Feasibility Study
USG Interiors Highway 99 Site
Milton, Washington

USG Corporation
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June 23, 2016

CDM Smith

A Report Prepared For:

USG Corporation
550 West Adams Street
Chicago, Illinois 60661-3676

FEASIBILITY STUDY
USG INTERIORS HIGHWAY 99 SITE
MILTON, WASHINGTON

June 23, 2016

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Section 1

Introduction

This document presents the results of CDM Smith Inc.'s (CDM Smith) feasibility study (FS) for the USG Interiors (USG) property located at 7110 Pacific Highway East in Milton, Washington (Highway 99 site). The site location is shown on **Figure 1**. This FS was performed to develop, evaluate, and provide recommendations for appropriate alternatives to remediate arsenic contamination in soil, groundwater, and sediment, and to satisfy the requirements of Agreed Order DE 6333 (current Order) between the Washington State Department of the Ecology (Ecology) and USG. The current Order came into effect on October 19, 2009.

1.1 FS Objectives

The objectives of this FS are summarized below:

- Develop remedial action objectives (RAOs) to achieve cleanup of the site.
- Screen potential remedial technologies to attain RAOs for the site.
- Combine remedial technologies, if necessary, to develop remedial action alternatives that address all of the RAOs.
- Develop conceptual level cost estimates for implementation, operation, and maintenance of the remedial action alternatives.
- Recommend the most appropriate remedial action alternative program for implementation at the site.

1.2 Location and Description

The USG Highway 99 site is located between Pacific Highway East and Interstate 5 in Milton, Washington. It is located in a commercial area situated along the east side of Pacific Highway East. Residences are located west of the property across Pacific Highway East.

Four businesses currently operate on the site: Freeway Trailer, Kanopy Kingdom, General Kingdom, and Linwood Custom Homes, as shown on **Figure 2**. Interstate 5 marks the eastern boundary of the site. Hylebos Creek is located east of the property adjacent to Interstate 5. The western paved portion of the site is relatively flat but drops off sharply east of the paved area where the surface slopes down either to Hylebos Creek or a roadside ditch. The site is located at an elevation of approximately 20 feet above Mean Sea Level (MSL).

Figure 2 shows the entire investigation area for the Remedial Investigation (RI) conducted between 2010 and 2012. For clarity, the extent of the exploration points shown on **Figure 2** is referred to as the "site" throughout this report. The majority of cleanup will occur in the core remediation area as shown on **Figure 3.** All RI tables and figures are shown in **Appendices A** and **B**, respectively.

1.3 Site History

The historical description that follows is based on CDM Smith's interpretation of historical aerial photographs, documents at Ecology, and a title search.

An aerial photograph from 1949 shows the site being used for residential and agricultural purposes. 12th Street East, an east-west road that connects the City of Milton proper with Pacific Highway East, is shown. This road runs between the current Kanopy Kingdom and Freeway Trailer properties.

Interstate 5 was constructed in this area in 1961. Hylebos Creek was re-routed to its current location as part of this construction. The freeway construction and re-routing of Hylebos Creek cut the site off from the adjoining agricultural land to the east. Freeway construction also did not make a provision for continued use of 12th Street East and so it was also abandoned at this time.

Fill was imported to bring the site up to grade with Pacific Highway East. This fill included industrial waste from USG's Tacoma plant. From 1959 through 1973, the USG Tacoma plant used ASARCO slag as a raw material for mineral fiber production. Baghouse dust and off-specification product high in arsenic was reportedly used as fill at the Highway 99 site from 1971 through 1973 (Ecology, 1986). USG did not own the property during the period when this fill was used.

In the early 1980s, USG became aware of the association between ASARCO slag and arsenic contamination. Subsequently, USG purchased what is now the Kanopy Kingdom property from Partner's Financial Incorporated on August 18, 1982. That same year USG voluntarily approached Ecology to negotiate an administrative process to govern removal of fill from the property. Soil and groundwater cleanup standards had not been established in Washington State at this time. Accordingly, Agreed Order No. DE 84-506 established project-specific arsenic cleanup standards for soil (0.5 milligrams per liter [mg/L]) by the EP Toxicity (leaching) method, and groundwater (0.5 mg/L). The 1984 Order also and required USG to conduct post-cleanup groundwater monitoring.

Cleanup of the Highway 99 site occurred between October 12, 1984 and January 25, 1985 (Ecology, 1986). Detailed records of the cleanup, termed the source removal action, have not been located. Ecology estimated that 20,000 to 30,000 cubic yards of material was excavated and disposed of off-site (Ecology, 1986). Native soil exceeding the project-specific cleanup standard was reportedly excavated in the southern portion of the property in the vicinity of monitoring well 99-1 (**Figure 3**). This is referred to as the contaminant source area. Ecology (1986) stated that soil cleanup standards for the project were met.

According to Ecology, approximately 10 percent of the total waste that was excavated and disposed of off-site was baghouse dust. We infer that the 20,000 to 30,000 cubic yards of waste included soil fill mixed with waste insulation, baghouse dust, and native soil exceeding the cleanup standard excavated from the vicinity of well 99-1.

A review of historical aerial photographs shows that the property was cleared and re-graded in June 1985 (approximately 5 months after completion of the source removal action). Verification groundwater sampling was performed by USG after the source removal action. In groundwater samples collected in wells 99-1 and 99-2 from June 1985 to February, arsenic concentrations averaged 2.46 mg/L and 0.61 mg/L, respectively.

USG sold the property to Herbert Rendell in 1986. The site subsequently underwent commercial development and by 1989 had been developed to its current configuration. USG maintained responsibility for verification monitoring, as specified in Agreed Order No. DE 87-506 issued in 1987. The 1987 Order retained the 0.5 mg/L groundwater cleanup level for the site.

The Model Toxics Control Act (MTCA) was enacted and went into effect in March 1989. MTCA governs state-led environmental cleanups in Washington State. In 1991, Ecology established MTCA 'Method A' arsenic cleanup levels of 20 milligrams per kilogram (mg/kg) for soil and 5 micrograms per liter (µg/L) for groundwater.

Long-term groundwater sampling performed by USG under the 1987 Order continued until early 2006. Arsenic concentrations in well 99-1 were still in excess of 2 mg/L. In 2006 Ecology required that USG conduct a soil and groundwater assessment for arsenic in the vicinity of well 99-1. This assessment showed that arsenic in soil and groundwater exceeded MTCA Method A cleanup standards. On March 30, 2007, Ecology sent USG a letter naming USG as a potentially liable party for the release of arsenic at the Highway 99 site. This led to the issuance of the current Order in 2009.

1.4 Site Geology and Hydrogeology

1.4.1 Site Geologic Conditions

The site is situated in a north-trending valley that is the floodplain of Hylebos Creek and its tributaries. The valley is located just north of the lower Puyallup River valley. Alluvium associated with Hylebos Creek and the lower Puyallup River forms the uppermost native soil at the property. The alluvium consists predominantly of overbank flood, slack water, and bar accretion deposits. Glacially consolidated glacial drift and interglacial deposits hundreds to thousands of feet thick underlie the alluvial deposits. Fife Heights, the upland region northwest of the property, is largely comprised of glacial drift.

The specific site geology is summarized in geologic cross-sections A - A' and B – B', which are shown in **Appendix B**. Generalized stratigraphy consists of fill overlying alluvium, over glacial drift. Each of these units is described in more detail below.

Fill

The property was originally low-lying farmland and fill was brought in during the 1960s and 1970s to bring the site up to grade with Highway 99 for development purposes. Fill at the site is differentiated into three units, described from youngest to oldest:

- Fill-3: Fill used as backfill for the 1984/1985 source removal action
- Fill-2: Fill containing industrial waste from USG's Tacoma plant
- Fill-1: Undifferentiated fill

Fill-3 was placed during remedial excavation backfilling in 1985. The soil consists of fine- to coarse-grained silty sand with gravel and silty sand (SM). The Fill-3 unit soil extends from the ground surface to maximum depths ranging from 4.5 to 14 feet below ground surface (bgs).

Fill-2 includes soil mixed with manmade materials. Fill-2 is likely residual fill representative of material not excavated in 1984/1985 during USG's removal action. These materials include what appears to be ASARCO slag, black and green glassy needle-like grains, glass-like gravel sized particles, and insulation debris. The ASARCO slag material does not appear to be processed like the other manmade materials. The material is associated with soil types that include poorly graded sand (SP) and sandy silt (ML). The Fill-2 material was encountered in borings A6, B6, B7, C7, and C8 (**Figure 3**) at depths extending from 6 to 12.5 feet bgs.

Fill-1 includes soil that was placed during initial development of the site and consists of silt (ML), sandy silt (ML), organic silt (OH), and silty sand (SM) with traces of debris, including wood chips and gravel. The Fill-1 soil extends to a maximum depth of 9 feet bgs.

Alluvium

Alluvium underlies fill at the site and pinches out to the west. The alluvium can be subdivided into two units based on soil type and hydraulic properties, including:

- Upper Silt Unit
- Alluvial Aquifer

The Upper Silt Unit is the uppermost alluvial unit. Soil in this unit is comprised of dark brown to gray brown silt and sandy silt (ML), often with bedding laminations. Minor amounts of wood fragments and rootlets are typically present. The Upper Silt Unit ranges in thickness from 1 to 6 feet. The presence of silt and organic matter indicate deposition in a lower energy depositional environment, such as wetlands.

The Alluvial Aquifer extends from the bottom of the Upper Silt Unit to the top of the Lower Silt Aquitard. Soil in the Alluvial Aquifer consists of fine-grained silty sand (SM), fine- to medium-grained sand (SP), and well-graded sand (SW). The soil includes minor silt (ML) interbeds, which are typically less than 0.25 inch thick. The thickness of the Alluvial Aquifer is approximately 30 feet at the center of the property.

Glacial Units

Glacial sediments underlie the alluvium east of Pacific Highway East. At monitoring well MW- 12, glacial sediments occurred directly beneath fill.

The glacial sediments are subdivided into the following units based on hydraulic properties:

- Lower Silt Aquitard
- Glacial Aquifer

Lower Silt Aquitard

The Lower Silt Aquitard underlies the Alluvial Aquifer. Soil in this unit consists of greenish-gray silt (MH or ML). The fine-grained nature of the soil indicates a low energy lacustrine (or possibly glacio-marine) depositional environment.

The total thickness of the Lower Silt Aquitard ranges from approximately 5 to 15 feet. The Alluvial Aquifer/Lower Silt Aquitard contact dips sharply to the east as shown in **Appendix B** (Figure 4, Section B-B').

Glacial Aquifer

Water-bearing sand (SP), silty gravel (GM), and silty sand with gravel (SM) underlie the Lower Silt Aquitard. This soil is classified as glacial drift based on texture and low organic content. The upper 10 feet of this soil is not consolidated and may have been deposited in a glaciofluvial depositional environment (recessional outwash). Below 52.5 feet bgs at MW-9, the soil changes to very dense silty sand (SM) and silty gravel that has a till-like texture. This consolidated soil is interpreted as glacial till.

1.4.2 Site Hydrologic Conditions

Alluvial Aquifer

Groundwater occurs under unconfined conditions within sand and silty sand of the Alluvial Aquifer. The low permeability soil of the Lower Silt Aquitard acts as a lower confining layer to the Alluvial Aquifer, limiting downward vertical flow. During the RI conducted between 2010 and 2012, groundwater was encountered at depths ranging from 4 to 14 feet bgs. Groundwater levels measured at each of the site monitoring wells are listed in **Appendix A**.

A groundwater elevation contour map for the Alluvial Aquifer, based on the July 15, 2010 depth to groundwater measurements, is shown on Figure 5 in **Appendix B**. The contours indicate that groundwater flows east toward Hylebos Creek and south parallel to the creek. The horizontal hydraulic gradient ranges from 0.003 foot/foot in the central area of the site, steepening to 0.03 foot/foot at the west bank of Hylebos Creek.

The vertical hydraulic gradient within the Alluvial Aquifer was calculated at the MW-5/MW-8 and MW-99-1/MW-7 well pairs. Wells in these pairs are completed within the shallow and deeper portions of the Alluvial Aquifer, respectively. The results of the vertical hydraulic gradient calculations indicate upward vertical hydraulic gradients ranging from 0.022 to 0.035 foot/foot, based on the July 15, 2010 groundwater elevation measurements. The upward gradient indicates significant potential for groundwater flow from the deeper to shallower reaches of the aquifer.

The predominant soil types in the Alluvial Aquifer are fine-grained silty sand (SM) and sand (SP). The hydraulic conductivity of these soils ranges from 0.3 to 30 feet/day, based on literature-derived hydraulic conductivity values for silty sand and fine sand (Anderson and Woessner, 1992).

Layers of coarser-grained sands (SP and SW) are also present within the Alluvial Aquifer. These sands have hydraulic conductivities ranging from 130 to 200 feet/day, based on an estimate using the Hazen (1911) method and the grain size distribution results for representative soil samples.

The average linear velocity (seepage velocity) of groundwater flow in the Alluvial Aquifer is estimated to range from 2 feet/day in the central area of the site. This is considered to be a maximum seepage velocity estimate and is based on a hydraulic conductivity of 200 feet/day, which is the maximum hydraulic conductivity estimated for the layers of coarser-grained sand present within the deeper Alluvial Aquifer. The seepage velocity for the fine-grained silty sand (SM) and sand (SP), typical of the shallow Alluvial Aquifer, is expected to be much lower.

Glacial Aquifer

The head differential between well pairs screened within the Alluvial Aquifer and the Glacial Aquifer (wells MW-99-1 and MW-9, respectively) was 6.58 feet based on the July 15, 2010 measurements. This large head differential indicates that the Glacial Aquifer is confined and exerting considerable hydraulic pressure on the overlying Lower Silt Aquitard. The different hydraulic and geochemical characteristics of the Glacial Aquifer and the Alluvial Aquifer indicate that the two aquifers are not in hydraulic communication.

The Glacial Aquifer is comprised of soil types ranging from silty sand (SM) to silty gravel (GM). Based on these soil types, the seepage velocity in the Glacial Aquifer is estimated to range from as low as 20 feet/day to as high as 70,000 feet/day. Typical hydraulic conductivity values for glacial aquifers in the site vicinity are at the lower end of this range.

1.4.3 Drinking Water Supply

Arsenic contamination in site groundwater does not pose a threat to the drinking water supplies of the Cities of Milton or Fife. The City of Milton's drinking water is produced from six groundwater wells located within the city limits. Well #3, Well #10, Well #12, Corridor Well #1, and Corridor Well #2 are located in the Redondo/Milton Aquifer in the north end of the city. Well #5 is located within the Edgewood/Eastern Upland Aquifer on the east side of the city. The Highway 99 site is located at the southwest corner of the City of Milton adjacent to the city limits and is situated outside of the city's aquifer recharge areas. Water supply wells are completed in the regional confined aquifer and are hydraulically separated from the alluvium.

The City of Fife is located directly west, southwest, and south of the Highway 99 site. Approximately 95 percent of the City of Fife's drinking water is purchased from Tacoma Water. The purchased water is mainly from the Green River. The remaining 5 percent of the city's drinking water comes from city-operated Well #4, which is located on the west side of Fife Heights. Well #4 is completed in the regional confined aquifer and hydraulically separated from the alluvium (i.e., the first screened interval is at 167 feet bgs).

1.4.4 Surface Water

The site is located in the watershed of Hylebos Creek. The two main branches of Hylebos Creek—known as East Hylebos Creek and West Hylebos Creek—originate in south King County and generally flow south. These two branches join in Milton at Porter Way (**Figure 1**), just north of the Highway 99 site on the east side of Interstate 5.

As shown on **Figure 3**, Hylebos Creek crosses under I-5 adjacent to the Highway 99 site. Prior to the construction of Interstate 5 in this area in 1961, Hylebos Creek flowed generally to the south along the current alignment of Interstate 5. As part of construction, Hylebos Creek was diverted to the west side of Interstate 5 and channelized into its current alignment between Interstate 5 and the property.

Hylebos Creek rejoins its pre-1961 channel at the south end of the Freeway Trailer property. It continues flowing generally south and crosses under Pacific Highway East before swinging to the northwest as it flows around the southern end of Fife Heights. Hylebos Creek then flows into the Hylebos Waterway, where it enters Commencement Bay as shown on **Figure 1**. The Hylebos Creek drainage basin as a whole is approximately 17 square miles. The average discharge of Hylebos Creek is approximately 20 cubic feet per second (TPCHD, 1993).

1.4.5 Groundwater/Surface Water Interaction

The nature of interaction between the Alluvial Aquifer and Hylebos Creek is difficult to characterize because of the 1961 diversion of Hylebos Creek into its current channelized section. The base of the channelized section adjacent to the contaminant source area intersects the Alluvial Aquifer. Alluvial Aquifer groundwater contours bend sharply adjacent to Hylebos Creek, indicating the Alluvial Aquifer does flow into Hylebos Creek. However, the very steep Alluvial Aquifer gradient of 0.03 foot/foot at the west bank of Hylebos Creek indicates there is a weak hydraulic connection between the Alluvial Aquifer and Hylebos Creek adjacent to the contaminant source area. This channelized section of Hylebos Creek does not appear to function as a true groundwater discharge area that would be found in an unconfined aquifer and an unmodified stream.

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Section 2

RI Summary

2.1 Summary of Site Investigations

Groundwater Monitoring Program (1985–2006)

USG implemented a groundwater monitoring program following completion of the 1984/1985 source removal action discussed in Section 1.3 to comply with the original Order. Groundwater was monitored on a monthly basis from 1985 through 2005, and on a semi-annual basis from 2005 to 2006. Two existing groundwater monitoring wells (99-1 and 99-2) were monitored. The locations of these wells are shown on **Figure 2**.

During the monitoring program, groundwater samples were analyzed for dissolved arsenic. In the last monitoring round, conducted in April 2006, arsenic was detected at a concentration of 2,250 µg/L in 99-1 and at 260 µg/L in 99-2, exceeding the MTCA Method A cleanup level of 5 µg/L. The groundwater data were evaluated and a slight downward trend was observed. However, the analysis indicated that the cleanup level would not be achieved by natural attenuation within a reasonable restoration timeframe.

Subsurface Investigation (2006)

USG conducted a subsurface investigation at the Highway 99 property in June 2006 to evaluate soil and groundwater quality in close proximity to groundwater monitoring well 99-1, reportedly the area where soil over-excavation occurred during the 1984/1985 source removal action. Nine direct push technology (DPT) borings (GP1 through GP9) were advanced at the site to a depth of approximately 16 feet bgs as shown on **Figure 3**. Soil and groundwater samples were collected for analysis. Results of this assessment are presented in a report CDM Smith prepared for USG (CDM, 2007).

Arsenic was detected in soil samples collected below the base of the former excavation at concentrations ranging from non-detect (GP-7 at 8 feet bgs) to 1,400 mg/kg at GP-2 at a depth of 15 feet bgs.

Remedial Investigation (2010 through 2012)

USG conducted an RI at the Highway 99 site in 2010 through 2012. The first phase of the field investigation was conducted in 2010 and focused on the contaminant source area. Supplemental investigations were conducted in 2011 and 2012. Results of the RI are presented in a CDM Smith report prepared for USG (CDM Smith, 2016a).

Phase I (2010)

Six surface soil samples were collected from the vegetated area between the west bank of Hylebos Creek and the paved parking surfaces to characterize arsenic concentrations in surface soil along the creek. **Figure 3** shows the location of the surface soil samples. Samples were analyzed for total arsenic by field portable x-ray fluorescence (XRF) and laboratory methods.

Thirty soil borings arrayed on a 50-foot offset grid were advanced using DPT to depths ranging from 12 feet to 24 feet bgs to characterize the lateral and vertical extent of arsenic. These borings were identified as A, B, C, or D followed by a number designation as shown on **Figure 3**. At each boring, soil samples were collected approximately every 2 feet from the ground surface to depths of between 16 and 24 feet bgs for field XRF analysis of arsenic.

Nine new groundwater monitoring wells (MW-1 through MW-9) were installed at the locations shown on **Figure 3** using a hollow-stem auger drill. Six of the wells were screened within the upper portion of the Alluvial Aquifer, two were screened in the deeper portion of the Alluvial Aquifer, and one well was screened within the Glacial Aquifer that underlies the Alluvial Aquifer. Soil samples were collected from each location at 5-foot intervals during drilling. Groundwater samples were also collected from each for dissolved arsenic analysis.

Surface water samples were collected from Hylebos Creek at six locations between the east edge of Interstate 5 and just downstream of the site as shown on **Figure 3**. Fourteen sediment samples were collected from the west bank and center of Hylebos Creek. The bank samples were taken from 6 inches below the water level of the creek. These samples were analyzed for total arsenic by field XRF and laboratory methods.

Supplemental Investigation Activities (2011/2012)

Supplemental field activities were conducted in 2011 and 2012 to further define the extent of arsenic in soil and groundwater at the site. Nine groundwater reconnaissance borings (GW-1 through GW-9) were advanced in 2011 to assist in locating additional groundwater monitoring wells to be installed at the site. The reconnaissance boring locations are shown on **Figure 3**. The reconnaissance borings were advanced using a DPT drill rig equipped with a Hydropunch™ groundwater sampling device. Groundwater samples were collected from each boring for laboratory analysis of arsenic.

Based on the analytical results from the groundwater reconnaissance borings, five additional monitoring wells (MW-10 through MW-14) were installed at the site. Two groundwater monitoring wells were installed in October 2011 using hand-drilled methods in the steep slopes east of the paved area of the site. MW-10 was installed on the east bank of Hylebos Creek and MW-11 was installed east of a ditch that flows into Hylebos Creek as shown on **Figure 3**.

Three monitoring wells were installed in May 2012 using a DPT drill rig to define the limits of groundwater exceeding the groundwater protection standard to the west, south, and north. MW-12 was installed on the west side of Pacific Highway East. MW-13 was installed at the southern end of the Freeway Trailer property, and MW-14 was installed at the northern end of the Kanopy Kingdom property. These well locations are shown on **Figure 2**. Groundwater samples were collected from each well for arsenic analysis. In addition, four soil samples were collected from MW-12 for arsenic analysis.

Two additional soil borings were advanced using a DPT drill in May 2012 to define the western limits of arsenic exceeding the cleanup level. Soil borings AA-6 and AA-7 were drilled on the east side of the Pacific Highway East right-of-way, as shown on **Figure 3**.

Remedial Investigation Addendum (2012)

A supplemental groundwater assessment was conducted in November 2012 as part of the RI for the site. The purpose of the supplemental assessment was to define the limits of groundwater exceeding the groundwater protection standard to the north, south, and east of the RI core investigation area shown on **Figure 3**. Results of this supplemental effort are presented in an addendum RI report (CDM Smith, 2016b).

Two new monitoring wells, MW-15 and MW-16 (shown on **Figure 2**), were installed in November 2012 using a DPT drill rig. MW-15 was installed on WDOT ROW south of the Freeway Trailer property. MW-16 was installed on the Linwood Custom Homes property north of Kanopy Kingdom. Groundwater samples were collected from each monitoring well for arsenic analysis. Two existing monitoring wells, PD-209A and PD-211 (located east of Interstate 5 and shown on **Figure 2**) were also sampled. Monitoring wells PD-209A and PD-211 are part of the B&L Landfill groundwater monitoring well network. Analytical results are provided on **Appendix B**, Table 3.

Arsenic was detected below the groundwater cleanup standard in the groundwater sample collected from MW-15, indicating the extent of arsenic exceeding the groundwater cleanup standard had been delineated to the south. Dissolved arsenic was detected at concentrations exceeding the groundwater cleanup level in MW-16, the northernmost well, and in PD-209A and PD-211, the wells sampled east of the property. Dissolved arsenic was detected at 7.2 µg/L, 8.5 µg/L, and 5.1 µg/L, respectively, in these wells.

2.1.1 Distribution of Arsenic in Soil in the Contaminant Source Area

The distribution of residual arsenic in soil was investigated during the 2006 subsurface assessment and the RI conducted in 2010 through 2012. Arsenic soil data from both the assessment and RI are tabulated in **Appendix A** and shown graphically in isocontour plots provided in **Appendix B**.

To help understand the distribution of arsenic in soil, it is helpful to refer to selected RI figures in **Appendix B**:

- Figures 3 and 4, Geologic Cross Sections
- Figure 6, Arsenic in Soil From 0-2 Feet bgs
- Figure 7, Arsenic in Soil From 4-6 Feet bgs
- Figure 8, Arsenic in Soil From 6-8 Feet bgs
- Figure 9, Arsenic in Soil From 8-10 Feet bgs
- Figure 10, Arsenic in Soil From 10-12 Feet bgs
- Figure 11, Arsenic in Soil from 12-14 Feet bgs
- Figure 12, Arsenic in Soil from 14-16 Feet bgs
- Figure 13, Arsenic in Soil from 16-18 Feet bgs

While soil depth plots don't correspond exactly with depth to groundwater, the 6 to 8 and 8 to 10 foot bgs arsenic soil concentration plots include the top of the water table, and arsenic in soil that may be saturated seasonally. Deeper arsenic soil concentration plots shown in Figures 9 through 13 (10 to 18 feet bgs.) in **Appendix B** represent arsenic concentrations in soil beneath the water table.

Elevated arsenic concentrations (>200 mg/kg) at depth are most typically encountered in Fill-1, Fill-2, or alluvium underlying the base of the 1984/1985 contaminant source removal action. The location of the greatest concern is soil boring B6. The 12-foot sample from B6 was of Fill-2 material with an arsenic concentration of 8,311 mg/kg and the 14-foot sample was alluvium with an arsenic concentration of 1,123 mg/kg. Arsenic concentrations in soil attenuate rapidly below 16 feet bgs.

2.1.2 Distribution of Arsenic in Groundwater

The distribution of dissolved total arsenic in groundwater at the site is shown in **Appendix B**. The highest arsenic concentrations were detected in the area bound by monitoring wells MW-4, MW-5, MW-99-1, MW-1, and MW-3. The dissolved arsenic concentrations in these wells ranged from 630 to 2,490 µg/L.

Arsenic concentrations in the Alluvial Aquifer attenuate with distance from MW-99-1. Arsenic concentrations in all Alluvial Aquifer monitoring wells exceed the MTCA Method A cleanup level of 5 µg/L, including the MW-13 (south end of Freeway Trailer property) and MW-16 (Linwood Custom Homes). Elevated arsenic concentrations extend east of Hylebos Creek. MW-10 located east of Hylebos Creek, had a dissolved arsenic concentration of 366 µg/L

Arsenic concentrations in groundwater in the deeper Alluvial Aquifer (MW-7 and MW-8) are two orders of magnitude lower than arsenic concentrations in groundwater from the shallow Alluvial Aquifer and are just slightly above the MTCA Method A cleanup level, indicating that arsenic attenuates rapidly with depth within this aquifer. Dissolved arsenic was detected at a concentration of 44 µg/L in the Glacial Aquifer (MW-9).

2.1.3 Site Conceptual Model

Industrial waste fill that served as the original source of arsenic at the site was removed in 1984/1985, along with some of the impacted native soil in the southern portion of the property in the vicinity of monitoring well 99-1. However, some residual fill containing industrial waste and what appears to be ASARCO slag remains at the site at depths extending from 6 to 12.5 feet bgs.

Elevated arsenic concentrations occur in soil from 6 feet and extend to 16 feet bgs as shown on **Appendix B** (Figures 8 through 12). This reflects the 1984/1985 contaminant source removal action as the shallower arsenic-bearing material was removed and replaced with imported fill. Elevated arsenic concentrations at depth are most typically encountered in Fill-1 or alluvium underlying the base of the 1984/1985 contaminant source removal action. This arsenic is interpreted to have leached out of the Fill-2 unit and adsorbed onto the underlying soil.

An exception to this is found in boring B6, where high concentrations of arsenic are associated with residual Fill-2. Arsenic concentrations in the residual Fill-2 material at other locations are often more than an order of magnitude less than observed at B6, indicating arsenic concentrations in Fill-2 are highly variable. The remaining Fill-2 material and the arsenic that leached out of the waste fill removed in 1984/1985 from approximately 1971 through 1985 serve as groundwater contaminant sources at the site.

Appendix B includes groundwater isocontour plots for key geochemical indicators such as arsenite and arsenate, redox potential, total organic carbon (TOC), and dissolved iron. Arsenic fate and transport at the site are summarized below:

- Arsenic exists predominantly in the reduced arsenite form at the site, although over time the arsenic is predicted to oxidize to the less mobile arsenate form.
- Iron and arsenic concentrations in groundwater at the site are likely controlled by ferric oxyhydroxides based on site-specific geochemical modeling performed for the RI.
- Redox conditions at the site are not in equilibrium with arsenic, dissolved oxygen, or TOC due to the presence of a redox gradient.
- Arsenic transport in the Alluvial Aquifer is at least 34 times slower than the groundwater velocity, resulting in long travel times for arsenic to migrate downgradient from the contaminant source area. This is a result of adsorption of arsenic to the surfaces of iron-bearing minerals and co-precipitation with iron hydroxides, which retards the transport of arsenic relative to groundwater. Using the minimum partitioning coefficient (Kd) of 4 L/kg, it would take approximately 17 years for arsenic to travel 50 feet from MW-99-1 to the groundwater beneath Hylebos Creek, and using the median Kd of 44 L/kg, it would take approximately 25 years for arsenic to travel this distance.

2.1.4 Terrestrial Ecological

A simplified terrestrial ecological evaluation (TEE) was conducted to assess the potential risk of exposure to wildlife from potential site contamination. The simplified TEE exposure analysis concluded that land use at the site and surrounding area makes substantial wildlife exposure unlikely (WAC 173-340-7492(2)(ii)).

Interstate 5, Pacific Highway East, and the site's paved surfaces and commercial land use form significant barriers to terrestrial wildlife movement and use (including birds) and would prevent most species from accessing the site. The site contamination is quite isolated from potential terrestrial wildlife use by highways and the risk of exposure is low. In addition, the habitats within 500 feet of the site are separated from the site by these major roadways. Species that would be expected in the forested hillside area to the west would not be attracted to the fields to the east or vice versa. Therefore, wildlife that might use the undeveloped lands to the west or east would not be expected to traverse the site.

2.2 Regulatory Analysis

MTCA, administered by Ecology (Washington Administrative Code [WAC] 173-340), establishes cleanup levels at contaminated sites. A cleanup level is the concentration of a particular hazardous substance that is considered a threat to human health or the environment. Points of compliance designate the location at a site where the cleanup must be met.

Under MTCA, cleanup levels that are protective of human health may be established under Method A, B, or C, as applicable. Method A provides tables of cleanup levels for 25 to 30 of the most common hazardous substances, including arsenic, found in soil and groundwater. Method A cleanup levels are available for both unrestricted and industrial land uses.

Cleanup levels under Method B are based upon unrestrictive land uses and established using applicable state and federal laws and risk-based concentrations calculated using the equations specified in the regulations. Method C is similar to Method B, but cleanup levels are based on less stringent exposure assumptions and the lifetime cancer risk for carcinogens is set at 1 in 100,000 instead of 1 in 1,000,000.

Use of Method C is limited to industrial sites where Method A or B cleanup levels are lower than technically possible, or when attainment of those levels may result in a significantly greater overall threat to human health and the environment. Method C requires that all practical methods of treatment have been used and institutional controls are in place. Natural background concentrations and the practical quantitation limit (PQL) are also considered when establishing Method A, B, or C cleanup levels.

In addition to the consideration for human health impacts, Methods A and B must account for potential terrestrial or aquatic ecological impacts unless it can be demonstrated that such impacts are not a concern at the site. A simplified TEE conducted for the site demonstrated that land use at the site and surrounding area makes substantial wildlife exposure unlikely and terrestrial ecological impacts are not a concern.

Because of the site's proximity to Hylebos Creek, surface water quality standards must also be considered when establishing cleanup levels. Method A surface water quality standards generally refer back to the water quality standards in WAC 173-201A. Method B and C values based on human health protection can be calculated from standard calculations in MTCA.

Determination of environmental effects on aquatic life may be determined from a literature search or whole effluent toxicity (WET) test (bioassay testing). Bioassay testing was not conducted for this site. The state designated uses of Hylebos Creek as identified in WAC 173-201A-600 are (note that Hylebos Creek is not identified in WAC 173-201 Table 602 – Use Designations for Fresh Waters by Water Resources Inventory Area so uses default to WAC 173-201A-600):

- Salmonid spawning, rearing, and migration
- Primary contact recreation
- Domestic water, industrial water, agricultural water, and stock water
- Wildlife habitat and harvesting
- Commerce and navigation, and boating (however, note that the City of Milton's Shoreline Master Program indicates Hylebos Creek is non-navigable)
- Aesthetic values

Review of Applicable or Relevant and Appropriate Requirements (ARARs) provided by Ecology for surface water in their Cleanup Levels and Risk Calculations (CLARC) database indicates that criteria based on human health are the most stringent criteria and would be the driver for cleanup. Ecology guidance indicates that if surface water is classified as suitable for use as a domestic water supply under state law, then the cleanup level must be at least as stringent as the potable groundwater cleanup level established under WAC 173-340-720 to protect drinking water beneficial uses.

The MTCA Method A groundwater cleanup level for arsenic is 5 µg/L. This value is based on natural background concentrations for Washington State in accordance with WAC 173-340-720 and would be applicable to the surface water.

2.3 Points of Compliance

2.3.1 Soil

MTCA (WAC 173-340-740(6)(d)) indicates that the point of compliance maximum depth for soil cleanup levels based on human exposure via direct contact is 15 feet bgs. An institutional control is not necessary if soil contamination is deeper than this since it is considered that this depth represents a reasonable estimate of the maximum depth at which soil could be excavated and distributed to the surface. For sites with soil contamination at shallower depths, Ecology may grant a site-specific conditional point of compliance as long as institutional controls (e.g., environmental covenant) are implemented.

The point of compliance for protection of human health via direct contact for the site is 15 feet bgs.

2.3.2 Groundwater

The point of compliance is the point(s) where the groundwater cleanup levels have been established. The standard point of compliance is throughout the site, both vertically and horizontally throughout the aquifer.

A conditional point of compliance may be used where it can be demonstrated that it is not practical to meet the cleanup level throughout the site. A conditional point of compliance cannot be outside of the property boundary except under three specific situations. One of these situations includes properties, such as the subject property, which abut surface water. Ecology may approve of a conditional point of compliance that is located within the surface water as close as technically possible to the point(s) points where the groundwater flows into the surface water subject to the following conditions:

1. Contaminated groundwater is entering the surface water and will continue to do so after implementation of the selected cleanup action.

2. It is not practicable to meet the cleanup standard at a point within the groundwater before entering the surface water within a reasonable restoration time frame.

3. Use of a mixing zone to demonstrate compliance with surface water cleanup levels is not allowed.

4. Groundwater discharges shall be provided with all known available and reasonable methods of treatment prior to discharge to the surface waters.

5. Groundwater discharges shall not result in exceedances of sediment quality standards.

6. Groundwater and surface water monitoring shall be conducted to assess the long-term performance of the selected cleanup action, including potential bioaccumulation problems resulting from surface water concentrations below method detection limits.

7. A notice of the proposal shall be mailed to the natural resources trustees, the Washington State Department of Natural Resources, and the United States Army Corps of Engineers.

2.3.3 Groundwater/Surface Water Interface

Shallow groundwater from the site appears to discharge into Hylebos Creek. Sediment data collected from the bank and center of Hylebos Creek show elevated arsenic concentrations downgradient of where the highest concentrations of arsenic were detected in groundwater at the site. This indicates that dissolved arsenic in groundwater is either adsorbing onto sediment or co-precipitating with iron onto sediment at the groundwater/surface water interface.

2.4 Cleanup Levels and Contaminant Distribution

Table 1 summarizes cleanup levels for arsenic relevant to the site based on affected media and protection of the various receptors of concern. The following subsections summarize how the proposed cleanup levels will be applied to site-specific conditions.

2.4.1 Soil

Isocontour maps of arsenic in soil were prepared for the RI to show the lateral and vertical extent of arsenic in soil at the site. The isocontour maps (**Appendix B**) were generated for the ground surface and at 2-foot depth intervals using computer software and kriging algorithms. As shown, arsenic concentrations are relatively low at ground surface and increase with depth, reflecting the 1984/1985 remedial action performed by USG that removed waste fill and some native soil in the southern portion of the property. These materials were replaced with clean fill as part of the site restoration.

In general, the highest arsenic concentrations in soil are found in an area encompassing boring locations B4, B5, and B6 on the west side of the site. Soil with high arsenic concentrations extend into the saturated zone and so are in direct contact with groundwater.

Arsenic in soil is widely disseminated at the site. Arsenic exceeding the MTCA Method A cleanup level of 20 mg/kg extends across most of the core remediation area shown in **Figure 3**. The widely disseminated arsenic at the site means that cleaning up soil to the MTCA Method A cleanup level would involve excavating nearly the core remediation area to a depth of 16 feet. In this scenario, soil would either be disposed of off-site (if it exceeds the cleanup level) or excavated and stockpiled to gain access to soil exceeding the cleanup level. This cleanup alternative serves as the baseline cleanup alternative against which other alternatives are evaluated as described in WAC 173-350 (8)(c)(ii).

As demonstrated in this FS, cleaning up the entire site to achieve the MTCA Method A soil cleanup for arsenic is a cost disproportionate remedy.

2.4.2 Groundwater

An isoconcentration map of dissolved arsenic in groundwater is presented in **Appendix B**. The highest concentrations of arsenic are observed in MW-99-1, which is located in the original contaminant source area. From there, arsenic migrates in the direction of groundwater flow to the east and south. Site geochemistry limits arsenic mobility as described in Section 2.1.3.

2.4.3 Sediment

RI sediment data are included in **Appendix B**. One out of the 14 sediment samples analyzed for arsenic exceeded the freshwater sediment screening criterion. This sample was collected on the bank of Hylebos Creek.

Arsenic is transported to sediment via the groundwater pathway. Upon reaching Hylebos Creek, dissolved arsenic in groundwater is either adsorbed onto sediment or is co-precipitated with iron onto sediment at the groundwater/surface water interface. The selected remedy will need to permanently mitigate the migration of arsenic to sediment so that ecological screening criteria or site-specific sediment cleanup levels are attained.

2.4.4 Summary

Residual arsenic in soil exhibits three characteristics:

- Arsenic concentrations are generally low at ground surface and increase with depth as a result of a cleanup action performed in 1984/1985. Waste fill and some native soil in the southern portion of the property were removed from the site and replaced with clean fill as part of site restoration.
- High (>500 mg/kg) arsenic concentrations in soil and waste fill are typically found in an area encompassing boring locations GP2, B4, B5, and B6 on the west side of the site. Soil with high arsenic concentrations extend into the saturated zone and so are in direct contact with groundwater.
- Moderately elevated (between 20 and 100 mg/kg) concentrations of arsenic in soil are widely disseminated across the core remediation area, typically in the saturated zone.

Figure 4 shows the conceptual site model. The principal threat to receptors is posed by residual arsenic in soil leaching to groundwater. Dissolved arsenic is then transported via the groundwater pathway to Hylebos Creek surface water and sediment. Water supply for the site and surrounding area is supplied by deep groundwater supply wells hydraulically separated from the alluvium. Therefore, impacted groundwater from the site does not pose an imminent threat to human health via the drinking water pathway.

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Section 3

Identification and Screening of Remedial Technologies

This section documents the initial steps involved in developing and screening remediation options for contaminated site soil and groundwater, identifies general response actions, and screens viable technology types to remediate contaminated groundwater and soil and attain MTCA requirements. Remedial technologies that are carried forward into the detailed description of selected technology alternatives (Section 4) are also summarized.

3.1 General Response Actions, Technologies, and Process Options

General response actions are broad classes of actions that may satisfy MTCA requirements for the site. General response action categories for the site are assembled based on the nature and extent of contamination, as described in Section 2. General response actions considered applicable to the arsenic contamination found at the site include treatment, containment, excavation, extraction, disposal, institutional controls, or a combination of these categories. The seven general response actions include the following:

- No Further Action
- Institutional Controls
- Monitored Natural Attenuation (MNA)
- Containment
- In-situ Treatment (soil and groundwater)
- Groundwater Pumping and Treatment
- Excavation and Off-site Disposal

Specific remedial technologies and process options potentially applicable to the site have also been identified within the general response actions listed above. These technologies are summarized in **Table 2**. The following subsections further describe, discuss, and evaluate each technology and its applicability to metals contamination in soil and groundwater at the site.

3.2 Screening of Remedial Technologies

This subsection describes the screening and evaluation of identified potential technology types for remediating contaminated soil and groundwater at the site. **Table 2** summarizes this screening and evaluation process.

Screening and evaluation of remedial technologies and related process options are based on the type, distribution, and volume of arsenic found in soil and groundwater at the site and on the MTCA requirements discussed in Section 2. Technology types were identified for each general response action. One or more process options were identified for each technology and then each was reviewed against site-specific conditions and evaluated based on three preliminary criteria: effectiveness, implementability, and relative cost. The basis for applying each of these three criterion to evaluate individual technology process option is described below.

Effectiveness Evaluation: This evaluation focused on the potential effectiveness of each process option in remediating the contaminated soil and groundwater and in meeting the MTCA requirements. Specific information considered included types and levels of contamination, volume and areal extent of contaminated soil and groundwater, and time required to achieve remediation goals. Each process option was classified as being effective, limited, or not effective.

Implementability Evaluation: This evaluation rated the relative degree of technical implementability and feasibility of implementing the process option. Aspects considered included any substantive requirements of potential permits for actions; availability of treatment, storage, and disposal services; space constraints of the property and location of Hylebos Creek; and availability of necessary equipment and skilled workers to implement the technology. The implementability of each process option was classified as easy, moderately difficult, difficult, or not implementable.

Cost Evaluation: Cost evaluation was based on engineering judgment, and each process option was evaluated relative to other process options of the same technology type. Both capital and operating costs were considered. The cost of each process option was classified as none, low, moderate, high, or very high.

The following subsections further describe and summarize the screening results for each general response action.

3.2.1 No Further Action

No Further Action implies that no remedial action will be conducted on the site. The site is allowed to continue in its current state, and no future actions are conducted to remove or remediate the contamination. No access restrictions are put into place, and no deed restrictions are placed on the site. The No Further Action response provides a baseline for comparison to other remedial response actions.

Effectiveness: The No Further Action option is not effective to remediate contaminated soil and groundwater at this site or meet MTCA requirements.

Implementability: The No Further Action option is easy to implement technically because it does not require any actions to be taken. Therefore, administrative implementability is not evaluated in this FS.

Cost: There are no construction or operation and maintenance costs associated with the No Further Action option because no actions are taken and no site monitoring is conducted.

Screening Summary: The No Further Action option will not achieve MTCA requirements and is not acceptable under MTCA, so it is not retained for further evaluation.

3.2.2 Institutional Controls

Institutional controls are non-engineering measures, such as administrative or legal controls, that help minimize the potential for human exposure to contamination and/or protect the integrity of a remedy by limiting land or resource use. Washington defines institutional controls under WAC 173-340-440 as measures undertaken to limit or prohibit activities that may interfere with the integrity of an interim action or cleanup action or that may result in exposure to hazardous substances at a site. These institutional controls may include:

- Physical measures such as fences.
- Restrictions such as limitations on the use of property or resources, or requirements that cleanup action occur if existing pavement is disturbed or removed.
- Maintenance requirements for engineered controls such as inspection and repair of monitoring wells, treatment systems, caps, or groundwater barrier systems.
- Educational programs such as signs, postings, public notices, health advisories, mailings, and similar measures that educate the public about site contamination and ways to limit exposure.
- Financial assurances.

Effectiveness: Institutional controls can be effective at managing human exposure to contaminated soil and groundwater; however, they do nothing to reduce existing contaminant concentrations. The effectiveness of institutional controls depends on the mechanisms used and the durability of the institutional control. The need for human actions to implement and maintain the controls makes them less reliable than engineering controls. Overall, institutional controls are considered to have limited effectiveness.

Implementability: Institutional controls are typically easy to implement.

Cost: Institutional controls are usually low cost.

Screening Summary: Institutional controls alone may not achieve MTCA requirements; however, when used in conjunction with other remedies, it can improve overall protectiveness. Therefore, institutional controls are retained.

3.2.3 Monitored Natural Attenuation

Monitored natural attenuation refers to the reliance on natural attenuation processes to achieve site-specific remedial objectives within a timeframe that is reasonable compared with that offered by other more active methods (EPA, 1999). The processes, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. *In-situ* processes for metals include dispersion, dilution, sorption, and the chemical or biological stabilization or transformation of contaminants. Ecology expects that natural attenuation of hazardous substances may be appropriate at sites where:

- Source control (including removal and/or treatment of hazardous substances) has been conducted to the maximum extent practicable.
- Leaving contaminants on-site during the restoration time frame does not pose an unacceptable threat to human health or the environment.
- There is evidence that naturally occurring adsorption, precipitation, biodegradation, or chemical degradation is occurring and will continue to occur at a reasonable rate at the site.
- Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

Effectiveness: The effectiveness of MNA at the site depends on site conditions such as source strength and persistence, soil adsorption capacity, soil and groundwater chemistry, pH, temperature, and oxidation-reduction coupling. MNA can be effective at reducing arsenic concentrations in groundwater when combined with source control measures and under certain geochemical conditions.

Implementability: Implementation of MNA as a remediation technology entails a groundwater monitoring program to provide data to evaluate attenuation rates and monitor plume extent. A monitoring well network exists at the site to adequately monitor natural attenuation. Equipment and methods to sample and analyze groundwater are readily available. Monitored natural attenuation is easy to implement.

Cost: Costs to implement and maintain a groundwater monitoring program to monitor natural attenuation are low to moderate, depending on the number of wells sampled and frequency and duration of sampling.

Screening Summary: MNA may be able to achieve MTCA requirements, and can improve overall protectiveness when used in conjunction with other remedies. MNA is typically used in conjunction with contaminant source control measures, where it will share the role of compliance monitoring. It is retained for consideration.

3.2.4 Containment

Containment serves two functions: 1) to isolate contaminated soil or groundwater to reduce the possibility of exposure by direct contact, and 2) to control or reduce migration of the contaminated materials into the surrounding environment. Typically, containment actions involve an engineered cap to block a contaminant migration pathway such as the surface water (precipitation)-to-soil pathway. The Highway 99 site is atypical in that infiltrating precipitation will promote oxidizing groundwater conditions and reduce arsenic mobility. Containment actions for contaminated groundwater typically include physical barriers or hydraulic gradient controls.

Capping

Most of the site is currently capped by asphalt pavement, which serves as a horizontal barrier to direct human contact. Creating a less permeable or impermeable cap at the Highway 99 site is not an appropriate remedial technology, however, because it would tend to create reducing groundwater conditions. Accordingly, a permeable cap may be used at the Highway 99 site, especially in the core remediation area.

Effectiveness: Pavement improvements at the site could reduce the infiltration of precipitation to groundwater, especially at the Freeway Trailer property extending south of the core remediation area where some areas are unpaved. However, arsenic fate and transport modeling indicates that oxidizing groundwater conditions at the site currently limit the mobility and transport of arsenic. Constructing conventional asphaltic concrete paving over the unpaved areas on Freeway Trailer would tend to make groundwater at the site more reducing and arsenic more mobile. Therefore, the capping remedy at the site may convert some of the relatively impermeable conventional paving at the site to a permeable cap that will promote oxidizing groundwater conditions.

Implementability: Capping is considered a standard construction practice and easily implemented if existing pavement can be incorporated into the cap. Equipment and construction methods associated with capping are readily available, and design methods and requirements are well understood.

Permeable pavement, however, is a specialty construction item. Pilot testing would need to be conducted to test permeable pavement designs, prior to full-scale implementation.

Cost: A permeable cap for the site source areas would have moderate construction and low maintenance costs.

Screening Summary: Containment with an impermeable cap might promote reducing groundwater conditions at the site, which would tend to increase arsenic mobility. This option is not retained. Capping with a permeable pavement is retained as part of a long-term remedy. Pilot testing would be performed prior to full-scale implementation.

Vertical Barriers

Vertical barriers are physical containment methods used to contain contaminated groundwater or direct its flow. Vertical barriers include sheet piling and slurry walls or curtains. At the Highway 99 site these types of physical barriers would be used to direct the flow of contaminated groundwater toward groundwater extraction wells or *in-situ* treatment walls in a “funnel and gate” arrangement.

The vertical barrier technology evaluated for this site is a slurry or sheet pile. Most slurry walls are constructed of a mixture of soil, bentonite, and water. The bentonite slurry is used primarily for wall stabilization during trench excavation. A soil-bentonite backfill material is then placed into the trench (displacing the slurry) to create the cutoff wall.

Walls of this composition provide a barrier with low permeability (typically 10^{-7} centimeters per second) and chemical resistance at low cost. Other wall compositions such as cement/bentonite, pozzolan/bentonite, attapulgite, organically modified bentonite, or slurry/geomembrane composite may be used if greater structural strength is required or if chemical incompatibilities between bentonite and site contaminants exist. Other critical factors include acceptability of site soil for use in backfill, trench stability, chemical compatibility, available work area, water availability, longevity, and availability of off-site backfill materials (if required).

Slurry walls can be constructed at depths up to 100 feet and are generally 2 to 4 feet thick. The most effective application of a slurry wall for site remediation or pollution control is to base (or key) the slurry wall 2 to 3 feet into a low-permeability layer such as clay or bedrock. This "keying-in" provides an effective foundation with minimum potential for leakage of contaminated groundwater under the slurry wall.

A steel sheet pile wall may also be an effective vertical barrier at the site. Sheet pile walls with interlocking joints can be used as a vertical barrier in this kind of application to minimize leakage of groundwater between the sheets. Sheet pile walls have the advantage of being strong. Also, when considering the spoils generated by a slurry wall construction, there might be an advantage of using a sheet pile instead of a slurry wall adjacent to Hylebos Creek. On the negative side, sheet pile walls are generally an expensive option when compared to slurry walls. A sheet pile wall construction will be evaluated further should the selected remedial action alternative include a barrier wall, but the following discussion focuses on a slurry wall, which is our preferred vertical barrier at this time.

Effectiveness: To be effective at the site, a vertical groundwater barrier would need to adequately reduce the rate of contaminated groundwater flow. This may require keying the barrier into the top of the Lower Silt Aquitard that underlies the Alluvial Aquifer. The Lower Silt Aquitard dips steeply to the east and could prove problematic to sealing. Pilot studies may be necessary to further evaluate this issue. In addition, the use of slurry walls without a “gate” or hydraulic controls (such as pump-and-treat) would likely result in higher groundwater elevations behind the wall and sharp hydraulic gradients across the walls. Higher groundwater levels could saturate arsenic-impacted soils currently within the vadose zone, while a high gradient would put pressure on the walls and possibly affect the integrity.

Implementability: Groundwater containment can be difficult to achieve; however, these actions have been successfully implemented at other similar sites. A slurry wall depth of between 20 and 40 feet is well within the normal range for excavation equipment used for constructing slurry walls. Groundwater containment using a vertical barrier such as a slurry wall is ranked as moderately difficult to implement.

Cost: A vertical groundwater barrier using a slurry wall at the site would have a moderate to high cost to construct. Maintenance costs of vertical groundwater barriers are considered low.

Screening Summary: Vertical groundwater containment using a slurry wall could improve overall protectiveness when used in conjunction with other remedies. Therefore, although a vertical groundwater barrier is not considered as a primary remedial method, it is retained as part of a funnel and gate remedy.

Hydraulic Containment

Groundwater containment can also be achieved by hydraulic containment. Typically, hydraulic containment includes using pumping wells, French drains, or extraction trenches to create hydraulic sinks that collect contaminated groundwater and reduce further migration. Hydraulic containment would require water treatment prior to on- or off-site disposal or reinjection (see Section 3.2.5 for additional discussion of pump-and-treat technologies).

Effectiveness: Hydraulic containment via conventional extraction methods is expected to be effective at reducing arsenic contaminant migration in groundwater, but does not remediate contaminated soil in source areas. Some reduction in source area contaminant mass would be achieved by this approach since hydraulic containment requires the removal of contaminated groundwater; however, containment by itself would not remediate source areas to achieve groundwater standards in a reasonable timeframe.

Implementability: Equipment and construction methods associated with conventional hydraulic containment are readily available, and design methods and requirements are well understood. Pump-and-treat systems can be difficult to maintain and are prone to fouling. Hydraulic containment is lost when components fail or are shut down for maintenance. However, groundwater containment at the site is not expected to pose any insurmountable difficulties; these actions have been successfully implemented at other similar sites. Maintenance of extraction well systems can be difficult depending on site-specific conditions and potential fouling. Therefore, hydraulic containment is ranked as moderately difficult to implement.

Cost: The cost of groundwater containment at the site is ranked high when considering long-term operations and maintenance costs.

Screening Summary: It is uncertain if conventional hydraulic containment would achieve MTCA requirements, and it is not retained as a primary remedial method. However, it may be considered further as part of a pump-and-treat alternative.

3.2.5 *In-Situ* Treatment

In-situ treatment consists of actions that treat contaminants in place and covers a broad range of technologies that include treatment of both soil and groundwater. Methods of *in-situ* chemical treatment generally involve adding reagents to the subsurface (via injection and deep mixing or treatment walls) that facilitate chemical stabilization or immobilization.

In-situ groundwater treatment commonly used for arsenic includes co-precipitation with iron, either through application of additional iron in the form of solutions or by injection of nano-scale zero-valent iron (ZVI). The iron-arsenic precipitates can be either: 1) oxyhydroxides if oxidizing groundwater conditions are created, or 2) sulfides if reducing groundwater conditions are created. These approaches are described in detail below.

In areas with arsenic contamination and higher concentrations of iron in a primarily reduced and soluble form, pressurized air can be injected by sparging into the aquifer to oxidize the existing iron to form solid iron oxyhydroxides. This will co-precipitate arsenic (and other metals) from solution and create a solid phase with a highly sorptive surface area. A similar geochemical process can be achieved by injecting or introducing an oxidant like permanganate or peroxide. Arsenite (As III) can be oxidized to the less mobile arsenate (As V) form using these stronger oxidants.

In-situ precipitation of arsenic can also be accomplished by creating reducing groundwater conditions. With this treatment method, a solution of iron is injected with an organic substrate. The reducing conditions created by bacterial action on the organic substrate keep the iron in the reduced ferrous state, allowing it to remain dissolved in the groundwater. Naturally occurring sulfate in the aquifer is reduced to sulfide, which then reacts with ferrous iron to precipitate out as iron sulfide. Iron sulfide can co-precipitate arsenic into its matrix and also provides a surface area that is highly sorptive.

Another form of *in-situ* groundwater treatment uses permeable treatment walls or gates, also known as permeable reactive barriers (PRBs). A PRB would most likely use ZVI or a proprietary metal remediation compound such as Adventus EHC-M® to treat arsenic. Groundwater with dissolved arsenic comes into contact with the ZVI (or other metal), which corrodes (rusts), forming a high surface area material that has a high adsorption capacity for arsenic. PRBs are placed in the subsurface across the natural flow path of the contaminant plume. They can be combined with vertical barriers (e.g., slurry wall) in a funnel and gate arrangement in which groundwater flow is directed through the treatment wall or gate.

In-situ treatment of arsenic soil contamination by stabilization or solidification involves physical mixing or pumping of cement, grout, or other reagent into the contaminated vadose zone soil to limit the leachability of the arsenic. Vitrification solidifies the soil matrix by high temperatures created using electric current. *In-situ* treatment methods to separate and remove contaminants include soil flushing or electrokinetic separation. Soil flushing involves introducing mixtures of water, acids, chemical surfactants, or cosolvents into the subsurface to strip or dissolve contaminants and then remove them through groundwater extraction. Electrokinetic separation uses electricity to separate and collect metals at electrodes.

Effectiveness: Air sparging is not expected to be an effective treatment method at the site because, while there is sufficient iron in groundwater, the majority of arsenic is in the As III valence state. Experience has shown that air injection is an inefficient method to create iron-arsenic oxides and hydroxides when the arsenic is predominantly in the As III valence state. In addition, geochemical modeling performed as part of the RI showed that the groundwater is supercharged with carbon dioxide. Air sparging would lead to stripping of carbon dioxide from the groundwater, resulting in a pH increase and precipitation of carbonate minerals such as calcite. Precipitation of carbonates as well as iron oxyhydroxides could lead to plugging of the sparging wells. Injecting an oxidant (e.g., peroxide or permanganate) is a better method to create oxidizing conditions for *in-situ* treatment of arsenic at the site without stripping carbon dioxide from the groundwater.

Creating reducing groundwater conditions to precipitate iron-arsenic sulfides is a potentially applicable approach to treating arsenic in groundwater. However, in order to be effective, the conditions within the aquifer must be sulfate-reducing. Should the reducing agent achieve only iron-reducing conditions, then the arsenic mobility at the site could actually be increased due to the dissolution of arsenic-bearing iron oxyhydroxides. Experience has shown that the use of reagents such as molasses to create bacterially mediated sulfate reduction to remove arsenic from solution has met with mixed results, and in some cases has made the problem worse.

Solidification of arsenic-contaminated vadose zone soil using grout mixtures is a well-established treatment method. Iron can be added to the solidification mix design to effect chemical stabilization in addition to solidification. Geochemical conditions are likely to be sufficiently stable for a permeable reactive barrier to be effective. Typical pH values within a ZVI-based PRB are about 10 standard units , which could lead to precipitation of iron carbonate (siderite) and/or calcite and plugging of the wall. Bench-scale and pilot-scale studies would be required to better predict treatment effectiveness of this technique. Other options such as *in-situ* soil flushing and electrokinetic separation are largely unproven. Due to these uncertainties, these options are considered to have a limited effectiveness at reaching MTCA requirements.

Implementability: Implementability of *in-situ* treatment technologies varies widely, ranging from moderate to difficult at the Highway 99 site. Injecting an oxidant or other reagents to treat arsenic-contaminated groundwater would be moderately difficult to implement. *In-situ* stabilization or solidification of soil would be relatively easy to implement. A PRB constructed on the downgradient edge to the Kanopy Kingdom/Freeway Trailer property would be moderately difficult to implement because of the potential depth of the wall, which would likely be greater than 40 feet. *In-situ* flushing and electrokinetic separation are considered difficult to implement due to treatment depth and saturated conditions.

In-situ treatment methods for soil and groundwater would require bench-scale and pilot testing to demonstrate effectiveness and provide design data.

Cost: The cost of *in-situ* treatment varies with the specific technology. The costs of reagent injections to treat groundwater and air sparging are moderately high. The cost of solidification to treat vadose zone soil is considered moderately high, especially because of mobilization costs. The cost of *in-situ* soil flushing and electrokinetic separation is considered to be high. The construction cost of a permeable reactive barrier is expected to be high, but the maintenance costs are typically low.

Screening Summary: *In-situ* treatment methods cover a broad range of technologies. Most *in-situ* treatment methods are associated with a high degree of uncertainty with regard to implementability and attaining MTCA requirements. Table 2 identifies *in-situ* technologies retained for further evaluation.

3.2.6 Groundwater Extraction and Treatment

Collection, treatment, and discharge (pump-and-treat) can be used to reduce groundwater arsenic levels more rapidly than plume containment or monitored natural attenuation. In addition, a pump-and-treat system can be used to lessen further plume migration.

An extraction system would be used to remove contaminated groundwater from the affected aquifer. This step is followed by treatment, if required, and discharge or reinjection of treated water back into the aquifer. Extraction can be achieved by using pumping wells, French drains, or extraction trenches. Pumping may be continuous or pulsed to remove contaminants after they have been given time to desorb from the aquifer material and equilibrate with groundwater.

Above-ground treatment may involve physical and chemical processes such as adsorption/absorption, ion exchange, membrane filtration, precipitation/coagulation, or evaporation, depending on the physical and chemical properties of the contaminants. Discharge options at the site include discharge to a publically owned treatment works (POTW), groundwater reinjection, or discharge to surface water.

Pump-and-treat expands on the hydraulic barrier option described previously by providing a means for treatment and discharge of the extracted groundwater.

Extraction Wells and Collection Trenches

Groundwater extraction wells are considered applicable to the site source area. Extraction wells are drilled into the aquifer and completed with a well screen and pump placed below the water table. Design of the extraction wells, including spacing, would be based on aquifer characteristics such as hydraulic gradient and hydraulic conductivity.

Computer modeling may be used to predict required well spacing and pumping rate, but a pumping test may be recommended to further define aquifer characteristics. Extraction wells could be designed to remove water from specific depths within the aquifer or from across the entire saturated thickness.

Effectiveness: Extraction wells are considered effective for intercepting and extracting groundwater and plume control. Pump-and-treat could be effective at removing arsenic mass from the area around monitoring well 99-1 or preventing off-site migration of contaminated groundwater through hydraulic containment. Pump-and-treat is not expected to be effective at remediating the source materials to the point where groundwater would one day no longer require treatment. Although pump-and-treat can remove a significant mass of arsenic, desorption and dissolution reactions from the source material are diffusion-limited, resulting in diminishing returns over time.

Implementability: Extraction wells are easy to construct and are a well-established and widely available technology.

Cost: Extraction well capital and maintenance costs are considered moderate to high and depend on the number of wells or trenches that must be installed and the length of operation.

Screening Summary: Pump-and-treat scenarios using extraction wells are effective methods for containing and treating groundwater, but it is unknown if MTCA Method A groundwater cleanup standards could be met within a reasonable timeframe. The technology is considered further as an alternative in conjunction with treatment and discharge options and also in conjunction with soil/source removal remedial methods.

Physical/Chemical Treatment of Extracted Groundwater

Adsorption: Adsorption treatment involves pumping groundwater through a series of vessels that contain arsenic-adsorbing material. Numerous types of adsorption media are available and include iron-based sorbents and activated alumina. The material may be either removed and regenerated or disposed of and replaced with new material, depending on the specific material and when the concentrations of contaminants in the effluent from the adsorbed material exceed a target level.

Adsorption-based systems alone may not be appropriate for the site due to the high concentrations of iron (5-30 mg/L over much of the site). Iron can cause plugging issues within the media and typically requires removal upstream of the adsorptive media. Manganese has not been measured in site groundwater but, if present, can also be problematic as coatings of manganese oxides or carbonates can passivate the surfaces of the media. Given the iron-reducing conditions within the groundwater, dissolved manganese is likely present.

Precipitation of calcite is predicted to occur in response to carbon dioxide degassing (based on modeling presented in the RI). Calcite also has the potential to passivate the media or cause plugging issues. The use of adsorptive media would only be effective when used in conjunction with a pre-oxidation/precipitation step.

Ion Exchange: Ion exchange removes ions from the aqueous phase by exchanging cations or anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from materials containing ionic functional groups that attach to exchangeable ions. Resins can be regenerated for re-use after the capacity of the resin has been exhausted.

Precipitation, Coagulation, and Flocculation: Precipitation has been a primary method for treating metals in industrial wastewater and proven successful in treating groundwater that contains arsenic. In groundwater treatment applications, the metal precipitation process is often used as a pretreatment for other treatment technologies such as microfiltration. In the precipitation process, coagulation and flocculation are used to increase particle size through aggregation and, therefore, the efficiency of the process. After the coagulants have increased particle size, flocculation is used to promote contact between the particles.

Membrane Technologies: Membrane technologies can include microfiltration, reverse osmosis, electrodialysis, or pervaporation. Reverse osmosis (RO) and microfiltration is the process of pushing a solution through a filter that traps solute on one side and allows the solvent to pass through to the other side. This process is best known for its use in desalination, but has been routinely applied for metals treatment. RO treatment results in the production of brine that typically represents 20 percent of the water volume treated, depending on the efficiency of the system. The RO brine would require disposal or additional treatment.

Electrodialysis is a physical method for removing ionic contaminants. Contaminated water is exposed to electric current as it passes through a semi-permeable membrane. This action separates the contaminant ions from groundwater and surface water. This technology is not retained because of the waste brine it would generate.

Evaporation Ponds: Extracted groundwater can also be discharged to lined ponds and allowed to evaporate. The ponds would periodically be dried and sludge removed and disposed of. This technology has limited effectiveness at the site because of the wet and cool climate and the limited site area available for evaporation ponds. This option is not retained.

Effectiveness: As can be seen by the descriptions above, there are numerous treatment technologies that could be effective for removing arsenic from groundwater at the site. It is expected that treatment would meet applicable discharge limits for a POTW, groundwater, or surface water as discussed below. Groundwater pump-and-treat would be effective at preventing off-site migration of contaminated groundwater through hydraulic containment or when used in conjunction with slurry wall containment. Pump-and-treat would be effective at removing arsenic from groundwater to address high concentrations of this contaminant in groundwater in the vicinity of well 99-1. However, groundwater pump-and-treat as a sole remedy has a poor record of achieving groundwater cleanup standards in a reasonable timeframe.

Implementability: Precipitation/coagulation/flocculation and membrane filtration are readily available technologies and would be relatively easy to construct and implement at the site. Depending on the size of the required facility, sufficient space may be available on-site for facilities and infrastructure.

Cost: Treatment using precipitation/coagulation/flocculation and membrane filtration is considered to have high capital and operation and maintenance costs.

Screening Summary: All identified treatment technologies except for evaporation ponds and membrane technologies are retained as potential options. The most appropriate technology or combination of technologies will be selected after bench or pilot studies. Pump-and-treat scenarios using on-site precipitation/coagulation/flocculation are retained for further evaluation as a representative treatment technology. The technology is considered further as an alternative in conjunction with groundwater extraction and discharge options.

Treated Groundwater Discharge

Injection Wells or Trenches: Reinjection of treated water into the aquifer would require that the water be treated to concentrations that comply with site cleanup levels. This would likely prove technically challenging. Reinjection can increase the hydraulic gradient in the aquifer and therefore the effectiveness of downgradient extraction wells or collection trenches. The volume of treated water that could be reinjected using infiltration trenches or an infiltration gallery, however, would be limited by available land. Reinjection to the aquifer is not retained in conjunction with extraction and treatment options.

Discharge to Surface Water: Discharge to surface waters would require the water meet surface water quality standards. The volume of treated water discharged in this manner is not expected to have any limitations. Achieving surface water quality standards for arsenic using on-site pre-treatment may be difficult. Discharge to surface water is not retained in conjunction with extraction and treatment options.

Discharge to a POTW: Treated groundwater can be discharged to a POTW. Discharge to a POTW would require that site effluent meet permit requirements for the POTW and that there is adequate capacity to receive the treated flows. Discharge of groundwater to a POTW is retained.

Effectiveness: Discharge of treated groundwater to a POTW appears to be a viable and effective alternative.

Implementability: Discharge of treated groundwater to a POTW would be easy to implement.

Cost: The cost of discharging treated groundwater to a POTW is considered moderate.

Screening Summary: Pump-and-treat scenarios using on-site pre-treatment and discharge to a POTW are retained for further analysis

3.2.7 Soil Excavation, Transport, and Disposal

This remedial technology was used during the 1984/1985 source removal action. RI data indicate the source removal action was successful and only small quantities of fill with elevated arsenic concentrations remain on site. For purposes of this discussion, the term elevated arsenic concentrations means greater than 500 mg/kg. Material with elevated arsenic concentrations can include either fill or soil. In addition, RI data indicate that arsenic dissolved in groundwater has precipitated onto soil and likely remains relatively immobile. Virtually all of fill and soil exceeding MTCA Method A arsenic cleanup standard is below the water table seasonally if not year-round.

This action involves excavation of contaminated soil and arsenic-impacted fill exceeding soil cleanup standards. Excavated soil and fill would then be transported off-site and disposed of in a landfill. Contaminated soil would be excavated using conventional earth-moving equipment such as front-end loaders and hydraulic excavators.

This remedial approach could be used in two different ways: 1) excavating and disposing of all soil and impacted fill exceeding the MTCA Method A or B cleanup standard, or 2) excavating the area of elevated arsenic in soil and fill identified in borings B5 and B6. Excavated contaminated soils and fill would be transported off-site in trucks to a transfer station in Tacoma. The contaminated soil and fill material would then be shipped by rail to Waste Management's Columbia Ridge Facility or Allied Waste's Roosevelt Landfill for disposal.

Likewise, contaminated sediment from Hylebos Creek could be dredged or excavated and transported off-site for disposal. Following removal, the embankment would be restored to riparian habitat similar to the adjoining embankment.

Effectiveness: Excavation and off-site disposal of fill and soil exceeding cleanup standards for arsenic would be effective in achieving soil and sediment cleanup standards.

Implementability: RI data indicate the contaminant source removal action was effective and only a relatively small amount of soil and fill with elevated arsenic concentrations remains in place. In the case of a limited hot-spot excavation, it would be challenging to fully delineate it prior to excavation. Excavation and removal of the clean fill above the water table would be relatively easy to implement. Excavation below the water table at the site would be difficult because it would require temporary shoring and dewatering.

Cost: Excavation and removal of contaminated soil beneath the water table is expected to have a very high cost. At the Highway 99 site, a considerable volume of 'clean' fill was used to backfill the contaminant source removal excavation. This fill would need to be excavated and stockpiled to reach deeper arsenic-impacted fill material and soil.

Screening Summary: Excavation and removal of contaminated soil and disposal at an off-site facility is expected to meet MCTA requirements for soil and sediment. This option is retained for further evaluation as an alternative.

3.3 Initial Alternatives Screening Summary

Technologies that are retained for further consideration in this FS include:

- Institutional Controls
    - Land use restrictions, groundwater use restrictions, and site administrative procedures

- Monitored Natural Attenuation and Compliance Monitoring
- Containment
  - Horizontal barrier (permeable pavement)
  - Vertical barrier (slurry wall or sheet pile wall)
- *In-Situ* Treatment
  - Oxidant injection or introduction (groundwater)
  - Permeable reactive barrier (groundwater)
  - Stabilization and solidification (soil and fill)
- Groundwater Pump-and-Treat
  - Extraction wells
  - On-site pre-treatment by precipitation/coagulation/flocculation.
  - Discharge of groundwater to the POTW.
- Soil Removal
  - Excavation and off-site disposal; both hot-spot and excavation and complete excavation of the site to achieve Method A or B soil cleanup levels.
- Sediment Removal

Section 4

Remedial Action Alternatives

4.1 Remedial Goals and Objectives

The overall goals for the proposed remedies at this site are to:

- Protect human health and the environment.
- Comply with applicable regulations.
- Satisfy all provisions of the Order and receive written notification from Ecology that USG has completed the remedial activity required by the Order.

The following remedial action objectives (RAOs) have been developed to meet these overall goals.

Remedial Action Objective #1 – Remediate Soil Exceeding Cleanup Levels. Arsenic exceeds MTCA cleanup levels in the core remediation area. An objective of the remedial action is to prevent exposure or remediate soil to be protective of human health and environmental receptors.

Remedial Action Objective #2 – Remediate Arsenic-Impacted Fill Material and Soil. The contaminant source removal action performed in 1984/1985 was unable to remediate arsenic-impacted fill encountered in boring B6. For purposes of this FS (remedy selection and cost estimating), the area requiring remediation is defined by the 500 mg/kg arsenic isocontours. An objective of this remedial action is to remediate residual fill and soil that is an ongoing source of groundwater contamination by *in-situ* treatment or excavation and off-site disposal.

Remedial Action Objective #3 – Remediate Groundwater in the Contaminant Source Area. Arsenic in groundwater in the former contaminant source (near monitoring well 99-1) is at a relatively high concentration relative to the rest of the plume. An objective of this remedial action is to remediate groundwater in the contaminant source area to a concentration that allows us to use a cost-effective remedy to achieve RAO 4 or 5.

Remedial Action Objective #4 – Achieve MTCA Method A Cleanup Standards for Arsenic in Groundwater at the Standard Point of Compliance. Remediate groundwater to achieve MTCA Method A cleanup standards for arsenic in groundwater across the entire site. This RAO will be used in conjunction with RAO 3.

Remedial Action Objective #5 – Mitigate Arsenic in Groundwater to be Protective of Surface Water or Sediment at a Conditional Point of Compliance. Set a conditional point of compliance for groundwater at monitoring wells closest to Hylebos Creek. This point of compliance would be protective of Hylebos Creek surface water and sediment. Conditional point of compliance would be established if achieving RAO 4 is technically impracticable or disproportionately costly. This RAO will be used in conjunction with RAO 3.

Remedial Action Objective #6 – Remediate Sediment Exceeding Cleanup Levels. Sediment in Hylebos Creek exceeds cleanup levels for arsenic. An objective of this remedial action is to remove impacted sediment to protect ecological receptors.

4.2 Remedial Technologies Evaluation

Section 3 and **Table 2** screened out remedial technologies that are not applicable to the site. This subsection evaluates the remaining remedial technologies potentially capable of meeting the RAOs listed in Section 4.1 by evaluating them against the criteria listed in Washington Administrative Code (WAC) 173-340-360, Model Toxics Control Act, 'Selection of Cleanup Actions'.

4.2.1 Minimum Requirements

CDM-Smith used minimum requirements drawn from WAC 173-340-360 (2) to develop the remedial action alternatives. These minimum requirements are divided into 'threshold requirements' and 'other requirements'. The threshold requirements are:

1. Protect Human Health and the Environment: This includes an evaluation of the degree to which existing risks to human health and the environment are reduced,
2. Compliance with Cleanup Standards: This includes an evaluation of the cleanup alternative and its ability to meet or exceed cleanup levels established in accordance with MTCA requirements.
3. Compliance with Applicable State and Federal Laws: Cleanup actions must comply with existing state or federal laws.
4. Compliance Monitoring: The cleanup action must provide for monitoring to verify that the cleanup action achieves cleanup or other performance standards and that it remains effective over time.

Remedial action alternatives that meet the threshold requirements must also be: 1) permanent solutions to maximum extent practicable; 2) provide for a reasonable restoration time frame; and 3) consider public concerns. MTCA refers to these as 'other requirements' which are a subset of the minimum requirements.

Remedial action alternatives that do not meet the minimum requirements are not considered further. An example of this would be a remedial action alternative that used only institutional controls and MNA. A remedial alternative consisting of these two remedial technologies would not meet MTCA's minimum requirements for a cleanup action. Institutional controls and MNA are included in the remedial action alternatives, but only in combination with active remedial technologies.

4.2.2 Remedial Technologies Evaluation

CDM Smith evaluated the most promising remedial technologies and compared them to the RAOs for applicability. The result of our evaluation is shown on **Table 3**. The criteria are 'yes,' 'uncertain,' and 'not applicable." The 'yes' and 'not applicable' criteria are self-evident. An example of how the 'uncertain' criterion is used is *in-situ* groundwater treatment by *in-situ* chemical oxidation (ISCO). ISCO is intended to remediate groundwater. However, an unintended beneficial side effect of ISCO is that it may also act to lessen the leachability of arsenic in soil to groundwater.

4.3 Description of Remedial Action Alternatives

Four remedial alternatives have been assembled with selected retained technology options. These four remedial alternatives are summarized in **Table 4**. Although additional combinations of technology options are possible, the alternatives presented here are considered to represent a reasonable range of approaches and costs. **Figure 2** shows the entire site. Outside of the core remediation area, the proposed remedy of institutional controls and MNA is common for all of the remedial action alternatives. The analysis of remedial action alternatives in the following subsections focuses primarily on actions in the core remediation area.

4.3.1 Technical Basis for the Selection of *In-Situ* Chemical Oxidation to Remediate Arsenic in Groundwater

Remedial action alternatives 1, 2, and 3 rely on *in-situ* chemical oxidation to remediate arsenic in groundwater. This subsection provides the technical basis for selecting ISCO. ISCO would be performed in much the same way as for treatment of organic compounds using oxidants such as:

- Potassium or sodium permanganate ($KMnO_4$ and $NaMnO_4$, respectively)
- Sodium persulfate (NaS_2O_8)
- Hydrogen peroxide (H_2O_2)
- Ozone (O_3)

Chemical oxidation would provide several benefits, including:

1. Oxidation of arsenic in groundwater from arsenite (As III) to the less mobile arsenate form (As V)
2. Oxidation of ferrous iron in groundwater to ferric iron and precipitation of iron oxyhydroxide and co-precipitation of arsenic

The site groundwater is naturally high in dissolved iron concentrations (up to 35 mg/L) and would likely not need any iron addition along with the oxidant. ISCO would enhance the attenuation process that is currently taking place by accelerating the oxidation rate of iron and arsenic. Currently, oxygen within the shallow groundwater flowing into the site from the west is believed to be oxidizing the iron to form an iron/arsenic oxyhydroxide coprecipitate. An oxidant such as permanganate not only accelerates the oxidation of ferrous iron, but the rate of oxidation of arsenic is much faster for permanganate than for dissolved oxygen in groundwater.

ISCO has the potential to rapidly remove arsenic from groundwater in-situ. Additionally, the coating of the arsenic-bearing soil grains and residual source material with the iron/arsenic oxyhydroxide coprecipitate also has the potential to render this arsenic in the hot-spots less leachable. However, this is not viewed as a stand-alone stabilization. Remedial action alternatives

1, 2, and 3 include stabilization or solidification to remediate the residual fill or soil with elevated arsenic concentrations such as that encountered in boring B6.

4.3.2 Remedial Action Alternative 1

Under this remedial action alternative the arsenic hot-spot of residual fill material and soil (RAO 2) identified in borings B-4, B-5, and B-6 would be chemically stabilized by injecting nano-scale ZVI or a reagent. The objective of this treatment will be to address this potential source of groundwater contamination.

The stabilization reagent would be selected by performing a bench-scale test. Besides nano-scale ZVI, reagents evaluated in the bench-scale test would include ferrous chloride and proprietary formulations. Because the soil hot-spot is largely below the water table, chemical oxidants will also be evaluated. For cost estimating purposes we assume the area requiring treatment (shown on **Figure 5**) corresponds to the maximum extent of the 500 mg/kg contour lines shown in **Appendix B**. The Cleanup Action Plan will include a soil remediation level that is based on the bench-scale test results and is protective of groundwater.

This hot-spot would be delineated by drilling additional soil borings and arsenic testing with an XRF. Samples would be collected for bench-scale testing to determine the most effective reagent, mix design, and grid spacing. *In-situ* treatment of the hot-spot would be accomplished by injecting the reagent with a DPT drill rig.

Treatment of arsenic in groundwater at the contaminant source area (vicinity of monitoring well 99-1, RAO 3) would be accomplished by *in-situ* chemical oxidation. Our conceptual design for costing purposes includes drilling 12 injection wells arrayed around well 99-1 as shown on **Figure 5**. An oxidant would be injected into these wells to cause the precipitation of iron oxyhydroxides and co-precipitation of arsenic. The effectiveness of the remediation method would be assessed by performance monitoring.

The appropriate oxidant, soil oxidant demand, and injection method and rate would be determined by bench-scale and pilot testing. A remediation level of 500 µg/L would be set for this treatment method.

If bench-scale or pilot testing indicates the *in-situ* chemical oxidation of the hot spot will not be effective or permanent, short-term groundwater pump-and-treat would be evaluated as a contingency. This remedial technology is described in Remedial Action Alternative 3.

After the remediation level in the contaminant source area has been achieved for groundwater, the remainder of the plume would be treated with ISCO. Our conceptual remediation plan includes injection trenches as shown on **Figure 5**. The oxidant selected for RAO 3 would be injected into these trenches, either by batch or metering methods. The effectiveness of this remediation method would be assessed by performance monitoring. Groundwater indicator parameters would also be collected during this performance monitoring to assess whether suitable geochemical conditions are being created so that co-precipitated arsenic remains sequestered.

Most of the site is currently capped by pavement, which serves as a horizontal barrier to isolate contaminated soil and groundwater and reduce the possibility of exposure by direct contact. Capping would serve the same function in the final remedy. The final remedy includes replacing a portion of pavement in the core remediation area with permeable pavement to allow precipitation to infiltrate, promoting oxidizing groundwater conditions and minimizing arsenic mobility. **Figure 5** shows, on a conceptual level, the area where permeable pavement may be employed. The cost estimate assumes that permeable pavement would be constructed in 20 percent of this area. The location of permeable paving within the area shown on **Figure 5** would be determined by analyzing groundwater monitoring data. During design, areas selected for permeable pavement would be evaluated to ensure permeable pavement was located away from areas of elevated arsenic concentrations, especially where that arsenic was located in the vadose zone. Permeable pavement would likely undergo pilot testing prior to full-scale implementation. Permeable pavement may also be constructed outside the core remediation area if it would facilitate the natural attenuation of arsenic.

Institutional controls are non-engineering measures, such as administrative or legal controls, that help minimize the potential for human exposure to contamination and/or protect the integrity of a remedy by limiting land or resource use. Examples of institutional controls that may apply to arsenic contamination at the site include land use controls and groundwater use restrictions. Institutional controls could also include health and safety policies and procedures to limit exposure to soil contaminants during construction activities or future development of the site. Institutional controls could be implemented at any time during the cleanup process.

MNA is an important component of this remedial action alternative and would be used to supplement the active remedial measures described above. The MNA program would ensure that arsenic concentrations decline over time and that geochemical conditions promote the stability of the iron-arsenic oxyhydroxide coprecipitates.

The final remedial action objective is remediating Hylebos Creek sediment. Sediment cleanup would be implemented when soil and groundwater cleanup actions have demonstrated that there is not a risk of recontamination of sediment from groundwater.

The Hylebos Creek sediment cleanup would take place during an in-water work period. The area of sediment cleanup used for cost estimating purposes is shown on **Figure 5** and includes all arsenic sediment concentrations exceeding the current no-effects sediment arsenic level of 14 mg/kg. A sediment sampling round would need to be performed prior to cleanup to provide current data. A site-specific arsenic cleanup level may be developed using a human health and environmental risk assessment as described in WAC 173-304.

Sediment cleanup consists of constructing coffer dams at both ends of the planned sediment cleanup area. Water from Hylebos Creek would be pumped around the section of the creek isolated by the coffer dams. Impacted sediment would be excavated from the creek channel and disposed of off-site. The creek channel would be restored using clean sand. The coffer dams would be removed as a final step.

4.3.3 Remedial Action Alternative 2

Remedial action alternative 2 is identical to alternative 1 except it includes solidification (as opposed to stabilization) of the arsenic hot-spot of residual fill material and soil (RAO 2) identified in borings B-4, B-5, and B-6. As in remedial action alternative 1, we assume for cost estimating purposes that the area requiring treatment (shown on **Figure 6**) corresponds to the maximum extent of the 500 mg/kg contour lines shown in **Appendix B**. This hot-spot would be delineated by drilling additional soil borings and arsenic testing with an XRF.

Remedial action alternative 2 would treat this arsenic hot-spot by solidification and deep mixing. Bench-scale studies performed at the USG Puyallup site showed that a cement/bentonite/iron reagent effectively reduced the leachability of arsenic by a factor of 60. The iron also acts to chemically stabilize the arsenic. So when solidification is referred to in this FS, arsenic will be immobilized by a combination of stabilization and solidification. As part of the additional delineation of the soil hot-spot, samples would be collected for bench-scale testing to determine the most effective solidification mix design. The mix design would account for the arsenic hot-spot below the water table.

Remedial action alternative 2 assumes the solidification reagent would be injected and mixed using an auger mixing system. This would allow complete mixing of the solidification reagent and the arsenic hot-spot of residual fill material and soil.

All other aspects of remedial action alternative 2 are the same as remedial action alternative 1.

4.3.4 Remedial Action Alternative 3

Remedial action alternative 3 would utilize solidification to remediate the arsenic hot-spot of residual fill material and soil (RAO 2) identified in borings B-4, B-5 and B-6. As in remedial action alternatives 1 and 2, we assume for cost estimating purposes that the area requiring treatment (shown on **Figure 7**) corresponds to the maximum extent of the 500 mg/kg contour lines shown in **Appendix B**. This hot-spot would be delineated by drilling additional soil borings and arsenic testing with an XRF.

Remedial action alternative 3 would treat this arsenic hot-spot by solidification and deep mixing. Bench-scale studies performed at the USG Puyallup site showed that a cement/bentonite/iron reagent effectively reduced the leachability of arsenic by a factor of 60. As part of the additional delineation of the soil hot-spot, samples would be collected for bench-scale testing to determine the most effective solidification mix design. The mix design would need to account for the fact that the arsenic hot-spot is below the water table.

Remedial action alternative 3 assumes the solidification reagent would be injected and mixed using an auger mixing system. This would allow complete mixing of the solidification reagent and the arsenic hot-spot of residual fill material and soil.

Arsenic in groundwater at the contaminant source area (vicinity of monitoring well 99-1, RAO 3) would be remediated by temporary groundwater pumping and treatment. Our conceptual design for costing purposes includes drilling a large-diameter groundwater extraction well in the vicinity of monitoring well 99-1 as shown on **Figure 7**. Conceptually, extracted groundwater would be pre-treated on site using a combination of precipitation and adsorption. The pre-treated groundwater would be discharged to a POTW.

For cost estimating purposes we assume the duration of temporary groundwater pumping and treatment would be 1 year. The effectiveness of the remediation method would be assessed by testing arsenic concentrations in the extraction well discharge and groundwater performance monitoring. During this timeframe we anticipate that groundwater pumping operations would cease (conceptually after 3 to 6 months) and groundwater monitoring conducted to test for rebound near the extraction well. Rebound would also be monitored in the groundwater extraction well discharge when it is re-started. A remediation level of 500 µg/L would be set for groundwater in a new replacement groundwater monitoring well for 99-1.

After the remediation level in the contaminant source area has been achieved for groundwater, the remainder of the plume would be treated with ISCO. Our conceptual remediation plan includes injection trenches as shown on **Figure 7**. The oxidant selected for RAO 3 would be injected into these trenches, either by batch or metering methods. The effectiveness of this remediation method would be assessed by performance monitoring. Groundwater indicator parameters would also be collected during this performance monitoring to assess whether suitable geochemical conditions are being created so that co-precipitated arsenic remains sequestered.

Groundwater in the core remediation area would be treated using a funnel (slurry or sheet pile wall) and gate (PRB) as shown on **Figure 7**. The effectiveness of this treatment would be determined by performance groundwater monitoring. Our cost estimate assumes a slurry wall would be constructed as opposed to a sheet pile wall. For cost estimating purposes, we assumed the slurry wall and PRB would be 35 feet deep. The PRB would be replaced after 15 years.

Most of the site is currently capped by pavement, which serves as a horizontal barrier to isolate contaminated soil and groundwater and reduce the possibility of exposure by direct contact. Capping would serve the same function in the final remedy. The final remedy includes replacing a portion of pavement in the core remediation area with permeable pavement to allow precipitation to infiltrate, promoting oxidizing groundwater conditions and minimizing arsenic mobility. **Figure 7** shows the area where permeable pavement is planned. The cost estimate assumes that permeable pavement would be constructed in 20 percent of this area. The location of permeable paving within the area shown on **Figure 7** would be configured to supplement the PRB's effectiveness. Permeable pavement may also be constructed outside the core remediation area if it would facilitate the natural attenuation of arsenic. Institutional controls could be implemented at any time during the cleanup process.

The other components (institutional controls, Hylebos Creek sediment cleanup) of remedial action alternative 3 are the same as remedial action alternatives 1 and 2.

4.3.5 Remedial Action Alternative 4

Remedial action alternative 4 includes removal of all soil exceeding MTCA Method A soil cleanup levels. This remedial action alternative would start with constructing coffer dams and diverting Hylebos Creek so it bypasses the property during remediation.

Conceptually, the excavation would start on the north end and progress southward. Temporary shoring such as sheet pile would be driven on both the east and west sides of the excavation (**Figure 8**) to prevent Hylebos Creek or Pacific Highway East collapsing into the excavation.

The upper 6 to 8 feet of clean soil used to backfill the 1984/1985 excavation would be excavated and stockpiled for subsequent re-use as backfill. Soil excavated from approximately 8 to 14 feet bgs would be disposed of off-site. Because most of this soil is beneath the water table, it is likely that temporary dewatering would be required during excavation. This temporary dewatering would likely be accomplished with a dewatering well point system.

Remedial action alternative 4 also includes extraction and treatment in the vicinity of well 99-1 during excavation. Dewatering at well 99-1 would likely be accomplished with a temporary large-diameter well installed with an excavator in a sump-type arrangement. Extracted groundwater would be pre-treated on-site using a combination of precipitation and adsorption. The pre-treated groundwater would be discharged to a POTW.

The excavation would proceed in sections with backfilling and compaction operations following behind the excavation. For purposes of this cost estimate, it is assumed that 3,500 cubic yards of clean fill would need to be excavated and stockpiled to access the soil exceeding MTCA Method A cleanup levels. An estimated 21,000 cubic yards of soil would be disposed of off-site.

Following restoration of the property, Hylebos creek sediment would be excavated. The area of sediment cleanup used for cost estimating purposes is shown on **Figure 8** and includes all arsenic sediment concentrations exceeding the current no-effects sediment arsenic level of 14 mg/kg. A sediment sampling round would need to be performed prior to cleanup to provide current data. A site-specific arsenic cleanup level may be developed using a human health and environmental risk assessment as described in WAC 173-304. Impacted sediment would be excavated from the creek channel and disposed of off-site. The creek channel would be restored using clean sand. The coffer dams would be removed as a final step.

The site would be restored using a combination of conventional asphaltic concrete pavement and permeable pavement. Both types of pavement would serve as a horizontal barrier to isolate contaminated soil and groundwater and reduce the possibility of exposure by direct contact. The permeable pavement would allow precipitation to infiltrate, promoting oxidizing groundwater conditions and assisting long-term natural attenuation of residual arsenic. **Figure 8** shows the area where permeable pavement is planned. The cost estimate assumes that permeable pavement would be constructed in 20 percent of this area. Permeable pavement may also be constructed outside the core remediation area if it would facilitate the natural attenuation of arsenic.

Institutional controls would be used to restrict groundwater use while arsenic concentrations in groundwater attenuate.

4.4 Cost Estimates

This section discusses CDM Smith's cost estimates for the four remedial action alternatives. **Table 5** presents the cost estimate summary for the alternatives. These cost estimates are current as of May 2013.

General assumptions for the conceptual level cost estimates shown on **Table 5** are as follows:

- Future capital costs and ongoing costs are presented in net present value terms with a 5 percent discount rate.
- All costs are rounded to the nearest 1,000 dollars.
- All construction costs include a construction fee (contractor overhead, profit, and business and occupation tax) of 20 percent.
- All construction items include 8.6 percent sales tax.
- Initial and future capital costs assume the engineering cost at 15 percent of the total and project management costs at 12 percent of the total. Ongoing monitoring and maintenance costs assume no engineering costs and project management costs at 12 percent of the total.
- All costs include a contingency of 15 percent.
- The duration of each alternative, including construction and/or long-term monitoring, totals 30 years.

Tables C-1 through C-3 in **Appendix C** provide alternative-specific assumptions used in preparing the cost estimates. Tables C-4 through C-6 in **Appendix C** provide detailed costs breakdowns of the four remedial action alternatives. These cost estimates are based on the conceptual remediation approaches described in this section and were prepared in May 2013 for the purposes of this FS. An engineer's cost estimate will be for the selected remedial action alternative and based on the remedial design.

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Section 5

Detailed Evaluation of Remedial Action Alternatives

This section evaluates the remedial action alternatives according to the process described in WAC 173-340-360.

5.1 Method of Evaluation

The evaluation criteria are listed in WAC 173-340-360 (3)(f) and described in detail below.

Protectiveness: Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the site and attain cleanup standards, risks resulting from implementing the alternative, and improvement of the overall environmental quality.

Permanence: The degree to which the technology permanently reduces the toxicity, mobility, or volume of hazardous substances, including its adequacy to destroy the hazardous substances, reduce or eliminate hazardous substance releases and sources of releases, degree of irreversibility of waste treatment process, and characteristics and quantity of treatment residuals generated.

Cost: The cost to implement the technology, including the cost of construction and the net present value of any long-term costs. Long-term costs include operation and maintenance, monitoring, equipment replacement, and maintaining institutional controls.

Effectiveness over the long term: Long-term effectiveness includes the degree of certainty that the technology will be successful, reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, magnitude of residual risk with the alternative in place, and effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components may be used as a guide, in descending order, when assessing the relative degree of long-term effectiveness: Reuse or recycling; destruction or detoxification; immobilization or solidification; on-site or off-site disposal in an engineered, lined, and monitored facility; on-site isolation or containment with attendant engineering controls; and institutional controls and monitoring.

Management of short-term risks: The risk to human health and the environment associated with the technology during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.

Technical and administrative implementability: Ability to be implemented, including consideration of whether the technology is technically possible, availability of necessary off-site facilities, services and materials, administrative and regulatory requirements, permitting, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with current commercial operations and other current or potential remedial actions.

Consideration of public concerns: Whether the community has concerns regarding the technology and, if so, the extent to which the technology addresses those concerns. This criterion includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

5.2 Comparative Evaluation of the Remedial Action Alternatives

This subsection comparatively evaluates the remedial action alternatives with regard to the criteria listed above. **Table 6** ranks the remedial active alternatives compared to the evaluation criteria listed above.

Protectiveness: All four remedial action alternatives improve the overall protectiveness. Residual contaminated soil exceeding the Method A cleanup standard is treated by a combination of stabilization, solidification, excavation and off-site disposal, and institutional controls. All remedial alternatives address impacts from groundwater to Hylebos Creek sediment and surface water. Also, all remedial alternatives remediate Hylebos Creek sediment, providing protectiveness to human and environmental receptors.

Remedial action alternatives 1 and 2 are the same overall except for how they address the soil hot spot, stabilization with a reagent by injection (alternative 1) and solidification by deep auger mixing (alternative 2). There is uncertainty associated with the extent of the soil hot-spot and what reagent of solidification design mix will be effective in addressing the arsenic in fill and soil here. Alternative 2 is ranked higher because of solidification's success in the bench-scale study for the USG Puyallup site.

Implementation of a barrier wall and PRB as a 'funnel and gate' configuration in remedial action alternative 3 presents technical uncertainty and risk. Barrier walls and PRBs function best when they are keyed into an aquitard. At the Highway 99 site, the Lower Silt Aquitard dips steeply to the east and may be approximately 40 to 50 feet deep adjacent to Hylebos Creek. Extending the barrier wall fully to the aquitard would be technically difficult given the configuration of the site.

Experience shows that groundwater tends to flow under a barrier's walls, and groundwater leaks (lateral flow) occur in the barrier wall and in the area where the barrier wall and PRB join. Additionally, groundwater with high arsenic concentrations can 'consume' a very small portion of the PRB and create a 'hole' with regard to treating the arsenic in groundwater. These leaks and holes are typically difficult to detect and isolate with groundwater monitoring. Accordingly, we rank remedial action alternative 3as uncertain for protectiveness .

Remedial action alternative 4 would remove the soil hot-spot identified at soil boring B6. But it would require much effort excavating and disposing of arsenic that poses little risk to Hylebos Creek sediment and surface water. Based on an evaluation of site geochemistry, much of the arsenic in soil that exceeds the MTCA Method A cleanup level has for the most part precipitated out of solution. Excavating and disposing of this soil off-site will do little to improve the overall protectiveness.

Permanence: All four remedial action alternatives provide permanent remedies to arsenic contamination in soil, groundwater, and sediment. Remedial action alternative 2 scores higher than alternative 1 because solidification by mixing is expected to be a more permanent remedy for the arsenic soil hotspot identified in B6 than stabilization by injection. Remedial action alternative 3 receives a favorable ranking for permanence as well. PRBs are typically effective at treating arsenic in groundwater.

The permanence of remedial action alternatives 1, 2, and 3 will depend on fostering oxidizing groundwater conditions in the core remediation area. Oxidizing groundwater conditions will limit the mobility of the iron-arsenic oxyhydroxides. The FS proposes using permeable pavement to allow precipitation to infiltrate directly into groundwater to create these oxidizing groundwater conditions.

Remedial action alternative 5 gets a very favorable rating for permanence because it includes excavating and off-site disposal of all soil and sediment exceeding MTCA cleanup standards.

Cost: The FS evaluates the cost estimate for each remedial action alternative shown on **Table 5** using the following criteria:

Evaluation Criteria	FS Cost Estimate Range	Remedial Action Alternative
Very Favorable	$100,000 to $1,500,000	None
Favorable	$1,500,000 to $3,000,000	1 and 2
Somewhat Favorable	$3,000,000 to $5,000,000	None
Unfavorable	$5,000,000 to $10,000,000	3
Very Unfavorable	Greater than $10,000,000	4

These rankings are shown on **Table 6**. Note that the FS cost estimate includes capital and the net present value of long-term operations, maintenance, and monitoring costs.

Effectiveness over the long term: Remedial action alternatives 1 and 2 rely on chemical oxidation to cause the precipitation of iron-arsenic oxyhydroxides, thus immobilizing the arsenic. Long-term effectiveness and permanence are closely related for these two alternatives. The long-term effectiveness of alternatives 1 and 2 depend on creating oxidizing groundwater conditions in the core remediation area. The FS proposes using permeable pavement to allow precipitation to infiltrate directly into groundwater. However, the FS gives these alternatives a score of 3 because this geochemical process will rely on long-term monitoring to verify their effectiveness.

An evaluation of remedial action alternative 3 found uncertainty over its long-term effectiveness. As discussed in the evaluation of the 'Protectiveness' criteria, groundwater contaminated with arsenic could bypass the PRB by flowing through leaks in the barrier wall or flow under the barrier wall or PRB. In addition, holes can develop in sections of the PRB that are in contact with portions of the plume with high arsenic concentrations. However, the FS assumes that the PRB will be replaced after 15 years.

Remedial action alternative 4 is very favorable for effectiveness over the long-term for the same rationale that is discussed in the evaluation of the 'Permanence' criteria.

Management of short-term risks: Remedial action alternatives 1 and 2 are favorable for managing short-term risks. *In-situ* treatment of soil and groundwater minimizes the chance of human exposure to arsenic during remediation. Care would need to be taken when using the oxidant and spill protection and containment engineering controls would need to be evaluated and implemented.

Remedial action alternative 3 is unfavorable for short-term risk management. Our main concern with this alternative is construction of the slurry wall adjacent to Hylebos Creek. Excavating for and constructing the slurry wall would pose risk of spilling excavation spoils, slurry, groundwater displaced by the slurry during construction, and/or wall material into Hylebos Creek.

Remedial action alternative 4 is very unfavorable for short-term risk management. This alternative calls for extensive excavation beneath the water table, which is inherently risky, especially with respect to caving. The conceptual design prepared for the FS specifies temporary shoring along Pacific Highway South and Hylebos Creek. However, if either of these shoring walls were to fail during construction, the results would be catastrophic.

Technical and administrative implementability: Remedial action alternatives 1 and 2 received a somewhat favorable or uncertain ranking for this criterion. Soil stabilization and solidification are technically possible. Some uncertainty results from the use of ISCO to immobilize the groundwater that is currently dissolved in groundwater. A bench-scale test would need to be performed to select the best oxidant and demonstrate its effectiveness. Additionally, authorization will need to be obtained from Ecology to inject the oxidant.

Remedial action alternative 3 received an unfavorable ranking for technical and administrative implementability. Using a PRB in a 'funnel and gate' configuration is technically possible, but its effectiveness is somewhat uncertain due to the factors described above such as the depth of the aquitard and potential for leaks in the barrier wall. The construction of deep barrier walls and PRB will be quite complex, given the relatively small size of the core remediation area and its proximity to Hylebos Creek. Construction of the barrier wall and PRB will impede current commercial operations.

Remedial action alternative 4 received a very unfavorable ranking for technical and administrative implementability. Excavation and off-site disposal envisioned in the FS conceptual design would be large, complex, and adversely impact the existing commercial operations. Access for hauling out the large volume of contaminated soil would be difficult given the location of the site relative to Pacific Highway East and traffic patterns on that highway. The large volume of trucks would also add to the existing traffic congestion at the Port of Tacoma.

Consideration of public concerns: Remedial action alternatives 1, 2, and 3 received a somewhat favorable to uncertain ranking for consideration of public concerns. The owners of Kanopy Kingdom and Freeway Trailer have cooperated with our investigation activities to date. Concerns from the general public about the Highway 99 site are unknown at this time. These remedial action alternatives all address the potential threat that groundwater poses to Hylebos Creek sediment and surface water.

Remedial action alternative 4 received an unfavorable ranking, primarily for the deep excavations next to Pacific Highway South and Hylebos Creek, and the concern that would be raised during project planning and construction.

5.3 Cost Disproportionate Analysis

MTCA Section 173-340-360(3) outlines the method for conducting a cost disproportionate analysis. The objective is to determine whether costs are disproportionate to benefits of the incremental cost of the alternative over that of the lower cost alternative.

Table 6 lists the evaluation criteria described above and provides a numeric ranking from 1 to 5 for each criterion for each alternative. Scores range from '1' as very unfavorable to '5' as very favorable. For each alternative the numeric rankings were summed and the total was divided by the number of criteria (7). The cost disproportionate analysis scored remedial action alternative 2 as the highest with a score of 3.6 and is the preferred alternative.

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Section 6

Implementation of the Preferred Alternative

This section describes USG's plan for implementing remedial action alternative 2.

Fill/soil hot-spot: The conceptual approach to address the fill/soil hot spot identified in B4, B5, and B6 and the surrounding area assumes an arsenic remediation level of 500 mg/kg and treating the soil/fill by solidification using a mix design similar for the one selected for the USG Puyallup site.

The fill/soil hot-spot will need to be thoroughly characterized and its relation to the water table assessed. A bench-scale test will need to be performed to select the optimal solidification/stabilization mix design. The conceptual approach will need to be evaluated once the detailed characterization and bench-scale test have been completed. At that time, the remediation level will need to be established with Ecology. In addition, alternate approaches for remediating the hot-spot will be evaluated.

As a contingency, the fill/hot-spot may be remediated by focused excavation and off-site disposal if it is too small to be economically treated by solidification.

Remediate arsenic in groundwater in the contaminant source area: Our conceptual approach to address arsenic in groundwater in the vicinity of monitoring well 99-1 is with ISCO, with the oxidant delivered via an array of vertical injection wells. The FS assumes a remediation level of 500 µg/L will be set for groundwater in a new replacement groundwater monitoring well for 99-1.

A bench-scale test will need to be performed to assess soil oxidant demand, select the best oxidant, and determine whether metered and batch delivery of the oxidant will work the best. Once the oxidant and delivery method has been selected, a pilot test and verification monitoring will be performed to demonstrate effectiveness in the field and estimate how long the system will need to be operated. Once effectiveness has been demonstrated, a full-scale treatment system will be implemented with verification monitoring. Verification monitoring will require stopping treatment and monitoring for rebound. The estimated time of ISCO operation and verification monitoring in the contaminant source area to demonstrate effectiveness is estimated at 1 to 2 years.

If ISCO does not prove to be effective, the contingency selected by USG will depend on an analysis of verification monitoring results. At this time, two potential remedial technologies appear to be potentially feasible:

- Injection of nano-scale ZVI would act to supplement ISCO by creating a solid phase with a highly sorptive surface area to immobilize dissolved arsenic by adsorption.

- A groundwater pump-and treat system as described in remedial action alternative 3 could be installed and operated as a contingency. Groundwater would be pre-treated on site and disposed to the POTW.

Verification monitoring would need to be continued if either one of these contingencies is implemented.

Remediate arsenic in groundwater in the core remediation area: Our conceptual approach to address arsenic in the core remediation area (in the vicinity of 99-1) is with ISCO delivered via injection trenches. The oxidant will be selected in the treatability study described above. Oxidant delivery will probably be accomplished by metering, but this will be determined in the design phase.

Conceptually, the estimated remediation timeframe for oxidant delivery by trenches is 10 years. We anticipate that operation of the ISCO injection wells in the vicinity of 99-1 will precede operation of the ISCO trenches, and that both ISCO systems will operate concurrently for a period of time. Remedy effectiveness will need to be verified by groundwater monitoring.

As a contingency, injection of nano-scale ZVI is compatible with ISCO and may be used to address hot-spots where arsenic concentrations in groundwater do not respond to ISCO treatment in a reasonable timeframe. Permeable pavement may also be constructed in select areas as ISCO progresses to maintain oxidizing groundwater conditions that promote the stability of the precipitated iron-arsenic oxyhydroxides.

Remediate sediment in Hylebos Creek: Hylebos Creek sediment will be cleaned up after arsenic concentrations in groundwater have been remediated to the point where they are protective of groundwater. Conceptually the remedial approach is straightforward and includes: 1) constructing coffer dams at both ends of the impacted section of Hylebos Creek; 2) pumping the creek water around the coffer dams; 3) excavating the sediment above arsenic cleanup levels and disposing of it off-site; and 4) restoring the stream bed. No contingencies for sediment remediation are considered necessary at this time.

Remediate arsenic in groundwater outside the core remediation area: The primary approach for remediating arsenic in groundwater outside the core remediation area is MNA. The MNA sampling program should be implemented early in the cleanup process. We expect these arsenic concentrations to attenuate gradually as precipitation and oxidizing shallow groundwater inflow recharges the site. The restoration timeframe is assumed to be 30 years.

Two contingencies are considered at this time if MNA trend data indicate that cleanup levels (either for standard point or alternate point of compliance) will not be attained within 30 years:

- Areas where arsenic concentrations in groundwater are not responding to MNA can be treated by injecting nano-scale ZVI. As described above, ZVI would act to create a solid phase with a highly sorptive surface area to immobilize dissolved arsenic by adsorption.

- Permeable pavement could be constructed in areas where monitoring indicates reducing groundwater conditions. The permeable pavement will promote oxidizing groundwater conditions and the precipitation of iron-arsenic oxyhydroxides. Permeable pavement would be evaluated in a pilot test prior to full-scale implementation.

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Section 7

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Tables

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Table 1
Development of Draft Cleanup Levels
USG Interiors Highway 99 Site
Milton, Washington

Cleanup Level Method and Basis [a]		Arsenic
Soil		**mg/kg**
Method A	Unrestricted Land Use	20
	Industrial	20
Method B	Unrestricted Land Use (Ingestion)	0.67
Method B	Groundwater Protection	N/A
Method C	Industrial	88
Background	Puget Sound (including Pierce County) [b]	7.3
Groundwater		**µg/L**
Method A	Unrestricted Use	5 [c]
Method B	Unrestricted Use	0.058
Method C	Industrial	0.58
MCL	Drinking Water Standards	10
Surface Water		**µg/L**
Method B	Human Ingestion of aquatic org.	0.098
Method C	Human Ingestion of aquatic org.	2.5
National Toxics Rule - 40 CFR 131	Human Health	0.018
Clean Water Act 304	Human Health	0.018
National Toxics Rule - 40 CFR 131	Fresh Water Aquatic Life - acute	360
	- chronic	190
Clean Water Act 304	Fresh Water Aquatic Life - acute	340
	- chronic	150
WAC 173-201A	Fresh Water Aquatic Life - acute	360
	- chronic	190
Sediment		**mg/kg**
WAC 173-204	Fresh Water Sediment Cleanup Screening Level	120

Notes:
a) Downloaded from Department of Ecology's Cleanup Levels and Risk Calculations (CLARC) online database except as noted. (Downloaded 03/15/2013)
b) San Juan, Charles. 1994 Natural Background Soil Metals Concentrations in Washington State. Washington State Dept. of Ecology. Publication 94-115, October.
c) This cleanup level is based on natural background concentrations for Washington State.
µg/L - micrograms per liter (parts per billion)
mg/kg - milligrams per kilogram (parts per million)
MCL - maximum contaminant level
WAC - Washington Administrative Code
N/A - not available

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Table 2
Identification and Screening of Potential Remedial Technologies
Feasibility Study - USG Highway 99 Site
Milton, Washington

General Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Cost	Screening Result
No Further Action	None	None	Conduct no further action	Not Effective	Easy	None	Not Retained
Institutional Controls	Administrative	Access controls, maintenance, education	Fences or site maintenance to limit exposure. Postings, public notices, health advisories, mailings to educate.	Limited effectiveness. Effective at minimzing human exposure	Easy	Low	Retained
	Legal	Deed restrictions, groundwater use controls, financial assurances	Limitations on the use of property or resources; or requirements that cleanup action occur if existing pavement is disturbed or removed.	Effective at minimzing human exposure	Easy	Low	Retained
Monitored Natural Attenuation	MNA	MNA	Natural biological, chemical, and physical processes. Primary future action is groundwater monitoring.	Effective at reducing arsenic concentrations in groundwater when combined with source control measures and under certain geochemical conditions	Easy	Low to Moderate	Retained
Containment	Horizontal Barrier - Impermeable	Surface cap (e.g. asphalt)	Form an impermeable barrier to direct contact, surface water, and infiltrating precipitation.	Effective at reducing infiltrating precipitation from coming in contact with fill in vadose zone. However, may make groundwater conditions more reducing and increase arsenic mobility.	Site partially paved. Easy if existing pavement can be incorporated into cap.	Moderate construction cost. Low maintenance cost	Not retained
	Horizontal Barrier - Permeable	Permeable surface cap	Specialized pavement that allows precipitation to infiltrate.	Permeable paving will promote oxidizing groundwater conditions over long term. Oxidizing groundwater conditions will limit the mobility of arsenic.	Moderately difficult. Existing pavement will need to be removed.	Moderate construction cost. Low maintenance cost	Retained
	Vertical Barrier	Sheet piling or slurry wall	Form an impermeable hydrologic barrier to groundwater flow. Placement options include downgradient edge of site or to encircle the source area.	Circumference barrier effective for containment, no reduction in source. Downgradient barrier may result in groundwater flowing around barrier. May be paired with other technology in "funnel and gate" application.	Moderately difficult.	Moderate to high to construction cost. Low maintenance cost	Retained
	Hydraulic Barrier	Extraction trenches or wells	Capture and remove groundwater to eventually reduce arsenic concentrations in groundwater. Must have corresponding discharge/treatment option.	Effective for controlling future off-property migration.	Moderately difficult	High when considering long-term operations and maintenance costs	Not Retained
	Phytoextraction	Roots intercept groundwater and uptake arsenic.	Plant a row of trees with roots extending to groundwater.	Limited	Easy	Low to Moderate	Not Retained
In Situ Treatment	Stabilization/ Precipitation	*In situ* stabilization of arsenic in fill and soil.	Inject reagent to chemical stabilize arsenic and reduce leaching.	This option evaluates injection of reagent rather mixing. Effectiveness will depend on whether an effective reagent can be found and if it can be effectively delivered.	Difficult	Moderate	Retained
		Inject reagent to create reducing groundwater conditions.	Inject ferrous iron and carbon substrate. Bacterial reduction of sulfate to sulfide and reaction with iron to precipitate iron sulfide. Arsenic co-precipitates with iron sulfide.	Ambient geochemical conditions are not favorable to create permanent sulfate-reducing conditions and ensure arsenic remains as a sulfide. Could potentially increase arsenic mobility by dissolving existing arsenic-bearing iron oxyhydroxides. Would require bench-scale and/or pilot test to demonstrate effectiveness.	Difficult	Moderate to high	Not Retained
		Inject oxidant to create oxidizing groundwater conditions.	Inject chemical oxidant (such as permanganate or hydrogen peroxide). This will create oxidizing conditions resulting in precipitation of iron oxides and hydroxides with co-precipitaiton of arsenic. In addition, arsenite would be oxidized to the less mobile arsenate form.	Ambient geochemical conditions in the shallow groundwater are more favorable for the permanence of this kind of arsenic remedy than trying to create reducing conditions. Oxidation appears to be the natural arsenic attenuation process at the site. Would require bench-scale and/or pilot test to demonstrate effectiveness and develop design data.	Difficult	Moderate	Retained
		Air sparging	Injection of air to oxidize naturally occurring iron at the site. Co-precipitate arsenic from solution and create a solid phase with a highly sorptive surface area.	Much of arsenic is in the As III valence state. Air sparging is not very effective in oxidizing and precipitating Arsenic III. Air sparging is predicted to result in calcite precipitation, which could result in plugging issues.	Moderately difficult	High when considering long-term operations and maintenance costs.	Not Retained
	Permeable Reactive Barrier (PRB)	ZVI	Treats groundwater as it flows through PRB. Can be used in a "funnel and gate" application with a slurry wall as well.	Effective for controlling future off-property migration. Would require bench-scale and/or pilot test to demonstrate effectiveness and develop design data. Assume PRB will need to be replaced after 15 years.	Moderately difficult	High	Retained
		EHC-M or similar compound	Treats groundwater as it flows through PRB. Can be used in a "funnel and gate" application with a slurry wall as well.	Potentially effective for controlling future off-property migration. Bench- or pilot-scale testing required to demonstrate effectiveness. However, is a less proven technology that ZVI and offers no real advantages over ZVI at this site.	Moderately difficult	Moderate to high	Not retained

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Table 2
Identification and Screening of Potential Remedial Technologies
Feasibility Study - USG Highway 99 Site
Milton, Washington

General Response Action	Technology	Process Option	Description	Effectiveness	Implementability	Cost	Screening Result
In Situ Treatment (continued)	Solidification	*In situ* injection and mixing of a cement grout.	Solidification of residual source material by pumping and mixing cement grout	Effective. Would require bench-scale test as part of design.	Moderately difficult	Moderate	Retained
		Vitrification	Uses electric current to create high temperatures to melt soil and create a vitrified mass	Technology is innappropriate for site where major contaminant source control action has already been conducted.	Difficult	Very high	Not Retained
	Soil Flushing	Acid/cosolvent/surfactant injection	Injection of acid/cosolvent/surfactant mixture upgradient of the contaminated area. The solvent with dissolved arsenic is then extracted downgradient and treated above ground.	Technology is largely unproven.	Difficult	High	Not Retained
	Electrokinetic Separation	Electrokinetic Separation	Application of a low-intensity direct current through the soil to mobilize arsenic. Removal of arsenic at the electrode may be accomplished through several means among which are: electroplating, precipitation or co-precipitation, pumping of water, or complexing with ion exchange resins.	Limited effectiveness. Most effective in clays - Highway 99 site is primarily sand and silt. Must be combined with another in situ or removal technology. Largely uproven.	Difficult	High	Not Retained
Pump-and-Treat	Extraction	Trenches	Horizontal extraction trench constructed of gravel, horizontal perforated pipe and vertical well(s). Can be effective where groundwater depth is shallow.	Groundwater is approximately 15 feet deep on east edge of property, requiring a deep trench. Vertical wells are a better application for the Highway 99 site.	Moderately difficult	Moderate to high when considering long-term operations and maintenance costs of groundwater treatment.	Not Retained
		Wells	Vertical wells screened in specific zones or across entire water producing zone.	Proven and well-established technology. Will require pumping test to determine aquifer properties. Well spacing determined by groundwater modeling.	Easy to moderately difficult	Moderate to high when considering long-term operations and maintenance costs of groundwater treatment.	Retained
	Ex situ treatment	Adsorption	Removal of arsenic by adsorption to media such as iron based sorbents and activated alumina.	Potentially Effective when used in conjunction with a pre-oxidation/preciptation step to remove iron and manganese.	Easy	Moderate	Retained
		Ion exchange	Removal of arsenic ions by exchange of cations or anions between groundwater and the exchange medium.	Effective	Easy to moderately difficult	High	Retained
		Membrane filtration	Separation of arsenic from water by passing through semi-permeable membrane.	Effective, but results in large volumes of arsenic-bearing brine requiring disposal.	Easy to moderately difficult	High	Not Retained
		Evaporation ponds	Water pumped to lined ponds to evaporate. Evaporation may be enhanced through spraying or other agitation methods.	Limited effectiveness due to low net evaporation at the site.	Difficult to implement due to limited area.	Moderate	Not Retained
	Discharge	Groundwater	Discharge treated water to groundwater through injection wells or infiltration gallery/trenches. Discharge limits set by groundwater standards. Capacity may be limited by available land and hydrogeological conditions.	Effective	Moderately difficult to implement for large flows due to limited infiltration capacity for the site. Also may be difficult to achieve groundwater standards for arsenic.	Moderate	Not Retained
		Surface water	Discharge treated water to surface water. Discharge limits usually established by surface water standards.	Effective	Hylebos Creek adjacent to site. NPDES permit would be required. May be difficult to achieve NPDES discharge standards.	Moderate	Not retained
		Publicly owned treatment works (POTW)	Pre-treat groundwater on-site and discharge to POTW. Discharge pre-treatment levels determined by POTW.	Effective	Easy to implement.	Moderate	Retained
Soil and Sediment Removal	Excavation	Excavation and off-site disposal of residual waste fill, and arsenic contaminated soil and sediment.	Physical removal of source material. Disposal in solid waste landfill.	Effective	Difficult to implement due to depth of residual waste material and arsenic contaminated soil. Would require de-watering and shoring.	Very high	Retained

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Table 3
Remedial Technologies Evaluation
Feasibility Study - USG Highway 99 Site
Milton, Washington

ID #	Remedial Technology	Remedial Action Objective	RAO 1: Remediate Soil Exceeding Cleanup Levels	RAO 2: Remediate Residual Arsenic-Impacted Fill Material and Soil	RAO 3: Remediate Groundwater in Contaminant Source Area	RAO 4: Achieve MTCA Method A Cleanup Standards for Arsenic in Groundwater at the Standard Point of Compliance	RAO 5: Mitigate Arsenic in Groundwater Exceeding Surface Water Standards at a Conditional Point of Compliance.	RAO 6: Remediate Sediment Exceeding Cleanup Screening Levels.
1	**Capping and Institutional Controls**		Y	U	Y	Y	Y	-
2	**Excavation and Off-Site Disposal**		Y	Y	-	-	-	Y
3	***In-Situ* Stabilization**		Y	Y	-	-	-	-
4	***In-Situ* Solidification**		Y	Y	-	-	-	-
5	***In Situ* Groundwater Treatment**		U	U	Y	Y	Y	-
6	**Short-Term Groundwater Extraction, Treatment**		-	-	Y	U	U	-
7	**Temporary Groundwater Extraction, Treatment**		-	-	Y	U	U	-
8	***In-Situ* Chemical Oxidation by Injection Trenches**		U	U	Y	Y	Y	-
9	**Permeable Reactive Barrier - Zero Valent Iron**		-	-	Y	-	-	-
10	**Engineered Permeable Cap**		Y	Y	Y	U	U	-
11	**Monitored Natural Attenuation - Post Remediation**		-	-	Y	Y	Y	-

Applicablity
Y Yes
U Uncertain
- Not Applicable

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Table 4
Remedial Alternatives Summary
Feasibility Study - USG Highway 99 Site
Milton, Washington

RAO	Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1	Remediate Soil Exceeding Cleanup Levels (not including fill in RAO 2)	Capping and institutional controls	Capping and institutional controls	Capping and institutional controls	Excavation and off-site disposal
2	Remediate Residual Arsenic-Impacted Fill Material and Soil	*In-situ* stabilization	*In-situ* solidification	*In-situ* solidification	Excavation and off-site disposal
3	Remediate Groundwater in Contaminant Source Area	*In-situ* chemical oxidation	*In-situ* chemical oxidation	Short-term groundwater pump and treat, discharge to POTW	Temporary groundwater extraction and treatment
4	Achieve MTCA Method A Groundwater Cleanup Levels - Standard Point of Compliance	ISCO via injection trenches, monitored natural attenuation, permeable pavement	ISCO via injection trenches, monitored natural attenuation, permeable pavement	ISCO via injection trenches, slurry walls, permeable reactive barrier, monitored natural attenuation, permeable pavement	Monitored natural attenuation, permeable pavement
5	Achieve MTCA Method A Groundwater Cleanup Levels - Conditional Point of Compliance	ISCO via injection trenches, monitored natural attenuation, permeable pavement, institutional controls	ISCO via injection trenches, monitored natural attenuation, permeable pavement, institutional controls	ISCO via injection trenches, slurry walls, permeable reactive barrier, monitored natural attenuation, permeable pavement, institutional controls	Monitored natural attenuation, permeable pavement, institutional controls
6	Remediate Sediment Exceeding Cleanup Levels	Excavation and off-site disposal	Excavation and off-site disposal	Excavation and off-site disposal	Excavation and off-site disposal

Note ISCO means *In-Situ* Chemical Oxidation

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Table 5
Cost Estimate Summary
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Alternative 1

	Pre-Design Activities	1st Phase	2nd Phase		3rd Phase	MNA Phase		
	Prepare Cleanup Action Plan, Perform Soil Delineation, Bench-Scale and Field Pilot Testing	Injection of Reagent at Soil Hot Spot (Stabilization) and Oxidation Compounds at Groundwater Hot Spot	Oxidation Compound Injection Trenches	Engineered Permeable Cap	Sediment Removal	Monitored Natural Attenuation	Institutional Controls	Total
Capital Cost	$ 220,000	$ 394,499	$ 193,136	$ 121,614	$ 326,805	$ 56,439	$ 37,749	$ 1,130,242
OM&M Cost			$ 50,000			$ 40,790	$ 10,000	$ 100,790
OM&M Duration (years)			5			5	30	
OM&M Cost			$ 25,000			$ 20,395		$ 45,395
OM&M Duration (years)			5			25		
Total - Present Worth	**$ 220,000**	**$ 394,000**	**$ 459,000**	**$ 122,000**	**$ 327,000**	**$ 438,000**	**$ 189,000**	**$ 2,150,000**

Alternative 2

	Pre-Design Activities	1st Phase		2nd Phase		3rd Phase	MNA Phase		
	Prepare Cleanup Action Plan, Perform Soil Delineation, Bench-Scale and Field Pilot Testing	Solidification of Soil Hot Spot (vicinity of Boring B6)	Injection of Oxidation Compounds at Groundwater Hot Spot	Oxidation Compound Injection Trenches	Engineered Permeable Cap	Sediment Removal	Monitored Natural Attenuation	Institutional Controls	Total
Capital Cost	$ 260,000	$ 426,447	$ 166,429	$ 193,136	$ 121,614	$ 326,805	$ 56,439	$ 37,749	$ 1,328,619
OM&M Cost				$ 50,000			$ 40,790	$ 10,000	$ 100,790
OM&M Duration (years)				5			5	30	
OM&M Cost				$ 25,000			$ 20,395		$ 45,395
OM&M Duration (years)				5			25		
Total - Present Worth	**$ 260,000**	**$ 426,000**	**$ 166,000**	**$ 459,000**	**$ 122,000**	**$ 327,000**	**$ 438,000**	**$ 189,000**	**$ 2,390,000**

Alternative 3

	Pre-Design Activities	1st Phase		2nd Phase		3rd Phase		4th Phase	MNA Phase		
	Prepare Cleanup Action Plan, Perform Soil Delineation, Bench-Scale and Field Pilot Testing	Solidification of Soil Hot Spot (vicinity of Boring B6)	Short-Term Pump and Treat (1 year) of Groundwater Hot Spot	Oxidation Compound Injection Trenches	Engineered Permeable Cap	Slurry Walls	Permeable Reactive Barrier	Sediment Removal	Monitored Natural Attenuation	Institutional Controls	Total
Capital Cost	$ 260,000	$ 426,447	$ 184,114	$ 193,136	$ 121,614	$ 1,063,838	$ 444,536	$ 326,805	$ 56,439	$ 37,749	$ 2,854,677
OM&M Cost				$ 50,000			$ 444,536		$ 40,790	$ 10,000	$ 545,326
OM&M Duration (years)				5					5	30	
OM&M Cost				$ 25,000			$ 444,536		$ 20,395		$ 489,931
OM&M Duration (years)				5					25		
Total - Present Worth	**$ 260,000**	**$ 426,000**	**$ 184,000**	**$ 459,000**	**$ 122,000**	**$ 1,064,000**	**$ 907,000**	**$ 327,000**	**$ 438,000**	**$ 189,000**	**$ 4,380,000**

Alternative 4

	Pre-Design Activities	1st Phase		2nd Phase	MNA Phase		
	Prepare Cleanup Action Plan and Perform Soil Delineation	Removal of Soil > 20 mg/kg Arsenic	Sediment Removal	Engineered Permeable Cap	Monitored Natural Attenuation	Institutional Controls	Total
Capital Cost	$ 80,000	$ 14,438,381	$ 326,805	$ 121,614	$ 56,439	$ 37,749	$ 14,980,988
OM&M Cost					$ 40,790	$ 10,000	$ 50,790
OM&M Duration (years)					5	30	
OM&M Cost					$ 20,395		$ 20,395
OM&M Duration (years)					5		
Total - Present Worth	**$ 80,000**	**$ 14,438,000**	**$ 327,000**	**$ 122,000**	**$ 274,000**	**$ 189,000**	**$ 15,430,000**

Notes:
1. Total - present worth values are calculated using a 5% discount rate (used only for O&M costs) with a 2014 initial construction year for all activities.
2. No discount is included for 2014 construct starts.
3. Monitored natural attenuation includes 5-year review and reports.
4. Semi-annual monitoring conducted years 1-5; annual monitoring conducted years 6-30.
5. All present value costs are rounded to the nearest one thousand dollars.
6. Stormwater enhancement costs are included in the cost to backfill the site in all Alternatives.

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Table 6
Evaluation of Remedial Action Alternatives and Disproportionate Cost Analysis
Feasibility Study - USG Highway 99 Site
Milton, Washington

Alternative	Description	Disproportionate Cost Analysis Criteria	Protectiveness	Permanence	Cost	Long-term Effectiveness	Management of Short-Term Risks	Technical and Administrative Implementability	Consideration of Public Concerns	Average Score	Overall Recommendation
1	*In-Situ* Source Area Soil Stabilization, Introduction of Oxidation Compounds in Up-Gradient Trenches, Construction of an Engineered Permeable Cap, Treatment of Groundwater Hot Spot with Injection of Oxidation Compounds, Sediment Removal, Monitored Natural Attenuation, and Institutional Controls		**3**	**3**	**4**	**3**	**4**	**3**	**3**	**3.3**	No
2	*In-Situ* Source Area Soil Solidification, Introduction of Oxidation Compounds in Up-Gradient Trenches, Construction of an Engineered Permeable Cap, Treatment of Groundwater Hot Spot with Injection of Oxidation Compounds, Sediment Removal, Monitored Natural Attenuation, and Institutional Controls		**4**	**4**	**4**	**3**	**4**	**3**	**3**	**3.6**	**Yes**
3	*In-Situ* Source Area Soil Stabilization, Short-Term Groundwater Extraction at Hot Spot, Groundwater Treatment with Oxidation Compounds, Slurry Walls, Permeable Reactive Barrier, Permeable Cap, Sediment Removal, Monitored Natural Attenuation, and Institutional Controls		**3**	**4**	**3**	**3**	**2**	**2**	**3**	**2.9**	No
4	Soil Removal to 20 mg/kg, Engineered Permeable Cap, Sediment Removal, MNA, and Institutional Controls		**3**	**5**	**1**	**5**	**1**	**1**	**2**	**2.6**	No

Disproportionate Cost Analysis Criteria
5 Very Favorable, Ideal (cost ranges from $100,000 to $1,500,000)
4 Favorable, Good (cost ranges from $1,500,000 to $3,000,000)
3 Somewhat Favorable or Uncertain (cost ranges from $3,000,000 to $5,000,000)
2 Unfavorable (cost ranges from $5,000,000 to $10,000,000)
1 Very Unfavorable (cost is greater than $10,000,000)

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Figures

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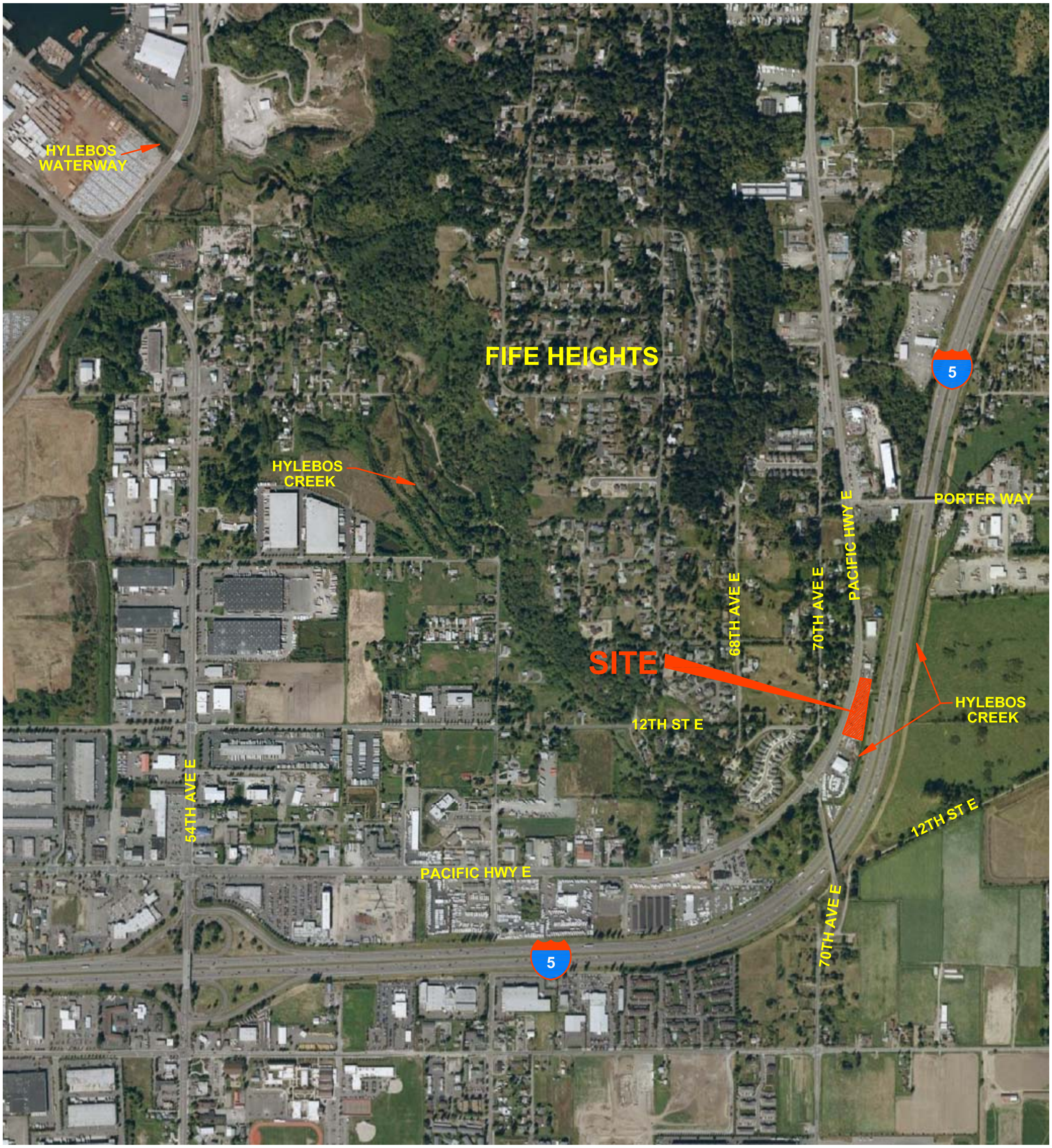

Source: GOOGLE EARTH PRO, 2009

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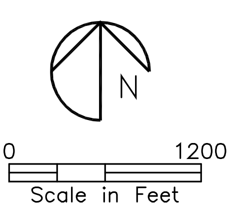

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 1
Vicinity Map

CDM

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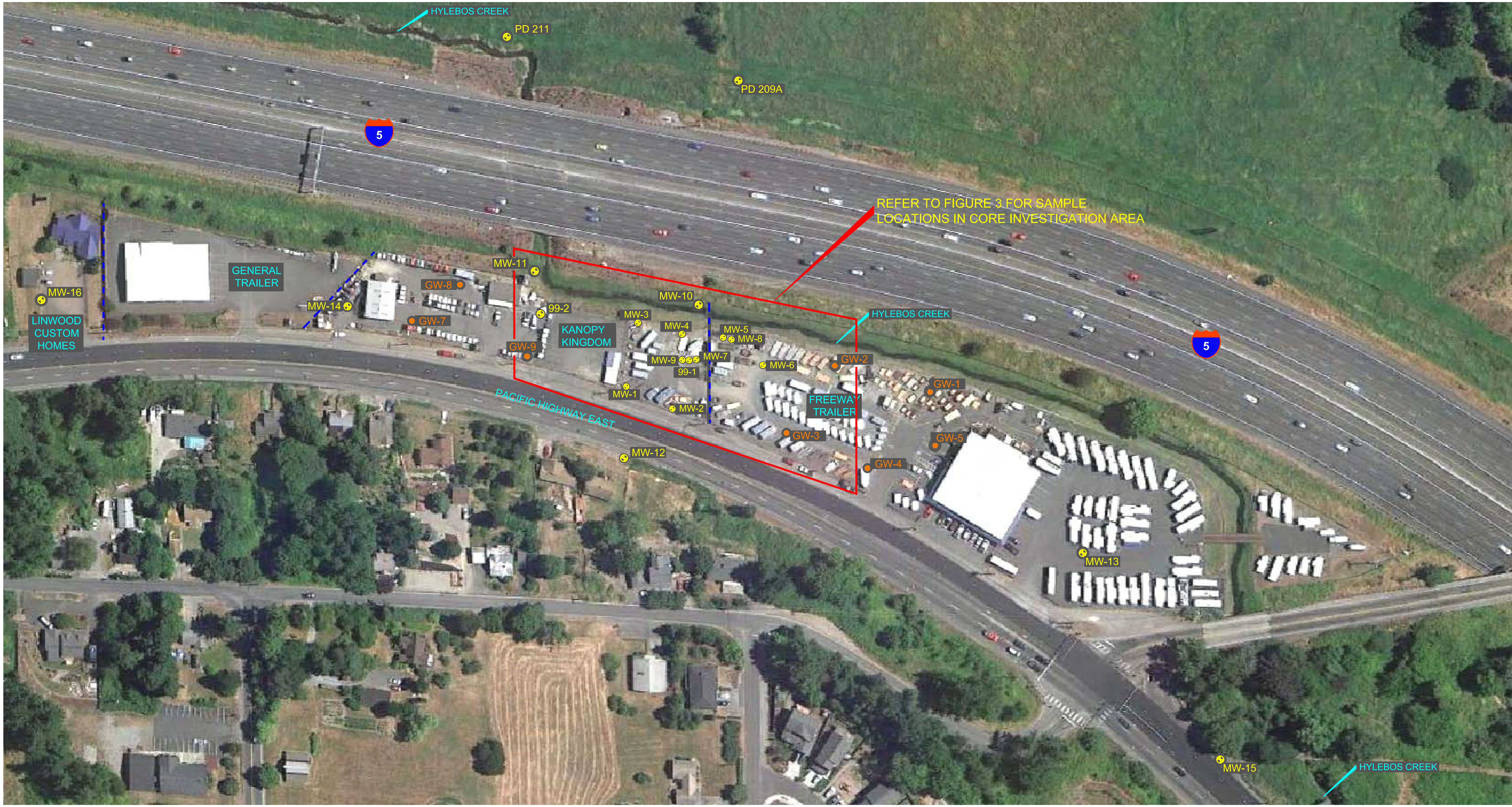

REFERENCE: GOOGLE EARTH PRO, 2012, IMAGE DATE AUGUST 20, 2011

LEGEND:

- MW-12 MONITORING WELL
- GW-3 PHASE 2 DPT BORING
- PROPERTY LINE

NOTE:

MONITORING WELL MW-14 WAS DRILLED AT THE LOCATION OF GW-6

N

1" = 120'

60 0 120

CDM Smith

USG INTERIORS
HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 2
Site Plan

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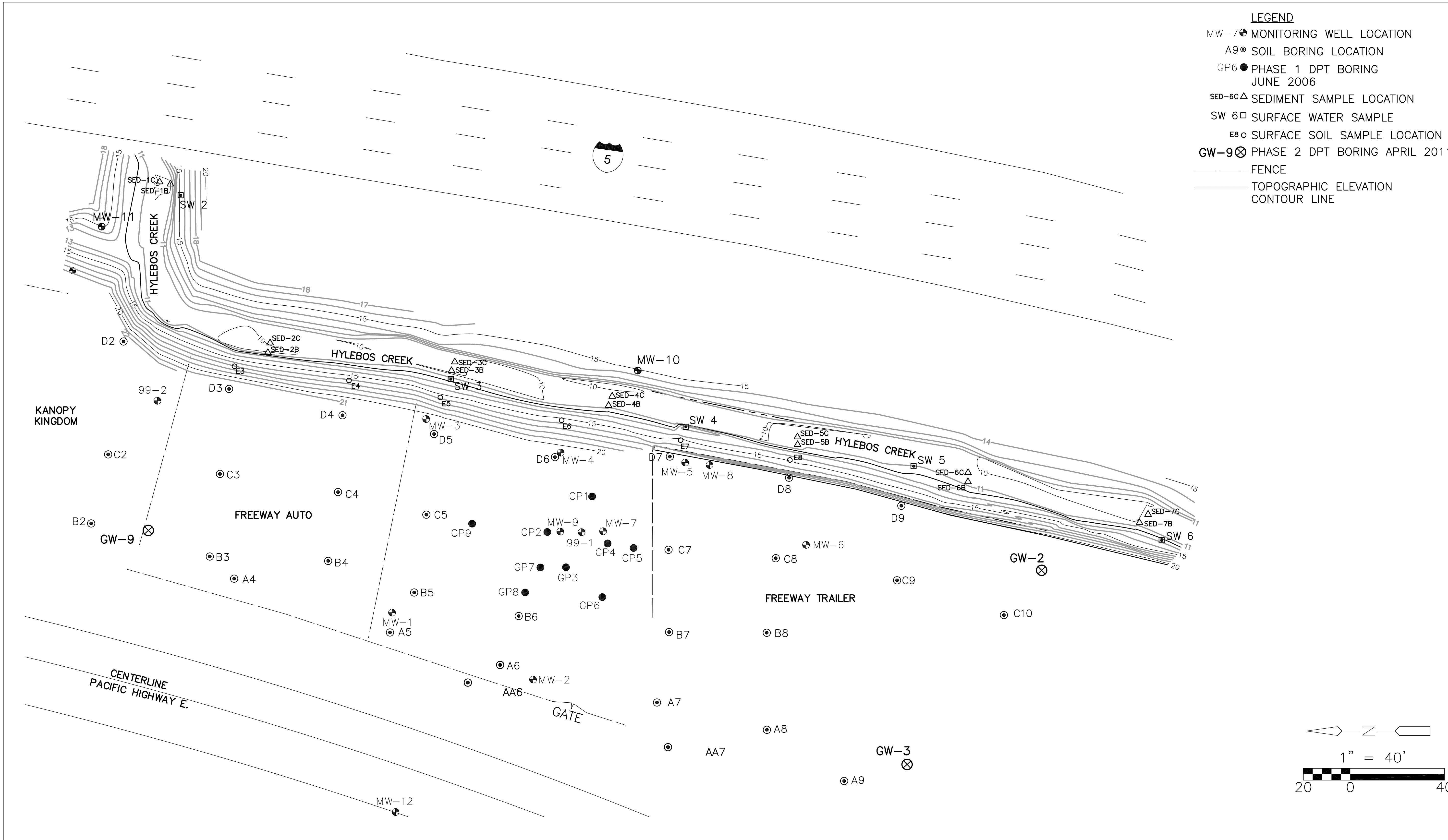

USG INTERIORS
HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 3
Site Plan – Core Remediation Area

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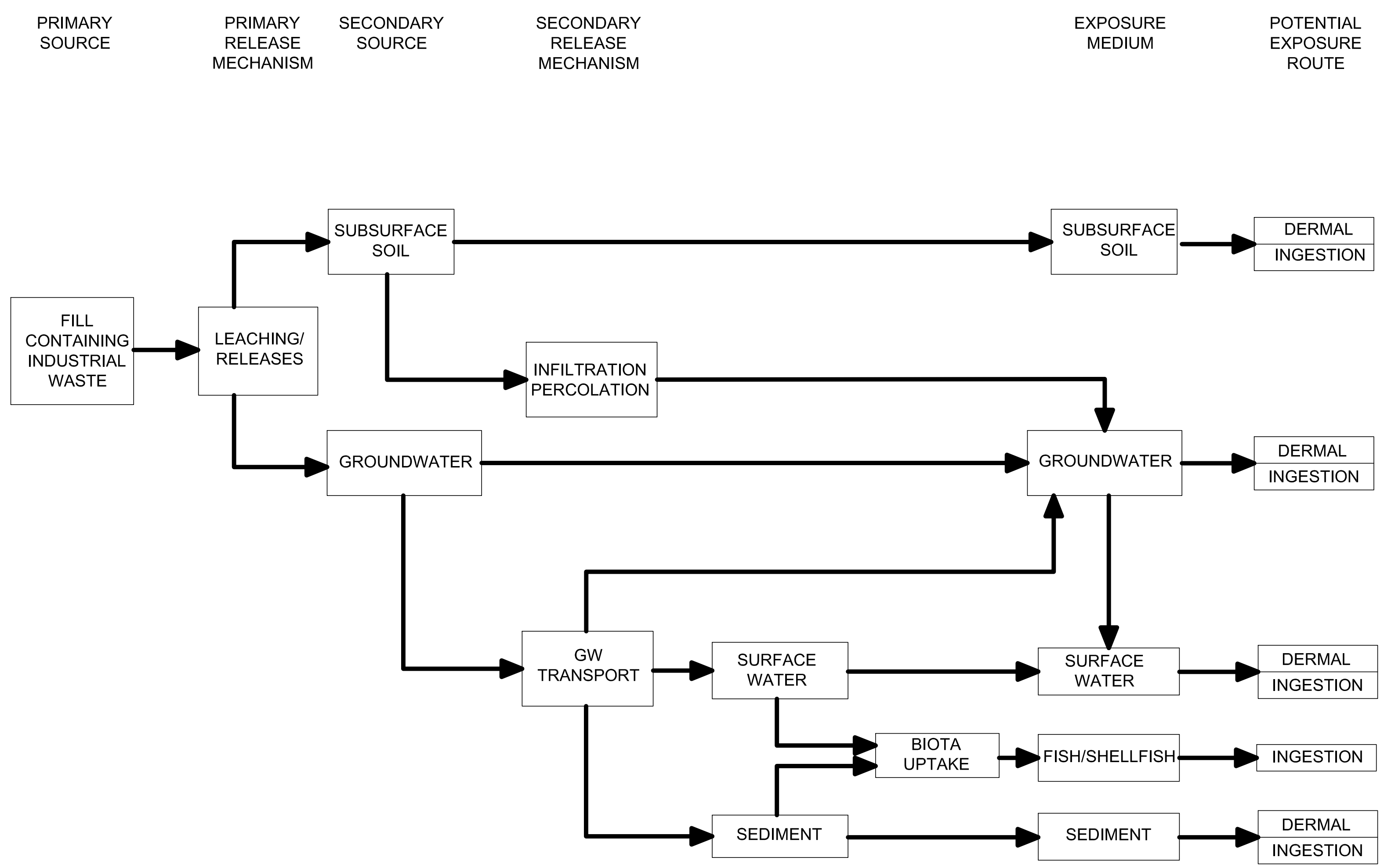

POTENTIAL HUMAN RECEPTOR

Exposure Medium	Potential Exposure Route	CURRENT LAND USE				FUTURE LAND USE				
		INDOOR WORKER	OUTDOOR WORKER	TRESPASSER	RECREATIONAL USER	INDOOR WORKER	OUTDOOR WORKER	CONSTRUCTION WORKER	TRESPASSER	RECREATIONAL USER
SUBSURFACE SOIL	DERMAL	X	●	X	X	X	X	●	X	X
SUBSURFACE SOIL	INGESTION	X	X	X	X	X	X	●	X	X
GROUNDWATER	DERMAL	X	X	X	X	X	X	●	X	X
GROUNDWATER	INGESTION	X	X	X	X	●	●	●	X	X
SURFACE WATER	DERMAL	X	X	●	●	X	X	X	●	●
SURFACE WATER	INGESTION	X	X	●	●	X	X	X	●	●
FISH/SHELLFISH	INGESTION	X	X	●	●	X	X	X	●	●
SEDIMENT	DERMAL	X	●	●	●	X	X	X	●	●
SEDIMENT	INGESTION	X	X	●	●	X	X	X	●	●

LEGEND:

● COMPLETE EXPOSURE PATHWAY

X INCOMPLETE EXPOSURE PATHWAY

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USG INTERIORS
HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 4
Conceptual Site Model

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FEASIBILITY STUDY
USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

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Figure No. 5
Alternative 1

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FEASIBILITY STUDY
USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 6
Alternative 2

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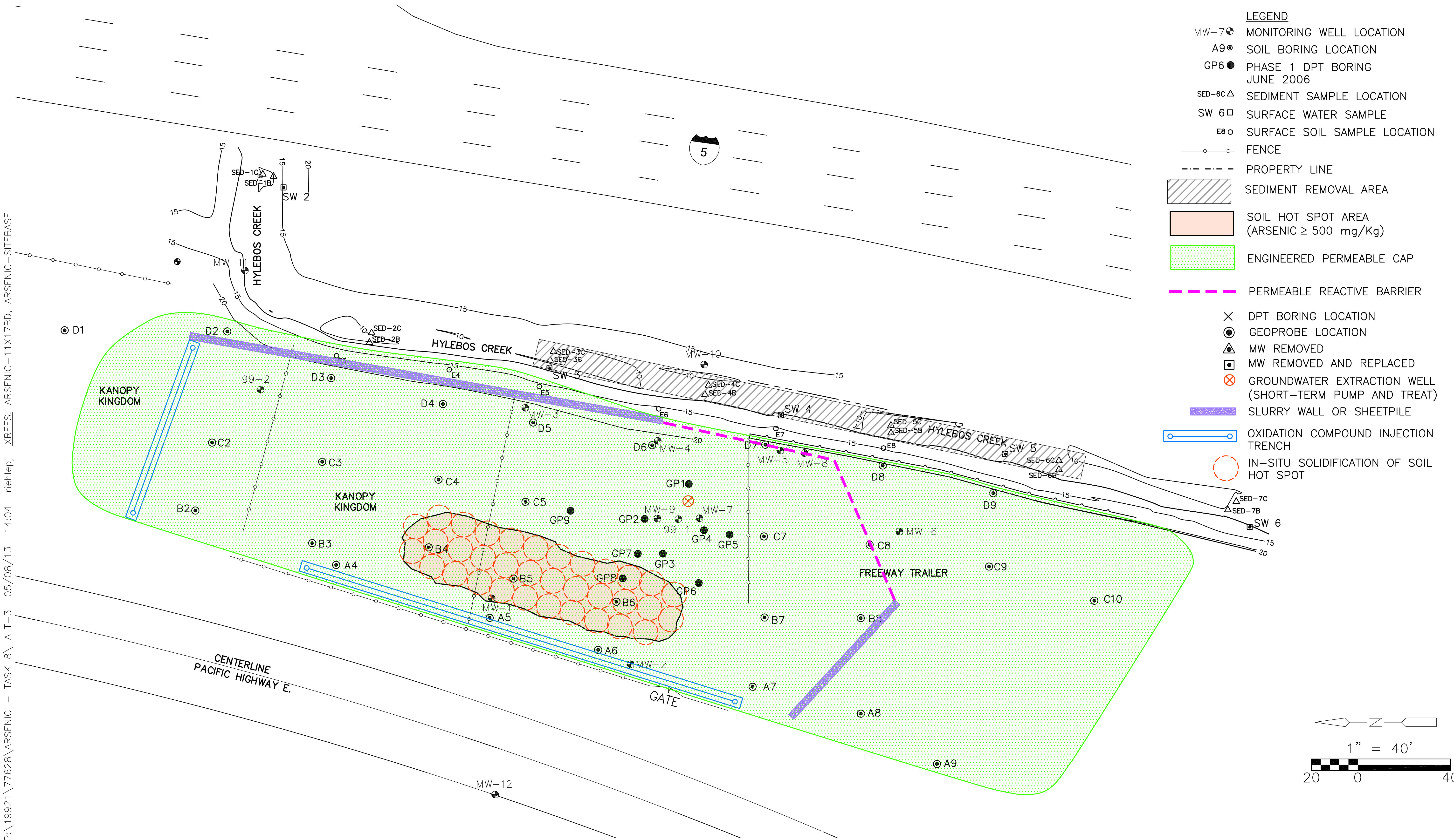

FEASIBILITY STUDY
USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 7
Alternative 3

CDM Smith

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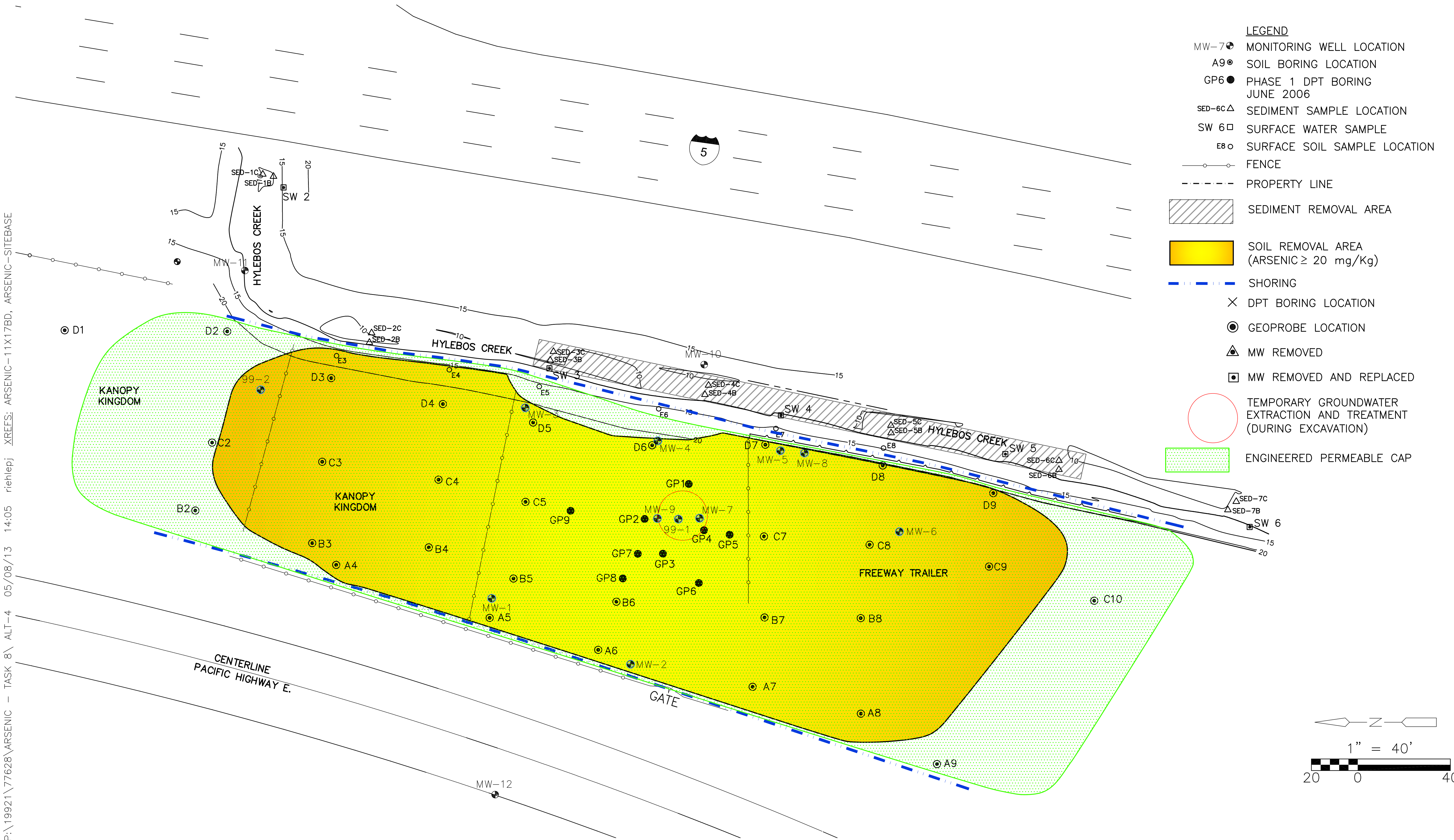

FEASIBILITY STUDY
USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 8
Alternative 4

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Appendix A

RI Tables

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Table 1
Well Construction Details
Highway 99 Site
USG Interiors
Milton, Washington

Well I.D.	Northing [a]	Easting [a]	TOC Elevation (ft AMSL) [b]	Boring Total Depth (ft)	Screen Depth Interval (ft)	Casing Diameter (in)	Slot Size (in)	Screen Type	Drilled Date
MW-1	703059.65	1184681.28	23.02	19.0	13-18	2	0.01	PVC	05/05/10
MW-2	702999.60	1184652.77	22.37	19.0	12-19	2	0.01	PVC	05/04/10
MW-3	703045.13	1184763.71	20.22	21.0	14.7-19.7	2	0.01	PVC	05/07/10
MW-4	702987.85	1184749.40	20.40	20.0	14-19	2	0.01	PVC	05/05/10
MW-5	702934.84	1184745.18	19.07	20.0	14.5-19.5	2	0.01	PVC	05/06/10
MW-6	702883.36	1184710.13	19.89	20.0	14.1-19.1	2	0.01	PVC	05/06/10
MW-7	702969.79	1184715.93	21.06	39.0	25-30	2	0.01	PVC	05/05/10
MW-8	702924.45	1184744.14	19.12	40.0	34.9-40.1	2	0.01	PVC	05/06/10
MW-9	702988.01	1184715.80	20.87	59.0	43-48	2	0.01	PVC	05/04/10
MW-10	702958.17	1184783.51	14.15	12.6	10.4-11.5	3/4	0.01	Stainless Steel	10/14/11
MW-11	703185.90	1184844.31	15.41	10.5	9.3-10.5	3/4	0.01	Stainless Steel	10/14/11
MW-12	703065.01	1184585.80	21.54	20.0	14-19	1	0.01	Pre-pack PVC	05/11/12
MW-13	702495.10	1184478.55	22.16	16.0	10-15	1	0.01	Pre-pack PVC	05/11/12
MW-14	703437.40	1184781.81	30.30	20.0	13-18	1	0.01	Pre-pack PVC	05/11/12
MW-15				12.0	7-12	1	0.01	PVC	11/20/12
MW-16				12.0	12-17	1	0.01	PVC	11/20/12
PD-209A	702899.19	1185072.73	17.13	~14	UNK	2	UNK	PVC	UNK
PD-211	703281	1185150	16.77	20.0	6-16	2	UNK	PVC	08/18/08
99-1	702978.95	1184715.54	21.34	28.0	15-25	4	0.01	PVC	05/1985
99-2	703159.55	1184771.51	22.64	25.5	15-25	4	0.01	PVC	05/1985

Notes:
a) Washington State Plane North American Datum of 1983 (NAD 83), Zone 12, feet.
b) ft AMSL - feet above mean sea level. Elevations based on North American Vertical Datum of 1988 (NAVD 88).
TOC - Top of casing.
PVC - Polyvinylchloride.
UNK - Unknown.

Table 2
Summary of Groundwater Elevation Measurements
Hwy 99 Site
USG Interiors
Milton, Washington

Monitoring Well I.D.	Date Measured	Top of Casing Elevation [a] (feet)	Depth to Groundwater (ft below TOC)	Groundwater Elevation (feet)
MW1	05/25/10	23.02	10.19	12.83
	07/15/10		9.85	13.17
	05/22/12		9.04	13.98
MW2	05/25/10	22.37	8.42	13.95
	07/15/10		8.51	13.86
	05/22/12		7.71	14.66
MW3	05/25/10	20.22	7.22	13.00
	07/15/10		7.32	12.90
	05/22/12		6.28	13.94
MW4	05/25/10	20.40	7.41	12.99
	07/15/10		7.51	12.89
	05/22/12		6.63	13.77
MW5	05/25/10	19.07	6.17	12.90
	07/15/10		6.22	12.85
	05/22/12		5.32	13.75
MW6	05/25/10	19.89	7.08	12.81
	07/15/10		7.16	12.73
	05/22/12		6.19	13.70
MW7	05/25/10	21.06	7.81	13.25
	07/15/10		8.02	13.04
	05/22/12		8.15	12.91
MW8	05/25/10	19.12	5.34	13.78
	07/15/10		5.57	13.55
	05/22/12		4.59	14.53
MW9	05/25/10	20.87	1.72	19.15
	07/15/10		1.89	18.98
	05/22/12		0.63	20.25
MW10	05/22/12	14.15	0.79	13.36
MW11	05/22/12	15.41	6.90	8.51
MW12	05/22/12	21.54	0.00	21.54
MW13	05/22/12	22.16	8.27	13.89
MW14	05/22/12	30.30	10.60	19.70
99-1	05/25/10	21.34	8.22	13.12
	07/15/10		8.47	12.87
	05/22/12		7.60	13.74
99-2	05/25/10	22.64	9.62	13.02
	07/15/10		9.71	12.93
	05/22/12		8.89	13.75

Notes:

a) Datum used: NAD 83/91 Washington South Zone NAVD '88, US Feet.
ft bgs - Feet below ground surface.
TOC - top of casing.

Table 3
Groundwater General Parameters
Hwy 99 Site
USG Interiors
Milton, Washington

Monitoring Well	Date Sampled	Time Sampled	Temperature (°C)	Specific Conductance (μs/cm)	pH	Turbidity (NTU)	Dissolved Oxygen (mg/L)	ORP (mV)	Appearance/ Odor
MW1	05/26/10	1435	12.72	318	6.73	5.79	0.25	-11.7	Clear, colorless/no odor
MW2	05/25/10	1445	13.28	331	6.79	0.57	0.22	-35.4	Clear, colorless/no odor
MW3	05/25/10	1615	12.53	449	6.73	16.6	0.20	-82.8	Yellow tint, slight turbidity/no odor
	07/15/10	1430	13.01	460	6.66	3.3	0.13	-107.4	Slight yellowish color, clear, no odor
MW4	05/26/10	1310	12.22	633	6.48	5.68	0.26	-0.7	Clear, colorless/no odor
	07/15/10	1305	13.51	664	6.61	0.00	0.15	-91.5	Clear, colorless, broken organic sheen /no odor
MW5	05/26/10	1025	11.79	394	6.74	4.58	0.30	-67.1	Clear, colorless/no odor
MW6	05/26/10	0915	12.66	456	6.68	8.96	0.39	-54.5	Clear, colorless/no odor
MW7	05/27/10	1045	13.28	420	6.99	10.15	0.21	-8.3	Clear, colorless/no odor
MW8	05/27/10	0940	12.05	419	7.00	8.62	0.27	16.3	Clear, colorless/no odor
MW9	05/27/10	1200	13.35	265	7.72	9.86	0.19	68.2	Clear, colorless/no odor
MW10	10/18/11	1335	13.44	349	6.88	49.8	0.47	-94.0	Clear, colorless/no odor
MW11	10/18/11	1225	13.90	670	6.48	12.8	0.16	-129.9	Clear, colorless/no odor
MW12	05/22/12	0950	11.91	188	6.67	26.9	2.00	-75	Clear, colorless, odorless, slight turbidity observable in bucket
MW13	05/22/12	1220	13.24	1024	6.56	84	0.98	-102.1	Clear, colorless, odorless, little bit swirled organic sheen
MW14	05/22/12	1440	12.21	1249	6.54	863	0.71	-101.1	Colorless, odorless, water in bucket is slightly muddy
MW-15	11/27/12	1400	13.10	363	7.40	>1000	8.18	-38.3	Colorless/no odor/turbid
MW-16	11/28/12	1530	12.58	669	7.06	449	1.30	-76.3	Colorless/no odor/turbid
PD-209A	11/27/12	1205	11.47	591	7.01	24.0	1.14	-91.9	Colorless/clear/no odor/small amount biomass
PD-211	11/27/12	1045	10.84	492	6.64	34.0	1.86	-92.8	Clear, colorless/no odor/small amount light-colored biomass
99-1	05/26/10	1200	12.90	415	6.92	5.62	0.32	-58.8	Clear, colorless/no odor
	07/15/10	1210	14.21	406	6.68	5.00	0.22	-144.6	Clear, slight yellowish color, odorless
99-2	05/27/10	1310	13.24	1201	6.52	17.6	0.29	-31	Clear, slight yellowish color, broken organic sheen /no odor

Notes:
°C - degrees Celsius.
μs/cm - microsiemens per centimeter.
mg/L - milligram per liter.
mV - millivolts.
NTU - nephelometric turbidity units.

Table 4
Surface Water General Parameters
Hwy 99 Site
USG Interiors
Milton, Washington

Monitoring Well	Date Sampled	Time Sampled	Temperature (^oC)	Specific Conductance (µs/cm)	pH	Dissolved Oxygen (mg/L)	ORP (mV)	Appearance/ Odor
SW1	05/25/10	1310	11.47	240	7.79	10.23	132.6	Clear/no odor, colorless
SW2	05/25/10	1250	11.35	242	7.66	10.00	149.0	Clear/no odor, colorless
SW3	05/25/10	1230	11.20	242	7.58	9.36	142.1	Clear/no odor, colorless
SW4	05/25/10	1205	11.20	241	7.70	9.56	142.8	Clear/no odor, colorless
SW5	05/25/10	1135	11.13	241	7.73	9.24	149.6	Clear/no odor, colorless
SW6	05/25/10	1110	11.11	241	7.76	9.18	158.7	Clear/no odor, colorless

Notes:
^oC - degrees Celsius.
µs/cm - microsiemens per centimeter.
mg/L - milligram per liter.
mV - millivolts.

Table 5
Vertical Hydraulic Gradient Between Shallow and Deeper Groundwater Monitoring Points
Alluvial Aquifer
USG Interiors/Remedial Investigation
Milton, Washington

Well Cluster	Date	Vertical Gradient Between Shallow and Deeper Groundwater Monitoring Points	
		Upward	**Downward**
99-1 / MW7	5/25/2010	0.017	
	7/15/2010	0.022	
MW5 / MW8	5/25/2010	0.044	
	7/15/2010	0.035	

Notes:
Vertical hydraulic gradient was calculated by dividing the head differential by the vertical distance between screen midpoint elevation for wells in each well cluster. Screen midpoint elevations used include: 99-1 = 1.3 feet; MW7 = -6.44 feet; MW5 = 1.57 feet; and MW8 = -18.38 feet.

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
A4-2	2	04/28/10	3.5
A4-4	4	04/28/10	13.4
A4-8	8	04/28/10	2.9
A4-10	10	04/28/10	3.5
A4-12	12	04/28/10	4.1
A4-14	14	04/28/10	3.5
A4-16	16	04/28/10	8.4
A5-2	2	04/28/10	3.5
A5-4	4	04/28/10	3.5
A5-6	6	04/28/10	3.5
A5-12	12	04/28/10	59.1
A5-14	14	04/28/10	44.5
A5-16	16	04/28/10	10.9
A6-2	2	04/28/10	3.5
A6-4	4	04/28/10	9.6
A6-8	8	04/28/10	9.6
A6-10	10	04/28/10	59.1
A6-12	12	04/28/10	18.5
A6-14	14	04/28/10	12.1
A6-16	16	04/28/10	10.9
A7-2	2	04/27/10	3.5
A7-4	4	04/27/10	<5 **
A7-6	6	04/27/10	313.4
A7-12	12	04/27/10	257 **
A7-14	14	04/27/10	75.2
A7-16	16	04/27/10	142.2
A7-18	18	04/27/10	31.4
A7-20	20	04/27/10	8.4
A8-2	2	04/28/10	3.5
A8-4	4	04/28/10	157.4
A8-6	6	04/28/10	160
A8-8	8	04/28/10	47.2
A8-8	8	04/28/10	35.3
A8-8	8	04/28/10	51.1
A8-8	8	04/28/10	53.8
A8-8	8	04/28/10	49.8
A8-8	8	04/28/10	52.5
A8-8	8	04/28/10	48.5
A8-8	8	04/28/10	48.5
A8-8	8	04/28/10	49.8
A8-10	10	04/28/10	3.5
A8-12	12	04/28/10	3.5
A8-14	14	04/28/10	3.5
A8-16	16	04/28/10	3.5

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
A9-2	2	04/29/10	3.5
A9-4	4	04/29/10	32.7
A9-6	6	04/29/10	8.4
A9-8	8	04/29/10	3.5
A9-10	10	04/29/10	8.4
A9-12	12	04/29/10	7.1
A9-14	14	04/29/10	3.5
A9-16	16	04/29/10	3.5
AA6-6	6	05/11/12	<12 **
AA6-10	10	05/11/12	<15 **
AA6-12	12	05/11/12	<13 **
AA6-14	14	05/11/12	<13 **
AA7-10	10	05/11/12	<19 **
AA7-12	12	05/11/12	<13 **
B2-2	2	04/28/10	3.5
B2-4	4	04/28/10	14.6
B2-6	6	04/28/10	3.5
B2-8	8	04/28/10	3.5
B2-10	10	04/28/10	8.4
B2-12	12	04/28/10	12.1
B2-14	14	04/28/10	8.4
B2-16	16	04/28/10	17.2
B3-2	2	04/28/10	23.6
B3-4	4	04/28/10	101
B3-6	6	04/28/10	3.5
B3-8	8	04/28/10	10.9
B3-10	10	04/27/10	3.5
B3-14	14	04/27/10	3.5
B3-15	15	04/27/10	3.5
B4-2	2	04/26/10	3.5
B4-4	4	04/26/10	3.5
B4-8	8	04/26/10	3.5
B4-10	10	04/26/10	12 **
B4-14	14	04/26/10	1680 **
B4-16	16	04/26/10	80 **
B4-18	18	04/26/10	17.2
B4-20	20	04/26/10	7.1
B5-2	2	04/26/10	43 **
B5-4	4	04/26/10	2.9
B5-6	6	04/26/10	7.1
B5-8	8	04/26/10	3.5
B5-12	12	04/26/10	3.5
B5-14	14	04/26/10	7430 **
B5-16	16	04/26/10	64.5
B5-18	18	04/26/10	48.5
B5-20	20	04/26/10	14.6

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
B6-2	2	04/27/10	20.0 **
B6-4	4	04/27/10	3.5
B6-6	6	04/27/10	8.4
B6-8	8	04/27/10	3.5
B6-10	10	04/27/10	13.4
B6-12	12	04/27/10	13086.3
B6-14	14	04/27/10	1920 **
B6-16	16	04/27/10	73 **
B6-18	18	04/27/10	35.3
B6-20	20	04/27/10	18.5
B6-20	20	04/27/10	21.0
B6-20	20	04/27/10	21.0
B6-20	20	04/27/10	17.2
B6-20	20	04/27/10	17.2
B6-20	20	04/27/10	21.0
B6-20	20	04/27/10	14.6
B7-2	2	04/27/10	8.4
B7-4	4	04/27/10	4.1
B7-4	4	04/27/10	3.5
B7-6	6	04/27/10	158.8
B7-8	8	04/27/10	49.8
B7-10	10	04/27/10	493 **
B7-12	12	04/27/10	63.2
B7-14	14	04/27/10	20.0 **
B7-16	16	04/27/10	15.9
B8-2	2	04/28/10	4.1
B8-4	4	04/28/10	9.6
B8-6	6	04/28/10	9.6
B8-8	8	04/28/10	21
B8-10	10	04/28/10	17.2
B8-12	12	04/28/10	21
B8-14	14	04/28/10	14.6
B8-16	16	04/28/10	10.9
C2-2	2	04/28/10	3.5
C2-4	4	04/28/10	10.9
C2-8	8	04/28/10	3.5
C2-10	10	04/28/10	30.1
C2-12	12	04/28/10	21
C2-14	14	04/28/10	15.9
C2-16	16	04/28/10	9.6
C3-2	2	04/27/10	3.5
C3-4	4	04/27/10	10.9
C3-6	6	04/27/10	5.9
C3-8	8	04/27/10	3.5
C3-12	12	04/27/10	188
C3-14	14	04/27/10	293.6

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
C3-15	15	04/27/10	199.2
C3-16	16	04/27/10	249.7
C3-18	18	04/27/10	45 **
C3-20	20	04/27/10	36.6
C3-22	22	04/27/10	4.1
C3-24	24	04/27/10	10.9
C4-2	2	04/26/10	8.4
C4-4	4	04/26/10	12.1
C4-4	4	04/26/10	9.6
C4-6	6	04/26/10	8.4
C4-8	8	04/26/10	31.4
C4-10	10	04/26/10	228 **
C4-12	12	04/26/10	40.6
C4-14	14	04/26/10	52.5
C4-16	16	04/26/10	13.4
C5-2	2	04/26/10	9.6
C5-4	4	04/26/10	14.6
C5-6	6	04/26/10	2.9
C5-8	8	04/26/10	3.5
C5-10	10	04/26/10	113.3
C5-12	12	04/26/10	61.8
C5-14	14	04/26/10	24.9
C5-16	16	04/26/10	49.0 **
C5-18	18	04/26/10	14.6
C5-20	20	04/26/10	17.2
C7-4	4	04/27/10	3.5
C7-6	6	04/27/10	4.1
C7-8	8	04/27/10	170 **
C7-10	10	04/27/10	167.1
C7-12	12	04/27/10	28.8
C7-14	14	04/27/10	28.8
C7-16	16	04/27/10	22.3
C8-2	2	04/28/10	3.5
C8-4	4	04/28/10	3.5
C8-5	5	04/28/10	10450
C8-6	6	04/28/10	287.9
C8-8	8	04/28/10	332
C8-10	10	04/28/10	59.1
C8-12	12	04/28/10	57.8
C8-14	14	04/28/10	10.9
C8-16	16	04/28/10	3.5
C9-2	2	04/29/10	57 **
C9-4	4	04/29/10	154.6
C9-6	6	04/29/10	39.2
C9-8	8	04/29/10	15.9
C9-10	10	04/29/10	3.5
C9-12	12	04/29/10	3.5

Sample C8-5 was slag. Arsenic value was not included in isocontour plot.

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
C9-14	14	04/29/10	3.5
C9-16	16	04/29/10	3.5
C10-2	2	04/29/10	69.9
C10-2	1	04/29/10	14.6 *
C10-4	4	04/29/10	15.9
C10-6	6	04/29/10	18.5
C10-8	8	04/29/10	14.6
C10-10	10	04/29/10	3.5
C10-12	12	04/29/10	3.5
D1-2	2	04/29/10	14.6
D1-4	4	04/29/10	3.5
D1-6	6	04/29/10	9.6
D1-8	8	04/29/10	13.4
D1-10	10	04/29/10	3.5
D1-12	12	04/29/10	10.9
D1-14	14	04/29/10	9.6
D2-2	2	04/28/10	3.5
D2-4	4	04/28/10	24.9
D2-8	8	04/28/10	36.6
D2-10	10	04/28/10	3.5
D2-12	12	04/28/10	3.5
D2-14	14	04/28/10	3.5
D2-16	16	04/28/10	8.4
D3-2	2	04/26/10	8.4
D3-4	4	04/26/10	24.9
D3-4	4	04/26/10	23.6
D3-6	6	04/26/10	36.6
D3-8	8	04/26/10	21 **
D3-10	10	04/26/10	3.5
D3-12	12	04/26/10	44.5
D3-16	16	04/26/10	30.1
D3-18	18	04/26/10	51.1
D3-20	20	04/26/10	39.2
D3-20	20	04/26/10	37.9
D3-22	22	04/26/10	18.5
D3-24	24	04/26/10	12.1
D4-2	2	04/26/10	8.4
D4-4	4	04/26/10	7 **
D4-8	8	04/26/10	3.5
D4-10	10	04/26/10	2.3
D4-12	12	04/26/10	17.2
D4-14	14	04/26/10	18.5
D4-16	16	04/26/10	13.4
D5-2	2	04/26/10	10.9
D5-4	4	04/26/10	9.6
D5-6	6	04/26/10	10.9
D5-8	8	04/26/10	8.4

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
D5-10	10	04/26/10	4.7
D5-12	12	04/26/10	8.4
D5-14	14	04/26/10	3.5
D5-16	16	04/26/10	3.5
D6-2	2	04/27/10	9.6
D6-4	4	04/27/10	10.9
D6-6	6	04/27/10	56.5
D6-8	8	04/27/10	47.2
D6-10	10	04/27/10	2.3
D6-12	12	04/27/10	3.5
D6-14	14	04/27/10	5.9
D6-16	16	04/27/10	7.1
D7-4	4	04/27/10	3.5
D7-6	6	04/27/10	3.5
D7-8	8	04/27/10	3.5
D7-10	10	04/27/10	3.5
D7-12	12	04/27/10	4.1
D7-14	14	04/27/10	7.1
D7-16	16	04/27/10	8.4
D8-1.5	1.5	04/29/10	30.1
D8-5	5	04/29/10	53.8
D8-8	8	04/29/10	45.8
D8-8	8	04/29/10	41.9
D8-8	8	04/29/10	45.8
D8-8	8	04/29/10	48.5
D8-8	8	04/29/10	47.2
D8-8	8	04/29/10	53.8
D8-8	8	04/29/10	48.5
D8-10	10	04/29/10	43.2
D8-12	12	04/29/10	9.6
D8-14	14	04/29/10	4.1
D8-16	16	04/29/10	12.1
D9-1	1	04/29/10	28.8
D9-4.5	4.5	04/29/10	13.4
D9-6	6	04/29/10	8.4
D9-8	8	04/29/10	12.1
D9-10	10	04/29/10	3.5
D9-12	12	04/29/10	3.5
E3	0	04/29/10	4.7
E4	0	04/29/10	13.4
E5	0	04/29/10	13.4
E6	0	04/29/10	22.3
E7	0	04/29/10	3.5
E8	0	04/29/10	18.5
GP1-5	5	06/05/06	310
GP1-10	10	06/05/06	200
GP1-15	15	06/05/06	320

Table 6
Arsenic in Soil
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
GP2-15	15	06/05/06	1400
GP3-12	12	06/05/06	19
GP3-14	14	06/05/06	23
GP4-9.5	9.5	06/05/06	570
GP4-13	13	06/05/06	31
GP5-10	10	06/05/06	240
GP5-13	13	06/05/06	15
GP6-11	11	06/05/06	72
GP7-8	8	06/06/06	<11
GP8-9	9	06/06/06	870
GP8-13	13	06/06/06	160
GP9-9	9	06/06/06	310
GP9-14	14	06/06/06	36
MW12-6	6	05/11/12	<16 **
MW12-8	8	05/11/12	<12 **
MW12-12	12	05/11/12	<13 **
MW12-14	14	05/11/12	<12 **

Notes:
Shaded concentrations exceed Washington Administration Code Chapter 173-340, Model Toxics Control Act, Method A cleanup levels
* Result from a 2nd locaton for Boring C10; moved due to refusal.
** As results from lab data.

Table 7
Arsenic in Sediment
Highway 99 Site
USG Interiors
Milton, Washington

Boring I.D.	Sample Depth (ft bgs)	Date Sampled	Total Arsenic (mg/kg)
SED-1B	Surface	04/30/10	2.9
SED-1C	Surface	04/30/10	7 **
SED-2B	Surface	04/29/10	3.5
SED-2C	Surface	04/29/10	2.9
SED-3B	Surface	04/29/10	205 **
SED-3C	Surface	04/29/10	2.9
SED-4B	Surface	04/29/10	90 **
SED-4C	Surface	04/29/10	9.6
SED-5B	Surface	04/29/10	14.6
SED-5C	Surface	04/29/10	45.8
SED-6B	Surface	04/29/10	30 **
SED-6C	Surface	04/29/10	17 **
SED-7B	Surface	04/30/10	2.9
SED-7C	Surface	04/30/10	8.1

Note:
** As results from lab data.

Table 8
Analytical Results - Groundwater
Highway 99 Site
USG Interiors
Milton, Washington

Analyte	Sample I.D. and Sample Date					
	USGHWY99-MW1-05/10	**USGHWY99-MW2-05/10**	**USGHWY99-MW3-05/10**	**USGHWY99-MW4-05/10**	**USGHWY99-MW0-05/10***	**USGHWY99-MW5-05/10**
	05/25/10	**05/25/10**	**05/25/10**	**05/26/10**	**05/26/10**	**05/26/10**
Dissolved Metals (µg/L)						
EPA Methods 200.8/7060A/6010B						
Arsenic (7060A)	630	34	780 **	1,030 **	1,060 **	1,090
Iron	4,290	1,560	29,900 **	31,500 **	32,000 **	5,070
Total Metals (µg/L)						
EPA Method 200.8/7090A/6010B						
Arsenic (200.8)	--	64.2	--	--	--	--
Arsenic (7060A)	--	79	--	--	--	--
Calcium	27,100	21,200	30,200	45,300	43,500	26,900
Iron	6,660	2,970	22,100	9,980	9,670	11,800
Magnesium	14,600	13,700	16,300	25,300	24,000	17,300
Potassium	2,830	3,120	4,910	6,240	5,840	3,860
Sodium	10,500	11,800	15,700	21,700	20,500	15,500
Arsenic Speciation (µg/L)						
Arsenic (III)	455	45.9	267	1,350	1,260	1,410
Arsenic (V)	33.5	2.27	19.2	29.8	24.9	36.6
Conventionals						
Alkalinity (SM 2320; mg/L $CaCO_3$)	152	142	175	264	269	178
Carbonate (SM 2320; mg/L $CaCO_3$)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate (SM 2320; mg/L $CaCO_3$)	152	142	175	264	269	178
Hydroxide (SM 2320; mg/L $CaCO_3$)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Dissolved Solids (EPA 260.1; mg/L)	--	--	--			
Total Suspended Solids (EPA 160.2; mg/L)	2.7	5.7	24.4	11.6	10.3	28.5
Chloride (EPA 300.0; mg/L)	4.4	6.7	5.2	9.6	10.0	7.6
N-Nitrate (EPA 300.0; mg-N/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N-Nitrite (EPA 300.0; mg-N/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfate (EPA 300.0; mg/L)	2.8	6.5	14.7	2.5	2.6	<0.1
Chemical Oxygen Demand (EPA 410.4; mg/L)	28.7	9.34	55.4	30.3	29.4	11.2
Total Organic Carbon (EPA 415.1; mg/L)	12.4	2.71	19.9	11.1	11.2	5.05

Table 8
Analytical Results - Groundwater
Highway 99 Site
USG Interiors
Milton, Washington

	Sample I.D. and Sample Date					
	USGHWY99-MW6-05/10	**USGHWY99-MW7-05/10**	**USGHWY99-MW8-05/10**	**USGHWY99-MW9-05/10**	**USGHWY99-99-1-05/10**	**USGHWY99-99-2-05/10**
Analyte	**05/26/10**	**05/27/10**	**05/27/10**	**05/27/10**	**05/26/10**	**05/27/10**
Dissolved Metals (µg/L)						
EPA Methods 200.8/7060A/6010B						
Arsenic (7060A)	310	10	13	44	2,490 **	410
Iron	6,200	1,800	980	<50	6,340 **	45,700
Total Metals (µg/L)						
EPA Method 200.8/7090A/6010B						
Arsenic (200.8)	--	--	14	--	2,220	--
Arsenic (7060A)	--	--	15	--	2,430	--
Calcium	35,300	17,600	21,400	11,000	35,600	86,900
Iron	14,400	7,400	4,870	290	4,840	57,200
Magnesium	20,200	14,400	12,900	8,230	16,900	53,900
Potassium	3,490	6,000	7,640	6,590	4,290	7,510
Sodium	14,300	36,400	35,300	28,500	17,900	31,700
Arsenic Speciation (µg/L)						
Arsenic (III)	351	--	--	--	1,780	310
Arsenic (V)	16.5	--	--	--	132	37.7
Conventionals						
Alkalinity (SM 2320; mg/L $CaCO_3$)	207	196	205	118	193	561
Carbonate (SM 2320; mg/L $CaCO_3$)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate (SM 2320; mg/L $CaCO_3$)	207	196	205	118	193	561
Hydroxide (SM 2320; mg/L $CaCO_3$)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Dissolved Solids (EPA 260.1; mg/L)						
Total Suspended Solids (EPA 160.2; mg/L)	41.5	22.2	18.1	4.3	9.9	50
Chloride (EPA 300.0; mg/L)	7.3	5.6	6.3	5.4	7.4	9.6
N-Nitrate (EPA 300.0; mg-N/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
N-Nitrite (EPA 300.0; mg-N/L)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5
Sulfate (EPA 300.0; mg/L)	<0.1	<0.1	0.2	7.5	1.6	<0.1
Chemical Oxygen Demand (EPA 410.4; mg/L)	20.5	10.9	7.75	6.48	7.43	62.7
Total Organic Carbon (EPA 415.1; mg/L)	9.27	4.17	3.83	<1.50	4.83	25.3

Table 8
Analytical Results - Groundwater
Highway 99 Site
USG Interiors
Milton, Washington

	Sample I.D. and Sample Date													
	GW-1	**GW-2**	**GW-3**	**GW-4**	**GW-5**	**GW-6**	**GW-7**	**GW-8**	**GW-9**	**MW10-10/11**	**MW11-10/11**	**MW12-05/12**	**MW13-05/12**	**MW14-05/12**
Analyte	**04/07/11**	**04/07/11**	**04/07/11**	**04/07/11**	**04/07/11**	**04/07/11**	**04/07/11**	**04/07/11**	**04/07/11**	**10/18/11**	**10/18/11**	**05/22/12**	**05/22/12**	**05/22/12**
Dissolved Metals (µg/L)														
EPA Method 6020														
Arsenic	55	2.4	38	120	21	19	<2	340	2.1	366	23.5	2.1	14.3	10.3
Iron	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Metals (µg/L)														
EPA Method 200.8/7090A/6010B														
Arsenic (200.8)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic (7060A)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Calcium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iron	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Magnesium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Potassium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sodium	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic Speciation (µg/L)														
Arsenic (III)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic (V)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Conventionals														
Alkalinity (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carbonate (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bicarbonate (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hydroxide (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Dissolved Solids (EPA 260.1; mg/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Suspended Solids (EPA 160.2; mg/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chloride (EPA 300.0; mg/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
N-Nitrate (EPA 300.0; mg-N/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
N-Nitrite (EPA 300.0; mg-N/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sulfate (EPA 300.0; mg/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chemical Oxygen Demand (EPA 410.4; mg/L	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total Organic Carbon (EPA 415.1; mg/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table 8
Analytical Results - Groundwater
Highway 99 Site
USG Interiors
Milton, Washington

	Sample I.D. and Sample Date				
	MW-15	**MW-16**	**PD-209A**	**PD-211**	**PD-311*****
Analyte	**11/27/12**	**11/28/12**	**11/27/12**	**11/27/12**	**11/27/12**
Dissolved Metals (µg/L)					
EPA Method 6020					
Arsenic	0.8	7.2	8.5	5.1	4.6
Iron	--	--	--	--	--
Total Metals (µg/L)					
EPA Method 200.8/7090A/6010B					
Arsenic (200.8)	--	--	--	--	--
Arsenic (7060A)	--	--	--	--	--
Calcium	--	--	--	--	--
Iron	--	--	--	--	--
Magnesium	--	--	--	--	--
Potassium	--	--	--	--	--
Sodium	--	--	--	--	--
Arsenic Speciation (µg/L)					
Arsenic (III)	--	--	--	--	--
Arsenic (V)	--	--	--	--	--
Conventionals					
Alkalinity (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--
Carbonate (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--
Bicarbonate (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--
Hydroxide (SM 2320; mg/L $CaCO_3$)	--	--	--	--	--
Total Dissolved Solids (EPA 260.1; mg/L)	--	--	--	--	--
Total Suspended Solids (EPA 160.2; mg/L)	--	--	--	--	--
Chloride (EPA 300.0; mg/L)	--	--	--	--	--
N-Nitrate (EPA 300.0; mg-N/L)	--	--	--	--	--
N-Nitrite (EPA 300.0; mg-N/L)	--	--	--	--	--
Sulfate (EPA 300.0; mg/L)	--	--	--	--	--
Chemical Oxygen Demand (EPA 410.4; mg/L	--	--	--	--	--
Total Organic Carbon (EPA 415.1; mg/L)	--	--	--	--	--

Notes:
*USGHWY-MW0-05/10 is a duplicate of USGHWY-MW4-05/10.
** Value from re-sampling on 7/15/10.
*** PD-311 is a duplicate of PD-211.
mg/L - milligrams per liter.
µg/L - micrograms per liter.
-- not analyzed.
< - analyte not detected at or greater than the listed concentration.

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Table 9
Analytical Results - Surface Water
Highway 99 Site
USG Interiors
Milton, Washington

Analyte	Sample I.D. and Sample Date					
	USGHwy99-SW1-05/10	**USGHwy99-SW2-05/10**	**USGHwy99-SW3-05/10**	**USGHwy99-SW4-05/10**	**USGHwy99-SW5-05/10**	**USGHwy99-SW6-05/10**
	05/25/10	**05/25/10**	**05/25/10**	**05/25/10**	**05/25/10**	**05/25/10**
Dissolved Metals (µg/L)						
EPA Methods 200.8/7060A/6010B						
Arsenic (200.8)	3.0	2.9	3.0	3.1	3.0	3.0
Arsenic (7060A)	4	4	4	3	4	4
Iron	280	--	--	270	280	
Total Metals (µg/L)						
EPA Method 200.8/7090A/6010B						
Arsenic (200.8)	3.4	--	--	3.4	3.5	--
Arsenic (7060A)	3	--	--	4	4	--
Calcium	19,000	--	--	17,900	18,100	--
Iron	410	--	--	390	420	--
Magnesium	13,100	--	--	12,200	12,400	--
Potassium	1,760	--	--	1,650	1,710	--
Sodium	7,500		--	7,040	7,120	--
Arsenic Speciation (µg/L)						
Arsenic (III)	0.403	--	--	0.444	0.539	--
Arsenic (V)	2.12	--	--	2.22	2.36	--
Conventionals						
Alkalinity (SM 2320; mg/L $CaCO_3$)	99.6	--	--	98.9	97.1	--
Carbonate (SM 2320; mg/L $CaCO_3$)	<1.0	--	--	<1.0	<1.0	--
Bicarbonate (SM 2320; mg/L $CaCO_3$)	99.6	--	--	98.9	97.1	--
Hydroxide (SM 2320; mg/L $CaCO_3$)	<1.0	--	--	<1.0	<1.0	--
Total Dissolved Solids (EPA 260.1; mg/L)	170	--	--	164	164	--
Total Suspended Solids (EPA 160.2; mg/L)	1.6	--	--	1.9	10.5	--
Chloride (EPA 300.0; mg/L)	8.0	--	--	8.0	7.8	--
N-Nitrate (EPA 300.0; mg-N/L)	0.7	--	--	0.7	0.7 J	--
N-Nitrite (EPA 300.0; mg-N/L)	<0.1	--	--	<0.1	<0.1 J	--
Sulfate (EPA 300.0; mg/L)	8.4	--	--	8.4	8.2	--
Chemical Oxygen Demand (EPA 410.4; mg/L)	14.7	--	--	16.0	11.9	--
Total Organic Carbon (EPA 415.1; mg/L)	5.22	--	--	5.19	7.38	--

Notes:
J - Value is estimated due to exceedance of holding time
µg/L - micrograms per liter.
-- not analyzed.
< - analyte not detected at or greater than the listed concentration.

Appendix B

RI Figures

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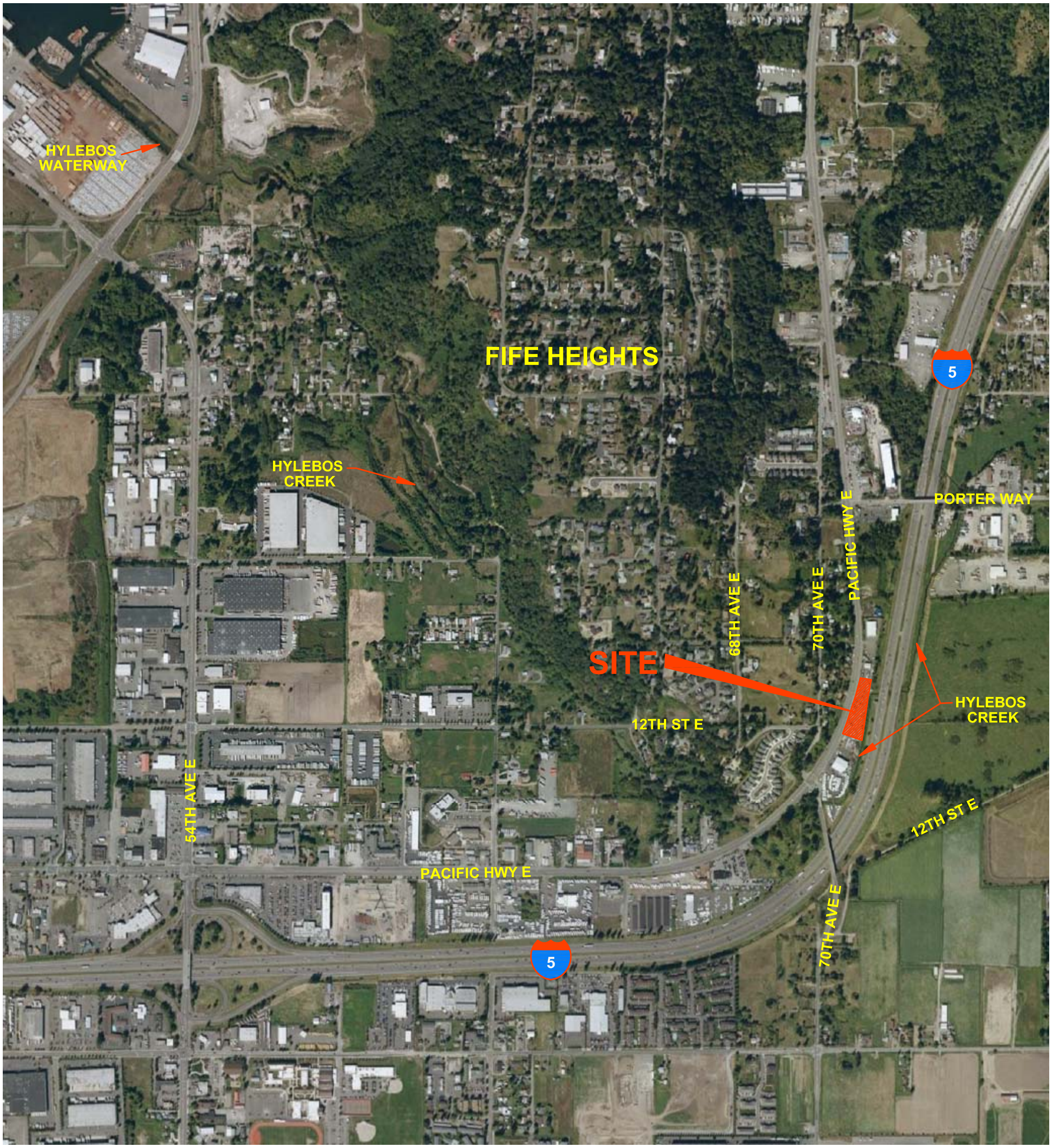

Source: GOOGLE EARTH PRO, 2009

P:\19921\65021\ FIG-1 12/14/09 11:36 riehlepj

N

0 1200

Scale in Feet

Washington

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 1
Vicinity Map

CDM

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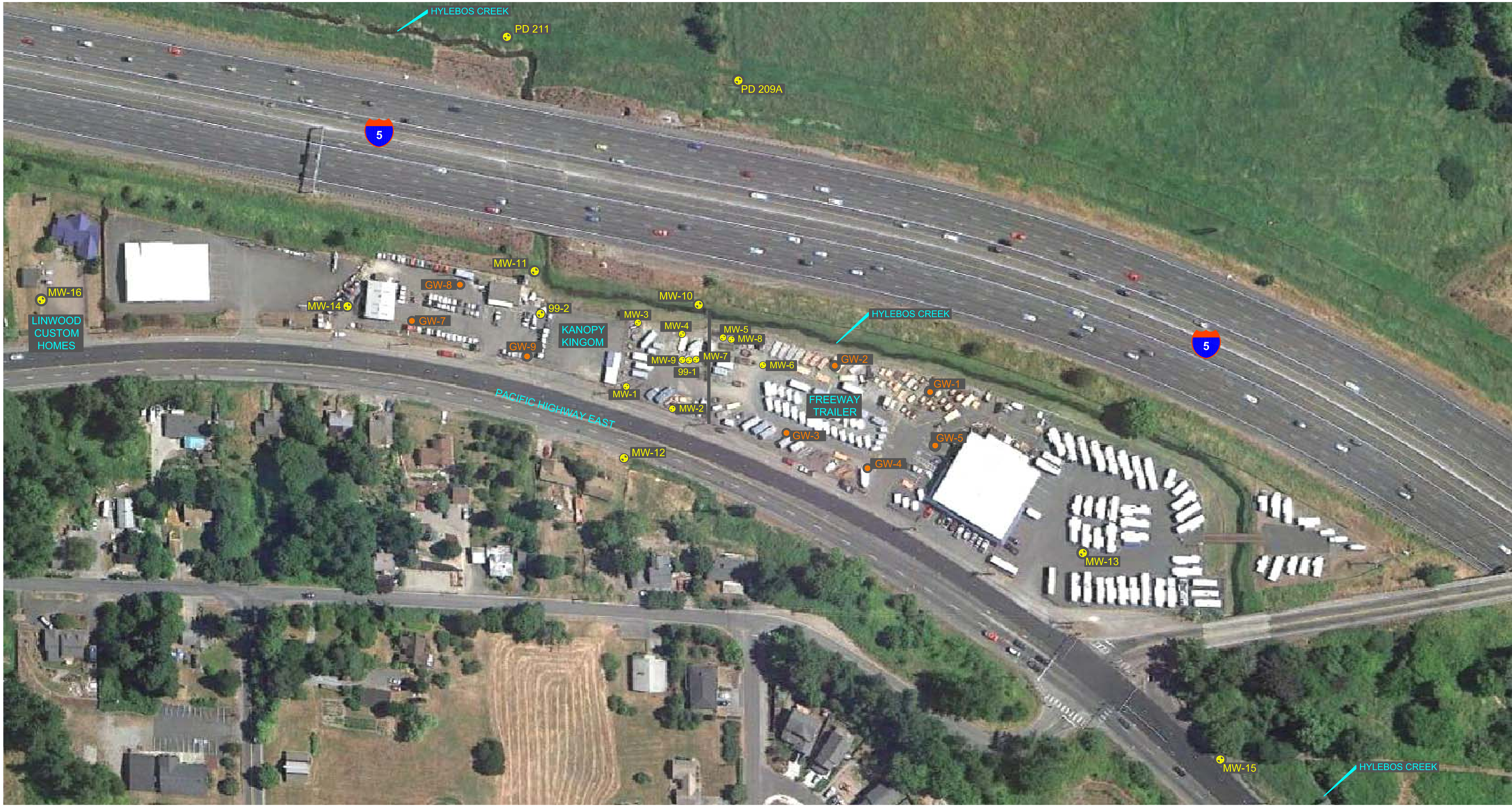

REFERENCE: GOOGLE EARTH PRO, 2012, IMAGE DATE AUGUST 20, 2011

LEGEND:

MW-12 MONITORING WELL

GW-3 PHASE 2 DPT BORING

NOTE:

MONITORING WELL MW-14 WAS DRILLED AT THE LOCATION OF GW-6

N

1" = 120'

60 0 120

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USG INTERIORS
HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 2A
Site Plan

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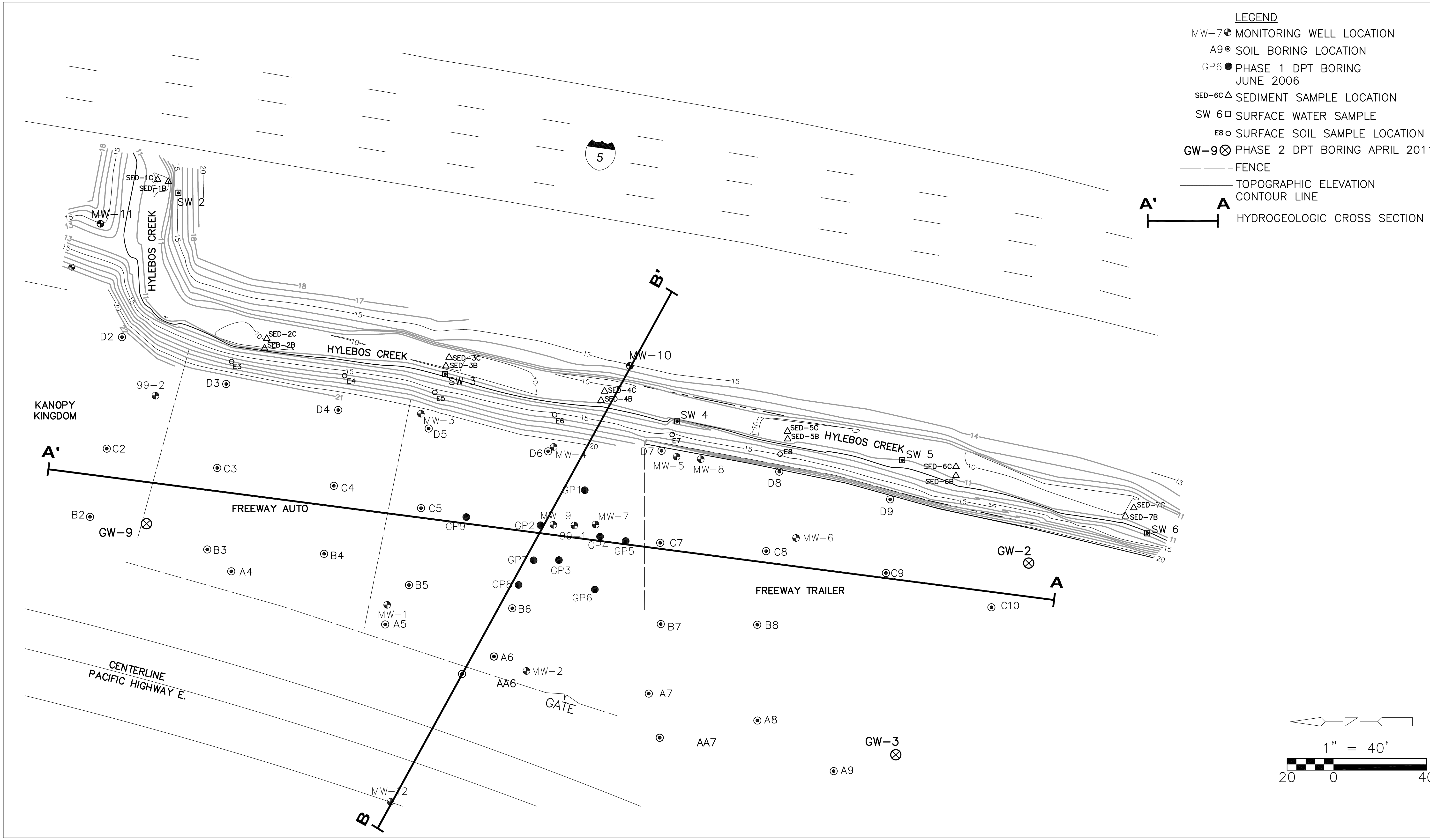

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USG INTERIORS
HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 2B
Site Plan

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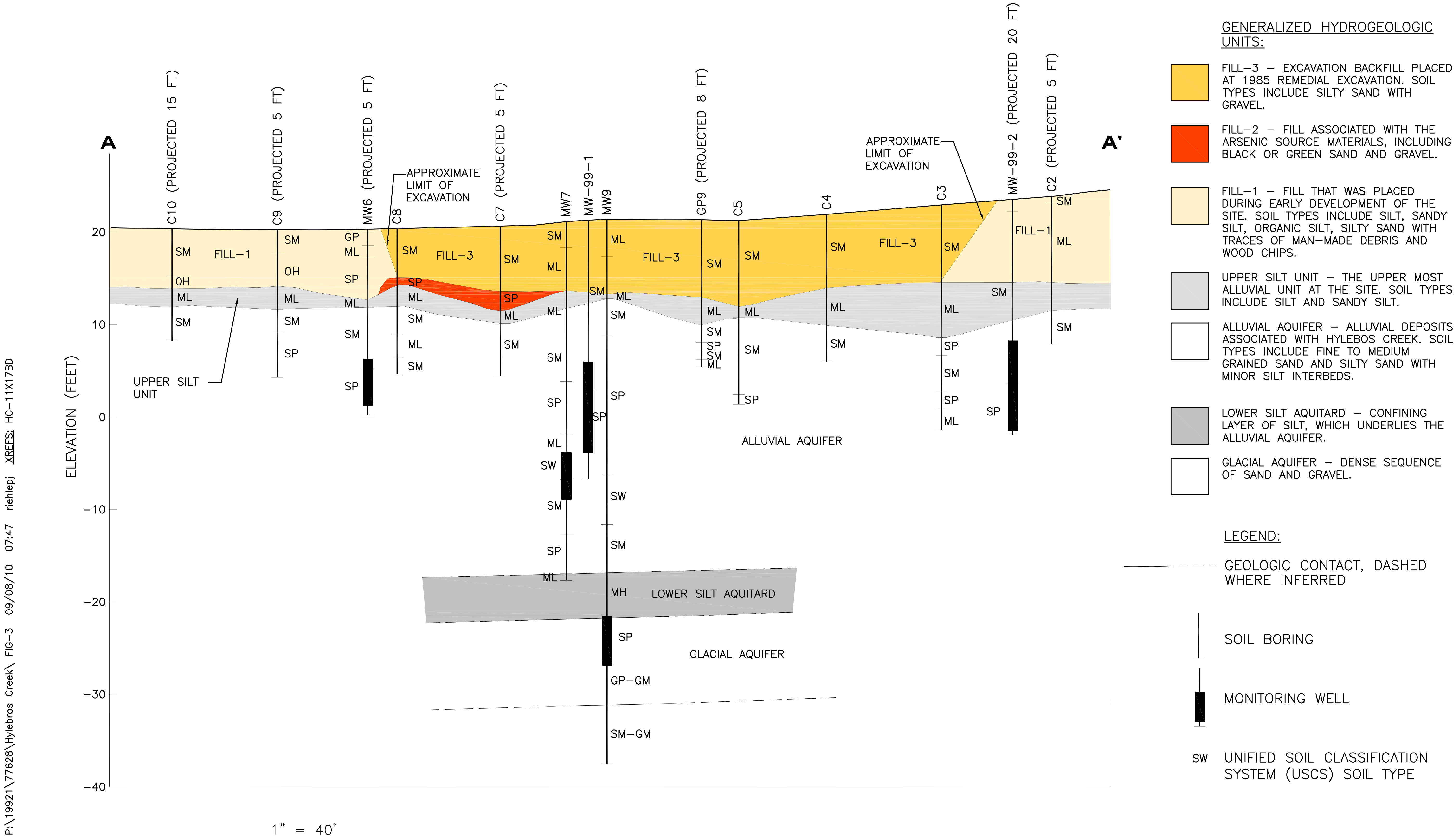

1" = 40'

20 0 40

VERTICAL EXAGGERATION 4X

CDM

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 3
Geologic Cross Section A–A'

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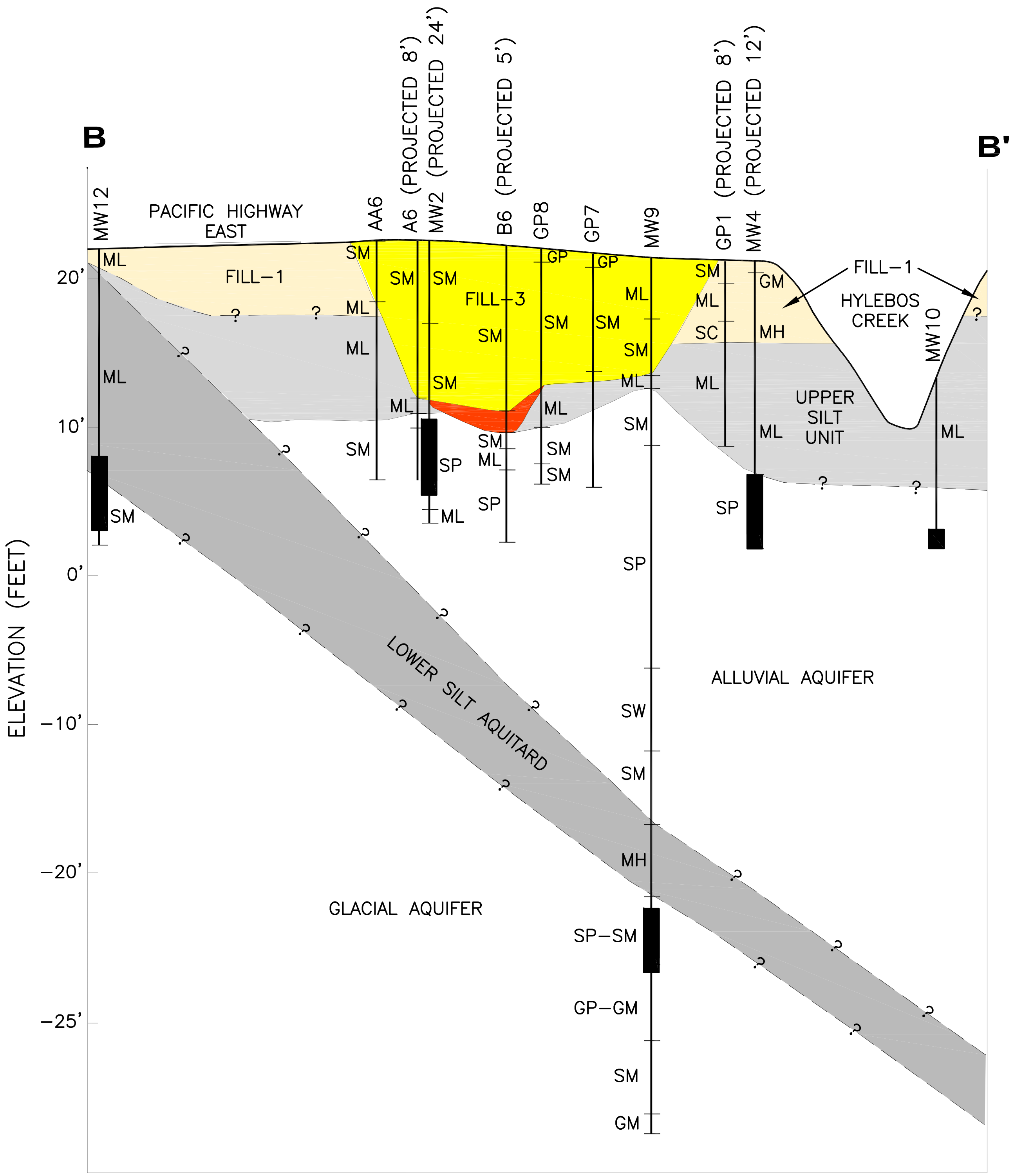

GENERALIZED HYDROGEOLOGIC UNITS:

FILL–3 – EXCAVATION BACKFILL PLACED AT 1985 REMEDIAL EXCAVATION. SOIL TYPES INCLUDE SILTY SAND WITH GRAVEL.

FILL–2 – FILL ASSOCIATED WITH THE ARSENIC SOURCE MATERIALS, INCLUDING BLACK OR GREEN SAND AND GRAVEL.

FILL–1 – FILL THAT WAS PLACED DURING EARLY DEVELOPMENT OF THE SITE. SOIL TYPES INCLUDE SILT, SANDY SILT, ORGANIC SILT, SILTY SAND WITH TRACES OF MAN–MADE DEBRIS AND WOOD CHIPS.

UPPER SILT UNIT – THE UPPER MOST ALLUVIAL UNIT AT THE SITE. SOIL TYPES INCLUDE SILT AND SANDY SILT.

ALLUVIAL AQUIFER – ALLUVIAL DEPOSITS ASSOCIATED WITH HYLEBOS CREEK. SOIL TYPES INCLUDE FINE TO MEDIUM GRAINED SAND AND SILTY SAND WITH MINOR SILT INTERBEDS.

LOWER SILT AQUITARD – CONFINING LAYER OF SILT, WHICH UNDERLIES THE ALLUVIAL AQUIFER.

GLACIAL AQUIFER – DENSE SEQUENCE OF SAND AND GRAVEL.

LEGEND:

GEOLOGIC CONTACT, DASHED WHERE INFERRED

SOIL BORING

MONITORING WELL

SW UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SOIL TYPE

1" = 40'
20 0 40
VERTICAL EXAGGERATION 4X

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 4
Geologic Cross Section B–B'

P:\19921\77628\Hylebros Creek\ FIG–4 REVISED 07/12/12 08:59 riehlepj XREFS: HC–11X17BD

CDM

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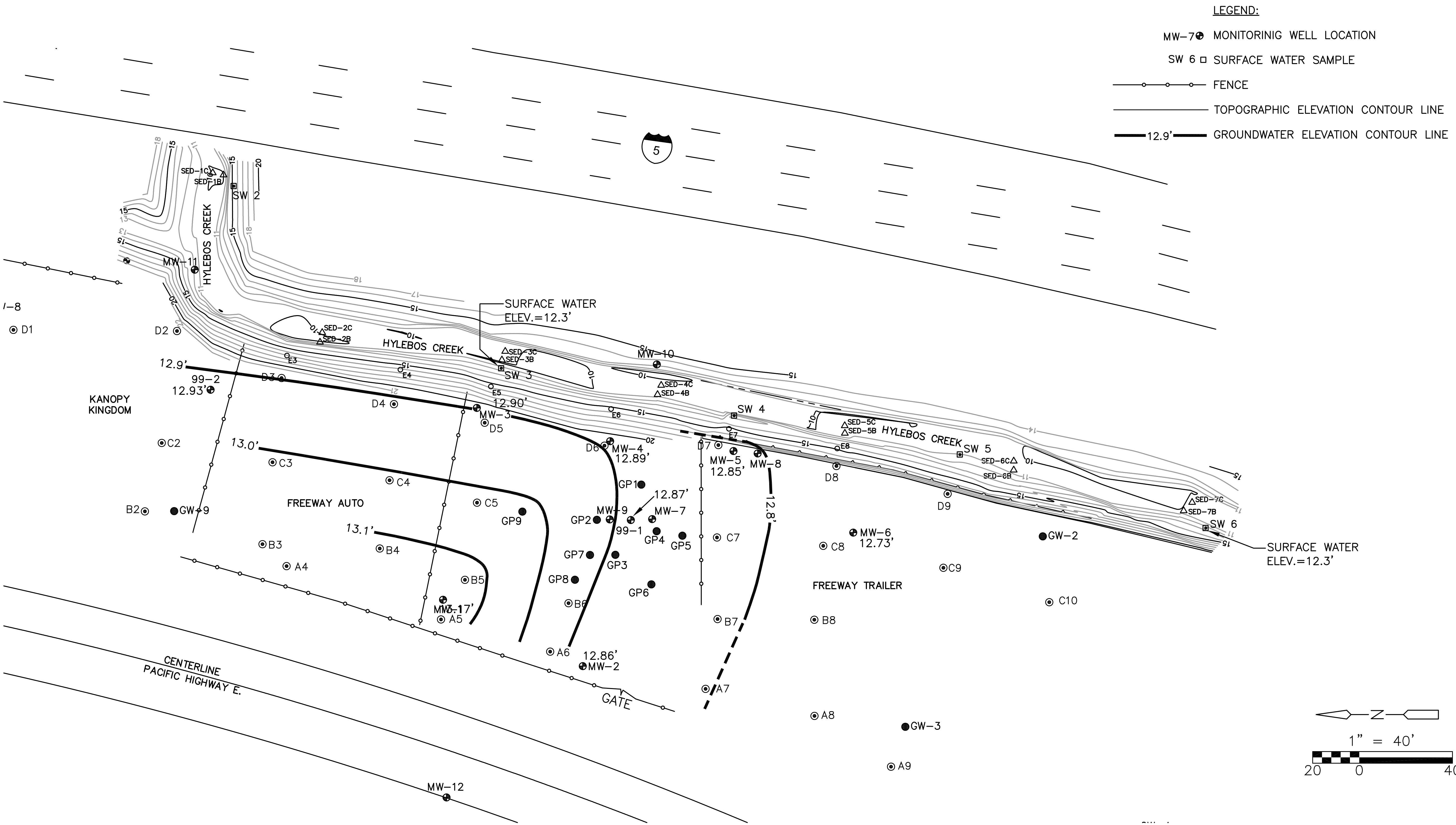

P:\19921\77628\Hylebros Creek\ FIG-5 07/12/12 09:17 riehlepj XREFS: HC-11X17BD, HC-SITEBASE

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 5
Groundwater Elevation Contour Map
Alluvial Aquifer
July 15, 2010

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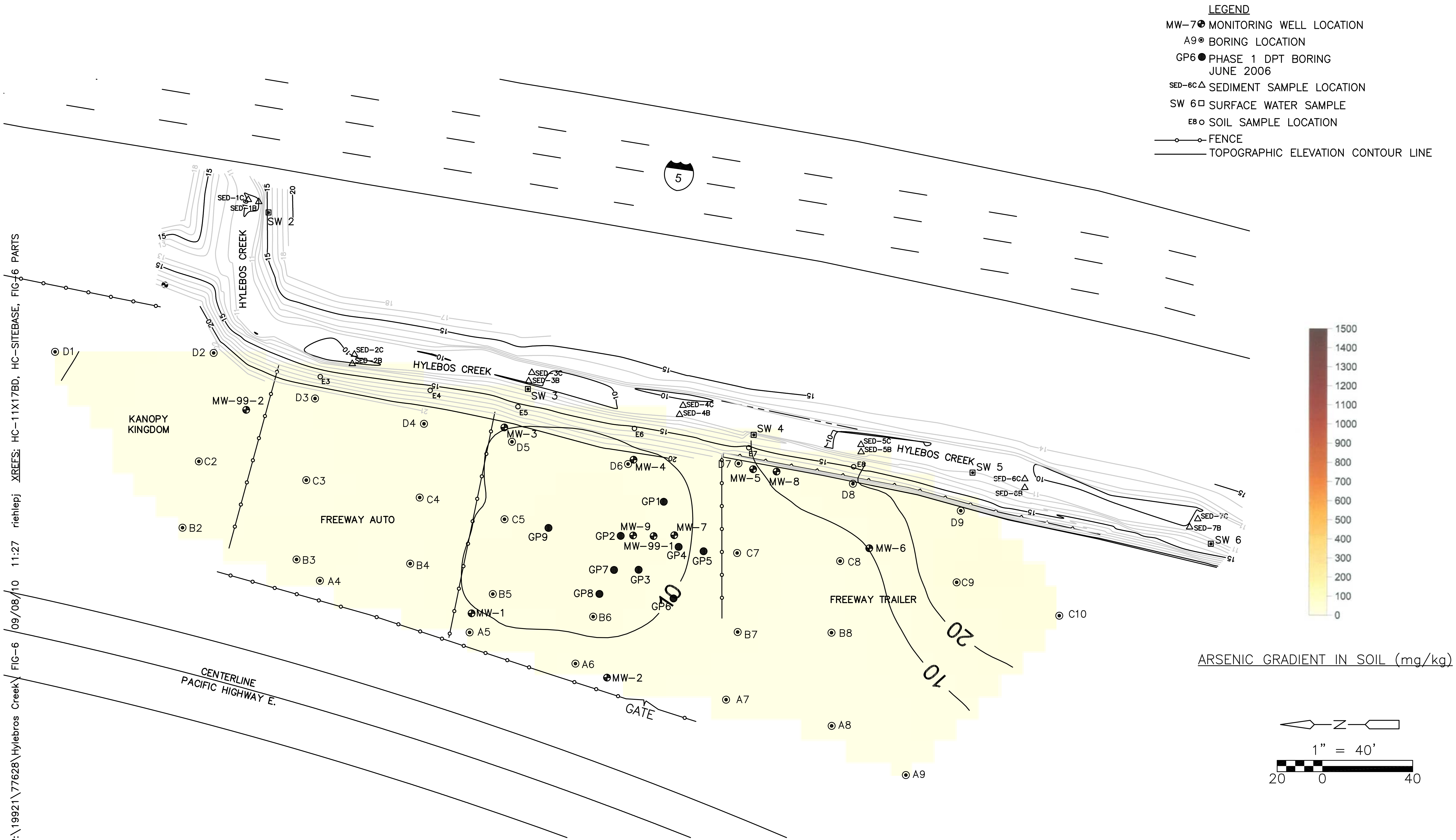

P:\19921\77628\Hylebros Creek\FIG-6 09/08/10 11:27 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-6 PARTS

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 6
Arsenic From 0-2 Feet bgs

CDM

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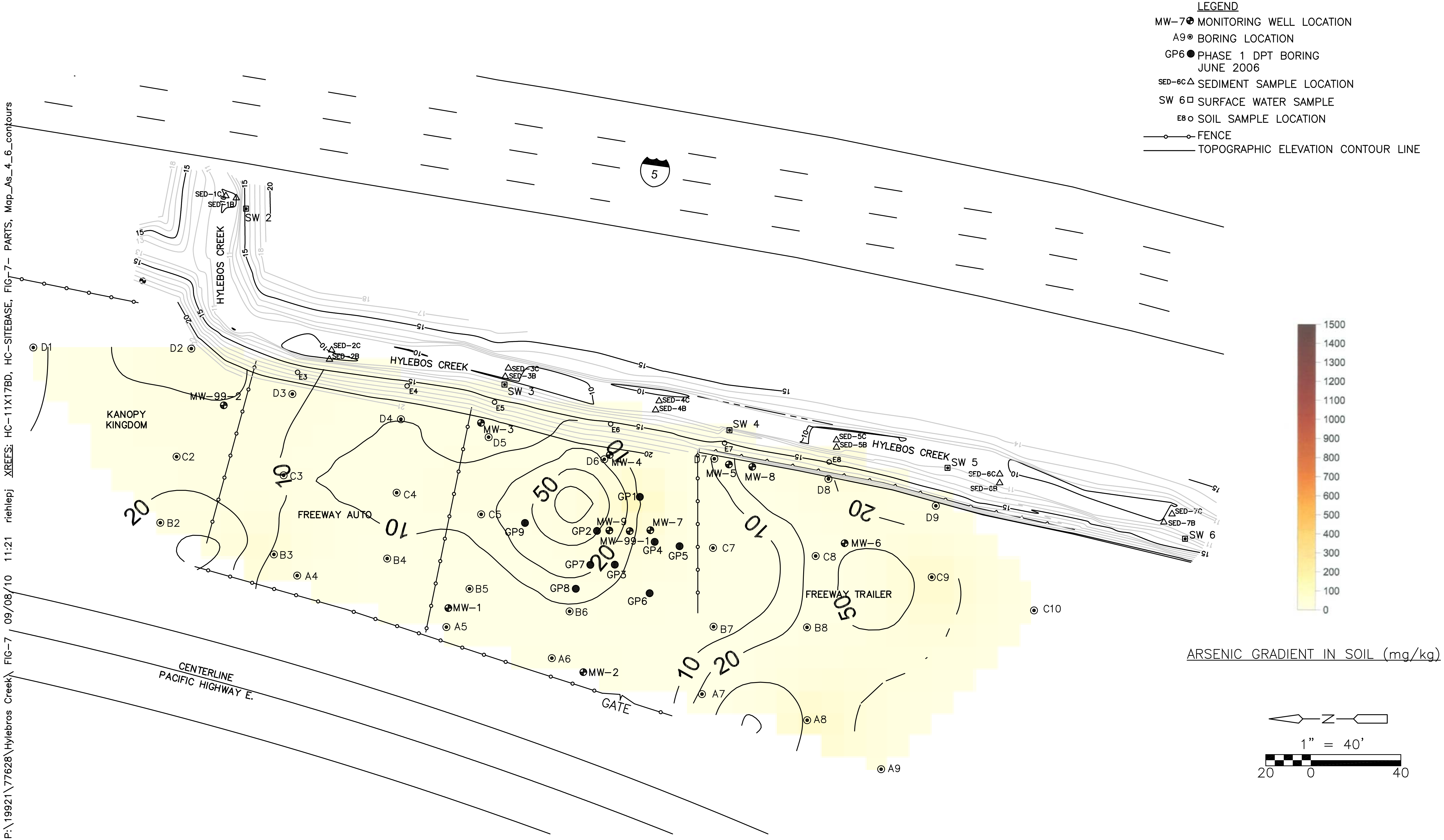

P:\19921\77628\Hylebros Creek\ FIG-7 09/08/10 11:21 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-7- PARTS, Map_As_4_6_contours

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 7
Arsenic From 4–6 Feet bgs

CDM

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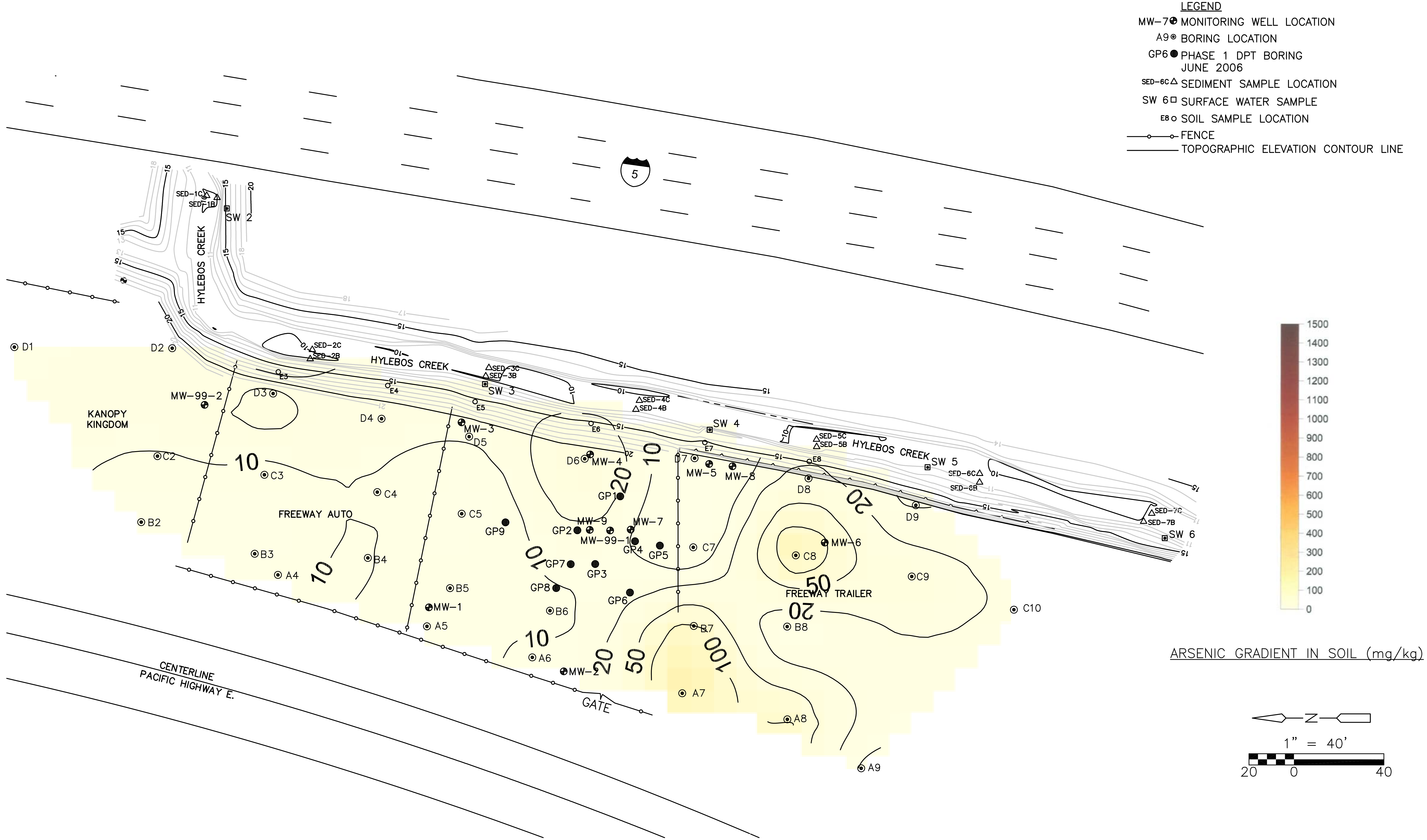

P:\19921\77628\Hylebros Creek\ FIG-8 09/08/10 11:17 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-8 PARTS

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

CDM

Figure No. 8
Arsenic From 6–8 Feet bgs

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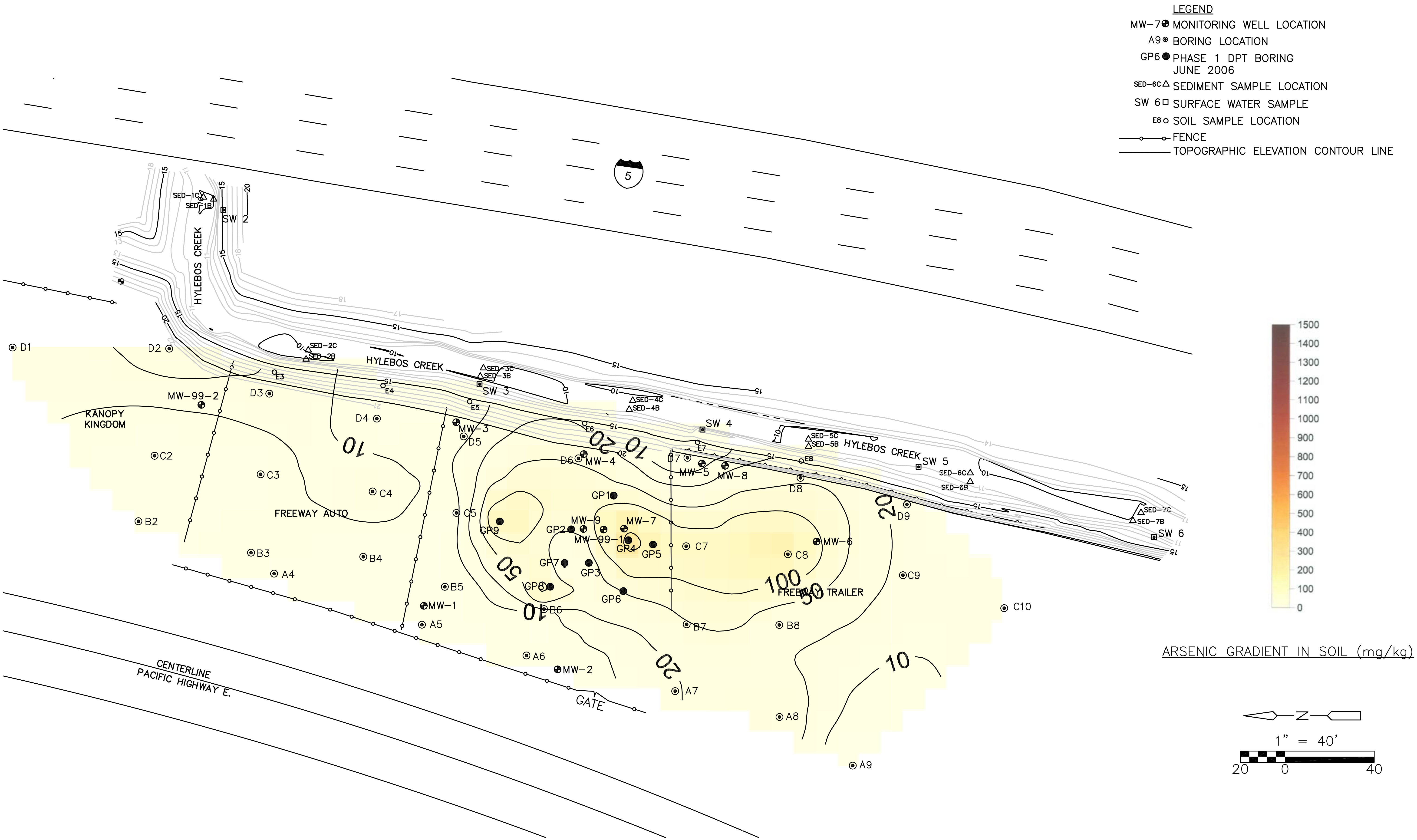

P:\19921\77628\Hylebros Creek\ FIG-9 09/08/10 10:56 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-9 PARTS

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 9
Arsenic From 8–10 Feet bgs

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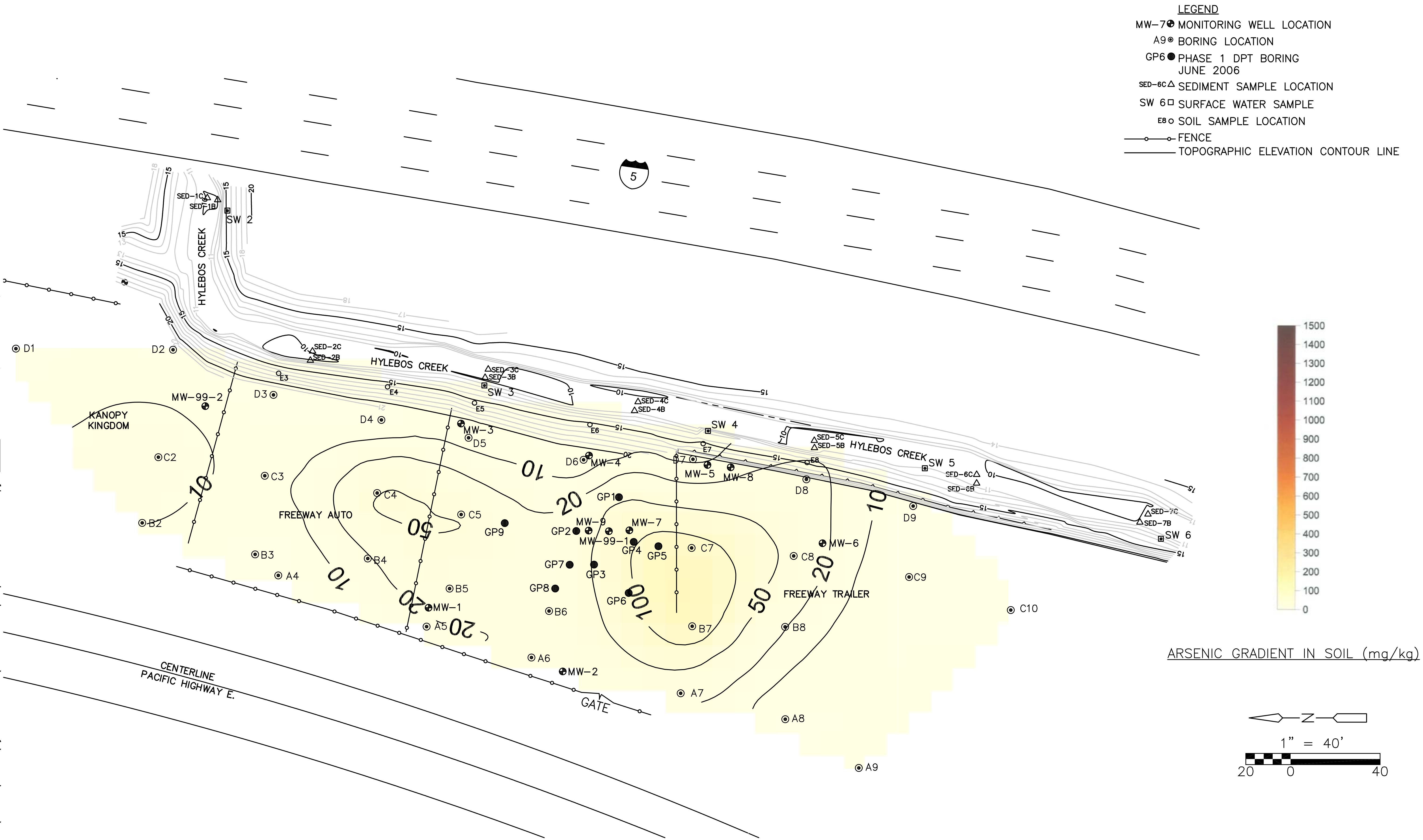

XREFS: HC-11X17BD, HC-SITEBASE, FIG-10 PARTS
P:\19921\77628\Hylebros Creek\ FIG-10 09/08/10 10:45 riehlepj

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 10
Arsenic From 10–12 Feet bgs

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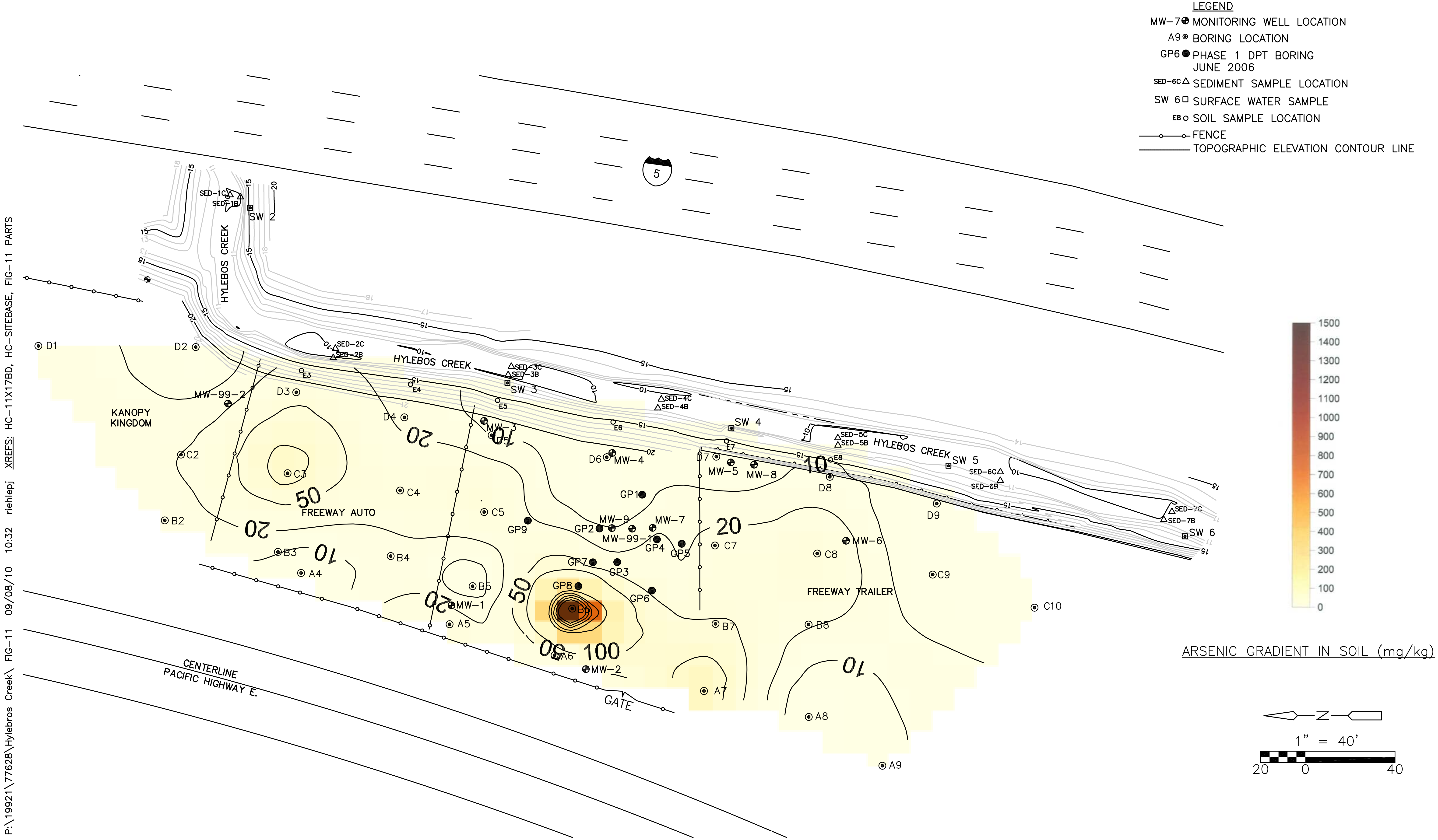

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 11
Arsenic From 12–14 Feet bgs

CDM

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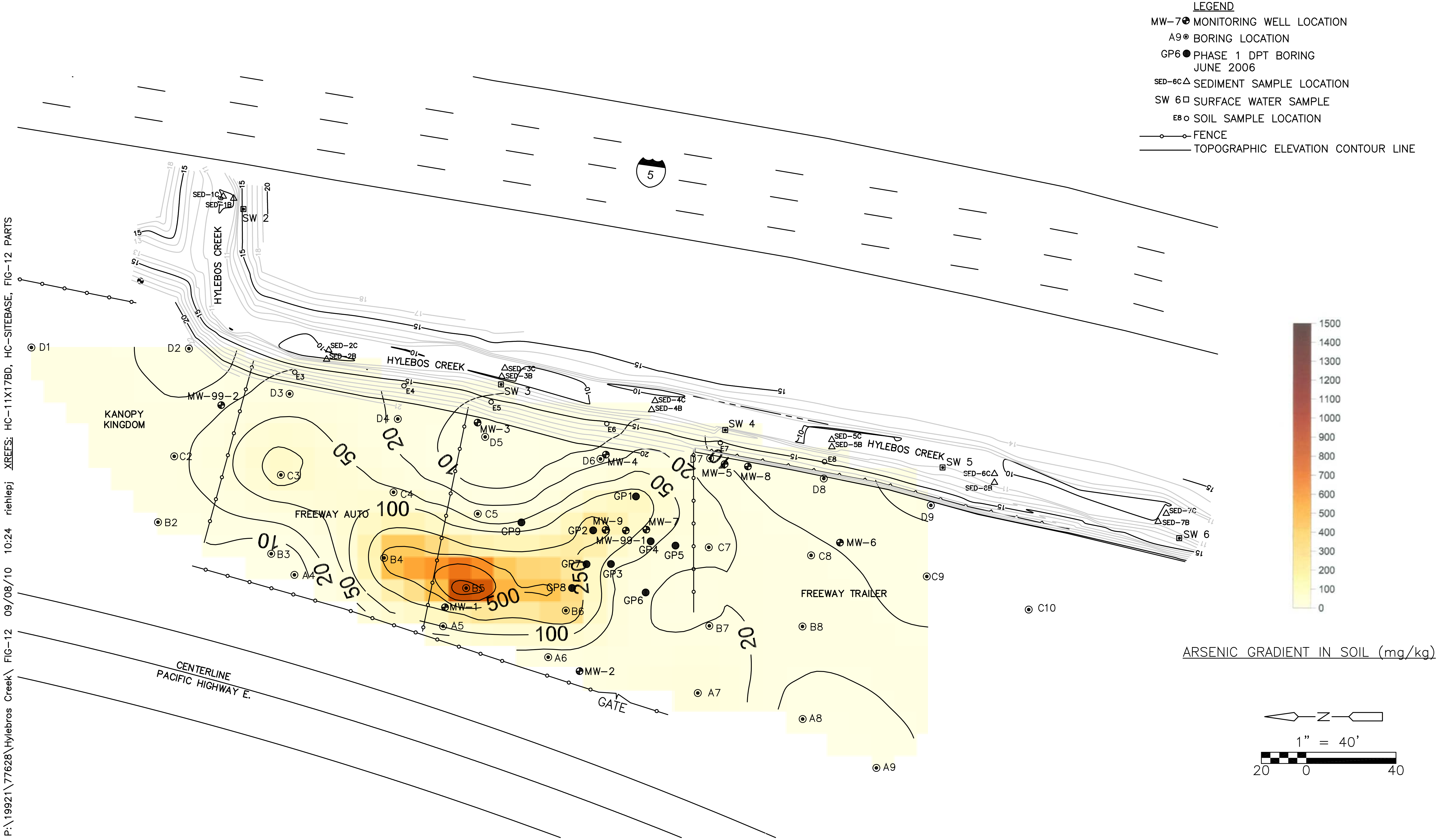

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 12
Arsenic From 14–16 Feet bgs

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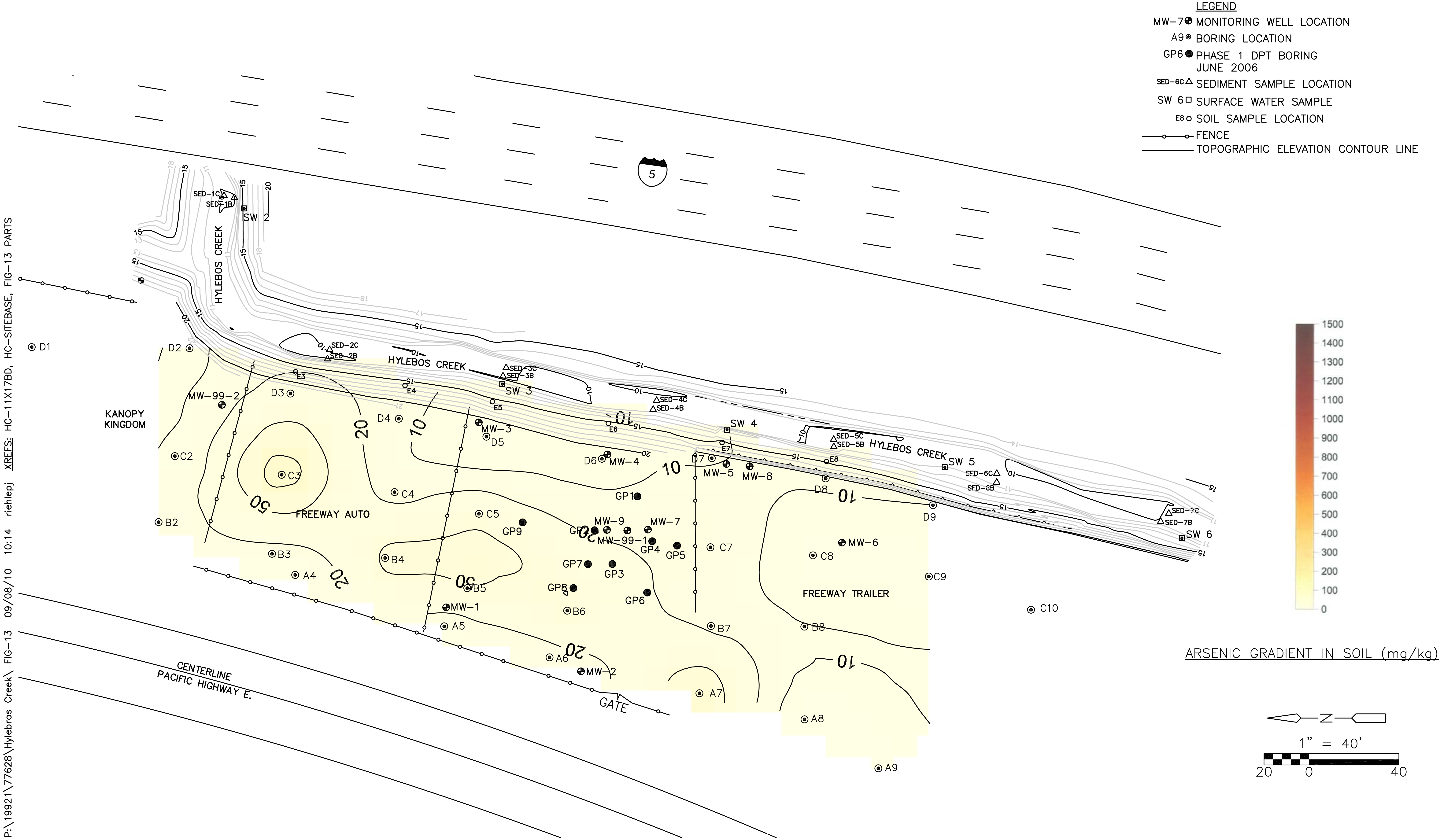

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 13
Arsenic From 16–18 Feet bgs

CDM

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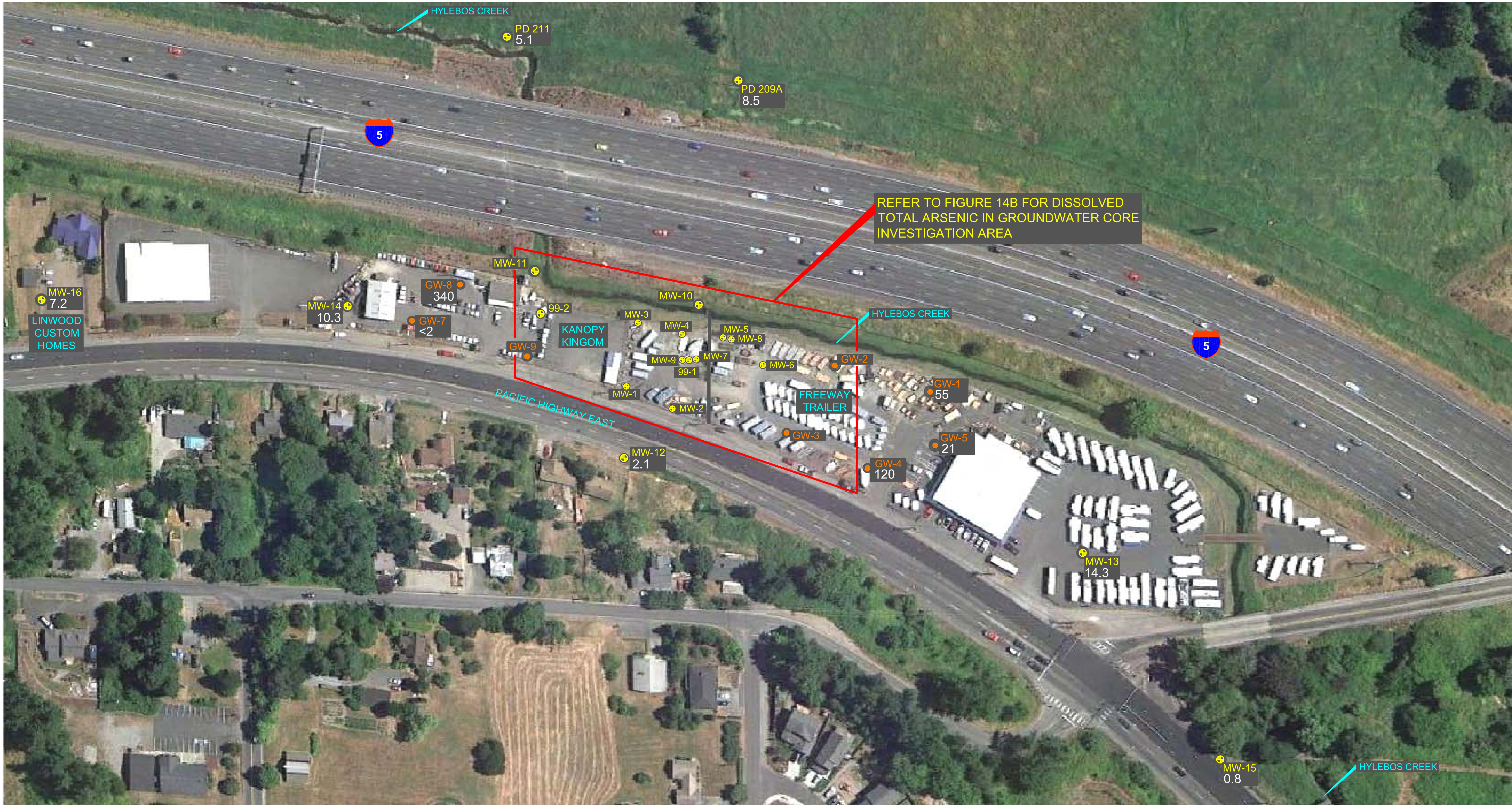

REFERENCE: GOOGLE EARTH PRO, 2012, IMAGE DATE AUGUST 20, 2011

LEGEND:

MW-12 2.1 — MONITORING WELL AND DISOLVED TOTAL ARSENIC CONCENTRATION (ug/L)

GW-1 55 — PHASE 2 DPT BORING AND DISOLVED TOTAL ARSENIC CENCENTRATION (ug/L)

NOTE:

MONITORING WELL MW-14 WAS DRILLED AT THE LOCATION OF GW-6

N

1" = 120'

60 0 120

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USG INTERIORS
HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 14A
Dissolved Total Arsenic in Groundwater

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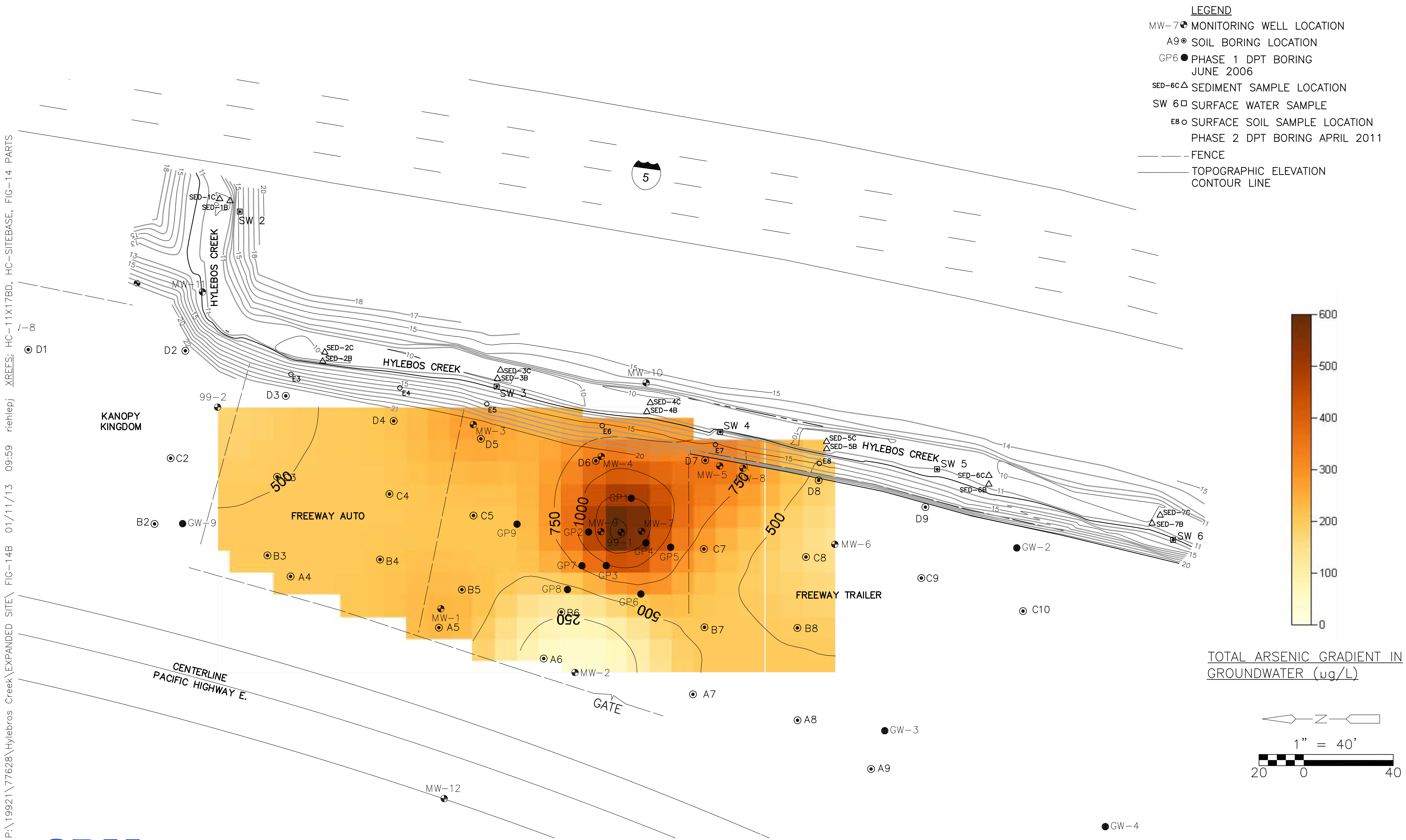

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USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 14B
Dissolved Total Arsenic in Groundwater

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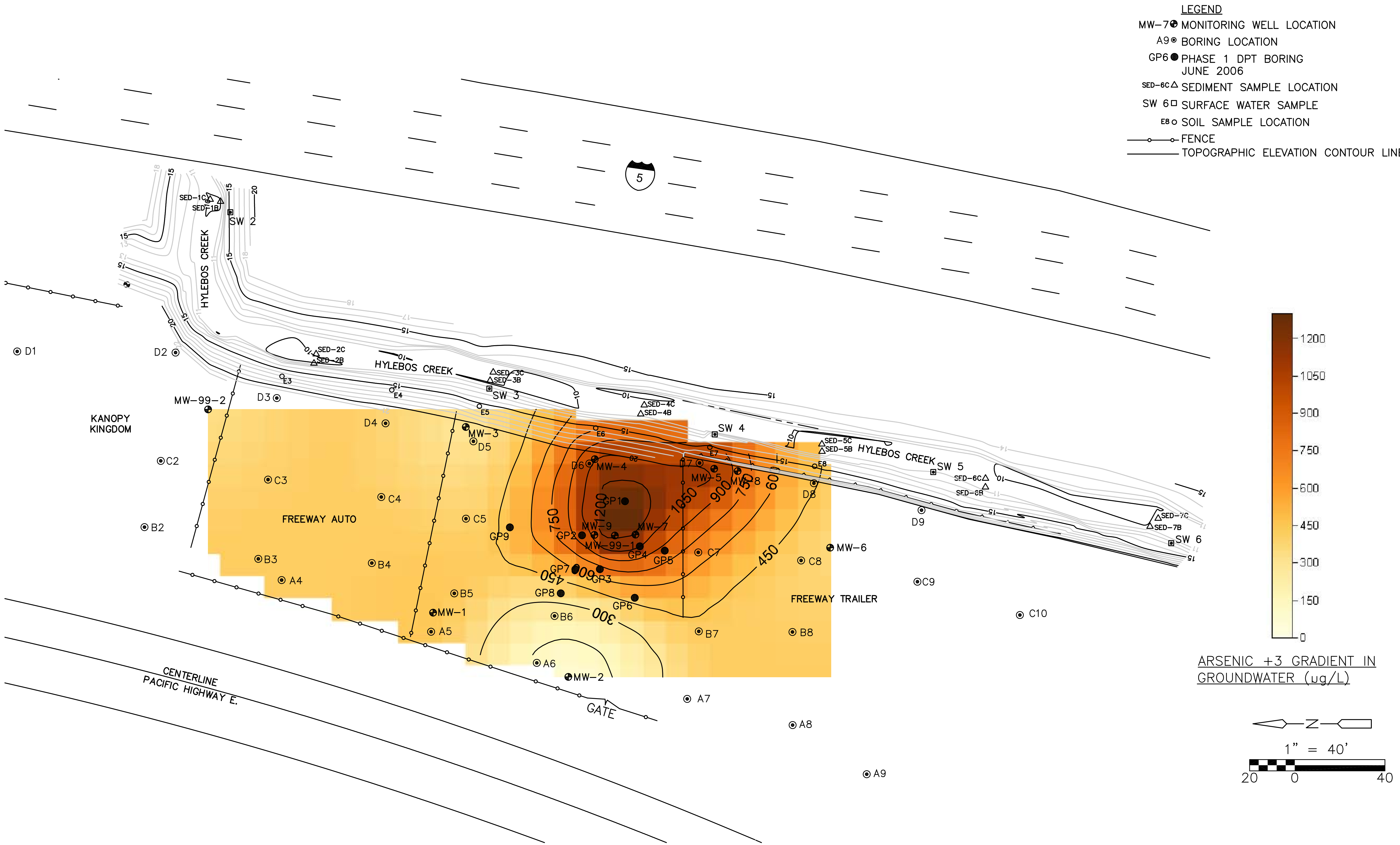

P:\19921\77628\Hylebros Creek\ FIG-15 09/08/10 09:54 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-15 PARTS

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 15
Arsenic +3 in Groundwater

CDM

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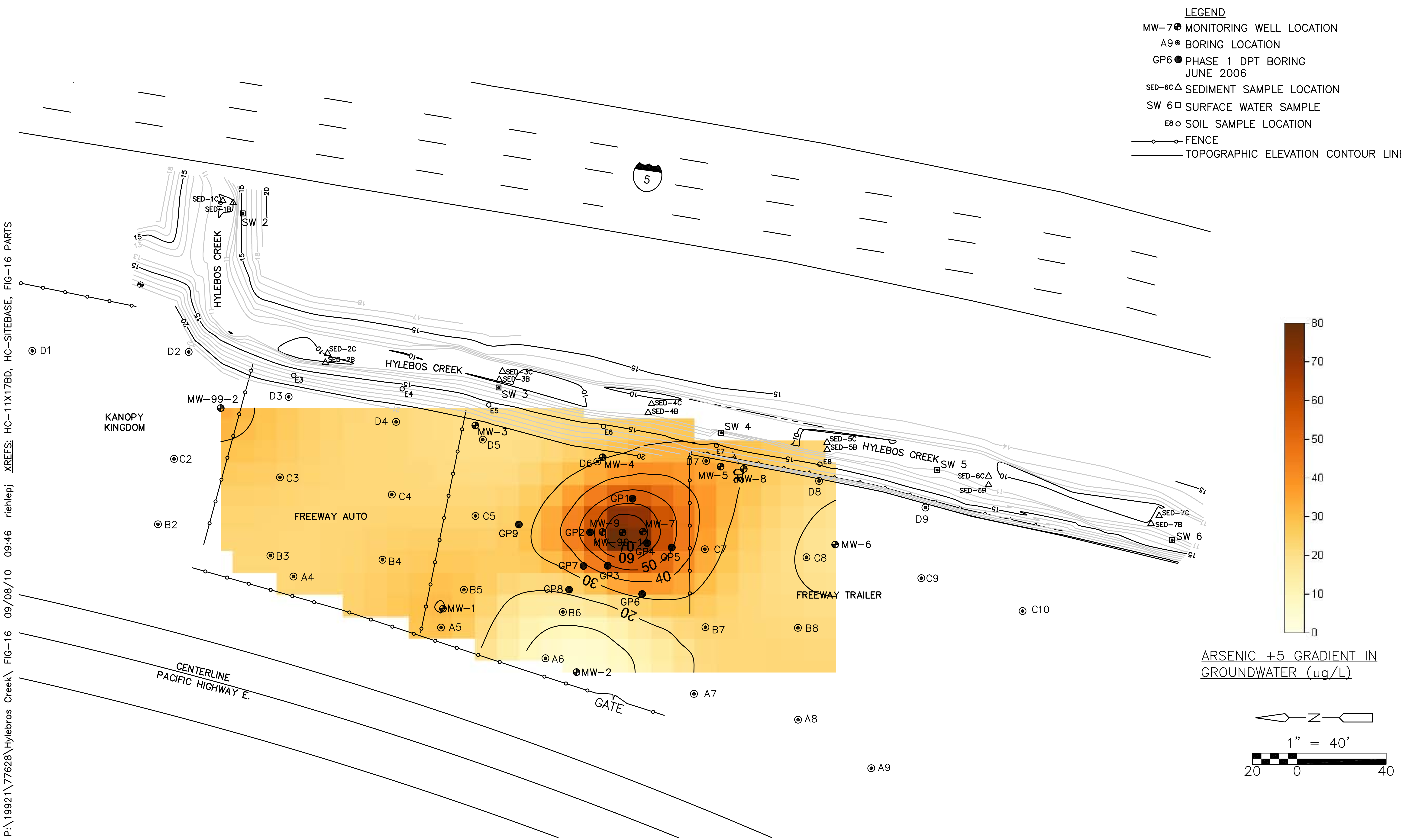

P:\19921\77628\Hylebros Creek\ FIG-16 09/08/10 09:46 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-16 PARTS

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 16
Arsenic +5 in Groundwater

CDM

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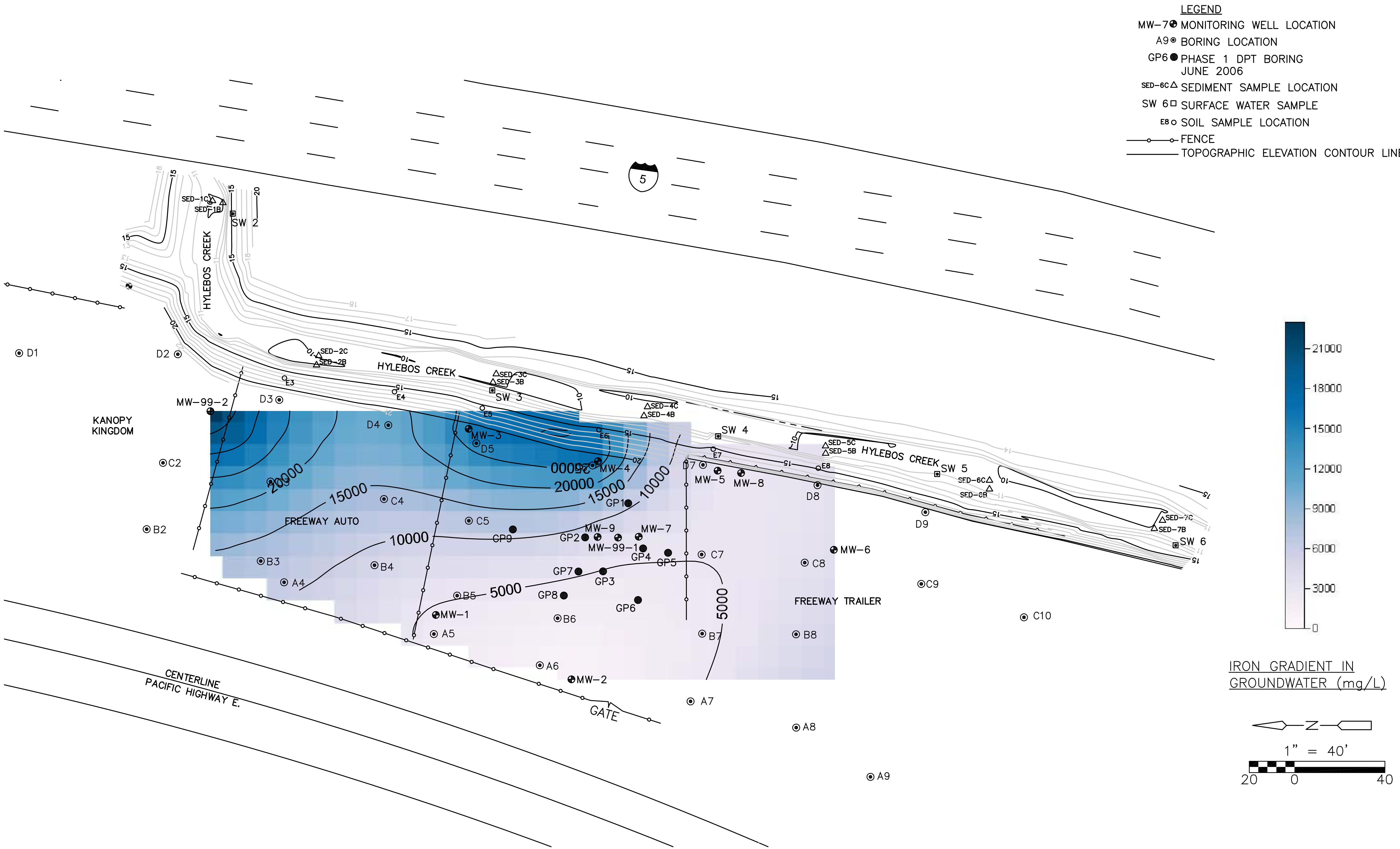

P:\19921\77628\Hylebros Creek\ FIG-17 09/08/10 09:35 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, FIG-17 PARTS

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 17
Dissolved Iron in Groundwater

CDM

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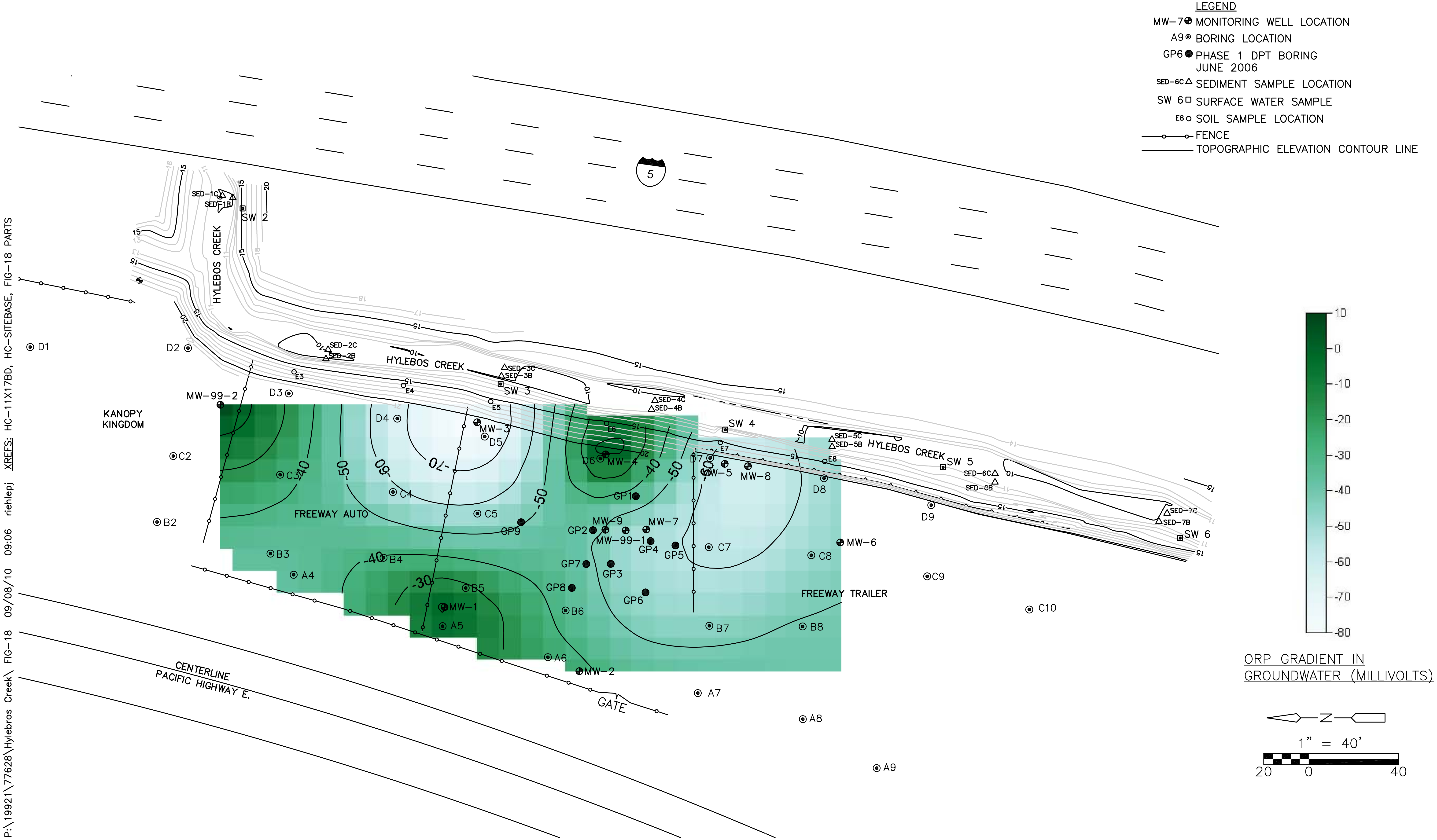

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 18
Oxidation Reduction Potential in Groundwater

CDM

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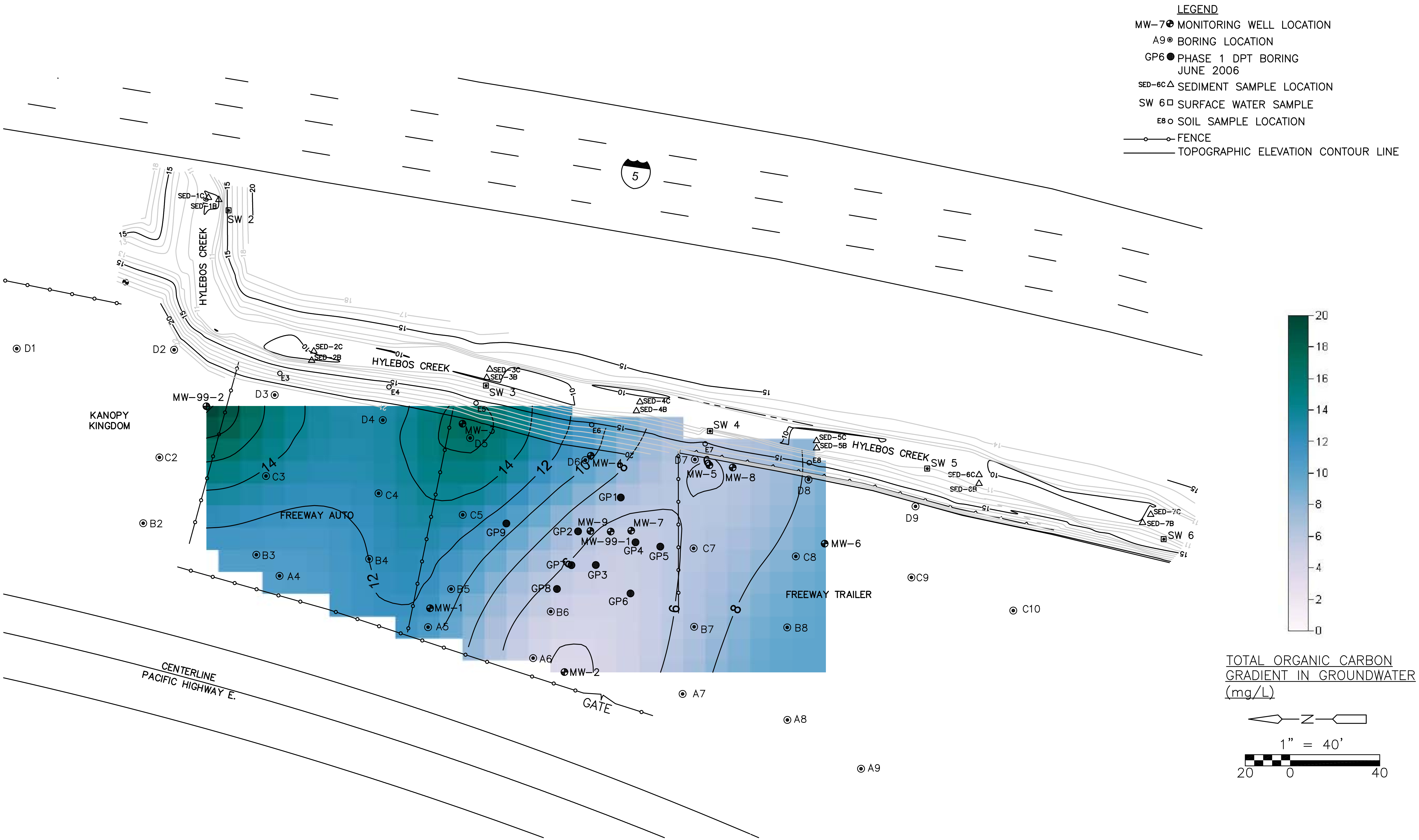

P:\19921\77628\Hylebros Creek\ FIG-19 09/08/10 11:29 riehlepj XREFS: HC-11X17BD, HC-SITEBASE, LAYOUT

USG INTERIORS/HIGHWAY 99 SITE
MILTON, WASHINGTON

Figure No. 19
Total Organic Carbon in Groundwater

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Appendix C

Alternative Design Assumptions and Cost Estimate

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Table C-1
Assumptions for Conceptual Design of Alternative 1
In-Situ Source Area Soil Stabilization, Introduction of Oxidation Compounds in Up-Gradient Trenches, Construction of an Engineered Permeable Cap, Treatment of Groundwater Hot Spot with Injection of Oxidation Compounds, Sediment Removal, Monitored Natural Attenuation, and Institutional Controls
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Component	Design Basis	
Focused Injection of Oxidation Compounds at Groundwater Hotspot		
Groundwater extraction well - casing construction (material):	PVC	
Groundwater extraction well - casing diameter (inches):	4	
Groundwater extraction well - depth (feet):	20	
Groundwater extraction well - quantity (number):	12	
Oxidation Compound Injection Trenches		
Length of trenches (feet):	260	
Bottom Depth of trench (feet) from surface:	24	
Top Depth of trench (feet) from surface:	6	
Thickness of trench (feet):	3	
Volume (bank cubic yards) of soild removed	520	
Volume (bank cubic yards) transported and disposed:		
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill	
Installation:	Trench	
Engineered Permeable Cap		
Excavation area (square feet)	57,600	
Excavation area (square yards)	6,400	
Excavation average depth (inches):	6	
Volume of shallow soil and other materials (bank cubic yards) excavated, transport/disposed:	1,067	
Volume of shallow soil and other materials (bank cubic yards) excavated, transport/disposed:	1,000	allowance
Weight of shallow soil and other materials (tons) excavated, transport/disposed:	1,000	allowance
Swell Factor of Shallow Soil	1.3 loose cubic yards to 1 bank cubic yard	
Density of Shallow Soil	1.5 tons soil to 1 loose cubic yard	
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill	
Area for Permeable Capping (square feet):	57,600	
Area for Permeable Capping (square yards):	6400	
Actual Area for Permeable Cap (percentage):	20	
Actual Area for Permeable Cap (square feet):	11520	
Volume of shallow soil and other materials (bank cubic yards) excavated, transport/disposed:	200	
Weight of shallow soil and other materials (tons) excavated, transport/disposed:	200	
Permeable Capping Thickness (inches):	3	
Permeable Capping Type:	pavers or pervious concrete	
Thickness of Base Material (inches):	3	
Type of Base Material (type):	3/4" minus crushed rock	
Swell Factor of Base Material:	1.15 loose cubic yards to 1 bank cubic yard	
Density of Base Material:	1.5 tons soil to 1 loose cubic yard	
Sediment Removal / Remediation		
Excavation length (feet):	12	
Excavation width (feet):	240	
Excavation area (square feet):	2880	
Excavation perimeter (feet):	504	
Excavation depth (feet):	3	
Volume (bank cubic yards) excavated, stockpiled, tested and disposed:	320	
Volume (bank cubic yards) transported and disposed - Non-Hazardous (100% of total disposed):	320	
Swell	1.2 loose cubic yards to 1 bank cubic yard	
Backfill conversion	1.45 tons earthen fill to 1 loose cubic yard	
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill	
Backfill Source	Off-Site	
Monitored Natural Attenuation		
Total Number of New Wells Installed:	10	
Total Number of Existing Wells (after construction):	6	
Average depth of new monitoring wells (feet):	25	
Analytes:	Dissolved metals	
Aquifer Sampling Frequency:	Semi-annual for first 5 years; annual thereafter	
Monitoring Duration:	30 years	
Institutional Controls	Restrictive covenants	
Impacted Soil Delineation, Bench-Scale and Pilot Tests, etc.		
Cost for Impacted Soil Delineation Investigation:	$60,000	
Cost for Oxidation Compound Demand Bench-Scale Study:	$60,000	
Cost for Oxidation Compound Demand Field Pilot Test:	$60,000	
Cost for Cleanup Action Plan	$40,000	
Total:	$220,000	

Notes:
1. Extent of plume above cleanup levels is not fully defined. Assumptions have been made to delineate the extent of the contaminating exceeding site

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Table C-2
Assumptions for Conceptual Design of Alternative 2
In-Situ Source Area Soil Solidification, Introduction of Oxidation Compounds in Up-Gradient Trenches, Construction of an Engineered Permeable Cap, Treatment of Groundwater Hot Spot with Injection of Oxidation Compounds, Sediment Removal, Monitored Natural Attenuation, and Institutional Controls
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Component	Design Basis
In-Situ Solidification of Soil > 500 mg/kg	
Treatment area length (feet):	125
Treatment area width (feet):	35
Treatment Area (square feet):	4,375
Mnimum treatment depth (feet):	12
Maximum treatment depth (feet):	16
Soil Volume (cubic yards):	427
Safety Factor:	25%
Design Soil Volume (cubic yards):	534
Source soil arsenic concentration (ppm):	>500
Cement mix (%):	10%
Short-term (Construction Dewatering) Water Treatment	
Groundwater extraction well - casing construction (material):	PVC
Groundwater extraction well - casing diameter (inches):	4
Groundwater extraction well - depth (feet):	20
Groundwater extraction well - quantity (number):	2
Average total extracted groundwater flow rate (gpm):	20
Maximum arsenic concentration (ug/L):	2,490
Average arsenic concentration (ug/L):	400
Discharge destination	City of Tacoma - Sanitary Sewer Collection System
Discharge requirement, arsenic (ug/L):	100
Average removal efficiency (%)	75%
# of days operating (number of days required to remove soil below water table)	30
Total extracted groundwater flow volume (gallons):	864,000
Focused Injection of Oxidation Compounds at Groundwater Hotspot	
Groundwater extraction well - casing construction (material):	PVC
Groundwater extraction well - casing diameter (inches):	4
Groundwater extraction well - depth (feet):	20
Groundwater extraction well - quantity (number):	12
Oxidation Compound Injection Trenches	
Length of trenches (feet):	260
Bottom Depth of trench (feet) from surface:	24
Top Depth of trench (feet) from surface:	6
Thickness of trench (feet):	3
Volume (bank cubic yards) of soild removed and disposed	520
Volume (bank cubic yards) transported and disposed:	
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill
Installation:	Trench
Media:	Zero-Valent Iron
Oxidation Compound Injection Trenches	
Oxygen Releasing Compound (ORC)	415 foot trench
ORC Application Rate	0.21 lb / cubic ft of soil in trench
Saturated thickness requiring ORC	10 feet
Engineered Permeable Cap	
Excavation area (square feet)	57,600
Excavation area (square yards)	6,400
Excavation average depth (inches):	6
Volume of shallow soil (bank cubic yards) excavated, transported and disposed:	1,067
Swell Factor of Shallow Soil	1.3 loose cubic yards to 1 bank cubic yard
Density of Shallow Soil	1.5 tons soil to 1 loose cubic yard
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill
Area for Permeable Capping (square feet):	57,600
Area to Permeable Capping (square yards):	6400
Permeable Capping Thickness (inches):	
Permeable Capping Type:	
Thickness of Base Material (inches):	x
Type of Base Material (type):	x
Swell Factor of Base Material:	1.15 loose cubic yards to 1 bank cubic yard
Density of Base Material:	1.5 tons soil to 1 loose cubic yard
Sediment Removal / Remediation	
Excavation length (feet):	12
Excavation width (feet):	240
Excavation area (square feet):	2880
Excavation perimeter (feet):	504
Excavation depth (feet):	3
Volume (bank cubic yards) excavated, stockpiled, tested and disposed:	320
Volume (bank cubic yards) transported and disposed - Non-Hazardous (100% of total disposed):	320
Swell	1.2 loose cubic yards to 1 bank cubic yard
Backfill conversion	1.45 tons earthen fill to 1 loose cubic yard
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill
Backfill Source	Off-Site
Monitored Natural Attenuation	
Total Number of New Wells Installed:	10
Total Number of Existing Wells (after construction):	6
Average depth of new monitoring wells (feet):	25
Analytes:	Dissolved metals
Aquifer Sampling Frequency:	Semi-annual for first 5 years; annual thereafter
Monitoring Duration:	30 years
Institutional Controls	Restrictive covenants
Impacted Soil Delineation, Bench-Scale and Pilot Tests, etc.	
Cost for Impacted Soil Delineation Investigation:	$60,000
Cost for Soil Stabilization Bench-Scale Treatability Study:	$40,000
Cost for Oxidation Compound Demand Bench-Scale Study:	$60,000
Cost for Oxidation Compound Demand Field Pilot Test:	$60,000
Cost for Cleanup Action Plan	$40,000
Total:	$260,000

Notes:
1. Extent of plume above cleanup levels is not fully defined. Assumptions have been made to delineate the extent of the contaminating exceeding site cleanup levels.

Table C-3
Assumptions for Conceptual Design of Alternative 3
In-Situ Source Area Soil Stabilization, Short-Term Groundwater Extraction at Hot Spot, Groundwater Treatment with Oxidation Compounds, Slurry Walls, Permeable Reactive Barrier, Permeable Cap, Sediment Removal, Monitored Natural Attenuation, and Institutional Controls
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Component	Design Basis
In-Situ Solidification of Soil > 500 mg/kg with Construction De-Watering	Same as Alt. 2
Slurry Wall	
Slurry Wall Length (linear feet):	300
Slurry Wall Maximum Depth (feet):	35
Slurry Wall Minimum Depth (feet):	6
Slurry Wall Area (square feet):	8,700
Short-Term Pump and Treat (1 year)	
Groundwater extraction well - casing construction (material):	PVC
Groundwater extraction well - casing diameter (inches):	4
Groundwater extraction well - depth (feet):	20
Groundwater extraction well - quantity (number):	1
Average total extracted groundwater flow rate (gpm):	10
Maximum arsenic concentration (ug/L):	2,490
Average arsenic concentration (ug/L):	400
Discharge destination	City of Tacoma - Sanitary Sewer Collection System
Discharge requirement, arsenic (ug/L):	100
Average removal efficiency (%)	75%
# of days operating (days)	365
Impacted Soil Delineation, Bench-Scale and Pilot Tests, etc.	
Cost for Impacted Soil Delineation Investigation:	$60,000
Cost for Soil Stabilization Bench-Scale Treatability Study:	$40,000
Cost for Oxidation Compound Demand Bench-Scale Study:	$60,000
Cost for Oxidation Compound Demand Field Pilot Test:	$60,000
Cost for Cleanup Action Plan	$40,000
Total:	$260,000
Permeable Reactive Barrier	
Length of PRB (feet):	140
Bottom Depth of PRB (feet) from surface:	35
Top Depth of PRB (feet) from surface:	6
Thickness of PRB (feet):	3
Volume (bank cubic yards) of PRB media	451
Volume (bank cubic yards) transported and disposed:	451
Volume (bank cubic yards) of fill to be emplaced above PRB media	93
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill
Installation:	Trench
Media:	Zero-Valent Iron
Sediment Removal, Engineered Permeable Cap, Monitored Natural Attenuation, Institutional Controls	Same as Alt. 1

Table C-4
Assumption for Conceptual Design of Alternative 4
Soil Removal to 20 mg/kg, Engineered Permeable Cap, Sediment Removal, MNA and Institutional Controls
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Component	Design Basis
Soil Removal to 20 mg/kg	
Excavation Area (square feet):	46,800
Excavation Perimeter (linear feet):	980
Volume (bank cubic yards) excavated, stockpiled, and tested:	24,209
Volume (bank cubic yards) transported and disposed:	20,742
Volume (bank cubic yards) transported and disposed - Non-Hazardous (95% of total disposed):	19,705
Volume (bank cubic yards) transported and disposed - Hazardous (5% of total disposal):	1,037
Volume (bank cubic yards) re-used as backfill:	3,467
Non-hazardous soil arsenic concentration (ppm):	Less than 500, greater than 20
Hazardous soil arsenic concentration (ppm):	Greater than 500
Excavation average depth (feet):	20
Average depth to groundwater (feet):	12
Shoring (sheet pile) length (feet):	800
Shoring (sheet pile or other) depth (feet):	40
Disposal Site (non-hazardous):	Waste Management - Columbia Ridge, Subtitle D Landfill
Disposal Site (hazardous):	Waste Management - Columbia Ridge, Subtitle C Landfill
Imported (off-site) backfill (bank cubic yards) - above groundwater:	12,445
Shrinkage	1.3 loose cubic yards to 1 bank cubic yard
Backfill conversion	1.45 tons earthen fill to 1 loose cubic yard
Imported (off-site) backfill (bank cubic yards) - below groundwater, quarry spalls:	8,297
Shrinkage - Quarry Spalls	1.15 loose cubic yards to 1 bank cubic yard
Backfill conversion - Quarry Spalls	1.35 tons rocky fill to 1 loose cubic yard
On-site backfill (cubic yards):	3,467
Number of wells to be abandoned:	12
Average depth of wells to be abandoned:	36
Short-term (Construction Dewatering) Water Treatment	
Groundwater extraction well - casing construction (material):	PVC
Groundwater extraction well - casing diameter (inches):	4
Groundwater extraction well - depth (feet):	20
Groundwater extraction well - quantity (number):	12
Average total extracted groundwater flow rate (gpm):	100
Maximum arsenic concentration (ug/L):	2,490
Average arsenic concentration (ug/L):	400
Discharge destination	City of Tacoma - Sanitary Sewer Collection System
Discharge requirement, arsenic (ug/L):	100
Average removal efficiency (%)	75%
# of days operating (number of days required to remove soil below water table)	90
Impacted Soil Delineation, Bench-Scale and Pilot Tests, etc.	
Cost for Impacted Soil Delineation Investigation:	$40,000
Cost for Cleanup Action Plan	$40,000
Total:	$80,000
Sediment Removal, Engineered Permeable Cap, Monitored Natural Attenuation, Institutional Controls	Same as Alt. 1

Notes:
1. Extent of plume above cleanup levels is not fully defined. Assumptions have been made to delineate the extent of the contaminating exceeding site cleanup levels.
2. Imported backfill for below the groundwater table is quarry spalls from an iron-rich rock.
3. Excavation cannot extend to edge of Puyallup River due to geotechnical stability concerns.

Table C-5
Cost Estimate for Alternative 1
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Engineered Permeable Cap					
Capital Cost					
Direct					
Excavation - misc pavement, soil, etc.	200	bcy	$ 24.00	$ 4,800	allowance
Transport/Disposal of misc pavement, soil, etc.	200	tons	$ 52.00	$ 10,400	allowance
Stormwater controls	1	ls	$ 10,000.00	$ 10,000	allowance
Crushed rock base installed	11,520	sf	$ 1.04	$ 11,985	
Permeable pavement/pavers installed	11,520	sf	$ 1.30	$ 14,976	
			Subtotal =	$ 52,161	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 5,216	
General Conditions (@10%)				$ 5,216	
Other (@10%)				$ 5,216	
				$ 15,648	
			Subtotal =	$ 67,810	
Construction Contingency (@25%)				$ 16,952	
Contractor Fee (@15%)				$ 10,171	
Escalation (@2%)				$ 1,356	
				$ 28,480	
			Subtotal =	$ 96,290	
Indirect-Other					
Engineering (10% of total cost)				$ 9,629	
Project Management (12% of total cost)				$ 11,555	
Sales Tax (8.6% of half capital cots)				$ 4,140	
				$ 25,324	
			Subtotal =	$ 121,614	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Short-Term Injection of Oxidation Compounds at Soil and Groundwater Hot Spots					
Capital Cost					
Direct					
Groundwater Extraction Well	33	each	3,000	$ 99,000	
Miscellaneous Equipment	1	each	5,000	$ 5,000	allowance
Injection - materials	4	injections	14,000	$ 56,000	allowance
Injection - labor	4	injections	8,000	$ 32,000	allowance
			Subtotal =	$ 192,000	
Indirect-Contractor					
OH&P of Subcontractors (@5%)				$ 9,600	
General Conditions (@5%)				$ 9,600	
Other (@10%)				$ 19,200	
				$ 38,400	
			Subtotal =	$ 230,400	
Construction Contingency (@25%)				$ 57,600	
Contractor Fee (@5%)				$ 11,520	
Escalation (@2%)				$ 4,608	
				$ 73,728	
			Subtotal =	$ 304,128	
Indirect-Other					
Engineering (15% of total cost)				$ 45,619	
Project Management (12% of total cost)				$ 36,495	
Sales Tax (8.6% of half capital cots)				$ 8,256	
				$ 90,371	
			Subtotal =	$ 394,499	

Table C-5
Cost Estimate for Alternative 1
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Oxidation Compound Trenches					
Capital Cost					
Direct					
Excavate Trench Soil	520	bcy	$ 8.56	$ 4,451	
Transportation and Disposal of Contaminated Soils	520	bcy	$ 110.00	$ 57,200	
Trench Pipe with pipe zone backfill - Installed	260	lf	$ 40	$ 10,400	
Place and Compact Backfill on Top of Trench Drain Pip	1,183	tons	$ 3.31	$ 3,916	
Analytical Testing - Disposal (832 ton, 1.6:1)	3	samples	$ 255	$ 765	1 TCLP / Total per 400 ton
			Subtotal =	$ 76,732	
Indirect-Contractor					
OH&P of Subcontractors (@15%)				$ 11,510	
General Conditions (@10%)				$ 7,673	
Other (@10%)				$ 7,673	
				$ 26,856	
			Subtotal =	$ 103,588	
Construction Contingency (@25%)				$ 25,897	
Contractor Fee (@15%)				$ 15,538	
Escalation (@2%)				$ 2,072	
				$ 43,507	
			Subtotal =	$ 147,095	
Indirect-Other					
Engineering (15% of total cost)				$ 22,064	
Project Management (12% of total cost)				$ 17,651	
Sales Tax (8.6% of half capital cots)				$ 6,325	
				$ 46,041	
			Subtotal =	$ 193,136	
Operations, Maintenance, and Monitoring Cost					
Years 1 - 5	5	ls	$ 50,000	$ 250,000	
Years 6 - 10	5	ls	$ 25,000	$ 125,000	
Indirect Costs					
			Total =	$ 799,478	
Later Phase Sediment Removal to 20 mg/kg Cleanup Level					
Capital Costs					
Direct					
Clearing and Grubbing Excavation Area	0.07	acres	$ 9,500	$ 628	
Excavation - Contaminated Sediment	320	bcy	$ 24.00	$ 7,680	
Transportation and Disposal of Non-Hazardous Sedime	691	tons	$ 52.00	$ 35,942	<20 mg/kg assumed Non-Hazardous
Imported Backfill Material	576	tons	$ 27.00	$ 15,552	1.5 tons : 1.2 lcy : 1 bcy
Place Backfill	576	tons	$ 6.00	$ 3,456	1.5 tons : 1.2 lcy : 1 bcy
Analytical Testing - Perimeter (504 lf)	11	samples	$ 85	$ 935	1 per 50 perimeter feet
Analytical Testing - Bottom (2,880 sf)	2	samples	$ 85	$ 170	1 per 2500 sf
Analytical Testing - Disposal (576 ton, 1.6:1)	2	samples	$ 255	$ 510	1 TCLP / Total per 400 ton
Creek Diversion	360	lf	$ 200	$ 72,000	
			Subtotal =	$ 136,873	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 13,687	
General Conditions (@10%)				$ 13,687	
Other (@10%)				$ 5,475	
				$ 32,850	
			Subtotal =	$ 169,723	
Construction Contingency (@25%)				$ 42,431	
Contractor Fee (@15%)				$ 25,458	
Escalation (@2%)				$ 3,394	
				$ 71,284	
			Subtotal =	$ 241,007	
Indirect-Other					
Engineering (15% of total cost)				$ 36,151	
Project Management (12% of total cost)				$ 28,921	
Sales Tax (8.6% of capital cost)				$ 20,727	
				$ 85,798	
			Subtotal =	$ 326,805	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no
Operating and Maintenance Costs		ls	$ -	$ -	maintenance
Indirect					
Project Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
			Total =	$ -	

Table C-5
Cost Estimate for Alternative 1
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Monitored Natural Attenuation					
Capital Cost					
Direct					
Install Monitoring Wells	10	wells	$ 1,361	$ 13,608	
Sampling / Field Staff	2	ls	$ 1,400	$ 2,800	14 hours @ $100 /hour: 2 times
Sample Analysis	32	samples	$ 100	$ 3,200	16 wells: 2 times per year
Instrumentation / Equipment	2	ls	$ 500	$ 1,000	
Vehicle	2	ls	$ 135	$ 270	
Expendable Suppies	2	ls	$ 250	$ 500	
Reporting	2	ls	$ 8,000	$ 16,000	
			Subtotal =	$ 37,378	
Indirect					
Engineering (15% of total cost)				$ 5,607	
Project Management (12% of total cost)				$ 4,485	
Sales Tax (8.6% of half capital cots)				$ 1,607	
			Subtotal =	$ 11,699	
			Total =	$ 49,077	
			Total with 15% Contingency =	$ 56,439	
Operations, Maintenance, and Monitoring Cost					
Monitoring and Sampling Events					
Years 1 - 5 (two sampling events per year)	5	ls	$ 40,790	$ 203,948	
Years 6 - 30 (one sampling event per year)	25	ls	$ 20,395	$ 509,871	
Indirect Costs					
Project Management	12	% of total		$ 85,658	
			Total =	$ 799,478	
Institutional Controls					
Capital Cost					
Direct					
Establish Restrictive Covenants and Conditional Point of Compliance	1	ls	$ 25,000	$ 25,000	
			Subtotal =	$ 25,000	
Indirect					
Engineering (15% of total cost)				$ 3,750	
Project Management (12% of total cost)				$ 3,000	
Sales Tax (8.6% of half capital cots)				$ 1,075	
			Subtotal =	$ 7,825	
			Total =	$ 32,825	
			Total with 15% Contingency =	$ 37,749	
Operations, Maintenance, and Monitoring Cost					
Inspection and Maintenance of Restrictive Covenants	1	ls	$ 10,000	$ 10,000	
			Total =	$ 10,000	Includes PM, Contingency

Table C-6
Cost Estimate for Alternative 2
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Source Soil Treatment - In-Situ Soil Solidification of Soil > 500 mg/kg					
Capital Cost					
Direct					
Surface Prep - Ramp Installation	1	ls	$ 10,000	$ 10,000	
Mix Design	1	ls	$ 15,000	$ 15,000	
Mobilization of Mixing Machine	1	ls	$ 75,000	$ 75,000	
Disposal allowance (30% of soil mixing volume)	302	bcy	$ 52.00	$ 15,695	
Construction Dewatering Wells	4	each	$ 2,000.00	$ 8,000	
Water Treatment System	1	each	$ 10,000.00	$ 10,000	
Water Treatment - Media	864,000	gallons	$ 0.007	$ 6,048	allowance
Discharge Fees	864,000	gallons	$ 0.007	$ 6,048	under City of Tacoma - industrial permit
Analytical Testing - Discharge Water	44	samples	$ 200	$ 8,800	1 per 20,000 gallons - Rushed Sample
Soil Mixing	534	bcy	$ 40	$ 21,350	
			Subtotal =	$ 175,941	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 17,594	
General Conditions (@10%)				$ 17,594	
Other (@10%)				$ 17,594	
				$ 52,782	
			Subtotal =	$ 228,724	
Construction Contingency (@25%)				$ 57,181	
Contractor Fee (@15%)				$ 34,309	
Escalation (@2%)				$ 4,574	
				$ 96,064	
			Subtotal =	$ 324,788	
Indirect-Other					
Engineering (15% of total cost)				$ 48,718	
Project Management (12% of total cost)				$ 38,975	
Sales Tax (8.6% of half capital cots)				$ 13,966	
				$ 101,659	
			Subtotal =	$ 426,447	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Engineered Permeable Cap					
Capital Cost					
Direct					
Excavation - misc pavement, soil, etc.	200	bcy	$ 24.00	$ 4,800	allowance
Transport/Disposal of misc pavement, soil, etc.	200	tons	$ 52.00	$ 10,400	allowance
Stormwater controls	1	ls	$ 10,000.00	$ 10,000	allowance
Crushed rock base installed	11,520	sf	$ 1.04	$ 11,985	
Permeable pavement/pavers installed	11,520	sf	$ 1.30	$ 14,976	
			Subtotal =	$ 52,161	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 5,216	
General Conditions (@10%)				$ 5,216	
Other (@10%)				$ 5,216	
				$ 15,648	
			Subtotal =	$ 67,810	
Construction Contingency (@25%)				$ 16,952	
Contractor Fee (@15%)				$ 10,171	
Escalation (@2%)				$ 1,356	
				$ 28,480	
			Subtotal =	$ 96,290	
Indirect-Other					
Engineering (10% of total cost)				$ 9,629	
Project Management (12% of total cost)				$ 11,555	
Sales Tax (8.6% of half capital cots)				$ 4,140	
				$ 25,324	
			Subtotal =	$ 121,614	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	

Table C-6
Cost Estimate for Alternative 2
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Short-Term Injection of Oxidation Compounds at Groundwater Hotspot					
Capital Cost					
Direct					
Groundwater Extraction Well	12	each	3,000	$ 36,000	
Miscellaneous Equipment	1	each	5,000	$ 5,000	allowance
Injection - materials	4	injections	6,000	$ 24,000	allowance
Injection - labor	4	injections	4,000	$ 16,000	allowance
			Subtotal =	$ 81,000	
Indirect-Contractor					
OH&P of Subcontractors (@5%)				$ 4,050	
General Conditions (@5%)				$ 4,050	
Other (@10%)				$ 8,100	
				$ 16,200	
			Subtotal =	$ 97,200	
Construction Contingency (@25%)				$ 24,300	
Contractor Fee (@5%)				$ 4,860	
Escalation (@2%)				$ 1,944	
				$ 31,104	
			Subtotal =	$ 128,304	
Indirect-Other					
Engineering (15% of total cost)				$ 19,246	
Project Management (12% of total cost)				$ 15,396	
Sales Tax (8.6% of half capital cots)				$ 3,483	
				$ 38,125	
			Subtotal =	$ 166,429	
Oxidation Compound Trenches					
Capital Cost					
Direct					
Excavate Trench Soil	520	bcy	$ 8.56	$ 4,451	
Transportation and Disposal of Contaminated Soils	520	bcy	$ 110.00	$ 57,200	
Trench Pipe with pipe zone backfill - Installed	260	lf	$ 40	$ 10,400	
Place and Compact Backfill on Top of Trench Drain Pipe	1,183	tons	$ 3.31	$ 3,916	
Analytical Testing - Disposal (832 ton, 1.6:1)	3	samples	$ 255	$ 765	1 TCLP / Total per 400 ton
			Subtotal =	$ 76,732	
Indirect-Contractor					
OH&P of Subcontractors (@15%)				$ 11,510	
General Conditions (@10%)				$ 7,673	
Other (@10%)				$ 7,673	
				$ 26,856	
			Subtotal =	$ 103,588	
Construction Contingency (@25%)				$ 25,897	
Contractor Fee (@15%)				$ 15,538	
Escalation (@2%)				$ 2,072	
				$ 43,507	
			Subtotal =	$ 147,095	
Indirect-Other					
Engineering (15% of total cost)				$ 22,064	
Project Management (12% of total cost)				$ 17,651	
Sales Tax (8.6% of half capital cots)				$ 6,325	
				$ 46,041	
			Subtotal =	$ 193,136	
Operations, Maintenance, and Monitoring Cost					
Years 1 - 5	5	ls	$ 50,000	$ 250,000	
Years 6 - 10	5	ls	$ 25,000	$ 125,000	
Indirect Costs					
			Total =	$ 799,478	

Table C-6
Cost Estimate for Alternative 2
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Later Phase Sediment Removal to 20 mg/kg Cleanup Level					
Capital Costs					
Direct					
Clearing and Grubbing Excavation Area	0.07	acres	$ 9,500	$ 628	
Excavation - Contaminated Sediment	320	bcy	$ 24.00	$ 7,680	
Transportation and Disposal of Non-Hazardous Sediment	691	tons	$ 52.00	$ 35,942	<20 mg/kg assumed Non-Hazardous
Imported Backfill Material	576	tons	$ 27.00	$ 15,552	1.5 tons : 1.2 lcy : 1 bcy
Place Backfill	576	tons	$ 6.00	$ 3,456	1.5 tons : 1.2 lcy : 1 bcy
Analytical Testing - Perimeter (504 lf)	11	samples	$ 85	$ 935	1 per 50 perimeter feet
Analytical Testing - Bottom (2,880 sf)	2	samples	$ 85	$ 170	1 per 2500 sf
Analytical Testing - Disposal (576 ton, 1.6:1)	2	samples	$ 255	$ 510	1 TCLP / Total per 400 ton
Creek Diversion	360	lf	$ 200	$ 72,000	
			Subtotal =	$ 136,873	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 13,687	
General Conditions (@10%)				$ 13,687	
Other (@10%)				$ 5,475	
				$ 32,850	
			Subtotal =	$ 169,723	
Construction Contingency (@25%)				$ 42,431	
Contractor Fee (@15%)				$ 25,458	
Escalation (@2%)				$ 3,394	
				$ 71,284	
			Subtotal =	$ 241,007	
Indirect-Other					
Engineering (15% of total cost)				$ 36,151	
Project Management (12% of total cost)				$ 28,921	
Sales Tax (8.6% of capital cost)				$ 20,727	
				$ 85,798	
			Subtotal =	$ 326,805	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Project Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Monitored Natural Attenuation					
Capital Cost					
Direct					
Install Monitoring Wells	10	wells	$ 1,361	$ 13,608	
Sampling / Field Staff	2	ls	$ 1,400	$ 2,800	14 hours @ $100 /hour: 2 times
Sample Analysis	32	samples	$ 100	$ 3,200	16 wells: 2 times per year
Instrumentation / Equipment	2	ls	$ 500	$ 1,000	
Vehicle	2	ls	$ 135	$ 270	
Expendable Suppies	2	ls	$ 250	$ 500	
Reporting	2	ls	$ 8,000	$ 16,000	
			Subtotal =	$ 37,378	
Indirect					
Engineering (15% of total cost)				$ 5,607	
Project Management (12% of total cost)				$ 4,485	
Sales Tax (8.6% of half capital cots)				$ 1,607	
			Subtotal =	$ 11,699	
			Total =	$ 49,077	
			Total with 15% Contingency =	$ 56,439	
Operations, Maintenance, and Monitoring Cost					
Monitoring and Sampling Events					
Years 1 - 5 (two sampling events per year)	5	ls	$ 40,790	$ 203,948	
Years 6 - 30 (one sampling event per year)	25	ls	$ 20,395	$ 509,871	
Indirect Costs					
Project Management	12	% of total		$ 85,658	
			Total =	$ 799,478	
Institutional Controls					
Capital Cost					
Direct					
Establish Restrictive Covenants and Conditional Point of Compliance	1	ls	$ 25,000	$ 25,000	
			Subtotal =	$ 25,000	
Indirect					
Engineering (15% of total cost)				$ 3,750	
Project Management (12% of total cost)				$ 3,000	
Sales Tax (8.6% of half capital cots)				$ 1,075	
			Subtotal =	$ 7,825	
			Total =	$ 32,825	
			Total with 15% Contingency =	$ 37,749	
Operations, Maintenance, and Monitoring Cost					
Inspection and Maintenance of Restrictive Covenants	1	ls	$ 10,000	$ 10,000	
			Total =	$ 10,000	Includes PM, Contingency

Table C-7
Cost Estimate for Alternative 3
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Source Soil Treatment - In-Situ Soil Solidification of Soil > 500 mg/kg					
Capital Cost					
Direct					
Surface Prep - Ramp Installation	1	ls	$ 10,000	$ 10,000	
Mix Design	1	ls	$ 15,000	$ 15,000	
Mobilization of Mixing Machine	1	ls	$ 75,000	$ 75,000	
Disposal allowance (30% of soil mixing volume)	302	bcy	$ 52.00	$ 15,695	
Construction Dewatering Wells	4	each	$ 2,000.00	$ 8,000	
Water Treatment System	1	each	$ 10,000.00	$ 10,000	
Water Treatment - Media	864,000	gallons	$ 0.007	$ 6,048	allowance
Discharge Fees	864,000	gallons	$ 0.007	$ 6,048	under City of Tacoma - industrial permit
Analytical Testing - Discharge Water	44	samples	$ 200	$ 8,800	1 per 20,000 gallons - Rushed Sample
Soil Mixing	534	bcy	$ 40	$ 21,350	
			Subtotal =	$ 175,941	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 17,594	
General Conditions (@10%)				$ 17,594	
Other (@10%)				$ 17,594	
				$ 52,782	
			Subtotal =	$ 228,724	
Construction Contingency (@25%)				$ 57,181	
Contractor Fee (@15%)				$ 34,309	
Escalation (@2%)				$ 4,574	
				$ 96,064	
			Subtotal =	$ 324,788	
Indirect-Other					
Engineering (15% of total cost)				$ 48,718	
Project Management (12% of total cost)				$ 38,975	
Sales Tax (8.6% of half capital cots)				$ 13,966	
				$ 101,659	
			Subtotal =	$ 426,447	
Operations, Maintenance, and Monitoring Cost					
Direct					
Operating and Maintenance Costs		ls	$ -	$ -	This portion of alternative will require no maintenance
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Oxidation Compound Trenches					
Capital Cost					
Direct					
Excavate Trench Soil	520	bcy	$ 8.56	$ 4,451	
Transportation and Disposal of Contaminated S	520	bcy	$ 110.00	$ 57,200	
Trench Pipe with pipe zone backfill - Installed	260	lf	$ 40	$ 10,400	
Place and Compact Backfill on Top of Trench D	1,183	tons	$ 3.31	$ 3,916	
Analytical Testing - Disposal (832 ton, 1.6:1)	3	samples	$ 255	$ 765	1 TCLP / Total per 400 ton
			Subtotal =	$ 76,732	
Indirect-Contractor					
OH&P of Subcontractors (@15%)				$ 11,510	
General Conditions (@10%)				$ 7,673	
Other (@10%)				$ 7,673	
				$ 26,856	
			Subtotal =	$ 103,588	
Construction Contingency (@25%)				$ 25,897	
Contractor Fee (@15%)				$ 15,538	
Escalation (@2%)				$ 2,072	
				$ 43,507	
			Subtotal =	$ 147,095	
Indirect-Other					
Engineering (15% of total cost)				$ 22,064	
Project Management (12% of total cost)				$ 17,651	
Sales Tax (8.6% of half capital cots)				$ 6,325	
				$ 46,041	
			Subtotal =	$ 193,136	
Operations, Maintenance, and Monitoring Cost					
Years 1 - 5	5	ls	$ 50,000	$ 250,000	
Years 6 - 10	5	ls	$ 25,000	$ 125,000	
Indirect Costs					
			Total =	$ 799,478	
Indirect Costs					
Project Management	12	% of total		$ 95,937	
			Total =	$ 799,478	

Table C-7
Cost Estimate for Alternative 3
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Short-Term Pump and Treat (1-year)					
Capital Cost					
Direct					
Groundwater Extraction Well	1	each	$ 3,000.00	$ 3,000	
Pump, Electrical Service, and Controls	1	each	$ 6,000.00	$ 6,000	
Water Treatment	5,256,000	gallons	$ 0.007	$ 36,792	allowance
Discharge Fees	5,256,000	gallons	$ 0.007	$ 36,792	under City of Tacoma - industrial permit
Analytical Testing - Discharge Water	12	samples	$ 200	$ 2,400	1 per month - Rushed Sample
			Subtotal =	$ 84,984	
Indirect-Contractor					
OH&P of Subcontractors (@5%)				$ 4,249	
General Conditions (@10%)				$ 8,498	
Other (@10%)				$ 8,498	
				$ 21,246	
			Subtotal =	$ 106,230	
Construction Contingency (@25%)				$ 26,558	
Contractor Fee (@5%)				$ 5,312	
Escalation (@2%)				$ 2,125	
				$ 33,994	
			Subtotal =	$ 140,224	
Indirect-Other					
Engineering (15% of total cost)				$ 21,034	
Project Management (12% of total cost)				$ 16,827	
Sales Tax (8.6% of half capital cots)				$ 6,030	
				$ 43,890	
			Subtotal =	$ 184,114	
Operations, Maintenance, and Monitoring Cost					
Direct					
Operating and Maintenance Costs		ls	$ -	$ -	This portion of alternative will require no maintenance
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Slurry Walls					
Capital Costs					
Direct					
Area of Slurry Wall	8,700	sf	$ 53.00	$ 461,100	from Means
Preparation	1	ea	$ 10,000	$ 10,000	
			Subtotal =	$ 471,100	
Indirect-Contractor					
OH&P of Subcontractors (@10%)				$ 47,110	
General Conditions (@10%)				$ 47,110	
Other (@10%)				$ 47,110	
				$ 141,330	
			Subtotal =	$ 612,430	
Construction Contingency (@25%)				$ 153,108	
Contractor Fee (@15%)				$ 91,865	
Escalation (@2%)				$ 12,249	
				$ 257,221	
			Subtotal =	$ 869,651	
Indirect-Other					
Engineering (10% of total cost)				$ 86,965	
Project Management (10% of total cost)				$ 86,965	
Sales Tax (8.6% of half capital cots)				$ 20,257	
				$ 194,187	
			Subtotal =	$ 1,063,838	
Operations, Maintenance, and Monitoring Cost					
Direct					
Operating and Maintenance Costs		ls	$ -	$ -	This portion of alternative will require no maintenance
Indirect					
Project Management (12% of total)	12	% of total		$ -	
			Total =	$ -	

Table C-7
Cost Estimate for Alternative 3
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Engineered Permeable Cap					
Capital Cost					
Direct					
Excavation - misc pavement, soil, etc.	200	bcy	$ 24.00	$ 4,800	allowance
Transport/Disposal of misc pavement, soil, etc.	200	tons	$ 52.00	$ 10,400	allowance
Stormwater controls	1	ls	$ 10,000.00	$ 10,000	allowance
Crushed rock base installed	11,520	sf	$ 1.04	$ 11,985	
Permeable pavement/pavers installed	11,520	sf	$ 1.30	$ 14,976	
			Subtotal =	$ 52,161	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 5,216	
General Conditions (@10%)				$ 5,216	
Other (@10%)				$ 5,216	
				$ 15,648	
			Subtotal =	$ 67,810	
Construction Contingency (@25%)				$ 16,952	
Contractor Fee (@15%)				$ 10,171	
Escalation (@2%)				$ 1,356	
				$ 28,480	
			Subtotal =	$ 96,290	
Indirect-Other					
Engineering (10% of total cost)				$ 9,629	
Project Management (12% of total cost)				$ 11,555	
Sales Tax (8.6% of half capital cots)				$ 4,140	
				$ 25,324	
			Subtotal =	$ 121,614	
Operations, Maintenance, and Monitoring Cost					
Direct					
Operating and Maintenance Costs		ls	$ -	$ -	This portion of alternative will require no maintenance
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Later Phase Sediment Removal to 20 mg/kg Cleanup Level					
Capital Costs					
Direct					
Clearing and Grubbing Excavation Area	0.07	acres	$ 9,500	$ 628	
Excavation - Contaminated Sediment	320	bcy	$ 24.00	$ 7,680	
Transportation and Disposal of Non-Hazardous	691	tons	$ 52.00	$ 35,942	<20 mg/kg assumed Non-Hazardous
Imported Backfill Material	576	tons	$ 27.00	$ 15,552	1.5 tons : 1.2 lcy : 1 bcy
Place Backfill	576	tons	$ 6.00	$ 3,456	1.5 tons : 1.2 lcy : 1 bcy
Analytical Testing - Perimeter (504 lf)	11	samples	$ 85	$ 935	1 per 50 perimeter feet
Analytical Testing - Bottom (2,880 sf)	2	samples	$ 85	$ 170	1 per 2500 sf
Analytical Testing - Disposal (576 ton, 1.6:1)	2	samples	$ 255	$ 510	1 TCLP / Total per 400 ton
Creek Diversion	360	lf	$ 200	$ 72,000	
			Subtotal =	$ 136,873	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 13,687	
General Conditions (@10%)				$ 13,687	
Other (@10%)				$ 5,475	
				$ 32,850	
			Subtotal =	$ 169,723	
Construction Contingency (@25%)				$ 42,431	
Contractor Fee (@15%)				$ 25,458	
Escalation (@2%)				$ 3,394	
				$ 71,284	
			Subtotal =	$ 241,007	
Indirect-Other					
Engineering (15% of total cost)				$ 36,151	
Project Management (12% of total cost)				$ 28,921	
Sales Tax (8.6% of capital cost)				$ 20,727	
				$ 85,798	
			Subtotal =	$ 326,805	
Operations, Maintenance, and Monitoring Cost					
Direct					
Operating and Maintenance Costs		ls	$ -	$ -	This portion of alternative will require no maintenance
Indirect					
Project Management (12% of total)	12	% of total		$ -	
			Total =	$ -	

Table C-7
Cost Estimate for Alternative 3
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Monitored Natural Attenuation					
Capital Cost					
Direct					
Install Monitoring Wells	10	wells	$ 1,361	$ 13,608	
Sampling / Field Staff	2	ls	$ 1,400	$ 2,800	14 hours @ $100 /hour: 2 times
Sample Analysis	32	samples	$ 100	$ 3,200	16 wells: 2 times per year
Instrumentation / Equipment	2	ls	$ 500	$ 1,000	
Vehicle	2	ls	$ 135	$ 270	
Expendable Suppies	2	ls	$ 250	$ 500	
Reporting	2	ls	$ 8,000	$ 16,000	
			Subtotal =	$ 37,378	
Indirect					
Engineering (15% of total cost)				$ 5,607	
Project Management (12% of total cost)				$ 4,485	
Sales Tax (8.6% of half capital cots)				$ 1,607	
			Subtotal =	$ 11,699	
			Total =	$ 49,077	
			Total with 15% Contingency =	$ 56,439	
Operations, Maintenance, and Monitoring Cost					
Monitoring and Sampling Events					
Years 1 - 5 (two sampling events per year)	5	ls	$ 40,790	$ 203,948	
Years 6 - 30 (one sampling event per year)	25	ls	$ 20,395	$ 509,871	
Indirect Costs					
Project Management	12	% of total		$ 85,658	
			Total =	$ 799,478	
Institutional Controls					
Capital Cost					
Direct					
Establish Restrictive Covenants and Conditional Point of Compliance	1	ls	$ 25,000	$ 25,000	
			Subtotal =	$ 25,000	
Indirect					
Engineering (15% of total cost)				$ 3,750	
Project Management (12% of total cost)				$ 3,000	
Sales Tax (8.6% of half capital cots)				$ 1,075	
			Subtotal =	$ 7,825	
			Total =	$ 32,825	
			Total with 15% Contingency =	$ 37,749	
Operations, Maintenance, and Monitoring Cost					
Inspection and Maintenance of Restrictive Covenants	1	ls	$ 10,000	$ 10,000	
			Total =	$ 10,000	Includes PM, Contingency
Permeable Reactive Barrier					
Capital Cost					
Direct					
Excavate PRB Trench	544	bcy	$ 8.56	$ 4,660	
Transportation and Disposal of Contaminated S	544	bcy	$ 110.00	$ 59,889	
Zero Valent Iron - Installed	451	bcy	$ 264	$ 119,130	
Place and Compact Backfill on Top of PRB	93	bcy			
Place and Compact Backfill on Top of PRB	131	tons	$ 3.31	$ 433	
Analytical Testing - Disposal (832 ton, 1.6:1)	3	samples	$ 255	$ 765	1 TCLP / Total per 400 ton
			Subtotal =	$ 184,876	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 18,488	
General Conditions (@10%)				$ 18,488	
Mobilization (@4%)				$ 7,395	
Risk and Liability Insurance (@1.2% of total)				$ 2,219	
G & A Overhead (@5.76% of total)				$ 10,649	
				$ 57,238	
			Subtotal =	$ 242,114	
Construction Contingency (@25%)				$ 60,529	
Contractor Fee (@15%)				$ 36,317	
Escalation (@2%)				$ 4,842	
				$ 101,688	
			Subtotal =	$ 343,802	
Indirect-Other					
Engineering (15% of total cost)				$ 51,570	
Project Management (10% of total cost)				$ 34,380	
Sales Tax (8.6% of half capital cots)				$ 14,783	
				$ 100,734	
			Subtotal =	$ 444,536	
Operations, Maintenance, and Monitoring Cost					
Direct Costs					
Operating and Maintenance Costs	2	ls	$ 444,536	$ 889,072	
Indirect Costs					
				$ -	
			Total =	$ 889,072	

Table C-8
Cost Estimate for Alternative 4
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Soil Removal to 20 mg/kg Cleanup Level					
Capital Costs					
Direct					
Clearing and Grubbing Excavation Area	0.00	acres	$ 9,500	$ -	
Excavate Adjacent Clean Soil	3,467	bcy	$ 24.00	$ 83,208	
Excavation - Contaminated Soil	20,742	bcy	$ 24.00	$ 497,808	
Transportation and Disposal of Non-Hazardous Soils	37,144	tons	$ 52.00	$ 1,931,474	<20 mg/kg assumed Non-Hazardous
Transportation and Disposal of Hazardous Soils	1,955	tons	$ 174.00	$ 340,158	>20 mg/kg assumed Hazardous
Imported Backfill Material - Below GW	14,312	tons	$ 27.00	$ 386,423	1.5 tons : 1.15 lcy : 1 bcy
Place Backfill - Below GW	14,312	tons	$ 6.00	$ 85,872	1.5 tons : 1.15 lcy : 1 bcy
Imported Backfill Material - Above GW	28,313	tons	$ 17.15	$ 485,565	1.75 tons : 1.3 lcy : 1 bcy
Place and Compact Backfill - Above GW	36,200	tons	$ 6.00	$ 217,202	1.75 tons : 1.3 lcy : 1 bcy
Shoring	32,000	sf	$ 40.00	$ 1,280,000	
Abandon Wells in Excavation Area	12	wells	$ 2,000.00	$ 24,000	
Analytical Testing - Perimeter (980 lf)	20	samples	$ 85	$ 1,700	1 per 50 perimeter feet
Analytical Testing - Bottom (46,800 sf)	19	samples	$ 85	$ 1,615	1 per 2500 sf
Analytical Testing - Disposal (24,209 ton, 1.6:1)	61	samples	$ 255	$ 15,555	1 TCLP / Total per 400 ton
Construction Dewatering Wells	6	each	$ 2,000.00	$ 12,000	
Water Treatment	12,960,000	gallons	$ 0.007	$ 90,720	allowance
Discharge Fees	12,960,000	gallons	$ 0.007	$ 90,720	under City of Tacoma - industrial permit
Analytical Testing - Discharge Water	648	samples	$ 200	$ 129,600	1 per 20,000 gallons - Rushed Sample
Creek Diversion	360	lf	$ 200	$ 72,000	
			Subtotal =	$ 5,745,621	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 919,299	assume 80% of work is subcontractor
General Conditions (@10%)				$ 574,562	
Mobilization (@4%)				$ 229,825	
Risk and Liability Insurance (@1.2% of total)				$ 68,947	
G & A Overhead (@5.76% of total)				$ 330,948	
				$ 2,123,581	
			Subtotal =	$ 7,869,202	
Construction Contingency (@25%)				$ 1,967,301	
Contractor Fee (@15%)				$ 1,180,380	
Escalation (@2%)				$ 157,384	
				$ 3,305,065	
			Subtotal =	$ 11,174,267	
Indirect-Other					
Engineering (15% of total cost)				$ 1,676,140	
Project Management (12% of total cost)				$ 1,340,912	
Sales Tax (8.6% of half capital cots)				$ 247,062	
				$ 3,264,114	
			Subtotal =	$ 14,438,381	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Project Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Later Phase Sediment Removal to 20 mg/kg Cleanup Level					
Capital Costs					
Direct					
Clearing and Grubbing Excavation Area	0.07	acres	$ 9,500	$ 628	
Excavation - Contaminated Sediment	320	bcy	$ 24.00	$ 7,680	
Transportation and Disposal of Non-Hazardous Sediment	691	tons	$ 52.00	$ 35,942	<20 mg/kg assumed Non-Hazardous
Imported Backfill Material	576	tons	$ 27.00	$ 15,552	1.5 tons : 1.2 lcy : 1 bcy
Place Backfill	576	tons	$ 6.00	$ 3,456	1.5 tons : 1.2 lcy : 1 bcy
Analytical Testing - Perimeter (504 lf)	11	samples	$ 85	$ 935	1 per 50 perimeter feet
Analytical Testing - Bottom (2,880 sf)	2	samples	$ 85	$ 170	1 per 2500 sf
Analytical Testing - Disposal (576 ton, 1.6:1)	2	samples	$ 255	$ 510	1 TCLP / Total per 400 ton
Creek Diversion	360	lf	$ 200	$ 72,000	
			Subtotal =	$ 136,873	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 13,687	
General Conditions (@10%)				$ 13,687	
Other (@10%)				$ 5,475	
				$ 32,850	
			Subtotal =	$ 169,723	
Construction Contingency (@25%)				$ 42,431	
Contractor Fee (@15%)				$ 25,458	
Escalation (@2%)				$ 3,394	
				$ 71,284	
			Subtotal =	$ 241,007	
Indirect-Other					
Engineering (15% of total cost)				$ 36,151	
Project Management (12% of total cost)				$ 28,921	
Sales Tax (8.6% of capital cost)				$ 20,727	
				$ 85,798	
			Subtotal =	$ 326,805	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Project Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
			Total =	$ -	

Table C-8
Cost Estimate for Alternative 4
Feasibility Study - USG Highway 99 Site
Milton, Washington
May 2013

Item	Quantity	Unit	Unit Cost	Cost	Comment
Engineered Permeable Cap					
Capital Cost					
Direct					
Excavation - misc pavement, soil, etc.	200	bcy	$ 24.00	$ 4,800	allowance
Transport/Disposal of misc pavement, soil, etc.	200	tons	$ 52.00	$ 10,400	allowance
Stormwater controls	1	ls	$ 10,000.00	$ 10,000	allowance
Crushed rock base installed	11,520	sf	$ 1.04	$ 11,985	
Permeable pavement/pavers installed	11,520	sf	$ 1.30	$ 14,976	
			Subtotal =	$ 52,161	
Indirect-Contractor					
OH&P of Subcontractors (@20%)				$ 5,216	
General Conditions (@10%)				$ 5,216	
Other (@10%)				$ 5,216	
				$ 15,648	
			Subtotal =	$ 67,810	
Construction Contingency (@25%)				$ 16,952	
Contractor Fee (@15%)				$ 10,171	
Escalation (@2%)				$ 1,356	
				$ 28,480	
			Subtotal =	$ 96,290	
Indirect-Other					
Engineering (10% of total cost)				$ 9,629	
Project Management (12% of total cost)				$ 11,555	
Sales Tax (8.6% of half capital cots)				$ 4,140	
				$ 25,324	
			Subtotal =	$ 121,614	
Operations, Maintenance, and Monitoring Cost					
Direct					This portion of alternative will require no maintenance
Operating and Maintenance Costs		ls	$ -	$ -	
Indirect					
Proejct Management (12% of total)	12	% of total		$ -	
			Total =	$ -	
Monitored Natural Attenuation					
Capital Cost					
Direct					
Install Monitoring Wells	10	wells	$ 1,361	$ 13,608	
Sampling / Field Staff	2	ls	$ 1,400	$ 2,800	14 hours @ $100 /hour: 2 times
Sample Analysis	32	samples	$ 100	$ 3,200	16 wells: 2 times per year
Instrumentation / Equipment	2	ls	$ 500	$ 1,000	
Vehicle	2	ls	$ 135	$ 270	
Expendable Suppies	2	ls	$ 250	$ 500	
Reporting	2	ls	$ 8,000	$ 16,000	
			Subtotal =	$ 37,378	
Indirect					
Engineering (15% of total cost)				$ 5,607	
Project Management (12% of total cost)				$ 4,485	
Sales Tax (8.6% of half capital cots)				$ 1,607	
			Subtotal =	$ 11,699	
			Total =	$ 49,077	
			Total with 15% Contingency =	$ 56,439	
Operations, Maintenance, and Monitoring Cost					
Monitoring and Sampling Events					
Years 1 - 5 (two sampling events per year)	5	ls	$ 40,790	$ 203,948	
Years 6 - 30 (one sampling event per year)	25	ls	$ 20,395	$ 509,871	
Indirect Costs					
Project Management	12	% of total		$ 85,658	
			Total =	$ 799,478	
Institutional Controls					
Capital Cost					
Direct					
Establish Restrictive Covenants and Conditional Point of Compliance	1	ls	$ 25,000	$ 25,000	
			Subtotal =	$ 25,000	
Indirect					
Engineering (15% of total cost)				$ 3,750	
Project Management (12% of total cost)				$ 3,000	
Sales Tax (8.6% of half capital cots)				$ 1,075	
			Subtotal =	$ 7,825	
			Total =	$ 32,825	
			Total with 15% Contingency =	$ 37,749	
Operations, Maintenance, and Monitoring Cost					
Inspection and Maintenance of Restrictive Covenants	1	ls	$ 10,000	$ 10,000	
			Total =	$ 10,000	Includes PM, Contingency

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