Legend

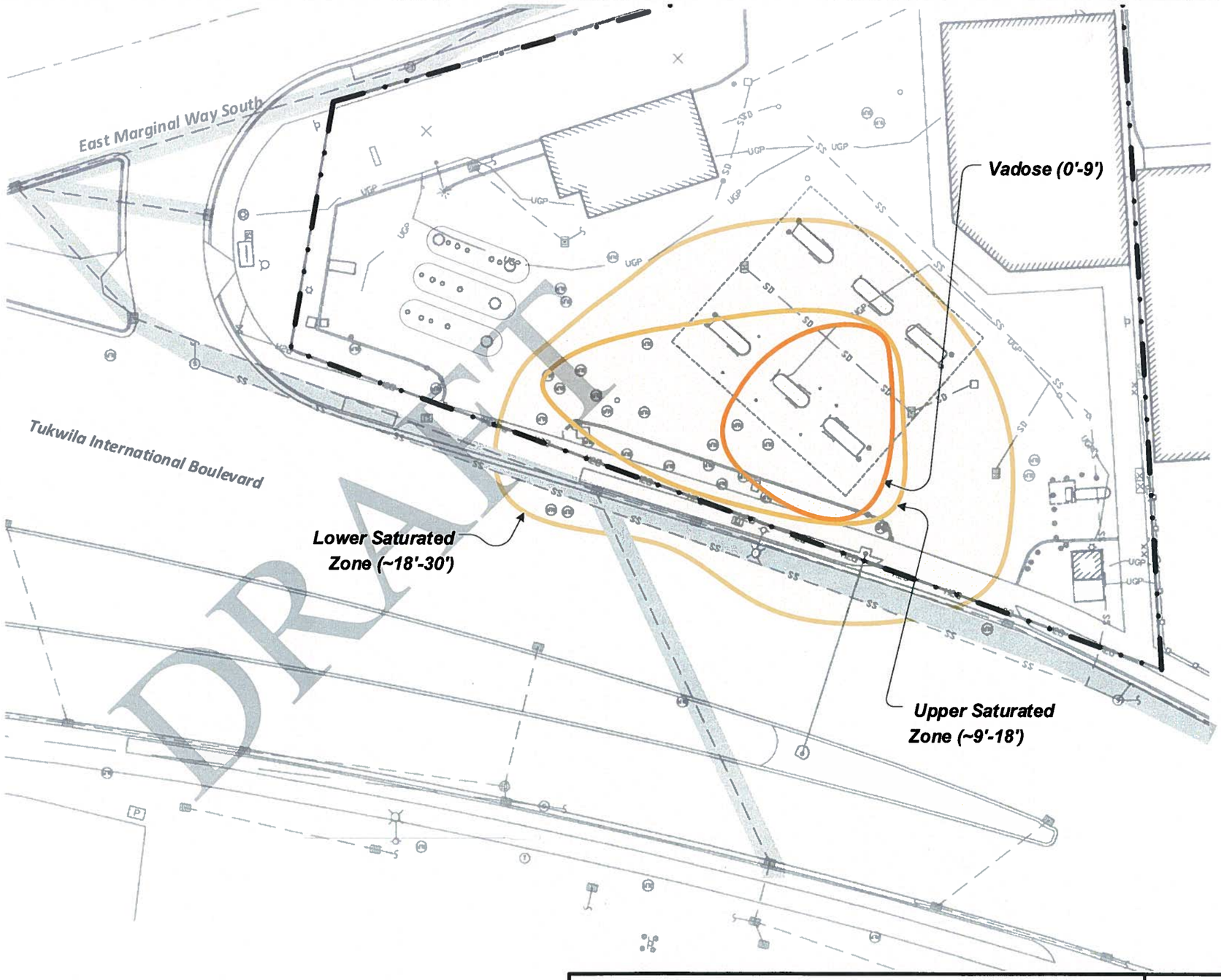
GRO/Benzene Detected Greater than MTCA Method A Cleanup Levels (30/0.03 mg/kg)

Property Boundary

Current UST Location (Approximate)

Approximate Utility Trench Locations (Adjacent to Property)

Note:
Interpreted shapes are based on available analytical data for soil samples collected between 2008 and 2019, see Figures 5-2, 5-3, and 5-4 for additional information.



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Drawing Scale: 1" = 30'

0 ft. 18 ft. 30 ft. 60 ft.

Summary, COCs Above Soil Cleanup Levels
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 5-1

Project File: 01-0410-M F5-1 COC Concentrations in Soil.vsdx

Mapping References: PLS Survey 2016, Tukwila Public Utility Documents, G-Logics Field Measurements, Previous Site Reports and Collected Analytical Data.

Legend

- **MW-22** — Monitoring Well (Installed 2016-2019)
- **GLB-5** — Soil Boring (2016-2019)
- **EW-5** — Extraction Well (Installed 2008)
- **IP-5** — Injection Well (Installed 2006)
- IP-5 — Soil Analytical Data Not Available/Not Used
- EW-8 / 928 (g) / nd (b) — Boring Identification; GRO (g) and Benzene (b) Concentration, red text indicates sample result exceeds cleanup level; Contaminant not-detected above laboratory reporting limits
- GRO/Benzene Detected Greater than MTCA Method A Cleanup Levels (30/0.03 mg/kg)
- GRO/Benzene Detected Greater than 300/0.3 mg/kg
- Area of LNAPL
- Property Boundary
- Current UST Location (Approximate)
- Approximate Utility Trench Locations (Adjacent to Property)

Note: Interpreted contours are based on available analytical data for soil samples collected between 2008 and 2019.

N

Car Wash

Current Station Store

MW-27S
MW-27D nd
GLB-13 nd
GLB-14 nd
MW-26S
GLB-12 nd
MW-26D nd
GLB-17 nd
EW-7 nd
EW-9 nd
TW-2 nd
TW-1 nd
SVE-1 nd
GLB-15 70.8 (g) nd (b)
EW-8 97 (g) 0.24 (b)
IP-7
IP-6
MW-29S nd
GLB-6 nd
GLB-8 nd
EW-6 nd
AS-2 nd
AS-1
IP-4
IP-3
EW-5 nd
EW-4 nd
EW-3 nd
IP-5
EW-1 10 (g) 0.32 (b)
EW-2 nd
TW-3 9.09 (g) 0.094 (b)
GLB-16 nd
MW-28D nd
MW-28S
GLVP-2 nd
GLB-7 nd
MW-23
GLB-18 nd
GLB-9 nd
GLB-10 nd
GLVP-1 nd
GLB-19 nd
GLB-2 nd
MW-30
GLB-3 nd
MW-25
GLB-11 nd
MW-24
MW-24D

Tukwila International Boulevard

Approximate Drawing Scale: 1" = 20'

0.0 in. 12 ft. 20 ft. 40 ft.

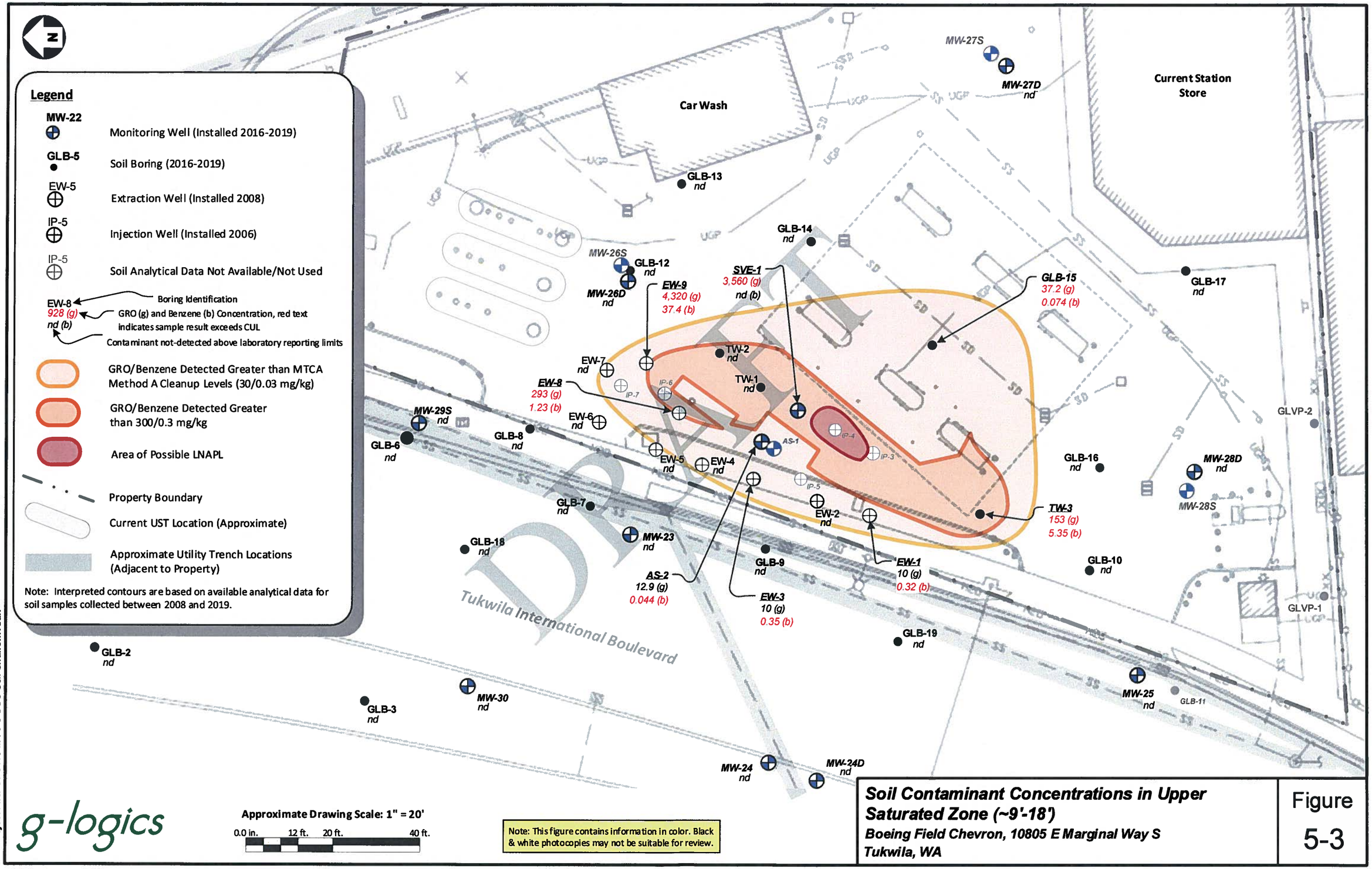
Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Soil Contaminant Concentrations in Vadose (0'-9')
Boeing Field Chevron
10805 E Marginal Way S
Tukwila, WA

Figure 5-2

Project File: 01-0410-M F5-2 COC Soil Vadose.vsdx

Mapping References: PLS Survey 2016, Tukwila Public Utility Documents, G-Logics Field Measurements, Previous Site Reports and Collected Analytical Data.



Project File: 01-0410-M F5-3 COC Soil Shallow.vsdx

g-logics

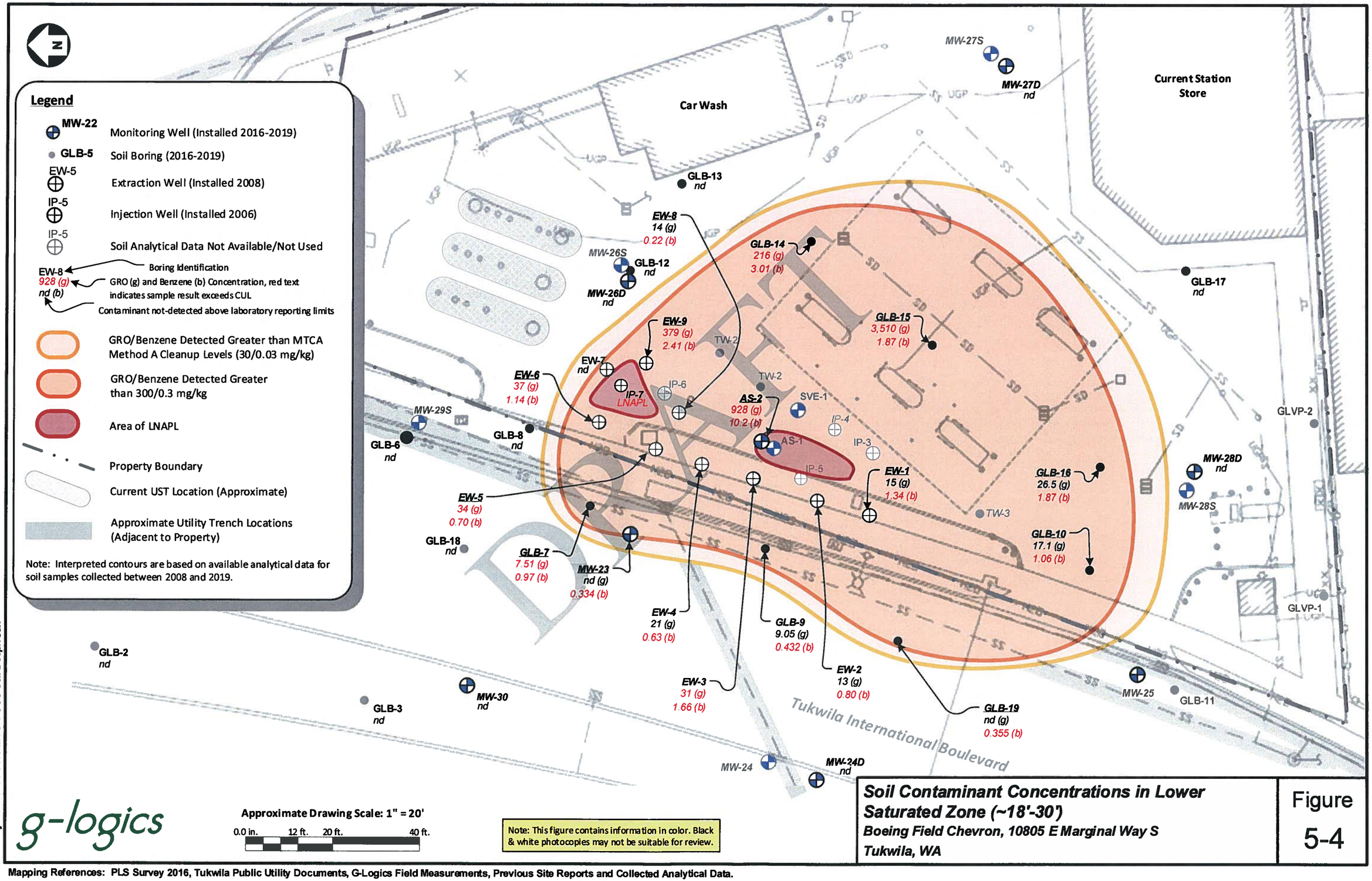
Soil Contaminant Concentrations in Upper Saturated Zone (~9'-18')

Boeing Field Chevron, 10805 E Marginal Way S

Tukwila, WA

Figure 5-3

Mapping References: PLS Survey 2016, Tukwila Public Utility Documents, G-Logics Field Measurements, Previous Site Reports and Collected Analytical Data.



g-logics

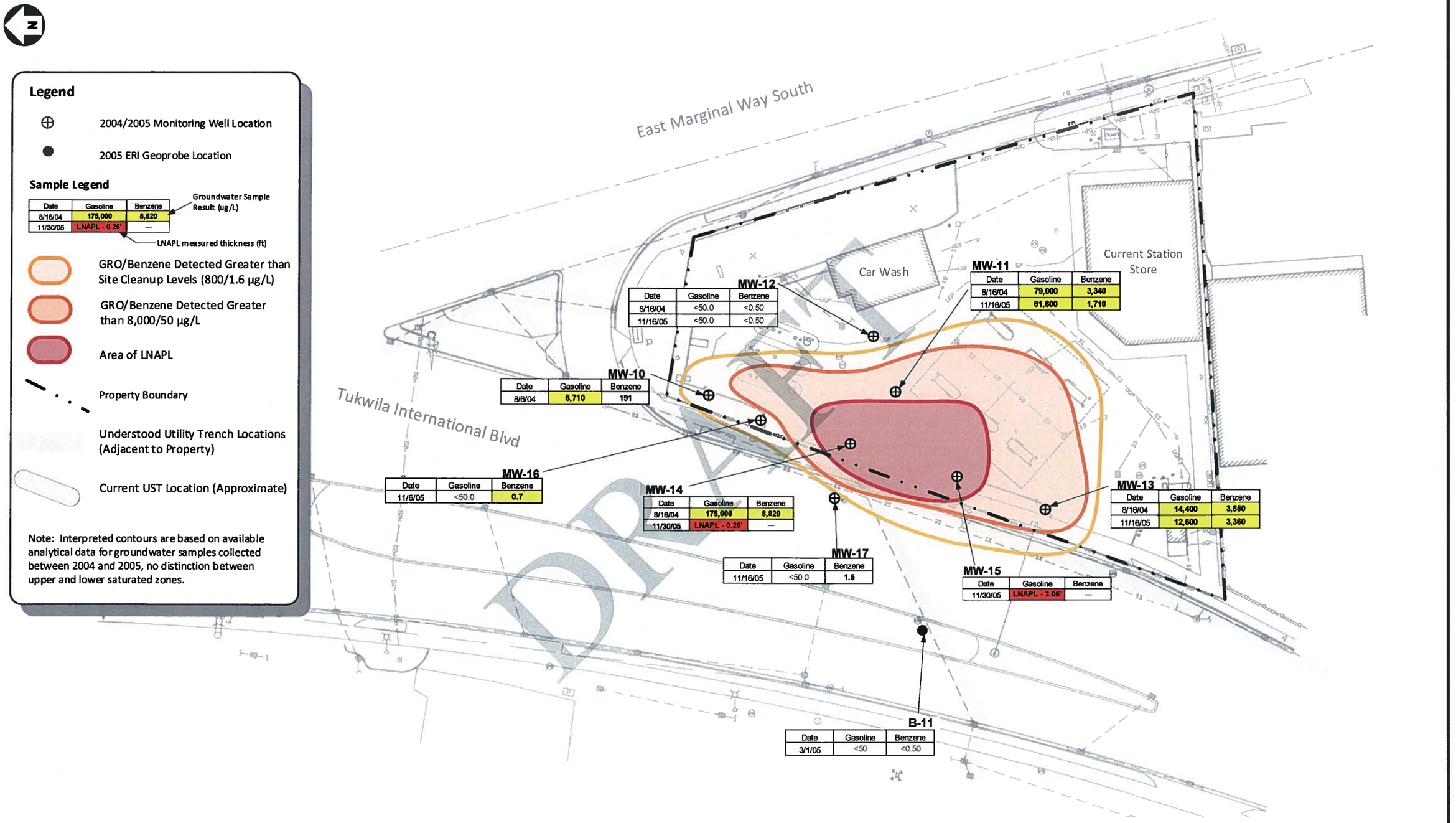
Soil Contaminant Concentrations in Lower Saturated Zone (~18'-30')

Boeing Field Chevron, 10805 E Marginal Way S

Tukwila, WA

Figure 5-4

Mapping References: PLS Survey 2016, Tukwila Public Utility Documents, G-Logics Field Measurements, Previous Site Reports and Collected Analytical Data.



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Drawing Scale: 1" = 40'

0 ft. 24 ft. 40 ft. 80 ft.

Site COC Concentrations in Groundwater, 2004-2005
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 6-1

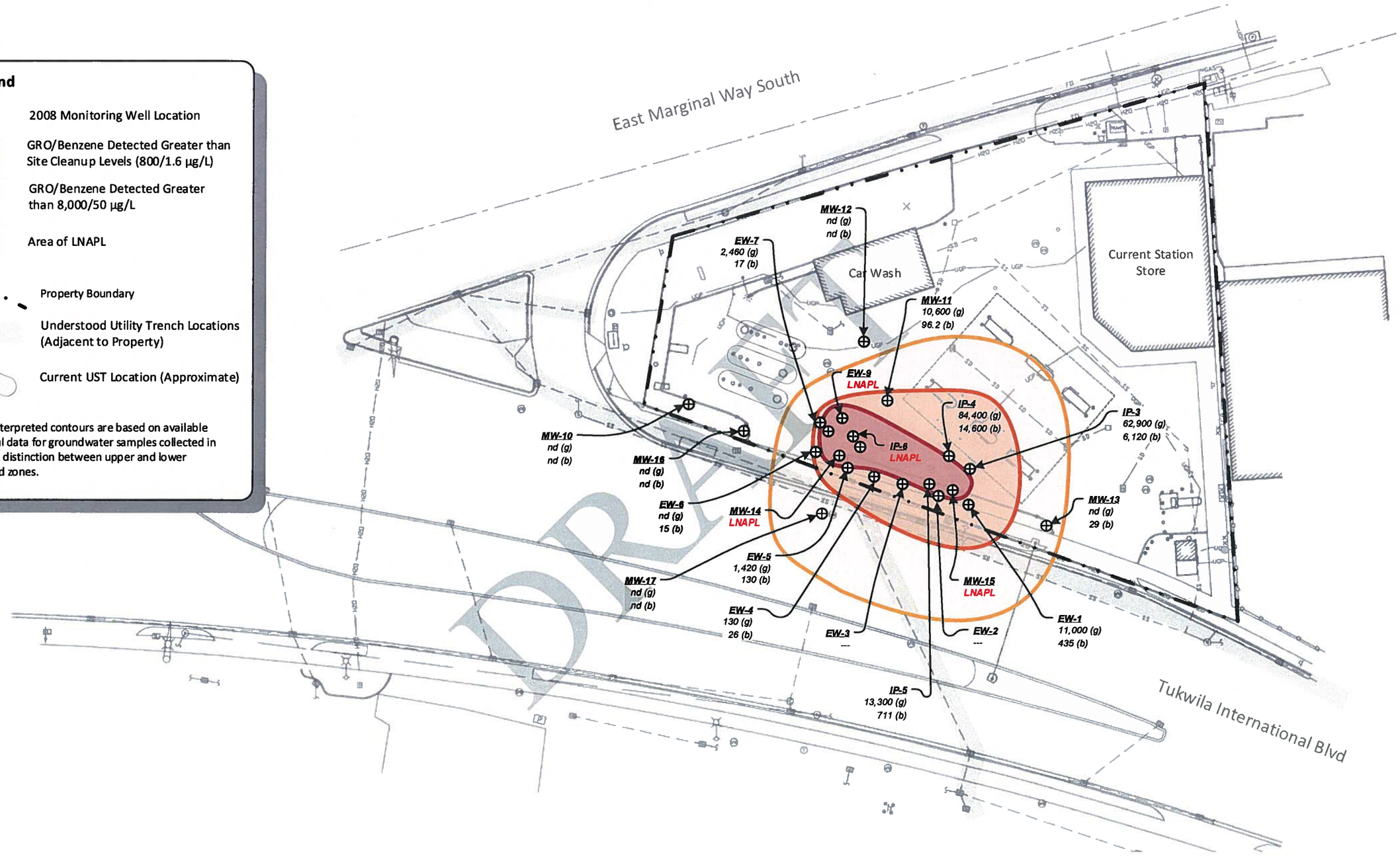
Project File: 01-0410-M F6-1 COCs Groundwater, 2004-2005.vsdx

Mapping References: PLS Survey 2016 and Collected Analytical Data.

Legend

- 2008 Monitoring Well Location
- GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)
- GRO/Benzene Detected Greater than 8,000/50 µg/L
- Area of LNAPL
- Property Boundary
- Understood Utility Trench Locations (Adjacent to Property)
- Current UST Location (Approximate)

Note: Interpreted contours are based on available analytical data for groundwater samples collected in 2008, no distinction between upper and lower saturated zones.



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Drawing Scale: 1" = 40'

0 ft. 24 ft. 40 ft. 80 ft.

Site COC Concentrations in Groundwater, 2008
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 6-2

Project File: 01-0410-M F6-2 COCs Groundwater, 2008.vsdx

Mapping References: PLS Survey 2016, Collected Analytical Data.

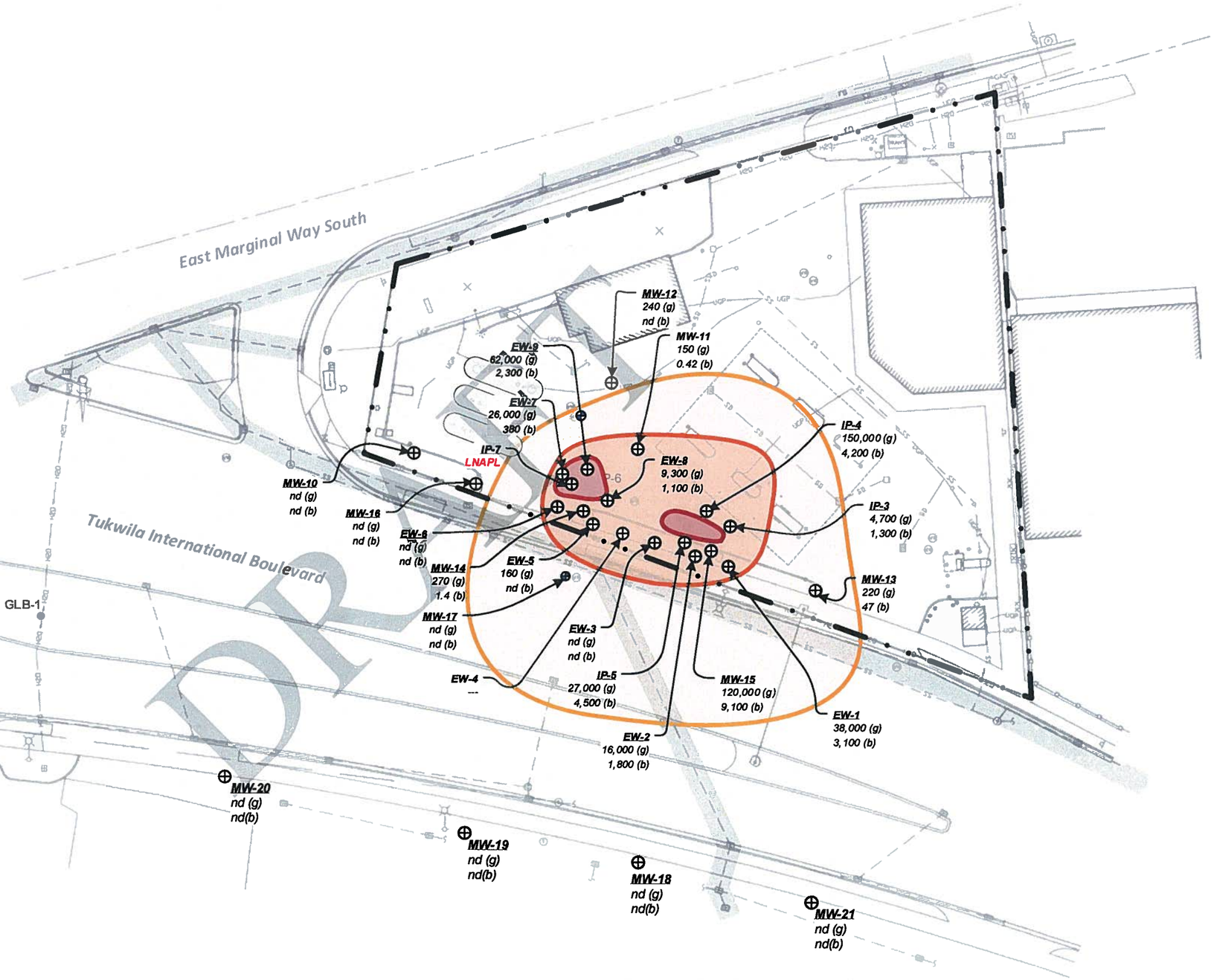
Legend

- 2015 Monitoring Well Location
- GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)
- GRO/Benzene Detected Greater than 8,000/50 µg/L
- Area of LNAPL

Note: Interpretations are based on analytical results from July 2015, summarized in Tables 5-1 and 5-2.

- Property Boundary
- Understood Utility Trench Locations (Adjacent to Property)
- Current UST Location (Approximate)

Note: Interpreted contours are based on available analytical data for groundwater samples collected in 2015, no distinction between upper and lower saturated zones.



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Drawing Scale: 1" = 40'

0 ft. 24 ft. 40 ft. 80 ft.

Site COC Concemtrations in Groundwater, 2015
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 6-3

Project File: 01-0410-M F6-3 COCs Groundwater, 2015.vsdx

Mapping References: PLS Survey 2016, G-Logics Field Measurements, Previous Site Report Figures.

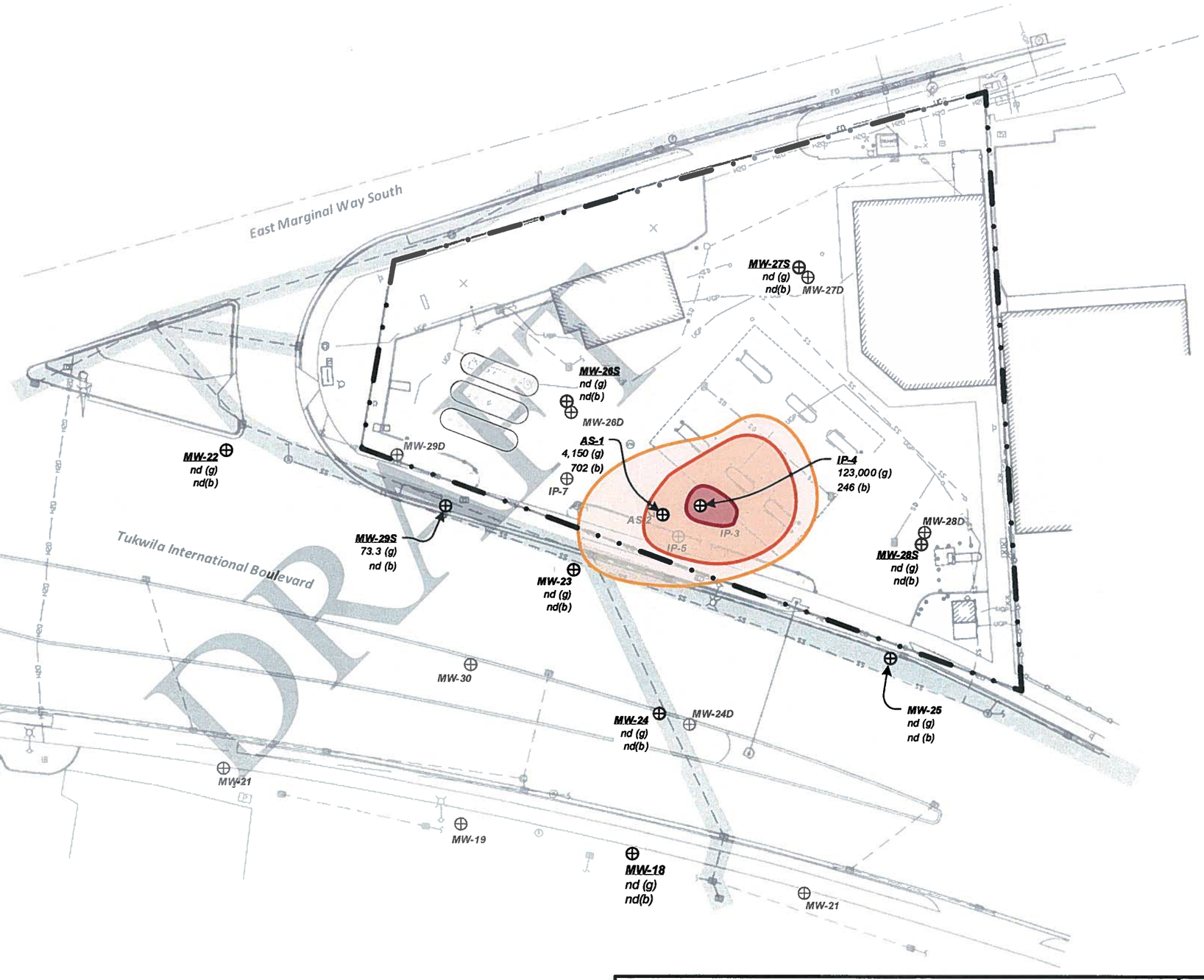
Legend

- 2018-2019 Monitoring Well
- Monitoring Well (Screened in Lower Saturated Zone)
- GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)
- GRO/Benzene Detected Greater than 8,000/50 µg/L
- Area of Possible LNAPL

Note: Interpretations are based on analytical results from July 2015, summarized in Tables 5-1 and 5-2.

- Property Boundary
- Understood Utility Trench Locations (Adjacent to Property)
- Current UST Location (Approximate)

Note: Interpreted contours are based on available analytical data for groundwater samples collected in November 2018 and April 2019.



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Drawing Scale: 1" = 40'

0 ft. 24 ft. 40 ft. 80 ft.

Site COC Concentrations in Groundwater, Upper Saturated Zone, 2018-2019
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 6-4

Project File: 01-0410-M F6-4 COCs USZ 2018-2019.vsdx

Mapping References: PLS Survey 2016, G-Logics Field Measurements, Previous Site Report Figures.

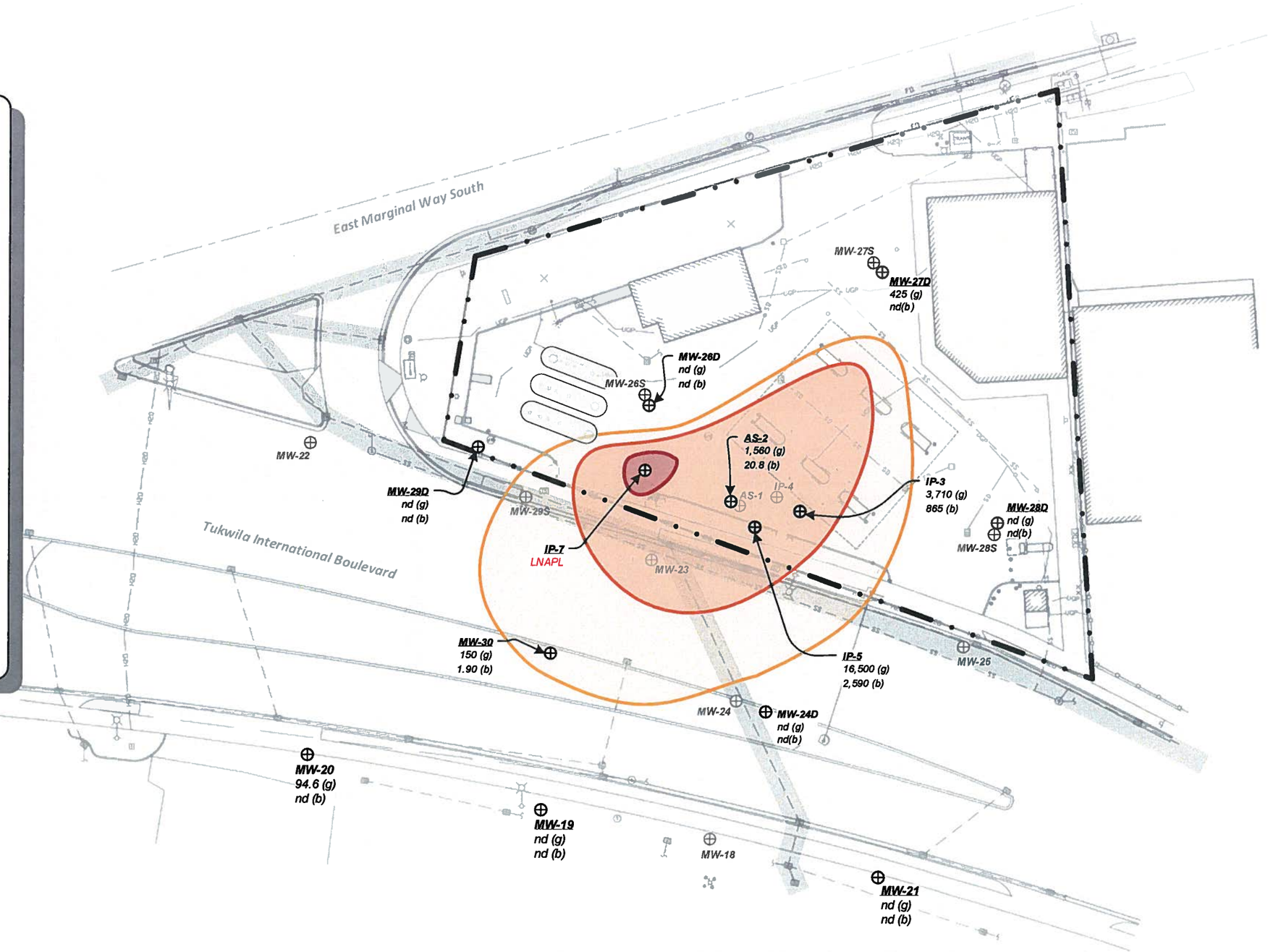
Legend

- 2018-2019 Monitoring Well
- Monitoring Well (Screened in Upper Saturated Zone)
- GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)
- GRO/Benzene Detected Greater than 8,000/50 µg/L
- Area of Possible LNAPL

Note: Interpretations are based on analytical results from July 2015, summarized in Tables 5-1 and 5-2.

- Property Boundary
- Understood Utility Trench Locations (Adjacent to Property)
- Current UST Location (Approximate)

Note: Interpreted contours are based on available analytical data for groundwater samples collected in November 2018 and April 2019.



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Drawing Scale: 1" = 40'

0 ft. 24 ft. 40 ft. 80 ft.

Site COC Concentrations in Groundwater, Lower Saturated Zone, 2018-2019
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 6-5

Project File: 01-0410-M F6-5 COCs LSZ 2018-2019.vsdx

Mapping References: PLS Survey 2016, G-Logics Field Measurements, Previous Site Report Figures.

Legend

MW-29D — Monitoring Well (screened in the lower saturated zone)

MW-22 — Monitoring Well (Sampled) (screened in the upper saturated zone)

GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)

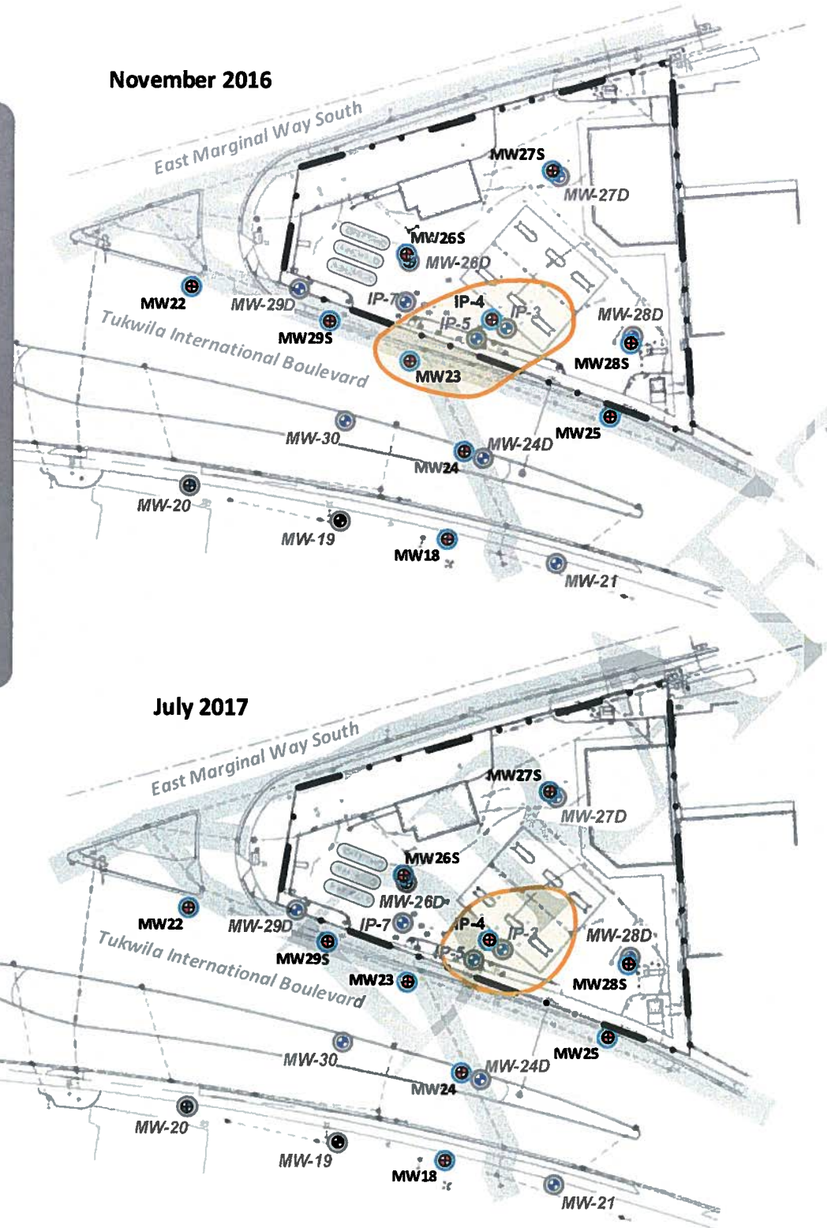
Property Boundary

Current UST Location (Approximate)

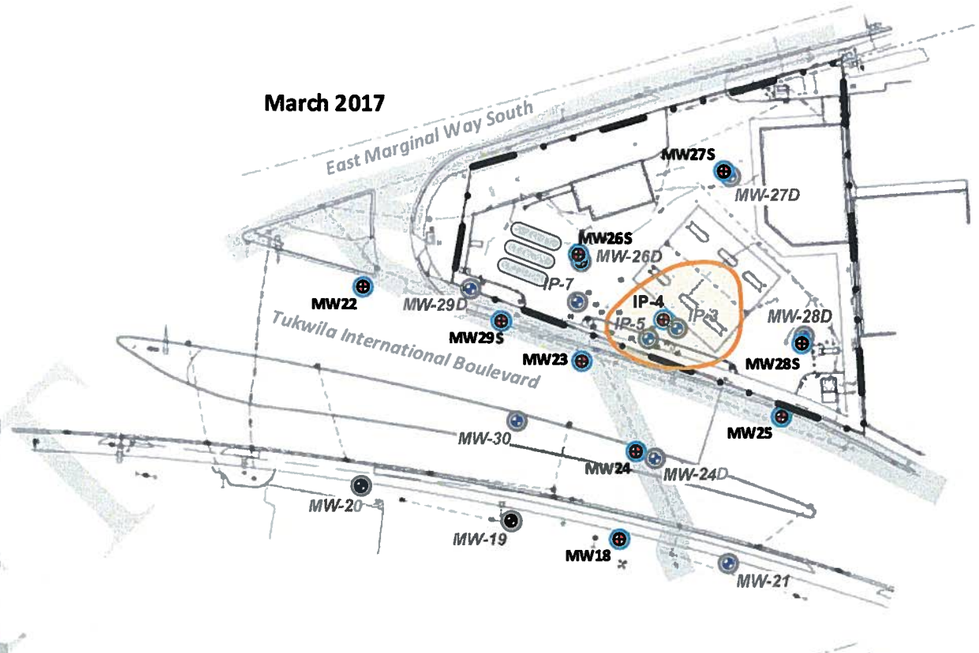
Approximate Utility Trench Locations (Adjacent to Property)

Note: Interpretations are based on analytical results , summarized in Tables 5-1 and 5-2.

November 2016

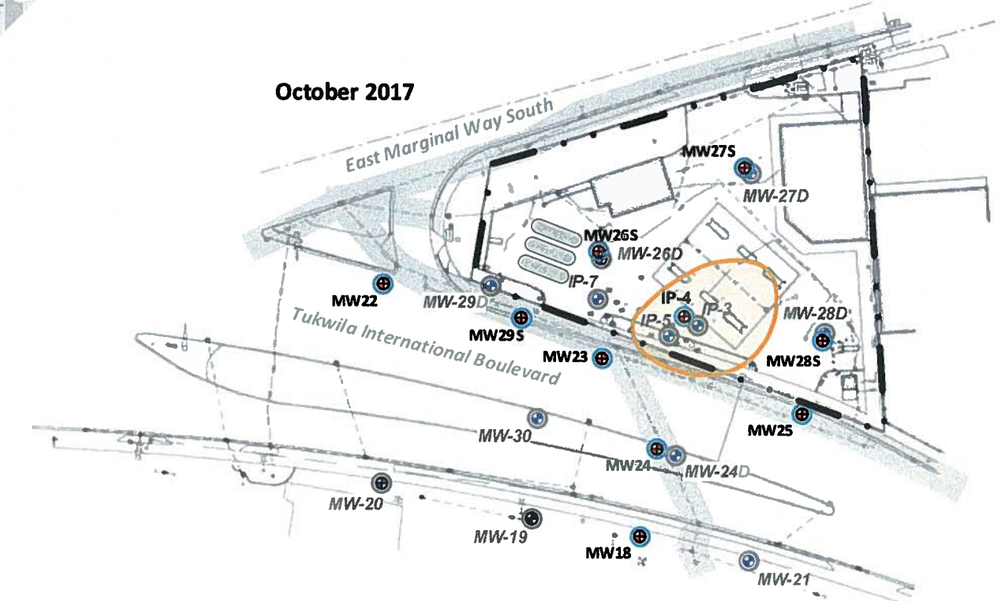


March 2017



July 2017

October 2017



Project File: 01-0410-M F7-1 Upper COCs Groundwater, 2016-2017.vsdx

g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Drawing not to Standard Scale

Mapping References: PLS Survey 2016 and Collected Analytical Data.

Upper Saturated Zone, Groundwater Samples, 2016-2017
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 7-1

Legend

MW-22 — Existing Monitoring Well (screened in the lower saturated zone)

MW-22 — Existing Monitoring Well (screened in the upper saturated zone)

GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)

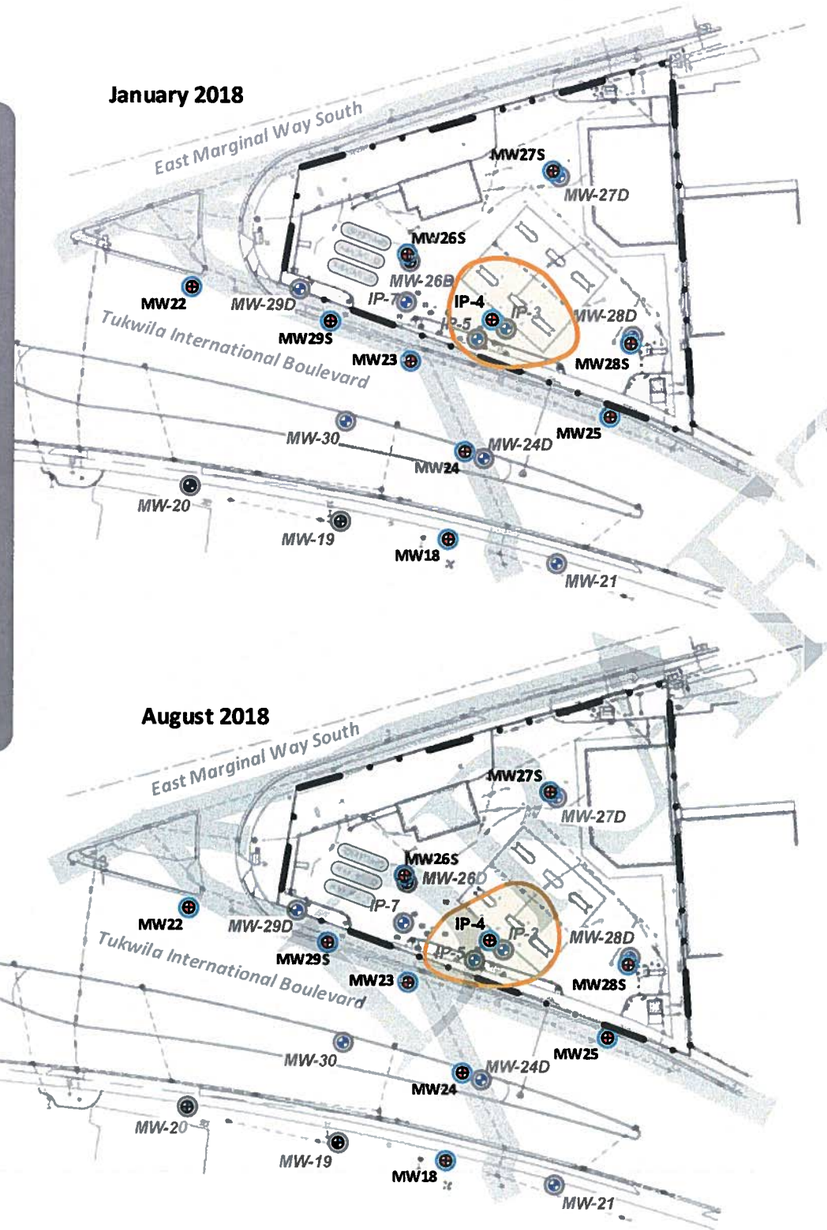
Property Boundary

Current UST Location (Approximate)

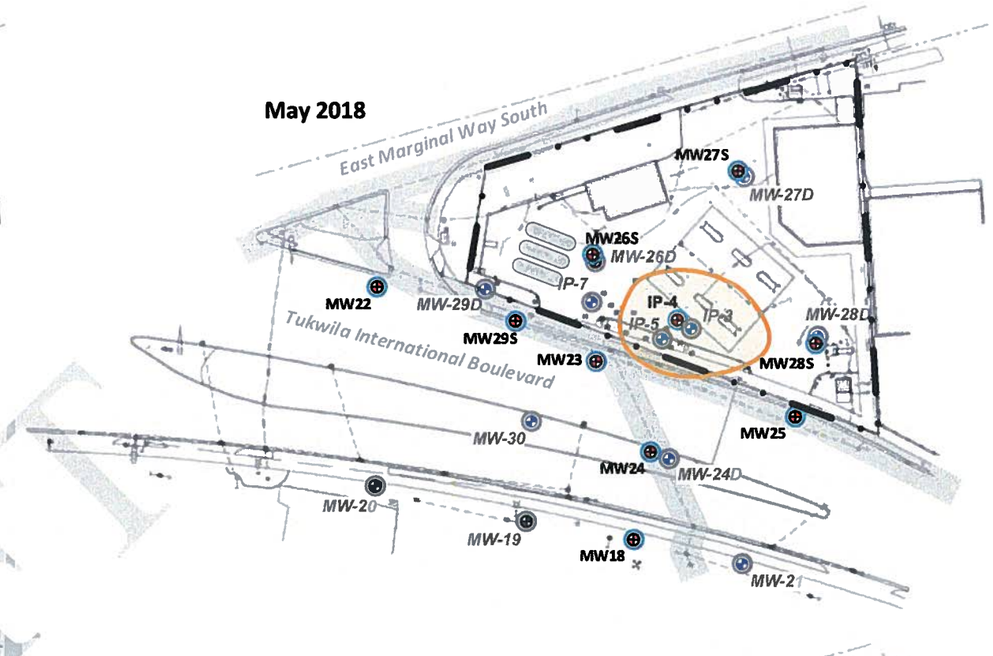
Approximate Utility Trench Locations (Adjacent to Property)

Note: Interpretations are based on analytical results , summarized in Tables 5-1 and 5-2.

January 2018

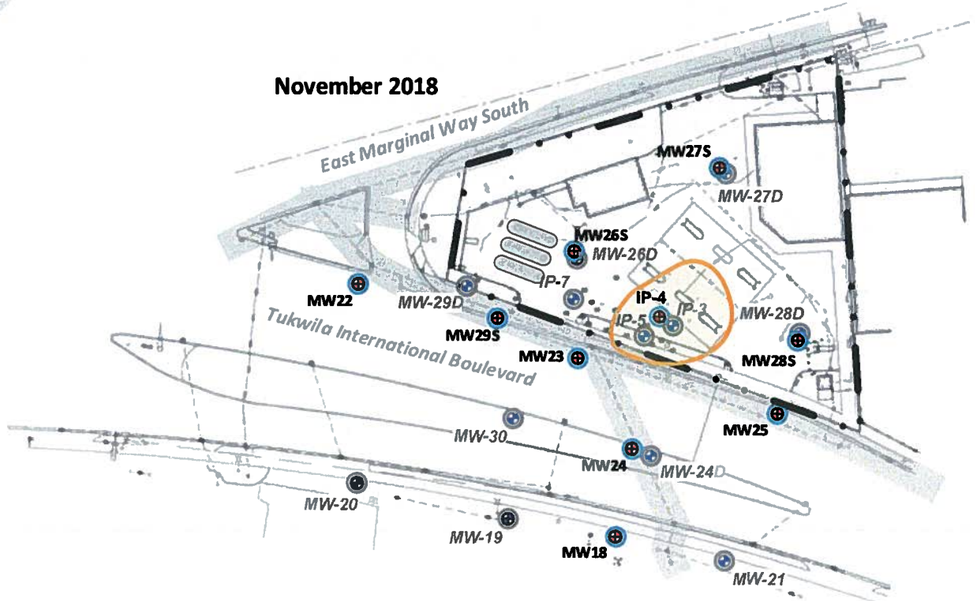


May 2018



August 2018

November 2018



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Drawing not to Standard Scale

Upper Saturated Zone, Groundwater Samples, 2018
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 7-2

Project File: 01-0410-M F7-2 Upper COCs Groundwater, 2018.vsdx

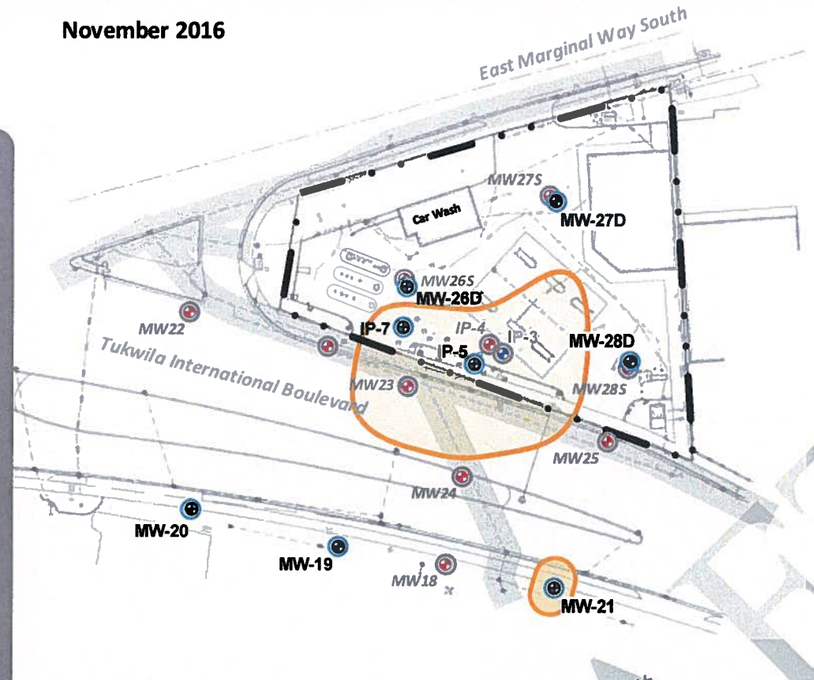
Mapping References: PLS Survey 2016 and Collected Analytical Data.

Legend

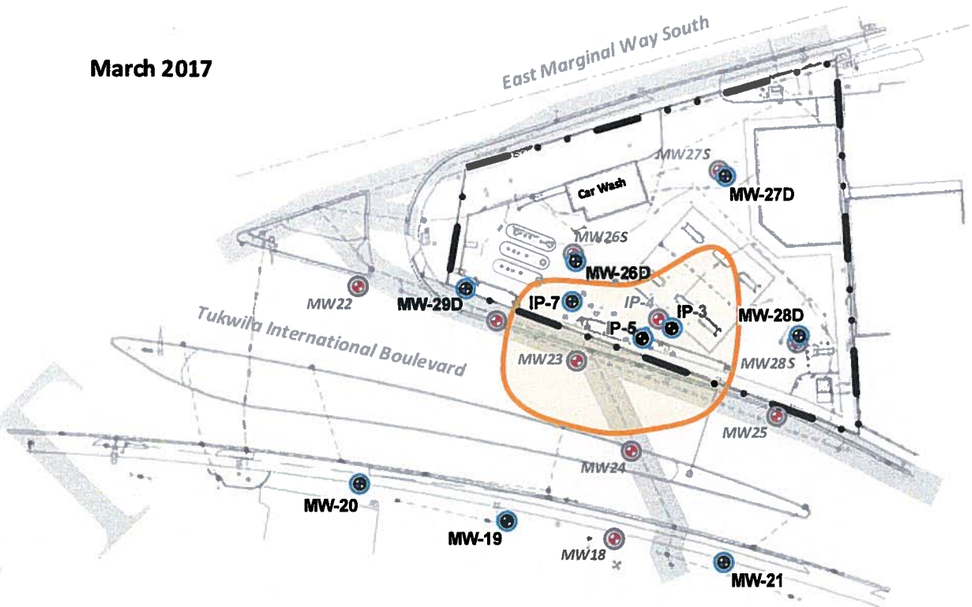
- **MW-28D** — Existing Monitoring Well (screened in the lower saturated zone)
- **MW-22** — Existing Monitoring Well (screened in the upper saturated zone)
- GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)
- Property Boundary
- Current UST Location (Approximate)
- Approximate Utility Trench Locations (Adjacent to Property)

Note: Interpretations are based on analytical results, summarized in Tables 5-1 and 5-2.

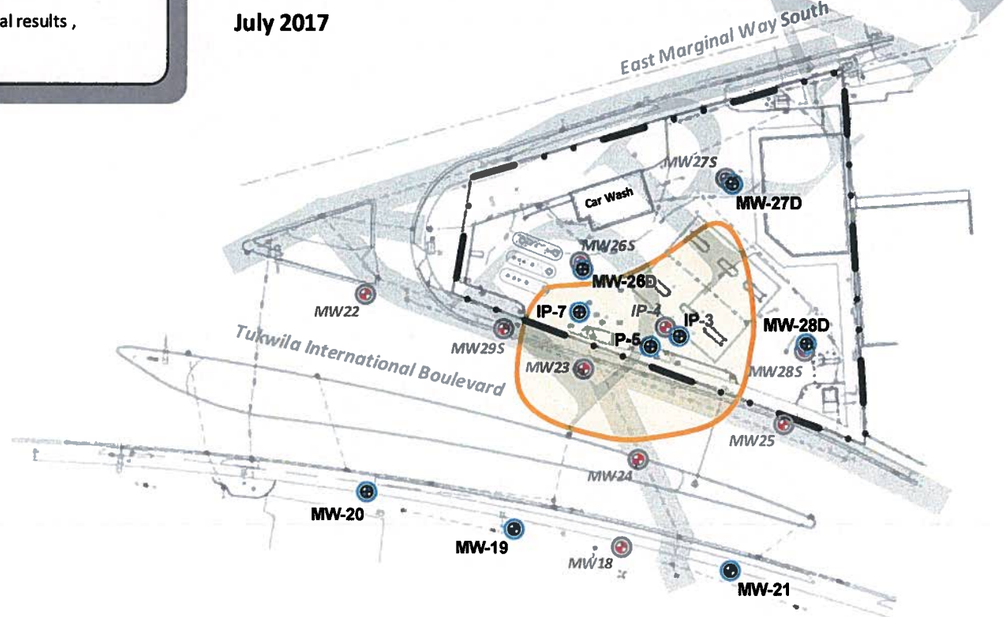
November 2016



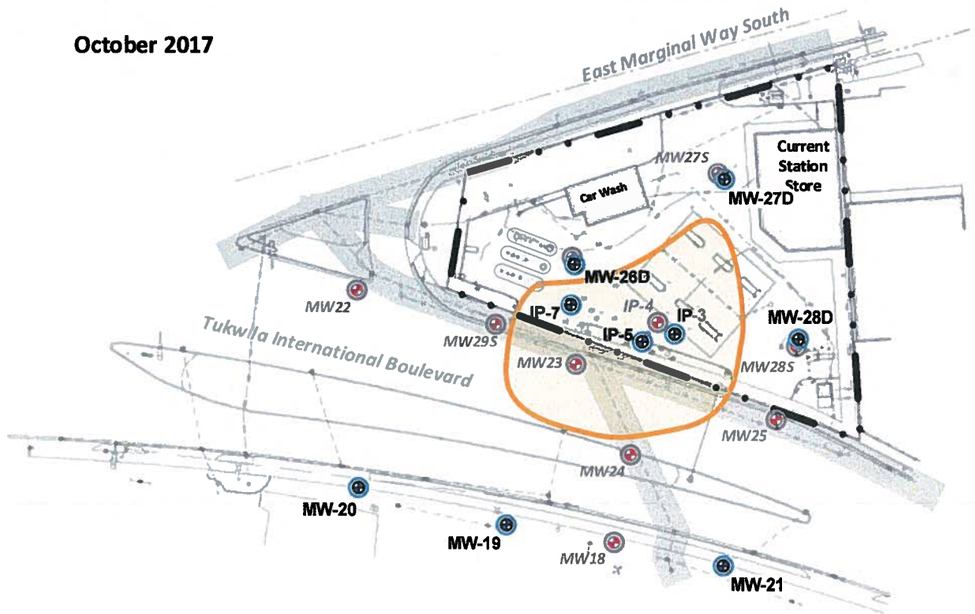
March 2017



July 2017



October 2017



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Drawing not to Standard Scale

Lower Saturated Zone, Groundwater Samples, 2016-2017
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 7-3

Project File: 01-0410-M F7-3 Lower COCs Groundwater, 2016-2017.vsdx

Mapping References: PLS Survey 2016 and Collected Analytical Data.

Legend

MW-22 — Existing Monitoring Well (screened in the upper saturated zone)

MW-22 — Existing Monitoring Well (screened in the lower saturated zone)

GRO/Benzene Detected Greater than Site Cleanup Levels (800/1.6 µg/L)

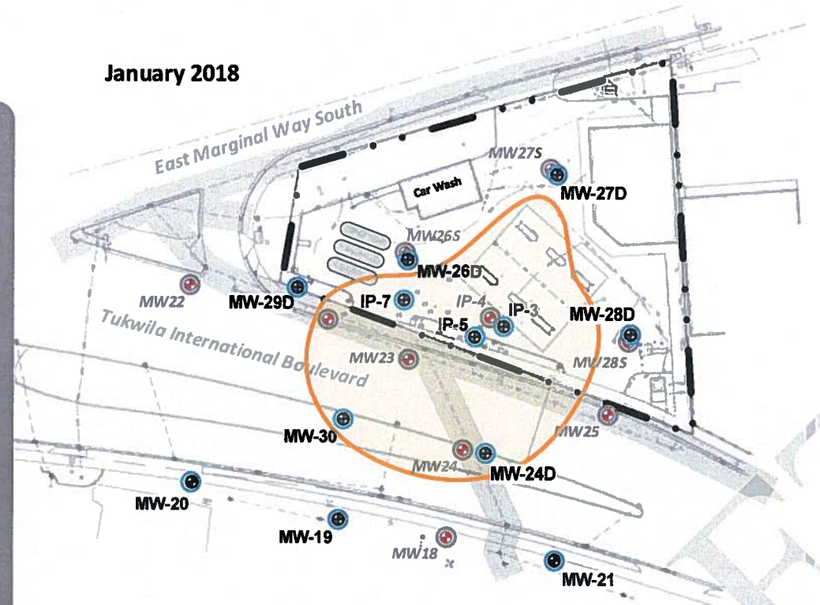
Property Boundary

Current UST Location (Approximate)

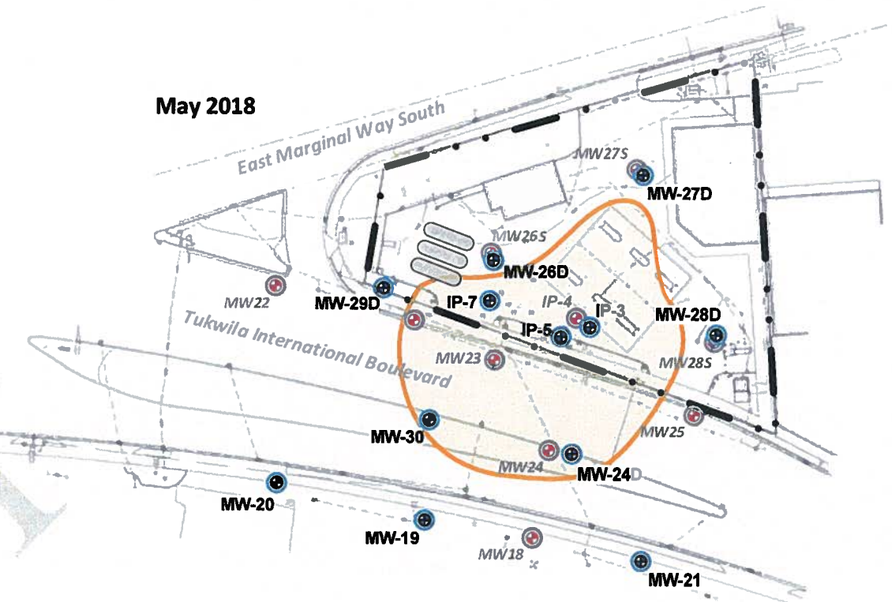
Approximate Utility Trench Locations (Adjacent to Property)

Note: Interpretations are based on analytical results , summarized in Tables 5-1 and 5-2.

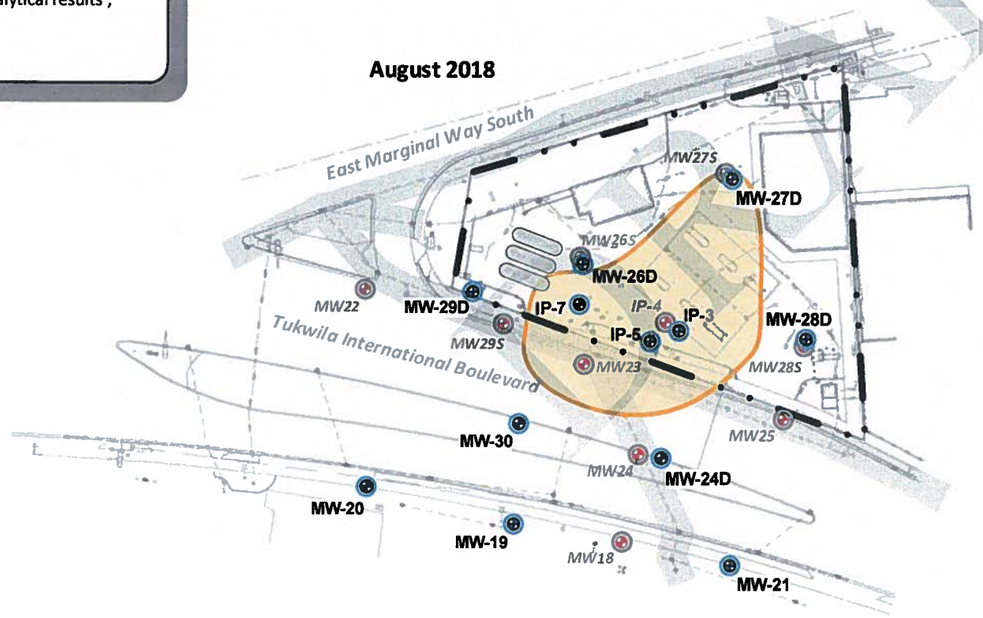
January 2018



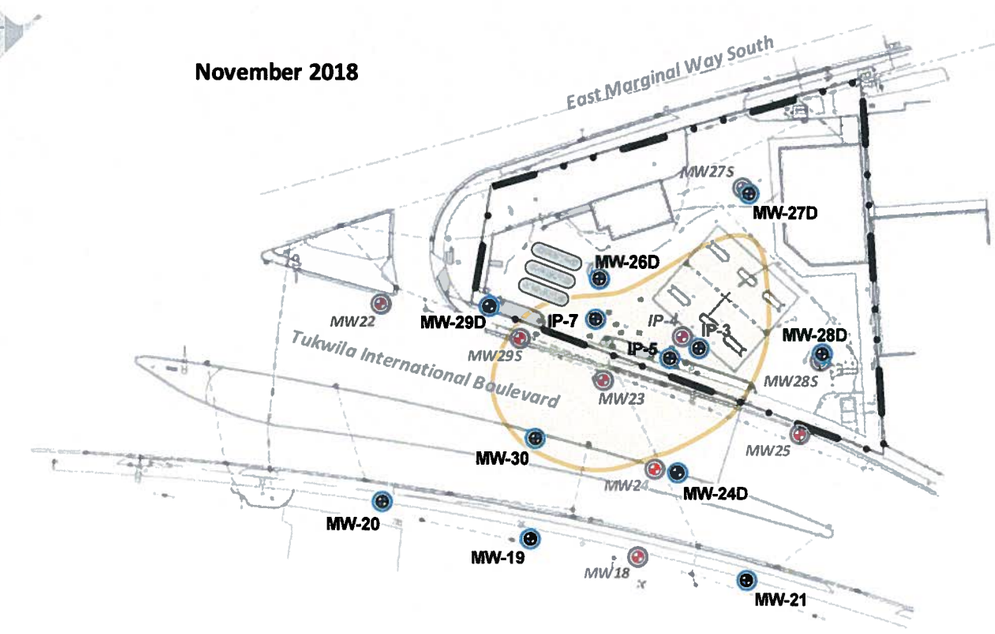
May 2018



August 2018



November 2018



g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Drawing not to Standard Scale

Lower Saturated Zone, Groundwater Samples, 2018
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 7-4

Project File: 01-0410-M F7-4 Lower COCs Groundwater, 2018.vsdx

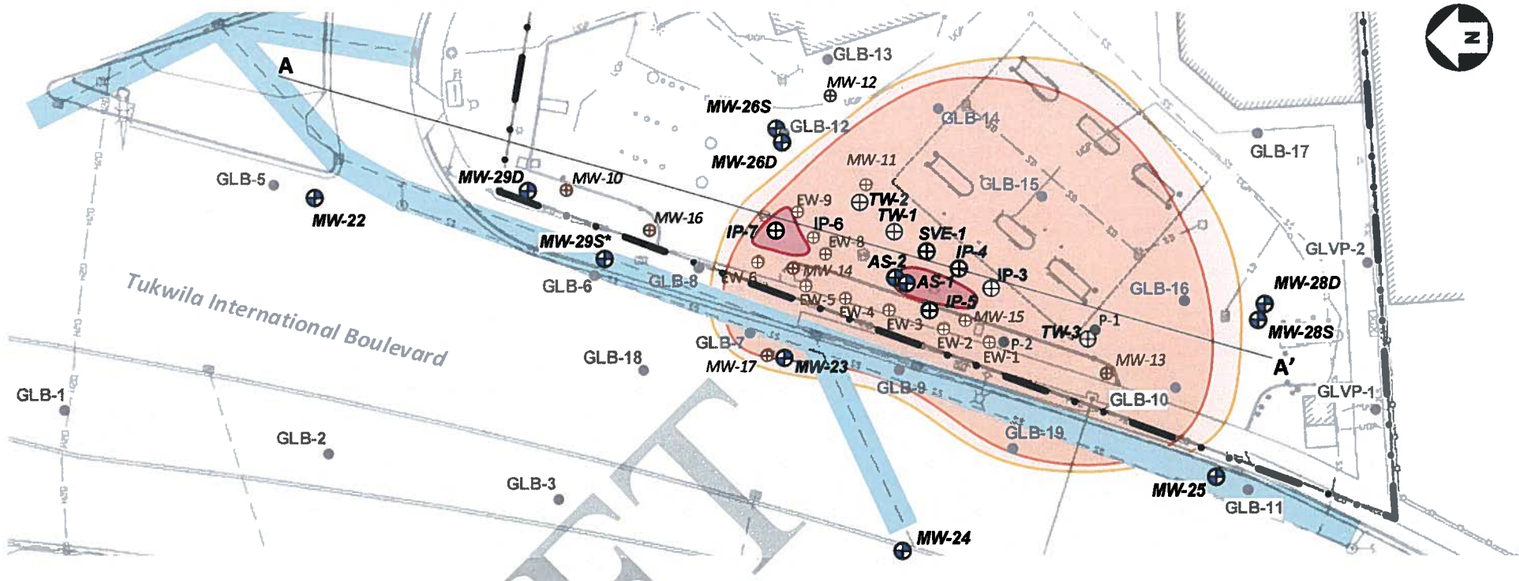
Mapping References: PLS Survey 2016 and Collected Analytical Data.

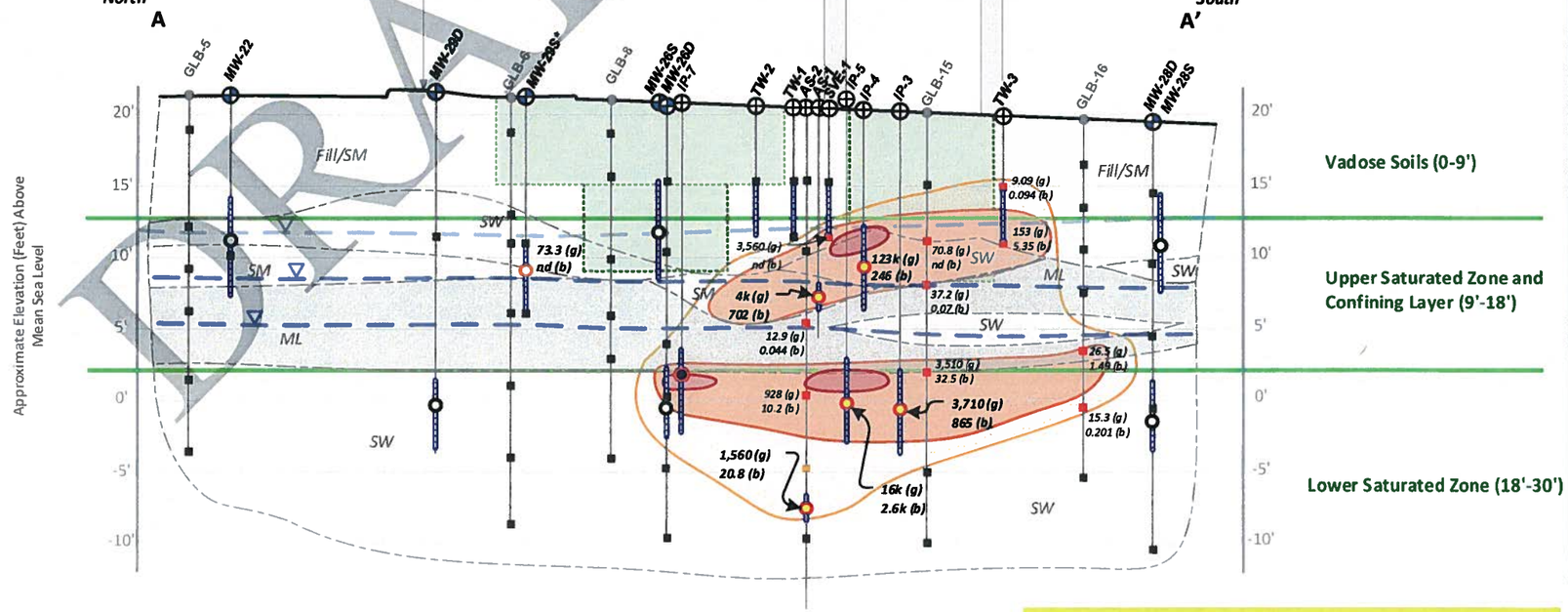
Legend

- **MW-22** — Monitoring Well (Installed 2016-2019)
- EW-2 — Monitoring Well (Decommissioned 2016)
- **EW-5** — Existing Site Exploration Location
- GLB-5 — Soil Boring (2016)
- GRO/Benzene Detected in Soil Greater than 30/0.03 mg/kg
- GRO/Benzene Detected in Soil Greater than 300/0.3 mg/kg
- Area of LNAPL, Understood
- Potentiometric Surface of Upper Water-Bearing Unit (Approximate)
- Potentiometric Surface of Lower Water-Bearing Unit (Approximate, shown at high and low tide)
- Property Boundary
- Approximate Extent of Historical Remedial Excavations/Fill (see Figures 2 and 3)
- Soil Sample, GRO/benzene not detected
- 12.9 (g) 0.044 (b) — Detected GRO (g) and benzene (b) concentrations in soil (mg/kg) above cleanup levels
- Groundwater Sample, GRO/benzene not detected
- Groundwater Sample, GRO/benzene concentrations present but less than cleanup levels
- 1,560 (g) 20.8 (b) — Groundwater Sample, GRO/benzene concentrations above MTCA cleanup levels
- Free product present in well
- Well Screen Interval

Note: Interpreted contours are based on available analytical data for soil samples collected between 2008 and 2019.

Groundwater analytical results from samples collected November 2018 and April 2019.





Note: Analytical results are summarized in Tables 4 and 5. Interpreted contaminant contours are based on available analytical data.

g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Vertical Drawing Scale: 1" = 10'
4X Vertical Exaggeration

Approximate Horizontal Drawing Scale: 1" = 40'
0 ft. 24 ft. 40 ft. 80 ft.

Cross-section A-A'
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

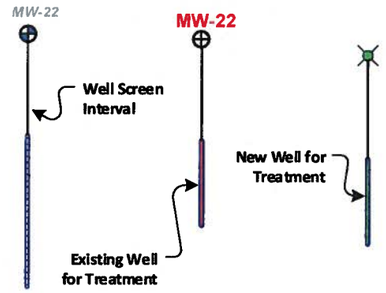
Figure 10-1

Project File: 01-0410-M F10-1 A-A.vsd

Mapping References: PLS Survey 2016, G-Logics Field Measurements, Compiled Data.

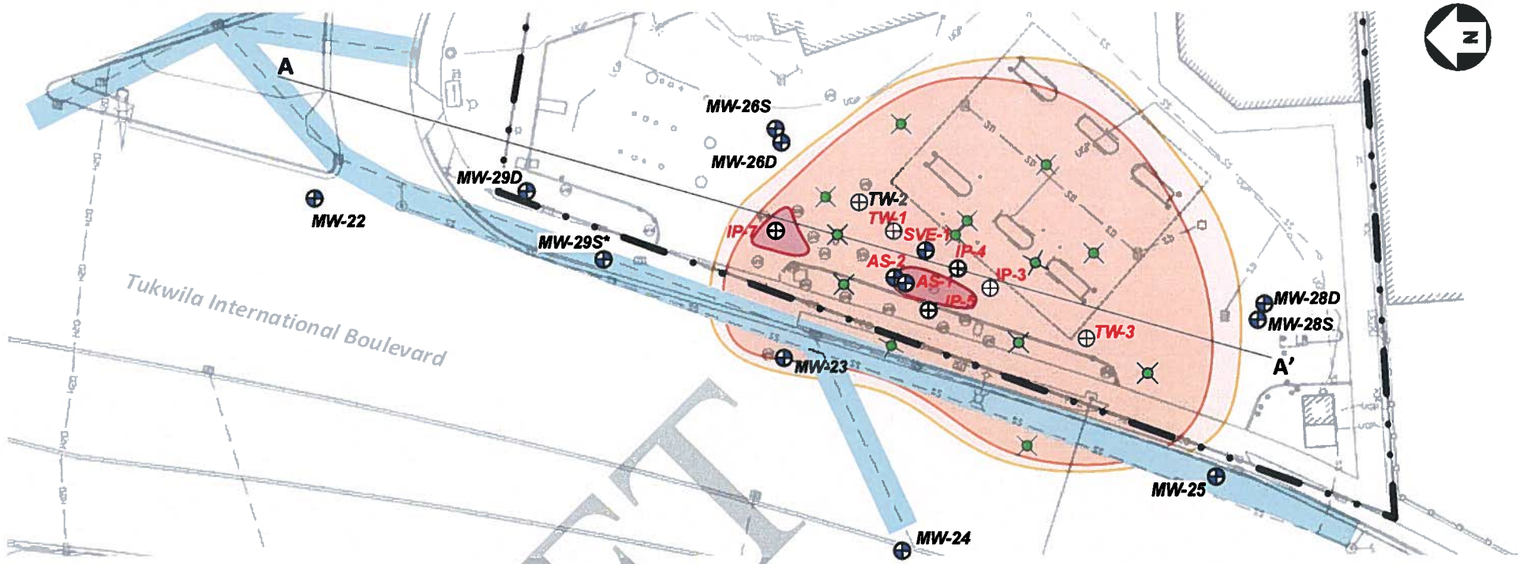
Legend

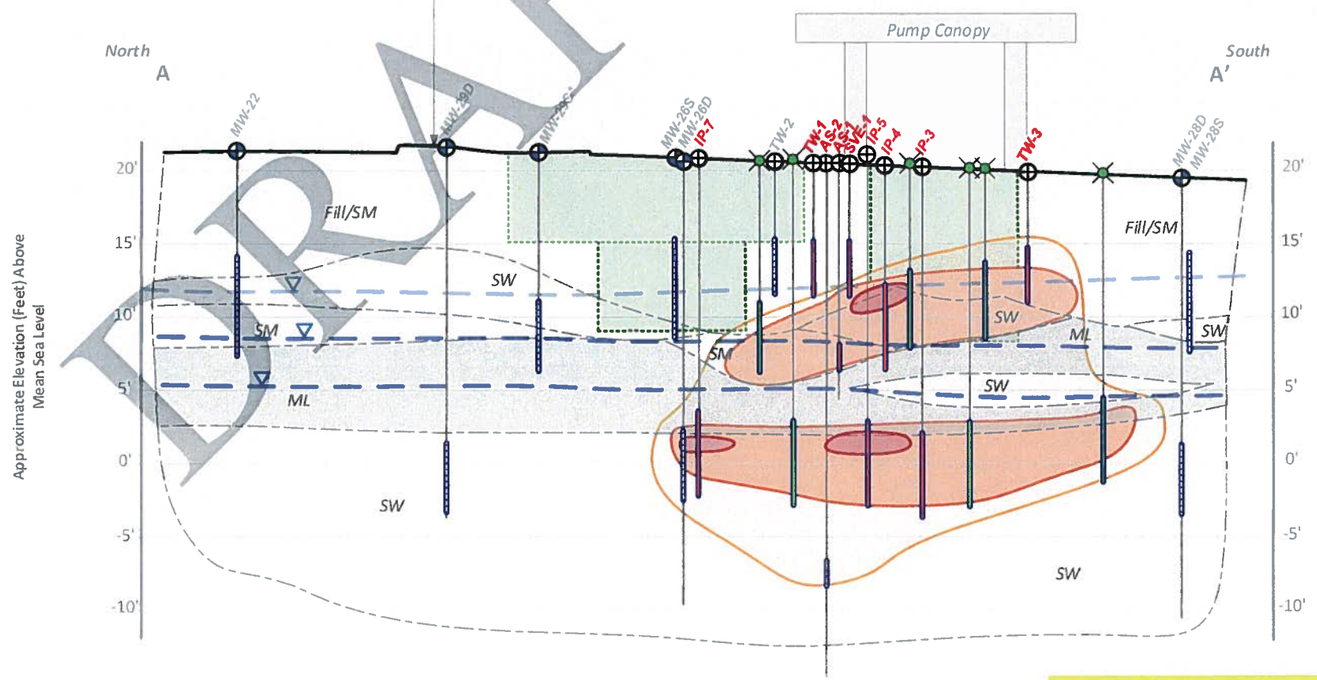
- **MW-22** — Monitoring Well (Installed 2016-2019)
- **EW-5** — Existing Site Exploration Location
- New Treatment Well
- GRO/Benzene Detected in Soil Greater than 30/0.03 mg/kg
- GRO/Benzene Detected in Soil Greater than 300/0.3 mg/kg
- Area of LNAPL, Understood
- Potentiometric Surface of Upper Water-Bearing Unit (Approximate)
- Potentiometric Surface of Lower Water-Bearing Unit (Approximate, shown at high and low tide)
- Property Boundary
- Approximate Extent of Historical Remedial Excavations/Fill (see Figures 2 and 3)



Note: Interpreted contours are based on available analytical data for soil samples collected between 2008 and 2019.

Groundwater analytical results from samples collected November 2018 and April 2019.





Note: Analytical results are summarized in Tables 4 and 5. Interpreted contaminant contours are based on available analytical data.

g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Approximate Vertical Drawing Scale: 1" = 10'
4X Vertical Exaggeration

Approximate Horizontal Drawing Scale: 1" = 40'
0 ft. 24 ft. 40 ft. 80 ft.

Cross-section A-A', Remediation Wells
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 10-1

Project File: 01-0410-M F10-1 A-A FS.vsd

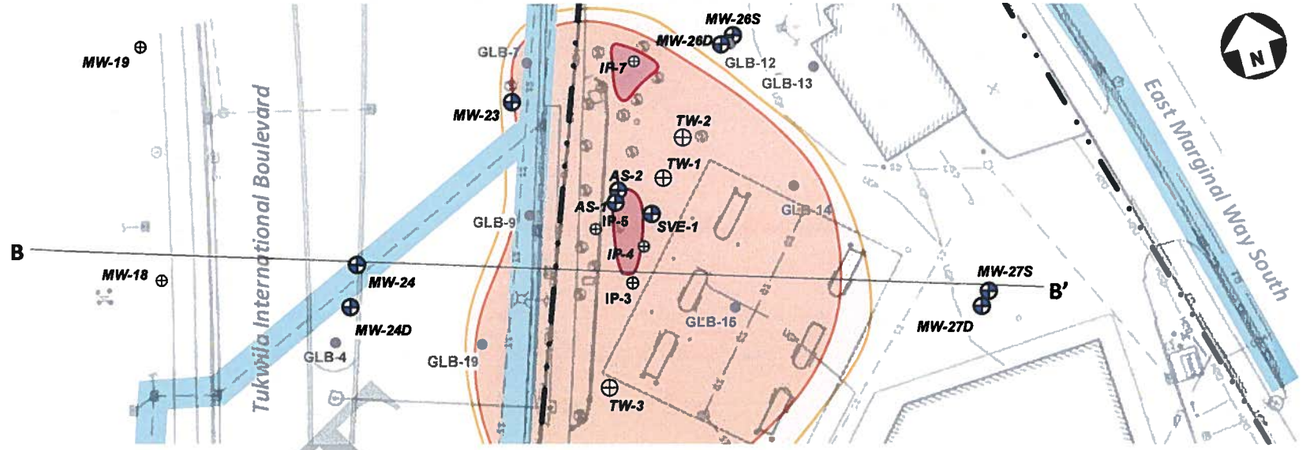
Mapping References: PLS Survey 2016, G-Logics Field Measurements, Compiled Data.

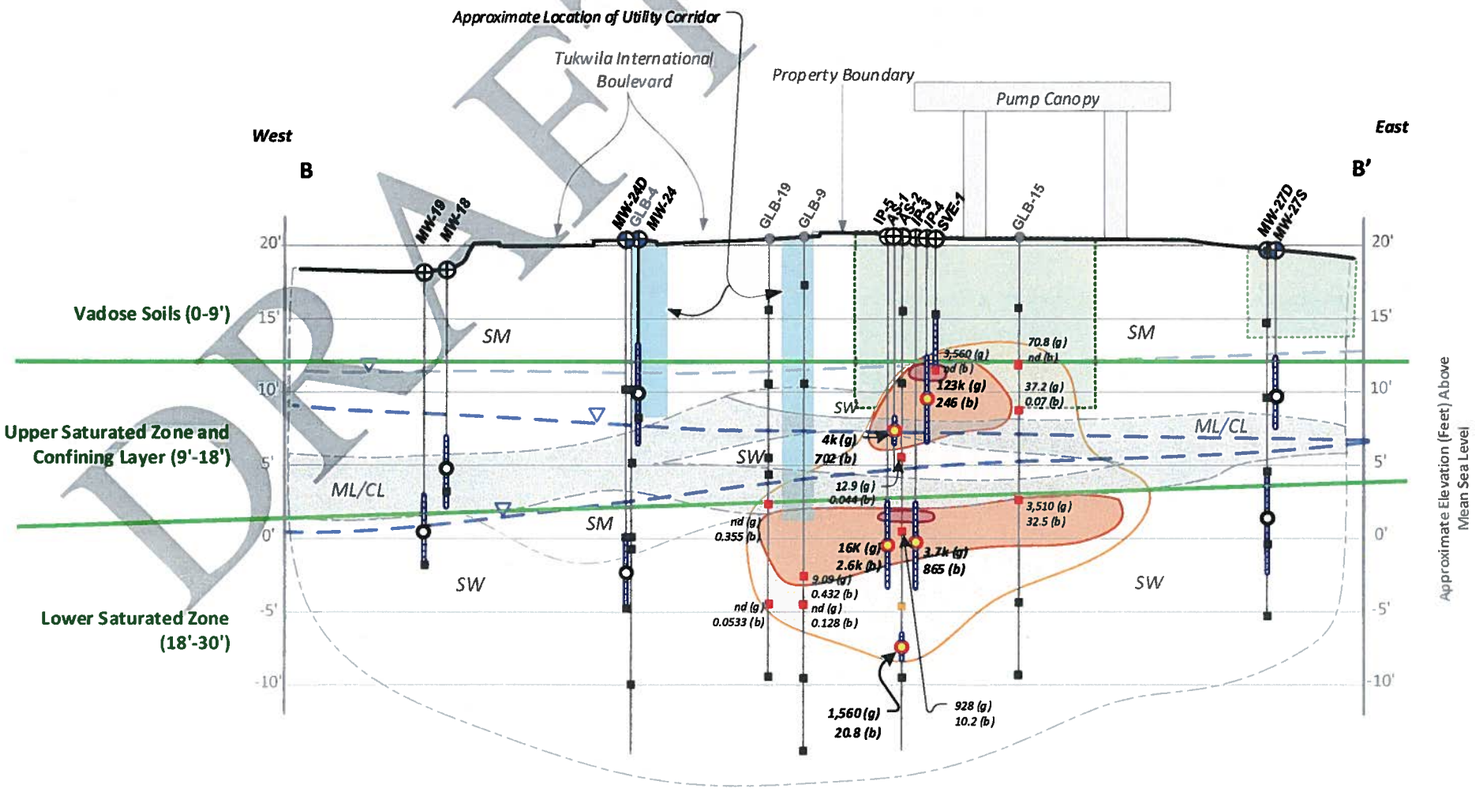
Legend

- **MW-22** — Monitoring Well (Installed 2016-2019)
- EW-2 — Monitoring Well (Decommissioned 2016)
- **EW-5** — Existing Site Exploration Location
- GLB-5 — Soil Boring (2016)
- GRO/Benzene Detected in Soil Greater than 30/0.03 mg/kg
- GRO/Benzene Detected in Soil Greater than 300/0.3 mg/kg
- Area of LNAPL, Understood
- Potentiometric Surface of Upper Water-Bearing Unit (Approximate)
- Potentiometric Surface of Lower Water-Bearing Unit (Approximate, shown at high and low tide)
- Property Boundary
- Approximate Extent of Historical Remedial Excavations/Fill (see Figures 2 and 3)
- Soil Sample, GRO/benzene not detected
- 12.9 (g) 0.044 (b) — Detected GRO (g) and benzene (b) concentrations in soil (mg/kg) above cleanup levels
- Groundwater Sample, GRO/benzene not detected
- Groundwater Sample, GRO/benzene concentrations present but less than cleanup levels
- 1,560 (g) 20.8 (b) — Groundwater Sample, GRO/benzene concentrations above MTCA cleanup levels
- Free product present in well
- Well Screen Interval

Note: Interpreted contours are based on available analytical data for soil samples collected between 2008 and 2019.

Groundwater analytical results from samples collected November 2018 and April 2019.





Note: Analytical results are summarized in Tables 4 and 5. Interpreted contaminant contours are based on available analytical data.

Approximate Vertical Drawing Scale: 1" = 10'
4X Vertical Exaggeration
Approximate Horizontal Drawing Scale: 1" = 40'
0 ft. 24 ft. 40 ft. 80 ft.

g-logics

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Cross Section B-B'

Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

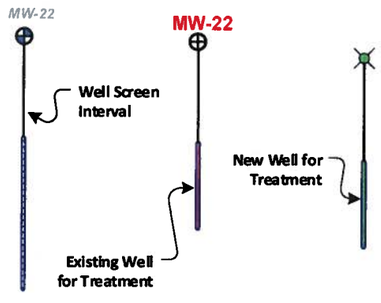
Figure 10-2

Project File: 01-0410-M F10-2 B-B.vsdx

Mapping References: PLS Survey 2016, G-Logics Field Measurements, Compiled Data.

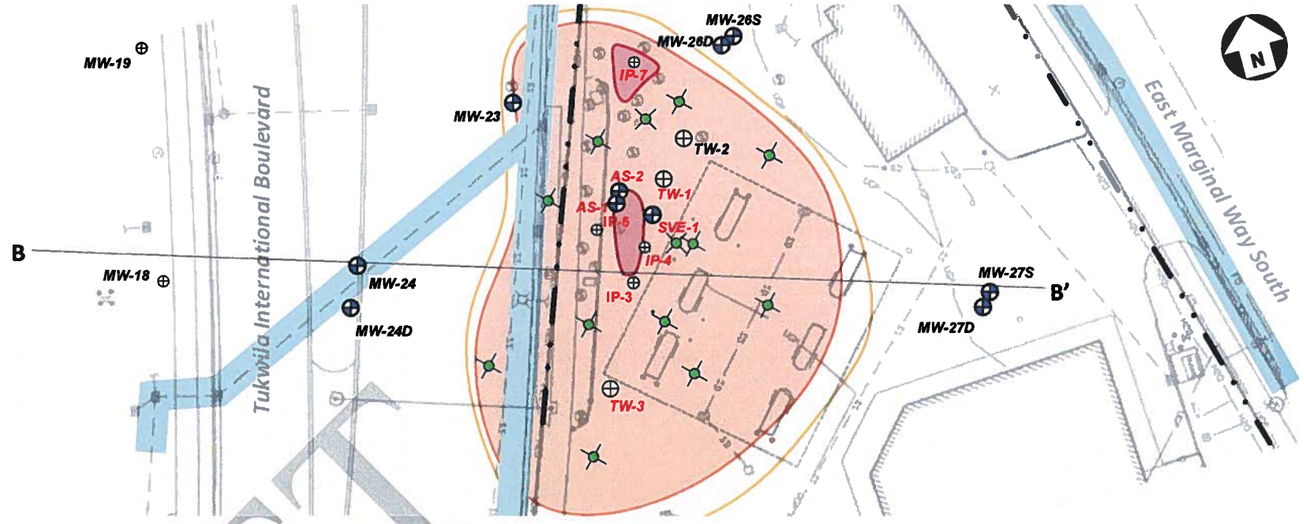
Legend

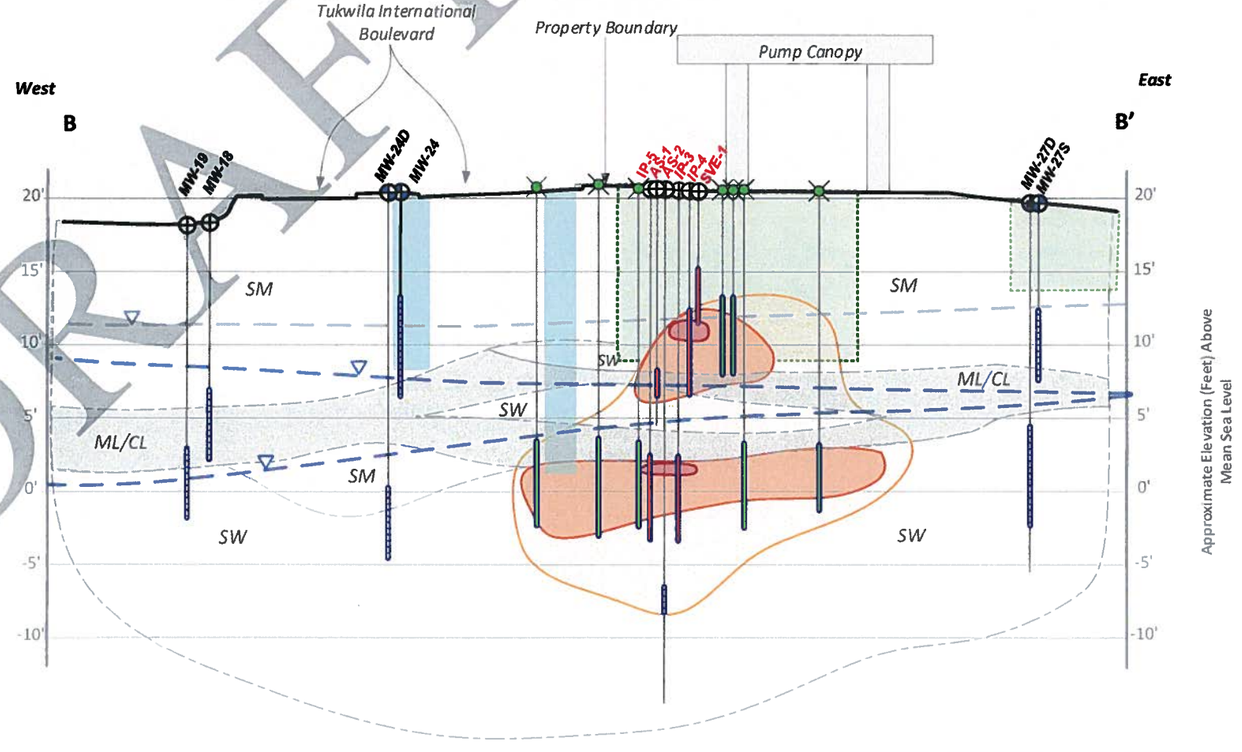
- **MW-22** — Monitoring Well (Installed 2016-2019)
- **EW-5** — Existing Site Exploration Location
- New Treatment Well
- GRO/Benzene Detected in Soil Greater than 30/0.03 mg/kg
- GRO/Benzene Detected in Soil Greater than 300/0.3 mg/kg
- Area of LNAPL, Understood
- Potentiometric Surface of Upper Water-Bearing Unit (Approximate)
- Potentiometric Surface of Lower Water-Bearing Unit (Approximate, shown at high and low tide)
- Property Boundary
- Approximate Extent of Historical Remedial Excavations/Fill (see Figures 2 and 3)



Note: Interpreted contours are based on available analytical data for soil samples collected between 2008 and 2019.

Groundwater analytical results from samples collected November 2018 and April 2019.





Note: Analytical results are summarized in Tables 4 and 5. Interpreted contaminant contours are based on available analytical data.

Approximate Vertical Drawing Scale: 1" = 10'
4X Vertical Exaggeration

Approximate Horizontal Drawing Scale: 1" = 40'
0 ft. 24 ft. 40 ft. 80 ft.

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

g-logics

Cross Section B-B', Remediation Wells
Boeing Field Chevron
10805 East Marginal Way South
Tukwila, Washington

Figure 10-2

Project File: 01-0410-M F10-2 B-B FS.vsdx

Mapping References: PLS Survey 2016, G-Logics Field Measurements, Compiled Data.

Legend

- GRO/Benzene Detected Greater than MTCA Method A Cleanup Levels (30/0.03 mg/kg)
- GRO/Benzene Detected Greater than 300/0.3 mg/kg
- Area of Possible LNAPL
- Property Boundary
- Current UST Location (Approximate)
- Approximate Utility Trench Locations (Adjacent to Property)

Note: Interpreted contours are based on available analytical data for soil samples collected between 2008 and 2019.

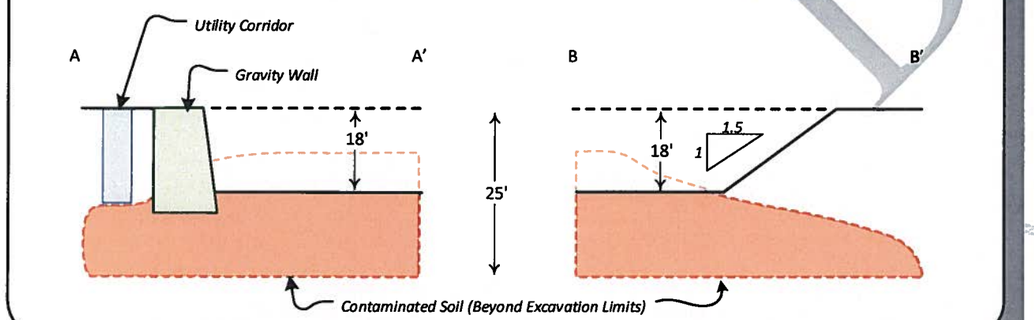
Edge of Excavation

Excavation Bottom

Gravity Wall

Tukwila International Boulevard

Schematic Excavation Cross-Sections



g-logics

Approximate Drawing Scale: 1" = 20'

0.0 in. 12 ft. 20 ft. 40 ft.

Note: This figure contains information in color. Black & white photocopies may not be suitable for review.

Hot Spot Excavation to 18' depth
Boeing Field Chevron
10805 E Marginal Way S
Tukwila, WA

Figure XX

Project File: 01-0410-M Excavation.vsdx

Mapping References: PLS Survey 2016, Tukwila Public Utility Documents, G-Logics Field Measurements, Previous Site Reports and Collected Analytical Data.

Table 9
Initial Evaluation of Remedial Actions and Technologies
Boeing Field Chevron
10805 E Marginal Way South

Remediation Option	Description	Advantages	Disadvantages	Further Consideration	Reason for Not Considering Further
No Action	Perform no remedial action.	No additional administrative or physical-work expenses.	Limited property use, possible elevated health risk.	No	Active remediation is required by MTCA.
Containment and Institutional Controls	Possible land-use restrictions, such as fencing, signage, deed restrictions, engineering controls and/or title restrictions, are required to minimize exposure pathways.	Easy to implement for owned property, low costs, minimal disruption to existing land uses. Can be used to support/supplement active remediation methods.	Not a permanent solution, less preferable MTCA Cleanup. May not be applicable for off-property areas. May require completion of active remedial methods first.	Yes	—
Monitored Natural Attenuation (MNA)	Monitoring the reduction of contaminants by natural processes, such as volatilization, dispersion, and natural biodegradation.	Low costs, minimal disruption to site operations, easy to implement. Applicable for off-property areas. Can be used to support/supplement active remediation methods.	Less preferable under MTCA. MNA may require multiple years to achieve cleanup levels. May require completion of active remedial methods first.	Yes	—
Excavation with Off-Site Disposal	Excavation of contaminated soils, with disposal at an off-site landfill for final disposal (or possible treatment and disposal).	For shallow soils, excavation is relatively easy to implement and contaminant removal is easy to document. Regulatory-agency acceptance also can be quickly obtained. Permanent and rapid solution for soil contamination. By removing the secondary source (soil), this method reduces the volume of contaminants possibly entering the groundwater.	Deeper excavations could require sloping/shoring to access contaminated soil. Excavation costs increase with depth. Excavation of all contaminated soil may not be possible given site constraints. Also may not actively address dissolved-phase contaminants in the groundwater.	Yes	—
In-situ Carbon Sorption	Activated carbon particles are injected into the subsurface. Contaminants are adsorbed onto the activated carbon particles for immediate mass-reduction and plume control. Carbon sorption is typically combined with chemical oxidation or bioremediation to further degrade contaminants.	Treatment can occur without significant disruption to surface improvements. Can be used to slow plume migration and reduce size of groundwater-contaminant plume. Can be injected at relatively low pressures. Does not generate water or soils for additional management/disposal.	Not effective as a stand-alone remedial method. Typically must be used in combination with other in-situ technologies, such as bioremediation.	Yes	—
In-situ Chemical Oxidation	Contaminant decomposition is accomplished in-situ with the addition of a chemical oxidant. Various oxidants exist, which can be used to suit site-specific conditions.	Treatment can occur without significant disruption to surface improvements. Can be injected at relatively low pressures. Does not generate water or soils for additional management/disposal.	Requires monitoring and works best with optimization of geochemical parameters. Dissolved contaminant concentrations may rebound following treatment. Applying chemical oxidants may present significant health and safety concerns. Chemical oxidants can react with organic soil material rather than organic contaminants.	Yes	

Table 9
Initial Evaluation of Remedial Actions and Technologies
Boeing Field Chevron
10805 E Marginal Way South

Remediation Option	Description	Advantages	Disadvantages	Further Consideration	Reason for Not Considering Further
In-situ Bioremediation	In-situ biological processes are enhanced with the addition of an amendment mixture and possibly bacteria. The amendment is designed to increase microbial activity (anaerobic or aerobic) and ultimately promote the degradation of site contaminants.	Treatment can occur without significant disruption to surface improvements. Amendment used to enhance microbial activity generally safe to handle. Treatment can be combined with other alternative methods.	Requires monitoring and works best with optimization of geochemical parameters. Requires a relatively continuous source of oxygen. Microbial growth may foul treatment-system equipment.	Yes	—
In-situ Bioremediation, with Oxygen Diffusion	In-situ biological processes are enhanced with the diffusion of oxygen into the groundwater. The oxygen is designed to increase microbial activity (aerobic) and ultimately promote the degradation of site contaminants.	Air diffusion is easy to implement if soil types, groundwater depth, and contaminant properties are suitable. This technology also presents low risks to construction and on-site workers. Other electron receptors and amendments can be introduced using the same equipment.	Requires treatment structures/facilities to be in place, monitoring, and maintenance of equipment. Site-specific conditions may limit the effectiveness of diffusion.	Yes	—
In-situ Thermal Remediation	Heat is applied to the subsurface (various methods) to volatilize/mobilize organic contaminants. Extraction wells capture contaminants in vapor/water/NAPL phases, which are treated ex-situ. Typically used as a source-area treatment.	Highly effective in mobilizing a larger quantity organic contaminants for extraction. Very short duration for operation, after initial startup. Can treat NAPL source areas and areas with high concentration of contaminants. More permanent solution for source-area contamination.	Requires significant surface and subsurface construction. Very expensive remedy (special equipment, electricity demands, construction, extensive permitting).	No	Existing site infrastructure precludes installation/operation of thermal remediation system.
Soil-Vapor Extraction (SVE)	Air is drawn through contaminated soils in the vadose zone, causing the volatilization and removal of contaminants. Reduces concentrations of contaminants possibly entering groundwater. Reduces the likelihood of vapor intrusion into overlying buildings.	Vapor extraction is easy to implement if soil types, groundwater depth, and contaminant properties are suitable. Can mitigate possible soil-vapor intrusion concerns. This technology also presents lower risks to construction and on-site workers. Can introduce oxygen to vadose soils, enhancing bio-degradation of contaminants.	Requires treatment structures/facilities to be in place, with ongoing maintenance, and monitoring. Requires electricity, noise considerations. Extracted water requires treatment/disposal. Contaminants are not destroyed but are transferred to the atmosphere (if not treated). Requires possible permits/treatments if discharge concentrations are high.	Yes	—
Air Sparging (AS)	Air is injected into the groundwater, causing volatilization of dissolved contaminants, which diffuse into the vadose zone.	Air sparging is easy to implement if soil types, groundwater depth, and contaminant properties are suitable. This technology also presents lower risks to construction and on-site workers.	Requires treatment structures/facilities to be in place, monitoring, and maintenance of equipment. Requires electricity, noise considerations. Site-specific conditions may limit the effectiveness of sparging.	No	Sparging in the upper zone has been tested and was found to be less effective due to limited groundwater. Sparging in the lower zone also has been tested and also found to be less effective due to the presence of a confining layer, possibly resulting in contaminant migration and un-recoverable vapors.

Table 9
Initial Evaluation of Remedial Actions and Technologies
Boeing Field Chevron
10805 E Marginal Way South

Remediation Option	Description	Advantages	Disadvantages	Further Consideration	Reason for Not Considering Further
Dual-Phase Extraction (DPE)	Groundwater extraction is used to lower the water table below the contaminated-soil zone. Removed water is treated/discharged. Volatile components in the expanded vadose zone are removed by air pulled through the subsurface (by SVE). Groundwater and soil-vapor extraction are both acheived by using the same equipment.	Site contaminants are removed from the subsurface, increased area of remedial influence, and decrease of contaminant migration. Can target inaccessible areas.	Requires treatment structures/facilities to be in place, with ongoing maintenance and monitoring. Requires electricity, noise considerations. Extracted water requires treatment/disposal. Contaminants are not destroyed,but are transferred to the atmosphere (if not treated). Requires possible permits/treatments if discharge concentrations are high.	Yes	---
Multi-Phase Extraction (MPE)	Similar to DPE (described above), however groundwater is extracted using dedicated pumps.	Site contaminants are removed from the subsurface, increased area of remedial influence, and decrease of contaminant migration. Can target inaccessible areas.	Requires treatment structures/facilities to be in place, with ongoing maintenance and monitoring. Requires electricity, noise considerations. Extracted water requires treatment/disposal. Contaminants are not destroyed but are transferred to the atmosphere (if not treated). Requires possible permits/treatments if discharge concentrations are high.	No	Offers no appreciable advantage over DPE, but requires additional equipment. The anticipated volume of water to be generated is not enough to justify dedicated groundwater pumps.
Groundwater Pump and Treat	Pumps are used to remove groundwater and contaminants from the subsurface. Removed water is treated and discharged. Alternatively, removed water can be treated and reintroduced into the subsurface.	Groundwater extraction can create cone of depression, reducing contaminant migration. Can target inaccessible areas.	Groundwater pump-and-treat does not address soil contaminants. Requires treatment structures/facilities to be in place, with ongoing maintenance and monitoring. Aquifers with high-recharge rates require a high pumping rates. Large volumes of contaminated water would be generated and would require treatment and/or disposal. Effectiveness may be limited in tidally-influenced aquifers.	Yes	---
Surfactant Treatment and LNAPL Extraction	LNAPL is removed from affected wells during short-term extraction events (via mobile vacuum-truck or other temporary method). Prior to extraction, a surfactant is applied to the subject well in order to temporarily increase the mobility of residual LNAPL in the saturated soil, enhancing the effectiveness of LNAPL recovery.	Treatment can occur without significant disruption to surface improvements. Rapid to implement. Surfactant can be introduced at relatively low pressures (via gravity feed). Several low-cost, commercially-available surfactants are fomulated for use with petroleum hydrocarbons. Additionally, many are non-toxic, food-grade, non-ionic, and biodegradable.	Does not address dissolved contaminant concentrations. Single-well surfactant treatment is a relatively new method. Accordingly, regulatory approval can be difficult to obtain.	Yes	---

Table 10
Secondary Evaluation of Remedial Actions and Technologies
Boeing Field Chevron
10805 E Marginal Way South

Remediation Option	Likely Success	Ease of Execution	Relative Cost	Evaluation Total	Retained for DCA	Discussion
Engineering and Institutional Controls	1	5	5	11	Yes	Retained after active remediation efforts have been completed.
Monitored Natural Attenuation (MNA)	1	5	5	11	Yes	Retained after active remediation efforts have been completed.
Vadose Zone Excavation with Off-Site Disposal	1	3	2	6	No	Soils shallower than 9 feet below the ground surface (vadose zone) are not significantly contaminated to justify excavation to the top of the upper saturated zone (see cross-sections and Figure 5-2). G-Logics has a preliminary estimate of $1M for removal of site-features, excavation and disposal of 6,000 tons of PCS, and reconstruction of site features. This estimate does not include sampling, documentation, reporting, and agency review.
Hot-Spot Excavation with Off-Site Disposal	3	2	2	7	Yes	G-Logics has an contractor estimate of approximately $1.3M to excavate to a depth of 18' in areas of highest contaminant concentrations on the Property. Additional treatment methods likely will be necessary in lateral and deeper unexcavated areas. Excavating through the confining layer could result in unintended consequences.
Site-Wide Excavation with Off-Site Disposal	4	1	1	6	No	Excavation of shallow and deeper soils, extending into Tukwila International Boulevard and beneath the existing canopy area, would be prohibitively expensive. G-Logics has an initial contractor estimate of approximately $3M to excavate to the depth of contamination on Property. Similar excavation off-Property, beneath roadways, to the same depth, would be at least $10M. Additionally, this alternative would be very disruptive to local businesses, utilities, traffic, etc., and would present a safety concern to workers and the general public. Excavating through the confining layer could result in unintended consequences.

Table 10
Secondary Evaluation of Remedial Actions and Technologies
Boeing Field Chevron
10805 E Marginal Way South

Remediation Option	Likely Success	Ease of Execution	Relative Cost	Evaluation Total	Retained for DCA	Discussion
Upper Saturated Zone, In-Situ Carbon Sorption	1	3	2	6	No	Groundwater data, collected from 2004 through 2019, indicate that the contaminant plume in the upper saturated zone is not migrating. Application of this material would not significantly aid the reduction of contaminant concentrations.
Lower Saturated Zone, In-Situ Carbon Sorption	1	3	2	6	No	Groundwater data, collected from 2004 through 2019, indicate that the contaminant plume in the upper saturated zone is not migrating. Application of this material would not significantly aid the reduction of contaminant concentrations.
Lower Saturated Zone, In-Situ Chemical Oxidation	3	3	3	9	Yes	Prior use of Fenton's Reagent proved to be effective in reducing area of plume and extent of LNAPL.
Upper Saturated Zone, In-Situ Bioremediation with Oxygen Diffusion	1	4	2	7	No	Retained for secondary purposes.
Lower Saturated Zone, In-Situ Bioremediation with Oxygen Diffusion	1	4	2	7	No	Retained for secondary purposes.
Upper Saturated Zone, Soil-Vapor Extraction (SVE)	1	3	3	7	No	SVE addresses soil and soil-gas contaminants located within the vadose zone. The majority of contaminant mass is located within the two saturated zones. Accordingly, this technology would not address the majority of Site contaminants.
Lower Saturated Zone, Soil-Vapor Extraction (SVE)	1	1	1	3	No	Lower Zone SVE would be ineffective due to water-saturated sediments.
Upper Saturated Zone Dual-Phase Extraction (DPE)	5	3	3	11	Yes	Recent pilot test demonstrated that this technology is applicable.

Table 10
Secondary Evaluation of Remedial Actions and Technologies
Boeing Field Chevron
10805 E Marginal Way South

Remediation Option	Likely Success	Ease of Execution	Relative Cost	Evaluation Total	Retained for DCA	Discussion
Lower Saturated Zone, Dual-Phase Extraction (DPE)	1	1	1	3	No	Lower Zone DPE would be ineffective and expensive due to significant groundwater removal and recharge.
Upper and Lower Saturated Zones, Groundwater Pump and Treat, On-Site Recharge	1	1	1	3	No	Small volumes of groundwater in the upper saturated zone would limit the effectiveness of water extraction and treatment. For the lower saturated zone, significant volumes of groundwater would be removed. Additionally, the water table in the lower zone is tidally influenced, making "upgradient re-injection" of treated water difficult to achieve and monitor. Technologically, pump and treat has not been found to be effective for LNAPL removal.
Upper and Lower Saturated Zones, Surfactant Treatment and LNAPL Extraction	3	3	4	10	Yes	Technology case studies indicate that single-well surfactant treatment is an applicable treatment method for limited volumes of LNAPL.

Remedial options are screened on a scale of 1 to 5, as described below. Evaluation totals of 7 or greater are retained for DCA review.

1 - Very unlikely to succeed, very difficult to implement, and very expensive.
3 - Somewhat likely to succeed, somewhat difficult, relatively expensive.
5 - Very likely to succeed, easy to implement, and relatively inexpensive.

Success is defined as significantly reducing Site contaminant concentrations to below remediation levels (as defined in the text).
Ease of execution considers the complexity of the task and likelihood of disruption to normal Site activities.
Relative cost is based on the comparison of each treatment alternative, given specific Site conditions and contaminants.

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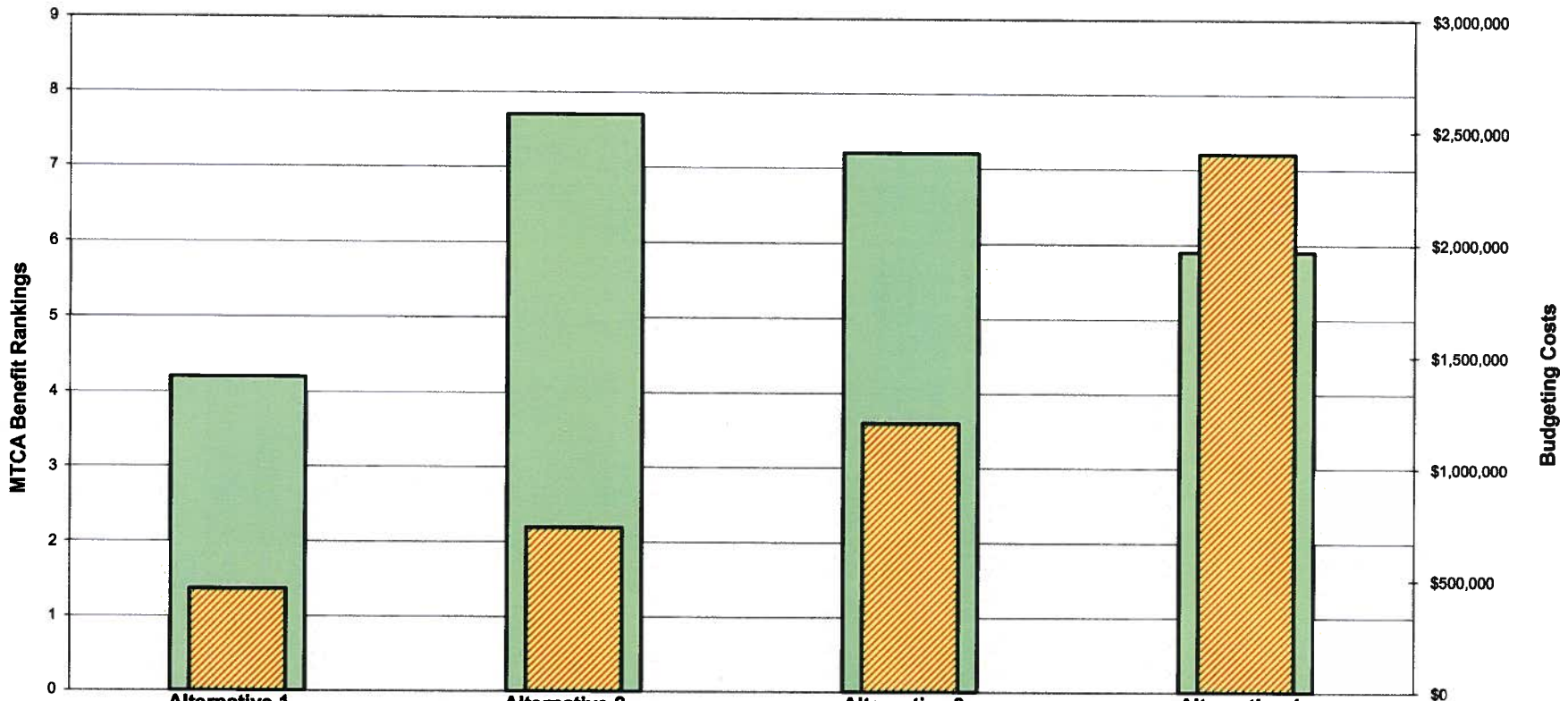
Graph 1, Disproportionate Cost Analysis



	Alternative 1, Surfactant, LNAPL Extraction, Engineering and Institutional Controls (E&IC) and MNA	Alternative 2, Surfactant, LNAPL Extraction, ISCO, E&IC, and MNA	Alternative 3, Surfactant, LNAPL Extraction, DPE (upper zone), ISCO (lower zone), E&IC, and MNA	Alternative 4, Focused Excavation with Off-Site Disposal (upper zone), ISCO (lower zone), E&IC, and MNA
Rank	4.2	7.7	7.2	5.9
Cost	$455,000	$730,000	$1,200,000	$2,400,000

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Table X

Detailed Evaluation of Cleanup Action Alternatives and DCA
Boeing Field Chevron
10805 E Marginal Way S, Tukwila, WA

Alternative	Alternative 1, Surfactant, LNAPL Extraction, Engineering and Institutional Controls (E&IC) and MNA			Alternative 2, Surfactant, LNAPL Extraction, ISCO, E&IC, and MNA		
Compliance with MTCA Threshold and Other Criteria						
Protection of Human Health and the Environment	Alternative will provide protection for human health and the environment if the identified restrictions are followed. Assumes contaminant concentrations will attenuate below identified cleanup levels.			Alternative can protect human health and the environment.		
Compliance with Cleanup Standards	Without the removal of elevated contaminant concentrations via any method, this alternative does not comply with Cleanup Standards.			Active remedial methods can be used to address contaminated-environmental media in order to comply with cleanup standards.		
Compliance with Applicable State and Federal Laws	Individually, alternative does not comply with cleanup requirements under MTCA.			Alternative can be designed to comply with applicable laws.		
Provision for Compliance Monitoring	Alternative includes provisions for compliance monitoring (e.g., groundwater sampling).			Alternative can include provisions for compliance monitoring (e.g., soil, groundwater, and soil-gas sampling).		
Restoration Time Frame	Six to twelve months for recording of Institutional Controls. Engineering and Institutional Controls would need to be maintained for indefinite number of years until contaminant concentrations at the entire Site degrade below identified cleanup levels.			Four to eight years needed to complete the remedial effort. This time period includes the design, permitting, setup, installation of the system, and the ongoing operation and maintenance of system equipment.		
DCA Evaluation Criteria		***Rank***	***Value***		***Rank***	***Value***
Protectiveness (30% Weighted Factor)	For specific Site-contaminants and conditions, proper application of Engineering and Institutional Controls provide protection of human health and the environment. Addition of LNAPL recovery also would be beneficial.	6	1.8	Surfactant treatment and fluid recovery will reduce LNAPL impacts to the Site. With initiation of treatment, this alternative will begin remediation of soil and groundwater. Contaminant-mass destruction rates are anticipated to be higher at the initiation of the treatment process. In-Situ Chemical Oxidants (ISCO), applied to both saturated zones, will achieve protection for saturated soil and groundwater.	8	2.4
Permanence (20% Weighted Factor)	Without active remediation, this alternative does not provide a permanent solution to Site contaminants.	2	0.4	Surfactant emulsifies LNAPL, rendering it available for physical removal (by vacuum-truck extraction). The ISCO portion of this alternative destroys contaminants in both of the saturated zones.	8	1.6
Long-Term Effectiveness (20% Weighted Factor)	This alternative is less preferable for Long-Term Effectiveness. Given the presence of groundwater impacts, continued monitoring would need to occur to record the conditions of Site contaminants over time. Because the Site contaminants do not appear to be quickly degrading, this alternative would not satisfy long-term effectiveness criteria.	2	0.4	Site contaminants would be removed/destroyed, resulting in long-term effectiveness. Additionally, residual contaminants would be expected to attenuate.	8	1.6
Short-Term Risk Management (10% Weighted Factor)	This Alternative can manage some short-term risks with the use of land-use restrictions and preventing/minimizing physical exposure to residual soil and groundwater contamination. Additionally, removal of LNAPL immediately reduces contaminant-mass impacts to the Site.	5	0.5	Removal of LNAPL and the application of chemical oxidants immediately begin to reduce contaminant impacts to the Site. Engineering and institutional controls prevent/minimize physical exposure to site contaminants. However, this alternative presents some short-term risks to human health, primarily to remediation-system workers handling chemical oxidants/extracted LNAPL	6	0.6
Implementability (10% Weighted Factor)	Institutional controls for the property can be implemented, but are less preferable to the State of Washington. Site restrictions cannot be placed on downgradient properties (Tukwila International Boulevard). Unlikely to be implementable without site-remediation efforts. LNAPL recovery can be performed with little disturbance to Site-operations. Groundwater monitoring is easily performed at the Site.	7	0.7	Moderately easy to implement, but some Site access would be restricted during treatment events. Regular performance/compliance monitoring would present minimal impact to the Site.	7	0.7
Public Concerns (10% Weighted Factor)	May be perceived as not doing enough to protect the public and the environment. Without prior active-remediation efforts, public concern regarding Institutional Controls at this Site may be an issue.	4	0.4	Site-access restrictions and traffic disruptions during treatment events could adversely impact the Site. However, the disruptions would be temporary and it is not likely to be a high concern for residents or other members of the community.	8	0.8
Overall Ranking			**4.2**			**7.7**
Estimated Cost			**$455,000**			**$730,000**

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Table X

Detailed Evaluation of Cleanup Action Alternatives and DCA
Boeing Field Chevron
10805 E Marginal Way S, Tukwila, WA

Alternative	Alternative 3, Surfactant, LNAPL Extraction, DPE (upper zone), ISCO (lower zone), E&IC, and MNA			Alternative 4, Focused Excavation with Off-Site Disposal (upper zone), ISCO (lower zone), E&IC, and MNA		
Compliance with MTCA Threshold and Other Criteria						
Protection of Human Health and the Environment	Alternative can protect human health and the environment.			Alternative will protect human health and the environment from direct contact and potential vapor-intrusion risks.		
Compliance with Cleanup Standards	Active remedial methods can be used to address contaminated-environmental media in order to comply with cleanup standards.			Active remedial methods can be used to address contaminated-environmental media in order to comply with cleanup standards.		
Compliance with Applicable State and Federal Laws	Alternative can be designed to comply with applicable laws.			Alternative can be designed to comply with applicable laws.		
Provision for Compliance Monitoring	Alternative can include provisions for compliance monitoring (soil, groundwater, and soil-gas sampling).			Alternative includes provisions for compliance monitoring (soil, groundwater, and soil-gas sampling).		
Restoration Time Frame	Three to six years needed to complete the remedial effort. This time period includes the design, permitting, setup, installation of the system, and the ongoing operation and maintenance of system equipment.			Twelve to twenty-four months needed to complete excavation of the entire Site. This time period includes the design, permitting, setup, building demolition, excavation, and Site/surface restoration efforts. This alternative will require extensive shoring in order to remove soil to a depth of approximately 18 feet.		
DCA Evaluation Criteria		***Rank***	***Value***		***Rank***	***Value***
Protectiveness (30% Weighted Factor)	Surfactant treatment and fluid recovery will reduce LNAPL impacts to the Site. With initiation of treatment, this alternative will begin remediation of soil, groundwater, and soil gas. Contaminant-mass removal rates are anticipated to be higher at the initiation of the treatment process. A DPE system will achieve protection for soil and soil gas in the vadose zone and upper saturated zone. DPE also would protect groundwater, as water within the upper saturated zone would be extracted, treated, and disposed. Chemical oxidants, applied to the lower saturated zone, will achieve protection for saturated soil and groundwater.	8	2.4	This Excavation would be designed to remove soils with high concentrations of COCs at the Property, to a depth of approximately 18 feet, providing protection as a significant portion of contaminant mass will have been physically removed. Contaminated soil would be transported to a disposal facility. Residual soil and groundwater contaminants would require additional treatment via ISCO.	7	2.1
Permanence (20% Weighted Factor)	DPE volatilizes and removes vadose-zone and upper saturated zone contaminants. Bio-degredation of contaminants in upper zone also is enhanced by increased air flow due to DPE-system operation. Surfactant emulsifies LNAPL, rendering it available for physical removal (by vacuum-truck extraction). The use of ISCO in the lower, and possibly within the upper saturated zone, destroys contaminants.	8	1.6	Within the excavation footprint, this method provides for the permanent removal of soils containing petroleum contaminants. Outside the excavated areas, chemical oxidants would be applied to reduce remaining contaminant mass.	7	1.4
Long-Term Effectiveness (20% Weighted Factor)	Soil and groundwater contaminants would be removed, resulting in long-term effectiveness. Additionally, groundwater contaminants would be expected to attenuate without a continuing source.	8	1.6	Partial-removal of contaminated soils combined with ISCO treatments would address long-term effectiveness criteria for soil, soil-gas, and groundwater contaminants.	8	1.6
Short-Term Risk Management (10% Weighted Factor)	Removal of LNAPL and the application of chemical oxidants immediately begin to reduce contaminant impacts to the Site. Engineering and institutional controls prevent/minimize physical exposure to site contaminants. However, this alternative presents some short-term risks to human health, primarily to remediation-system workers handling chemical oxidants/extracted LNAPL. This alternative also poses moderate-to-higher short-term risks, due to the required drilling/trenching and related construction activities, as well as the handling and discharge of removed groundwater. These tasks present some short-term risks to human health, primarily to remediation-system workers.	5	0.5	Excavation would require the demolition of the on-site fueling canopy and the design/permitting for excavation-stability concerns. This work would create construction hazards and would create worker-exposures to the Site contaminants. This alternative poses the highest short-term risk due to the nature of the work (construction safety-related concerns). This method also would require the handling of chemical oxidants.	2	0.2
Implementability (10% Weighted Factor)	More difficult to implement, as system design and installation is more difficult, given water extraction/disposal steps. Site access would be restricted and noise disruptions could occur during system installation. Once the system is installed, regular operation and monitoring of the system may present minimal-to-expanded impacts to the Site, largely due to water treatment and disposal.	4	0.4	Building demolition and excavation of the area will require extensive design and permitting. Site access would be restricted and noise/traffic disruptions would occur. Business operations would be closed during demolition, excavation, and construction. Backfilled areas would require compaction or future-construction modifications.	2	0.2
Public Concerns (10% Weighted Factor)	Noise, Site access restrictions, and traffic disruptions during system installation could adversely impact the neighborhood. However, the alternative utilizes equipment that can be placed in unobtrusive areas, therefore it is not likely to be a high concern for residents or other members of the community.	7	0.7	Noise, access restrictions, dust/odors, and traffic disruptions would adversely impact the business and surrounding area. Business operations would be closed during demolition, excavation, and construction.	4	0.4
Overall Ranking			**7.2**			**5.9**
Estimated Cost			**$1,200,000**			**$2,400,000**

These estimates are subject to numerous assumptions and are based on currently-known information. These estimates should be used only for comparison of the alternatives.
For purposes of this Feasibility Study, order-of-magnitude costs have been used rather than detailed cost estimates.
The presented estimates are based many years of monitoring/operation and G-Logics experience on similar Sites.
Alternative rankings are from 1 to 10, low to high. The presented estimates assume that G-Logics and G-Logics contractors will perform/manage all selected work.