
To: Kevin Dana, Oregon Department of Environmental Quality (DEQ)
From: Amanda Spencer, PE, RG, Senior Principal Hydrogeologist, GeoEngineers
Date: February 27, 2024
File: 006209-010-04
Cc: Dave Lacey, DEQ
Erin McDonnell, DEQ
Mat Cusma, Radius Recycling
Tom Leaptrott, Steel Hammer Properties
Subject: Evaluation of Flux Rates for Use in Chemical Isolation Modeling
Crawford Street South Site

Design of a riverbank source control measure (RBSCM) is currently being implemented for the Crawford Street South site (the Site; ECSI # 2363). The Site is located near North Burlington Avenue and North Crawford Street and is identified with the address of 8524 North Crawford Street in Portland, Oregon. Figure 1, attached, provides a site location map; Figure 2 provides a site plan. The proposed RBSCM includes laying the current riverbank back to a 5:1 slope below ordinary high water (OHW) and a 3:1 slope above OHW, and capping the leave surface with a sand cap. The sand cap will be overlain by filter and anchoring materials below OHW and filter/anchor materials with a planting mix to promote vegetative plantings consistent with City of Portland greenway requirements above OHW. The RBSCM will extend from the top of the riverbank to the Site boundary, which is the ordinary low water (OLW) elevation along the river.

A Preliminary (30%) Design Report (GeoEngineers, 2023) was prepared for the RBSCM based on the approved Basis of Design Report (BODR; GeoEngineers, 2022b) and was submitted to Oregon Department of Environmental Quality (DEQ) on June 15, 2023. Comments on the Preliminary Design Report were received from DEQ on October 30, 2023, and included a request from the U.S. Environmental Protection Agency (EPA) to consider conducting a seepage study to assess flux rates for use in the chemical isolation (i.e., CapSim) modeling performed for the capping design. At approximately the same time, the Willamette Cove (WC) Group¹ submitted a Supplemental Preliminary Design Investigation (SPDI) Evaluation Report for the WC Project Area (Groundwater Solutions, Inc. [GSI], November 2023), which included results of a seepage study conducted using UltraSeep flowmeter technology near and just upriver from the Site. As detailed in this memorandum, the WC seepage study corroborates well with the flux rates estimated for the Site based on groundwater gradient data, with the exception of one flux rate measurement observed at the WC Project Area, which appears to be an anomaly.

Based on our review of the available data, we believe that the flux rates estimated based on groundwater gradient data from the Site and augmented by the WC seepage study are sufficient to complete the chemical isolation modeling in support of our cap design and that additional seepage studies are not needed. This memorandum assesses the currently available flux rate data to: (1) establish that the one elevated flux rate measurement at the WC Project Area appears anomalous and is not applicable to the Site, and (2) identify the

¹ The performing parties for the Willamette Cove In-Water Project Area in the Portland Harbor Superfund Site (PHSS) consist of the Port of Portland, the City of Portland, and the State of Oregon acting by and through the Department of State Lands.

appropriate range of flux rates to use in CapSim modeling being conducted in support of the chemical isolation modeling for the RBSCM cap design.

Additionally, we understand that EPA has conducted a seepage study using UltraSeep flowmeter technology for the Cathedral Park Project Area, which is located adjacent to and downriver of the Site, and several of the UltraSeep locations were deployed adjacent to the downriver portion of the Site. The Cathedral Park Project Area seepage study report is pending. Once these additional flux data are available, they will be used to supplement the flux rate data set for the Site, and the range of flux rates proposed for use in the CapSim modeling will be reassessed to confirm the range proposed in this memorandum is still applicable.

BACKGROUND

The Site is an approximately 11-acre property located along the Willamette River in the St. Johns neighborhood of Portland, Oregon. The Site is situated in the northeast quarter of Section 12, Township 1 North, Range 1 West and is bordered by the Willamette River to the south, North Burlington and North Richmond Avenues to the west and east, respectively, and by the North Crawford Street North site (ECSI #6167) to the north.

In March 2021, Crawford Street Corporation and Steel Hammer Properties, LLC entered into an Order on Consent (“Consent Order”) with the DEQ to complete the RBSCM and other related tasks. Results of an investigation of the chemical characterization of the anticipated leave surface for the RBSCM were presented in a Source Control Evaluation (SCE) Work Plan (Cascadia, 2021), which was reviewed and commented on by EPA and DEQ. A revised SCE Work Plan was submitted, which addressed the EPA and DEQ comments and was approved by DEQ on October 12, 2021. The SCE Work Plan identified a few data gaps for completing the characterization of the riverbank leave surface. Additional riverbank characterization was performed October through December of 2021 to fill the data gaps, and the results were presented in the Additional Riverbank Soil Characterization Report submitted to DEQ and EPA on March 7, 2022 (GeoEngineers, 2022a).

The BODR was prepared pursuant to the Consent Order to identify the data and information necessary to design the RBSCM (GeoEngineers, 2022b). The BODR included the basis for chemical isolation analysis using CapSim modeling to be performed in support of the cap design. EPA provided comments on October 17, 2022; DEQ did not have comments. The BODR was revised to address EPA comments and was approved by DEQ on December 14, 2022.

EVALUATION OF AVAILABLE FLUX DATA

As indicated above, two sets of groundwater flux data are available to aid in selecting the appropriate range of flux rates to use in the CapSim modeling for the Site: (1) flux rates estimated based on groundwater gradient data in the riverbank area of the Site²; and (2) the seepage study performed directly upriver in the WC Project Area. The flux rates estimated based on gradient data in the riverbank area of the Site used groundwater elevation data from monitoring wells located at the top of the riverbank and river stage data from the USGS gauging station at Morrison Bridge. These gradient-based flux rates were presented in Appendix H of the

² The flux is estimated using standard groundwater velocity and discharge calculations as presented in textbooks such as Freeze & Cherry (1979) (i.e., $q = K \cdot I \cdot A$, where q is the flux rate, K is the hydraulic conductivity; I is the gradient between the top of the riverbank groundwater elevation and the elevation of the surface at the points of discharge; and A is the cross-sectional area of discharge).

Preliminary Design Report and are summarized in Table 1, below; Appendix H is included as Attachment A to this memorandum for reference. An additional groundwater elevation data set was collected on December 7, 2023, and the flux rates calculated from the December 2023 elevation data have been added to Table 1.

TABLE 1. ESTIMATED FLUX RATES IN THE RIVERBANK AREA OF THE CRAWFORD STREET SITE

Measurement Date	Range in Flux Rate (cm/day)		
9-Nov-21	-0.07	to	0.02
20-Dec-21	-0.13	to	0.18
15-Mar-22	0.11	to	0.14
27-Jun-22	-0.38	to	-0.04
7-Sep-22	0.27	to	0.44
17-Apr-23	0.12	to	0.23
7-Dec-23	-0.10	to	0.47
Annual-normalized	-0.02	to	0.22

The seepage study in the WC Project Area was conducted in late August 2022 and the results were presented in the WC SPDI Evaluation Report (GSI, 2023). The results are summarized below and shown, by location, on the figure contained in Attachment B.

TABLE 2. MEASURED FLUX RATES FROM THE WILLAMETTE COVE SEEPAGE STUDY

Location ID	Measured Flux Rate (cm/day) August 22, 2022
A-02	78
A-04	0.41
A-06	0.23
B-01	1.78
B-04	1.98
B-06	0.69
C-01	0.54
C-04	0.81
Average (excluding A-02):	0.92

With the exception of the flux rate measured at location A-02, the flux rates from the seepage study ranged from 0.23 centimeter (cm)/day to 1.98 cm/day. The 78 cm/day value measured at location A-02 appears anomalous as it is almost two orders of magnitude higher than the average flux rate in the area based on the other measurements. Additionally, if the 78 cm/day measurement was real, it would represent an upwelling area of a preferential pathway, and we would anticipate the porewater chemical data from this location to mirror adjacent upland groundwater chemical data. However, this is not the case. Table 3, below, summarizes the chemical results of the porewater samples collected at location A-02 and the groundwater samples collected at riverbank wells MW-6 through MW-8 which are located directly upland of location A-02. The figure in

Attachment C shows the locations of the wells relative to location A-02 and in-water porewater sampling data collected during the WC SPDI.

As shown on Table 3, the chemical signature and magnitudes are not correlative between upland groundwater at the riverbank wells and porewater at location A-02. Specifically, both total DDx and total PCB concentrations are higher in porewater at location A-02 than the riverbank wells. In the case of total DDx, the porewater concentrations are 3 to 10 times higher; the PCB concentrations in porewater are more than two orders of magnitude higher than groundwater at the Site. Additionally, arsenic was detected in upland groundwater but not in the porewater sample.

TABLE 3. COMPARISON OF POREWATER AND GROUNDWATER CHEMICAL RESULTS FOR KEY POREWATER CONSTITUENTS

Porewater Location or Groundwater Monitoring Well ID	Sample Type	Date	Arsenic (µg/L)	cPAHs (µg/L)	DDx (ng/L)	Total PCBs (µg/L)
WC-P023 (Collocated with A-02)	PW 0.5-1.0 ft bml	8/25 – 8/29/2022	<0.717	<0.0265	0.354	0.0144 J
	PW 1.5-2.0 ft bml	8/25 – 8/29/2022	<0.890	<0.0253	0.316	0.0145 J
MW-8	GW	3/16/2022	35.2	<0.0143	0.10	<0.0204
	GW	6/27/2022	6.91	<0.0143	0.09	0.000300
	GW	9/8/2022	9.89	<0.0150	0.10	0.000313
	GW	12/7/2023	11.4	<0.00510	0.26	NA
MW-7	GW	3/16/2022	2.11	<0.0142	0.22	<0.0196
	GW	6/27/2022	1.29	<0.0146	0.09	0.00043
	GW	9/8/2022	1.05	<0.0155	0.13	0.00139
	GW	12/7/2023	1.04	<0.00422	0.17 J	NA
MW-6	GW	3/16/2022	3.42	<0.0144	<0.040	<0.0189
	GW	6/27/2022	2.50	<0.0149	<0.050	0.00025
	GW	9/8/2022	1.41	<0.0158	<0.050	0.000301
	GW	12/7/2023	1.57	<0.00412	0.15 J	NA

Notes: PW = porewater; ft bml = feet below mud line; GW = groundwater; ng/L = nanograms/liter.

In addition to appearing anomalous, the one high reading from the WC seepage study is not applicable to our Site, based on the following lines of evidence:

1. As shown in Tables 1 and 2, above, the estimated flux rates from the gradient data collected at the Site during the same time frame as the WC seepage study (August/September 2022) are consistent with the measured flux rates from the WC seepage study, except for the one high value. As shown in Tables 1 and 2 (see the green shaded rows), the estimated flux rate ranged between 0.27 cm/day to 0.44 cm/day in the riverbank area at the Site on September 7, 2022, which is almost identical to the results measured at the two locations closest to the riverbank during the WC seepage study conducted

in late August 2022 (locations A-04 and A-06, with flux rates of 0.41 cm/day and 0.23 cm/day, respectively).

2. If real and applicable to the Site, the 78 cm/day flux would indicate a hydraulic conductivity 2 to 3 orders of magnitude higher than estimated for the Site based on observed lithology. For example, the hydraulic conductivity of the fill at the Site would need to be in the range of 10^{-2} to 10^{-1} cm/s (30 to 300 feet/day), which would be that of a clean coarse sand to a gravelly sand with no fines (Freeze & Cherry, 1979). Clean sand or gravelly sand with no fines was not observed in any of the borings installed in the riverbank or upland areas of the Site, not even on the beaches. As shown on the logs contained in Attachment D, the lithology of the Site consists of fill over alluvium; the fill is typically silt with some sand and debris and the alluvium is typically silt with some sand. The beach material is typically silty sand or sand with silt. The flux rates estimated from the gradient data collected at the Site used a hydraulic conductivity of 10^{-4} cm/s (0.3 feet/day) that is consistent with this type of lithology (Freeze & Cherry, 1979).
3. Alternatively, if real, the 78 cm/day would indicate a preferential pathway or fissure allowing localized upwelling. But if this were occurring at our Site, which is landward of OLW, it would be observable as a substantial seep in the beach material or on the riverbank. No seeps have been observed on the beach or below OHW on the riverbank at the Site.

THE DATA SUPPORT THAT A FLUX RATE RANGING BETWEEN 0.2 TO 2.0 CM/DAY FOR CHEMICAL ISOLATION MODELING IS CONSERVATIVE

Because the WC seepage study is directly upriver of the Site, the results of the study are useful in developing a conservative range of flux rates to use in the chemical isolation modeling for the RBSCM at the Site. With the exception of the one apparently anomalous measurement, the results corroborate well with the flux rates estimated based on groundwater gradient data from the Site and an additional seepage study is not needed. The chemical isolation modeling performed for the Preliminary Design Report using the CapSim model assumed a range of flux rates from 0.1 to 1.0 cm/day. Based on a review of the WC seepage study results in concert with the flux rates estimated based on gradient data from the Site, we are proposing to increase the range of flux rates used for sensitivity analysis up to 2.0 cm/day and use a low range flux of 0.2 cm/day. This range is considered conservative based on the following lines of evidence:

1. The low end (0.2 cm/day) of the range is consistent with the high end (0.22 cm/day) of the range of annualized average flux rate estimates based on gradient information as shown on Table 1, and the high end (2.0 cm/day) of the range is 10 times the estimated high annualized average flux based on groundwater gradient data.
 2. The high end is four times higher than the estimated highest flux rate based on gradient information.
 3. The high end is consistent with the highest flux measured during the WC seepage study (except for the apparent anomalous result) and twice the average flux rate of the WC results. The flux rates identified during the WC seepage study were collected during the highest flux period of 2022, when the river stage was low and groundwater elevations were relatively high.
 4. The chemical isolation study assumes that the flux rates of 0.2 to 2.0 cm/day occur year-round, when in fact, the highest rates will only occur when the river stage is low and groundwater elevations are
-

high—conditions which only occur for a few months each year. Attachment E contains a figure that presents the river surface elevation data for the Morrison Bridge station for January 2021 through December 2023, and overlays the measured range in groundwater elevations from the Site. As can be seen in the figure, the timeframe when groundwater elevations are consistently higher than river surface elevations (i.e., when groundwater discharge can occur from the Site) is limited and, in 2022, only occurred consistently from July through October—only four of the 12 months. This fact provides a three-fold factor of safety in the cap modeling results in addition to the conservatism of selecting the maximum estimated or observed flux rates for the CapSim model input parameters.

- The chemical isolation study assumes discharge occurs throughout the entire cap at all times, when in fact discharge will occur only through a small portion of the capped area. The modeled area of the cap extends from OHW down to OLW. Because no seeps below OHW are observed at the Site, we know that discharge through the capped area below OHW could only occur when the area is covered by river water, and therefore is not observable. As shown in the below table (and documented from the Morrison Bridge river surface measurements shown in Attachment E), the river extends up to OHW less than 1 percent of the time and the beach area is covered for only 2 to 40 percent of the time (depending on the beach surface elevation). Since we do not observe seeps in the beach, this suggests that groundwater discharge through a capped beach could only occur between 2 and 40 percent of the time.

TABLE 4. PERCENT OF TIME BEACH AREA OF THE SITE IS COVERED BY RIVER WATER

Reference	Reference Elevation (feet NAVD88)	Percent of time Inundated ¹
OHW	20	0.33%
"Beach"	16	2.38%
	15	3.72%
	14	5.21%
	13–Mean High Water (MHW)	7.44%
	12	10.22%
	11	15.67%
	10	25.41%
	9	41.20%
OLW (Boundary of Project)	8	60.54%
Mean Low Water (MLW)	4.4	99.64%

Note 1: See Attachment E for the calculation of these percentages based on data from the USGS River gauge at Morrison Bridge, Portland.

The fact that discharge only occurs through a small portion of the capped area is additionally supported by groundwater elevation data. Based on the groundwater elevation data collected during the quarterly monitoring program at the Site, groundwater elevations at the top of the riverbank are most consistently between approximately 10 and 12 feet North American Vertical Datum of 1988 (NAVD88) and have not been measured above 17 feet (NAVD88), suggesting that groundwater will rarely if ever exceed the OHW elevation of 20 feet NAVD88. Attachment F contains the tabulated groundwater elevation data for the Site, for reference. If groundwater elevations measured from the top of bank do not exceed OHW elevations, it cannot be discharging through a cap at this elevation. Furthermore, the groundwater elevation data suggest that discharge rarely

occurs above an elevation of about 11 feet NAVD88. Therefore, assuming that discharge can occur between OHW to 11 feet NAVD88 adds significant conservatism into the chemical isolation modeling and the cap design.

ATTACHMENTS

Figure 1. Vicinity Map

Figure 2. Site Plan with Geologic Cross-Section Locations

A. Appendix H (Flux Rate Calculations) from Preliminary Design Report

B. Seepage Study Results from WC Project Area

C. Porewater Results from WC Project Area

D. Lithologic Logs for the Riverbank Wells at the Crawford Street South Site

E. River Surface Elevations Relative to Groundwater Elevations at Crawford Street South Site

F. Tabulated Groundwater Elevation Data for the Crawford Street South Site

REFERENCES

Cascadia Associates, 2021. *Source Control Evaluation (SCE) Work Plan. Crawford Street Site*. August 16, 2021.

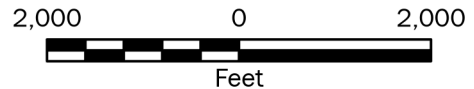
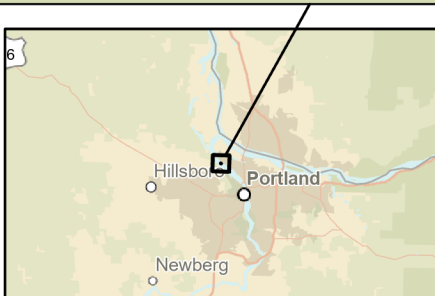
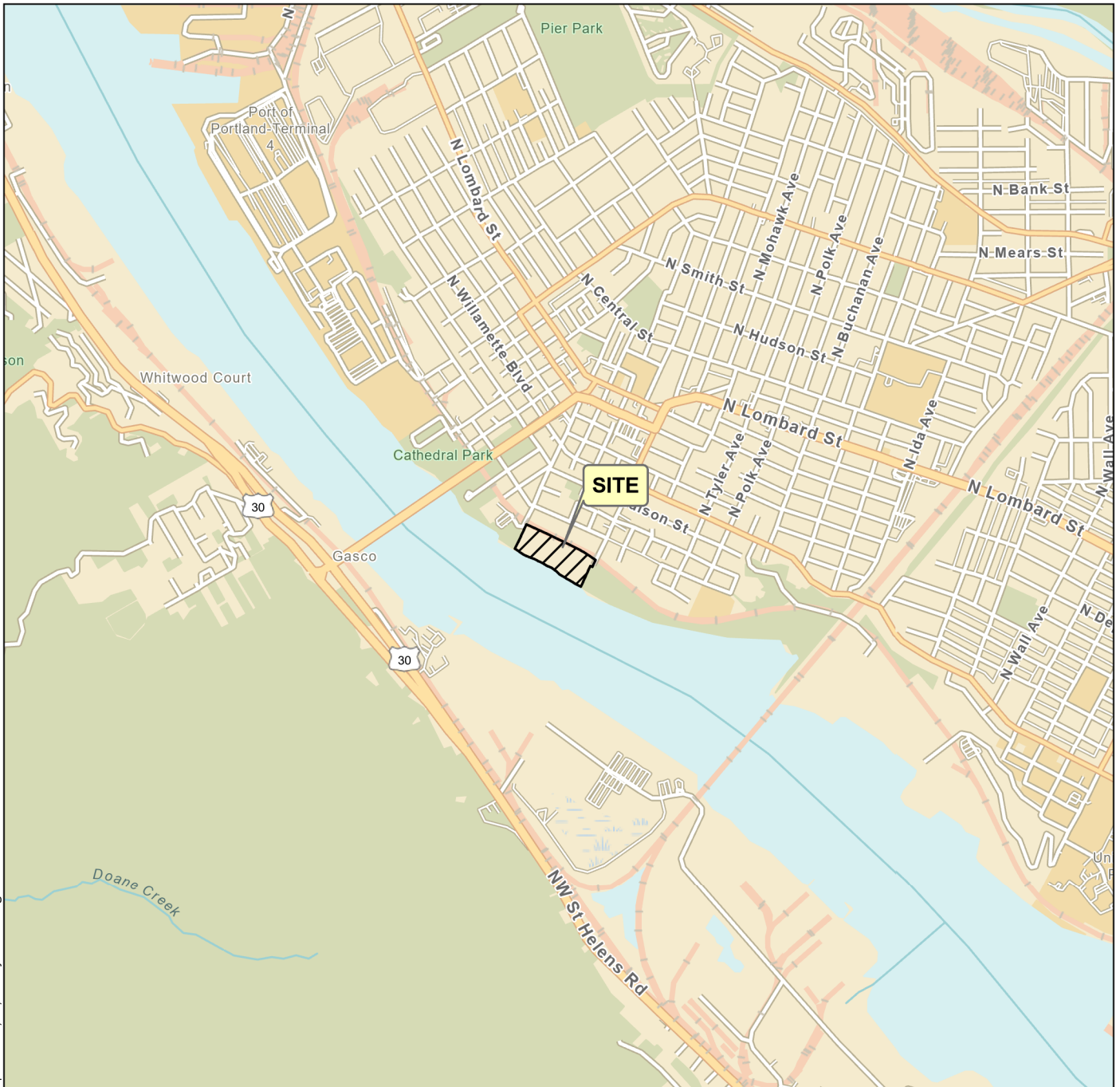
Freeze, R. Allan, and Cherry, John A., 1979. *Groundwater*. Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632.

GeoEngineers, 2022a. *Additional Riverbank Soil Characterization Report* submitted to DEQ on March 7, 2022

GeoEngineers, 2022b. *Basis of Design Report—Riverbank Source Control Measure, Crawford Street South Site*. November 17, 2022.

GeoEngineer, 2023. *Preliminary (30%) Design Report Riverbank Source Control Measure. Crawford Street South Site*. June 15, 2023.

Groundwater Solutions, Inc. (GSI), 2023. *Supplemental Preliminary Design Investigation Evaluation Report. Willamette Cove In-Water Project Area*. November 2023.



Vicinity Map

Crawford Street Site
Portland, Oregon



Figure 1

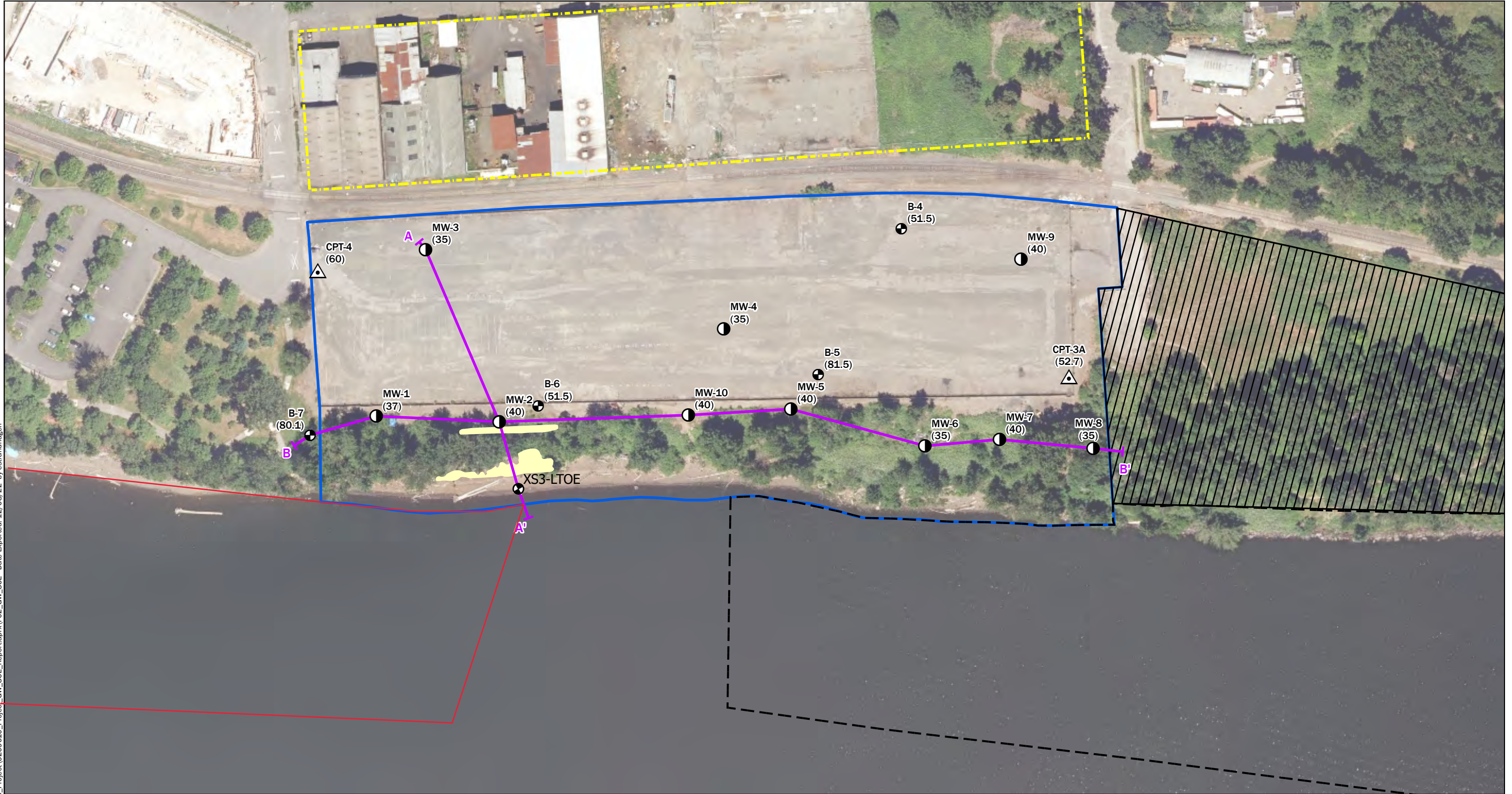
Notes:

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: ESRI

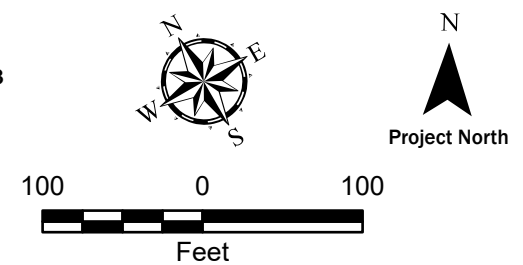
Projection: NAD 1983 UTM Zone 10N

P:\6209010\GIS\6209010_Project\6209010_Project\6209010_Project\6209010_Report\aprx\F02_GW_SCE Date Exported: 12/08/22 by estrandhagen



- Legend**
- MW-1 ● 2021 Monitoring Well
 - B-4 ● 2015 Boring ¹
 - CPT-4 ▲ 2015 Cone Penetrometer ¹
 - Geologic Cross Section Alignment
 - Black Sand Removal Areas
 - Boundary of Adjacent Site - ECSI #6167
 - Boundary of Crawford Street South Property - ECSI #2363
 - Willamette Cove In-Water Project Area
 - Willamette Cove Upland Site
 - Cathedral Parks In-Water Project Area
- ¹ (60) Completion Depth in Feet

Data Source: City of Portland Air Photo (Summer 2021)



Site Plan with Geologic Cross-Section Locations	
Crawford Street Site Portland, Oregon	
	Figure 2

APPENDIX A
Appendix H (Flux Rate Calculations)
from Preliminary Design Report

APPENDIX H
Groundwater Flux Rate Calculations



P:\6 620901002_GIS\620901002_Chem_30percent.aprx F_H-1_Flux_Analysis Date Exported: 06/07/23 by estrandhagen

Notes:

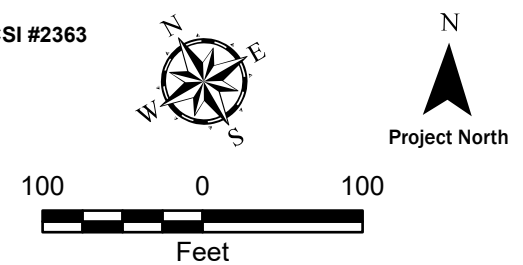
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers,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

Data Source: City of Portland Air Photo (Summer 2021)

Projection: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl

- Legend**
- MW-1 2021 Monitoring Well
 - L-1 Flux_Analysis_Transect
 - Black Sand Removal Areas
 - Boundary of Adjacent Site - ECSI #6167

- Boundary of Crawford Street South Property - ECSI #2363
- Willamette Cove In-Water Project Area
- Willamette Cove Upland Site



Flux Analysis Segments - Discharge Rate Estimates	
Crawford Street Site Portland, Oregon	
	Figure H-1

Table H-1: Groundwater Flux Rate Using November 9, 2021 Data

Crawford Street South Site

Well	Riverbank Linear Feet (L)	Gauging Time	Casing Elevation (ft NAVD88)	Well Depth (ft)	Depth to Water (ft)	GroundWater Elevation (ft NAVD88)	River Water Elevation (ft NAVD88)	River Elevation	Time	Δh Well to River (ft)	Well to River ΔL (ft)	i ($\Delta h/\Delta L$)	$q=Ki$ (ft/day)	$q=Ki$ (cm/day)	$q*L$	$q*L$ (negative flux - 0)
MW-1	145	8:55	35.25	37	25.52	9.73	10.22	9:00		-0.49	100	-0.005	-0.0014	-0.04	-6.06	0.00
MW-2	200	8:53	36.03	40	26.43	9.6	10.22	9:00		-0.62	80	-0.008	-0.0022	-0.07	-13.23	0.00
MW-10	175	8:51	36.40	40	26.79	9.61	10.11	8:45		-0.5	80	-0.006	-0.0018	-0.05	-9.33	0.00
MW-5	153	8:47	36.65	40	27.06	9.59	10.11	8:45		-0.52	90	-0.006	-0.0016	-0.05	-7.54	0.00
MW-6	128	8:43	33.75	35	24.08	9.67	10.11	8:45		-0.44	70	-0.006	-0.0018	-0.05	-6.87	0.00
MW-7	102	8:37	36.14	40	25.82	10.32	10.11	8:45		0.21	90	0.002	0.0007	0.02	2.03	2.03
¹ MW-8	87	NM	36.05	35	NM						100	0.000	0.0007	0.02	1.73	1.73
Total	990															
															q (cm/day) total ⁴ :	-0.04
															q (cm/day) total assuming inward flux = 0 and normalized across entire riverbank:	0.00
															q (cm/day) total normalized across riverbank segments with discharge flow (positive flux):	0.02
			² Hydraulic Conductivity Constant:	0.28 ft/day												
				10 ⁻⁴ cm/s												
			OLW:	7 NAVD88												

- MW-7 used to represent riverbank section of MW-8 because MW-8 not installed at this time.
- Gradient (i) is estimated by the difference in elevation between the groundwater elevation and river elevation at time of measurement divided by the distance from the well to the river
- Hydraulic conductivity estimated from Freeze & Cherry (1979), value taken from upper estimate for Silt, Loess, and lower estimate for Silty Sand. Soil at Site is sandy silt or silt loam.
- Total q is normalized by length of each section, i.e., $q(\text{total}) = \text{sum}(q*L)$ for each section divided by total length of riverbank.
- Elevation of the surface of the river ("River Water Elevation") obtained from the USGS gauge at Morrison Bridge and subtracting 1 foot to account for the stream gradient between Morrison Bridge and the Site.

Table H-2: Groundwater Flux Rate Using December 20, 2021 Data

Crawford Street South Site

Well	Riverbank Linear Feet (L)	Gauging Time	Casing Elevation (ft NAVD88)	Depth to Water (ft)	GroundWater Elevation (ft NAVD88)	River Water Elevation (ft NAVD88)	River Elevation Time	Δh (ft)	Well to River ΔL (ft)	i ($\Delta h/\Delta L$)	$q=Ki$ (ft/day)	$q=Ki$ (cm/day)	$q*L$	$q*L$ (negative flux - 0)
MW-1	145	8:52	35.25	24.12	11.13	12.05	8:45	-0.92	100	-0.009	0.00	-0.08	-11.4	0
MW-2	200	8:57	36.03	25.24	10.79	12.03	9:00	-1.24	80	-0.016	0.00	-0.13	-26.5	0
MW-10	175	9:02	36.40	25.57	10.83	12.03	9:00	-1.2	80	-0.015	0.00	-0.13	-22.4	0
MW-5	153	9:16	36.65	25.72	10.93	12.00	9:15	-1.07	90	-0.012	0.00	-0.10	-15.5	0
MW-6	128	9:24	33.75	22.29	11.46	12.00	9:30	-0.54	70	-0.008	0.00	-0.07	-8.4	0
MW-7	102	9:58	36.14	23.96	12.18	11.89	10:00	0.29	90	0.003	0.00	0.03	2.8	2.80
MW-8	87	9:52	36.05	22.07	13.98	11.92	9:45	2.06	100	0.021	0.01	0.18	15.3	15.30
Total	990													

q (cm/day) total³: -0.07
 q (cm/day) total assuming inward flux = 0 and normalized across entire riverbank: 0.02
 q (cm/day) total normalized across riverbank with discharge flow: 0.10

²Hydraulic Conductivity Constant: 0.28 ft/day
 10^{-4} cm/s
 OLW: 7 NAVD88

1. Gradient (i) is estimated by the difference in elevation between the groundwater elevation and river elevation at time of measurement divided by the distance from the well to the river
2. Hydraulic conductivity estimated from Freeze & Cherry (1979), value taken from upper estimate for Silt, Loess, and lower estimate for Silty Sand. Soil at Site is sandy silt or silt loam
3. Total q is normalized by length of each section, i.e., $q(\text{total}) = \text{sum}(q*L)$ for each section divided by total length of riverbank
4. Elevation of the surface of the river ("River Water Elevation") obtained from the USGS gauge at Morrison Bridge and subtracting 1 foot to account for the stream gradient between Morrison Bridge and the Site

Table H-3: Groundwater Flux Rate Using March 15, 2022 Data

Crawford Street South Site

Well	Riverbank Linear Feet (L)	Gauging Time	Casing Elevation (ft NAVD88)	Depth to Water (ft)	GroundWater Elevation (ft NAVD88)	River Water Elevation (ft NAVD88)	River Elevation Time	Δh (ft)	Well to River ΔL (ft)	i ($\Delta h/\Delta L$)	$q=Ki$ (ft/day)	$q=Ki$ (cm/day)	$q*L$	$q*L$ (negative flux - 0)
MW-1	145	8:15	35.25	23.16	12.09	10.62	8:15	1.47	100	0.015	0.0041	0.13	18.2	18.2
MW-2	200	8:18	36.03	24.41	11.62	10.62	8:15	1.00	80	0.013	0.0035	0.11	21.3	21.3
MW-10	175	8:24	36.40	24.86	11.54	10.58	8:30	0.96	80	0.012	0.0034	0.10	17.9	17.9
MW-5	153	8:39	36.65	24.95	11.70	10.52	8:45	1.18	90	0.013	0.0037	0.11	17.1	17.1
MW-6	128	8:44	33.75	22.07	11.68	10.52	8:45	1.16	70	0.017	0.0046	0.14	18.1	18.1
MW-7	102	8:48	36.14	24.13	12.01	10.52	8:45	1.49	90	0.017	0.0046	0.14	14.4	14.4
MW-8	87	8:53	36.05	23.98	12.07	10.48	9:00	1.59	100	0.016	0.0045	0.14	11.8	11.8
Total:	990													
² Hydraulic Conductivity Constant:			0.28 ft/day								q (cm/day) total ³ :		0.12	
			10 ⁻⁴ cm/s								q (cm/day) total assuming inward flux = 0 and normalized across entire riverbank:		0.12	
OLW:			7 NAVD88								q (cm/day) total normalized across riverbank with discharge flow:		0.12	

1. Gradient (i) is estimated by the difference in elevation between the groundwater elevation and river elevation at time of measurement divided by the distance from the well to the river.
2. Hydraulic conductivity estimated from Freeze & Cherry (1979), value taken from upper estimate for Silt, Loess, and lower estimate for Silty Sand. Soil at Site is sandy silt or silt loam.
3. Total q is normalized by length of each section. i.e., $q(\text{total}) = \text{sum}(q*L)$ for each section divided by total length of riverbank.
4. Elevation of the surface of the river ("River Water Elevation") obtained from the USGS gauge at Morrison Bridge and subtracting 1 foot to account for the stream gradient between Morrison Bridge and the Site.

Table H-4: Groundwater Flux Rate Using June 27, 2022 Data

Crawford Street South Site

Well	Riverbank Linear Feet (L)	Gauging Time	Casing Elevation (ft NAVD88)	Depth to Water (ft)	GroundWater Elevation (ft NAVD88)	River Water Elevation (ft NAVD88)	River Elevation Time	Δh (ft)	Well to River ΔL (ft)	i ($\Delta h/\Delta L$)	$q=Ki$ (ft/day)	$q=Ki$ (cm/day)	q^*L	q^*L (negative flux - 0)
MW-1	145	8:01	35.25	20.22	15.03	16.87	8:00	-1.84	100	-0.018	-0.01	-0.16	-22.8	0
MW-2	200	7:55	36.03	21.8	14.23	16.87	8:00	-2.64	80	-0.033	-0.01	-0.28	-56.3	0
MW-10	175	7:44	36.40	23.08	13.32	16.87	7:45	-3.55	80	-0.044	-0.01	-0.38	-66.3	0
MW-5	153	7:38	36.65	21.77	14.88	16.87	7:45	-1.99	90	-0.022	-0.01	-0.19	-28.9	0
MW-6	128	7:28	33.75	17.19	16.56	16.89	7:30	-0.33	70	-0.005	0.00	-0.04	-5.1	0
MW-7	102	7:25	36.14	20.28	15.86	16.89	7:30	-1.03	90	-0.011	0.00	-0.10	-10.0	0
MW-8	87	7:11	36.05	19.59	16.46	16.90	7:15	-0.44	100	-0.004	0.00	-0.04	-3.3	0
Total:	990													
												q (cm/day) tot	-0.2	
												q (cm/day) total assuming inward flux = 0 and normalized across entire riverbank:		0
												q (cm/day) total normalized across riverbank with discharge flow:		0

²Hydraulic Conductivity Constant: 0.28 ft/day
10⁻⁴ cm/s

OLW: 7 NAVD88

1. Gradient (i) is estimated by the difference in elevation between the groundwater elevation and river elevation at time of measurement divided by the distance from the well to the river.
2. Hydraulic conductivity estimated from Freeze & Cherry (1979), value taken from upper estimate for Silt, Loess, and lower estimate for Silty Sand. Soil at Site is sandy silt or silt loam.
3. Total q is normalized by length of each section, i.e., $q(\text{total}) = \sum (q^*L)$ for each section divided by total length of riverbank.
4. Elevation of the surface of the river ("River Water Elevation") obtained from the USGS gauge at Morrison Bridge and subtracting 1 foot to account for the stream gradient between Morrison Bridge and the Site.

Table H-5: Groundwater Flux Rate Using September 7, 2022 Data

Crawford Street South Site

Well	Riverbank Linear Feet (L)	Gauging Time	Casing Elevation (ft NAVD88)	Depth to Water (ft)	GroundWater Elevation (ft NAVD88)	River Water Elevation (ft NAVD88)	River Elevation Time	Δh (ft)	Well to River ΔL (ft)	i ($\Delta h/\Delta L$)	$q=Ki$ (ft/day)	$q=Ki$ (cm/day)	q^*L	q^*L (negative flux - 0)
MW-1	145	8:25	35.25	23.45	11.80	7.34	8:30	4.46	100	0.045	0.012	0.38	55	55
MW-2	200	8:19	36.03	24.75	11.28	7.44	8:15	3.84	80	0.048	0.013	0.41	82	82
MW-10	175	8:13	36.40	24.86	11.54	7.44	8:15	4.1	80	0.051	0.014	0.44	77	77
MW-5	153	8:06	36.65	25.18	11.47	7.50	8:00	3.97	90	0.044	0.012	0.38	58	58
MW-6	128	7:59	33.75	22.64	11.11	7.50	8:00	3.61	70	0.052	0.014	0.44	56	56
MW-7	102	7:52	36.14	25.01	11.13	7.65	7:45	3.48	90	0.039	0.011	0.33	34	34
MW-8	87	7:45	36.05	25.29	10.76	7.65	7:45	3.11	100	0.031	0.009	0.27	23	23
Total	990													

q (cm/day) total³: 0.39
 q (cm/day) total assuming inward flux = 0 and normalized across entire riverbank: 0.39
 q (cm/day) total normalized across riverbank with discharge flow: 0.39

²Hydraulic Conductivity Constant: 0.28 ft/day
 10^{-4} cm/s
 OLV: 7 NAVD88

1. Gradient (i) is estimated by the difference in elevation between the groundwater elevation and river elevation at time of measurement divided by the distance from the well to the river.
2. Hydraulic conductivity estimated from Freeze & Cherry (1979), value taken from upper estimate for Silt, Loess, and lower estimate for Silty Sand. Soil at Site is sandy silt or silt loam.
3. Total q is normalized by length of each section, i.e., $q(\text{total}) = \text{sum}(q^*L)$ for each section divided by total length of riverbank.
4. Elevation of the surface of the river ("River Water Elevation") obtained from the USGS gauge at Morrison Bridge and subtracting 1 foot to account for the stream gradient between Morrison Bridge and the Site.

Table H-6: Groundwater Flux Rate Using April 17, 2023 Data

Crawford Street South Site

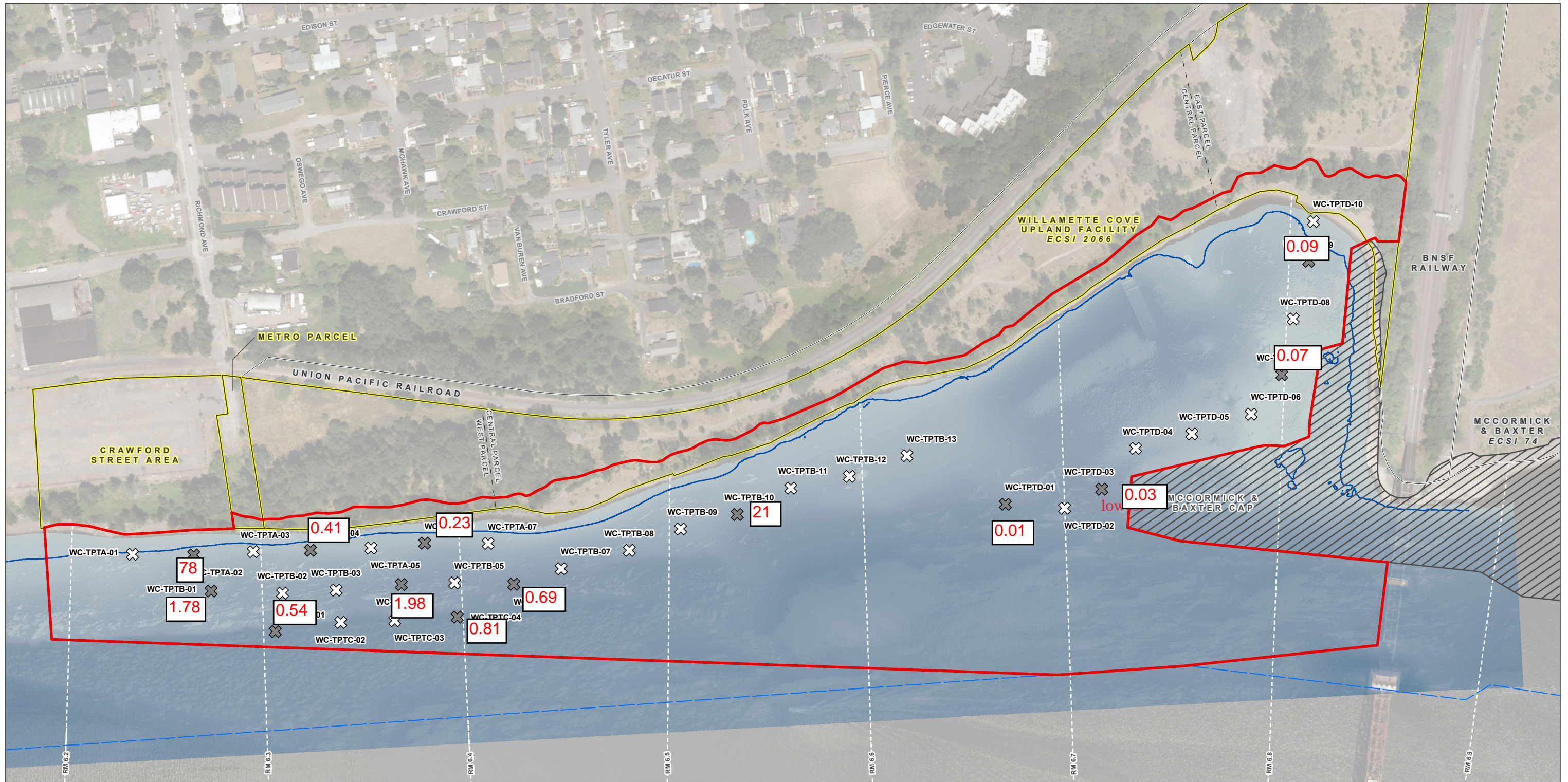
Well	Riverbank Linear Feet (L)	Gauging Time	Casing Elevation (ft NAVD88)	Depth to Water (ft)	GroundWater Elevation (ft NAVD88)	River Water Elevation (ft NAVD88)	River Elevation Time	Δh (ft)	Well to River ΔL (ft)	i ($\Delta h/\Delta L$)	$q=Ki$ (ft/day)	$q=Ki$ (cm/day)	$q*L$	$q*L$ (negative flux - 0)
MW-1	145	10:21	35.25	23.36	11.89	9.61	10:20	2.28	100	0.023	0.006	0.19	28	28
MW-2	200	10:09	36.03	25.04	10.99	9.63	10:10	1.36	80	0.017	0.005	0.15	29	29
MW-10	175	9:58	36.40	25.46	10.94	9.67	10:00	1.27	80	0.016	0.004	0.14	24	24
MW-5	153	9:42	36.65	25.67	10.98	9.74	9:40	1.24	90	0.014	0.004	0.12	18	18
MW-6	128	9:35	33.75	22.41	11.34	9.80	9:35	1.54	70	0.022	0.006	0.19	24	24
MW-7	102	9:26	36.14	24.05	12.09	9.84	9:25	2.25	90	0.025	0.007	0.21	22	22
MW-8	87	9:12	36.05	23.47	12.58	9.94	9:10	2.64	100	0.026	0.007	0.23	20	20
Total:	990													

q (cm/day) total³: 0.17
 q (cm/day) total assuming inward flux = 0 and normalized across entire riverbank: 0.17
 q (cm/day) total normalized across riverbank with discharge flow: 0.17

²Hydraulic Conductivity Constant: 0.28 ft/day
 10^{-4} cm/s
 OLV: 7 NAVD88

1. Gradient (i) is estimated by the difference in elevation between the groundwater elevation and river elevation at time of measurement divided by the distance from the well to the river.
2. Hydraulic conductivity estimated from Freeze & Cherry (1979), value taken from upper estimate for Silt, Loess, and lower estimate for Silty Sand. Soil at Site is sandy silt or silt loam.
3. Total q is normalized by length of each section. i.e., $q(\text{total}) = \text{sum}(q*L)$ for each section divided by total length of riverbank.
4. Elevation of the surface of the river ("River Water Elevation") obtained from the USGS gauge at Morrison Bridge and subtracting 1 foot to account for the stream gradient between Morrison Bridge and the Site.

APPENDIX B
Seepage Study Results
from WC Project Area



LEGEND

- ⊗ Trident Probe
- ⊗ UltraSeep Meter and Trident Probe
- Bathymetry**
- 10 feet
- 66 feet

- All Other Features**
- Project Area Boundary
 - Adjacent Upland Parcel
 - Adjacent Upland Subparcel
 - Upland Parcel
 - Capped Area
 - Navigation Channel
 - 3.2 feet NAVD 88 (-2 feet CRD)
 - River Mile (RM)

NOTES

1. The riverward boundary of the Crawford Street Area is at ordinary low water, as defined by USACE (2017).
2. The 3.2 feet NAVD 88 (-2 feet CRD) contour is generated from 2021 site bathymetry, Solmar Hydro.
3. The Project Area boundary line adjacent to the Willamette Cove Upland Facility is based on the 2022 Supplemental Pre-Design Investigation top of bank field survey.

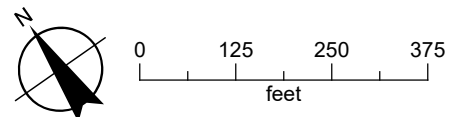
CRD: Columbia River Datum
 ECSI: Environmental Cleanup Site Information
 NAVD 88: North American Vertical Datum of 1988
 USACE: U.S. Army Corps of Engineers
 Date: August 25, 2023
 Data Sources: City of Portland 2019, METRO 2022, ESRI, USACE 2014, Aerial City of Portland 2020

1.98

Seepage meter results in cm/day **Trident Probe Survey and UltraSeep Meter Locations**

Supplemental Pre-Design Investigation Evaluation Report

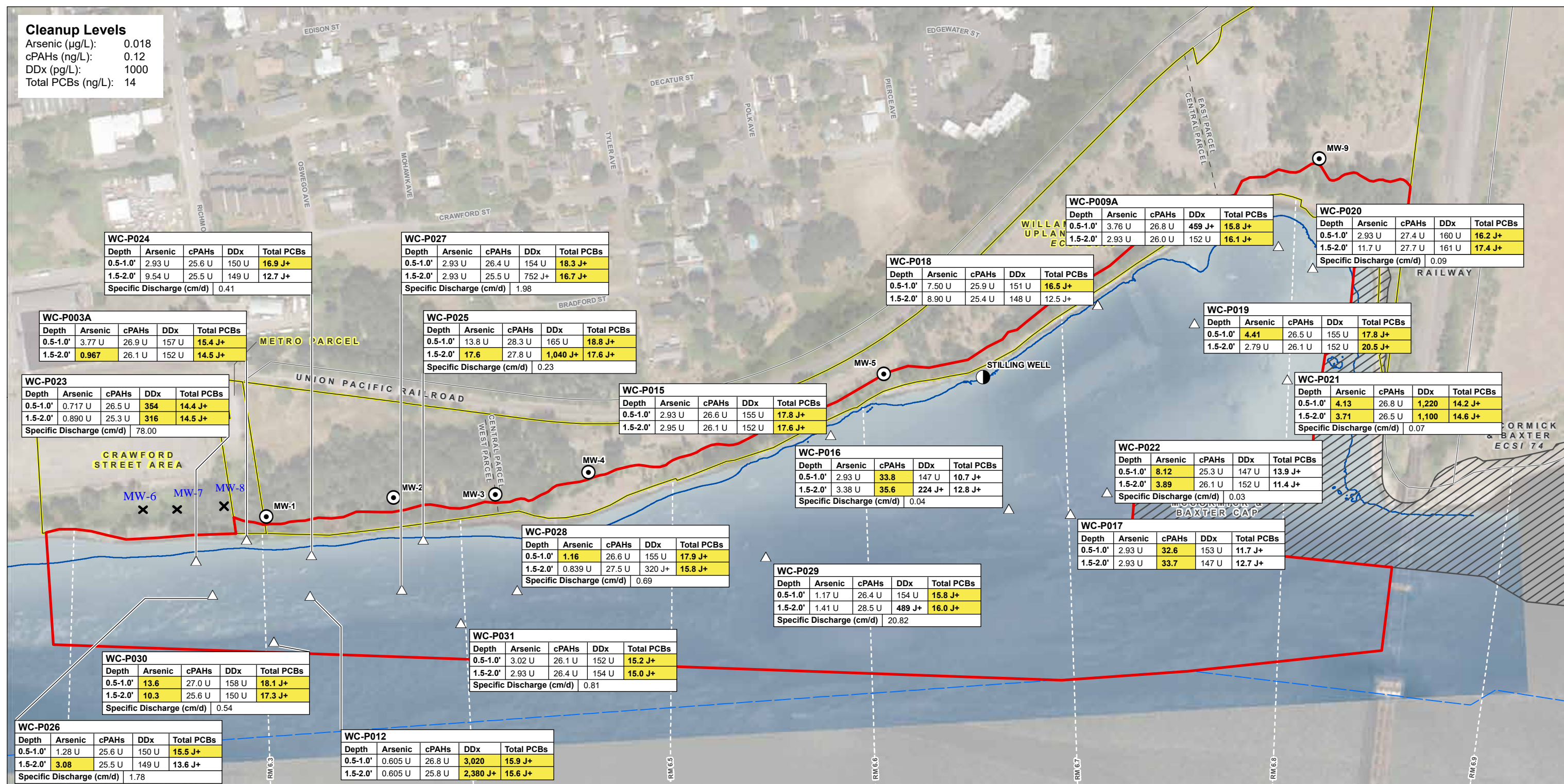
FIGURE 2-8



APPENDIX C
Porewater Results from WC Project Area

Cleanup Levels

Arsenic (µg/L):	0.018
cPAHs (ng/L):	0.12
DDx (pg/L):	1000
Total PCBs (ng/L):	14



LEGEND

- Upland Monitoring Well
- Stilling_Well
- Sample Method**
 - Porewater
 - Groundwater CUL Exceedance
- Bathymetry**
 - 10 feet
 - 66 feet
- All Other Features**
 - Project Area Boundary
 - Adjacent Upland Parcel
 - Adjacent Upland Subparcel
 - Upland Parcel
 - Capped Area
 - Navigation Channel
 - 3.2 feet NAVD 88 (-2 feet CRD)
 - River Mile (RM)

NOTES

- The riverward boundary of the Crawford Street Area is at ordinary low water, as defined by USACE (2017).
- The 3.2 feet NAVD 88 (-2 feet CRD) contour is generated from 2021 site bathymetry, Solmar Hydro.
- The Project Area boundary line adjacent to the Willamette Cove Upland Facility is based on the 2022 Supplemental Pre-Design Investigation top of bank field survey.
- Average specific discharge values measured during the UltraSeep Survey. See Appendix L for complete data analysis.
- Summation of PCB congeners includes non-detects at one half the detection limit. Some sample results would not exceed cleanup levels if non-detects were not included in the summation.

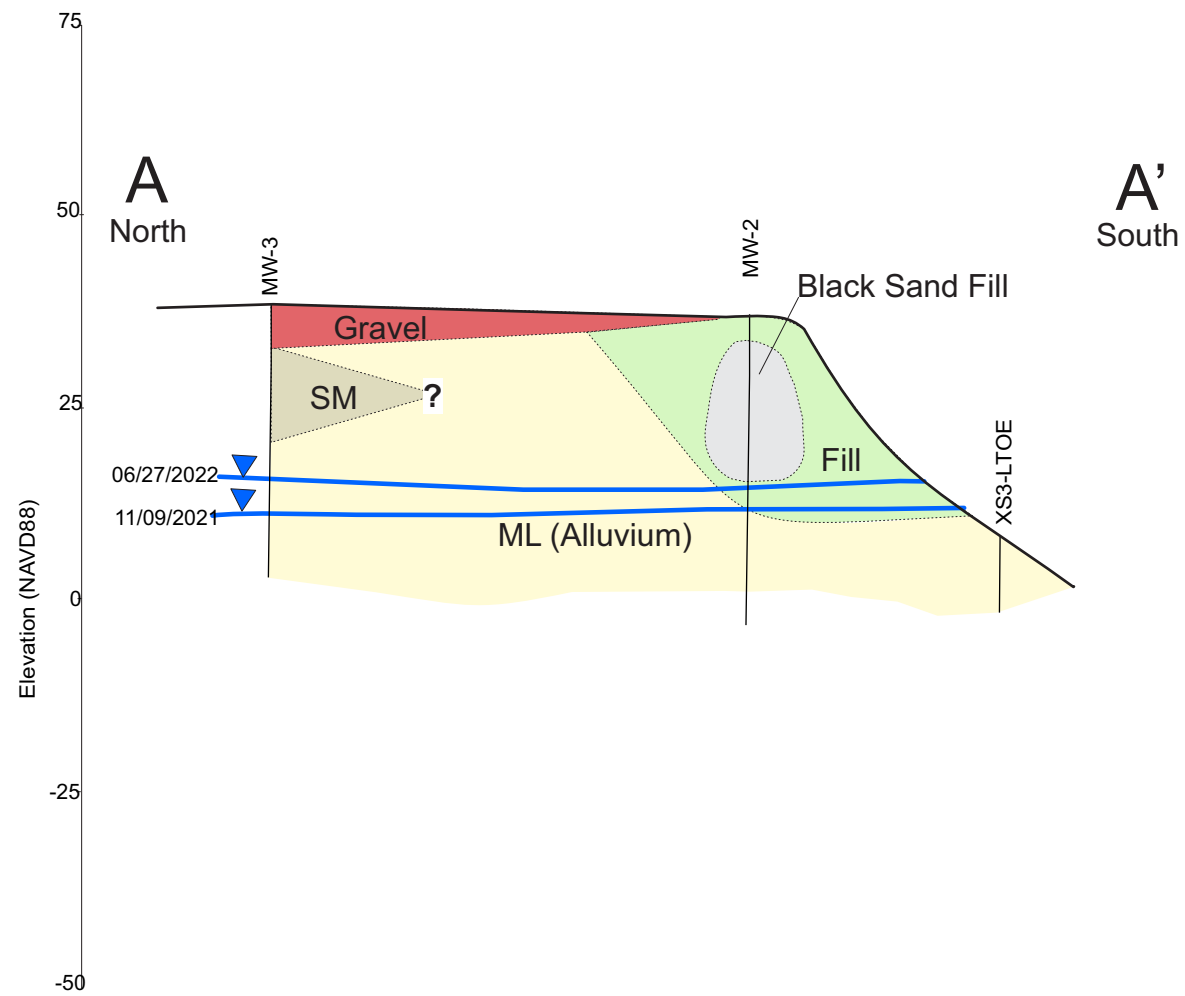
BOLD: Detection
U: Non Detect
J: Estimated

CRD: Columbia River Datum
cm/d centimeter per day
ECSI: Environmental Cleanup Site Information
NAVD 88: North American Vertical Datum of 1988
ng/L: Nanograms per liter
pg/L: Picograms per liter
µg/L Micrograms per liter
USACE: U.S. Army Corps of Engineers

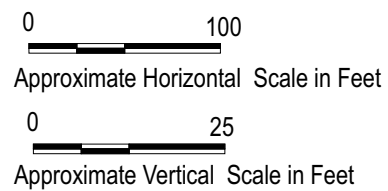
FIGURE 4-17
Porewater Results
 Supplemental Pre-Design Investigation
 Evaluation Report

Date: September 1, 2023
 Data Sources: City of Portland 2019, METRO 2022, ESRI, USACE 2014, Aerial City of Portland 2020

APPENDIX D
Lithologic Logs for the Riverbank Wells
at the Crawford Street South Site



Note: the topography between borings is estimated based on site observation.



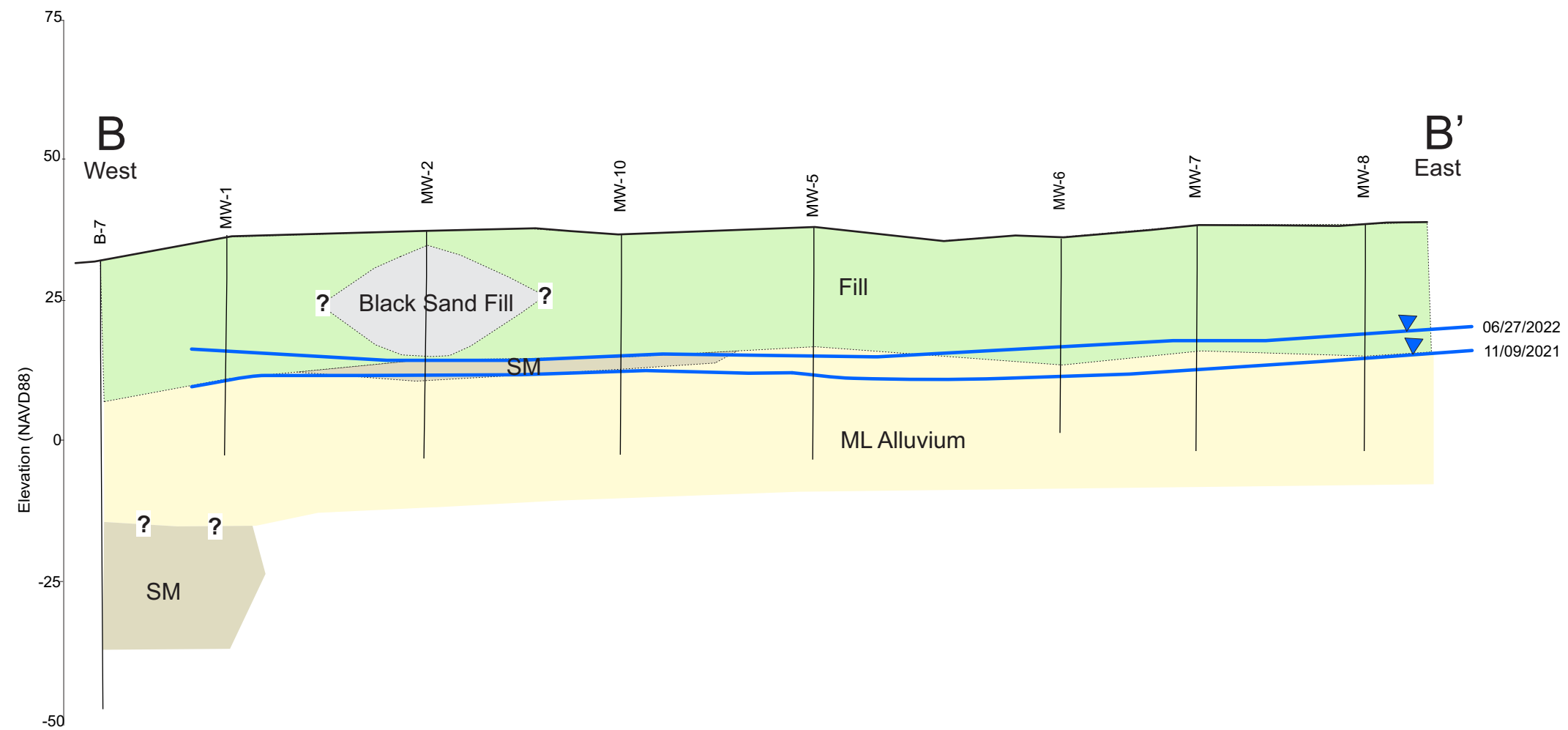
- Sand with Silt (SM) and Sand (SP) Alluvium
- Silt and Sandy Silt (ML) Alluvium
- Fill - Silt, Sandy Silt with Wood and Other Debris
- Black Sand Fill
- Gravel Fill
- Groundwater elevation measured on date indicated.

Geologic Cross Section A-A'

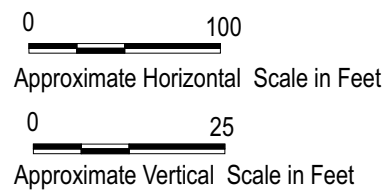
Crawford Street Site
Portland, Oregon



Project Number	06209-010-01	Figure
December 2022		4



Note: the topography between borings is estimated based on site observation.



- Sand with Silt (SM) and Sand (SP) Alluvium
- Silt and Sandy Silt (ML) Alluvium
- Fill - Silt, Sandy Silt with Wood and Other Debris
- Black Sand Fill
- Groundwater elevation measured on date indicated.

Geologic Cross Section B-B'

Crawford Street Site
Portland, Oregon



Project Number	06209-010-01	Figure
December 2022		5

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS <small>(LITTLE OR NO FINES)</small>		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES <small>(APPRECIABLE AMOUNT OF FINES)</small>		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH FINES <small>(APPRECIABLE AMOUNT OF FINES)</small>		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
	SAND AND SANDY SOILS	CLEAN SANDS <small>(LITTLE OR NO FINES)</small>		SW	WELL-GRADED SANDS, GRAVELLY SANDS
		SANDS WITH FINES <small>(APPRECIABLE AMOUNT OF FINES)</small>		SP	POORLY-GRADED SANDS, GRAVELLY SAND
		SANDS WITH FINES <small>(APPRECIABLE AMOUNT OF FINES)</small>		SM	SILTY SANDS, SAND - SILT MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
		LIQUID LIMIT LESS THAN 50		CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		LIQUID LIMIT LESS THAN 50		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
		LIQUID LIMIT GREATER THAN 50		CH	INORGANIC CLAYS OF HIGH PLASTICITY
		LIQUID LIMIT GREATER THAN 50		OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

Sampler Symbol Descriptions

	2.4-inch I.D. split barrel / Dames & Moore (D&M)
	Standard Penetration Test (SPT)
	Shelby tube
	Piston
	Direct-Push
	Bulk or grab
	Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTIONS
GRAPH	LETTER	
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact



Measured groundwater level in exploration, well, or piezometer



Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Laboratory / Field Tests

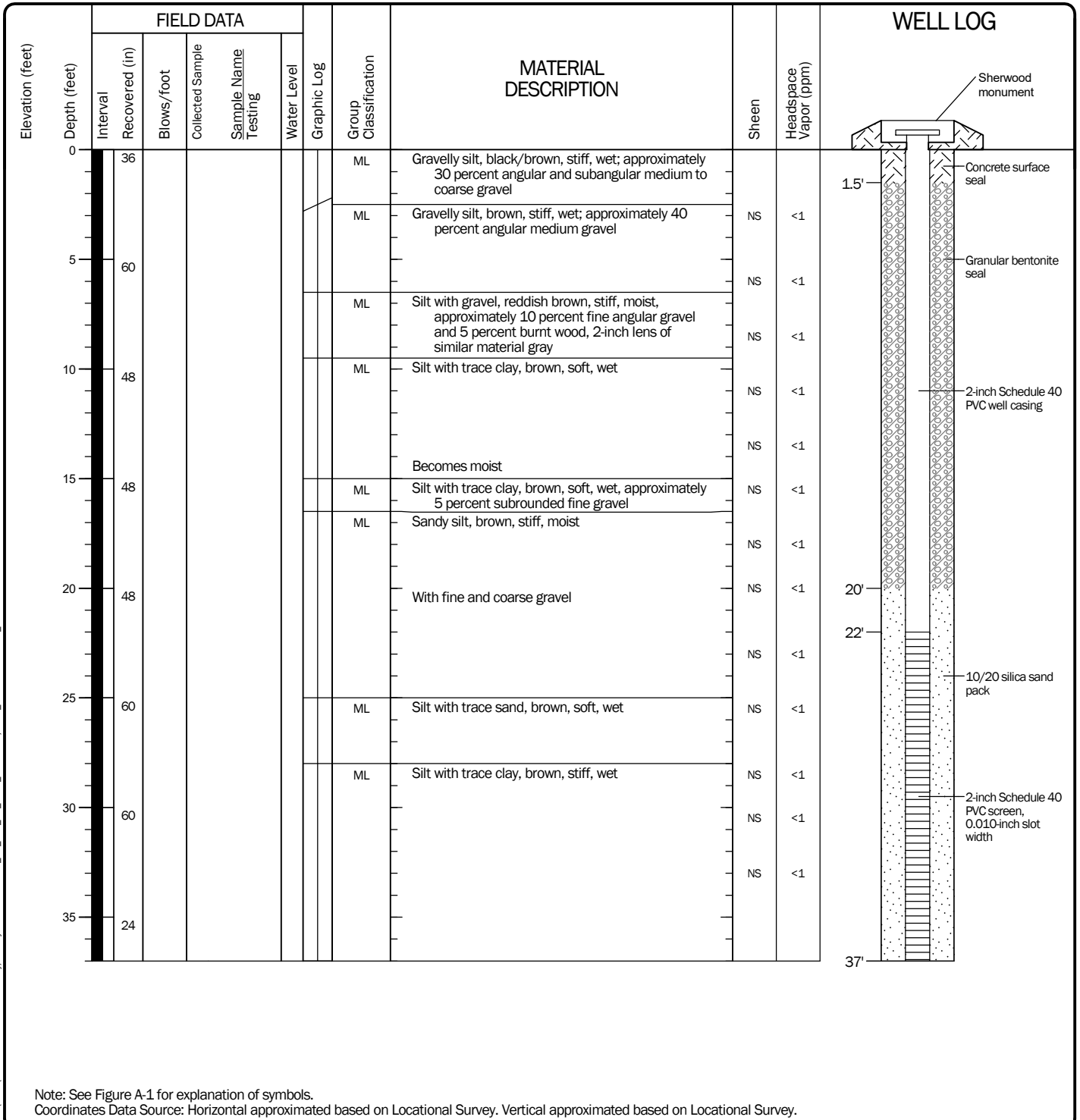
%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point lead test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
UU	Unconsolidated undrained triaxial compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

Key to Exploration Logs

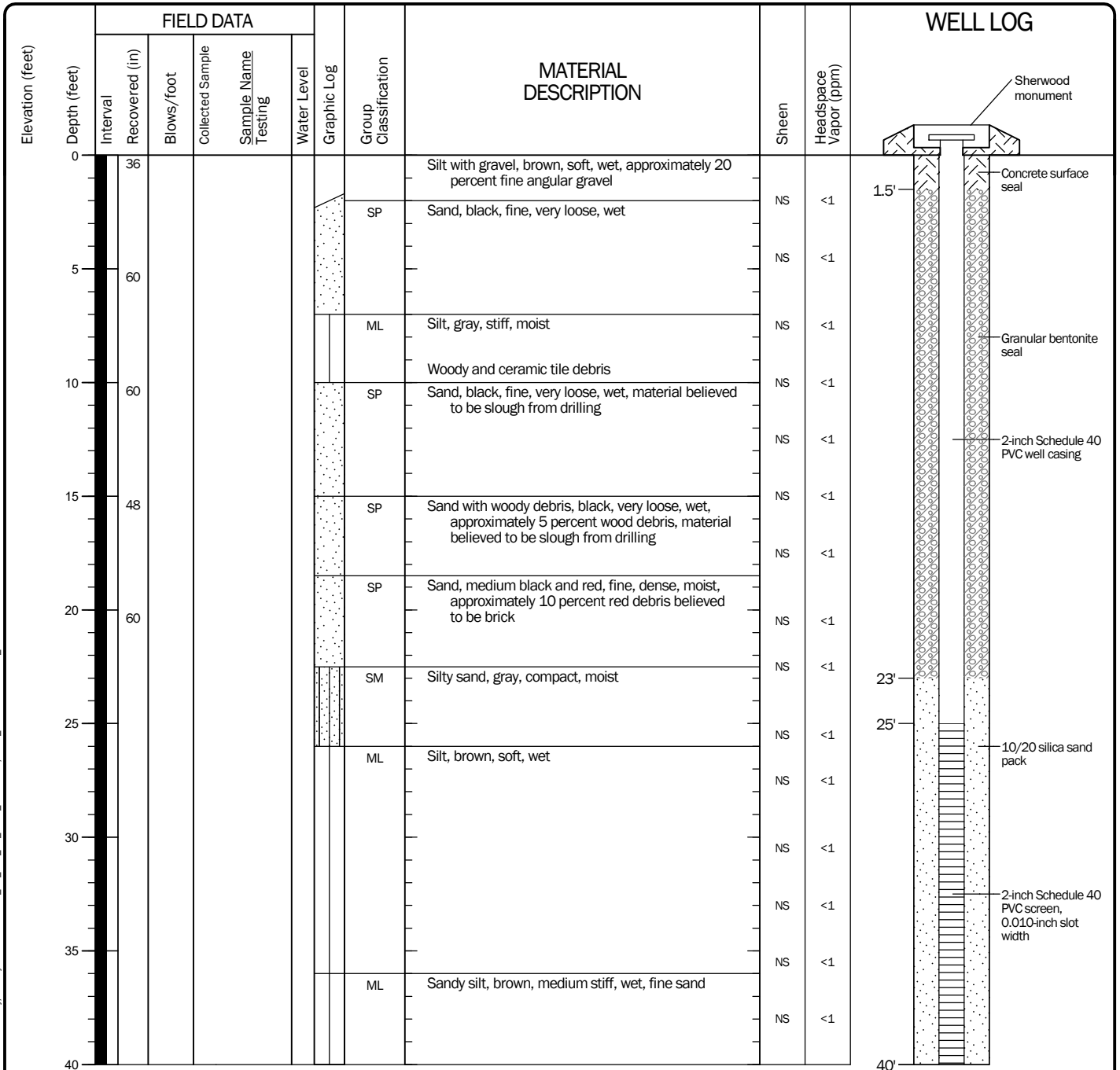
Start Drilled 10/27/2021	End 10/27/2021	Total Depth (ft)	37	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 10/27/2021 to a depth of 37 ft.	
Surface Elevation (ft) Vertical Datum		Undetermined NAVD88		Top of Casing Elevation (ft)		35.25		Groundwater Date Measured	
Easting (X) Northing (Y)		7624022.678 707185.561		Horizontal Datum		OR State Plane North NAD83 (feet)		Depth to Water (ft)	
								Elevation (ft)	
Notes:									



Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary\Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEB6_ENVIRONMENTAL_WELL

Log of Monitoring Well MW-1		
	Project:	Crawford Street
	Project Location:	Portland, Oregon
	Project Number:	6209-010-02
		Figure B-2 Sheet 1 of 1

Start Drilled 10/27/2021	End 10/27/2021	Total Depth (ft)	40	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 10/27/2021 to a depth of 40 ft.	
Surface Elevation (ft)		Undetermined		Top of Casing Elevation (ft)		36.03		Groundwater	
Vertical Datum		NAVD88		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
Easting (X) Northing (Y)		7624152.847 707102.236						Depth to Water (ft)	
								Elevation (ft)	
Notes:									



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

Log of Monitoring Well MW-2

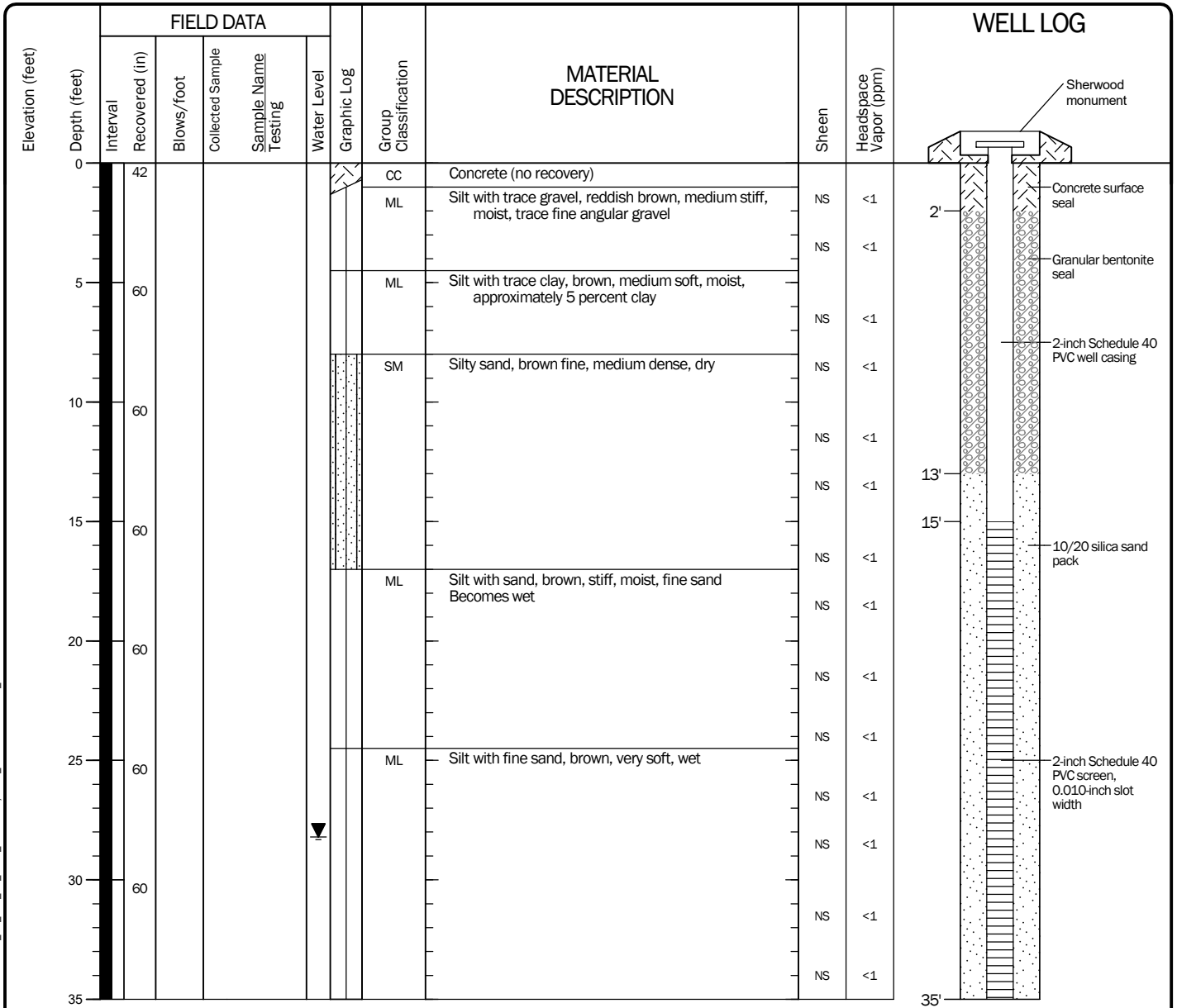


Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Figure B-3
Sheet 1 of 1

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEB6_ENVIRONMENTAL_WELL

Start Drilled 10/25/2021	End 10/26/2021	Total Depth (ft)	35	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 10/26/2021 to a depth of 35 ft.	
Surface Elevation (ft)		Undetermined		Top of Casing Elevation (ft)		37.54		Groundwater	
Vertical Datum		NAVD88		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
Easting (X)		7624180.869		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
Northing (Y)		707335.509		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
								10/26/2021	
								28.20	
								Elevation (ft)	
Notes:									



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

Log of Monitoring Well MW-3



Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEI6_ENVIRONMENTAL_WELL

Start Drilled 10/26/2021	End 10/26/2021	Total Depth (ft)	35	Logged By Checked By	JMP/LW JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 10/26/2021 to a depth of 35 ft.	
Surface Elevation (ft)		Undetermined		Top of Casing Elevation (ft)		38.43		Groundwater	
Vertical Datum		NAVD88		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
Easting (X)		7624455.248		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
Northing (Y)		707062.084		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured	
								10/26/2021	
								29.30	
								Elevation (ft)	
Notes:									

Elevation (feet)	FIELD DATA						MATERIAL DESCRIPTION	Sheen	Headspace Vapor (ppm)	WELL LOG
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level				
0	36					CC	Concrete (no recovery)	NS	<1	1.5'
						ML	Silt with trace gravel, brown, medium stiff, moist, fine angular gravel	NS	<1	
5	60					SM	Silty sand, brown, medium dense, moist, fine sand	NS	<1	
						ML	Silt, brown, medium stiff, moist, 2-inch lens	NS	<1	
						SM	Silty sand, brown, fine, medium dense, moist	NS	<1	
10	60					ML	Silt with trace clay, brown, stiff, moist	NS	<1	
						SP	Sand with silt and trace debris, brown, medium dense, moist	NS	<1	
						ML	Silt with trace clay, brown, stiff, moist	NS	<1	
15	60						Becomes wet	NS	<1	
								NS	<1	
20	60							NS	<1	18'
								NS	<1	20'
								NS	<1	
25	60							NS	<1	
								NS	<1	
30	60							NS	<1	
								NS	<1	
								NS	<1	
35	60							NS	<1	35'

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEB6_ENVIRONMENTAL_WELL

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

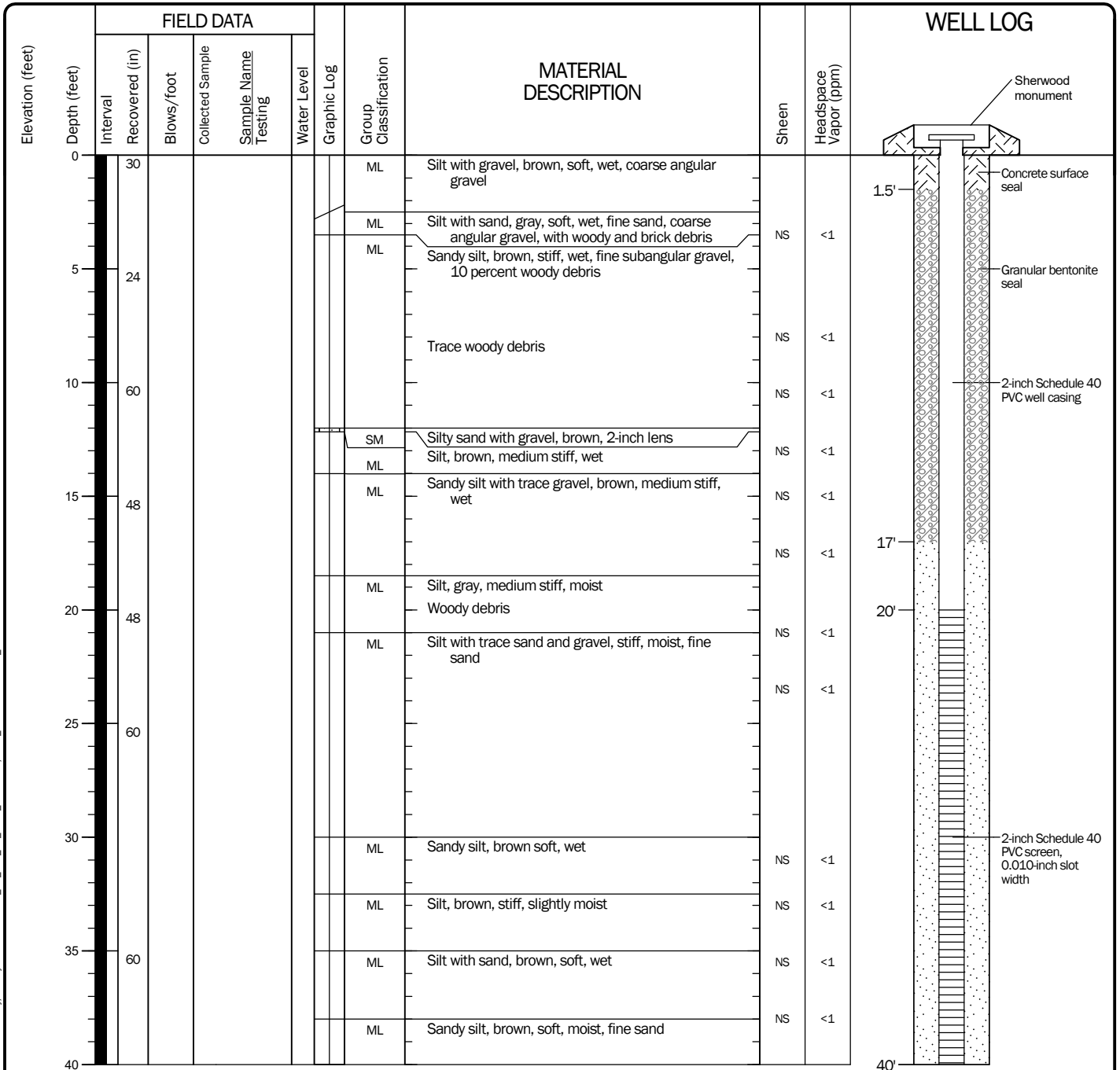
Log of Monitoring Well MW-4



Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Figure B-5
Sheet 1 of 1

Start Drilled 10/28/2021	End 10/29/2021	Total Depth (ft)	40	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data	N/A			Drilling Equipment	Geoprobe 3230 DT		A 2-in well was installed on 10/28/2021 to a depth of 40 ft.		
Surface Elevation (ft) Vertical Datum	Undetermined NAVD88			Top of Casing Elevation (ft)	36.65		Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
Easting (X) Northing (Y)	7624478.004 706932.849			Horizontal Datum	OR State Plane North NAD83 (feet)				
Notes:									



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

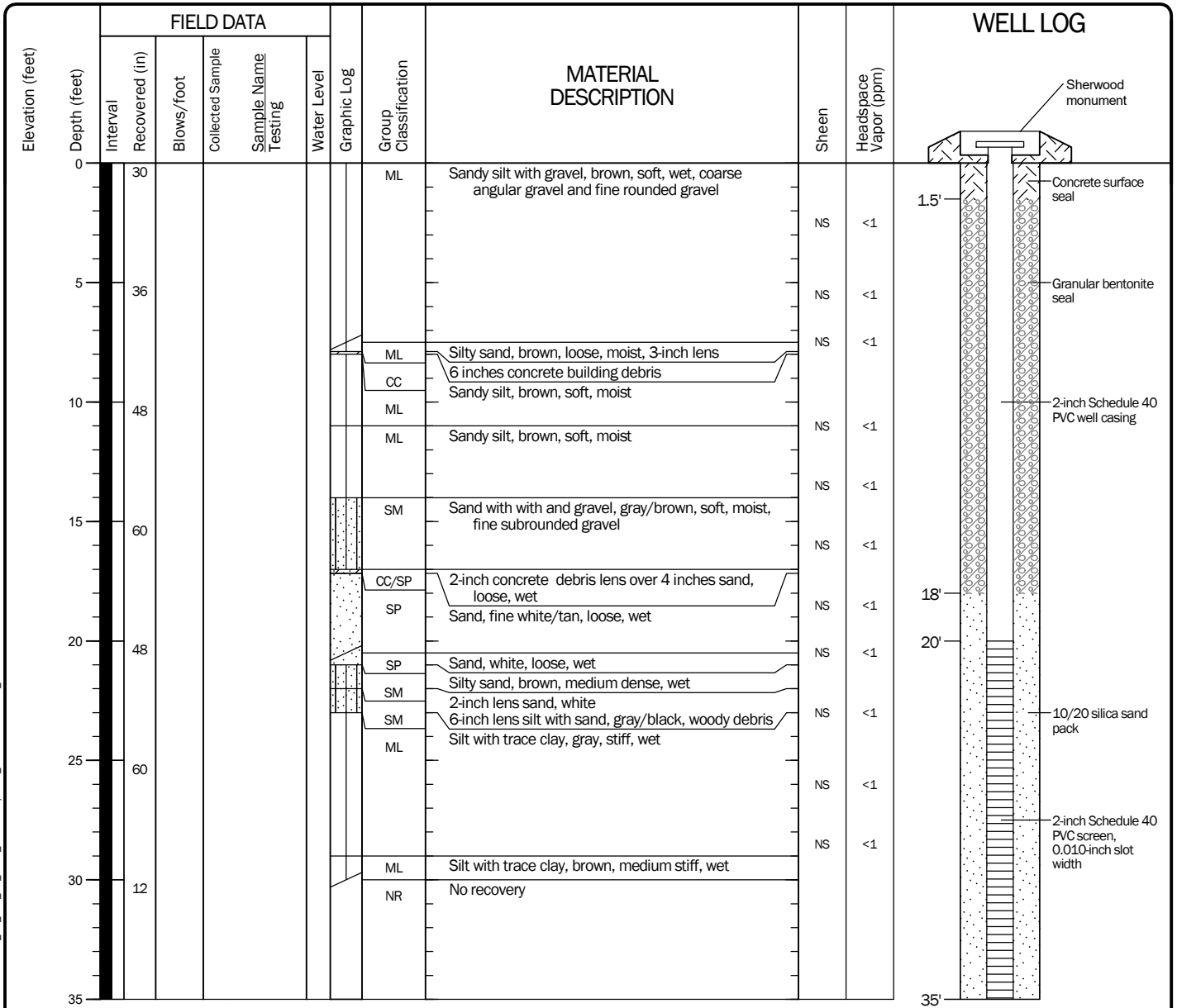
Log of Monitoring Well MW-5



Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEI6_ENVIRONMENTAL_WELL

Start Drilled 10/29/2021	End 10/29/2021	Total Depth (ft)	35	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data	N/A			Drilling Equipment	Geoprobe 3230 DT		A 2-in well was installed on 10/29/2021 to a depth of 35 ft.		
Surface Elevation (ft) Vertical Datum	Undetermined NAVD88			Top of Casing Elevation (ft)	33.75		Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
Easting (X) Northing (Y)	7624600.755 706808.6			Horizontal Datum	OR State Plane North NAD83 (feet)				
Notes:									



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

Log of Monitoring Well MW-6

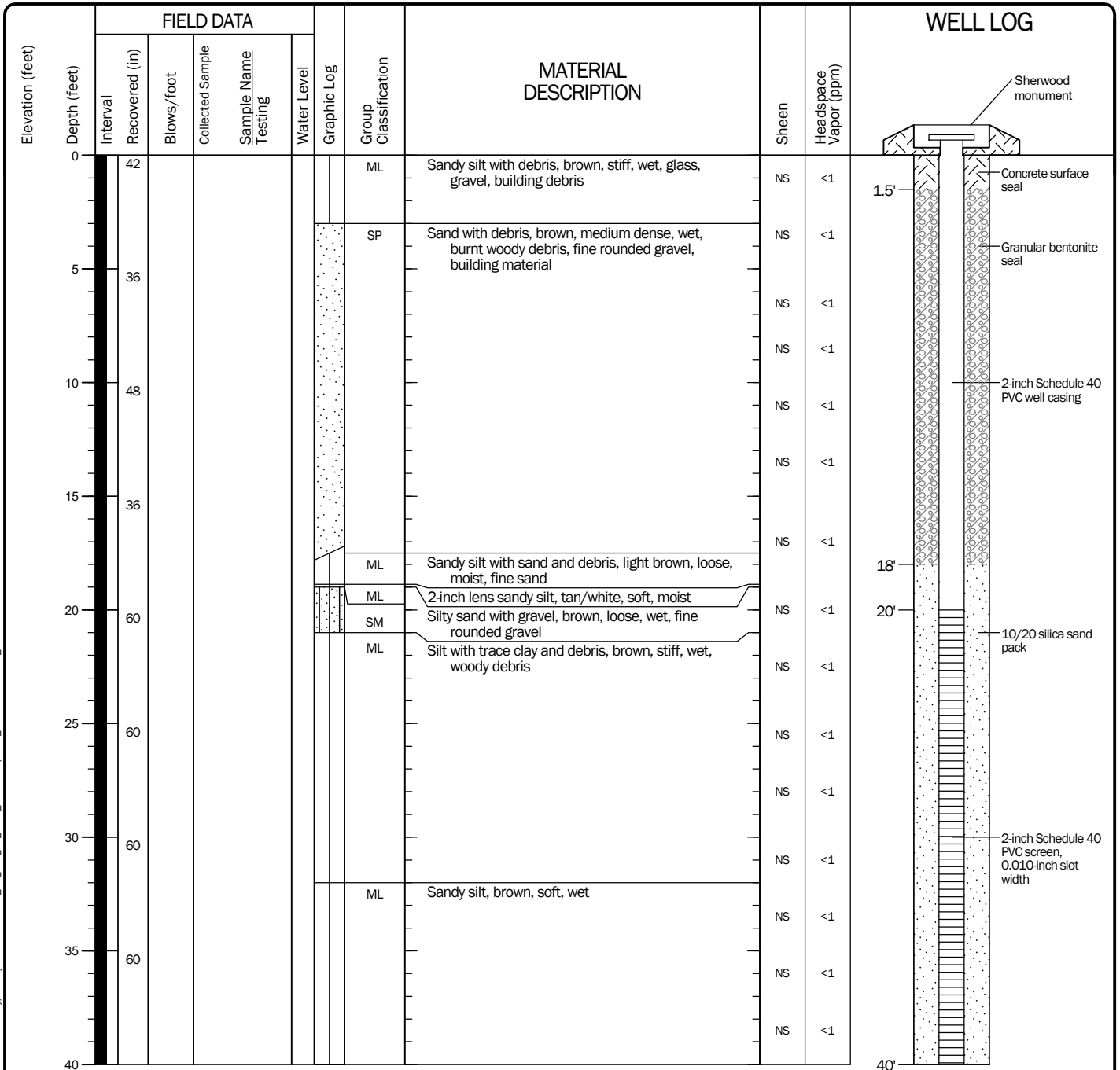


Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Figure B-7
Sheet 1 of 1

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEB6_ENVIRONMENTAL_WELL

Drilled	Start 11/4/2021	End 11/4/2021	Total Depth (ft)	40	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data	N/A				Drilling Equipment	Geoprobe 3230 DT		A 2-in well was installed on 11/4/2021 to a depth of 40 ft.		
Surface Elevation (ft) Vertical Datum	Undetermined NAVD88		Top of Casing Elevation (ft)	36.14		Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)		
Easting (X) Northing (Y)	7624685.88 706768.867		Horizontal Datum	OR State Plane North NAD83 (feet)						
Notes:										



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

Log of Monitoring Well MW-7

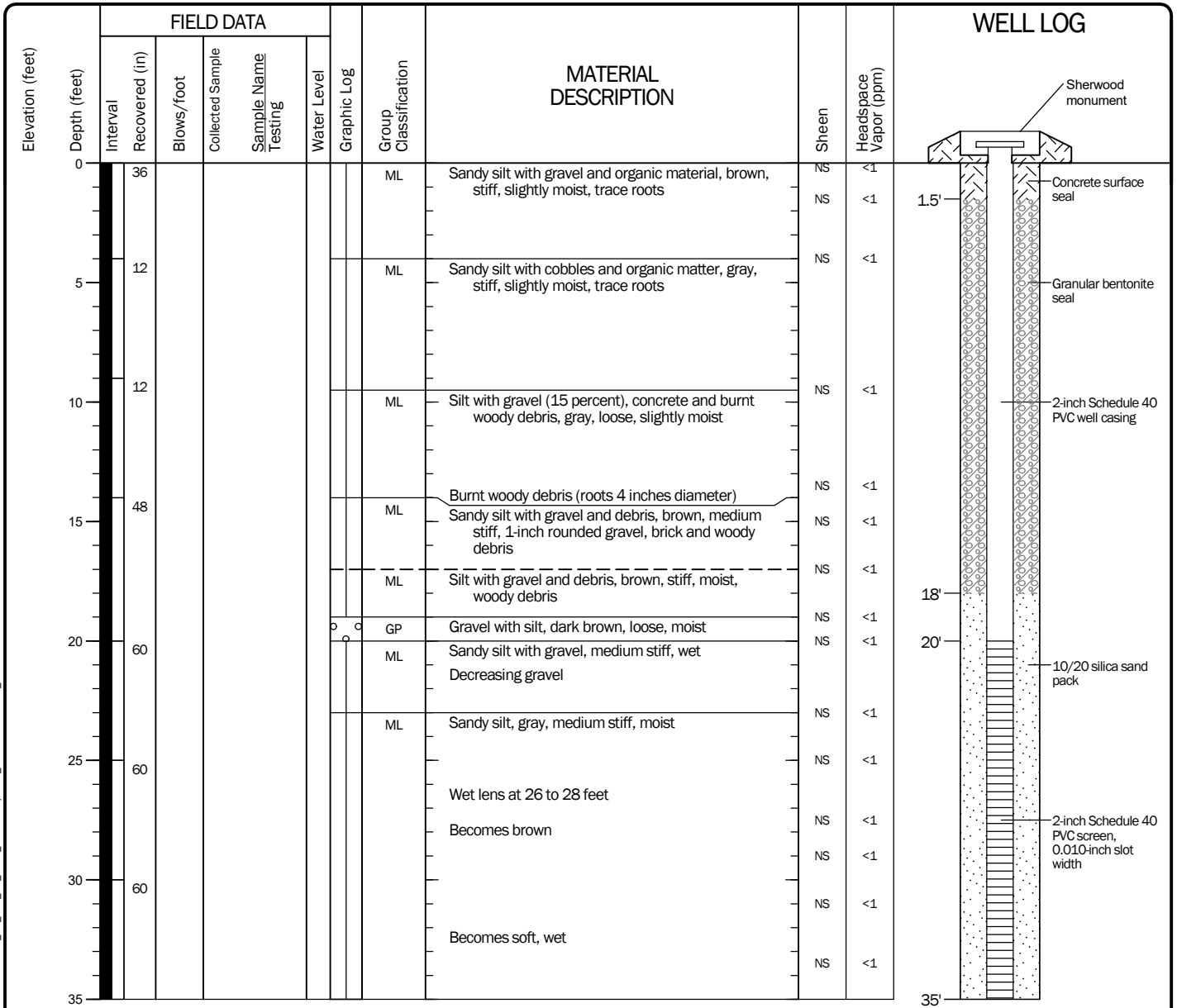


Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Figure B-8
Sheet 1 of 1

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEI6_ENVIRONMENTAL_WELL

Start Drilled 11/18/2021	End 11/18/2021	Total Depth (ft)	35	Logged By LW/JMP	Checked By JMP	Driller Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 11/18/2021 to a depth of 35 ft.
Surface Elevation (ft)		Undetermined		Top of Casing Elevation (ft)		36.05		Groundwater
Vertical Datum		NAVD88		Horizontal Datum		OR State Plane North NAD83 (feet)		Date Measured
Easting (X)		7624782.209		Horizontal Datum		OR State Plane North NAD83 (feet)		Depth to Water (ft)
Northing (Y)		706700.404		Horizontal Datum		OR State Plane North NAD83 (feet)		Elevation (ft)
Notes:								



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

Log of Monitoring Well MW-8



Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Figure B-9
Sheet 1 of 1

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEB6_ENVIRONMENTAL_WELL

Start Drilled 10/26/2021	End 10/26/2021	Total Depth (ft)	40	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 10/26/2021 to a depth of 40 ft.	
Surface Elevation (ft) Vertical Datum		Undetermined NAVD88		Top of Casing Elevation (ft)		41.45		Groundwater Date Measured	
Easting (X) Northing (Y)		Horizontal Datum		OR State Plane North NAD83 (feet)				Depth to Water (ft)	
								Elevation (ft)	
Notes:									

Elevation (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Sheen	Headspace Vapor (ppm)	WELL LOG
	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
0	42						AC	Asphalt overlying gravel/silt	NS	<1	1.5'	<p>Sherwood monument</p> <p>Concrete surface seal</p> <p>Granular bentonite seal</p> <p>2-inch Schedule 40 PVC well casing</p> <p>10/20 silica sand pack</p> <p>2-inch Schedule 40 PVC screen, 0.010-inch slot width</p>
							ML	Sandy silt, brown, stiff, dry	NS	<1		
5	60						ML	Silt, brown, medium stiff, dry	NS	<1		
							ML	Sandy silt, brown, medium stiff, slightly moist	NS	<1		
							ML	Sandy silty, brown, soft, slightly moist	NS	<1		
10	60						ML	Silt brown, medium stiff, slightly moist	NS	<1		
							ML	Sandy silt, brown, soft, dry	NS	<1		
							ML	Becomes slightly moist	NS	<1		
							ML	Silt, brown, medium stiff, slightly moist	NS	<1		
20	60						ML	Sandy silt, brown, soft, dry	NS	<1		
							ML	Silt with trace clay, brown, soft, moist	NS	<1		
							ML	Sandy silt, brown, medium stiff, moist	NS	<1		
							ML	Silt with sand, brown, soft, dry, fine sand	NS	<1		
30	36						NR	No recovery	NS	<1		
							ML	Silt with trace clay, brown, soft, wet	NS	<1		
35	60						SM	Sand with silt, fine, brown, soft, wet	NS	<1		
40									NS	<1		

Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

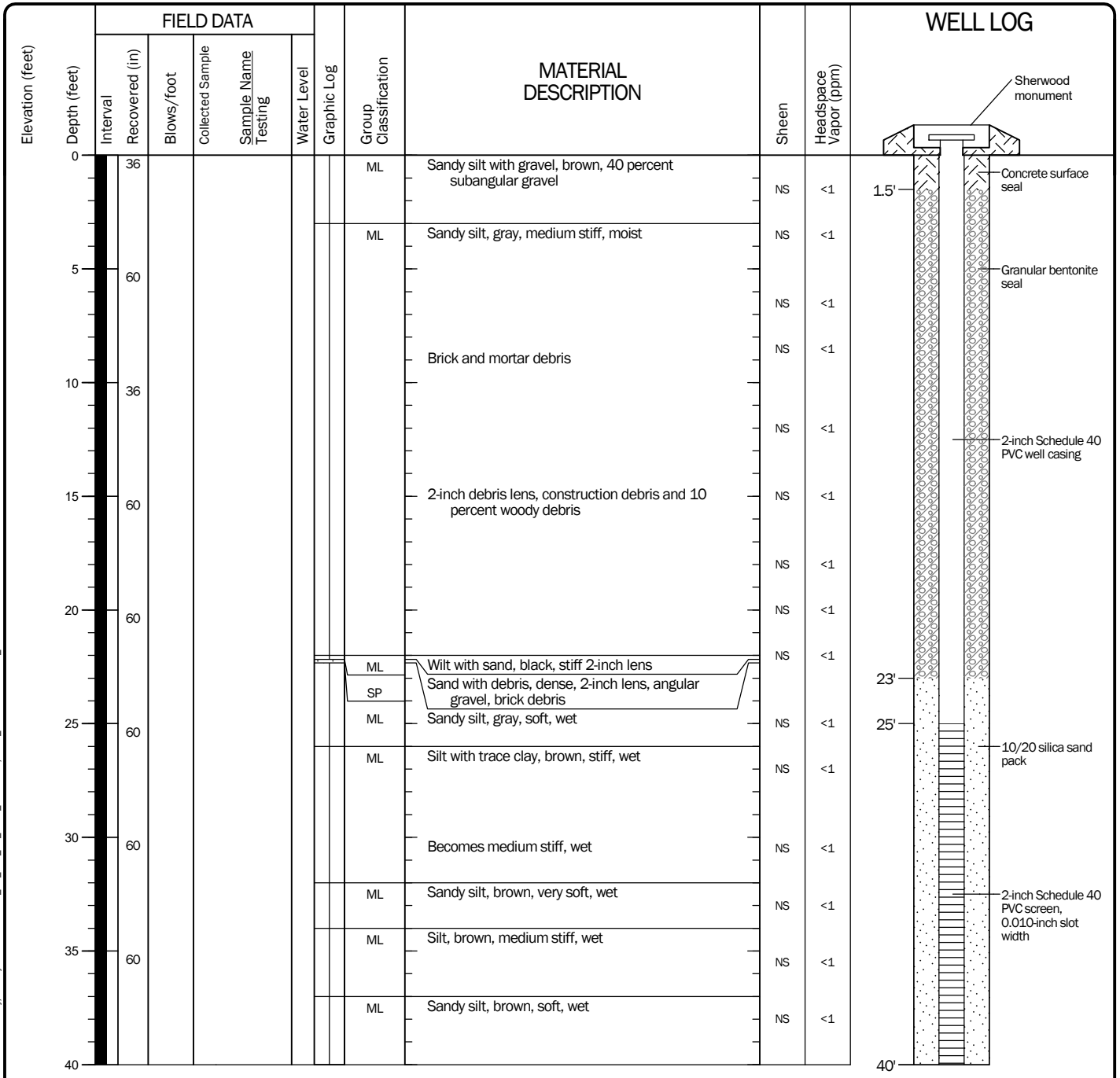
Log of Monitoring Well MW-9



Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\ENVIRONMENTAL_WELL

Start Drilled 10/28/2021	End 10/28/2021	Total Depth (ft)	40	Logged By Checked By	JMP JMP	Driller	Cascade Drilling, Inc.	Drilling Method	Direct Push
Hammer Data		N/A		Drilling Equipment		Geoprobe 3230 DT		A 2-in well was installed on 10/28/2021 to a depth of 40 ft.	
Surface Elevation (ft) Vertical Datum		Undetermined NAVD88		Top of Casing Elevation (ft)		36.40		Groundwater Date Measured	
Easting (X) Northing (Y)		Horizontal Datum		OR State Plane North NAD83 (feet)				Depth to Water (ft)	
								Elevation (ft)	
Notes:									



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Locational Survey. Vertical approximated based on Locational Survey.

Log of Monitoring Well MW-10



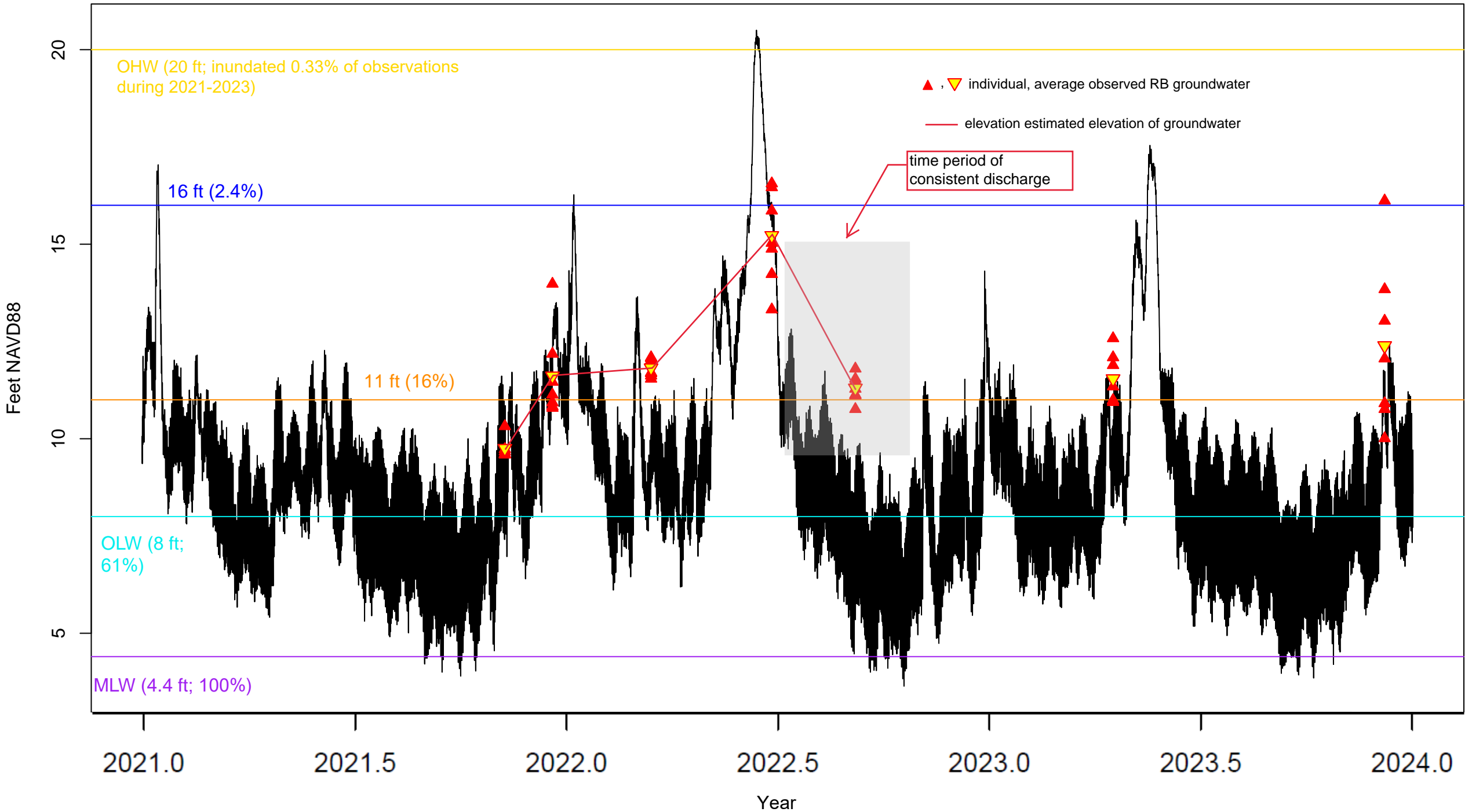
Project: Crawford Street
Project Location: Portland, Oregon
Project Number: 6209-010-02

Figure B-11
Sheet 1 of 1

Date: 3/22/22 Path: P:\6209010\GINT\620901002.GPJ DBLibrary/Library\GEOENGINEERS_DF_STD_US_JUNE_2017.GLB\GEIS_ENVIRONMENTAL_WELL

APPENDIX E
River Surface Elevations Relative to Groundwater
Elevations at Crawford Street South Site

Crawford Street River Height



APPENDIX F
Tabulated Groundwater Elevation Data for the
Crawford Street South Site

Appendix F
Groundwater Elevation Measurements
 Crawford Street Site
 Portland, Oregon

Well ID	Well Depth (feet bgs)	Well Screen (feet)	Measurement Date	Top of Casing Elevation (feet MSL)	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Depth to Product (feet)
MW-1	37	22 - 37	11/9/2021	35.25	25.52	9.73	--
			12/20/2021		24.12	11.13	--
			3/15/2022		23.16	12.09	--
			6/27/2022		20.22	15.03	--
			9/7/2022		23.45	11.80	--
			12/7/2023		24.34	10.91	--
MW-2	40	25 - 40	11/9/2021	36.03	26.43	9.60	--
			12/20/2021		25.34	10.69	--
			3/15/2022		24.41	11.62	--
			6/27/2022		21.80	14.23	--
			9/7/2022		24.75	11.28	--
			12/7/2023		26.27	9.76	--
MW-3	35	15 - 35	11/9/2021	37.54	28.60	8.94	--
			12/20/2021		26.78	10.76	--
			3/15/2022		25.80	11.74	--
			6/27/2022		22.64	14.90	--
			9/7/2022		26.08	11.46	--
			12/7/2023		27.18	10.36	--
MW-4	35	20 - 35	11/9/2021	38.43	28.88	9.55	--
			12/20/2021		27.64	10.79	--
			3/15/2022		26.71	11.72	--
			6/27/2022		23.45	14.98	--
			9/7/2022		27.03	11.40	--
			12/7/2023		28.01	10.42	--
MW-5	40	20 - 40	11/9/2021	36.65	27.06	9.59	--
			12/20/2021		25.75	10.90	--
			3/15/2022		24.95	11.70	--
			6/27/2022		21.77	14.88	--
			9/7/2022		25.18	11.47	--
			12/7/2023		26.64	10.01	--
MW-6	35	20 - 35	11/9/2021	33.75	24.08	9.67	--
			12/20/2021		22.29	11.46	--
			3/15/2022		22.07	11.68	--
			6/27/2022		17.19	16.56	--
			9/7/2022		22.64	11.11	--
			12/7/2023		19.91	13.84	--

Well ID	Well Depth (feet bgs)	Well Screen (feet)	Measurement Date	Top of Casing Elevation (feet MSL)	Depth to Groundwater (feet)	Groundwater Elevation (feet)	Depth to Product (feet)
MW-7	40	20 - 40	11/9/2021	36.14	25.82	10.32	--
			12/20/2021		23.96	12.18	--
			3/15/2022		24.13	12.01	--
			6/27/2022		20.28	15.86	--
			9/7/2022		25.01	11.13	--
			12/7/2023		20.02	16.12	--
MW-8	35	20 - 35	11/9/2021	36.05	NM	NM	--
			12/20/2021		22.07	13.98	--
			3/15/2022		23.98	12.07	--
			6/27/2022		19.59	16.46	--
			9/7/2022		25.29	10.76	--
			12/8/2023		23.02	13.03	--
MW-9	40	25 - 40	11/9/2021	41.45	31.94	9.51	--
			12/20/2021		30.72	10.73	--
			3/15/2022		29.82	11.63	--
			6/27/2022		26.47	14.98	--
			9/7/2022		30.16	11.29	--
			12/7/2023		31.10	10.35	--
MW-10	40	25 - 40	11/9/2021	36.40	26.79	9.61	--
			12/20/2021		25.57	10.83	--
			3/15/2022		24.86	11.54	--
			6/27/2022		23.08	13.32	--
			9/7/2022		24.86	11.54	--
			12/7/2023		24.34	12.06	--

Notes:

bgs = below ground surface

feet MSL = feet relative to mean sea level, NAVD88 datum

NM = not measured

-- = not detected

