Elevation (ft)	WELL DIAGRAM
80							
	78-88	70	GW		Light brown fine-coarse subrounded GRAVEL with fine-medium sand with subrounded cobbles to 3 inches. Wet, loose. (continued)		
						84.0 1954.2	
85			SW		Dark grayish brown gravelly fine-coarse SAND, trace silt. Gravel is fine, subrounded. Moist, loose.	85.5 1952.7	
					Brown fine-coarse subrounded GRAVEL with fine-medium sand with subrounded cobbles to 3 inches. Wet, loose.		
90			GW				
	88-98	70				94.0 1944.2	
95					Granitic boulder from 94 to 95 feet bgs.	95.0 1943.2	
					Brownish gray fine-coarse SAND with fine subrounded gravel. Moist, loose.		
100			SW				
	98-108	70				108.0 1930.2	
105							
			GW		Medium gray fine-medium sandy subrounded GRAVEL. Sand is coarse. Wet, loose. Moisture from drill head water.	110.0 1928.2	
110					Brownish gray fine-coarse SAND with fine subrounded gravel. Moist, loose.		
115			SW				
	108-128	95					
120							

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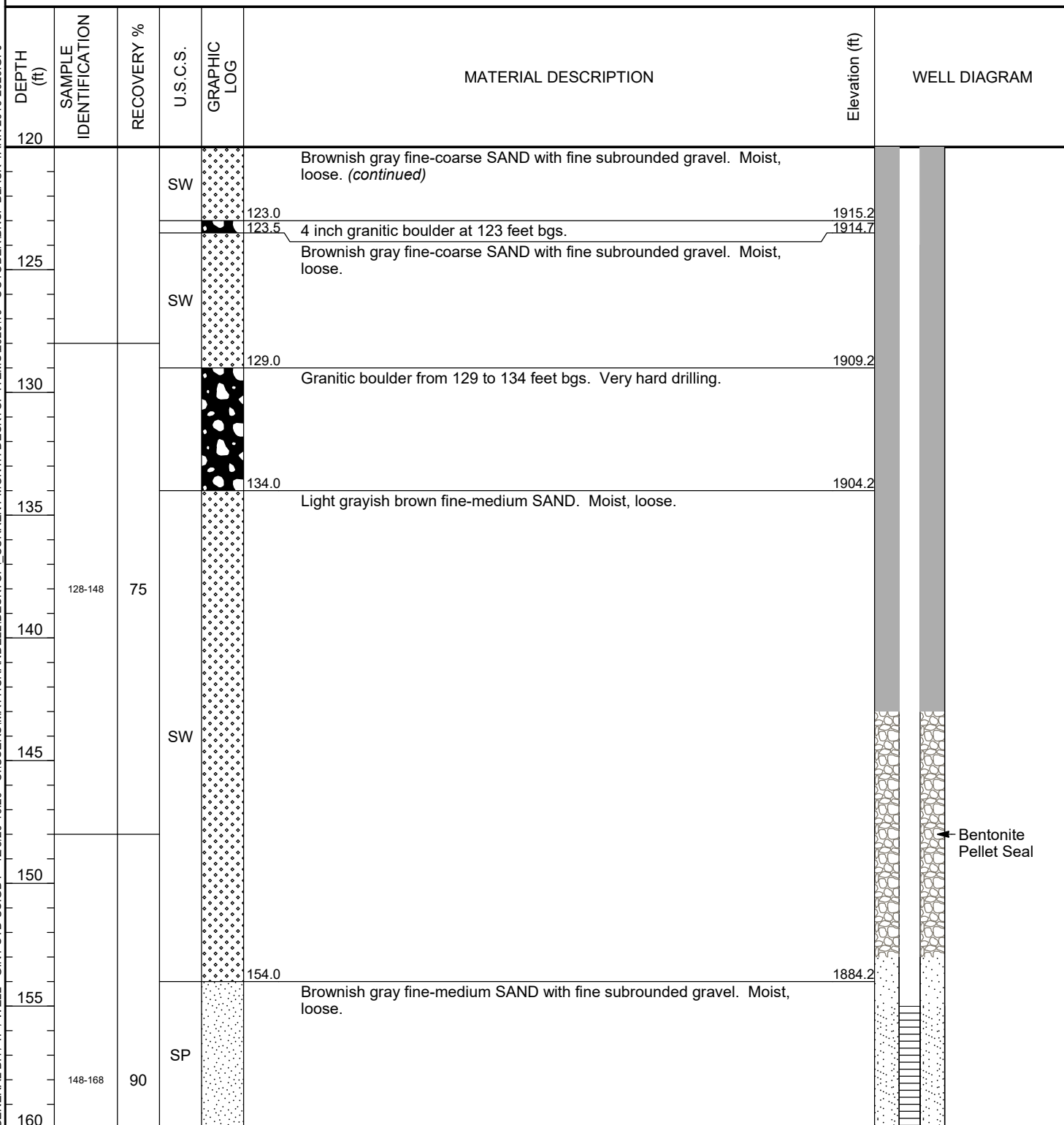


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CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	9/2/20	COMPLETED	9/8/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2038.21 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 8 feet bgs		
		GROUND WATER LEVELS:	
		▽ AT TIME OF DRILLING	163.50 ft / Elev 1874.71 ft
		AT END OF DRILLING	---
		AFTER DRILLING	---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDALL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\2020\10 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ



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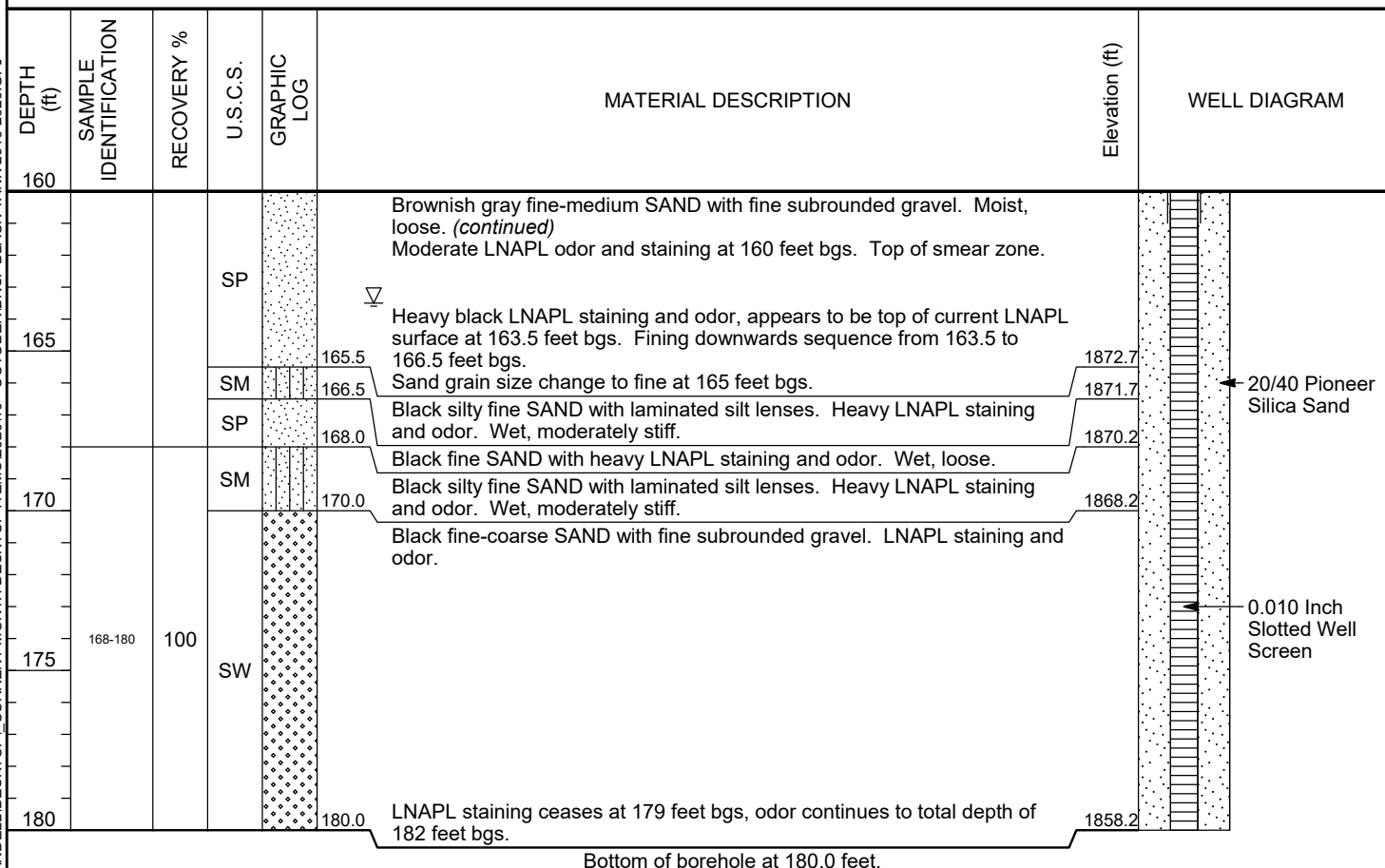


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CLIENT	BNSF and Husky Oil	PROJECT NAME	Black Tank Site
PROJECT NUMBER	0175844	PROJECT LOCATION	Spokane, WA
DATE STARTED	9/2/20	COMPLETED	9/8/20
CONTRACTOR	Environmental West	GROUND ELEVATION	2038.21 feet
EQUIPMENT	Sonic	HOLE SIZE	6 inches
LOGGED BY	Matt Crandell	CHECKED BY	Dave Edwards
NOTES	Pre-cleared to 8 feet bgs	GROUND WATER LEVELS:	
		▽ AT TIME OF DRILLING	163.50 ft / Elev 1874.71 ft
		AT END OF DRILLING	---
		AFTER DRILLING	---

GENERAL BH / TP / WELL - GINT STD US.GDT - 12/8/20 16:20 - C:\USERS\MATT.CRANDELL\DESKTOP\1 - CURRENT MONTH DESKTOP ITEMS\202010 - OCTOBER\BNSF BLACK TANK 2016-2020.GPJ



APPENDIX C RADIUS OF INFLUENCE TEST DATA

Figure C-1	Bioventing Pressure vs. Flow
Table C-1	Bioventing Pilot Test Vapor Data
Figure C-2	Biosparge Pressure vs. Flow
Table C-2	Sparging Pilot Test Vapor Data
Table C-3	Bioventing Pilot Test Oxygen Data
Table C-4	Bioventing Pilot Test Helium Data
Table C-5	Biosparging Pilot SF ₆ Test Data
Figure C-3	Bioventing ROI O ₂ Results
Figure C-4	Bioventing ROI Helium Results
Figure C-5	Biosparging ROI SF ₆ Results
Figure C-6	Biosparging ROI Dissolved Oxygen Results at MW-31
Photo Log	

BIOVENTING TEST DATA

Figure C-1 - Bioventing Pressure vs. Flow

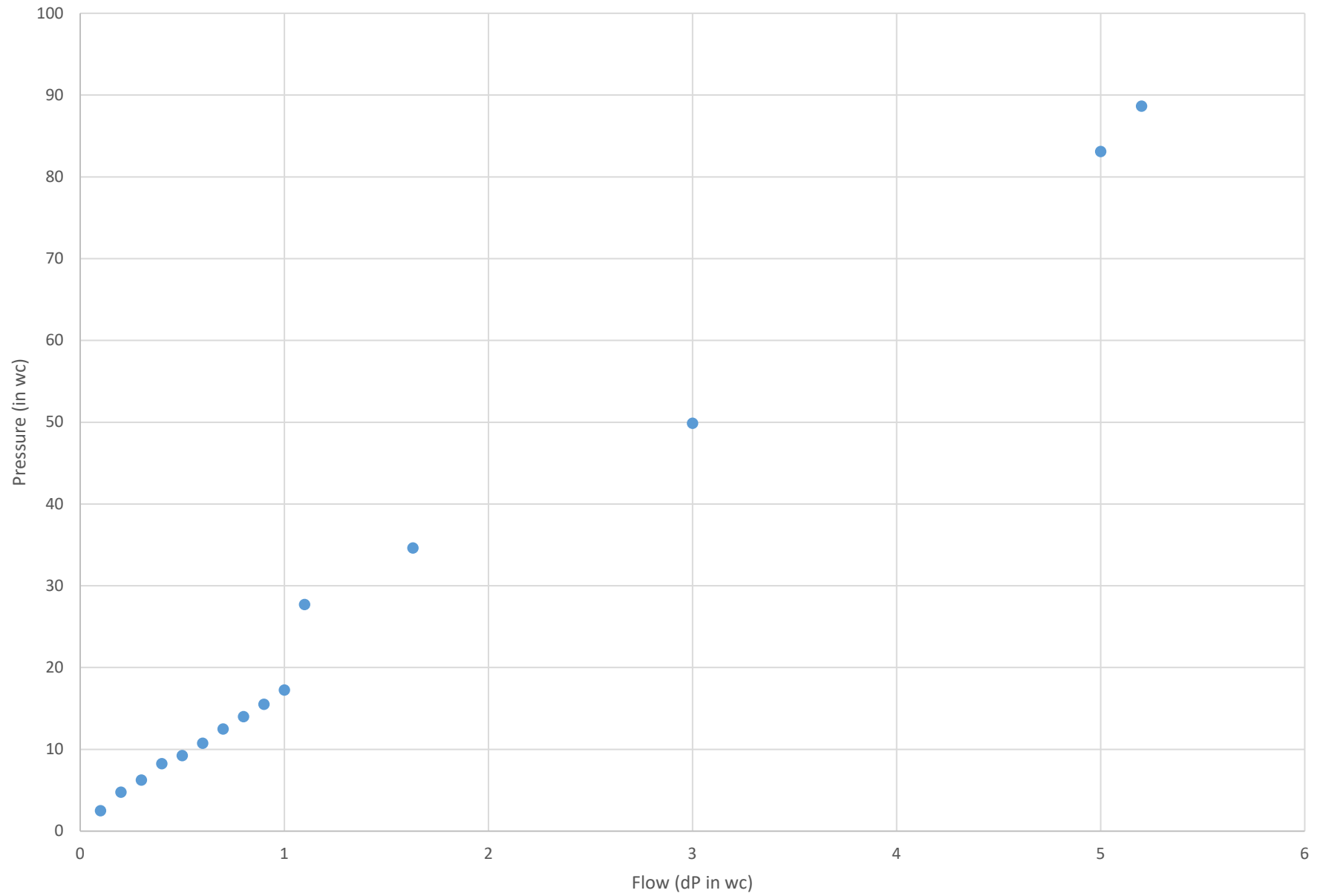


Table C-1
Bioventing Pilot Test Vapor Data
BNSF Black Tank
Spokane, WA

				Distance from Injection (ft)													
				32	68	96	114	124									
Start time	Injection Pressure (psi)	Injection dP (in. w.c.)	Injection Helium Concentration (ppmv)	MW-5 Helium (ppmv)	MW-7 Helium (ppmv)	MW-9 Helium (ppmv)	MW-22R Helium (ppmv)	MW-23R Helium (ppmv)	MW-5 CH4 %	MW-7 CH4 %	MW-9 CH4 %	MW-22R CH4 %	MW-23R CH4 %	MW-5 CO2 %	MW-7 CO2 %	MW-9 CO2 %	MW-22R CO2 %
10/6/2020 15:50	0	0.1	9150	0	0	0	0	0	0.3	0.4	1.7	3	3.2	6.2	3.1	4.2	3.3
10/6/2020 17:11	0	0.46	9500	0	0	0	0	0	0.4	0.4	1.8	3	3	6	3	4.2	3
10/7/2020 9:32	1	1.1	9325	0	0	0	0	0	0.3	0.3	1.7	3.1	2	6.8	3.1	4.8	3.5
10/7/2020 11:51	1.25	1.63	6800	0	0	0	0	0	0.4	0.4	1.9	3.3	0.7	6.5	3	4.6	3.3
10/7/2020 13:22	1.5	3	12475	0	0	0	0	0	0.4	0.5	1.8	3.2	2.8	6.4	3	4.5	3.2
10/7/2020 16:03	1.5	3	8500	0	0	0	0	600	0.5	0.6	1.9	3.6	0.7	6.2	2.8	4.4	3.1
10/8/2020 9:32	2	3	9725	0	0	0	0	1625	0.3	0.3	1.7	2.7	0.6	6.7	3.1	4.8	3.4
10/8/2020 11:49	1.8	3	8725	0	0	0	0	1275	4.3	0.4	1.8	3	0.9	6.6	3	4.6	3.3
10/8/2020 14:45	1.8	3	0	0	1450	0	0	3950	0.4	3	1.8	2.8	0.8	6.4	3.1	4.5	3.1
10/8/2020 16:38	1.8	3	0	0	2800	0	0	8825	0.3	0.3	1.7	2.5	0.4	6.2	3	4.5	3.1
10/9/2020 9:11	1.8	3	0	0	3525	0	0	175	0.3	0.3	1.8	1	0.4	6.9	2.9	4.8	2.8
10/9/2020 14:08	1.8	3	0	0	3475	0	0	0	0.5	0.4	1.9	3	0.8	6.3	2.5	4.4	3.1
10/9/2020 15:32	1.8	3	0	0	2525	0	0	0	0.4	0.3	1.8	2.7	0.5	6.3	2.3	4.4	3.1
10/9/2020 16:55	1.8	3	0	0	2800	0	0	75	0.3	0.3	1.8	2.9	0.4	6.4	2.6	4.5	3.2
10/10/2020 9:00	1.8	3	0	0	875	0	0	125	0.2	0.3	1.7	2.7	0.5	6.5	2	4.6	3.3
10/10/2020 11:10	1.8	3	0	0	775	0	0	0	0.3	0.3	1.8	2.9	0.6	6.3	1.8	4.5	3.2
10/10/2020 19:30	3	5	0	0	150	0	0	25	0.3	0.3	1.7	1.8	0.3	6.8	1.6	4.8	3.2
10/11/2020 8:05	3.2	5.2	0	0	0	0	0	0	0.2	0.3	1.8	1.9	0.2	7.2	1.2	5.1	3.5
10/11/2020 12:05	3.2	5.2	0	0	0	0	0	75	0.2	0.2	1.8	1.5	0.2	7.1	1.1	4.9	3.3
10/11/2020 18:25	0	0	0	0	0	0	0	0	0.2	0.3	1.8	2.7	0.8	7	1.3	5	3.7
10/12/2020 10:40	0	0	0	0	100	0	0	0	0.1	0.3	1.7	1.9	0.7	6.7	1.4	4.7	3.3
10/12/2020 13:35	0	0	0	0	100	0	0	0	0.3	0.2	1.7	2.6	1.4	6.8	1.4	4.7	3.5
10/12/2020 16:35	0	0	0	0	150	0	0	0	0.4	0.3	1.8	2.4	1.5	6.9	1.4	4.8	3.5
10/13/2020 7:50	0	0	0	0	25	0	0	0	0.2	0.3	1.8	3.1	2.1	6.9	1.6	4.9	3.7
10/13/2020 13:00	0	0	0	0	0	0	0	0	0.2	0.2	1.8	3.1	2.2	7	1.4	4.8	3.7

Notes:
CH4 = Methane
CO2 = Carbon dioxide
in. w.c. = inches water column
L/min = Liters per minute
O2 = Oxygen
psi = Pounds per square inch

Table C-1
Bioventing Pilot Test Vapor Data
BNSF Black Tank
Spokane, WA

Start time	Injection Pressure (psi)	MW-23R CO2 %	MW-5 O2 %	MW-7 O2 %	MW-9 O2 %	MW-22R O2 %	MW-23R O2 %	MW-5 Flow (L/min)	MW-7 Flow (L/min)	MW-9 Flow (L/min)	MW-22R Flow (L/min)	MW-23R Flow (L/min)	MW-5 Pressure (in w.c.)	MW-7 Pressure (in w.c.)	MW-9 Pressure (in w.c.)	MW-22R Pressure (in w.c.)
10/6/2020 15:50	0	5.6	12.2	16.5	0	0.2	0.7	0	0	0	0	0	0	0	0	0
10/6/2020 17:11	0	5.6	12.4	16.7	0	0.5	1.8	0	0	0	0	0	0	0	0	0
10/7/2020 9:32	1	5.9	12.3	17.3	0	0.4	6.3	0	0	0	0	0	0	0	0	0
10/7/2020 11:51	1.25	4.2	12.1	16.8	0	0.6	13.8	0	0	0	0	0	0	0	0	0
10/7/2020 13:22	1.5	6.2	12.1	16.7	0	0.2	2.9	0	0	0	0	0	0	0	0	0
10/7/2020 16:03	1.5	3.4	12.2	16.9	0	0.2	16.3	0	0	0	0	0	0	0	0	0
10/8/2020 9:32	2	1.7	12.3	17.4	0	2.3	17.6	0	0	0	0	0	0	0	0	0
10/8/2020 11:49	1.8	2.3	11.9	17.3	0	1.2	14.7	0	0	0	0	0	0	0	0	0
10/8/2020 14:45	1.8	1.8	12	17.8	0	1.6	16.2	0	0	0	0	0	0	0	0	0
10/8/2020 16:38	1.8	0.7	12.5	18.7	0	3.3	19.6	0	0	0	0	0	0	0	0	0
10/9/2020 9:11	1.8	0.5	11.9	19	0	11.7	19.3	0	0	0	0	0	0	0	0	0
10/9/2020 14:08	1.8	1.4	12.1	19.6	0	1.7	16.1	0	0	0	0	0	0	0	0	0
10/9/2020 15:32	1.8	0.8	11.7	19.2	0	1.2	17.8	0	0	0	0	0	0	0	0	0
10/9/2020 16:55	1.8	0.5	12.1	19.7	0	0.5	19.3	0	0	0	0	0	0	0	0	0
10/10/2020 9:00	1.8	1	12	20.1	0	1.7	18.8	0	0	0	0	0	0	0	0	0
10/10/2020 11:10	1.8	0.9	12.2	20.3	0	1.4	18.9	0	0	0	0	0	0	0	0	0
10/10/2020 19:30	3	0.2	12.6	20.2	0	6.4	21.5	0	0	0	0	0	0	0	0	0
10/11/2020 8:05	3.2	0.2	12.6	20.8	0	5.8	21.6	0	0	0	0	0	0	0	0	0
10/11/2020 12:05	3.2	0.1	12	19.8	0	7.5	20.2	0	0	0	0	0	0	0	0	0
10/11/2020 18:25	0	1.5	12.3	20.7	0	0.7	15.1	0	0	0	0	0	0	0	0	0
10/12/2020 10:40	0	1.5	12.3	20.4	0	6	16	0	0	0	0	0	0	0	0	0
10/12/2020 13:35	0	3.6	12.5	20.4	0	2.4	8.5	0	0	0	0	0	0	0	0	0
10/12/2020 16:35	0	3.7	12.5	20.6	0	2.7	8.4	0	0	0	0	0	0	0	0	0
10/13/2020 7:50	0	6.1	12.3	20.7	0	0.2	1.4	0	0	0	0	0	0	0	0	0
10/13/2020 13:00	0	6.4	12.3	20.2	0	0.2	0.8	0	0	0	0	0	0	0	0	0

Notes:
CH4 = Methane
CO2 = Carbon dioxide
in. w.c. = inches water column
L/min = Liters per minute
O2 = Oxygen
psi = Pounds per square inch

BIOSPARGING TEST DATA

Figure C-2 - Biosparge Pressure vs. Flow

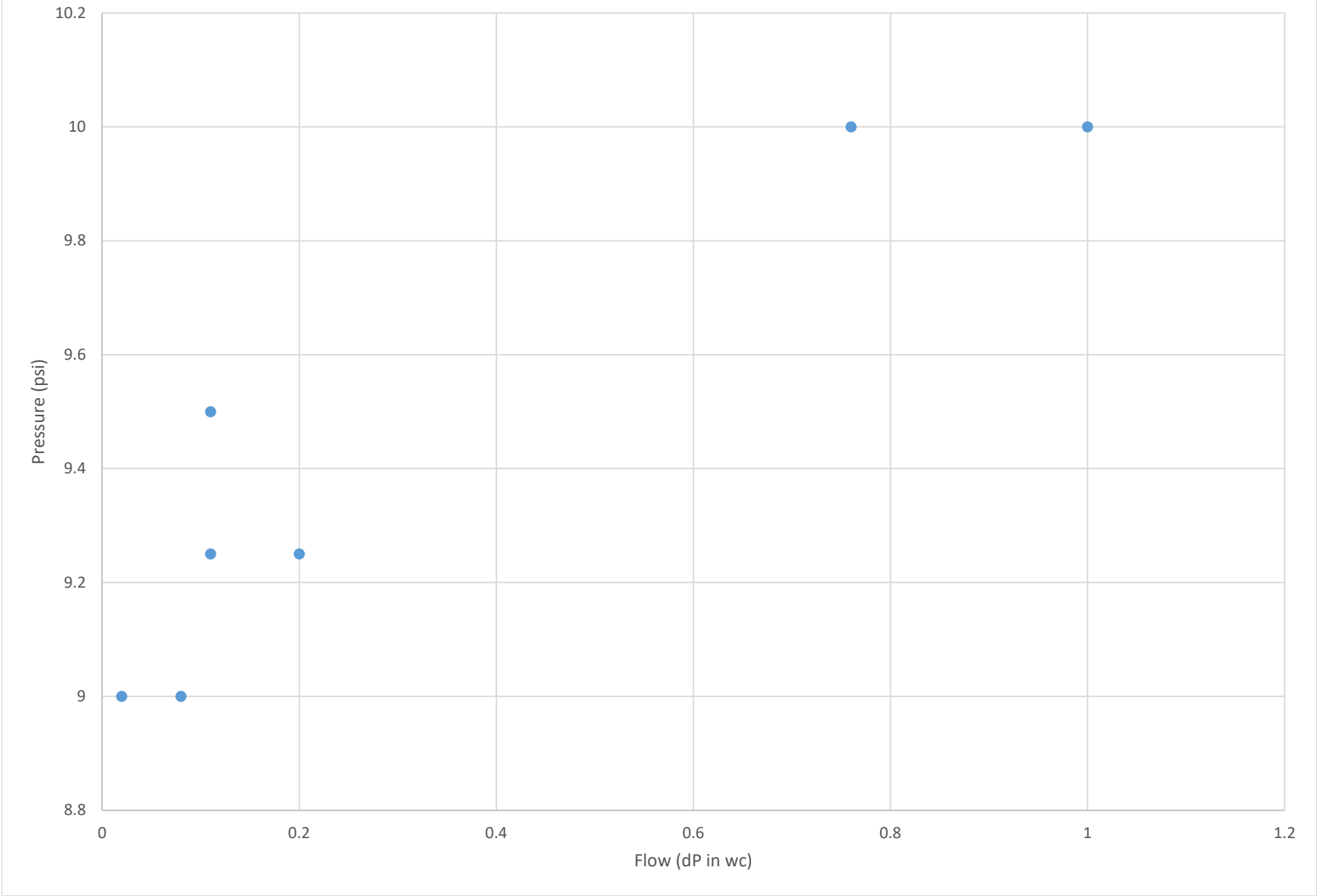


Table C-2
Sparging Pilot Test Vapor Data
BNSF Black Tank
Spokane, WA

Start time	Injection DP (in wc)	Injection He (ppm)	Injection Pressure (psi)	Injection SF6 (L/min)	Distance from Injection (ft)				MW-03 He (ppm)	MW-04 He (ppm)	MW-05 He (ppm)	MW-31 He (ppm)	MW-03 flow (L/min)	MW-04 flow (L/min)	MW-05 flow (L/min)	MW-31 flow (L/min)	MW-03 pressure (in wc)	MW-04 pressure (in wc)	MW-05 pressure (in wc)	MW-31 pressure (psi)	MW-03 CO2 (%)	MW-04 CO2 (%)	MW-05 CO2 (%)	MW-31 CO2 (%)	MW-03 O2 (%)	MW-04 O2 (%)	MW-05 O2 (%)	MW-31 O2 (%)
					32	59	133	11																				
10/16/2020 10:31	0	0	0	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.9	8.4	7	13.6	0	10.3	12.4	2.9
10/16/2020 12:58	0.02	9100	9	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	10	16.6	10.4	6.9	14.6	0	7.8	12.4	1.2
10/16/2020 14:13	0.08	10300	9	0	0.2	0.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	16.6	8.7	7	15.1	0	9.7	12.3	0.7
10/16/2020 15:19	0.2	10400	9.25	0	0.2	0.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	16.7	7.5	7	14.8	0	11.2	12.1	1.3
10/16/2020 16:31	0.76	10925	10	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.7	8.6	6.9	14	0	9.4	12.2	2.8
10/17/2020 8:46	0.11	8800	9.5	0.5	0.2	0.2	0.2	0.6	0	0	0	0	0	0	0	0	0	0	0	0	16.8	6.5	7	15.2	0	12.8	12.5	1.3
10/17/2020 10:28	0.11	12000	9.5	0.5	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.4	6.9	6.8	15.3	0	11.8	11.9	0.2
10/17/2020 12:50	0.11	12500	9.5	0.5	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	10	0	16.3	6	6.7	15.3	0	13	12.1	0.6
10/17/2020 17:16	0.11	10000	9.5	0.5	0.2	0.2	0.2	0.8	0	0	0	0	0	0	0	0	0	0	0	0	16.4	6.4	6.8	14.4	0	12.8	12.5	3
10/18/2020 9:00	0.11	8900	9.5	0.5	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.9	6.5	7	15.4	0	13	12.6	0.9
10/18/2020 12:22	0.11	11175	9.5	0.5	0.2	0.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	17	7.7	7.1	15.9	0	10.8	12.3	0.6
10/18/2020 13:54	0.11	11025	9.5	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.9	5.9	7	15.5	0	13.6	12.4	0.8
10/19/2020 8:32	0.11	9725	9.5	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	10	0	17.1	7.3	7.1	16	0	11.7	12.4	0.4
10/19/2020 9:36	0.13	0	9.25	0	0.2	0.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	16.4	7.6	6.8	15.2	0	10.8	12	0.3
10/19/2020 13:56	0.13	0	9.25	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.2	7.9	6.5	15	0	9.9	12.2	0.5
10/19/2020 16:34	0.13	0	9.25	0	0.2	0.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	16.3	7.6	6.7	15.1	0	10.4	12.9	0.5
10/20/2020 10:20	0.11	0	9.5	0	0.2	0.2	0.2	0.4	0	0	0	0	0	0	0	0	0	0	0	0	16.8	7.5	7	15.7	0	11.5	12.8	0.3
10/20/2020 12:33	0.11	0	9.25	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	16.3	8	6.7	15	0	10.3	12.3	0.4
10/21/2020 8:23	0	0	0	0	0.2	0.2	0.2	0.5	0	0	0	0	0	0	0	0	0	0	0	0	17.2	7.8	7.2	16.1	0	11.7	12.6	0.2

Notes:
CH4 = Methane
CO2 = Carbon dioxide
in. w.c. = inches water column
L/min = Liters per minute
O2 = Oxygen
psi = Pounds per square inch

Table C-3
Bioventing Pilot Test Oxygen Data
Engineering Design Report
BNSF Black Tank
Spokane, WA

Start time	Injection Pressure (psi)	Injection dP (in. w.c.)	Distance from Injection (ft)					Notes
			32	68	96	114	124	
			MW-23R O2 %	MW-7 O2 %	MW-22R O2 %	MW-9 O2 %	MW-5 O2 %	
10/6/2020 15:50	0	0.1	0.7	16.5	0.2	0	12.2	Sustained Test Start (110 cfm)
10/6/2020 17:11	0	0.46	1.8	16.7	0.5	0	12.4	
10/7/2020 9:32	1	1.1	6.3	17.3	0.4	0	12.3	
10/7/2020 11:51	1.25	1.63	13.8	16.8	0.6	0	12.1	
10/7/2020 13:22	1.5	3	2.9	16.7	0.2	0	12.1	
10/7/2020 16:03	1.5	3	16.3	16.9	0.2	0	12.2	~ 1 day after Sustained Test Start
10/8/2020 9:32	2	3	17.6	17.4	2.3	0	12.3	
10/8/2020 11:49	1.8	3	14.7	17.3	1.2	0	11.9	
10/8/2020 14:45	1.8	3	16.2	17.8	1.6	0	12	
10/8/2020 16:38	1.8	3	19.6	18.7	3.3	0	12.5	~ 2 days after Sustained Test Start
10/9/2020 9:11	1.8	3	19.3	19	11.7	0	11.9	
10/9/2020 14:08	1.8	3	16.1	19.6	1.7	0	12.1	
10/9/2020 15:32	1.8	3	17.8	19.2	1.2	0	11.7	
10/9/2020 16:55	1.8	3	19.3	19.7	0.5	0	12.1	~ 3 days after Sustained Test Start
10/10/2020 9:00	1.8	3	18.8	20.1	1.7	0	12	
10/10/2020 11:10	1.8	3	18.9	20.3	1.4	0	12.2	
10/10/2020 19:30	3	5	21.5	20.2	6.4	0	12.6	~ 4 days after Sustained Test Start (flow increase ~150 cfm)
10/11/2020 8:05	3.2	5.2	21.6	20.8	5.8	0	12.6	
10/11/2020 12:05	3.2	5.2	20.2	19.8	7.5	0	12	~ 1 day after flow increase (~150 cfm)
10/11/2020 18:25	0	0	15.1	20.7	0.7	0	12.3	
10/12/2020 10:40	0	0	16	20.4	6	0	12.3	
10/12/2020 13:35	0	0	8.5	20.4	2.4	0	12.5	
10/12/2020 16:35	0	0	8.4	20.6	2.7	0	12.5	
10/13/2020 7:50	0	0	1.4	20.7	0.2	0	12.3	
10/13/2020 13:00	0	0	0.8	20.2	0.2	0	12.3	

Notes:
CH4 = Methane
CO2 = Carbon dioxide
in. w.c. = inches water column
L/min = Liters per minute
O2 = Oxygen
psi = Pounds per square inch

Table C-4
Bioventing Pilot Test Helium Data
Engineering Design Report
BNSF Black Tank
Spokane, WA

Start time	Injection Pressure (psi)	Injection dP (in. w.c.)	Distance from Injection (ft)						Notes
			0	32	68	96	114	124	
10/6/2020 15:50	0	0.1	9150	0	0	0	0	0	He Injection Start w/ Sustained Test
10/6/2020 17:11	0	0.46	9500	0	0	0	0	0	
10/7/2020 9:32	1	1.1	9325	0	0	0	0	0	
10/7/2020 11:51	1.25	1.63	6800	0	0	0	0	0	
10/7/2020 13:22	1.5	3	12475	0	0	0	0	0	
10/7/2020 16:03	1.5	3	8500	600	0	0	0	0	~ 1 day after He Injection Start
10/8/2020 9:32	2	3	9725	1625	0	0	0	0	
10/8/2020 11:49	1.8	3	8725	1275	0	0	0	0	
10/8/2020 14:45	1.8	3	0	3950	1450	0	0	0	
10/8/2020 16:38	1.8	3	0	8825	2800	0	0	0	~ 2 days after He Injection Start (He Injection Complete)
10/9/2020 9:11	1.8	3	0	175	3525	0	0	0	
10/9/2020 14:08	1.8	3	0	0	3475	0	0	0	
10/9/2020 15:32	1.8	3	0	0	2525	0	0	0	
10/9/2020 16:55	1.8	3	0	75	2800	0	0	0	~ 3 days after He Injection Start
10/10/2020 9:00	1.8	3	0	125	875	0	0	0	
10/10/2020 11:10	1.8	3	0	0	775	0	0	0	
10/10/2020 19:30	3	5	0	25	150	0	0	0	
10/11/2020 8:05	3.2	5.2	0	0	0	0	0	0	
10/11/2020 12:05	3.2	5.2	0	75	0	0	0	0	
10/11/2020 18:25	0	0	0	0	0	0	0	0	
10/12/2020 10:40	0	0	0	0	100	0	0	0	
10/12/2020 13:35	0	0	0	0	100	0	0	0	
10/12/2020 16:35	0	0	0	0	150	0	0	0	
10/13/2020 7:50	0	0	0	0	25	0	0	0	
10/13/2020 13:00	0	0	0	0	0	0	0	0	

Notes:
CH4 = Methane
CO2 = Carbon dioxide
in. w.c. = inches water column
L/min = Liters per minute
O2 = Oxygen
psi = Pounds per square inch

Table C-5

Biosparing Pilot SF⁶ Test Data
Engineering Design Report
BNSF Black Tank
Spokane, WA

ID	Distance from Injection	Sample Date	Reported Concentration (ppb)	Measured Concentration (ppb)
BSI-1-CO-DUP-102120	-	16-Oct-20	30.6	30.6
BSI-1-CO-102120	-	16-Oct-20	31.9	31.9
BSI-01-102120	0	21-Oct-20	0.108	0.108
MW-31-102120	11	21-Oct-20	3.15	3.15
MW-03-102120	28	21-Oct-20	0.124	0.124
MW-04-102120	59	21-Oct-20	<LOD	0.019
Field Blank	-	21-Oct-20	0.140	0.14
MW-07-102120	~250	21-Oct-20	<LOD	0.016
MW-22R-102120	~330	21-Oct-20	<LOD	0.023
BSI-1-110420	0	4-Nov-20	0.026	0.026
MW-31-110420	11	4-Nov-20	0.321	0.321
MW-03-110420	28	4-Nov-20	<LOD	0.009
MW-04-110420	59	4-Nov-20	<LOD	0.013
Field Blank	-	4-Nov-20	<LOD	0.012
MW-07-110420	~250	4-Nov-20	<LOD	0.014
MW-22R-110420	~330	4-Nov-20	<LOD	0.014

Notes:

LOD = Limit of detection (25 ppt)

LOQ = Limit of quantitation (40 ppt)

ppb = Parts per million

ppt = Parts per trillion

1. Data validator reviewed results and concluded that the SF₆ detection in the field blank does not indicate cross-contamination in the investigative samples because three of the associated investigative samples are non-detect for SF₆. Therefore, none of the results are qualified as having blank contamination.

2. During sampling of MW-05 for SF₆, the connector on the bailer broke, leaving the bailer in the bottom of the well, where it blocked access to the groundwater in the well. The bailer could not be immediately retrieved so no groundwater samples were collected from MW-05 for SF₆ analysis. Retrieval will be attempted on 11/16/20 and if successful, the well will be sampled for SF₆. Wells immediately downgradient of MW-05 (MW-07 and MW-22R) were sampled and showed no detectable SF₆.

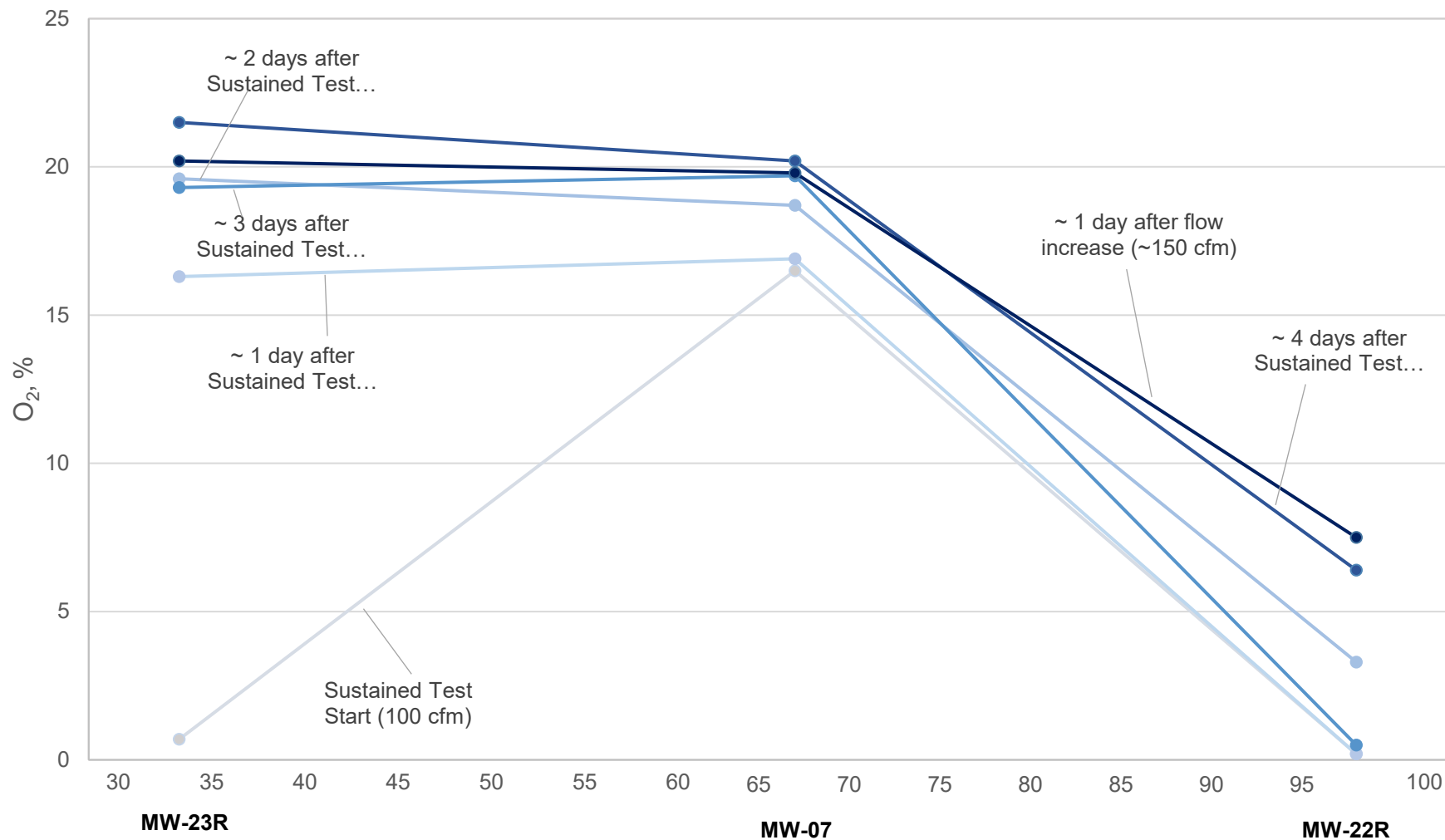


Figure C-3
 Bioventing ROI O₂ Results
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington

Notes: Initial concentration (i.e., start of sustained test) at MW-07 considered anomalous, concentration increases were observed during test.

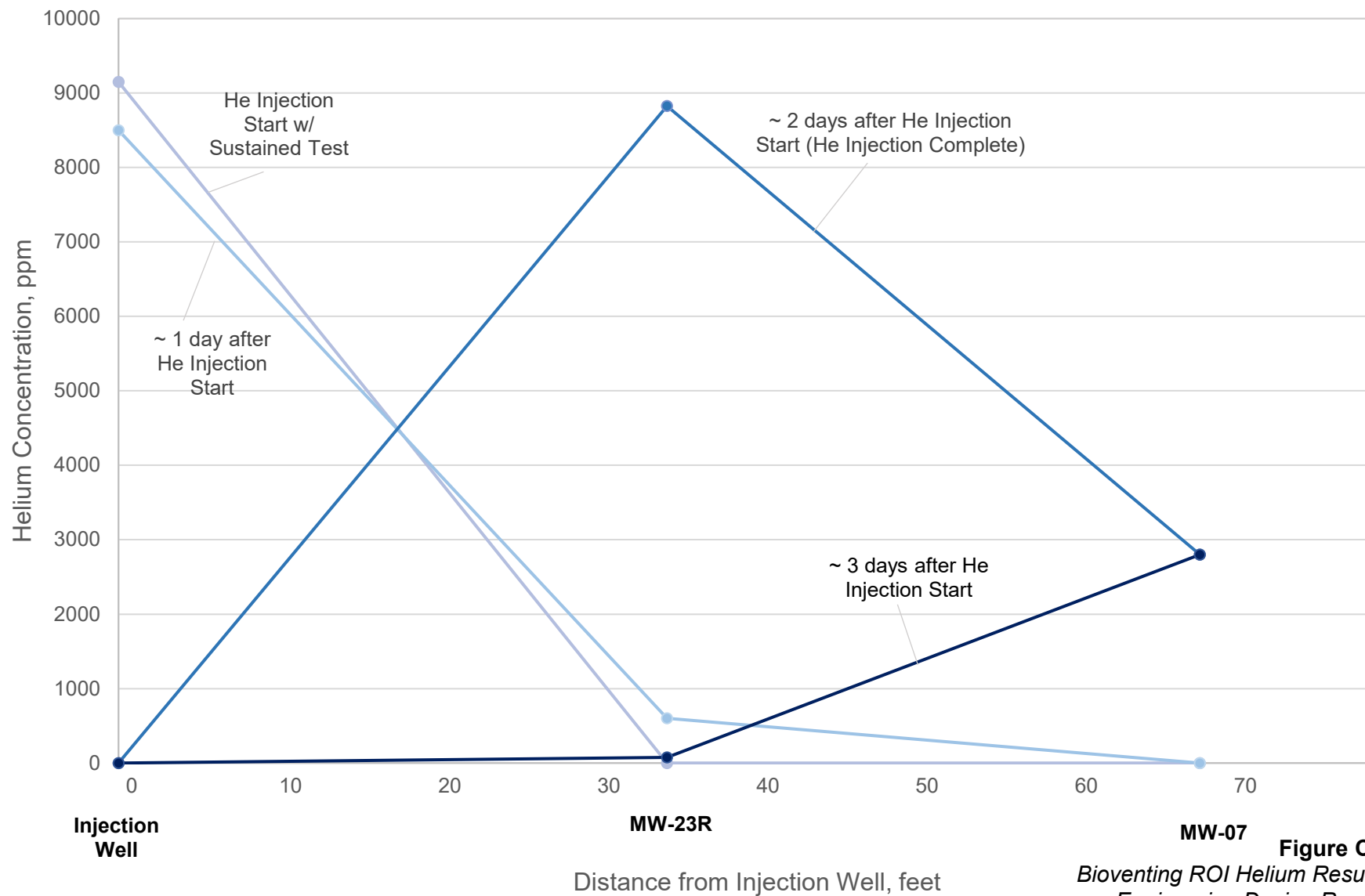


Figure C-4
 Bioventing ROI Helium Results
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington

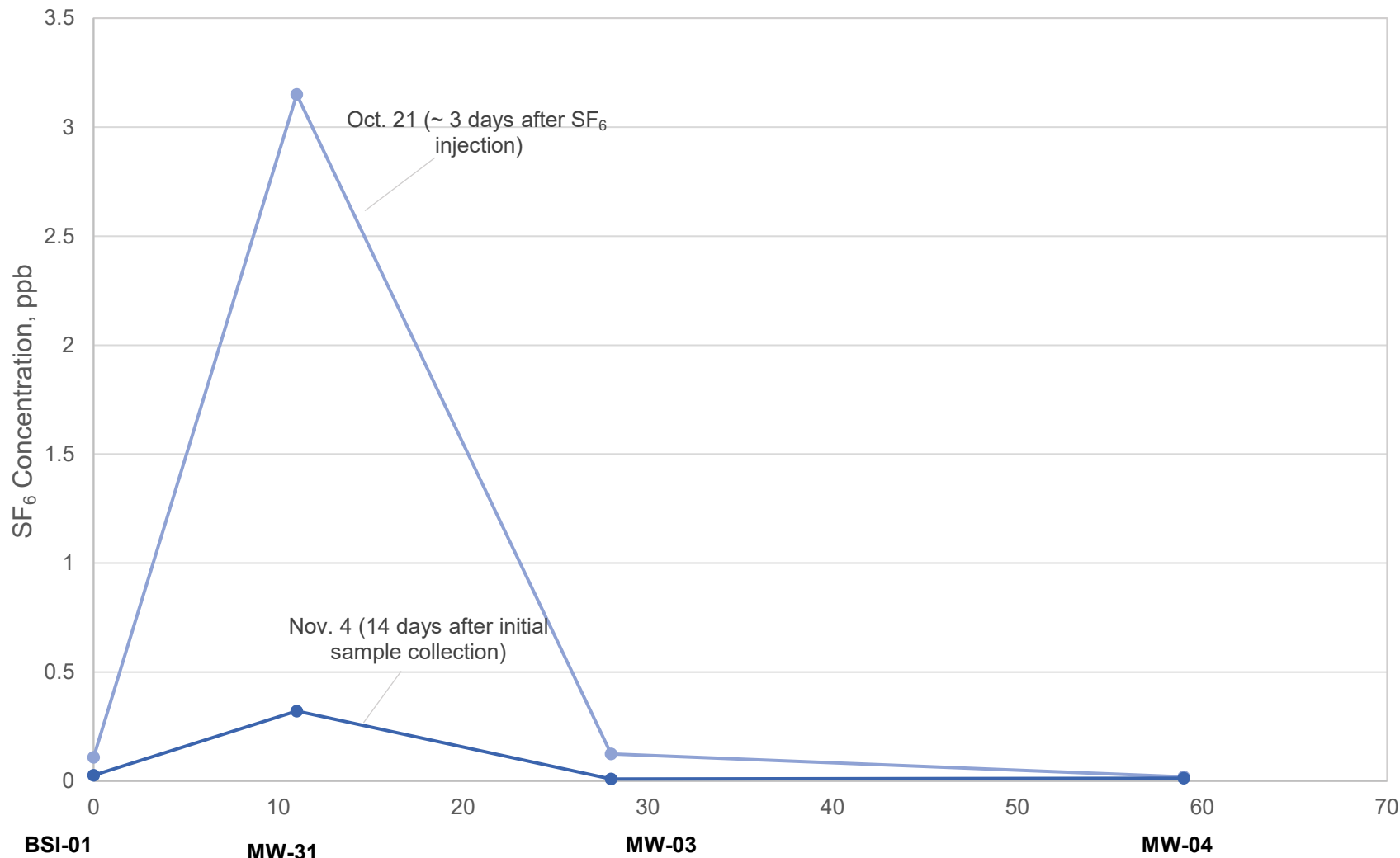


Figure C-5
Biosparging ROI SF₆ Results
Engineering Design Report
BNSF Black Tank
Spokane, Washington

—●— Oct. 21 (~ 3 days after SF₆ injection)

—●— Nov. 4 (14 days after initial sample collection)

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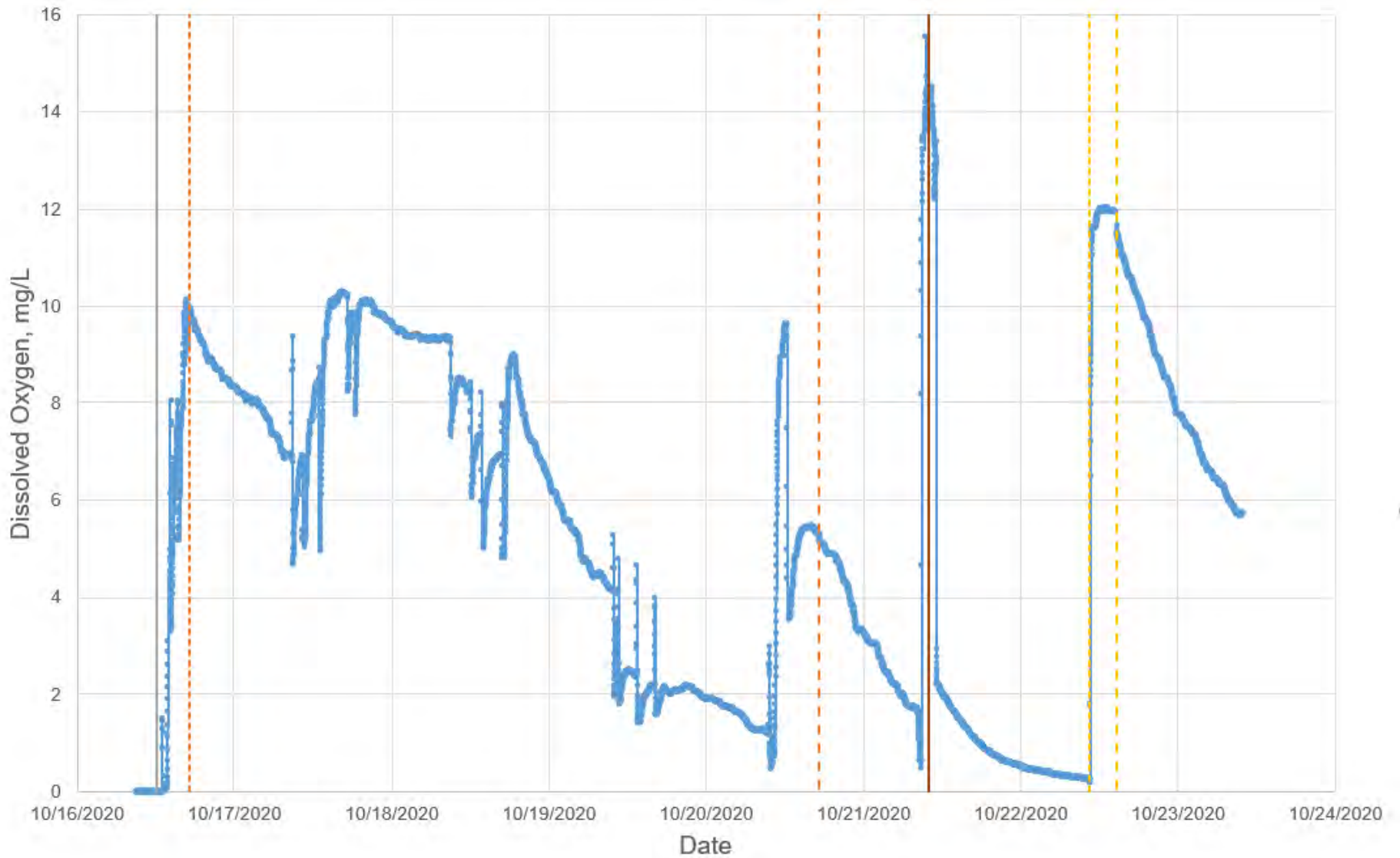


Figure C-6
 Biosparging ROI Dissolved Oxygen Results at MW-31
 Engineering Design Report
 BNSF Black Tank
 Spokane, Washington

PHOTOLOG



Photo 1: BS ROI set up



Photo 2: Manifold



Photo 3: Wellhead

APPENDIX D UPDATED BASELINE LNAPL PARAMETER DATA

Figure D-1 Mobile LNAPL Thickness - September 2019

Table D-1 Estimated Mobile LNAPL Volume

Table D-2 LNAPL Thickness Variation Analysis

Figure D-2 Converted Field Viscosities

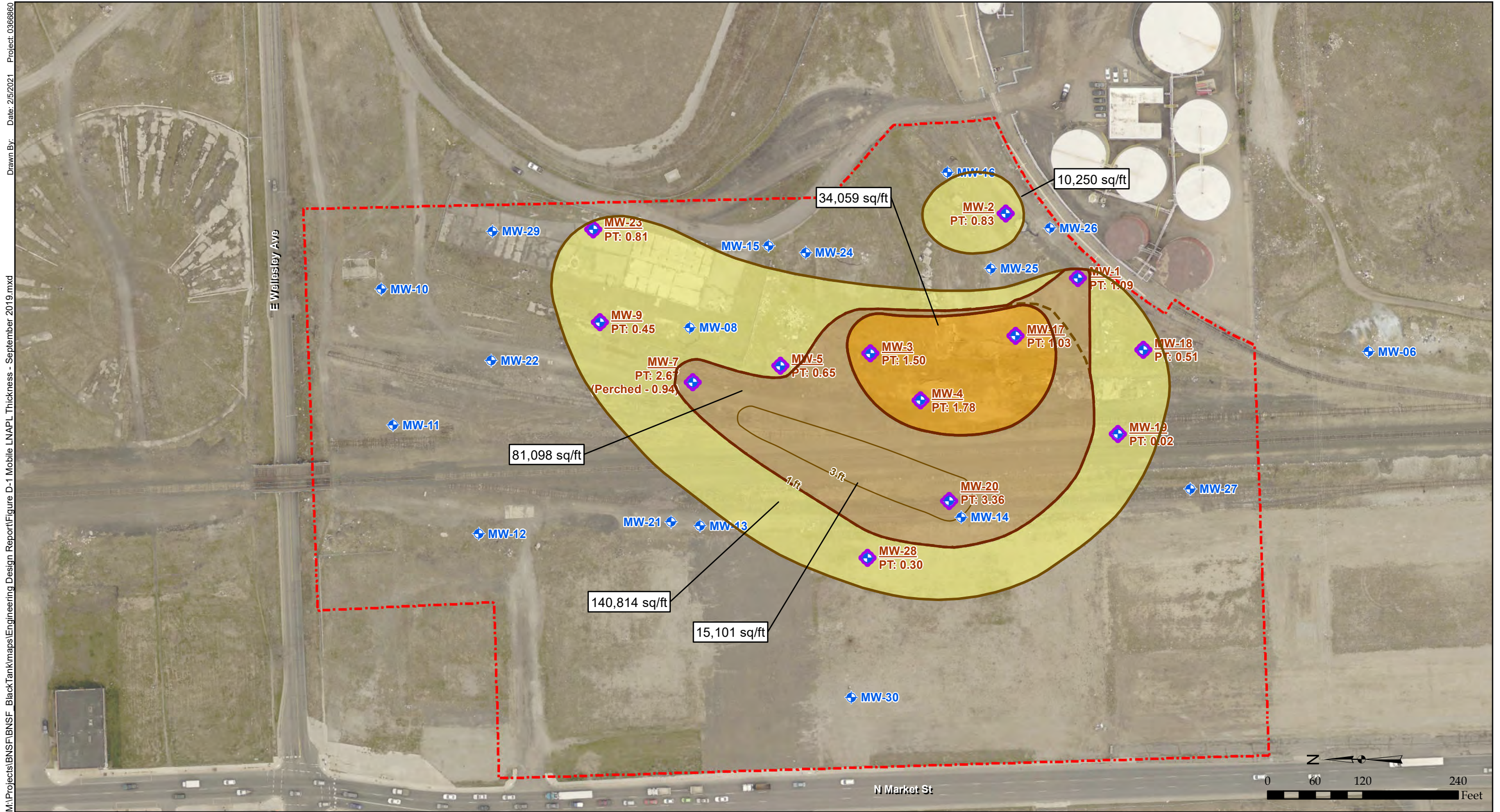
Figure D-3 Converted RI Viscosities

Figure D-4 Viscosity-Test Duration Correlation

LNAPL Viscosity Lab Report

Table D-3 LNAPL Skimming Test Data

MOBILE LNAPL ANALYSIS



- Legend**
- Monitoring Well with LNAPL
 - Monitoring Well without LNAPL
 - LNAPL 2019 Contour
 - LNAPL 2016 Contour
 - High RTF Area
 - Medium RTF Area
 - Low RTF Area
 - BNSF Black Tank Site Boundary

Notes:
*MW-21 was not used for contouring.
** MW-22 water level is anomalous and is used for contouring
† = Biased low due to submerged screen greater than 1 foot.
Dry = No water detected or water level was below screened interval.
LNAPL = Light Non-Aqueous Phase Liquid.
NM = Not Measured.
PT = LNAPL thickness in feet.
SS = Well screened below the water table; screen is submerged. Not used for Contouring.
All elevations in Feet Above Mean Sea Level (ft. AMSL).
Contour Interval = 0.25 feet.
Aerial Photo: Esri World Imagery Webservice, Spokane Image Consortium, 2018.

Figure D-1
Mobile LNAPL Thickness - September 2019
Engineering Design Report
BNSF Black Tank
Spokane, Washington

Table D-1
Estimated Mobile LNAPL Volume - September 2019
Engineering Design Report
BNSF Black Tank
Spokane, WA

LNAPL Thickness Interval	Mean LNAPL Thickness (ft)	Area (sq ft)	Area (acres)	Estimated % Mobile LNAPL Saturation	Porosity	Mobile LNAPL Thickness using Mean Thickness (ft)	Estimated Mobile LNAPL Volume using Mean Thickness (gal)	Mean + 1SD LNAPL Thickness (ft)	Mobile LNAPL Thickness using Mean + 1SD Thickness (ft)	Estimated Mobile LNAPL Volume using Mean + 1SD Thickness (gal)
High RTF										
1 - 3 feet	2.00	34,059	0.8	10%	0.421	0.08	21,454	2.68	0.11	28,709
Totals		34,059	0.8				21,454			28,709
Medium RTF										
1 - 3 feet	2.00	65,997	1.5	10%	0.421	0.08	41,572	2.68	0.11	55,631
3 - 3.36 ft	3.18	15,101	0.3	10%	0.421	0.13	15,124	3.86	0.16	18,341
Totals		81,098	1.9				56,696			73,972
Low RTF										
0-1 feet	0.50	146,405	3.4	5%	0.421	0.01	11,528	1.18	0.02	27,122
Totals		146,405	3.4				11,528			27,122
All RTF Areas										
Totals		261,562.0	6.0				89,677			129,804

Notes:

1SD = one standard deviation

One standard deviation above and below the average contains 68% of the data

ft = feet

sq ft = square feet

gal = gallons

LNAPL = Light Non-Aqueous Phase Liquid

Table D-2
LNAPL Thickness Variation Analysis
Engineering Design Report
BNSF Black Tank
Spokane, WA

Monitoring Well	Mean Thickness (2017 - 2020) feet	Standard Deviation (2017 - 2020) feet
MW-01	0.95	0.84
MW-02	0.38	0.42
MW-03	1.30	0.86
MW-04	1.56	0.61
MW-05	1.20	0.48
MW-07	1.02	0.67
MW-09	0.18	0.11
MW-17	0.76	0.48
MW-18	0.62	0.59
MW-19	0.44	0.53
MW-20	4.35	2.24
MW-23	0.20	0.28
Mean Standard Deviation		0.68

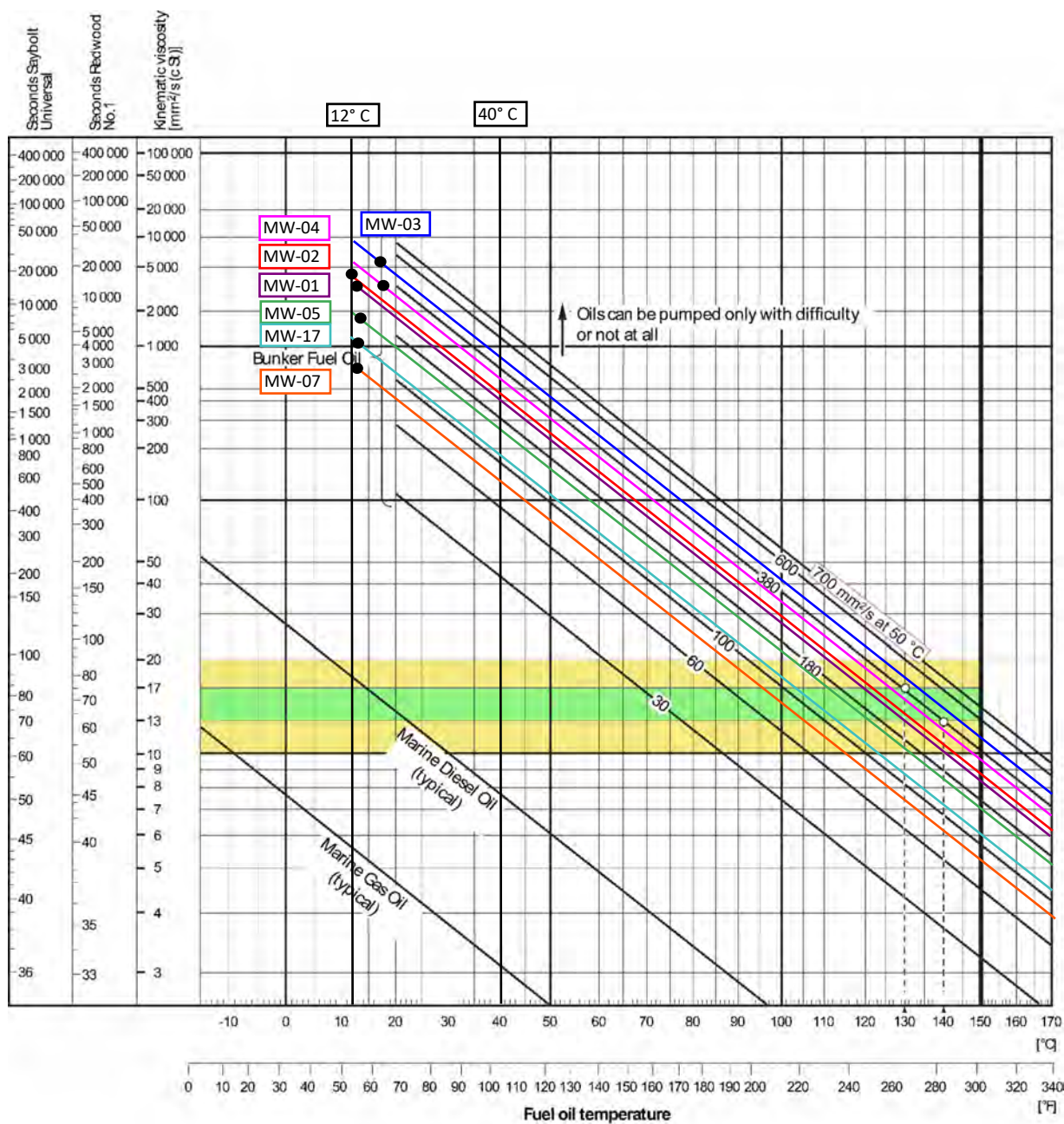
Notes:

Averages for wells abandoned in Sept 2019 (MW-18, MW-19, MW-20, and MW-23) are only through that date.

VISCOSITY ANALYSIS

Fig 1 Viscosity / Temperature diagram

● = field sample temperature



Recommended viscosity range for Generation X, X-DF and RT-flex engines

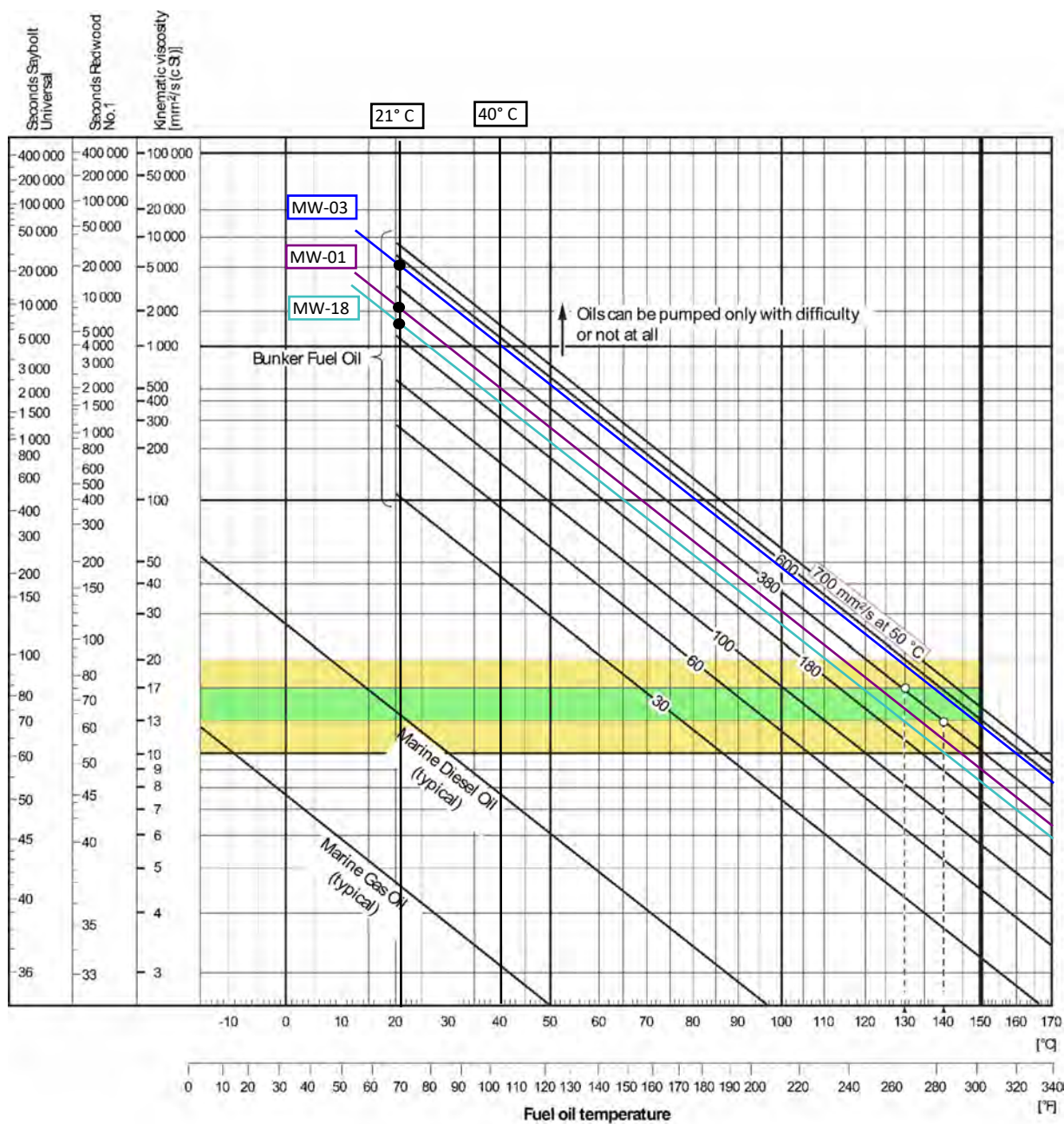


Required viscosity range for Generation X, X-DF and RT-flex engines

00099

Fig 1 Viscosity / Temperature diagram

● = RI lab sample temperature



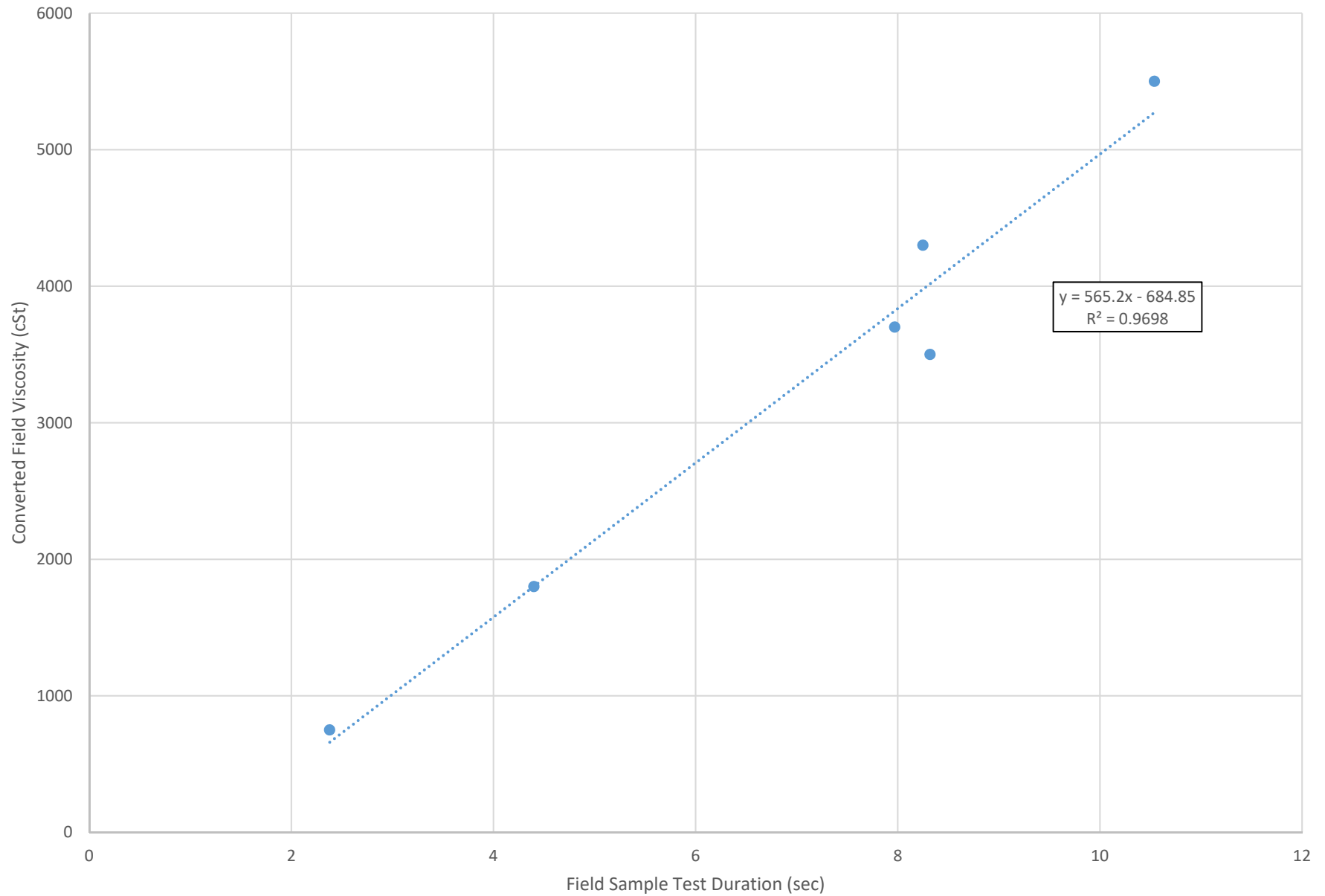
Recommended viscosity range for Generation X, X-DF and RT-flex engines



Required viscosity range for Generation X, X-DF and RT-flex engines

00099

Figure D-4: Converted Field Viscosity vs. Sample Test Duration



October 13, 2020

Emily Ponaski
ERM West Inc.
1050 SW 6th Ave
Suite 1650
Portland, OR 97204

RE: Project: 559481 Black Tank
Pace Project No.: 10533594

Dear Emily Ponaski:

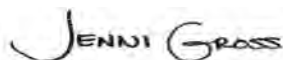
Enclosed are the analytical results for sample(s) received by the laboratory on September 29, 2020. The results relate only to the samples included in this report. Results reported herein conform to the applicable TNI/NELAC Standards and the laboratory's Quality Manual, where applicable, unless otherwise noted in the body of the report.

Some analyses were subcontracted outside of the Pace Network. The test report from the external subcontractor is attached to this report in its entirety.

The test results provided in this final report were generated by each of the following laboratories within the Pace Network:

If you have any questions concerning this report, please feel free to contact me.

Sincerely,



Jennifer Gross
jennifer.gross@pacelabs.com
(612)607-1700
Project Manager

Enclosures

cc: Todd McGovern, ERM West Inc.



REPORT OF LABORATORY ANALYSIS

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without the written consent of Pace Analytical Services, LLC.

SAMPLE SUMMARY

Project: 559481 Black Tank

Pace Project No.: 10533594

Lab ID	Sample ID	Matrix	Date Collected	Date Received
10533594001	MW-2-LNAPL	Non Aqueous	09/25/20 11:15	09/29/20 08:50
10533594002	MW-1-LNAPL	Non Aqueous	09/25/20 11:57	09/29/20 08:50
10533594003	MW-7-LNAPL	Non Aqueous	09/25/20 14:06	09/29/20 08:50
10533594004	MW-17-LNAPL	Non Aqueous	09/25/20 13:03	09/29/20 08:50
10533594005	MW-5-LNAPL	Non Aqueous	09/25/20 15:06	09/29/20 08:50
10533594006	MW-9-LNAPL	Non Aqueous	09/28/20 08:35	09/29/20 08:50
10533594007	MW-4-LNAPL	Non Aqueous	09/28/20 09:52	09/29/20 08:50
10533594008	MW-31-LNAPL	Non Aqueous	09/28/20 11:13	09/29/20 08:50
10533594009	MW-3-LNAPL	Non Aqueous	09/28/20 12:01	09/29/20 08:50

REPORT OF LABORATORY ANALYSIS

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without the written consent of Pace Analytical Services, LLC.

PROJECT NARRATIVE

Project:

Pace Project No.:

Method:

Description:

Client:

Date:

This data package has been reviewed for quality and completeness and is approved for release.

REPORT OF LABORATORY ANALYSIS

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without the written consent of Pace Analytical Services, LLC.

	Document Name: Sample Condition Upon Receipt (SCUR) - MN	Document Revised: 12Aug2020 Page 1 of 1
	Document No.: ENV-FRM-MIN4-0150 Rev.01	Pace Analytical Services - Minneapolis

Sample Condition Upon Receipt	Client Name: <u>ERM</u>	Project #:	WO# : 10533594 PM: JMG Due Date: 10/06/20 CLIENT: ERM_WA
Courier:	☒ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Pace ☐ Speedee ☐ Commercial		
Tracking Number:	<u>1456 2247 9157</u>	See Exceptions ☐ ENV-FRM-MIN4-0142	
Custody Seal on Cooler/Box Present?	☐ Yes ☒ No	Seals Intact?	☐ Yes ☒ No Biological Tissue Frozen? ☐ Yes ☐ No ☒ N/A
Packing Material:	☒ Bubble Wrap ☒ Bubble Bags ☐ None ☐ Other: _____	Temp Blank?	☒ Yes ☐ No
Thermometer:	☐ T1(0461) ☐ T2(1336) ☐ T3(0459) ☒ T4(0254) ☐ T5(0489)	Type of Ice:	☒ Wet ☐ Blue ☐ None ☐ Dry ☐ Melted

Did Samples Originate in West Virginia? ☐ Yes ☒ No	Were All Container Temps Taken? ☐ Yes ☐ No ☒ N/A
Temp should be above freezing to 6°C Cooler Temp Read w/temp blank: _____ °C	Average Corrected Temp (no temp blank only): <u>3.0</u> °C
Correction Factor: <u>+0.1</u> Cooler Temp Corrected w/temp blank: _____ °C	☒ See Exceptions ENV-FRM-MIN4-0142 ☐ 1 Container

USDA Regulated Soil: (☐ N/A, water sample/Other: _____) **Date/Initials of Person Examining Contents:** 9/27/20 JJ

Did samples originate in a quarantine zone within the United States: AL, AR, CA, FL, GA, ID, LA, MS, NC, NM, NY, OK, OR, SC, TN, TX or VA (check maps)? ☐ Yes ☒ No Did samples originate from a foreign source (internationally, including Hawaii and Puerto Rico)? ☐ Yes ☒ No

If Yes to either question, fill out a Regulated Soil Checklist (F-MN-Q-338) and include with SCUR/COC paperwork.

		COMMENTS:
Chain of Custody Present and Filled Out?	☒ Yes ☐ No	1.
Chain of Custody Relinquished?	☒ Yes ☐ No	2.
Sampler Name and/or Signature on COC?	☒ Yes ☐ No ☐ N/A	3.
Samples Arrived within Hold Time?	☒ Yes ☐ No	4.
Short Hold Time Analysis (<72 hr)?	☐ Yes ☒ No	5. ☐ Fecal Coliform ☐ HPC ☐ Total Coliform/E coli ☐ BOD/cBOD ☐ Hex Chrome ☐ Turbidity ☐ Nitrate ☐ Nitrite ☐ Orthophos ☐ Other _____
Rush Turn Around Time Requested?	☐ Yes ☒ No	6.
Sufficient Volume?	☒ Yes ☐ No	7.
Correct Containers Used?	☒ Yes ☐ No	8.
-Pace Containers Used?	☒ Yes ☐ No	9.
Containers Intact?	☒ Yes ☐ No	10. Is sediment visible in the dissolved container? ☐ Yes ☐ No
Field Filtered Volume Received for Dissolved Tests?	☐ Yes ☐ No ☒ N/A	11. If no, write ID/ Date/Time on Container Below: See Exception ☐ ENV-FRM-MIN4-0142
Is sufficient information available to reconcile the samples to the COC?	☒ Yes ☐ No	
Matrix: ☐ Water ☒ Soil ☐ Oil ☐ Other _____		
All containers needing acid/base preservation have been checked?	☐ Yes ☐ No ☒ N/A	12. Sample #
All containers needing preservation are found to be in compliance with EPA recommendation? (HNO₃, H₂SO₄, <2pH, NaOH >9 Sulfide, NaOH >10 Cyanide)	☐ Yes ☐ No ☒ N/A	☐ NaOH ☐ HNO ₃ ☐ H ₂ SO ₄ ☐ Zinc Acetate
Exceptions: VOA, Coliform, TOC/DOC Oil and Grease, DRO/8015 (water) and Dioxin/PFAS	☐ Yes ☐ No ☒ N/A	Positive for Res. ☐ Yes ☐ No See Exception ☐ Chlorine? ☐ Yes ☐ No ENV-FRM-MIN4-0142 Res. Chlorine 0-6 Roll 0-6 Strip 0-14 Strip
Extra labels present on soil VOA or WIDRO containers?	☐ Yes ☐ No ☒ N/A	13. See Exception ☐ ENV-FRM-MIN4-0140
Headspace in VOA Vials (greater than 6mm)?	☐ Yes ☐ No ☒ N/A	
Trip Blank Present?	☐ Yes ☐ No ☒ N/A	14.
Trip Blank Custody Seals Present?	☐ Yes ☐ No ☒ N/A	Pace Trip Blank Lot # (if purchased): _____

CLIENT NOTIFICATION/RESOLUTION

Person Contacted: _____ Date/Time: _____ **Field Data Required?** ☐ Yes ☐ No

Comments/Resolution: _____

Project Manager Review: JENNI GROSS **Date:** 09/30/20

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e. out of hold, incorrect preservative, out of temp, incorrect containers).

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Greensburg , PA 15601
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CLARK
TESTING

Fuels & Lubrication Lab
1801 Route 51 South
Building 9
Jefferson Hills, PA 15025
Ph: 412-387-1001
Fax: 412-387-1028

FINAL REPORT

This report and the data within has completed QA/QC review

Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-2-LNAPL

Pace Analytical Services

2019

Client Sample# MW-2-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	460.06 cSt

Tracking #	414052-1
Client Sample #	MW-2-LNAPL
Sample Date	09/25/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 460.06 cSt

Authorized Signature

Analyst:

Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

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Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-1-LNAPL

Pace Analytical Services

2019

Client Sample# MW-1-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	412.06 cSt

Tracking #	414052-2
Client Sample #	MW-1-LNAPL
Sample Date	09/25/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 412.06 cSt

Authorized Signature

Analyst:  Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

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Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-7-LNAPL

Pace Analytical Services

2019

Client Sample# MW-7-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	141.18 cSt

Tracking #	414052-3
Client Sample #	MW-7-LNAPL
Sample Date	09/25/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 141.18 cSt

Authorized Signature

Analyst:

Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

Pace Analytical Services
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Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-17-LNAPL

Pace Analytical Services

2019

Client Sample# MW-17-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	192.38 cSt

Tracking #	414052-4
Client Sample #	MW-17-LNAPL
Sample Date	09/25/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 192.38 cSt

Authorized Signature

Analyst:

Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

Pace Analytical Services
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Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-5-LNAPL

Pace Analytical Services

2019

Client Sample# MW-5-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	280.76 cSt

Tracking #	414052-5
Client Sample #	MW-5-LNAPL
Sample Date	09/25/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 280.76 cSt

Authorized Signature

Analyst:

Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

Pace Analytical Services
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Pace Analytical Services	Pace Analytical Services	Lube Supplier	Level 3	Level 4
Pace Analytical Services/Minneapolis, MN	2019	Unknown	Make: UNKNOWN	Make: UNKNOWN
559481 BLACK TANK		Lube Type	Model: UNKNOWN	Model: UNKNOWN
MW-9-LNAPL		Unknown		Serial No: UNKNOWN
	Client Sample# MW-9-LNAPL	PO# 10533594		

Kinematic Viscosity - ASTM D445 40C - new	
Test Code: VISC40 new / Method: D445, SOP 0107	
Result Date	10/08/2020
Viscosity @40C	46.889 cSt

Tracking #	414052-6
Client Sample #	MW-9-LNAPL
Sample Date	09/28/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 46.889 cSt

Authorized Signature

Analyst:  Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

Pace Analytical Services
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Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-4-LNAPL

Pace Analytical Services

2019

Client Sample# MW-4-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	655.38 cSt

Tracking #	414052-7
Client Sample #	MW-4-LNAPL
Sample Date	09/28/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 655.38 cSt

Authorized Signature

Analyst:

Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

Pace Analytical Services
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Pace Analytical Services
Pace Analytical Services/Minneapolis, MN 2019
559481 BLACK TANK
MW-31-LNAPL

Pace Analytical Services
Unknown

Client Sample# MW-31-LNAPL
PO# 10533594

Lube Supplier Level 3
Unknown

Lube Type
Unknown

Level 4
Make: UNKNOWN
Model: UNKNOWN
Level 4
Make: UNKNOWN
Model: UNKNOWN
Serial No: UNKNOWN

1	2	3	4	5
Normal		Abnormal		Critical

Tracking #	414052-8
Client Sample #	MW-31-LNAPL
Sample Date	09/28/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	
Mach Cond	-
Lube Cond	-

General Diagnostic Notes

Viscosity fails at 40C and 100C. Sample too thick. Sample fails to flow adequately to fill viscosity cell.

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Sample Date	09/28/2020		
Result Date	10/08/2020	REF	
Tracking #	414052-8	LOWER	UPPER
Viscosity @40C	cSt -	-	-

Comments for section

Viscosity fails at 40C and 100C.

Authorized Signature

Analyst:  Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

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FINAL REPORT

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Pace Analytical Services

Pace Analytical Services/Minneapolis, MN
559481 BLACK TANK
MW-3-LNAPL

Pace Analytical Services

2019

Client Sample# MW-3-LNAPL

Lube Supplier

Unknown

Lube Type

Unknown

PO# 10533594

Level 3

Make: UNKNOWN

Model: UNKNOWN

Level 4

Make: UNKNOWN

Model: UNKNOWN

Serial No: UNKNOWN

Kinematic Viscosity - ASTM D445 40C - new

Test Code: VISC40 new / Method: D445, SOP 0107

Result Date	10/08/2020
Viscosity @40C	870.52 cSt

Tracking #	414052-9
Client Sample #	MW-3-LNAPL
Sample Date	09/28/2020
Received Date	10/02/2020
Time on Oil	
Time on Unit	

General Diagnostic Notes

Viscosity @ 40 C: 870.52 cSt

Authorized Signature

Analyst:  Date: 10/08/2020

Shannan Burnett

Results relate only to items tested.

TRANSMISSIVITY ANALYSIS

Table D-3
LNAPL Skimming Test Field Data Summary - September 2020
Engineering Design Report
BNSF Black Tank
Spokane, WA

Well ID	Initial Conditions		Recovery Event 1		Recovery Event 2		Recovery Event 3		Recovery Event 4		LNAPL Discharge Rate, Q_n (ft ³ /day)
	Gauged LNAPL Thickness (feet)	LNAPL Volume Removed (ml)	Elapsed Time (min)	LNAPL Volume Removed (ml)	Elapsed Time (min)	LNAPL Volume Removed (ml)	Elapsed Time (min)	LNAPL Volume Removed (ml)	Elapsed Time (min)	LNAPL Volume Removed (ml)	
MW-01	1.19	740	4421	10	4196	20	25889	15			2.9E-05
MW-02	0.32	200	4474	10	4204	20	25886	5			9.8E-06
MW-03	0.26	160	1566	30	4111	190	16020	100			3.2E-04
MW-04	0.72	450	1609	10	4234	10	16039	15			4.8E-05
MW-05	0.83	515	4291	280	1238	10	4306	20	26176	100	1.9E-04
MW-07	2.02	1260	4331	40	2729	10	28721	160			2.8E-04
MW-09	0.11	70	1622	10							3.1E-04
MW-17	1.00	625	4365	290	1378	20	4128	90	24612	735	1.5E-03
MW-31	0.21	130	2885	80	1495	40	8771	75	8695	10	5.8E-05

Notes:

Elapsed time is the time between LNAPL recovery events.

Grey-shaded cells indicate no LNAPL recovered.

Conversion factors:

1,440 minutes/day

28,320 ml/ft³

Abbreviations:

ft³/day = cubic feet per day

LNAPL = light non-aqueous phase liquid

ml = milliliters

APPENDIX E DESIGN CALCULATIONS

Appendix E
Design Calculations - Theoretical BV ROI
Engineering Design Report
BNSF Black Tank
Spokane, WA

Equation 2-27 (USACOE 2002)

Where:

$$t = \frac{\pi r^2 b n}{Q}$$

	Input Value	Units
Flow (Q)	110	cfm
Increased flow	150	cfm
Thickness (b)	60	ft
Porosity (n)	0.34	-
Time (t)	various	days
O ₂ Radius (r)	various	ft

Theoretical Cumulative			Pilot Test	
Time (days)	Injected Volume	O ₂ Radius (ft)	Time (days)	O ₂ Radius (ft)
0.00	0	0		
0.04	6600	10	0.34	32
0.08	13200	14	2.05	68
0.13	19800	18	3.48	96
0.17	26400	20		
0.21	33000	23		
0.25	39600	25		
0.29	46200	27		
0.33	52800	29		
0.38	59400	30		
0.42	66000	32		
0.46	72600	34		
0.50	79200	35		
0.54	85800	37		
0.58	92400	38		
0.63	99000	39		
0.67	105600	41		
0.71	112200	42		
0.75	118800	43		
0.79	125400	44		
0.83	132000	45		
0.88	138600	47		
0.92	145200	48		
0.96	151800	49		
1.00	158400	50		
1.04	165000	51		
1.08	171600	52		
1.13	178200	53		
1.17	184800	54		
1.21	191400	55		
1.25	198000	56		

1.29	204600	57
1.33	211200	57
1.38	217800	58
1.42	224400	59
1.46	231000	60
1.50	237600	61
1.54	244200	62
1.58	250800	63
1.63	257400	63
1.67	264000	64
1.71	270600	65
1.75	277200	66
1.79	283800	67
1.83	290400	67
1.88	297000	68
1.92	303600	69
1.96	310200	70
2.00	316800	70
2.04	323400	71
2.08	330000	72
2.13	336600	72
2.17	343200	73
2.21	349800	74
2.25	356400	75
2.29	363000	75
2.33	369600	76
2.38	376200	77
2.42	382800	77
2.46	389400	78
2.50	396000	79
2.54	402600	79
2.58	409200	80
2.63	415800	81
2.67	422400	81
2.71	429000	82
2.75	435600	82
2.79	442200	83
2.83	448800	84
2.88	455400	84
2.92	462000	85
2.96	468600	86
3.00	475200	86

					Cumulative	O ₂ Radius
			Increased Flow	Time (days)	Injected Volume	(ft)
3.04	481800	87		3.0	657000	101
3.08	488400	87		3.1	666000	102
3.13	495000	88		3.1	675000	103
3.17	501600	88		3.2	684000	103
3.21	508200	89		3.2	693000	104
3.25	514800	90				

3.29	521400	90	3.3	702000	105
3.33	528000	91	3.3	711000	105
3.38	534600	91	3.3	720000	106
3.42	541200	92	3.4	729000	107
3.46	547800	92	3.4	738000	107
3.50	554400	93	3.5	747000	108
3.54	561000	94	3.5	756000	109
3.58	567600	94	3.5	765000	109
3.63	574200	95	3.6	774000	110
3.67	580800	95	3.6	783000	111
3.71	587400	96	3.7	792000	111
3.75	594000	96	3.7	801000	112
3.79	600600	97	3.8	810000	112
3.83	607200	97	3.8	819000	113
3.87	613800	98	3.8	828000	114
3.92	620400	98	3.9	837000	114
3.96	627000	99	3.9	846000	115
4.00	633600	99	4.0	855000	116
4.04	640200	100	4.0	864000	116
4.08	646800	100	4.0	873000	117
4.12	653400	101	4.1	882000	117
4.17	660000	101	4.1	891000	118
4.21	666600	102	4.2	900000	119
4.25	673200	102	4.2	909000	119
4.29	679800	103	4.3	918000	120
4.33	686400	103	4.3	927000	120
4.38	693000	104	4.3	936000	121
4.42	699600	104	4.4	945000	121
4.46	706200	105	4.4	954000	122
4.50	712800	105	4.5	963000	123
4.54	719400	106	4.5	972000	123
4.58	726000	106	4.5	981000	124
4.63	732600	107	4.6	990000	124
4.67	739200	107	4.6	999000	125
4.71	745800	108	4.7	1008000	125
4.75	752400	108	4.7	1017000	126
4.79	759000	109	4.8	1026000	127
4.83	765600	109	4.8	1035000	127
4.88	772200	110	4.8	1044000	128
4.92	778800	110	4.9	1053000	128
4.96	785400	111	4.9	1062000	129
5.00	792000	111	5.0	1071000	129
5.04	798600	112	5.0	1080000	130
5.08	805200	112	5.0	1089000	130
5.13	811800	113	5.1	1098000	131
5.17	818400	113	5.1	1107000	131
5.21	825000	113	5.2	1116000	132
5.25	831600	114	5.2	1125000	132
5.29	838200	114	5.3	1134000	133
5.33	844800	115	5.3	1143000	134

5.38	851400	115	5.3	1152000	134
5.42	858000	116	5.4	1161000	135
5.46	864600	116	5.4	1170000	135
5.50	871200	117	5.5	1179000	136
5.54	877800	117	5.5	1188000	136
5.58	884400	117	5.5	1197000	137
5.63	891000	118	5.6	1206000	137
5.67	897600	118	5.6	1215000	138
5.71	904200	119	5.7	1224000	138
5.75	910800	119	5.7	1233000	139
5.79	917400	120	5.8	1242000	139
5.83	924000	120	5.8	1251000	140
5.88	930600	121	5.8	1260000	140
5.92	937200	121	5.9	1269000	141
5.96	943800	121	5.9	1278000	141
6.00	950400	122	6.0	1287000	142
6.04	957000	122	6.0	1296000	142
6.08	963600	123	6.0	1305000	143
6.13	970200	123	6.1	1314000	143
6.17	976800	123	6.1	1323000	144
6.21	983400	124	6.2	1332000	144
6.25	990000	124	6.2	1341000	145
6.29	996600	125	6.3	1350000	145
6.33	1003200	125	6.3	1359000	146
6.38	1009800	126	6.3	1368000	146
6.42	1016400	126	6.4	1377000	147
6.46	1023000	126	6.4	1386000	147
6.50	1029600	127	6.5	1395000	148
6.54	1036200	127	6.5	1404000	148
6.58	1042800	128	6.5	1413000	148
6.63	1049400	128	6.6	1422000	149
6.67	1056000	128	6.6	1431000	149
6.71	1062600	129	6.7	1440000	150
6.75	1069200	129	6.7	1449000	150
6.79	1075800	130	6.8	1458000	151
6.83	1082400	130	6.8	1467000	151
6.88	1089000	130	6.8	1476000	152
6.92	1095600	131	6.9	1485000	152
6.96	1102200	131	6.9	1494000	153
7.00	1108800	132	7.0	1503000	153
7.04	1115400	132	7.0	1512000	154
7.08	1122000	132	7.0	1521000	154
7.13	1128600	133	7.1	1530000	155
7.17	1135200	133	7.1	1539000	155
7.21	1141800	133	7.2	1548000	155
7.25	1148400	134	7.2	1557000	156
7.29	1155000	134	7.3	1566000	156
7.33	1161600	135	7.3	1575000	157
7.38	1168200	135	7.3	1584000	157
7.42	1174800	135	7.4	1593000	158

7.46	1181400	136	7.4	1602000	158
7.50	1188000	136	7.5	1611000	159
7.54	1194600	137	7.5	1620000	159
7.58	1201200	137	7.5	1629000	159
7.63	1207800	137	7.6	1638000	160
7.67	1214400	138	7.6	1647000	160
7.71	1221000	138	7.7	1656000	161
7.75	1227600	138	7.7	1665000	161
7.79	1234200	139	7.8	1674000	162
7.83	1240800	139	7.8	1683000	162
7.88	1247400	140	7.8	1692000	162
7.92	1254000	140	7.9	1701000	163
7.96	1260600	140	7.9	1710000	163
8.00	1267200	141	8.0	1719000	164
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8.08	1280400	141	8.0	1737000	165
8.13	1287000	142	8.1	1746000	165
8.17	1293600	142	8.1	1755000	165
8.21	1300200	142	8.2	1764000	166
8.25	1306800	143	8.2	1773000	166
8.29	1313400	143	8.3	1782000	167
8.33	1320000	144	8.3	1791000	167
8.38	1326600	144	8.3	1800000	168
8.42	1333200	144	8.4	1809000	168
8.46	1339800	145	8.4	1818000	168
8.50	1346400	145	8.5	1827000	169
8.54	1353000	145	8.5	1836000	169
8.58	1359600	146	8.5	1845000	170
8.63	1366200	146	8.6	1854000	170
8.67	1372800	146	8.6	1863000	170
8.71	1379400	147	8.7	1872000	171
8.75	1386000	147	8.7	1881000	171
8.79	1392600	147	8.8	1890000	172
8.83	1399200	148	8.8	1899000	172
8.88	1405800	148	8.8	1908000	173
8.92	1412400	148	8.9	1917000	173
8.96	1419000	149	8.9	1926000	173
9.00	1425600	149	9.0	1935000	174
9.04	1432200	149	9.0	1944000	174
9.08	1438800	150	9.0	1953000	175
9.13	1445400	150	9.1	1962000	175
9.17	1452000	151	9.1	1971000	175
9.21	1458600	151	9.2	1980000	176
9.25	1465200	151	9.2	1989000	176
9.29	1471800	152	9.3	1998000	177
9.33	1478400	152	9.3	2007000	177
9.38	1485000	152	9.3	2016000	177
9.42	1491600	153	9.4	2025000	178
9.46	1498200	153	9.4	2034000	178
9.50	1504800	153	9.5	2043000	179

9.54	1511400	154	9.5	2052000	179
9.58	1518000	154	9.5	2061000	179
9.63	1524600	154	9.6	2070000	180
9.67	1531200	155	9.6	2079000	180
9.71	1537800	155	9.7	2088000	180
9.75	1544400	155	9.7	2097000	181
9.79	1551000	156	9.8	2106000	181
9.83	1557600	156	9.8	2115000	182
9.87	1564200	156	9.8	2124000	182
9.92	1570800	157	9.9	2133000	182
9.96	1577400	157	9.9	2142000	183
10.00	1584000	157	10.0	2151000	183
10.04	1590600	158	10.0	2160000	184
10.08	1597200	158	10.0	2169000	184
10.13	1603800	158	10.1	2178000	184
10.17	1610400	159	10.1	2187000	185
10.21	1617000	159	10.2	2196000	185
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10.29	1630200	159	10.3	2214000	186
10.33	1636800	160	10.3	2223000	186
10.38	1643400	160	10.3	2232000	187
10.42	1650000	160	10.4	2241000	187
10.46	1656600	161	10.4	2250000	187
10.50	1663200	161	10.5	2259000	188
10.54	1669800	161	10.5	2268000	188
10.58	1676400	162	10.5	2277000	188
10.63	1683000	162	10.6	2286000	189
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10.75	1702800	163	10.7	2313000	190
10.79	1709400	163	10.8	2322000	190
10.83	1716000	164	10.8	2331000	191
10.88	1722600	164	10.8	2340000	191
10.92	1729200	164	10.9	2349000	191
10.96	1735800	165	10.9	2358000	192
11.00	1742400	165	11.0	2367000	192
11.04	1749000	165	11.0	2376000	193
11.08	1755600	166	11.0	2385000	193
11.13	1762200	166	11.1	2394000	193
11.17	1768800	166	11.1	2403000	194
11.21	1775400	166	11.2	2412000	194
11.25	1782000	167	11.2	2421000	194
11.29	1788600	167	11.3	2430000	195
11.33	1795200	167	11.3	2439000	195
11.38	1801800	168	11.3	2448000	195
11.42	1808400	168	11.4	2457000	196
11.46	1815000	168	11.4	2466000	196
11.50	1821600	169	11.5	2475000	197
11.54	1828200	169	11.5	2484000	197
11.58	1834800	169	11.5	2493000	197

11.63	1841400	170	11.6	2502000	198
11.67	1848000	170	11.6	2511000	198
11.71	1854600	170	11.7	2520000	198
11.75	1861200	170	11.7	2529000	199
11.79	1867800	171	11.8	2538000	199
11.83	1874400	171	11.8	2547000	199
11.88	1881000	171	11.8	2556000	200
11.92	1887600	172	11.9	2565000	200
11.96	1894200	172	11.9	2574000	200
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12.04	1907400	173	12.0	2592000	201
12.08	1914000	173	12.0	2601000	201
12.13	1920600	173	12.1	2610000	202
12.17	1927200	173	12.1	2619000	202
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12.50	1980000	176	12.5	2691000	205
12.54	1986600	176	12.5	2700000	205
12.58	1993200	176	12.5	2709000	206
12.63	1999800	177	12.6	2718000	206
12.67	2006400	177	12.6	2727000	206
12.71	2013000	177	12.7	2736000	207
12.75	2019600	178	12.7	2745000	207
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12.92	2046000	179	12.9	2781000	208
12.96	2052600	179	12.9	2790000	209
13.00	2059200	179	13.0	2799000	209
13.04	2065800	180	13.0	2808000	209
13.08	2072400	180	13.0	2817000	210
13.12	2079000	180	13.1	2826000	210
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13.29	2105400	181	13.2	2862000	211
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13.54	2145000	183	13.5	2916000	213
13.58	2151600	183	13.5	2925000	214
13.62	2158200	184	13.6	2934000	214
13.67	2164800	184	13.6	2943000	214

13.71	2171400	184	13.7	2952000	215
13.75	2178000	184	13.7	2961000	215
13.79	2184600	185	13.7	2970000	215
13.83	2191200	185	13.8	2979000	216
13.87	2197800	185	13.8	2988000	216
13.92	2204400	185	13.9	2997000	216
13.96	2211000	186	13.9	3006000	217
14.00	2217600	186	14.0	3015000	217
14.04	2224200	186	14.0	3024000	217
14.08	2230800	187	14.0	3033000	218
14.12	2237400	187	14.1	3042000	218
14.17	2244000	187	14.1	3051000	218
14.21	2250600	187	14.2	3060000	219
14.25	2257200	188	14.2	3069000	219
14.29	2263800	188	14.2	3078000	219
14.33	2270400	188	14.3	3087000	219
14.37	2277000	188	14.3	3096000	220
14.42	2283600	189	14.4	3105000	220
14.46	2290200	189	14.4	3114000	220
14.50	2296800	189	14.5	3123000	221
14.54	2303400	190	14.5	3132000	221
14.58	2310000	190	14.5	3141000	221
14.62	2316600	190	14.6	3150000	222
14.67	2323200	190	14.6	3159000	222
14.71	2329800	191	14.7	3168000	222
14.75	2336400	191	14.7	3177000	223
14.79	2343000	191	14.7	3186000	223
14.83	2349600	191	14.8	3195000	223
14.87	2356200	192	14.8	3204000	224
14.92	2362800	192	14.9	3213000	224
14.96	2369400	192	14.9	3222000	224
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15.04	2382600	193	15.0	3240000	225
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15.12	2395800	193	15.1	3258000	225
15.17	2402400	194	15.1	3267000	226
15.21	2409000	194	15.2	3276000	226
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15.54	2461800	196	15.5	3348000	229
15.58	2468400	196	15.5	3357000	229
15.62	2475000	197	15.6	3366000	229
15.67	2481600	197	15.6	3375000	229
15.71	2488200	197	15.7	3384000	230
15.75	2494800	197	15.7	3393000	230

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15.87	2514600	198	15.8	3420000	231
15.92	2521200	198	15.9	3429000	231
15.96	2527800	199	15.9	3438000	232
16.00	2534400	199	16.0	3447000	232
16.04	2541000	199	16.0	3456000	232
16.08	2547600	199	16.0	3465000	233
16.12	2554200	200	16.1	3474000	233
16.17	2560800	200	16.1	3483000	233
16.21	2567400	200	16.2	3492000	233
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16.29	2580600	201	16.2	3510000	234
16.33	2587200	201	16.3	3519000	234
16.37	2593800	201	16.3	3528000	235
16.42	2600400	201	16.4	3537000	235
16.46	2607000	202	16.4	3546000	235
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16.67	2640000	203	16.6	3591000	237
16.71	2646600	203	16.7	3600000	237
16.75	2653200	203	16.7	3609000	237
16.79	2659800	204	16.7	3618000	238
16.83	2666400	204	16.8	3627000	238
16.87	2673000	204	16.8	3636000	238
16.92	2679600	204	16.9	3645000	238
16.96	2686200	205	16.9	3654000	239
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17.37	2752200	207	17.3	3744000	242
17.42	2758800	207	17.4	3753000	242
17.46	2765400	208	17.4	3762000	242
17.50	2772000	208	17.5	3771000	243
17.54	2778600	208	17.5	3780000	243
17.58	2785200	208	17.5	3789000	243
17.63	2791800	209	17.6	3798000	243
17.67	2798400	209	17.6	3807000	244
17.71	2805000	209	17.7	3816000	244
17.75	2811600	209	17.7	3825000	244
17.79	2818200	210	17.8	3834000	245
17.83	2824800	210	17.8	3843000	245

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17.92	2838000	210	17.9	3861000	245
17.96	2844600	211	17.9	3870000	246
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18.08	2864400	211	18.0	3897000	247
18.13	2871000	212	18.1	3906000	247
18.17	2877600	212	18.1	3915000	247
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18.33	2904000	213	18.3	3951000	248
18.38	2910600	213	18.3	3960000	249
18.42	2917200	213	18.4	3969000	249
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18.71	2963400	215	18.7	4032000	251
18.75	2970000	215	18.7	4041000	251
18.79	2976600	216	18.8	4050000	251
18.83	2983200	216	18.8	4059000	252
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18.96	3003000	216	18.9	4086000	252
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19.04	3016200	217	19.0	4104000	253
19.08	3022800	217	19.0	4113000	253
19.13	3029400	217	19.1	4122000	254
19.17	3036000	218	19.1	4131000	254
19.21	3042600	218	19.2	4140000	254
19.25	3049200	218	19.2	4149000	254
19.29	3055800	218	19.3	4158000	255
19.33	3062400	219	19.3	4167000	255
19.38	3069000	219	19.3	4176000	255
19.42	3075600	219	19.4	4185000	256
19.46	3082200	219	19.4	4194000	256
19.50	3088800	220	19.5	4203000	256
19.54	3095400	220	19.5	4212000	256
19.58	3102000	220	19.5	4221000	257
19.63	3108600	220	19.6	4230000	257
19.67	3115200	220	19.6	4239000	257
19.71	3121800	221	19.7	4248000	257
19.75	3128400	221	19.7	4257000	258
19.79	3135000	221	19.8	4266000	258
19.83	3141600	221	19.8	4275000	258
19.88	3148200	222	19.8	4284000	259
19.92	3154800	222	19.9	4293000	259

19.96	3161400	222	19.9	4302000	259
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20.13	3187800	223	20.1	4338000	260
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20.21	3201000	223	20.2	4356000	261
20.25	3207600	224	20.2	4365000	261
20.29	3214200	224	20.3	4374000	261
20.33	3220800	224	20.3	4383000	262
20.38	3227400	224	20.3	4392000	262
20.42	3234000	225	20.4	4401000	262
20.46	3240600	225	20.4	4410000	262
20.50	3247200	225	20.5	4419000	263
20.54	3253800	225	20.5	4428000	263
20.58	3260400	226	20.5	4437000	263
20.63	3267000	226	20.6	4446000	263
20.67	3273600	226	20.6	4455000	264
20.71	3280200	226	20.7	4464000	264
20.75	3286800	226	20.7	4473000	264
20.79	3293400	227	20.8	4482000	264
20.83	3300000	227	20.8	4491000	265
20.88	3306600	227	20.8	4500000	265
20.92	3313200	227	20.9	4509000	265
20.96	3319800	228	20.9	4518000	266
21.00	3326400	228	21.0	4527000	266
21.04	3333000	228	21.0	4536000	266
21.08	3339600	228	21.0	4545000	266
21.13	3346200	228	21.1	4554000	267
21.17	3352800	229	21.1	4563000	267
21.21	3359400	229	21.2	4572000	267
21.25	3366000	229	21.2	4581000	267
21.29	3372600	229	21.3	4590000	268
21.33	3379200	230	21.3	4599000	268
21.38	3385800	230	21.3	4608000	268
21.42	3392400	230	21.4	4617000	268
21.46	3399000	230	21.4	4626000	269
21.50	3405600	231	21.5	4635000	269
21.54	3412200	231	21.5	4644000	269
21.58	3418800	231	21.5	4653000	269
21.63	3425400	231	21.6	4662000	270
21.67	3432000	231	21.6	4671000	270
21.71	3438600	232	21.7	4680000	270
21.75	3445200	232	21.7	4689000	270
21.79	3451800	232	21.8	4698000	271
21.83	3458400	232	21.8	4707000	271
21.88	3465000	233	21.8	4716000	271
21.92	3471600	233	21.9	4725000	272
21.96	3478200	233	21.9	4734000	272
22.00	3484800	233	22.0	4743000	272

22.04	3491400	233	22.0	4752000	272
22.08	3498000	234	22.0	4761000	273
22.13	3504600	234	22.1	4770000	273
22.17	3511200	234	22.1	4779000	273
22.21	3517800	234	22.2	4788000	273
22.25	3524400	235	22.2	4797000	274
22.29	3531000	235	22.3	4806000	274
22.33	3537600	235	22.3	4815000	274
22.38	3544200	235	22.3	4824000	274
22.42	3550800	235	22.4	4833000	275
22.46	3557400	236	22.4	4842000	275
22.50	3564000	236	22.5	4851000	275
22.54	3570600	236	22.5	4860000	275
22.58	3577200	236	22.5	4869000	276
22.63	3583800	236	22.6	4878000	276
22.67	3590400	237	22.6	4887000	276
22.71	3597000	237	22.7	4896000	276
22.75	3603600	237	22.7	4905000	277
22.79	3610200	237	22.8	4914000	277
22.83	3616800	238	22.8	4923000	277
22.88	3623400	238	22.8	4932000	277
22.92	3630000	238	22.9	4941000	278
22.96	3636600	238	22.9	4950000	278
23.00	3643200	238	23.0	4959000	278
23.04	3649800	239	23.0	4968000	278
23.08	3656400	239	23.0	4977000	279
23.13	3663000	239	23.1	4986000	279
23.17	3669600	239	23.1	4995000	279
23.21	3676200	240	23.2	5004000	279
23.25	3682800	240	23.2	5013000	280
23.29	3689400	240	23.3	5022000	280
23.33	3696000	240	23.3	5031000	280
23.38	3702600	240	23.3	5040000	280
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23.46	3715800	241	23.4	5058000	281
23.50	3722400	241	23.5	5067000	281
23.54	3729000	241	23.5	5076000	281
23.58	3735600	241	23.5	5085000	282
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23.67	3748800	242	23.6	5103000	282
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23.75	3762000	242	23.7	5121000	283
23.79	3768600	242	23.8	5130000	283
23.83	3775200	243	23.8	5139000	283
23.88	3781800	243	23.8	5148000	283
23.92	3788400	243	23.9	5157000	284
23.96	3795000	243	23.9	5166000	284
24.00	3801600	244	24.0	5175000	284
24.04	3808200	244	24.0	5184000	284
24.08	3814800	244	24.0	5193000	285

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24.17	3828000	244	24.1	5211000	285
24.21	3834600	245	24.2	5220000	285
24.25	3841200	245	24.2	5229000	286
24.29	3847800	245	24.3	5238000	286
24.33	3854400	245	24.3	5247000	286
24.38	3861000	245	24.3	5256000	286
24.42	3867600	246	24.4	5265000	287
24.46	3874200	246	24.4	5274000	287
24.50	3880800	246	24.5	5283000	287
24.54	3887400	246	24.5	5292000	287
24.58	3894000	246	24.5	5301000	288
24.63	3900600	247	24.6	5310000	288
24.67	3907200	247	24.6	5319000	288
24.71	3913800	247	24.7	5328000	288
24.75	3920400	247	24.7	5337000	289
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24.88	3940200	248	24.8	5364000	289
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24.96	3953400	248	24.9	5382000	290
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25.08	3973200	249	25.0	5409000	291
25.13	3979800	249	25.1	5418000	291
25.17	3986400	249	25.1	5427000	291
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25.25	3999600	250	25.2	5445000	291
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25.33	4012800	250	25.3	5463000	292
25.38	4019400	250	25.3	5472000	292
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25.46	4032600	251	25.4	5490000	293
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25.54	4045800	251	25.5	5508000	293
25.58	4052400	251	25.5	5517000	293
25.63	4059000	252	25.6	5526000	294
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25.71	4072200	252	25.7	5544000	294
25.75	4078800	252	25.7	5553000	294
25.79	4085400	252	25.8	5562000	295
25.83	4092000	253	25.8	5571000	295
25.88	4098600	253	25.8	5580000	295
25.92	4105200	253	25.9	5589000	295
25.96	4111800	253	25.9	5598000	296
26.00	4118400	253	26.0	5607000	296
26.04	4125000	254	26.0	5616000	296
26.08	4131600	254	26.0	5625000	296
26.13	4138200	254	26.1	5634000	296
26.17	4144800	254	26.1	5643000	297

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26.29	4164600	255	26.3	5670000	297
26.33	4171200	255	26.3	5679000	298
26.38	4177800	255	26.3	5688000	298
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26.46	4191000	256	26.4	5706000	298
26.50	4197600	256	26.5	5715000	299
26.54	4204200	256	26.5	5724000	299
26.58	4210800	256	26.5	5733000	299
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26.71	4230600	257	26.7	5760000	300
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26.79	4243800	257	26.8	5778000	300
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26.92	4263600	258	26.9	5805000	301
26.96	4270200	258	26.9	5814000	301
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27.04	4283400	259	27.0	5832000	302
27.08	4290000	259	27.0	5841000	302
27.13	4296600	259	27.1	5850000	302
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27.42	4342800	260	27.4	5913000	304
27.46	4349400	261	27.4	5922000	304
27.50	4356000	261	27.5	5931000	304
27.54	4362600	261	27.5	5940000	304
27.58	4369200	261	27.5	5949000	305
27.63	4375800	261	27.6	5958000	305
27.67	4382400	261	27.6	5967000	305
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27.75	4395600	262	27.7	5985000	306
27.79	4402200	262	27.8	5994000	306
27.83	4408800	262	27.8	6003000	306
27.88	4415400	262	27.8	6012000	306
27.92	4422000	263	27.9	6021000	307
27.96	4428600	263	27.9	6030000	307
28.00	4435200	263	28.0	6039000	307
28.04	4441800	263	28.0	6048000	307
28.08	4448400	263	28.0	6057000	307
28.13	4455000	264	28.1	6066000	308
28.17	4461600	264	28.1	6075000	308
28.21	4468200	264	28.2	6084000	308
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28.33	4488000	265	28.3	6111000	309
28.38	4494600	265	28.3	6120000	309
28.42	4501200	265	28.4	6129000	309
28.46	4507800	265	28.4	6138000	309
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28.54	4521000	266	28.5	6156000	310
28.58	4527600	266	28.5	6165000	310
28.63	4534200	266	28.6	6174000	310
28.67	4540800	266	28.6	6183000	311
28.71	4547400	266	28.7	6192000	311
28.75	4554000	267	28.7	6201000	311
28.79	4560600	267	28.8	6210000	311
28.83	4567200	267	28.8	6219000	312
28.88	4573800	267	28.8	6228000	312
28.92	4580400	267	28.9	6237000	312
28.96	4587000	268	28.9	6246000	312
29.00	4593600	268	29.0	6255000	312
29.04	4600200	268	29.0	6264000	313
29.08	4606800	268	29.0	6273000	313
29.13	4613400	268	29.1	6282000	313
29.17	4620000	268	29.1	6291000	313
29.21	4626600	269	29.2	6300000	314
29.25	4633200	269	29.2	6309000	314
29.29	4639800	269	29.3	6318000	314
29.33	4646400	269	29.3	6327000	314
29.38	4653000	269	29.3	6336000	314
29.42	4659600	270	29.4	6345000	315
29.46	4666200	270	29.4	6354000	315
29.50	4672800	270	29.5	6363000	315
29.54	4679400	270	29.5	6372000	315
29.58	4686000	270	29.5	6381000	316
29.63	4692600	271	29.6	6390000	316
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29.71	4705800	271	29.7	6408000	316
29.75	4712400	271	29.7	6417000	316
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30.21	4785000	273	30.2	6516000	319
30.25	4791600	273	30.2	6525000	319
30.29	4798200	274	30.3	6534000	319
30.33	4804800	274	30.3	6543000	320

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30.42	4818000	274	30.4	6561000	320
30.46	4824600	274	30.4	6570000	320
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31.04	4917000	277	31.0	6696000	323
31.08	4923600	277	31.0	6705000	323
31.13	4930200	277	31.1	6714000	324
31.17	4936800	278	31.1	6723000	324
31.21	4943400	278	31.2	6732000	324
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31.42	4976400	279	31.4	6777000	325
31.46	4983000	279	31.4	6786000	325
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31.54	4996200	279	31.5	6804000	326
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32.17	5095200	282	32.1	6939000	329
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33.42	5293200	287	33.4	7209000	335
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33.63	5326200	288	33.6	7254000	336
33.67	5332800	288	33.6	7263000	337
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33.75	5346000	289	33.7	7281000	337
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35.54	5629800	296	35.5	7668000	346
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35.92	5689200	298	35.9	7749000	348
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36.46	5775000	300	36.4	7866000	350
36.50	5781600	300	36.5	7875000	351
36.54	5788200	301	36.5	7884000	351
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36.71	5814600	301	36.7	7920000	352
36.75	5821200	301	36.7	7929000	352
36.79	5827800	302	36.8	7938000	352
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36.92	5847600	302	36.9	7965000	353
36.96	5854200	302	36.9	7974000	353
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37.04	5867400	303	37.0	7992000	353
37.08	5874000	303	37.0	8001000	353
37.13	5880600	303	37.1	8010000	354
37.17	5887200	303	37.1	8019000	354
37.21	5893800	303	37.2	8028000	354
37.25	5900400	303	37.2	8037000	354
37.29	5907000	304	37.3	8046000	354
37.33	5913600	304	37.3	8055000	355
37.38	5920200	304	37.3	8064000	355
37.42	5926800	304	37.4	8073000	355
37.46	5933400	304	37.4	8082000	355
37.50	5940000	304	37.5	8091000	355
37.54	5946600	305	37.5	8100000	356
37.58	5953200	305	37.5	8109000	356
37.63	5959800	305	37.6	8118000	356
37.67	5966400	305	37.6	8127000	356
37.71	5973000	305	37.7	8136000	356
37.75	5979600	305	37.7	8145000	356
37.79	5986200	306	37.8	8154000	357
37.83	5992800	306	37.8	8163000	357
37.88	5999400	306	37.8	8172000	357
37.92	6006000	306	37.9	8181000	357
37.96	6012600	306	37.9	8190000	357
38.00	6019200	306	38.0	8199000	358
38.04	6025800	307	38.0	8208000	358
38.08	6032400	307	38.0	8217000	358
38.13	6039000	307	38.1	8226000	358
38.17	6045600	307	38.1	8235000	358
38.21	6052200	307	38.2	8244000	359
38.25	6058800	307	38.2	8253000	359
38.29	6065400	308	38.3	8262000	359
38.33	6072000	308	38.3	8271000	359
38.38	6078600	308	38.3	8280000	359
38.42	6085200	308	38.4	8289000	360
38.46	6091800	308	38.4	8298000	360
38.50	6098400	308	38.5	8307000	360
38.54	6105000	309	38.5	8316000	360
38.58	6111600	309	38.5	8325000	360
38.63	6118200	309	38.6	8334000	361
38.67	6124800	309	38.6	8343000	361

38.71	6131400	309	38.7	8352000	361
38.75	6138000	309	38.7	8361000	361
38.79	6144600	310	38.8	8370000	361
38.83	6151200	310	38.8	8379000	362
38.88	6157800	310	38.8	8388000	362
38.92	6164400	310	38.9	8397000	362
38.96	6171000	310	38.9	8406000	362
39.00	6177600	310	39.0	8415000	362
39.04	6184200	311	39.0	8424000	363
39.08	6190800	311	39.0	8433000	363
39.13	6197400	311	39.1	8442000	363
39.17	6204000	311	39.1	8451000	363
39.21	6210600	311	39.2	8460000	363
39.25	6217200	311	39.2	8469000	364
39.29	6223800	312	39.3	8478000	364
39.33	6230400	312	39.3	8487000	364
39.37	6237000	312	39.3	8496000	364
39.42	6243600	312	39.4	8505000	364
39.46	6250200	312	39.4	8514000	364
39.50	6256800	312	39.5	8523000	365
39.54	6263400	313	39.5	8532000	365
39.58	6270000	313	39.5	8541000	365
39.62	6276600	313	39.6	8550000	365
39.67	6283200	313	39.6	8559000	365
39.71	6289800	313	39.7	8568000	366
39.75	6296400	313	39.7	8577000	366
39.79	6303000	314	39.7	8586000	366
39.83	6309600	314	39.8	8595000	366
39.87	6316200	314	39.8	8604000	366
39.92	6322800	314	39.9	8613000	367
39.96	6329400	314	39.9	8622000	367
40.00	6336000	314	40.0	8631000	367
40.04	6342600	315	40.0	8640000	367
40.08	6349200	315	40.0	8649000	367
40.12	6355800	315	40.1	8658000	368
40.17	6362400	315	40.1	8667000	368
40.21	6369000	315	40.2	8676000	368
40.25	6375600	315	40.2	8685000	368
40.29	6382200	316	40.2	8694000	368
40.33	6388800	316	40.3	8703000	369
40.37	6395400	316	40.3	8712000	369
40.42	6402000	316	40.4	8721000	369
40.46	6408600	316	40.4	8730000	369
40.50	6415200	316	40.5	8739000	369
40.54	6421800	317	40.5	8748000	369
40.58	6428400	317	40.5	8757000	370
40.62	6435000	317	40.6	8766000	370
40.67	6441600	317	40.6	8775000	370
40.71	6448200	317	40.7	8784000	370
40.75	6454800	317	40.7	8793000	370

40.79	6461400	318	40.7	8802000	371
40.83	6468000	318	40.8	8811000	371
40.87	6474600	318	40.8	8820000	371
40.92	6481200	318	40.9	8829000	371
40.96	6487800	318	40.9	8838000	371
41.00	6494400	318	41.0	8847000	372
41.04	6501000	318	41.0	8856000	372
41.08	6507600	319	41.0	8865000	372
41.12	6514200	319	41.1	8874000	372
41.17	6520800	319	41.1	8883000	372
41.21	6527400	319	41.2	8892000	372
41.25	6534000	319	41.2	8901000	373
41.29	6540600	319	41.2	8910000	373
41.33	6547200	320	41.3	8919000	373
41.37	6553800	320	41.3	8928000	373
41.42	6560400	320	41.4	8937000	373
41.46	6567000	320	41.4	8946000	374
41.50	6573600	320	41.5	8955000	374
41.54	6580200	320	41.5	8964000	374
41.58	6586800	321	41.5	8973000	374
41.62	6593400	321	41.6	8982000	374
41.67	6600000	321	41.6	8991000	375
41.71	6606600	321	41.7	9000000	375
41.75	6613200	321	41.7	9009000	375
41.79	6619800	321	41.7	9018000	375
41.83	6626400	322	41.8	9027000	375
41.87	6633000	322	41.8	9036000	375
41.92	6639600	322	41.9	9045000	376
41.96	6646200	322	41.9	9054000	376
42.00	6652800	322	42.0	9063000	376
42.04	6659400	322	42.0	9072000	376
42.08	6666000	323	42.0	9081000	376
42.12	6672600	323	42.1	9090000	377
42.17	6679200	323	42.1	9099000	377
42.21	6685800	323	42.2	9108000	377
42.25	6692400	323	42.2	9117000	377
42.29	6699000	323	42.2	9126000	377
42.33	6705600	323	42.3	9135000	378
42.37	6712200	324	42.3	9144000	378
42.42	6718800	324	42.4	9153000	378
42.46	6725400	324	42.4	9162000	378
42.50	6732000	324	42.5	9171000	378
42.54	6738600	324	42.5	9180000	378
42.58	6745200	324	42.5	9189000	379
42.62	6751800	325	42.6	9198000	379
42.67	6758400	325	42.6	9207000	379
42.71	6765000	325	42.7	9216000	379
42.75	6771600	325	42.7	9225000	379
42.79	6778200	325	42.7	9234000	380
42.83	6784800	325	42.8	9243000	380

42.87	6791400	326	42.8	9252000	380
42.92	6798000	326	42.9	9261000	380
42.96	6804600	326	42.9	9270000	380
43.00	6811200	326	43.0	9279000	381
43.04	6817800	326	43.0	9288000	381
43.08	6824400	326	43.0	9297000	381
43.12	6831000	326	43.1	9306000	381
43.17	6837600	327	43.1	9315000	381
43.21	6844200	327	43.2	9324000	381
43.25	6850800	327	43.2	9333000	382
43.29	6857400	327	43.2	9342000	382
43.33	6864000	327	43.3	9351000	382
43.37	6870600	327	43.3	9360000	382
43.42	6877200	328	43.4	9369000	382
43.46	6883800	328	43.4	9378000	383
43.50	6890400	328	43.5	9387000	383
43.54	6897000	328	43.5	9396000	383
43.58	6903600	328	43.5	9405000	383
43.62	6910200	328	43.6	9414000	383
43.67	6916800	329	43.6	9423000	383
43.71	6923400	329	43.7	9432000	384
43.75	6930000	329	43.7	9441000	384
43.79	6936600	329	43.7	9450000	384
43.83	6943200	329	43.8	9459000	384
43.87	6949800	329	43.8	9468000	384
43.92	6956400	329	43.9	9477000	385
43.96	6963000	330	43.9	9486000	385
44.00	6969600	330	44.0	9495000	385
44.04	6976200	330	44.0	9504000	385
44.08	6982800	330	44.0	9513000	385
44.12	6989400	330	44.1	9522000	385
44.17	6996000	330	44.1	9531000	386
44.21	7002600	331	44.2	9540000	386
44.25	7009200	331	44.2	9549000	386
44.29	7015800	331	44.2	9558000	386
44.33	7022400	331	44.3	9567000	386
44.37	7029000	331	44.3	9576000	387
44.42	7035600	331	44.4	9585000	387
44.46	7042200	331	44.4	9594000	387
44.50	7048800	332	44.5	9603000	387
44.54	7055400	332	44.5	9612000	387
44.58	7062000	332	44.5	9621000	387
44.62	7068600	332	44.6	9630000	388
44.67	7075200	332	44.6	9639000	388
44.71	7081800	332	44.7	9648000	388
44.75	7088400	333	44.7	9657000	388
44.79	7095000	333	44.7	9666000	388
44.83	7101600	333	44.8	9675000	389
44.87	7108200	333	44.8	9684000	389
44.92	7114800	333	44.9	9693000	389

44.96	7121400	333	44.9	9702000	389
45.00	7128000	333	45.0	9711000	389
45.04	7134600	334	45.0	9720000	389
45.08	7141200	334	45.0	9729000	390
45.12	7147800	334	45.1	9738000	390
45.17	7154400	334	45.1	9747000	390
45.21	7161000	334	45.2	9756000	390
45.25	7167600	334	45.2	9765000	390
45.29	7174200	335	45.2	9774000	391
45.33	7180800	335	45.3	9783000	391
45.37	7187400	335	45.3	9792000	391
45.42	7194000	335	45.4	9801000	391
45.46	7200600	335	45.4	9810000	391
45.50	7207200	335	45.5	9819000	391
45.54	7213800	335	45.5	9828000	392
45.58	7220400	336	45.5	9837000	392
45.62	7227000	336	45.6	9846000	392
45.67	7233600	336	45.6	9855000	392
45.71	7240200	336	45.7	9864000	392
45.75	7246800	336	45.7	9873000	392
45.79	7253400	336	45.7	9882000	393
45.83	7260000	337	45.8	9891000	393
45.87	7266600	337	45.8	9900000	393
45.92	7273200	337	45.9	9909000	393
45.96	7279800	337	45.9	9918000	393
46.00	7286400	337	46.0	9927000	394
46.04	7293000	337	46.0	9936000	394
46.08	7299600	337	46.0	9945000	394
46.12	7306200	338	46.1	9954000	394
46.17	7312800	338	46.1	9963000	394
46.21	7319400	338	46.2	9972000	394
46.25	7326000	338	46.2	9981000	395
46.29	7332600	338	46.2	9990000	395
46.33	7339200	338	46.3	9999000	395
46.37	7345800	339	46.3	10008000	395
46.42	7352400	339	46.4	10017000	395
46.46	7359000	339	46.4	10026000	396
46.50	7365600	339	46.5	10035000	396
46.54	7372200	339	46.5	10044000	396
46.58	7378800	339	46.5	10053000	396
46.62	7385400	339	46.6	10062000	396
46.67	7392000	340	46.6	10071000	396
46.71	7398600	340	46.7	10080000	397
46.75	7405200	340	46.7	10089000	397
46.79	7411800	340	46.7	10098000	397
46.83	7418400	340	46.8	10107000	397
46.87	7425000	340	46.8	10116000	397
46.92	7431600	341	46.9	10125000	397
46.96	7438200	341	46.9	10134000	398
47.00	7444800	341	47.0	10143000	398

47.04	7451400	341	47.0	10152000	398
47.08	7458000	341	47.0	10161000	398
47.12	7464600	341	47.1	10170000	398
47.17	7471200	341	47.1	10179000	399
47.21	7477800	342	47.2	10188000	399
47.25	7484400	342	47.2	10197000	399
47.29	7491000	342	47.2	10206000	399
47.33	7497600	342	47.3	10215000	399
47.37	7504200	342	47.3	10224000	399
47.42	7510800	342	47.4	10233000	400
47.46	7517400	342	47.4	10242000	400
47.50	7524000	343	47.5	10251000	400
47.54	7530600	343	47.5	10260000	400
47.58	7537200	343	47.5	10269000	400
47.62	7543800	343	47.6	10278000	400
47.67	7550400	343	47.6	10287000	401
47.71	7557000	343	47.7	10296000	401
47.75	7563600	344	47.7	10305000	401
47.79	7570200	344	47.7	10314000	401
47.83	7576800	344	47.8	10323000	401
47.87	7583400	344	47.8	10332000	402
47.92	7590000	344	47.9	10341000	402
47.96	7596600	344	47.9	10350000	402
48.00	7603200	344	48.0	10359000	402
48.04	7609800	345	48.0	10368000	402
48.08	7616400	345	48.0	10377000	402
48.12	7623000	345	48.1	10386000	403
48.17	7629600	345	48.1	10395000	403
48.21	7636200	345	48.2	10404000	403
48.25	7642800	345	48.2	10413000	403
48.29	7649400	345	48.2	10422000	403
48.33	7656000	346	48.3	10431000	403
48.37	7662600	346	48.3	10440000	404
48.42	7669200	346	48.4	10449000	404
48.46	7675800	346	48.4	10458000	404
48.50	7682400	346	48.5	10467000	404
48.54	7689000	346	48.5	10476000	404
48.58	7695600	347	48.5	10485000	404
48.62	7702200	347	48.6	10494000	405
48.67	7708800	347	48.6	10503000	405
48.71	7715400	347	48.7	10512000	405
48.75	7722000	347	48.7	10521000	405

APPENDIX F DRAFT ENVIRONMENTAL COVENANT

After Recording Return

Original Signed Covenant to: ¹

Jeremy Schmidt, P.E.

Toxics Cleanup Program

Department of Ecology

Eastern Regional Office

4601 N. Monroe Street

Spokane, WA 99205-1295

Environmental Covenant

(For MTCA Sites – August 20, 2015 Version)

Grantors: BNSF Railway Company (BNSF) ²

Grantee: State of Washington, Department of Ecology (hereafter “Ecology”)

Brief Legal Description: Generally congruent with property located at 3202 East Wellesley Avenue in Spokane, Spokane County, Washington

Tax Parcel Nos.: BNSF parcels #35032.4401 and #35032.4501 and

Cross Reference: Consent Decree (CD) No. 19203114-32 (2019) between BNSF, Marathon Oil Company, and Ecology. Marathon Oil Company’s obligations for this project are being performed by Husky Oil Operations Limited (HOOL). Prior to CD was Agreed Order No. 9188.

RECITALS ³

a. This document is an environmental (restrictive) covenant (hereafter “Covenant”) executed pursuant to the Model Toxics Control Act (“MTCA”), chapter 70.105D RCW, and Uniform Environmental Covenants Act (“UECA”), chapter 64.70 RCW.

b. The Property that is the subject of this Covenant is part or all of a site commonly known as “BNSF Railway Black Tank Property Site,” Facility Site Identification (ID) No. 98615712. The Property is legally described in Exhibit A, and illustrated in Exhibit B, both of which are attached (hereafter “Property”). If there are differences between these two Exhibits, the legal description in Exhibit A shall prevail.

c. Portions of the Property are the subject of remedial action conducted under MTCA. Exhibit C illustrates the portions of the Property affected by this Covenant (hereafter the “Affected Property”). This Covenant is required because residual contamination will remain on the Affected Property during and after completion of remedial actions. Specifically, the following principal contaminants will remain on the Affected Property: ⁴

¹ Some counties keep the original Covenant, others don’t. If the signed original is available, it must be sent to Ecology. If the signed original is not available, send a legible copy to Ecology.

² The Grantor of a Covenant typically is the fee simple land owner of the property. The Grantor may also include holders of other property interests such as a holder of an easement, right-of-way, mineral right, lien, or mortgage.

³ This section is primarily used to describe this document and its purpose. It should not be used for substantive binding provisions.

⁴ List the contaminants for the associated media. If more than a few are present, list the top three to five for each medium.

NOTE: BNSF is working to refine the extent of property impacted and evaluating various ownership interests.

Medium	Principal Contaminants Present
Soil	TPH-D/HO, LNAPL, cadmium, cPAHs, and naphthalenes
Groundwater	TPH-D/HO, LNAPL
Surface Water/Sediment	None

d. It is the purpose of this Covenant to restrict certain activities and uses of the Property to protect human health and the environment and the integrity of remedial actions conducted at the site. Records describing the extent of residual contamination and remedial actions conducted are available through Ecology. This includes a Remedial Investigation and Feasibility Study (RI/FS), Cleanup Action Plan (CAP), Surface Soil Interim Action Completion Report, and Engineering Design Report.

e. This Covenant grants Ecology certain rights under UECA and as specified in this Covenant. As a Holder of this Covenant under UECA, Ecology has an interest in real property, however, this is not an ownership interest which equates to liability under MTCA or the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. § 9601 *et seq.* The rights of Ecology as an “agency” under UECA, other than its’ right as a holder, are not an interest in real property.

COVENANT

BNSF, as Grantor⁵ and FEE SIMPLE, EASEMENT OR OTHER owner of the Property hereby grants to the Washington State Department of Ecology, and its successors and assignees, the following covenants. Furthermore, it is the intent of the Grantors that such covenants shall supersede any prior interests the GRANTORS have in the property and run with the land and be binding on all current and future owners of any portion of, or interest in, the Property.

Section 1. General Restrictions and Requirements.

The following general restrictions and requirements shall apply to the Property:

a. **Interference with Remedial Action.** The Grantors shall not engage in any activity on the Property that may impact or interfere with the remedial action and any operation, maintenance, inspection or monitoring of that remedial action without prior written approval from Ecology.

b. **Protection of Human Health and the Environment.** The Grantors shall not engage in any activity on the Property that may threaten continued protection of human health or the environment without prior written approval from Ecology. This includes, but is not limited to, any activity that results in the release of residual contamination that was contained as a part of the remedial action or that exacerbates or creates a new exposure to residual contamination remaining on the Property.

⁵ If there is more than one Grantor, use the term “Grantors” here and throughout this document.

c. Continued Compliance Required. Grantors shall not convey any interest in any portion of the Property without providing for the continued adequate and complete operation, maintenance and monitoring of remedial actions and continued compliance with this Covenant.

d. Leases. Grantors shall restrict any lease for any portion of the Property to uses and activities consistent with this Covenant and notify all lessees of the restrictions on the use of the Property.

e. Preservation of Reference Monuments. Grantors shall make a good faith effort to preserve any reference monuments and boundary markers used to define the areal extent of coverage of this Covenant. Should a monument or marker be damaged or destroyed, Grantors shall have it replaced by a licensed professional surveyor within 30 days of discovery of the damage or destruction.

Section 2. Specific Prohibitions and Requirements.

In addition to the general restrictions in Section 1 of this Covenant, the following additional specific restrictions and requirements shall apply to the Property.

a. Land use - BNSF's property is zoned Light Industrial, and WSDOT's easement is zoned Center and Corridor Core, which allows for many types of uses including commercial, office, residential, and parks.

b. Containment of soil/waste materials – Any drilling or excavation on the site is prohibited for purposes other than (i) remediation or (ii) construction, operation or maintenance of the North Spokane Corridor (NSC) Project or interstate railroad facilities.

c. Stormwater facilities – To minimize the potential for mobilization of contaminants remaining in the soil and groundwater on the Property, no stormwater infiltration facilities or ponds shall be constructed over any portion of the LNAPL plume (the high, medium, and low RTF areas) on the affected Property as illustrated in Exhibit C. All stormwater catch basins, conveyance systems, and other appurtenances located over these areas shall be of water-tight construction.

d. Vapor/gas controls – Not applicable.

e. Groundwater use – The groundwater beneath the property remains contaminated and shall not be extracted for any purpose other than temporary construction dewatering, investigation, monitoring or remediation. Drilling of a well for any water supply purpose is strictly prohibited. Groundwater extracted from the Affected Property for any purpose shall be considered potentially contaminated and any discharge of this water shall be done in accordance with state and federal law.

f. Sediments – Not applicable.

g. Monitoring – Any monitoring of groundwater for purposes other than remediation is prohibited. Several groundwater monitoring wells and vapor monitoring wells are located on the Affected Property to monitor the performance of the remedial action. The Grantors shall maintain clear access to these devices and protect them from damage. The Grantors shall report to Ecology within forty-eight (48) hours of the discovery of any damage to any monitoring device. Unless Ecology approves of an alternative plan in writing, the Grantors shall promptly repair the damage and submit a report documenting this work to Ecology within thirty (30) days of completing the repairs.

h. Other. – Not applicable.

Section 3. Access.

a. The Grantors shall maintain clear access to all remedial action components necessary to construct, operate, inspect, monitor and maintain the remedial action.

b. The Grantors freely and voluntarily grants Ecology and its authorized representatives, upon reasonable notice for security and safety purposes and subject to Ecology and its authorized representatives' compliance with railroad safety procedures, the right to enter the Property at reasonable times to evaluate the effectiveness of this Covenant and associated remedial actions, and enforce compliance with this Covenant and those actions, including the right to take samples, inspect any remedial actions conducted on the Property, and to inspect related records.

c. No right of access or use by a third party to any portion of the Property is conveyed by this instrument.

Section 4. Notice Requirements.

a. **Conveyance of Any Interest.** The Grantors, when conveying any interest in the Affected PROPERTY DESCRIBED AND ILLUSTRATED IN EXHIBIT C, including but not limited to title, easement, leases, and security or other interests, must:

- i. Provide written notice to Ecology of the intended conveyance at least thirty (30) days in advance of the conveyance.⁶
- ii. Include in the conveying document a notice in substantially the following form, as well as a complete copy of this Covenant:

NOTICE: THIS PROPERTY IS SUBJECT TO AN ENVIRONMENTAL COVENANT GRANTED TO THE WASHINGTON STATE DEPARTMENT OF ECOLOGY ON [DATE] AND RECORDED WITH THE SPOKANE COUNTY AUDITOR UNDER RECORDING NUMBER [RECORDING NUMBER]. USES AND ACTIVITIES ON THIS PROPERTY MUST COMPLY WITH THAT COVENANT, A COMPLETE COPY OF WHICH IS ATTACHED TO THIS DOCUMENT.

- iii. Unless otherwise agreed to in writing by Ecology, provide Ecology with a complete copy of the executed document within thirty (30) days of the date of execution of such document.

b. **Reporting Violations.** Should the Grantors become aware of any violation of this Covenant, Grantors shall promptly report such violation in writing to Ecology.

c. **Emergencies.** For any emergency or significant change in site conditions resulting in a violation of this Covenant, the Grantors are authorized to respond to such an event in accordance with state and federal law. The Grantors must notify Ecology in writing of the event and response actions planned or taken as soon as practical but no later than within 24 hours of the discovery of the event.

⁶ Ecology may waive this notice provision for some units at a Property where the anticipated use is a multi-tenant/owner building where some owners or tenants are unlikely to be exposed to residual contamination. For example: upper story apartments or condominiums, or commercial tenants in a strip mall, with limited rights to use the grounds under and around the building (such as for parking).

If Ecology agrees to such a waiver, the circumstances of the waiver must be detailed in paragraph 4.a.i. In addition to the specific circumstances, this provision must include the following statement: "Waiver of this advance notice to Ecology for these transactions does not constitute waiver of this notice for the entire Property nor a waiver of the requirement in Section 4.a.ii. to include this notice in any document conveying interest in the Property."

d. Notification procedure. Any required written notice, approval, reporting or other communication shall be personally delivered or sent by first class mail to the following persons. Any change in this contact information shall be submitted in writing to all parties to this Covenant. Upon mutual agreement of the parties to this Covenant, an alternative to personal delivery or first class mail, such as e-mail or other electronic means, may be used for these communications.

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Shane DeGross BNSF Railway Company 605 Puyallup Avenue Tacoma, WA 98134 (253) 591-2567 Shane.DeGross@BNSF.com	Environmental Covenants Coordinator Washington State Department of Ecology Toxics Cleanup Program P.O. Box 47600 Olympia, WA 98504 – 7600 (360) 407-6000 ToxicsCleanupProgramHQ@ecy.wa.gov
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Section 5. Modification or Termination.

a. Grantors must provide written notice and obtain approval from Ecology at least sixty (60) days in advance of any proposed activity or use of the Property in a manner that is inconsistent with this Covenant.⁷ For any proposal that is inconsistent with this Covenant and permanently modifies an activity or use restriction at the site:⁸

i. Ecology must issue a public notice and provide an opportunity for the public to comment on the proposal; and

ii. If Ecology approves of the proposal, the Covenant must be amended to reflect the change before the activity or use can proceed.

b. If the conditions at the site requiring a Covenant have changed or no longer exist, then the Grantors may submit a request to Ecology that this Covenant be amended or terminated. Any amendment or termination of this Covenant must follow the procedures in MTCA and UECA and any rules promulgated under these chapters.⁹

Section 6. Enforcement and Construction.

a. This Covenant is being freely and voluntarily granted by the Grantors.

b. Within ten (10) days of execution of this Covenant, Grantors shall provide Ecology with an original signed Covenant and proof of recording and a copy of the Covenant and proof of recording to others required by RCW 64.70.070.

c. Ecology shall be entitled to enforce the terms of this Covenant by resort to specific performance or legal process. All remedies available in this Covenant shall be in addition to any and all remedies at law or in equity, including MTCA and UECA. Enforcement of the terms of this Covenant shall be at the discretion of Ecology, and any forbearance, delay or omission to exercise its rights under this Covenant in the event of a breach of any term of this Covenant is

⁷ Example of inconsistent uses are using the Property for a use not allowed under the covenant (i.e. mixed residential and commercial use on a property restricted to industrial uses), OR drilling a water supply well when use of the groundwater for water supply is prohibited by the covenant.

⁸ An example of an activity that is unlikely to be considered a permanent modification is a proposal to disturb a cap to repair an existing underground utility that passes through the site. However, installing a new underground utility within a capped area would be a permanent change.

⁹ As time passes, the original grantor and other signers of the Covenant may no longer exist as viable entities. This provision is intended to allow future amendments or termination of the Covenant without Ecology having to seek court authorization, as provided by RCW 64.70.100.

not a waiver by Ecology of that term or of any subsequent breach of that term, or any other term in this Covenant, or of any rights of Ecology under this Covenant.

d. The Grantors shall be responsible for all costs associated with implementation of this Covenant. Furthermore, the Grantors, upon request by Ecology, shall be obligated to pay for Ecology's costs to process a request for any modification or termination of this Covenant and any approval required by this Covenant.

e. This Covenant shall be liberally construed to meet the intent of MTCA and UECA.

f. The provisions of this Covenant shall be severable. If any provision in this Covenant or its application to any person or circumstance is held invalid, the remainder of this Covenant or its application to any person or circumstance is not affected and shall continue in full force and effect as though such void provision had not been contained herein.

g. A heading used at the beginning of any section or paragraph or exhibit of this Covenant may be used to aid in the interpretation of that section or paragraph or exhibit but does not override the specific requirements in that section or paragraph.

h. Neither Ecology nor Grantors intend to include any third party beneficiaries with enforcement rights under this Covenant.

g. By signing this Covenant, the BNSF does not intend to affect the scope of existing preemption under federal law, including but not limited to the Interstate Commerce Commission Termination Act, 49 U.S.C. § 100501.

[GRANTOR'S SIGNATURE BLOCK FOR ORIGINAL COVENANTS]

Each person who signs must have a separate signature block and applicable notary acknowledgment. Repeat as many times as necessary.

Holders of other property interests must either sign the amended Covenant as a GRANTOR or sign the subordination agreement in Exhibit D.

The undersigned Grantor warrants he/she holds the title **[to the Property] OR [to an (Easement/Right of Way/etc.) on the Property]** and has authority to execute this Covenant.

EXECUTED this _____ day of _____, 20____.

_____ **[SIGNATURE]** _____

by: _____ **[PRINTED NAME]** _____

Title: _____

Insert one of the following, as applicable after each signature. See example format on page after next:

INDIVIDUAL ACKNOWLEDGMENT

CORPORATE ACKNOWLEDGMENT

REPRESENTATIVE ACKNOWLEDGEMENT

INDIVIDUAL ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** is the individual described herein and who executed the within and foregoing instrument and signed the same at **his/her** free and voluntary act and deed for the uses and purposes therein mentioned.

Notary Public in and for the State of Washington ¹⁰
Residing at _____
My appointment expires _____

CORPORATE ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** is the _____ of the corporation that executed the within and foregoing instrument, and signed said instrument by free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that **he/she** was authorized to execute said instrument for said corporation.

Notary Public in and for the State of Washington ¹⁵
Residing at _____
My appointment expires _____

REPRESENTATIVE ACKNOWLEDGEMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** signed this instrument, on oath stated that **he/she** was authorized to execute this instrument, and acknowledged it as the _____ [TYPE OF AUTHORITY] of _____ [NAME OF PARTY BEING REPRESENTED] to be the free and voluntary act and deed of such party for the uses and purposes mentioned in the instrument.

Notary Public in and for the State of Washington ¹⁵
Residing at _____
My appointment expires _____

¹⁰ Where landowner is located out of state, replace with appropriate out-of-state title and location.

[ECOLOGY'S SIGNATURE BLOCK]

The Department of Ecology, hereby accepts the status as GRANTEE and HOLDER of the above Environmental Covenant.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

_____ **[SIGNATURE]** _____

by: _____ **[PRINTED NAME]** _____

Title: _____

Dated: _____

STATE ACKNOWLEDGMENT

STATE OF _____

COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** is the _____ of the state agency that executed the within and foregoing instrument, and signed said instrument by free and voluntary act and deed, for the uses and purposes therein mentioned, and on oath stated that **he/she** was authorized to execute said instrument for said state agency.

Notary Public in and for the State of Washington

Residing at _____

My appointment expires _____

Exhibit A

LEGAL DESCRIPTION

DRAFT

NOTE: BNSF is working to refine the extent of property impacted and is evaluating various ownership interests.

Parcel Number: 35032.4501

MINNEHAHA ADDITION NORTH BEG AT NE COR OF LT 6, BK 108, TH S ALG E LNS OF STS 6 & 7 OF BK 108 TO SE COR OF LT 7, TH W ALG S LN OF LT 7 & ALG SD S LN EXTENDED W ACROSS RALPH ST TO SE COR OF BK 109, THS ALG E LN OF BK 109 EXTENDED S ACROSS HOFFMAN AVE TO NE COR BK 102, TH CONTINUING S ALG E LN OF BK 102 TO SE COR OF BK 102, TH W ALG S LN OF BK 102 TO SE COR OF LT 7 IN SD BK 102, TH S ALG E LN OF SDLT 7 EXTENDED S ACROSS HEROY AVE TO NE COR OF LT 3 OF BK 95, TH CONTINUING S ALG E LNS OF LTS 3, 4, 5, 6 & 7 OF BK 95 & ACROSS LONGFELLOW AVE TO NE COR OF LT 3 OF BK 88 & CONTINUING S ALG E LNS OF LTS 3, 4, 5, 6 & 7 OF BK 88 & ACROSS RICH AVE TO NE COR OF LT 3 OF BK 81, TH W ALG N LN OF LT 3 TO NW COR OF SD LT 3 OF BK 81, TH N ACROSS RICH AVE TO SW COR OF BK 88, TH CONTINUING N ALG W LNS OF BKS 88, 95, 102 & 109 A ALG SD W LNS EXTENDED ACROSS LONGFELLOW AVE & HEROY AVE & HOFFMAN AVE TO NW COR OF BK 109, TH E ALG N LN OF BK 109 & ALG SD N LN EXTENDED ACROSS RALPH ST TO NW COR OF LT 6 OF BK 108 & ALG N LN OF SD LT 6 TO POB & INCLUDING ALL STREETS & AVENUES & ALLEYS CONTAINED WITHIN THE ABOVE DESCRIPTION

Parcel Number: 35032.4401

MINNEHAHA ADDITION NORTH BEG AT NE COR OF LT 6, BLK 108; TH S ALG E LNS OF LTS 6 & 7 OF BLK 108 TO SE COR OF LT 7; TH W ALG S LN OF LT 7 & ALG SD S LN EXTENDED W ACROSS RALPH ST TO SE COR OF BLK 109; TH S ALG E LN OF BLK 109 EXTENDED S ACROSS HOFFMAN AVE TO NE COR OF BLK 102; TH CONTINUING S ALG E LN OF BLK 102 TO SE COR OF BLK 102; TH W ALG S LN OF BLK 102 TO SE COR OF LT 7 IN SD BLK 102; TH S ALG E LN OF SD LT 7 EXTENDED S ACROSS HEROY AVE TO NE COR OF LT 3 OF BLK 95; TH CONTINUING S ALG E LNS OF LOTS 3, 4, 5, 6, & 7 OF BLK 95 & ACROSS LONGFELLOW AVE TO NE COR OF LT 3 OF BLK 88 & CONTINUING S ALG E LNS OF LTS 3, 4, 5, 6, & 7 OF BLK 88 & ACROSS RICH AVE TO NE COR OF LT 3 OF BLK 81; TH W ALG N LN OF LT 3 TO NW COR OF SD LT 3 & OF SD BLK 81; TH S ALG W LN OF BLK 81 TO SW COR OF BLK 81; TH E ALG S LN OF SD BLK TO SE COR OF SD BLK 81; TH N ALG E LN OF BLK 81 & ALG SD E LN EXTENDED N ACROSS RICH AVE TO SE COR OF BLK 88; TH E ALG S LN EXTENDED E OF BLK 88 ACROSS RALPH ST TO SW COR OF BLK 89; TH CONTINUING E ALG S LNS OF BLKS 89 & 90 & ALG SD S LNS EXTENDED ACROSS THOR ST TO SE COR OF BLK 90; TH N ALG E LNS OF BLKS 90, 93, 104, & 107 & ALG SD E LNS EXTENDED ACROSS LONGFELLOW AVE & HEROY AVE & HOFFMAN AVE TO NE COR OF BLK 107; TH W ALG N LNS OF BLKS 107 & 108 & ALG SD N LNS EXTENDED ACROSS THOR ST TO NE COR OF LT 6 OF BLK 108 & POB & INCLUDING ALL THE STREETS & AVENUES & ALLEYS CONTAINED WITHIN THE ABOVE DESCRIPTION NOW FULLY VACATED.

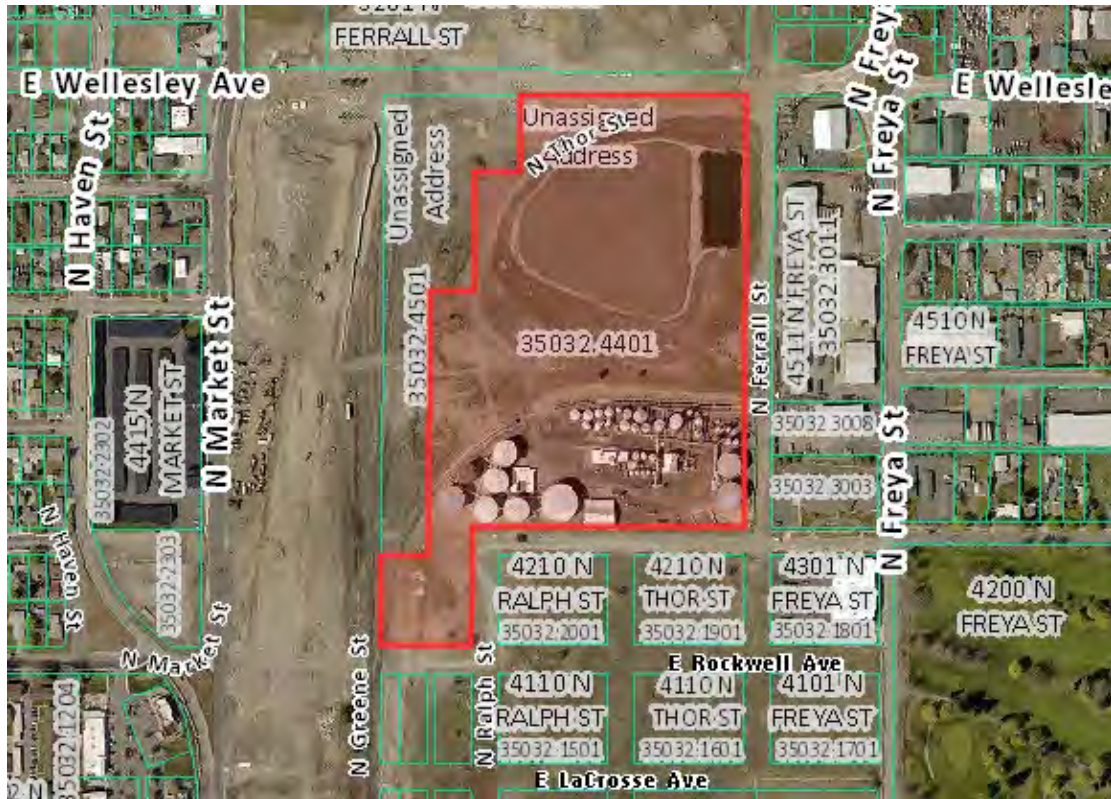
Exhibit B

PROPERTY MAP

DRAFT

NOTE: BNSF is working to refine the extent of property impacted and is evaluating various ownership interests.

Parcel No. 35032.4401



Parcel No. 35032.4501

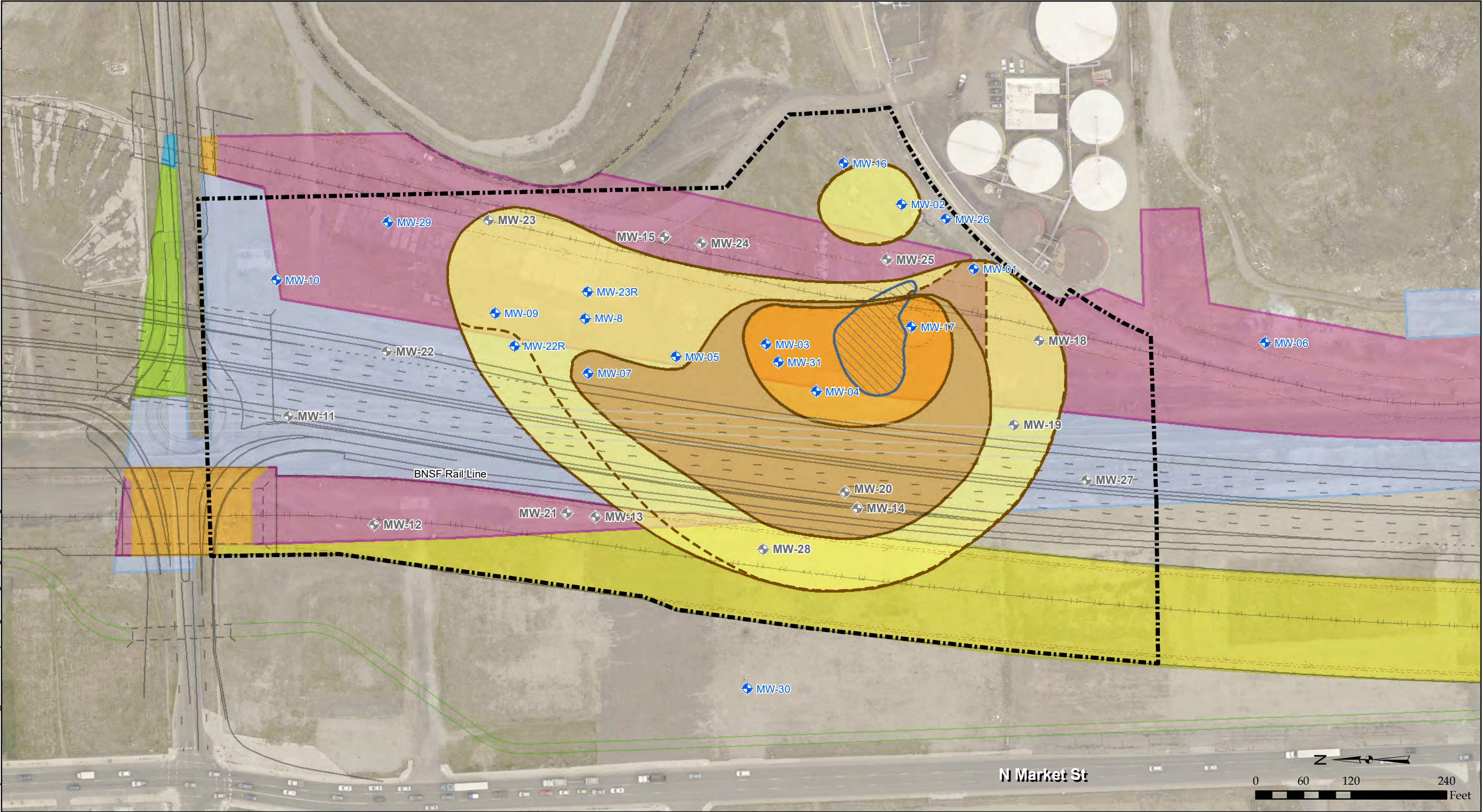


Exhibit C

MAP ILLUSTRATING LOCATION OF RESTRICTIONS

DRAFT

M:\Projects\BNSF\BNSF BlackTank\maps\Engineering Design Report\Figure Exhibit C Site Layout Easements.mxd
Drawn By: Kara Batdorff Date: 2/11/2021 Project: 0197977



Legend

- | | | | |
|---|------------------------------|---|--------------------|
| Monitoring Well | Low RTF Area | BNSF Perm. Easement to WSDOT | Bridge |
| Monitoring Well - Abandoned September 2019 | Location of Restrictions | BNSF TCE | Fence |
| TPH-D/HO in Intermediate Soil Exceeding the CUL | Alta Area | WSDOT Proposed Highway Alignment (2018 Version) | Pedestrian Pathway |
| High RTF Area | BN Leasing Crossing Easement | Proposed Railroad Alignment | Ditch |
| Medium RTF Area | BN Leasing Perm. Easement | Centerline | Curb/Sidewalk |
| | BNSF Crossing Easement | | |

Notes:
1 Alignment subject to change
CUL = Cleanup Level
LNAPL = Light Non-Aqueous Phase Liquid
RTF: Restoration Timeframe
NSC = North Spokane Corridor
TPH-D/HO = Combined Diesel and Heavy Oil-Range Petroleum Hydrocarbons
CUL = 5,360 milligrams per kilogram
WSDOT = Washington State Department of Transportation
Aerial Photo: Spokane Image Consortium, 2018.

Exhibit C of Environmental Covenant
Site Layout and Location of Restrictions
Engineering Design Report
BNSF Black Tank
Spokane, Washington

Exhibit D**SUBORDINATION AGREEMENT**

KNOW ALL PERSONS, That ___ [HOLDER'S NAME] ___, the owner and holder of that certain ___ [INSTRUMENT – E.G. EASEMENT/ROW/MORTGAGE/ETC.] ___ bearing the date the _____ day of ___ [MONTH] ___, ___ [YEAR] ___, executed by ___ [NAME OF PERSON THAT GRANTED THE INTEREST BEING SUBORDINATED] ___, ___ [LEGAL STATUS OF ORIGINAL GRANTOR – E.G. LANDOWNER, CORPORATE OFFICER, ETC.] ___, and recorded in the office of the County Auditor of ___ [COUNTY] ___ County, State of Washington, on ___ [DATE] ___, under Auditor's File Number _____, does hereby agree that said Instrument shall be subordinate to the interest of the State of Washington, Department of Ecology, under the environmental (restrictive) covenant dated ___ [DATE] ___, executed by ___ [NAME OF PERSON SIGNING THIS SUBORDINATION AGREEMENT] ___, and recorded in ___ [COUNTY] ___ County, Washington under Auditor's File Number _____.

_____ [SIGNATURE] _____

by: _____ [PRINTED NAME] _____

Title: _____

Dated: _____

Insert one of the following, as applicable. See example format on next page:

INDIVIDUAL ACKNOWLEDGMENT

CORPORATE ACKNOWLEDGMENT

REPRESENTATIVE ACKNOWLEDGEMENT

INDIVIDUAL ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** is the individual described herein and who executed the within and foregoing instrument and signed the same at **his/her** free and voluntary act and deed for the uses and purposes therein mentioned.

Notary Public in and for the State of Washington ¹¹
Residing at _____
My appointment expires _____

CORPORATE ACKNOWLEDGMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** is the _____ of the corporation that executed the within and foregoing instrument, and signed said instrument by free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that **he/she** was authorized to execute said instrument for said corporation.

Notary Public in and for the State of Washington ¹⁶
Residing at _____
My appointment expires _____

REPRESENTATIVE ACKNOWLEDGEMENT

STATE OF _____
COUNTY OF _____

On this _____ day of _____, 20____, I certify that _____ personally appeared before me, acknowledged that **he/she** signed this instrument, on oath stated that **he/she** was authorized to execute this instrument, and acknowledged it as the _____ [TYPE OF AUTHORITY] of _____ [NAME OF PARTY BEING REPRESENTED] to be the free and voluntary act and deed of such party for the uses and purposes mentioned in the instrument.

Notary Public in and for the State of Washington ¹⁶
Residing at _____
My appointment expires _____

¹¹ Where landowner is located out of state, replace with appropriate out-of-state title and location.