GeoEngineers

Technical Memorandum

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To:	Ching-Pi Wang Site Manager Washington State Department of Ecology
From:	Claudia De La Via and Dan Baker
Date:	December 19, 2016
File:	0186-846-01
Subject:	Gas Works Park Site Play Area Injection Infrastructure Groundwater Monitoring Well Network

Gas Works Park Site (GWPS) Play Area injection infrastructure installation is being planned in conjunction with Seattle Parks and Recreation (SPR) renovations at the Gas Works Park Play Area. Infrastructure installation is planned before substantial renovation begins within the Play Area footprint. The proposed Play Area injection infrastructure was described in the August 18, 2016, *Technical Memorandum*[1] (Tech Memo). This memorandum was prepared on behalf of Puget Sound Energy (PSE) and the City of Seattle (City), and presents the layout of the injection infrastructure and the location of monitoring wells proposed to evaluate system performance, and monitor groundwater conditions upgradient and downgradient of the system.

BACKGROUND

SPR will be conducting a maintenance project at Gas Works Park. Maintenance work or renovations will be completed in the Play Area, Comfort Station, and East Entry areas. PSE and the City propose to install injection infrastructure for testing and possible future groundwater treatment in conjunction with the Play Area renovation. This is a time-critical action as once Play Area renovation work is completed, access to the arsenic impacted soil and groundwater beneath the Play Area will not be possible without disturbing the newly renovated Play Area. The Tech Memo described supplemental investigation activities intended to refine the characterization of dissolved arsenic impacts to groundwater in the Play Area and inform the design of the injection infrastructure. The field work and analyses for the supplemental investigation were completed during September and October 2016, in accordance with the Sampling and Analysis Plan and Quality Assurance Project Plan Addendum No. 2, included as Attachment 1 of the Tech Memo. A summary of the general findings of the investigation is presented below. A Supplemental Investigation Data Report summarizing the investigation activities will be provided to Washington State Department of Ecology (Ecology).

Ecology's August 31, 2016, letter approving supplemental investigation and infrastructure installation requested the opportunity to review proposed monitoring well locations once they have been determined. Proposed monitoring well locations were provided to Ecology in a draft version of this memo on November 30, 2016. Ecology provided comments on December 5, 2016. GeoEngineers, Inc. (GeoEngineers) discussed monitoring well location revisions with Ecology and revised well locations were verified in the field with Ecology on December 14, 2016.

[1] *Supplemental Play Area Investigation and Treatment Infrastructure Construction*, GeoEngineers, August 18, 2016.

PLAY AREA INVESTIGATION FINDINGS

The supplemental Play Area investigations in 2014 and 2016 involved soil and/or groundwater sampling at borings in more than 30 locations to characterize arsenic concentrations in soil and dissolved arsenic concentrations in groundwater, as well as characterize geochemical conditions that may impact possible future treatment of groundwater (e.g., pH, iron and sulfide concentrations). Borings were completed using direct-push drilling methods where possible. In locations where direct-push methods were unable to achieve the planned sample depth, sonic drilling methods were used to complete the planned borings. Figure 1 presents the locations of the soil borings.

Temporary pre-packed well screens were installed in soil borings to allow collection of grab groundwater samples. Groundwater samples were collected from the saturated fill and outwash units and analyzed for dissolved arsenic, dissolved iron, sulfide, and chemical oxygen demand (COD). In addition, field measurements of pH, dissolved oxygen, specific conductance and turbidity were collected during the supplemental investigation. Figure 2 presents the dissolved arsenic concentrations in fill groundwater samples. Dissolved arsenic concentrations detected in fill groundwater samples collected during the 2016 supplemental investigation ranged from 140 micrograms per liter (µg/L) to 10,500 µg/L. Figure 3 presents the dissolved arsenic concentrations in outwash groundwater samples. Dissolved arsenic concentrations detected in outwash groundwater samples collected during the 2016 supplemental investigation ranged from 39 µg/L to 23,400 µg/L. Non-aqueous phase liquid (NAPL) was observed in borings; NAPL was known to be present in the area from previous investigations (see Figures 8-8 and 8-9 in *Agency Review Draft Remedial Investigation/Feasibility Study Volume I: Remedial Investigation Report*). Additional details of the groundwater sample analyses will be provided to Ecology in a forthcoming data summary report.

The Play Area supplemental investigation included five hydraulic profiling tool (HPT) borings to estimate hydraulic conductivity in fill and outwash soil. HPT borings and resulting hydraulic conductivity estimates were used to support the flow analysis for reagent injection and design of the injection infrastructure layout. The HPT boring locations are presented on Figure 1.

INJECTION AND GROUNDWATER MONITORING WELL NETWORK LAYOUT

Based on the results of analysis of groundwater chemistry data, HPT data, and geology observed at the soil borings, the layout of the reagent injection well system presented in the Tech Memo was refined, and a monitoring well network was developed to allow sampling to evaluate the performance of possible future in-situ treatment. The anticipated injection well system includes 22 injection wells screened in the fill unit and 13 injection wells screened in the outwash unit. The injection wells will be connected below grade to conveyance piping trenched to utility vaults located outside the Play Area footprint to allow injection from outside the Play Area after the Play Area renovation is complete. Figures 4 and 5 present the anticipated layout of the injection well system.

To evaluate the performance of the reagent injection, fifteen new monitoring wells will be installed. The proposed monitoring well network is presented on Figure 4 with the fill dissolved arsenic extent and Figure 5 with the outwash dissolved arsenic extent. Rationale for each well is presented in Table 1. The proposed monitoring wells will be installed using hollow-stem auger or sonic drilling methods, depending on the presence of subsurface debris that may inhibit hollow-stem auger drilling. Monitoring wells will be completed with 2-inch

diameter polyvinyl chloride (PVC) well casing and screen with flush-mount monuments, similar to other wells installed at the GWPS. Well installation will be consistent with the Sampling and Analysis Plan (Appendix A) of the March 13, 2013, *Supplemental Investigation Work Plan*. The 15 new monitoring wells in combination with two existing wells (MW-36S and MW-36D) (Table 1) will provide a 17-well monitoring network consisting of:

- Nine performance monitoring wells located within the expected area of influence of possible future in-situ treatment (six wells screened in the fill unit and three wells screened in the outwash unit),
- Two upgradient monitoring wells (one well screened in the fill unit and one well screened in the outwash unit), and
- Six downgradient monitoring wells near the shoreline (two wells screened in the fill unit and four wells screened in the outwash unit).

NEXT STEPS

Completion of the injection infrastructure is a time-critical action as, once Play Area renovation work is completed, access to the arsenic impacted groundwater beneath the Play Area will not be possible without disturbing the newly renovated Play Area. Installation of the injection infrastructure and monitoring well network is expected to start in January 2017 and anticipated to take approximately 6 weeks. Monitoring wells will be installed following injection well installation. After injection infrastructure and monitoring well installation are complete, an Interim Action Work Plan (work plan) will be prepared to present operating procedures including the selected reagent, and the proposed monitoring plan to evaluate system performance. The work plan will include a proposed schedule for reagent injection and monitoring and will specify analyses and analytical methods for groundwater monitoring. The work plan will be submitted to Ecology for approval before system operation begins.

Attachments:

Figure 1. Site Plan

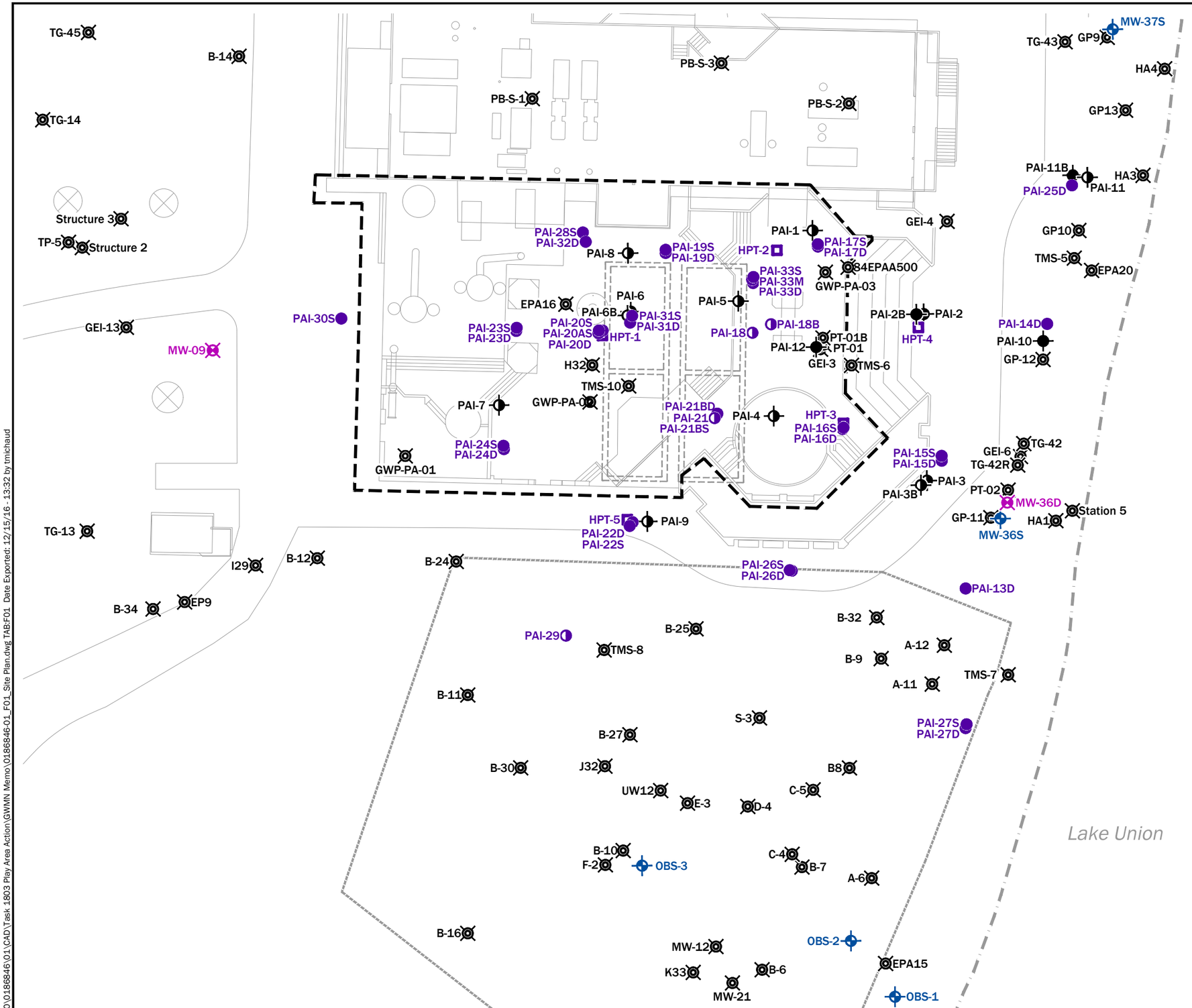
Figure 2. Fill Dissolved Arsenic

Figure 3. Outwash Dissolved Arsenic

Figure 4. Proposed Injection Infrastructure and Monitoring Well Network—Fill Dissolved Arsenic

Figure 5. Proposed Injection Infrastructure and Monitoring Well Network—Outwash Dissolved Arsenic

Table 1. Proposed Play Area Groundwater Monitoring Network



Legend

- Consent Decree Boundary
- Play Area Renovation Boundary
- Approximate Air Sparging/Soil Vapor Extraction Liner Limits
- Former Subgrade Tank (Subgrade Concrete Rubble)
- HPT-1 — 2016 Hydraulic Profiling Tool Exploration
- PAI-18 — 2016 Subsurface Exploration (Soil)
- PAI-21 — 2016 Subsurface Exploration (Soil and Groundwater)
- PAI-4 — 2014 Subsurface Exploration (Soil)
- PAI-2B — 2014 Subsurface Exploration (Soil and Groundwater)
- B-10 — Pre-2014 Subsurface Exploration
- MW-36S — Fill Monitoring Well
- MW-36D — Outwash Monitoring Well

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source:

- Existing conditions survey by Seattle Parks and Recreation, November 2002
- Construction Completion Report by Thermo RETEC, January 2001
- Earthwork & Demolition plan by Department of Parks and Recreation, July 1974

N W E S

30 0 30
Feet

Site Plan and Upland Explorations

Gas Works Park Site
Seattle, Washington

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Figure 1

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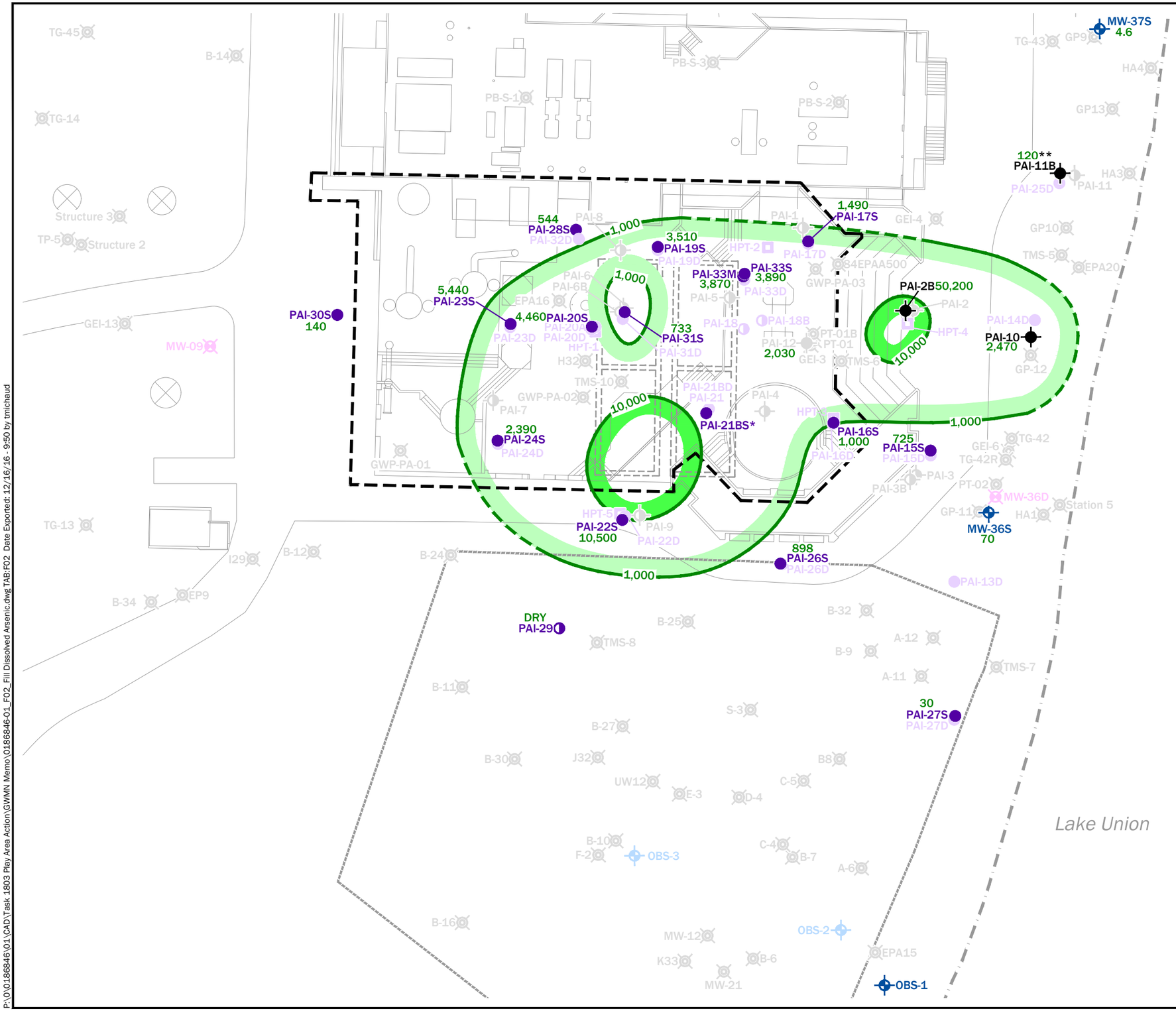

Legend

- Consent Decree Boundary
- Play Area Renovation Boundary
- Approximate Air Sparging/Soil Vapor Extraction Liner Limits
- Former Subgrade Tank (Subgrade Concrete Rubble)
- HPT-1 — 2016 Hydraulic Profiling Tool Exploration
- PAI-29 — Fill 2016 Subsurface Exploration (Soil)
- PAI-18 — 2016 Subsurface Exploration (Soil)
- PAI-17S — Fill 2016 Subsurface Exploration (Soil and Groundwater)
- PAI-17D — 2016 Subsurface Exploration (Soil and Groundwater)
- PAI-4 — 2014 Subsurface Exploration (Soil)
- PAI-11B — Fill 2014 Subsurface Exploration (Soil and Groundwater)
- PAI-2B — 2014 Subsurface Exploration (Soil and Groundwater)
- B-10 — Pre-2014 Subsurface Exploration
- MW-36S — Fill Monitoring Well
- MW-36D — Outwash Monitoring Well
- 1,000 — Interpolated Fill Dissolved Arsenic Concentration Contour (Dashed Where Inferred) (µg/L)
- 10,500 — Fill Dissolved Arsenic Concentration (µg/L)
- * — Well Contained NAPL - Groundwater was Not Sampled
- ** — Temporary Well Screen Spanned Fill and Outwash

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N W E S

30 0 30
Feet

Fill Dissolved Arsenic

Gas Works Park Site
Seattle, Washington

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Figure 2

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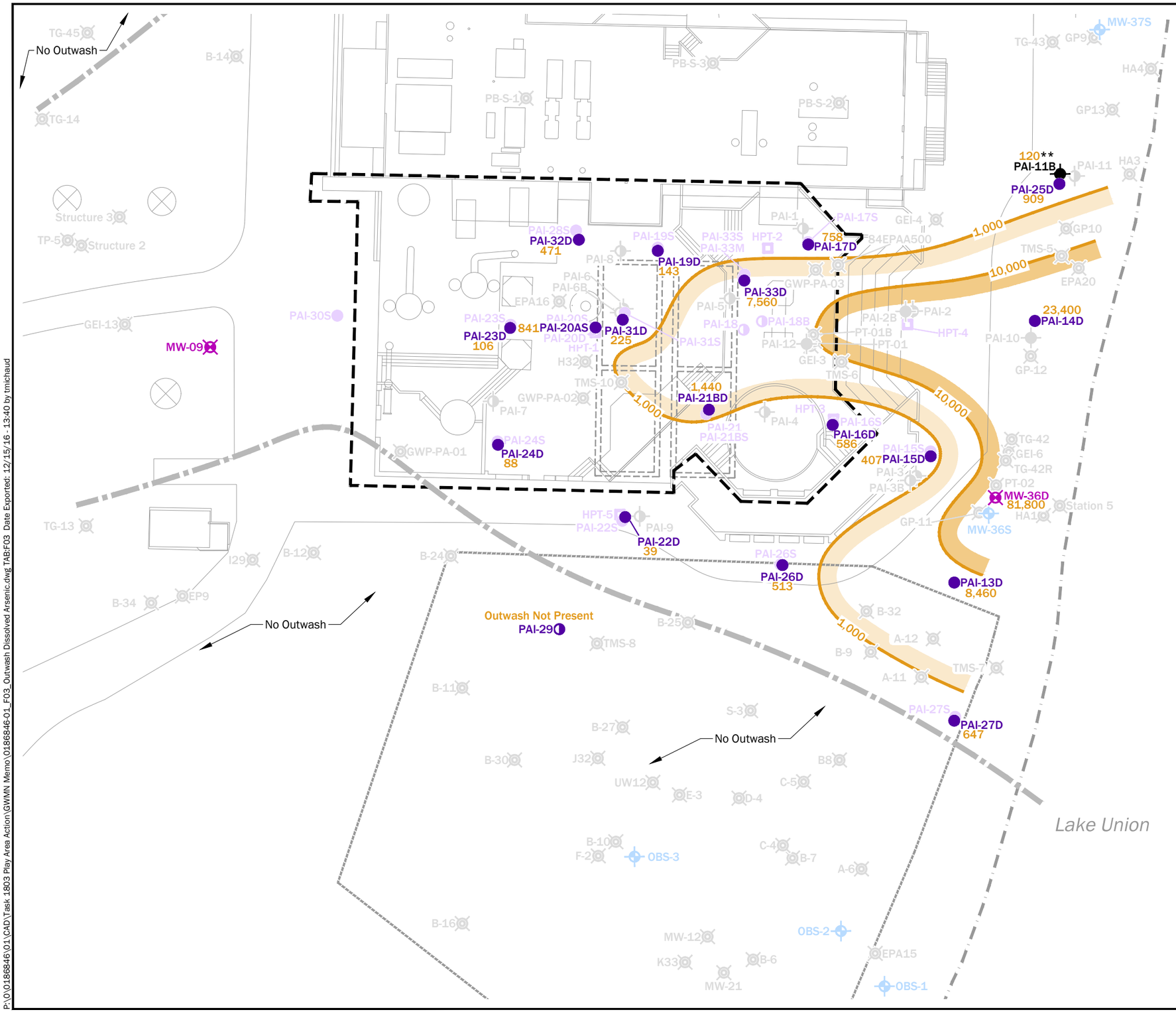

Legend

- Consent Decree Boundary
- Play Area Renovation Boundary
- Approximate Air Sparging/Soil Vapor Extraction Liner Limits
- Former Subgrade Tank (Subgrade Concrete Rubble)
- HPT-1 — 2016 Hydraulic Profiling Tool Exploration
- PAI-29 — Till 2016 Subsurface Exploration (Soil)
- PAI-18 — 2016 Subsurface Exploration (Soil)
- PAI-17D — Outwash 2016 Subsurface Exploration (Soil and Groundwater)
- PAI-17S — 2016 Subsurface Exploration (Soil and Groundwater)
- PAI-4 — 2014 Subsurface Exploration (Soil)
- PAI-11B — Outwash 2014 Subsurface Exploration (Soil and Groundwater)
- PAI-2B — 2014 Subsurface Exploration (Soil and Groundwater)
- B-10 — Pre-2014 Subsurface Exploration
- MW-36S — Fill Monitoring Well
- MW-36D — Outwash Monitoring Well
- 1,000 — Interpreted Outwash Dissolved Arsenic Concentration Contour (µg/L)
- 10,500 — Outwash Dissolved Arsenic Concentration (µg/L)
- ** — Temporary Well Screen Spanned Fill and Outwash
- Estimated Lateral Extent of Outwash

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N W E S

30 0 30
Feet

Outwash Dissolved Arsenic

Gas Works Park Site
Seattle, Washington

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Figure 3

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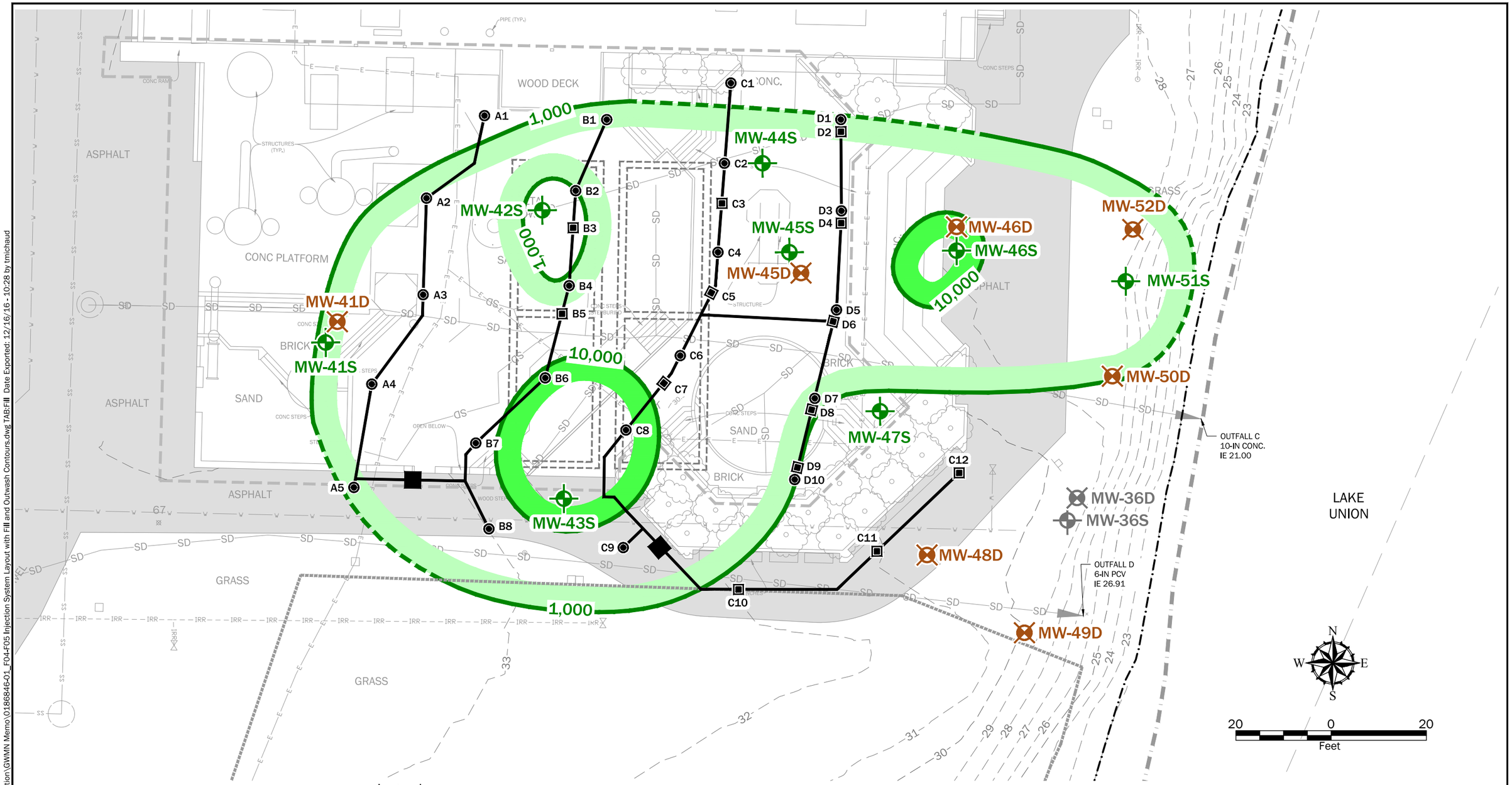

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Data Source:

- Existing conditions survey by Seattle Parks and Recreation, November 2002
- Construction Completion Report by Thermo RETEC, January 2001
- Outfall C and D based on APS Survey, December 2014

Legend

- Existing Contour (USACOE)
- Existing Stormdrain
- Existing Water
- Existing Electrical
- Play Area Renovation Footprint
- Approximate Edge of Existing Impermeable Liner
- Existing Asphalt, Gravel, and/or Concrete
- Existing Monitoring Well - Fill
- Existing Monitoring Well - Outwash
- Interpreted Fill Dissolved Arsenic Concentration Contour (Dashed where inferred) (µg/L)
- Ordinary High Water

Proposed Injection Infrastructure and Monitoring Wells

- A1 Injection Well - Fill
- B3 Injection Well - Outwash
- Trenched Injection Pipe and System Vault
- MW-46S Monitoring Well - Fill
- MW-46D Monitoring Well - Outwash

Proposed Injection Infrastructure and Monitoring Well Network - Fill Dissolved Arsenic

Gas Works Park Site
Seattle, Washington

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Figure 4

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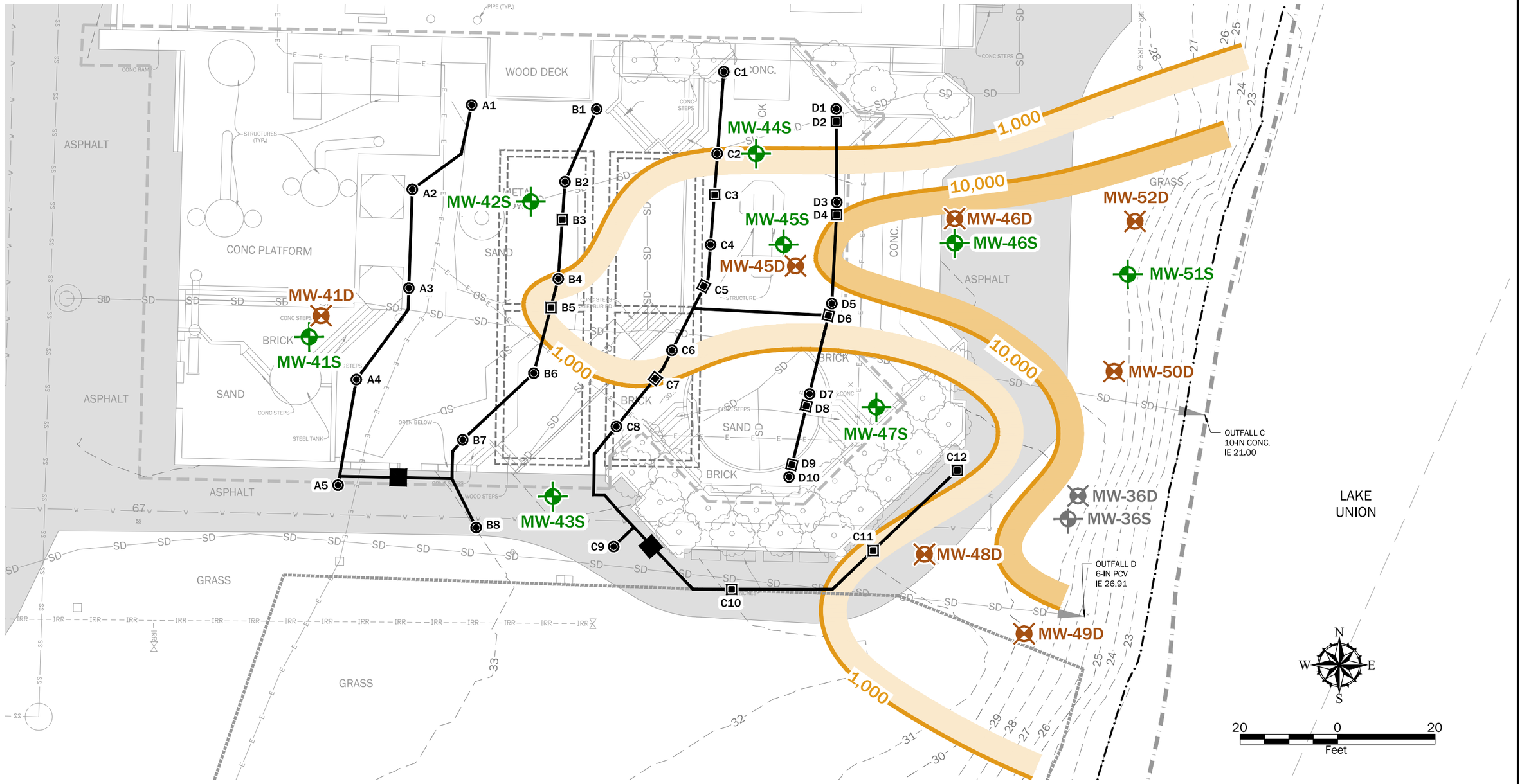

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- Construction Completion Report by Thermo RETEC, January 2001
- Outfall C and D based on APS Survey, December 2014

Legend

- Existing Contour (NAVD88)
- Existing Stormdrain
- Existing Water
- Existing Electrical
- Play Area Renovation Footprint
- Approximate Edge of Existing Impermeable Liner
- Existing Asphalt, Gravel, and/or Concrete
- Existing Monitoring Well - Fill
- Existing Monitoring Well - Outwash
- Interpreted Outwash Dissolved Arsenic Concentration Contour (µg/L)
- Ordinary High Water

Proposed Injection Infrastructure and Monitoring Wells

- A1 Injection Well - Fill
- B3 Injection Well - Outwash
- Trenched Injection Pipe and System Vault
- MW-46S Monitoring Well - Fill
- MW-46D Monitoring Well - Outwash

Proposed Injection Infrastructure and Monitoring Well Network - Outwash Dissolved Arsenic

Gas Works Park Site
Seattle, Washington

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Figure 5

P:\0\0186846\01\CAD\Task 1803 Play Area Action\GWMN Memo\0186846-01_F04-F05 Injection System Layout with Fill and Outwash Contours.dwg TAB:Outwash Date Exported: 12/16/16 - 10:30 by tmichaud

Table 1

Proposed Play Area Groundwater Monitoring Network

Gas Works Park Site
Seattle, Washington

No.	Well ID	Unit	Type	Purpose/Rationale
1	MW-36S	Fill	Downgradient	Part of existing shoreline network to monitor groundwater quality downgradient of Play Area injection system. Sampling optional.
2	MW-36D	Outwash	Downgradient	Part of existing shoreline network to monitor groundwater quality downgradient of Play Area injection system.
3	MW-41S	Fill	Upgradient	Characterize groundwater entering the treatment area. Upgradient of injection wells to avoid treatment effects.
4	MW-41D	Outwash	Upgradient	Characterize groundwater entering the treatment area. Upgradient of injection wells to avoid treatment effects.
5	MW-42S	Fill	Performance	Monitor groundwater within treatment area downgradient of injection lateral A.
6	MW-43S	Fill	Performance	Monitor groundwater within treatment area downgradient of injection lateral B.
7	MW-44S	Fill	Performance	Monitor groundwater within treatment area downgradient of injection lateral C -- closer to injection well.
8	MW-45S	Fill	Performance	Monitor groundwater within treatment area downgradient of injection lateral C -- farther from injection well.
9	MW-45D	Outwash	Performance	Monitor groundwater within treatment area downgradient of injection lateral C.
10	MW-46S	Fill	Performance	Monitor groundwater near downgradient edge of treatment area along plume centerline (higher concentration area).
11	MW-46D	Outwash	Performance	Monitor groundwater near downgradient edge of treatment area along plume centerline.
12	MW-47S	Fill	Performance	Monitor groundwater within treatment area downgradient of injection lateral D south of plume centerline (lower concentration area).
13	MW-48D	Outwash	Performance	Monitor groundwater within treatment area downgradient of injection laterals C and D.
14	MW-49D	Outwash	Downgradient	Part of shoreline network to monitor groundwater quality downgradient of Play Area injection system -- southern well.
15	MW-50D	Outwash	Downgradient	Part of shoreline network to monitor groundwater quality downgradient of Play Area injection system -- central well.
16	MW-51S	Fill	Downgradient	Part of shoreline network to monitor groundwater quality downgradient of Play Area injection system and centerline of plume.
17	MW-52D	Outwash	Downgradient	Part of shoreline network to monitor groundwater quality downgradient of Play Area injection system -- northern well.

Notes:

1. Monitoring well locations are shown on Figure 4 and 5.