

Technical Memorandum

To: Andy Oien, City of Centralia
From: Glenn Mutti-Driscoll, Pacific Groundwater Group
Re: Nitrate Monitoring Well Installation
Date: October 30, 2019

The City of Centralia has concerns about the potential for nitrate contamination in the Centralia Outwash Gravel Aquifer (COGA), a shallow water supply aquifer underlying the City. Septic systems within the City limits and in unincorporated areas of its Urban Growth Area (UGA) overlie the COGA, as well as agricultural land uses, and may cause nitrate contamination within the shallow aquifer. Most septic systems overlying the COGA are in the Fords Prairie and Waunch Prairie. Most of the City's active production wells are also in the Fords Prairie, and therefore nitrogen loading in this part of the City is of greatest concern.

This memorandum documents the installation of six monitoring wells for the City of Centralia, five of which are located in the Fords Prairie vicinity and one in Waunch Prairie. The monitoring wells were located and designed with the primary intent of monitoring groundwater nitrate concentrations, but they also can be used for groundwater elevation monitoring or wellhead protection area monitoring. This work builds on a prior investigation (PGG, 2017) that reviewed historic groundwater nitrate concentrations in the Centralia area and recommended monitoring well locations based on the distribution of elevated groundwater nitrate concentrations, land use, and existing and potential future water supply sources. A groundwater nitrate monitoring network which includes both the recently installed monitoring wells and existing wells is proposed as part of this memo.

MONITORING WELL INSTALLATION

Six monitoring wells with depths ranging from 25 to 40 feet were installed between July 15 and July 17, 2019 in and around the City of Centralia (**Figure 1**). Relatively shallow completions were chosen so that nitrate concentrations near the water table (where they are expected to be highest) would be monitored. The monitoring wells were drilled by a licensed driller with Holocene Drilling using a sonic drill rig and were completed flush-to-ground. Each two-inch diameter PVC monitoring well was completed with 10 feet of screen installed and was developed by Holocene Drilling. Right-of-way permits for drilling the wells were obtained by the City where needed, and utility locate services were provided by One-Call and CNI Locates. Well locations and elevations were surveyed by the City of Centralia Engineering Department. PGG geologically logged the boreholes and recorded

their as-built construction. Construction details for each well are summarized in **Table 1**, and well logs are included in **Appendix A**.

PROPOSED GROUNDWATER NITRATE MONITORING LOCATIONS

PGG in coordination with the City of Centralia identified the following wells as potential monitoring locations for a City-wide groundwater nitrate monitoring network:

- The six monitoring wells documented in this memo should be monitored.
- An irrigation well at the City's Waste Water Treatment Plant (WWTP) should be monitored since several agricultural and numerous septic parcels are upgradient of this area. Due to high aquifer yields near the WWTP, the vicinity has been identified as a preferred area for future water supply (PGG, 2016).
- High groundwater nitrate concentrations were documented near Trailer Village in the 1990s (PGG, 2017). Parcels that historically were on septic tanks in this area have since been connected to sewer, but more recent groundwater nitrate monitoring in this vicinity has not occurred. Additionally, this area is upgradient of the Eshom and Fords Prairie wells, and therefore MW-2 at Trailer Village (identified as MW-2 (Laundromat) on **Figure 1**) should be monitored.
- Unblended water samples from Fords Prairie Well 2 should be collected. Fords Prairie Well 2 is a primary water source for the City and has areas on septic drain-fields upgradient of it and in close proximity.
- Unblended water samples from Tennis Court Well 2 should be collected. Tennis Court Well 2 is also a primary water source for the City and has numerous playing fields and a cemetery (which likely receive fertilizer) within its capture zone.
- Monitoring well AKB696 (located at the north end of Borst Park adjacent to Borst Avenue) should be included as a monitoring point since it is in the Tennis Court and Fords Prairie capture zones. Additionally, the Department of Ecology has historically monitored this well and it has an existing groundwater nitrate and water level data set.
- The K Street well should be monitored to provide additional information regarding groundwater nitrate concentrations near Waunch Prairie, and has a long data historic data set associated with it from prior City monitoring.

Groundwater nitrate samples should be collected quarterly for one to two years to create a baseline dataset so seasonal concentration variability can be observed. The baseline monitoring data can then be used to help refine the monitoring network through the identification of potential problem areas or areas where nitrogen loading appears minimal. Long-term monitoring frequencies can also be optimized based on the seasonality observed in the baseline data.

REFERENCES

Pacific Groundwater Group, 2016. Interim Drought Vulnerability Assessment to Optimize Existing Production Wells City of Centralia. Consultant's report for the City of Centralia. April 12, 2016.

Pacific Groundwater Group, 2017. City of Centralia Groundwater Nitrate Evaluation. Consultant's report for the City of Centralia. July 20, 2017.

Table 1. City of Centralia Monitoring Well Installation Summary

Well Name	Ecology Unique Well ID	Measuring Point Elevation (ft)	Vertical Datum	Latitude (NAD 83/91)	Longitude (NAD 83/91)	Stick Down from Monument Top (ft)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Total Depth (ft bgs)	Depth to Water (ft bmp)	Depth to Water Measurement Date
MW-3	BLT 951	170.74	NAVD88	46.7229731	-122.9808001	0.42	24.38	34.38	34.56	19.86	7/16/2019
MW-4	BLT 948	173.20	NAVD88	46.7349008	-122.9842750	0.38	24.57	34.57	34.9	22.94	7/16/2019
MW-5	BLT 953	167.18	NAVD88	46.7491858	-123.0034564	0.31	24.53	34.53	34.71	25.01	7/17/2019
MW-6	BLT 950	171.95	NAVD88	46.7251817	-122.9960924	0.45	30.02	40.02	40.2	26.42	7/16/2019
MW-7	BLT 952	193.13	NAVD88	46.7425288	-122.9473010	0.3	14.64	24.64	24.82	10.8	7/17/2019
MW-8	BLT 949	167.25	NAVD88	46.741869	-123.0023553	0.53	29.84	39.84	40.02	26.95	7/16/2019

Notes

bgs = below ground surface; bmp = below measuring point

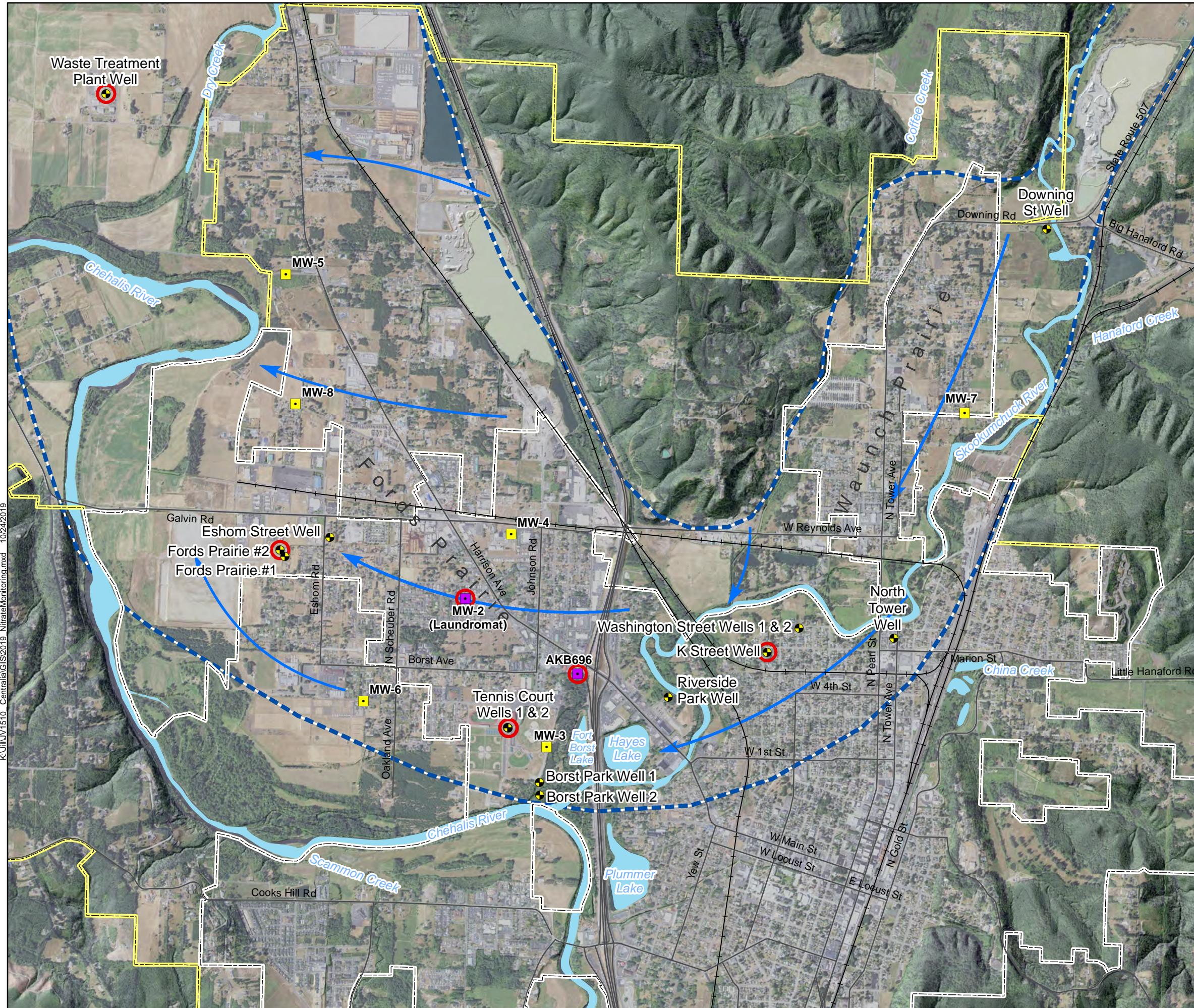


Figure 1

Centralia Monitoring Wells and Proposed Groundwater Nitrate Monitoring Network

PgG

- City Production Wells
- City Monitoring Wells
- Other Monitoring Wells
- Existing Wells Where Groundwater Nitrate Monitoring is Proposed

→ Groundwater Flow Directions

 Mapped Extent of Centralia Outwash Gravel Aquifer

 Centralia Incorporated Area

 Centralia UGA

0 Feet 2,000

APPENDIX A
2019 GROUNDWATER NITRATE MONITORING WELL LOGS
CITY OF CENTRALIA

Depth (ft)	Graphic Log	Recovery	Soil Description	Sample Results
0			Moist, dark brown, slightly gravelly, silty, SAND with organics (Topsoil)	
1			Moist, brown, slightly silty, very gravelly, SAND (Fill). 1.4 - 2.1 ft: gray	Flush-mount steel monument. PVC measuring point stickdown 0.42 ft.
2			Moist, brown to dark brown, silty CLAY.	
3				0 - 1.5 ft: neat cement surface seal
4				
5				
6				
7			Moist, brown, trace to slightly silty, fine SAND. Local pebbles.	1.5 - 23 ft: bentonite seal
8			Moist, brown, slightly silty, gravelly, fine-to-coarse SAND.	
9			Moist, brown, silty, very gravelly, fine-to-coarse SAND.	
10			Moist, brown, fine-to-coarse sandy, very silty, GRAVEL (silt-bound).	
11			Very moist, dark brown, trace to slightly gravelly, slightly sandy, CLAY.	0.42 - 24.4 ft: 2-inch PVC schedule 40 riser pipe. Joints threaded with o-rings.
12			Very moist, brown, very clayey, very fine-to-coarse sandy, GRAVEL (clay-bound).	
13			Very moist, brown, gravelly, fine-to-coarse SAND. Sand is predominately fine-to-medium.	
14			Very moist, dark gray, silty, sandy, GRAVEL (silt-bound). Cobbles present.	
15				0 - 35 ft: 6-inch diameter borehole
16			Wet, brown, slightly silty, fine-to-coarse sandy, GRAVEL.	
17			Wet, brown, very gravelly, fine-to-coarse SAND.	
18			Very moist, silty, sandy, GRAVEL (silt-bound).	
19			Very moist, brown, very fine-to-coarse sandy, GRAVEL. Trace silty, local cobbles.	
20			Moist, silty, fine-to-coarse sandy, GRAVEL & COBBLES (silt-bound).	
21			Very moist, trace to slightly silty, gravelly, fine-to-coarse SAND. Sand predominately fine-to-medium.	Depth to water (bgs): 20.28 ft, 7/16/19
22			Wet, brown, silty, gravelly, fine-to-coarse SAND. Local cobbles.	
23			Interbedded layers of brown, fine-to-coarse sandy, GRAVEL and very gravelly, clean fine-to-coarse SAND. Layers approximately 0.5 to 1 ft thick, gravel layers are loose.	23 - 35 ft: 12-20 silica sand filter pack
24				
25				
26				
27			Brown, fine-to-coarse SAND & GRAVEL. Clean.	24.4 - 34.4 ft: 2-inch PVC schedule 40 screen, 10-slot (0.01-inch)
28				
29				
30			Brown, fine-to-medium SAND. Clean, local fine gravel.	
31			33.2 - 35 ft: slightly gravelly, local cobbles	34.4 - 34.6 ft: 2-inch PVC schedule 40 end cap (flat), 0.18 ft length
32				
33				
34				
35				35 ft: Bottom of hole
Latitude: 46.7229731 Longitude: -122.9808001 Measuring Point Elevation: 170.74 ft NAVD88 Ecology UWID: BLT 951 Drilled: 07/16/2019 Location Description: Borst Park, east of ball diamonds & ~800' south of Pioneer Way			<p>Driller: Zach Bailey, Holocene Drilling Drilling Method: Sonic Logged by: Glenn Mutti-Driscoll, PGG Depth to Water (bpm): 19.86 ft, 7/16/19</p> <p>MW-3 Boring Log and As-Built</p> <p>Centralia Monitoring Wells Task 4 JV1805.04</p>	

Depth (ft)	Graphic Log	Recovery	Soil Description	Sample Results
0			Moist, dark brown, slightly gravelly, silty, fine SAND (Topsoil). Root matter in top 6 inches.	Flush-mount steel monument. PVC measuring point stickdown 0.38 ft.
1				
2			Moist, gray, sandy, GRAVEL. Large gravel to cobble size clasts, trace silty. 2.4 - 2.6 ft: orange-light brown color	0 - 1.5 ft: neat cement surface seal
3			Moist, brown (rust colored), slightly silty, very sandy, GRAVEL. Cobbles present.	
4				
5			Moist, dark gray, sandy, silty, GRAVEL and COBBLES (silt-bound). 6.3 - 7.2 ft: cobbles absent, greater matrix support. 6.3 - 8.2 ft: brown/orange-brown color.	1.5 - 23 ft: bentonite seal
6				
7				
8				
9				
10			Moist, brown-gray, very fine-to-coarse sandy, GRAVEL. Local cobble, trace silt. 11 - 13.8 ft: gray, slightly silty 13.8 - 14.2 ft: dark red, slightly silty	0.38 - 24.6 ft: 2-inch PVC schedule 40 riser pipe. Joints threaded with o-rings.
11				
12				
13				
14				
15			Moist, brown to dark brown, fine-to-coarse sandy, silty, GRAVEL & COBBLES (silt-bound).	0 - 35 ft: 6-inch diameter borehole
16				
17				
18			Wet, brown, trace to slightly silty, fine-to-coarse sandy, GRAVEL. Grades coarse with depth. Wet, brown, GRAVEL and COBBLES. Loose. Wet, brown, coarse sandy, GRAVEL. Progressively more coarse sandy matrix with depth. Wet, silty, sandy, GRAVEL & COBBLES (silt-bound).	
19				
20				
21				
22				
23			Wet, gray-brown, slightly sandy, GRAVEL & COBBLES Gray-brown, slightly silty, slightly sandy, gravelly, COBBLES (silt-bound). Gray-brown, trace to slightly silty, coarse sandy, GRAVEL. Brown, slightly to fine-to-coarse sandy, GRAVEL. Local cobbles, trace silt, sand is mostly coarse. Brown, gravelly, fine-to-coarse SAND. Sand is mostly coarse. Gray, silty, fine-to-coarse sandy, GRAVEL & COBBLES (silt-bound). Brown, slightly gravelly, fine SAND. Local cobbles. Gray, silty to very silty, fine SAND. Trace fine gravel. Gray, silty, sandy, GRAVEL & COBBLES (silt-bound). Gray, silty, sandy, GRAVEL & COBBLES (silt-bound).	Depth to water (bgs): 23.32 ft, 7/16/19 23 - 35 ft: 12-20 silica sand filter pack 24.6 - 34.6 ft: 2-inch PVC schedule 40 screen, 10-slot (0.01-inch) 34.6 - 34.9 ft: 2-inch PVC schedule 40 pointed end cap, 0.33 ft length 35 ft: Bottom of hole
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
Latitude: 46.7349008 Longitude: -122.9842750 Measuring Point Elevation: 173.20 ft Ecology UWID: BLT 948 Drilled: 07/15/2019 Location Description: 2600 W Reynolds Ave, 190' S of W Reynolds and 50' E of shop building			Driller: Zach Bailey, Holocene Drilling Drilling Method: Sonic Logged by: Glenn Mutti-Driscoll, PGG Depth to Water (bpm): 22.94 ft, 7/16/19	MW-4 Boring Log and As-Built Centralia Monitoring Wells Task 4 JV1805.04

Depth (ft)	Graphic Log	Recovery	Soil Description	Sample Results
0			No sample recovery, hydro-excavated with vacuum truck.	Flush-mount steel monument. PVC measuring point stickdown 0.31 ft.
1				0 - 1.5 ft: neat cement surface seal
2				
3				
4				
5				
6			Moist, gray-brown, fine-to-coarse SAND and GRAVEL. 7.1 - 8.3 ft: trace to slightly silty 7.8 ft: dark red color band	1.5 - 23 ft: bentonite seal
7				
8			Moist, gray, silty, fine-to-medium sandy, GRAVEL. Local cobbles	
9				
10			Moist, gray-brown, fine-to-medium SAND and GRAVEL. Trace silty. 11.1 - 11.8 ft: sand fine-to-coarse, local cobbles 11.8 - 13.1 ft: sand fine-to-coarse, clean 13.1 - 14 ft: gray, trace to slightly silty, very fine-to-coarse sandy, GRAVEL. Cobbles present.	0.31 - 24.5 ft: 2-inch PVC schedule 40 riser pipe. Joints threaded with o-rings.
11				
12				
13				
14			Moist, dark brown, slightly fine-sandy, very gravelly, SILT.	
15			Moist, brown, slightly gravelly to gravelly, slightly silty to silty, fine-to-medium SAND.	0 - 35 ft: 6-inch diameter borehole
16			Moist, brown to dark brown, silty, very gravelly, fine-to-medium SAND.	
17			Moist, brown, very gravelly, fine-to-coarse SAND. Trace silty, local cobbles.	
18			Moist, gray-brown, silty, fine-to-coarse sandy, GRAVEL. Locally cleaner sand lenses.	
19			Moist, brown, slightly silty, very gravelly, fine-to-medium SAND.	
20			Moist to wet, fine-to-coarse SAND & GRAVEL. Cobbles interpersed.	
21				
22				
23				23 - 35 ft: 12-20 silica sand filter pack
24				
25			Wet, brown, fine SAND. Clean, local gravel. Bottom 0.2 ft grades into fine-to-medium SAND.	Depth to water (bgs): 25.32 ft, 7/17/19
26			Gray-brown, very fine-to-coarse sandy, GRAVEL. Trace silty.	
27			Gray-brown, fine-to-medium SAND. Clean, local gravel.	
28			Gray-brown, very fine-to-coarse sandy, GRAVEL.	
29				24.5 - 34.5 ft: 2-inch PVC schedule 40 screen, 10-slot (0.01-inch)
30			Gray-brown, fine-to-medium SAND. Clean.	
31			Gray, slightly silty, very fine-to-coarse sandy, GRAVEL. Local cobbles.	
32			Gray, very fine-to-coarse sandy, GRAVEL. Trace silty.	
33			Brown, fine-to-medium SAND. Clean, local cobbles.	
34			31.4 - 31.7 ft: gravelly 32.6 - 32.7 ft and 33.2 - 33.3 ft: silty, very-fine SAND layers	34.5 - 34.7 ft: 2-inch PVC schedule 40 end cap (flat), 0.18 ft length
35			Brown, very fine-to-fine SAND and COBBLES.	
			Brown, very fine-to-coarse sandy, GRAVEL.	35 ft: Bottom of hole
Latitude: 46.7491858 Longitude: -123.0034564 Measuring Point Elevation: 167.18 ft Ecology UWID: BLT 953 Drilled: 07/17/2019 Location Description: 670' West of Harrison Ave on WWTP Access Rd			<p>Driller: Zach Bailey, Holocene Drilling Drilling Method: Sonic Logged by: Glenn Mutti-Driscoll, PGG Depth to Water (bpm): 25.01 ft, 7/17/19</p> <p>MW-5 Boring Log and As-Built</p> <p>Centralia Monitoring Wells Task 4 JV1805.04</p>	

Depth (ft)	Graphic Log	Recovery	Soil Description	Sample Results
0			Moist, dark brown, sandy, silty, angular GRAVEL (road FILL and TOPSOIL).	Flush-mount steel monument. PVC measuring point stickdown 0.45 ft.
1			Moist, dark brown, slightly sandy, very gravelly, SILT. Soft, cohesive core.	0 - 1.5 ft: neat cement surface seal
2			Moist, brown, silty, very sandy, GRAVEL. Cobbles present.	
3			Moist, brown, slightly silty, very fine-to-coarse sandy, GRAVEL. Cobbles present	
4			Moist, gray, very gravelly, fine-to-coarse SAND. Trace silty.	1.5 - 28 ft: bentonite seal
5			Moist, brown, very fine-to-coarse sandy, GRAVEL. Clean.	
6			Moist, brown, fine-to-medium SAND. Clean.	
7			Moist, brown, trace to slightly silty, very fine-to-coarse sandy, GRAVEL. Cobbles present.	
8			Very moist, very gravelly, fine-to-coarse SAND. Clean, local cobbles.	0.45 - 30 ft: 2-inch PVC schedule 40 riser pipe. Joints threaded with o-rings.
9			11.9 ft: dark red layer, roughly 1 cm thick	
10			13.2 - 13.8 ft: sand fine-to-medium, gravel content slightly lower.	
11			Moist, gray-brown, slightly silty to silty, fine-to-coarse sandy, GRAVEL (silt-bound). Local cobbles.	
12			Moist, brown, slightly gravelly, silty, fine-to-medium SAND (cohesive silty-sand binder)	0 - 40.2 ft: 6-inch diameter borehole
13			Very moist, very gravelly, fine-to-coarse SAND. Clean.	
14			Very moist, gravelly, fine-to-medium SAND. Clean.	
15			Moist, brown, slightly silty, very fine-to-coarse sandy, GRAVEL (silt-bound). Local cobbles.	
16			Moist, gray, slightly fine-to-coarse sandy, very silty, GRAVEL (silt-bound). Cobbles present.	
17			Moist, gray, slightly sandy to sandy, silty, GRAVEL (lightly silt-bound). Cobbles present.	
18			Moist, gray, slightly silty, very fine-to-coarse sandy, GRAVEL. Cleaner layers (trace silty) locally.	
19			Moist, brown, silty, gravelly, fine SAND (cohesive binder).	
20			Moist, brown, silty, fine SAND. Local gravel.	
21			Moist, gray, slightly fine-to-coarse sandy, very silty, GRAVEL (silt-bound). Cobbles present.	
22			Moist, gray, slightly sandy to sandy, silty, GRAVEL (lightly silt-bound). Cobbles present.	
23			Moist, gray-brown, slightly silty, very fine-to-coarse sandy, GRAVEL. Cleaner layers (trace silty) locally.	
24			Moist, brown, silty, gravelly, fine SAND (cohesive binder).	
25			Wet, gray, slightly fine-to-coarse sandy, silty, GRAVEL (silt-bound). Cobbles present.	
26			Gray, fine-to-coarse sandy, GRAVEL. Trace silty 28.1 - 28.8 ft: slightly silty, sand and gravel finer grained.	Depth to water (bgs): 26.87 ft, 7/16/19
27			30 - 32.1 ft: gray-brown, sand is mostly medium-to-coarse and clean.	28 - 40 ft: 12-20 silica sand filter pack
28			32.1 - 32.6 ft: brown	
29			Brown, very gravelly, fine-to-coarse SAND. Sand is clean and predominately fine-to-medium. Progressively less gravel at depth.	30 - 40 ft: 2-inch PVC schedule 40 screen, 10-slot (0.01-inch)
30			Gray, fine-to-coarse sandy, GRAVEL. Large cobbles present.	
31			Gray-brown, very fine-to-coarse sandy, GRAVEL. Clean. Bottom 6 inches grading into unit below.	
32			Gray-brown, very fine-to-coarse SAND. Top 1 ft is gravelly (gradational contact with unit above).	40 - 40.2 ft: 2-inch PVC schedule 40 end cap (flat), 0.18 ft length
33			Gray-brown, very fine-to-coarse SAND. Top 1 ft is gravelly (gradational contact with unit above).	40.2 ft: Bottom of hole
34			Gray-brown, very fine-to-coarse sandy, GRAVEL. Clean. Bottom 6 inches grading into unit below.	
35			Gray-brown, very fine-to-coarse sandy, GRAVEL. Clean. Bottom 6 inches grading into unit below.	
36			Gray-brown, very fine-to-coarse SAND. Top 1 ft is gravelly (gradational contact with unit above).	
37			Gray-brown, very fine-to-coarse SAND. Top 1 ft is gravelly (gradational contact with unit above).	
38			Gray-brown, very fine-to-coarse SAND. Top 1 ft is gravelly (gradational contact with unit above).	
39			Gray-brown, very fine-to-coarse SAND. Top 1 ft is gravelly (gradational contact with unit above).	
40	Latitude: 46.7251817 Longitude: -122.9960924 Measuring Point Elevation: 171.95 ft NAVD88 Ecology UWID: BLT 950 Drilled: 07/16/2019 Location Description: In front of 3302 Mt Vista Rd	NAD83/91 Logged by: Glenn Mutti-Driscoll, PGG Driller: Zach Bailey, Holocene Drilling Drilling Method: Sonic Depth to Water (bpm): 26.42 ft, 7/16/19		MW-6 Boring Log and As-Built Centralia Monitoring Wells Task 4 JV1805.04

Depth (ft)	Graphic Log	Recovery	Soil Description	Sample Results
0			Moist, brown, gravelly, silty, SAND (topsoil).	Flush-mount steel monument. PVC measuring point stickdown 0.30 ft.
1			Moist, brown, silty, sandy, GRAVEL & COBBLES.	
2			Moist, brown, silty, sandy, GRAVEL (silt-bound)	
3				0 - 1.5 ft: neat cement surface seal
4				1.5 - 13 ft: bentonite seal
5			Moist, dark brown, fine-to-coarse sandy, very silty, GRAVEL (silt-bound). Cobbles present.	
6				0.3 - 14.6 ft: 2-inch PVC schedule 40 riser pipe. Joints threaded with o-rings.
7				
8				
9			Moist to wet, brown to dark brown, silty, fine-to-coarse sandy, GRAVEL (silt-bound). Cobbles present.	
10			Wet, brown, slightly silty, fine-to-coarse sandy, gravelly, COBBLES. Loose.	
11				Depth to water (bgs): 11.10 ft, 7/17/19
12			Brown, slightly silty to silty, gravelly, fine-to-coarse SAND.	
13			Brown, slightly silty to silty, fine-to-coarse sandy, GRAVEL. Cobbles present. Loose.	0 - 25 ft: 6-inch diameter borehole
14				
15			Brown, fine-to-coarse SAND & GRAVEL. Cobbles present.	13 - 25 ft: 12-20 silica sand filter pack
16				
17			Brown, slightly fine-to-coarse sandy, GRAVEL. Cobbles present, loose.	14.6 - 24.6 ft: 2-inch PVC schedule 40 screen, 10-slot (0.01-inch)
18				
19			Brown-gray, very gravelly, fine-to-coarse SAND. Sand predominately medium-to-coarse. Trace silty.	
20				
21			Brown-gray, very fine-to-coarse sandy, GRAVEL. Sand is clean and predominately fine-to-medium.	24.6 - 24.8 ft: 2-inch PVC schedule 40 end cap (flat), 0.18 ft length
22			Brown-gray, fine sandy, GRAVEL & COBBLES. Trace silty.	
23			Brown-gray, gravelly, fine-to-coarse SAND. Sand is predominately coarse.	
24			Brown, GRAVEL. Loose.	25 ft: Bottom of hole
25				
Latitude: 46.7425288 Longitude: -122.9473010 Measuring Point Elevation: 193.13 ft NAVD88 Ecology UWID: BLT 952 Drilled: 07/17/2019 Location Description: 60 ft east of E Oakview Ave & Eureka Ave intersection				MW-7 Boring Log and As-Built Centralia Monitoring Wells Task 4 JV1805.04

Depth (ft)	Graphic Log	Recovery	Soil Description	Sample Results
0			Moist, brown to dark brown, slightly gravelly, silty, SAND (Topsoil). Organics present. Cobble blocked inner core barrel, no undisturbed sample recovery. Composted outer core barrel cuttings are moist, brown, slightly silty, very fine-to-medium sandy, GRAVEL and COBBLES.	Flush-mount steel monument. PVC measuring point stickdown 0.53 ft.
1			Moist, brown, gravelly, fine-to-medium SAND. Clean.	0 - 1.5 ft: neat cement surface seal
2			Moist, gray-brown, fine-to-coarse SAND and GRAVEL. Cobbles present, sand mostly fine-to-medium.	1.5 - 27 ft: bentonite seal
3			Moist, brown, slightly silty, fine-to-coarse sandy, GRAVEL. Sand is predominately fine-to-medium.	
4			Moist, brown, slightly gravelly, fine-to-coarse SAND. Clean.	
5			Moist, brown, silty, sandy, GRAVEL (silt-bound). Large cobbles present.	
6			Very moist, brown, sandy, GRAVEL. Clean, cobbles present. 10.2 - 10.7 ft: trace silty, higher sand content.	0.53 - 29.8 ft: 2-inch PVC schedule 40 riser pipe. Joints threaded with o-rings.
7			Very moist, brown, slightly silty, slightly sandy, fine GRAVEL.	
8			Very moist, brown, slightly silty, fine-to-coarse sandy, GRAVEL. Small cobbles present. 12.9 - 13.6 ft: silt absent, clean 13.6 - 15 ft: slightly silty to silty	
9			Very moist, brown, slightly gravelly, fine-to-coarse SAND. Clean.	
10			Moist, brown, silty, sandy, GRAVEL (silt-bound). Large cobbles present.	
11			Very moist, brown, sandy, GRAVEL. Clean, cobbles present. 10.2 - 10.7 ft: trace silty, higher sand content.	
12			Very moist, brown, slightly silty, slightly sandy, fine GRAVEL.	
13			Very moist, brown, slightly silty, fine-to-coarse sandy, GRAVEL. Small cobbles present. 12.9 - 13.6 ft: silt absent, clean 13.6 - 15 ft: slightly silty to silty	
14			Very moist, brown, silty, fine-to-coarse sandy, GRAVEL. Bottom 0.3 ft baked dry by drill action.	
15			Dry to Moist, brown, silty, very sandy, GRAVEL (silt-bound). Local cobbles, hard drilling & core locally baked dry by drill action.	0 - 40 ft: 6-inch diameter borehole
16			17.5 - 19.6 ft: sandy, very silty, GRAVEL with COBBLES (silt-bound).	
17			Dry, gray, silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
18			Dry, gray, silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
19			Dry, gray, silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
20			Very moist, brown, slightly silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
21			Very moist, brown, slightly silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
22			Very moist, brown, slightly silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
23			Very moist, brown, slightly silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
24			Very moist, brown, slightly silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
25			Very moist, brown, slightly silty, sandy, GRAVEL (silt-bound). Cobbles present, baked dry by drill action.	
26			Dry, brown, sandy, silty, GRAVEL (silt-bound). Cobbles present, baked dry by drill action. 26.9 - 27.8 ft: very sandy. Lower silt content. 27.8 - 28.9 ft: moist to wet, silty, very sandy GRAVEL (siltbound) interbedded with slightly gravelly, fine-to-medium SAND. Interbeds 3 - 6 inches thick.	Depth to water (bgs): 27.48 ft, 7/16/19 27 - 40 ft: 12-20 silica sand filter pack
27			Dry, brown, sandy, silty, GRAVEL (silt-bound). Cobbles present, baked dry by drill action. 26.9 - 27.8 ft: very sandy. Lower silt content. 27.8 - 28.9 ft: moist to wet, silty, very sandy GRAVEL (siltbound) interbedded with slightly gravelly, fine-to-medium SAND. Interbeds 3 - 6 inches thick.	
28			Dry, brown, sandy, silty, GRAVEL (silt-bound). Cobbles present, baked dry by drill action. 26.9 - 27.8 ft: very sandy. Lower silt content. 27.8 - 28.9 ft: moist to wet, silty, very sandy GRAVEL (siltbound) interbedded with slightly gravelly, fine-to-medium SAND. Interbeds 3 - 6 inches thick.	
29			Wet, brown, slightly gravelly, fine-to-medium SAND. Clean, local cobbles. 31.4 - 32 ft: trace silty 32 - 33.2 ft: sand if fine-to-medium grained	
30			Brown, fine-to-coarse sandy, GRAVEL to gravelly, fine-to-coarse SAND. Clean. 31.4 - 32 ft: trace silty 32 - 33.2 ft: sand if fine-to-medium grained	
31			Brown, slightly silty to silty, sandy, GRAVEL. Cobbles present, one observed with silty-sand binder. 32 - 33.2 ft: sand if fine-to-medium grained	
32			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
33			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
34			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
35			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
36			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
37			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
38			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
39			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
40			Gray, gravelly, fine-to-coarse SAND. Clean. 36.9 - 38 ft: brown, fine-to-coarse sandy, GRAVEL.	
Latitude: 46.741869 Longitude: -123.002353 Measuring Point Elevation: 167.25 ft Ecology UWID: BLT 949 Drilled: 07/16/2019 Location Description: North side of intersection of Ives Rd & Lemar Lane				
Driller: Zach Bailey, Holocene Drilling Drilling Method: Sonic Logged by: Glenn Mutti-Driscoll, PGG Depth to Water (bpm): 26.95 ft, 7/16/19				
MW-8 Boring Log and As-Built Centralia Monitoring Wells Task 4 JV1805.04				