Revised Feasibility Study

BOEING KENT SPACE CENTER FACILITY

South 208th Street

KENT, WASHINGTON

May 2025

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ACRONYMNS AND ABBREVIATIONS

AO	Agreed Order No. DE 12820
AOCs	Areas of Concern
As^{3+}	Trivalent arsenic
Boeing	The Boeing Company
CCR	Covenants, Conditions, and Restrictions
COCs	Contaminants of Concern
CPOC	Conditional Point of Compliance
CWA	Federal Clean Water Act
DCA	Disproportionate Cost Analysis
DOF	Dalton, Olmsted, and Fuglevand
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management Database
EPA	Environmental Protection Agency
Fe^{2+}	Ferrous iron
Fe^{3+}	Ferric iron
FS	Feasibility Study
FFS	Focused Feasibility Study
ISCR	In-Situ Chemical Reduction
mg/Kg	milligram per kilogram
mg/L	milligram per liter
MNA	Monitored Natural Attenuation
MTCA	Model Toxics Control Act
NDP	North Detention Pond
NHPA	National Historic Preservation Act of 1966
NPDES	National Pollutant Discharge Elimination System
ORP	Oxidation-Reduction Potential
PMEP	Permanent to the Maximum Extent Practicable
POC	Point of Compliance
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
REDOX	Reduction-Oxidation
RI	Revised Remedial Investigation Report
SEPA	State Environmental Policy Act
Site	Boeing Kent Space Center
SPOC	Standard Point of Compliance
SWMUs	Solid Waste Management Units
SWPPP	Stormwater Pollution Prevention Plan
TOC	Total Organic Carbon
µg/L	microgram per liter
UIC	Underground injection Control
US	United States
WAC	Washington Administrative Code
ZVI	Zero Valent Iron

1.0 INTRODUCTION

This Revised Focused Feasibility Study (FFS) was prepared by Dalton, Olmsted, and Fuglevand (DOF) on behalf of the Boeing Company (Boeing). The Boeing Kent Space Center (Site) is located in Kent, Washington on approximately 121 acres, bounded by South 208th Street to the south, 68th Avenue South to the east, South 199th Place to the north, and by 59th Place South and a large distribution center to the west as shown in Figure 1. The Washington State Department of Ecology (Ecology) facility site identification number is 2099 and the Cleanup Site Identification number is 12671.

As specified in Boeing's Agreed Order No. DE 12820 (AO; Ecology 2016) with the Washington State Department of Ecology (Ecology), Boeing completed a Revised Remedial Investigation Report (RI) to assess the nature and extent of contamination at the Site (DOF, 2022a). For facilities where the results of the RI indicate a potential risk is present for human health and the environment, the Model Toxics Control Act (MTCA) regulations specify that a feasibility study (FS) must be conducted to identify appropriate remedial actions needed to control or mitigate the potential risks.

In a letter to Boeing in June 2022 (Ecology, 2022b), Ecology requested that Boeing:

- Prepare a FFS on arsenic to evaluate a monitored natural attenuation (MNA) remedy and environmental covenant; and
- Propose additional data collection in support of the FS related to arsenic present in groundwater at the Site.

In Ecology's 2022 RI communications (Ecology, 2022a) Ecology agreed that Boeing has adequately evaluated all contaminants of concern (COCs) except arsenic in groundwater. Ecology concurred with Boeing that hydrocarbon releases from petroleum source areas may have contributed to groundwater REDOX condition changes and that elevated arsenic concentrations in groundwater could have resulted from changes in groundwater geochemistry. Boeing submitted the Revised RI to Ecology in November 2022 and acknowledged Ecology's request to conduct a FS to evaluate a MNA remedy for arsenic in groundwater.

A Feasibility Study Work Plan (DOF, 2022b) was prepared to document the planned approach for completing the FS and address data collection activities requested by Ecology after submittal of the RI and in preparation for completion of the FS. That work plan was approved by Ecology on May 15, 2023, and the AO was amended on August 3, 2023, to include the requirement that Boeing submit:

> A focused feasibility study that meets the requirements of WAC 173-340-350 and includes the following:
>
> 1. An analysis of cleanup alternatives for arsenic in groundwater and affected media in the migration pathways identified in the final Revised Remedial Investigation Report.
> 2. Collection and presentation of relevant site characterization data to delineate the Facility's arsenic re-adsorption zone.
> 3. An evaluation of a MNA remedy.
> 4. An evaluation of the need for institutional controls, including environmental covenants, for the Facility.

Data collection under the FS Work Plan (pre requirement 2 of the AO amendment) was conducted between October 2023 and June 2024.

This FS addresses arsenic in groundwater as the COC, affected media, and migration pathways identified in the final RI report. As discussed in Ecology's June 2022 letter regarding the need for a FS and in the FS Work Plan, the scope of the FS is limited to evaluating an MNA remedy and environmental covenant for the site since source removal of potential petroleum sources has already been performed.

1.1 Report Organization

The FS is organized into the following sections:

- **Section 1.0 – Introduction.** This section presents a general overview of the Facility and describes the general document organization.
- **Section 2.0 – Background and Characterization Summary**. This section summarizes the information contained in the RI as it pertains to the FS.
- **Section 3.0** – **Cleanup Goals** This section outlines the scope of the FS and defines the cleanup goals.
- **Section 4.0 - Remediation Considerations**. This section presents site-specific factors that may affect performance of the FS.
- **Section 5.0** – **Regulatory Requirements**. This section is an overview of the regulatory requirements related to this site and how those regulations will be considered in the FS.
- **Section 6.0** – **Remedial Alternatives Development**. This section outlines the remedial alternatives considered in the FS.
- **Section 7.0 – Evaluation of Remedial Alternatives**. This section evaluates the alternatives and describes the preferred remedial alternative.
- **Section 8.0 – Closing and Limitations.**
- **Section 9.0 – References.**

2.0 BACKGROUND AND CHARACTERIZATION SUMMARY

This section summarizes site information discussed in the RI Report and the additional data collected during the pre-FS investigation in 2023 and 2024.

2.1 Site Description

The Site occupies approximately 121 acres with 26 parcels of land; 12 of these parcels are currently owned by Boeing and operated by Boeing Defense, Space and Security. Thirteen parcels of land were sold by Boeing to Pacific Gateway (also referred to as Panattoni) in 2019. A separate parcel was sold by Boeing to the Boeing Tennis Club (a separate non-profit organization) in 2022. The current layout of the site is shown in Figure 1.

The Site is located in the Green River Valley. The Green River is located approximately 0.3 miles west of the Site. The average elevation of the Site is approximately 25 to 30 feet above mean sea level. Surface topography at and in the vicinity of the Site is generally level and slopes slightly toward the Green River to the west-northwest (USGS, 1995). The Site is zoned I1 for Industrial Business District and I2 for Mixed Industrial District.

The Site is currently operating under a Resource Conservation and Recovery Act (RCRA) interim-status permit issued by the US Environmental Protection Agency (EPA). Boeing seeks to remove the Facility from coverage under the permit and entered into the AO with Ecology, the administrator of the RCRA corrective action program, as part of that process. Work conducted under the AO is managed by the Boeing Remediation Group under project manager Bo Cherry.

2.2 Site Geology and Hydrogeology

Geology at the site is consistent with conditions anticipated for this part of the Green River valley. The site is relatively flat, and soil types are predominantly sand, sandy silts, and silt. Shallow groundwater is present at approximately 7 to 11 feet below ground surface and the elevation of the water table varies seasonally by several feet. Groundwater flows predominantly to the north, but flat, varying in flow direction from northwest to northeast with a slow groundwater flow rate measured between 30 and 70 feet per year.

Groundwater is not currently a source of drinking water at the Site. Groundwater and stormwater at the Site discharge to Mill Creek during the wet season and heavy precipitation events. Stormwater from the North Detention Pond flows through a stormwater ditch and stormwater conveyances to Mill Creek. Mill Creek and regional groundwater discharge to the Green River approximately 3.5 miles north of the Site. Mill Creek has been the focus of several historical studies that found it did not meet Surface Water Quality criteria under Washington Administrative Code (WAC)173-201A-200 that would be expected to support aquatic life, nor did it meet recreational use levels.

2.3 Nature and Extent of Contamination

Soil, soil vapor, ambient air, indoor air, groundwater, stormwater, and stormwater conveyance system sediment samples were collected as part of the RI and concurrent due diligence investigations. The majority of samples did not reveal concentrations above screening levels and no new sources of contamination were identified. The nature and extent of contamination at individual Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) were each investigated. Where releases or sources were identified, they have been addressed, and the RI did not identify any instances of unaddressed contamination that presents an unacceptable risk to human health or the environment at any SWMU or AOC.

Arsenic concentrations in groundwater collected as part of the RI varied widely, from less than 2 to 266 µg/L. The highest concentrations are present, in general, at the shallowest depths of approximately 10 to 15 feet below ground surface. No other contaminants of concern were identified for consideration in the FS.

As documented in the RI, the historical, pre-development agricultural land surface at the Site received airborne arsenic fallout from the ASARCO smelter. In addition, hydrocarbon releases have occurred in the past that likely affected reduction-oxidation (REDOX) conditions across the Site. However, multiple interim remedial efforts were conducted at the Site to remove affected soil as described in the RI. Total organic carbon (TOC) in native soils also likely promotes REDOX conditions in the shallow groundwater which allows native and ASARCO-plume arsenic in the soil to mobilize in shallow groundwater. These conditions result in variable dissolved arsenic concentrations across the Site and in the larger area. Ecology has recognized similar conditions in the Kent valley (DOF, 2022a).

Appendix B includes several figures from the RI that show the historical dissolved arsenic concentrations. As shown, dissolved arsenic concentrations vary widely across the Site, even for samples taken relatively close together, or in areas that have only been used as parking lots. Stormwater was also sampled for arsenic several times as part of the RI. Samples were collected from the North Detention Pond (NDP) as well as several outfall locations near Mill Creek. Results of stormwater sampling showed much lower arsenic concentrations ranging from not detected to 0.562 µg/L, as would be expected if the oxidation condition has a strong influence on the dissolved phase concentrations.

Recent groundwater results collected as part of the FS confirmed results of the RI, and verified that arsenic concentrations at the northernmost downgradient monitoring well installed (MW-14) and wells closest to Mill Creek (MW-15 and MW-16) are below the preliminary cleanup level. Additional information about FS data are described in the following section.

2.4 Pre-Feasibility Study Data Collection

Boeing collected additional data in support of the FS to further evaluate the nature and extent of arsenic concentrations in groundwater. Five additional groundwater monitoring wells (MW-13, -14, -15, -16, and -17) were installed at the Site in 2023 as shown in Figure 2 and were sampled along with the existing groundwater monitoring well network. These samples were particularly focused on evaluating the downgradient areas of anticipated arsenic re-adsorption, and near stormwater management or surface water features. As discussed in the RI, dissolved arsenic concentrations likely correlate with TOC, ferrous iron, and oxidation-reduction potential (ORP). Microbial degradation of TOC is likely responsible for establishing and maintaining REDOX conditions, which is conducive to the dissolution of arsenic and is present in the shallow groundwater of the Site.

Ecology determined that Boeing adequately evaluated all COCs except arsenic in groundwater. After approval of the FS Work Plan Boeing collected additional groundwater data to support this focused Feasibility Study for arsenic in groundwater. Five additional groundwater monitoring wells were installed in 2023, and four rounds of groundwater sampling were performed in 2023 and 2024. The following subsections describe well installation, additional groundwater monitoring, and the analytical methods used during the Pre-Feasibility Study Data collection effort.

2.4.1 Groundwater Monitoring Well Installation

Boeing installed five additional groundwater monitoring wells to further evaluate Site-wide groundwater geochemistry and its effect on dissolved arsenic concentrations. This work was reported to Ecology in Progress Report No. 46 (Boeing, 2023a). Figure 2 shows the location of the existing monitoring well network at the Site.

During drilling, soil samples were collected for inspection and geologic classification, and to document the shallow subsurface stratigraphy. Select soil samples from each of the new well locations were submitted for the analysis of TOC and arsenic, per the FS Work Plan. Copies of the boring and well construction logs are included in Appendix A.

2.4.2 Groundwater Monitoring Results

Boeing conducted quarterly groundwater monitoring events utilizing existing wells during four groundwater monitoring rounds during 2023 and 2024. Results were reported to Ecology as part of regular Bimonthly Reports, as results were received, and uploaded to EIM.

Boeing measured water levels at all monitoring wells and staff gauges and recorded the water level elevation at the NDP as well as the adjacent City of Kent's stormwater pond across all seasons for one year to aid in evaluating the groundwater flow direction and gradient. Figures 3 through 6 are maps showing the quarterly groundwater elevation contour maps during the year of additional data collection. Results showed similar patterns to those in the RI, with fairly flat groundwater flow generally northward during these events and seasonal variation near the NDP and the City of Kent stormwater ponds.

Table 1 summarizes the groundwater analytical results for the four quarters of groundwater monitoring that was completed as part the additional data collection task. Table 1 also lists historical data for all wells sampled during 2023 and 2024. Figure 7 shows the average arsenic concentration at each well for this monitoring period. Table 2 includes additional groundwater geochemical analytical data.

2.4.3 Soil Sampling Results

The soil sample results for arsenic, TOC and total solids are listed in Tables 3 and 4. Results were reported to Ecology as part of Progress Report No. 47 (Boeing, 2023b) and uploaded to EIM. These results show that arsenic is present at similar concentrations seen in soil samples that were collected during the RI. The TOC concentrations in the shallow soils ranged in concentration from 0.05 to 5.65 percent.

2.5 Arsenic Geochemistry

Arsenic is a heavy metal that can easily be dissolved and transported in groundwater under reducing conditions known to be prevalent both at the Site and the surrounding Green River valley. The primary control on reduction/oxidation is the presence of dissolved oxygen in a given groundwater sample. As expected, dissolved arsenic correlates with TOC, ferrous iron, and ORP at the Site because microbial degradation of TOC is likely responsible for establishing and maintaining REDOX conditions present in the shallow groundwater.

However, dissolved oxygen can be consumed by microbial degradation of organic carbon. Dissolved oxygen readings less than 1.0 mg/L are typically considered to represent anaerobic conditions. Dissolved oxygen readings at this Site are generally less than 1.0 mg/L and considered anaerobic.

ORP readings, typically measured in millivolts, are another indication of whether groundwater conditions are aerobic or anaerobic. Negative ORP readings are typical of anaerobic conditions. Under anaerobic conditions, insoluble ferric iron (Fe^{3+}) is converted to soluble ferrous (Fe^{2+}) iron. Ferrous iron concentrations at the Site vary from 2.5 mg/L to 107 mg/L, with arsenic concentrations corresponding to higher iron concentrations, as expected. ORP measurements at the Site collected from groundwater monitoring wells are typically negative. The majority of higher arsenic concentrations correspond to lower ORP values, as might be expected if anaerobic conditions are influencing arsenic concentrations. See Appendix B for graphical representations of these data previously presented in the RI.

Iron oxides containing arsenic can be dissolved in groundwater in the presence of total organic carbon, whether from naturally occurring organic matter (as in the case of former wetlands) or from anthropogenic sources of organic carbon, such as agricultural land use or releases of TPH. It is important to note that TOC concentrations in soil are typically reported in percentages, and that 1% TOC is equivalent to 10,000 mg/kg. TOC was measured in groundwater samples collected onsite during the RI and pre-FS with values ranging from less than 1 mg/L to 65 mg/L (Table 2). Arsenic is consistently found to be higher at locations where TOC was also higher at the Site.

Dissolved arsenic at the Site is likely to be predominantly present in the trivalent form and present as an uncharged hydroxy ion at negative ORP readings. The widespread presence of naturally occurring TOC, when degraded by microbial processes, establishes anaerobic conditions that solubilize ferrous iron and promote migration of dissolved arsenic species. Arsenic is less mobile under aerobic conditions because the charged arsenate species that predominate with higher oxygen concentrations are more easily adsorbed on aquifer materials, or on sediments (Herath, et al, 2016). This is shown by the low concentrations of arsenic present in the stormwater samples collected during the RI, which were orders of magnitude lower than those observed in groundwater.

Geochemistry, particularly TOC and REDOX, are expected to have a large influence on the extent of elevated arsenic concentrations in groundwater and re-adsorption downgradient of higher concentration areas.

2.6 2022 Ecology Regional Arsenic Evaluation

In 2022, Ecology released guidance concerning the natural background concentration of arsenic in groundwater in Washington State (Ecology, 2022c). The guidance discusses that arsenic geochemistry varies depending on climate and geology, and notes that the western United States has, in general, higher concentrations of dissolved arsenic in groundwater than other regions of the US.

The guidance notes that: "Groundwater arsenic concentrations > 10 µg/L are more typically the result of geochemical changes in iron oxide. Arsenic may be released by reactions of iron oxide with natural or anthropogenic organic carbon (e.g., petroleum products)." As discussed in the RI, the shallow soils at the Site have high concentrations of naturally occurring organic carbon due to their depositional environment. The anaerobic conditions promoted by this organic carbon correlate with dissolved arsenic mobilized in some areas of shallow groundwater at the Site.

The guidance also acknowledged: "In terms of higher naturally occurring arsenic levels, the key variables are typically: 1) groundwater geochemistry (reduced conditions), and 2) increased soil organic matter / content. If the groundwater is geochemically reduced (less than 50 mV oxidation- reduction potential), then it will oxidize the soil organic matter. This geochemical trigger results in the release of arsenic from iron oxides (reductive desorption and dissolution). Low- lying topography, with flat groundwater gradients, may also result in higher arsenic (i.e., not enough dilution; Smedley and Kinniburgh 2002)." The Site has both reduced conditions and low-lying topography with relatively flat groundwater gradients.

The Ecology study found statewide average natural background values of arsenic in groundwater to range from 4.9 to 15.4 µg/L, with a value of 8 µg/L assigned to the Puget Sound Basin (Ecology, 2022c).

2.7 Summary

In summary, the conceptual site model for arsenic at the Site shows:

- Arsenic is present in the Site soils at sporadic and variable concentrations and appears to be within the ranges of anthropogenic background values of regional and abutting areas.
- Soil and stormwater data do not indicate an arsenic release from operations of the KSC Site.
- Arsenic in shallow groundwater is mobilized due to anaerobic degradation of TOC, which favors the migration of dissolved arsenic as an uncharged hydroxy-complex in the trivalent (As^{3+}) form (Herath, et al, 2016).
- Geochemistry, particularly TOC and REDOX, are expected to have a large influence on the extent of elevated arsenic concentrations in groundwater and re-adsorption downgradient of higher concentration areas.
- Groundwater containing arsenic may discharge to offsite surface water via onsite storm water conveyances, or through groundwater discharge to offsite surface water. However, surface waters are aerobic, unlike the anaerobic groundwater, and the trivalent form of arsenic will convert to As(V) oxidation state and form negatively charged hydroxyions, which are likely to adsorb to particulate matter and mineral surfaces (Herath, et al, 2016).
- Concentrations of arsenic in groundwater at the most downgradient well and those closest to Mill Creek are already below the Ecology established regional natural background level of 8 µg/L.

3.0 CLEANUP GOALS

The cleanup goals for the Site were established in the FS Work Plan. The primary goal is to reduce the risks to human health and the environment resulting from arsenic in groundwater at the Site to acceptable levels.

Specifically, the cleanup goals for the Site include:

- Minimize infiltration and resultant leaching of arsenic to groundwater from the fill materials that may be a source of this COC.
- Prevent discharge of groundwater affected by arsenic at levels that may cause adverse effects to human health and the environment.

The remedial alternative recommended in this FFS will be designed to attain these goals. In addition, general cleanup goals applicable to the Site include:

- Support current and future industrial use of the property.
- Attain cleanup goals as soon as possible and cleanup standards within a reasonable time frame.
- Ensure institutional controls and compliance monitoring are put in place that: prohibit or limit activities that could interfere with the long-term integrity of the cleanup.

3.1 Local Land Use

The current and future use of the Site is industrial. Based on WAC 173-340-200, the Site is defined as "*industrial property*," meaning a property that has been characterized by, or is to be committed to, traditional industrial uses, and that is zoned for industrial use under land use planning under the Revised Code of Washington (RCW), Chapter 36.70A (Growth Management Act) or zoned for industrial use and adjacent to properties currently used or designated for industrial purposes. In addition, the following criteria established under WAC 173-340-745(1) for identification of an industrial property allow for establishing industrial soil cleanup standards for the Site if it is expected that the Site will remain in industrial land use for the foreseeable future:

- The primary potential exposure is to adult employees of businesses located on the industrial property.
- Access to the industrial property by the general public is not allowed or is highly limited and controlled.
- Food is not grown on the property.
- Operations are characterized by use and storage of chemicals, noise, odors, and truck traffic.
- The land surface is primarily covered by buildings, structures, and paving, minimizing potential exposure to the soil. Part of the Site is currently unimproved, but the majority of the Site is covered.

- Support facilities on the Site, such as offices and other facilities, are primarily intended to serve the industrial operations and not the general public.
- If necessary, additional institutional controls will be established at the Site in accordance with WAC 173-340-440 to limit potential exposure to residual hazardous substances. These institutional controls shall include, at a minimum, placement of a covenant on the property restricting use of areas impacted with hazardous substances to industrial property uses.

The Site is located within the City of Kent's designated manufacturing/industrial center. The City of Kent's Comprehensive Plan adopted implementing zoning regulations under the Growth Management Act (Chapter 36.60A. Revised Code of Washington), which designated a manufacturing/industrial center and discourages, and limits land uses other than manufacturing, high technology, and warehousing within the boundaries of the center.

Boeing is prepared to enter an environmental covenant for the property, as was completed for a portion of the property and for the Striker property, restricting the use of groundwater from the Site. Boeing plans to continue to operate under the ISGP as well, monitoring and maintaining the stormwater conveyance system at the Site for operations consistent with the industrial levels allowed under that permit.

3.2 Cleanup Levels

Ecology established a natural background value of 8 µg/L for the Puget Sound Basin as part of their published 2022 study results for Natural Background Groundwater Arsenic Concentrations in Washington State (Ecology, 2022c). This value was selected as the preliminary groundwater cleanup level for arsenic.

3.3 Point of Compliance

To develop and evaluate a reasonable range of cleanup alternatives in the FS, a point of compliance (POC) must be defined for contaminated sites. As defined in the MTCA regulations, the POC is the point or points at which cleanup levels must be attained. The POC, cleanup levels, and other applicable standards taken together define the cleanup standard. Sites that achieve the cleanup standards at the POC and comply with applicable state and federal laws are presumed to be protective of human health and the environment, as approved by Ecology. The POC is used in the FS for design and evaluation of potential remedial alternatives. After approval of the FS, the final POC will be incorporated into the design for the cleanup.

The MTCA regulations specify POCs for various media that may become contaminated. MTCA defines both the standard POC (SPOC) and the less stringent conditional POC (CPOC). The SPOC applies to all soil, groundwater, air, or surface water at or adjacent to any location where releases of hazardous substances have occurred or that has been impacted by releases from the location. A CPOC is usually defined only for groundwater, air, or surface water. A CPOC typically applies to a specific location as near as possible to the source of the release. Site-specific conditions determine whether the SPOC or CPOC would be appropriate for a site. Several requirements are specified in the MTCA regulations for establishing a CPOC, as discussed in more detail below. The most important criterion for approval of a CPOC is the practicality of attaining cleanup levels within a reasonable time frame.

A common situation for use of a CPOC is migration of contaminated groundwater beyond the property boundary. In this case, a CPOC is most frequently established at the property boundary beyond which contaminated groundwater has migrated. However, in certain instances a CPOC may be established beyond the property boundary if Ecology and any landowners located between the source area and the CPOC approve the CPOC before it can be incorporated into a final cleanup action.

The groundwater SPOC, as described in WAC 173-340-720(8)(b), would include all groundwater within the saturated zone beneath the Site and in any area affected by releases. Under WAC 173-340-720(8)(c), Ecology may approve use of a CPOC if the responsible person demonstrates that it is not practicable to attain the SPOC within a reasonable restoration time frame and that all practicable methods of treatment have been used. Groundwater cleanup levels would apply everywhere downgradient from the CPOC; groundwater cleanup levels could be exceeded upgradient from the CPOC. Under WAC 173-340-720(8)(c), a CPOC must be as close as practicable to the source of hazardous substances and not exceed the property boundary.

The CPOC must be located as close to the source area as practicable. At this Site, where groundwater's highest beneficial use is discharge to surface water, protectiveness of that beneficial use is dependent on meeting surface water based groundwater cleanup levels at the points where groundwater discharges to surface water. Therefore, a groundwater conditional point of compliance closer to surface water would achieve protection of the environment.

The practicability of meeting groundwater cleanup levels throughout the Site within a reasonable restoration time frame is determined in the screening of remedial alternatives prior to the more detailed comparison of remedial alternatives for determination of which alternative is permanent to the maximum extent practicable (PMEP). Based on a preliminary analysis it is impracticable to meet groundwater cleanup levels throughout the Site within a reasonable timeframe with a SPOC due to the geochemical conditions present at the Site as discussed in Section 2. As such, Ecology required preparation of a focused FS on arsenic to evaluate monitored natural attenuation. Treating the naturally occurring organic carbon across the entire Site would be the only way to address the reducing groundwater conditions that contribute to arsenic detected in groundwater.

A CPOC is proposed for use at the Site and incorporated in each remedial alternative.

4.0 REMEDIATION CONSIDERATIONS

The Site conditions must be considered when developing and evaluating potential remediation alternatives. Geochemical conditions, site development, and controls in place and planned in the future will affect the approach to arsenic remediation.

4.1 Site Use

The Site is located in an industrial park, and local planning and zoning supports continued similar types of land use. Boeing sold approximately half of the property to another party in 2019, and that portion of the Site has been redeveloped as an industrial and business park. Boeing sold a single parcel to the Boeing Tennis Club (a separate non-profit organization) in 2022. As part of the conditions of the property sales, Boeing filed Covenants, Conditions, and Restrictions (CCR) on the property that require the following:

- No sensitive land use (residential, school, daycare, hospital, assisted living, medical office, extended stay hotel) or agricultural use.
- No drinking water wells or other use of groundwater under the property.
- Provisions related to stormwater management and protection; severance of stormwater infrastructure between Sale and Retained Properties; and compliance with all applicable laws and permits.
- Soil over-excavation and vapor barriers are required for new buildings in the area of former industrial buildings 18-42 and 18-43; vapor intrusion evaluations are required for new buildings in other areas.
- Future Owners to take necessary steps to record and comply with restrictive covenants, institutional controls, and soil management plans if so required.

Similar controls are expected to be placed on the rest of the Site.

Groundwater is not currently a source of drinking water at the Site.

4.2 Previous Site Remediation

As mentioned in Section 2, the presence of TOC, whether naturally occurring or from anthropogenic sources, may affect geochemistry that then influences observed concentrations of arsenic at the Site. Ecology noted their concern regarding the consideration of TPH as an anthropogenic source at the Site in their 2022 RI communications (Ecology, 2022a). With regards to these sources, several small releases occurred, and cleanups have been completed at the Site to address those releases. No major unaddressed fuel or hydrocarbon releases are known to be present at the Site.

5.0 REGULATORY REQUIREMENTS

Regulatory requirements for general and site-specific aspects that the FFS will achieve are described in the following sections.

5.1 MTCA Requirements

The remedial alternative considered in the FFS was designed to comply with MTCA. The MTCA regulations (WAC 173-340-360) present the general requirements for selecting cleanup actions for a contaminated site. The minimum requirements applicable to all cleanup actions include specific threshold requirements and other requirements that must be met by all cleanup actions.

The threshold requirements specify that the cleanup action should:

- Protect human health and the environment including likely vulnerable populations and overburdened communities; (WAC 173-340-360(3)(a)(i));
- Comply with cleanup standards specified in WAC 173-340-700 through WAC 173-340-760 (WAC 173-340-360(3)(a)(ii));
- Comply with applicable state and federal laws (WAC 173-340-360(3)(a)(iii));
- Prevent or minimize present and future releases and migration of hazardous substances in the environment (WAC 173-340-360(3)(a)(iv));
- Provide resilience to climate change impacts that have a high likelihood of occurring and severely compromising its long-term effectiveness (WAC 173-340-360(3)(a)(v));
- Provide for compliance monitoring (see WAC 173-340-410 and Part 7 of WAC-340-360) (WAC 173-340-360(3)(a)(vi));
- Not rely primarily on institutional controls and monitoring at a site, or portion thereof, if it is technically possible to implement a more permanent cleanup action (WAC 173-340-360(3)(a)(vii));
- Not rely primarily on dilution and dispersion unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures over the benefits of dilution and dispersion. Determine the benefits and costs using the criteria in subsection (5)(d) of WAC-340-360 (WAC 173-340-360(3)(a)(viii));
- Provide for a reasonable restoration time frame (see subsection (4) of WAC-340-360) (WAC 173-340-360(3)(a)(ix)); and
- Use permanent solutions to the maximum extent practicable (see subsection (5) of WAC-340-360).

Action specific requirements cited in the MTCA regulations (WAC 173-340-360(3)(b)) specify that the cleanup action should:

- Use remediation levels in accordance with WAC 173-340-355;
- Use institutional controls in accordance with WAC 173-340-440;
- Provide financial assurances in accordance with WAC 173-340-440(11); and

- Provide for periodic reviews in accordance with WAC 173-340-420(2).

Of the media-specific requirements cited in the MTCA regulations (WAC 173-340-360(3)(c)), the following groundwater requirements apply:

- A groundwater cleanup action must be permanent (achieve groundwater cleanup levels at the standard point of compliance without further remedial action being required) if:
  - Such an action is practicable; or
  - Ecology determines such an action is in the public interest.
- A nonpermanent groundwater cleanup action must:
  - Treat or remove the source of groundwater contamination at sites where there are liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances, or hazardous substances that cannot be reliably contained; and
  - Contain contaminated groundwater to the maximum extent practicable to prevent lateral and vertical expansion of the groundwater volume affected by the hazardous substances and to prevent the migration of the hazardous substances. This includes barriers or hydraulic control through groundwater pumping, or both. Use remediation levels in accordance with WAC 173-340-355.

Specific requirements for public concerns as well as tribal rights and interests cited in the MTCA regulations (WAC 173-340-360(3)(d)) specify that the cleanup action should address:

- Public concerns, including the concerns of likely vulnerable populations and overburdened communities, identified under WAC 173-340-600 (13) and (14); and
- Indian tribes' rights and interests identified under WAC 173-340-620.

Restoration time frame is the time required to achieve the cleanup standard. The regulatory requirements for assessing the reasonableness of the restoration time for a cleanup action are described at WAC 173-340-360(4). In determining a reasonable restoration time frame, the following factors must be considered:

- Potential risks to human health and the environment , including likely vulnerable populations and overburdened communities (WAC 173-340-360(4)(c)(i));
- Practicability of achieving a shorter restoration time. A restoration time frame is not reasonable if an active remedial measure with a shorter restoration time frame is practicable (WAC 173-340-360(4)(c)(ii));
- Long-term effectiveness of the alternative. A longer restoration time frame may be reasonable if the alternative has a greater degree of long-term effectiveness than one that primarily relies on onsite or offsite disposal, isolation, or containment (WAC 173-340-360(4)(c)(iii));
- Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site (WAC 173-340-360(4)(c)(iv));

- Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site (WAC 173-340-360(4)(c)(v));
- Availability of alternative water supplies (WAC 173-340-360(4)(c)(vi));
- Likely effectiveness and reliability of institutional controls (WAC 173-340-360(4)(c)(vii));
- The ability to control and monitor the migration of hazardous substances from the Site (WAC 173-340-360(4)(c)(viii));
- The toxicity of the hazardous substances at the Site (WAC 173-340-360(4)(c)(ix));
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions (WAC 173-340-360(4)(c)(x)); and
- For Ecology-conducted or ecology-supervised remedial actions, public concerns identified under WAC 173-340-600 (13) and (14) and Indian tribes' rights and interests identified under WAC 173-340-620 conditions (WAC 173-340-360(4)(c)(xi)).

MTCA also requires determination whether a cleanup action uses permanent solutions to the maximum extent practicable (WAC 173-340-360(5)) including criteria for determining the benefits and costs of each cleanup action alternative. These criteria are discussed in Section 6.

5.2 Applicable or Relevant and Appropriate Regulations

In accordance with MTCA, all cleanup actions must comply with applicable state and federal laws (WAC 173-340-710[1]). MTCA defines applicable state and federal laws to include legally applicable requirements and those requirements that are relevant and appropriate. Collectively, these requirements are referred to as ARARs. This section provides a brief overview of potential ARARs for the Site cleanup. The primary ARAR is the MTCA cleanup regulation (WAC 173-340), which outlines requirements for the development of cleanup standards and procedures for development and implementation of a cleanup under MTCA. The requirements of this ARAR and other associated ARARs were followed and used in identifying, evaluating, and recommending a cleanup action alternative in this FFS.

Other ARARs that may be applicable to the cleanup action include the following:

- Federal RCRA regulations and the corresponding Washington regulations (WAC 173-303) involving hazardous waste management may pertain to waste identification, waste generation and transportation, land disposal restrictions, and treatment, storage, and disposal (TSD) facilities.
- Hazardous Waste Operations (WAC 296-843) would be used to establish safety requirements applicable to onsite cleanup activities and would be addressed in a Site health and safety plan prepared specifically for these activities.
- Federal Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) Permit and State Construction Stormwater General Permit may apply. Construction activities that disturb one or more acres of land typically need to obtain an NPDES Construction Stormwater General Permit from Ecology. Related Washington regulations are found in WAC 173-200. A

substantive requirement would be to prepare a stormwater pollution prevention plan (SWPPP) prior to earthwork activities. The SWPPP would document planned procedures designed to prevent stormwater pollution by controlling erosion of exposed soil and by containing soil stockpiles and other materials that could contribute pollutants to stormwater.

- State Environmental Policy Act (SEPA), RCW 43.21.036, WAC 197-11-250 through 268. Under the SEPA rules, MTCA and SEPA processes are to be combined to reduce duplication and improve public participation. Ecology is the lead agency for implementing the substantive requirements of SEPA as described in WAC 197-11-253. A SEPA checklist will be completed and attached to the Cleanup Action Plan.
- Underground Injection Control Program (WAC 173-218). Under WAC 173-160, underground injection control (UIC) registration would be required for the injection of any materials below ground surface for the purposes of groundwater cleanup.
- Washington Minimum Standards for Construction and Decommissioning Wells (WAC 173-160-381). Under WAC 173-160-381, Ecology or its delegated authority establishes requirements for the installation and decommissioning of monitoring wells that may occur as part of the cleanup.
- Historic and Cultural Resources Protection must be considered as part of remedy planning. This is required under SEPA and potentially applies under the National Historic Preservation Act of 1966 (NHPA); Indian Graves and Records (RCW 27.44); Archaeological Sites and Resources (RCW 27.53); and Archaeological Excavation and Removal Permit (WAC 25-48).

6.0 REMEDIAL ALTERNATIVES DEVELOPMENT

This section presents the criteria used to evaluate the potential remedial alternatives identified for the Site and select the preferred alternative. The remedial alternatives presented in were designed to attain the cleanup goals presented in Section 3.

6.1 Use of Permanent Solutions to the Maximum Extent Practicable

MTCA defines how to determine whether a cleanup action uses permanent solutions to the maximum extent practicable (WAC 173-340-360(5)). MTCA specifies that:

- Step 1-Determine the benefits and costs of each cleanup action alternative using the criteria in (d) of WAC 173-340-360(5).
- Step 2: Rank the cleanup action alternatives by degree of permanence. To determine the relative permanence of an alternative, consider the definition of a permanent cleanup action in WAC 173-340-200 and the criteria in (d)(ii) of WAC 173-340-360(5).
- Step 3: Identify the initial baseline alternative for use in the disproportionate cost analysis in Step 4.
- Step 4: Conduct a disproportionate cost analysis of the ranked list of cleanup action alternatives identified in Step 2. Use the cleanup action alternative identified in Step 3 as the initial baseline for the analysis.

6.2 Feasibility Study Evaluation Criteria

The MTCA regulations were followed to determine whether certain types of remediation are warranted at the Site following a disproportionate cost analysis as per WAC 173-340-360(5)(d). The following criteria are required to evaluate and compare the costs and benefits of each cleanup action:

- Protectiveness. The degree to which the alternative protects human health and the environment, including likely vulnerable populations and overburdened communities.
- Permanence. The degree to which the alternative permanently reduces the toxicity, mobility, or mass of hazardous substances.
- Effectiveness over the long term. The degree to which the alternative is likely to be effective over the long term, including for likely vulnerable populations and overburdened communities.
- Other Factors. When assessing the long-term effectiveness of the alternative, consider:
    - The degree of certainty that the alternative will be successful;
    - The reliability of the alternative during the period of time hazardous substances are expected to remain onsite at concentrations that exceed cleanup levels;
    - The resilience of the alternative to climate change impacts;
    - The magnitude of residual risk with the alternative in place; and
    - The effectiveness of controls required to manage treatment residues or remaining wastes.
- Hierarchy. When assessing the relative degree of long-term effectiveness of cleanup action components, the following types of components may be used as a guide, in descending order:

- Reuse or recycling;
- Destruction or detoxification;
- Immobilization or solidification;
- Onsite or offsite disposal in an engineered, lined and monitored facility;
- Onsite isolation or containment with attendant engineering controls; and
- Institutional controls and monitoring.

- Management of implementation risks. The risks to human health and the environment, including likely vulnerable populations and overburdened communities, associated with the alternative during construction and implementation, and the effectiveness of the alternative to manage such risks.
- Technical and administrative implementability.
- Costs. The costs of remedial actions necessary to implement the alternative.

All remedial alternatives provided in this FS meet the threshold requirements set forth under MTCA. In addition, the remaining portions of WAC 173-340-360(3)(c through d) identify further requirements to be addressed.

6.3 Remedial Alternatives

Three remedial alternatives were developed for this FS, as described in the sections below. Table 5 summarizes the cleanup actions for each of the alternatives.

6.3.1 Remedy Components Common to All Alternatives

All three remedial alternatives share several common elements, though the extent and timing of implementation will vary for each alternative. The three components below are common across each alternative, but implementation would vary based on the restoration time frame for each alternative.

- A CPOC located near the northern property boundary and the eastern property boundary (near Mill Creek);
- Institutional controls;
- Groundwater monitoring;

The NDP is an onsite stormwater feature that controls stormwater discharges to Mill Creek (the nearest surface water body) and eventually the Green River. The NDP is deeper than the adjacent City of Kent stormwater ponds and extends well below the water table. Groundwater level measurements and staff gauge measurements at SG-1 show that groundwater may seasonally discharge to the NDP and is routed to the Boeing facilities stormwater system (DOF, 2022a). Wells have been installed as close to the NDP as is practicable (MW-8 and MW-11). However, as shown in Figure 8 (and detailed in the RI) the groundwater flow direction changes seasonally and these wells are within the influence of the seasonal fluctuations. Overall groundwater flow is generally to the North, and the closest surface water body is Mill Creek to the east of the site and the Green River several miles north of the Site. Therefore, monitoring MW-12, MW-13, MW-14, MW-15, and MW-16 will be protective of offsite groundwater discharges.

Institutional controls are non-engineered instruments such as administrative and legal controls that help reduce the potential for human exposure to contamination and/or protect the integrity of the remedy, i.e., development restrictions. Institutional controls would be implemented following completion of the implementation phase of the selected remedial alternative and would be negotiated with Ecology to protect human health and the environment. Given that the Site includes active industrial and commercial facilities and that several buildings with contamination under them are actively in use, long term institutional controls and temporary institutional controls (for control during the remediation phases) are proposed for each alternative. Temporary institutional controls would be implemented to protect human health and the environment while remedial actions are underway. Once successful completion of remediation is confirmed, temporary institutional controls will be removed.

The long term institutional controls for the Site are expected to include:

- No sensitive land usage will be allowed (residential, school, daycare, hospital, assisted living, medical office, extended stay hotel) or agricultural use.
- No drinking water wells will be installed or operated or other possible uses of groundwater under the property.
- Existing pavement and stormwater facilities will be maintained and repaired as needed to ensure that stormwater does not infiltrate to groundwater.

Verification of groundwater remediation and MNA effectiveness would be implemented through a groundwater monitoring program. Duration and frequency of the program would be dependent on the selected remedial alternative and the alternative's effectiveness over time to obtain cleanup levels. Once successful completion of remediation is confirmed by groundwater monitoring, the groundwater component of the remedial action would be deemed complete. However, for every alternative longer term groundwater monitoring would be required to confirm stable long term trends (since non-anthropogenic TOC will remain at the Site).

Details of how each of these measures would be implemented for each alternative are provided in the sections below and in the associated tables, figures, and appendices describing each alternative.

6.3.2 Alternative 1 - Monitored Natural Attenuation

MNA is proposed as the primary remedial technology for Alternative 1 as it directly addresses dissolved arsenic in groundwater. As discussed in Section 2.5, arsenic geochemistry is sensitive to redox conditions. Groundwater at the Site is typically anaerobic so dissolved arsenic is the prevalent form of arsenic.

The MNA program will include:

- Groundwater monitoring from selected existing groundwater monitoring wells, as shown in Figure 10 for analysis of dissolved metals including arsenic, iron, and TOC.
- Recording general water quality measurements during groundwater sampling.
- Collection of groundwater elevation measurements from selected groundwater monitoring wells at the Site as well as the NDP.

Monitoring events will be conducted semi-annually for four years in the first and third quarters, with monitoring reduced to annual for years five and six, and a final sampling event planned in year 10 to confirm long term trends.

6.3.3 Alternative 2 – Biosparging

Biosparging is proposed as the primary remedial technology for Alternative 2 as it adds oxygen to the groundwater, changing the treated groundwater from anaerobic to aerobic conditions. As discussed in Section 2.5, arsenic geochemistry is sensitive to redox conditions, and biosparging will precipitate arsenic out of groundwater.

Alternative 2 will include:

- Air sparging for approximately 1,000 linear feet down to about 15 feet below ground surface as shown on Figure 11.
- Groundwater monitoring from selected existing groundwater monitoring wells, as shown in Figure 11 for analysis of dissolved metals including arsenic, iron, and TOC. Recording general water quality measurements during groundwater sampling.
- Collection of groundwater elevation measurements from selected existing groundwater monitoring wells at the Site as well as the NDP.

Biosparging spacing design was based on typical spacing necessary for the Site soil types and checked against spacing estimated by injection subcontractors. An approximate 30-foot radius of influence was assumed. Biosparging was assumed for two years but may need to be restarted depending on groundwater monitoring results.

Monitoring events will be conducted semi-annually for three years in the first and third quarters, with monitoring reduced to annual for years four and five, and a final sampling event planned in year eight to confirm long term trends.

6.3.4 Alternative 3 –In-Situ Chemical Reduction

In-situ chemical reduction (ISCR) utilizing zero valent iron (ZVI) is proposed as the primary remedial technology for Alternative 3 as it uses the existing reducing conditions to bind arsenic into iron complexes, precipitating the arsenic from Site groundwater.

Alternative 3 will include:

- Bench testing to determine ISCR substrate and dosing.
- Injection of a substrate, presumed to be ZVI, for approximately 1,000 linear feet down to about 15 feet below ground surface as shown on Figure 12.
- Groundwater monitoring from selected existing groundwater monitoring wells, as shown in Figure 12 for analysis of dissolved metals including arsenic, iron, and TOC. Recording general water quality measurements during groundwater sampling.
- Collection of groundwater elevation measurements from selected existing groundwater monitoring wells at the Site as well as the NDP.

ISCR spacing design was based on typical spacing necessary for the Site soil types and checked against spacing estimated by injection subcontractors. Two rows of injections with approximately seven-foot on center spacing was assumed.

Monitoring events will be conducted semi-annually for two years in the first and third quarters, with monitoring reduced to annual for years three, four, and five to confirm long term trends.

7.0 EVALUATION OF REMEDIAL ALTERNATIVES

In the amended Agreed Order (Ecology, 2023) Ecology said that a remedial alternative that included MNA should be included in a focused Feasibility Study. The MNA remedial alternatives in Section 6.0 are compared to the MTCA ranking criteria in the following sections.

Each of the alternatives is compared to the criteria under MTCA (WAC 173-360(5)(d)). Each alternative was scored based on professional judgement of how technologies would likely perform in the context of available Site data and general technology performance data.

A summary of the rankings is provided in Table 6 with more detailed analysis provided in Table 7. While Alternative 1 does not include an active treatment, monitoring data indicate that arsenic concentrations are stable or decreasing at the Site, and ongoing oxidation and precipitation of arsenic is occurring prior to reaching nearby surface water bodies.

7.1 Determination of the Baseline Alternative

MTCA requires the most permanent cleanup action be used as the baseline alternative in an FS (WAC 173-360(5)(c)(iii)). Permanence is defined as the degree to which the alternative permanently reduces the toxicity, mobility, or mass of hazardous substances (WAC 173-360(5)(d)(ii)), including:

(A) The adequacy of the alternative in destroying the hazardous substances;

(B) The reduction or elimination of hazardous substance releases and sources of releases;

(C) The degree of irreversibility of waste treatment process; and

(D) The characteristics and quantity of treatment residuals generated.

The most permanent cleanup action that is technically possible and not clearly impracticable under MTCA is Alternative 3, which provides ISCR treatment for arsenic in groundwater. Alternative 3 received a ranking of 9 out of 10 for permanence, because site specific effects on geochemistry is uncertain until bench testing can be completed. Alternative 1 received a 7, since MNA is a permanent remedy, but it is passive. While Alternative 2 received an 8 for permanence, scoring higher than MNA since its active, but lower than ISCR since it is counter to the reducing conditions present onsite.

7.2 Protectiveness

Protectiveness is defined as the degree to which the alternative protects human health and the environment, including likely vulnerable populations and overburdened communities (WAC 173-360(5)(d)(i)). When assessing protectiveness, the following must be considered:

(A) The degree to which the alternative reduces existing risks;

(B) The time required for the alternative to reduce risks at the Site and attain cleanup standards;

(C) The onsite and offsite risks remaining after implementing the alternative; and

(D) Improvement of the overall environmental quality.

The most protective cleanup action is Alternative 3, which provides the fastest and longest lasting treatment for arsenic in shallow groundwater. Alternative 3 received a 9/10 for protectiveness, because even though the technology has proved successful at many sites, until bench testing can be completed longevity and performance are uncertain. Alternative 1 received a 5, since it primarily relies on MNA but did not receive a 1, because current groundwater monitoring indicates limited risk to offsite receptors and risks to onsite receptors can be readily managed with institutional controls. While Alternative 2 received a 7 for protectiveness, scoring higher than MNA since it is more aggressive than MNA, but less than ISCR.

7.3 Permanence

As noted above, Alternative 3 is ranked as the most permanent of the alternatives since it removes or chemically destroys the most mass of arsenic while Alternative 1 is ranked as the least permanent (primarily since it relies on MNA). Alternative 2 is ranked in the middle, since it is actively treating groundwater, but is not as aggressive or long lasting as Alternative 3.

7.4 Long Term Effectiveness

Effectiveness over the long term is defined as the degree to which the alternative is likely to be effective over the long term, including for likely vulnerable populations and overburdened communities (WAC 173-360(5)(d)(iii)).

> (A) Factors. When assessing the long-term effectiveness of the alternative, the following must be considered:
>
> > (I) The degree of certainty that the alternative will be successful;
> > (II) The reliability of the alternative during the period of time hazardous substances are expected to remain onsite at concentrations that exceed cleanup levels;
> > (III) The resilience of the alternative to climate change impacts;
> > (IV) The magnitude of residual risk with the alternative in place; and
> > (V) The effectiveness of controls required to manage treatment residues or remaining wastes.
>
> (B) Hierarchy. When assessing the relative degree of long-term effectiveness of cleanup action components, the following types of components may be used as a guide, in descending order:
>
> > (I) Reuse or recycling;
> > (II) Destruction or detoxification;
> > (III) Immobilization or solidification;
> > (IV) Onsite or offsite disposal in an engineered, lined and monitored facility;
> > (V) Onsite isolation or containment with attendant engineering controls; and
> > (VI) Institutional controls and monitoring.

Since each of the alternatives rely on MNA and institutional controls for the upgradient areas of the Site, none of them received scores at the high end of the scale. Alternative 1, solely relying on MNA with institutional controls, was ranked the lowest with a score of 4. It was given a moderate score because monitoring data indicate effective management of risks.

Alternative 3 scores the highest (6), but does not get a 10, due to uncertainties in effectiveness given the geochemistry of the Site. Alternative 2 mostly relies on in-situ destruction of arsenic but is ranked in the middle due to uncertainties in overcoming Site-specific conditions (high TOC, etc.).

7.5 Management of Short-term Risks

Management of implementation risks is defined as the risks to human health and the environment, including likely vulnerable populations and overburdened communities, associated with the alternative during construction and implementation, and the effectiveness of the alternative to manage such risks (WAC 173-360(5)(d)(iv)).

Short term risks are higher for cleanup alternatives that are more aggressive and could lead to additional impacts on human health. For example, excavation and offsite disposal not only puts cleanup contractors at higher risk of exposure to contaminants but exposes the greater community to risks from the transport of the waste and additional greenhouse gases due to use of trucks for offsite disposal. In the case of the three alternatives considered in this FS, while injections of air or chemicals are occurring may get pushed into utility corridors or other new exposure pathways. So, Alternatives 2 and 3 score lower, with Alternative 3 scoring lowest due to the potential to mobilize contaminants and management of chemicals during injections. Alternative 1 is proposing the least amount of disturbance to the Site subsurface and no use of chemicals. Groundwater and stormwater monitoring also indicate that risks have been effectively managed to date, so Alternative 1 scores the highest. Alternative 2 scores the second lowest, as Biosparging installation requires the most excavation and offsite disposal.

7.6 Technical and Administration

Technical and administrative implementability is defined (WAC 173-360(5)(d)(v)) as the ability to implement the alternative with consideration of:

(A) The technical difficulty of designing, constructing, and otherwise implementing the alternative in a reliable and effective manner, regardless of cost;
(B) The availability of necessary offsite facilities, services, and materials;
(C) Administrative and regulatory requirements;
(D) Scheduling, size, and complexity;
(E) Monitoring requirements;
(F) Access for construction operations and monitoring; and
(G) Integration with existing facility operations and other current or potential remedial actions.

Managing disposal of large volumes of waste is administratively more complicated and challenging than implementing in-situ treatments with minimal waste generated. So, Alternative 2 scores low, with Alternative 3 scoring low as well due to the technical challenge of chemical substrate handling and injection. Alternative 1 has very little subsurface disturbance (so no impacts to Site operations) and requires no additional permitting, so it scores the highest. Alternative 2 scores the second highest, as implementation of biosparging is simple in comparison to relying on complex chemistry for reduction technologies. In addition, no underground injection control permit is required for injection of air into the subsurface.

7.7 Cost

Costs are defined as the costs of remedial actions necessary to implement the alternative (WAC 173-360(5)(d)(vi)), including:

(A) Construction costs, and

(B) Postconstruction costs including design life with future costs discounted using present worth analysis.

Detailed cost estimates are provided in Appendix C, and include implementation costs, recurring costs, and a Net Present Value (NPV) analysis.

Alternative 3 is by far the most costly of the alternatives, with an estimated NPV cost of approximately $1.2 million dollars. Alternative 1 is the least costly at approximately $250,000 dollars, with Alternatives 2 in the middle at approximately $580,000 dollars (Table 6).

A sensitivity analysis (Appendix C, Table C-17) of NPV cost includes potential scenarios of lower and higher costs for each alternative. Alternative 1 is the lowest cost in all scenarios, Alternative 2 the second lowest, and Alternative 3 the highest, even with more favorable starting assumptions.

7.8 Disproportionate Cost Analysis (DCA)

As noted in Section 7.1, Alternative 3 (ISCR) is the most permanent alternative (Table 6). The DCA was performed in accordance with MTCA using Alternative 3 as the baseline alternative.

7.8.1 First Iteration of the DCA

Alternative 2 (biosparging) is the next most permanent alternative (Table 6). So, for the first iteration of the DCA, the cost benefit ratio for Alternative 2 ($18.20) is compared to the baseline Alternative 3 ($35.20). Alternative 3 is not practicable because it is less cost-effective than the next most permanent Alternative 2. The baseline alternative's incremental costs are disproportionate to its incremental degree of benefits. Given that the benefit ratio is not close (Alternative 3 is almost twice as costly than Alternative 2), no additional sensitivity analysis is necessary.

7.8.2 Second Iteration of the DCA

Following the first iteration of the DCA, Alternative 2 (biosparging) is the new baseline alternative. The cost benefit ratio for Alternative 1 ($6.90) is compared to the new baseline Alternative 2 ($18.20). Alternative 2 is not practicable because it is less cost-effective than the next most permanent Alternative 1. NPV cost sensitivity analysis (Appendix C, Table C-17) provided that even under more conservative assumptions Alternatives 2 and 3 were significantly more costly, with little additional benefit.

7.9 Selection of the Preferred Remedial Alternative

Based on the DCA, Alternative 1 (MNA) is the most permanent remedial alternative to the maximum extent practicable and therefore the Preferred Alternative.

The Preferred Alternative for the Site, Alternative 1 (MNA), would attain cleanup goals, provide a permanent solution to the maximum extent practicable, with a reasonable restoration time frame, and takes into account public concerns (including vulnerable populations and overburdened communities). Specifically, the Preferred Alternative would:

- Protect human and ecological receptors by reducing arsenic concentrations in groundwater and meeting groundwater cleanup goals within a reasonable time frame.
- Support current and future industrial use of the property.

- Ensure institutional controls and compliance monitoring are put in place that prohibit or limit activities that could interfere with the long-term integrity of the cleanup.

In addition, the Preferred Alternative would provide:

- A reliable remediation approach using proven, robust sustainable technology with low long-term maintenance requirements.
- An approach that would create moderate short-term risks and have minimal potential for causing public concern about exposure to Site constituents during construction.

The Preferred Alternative 1 (MNA) would fully comply with MTCA with containment of contamination under WAC 173-340-360(2)(c)(ii) for groundwater, the Dangerous Waste Regulations (WAC 173-303), and the RCRA regulations.

8.0 CLOSING AND LIMITATIONS

Within the limitations of the agreed-upon scope of work, this assessment has been undertaken and performed in a professional manner in accordance with generally accepted practices, using the degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. Due to physical limitations inherent to this or any environmental assessment, DOF expressly do not warrant that the Site is free of pollutants or that all pollutants have been identified. No other warranties, express or implied, are made.

In preparing this report, DOF has relied upon documents provided by the others. Except as discussed within the report, DOF did not attempt to independently verify the accuracy or completeness of that information. To the extent that the conclusions in this report are based in whole or in part on such information, those conclusions are contingent on its accuracy and validity. DOF assumes no responsibility for any consequence arising from any information or condition that was concealed, withheld, misrepresented, or otherwise not fully disclosed or available to DOF.

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This report does not constitute legal advice. In addition, DOF makes no determination or recommendation regarding the decision to purchase, sell, or provide financing for this Site.

9.0 REFERENCES

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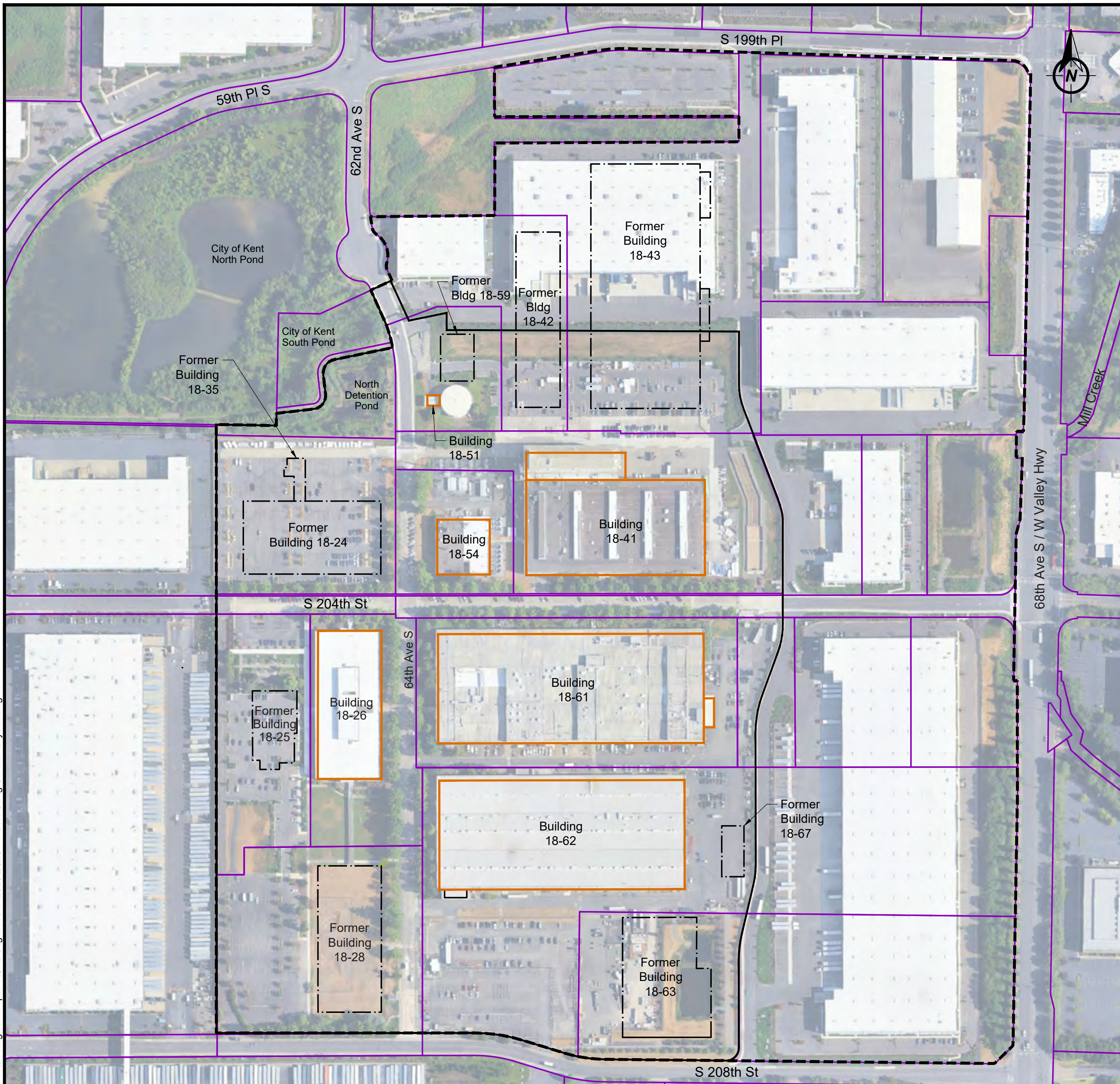
Figures



Source: Aerial Photography - Google Earth Pro, June 2024.

Notes:

Aerial Photography: Google Earth Pro, August 24, 2024.

Parcel Boundary Information: King County, Washington

Legend

- Site Boundary
- Boeing Property
- Parcel Boundary
- Current Building
- Former Building

0 400
Scale in Feet

Boeing Space Center
Kent, Washington
Focused Feasibility Study

Site Layout

DALTON OLMSTED FUGLEVAND

FIGURE 1

April 2025

PLOT TIME: 4/17/2025 9:57 AM MOD TIME: 4/17/2025 9:55 AM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\FS 2025\2025 FS BKSC Fig 01 Site Layout.dwg

Source: Aerial Photography - Google Earth Pro, June 2024.

Legend

MW-7 ⌖	Groundwater Monitoring Well/Measured	- - - -	Site Boundary
MW-3 ⌖	Abandoned Groundwater Monitoring Well	——	Boeing Current Property Boundary
SG-1 ⊞	Staff Gauge Measured Stormwater		

0 400
Scale in Feet

Boeing Space Center
Kent, Washington

Focused Feasibility Study

Groundwater Monitoring Well Locations

DOF DALTON OLMSTED FUGLEVAND

FIGURE 2

April 2025

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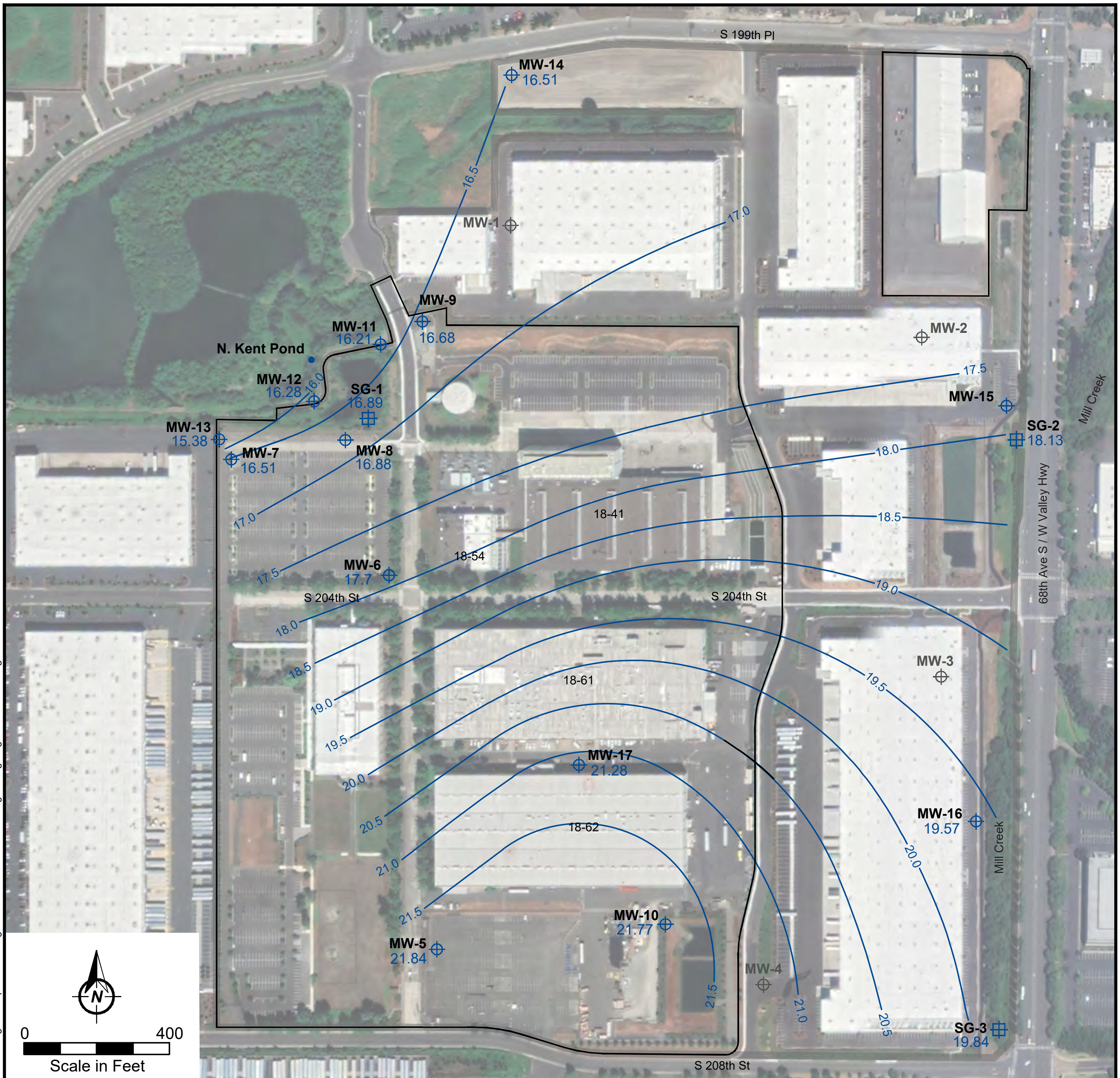


Source: Aerial Photography - Google Earth Pro, July 2022.

Legend

MW-7 16.51	Groundwater Monitoring Well/Measured Groundwater Elevation (Feet NAVD 88)
MW-3	Abandoned Groundwater Monitoring Well
SG-1 16.89	Staff Gauge Measured Stormwater or Surface Water Elevation (Feet NAVD 88)
•	Measured Stormwater Spot Elevation (Feet NAVD 88)
21.0 ——	Estimated Groundwater Elevation Contour
	Site Boundary
——	Boeing Current Property Boundary

Notes:

1. Water level at North Kent Pond was below ground level during monitoring event.
2. MW-15 was dry during monitoring event.
3. Stormwater/surface water elevations for informational purposes only.

Boeing Space Center
Kent, Washington

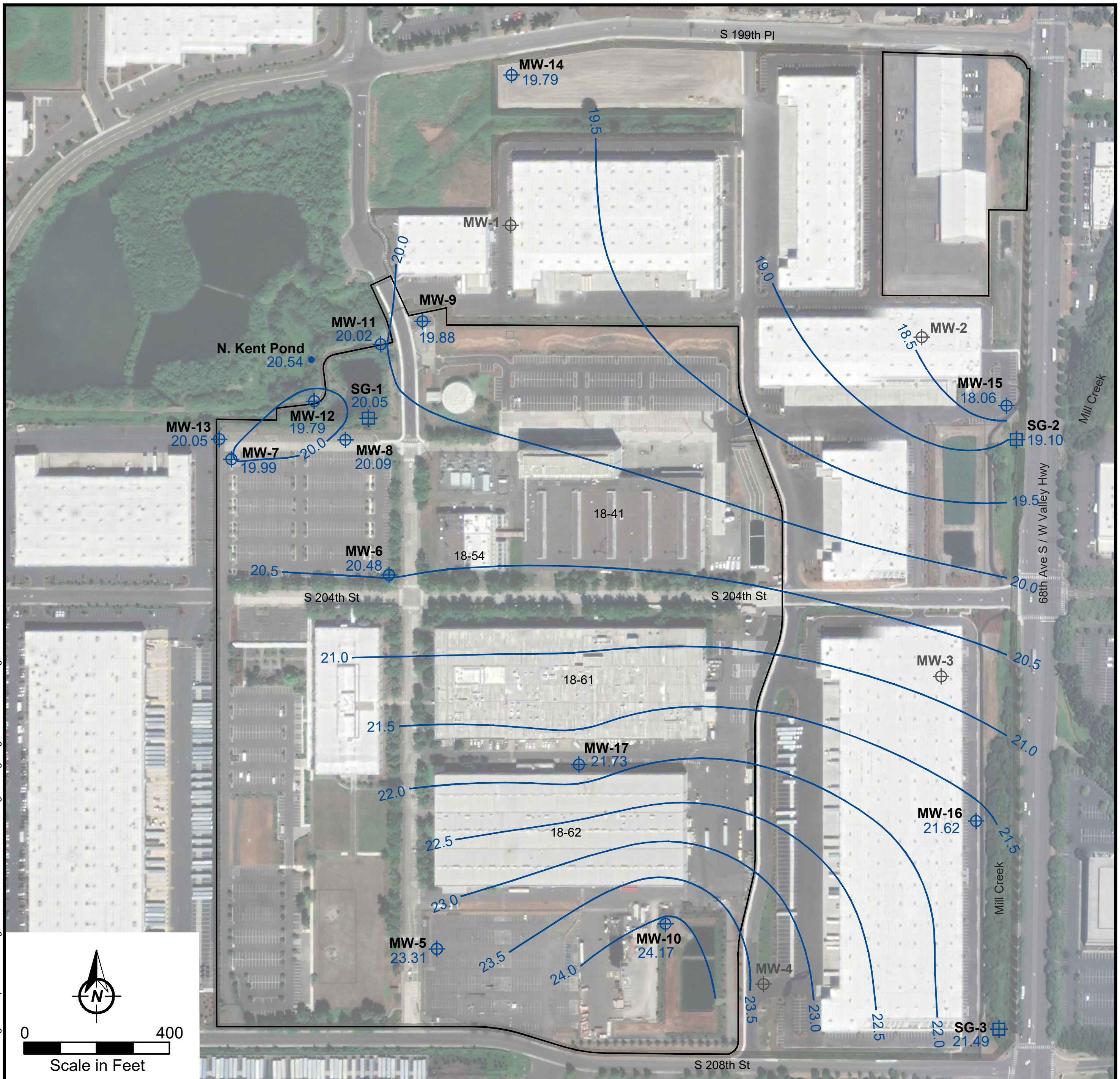
Focused Feasibility Study

Groundwater Elevation Map
August 2023

DOF DALTON OLMSTED FUGLEVAND

FIGURE 3

PLOT TIME: 11/8/2023 6:08 PM MOD TIME: 11/8/2023 6:07 PM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\2023-11\2023-11 Boeing SC Fig xx gw conts 2023.dwg



Source: Aerial Photography - Google Earth Pro, July 2022.

Legend

MW-7 19.99	Groundwater Monitoring Well/Measured Groundwater Elevation (Feet NAVD 88)
MW-3	Abandoned Groundwater Monitoring Well
SG-1 20.09	Staff Gauge Measured Stormwater or Surface Water Elevation (Feet NAVD 88)
•	Measured Stormwater Spot Elevation (Feet NAVD 88)
21.0	Estimated Groundwater Elevation Contour
	Site Boundary
	Boeing Current Property Boundary

Note:
1. Stormwater/surface water elevations for informational purposes only.

Boeing Space Center
Kent, Washington

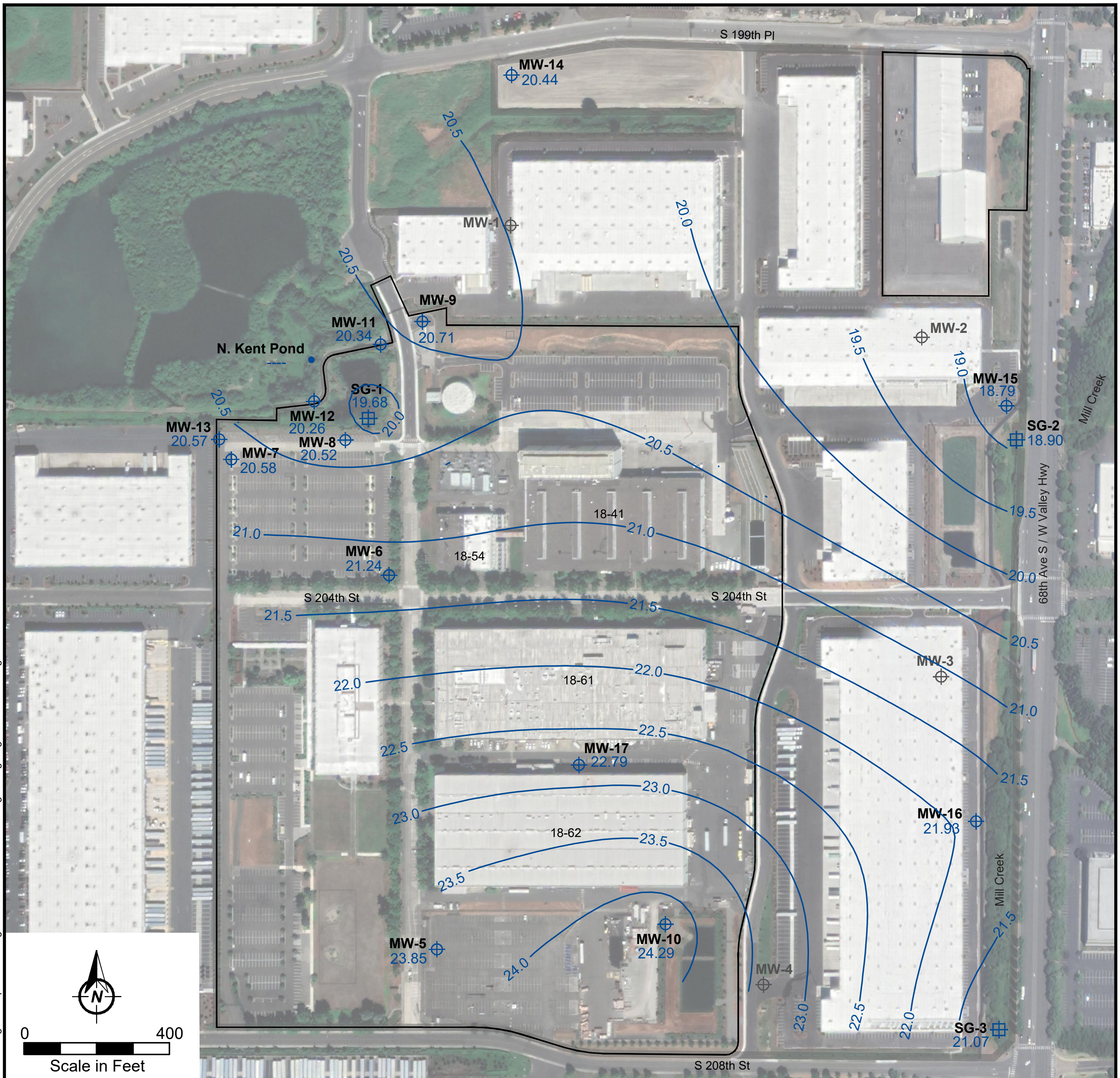
Focused Feasibility Study

Groundwater Elevation Map
November 17, 2023

DALTON OLMSTED FUGLEVAND

FIGURE 4

PLOT TIME: 1/10/2024 9:13 AM MOD TIME: 1/10/2024 9:11 AM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\2023-12\2023-12 Boeing SC Fig xx gw conts 2023.dwg



Source: Aerial Photography - Google Earth Pro, July 2022.

Legend

MW-7 20.58	Groundwater Monitoring Well/Measured Groundwater Elevation (Feet NAVD 88)
MW-3	Abandoned Groundwater Monitoring Well
SG-1 19.68	Staff Gauge Measured Stormwater or Surface Water Elevation (Feet NAVD 88)
•	Measured Stormwater Spot Elevation (Feet NAVD 88)
21.0	Estimated Groundwater Elevation Contour
	Site Boundary
	Boeing Current Property Boundary

Note:

1. Stormwater/surface water elevations for informational purposes only.
2. City of Kent Pond surface elevation not recorded during

Boeing Space Center
Kent, Washington

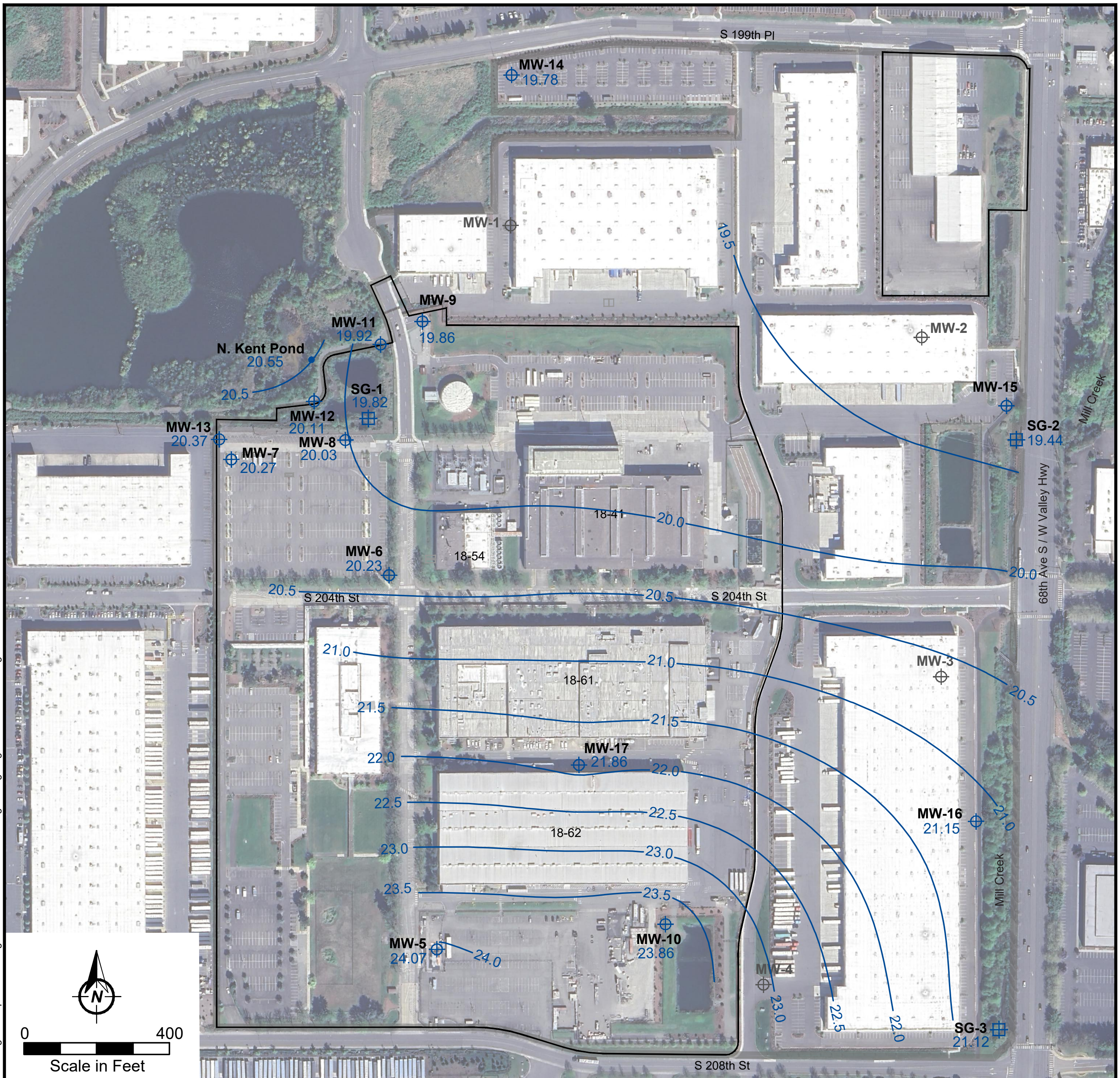
Focused Feasibility Study

Groundwater Elevation Map
March 11, 2024

DALTON OLMSTED FUGLEVAND

FIGURE 5

PLOT TIME: 4/23/2024 4:24 PM MOD TIME: 4/23/2024 4:24 PM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\2024-04\2024-04 Boeing SC Fig xx gw conts 2024.dwg



Source: Aerial Photography - Google Earth Pro, April 04, 2024.

Legend

MW-7 20.27	Groundwater Monitoring Well/Measured Groundwater Elevation (Feet NAVD 88)		Site Boundary
MW-3	Abandoned Groundwater Monitoring Well		Boeing Current Property Boundary
SG-1 19.82	Staff Gauge Measured Stormwater or Surface Water Elevation (Feet NAVD 88)		
•	Measured Stormwater Spot Elevation (Feet NAVD 88)		
21.0	Estimated Groundwater Elevation Contour		

Note:
1. Stormwater/surface water elevations for informational purposes only.
2. MW-15 was dry during monitoring event.

Boeing Space Center
Kent, Washington

Focused Feasibility Study

Groundwater Elevation Map
June 03, 2024

DALTON OLMSTED FUGLEVAND

FIGURE 6

PLOT TIME: 7/8/2024 2:03 PM MOD TIME: 7/8/2024 2:02 PM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\2024-07\2024-07 Boeing SC Fig xx gw conts 2024-06.dwg

Source: Aerial Photography - Google Earth Pro, June 2024.

Legend

MW-7	Groundwater Monitoring Well/Measured		Site Boundary
MW-3	Abandoned Groundwater Monitoring Well		Boeing Current Property Boundary
SG-1	Staff Gauge		
	Average Arsenic Concentration Below Preliminary Cleanup Level (8 ug/L)		
	Average Arsenic Concentration Above Preliminary Cleanup Level (8 ug/L)		
13	Average Arsenic Concentration in 2023-24 (ug/L)		

0 400
Scale in Feet

Boeing Kent Space Center
Kent, Washington

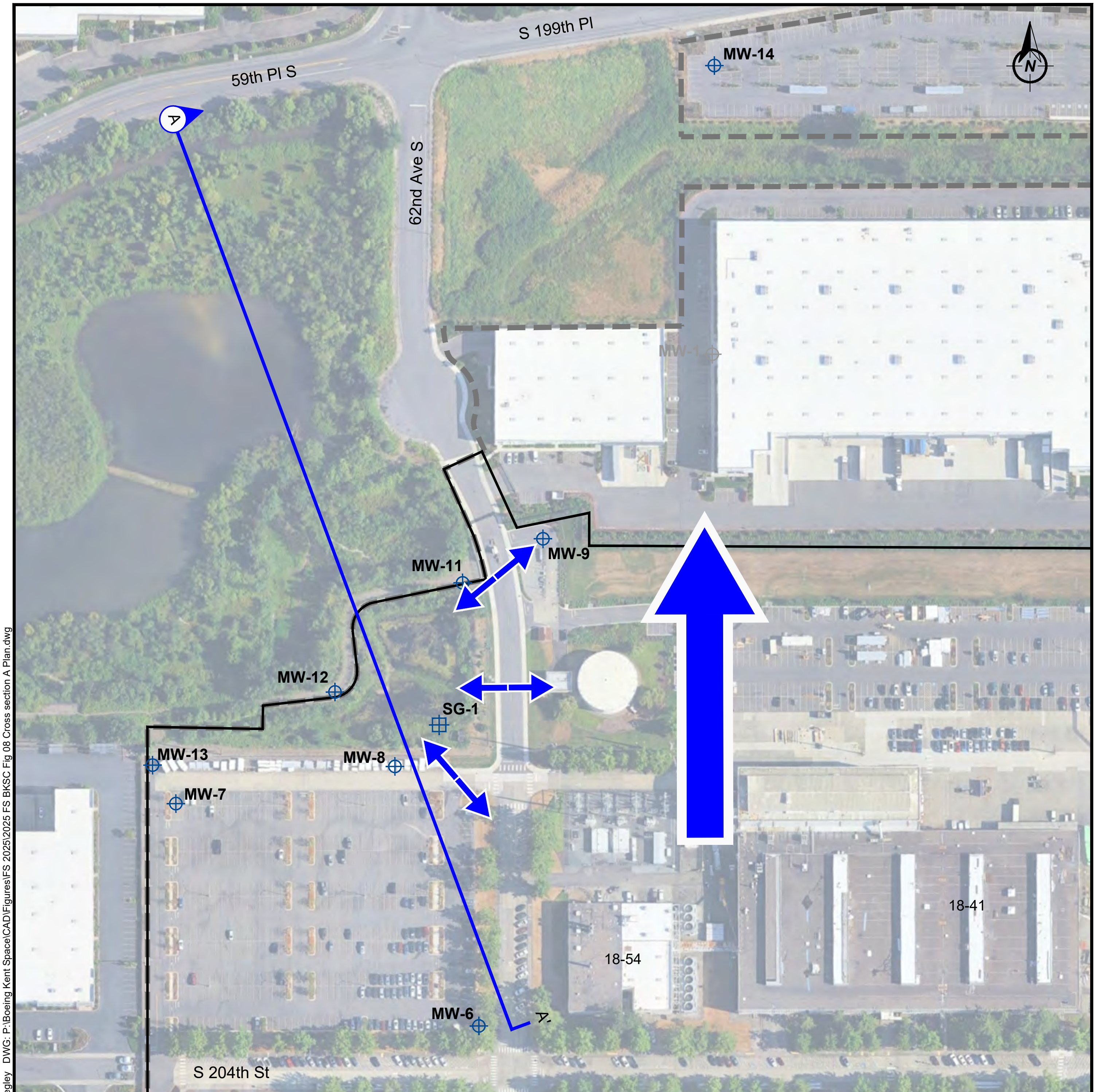
Focused Feasibility Study

2023-2024 Arsenic Groundwater Concentrations

DOF DALTON OLMSTED FUGLEVAND

FIGURE 7

March 2025



Source: Aerial Photography - Google Earth Pro, June 2024.

Legend

- Cross Section Location (A — A')
- Site Boundary
- Boeing Current Property Boundary
- MW-7 — Groundwater Monitoring Well
- MW-3 — Abandoned Groundwater Monitoring Well
- SG-1 — Staff Gauge
- Localized Groundwater Flow Directions
- Overall Site Groundwater Flow Direction

0 200
Scale in Feet

Boeing Space Center
Kent, Washington
Focused Feasibility Study

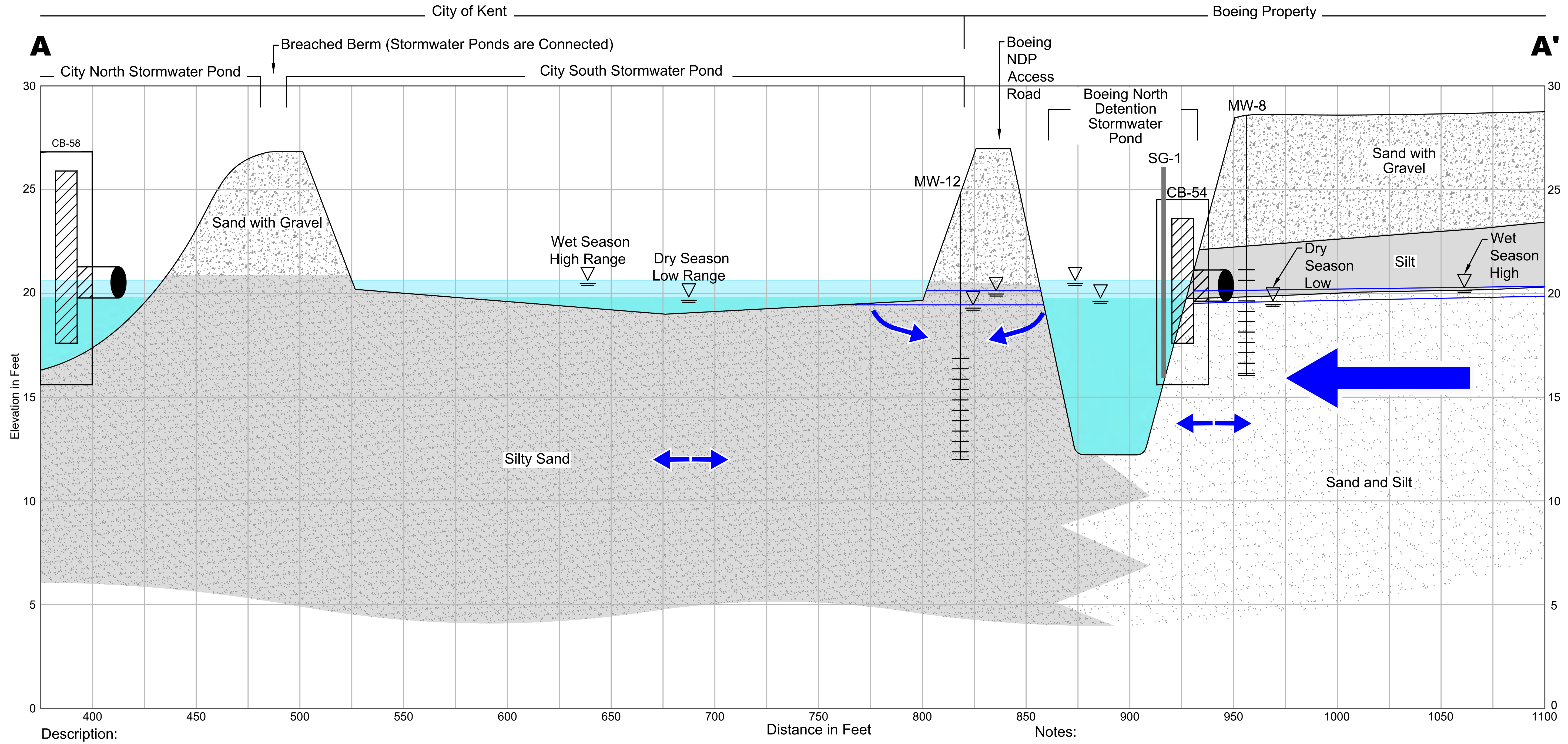
Cross Section Location

DOF DALTON OLMSTED FUGLEVAND

FIGURE 8

April 2025

PLOT TIME: 4/17/2025 9:57 AM MOD TIME: 4/17/2025 9:55 AM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\FS 2025\2025 FS BKSC Fig 08 Cross section A Plan.dwg



Description:
A cross section of the Northwest corner of the Site with stormwater ponds showing the changes in seasonal surface water and groundwater elevations relative to site wells.

SECTION A-A' DETAIL

0 50
Scale in Feet
Vertical Exaggeration: 10x

Notes:
1. Elevations north of southern edge of City of Kent Stormwater Pond estimated based on Boeing As-Built Plan C313.1 from March 2014.
2. Flow restrictor catch basins are a pictorial representation only.
3. CB-54 based on Boeing As-Built Plan C9 July, 2012.
4. CB-58 based on Boeing As-Built Plan C504 March, 2014.
5. Outlet invert elevations:
   CB54 = 19.63
   CB58 = 19.78

Legend

- Monitoring well/Temporary Boring with Screened Interval
- Groundwater Elevation
- Stormwater Elevation Dry Season Low Range
- Stormwater Elevation Wet Season High Range
- Silt
- Sand and Silt
- Silty Sand
- Sand with Gravel
- Flow Restrictor Catch Basin Detail
- Outflow to Mill Creek
- Localized Groundwater Flow Directions
- Regional Groundwater Flow Direction (Generally to the North)

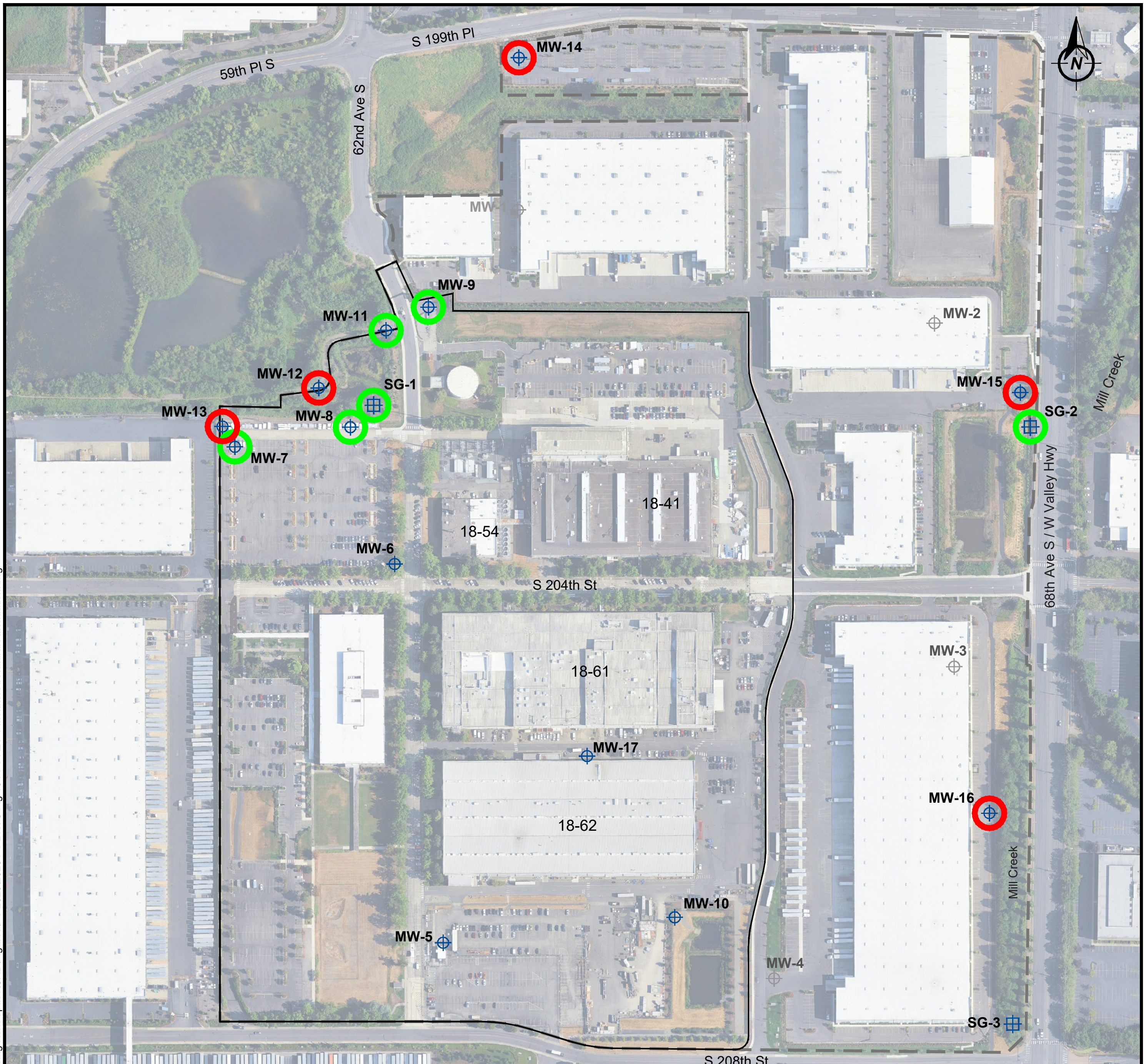
Boeing Space Center
Kent, Washington
Focused Feasibility Study

Cross Section A-A' Detail

DOF DALTON OLMSTED FUGLEVAND

FIGURE 9

April 2025



Source: Aerial Photography - Google Earth Pro, June 28, 2024.

Legend

- MW-# — Proposed Conditional Point of Compliance Monitoring Well
- SG-# — Proposed Surface water Elevation Measuring Location (Staff Gauge)
- Proposed Water Level Only Monitoring Location
- MW-3 — Abandoned Groundwater Monitoring Well
- Site Boundary
- Boeing Current Property Boundary

0 400
Scale in Feet

Boeing Space Center
Kent, Washington

Focused Feasibility Study

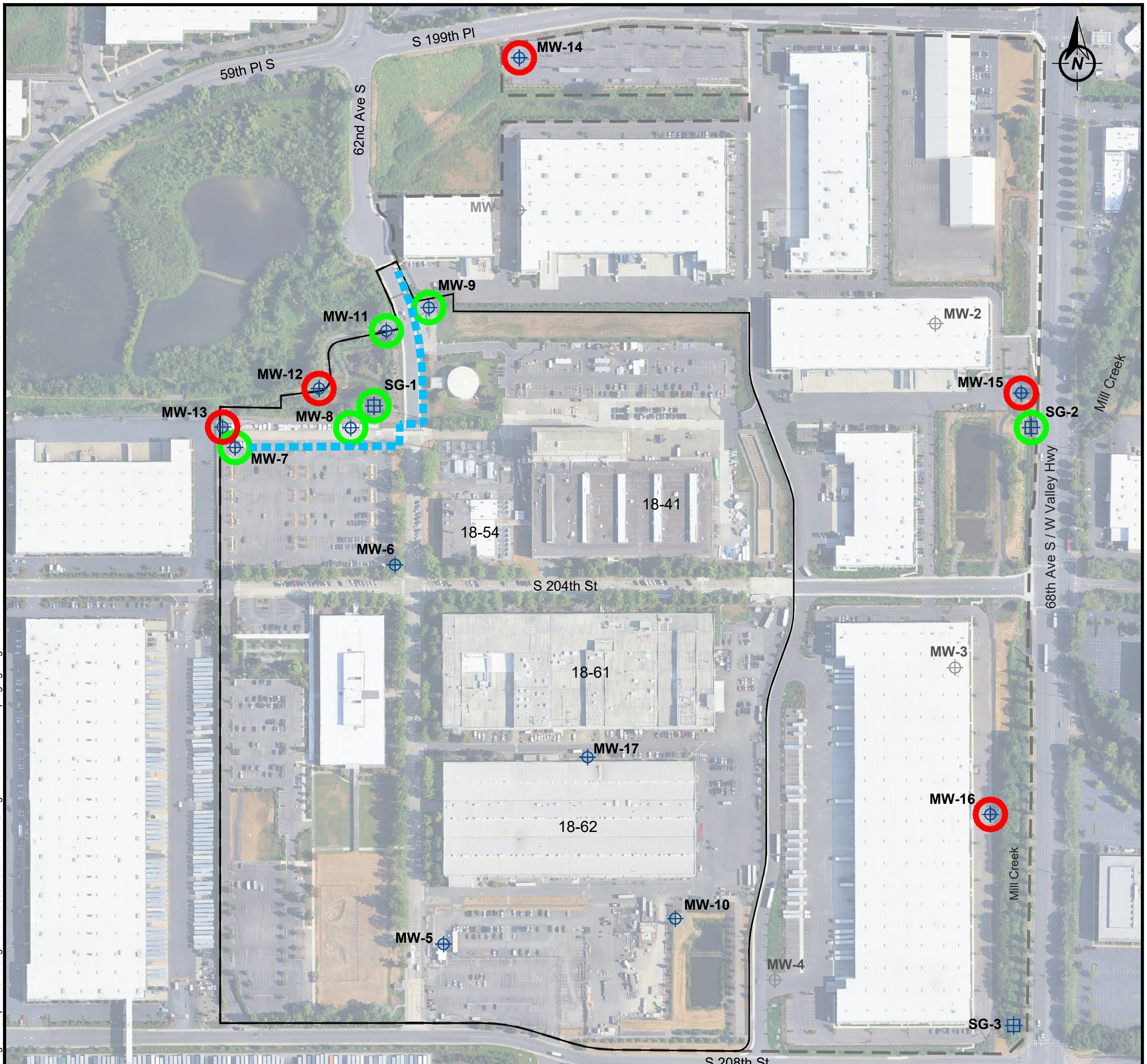
Alternative 1
Monitored Natural Attenuation

DOF DALTON OLMSTED FUGLEVAND

FIGURE 10

April 2025

PLOT TIME: 4/18/2025 11:23 AM MOD TIME: 4/18/2025 11:22 AM USER: Lee Barras DWG: P:\Boeing Kent Space\CAD\Figures\FS 2025\2025 FS BKSC Fig 10 FFS ALT 1 Monitored Natural Attenuation.dwg



Source: Aerial Photography - Google Earth Pro, June 28, 2024.

Legend

MW-# (red circle)	Proposed Conditional Point of Compliance Monitoring Well
SG-#	Proposed Surface water Elevation Measuring Location (Staff Gauge)
(green circle)	Proposed Water Level Only Monitoring Location
(blue dashed line)	Biosparge Location
MW-3	Abandoned Groundwater Monitoring Well
(dashed line)	Site Boundary
(solid line)	Boeing Current Property Boundary

0 400
Scale in Feet

Boeing Space Center
Kent, Washington

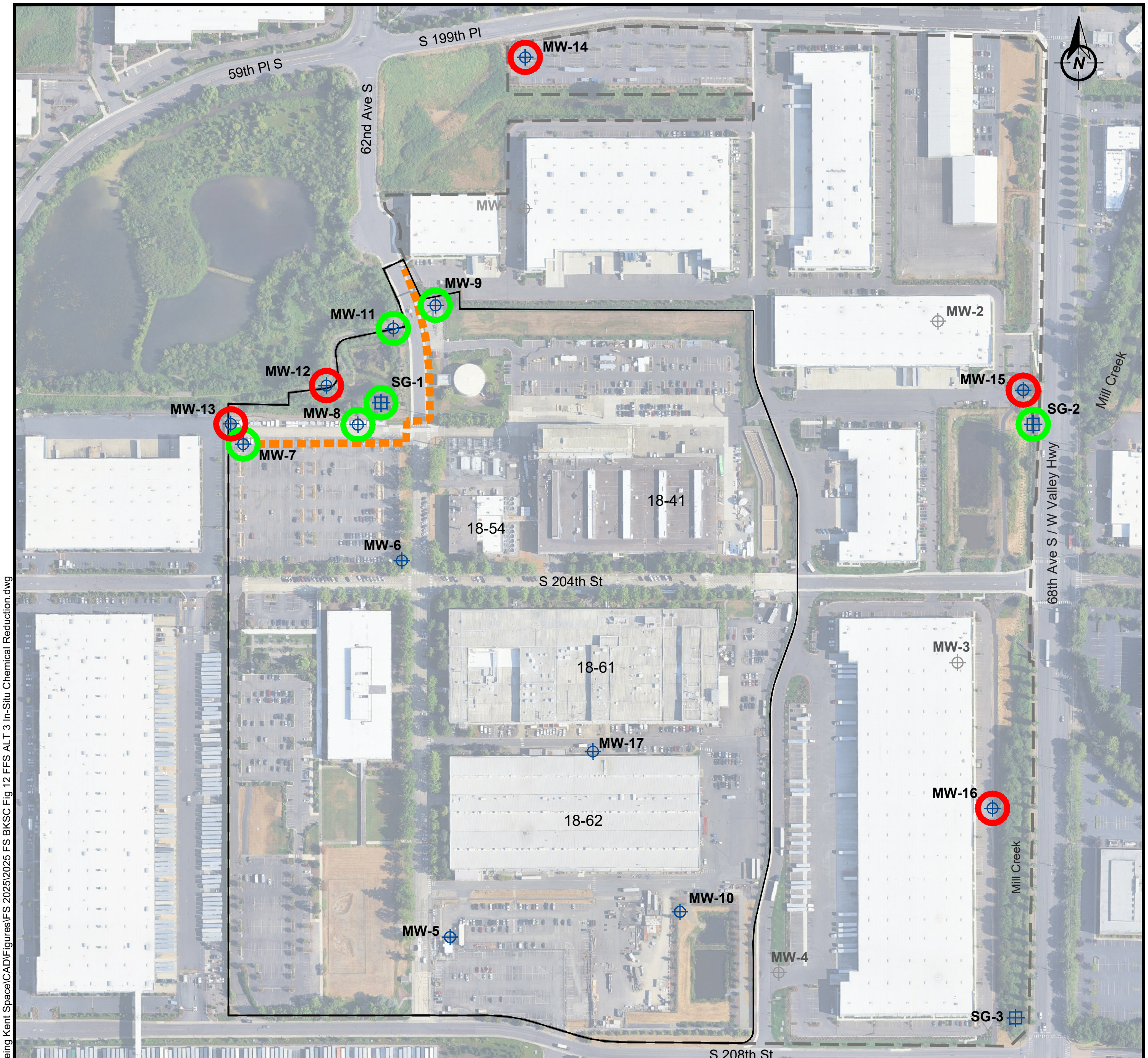
Focused Feasibility Study

Alternative 2
Biosparging

DOF DALTON OLMSTED FUGLEVAND

FIGURE 11

April 2025



Source: Aerial Photography - Google Earth Pro, June 28, 2024.

Legend

- MW-# — Proposed Conditional Point of Compliance Monitoring Well
- SG-# — Proposed Surface water Elevation Measuring Location (Staff Gauge)
- Proposed Water Level Only Monitoring Location
- ZVI Injection Location
- MW-3 — Abandoned Groundwater Monitoring Well
- Site Boundary
- Boeing Current Property Boundary

0 400
Scale in Feet

Boeing Space Center
Kent, Washington

Focused Feasibility Study

Alternative 3
In-Situ Chemical Reduction

DALTON OLMSTED FUGLEVAND

FIGURE 12

April 2025

PLOT TIME: 4/18/2025 11:17 AM MOD TIME: 4/18/2025 11:11 AM USER: Lee Barras DWG: P:\Boeing Kent Space\CAD\Figures\FS 2025\2025 FS BKSC Fig 12 FFS ALT 3 In-Situ Chemical Reduction.dwg

Tables

Table 1
Arsenic Groundwater Monitoring Results
Feasibility Study
Boeing Kent Space Center

Well ID	Sample Date	Dissolved Arsenic (µg/L)
Preliminary Cleanup Level		**8**
MW-5	5/3/2017	**3.3**
	6/18/2019	2.0 U
	9/23/2019	**7.2**
	12/17/2019	2.1 U
	3/4/2020	**16.8**
	6/2/2020	2.1 U
	12/8/2020	5.5 U
	8/16/2023	**2.27**
	11/20/2023	**0.493**
	3/13/2024	**0.366 J**
	6/4/2024	**0.404**
MW-6	5/4/2017	**27.9**
	6/19/2019	**21.7**
	9/20/2019	**36.5**
	12/18/2019	**18**
	3/4/2020	**32.3**
	6/3/2020	**129**
	12/9/2020	**61.6**
	8/17/2023	**51.5**
	11/20/2023	**35.2**
	3/13/2024	**45.7**
	6/5/2024	**59.1**
MW-7	5/4/2017	**27.1**
	6/19/2019	**47.4**
	9/19/2019	**50.3**
	12/18/2019	**53.2**
	3/4/2020	**50.5**
	6/3/2020	**62**
	12/8/2020	**80.2**
	6/10/2021	**63**
	10/28/2021	**61.3**
	8/17/2023	**50.2**
	11/21/2023	**78.4**
	11/21/23 (dup)	**78.1**
	3/13/2024	**60.3**
	6/5/2024	**51.6**
MW-8	6/3/2020	**36.6**
	12/9/2020	**77.1**
	6/10/2021	**72.2**
	10/28/2021	**80.7**
	8/17/2023	**90**
	11/21/2023	**106**
	3/13/2024	**87.3**
	6/6/2024	**85.5**

Table 1
Arsenic Groundwater Monitoring Results
Feasibility Study
Boeing Kent Space Center

Well ID	Sample Date	Dissolved Arsenic (µg/L)
MW-9	6/3/2020	**74.5**
	12/9/2020	**159**
	12/9/2020 (dup)	**165**
	6/10/2021	**158**
	6/10/2021 (dup)	**160**
	10/28/2021	**190**
	8/16/2023	**180**
	11/20/2023	**206**
	3/14/2024	**186**
	6/6/2024	**169**
MW-10	6/2/2020	**18.7**
	12/8/2020	**7.25**
	8/16/2023	**11.4**
	11/20/2023	**13.4**
	3/12/2024	**8.46**
	6/4/2024	**16.9**
MW-11	6/10/2021	**70.8**
	10/28/2021	**118**
	10/28/2021 (dup)	**118**
	8/17/2023	**94.7**
	11/21/2023	**125**
	3/12/2024	**109**
	3/12/2024 (dup)	**107**
	6/6/2024	**109**
	6/6/2024 (dup)	**107**
MW-12	6/10/2021	**9.31**
	10/28/2021	**6.2**
	8/17/2023	**4.6**
	11/21/2023	**4.6**
	3/12/2024	**9.43**
	6/6/2024	**10.9**
MW-13	8/17/2023	**6.05**
	8/17/2023 (dup)	**6.35**
	11/21/2023	**6.24**
	3/13/2024	**3.58**
	6/5/2024	**6.12**
MW-14	8/15/2023	**3.39**
	11/17/2023	**4.82**
	3/11/2024	**4.32**
	6/4/2024	**4.5**
MW-15	11/21/2023	**3.93**
	3/14/2024	**0.934**
MW-16	8/15/2023	**7.08**
	11/20/2023	**3.39**
	3/12/2024	**2.06**
	6/4/2024	**2.64**

Table 1
Arsenic Groundwater Monitoring Results
Feasibility Study
Boeing Kent Space Center

Well ID	Sample Date	Dissolved Arsenic (µg/L)
MW-17	8/16/2023	**114**
	11/20/2023	**108**
	3/12/2024	**94.1**
	6/4/2024	**90.1**

Notes and Abbreviations
Bolded values are detections
Grey indicates detection above preliminary cleanup level
J = The result value is qualified as estimated
U = The compound was analyzed for, but not detected at the reported concentration
ug/L = micrograms per liter
dup = Field Duplicate

DALTON OLMSTED FUGLEVAND

Table 2
Geochemistry Groundwater Results
Feasibility Study
Boeing Kent Space Center

Sample Date	Location ID	TOC (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Alkalinity (mg/L)	TDS (mg/L)	TSS (mg/L)	Calcium (mg/L)	Ferric Iron (mg/L)	Ferrous Iron (mg/L)	Total Iron (mg/L)	Dissolved Iron (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Oxidation-Reduction Potential (mV)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
Analyical Method																		field meter	field meter	field meter
5/3/2017	MW-5	--	--	1.6	--	36.7	--	-	--	--	--	--	1.5[1]	--	--	--	--	4	407	1.8
9/23/2019		2.5	2.4	0.15	0.10 U	25.0	2.0 U	223	288	--	38.9	0.5 U	3.08	3.32	--	4.7 J	34.4	-6	430	0
3/4/2020		1.0 U	3	4.8	0.10 U	75	2.0 U	174	306	--	42.8	0.21 U	0.10 U	0.206 U	--	2.21	16.8	-60.5	510	0.56
8/16/2023		2.75	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	163	334	0.8
11/20/2023		1.32	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	146.6	399	0.64
3/13/2024		1.65	--	--	--	--	--	--	--	--	--	--	--	--	0.364 U	--	--	13.7	454	2.19
6/4/2024		1.88	--	--	--	--	--	--	207	5	--	--	--	--	0.0364 U	--	--	68.8	263	5.03
5/4/2017	MW-6	--	--	0.1 UJ	--	14.6 J	--	-	--	--	--	--	6[1]	--	--	--	--	-6.3	397	0.6
9/20/2019		5.6	9.3	0.10 U	0.10 UJ	15.1	2.0 U	213	292	--	48.6	5.0 U	40.3	37.0	--	1.22	20.1	-79	560	0
3/4/2020		13.5	9.8 J	0.10 U	0.10 U	18.4 J	2.0 U	243	338	--	56.9	5.0 U	45.4	42.8	--	0.949	17.6	-28.6	620	0.16
8/17/2023		14.38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	80	398	0.14
11/20/2023		16.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-69.8	722	0.22
3/13/2024		17.34	--	--	--	--	--	--	--	--	--	--	--	--	60.4	--	--	-76	708	0.22
6/5/2024		15.77	--	--	--	--	--	--	374	123	--	--	--	--	72.1	--	--	-68.4	607	0.2
5/4/2017	MW-7	--	--	0.1 UJ	--	1.2 J	--	-	--	--	--	--	4.3[1]	--	--	--	--	-5.1	483	1.28
9/19/2019		27	5.9 J	0.10 U	0.10 UJ	1.0 U	2.0 U	292	359	--	54.7	5.0 U	46.5	40.4	--	1.58	31.1	-136	704	0
3/4/2020		26.4	4.5	0.10 U	0.10 U	1.0 U	2.0 U	288	345	--	56	5.0 U	41.1	40	--	1.32	25.7	-135.2	628	0.27
8/17/2023		19.65	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	86.5	215	0.15
11/21/2023		21.75	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-130	450	0.19
11/21/2023		21.72	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-130	450	0.19
3/13/2024		20.31	--	--	--	--	--	--	--	--	--	--	--	--	17.4	--	--	-104.1	323	0.29
6/5/2024		21.61	10.8	--	--	--	--	141	263	6	29.5	--	--	--	17.1	0.789	16.2	-144.6	277	0.55
11/21/2023	MW-8	24.91	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-131.8	765	0.23
3/13/2024		20.59	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-124.7	750	0.22
6/6/2024		19.56	3.97	--	--	--	--	275	313	116	48.6	--	--	--	--	0.805	21.9	-120.2	594	0.36
8/16/2023	MW-9	62.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	87.4	680	0.17
11/20/2023		65.11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-132.5	1151	0.65
3/14/2024		62.3	14.2	--	--	0.1 U	--	880	500	273	83.9	--	--	123	75.2	1.53	42.6	-105.9	1093	0.23
6/6/2024		66	13.4	--	--	--	--	441	566	176	74.4	--	--	--	17.1	1.47	38.2	-107.3	904	1.42
8/16/2023	MW-10	2.94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	111	266	0.24
11/20/2023		3.27	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-68.6	329.4	0.34
3/12/2024		2.65	--	--	--	--	--	--	--	--	--	--	--	--	5.18	--	--	-45.5	322	0.25
6/4/2024		3.2	--	--	--	--	--	--	186	9	--	--	--	--	4.34	--	--	19.2	242	0.43
8/17/2023	MW-11	34.96	19.8	0.21 U	0.071[3]	0.1	--	392	466 J	177	66.7	--	--	115	114	1.4	25.4	82.4	464	0.19
11/21/2023		40.04	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-119.2	975	0.2
3/12/2024		40.79	--	--	--	--	--	--	--	--	--	--	--	--	145	--	--	-116.8	1067	0.19
3/12/2024		39.03	--	--	--	--	--	--	--	--	--	--	--	--	145	--	--	-116.8	1067	0.19
6/6/2024		41.32	20	--	--	--	--	401	500	229	72	--	--	--	140	1.37	26.4	-125.5	822	0.26

DOF DALTON OLMSTED FUGLEVAND

Table 2
Geochemistry Groundwater Results
Feasibility Study
Boeing Kent Space Center

Sample Date	Location ID	TOC (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Alkalinity (mg/L)	TDS (mg/L)	TSS (mg/L)	Calcium (mg/L)	Ferric Iron (mg/L)	Ferrous Iron (mg/L)	Total Iron (mg/L)	Dissolved Iron (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Oxidation-Reduction Potential (mV)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
6/6/2024		40.98	--	--	--	--	--	--	--	--	--	--	--	--	136	--	--	-125.5	822	0.26
8/17/2023	MW-12	7.69	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	117	174	0.18
11/21/2023		4.38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-17.9	110	0.28
3/12/2024		7.12	--	--	--	--	--	--	--	--	--	--	--	--	8.76	--	--	-40.5	235	0.25
6/6/2024		9.49	11.7	--	--	--	--	100	182	8	18.6	--	--	--	16.3	1.74	13.8	-105.3	213	0.08
8/17/2023	MW-13	2.78	7.1	0.02 U	0.01 U	--	--	89.4	271 J	1 U	14.5	--	--	0.0966 J	0.0795 J	3.28	17.8	64	145	0.14
8/17/2023		2.96	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	674	145	0.14
11/21/2023		2.69	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-70.6	221	0.23
3/13/2024		2.18	--	--	--	--	--	--	--	--	--	--	--	--	1.08	--	--	-58.6	222	0.34
6/5/2024		2.78	10.9	--	--	--	--	60	109	1 U	15	--	--	--	3.39	0.999	9.08	-52.5	132	0.52
8/15/2023	MW-14	36.75	7.46	0.02 U	0.01 U	--	--	800	873 J	3	148	--	--	2.51	1.87	2.42	41.3	143	1011	0.36
11/17/2023		52.09	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.5	1460	0.35
3/11/2024		48.46	--	--	--	--	--	--	--	--	--	--	--	--	3.67	--	--	-11.4	1534	0.32
6/4/2024		49.09	--	--	--	--	--	--	1020	16	--	--	--	--	5.06	--	--	101.7	1261	0.54
11/21/2023	MW-15	4.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60.2	349	2.45
3/14/2024		5.71	--	--	--	--	--	--	--	--	--	--	--	--	0.719 J	--	--	93.2	397	0.53
8/15/2023	MW-16	2.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	130	470	0.27
11/20/2023		1.98	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	17.5	465	0.33
3/12/2024		1.91	--	--	--	--	--	--	--	--	--	--	--	--	4.73	--	--	61.4	422	0.21
6/4/2024		2.01	--	--	--	--	--	--	291	8	--	--	--	--	10.1	--	--	86	295	0.5
8/16/2023	MW-17	13.76	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	62.2	337	0.23
11/20/2023		13.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	-158	517	0.21
3/12/2024		12.97	--	--	--	--	--	--	--	--	--	--	--	--	35.9	--	--	-145.8	613	0.31
6/4/2024		11.05	42.3	0.1 J,U	0.1 J,U	0.1 U	0.050 U	187	280	87	38.4	--	--	--	36.5	1.38	24.8	-87.3	473	0.58

Notes and Abbreviations

1. Values recorded with field kit.

TOC = total organic carbon
-- not analyzed
J = The result value is qualified as estimated
U = The compound was analyzed for, but not detected at the reported concentration
mg/L = milligrams per liter
dup = Field Duplicate
µS/cm = microSiemens per centimeter

DALTON OLMSTED FUGLEVAND

Table 3
Soil Results - Arsenic
Feasibility Study
Boeing Kent Space Center

Sample Date	Location ID	Depth (ft. bgs)	Total Arsenic (mg/kg)
7/20/2023	MW-13	7.5-8.0	4.37
7/20/2023		8.8-9.0	1.89
7/20/2023		14.0-14.5	2.26
7/20/2023	MW-14	23.0-23.5	5.35
7/18/2023	MW-15	7.0-7.5	8.26
7/18/2023		10.5-11.0	2.86
7/18/2023	MW-16	8.4-9.0	4.9
7/20/2023	MW-17	8.0-8.5	13.5
7/20/2023		12.5-13.0	8.71
7/20/2023		14.0-14.5	10

Table 4
Soil Results - TOC and Total Solids
Feasibity Study
Boeing Kent Space Center

Location ID	Sample Date	Sample Depth (ft bgs)	TOC (%)	Total Solids (%)
MW-13	7/20/2023	7.5-8.0	0.28 J	78.09
		8.8-9.0	0.11 J	76.73
		14.0-14.5	0.05 J	77.33
MW-14	7/20/2023	16.5-17.0	0.36 J	68.13
		23.0-23.5	5.65 J	59.72
MW-15	7/18/2023	7.0-7.5	0.30 J	76.87
		10.5-11.0	0.10 J	71.72
MW-16	7/18/2023	8.4-9.0	0.08 J	70.09
MW-17	7/20/2023	8.0-8.5	2.28 J	68.04
		12.5-13.0	0.07 J	71.36
		14.0-14.5	0.33 J	69.43

Notes:
Data flags are as follows:
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

Abbreviations:
TOC = Total Organic Carbon

Table 5

Proposed Remedial Alternatives

Feasibility Study

Boeing Kent Space Center

General Target Description	Alternative 1- Monitored Natural Attenuation	Alternative 2- Biosparging	Alternative 3- In-Situ Chemical Reduction
Common to all alternatives	Maintain exisiting surface cover, and limit infiltration new stormwater features/conveyance will be lined/sealed pipe [1]		
	Verification of GW remediation progress and effectiveness through GW monitoring		
	Long Term and Temporary Institutional Controls		
GW-Shallow Source Areas	MNA (As)	MNA (As)	MNA (As)
GW-Shallow Downgradient	MNA (As)	Biosparging, MA (As)	In-Situ Chemical Reduction PRB (ZVI), MA (As)
Comparison of Alternative Timing			
	Alternative 1	**Alternative 2**	**Alternative 3**
Active Remediation Duration (years) [2]	0	2	6+
Restoration Time Frame (years)	< 10	< 8	< 6

Notes

1. Properly designed stormwater infiltration may benefit arsenic remedial timelines, but infiltration would be restricted by default.

2. Active remediation indicates the expected duration of accelerated degradation rates, except in the case of MNA which has no active component, so a timeframe of zero years was provided. In the case of Alternative 3, injected substrate will likely remain active, even after groundwater monitoring is met at the conditional point of compliance.

Abbreviations:

As = Arsenic

GW= Groundwater

PRB = Permeable Reactive Barrier

MA= Monitored Attenuation

MNA= Monitored Natural Attenuation

ZVI= Zero Valent Iron

TABLE 6
EVALUATION OF REMEDIAL ALTERNATIVES
Feasibility Study
Boeing Kent Space Center

Standards/Criteria[2]	Alternative Rating[1]		
	A-1	A-2	A-3
	MNA	Biosparging	In-Situ Chemical Reduction
Protectiveness and Risk Reduction	5	7	9
Permanence	7	8	9
Long-term Effectiveness	4	5	6
Management of Short-Term Risks	10	6	5
Technical and Administrative Implementability	10	6	5
Benefit Score Total[2]	**36**	**32**	**34**
Permanence Rank	3	2	1
Implementation Cost	$10,000	$282,100	$821,200
NPV Cost (estimated)	$248,000	$583,000	$1,197,000
Cost/Benefit (per $1000)	$6.90	$18.20	$35.20
Cost/Benefit Rank	1	2	3
Restoration Time Frame (years)	< 10	< 8	< 6

Notes

1. Alternatives are rated from 10 to 1, with a rating of 10 indicating the highest or most favorable performance for that criterion.

2. In accordance with EPA guidance for each criterion and the MTCA regulations, all standards and/or criteria are considered equal; no weighting is given to any individual criterion.

Abbreviations

MNA = monitored natural attenuation

Table 7
Remedial Alternative Evaluation Details
Feasibility Study
Boeing Kent Space Center

Remedial Alternatives	Alternative 1	Alternative 2	Alternative 3
	Monitored Natural Attenuation	Biosparging	In-Situ Chemical Reduction
MTCA Criteria - subcriteria	Notes	Notes	Notes
Protectiveness- Degree existing risks reduced	+ IC's control onsite exposure to arsenic + Monitoring has shown arsenic is not a threat to offsite receptors, MNA is already working + GW monitoring will detect if the potential threat to receptors increases, more active measures can be implemented. + GW monitoring will detect if the potential threat to receptors increases, more active measures can be implemented. - Potential risk of increased O&M of stormwater infrastructure due to arsenic precipitation.	+ IC's control onsite exposure to arsenic + Aerobic treatment of dissolved arsenic is a proven full scale treatment technology + Reduction of risk of arsenic precipitation in stormwater infrastructure in year 1 + Air sparging may also help biodegrade carbon sources in GW as well as precipitating arsenic. - Air sparging for more than 2 years may be necessary.	+ IC's control onsite exposure to arsenic + ISCR treatment using ZVI (with other additives such as sulfur or electron donors) is a proven full scale treatment technology + Reduction of risk of arsenic precipitation in stormwater infrastructure in year 1 - Reducing substrates may slow degradation of carbon sources, extending the time of reducing conditions in GW onsite - ZVI injections may be necessary 10 to 15 years in the future.
Protectiveness- Time until reduced risk	- Slow incremental reductions in risk of increased O&M of stormwater infrastructure due to arsenic precipitation. - Upgradient areas still rely on MNA and ICs	+ Reduction of risk of increased O&M of stormwater infrastructure due to arsenic precipitation in year 1 + Treatment of highest potential exposure to GW in year 1 - Upgradient areas still rely on MNA and ICs	+ Reduction of risk of increased O&M of stormwater infrastructure due to arsenic precipitation in year 1 + Treatment of highest potential exposure to GW in year 1 - Upgradient areas still rely on MNA and ICs
Protectiveness- Time to cleanup standards	+ Monitoring at proposed CPOC may indicate cleanup levels are currently being met. - Upgradient areas still rely on MNA and ICs	+ Monitoring at proposed CPOC may indicate cleanup levels are currently being met. - Upgradient areas still rely on MNA and ICs	+ Monitoring at proposed CPOC may indicate cleanup levels are currently being met. - Upgradient areas still rely on MNA and ICs
Protectiveness- risks remaining after implementation	+ IC's control onsite exposure to arsenic - Higher concentrations will remain onsite, for longer than other alternatives	+ IC's control onsite exposure to arsenic + Reduced chance of exposure to higher arsenic GW concentrations - Injections may plug aquifer changing GW flow patterns	+ IC's control onsite exposure to arsenic + Reduced chance of exposure to higher arsenic GW concentrations - Injections may cause changes to aquifer chemistry resulting in slowing of contaminant degradation - Injections may plug aquifer changing GW flow patterns

Table 7
Remedial Alternative Evaluation Details
Feasibility Study
Boeing Kent Space Center

Remedial Alternatives		Alternative 1 Monitored Natural Attenuation		Alternative 2 Biosparging		Alternative 3 In-Situ Chemical Reduction
MTCA Criteria - subcriteria		Notes		Notes		Notes
Protectiveness- Improvement of the overall environmental quality	+	Long Term reduced risk to GW exposure	+	Short and Long term reduced risk to GW exposure.	+	Short and Long term reduced risk to GW exposure.
	+	GW monitoring will detect if the potential threat to receptors increases, more active measures can be implemented.	+	Lower potential side effects of active remedial actions	+	Potential side effects of active remedial actions are unknown until bench testing
	+	Lowest potential side effects of the remedial actions	+	Lower potential side effects of active remedial actions	-	Potential side effects of active remedial actions are unknown until bench testing
	-	Upgradient areas still rely on MNA and ICs	-	Upgradient areas still rely on MNA and ICs	-	Upgradient areas still rely on MNA and ICs
Permanence	+	Once anthropogenic sources of carbon are degraded, groundwater conditions should return to less reducing conditions resulting in a drop in arsenic concentrations	+	Once anthropogenic sources of carbon are degraded, groundwater conditions should return to less reducing conditions resulting in a drop in arsenic concentrations	+	Once anthropogenic sources of carbon are degraded, groundwater conditions should return to less reducing conditions resulting in a drop in arsenic concentrations
	+	Monitoring has shown arsenic is not a threat to offsite receptors, MNA is already working	+	Aerobic treatment of dissolved arsenic is a provenfull scale treatment technology	+	ISCR treatment using ZVI (with other additives such as sulfur or electron donors) is a proven full scale treatment technology
	+	Precipitation of dissolved arsenic is permanent in aerobic conditions	+	Precipitation of dissolved arsenic is permanent in aerobic conditions	+	Precipitation of dissolved arsenic is permanent with the correct application of reducing substrates
	-	It may be a long time for MNA to treat all upgradient sources of carbon	-	Sources of carbon from the former marsh and wetlands may cause rebound to reducing conditions after air sparging ceases	-	Until bench testing is complete, permanence is based on similar case studies in literature
	-	Sources of carbon from the former marsh and wetlands at the Site may still cause reducing conditions				

DALTON OLMSTED FUGLEVAND

Table 7
Remedial Alternative Evaluation Details
Feasibility Study
Boeing Kent Space Center

Remedial Alternatives		Alternative 1		Alternative 2		Alternative 3
		Monitored Natural Attenuation		**Biosparging**		**In-Situ Chemical Reduction**
MTCA Criteria - subcriteria		Notes		Notes		Notes
Long Term Effectiveness	+	The remedy will eventually be successful and is reliable, but may take a long time	+	The remedy will be successful in the short term and is reliable, but the exact length of time for long term success can only be determined during implementation	+	The remedy will be successful in the short term and is reliable, but the exact length of time the remedy lasts will unknown until bench testing
	+	Initial GW and stormwater monitoring indicates limited risk to potential receptors	+	Active in-situ destruction of contaminants	+	Active in-situ destruction of contaminants
	+	Climate change should have little to no impact	+	Climate change should have little to no impact	+	Climate change should have little to no impact
	+	The least waste creation requiring offsite disposal of all remedies	+	Reduces magnitude of residual risk	+	Reduces magnitude of residual risk
	-	Potential risk to receptors upgradient of the CPOC in GW above CULs for many years	-	The most waste creation requiring offsite disposal of the remedies	+	The second least waste creation requiring offsite disposal of the remedies
	-	Requires ICs and monitoring	-	Concentrations of arsenic may rebound once air sparge is turned off	-	May increase mobility of some other contaminants
			-	Requires ICs and monitoring	-	Requires ICs and monitoring
Management of Short-Term Risks	+	Reduced risk- only GW monitoring	+	Moderate risk- excavation work is significant exposure hazard	+	Reduced risk- low amount of high risk work above ground (small amount of chemical mixing)
	+	Least amount of air, wastewater, or soil contamination transferred offsite	-	Potential short term mobilization of contaminants from air sparging (TPH)	-	Potential short term mobilization of other contaminants from chemical injection pushing GW faster than seepage velocity
	+	Initial GW and stormwater monitoring indicates limited risk to potential receptors	-	Highest amount of offsite waste disposal	-	2nd highest amount of offsite waste disposal
	-	Potentitial risk of increased O&M of stormwater infrastructure due to arsenic precipitation.	-	Short term risks related to drilling and associated waste disposal	-	Short term risks related to drilling and associated (small amount of) waste disposal
			-	Trenching and excavation activity resulting in highest potential for construction related risks (dust generation, heavy equipment)	-	Additional management of construction worker potential exposure to treatment chemicals
			-	Potential short term risk of air sparging pushing GW faster than seepage velocity or causing mounding to reach utility corridors	-	Potential risks of injected chemicals shortcircuiting to utilities or stormwater infrastructure

DALTON OLMSTED FUGLEVAND

Table 7

Remedial Alternative Evaluation Details

Feasibility Study

Boeing Kent Space Center

Remedial Alternatives	Alternative 1 Monitored Natural Attenuation	Alternative 2 Biosparging	Alternative 3 In-Situ Chemical Reduction
MTCA Criteria - subcriteria	Notes	Notes	Notes
Technical and Administrative Implementability	+ Least disruptive treatment alternative + Least permitting requirements	+ Low permitting requirements + Low technical design challenges - Most disruptive with trenching across active roadways and crossing utility corridors - Most offsite waste disposal	+ Injections are less disruptive and more flexible to working around roadways and utilities than trenching - Moderate technical design challenges - Significant permitting requirements - ISCR Implementability is dependent on direct contact of chemicals with COCs, technical performance is unclear until bench/pilot scale studies are completed

Notes

1) Protectiveness evaluation includes potential risks posed by the site to human health and the environment, including likely vulnerable populations and overburdened communities. All remedial alternatives include institutional controls including (but not limited to) surface cover, inhalation pathway measures, and long term groundwater monitoring designed to protect human health and the environment under WAC 173-340-360(3)(a)(i).

+ = Generally considered a beneficial aspect of the remedial alternative

- = Generally considered a detrimental aspect of the remedial alternative

Abbreviations

MNA = monitored natural attenuation

MTCA = Model Toxics Control Act

COC= Contaminant of Concern

ICs= institutional controls

GW = Groundwater

DALTON OLMSTED FUGLEVAND

Appendix A

Well Construction Logs

LOG OF MW-13

DALTON OLMSTED FUGLEVAND

PROJECT: Boeing Kent Space Center	COORDINATES: **N**156630.9 **E**1287599.5 (NAD83)
LOCATION: NDP South of Fence Line (NW Corner)	SURFACE ELEVATION: 28.28 ft
DRILLING CONTRACTOR: Cascade Drilling	DATE: 7/20/2023
DRILLING EQUIPMENT: CME 75 8.25" ODx4" 10x5' HAS	TOTAL DEPTH OF BORING: 15.5 ft. — ECOLOGY ID: **BPR-418**
SAMPLING METHOD: 300 lb. hammer w/ 30" drop and 3.0" ODx18" D&M	LOGGED BY: A.Cerruti
	RESPONSIBLE PROF.: Anthony Cerruti — REG. NO.: 21013797
NOTES: 65' NW of MW-7	

SAMPLES

DEPTH (feet)	Lab Sample	Sample Recovery	Blow Count (18")	PID (ppm) / Sheen
0–5		Airknife pre-clear		
5–6.5			4	0.0 NS
6.5–8	■ (~7.5–8)		3	0.0 NS
8–9.5	■ (~8.8–9)		6	0.0 NS
9.5–11			8	0.0 NS
11–12.5			11	0.0 NS
12.5–14			10	0.0 NS
14–15.5	■ (~14–14.5)		10	0.0 NS

SOIL DESCRIPTION
based on visual-manual procedures in ASTM-D2488

gravel surface
cleared via airknife to 5 ft. bgs

POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)
brown, moist, medium dense
about 70% sand, 20% gravel, 10% silt

SILT (ML)
dark grey (7.5 YR 4/1), moist, low plasticity, medium firm, trace organics

3 cm medium sand lense at 7.5 ft.
becomes mottled at 7.8 ft. (light bown)

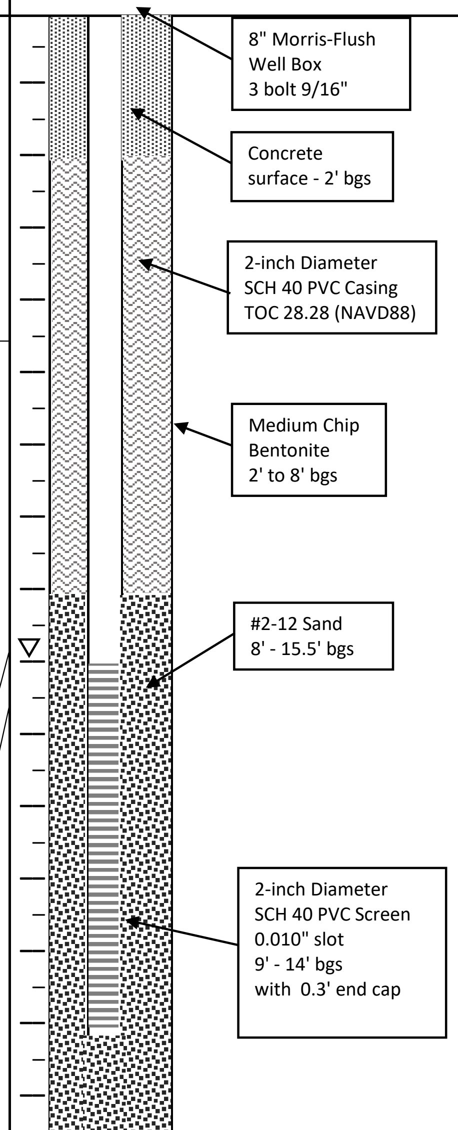
~2 cm. dark brown sand (F-M) lense at 8.8 ft.

SILTY SAND (SM)
dark brown (7.5 YR 3/2), wet, medium dense,
about 80% sand, 20% silt

SAND (SP)
dark brown (7.5 YR 3/2) saturated, loose,
95% sand, 5% silt
silty nodules at 14.0-14.5 ft.

Bottom of boring 15.5 ft.

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

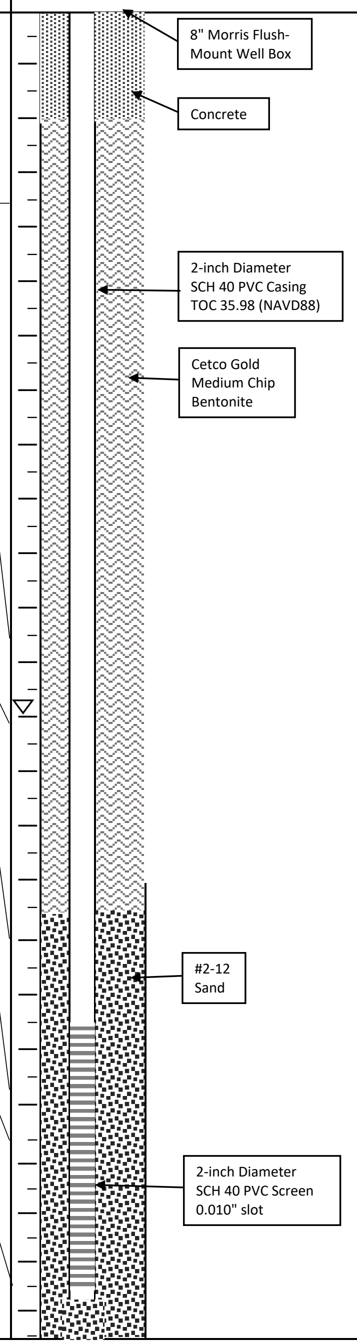
LOG OF MW-14

DALTON OLMSTED FUGLEVAND

PROJECT: Boeing Kent Space Center	COORDINATES: **N**157630.5 **E**1288402.3 (NAD83)
LOCATION: NDP South of Fence Line (NW Corner)	SURFACE ELEVATION: 35.98 ft
DRILLING CONTRACTOR: Cascade Drilling	DATE:7/18/2023 - 7/20/2023
DRILLING EQUIPMENT: CME 75 8.25" ODx4" 10x5' HAS	TOTAL DEPTH OF BORING: 24.5 ft. — ECOLOGY ID: **BPR- 417**
SAMPLING METHOD: 300 lb. hammer w/ 30" drop and 3.0" ODx18" D&M	LOGGED BY: A.Cerruti
	RESPONSIBLE PROF.: Anthony Cerruti — REG. NO.: 21013797
NOTES:	

DEPTH (feet)	Lab Sample	Sample Recovery	Blow Count (18")	PID (ppm)	SOIL DESCRIPTION based on visual-manual procedures in ASTM-D2488
0–3.5		Airknife pre-clear			5 in. asphalt/concrete surface **POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown (7.5 YR 5/3) moist, medium dense about 70% sand, 20% gravel, 10% silt
3.5–5		Airknife pre-clear			**SILTY SAND WITH GRAVEL (SM)** dark brown (7.5 YR 3/1), moist, wet, medium dense about 70% sand, 20% silt, 10% gravel
5–6.5			6		
6.5–8			7	0.0 NS	slight mottling
8–9.5			26	0.0 NS	
9.5–11			25	0.0 NS	**POORLY GRADED SAND (SP)** black (7.5 YR 2.5/1), moist, medium dense, about 90% sand, 5% trace fines, <5% gravel
11–12.5			10	0.0 NS	trace white shell at 13 ft.
12.5–14			22	0.0 NS	**SANDY SILT (ML)** gray (7.5 YR 5/1), moist, low plasticity mottled with trace rootless
14–15.5			6		
15.5–17			6		**POORLY GRADED SAND (SP)** dark brown (7.5 YR 3/2), wet/saturated, loose, about 95% sand, 5% silt medium clasts and mottling between 17.2 ft. and 18.5 ft.
17	■				
17–18.5			7		
18.5–20			6		**SILTY SAND (SM)** dark gray (7.5 YR 4/1), wet, mottled, medium dense, 80% fine sand, 20% silt
20–21.5			6	0.0 NS	**SAND (SP)** dark brown (7.5 YR 3/2), saturated, loose about 95% F-M sand, 5% trace fines becomes moist at 20.5 ft. dark brown lense at 23.4 ft.
21.5–23			10	0.0 NS	**SILTY SAND (SM)** gray (7.5 YR 5/1), wet, medium dense, about 65% fine sand, 35% silt
23–24.5	■		5	0.0 NS	<1 cm. fine sandy lenses Bottom of boring 24.5 ft.

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

LOG OF MW-15

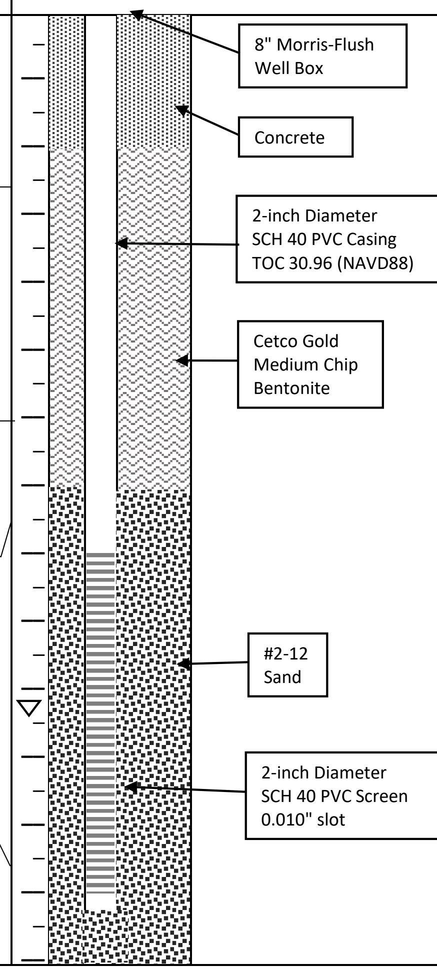
DALTON OLMSTED FUGLEVAND

PROJECT: Boeing Kent Space Center	COORDINATES: **N**156723.0 **E**1289760.6 (NAD83)
LOCATION: North of Bend in Mill Creek	SURFACE ELEVATION: 30.96 ft
DRILLING CONTRACTOR: Cascade Drilling	DATE: 7/18/2023
DRILLING EQUIPMENT: CME 75 8.25" OD HAS 4"1D	TOTAL DEPTH OF BORING: 14 ft. — ECOLOGY ID: **BPR-415**
SAMPLING METHOD: 300 lb. hammer w/ 30" drop and 3.0" ODx18" D&M	LOGGED BY: A.Cerruti
	RESPONSIBLE PROF.: Anthony Cerruti — REG. NO.: 21013797

NOTES:

DEPTH (feet)	Lab Sample	Sample Recovery	Blow Count (18")	PID (ppm)	SOIL DESCRIPTION based on visual-manual procedures in ASTM-D2488
0		Airknife pre-clear			4 in. asphalt concrete surface **POORLY GRADED SAND WITH GRAVEL (SP)** brown (7.5 YR 5/3), moist, medium dense, about 70% sand, 25% gravel, 5% silt
2.5		Airknife pre-clear			**SILTY SAND WITH GRAVEL (SM)** grey (7.5 YR 5/1), moist, medium dense, about 60% sand, 20% silt, 20% gravel
5–6.5			8	0.1 NS 0.0 NS	
6.5–8	X		5	0.0 NS 0.0 NS	**SILT (ML)** dark grey (7.5 YR 4/1), moist, medium firm, low plasticity, about 90% silt, 10% fine sand becomes mottled and contains organics/sticks
8–9.5			6	0.0 NS	**POORLY GRADED SAND WITH SILT (SP-SM)** brown (7.5 YR 4/3), moist, medium dense, some grey mottling about 90% sand, 10% fines
9.5–11	X		4	0.0 NS	transitions to (7.5 YR 5/1) mottled with light browns
11–12			4	0.0 NS	interbedded with silty stringers
12.5–14			5	0.0 NS	**POORLY GRADED SAND (SP)** black (7.5 YR 2.5/1), saturated, loose, about 90% sand, 5% fines Bottom of boring 14.0 ft.

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

LOG OF MW-16

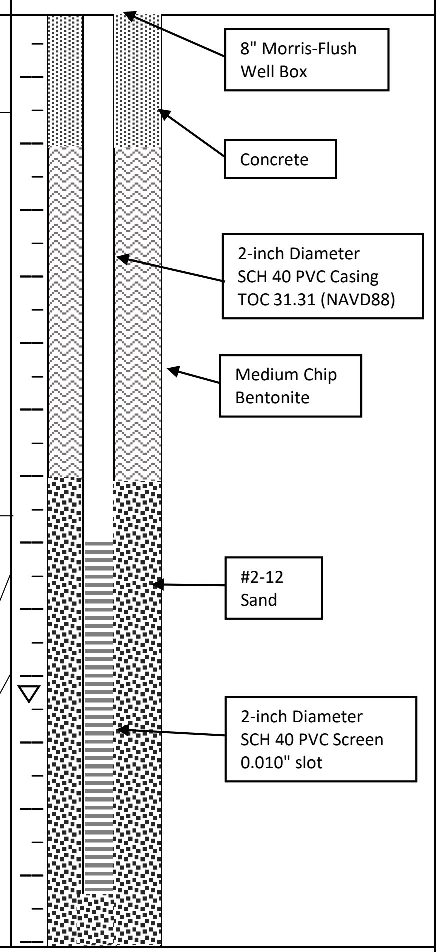
DALTON OLMSTED FUGLEVAND

Sheet 1 of 1

PROJECT: Boeing Kent Space Center	COORDINATES: **N**155582.8 **E**1289677.0 (NAD83)	
LOCATION: SE portion of property along Mill Creek	SURFACE ELEVATION: 31.31 ft	
DRILLING CONTRACTOR: Cascade Drilling	DATE: 7/18/2023	
DRILLING EQUIPMENT: CME 75 8.25" OD x 4" 1Dx 5' HSA	TOTAL DEPTH OF BORING: 14 ft.	ECOLOGY ID: **BPR-416**
SAMPLING METHOD: 300 lb. hammer w/ 30" drop and 3.0" ODx18" D&M	LOGGED BY: A.Cerruti	
	RESPONSIBLE PROF.: Anthony Cerruti	REG. NO.: 21013797
NOTES:		

DEPTH (feet)	Lab Sample	Sample Recovery	Blow Count (18")	PID (ppm)	SOIL DESCRIPTION based on visual-manual procedures in ASTM-D2488
0–1.5		Airknife pre-clear			**POORLY GRADED SAND WITH GRAVEL (SP)** brown (7.5 YR 5/3), moist, medium dense, 70% sand, 25% gravel, 5% silt
1.5–5		Airknife pre-clear			**SILTY SAND (SM)** grey (7.5 YR 5/1), moist, medium dense, about 70% sand, 25% silt, 5% gravel
5–6.5			4	0.0 NS	becomes brown (7.5 YR 4/4)
6.5–7.75			3	0.0 NS 0.0 NS	becomes wet at 7.5 ft. medium sand lenses with grey mottling and silty lenses ~3 cm.
7.5–9					**SAND (SP)** dark brown (7.5 YR 2.5/2), moist, loose 95% fine sand, 5% trace fines
8.3–9.3	■		3	0.0 NS	
9–10.5					**SILTY SAND (SM)** (7.5 YR 4/4), grey mottling, saturated 85% very fine sand, 15% silt. Occassional medium sand lenses
9.8–11.3			4	0.0 NS	
10.5–14					**SAND (SP)** dark brown (7.5 YR 2.5/2), loose F-M sand, trace fines with silty inclusions ~1-5 cm. rounded
11.3–12.8			3	0.0 NS	
12.8–14			7	0.0 NS	
14					Bottom of boring 14.0 ft.

WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS



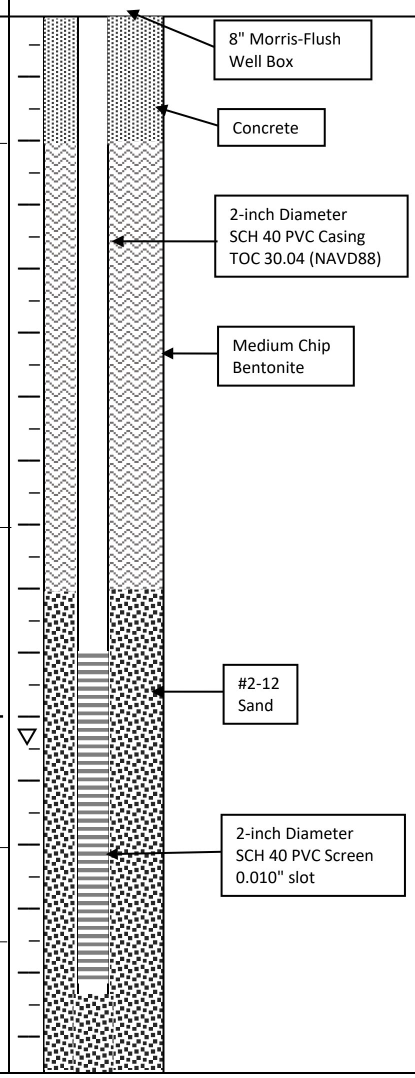
Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

LOG OF MW-17

PROJECT: Boeing Kent Space Center	COORDINATES: **N**155737.6 **E**1288587.1 (NAD83)	
LOCATION: North of 18-62 - Centrally Located	SURFACE ELEVATION: 30.04 ft	
DRILLING CONTRACTOR: Cascade Drilling	DATE: 7/20/2023	
DRILLING EQUIPMENT: CME 75	TOTAL DEPTH OF BORING: 16.5 ft.	ECOLOGY ID: **BPR-419**
SAMPLING METHOD: 300 lb. hammer w/ 30" drop and 3.0" ODx18" D&M	LOGGED BY: A.Cerruti	
	RESPONSIBLE PROF.: Anthony Cerruti	REG. NO.: 21013797
NOTES:		

DEPTH (feet)	SAMPLES: Lab Sample	SAMPLES: Sample Recovery	SAMPLES: Blow Count (18")	SAMPLES: PID (ppm)	SOIL DESCRIPTION based on visual-manual procedures in ASTM-D2488
0–2		Airknife pre-clear			6 in. asphalt surface **POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM)** brown, moist-wet, seepage at 2 ft. (perched), about 70% sand, 20% gravel, 10% silt
2–4		Airknife pre-clear			**SILTY SAND WITH GRAVEL (SM)** brown (7.5 YR 5/3), moist, very dense, brown mottling, about 60% sand, 20% gravel, 20% silt,
4–5.5			10	0.0 NS	
5.5–6.5			16	0.0 NS	
7–8.3			8	0.0 NS	
8–8.7	■				**SILT (ML)** dark brown (7.5 YR 3/2), moist, firm, low plasticity, about 95% organic silt, 5% trace fine sand with roots and mottling to 8.5 ft.
8.5–9.7			5	0.0 NS	
10–11.5		0"	0	0.0 1	becomes gray (7.5 YR 5/1)
11–13					**SILTY SAND (SM)** dark gray (7.5 YR 4/1), saturated, loose, silty (20%) fine sand (80%) about 80% fine sand and 20% silt
12–13.3	■		5	0.0 NS	
13–14.5					**SILT (ML)** dark grey (7.5 YR 4/1), silt with 2 cm. brown fine sand stringer
13.5–15	■		3	0.0 NS	
14.5–16.5					**POORLY GRADED SAND (SP)** very dark grey (7.5 YR 3/1), loose, saturated, 95% fine sand, 5% trace silt
15–16.5			5	0.0 NS	Bottom of boring 16.5 ft.

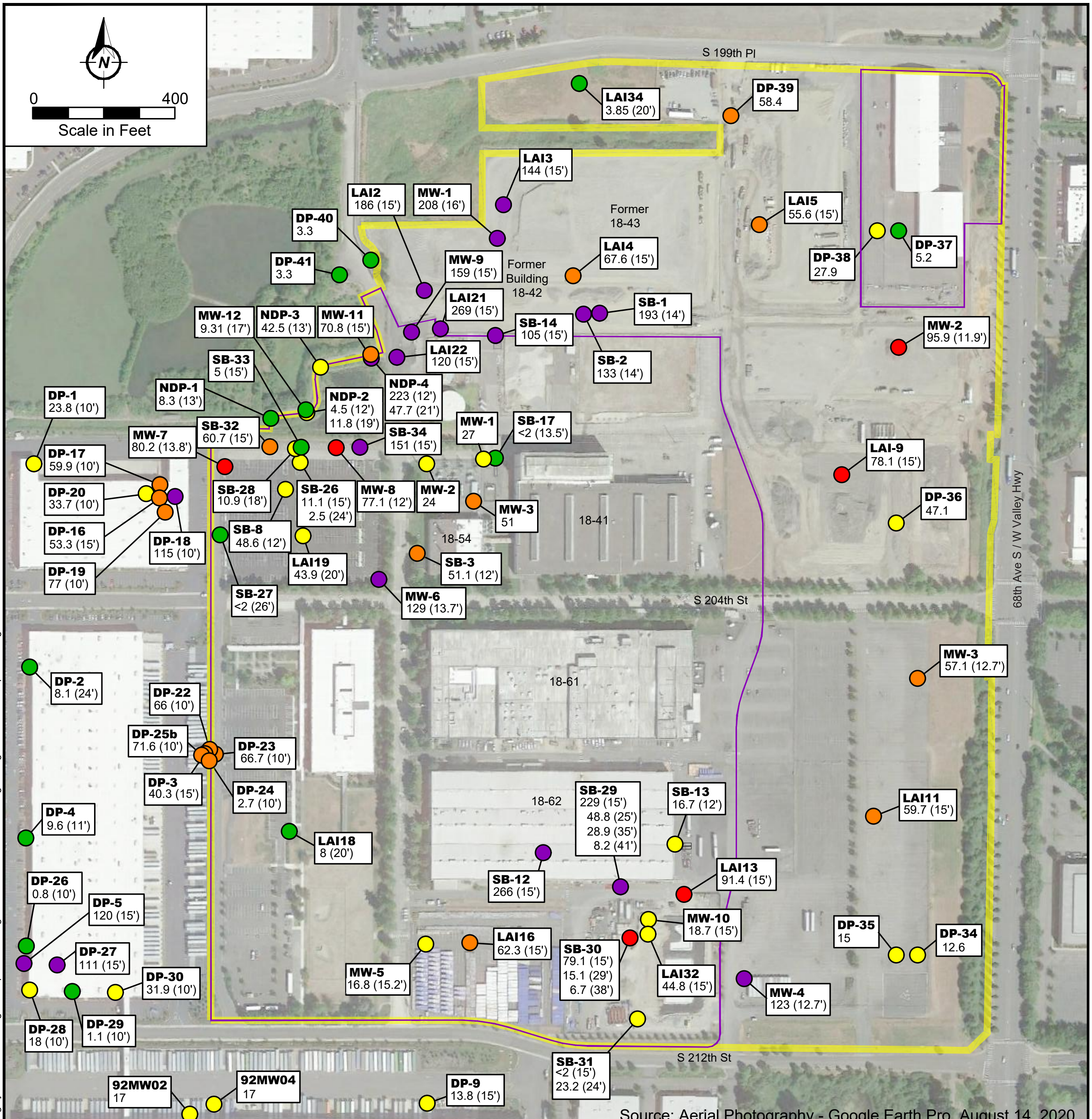
WELL CONSTRUCTION DETAILS AND/OR DRILLING REMARKS



Note: The summary log is an interpretation based on samples, drill action, and interpolation. Variations between what is shown and actual conditions should be anticipated.

Appendix B

RI Background Information



Source: Aerial Photography - Google Earth Pro, August 14, 2020.

Legend

- LAI17 Groundwater Sample Location
- 115 Arsenic Concentration (in ug/L)
- (24') Bottom of Screen Depth (Ft)
- Site Boundary
- Boeing Property
- MW-7 Groundwater Monitoring Well
- MW-3 Abandoned Groundwater Monitoring Well

Symbol Color	Arsenic Concentrations (ug/L)
	>100
	>75
	>50
	>10
	<10

Note:
1. Highest concentration of Arsenic in groundwater detected throughout multiple sampling events. See Table 2 for all results.

Boeing Space Center
Kent, Washington

Remedial Investigation

Arsenic Concentrations in Groundwater

DOF DALTON OLMSTED FUGLEVAND

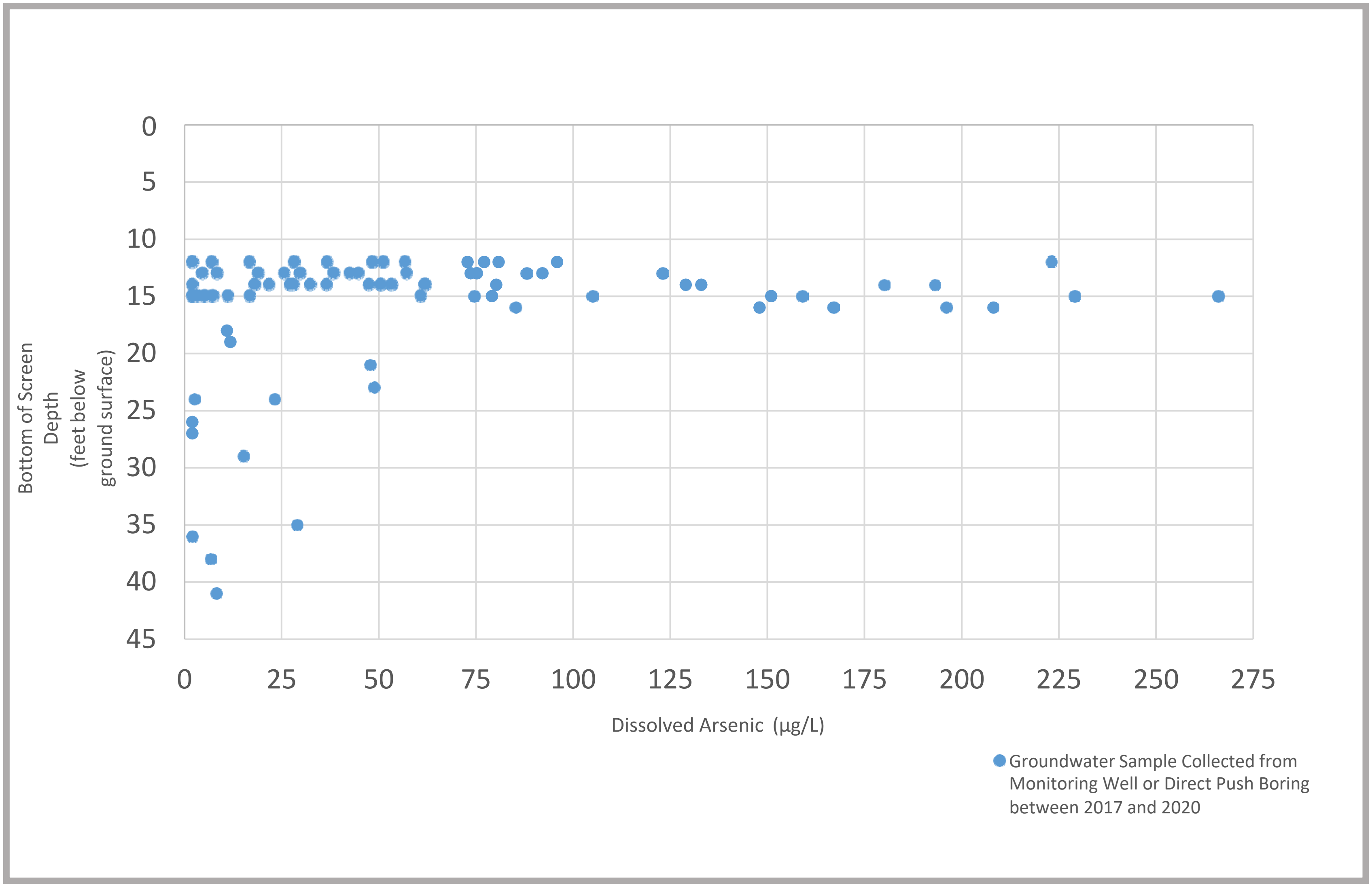
FIGURE 52

Figure 53

Groundwater Sample Depth vs. Arsenic Concentrations

Boeing Kent Space Center

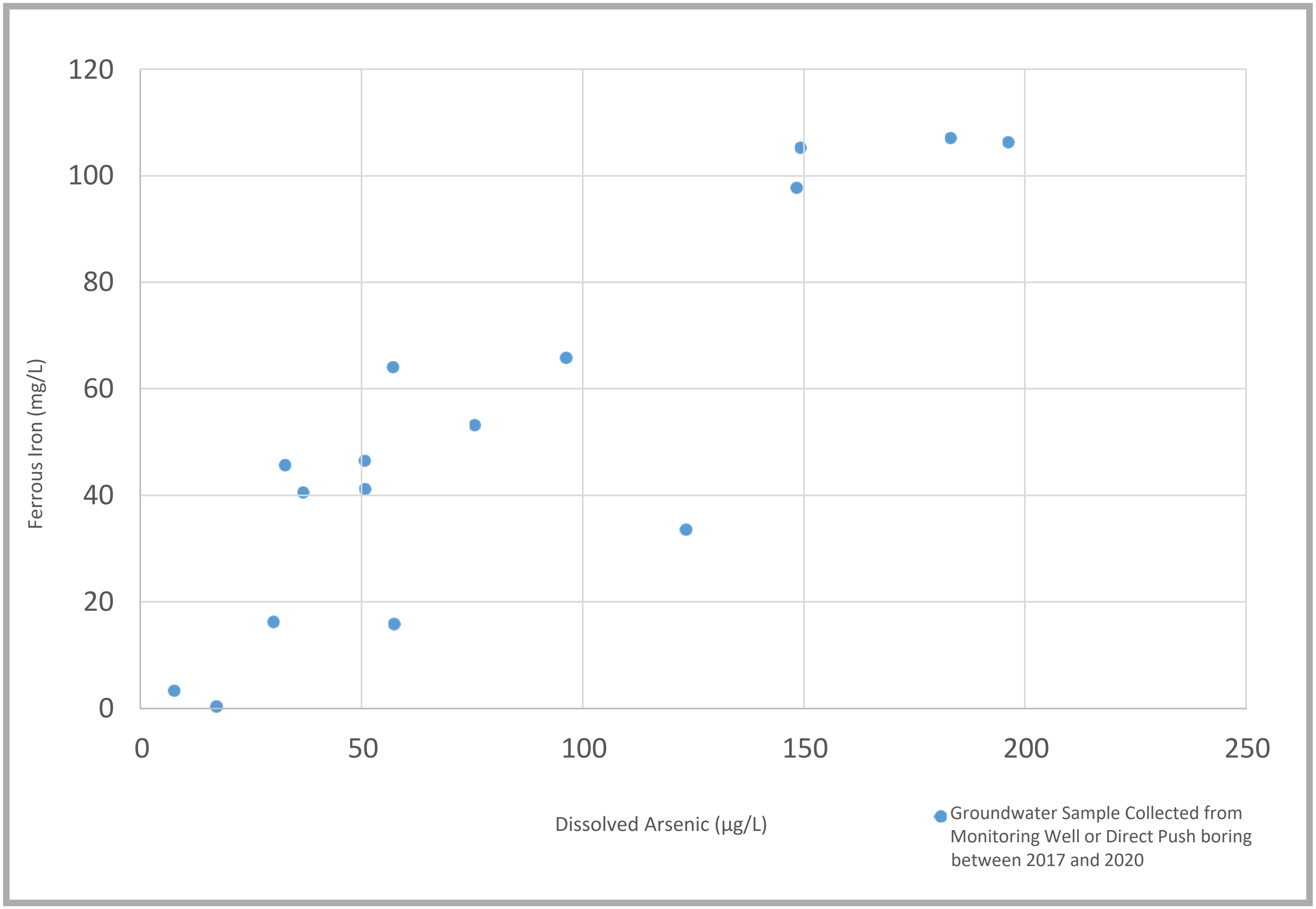
Kent, Washington



Note: Non-detect values shown at the reporting limit

DALTON OLMSTED FUGLEVAND

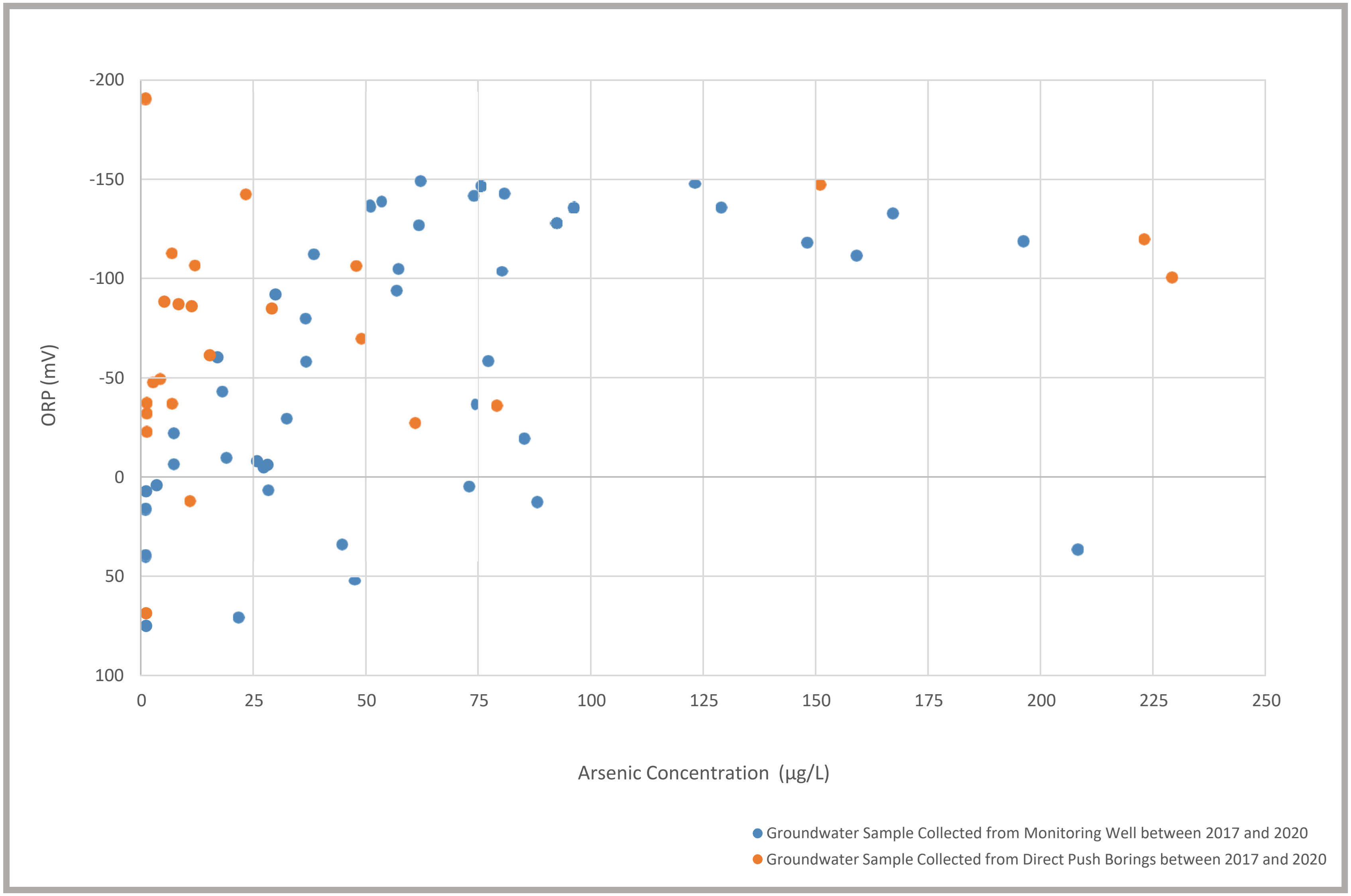
Figure 54
Arsenic vs. Ferrous Iron Concentrations
Boeing Kent Space Center
Kent, Washington

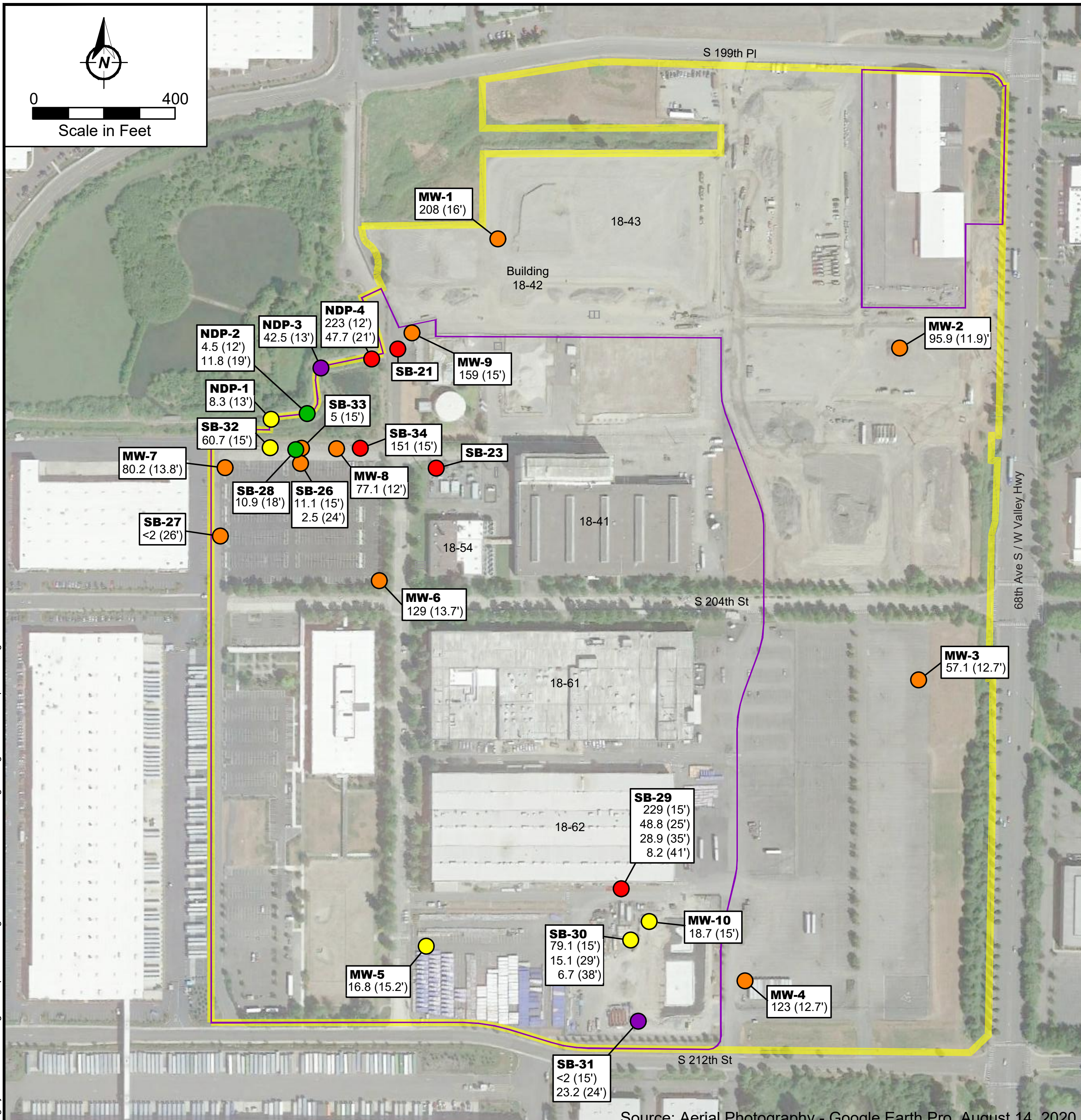


DALTON OLMSTED FUGLEVAND

Figure 55
ORP Measurements vs. Arsenic Concentrations

Boeing Kent Space Center
Kent, Washington





Legend

LAI17	Groundwater Sample Location
115	Arsenic Concentration (in ug/L)
(24')	Bottom of Screen Depth (Ft)
	Site Boundary
	Boeing Property
MW-7	Groundwater Monitoring Well
MW-3	Abandoned Groundwater Monitoring Well

Symbol Color	ORP Values (mV)
Purple	-150 to -200
Red	-100 to -150
Orange	-50 to -100
Yellow	0 to -50
Green	+50 to 0

Note:
1. Highest concentration of Arsenic in groundwater detected throughout multiple sampling events.
2. ORP values shown are average value where multiple events were completed. See Table 4 for actual values.

Boeing Space Center
Kent, Washington
Remedial Investigation

ORP Distribution Related to Arsenic Concentrations in Groundwater

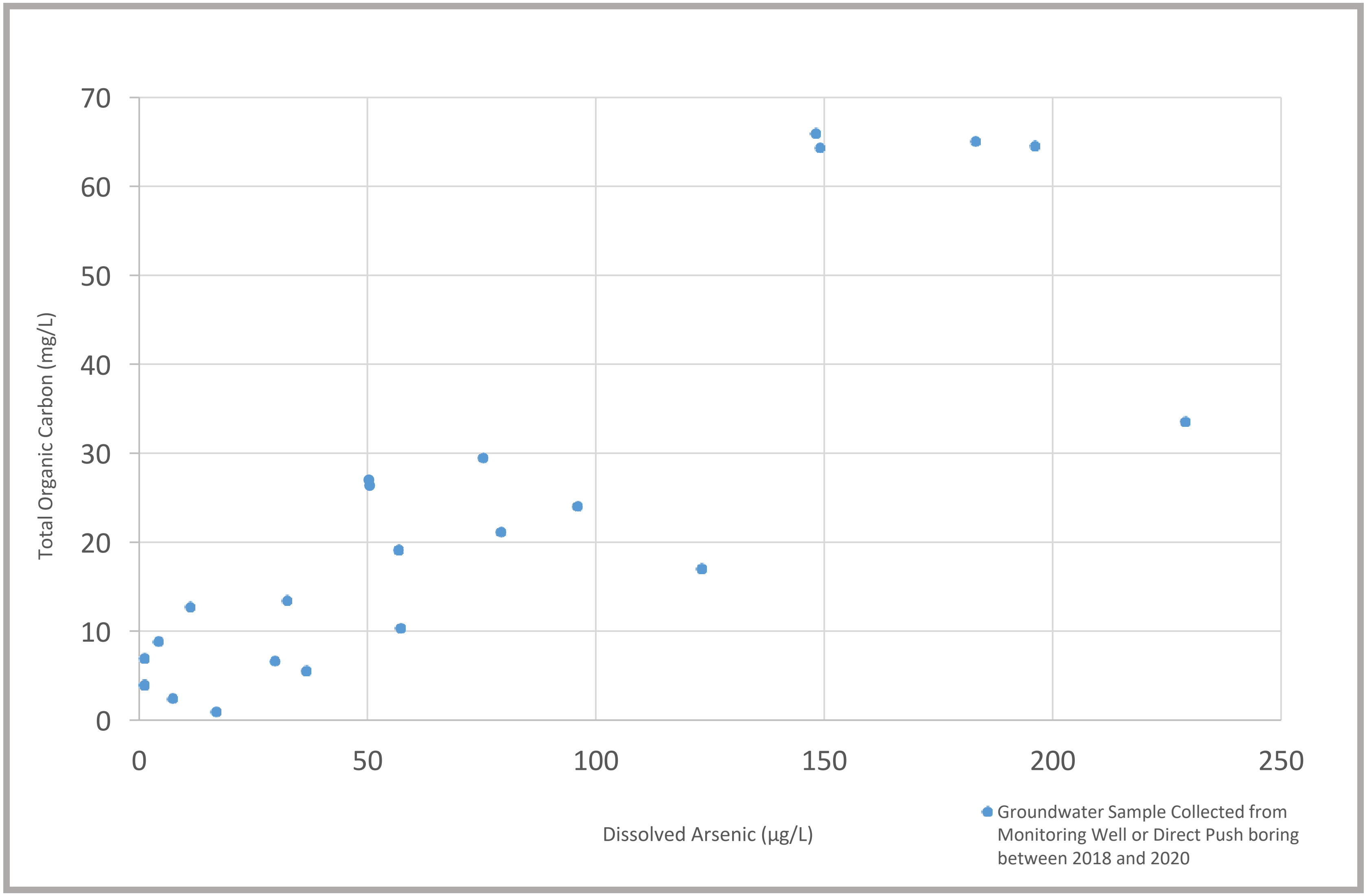
DALTON OLMSTED FUGLEVAND

FIGURE 56

PLOT TIME: 7/8/2022 4:24 PM MOD TIME: 7/8/2022 3:25 PM USER: Kelley Begley DWG: P:\Boeing Kent Space\CAD\Figures\2022-06\2022-06 Boeing SC Fig 56 ORP Samp Locs.dwg

Figure 57
Arsenic vs. Total Organic Carbon Concentrations

Boeing Kent Space Center
Kent, Washington



DALTON OLMSTED FUGLEVAND

Appendix C

Cost Backup

Appendix C - Cost Backup

Table of Contents

TABLES

1.0 INTRODUCTION

This appendix was prepared by Dalton, Olmsted, and Fuglevand (DOF) on behalf of the Boeing Company (Boeing). This appendix presents detailed cost estimates for each of the remedial alternatives developed for the Boeing Kent Space Center (Site) in Kent, Washington. The cost estimates were developed based on the conceptual designs for the alternatives described in Section 6 and shown in Figures 10, 11, and 12 of the Feasibility Study (FS) Report. The cost estimates were prepared in accordance with the methods developed by the U.S. Environmental Protection Agency (EPA, 2000) and WAC-173-340. General assumptions and details applied for preparation of the costs estimates for all of the remedial alternatives are presented in Section 2.0. Specific assumptions applied to individual alternatives are described in detail in Section 3.0. The three alternatives are:

- Alternative 1- Monitored Natural Attenuation (MNA)
- Alternative 2- Biosparging
- Alternative 3- In-Situ Chemical Reduction (ISCR)

2.0 GENERAL ASSUMPTIONS

Net present value (NPV) cost estimates were prepared for each alternative. A summary of the estimated NPV cost for each remedial alternative is presented in Table C-1. The total NPV costs shown in Table C-1 are rounded to the nearest thousand. The NPV cost estimates combine initial implementation costs (Year 0) as well as long-term recurring costs (Years 1 to the end of remedy). NPV discount rates were applied to recurring costs only. The initial implementation costs involve the cost to design, build, and implement the remedial alternative, and include permitting, engineering design, purchase of facilities and equipment, pilot studies, construction, and construction management costs. Recurring costs are the costs that would be incurred over the life of the remedial action and would include costs for operation, project management, repair and maintenance, compliance and confirmational monitoring, property access, materials, and replacement of equipment that may become worn out. All costs were provided in 2025 dollars.

The NPV cost for each alternative (Table C-1) was calculated using a net discount (interest) rate of 4.65 percent based on the U.S. Treasury 30-year real interest rate as per WAC 173-340-360(5)(d)(vi)(B)(ii).

Each alternative has three tables that show how the total NPV cost was calculated (Tables C-2 through C-10).

- Implementation Costs - costs in Year 0, for permitting, design, construction, and implementation of the remedial action.
- Recurring Operational Costs - ongoing remedial actions, maintenance, monitoring, and project management.
- NPV Costs - Costs shown for each year of the remedy, with costs pulled into each year as appropriate from the first two tables.

- A 10% contingency was applied to each column and added to the total for each year (unless otherwise noted).
- The total cost without NPV rates applied is provided.
- NPV discount rates are applied on Years 1 through alternative completion to produce an NPV Total cost.

The quantities shown in the cost tables were estimated based on the assumed scope of the remedial alternatives and preliminary conceptual designs, as described in the FS. The cost estimates are based on the areas where remedial actions would occur as shown in Figures 10, 11, and 12 of the FS. Reasonable assumptions based on best professional judgment were made as appropriate to estimate quantities for individual line items. The cost estimates based on these quantities are, therefore, preliminary estimates suitable for use in this FS Report to compare the alternatives only. These cost estimates are not suitable for final design or for budgeting.

The unit prices for most of the line items presented in the cost estimate tables were based on vendor quotes and experience with similar work. Technology vendors were consulted for costing on their specific technology's physical layout requirements and potential complications that could arise during implementation. Dalton, Olmsted, and Fuglevand, Inc. (DOF) then reviewed vendor supplied information against site specific trend data and layout to build the costs for each alternative.

The following general assumptions were made in estimating costs for each of the alternatives.

- Production rates and prices would be based on a standard 40-hour work week; no overtime or shift differential were included.
- The personal protective equipment would be Level D, unless otherwise noted.
- Waste generated is assumed to be non-hazardous waste.
- Any surface asphalt and concrete removed as part of remediation would be uncontaminated and would be recycled.
- Costs for potable water have not been estimated and have not been included in the remediation cost estimates.
- No security guards or extensive security precautions would be required. Treatment equipment, controls, or skids were assumed to be housed in a protective enclosure.
- Work would be performed without interruptions or multiple mobilizations and setups, unless noted otherwise.
- No prevailing wage or union standby labor costs have been included.
- Costs for legal fees associated with gaining access for remedial construction have not been included.

The implementation cost estimates include the consultant cost (professional technical services) for individual tasks. The professional technical services were estimated as a specified percentage of the remediation construction cost (see detailed cost estimates for each alternative) or as a lump sum. The specific line items for professional technical services have been divided into permitting, remedial design, construction management, and project management, as appropriate. The assigned percentages for remedial design, construction management, and project management were obtained from EPA guidance (EPA, 2000) and from professional experience for permitting.

The following assumptions were made in estimating implementation costs :

- A conditional point of compliance (CPOC) is assumed for groundwater in all alternatives.
- No new groundwater monitoring wells would be necessary.
- Site use/zoning would remain as they are currently designated (i.e., industrial use areas would remain industrial use, ponds would remain ponds, etc.).
- Six inch thick asphalt replacement (where necessary) was assumed to be sufficient.

The following assumptions were made in estimating recurring costs :

- The unit prices used for recurring cost estimates include consultant and contractor costs, as appropriate.
- Recurring cost rates were kept flat over the time of remediation (e.g., if analysis for arsenic was $75 in Year 1, it was assumed to still cost $75 in Year 10).
- Annual project management costs were estimated as $18,000 for all the alternatives when any activity was occurring in that year. For years with no activity (i.e., no groundwater monitoring) project management costs were halved. The recurring project management costs include costs related to the planning, designing, coordinating implementation, and reporting of groundwater monitoring and maintenance items detailed in the recurring cost tables for each alternative.
- Groundwater monitoring recurring costs included the following:
    - Labor costs were based on consultant staff providing the sampling labor.
    - Analytical costs were based on 2025 laboratory rates with analysis for dissolved and total arsenic and iron, and total organic carbon for all wells. Validation costs were estimated as part of analytical cost per well at $100 per well.
    - No annual increase in costs for laboratory analysis or data validation assumed.
    - No reduction in analytes assumed over time of the groundwater monitoring.
- Well abandonment is assumed to at the completion of monitoring.
- Site inspection and project management were assumed to be the same for all alternatives; additional monitoring costs for active remediation tasks were embedded in the line items for recurring active treatment tasks.

3.0 SPECIFIC ASSUMPTIONS

Detailed assumptions made for each remedial alternative that are not noted above are described in the following subsections.

3.1 Assumptions for Alternative 1

Detailed cost estimates for Alternative 1 are presented in Tables C-2 through C-4. Detailed assumptions were made as follows for remedial Alternative 1.

1. For Implementation Costs
    a. Deed restriction costs included only consultant support time, no legal fees were included.
    b. Stilling well installation would not require any heavy equipment and would be installed by hand with anchoring provided by stakes installed by hand.
    c. No permitting was necessary for this work.
2. For Recuring Costs
    a. Groundwater monitoring would be semi-annual for the first four years in order to assess long term chemistry trends post capping. After that, monitoring would be reduced to annual events in years 5 and 6. A final monitoring event would occur in Year 10 to confirm long term trends.

3.2 Assumptions for Alternative 2

Detailed cost estimates for Alternative 2 are presented in Tables C-5 through C-7. Detailed assumptions were made as follows for remedial Alternative 2.

1. For Implementation Costs
    a. Deed restrictions- Same as Alternative 1.
    b. Stilling well- Same as Alternative 1.
    c. Permitting would include grading and stormwater permitting with the City of Kent as well as CSGP permitting with Ecology.
    d. Excavation was assumed to occur in the dry season and to go to a depth of four feet below ground surface, with all excavation above the water table.
    e. Major utilities would not be encountered in the proposed work area or could be easily worked around.
    f. Biosparging would be low pressure and low flow, encouraging dissolution of oxygen in the groundwater (to a depth of approximately 15 feet below ground surface) and saturating the groundwater with oxygen to encourage precipitation of arsenic.
        i. Spacing was costed at roughly 30 feet on center.
        ii. Power is assumed to be from existing electrical service.
        iii. Treatment skid and controls will be in a secure container or compound.
        iv. All piping was assumed to be buried. 4-foot depth and 4-foot-wide trenches were assumed for the length of the treatment zone.
        v. 75% of site soils were assumed to be able to be re-used for backfill for piping trenches, with 25% sent offsite for disposal.

2. For Recuring Costs
    a. Air sparging would be operated for 2 years with monthly operation and maintenance performed on the blower and monthly system inspections.
    b. Groundwater monitoring would be semi-annual for the first three years in order to assess sparging effectiveness during operations and after shutdown. After that, monitoring would be reduced to annual events in years 4 and 5. A final monitoring event would occur in Year 8 to confirm long-term trends.

3.3 Assumptions for Alternative 3

Detailed cost estimates for Alternative 3 are presented in Tables C-8 through C-10. Detailed assumptions were made as follows for remedial Alternative 3.

1. For Implementation Costs
    a. Deed restrictions- Same as Alternative 1.
    b. Stilling well- Same as Alternative 1.
    c. Permitting would include grading and stormwater permitting with the City of Kent as well as CSGP and Underground Injection Control (UIC) permitting with Ecology.
    d. Bench testing would be used to confirm substrate dosing and type. For costing purposes, estimates from the chemical injection contractor were used based on existing groundwater and soil data.
    e. One round of treatment using in-situ chemical reduction would be performed in year zero. Injections would be performed in 2 rows with spacing between points of 7 feet on center to a depth of 15 feet. Injection and dosing costs based on vendor estimate (ISOTEC 2025).
    f. Major utilities would not be encountered in the proposed work area or could be easily worked around.
2. For Recuring Costs
    a. Groundwater monitoring would be semi-annual for the first 2 years in order to assess ISCR effectiveness. After that, monitoring would be reduced to annual events in years 3, 4, and 5.

3.4 Sensitivity Analysis

A summary of sensitivity analysis findings for all three alternatives was presented in Table C-11. Site conditions were taken into account to propose reasonable lower and higher cost scenarios for each alternative.

Detailed assumptions were made as follows for the sensitivity analysis.

1. For Alternative 1
    a. Lower Cost Scenario
        i. Assumed initial results showed compliance at the CPOC and groundwater monitoring would be continued annually for 5 years.

b. Higher Cost Scenario

   i. Assumed additional annual groundwater monitoring was necessary, out to 10 years.

2. For Alternative 2

   a. Lower Cost Scenario

      i. Removed the 10% contingency from the proposed scenario.

   b. Higher Cost Scenario

      i. Assumed in Year 3 that arsenic concentrations rebounded, and that an additional 2 years of air sparging would be completed and additional groundwater monitoring was necessary until year 10.

3. For Alternative 3

   a. Lower Cost Scenario

      i. A lower dose of substrate and/or well spacing could be increased based on bench testing results, reducing overall costs by 25%.

   b. Higher Cost Scenario

      i. A higher dose of substrate and three rows of wells is necessary based on bench testing results, leading to increased overall costs (approximately 40% higher costs).

4.0 REFERENCES

EPA, (U.S. Environmental Protection Agency), 2000, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study.

ISOTEC, , In-situ bioremediation and In-situ chemical treatment cost estimates, February 2025.

TABLE C-1

SUMMARY OF COSTS AND TIMING FOR REMEDIAL ALTERNATIVES
Boeing Kent Space Center
Kent, Washington

Alternatives	Initial Implementation Cost	Net Present Value Cost [1]	Start of Significant COC Reduction (years)	Active Remediation Duration (years) [2]	Restoration Time Frame (years)
Alternative 1- Monitored Natural Attenuation	$14,900	$290,000	1	0	< 10
Alternative 2- Biosparging	$286,500	$619,000	1	2	< 8
Alternative 3- In-Situ Chemical Reduction	$794,000	$1,186,000	1	10 +	< 6

Notes

1. Color gradation from green (low cost) to red (high cost) indicates relative cost between alternatives
2. Active remediation indicates the expected duration of accelerated degradation rates, except in the case of MNA which has no active component, so a timeframe of zero years was provided.

TABLE C-2

IMPLEMENTATION COSTS FOR ALTERNATIVE 1
Boeing Kent Space Center
Kent, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Institutional Controls**					
Creating Deed Restriction and Other ICs	LS	$10,000	1	$10,000	50 hours Consultant at $200 per hour
Task 1 Subtotal				**$ 10,000**	
2 **New Stilling Well**					
Stilling Well Equipment Cost	LS	$200	2	$400	6 inch HDPE pipe on bank of Boeing North Detention Stormwater Pond
Stilling Well Installation	person/day	$1,500	2	$3,000	2 DOF Field Staff +H&S equipment/PPE
Task 2 Subtotal				**$3,400**	
Implementation Subtotal				**$13,400**	
Professional Technical Services					
Permitting	LS	$0	0	$0	No permitting expected
Remedial Design	%	20%		$700	from EPA, 2000, Exhibit 5-8
Construction Management	%	15%		$500	from EPA, 2000, Exhibit 5-8
Project Management	%	10%		$300	from EPA, 2000, Exhibit 5-8
Subtotal, Professional Services				**$1,500**	
TOTAL INITIAL IMPLEMENTATION COST				**$14,900**	

Abbreviations

LS = Lump Sum
EPA = Environmental Protection Agency
DOF = Dalton, Olmsted & Fuglevand, Inc.
HDPE = High Density Polyethylene
PPE= Personal Protective Equipement

TABLE C-3

RECURRING COSTS FOR ALTERNATIVE 1[1,2]

Boeing Kent Space Center
Kent, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**Inspection**					
	Site Inspection	each	$750	1	$750	DOF Staff 1/2 Day
	Subtotal				**$750**	
2	**Groundwater Monitoring**					
	7 wells - Semi-Annual Compliance Monitoring	each	$1,570	14	$21,980	GW monitoring costs with validation, Years 1 to 4
	7 wells - Annual Compliance Monitoring	each	$1,570	7	$10,990	Years 5, 6, and 10
3	**Repairs**					
	Well replacement/fouling every 5 years	LS	$5,667	1	$6,000	Assume 1 well in year 5
	Subtotal				**$6,000**	
4	**Well Abandonment**					
	Monitoring Well Abandonment (after 10 years)	each	$800	16	$12,800	Cascade Drilling abandonment estimate
5	**Project Management**					
	Project Management	year	$18,000	1	$18,000	4 hours per quarter senior oversite and reporting (no GW monitoring assume 50%)
	Subtotal				**$18,000**	

Notes:

1. Assumes 40-hour work week.
2. No taxes have been included.

3.Groundwater Monitoring well network consists of:MW-8,11,12,13,14; 2 new stilling wells; WLs only at MW-7, SG-1, MW-9

Abbreviations
GW = groundwater
LS = Lump Sum

TABLE C-4

NET PRESENT VALUE FOR ALTERNATIVE 1
Boeing Kent Space Center
Kent, Washington

Year	Implementation Cost/Repairs	Inspection & Project Management	Groundwater Monitoring[1]	10% Contingency[2]	Yearly Total
0	$14,900			$1,490	$16,000
1		$18,750	$21,980	$4,073	$45,000
2		$18,750	$21,980	$4,073	$45,000
3		$18,750	$21,980	$4,073	$45,000
4		$18,750	$21,980	$4,073	$45,000
5	$6,000	$18,750	$10,990	$3,574	$39,000
6		$18,750	$10,990	$2,974	$33,000
7		$9,750		$975	$11,000
8		$9,750		$975	$11,000
9		$9,750		$975	$11,000
10	$6,000	$18,750	$23,790	$4,854	$53,000
TOTAL	$27,000	$161,000	$134,000	$32,000	$354,000

Net Discount rate: 4.65% **NPV** **$290,000**

As of March 25, 2025, the 30-year Treasury rate was4.65%

Notes
1. Groundwater monitoring costs include costs for monitoring well abandonment
2. Contingency estimate is included for implementation costs, repairs, inspection, project management, and groundwater monitoring.

TABLE C-5

IMPLEMENTATION COSTS FOR ALTERNATIVE 2

Boeing Kent Space Center

Kent, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Institutional Controls**					
Creating Deed Restriction and Other ICs	LS	$10,000	1	$10,000	50 hours Consultant at $200 per hour
Task 1 Subtotal				**$ 10,000**	
2 **New Stilling Well**					
Stilling Well Equipment Cost	LS	$200	2	$400	6 inch HDPE pipe on bank of Boeing North Detention Stormwater Pond
Stilling Well Installation	person/day	$1,500	2	$3,000	2 DOF Field Staf +H&S equipment/PPE
Task 2 Subtotal				**$3,400**	
3 **Biosparging**					
Mobilization/Demobilization	%	10%	17,000	$ 17,000.00	Engineer Estimate
Air Sparging Skid + Manifold	LS	$10,000	1	$10,000	Engineer Estimate Similar job AS skid with enclosure
Air Sparge Wells	EACH	$1,500	30	$45,000	Cascade Drilling
AS Piping & Fittings - below ground	LS	$5,000	1	$5,000	Engineer Estimate BCM Guide
Sawcutting	LF	$6	2,000	$12,400	Engineer Estimate BCM Guide
Excavation	CY	$20	540	$10,800	Engineer Estimate BCM Guide
Crushed Surfacing Base Course (CSBC)	TON	$45	160	$7,200	5/8-minus crushed rock, 3 inch thickness
Asphalt Paving	TON	$200	150	$30,000	6" hot mix asphalt
Electrical Connection of Skid	EACH	$15,000	1	$15,000	Engineer Estimate, assumes electrical service nearby
Transport & Disposal, Non-hazardous waste	Ton	$160	216	$34,600	Non-hazardous waste disposal, assume 75% of soils can be reused for trench backfill
Task 3 Subtotal				**$187,000**	
Implementation Subtotal				**$ 200,400**	
Professional Technical Services					
Permitting	LS	$20,000	1	$20,000	Engineer estimate based on similar project
Remedial Design	%	15%		$30,100	from EPA, 2000, Exhibit 5-8
Construction Management	%	10%		$20,000	from EPA, 2000, Exhibit 5-8
Project Management	%	8%		$16,000	from EPA, 2000, Exhibit 5-8
Subtotal, Professional Services				**$86,100**	
TOTAL INITIAL IMPLEMENTATION COST				**$286,500**	

Abbreviations

BCY = bank cubic yard
CY = cubic yard
TON = Tonnage
LS = Lump Sum
EPA = Environmental Protection Agency

DOF = Dalton, Olmsted & Fuglevand, Inc.
BCM = Building Construction Materials - The Guide
CWM = Chemical Waste Management
HDPE = High Density Polyethylene
PPE= Personal Protective Equipement

TABLE C-6

RECURRING COSTS FOR ALTERNATIVE 2[1,2]

Boeing Kent Space Center
Kent, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**Inspection**					
	Site Inspection	each	$750	1	$750	DOF Staff 1/2 Day
	Subtotal				**$750**	
2	**Groundwater Monitoring**					
	7 wells - Semi-Annual Compliance Monitoring	each	$1,570	14	$21,980	GW monitoring costs with validation, Years 1 to 3
	7 wells - Annual Compliance Monitoring	each	$1,570	7	$10,990	Years 4, 5, and 8
3	**Repairs**					
	Well replacement/fouling every 5 years	LS	$5,667	1	$6,000	Assume 1 well in year 5
	Subtotal				**$6,000**	
4	**Air Sparging Operations**					
	Annual Costs	LS	$50,000	1	$25,000	Years 1 and 2, electrical, operation, and maintenance costs
5	**Well Abandonment**					
	Air Sparge Well Abandonment (after 8 years)	each	$800	30	$24,000	Cascade Drilling abandonment estimate
	Monitoring Well Abandonment (after 8 years)	each	$800	16	$12,800	Cascade Drilling abandonment estimate
6	**Project Management**					
	Project Management	year	$18,000	1	$18,000	4 hours per quarter senior oversite and reporting (no GW monitoring assume 50%)
	Subtotal				**$18,000**	

Notes:
1. Assumes 40-hour work week.
2. No taxes have been included.
3.Groundwater Monitoring well network consists of:MW-8,11,12,13,14; 2 new stilling wells; WLs only at MW-7, SG-1, MW-9

Abbreviations
GW = groundwater
LS = Lump Sum

TABLE C-7

NET PRESENT VALUE FOR ALTERNATIVE 2

Boeing Kent Space Center

Kent, Washington

Year	Implementation Cost/Repairs	Inspection & Project Management	Groundwater Monitoring[1]	10% Contingency[2]	Yearly Total
0	$286,500			$28,650	$315,000
1	$25,000	$18,750	$21,980	$6,573	$72,000
2	$25,000	$18,750	$21,980	$6,573	$72,000
3		$18,750	$21,980	$4,073	$45,000
4		$18,750	$10,990	$2,974	$33,000
5	$6,000	$18,750	$10,990	$3,574	$39,000
6		$9,750		$975	$11,000
7		$9,750		$975	$11,000
8	$6,000	$18,750	$47,790	$7,254	$80,000
TOTAL	$349,000	$132,000	$136,000	$62,000	$678,000

Net Discount rate: 4.65% **NPV** **$619,000**

As of March 25, 2025, the 30-year Treasury rate was 4.65%

Notes

1. Groundwater monitoring costs include costs for monitoring well abandonment.
2. Contingency estimate is included for implementation costs, repairs, inspection, project management, and groundwater monitoring.

TABLE C-8

IMPLEMENTATION COSTS FOR ALTERNATIVE 3
Boeing Kent Space Center
Kent, Washington

Item	Unit	Unit Cost	Quantity	Cost	Sources/Notes
1 **Institutional Controls**					
Creating Deed Restriction and Other ICs	LS	$10,000	1	$10,000	50 hours Consultant at $200 per hour
Task 1 Subtotal				**$ 10,000**	
2 **New Stilling Well**					
Stilling Well Equipment Cost	LS	$200	2	$400	6 inch HDPE pipe on bank of Boeing North Detention Stormwater Pond
Stilling Well Installation	person/day	$1,500	2	$3,000	2 DOF Field Staf +H&S equipment/PPE
Task 2 Subtotal				**$3,400**	
3 **In-Situ Chemical Treatment**					
Bench scale test	LS	$25,000	1	$25,000	
ISOTEC Injection Cost (labor, equipement)	day	$15,000	30	$450,000	ISOTEC 10 points per day, 7 ft spacing, 2 rows, 1000, feet, 290 points- 1 day extra
Injection Media Cost	%	30%	450,000	$135,000	ISOTEC Typical Substrate Usage (Dependent on bench testing)
Task 3 Subtotal				**$585,000**	
Implementation Subtotal				**$ 598,400**	
Professional Technical Services					
Permitting	LS	$40,000	1	$40,000	Engineer estimate based on similar project
Remedial Design	%	12%		$71,800	from EPA, 2000, Exhibit 5-8
Construction Management	%	8%		$47,900	from EPA, 2000, Exhibit 5-8
Project Management	%	6%		$35,900	from EPA, 2000, Exhibit 5-8
Subtotal, Professional Services				**$195,600**	
TOTAL INITIAL IMPLEMENTATION COST				**$794,000**	

Abbreviations
BCY = bank cubic yard
CY = cubic yard
TON = Tonnage
LS = Lump Sum
EPA = Environmental Protection Agency
DOF = Dalton, Olmsted & Fuglevand, Inc.
BCM = Building Construction Materials - The Guide
CWM = Chemical Waste Management
HDPE = High Density Polyethylene
PPE= Personal Protective Equipement

TABLE C-9

RECURRING COSTS FOR ALTERNATIVE 3[1,2]

Boeing Kent Space Center
Kent, Washington

	Item	Unit	Unit Cost	Annual Quantity	Annual Cost	Sources
1	**Inspection**					
	Site Inspection	each	$750	1	$750	DOF Staff 1/2 Day
	Subtotal				**$750**	
2	**Groundwater Monitoring**					
	7 wells - Semi-Annual Compliance Monitoring	each	$1,570	14	$21,980	GW monitoring costs with validation, Years 1 to 2
	7 wells - Annual Compliance Monitoring	each	$1,570	7	$10,990	Years 3-5
3	**Well Abandonment**					
	Monitoring Well Abandonment (Year 6)	each	$800	16	$12,800	Cascade Drilling abandonment estimate
4	**Project Management**					
	Project Management	year	$18,000	1	$18,000	4 hours per quarter senior oversite and reporting
	Subtotal				**$18,000**	

Notes:
1. Assumes 40-hour work week.
2. No taxes have been included.
3.Groundwater Monitoring well network consists of:MW-8,11,12,13,14; 2 new stilling wells; WLs only at MW-7, SG-1, MW-9

Abbreviations
GW = groundwater
LS = Lump Sum

TABLE C-10

NET PRESENT VALUE FOR ALTERNATIVE 3

Boeing Kent Space Center
Kent, Washington

Year	Implementation Cost/Repairs	Inspection & Project Management	Groundwater Monitoring[1]	25% Contingency[2]	Yearly Total
0	$794,000			$198,500	$993,000
1		$18,750	$21,980	$4,073	$45,000
2		$18,750	$21,980	$4,073	$45,000
3		$18,750	$10,990	$2,974	$33,000
4		$18,750	$10,990	$2,974	$33,000
5		$18,750	$10,990	$2,974	$33,000
6		$18,750	$12,800	$3,155	$35,000
TOTAL	$794,000	$113,000	$90,000	$219,000	$1,217,000

Net Discount rate: 4.65% **NPV** **$1,186,000**

As of March 25, 2025, the 30-year Treasury rate was 4.65%

Notes

1. Groundwater monitoring costs include costs for monitoring well abandonment.
2. Contingency estimate is included for implementation costs (25%), with recurring costs at 10 % (repairs, inspection, project management, and groundwater monitoring.)

TABLE C-11

Sensitivity Analysis: Comparison of Cost Contingencies for Each Alternative
Boeing Kent Space Center
Kent, Washington

	Alternatives					
	Alternative 1- Monitored Natural Attenuation		**Alternative 2- Biosparging**		**Alternative 3- In-Situ Chemical Reduction**	
Contingency	Description	Net Present Value	Description	Net Present Value	Description	Net Present Value
Lower	5 years of annual GW monitoring	$194,000	2 years AS treatment, 8 years GW monitoring, no contingency (-10%)	$557,000	25% lower costs than proposed alternative	$890,000
100% of proposed alternatives	5 years of annual GW monitoring,with another round in year 10	$290,000	2 years AS treatment, 8 years GW monitoring	$619,000	5 years of annual GW monitoring, 2 rows of injections, 30% substrate cost	$1,186,000
Higher	10 years of annual GW monitoring	$336,000	4 years AS treatment, 10 years GW monitoring	$742,000	5 years of annual GW monitoring, 3 rows of injections, 40% substrate cost	$1,686,000

Abbreviations
GW = groundwater
AS = Air Sparge