Appendix A

Field Exploration Program Summary

Pacific
Groundwater
Group

Appendix A
Field Exploration Program Summary

1 Introduction

From November 9 to 23, 1999 five 6-inch diameter observation wells were installed for the Maury Island gravel mining impact studies. The wells were completed for characterization of subsurface geologic conditions and for measurement of groundwater levels. Table A-1 presents the location and completion detail of each well.

2 Drilling Locations

Drilling locations for project explorations are shown in Figure A-1. These locations were selected to optimize spatial distribution of new subsurface information and to assess geologic logging performed during earlier borings (AESI, 1999a). Wells MW-1 and MW-2 were sited to evaluate conditions along the northwest and southeast margins of the mine site, respectively. They are located next to Wells OBW-5 and OBW-9, respectively. Wells MW-3, MW-4, and MW-5 were sited to evaluate conditions outside the mine site. They are located between the mine site and nearby water supplies that could be impacted by proposed mining operations. The off-site wells were sited to provide better control of groundwater levels in the Principal Aquifer. The Washington State Department of Ecology coordinated well site access and negotiated final well sites with off-site property owners.

3 Drilling Method and Well Installation

The wells were drilled, installed and developed by Cascade Drilling, Inc. of Woodinville, Washington using an Ingersoll Rand T3W air rotary rig. A surface seal was constructed by drilling a 10-inch hole to a minimum depth of 18 feet below ground surface (bgs). Standard 6-inch diameter well casing was then lowered into the hole and high-solids bentonite chips were used to fill the annular space to surface. Additional bentonite chips were added to the annular space as drilling progressed.

The 6-inch diameter steel well casing was advanced into the ground in 20-foot flights. The target completion depth was generally about 20 to 30 feet below the regional water table in the Principal Aquifer such that a water well could be completed. Well completion depths range from 72 feet at MW-2 to 203 feet at MW-1 as described in Table A-1. Once the completion depth was reached, a 5-foot long stainless steel, v-wire wrapped well screen with a neoprene K-packer was lowered into the casing at the desired completion interval. Screen slot size was selected based a visual inspection of sediments in the completion interval and ranged from $4/1000^{th}$ of an inch (4 slot) to $6/1000^{th}$ of an inch (6 slot). The casing was then pulled back to expose the screen. Each well was developed by air-lifting formation water and suspended sediment from the screen for a minimum of one hour.

4 Sample Logging

A hydrogeologist from Pacific Groundwater Group continuously logged each borehole. Boring logs with well completion schematics are presented in Figures A-2 through A-5. Depth control was maintained during the advance of each 20-foot casing length by using 5-foot incremental markings on the outside of the casing. Cuttings from the cyclone were observed and logged during each casing advance. Return from each five-foot increment was also collected in a bucket and then used at the end of the advance to verify sample descriptions. Any changes in the rate of advance or return of the cuttings were also noted in field logs. In order to maintain library samples for future reference, cuttings from the first couple of feet of each new casing advance or from significant stratigraphic changes were placed in ZipLoc™ bags and stored at PGG.

Use of water was minimized as the borehole was advanced so changes in moisture content and/or the presence of perched groundwater could be observed. Additional information on water content was collected by looking for evidence of water on the drive samplers as well as checking the boreholes for standing water after each length of casing was welded on. The depth to water values shown on the boring logs were measured after the well was developed. No perched water was observed during the project explorations.

5 Collection of Drive Samples

Drive samples, in the form of a Shelby tube or a sleeve-lined split-spoon sample, were collected at the end of selected 20-foot sections as shown in Table A-2. Drive samples were collected at regular intervals throughout the boring depth within the limits of the project's sampling budget. Drive samples were collected to characterize relatively undisturbed samples of the geologic profile and for assessing moisture content ahead of the air rotary drill bit. The Shelby tube samples were sealed on site using plastic caps and duct tape. The split-spoon samples were examined on site and then placed in a ZipLoc™ bag as library samples retained by PGG.

6 Laboratory Analysis of Soil Samples

Table A-2 presents which drive samples were submitted for laboratory analysis. Defining material properties was necessary for modeling of unsaturated flow to the water table as presented in Appendix E of this report. Four samples were submitted for laboratory analysis to define material properties of finer-grained materials encountered above the regional water table at or near the mine site. Three samples were selected for analysis from exploration MW-1 because these samples represent a profile of finer-grained outwash. One sample was selected for analysis from exploration MW-4 to allow comparison of material properties near the mine.

The following physical property analyses were performed on each soil sample submitted to the laboratory:

- grain size distribution
- porosity
- residual water content
- saturated hydraulic conductivity
- moisture retention properties (main drying curves)

Analyses were performed by the Rosa Environmental and Geotechnical Laboratory ("REG Labs") in Seattle, Washington. Results of the analyses are summarized in Table A-3 with a supporting laboratory report presented in Attachment 1.

7 Discussion of Geologic Conditions

Boring depths ranged from 72 feet at MW-2 to 205 feet at boring MW-1. Boring depths ranged considerably because of differing ground surface elevations at each exploration location and because each boring stopped in the Principal Aquifer. Boring MW-2, located near Puget Sound on the mine's southeast margin, is drilled from a ground elevation of about 40 feet and is therefore relatively shallow. Boring MW-1, located on the mine's northern boundary, is drilled from a ground elevation of about 265 feet is therefore relatively deep. Total depths of other project borings decrease at lower ground surface elevations.

Geologic logs for the five project borings describe a sequence of gravelly to silty glacial outwash sand fining downward into very fine sand and sandy silt. These materials represent the distal facies of the outwash or upper transitional beds. Borings MW-2, MW-3, and MW-5 encountered primarily sandy sediments with lesser amounts of silt. Materials observed in these boring are more typical of the outwash deposits although dry silty interbeds occur at these locations. Borings MW-1 and MW-4 encountered more silty fine sand in their lower stratigraphic sections. These borings show the fining-downward gradation that occurs in the lower outwash section and upper transitional beds.

Boring MW-1 was drilled about 10 feet from OBW-5, a boring (and well) installed by AESI in January 1999 (see AESI, 1999a). The textural and moisture characteristics that were observed in boring MW-1 are generally similar to those described in AESI's drilling log for OBW-5 above a depth of 185 feet. However, silt stringers observed at 82 feet in MW-1 were not described in OBW-5. Conversely, silt clasts described in OBW-5 at 108 feet were not observed in MW-1. These and other textural differences are minor, however, and the geologic conditions encountered at these borings are considered to be effectively the same. Between 185 and 203 feet (bottom of hole [BOH] for MW-1), slight textural differences exist between the logs of MW-1 and OBW-5. MW-1 is logged as very sandy silt over this depth interval while OBW-5 is logged as very fine sand with occasional medium sand. This textural difference likely represents interpretive differences between the logging of PGG and AESI. It may also represent differences in cutting return efficiency between the two borings. Given the similarity of logging information in the upper portions of these boreholes, the textural descriptions provided for OBW-5 below 203 feet are considered to be representative. However, PGG considers all materials encountered in OBW-5 (and all other on-site borings) to be representative of fine-grained glacial outwash materials and not the "pre-Vashon non-glacial" unit designated in the log for OBW-5. The sandy to gravely texture of sediments encountered between 240 and 260 feet (BOH in OBW-5) suggest that pre-Vashon age interglacial sediments (i.e., aquitard materials) had not been encountered at this location.

Boring MW-2 was drilled about 12 feet from OBW-9, a boring (and well) also installed by AESI. Small differences in sediment texture exist between the two borings although the overall geologic profile described is very similar. Most notably, the carbonized wood fragments described in OBW-9 from 35 to 45 feet were not observed in cuttings or a split spoon sample collected from MW-2 at the same depth interval. Wood fragments were used by AESI to mark the beginning of pre-Vashon age sediments. The occurrence of fine to medium sand between 50 and 72 feet (BOH in MW-2) suggests that the boring is still in advance outwash sediments and that pre-Vashon non-glacial sediments had not been encountered yet at this depth.

8 Discussion of Groundwater Conditions

Project borings were logged to investigate the occurrence of perched groundwater above the regional water table (Principal Aquifer) and the occurrence of groundwater in the Principal Aquifer. Perched water was not observed in any of the project borings. With exception of sample MW-1-179, all cuttings and drive samples collected above the Principal Aquifer were dry to moist, indicating that perched conditions do not occur at boring locations. Sounder measurements conducted in the drill casing before and after casing welds did not detect perched groundwater above the regional water table. Sample MW-1-179 was collected in a very sandy silt horizon just above the regional water table. Saturation observed in this sample is likely caused by capillary rise above the water table at about 180 feet and by not perched groundwater.

Project borings were also logged to investigate the sediments that comprise the Principal Aquifer. The aquifer occurs in the lower outwash section of each exploration, generally in fine-grained sediments. In project borings, the Principal Aquifer occurs in sediments ranging from medium-to-fine sand to sandy silt. Sediments encountered at and below the water table are described in geologic logs presented in Figures A-2 through A-6.

Depth to groundwater at time of drilling ranged from about 37 feet below ground surface in MW-2 to about 180 feet below ground surface in MW-1. PGG measured depth to water in project wells in November 1999 and March 2000 as part of the project water level survey. Results of the water level survey are presented in Section 6 of the main body of the hydrogeologic impact assessment report.

9 References

Associated Earth Sciences Inc. 1999a. *Addendum Geology and Ground Water Report, Maury Island Pit, King County, Washington*. Unpublished consulting report prepared for Lone Star Northwest, Inc., revised date of March 3, 1999.

Table A-1 Summary of Project Wells

Project Well ID Number	MW-1	MW-2	MW-3	MW-4	MW-5
Ecology Unique ID Number	AFG 349	AFG 348	AFG 347	AFG 345	AFG 346
Total Depth Drilled (feet, bgs)	205	72	76	178	157
Screen Depth (feet, bgs)	198 to 203	67 to 72	69 to 74	110 to 115	152 to 157
Screen Elevation (feet)	54 to 59	-29 to -34	19 to 24	45 to 50	34 to 39
Screen Slot Size (inches)	0.004	0.004	0.006	0.004	0.006
TOC Elevation (feet)	265.2	41.1	100.2	168.1	199.4
Location	On-site. next to OBW-5	On site. next to OBW-9	Off site. NE corner of SW 264th and 94th SW	Off site. SW 260th, E of Dockton Road SW	Off site. #25421 Dockton Road SW

Notes:
bgs = below ground surface
TOC = top of casing
Elevations are relative to NAVD 88 datum
Well locations shown on Figure A-1

Table A-2 Drive Sample Summary

Project Well ID	Sample Depth (feet, bgs)	Sampler Used	Material Summary[1]	Submitted to Laboratory[2]
MW-1 (TD = 205 ft bgs)				
	33 - 34	split-spoon	m. sand	no
	77 - 79	shelby	m. sand	Sample MW-1-79
	117 - 118	shelby	f-m sand	no
	157 - 159	shelby	f-m sand	Sample MW-1-159
	177 - 179	shelby	v. sandy silt	Sample MW-1-179
	197 - 199	shelby	v. sandy silt	no
MW-2 (TD = 72 ft bgs)				
	18 - 19	shelby	gravel	no
	37 - 39	split-spoon	m. sand	no
	70 - 72	split-spoon	f-m sand	no
MW-3 (TD = 76 ft bgs)				
	17 - 19	split-spoon	sandy silt	no
	37 - 38	split-spoon	sandy silt	no
	57 - 58	split-spoon	m. sand	no
MW-4 (TD = 178 ft bgs)				
	38 - 40	shelby	f-m sand	Sample MW-4-40
	58 - 60	shelby	f-m sand	no
	78 - 79	shelby	f-m sand	no
	98 - 99	split-spoon	sandy silt	no
	118 - 120	shelby	f. sand	no
MW-5 (TD = 157 ft bgs)				
	36 - 37	split-spoon	f-m sand	no
	56 - 57	split-spoon	f-m sand	no
	76 - 77	split-spoon	f-m sand	no
	96 - 97	split-spoon	f. sand	no
	116 - 117	split-spoon	f. sand	no

Notes:

bgs = below ground surface

TD = total depth

[1] See geologic logs in Figures A-2 through A-6 for detailed sample descriptions.

[2] Samples submitted to REG Lab for physical property testing.

Table A-3 Results from Laboratory Analyses

Testing Parameter[1]	Sample Number			
	MW-1-79	MW-1-159	MW-1-179	MW-4-40
Sample Depth (feet, bgs)	77 - 79	157 - 159	177 - 179	38 - 40
% Gravel (>4 mm)	0	0	0	0.3
% Sand (0.074 - 4 mm)	91.2	88.8	17.4	80
% Silt+Clay (<0.074 mm)	8.8	11.2	82.6	19.7
Porosity	0.43	0.41	0.39	0.42
Saturation (percent)	2.2	6.7	91.8	14.9
Vertical Hydraulic Conductivity (cm/sec)	2.2E-05	3.2E-05	1.6E-06	2.3E-05
Sediment Description	dry to moist, brown, silty, medium SAND	dry to moist, brown, silty, fine to medium SAND	wet, brown, very sandy SILT	dry to moist, brown, silty, fine to medium SAND

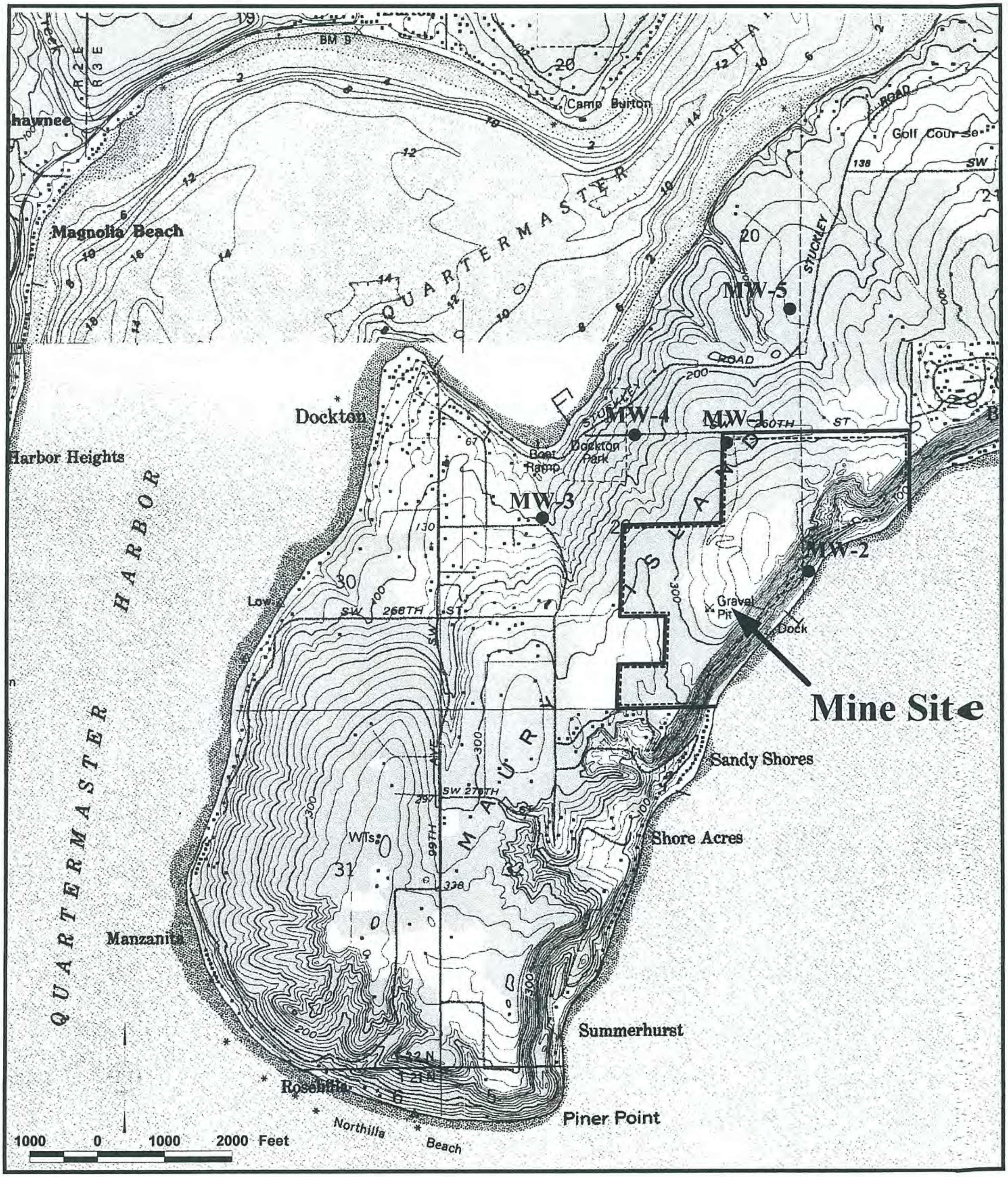
Notes:

bgs = below ground surface

mm = millimeters

cm/sec = centimeters per second

[1] Grain size and moisture retention curves presented in laboratory report by REG Lab dated 12/22/99.



Legend

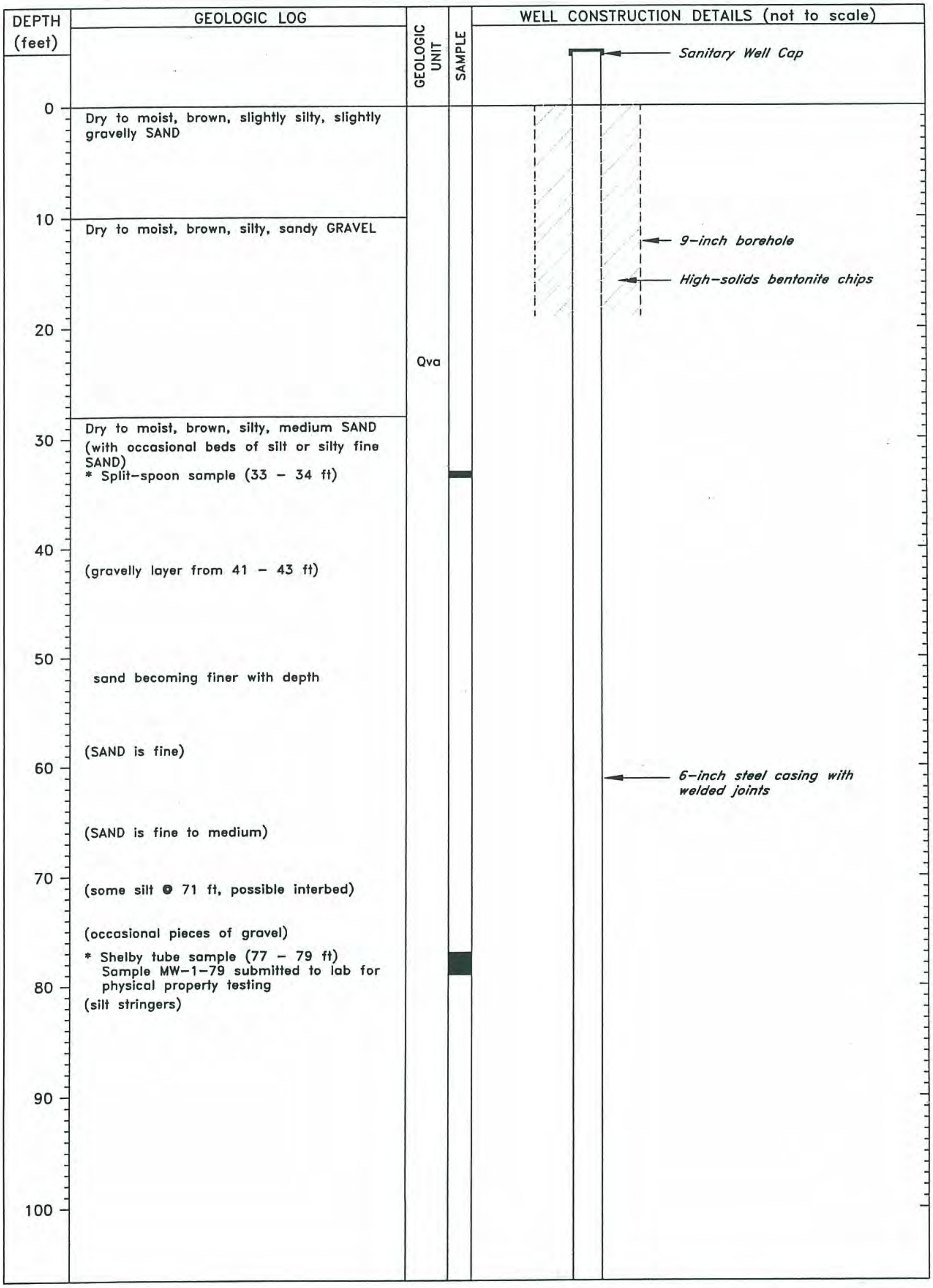
Mine Boundary

Well Location

Figure A-1
Project Well Locations

Maury Island Gravel Mine
Hydrogeologic Impact Assessment
JK 9908, Final_Maury.APR, 4/2000

Pacific Groundwater Group



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SE ¼ NE ¼ Sec. 29, T22N, R3E
DATUM: NAVD 88

WELL NAME: MW-1
UWID No. AFG 349
MEASURING POINT ELEV.: 265.2 ft
INSTALLED: 11/9/99 - 11/15/99
DEVELOPED: 11/15/99 for 1 hour
WATER LEVEL: 183.00 ft

FIGURE A-2 (1 of 2)
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-1

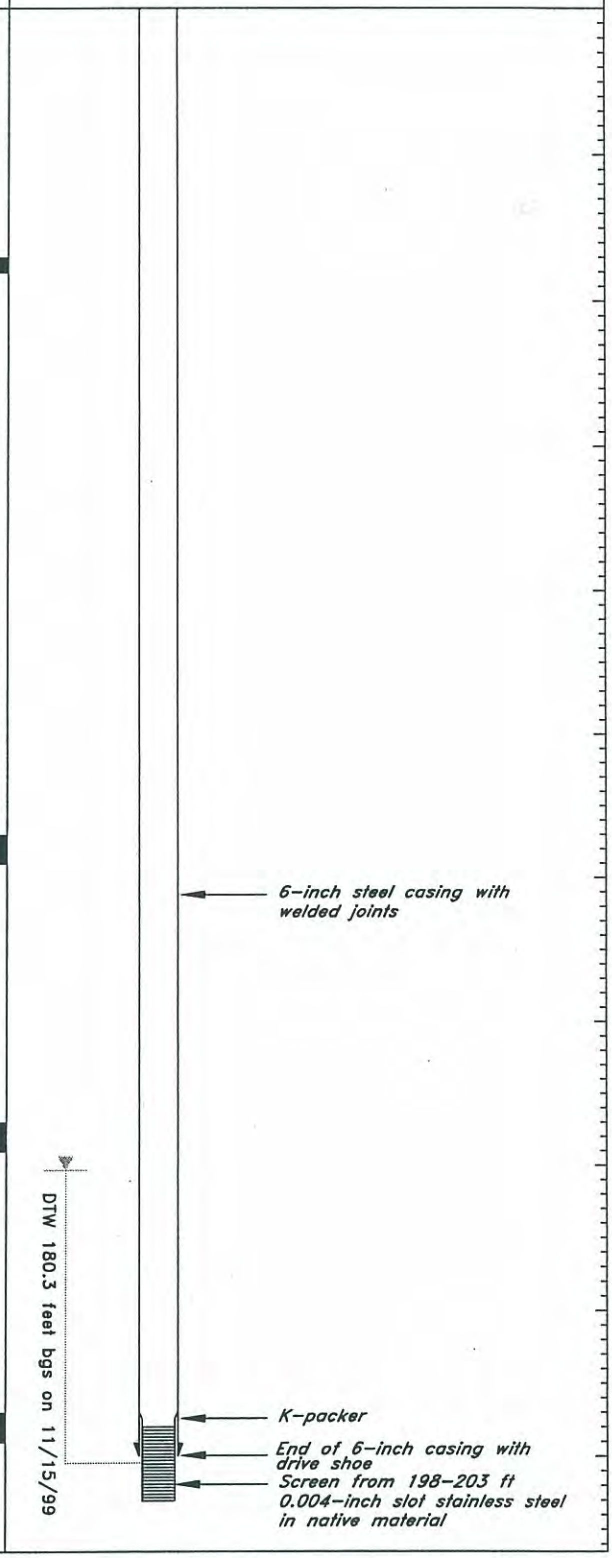
Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-1.dwg, 4/00

DEPTH (feet)	GEOLOGIC LOG	GEOLOGIC UNIT	SAMPLE
100	Dry to moist, brown, silty, fine to medium SAND	Qva	
	(trace gravel)		
110	(sand is very fine from 111 to 114 ft)		
	* Shelby tube sample (117 – 118 ft)		■
120			
	(sand is fine from 126 to 127 ft)		
130			
140			
	(sand is fine from 145 to 150 ft)		
150			
	* Shelby tube sample (157 – 159 ft) Sample MW-1-159 submitted to lab for physical property testing		■
160	(interbeds of silty fine SAND)		
170	------ gradational contact ------		
	Wet, brown, very sandy, SILT		
	* Shelby tube sample (177 – 179 ft) Sample MW-1-179 submitted to lab for physical property testing		■
180			
190			
	* Shelby tube sample (197 – 199 ft)		■
200			
	Bottom of Hole 205 ft on 11/12/99		

WELL CONSTRUCTION DETAILS (not to scale)



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SE ¼ NE ¼ Sec. 29, T22N, R3E
DATUM: NAVD 88

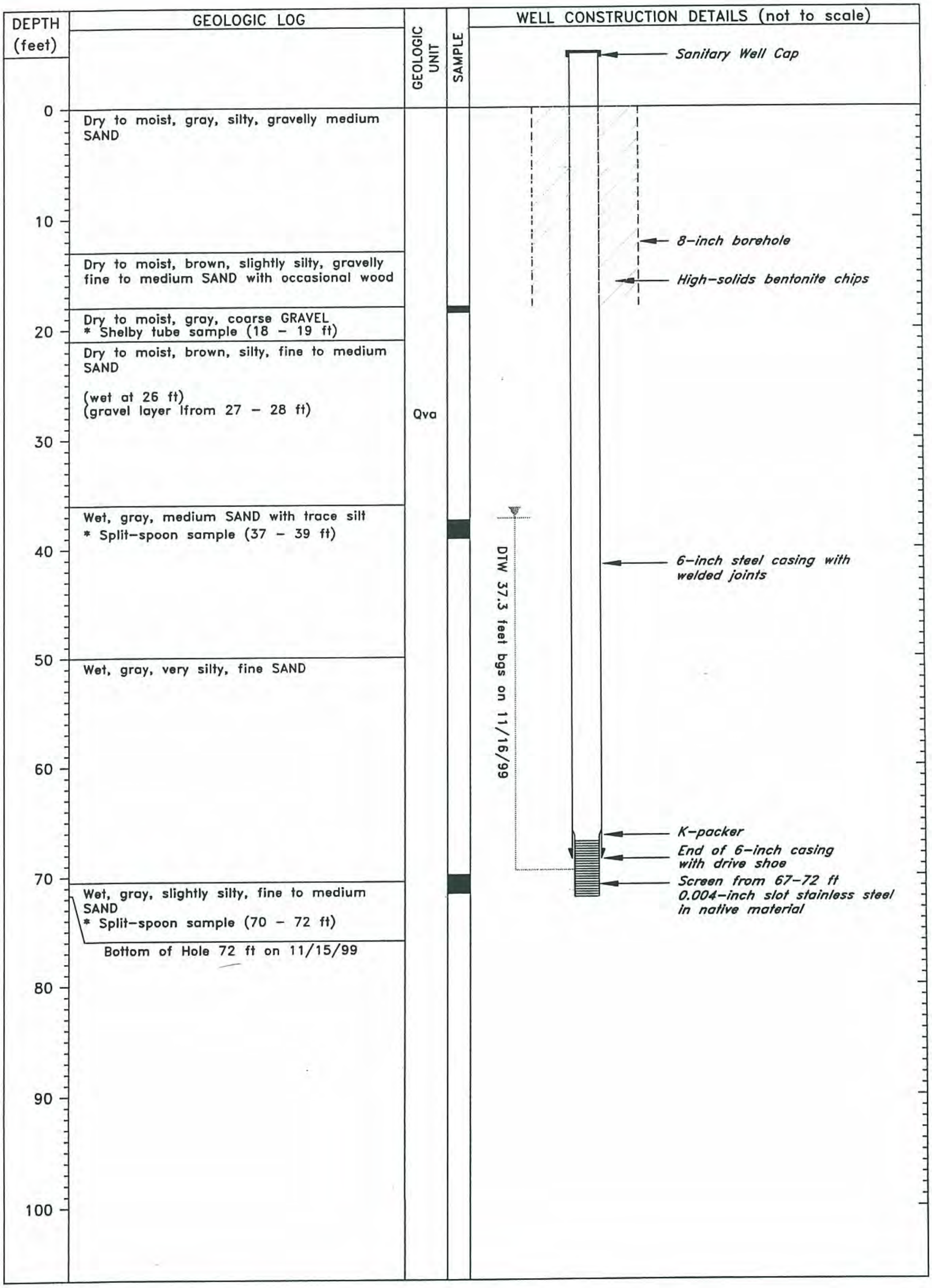
WELL NAME: MW-1
UWID No. AFG 349
MEASURING POINT ELEV.: 265.2 ft
INSTALLED: 11/9/99 – 11/15/99
DEVELOPED: 11/15/99 for 1 hour
WATER LEVEL: 183.00 ft

FIGURE A-2 (2 of 2)
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-1

Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-1.dwg, 4/00



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: NW¼ SW¼ Sec. 28, T22N, R3E
DATUM: NAVD 88

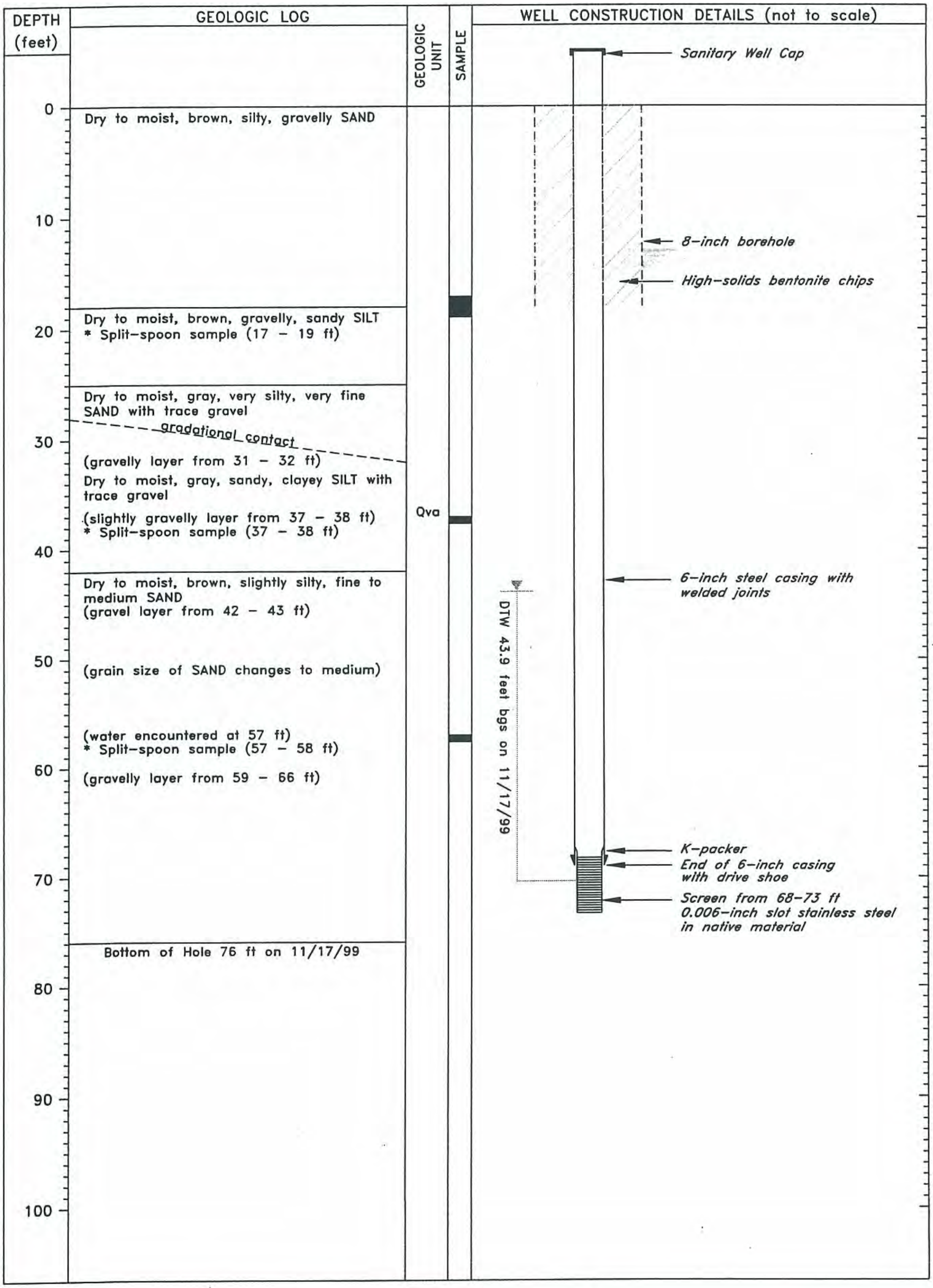
WELL NAME: MW-2
UWID No. AFG 348
MEASURING POINT ELEV.: 41.1 ft
INSTALLED: 11/15/99 - 11/16/99
DEVELOPED: 11/16/99 for 1 hour
WATER LEVEL: 33.44 ft

FIGURE A-3
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-2

Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-2.dwg, 4/00



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SE ¼ NW ¼ Sec. 29, T22N, R3E
DATUM: NAVD 88

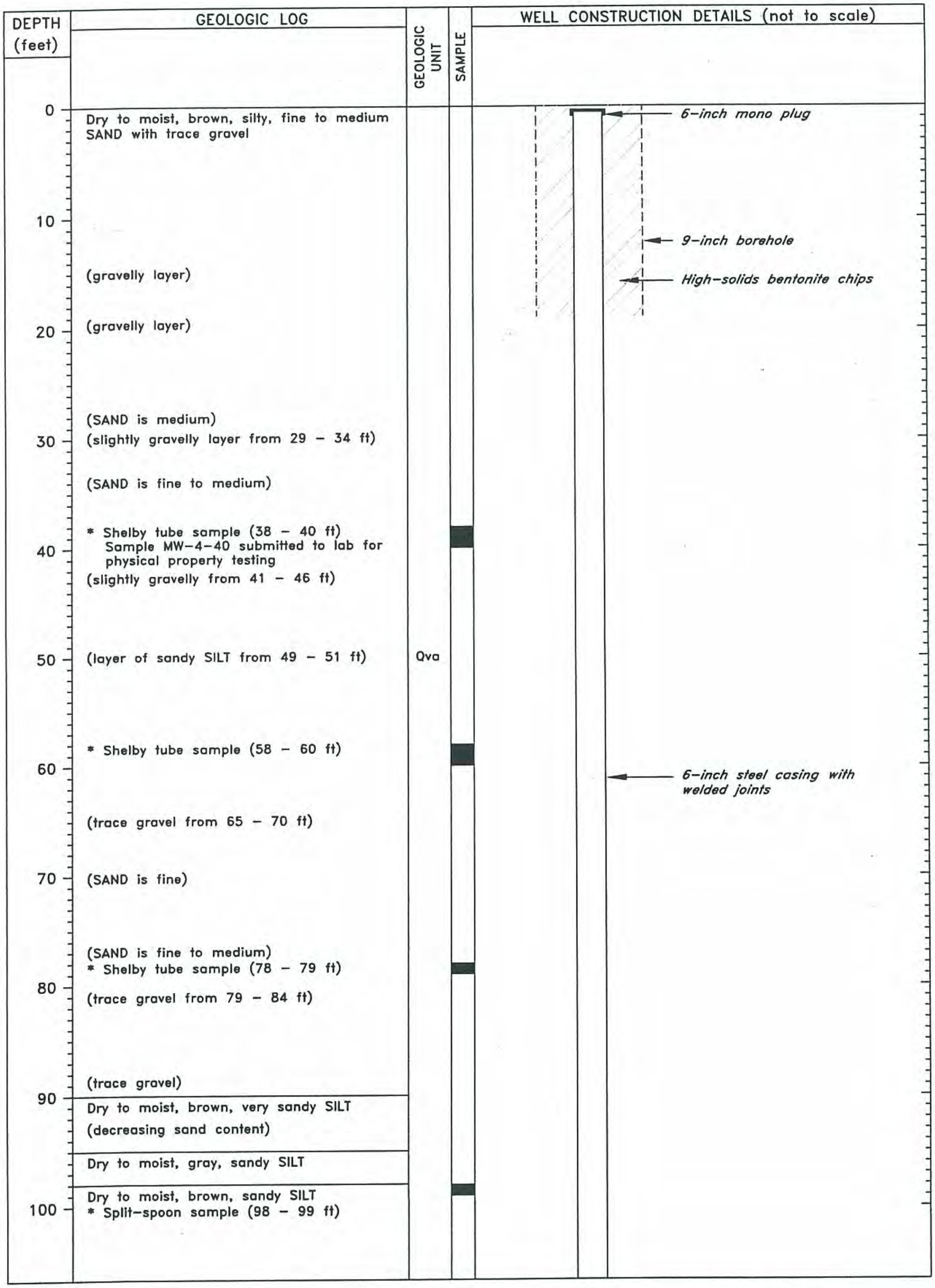
WELL NAME: MW-3
UWID No. AFG 347
MEASURING POINT ELEV.: 100.2 ft
INSTALLED: 11/16/99 - 11/17/99
DEVELOPED: 11/17/99 for 1 hour
WATER LEVEL: 45.72 ft

FIGURE A-4
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-3

Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-3.dwg, 4/00



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SW¼ NE¼ Sec. 29, T22N, R3E
DATUM: NAVD 88

WELL NAME: MW-4
UWID No. AFG 345
MEASURING POINT ELEV.: 168.1 ft
INSTALLED: 11/22/99 - 11/24/99
DEVELOPED: 11/23/99 for 2 hours
WATER LEVEL: 101.34 ft

FIGURE A-5 (1 of 2)
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-4

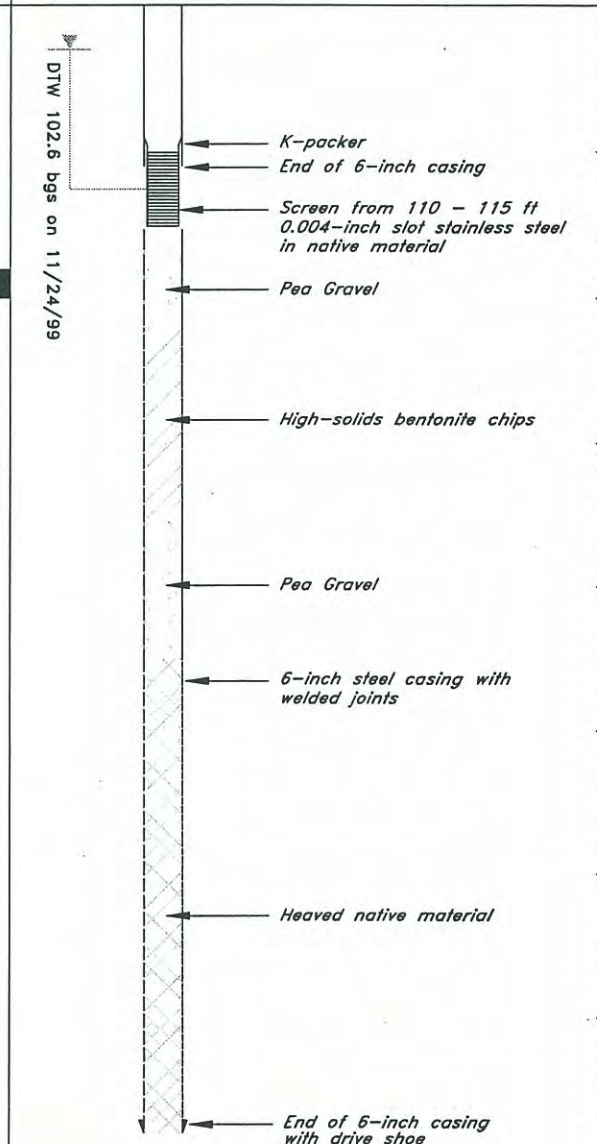
Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-4.dwg, 4/00

DEPTH (feet)	GEOLOGIC LOG	GEOLOGIC UNIT	SAMPLE
100	Dry to moist, brown, sandy SILT (slight increase in sand content)		
113	Dry to moist, brown, silty, fine SAND * Shelby tube sample (118 – 120 ft) (wet at 118 ft) (very silty)	Qva	■ (118–120 ft)
125	Wet, gray, SILT and very fine SAND (gradual decrease in sand content to a very sandy SILT) (sand content continues to decrease) (sand content increasing gradually) (back to gray SILT and very fine SAND) (increase in silt content)		
178	Bottom of Hole 178 ft on 11/23/99		

WELL CONSTRUCTION DETAILS (not to scale)



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SW¼ NE¼ Sec. 29, T22N, R3E
DATUM: NAVD 88

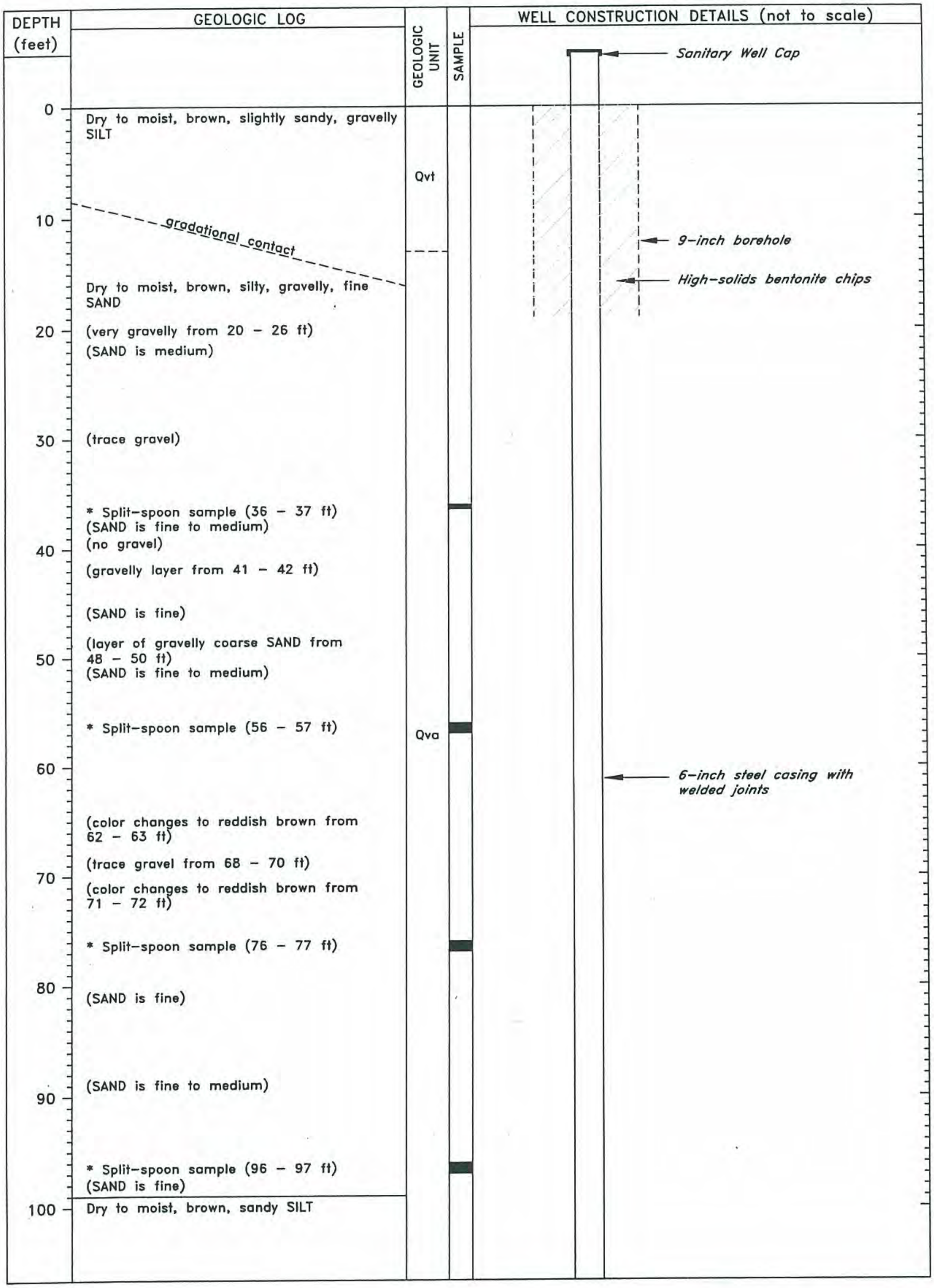
WELL NAME: MW-4
UWID No. AFG 345
MEASURING POINT ELEV.: 168.1 ft
INSTALLED: 11/22/99 – 11/24/99
DEVELOPED: 11/23/99 for 2 hours
WATER LEVEL: 101.34 ft

FIGURE A-5 (2 of 2)
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-4

Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-4.dwg, 4/00



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SW¼ NW¼ Sec. 21, T22N, R3E
DATUM: NAVD 88

WELL NAME: MW-5
UWID No. AFG 346
MEASURING POINT ELEV.: 199.4
INSTALLED: 11/18/99 - 11/19/99
DEVELOPED: 11/19/99 for 1 hour
WATER LEVEL: 111.65 ft

FIGURE A-6 (1 of 2)
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-5

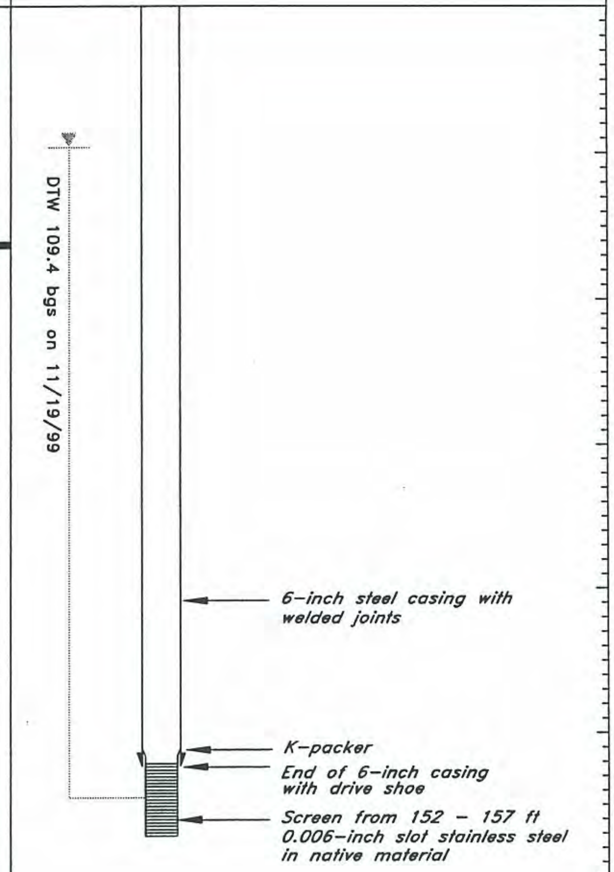
Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-5.dwg, 4/00

DEPTH (feet)	GEOLOGIC LOG	GEOLOGIC UNIT	SAMPLE
100	Dry to moist, brown, sandy SILT (color changes to gray)	Qva	
	Dry to moist, brown, silty, fine to medium SAND (SAND is very fine)		
110	(silt content increasing)		
	* Split-spoon sample (116 - 117 ft) (SAND is fine)		116 - 117 ft
120			
	(SAND is fine to medium)		
130	(SAND is fine)		
	(wet at 136 ft)		
140			
150			
	Bottom of Hole 157 ft on 11/18/99		
160			
170			
180			
190			
200			

WELL CONSTRUCTION DETAILS (not to scale)



PROJECT NAME: Maury Island Impact Studies
DRILLING METHOD: Air Rotary, 6-inch casing
DRILLER: Todd Mecham
FIRM: Cascade Drilling Inc.
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Leslie Major
LOCATION: SW¼ NW¼ Sec. 21, T22N, R3E
DATUM: NAVD 88

WELL NAME: MW-5
UWID No. AFG 346
MEASURING POINT ELEV.: 199.4
INSTALLED: 11/18/99 - 11/19/99
DEVELOPED: 11/19/99 for 1 hour
WATER LEVEL: 111.65 ft

FIGURE A-6 (2 of 2)
GEOLOGIC LOG AND AS-BUILT FOR WELL MW-5

Maury Island Gravel Mine
Hydrogeologic Impact Assessment

Pacific Groundwater Group

JK9908.4, MW-5.dwg, 4/00

Attachment A-1

Laboratory Testing Results

Pacific
Groundwater
Group

REG Lab WMBE
Rosa Environmental & Geotechnical Laboratory, LLC

815 Harrison Street, #100
Seattle, WA 98109-5187
(206) 287-9122

December 22, 1999

Mr. Peter Schwartzman
Pacific Groundwater Group, Inc.
2377 Eastlake Avenue East
Seattle, WA 98102

Subject: Project JK9908.4; REGL No. 1044-001

Dear Mr. Schwartzman

Samples from the referenced project have been tested according to the attached chain of custody and are reported on the attached pages. The report includes summary tables, a narrative, and the chain of custody.

Please call me if you have any questions on the data or its presentation.

Sincerely,
Rosa Environmental & Geotechnical Laboratory LLC

Harold Benny
Quality Assurance Manager

REG Lab WMBE
Rosa Environmental & Geotechnical Laboratory, LLC

815 Harrison Street, #100
Seattle, WA 98109-5187
(206) 287-9122

Client: Pacific Groundwater Group, Inc.	Project No.: 1044-001
Client Project No.: JK9908.4	Sample Batch No.: NA

Case Narrative

1. The samples were received on November 29, 1999, and were in good condition. The samples consisted of 4, 2.85 inch diameter Shelby tubes.
2. The grain size analysis was performed according to ASTM D-422. Only one sample required hydrometer analysis, the others were sieve only.
3. The moisture content was measured according to ASTM D-2216. The data is listed in the accompanying summary tables and on the conductivity tables.
4. The bulk density was calculated by first measuring the length and diameter of the soil in the sleeve. The volume of the soil was calculated from this data. Dividing the wet weight of the soil by the volume provides the wet density. Dry density was calculated by dividing the wet density by the quantity (1 + moisture content).
5. Saturated hydraulic conductivity was measured in either a rigid wall or flexible wall system. Each sample was visually examined and an estimate of the conductivity was made. For conductivities estimated below 10E-5 cm/s, a flexible wall system was chosen. Rigid wall tests were run in general accordance with ASTM D-2434. Flexible wall tests were run according to ASTM D-5084. Sample MW-1-159 did not reach a saturation of 95% during the test, as required by the method. However, the test was run for 6 days and the flow rate was steady and very consistent over the last 3 days, and this usually indicates that the sample is at or very near saturation.
6. Porosity was calculated from the specific gravity and bulk density of the samples. Specific gravity was measured according to ASTM D-854.
7. The moisture retention curves were measured according to the guidance contained in "Methods of Soil Analysis" Part 1 Section 26, (SSSA, 1986).
8. There were no sample or test anomalies.

Approved by: [signature] Date: 12/22/99
Title: General Manager

Grain Size Analysis
ASTM D-422

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY, LLC

Client: Pacific Groundwater Group, Inc.

Project No.: JK9908.4

Percent Finer Than Indicated Size

Sieve Size (microns)	3/4"	1/2"	3/8"	#4	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)
MW-1-79	-	100.0	100.0	100.0	100.0	99.9	89.7	43.0	24.9	8.3
MW-1-159	-	100.0	100.0	100.0	100.0	99.9	95.6	63.6	21.7	11.2
MW-4-40	-	100.0	100.0	99.7	99.5	99.4	91.5	40.7	23.0	19.7

Tests conducted according to ASTM D421/D422

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY, LLC

Client: Pacific Groundwater Group, Inc.

Project No.: JK9908.4

Percent Retained in Each Size Fraction

Sieve Size (microns)	>4750	4750-2000	2000-850	850-425	425-250	250-125	125-75	<75
MW-1-79	0.0	0.0	0.1	10.2	46.6	18.2	16.6	8.3
MW-1-159	0.0	0.0	0.1	4.2	32.0	41.9	10.5	11.2
MW-4-40	0.3	0.2	0.1	7.9	50.8	17.7	3.3	19.7

Tests conducted according to ASTM D421/D422

Rosa Environmental Geotechnical Laboratory, LLC

Client: Pacific Groundwater Group, Inc.

Project No.: JK9908.4

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	1"	3/4"	1/2"	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (125)	#200 (75)	32	22	13	9	7	3.2	1.3
MW-1-179	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.4	98.3	82.6	31.5	17.8	11.0	9.6	6.8	5.5	4.1

Testing performed according to ASTM D421/D422

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY

Client: Pacific Groundwater Group, Inc.

Project No.: JK9908.4

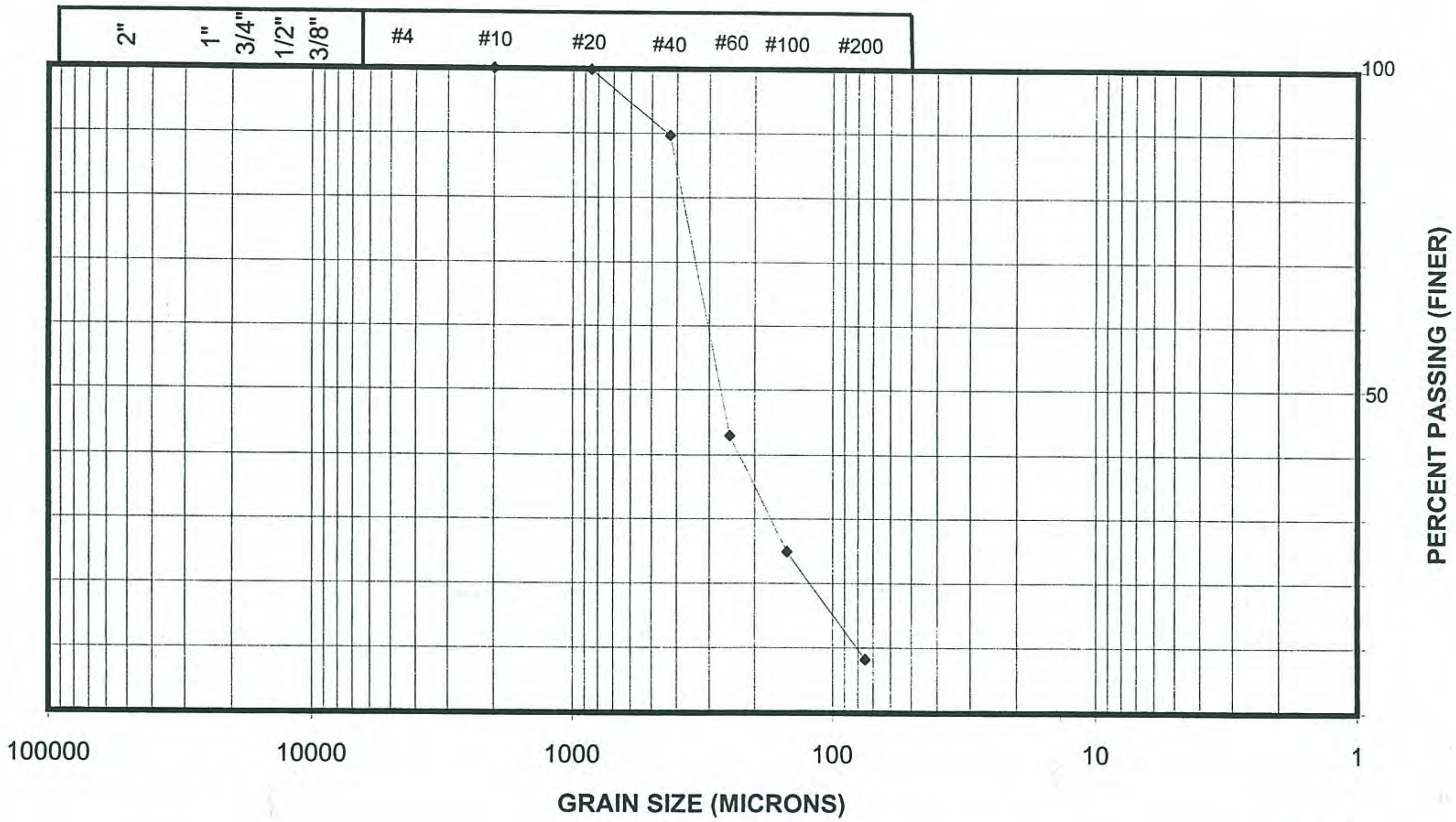
Percent Retained in Each Size Fraction

Sample No.	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Total Sand	% Silt	% Clay
Size (microns)	> 4750	4750-2000	2000-425	425-75	4750-75	75-3	<3
MW-1-179	0.0	0.0	0.1	17.4	17.4	77.1	5.5

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY, LLC.

ASTM D-422 GRAIN SIZE DISTRIBUTION

Client: Pacific Groundwater Group, Inc.
Sample No.: MW-1-79

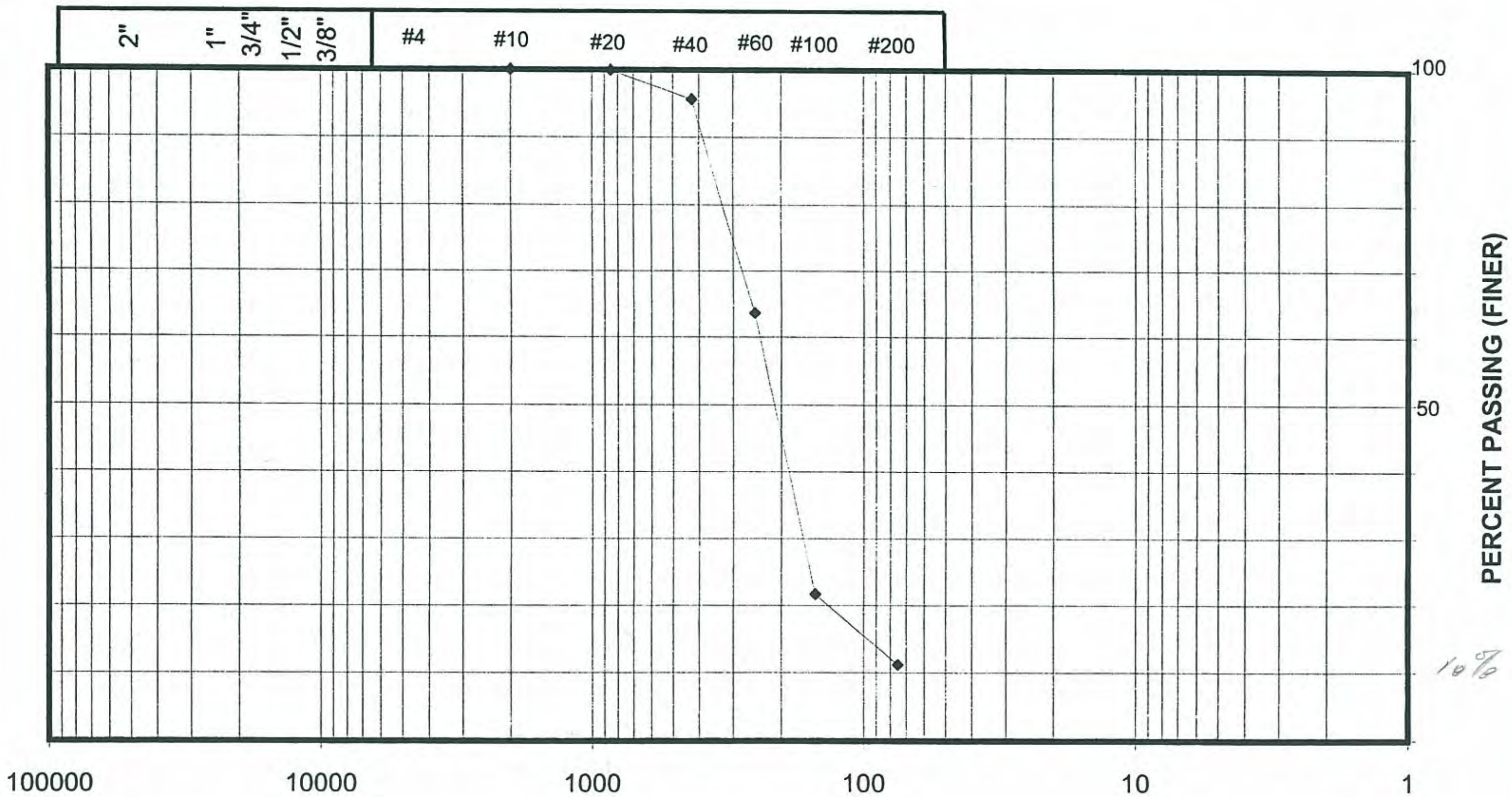


1044-001

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY, LLC.

ASTM D-422 GRAIN SIZE DISTRIBUTION

Client: Pacific Groundwater Group, Inc.
Sample No.: MW-1-159

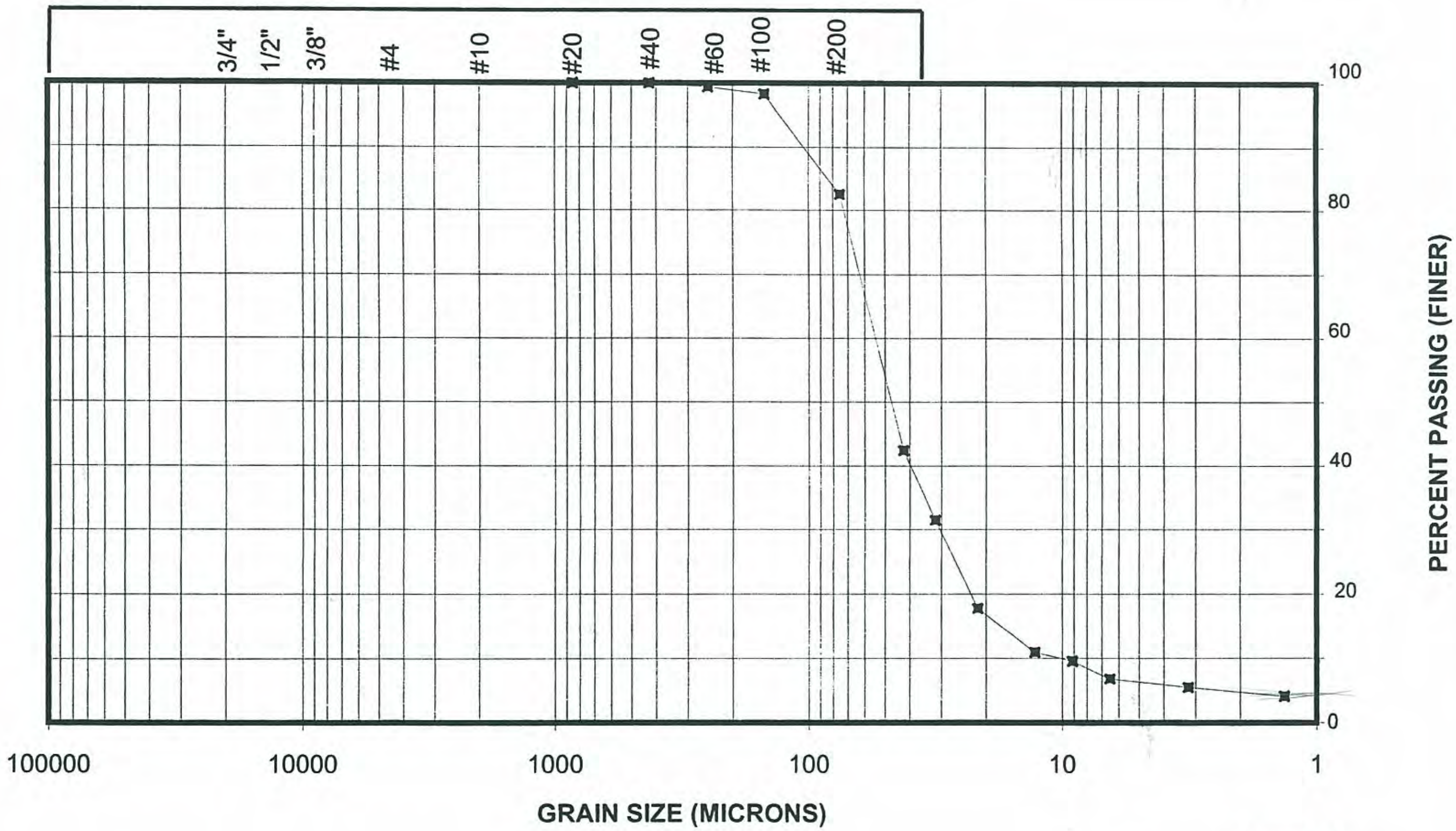


1044-001

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY

ASTM D-422 GRAIN SIZE DISTRIBUTION

Client: Pacific Groundwater Group, Inc
Sample No.: MW-1-179

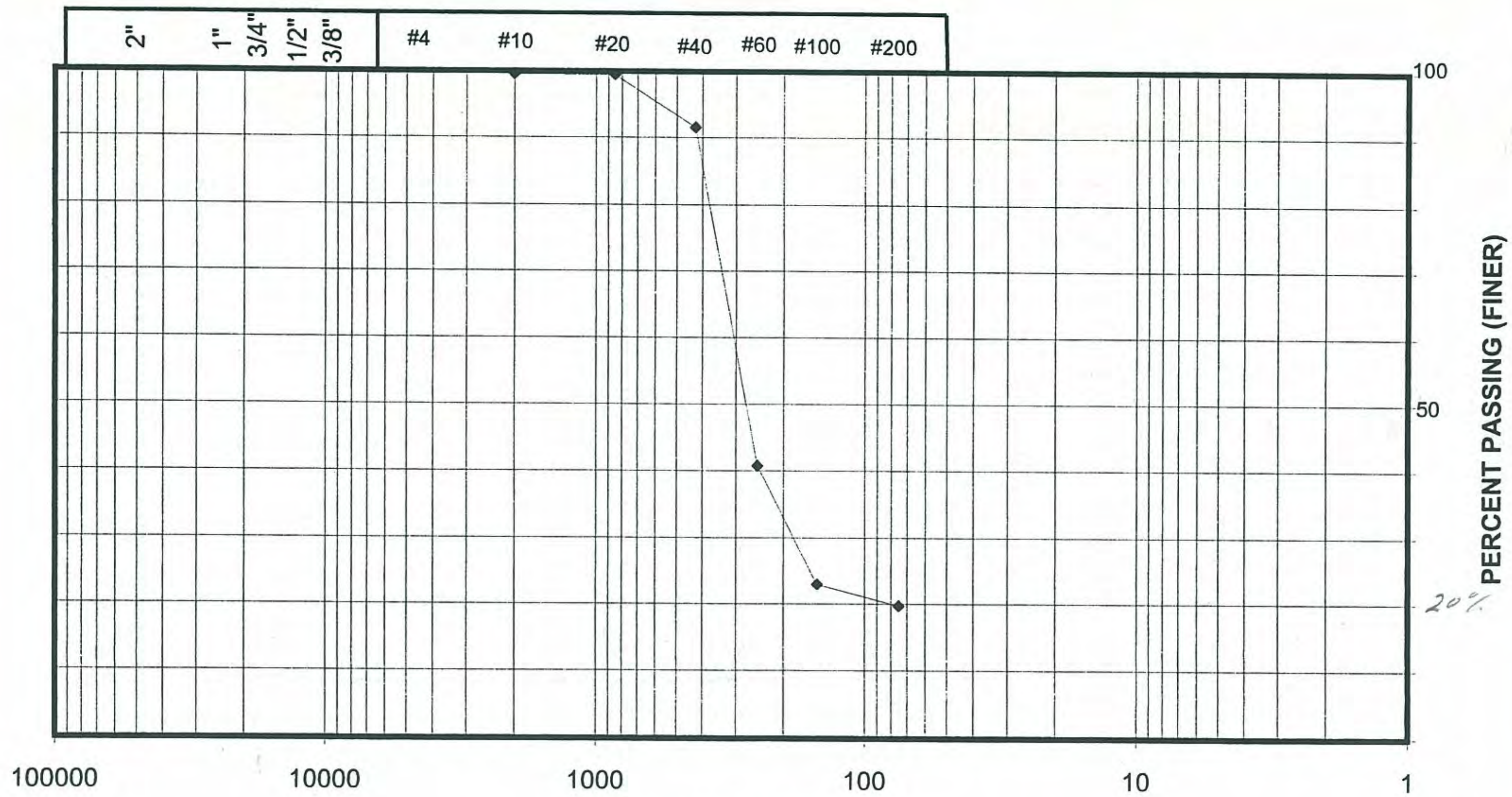


1044-001

ROSA ENVIRONMENTAL & GEOTECHNICAL LABORATORY, LLC.

ASTM D-422 GRAIN SIZE DISTRIBUTION

Client: Pacific Groundwater Group, Inc.
Sample No.: MW-4-40



1044-001

Saturated Hydraulic Conductivity
ASTM D-2434 / D-5084

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY

Pacific Groundwater Group, Inc.
Project No. JK9908.4

Test Results for Rigid Wall Hydraulic Conductivity Testing

Sample ID	Depth (ft)	Before Parameters				After Parameters				Hydraulic Conductivity cm/s
		Wet Density (lbs/ft^3)	Porosity	Saturation (%)	Moisture Content (%)	Wet Density (lbs/ft^3)	Porosity	Saturation (%)	Moisture Content (%)	
MW-1-79	79.0	98.2	0.43	2.2	0.6	123.7	0.43	96.9	26.8	2.2×10^{-5}
MW-1-159	159.0	101.1	0.41	6.7	1.7	123.1	0.41	92.1	23.9	3.2×10^{-5}
MW-4-40	40.0	102.1	0.42	14.9	4.0	124.4	0.42	99.6	26.7	2.3×10^{-5}

Notes:

1. The test was performed using tap water for the permeant.
2. The porosity and the saturation were calculated using the measured specific gravity: 79 - 2.75, 159 - 2.71, 40 - 2.72.

ROSA ENVIRONMENTAL AND GEOTECHNICAL LABORATORY

Client: Pacific Groundwater Group, Inc.
Project No.: JK9908.4

Test Results for Flexible Wall Hydraulic Conductivity Testing

Sample ID	Depth (ft)	Before Parameters				After Parameters				Gradient (h/l)	Hydraulic Conductivity (cm/s)
		Wet Density (lbs/ft^3)	Porosity	Saturation (%)	Moisture Content (%)	Wet Density (lbs/ft^3)	Porosity	Saturation (%)	Moisture Content (%)		
MW-1-179	179	126	0.396	91.8	21.9	128	0.392	98.3	23.0	3.33	1.6×10^{-6}

Notes:

1. Testing performed according to ASTM D-5080
2. The test was performed using tap water for the permeant.
3. The porosity and the saturation were calculated using a measured specific gravity of 2.75.
4. The sample, as extruded from the shelby tube, was very soft and fell apart before it could be placed in a membrane for testing. It was re-compacted to the as received density in a shorter, smaller diameter mold and tested.

Sample Description and Dimensions

Sample ID	Visual Description	Depth (ft)	Confining Pressure (psi)	Initial Average Length (cm)	Initial Average Diameter (cm)	Final Average Length (cm)	Final Average Diameter (cm)
MW-1-179	Fine Sandy Silt	179	0.0	9.14	6.10	9.16	6.07

Moisture Retention
(Main Drying Curves)

Rosa Environmental and Geotechnical Laboratory, LLC

Client: Pacific groundwater Group, Inc.
Project No.: JK9908.4

Moisture Retention Test Summary

Sample No. MW-1-79

Tension (cm)	5	23.6	50	100	333	1000
Moisture Content (%)	23.3	21.2	9.5	4.7	3.5	3.2

Sample No. MW-1-159

Tension (cm)	10.8	25	50	100	333	1000
Moisture Content (%)	12.9	6.0	2.1	1.1	0.5	0.2

Sample No. MW-1-179

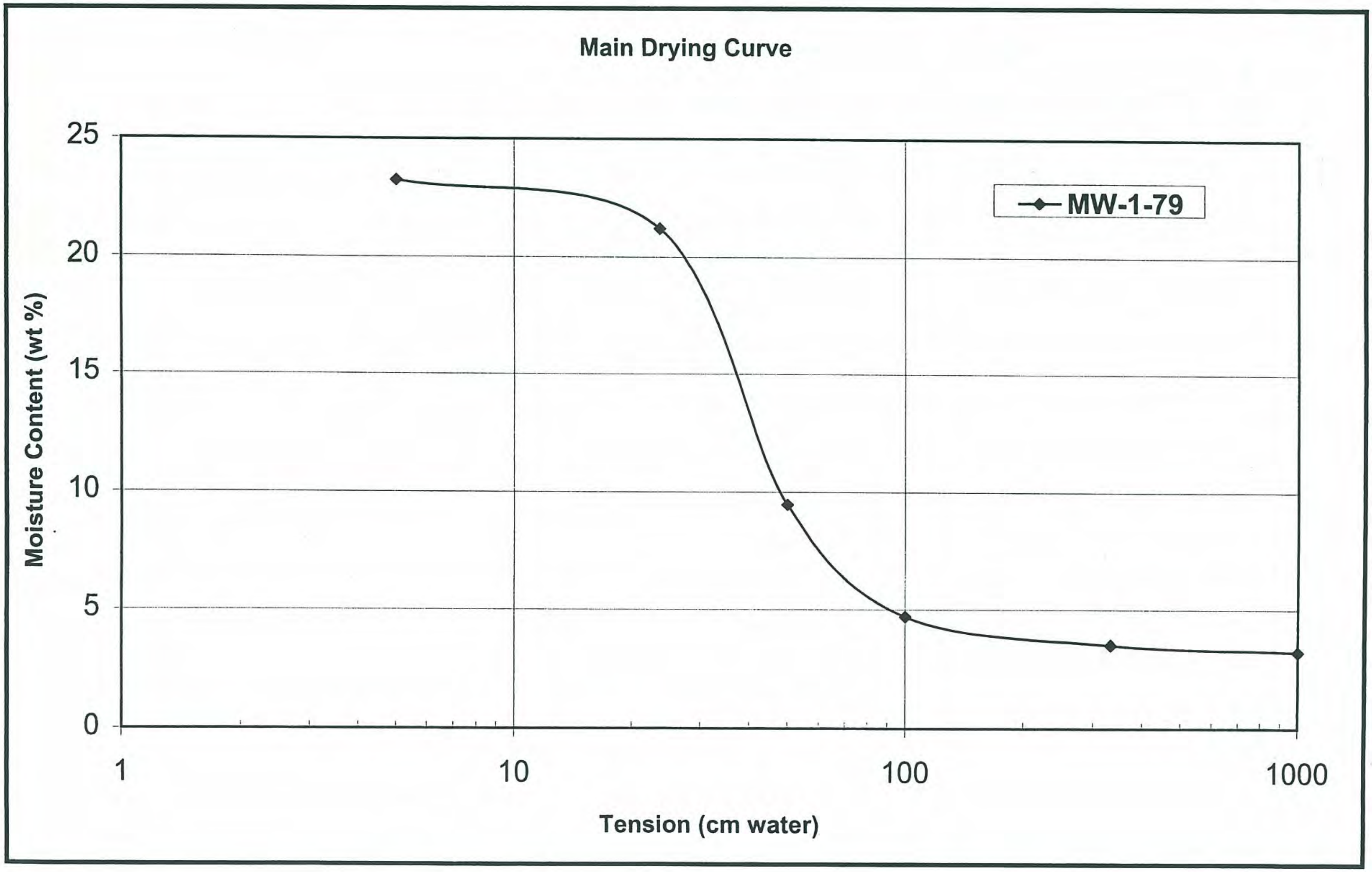
Tension (cm)	5	23.6	50	100	333	1000
Moisture Content (%)	26.6	26.6	26.5	24.4	15.7	14.2

Sample No. MW-4-40

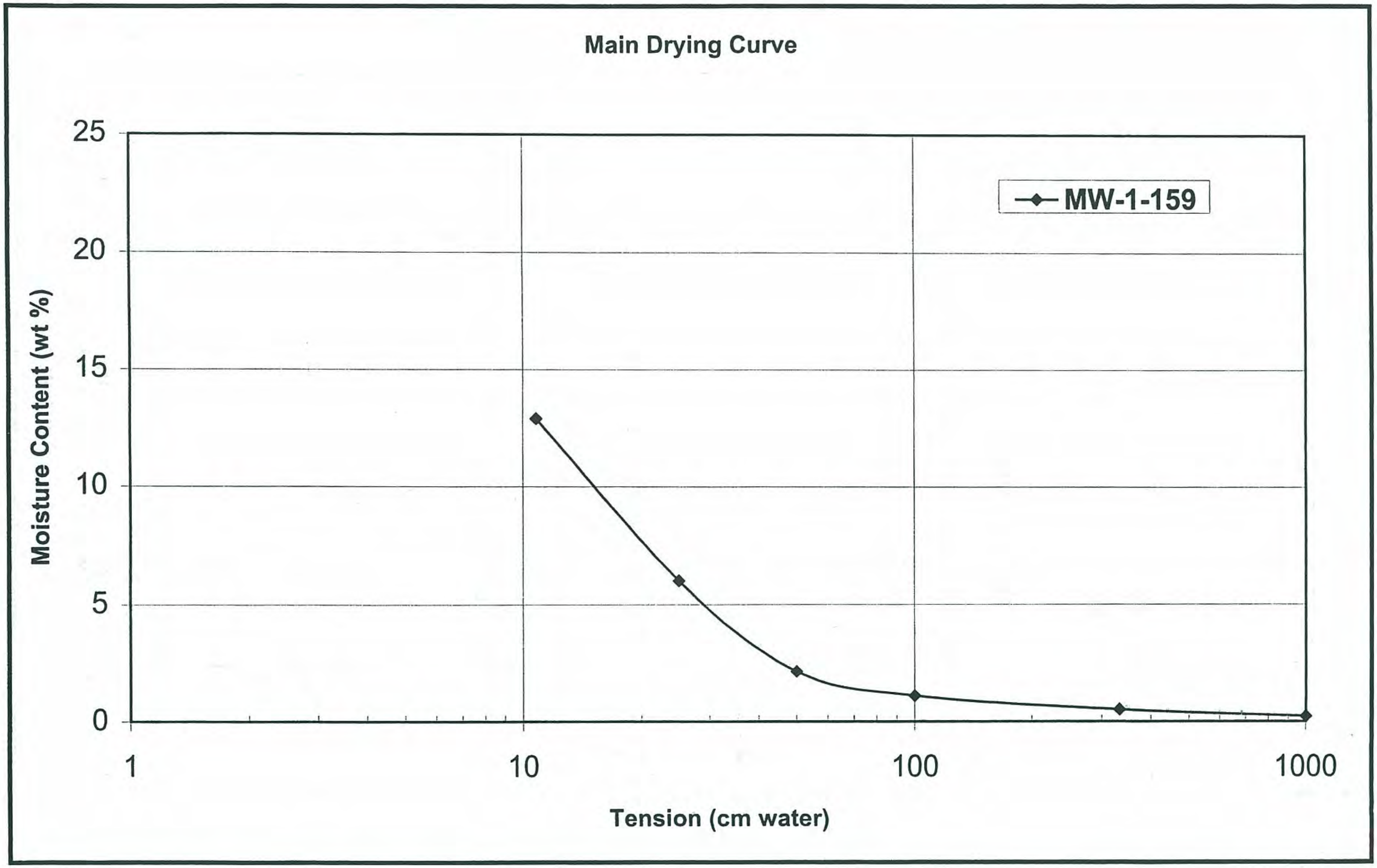
Tension (cm)	10.8	25	50	100	333	1000
Moisture Content (%)	10.8	10.4	9.6	8.8	6.7	5.3

Rosa Environmental and Geotechnical Laboratory, LLC

Client: Pacific Groundwater Group, Inc.
Project No.: JK9908.4

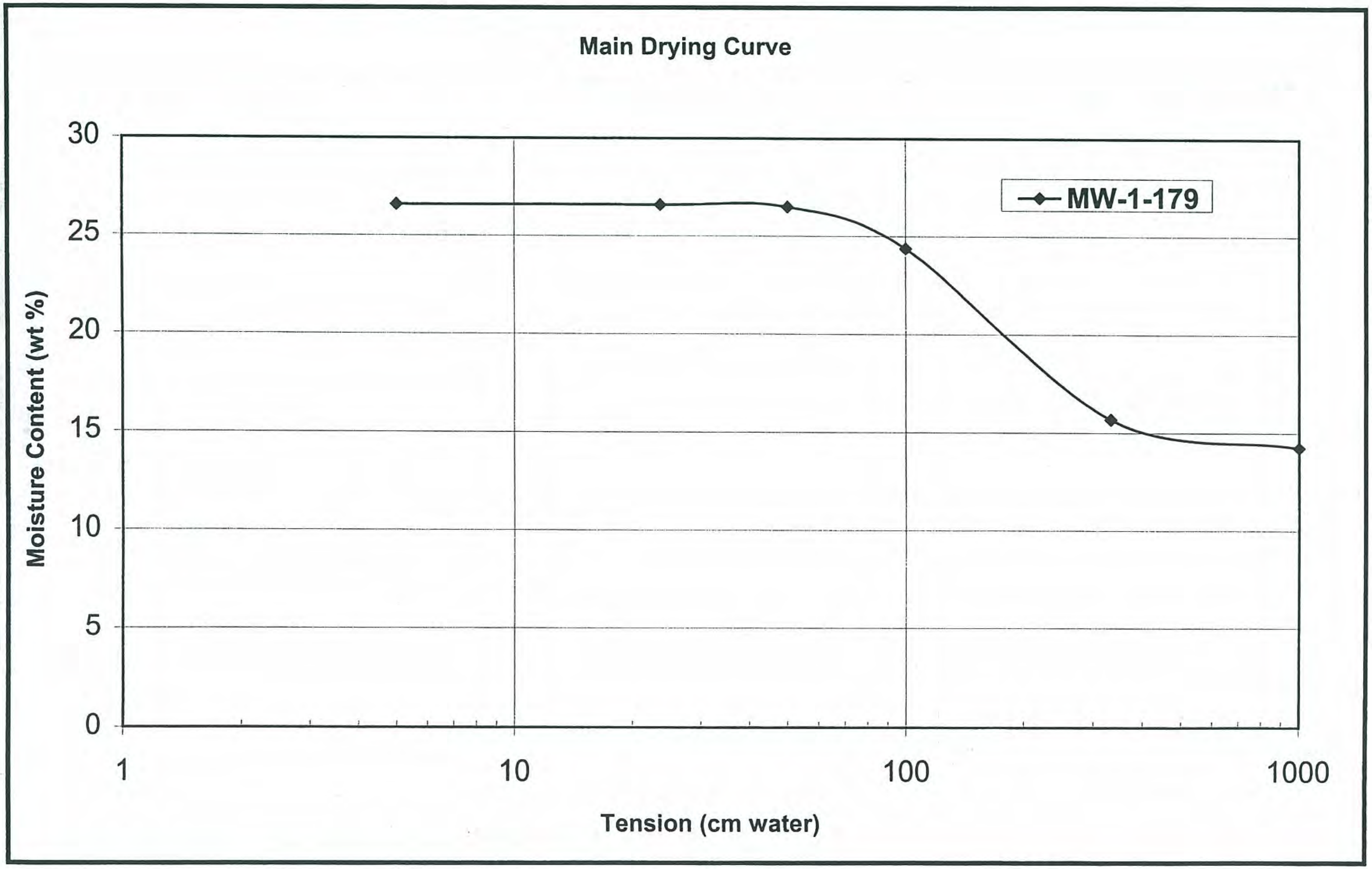


Client: Pacific Groundwater Group, Inc.
Project No.: JK9908.4



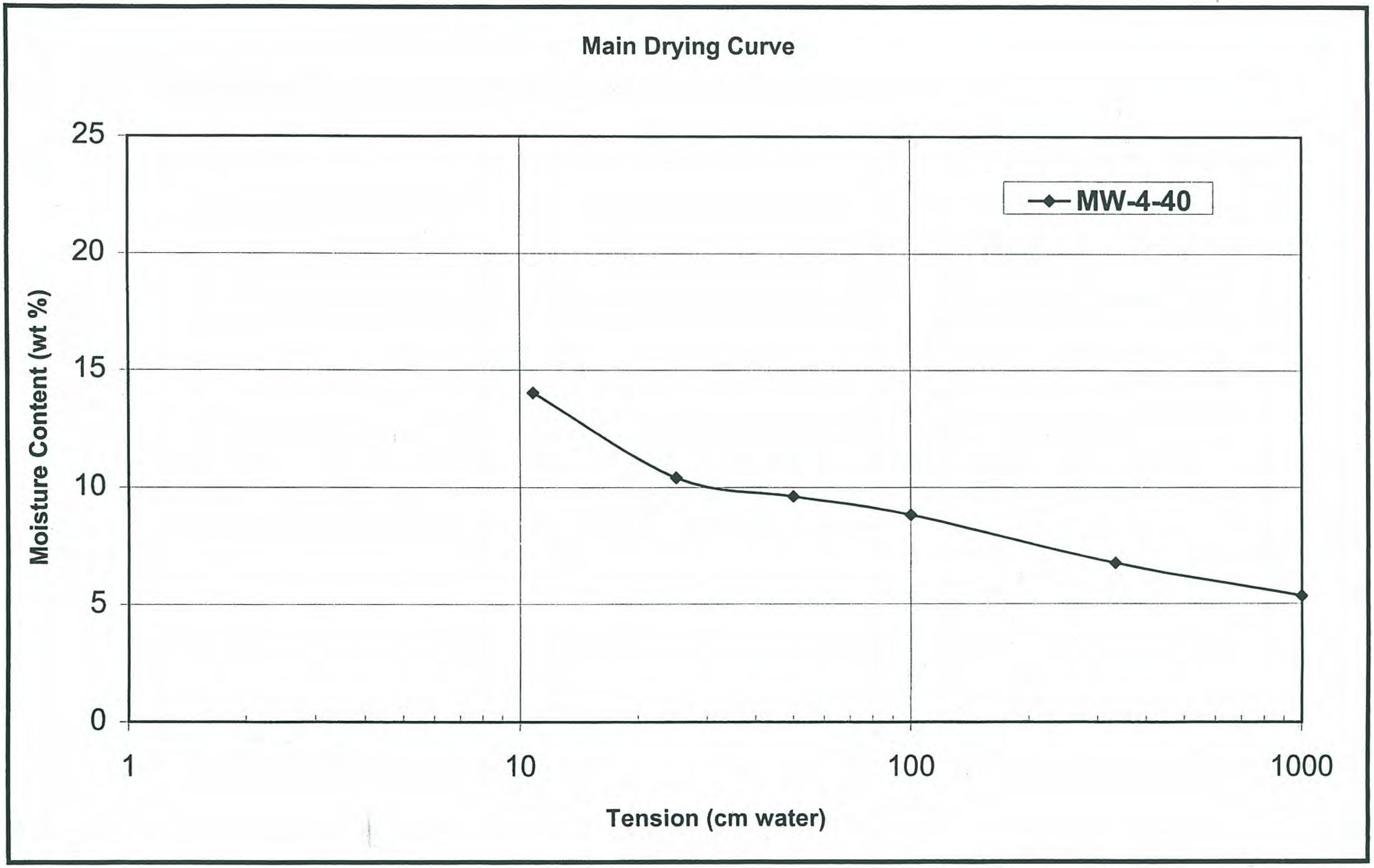
Rosa Environmental and Geotechnical Laboratory, LLC

Client: Pacific Groundwater Group, Inc.
Project No.: JK9908.4



Rosa Environmental and Geotechnical Laboratory, LLC

Client: Pacific Groundwater Group, Inc.
Project No.: JK9908.4



Chain of Custody Record & Laboratory Analysis Request

1044-001

Pacific Groundwater Group
2377 Eastlake Avenue East
Seattle, Washington 98102
206.329.0141 FAX 329.6968

Date: 11/29/99
Page 1 of 1
Number of coolers: 0

Client: Pacific Groundwater Group Phone #: 329-0141
Client Contact: Crispin Prahl X221
Client Project ID: JK9908.4
Samplers: L. Major

	Sample ID	Date	Time	Matx	No Cont	Lab ID	Saturated Hydraulic Conductivity	Porosity	Grain Size Distribution	Moisture Retention Curves	Wilting Point Residual Water Content				Notes/Comments
1	MW-1-79	11/9/99		S	1	911594	✓	✓	✓	✓	✓				See attached Rate sheet & analysis description from the Benny of Rosa REGL
2	MW-1-159	11/11/99		S	1	95	✓	✓	✓	✓	✓				
3	MW-1-179	11/11/99		S	1	96	✓	✓	✓	✓	✓				
4	MW-4-40	11/22/99		S	1	97	✓	✓	✓	✓	✓				
5															
6															
7															

Comments/Special Instructions:
Cost of analyses specified is 1214.40 as per attached rate sheet

Relinquished by: (Signature) [signature]	Relinquished by: (Signature)	Relinquished by: (Signature)
Printed Name: Crispin Prahl	Printed Name:	Printed Name:
Company: Pacific Groundwater GP	Company:	Company:
Date: 11/29/99 Time:	Date: Time:	Date: Time:
Received by: (Signature) H Benny	Received by: (Signature)	Received by: (Signature)
Printed Name: H. Benny	Printed Name:	Printed Name:
Company: REGL	Company:	Company:
Date: 11/29/99 Time: 1400	Date: Time:	Date: Time:

Appendix B

Appendix B

Well Logs for Study Area

Pacific Groundwater Group

1

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

ENTERED

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W069732
UNIQUE WELL I.D. #
Water Right Permit No.

(1) OWNER: Name ED WILLIAMS Address 24801 DOCKTON Rd S.W. VASHON

(2) LOCATION OF WELL: County KING SE 1/4 NE 1/4 Sec 20 T. 22 N., R 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 22-3E-20H

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 90 feet. Depth of completed well 90 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6 " Diam. from 0 ft. to 80 ft.
Welded [ ] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [X] No [ ]
Manufacturer's Name JOHNSON
Type STAINLESS Model No.
Diam. 6 Slot size 004 from 80 ft. to 90 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 60 ft. below top of well Date 5/30/96
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 2 gal./min. with 10 ft. drawdown after 1 hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN CLAY	0	23
BROWN SANDY CLAY	23	60
GREY CLAY	60	80
GREY SILTY SAND	80	90

RECEIVED
SEP 10 1995
Department of Ecology

Work Started 5/30/96, 19. Completed 5/30, 19 96

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME [illegible] DRILLING CO. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address [illegible]
(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEDC136R6 Date 6/1, 19 96

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

ECY 050-1-20 (9/93)

3

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON 22/3-20Q

Application No. ....

Permit No. ....

Cornutt

(1) OWNER: Name Jo Cornutt Address Rt 3 Box 189 B Vashon WN

(2) LOCATION OF WELL: County King SW ¼ SE ¼ Sec. 20 T. 22 N., R. 3E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 755 ft. Depth of completed well 755 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from 0 ft. to 290 ft.
Threaded ☐ 6" Diam. from 0 ft. to 730 ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☐ No ☒
Manufacturer's Name
Type ..... Model No. .....
Diam. ..... Slot size ..... from ..... ft. to ..... ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite & NATURAL CLAY
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 135 ft. below top of well Date 8-7-84
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? .....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

DRY HOLE

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
BROWN SILTY SAND	0	95
FINE BROWN SAND (SOME W.)	95	103
BLUE CLAY	103	140
BLUE SILTY CLAYEY SAND (SOME WATER)	140	340
BLUE CLAY	340	480
BLUE CLAYEY SILT/SMALL GRAVEL	480	490
BLUE CLAY	490	660
BLUE CLAYEY SILT/SMALL GRAVEL	660	755

RECEIVED
AUG 8 1984
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started ....., 19..... Completed ....., 19.....

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME STATEWIDE DRILLING CO. 1333 Beacon Way S. Renton, WA 98055 772-5771 (Person, firm, or corporation) (Type or print)

Address .....

[Signed] Laurence R Johnson (Well Driller)

License No. 0220 Date 8-8, 1984

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

4

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. 22/03-20 R

Permit No.

(1) OWNER: Name Gladen R. Hamilton Address P.O. Box 1610 Vashon, Wa. 98070

(2) LOCATION OF WELL: County King — NE ¼ SE ¼ Sec. 20 T. 22 N., R. 3E W.M.

Bearing and distance from section or subdivision corner None SE T.T. Per field inspection

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 1

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.

Drilled 180 ft. Depth of completed well 80 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 60 ft.

Threaded ☐ " Diam. from ft. to ft.

Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒

Type of perforator used

SIZE of perforations in. by in.

perforations from ft. to ft.

perforations from ft. to ft.

perforations from ft. to ft.

Screens: Yes ☒ No ☐

Manufacturer's Name Johnson Well

Type Stainless steel Model No.

Diam. 6 Slot size 10 from 60 ft. to 80 ft.

Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:

Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal Bentonite

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? Depth of strata

Method of sealing strata off

(7) PUMP: Manufacturer's Name

Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.

Static level 59 ft. below top of well Date 7-16-87

Artesian pressure lbs per square inch Date

Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☒ If yes, by whom?

Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test

Bailer test 7 gal./min. with 4 ft. drawdown after 2 hrs.

Artesian flow g.p.m. Date 7-16-87

Temperature of water Was a chemical analysis made? Yes ☒ No

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	2
Hard packed clay	2	8
Hardpan	8	15
Clay & gravel	15	18
Gravel, sand & seepage	18	25
Fine packed sand	25	58
Sand & seepage	58	78
Alittle water, sand & some gravel	78	85
Packed dirty sand	85	136
Packed sand & wood	136	158
Gray packed sand & wood	158	167
~~167~~		
Cemented sand	167	185

MAR 8 1988

Work started 7-14, 19 87 Completed 7-16, 19 87

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling Co. (Person, firm, or corporation) (Type or print)

Address P.O. Box 44427 Tacoma, Wa. 98444

[Signed] (Well Driller)

License No. 0419 Date 3-3, 19 88

(USE ADDITIONAL SHEETS IF NECESSARY)

(4b)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 98569 (98569)
UNIQUE WELL I.D. # AEP 401
Water Right Permit No. 22-3-20L

(1) OWNER: Name JERRY WILLIAMS Address 11413 98th AVE S.W. VASHON

(2) LOCATION OF WELL: County KING SW 1/4 NE 1/4 Sec 20 T. 22 N., R 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☒ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (If more than one)
☐ Abandoned ☒ New well ☐ Deepened ☐ Reconditioned
Method: ☐ Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 122 feet. Depth of completed well 122 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 112 ft.
☐ Welded ___" Diam. from ___ ft. to ___ ft.
☐ Liner installed ___" Diam. from ___ ft. to ___ ft.
☐ Threaded

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name COOK
Type STAINLESS Model No.
Diam. 6 Slot size 008 from 112 ft. to 122 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 95 ft. below top of well Date 6/8/98
Artesian pressure ___ lbs. per square inch Date
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 7½ gal./min. with 5 ft. drawdown after 1 hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date
Temperature of water ___ Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN CLAYEY TILL	0	23
BROWN SAND	23	103
GRAY FINE SAND	103	122

RECEIVED
JUN 11 1998
NWRO-WR
DEPT OF ECOLOGY

Work Started 6/8/98 19. Completed 6/8, 1998

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO. 1333 [illegible] Way S (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Renton, WA 98055 772-577[illegible]
(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEWDC[illegible] Date ___, 19__

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

(5)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

22/3E/21
Start Card No. 074400 B

Water Right Permit No. ______

(1) OWNER: Name E. WOLFE Address 3260 LAKEWOOD AVE S. SEATTLE

(2) LOCATION OF WELL: County KING NW ¼ NE ¼ Sec. 21 T. 22 N., R. 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW. 240th St & 80th PL SW

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 138 feet. Depth of completed well 130 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 125 ft.
Welded [X] ___" Diam. from ___ ft. to ___ ft.
Liner installed [ ]
Threaded [ ] ___" Diam. from ___ ft. to ___ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes [X] No [ ]
Manufacturer's Name JOHNSON
Type STAINLESS Model No. ______
Diam. 6 Slot size .006 from 125 ft. to 130 ft.
~~Diam.~~ 5" ~~Slot size~~ RISER from 120 ft. to 125 ft.

Gravel packed: Yes [ ] No [ ] Size of gravel ______
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 80 ft. below top of well Date 5/13/91
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ______
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 15 gal./min. with 10' ft. drawdown after 1 hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ______
Temperature of water ___ Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
TOP SOIL	0	2
BROWN SANDY CLAY	2	13
GREY GRAVELLY H.P.	13	26
GREY SANDY CLAY	26	80
GREY SILTY SAND	80	100
GREY SILTY SAND (WATER)	100	125
BROWN SAND FINE	125	130
GREY SILTY CLAY	130	138

RECEIVED
JUN 20 1991
DEPT. OF ECOLOGY

Work started ______, 19__. Completed 5/13, 1991

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 1333 BENSON WAY S. RENTON WA
(Signed) [signature] (WELL DRILLER) License No. 0220
Contractor's Registration No. STATEDC136RC Date 5/14, 1991

(USE ADDITIONAL SHEETS IF NECESSARY)

6

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

22/03-21B
Application No.
Permit No.

(1) OWNER: Name FRANK SILKETT Address Rt 1-B322 Vashon Wn

(2) LOCATION OF WELL: County King — NW ¼ NE ¼ Sec 21 T 22 N., R 3E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one)
New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 163 ft. Depth of completed well 162 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 156 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☐ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name JOHNSON
Type STAINLESS Model No.
Diam. 6 Slot size 010 from 156 ft. to 162 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 60 ft. below top of well Date 12/28/87
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test —
Bailer test 25 gal./min. with 30 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
BROWN GRAVEL, H.P.	0	35
BLUE SILTY CLAY	35	150
BROWN SAND	150	162

RECEIVED FEB 9 1988 DEPARTMENT OF ECOLOGY NORTHWEST REGION

Work started , 19 Completed 1/5 , 19 88

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME STATEWIDE DRILLING Co (Person, firm, or corporation) (Type or print)
Address 1333 Benson Way S. Renton
[Signed] [signature] (Well Driller)
License No. 0220 Date 1/5 , 19 88

(USE ADDITIONAL SHEETS IF NECESSARY)

8

22/3E/21 C

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

Start Card [redacted] 5

STATE OF WASHINGTON

Water Right Permit No.

(1) OWNER: Name Sidney Tracy Address 24437 Doctor Rd Vashon Is.

DEPT. OF ECOLOGY

(2) LOCATION OF WELL: County King NE ¼ NW ¼ Sec 21 T 22 N., R 3 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (if more than one)
[ ] Abandoned [X] New well [ ] Deepened [ ] Reconditioned
Method: [ ] Dug [X] Cable [ ] Rotary [ ] Bored [ ] Driven [ ] Jetted

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 205 feet. Depth of completed well 205 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1 ft. to 200 ft.
[X] Welded ___ " Diam. from ___ ft. to ___ ft.
[ ] Liner installed
[ ] Threaded ___ " Diam. from ___ ft. to ___ ft.

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes [X] No [ ]
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 5 Slot size 6 from 200 ft. to 205 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes [X] No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Sta Rite
Type: Sub. H.P. 1/2

(8) WATER LEVELS: Land-surface elevation above mean sea level 3-1-91 ft.
Static level 160 ft. below top of well Date
Artesian pressure ___ lbs. per square inch Date
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [X] If yes, by whom?
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 5 gal./min. with 40 ft. drawdown after 2 hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date
Temperature of water ___ Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown clay.	0	15
Clay	15	104
~~Sand~~ Pebbles clay	105	119
water seep.		
Silty sand gravel	120	135
Clay silty	136	183
Sand w/water	184	205

Work started 2-12, 1991 Completed 3-1, 1991

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Mueller Drlg Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address Box 366 Duvall WA 98019
(Signed) Randle Harris (WELL DRILLER) License No. 1374
Contractor's Registration No. MuellDI108PW Date 4-1, 1991

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

(10)

22-03-21C

Edith

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 017449
Water Right Permit No.

(1) OWNER: Name WILLIAMS, A M Address RT 3 BOX 180 VASHON, WA 98070-

(2) LOCATION OF WELL: County KING - NE 1/4 NW 1/4 Sec 21 T 22 N., R 3 WM
(2a) STREET ADDRESS OF WELL (or nearest address) RT 3 BOX 180

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 140 ft. Depth of completed well 140 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from 0 ft. to 140 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: NO
Manufacturer's Name
Type Model No.
Diam. slot size from ft. to ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 18 ft.
Material used in seal BENTONITE CLAY
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type N/A H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 85 ft. below top of well Date 09/15/88
Artesian Pressure lbs. per square inch Date / /
Artesian water controlled by

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data

Time	Water Level	Time	Water Level	Time	Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test 10 gal/min. w/ stem set at 140 ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
TOPSOIL	0	2
BROWN CLAY	2	10
BLUE CLAY W/OCC GRAVEL	10	78
BLUE CLAY	78	126
BLUE SILT	126	136
BLUE CLAYSTONE	136	140

Work started 09/14/88 Completed 09/15/88

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME NORTHWEST PUMP & DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS 3245 AUBURN WAY SOUTH

[SIGNED] R.B. DeRenet License No. 0091

Contractor's Registration No. NORTHPD137PQ Date 09/15/88

RECEIVED
OCT 14 1988
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

(11)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. 22/ϕ3-21D

Permit No. ....

(1) OWNER: Name Tom Bardeen Address Rt. 3 Box 183 Vashon, Wa. 98070

(2) LOCATION OF WELL: County King — NW ¼ NW ¼ Sec. 21 T. 22 N., R3E W.M.

Bearing and distance from section or subdivision corner 24411-81st Pl SW Vashon

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 1

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 279 ft. Depth of completed well 277 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8 " Diam. from 0 ft. to 272 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson Well
Type Stainless steel Model No.
Diam. 8 Slot size 45 from 272 ft. to 277 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Jacuzzi Bros.
Type: B15S418 H.P. 1½

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 73 ft. below top of well Date 10-13-87
Artesian pressure lbs per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 40 gal./min. with 8 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date 10-13-87
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Top soil	0	2
Sandy clay	2	16
Blue sticky clay	16	47
Blue grey clay	47	83
Gray sticky clay	83	137
Hard packed gray clay	137	163
Sticky gray clay & water	163	168
Sticky gray clay	168	212
Sticky clay & grit	212	216
Sticky clay	216	269
Clay, gravel & wood	269	270
Water, sand & gravel	270	272
Water, gravel & sand	272	277
Clay & gravel	277	279

RECEIVED MAR 8 1988 DEPARTMENT OF ECOLOGY NORTHWEST REGION

Work started 10-6 1987 Completed 10-13 1987

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling Co. (Person, firm, or corporation) (Type or print)

Address P.O. Box 44427 Tacoma, Wa. 98444

[Signed] (signature) (Well Driller)

License No. 0419 Date 10-28, 1987

Mehr

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

(13)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 20625

Water Right Permit No. ____

(1) OWNER: Name VASHON GOLF & COUNTY CLUB Address 24615 75th ave S.W VASHON

(2) LOCATION OF WELL: County KING SE ¼ NW ¼ Sec. 21 T. 22 N., R. 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) 24615 75th ave S. VASHON 22/3E/21 F

(3) PROPOSED USE: ☐ Domestic ☒ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☒ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 450 feet. Depth of completed well 440 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8 " Diam. from 0 ft. to 323 ft.
Welded ☐ 6 " Diam. from 0 ft. to 420 ft.
Liner installed ☐ ____ " Diam. from ____ ft. to ____ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name SMITH
Type STAINLESS Model No. ____
Diam. 6 Slot size 012 from 420 ft. to 440 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 155 ft. below top of well Date 10/1/93
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 10 gal./min. with 10 ft. drawdown after 10 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN CLAY	0	24
GREY CLAY	24	180
GREY CLAYEY SAND	180	220
GREY SILTY CLAY	220	310
GREY CLAY	310	380
MED. GREY SAND	380	440
TIGHT GREY CLAY	440	450

RECEIVED
DEC - 6 1993
DEPT. OF ECOLOGY

Work started ____, 19__. Completed 10/10, 19 93

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO. 1333 Beacon Way S. Benson, WA 98055 772-5771 (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address ____

(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEDC136RG Date 10/27, 19 93

(USE ADDITIONAL SHEETS IF NECESSARY)

(14)

22/03-21E E

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name Vashon Island Golf & Country Club Address P.O.Box 370, Vashon, WA 98070

(2) LOCATION OF WELL: County King — SE ¼ NW ¼ Sec 21 T 22 N., R 3E W.M.
Bearing and distance from section or subdivision corner None

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☒ Jetted ☐

(5) DIMENSIONS: Diameter of well 8 inches.
Drilled 244 ft. Depth of completed well ..... ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6 " Diam. from 0 ft. to 170 ft.
Threaded ☐ ..... " Diam. from ..... ft. to ..... ft.
Welded ☒ ..... " Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used .....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type telescoping Model No. .....
Diam. 6" Slot size .010 from 170 ft. to 185 ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ..... Depth of strata .....
Method of sealing strata off .....

(7) PUMP: Manufacturer's Name .....
Type: ..... H.P. .....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 32 ft. below top of well Date 3-25-87
Artesian pressure ..... lbs. per square inch Date .....
Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? .....
Yield: 60 gal./min. with 28 ft. drawdown after 9 hrs.
" " "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....
Bailer test ..... gal./min. with ..... ft. drawdown after ..... hrs.
Artesian flow ..... g.p.m. Date .....
Temperature of water ..... Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Topsoil	0	1
Moist light brown clay	1	3
Brown clay	3	15
Grey clay w/small gravel	15	23
Grey clay	23	60
Grey clay	60	63
Sand & small gravel w/water 2gpm	63	65
Grey clay	65	94
Grey clay, sand & shale w/water, 4gpm	94	100
Grey sand & small gravel w/water 45+gpm	100	118
Grey sand w/water, 60+gpm	118	128
Grey clay	128	132
Grey sand w/water, 60+gpm	132	154
Grey clay	154	170
Grey sand w/water 100+gpm	170	184
Grey clay	184	244

OCT 05 1987

Work started 3-9, 1987. Completed 3-30, 1987

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling Co., Inc. (Person, firm, or corporation) (Type or print)
Address P. O. Box 44427, Tacoma, WA 98444

[Signed] [signature] (Well Driller)

License No. ~~223-03-6500~~ 0419 Date 9-15, 1987

(USE ADDITIONAL SHEETS IF NECESSARY)

(15)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [redacted]516
22/3/21G
Water Right Permit No. ______

(1) OWNER: Name FRANK SALTARELLI Address P.O. BOX 153 VASHON WA

(2) LOCATION OF WELL: County KING SW ¼ NE ¼ Sec 21 T. 22 N., R. 3E W.M.

RECEIVED DEC 2 3 1992 DEPT OF ECOLOGY

(2a) STREET ADDDRESS OF WELL (or nearest address) ______

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 138 feet. Depth of completed well 138 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from 0 ft. to 138 ft.
Welded [ ] ______ " Diam. from ______ ft. to ______ ft.
Liner installed [ ] ______ " Diam. from ______ ft. to ______ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name F/W
Type: SUB H.P. 3/4

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 103 ft. below top of well Date 11/2/92
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 10 gal./min. with 15 ft. drawdown after 1 hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN CLAYEY SANDY H.P.	0	60
GRAY CLAY	60	133
COARSE SAND & GRAVEL	133	138

Work started ______, 19__. Completed 11/2, 1992

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME ______ (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address ______

(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. [illegible] Date 11/2, 1992

(USE ADDITIONAL SHEETS IF NECESSARY)

(16)

ENTERED

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 058690
Unique Well I.D. #
Water Right Permit No.

(1) OWNER: Name RIDGEWAY, MARK   Address 26328 WAX ORCHARD RD SW VASHON, WA 98070- 22/3/21-K

(2) LOCATION OF WELL: County KING   - NW 1/4 SE 1/4 Sec 21 T 22 N., R 3 WM
(2a) STREET ADDRESS OF WELL (or nearest address) 25015 75 AVE SW, VASHON

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL   Method: ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 553 ft. Depth of completed well 553 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8 " Dia. from 0 ft. to 160 ft.
WELDED 6 " Dia. from 0 ft. to 553 ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: NO
Manufacturer's Name
Type Model No.
Diam. slot size from ft. to ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 20 ft.
Material used in seal BENTONITE CLAY
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off N/A

(7) PUMP: Manufacturer's Name
Type N/A H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 388 ft. below top of well Date 05/09/95
Artesian Pressure lbs. per square inch Date
Artesian water controlled by N/A

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data
Time Water Level Time Water Level Time Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test 40 gal/min. w/ stem set at 550 ft. for 3 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
TOPSOIL	0	4
BROWN CEMENTED SAND & GRAVEL	4	300
BLUE CLAY	300	370
BROWN CEMENTED SAND & GRAVEL	370	380
BLUE SILTY SAND W/OCC GRAVEL	380	485
BLUE CLAY	485	535
WATER BEARING SAND & GRAVEL	535	553

RECEIVED
JUN 01 1995
DEPT. OF ECOLOGY

Work started 05/01/95 Completed 05/09/95

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME NORTHWEST PUMP & DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS 3245 AUBURN WAY SOUTH

[SIGNED] ____________________ License No. 0097

Contractor's Registration No. NORTHPD137PO Date 05/10/95

ENTERED

(17)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 17482
UNIQUE WELL I.D. #
Water Right Permit No. 22/3/21K

(1) OWNER: Name D. CHING Address 4212 2nd AVE N.W. SEATTLE

(2) LOCATION OF WELL: County KING — NW 1/4 SE 1/4 Sec 21 T. 22 N., R 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [X] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 460 feet. Depth of completed well 460 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8" Diam. from 0 ft. to 240 ft.
Welded [ ] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [X] No [ ]
Manufacturer's Name SMITH
Type STAINLESS Model No.
Diam. 6 Slot size 012 from 455 ft. to 460 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 330 ft. below top of well Date 6/13/94
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 0 ft. drawdown after 1 hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN SAND & GRAVEL	0	78
BROWN H.P.	78	150
GREY GRAVELLY H.P.	150	240
BROWN H.P.	240	260
GREY CLAYEY H.P.	260	290
GREY GRAVELLY H.P.	290	350
GREY CLAY	350	450
GREY SAND MED to FINE	450	460

RECEIVED
JUN 28 1994
DEPT. OF ECOLOGY

Work Started , 19. Completed 4/14, 1994

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 1333 BEACON WAY S. RENTON
(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEDC136RG Date 6/15, 1994

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

(18)

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File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W069728
UNIQUE WELL I.D. #
Water Right Permit No. 22-3E-21M

(1) OWNER: Name LEE TURNER Address 19563 137th SW VASHON WA

(2) LOCATION OF WELL: County KING — NW 1/4 SW 1/4 Sec 21 T. 22 N., R. 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (If more than one)
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 78 feet. Depth of completed well 75 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 65 ft.
Welded [ ] " Diam. from ft. to ft.
Liner installed [ ] " Diam. from ft. to ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [X] No [ ]
Manufacturer's Name JOHNSON
Type STAINLESS Model No.
Diam. 6 Slot size 004 from 65 ft. to 70 ft.
Diam. 6 Slot size 006 from 70 ft. to 75 ft.

Gravel packed: Yes [ ] No [X] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [X] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [ ]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 60 ft. below top of well Date 4/29/96
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 22 gal./min. with 1 ft. drawdown after 1 hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN CLAY	0	23
BROWN SANDY CLAY	23	65
FINE BROWN SAND	65	70
FINE GREY SAND	70	75

RECEIVED
MAY 16 1996
DEPT. OF ECOLOGY

Work Started 4/28 1996. Completed 4/29, 1996

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT) [stamp, partly legible: 1333 ... 772-577...]

Address

(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEMC136... Date , 19

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

19

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. [redacted]
Water Right Permit No.

(1) OWNER: Name WEINSHEL JOHN Address 15120 WESTSIDE HWY SW VASHON, WA 98070- 22-3E-21M

(2) LOCATION OF WELL: County KING - NW 1/4 SW 1/4 Sec 21 T 22 N., R 3E WM
(2a) STREET ADDRESS OF WELL (or nearest address) 8099 248TH SW VASHON 98070

(3) PROPOSED USE: DOMESTIC

(4) TYPE OF WORK: Owner's Number of well (If more than one)
NEW WELL Method: AIR ROTARY

(5) DIMENSIONS: Diameter of well 6 inches
Drilled 245 ft. Depth of completed well 243 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Dia. from 0 ft. to 237 ft.
WELDED " Dia. from ft. to ft.
" Dia. from ft. to ft.

Perforations: NO
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: YES
Manufacturer's Name JOHNSON WELL
Type Model No.
Diam. 6 slot size 8 from 243 ft. to 237 ft.
Diam. slot size from ft. to ft.

Gravel packed: NO Size of gravel
Gravel placed from ft. to ft.

Surface seal: YES To what depth? 18 ft.
Material used in seal BENTONITE CLAY
Did any strata contain unusable water? NO
Type of water? Depth of strata ft.
Method of sealing strata off

(7) PUMP: Manufacturer's Name RED JACKET
Type SUBMERSIBLE H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level ... ft.
Static level 131 ft. below top of well Date 08/19/91
Artesian Pressure lbs. per square inch Date / /
Artesian water controlled by

(10) WELL LOG

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change in formation.

MATERIAL	FROM	TO
TOPSOIL	0	2
CLAY & SAND	2	9
SAND & GRAVEL	9	16
SEEPAGE SAND & GRAVEL	16	18
CLAY & SAND AND GRAVEL	18	32
SILTY SAND	32	76
SILTY SAND	76	111
SILTY SAND CLAY	111	146
GREY STICKY CLAY	146	178
SILTY SAND WATER CLAY	178	206
GREY STICKY CLAY	206	212
SANDY CLAY	212	218
GREY STICKY CLAY	218	242
WATER CLAY & SAND	242	243
CLAY	243	245

Work started 08/15/91 Completed 08/19/91

(9) WELL TESTS: Drawdown is amount water level is lowered below static level.
Was a pump test made? NO If yes, by whom?
Yield: gal./min with ft. drawdown after hrs.

Recovery data

Time	Water Level	Time	Water Level	Time	Water Level

Date of test / /
Bailer test gal/min. ft. drawdown after hrs.
Air test 8 gal/min. w/ stem set at 233 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? NO

WELL CONSTRUCTOR CERTIFICATION:
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME RICHARDSON WELL DRILLING
(Person, firm, or corporation) (Type or print)

ADDRESS PO BOX 44427 TAC WA 98444

[SIGNED] Sieg Melin By GLE License No. 0284

Contractor's Registration No. RICHAW*321OB Date 12/10/91

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JAN 30 1992
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(20)

22/03-21P

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. ....

Permit No. ....

(1) OWNER: Name Iliad, Inc. Address 3711 East Madison, Seattle, WA 98112

(2) LOCATION OF WELL: County King — SE ¼ SW ¼ Sec. 21 T. 22 N., R. 3E W.M.

Bearing and distance from section or subdivision corner E side of 75th Ave SW at top of hill ½ mi so. of Gold Beach entrance

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 5 inches.
Drilled 520 ft. Depth of completed well 520 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8 " Diam. from 0 ft. to 373 ft.
Threaded ☐ 6 " Diam. from 373 ft. to 472 ft.
Welded ☒ 5 " Diam. from 472 ft. to 520 ft.

Perforations: Yes ☐ No ☑
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Steel Model No. ....
Diam. 5" Slot size 30 from 516 ft. to 520 ft.
Diam. 5" Slot size 25 from 511 ft. to 516 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 300 ft. below top of well Date 3-6-80
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ....
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ....
Bailer test 6 gal./min. with 0 ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☐ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
brown silty clay very little grav.	0	5
silty sand & gravel dry brown clay	5	20
silty sand & gravel dry	20	42
wet silty sand & gravel w/ br clay	42	73
sand & grav. med. size	73	142
medium sand	142	179
brown clay w/ medium sand	179	185
blue hard clay	185	194
gray clay w/ a few sm. seems grav.	194	210
gray clay	210	230
rock	230	234
sand & Gravel w/ brown clay	234	242
silty gray clay some gravel	242	280
silty gray clay w/ some grit & gr	280	320
sand & gravel w/ gray clay	320	365
medium sand & gravel v/l gray clay	365	385
small gravel w/sand,wood chips	385	405
finer sand w/still some wood	405	425
fine sand v/l water	425	444
fine sand & little gray clay	444	451
gray clay silty w/sand & gravel	451	462
silty gray clay	462	472
gray clay and sand	472	490
gray clay and sand	490	510
water sand and gravel	510	520

Work started 2/14, 19 80. Completed 3/10, 19 80

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling
(Person, firm, or corporation) (Type or print)

Address 219 S. 115th St. Tacoma, WA 98444

[Signed] [signature] (Well Driller)

License No. 0419 Date 3/10, 19 80

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

(21)

ENTERED

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W069748

UNIQUE WELL I.D. #

Water Right Permit No. 22-3E-29B

(1) OWNER: Name GORDON JOHNSON Address 1309 114th Ave SE. BELLEVUE WA

(2) LOCATION OF WELL: County KING NW 1/4 NE 1/4 Sec 29 T. 22 N., R 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: [x] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) TYPE OF WORK: Owner's number of well (If more than one)
[ ] Abandoned [x] New well [ ] Deepened [ ] Reconditioned
Method: [ ] Dug [x] Cable [ ] Rotary [ ] Bored [ ] Driven [ ] Jetted

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 150 feet. Depth of completed well 150 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from 0 ft. to 140 ft.
[ ] Welded " Diam. from ft. to ft.
[ ] Liner installed " Diam. from ft. to ft.
[ ] Threaded

Perforations: Yes [ ] No [x]
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes [x] No [ ]
Manufacturer's Name JOHNSON
Type STAINLESS Model No.
Diam. 6 Slot size 004 from 140 ft. to 150 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes [ ] No [x] Size of gravel
Gravel placed from ft. to ft.

Surface seal: Yes [x] No [ ] To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [x]
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level ft.
Static level 100 ft. below top of well Date 1/10/96
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 32 gal./min. with 15 ft. drawdown after 1 hrs.
Airtest gal./min. with stem set at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes [ ] No [x]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN SILTY SAND	0	100
GREY CLAY	100	130
GREY SANDY SILT	130	135
FINE SAND	135	150

RECEIVED
JAN 28 1997
DEPT. OF ECOLOGY

Work Started , 19. Completed 1/10, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME [illegible] CO. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address [illegible]
(Signed) [signature] (WELL DRILLER) License No. 0220
Contractor's Registration No. STATEDC134RB Date 1/10, 1996

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

(22)

22/3E/29 B

Start Card No. 030435

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Water Right Permit No. —

(1) **OWNER:** Name John Vangolen Address 15319 91st Ave S.W. - Vashon

(2) **LOCATION OF WELL:** County King NW ¼ NE ¼ Sec 29 T 22 N., R 3E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) 75th PL S.W & Docton Park

(3) **PROPOSED USE:** [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ]
Method: Dug [ ] Cable [X] Rotary [ ] Bored [ ] Driven [ ] Jetted [ ]

(5) **DIMENSIONS:** Diameter of well 12" inches.
Drilled 55 feet. Depth of completed well 54' ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 8" Diam. from 0 ft. to 34 ft.
Welded [ ] ____" Diam. from ____ ft. to ____ ft.
Liner installed [ ] ____" Diam. from ____ ft. to ____ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [X] No [ ]
Manufacturer's Name Hydrophilic
Type Plastic Model No. ____
Diam. 8 Slot size 013 from 34 ft. to 54 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes [X] No [ ] Size of gravel ____
Gravel placed from 20 ft. to 54' ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) **PUMP:** Manufacturer's Name ____
Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ____ ft.
Static level 34 ft. below top of well Date 8/5/90
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 5 gal./min. with 6 ft. drawdown after 1 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [X]

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
top soil	0	2
Brown clay	2	23
Brown sand	23	54

RECEIVED
SEP 05 1990
DEPT. OF ECOLOGY

Work started ____, 19__. Completed 8/5, 1990

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address 1333 Beacon Way S. Renton, WA 98055 772-5771

(Signed) [signature] (WELL DRILLER) License No. C220

Contractor's Registration No. ____ Date 8/5, 1990

(USE ADDITIONAL SHEETS IF NECESSARY)

(26)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. [redacted]5710
22/3/30K
Water Right Permit No. ______

(1) **OWNER:** Name J. BRYANT Address 10179 SW. 265th Docton WA

(2) **LOCATION OF WELL:** County King NW ¼ SE ¼ Sec 30 T. 22 N., R. 3E W.M.

(2a) **STREET ADDDRESS OF WELL** (or nearest address) 10179 SW. 265th VASHON WA

(3) **PROPOSED USE:** [X] Domestic [ ] Irrigation [ ] DeWater [ ] Industrial [ ] Test Well [ ] Municipal [ ] Other

(4) **TYPE OF WORK:** Owner's number of well (if more than one) ______
[ ] Abandoned [X] New well [ ] Deepened [ ] Reconditioned
Method: [ ] Dug [ ] Cable [X] Rotary [ ] Bored [ ] Driven [ ] Jetted

(5) **DIMENSIONS:** Diameter of well 6 inches.
Drilled 200' feet. Depth of completed well 200' ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 6 " Diam. from 0 ft. to 200' ft.
[ ] Welded ______ " Diam. from ______ ft. to ______ ft.
[ ] Liner installed
[ ] Threaded ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes [ ] No [X]
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes [ ] No [X]
Manufacturer's Name ______
Type ______ Model No. ______
Diam. ______ Slot size ______ from ______ ft. to ______ ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes [ ] No [X] Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) **PUMP:** Manufacturer's Name ______
Type: ______ H.P. ______

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ______ ft.
Static level NO WATER ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes [ ] No [ ]

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

RECEIVED
DEC 2 2 1992
DEPT. OF ECOLOGY

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN SAND	0	23
GRAY CLAY	23	200

Work started ______, 19__. Completed 11/6, 1992

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME ______ (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address ______

(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEMC136RG Date 11/6, 1992

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10-87) -1329- 3

(30)

1c

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT C4005A

WELL LOG

No. Appl. 5528 -

Date 6/23, 19 60

Record by well driller

Source driller's record

Location: State of WASHINGTON

County King

Area

Map

NE¼NE¼SE ¼ sec. 21 T. 22 N., R. 3 E./W.

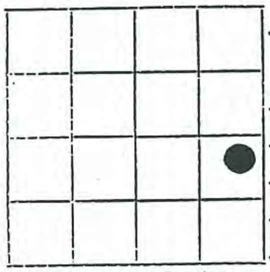


Diagram of Section

Drilling Co. L. R. Gaudio

Address Route 6, Box 330, Tacoma, Washington

Method of Drilling drilled Date , 19

Owner Arthur A. Schmidt

Address Rt. 1, Box 120, Burton, Washington

Land surface, datum ft. above/below

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	Thickness (feet)	Depth (feet)
	Hardpan	28	28
	Sand, gravel, some clay	17	45
	Hardpan	51	96
	Sand, gravel, coarse(dry)	15	101
	Sand, with little gravel	24	125
	Clay, blue	5	130
	Sand clay and gravel	32	162
	Hardpan	24	186
	Clay, sandy brown, little gravel	32	218
	Sand, dry, brown	7	225
	Clay and gravel	73	298
	Clay, blue	7	305
	Gravel, streaks of clay, little water	3	308
	Clay, blue	30	338
	Clay, sandy	22	360
	Sand with little gravel	5	365

Turn up (OVER)

Sheet ___ of ___ sheet S. F. No. 7449—12-54—3M. 40108.

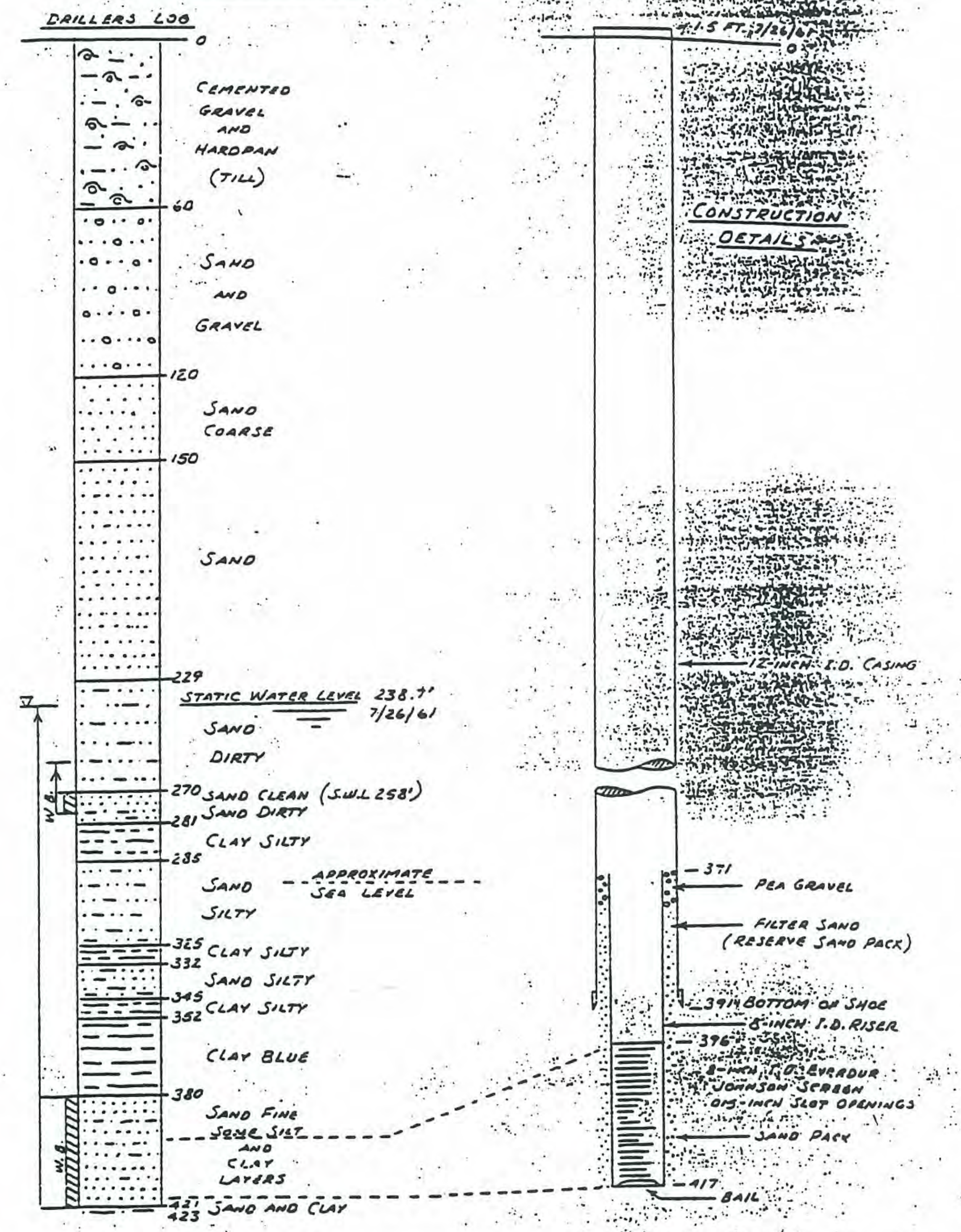
WELL LOG.—Continued

No. Appl.5528 / -

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward	365	
	Sand and gravel, coarse	5	37
	Sand with little gravel	6	37
	Clay, blue	29	40
	"Shale" and sand, some water	5	41
	Sand, fine	35	44
	Clay, blue	69	51
	Sand, coarse with little gravel, water-bearing	4	51
	PUMP TEST:		
	Diam: 518'x6"		
	SWL: 378 ft		
	Yield: 25 gpm		
	Type & size of pump: submersible electric type 5 hp, 25 gallons per min.		
	Type & size of motor or engine: Electric 5 H		
	CASING:		
	6 inch diam. from 0 to 514 ft.		
	Casing down 514 feet; open hole below to 518'		
	PERFORATIONS:		
	No perforations or screen		

31

SANDY SHORES, MAURY ISLAND



SANDY SHORES
MAURY ISLAND
BARD & HOWARD

DRILLED BY:
L. R. GAUDIO DRILLING CO.
TACOMA, WASH.

ROBINSON AND ROBERTS
GROUND WATER GEOLOGISTS
TACOMA, WASHINGTON

John W. Robinson

AUG. 2, 1961

A-497.1 H.H.

22-3E-32 C1 C1

31

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG

No. A.6019

Date 8-22, 1961

Record by well driller

Source driller's record

Location: State of WASHINGTON

County King

Area

Map

NE ¼ NW¼ sec. 32 T. 22 N., R. 3 E.

Diagram of Section

Drilling Co. Robinson & Roberts

Address 1315 S. 59th, Tacoma 8, Wash.

Method of Drilling — Date July 25, 1961

Owner Bard & Howard

Address Vashon, Wash.

Land surface, datum ft. above/below

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	Thickness (feet)	Depth (feet)
	Till	60	60
	Sand & gravel	60	120
	Sand, coarse	30	150
	Sand	79	229
	Sand, dirty	41	270
	Sand, fine to medium w/b	5	275
	Sand, dirty, fine	6	281
	Clay, silty	14	295
	Sand, silty	30	325
	Clay, silty	7	332
	Sand, dirty	13	345
	Clay, silty	7	352
	Clay, blue	28	380
	Sand, fine some silt & clay layers	41	421
	Sand & clay	2	423
	PUMP TEST:		
	Dim. 12"x423'		

Turn up (over) Sheet of sheets

WELL LOG.—Continued

No. /

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward		
	SWL: 237½ ft.		
	DD: 80 ft.		
	Yield: 128 g.p.m.		
	Water Temp. 52½°		
	CASING:		
	12" diam. Std. drive pipe from +2 to -391 ft.		
	PERFORATIONS:		
	8" I.D. Everdur screen from 396 to 417 ft.		
	15 slot - 25 ft. of 8" casing above screen		
	Screen packed with filter sand.		

22/3E-32C: Bard and Howard. Altitude 300 ft. Drilling supervised by Robinson and Roberts, 1961. 423' x 12". Cased to 391. Perforated 371-396 ft. Screened 396-417 ft. SWL 237½ ft. Dd 80 ft. at 128 gpm. Temperature 52½°F.

till	60	60
sand and gravel	60	120
sand, fine to coarse	161	281
clay and sand, silty	142	423

31

32

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG No. A.6421

Date 9-24, 19 62
Record by owner
Source driller's record

Location: State of WASHINGTON
County King
Area
Map
¼ ¼ sec. 31 T. 22 N., R. 3 E.
Drilling Co. owner
Address
Method of Drilling Date , 19
Owner George V. Fischer
Address 813 Main St., Edmonds, Wash.
Land surface, datum ft. above/below

Diagram of Section

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	Thickness (feet)	Depth (feet)
	Topsoil	13	13
	Clay & sand	40	53
	Sand & gravel	22	75
	Brown clay & gravel	10	85
	Sand & gravel - some clay	111	196
	Sand - some water	20	216
	Blue clay	183	399
	Sand, gravel & clay - some water	41	440
	Sand, heavy with clay	30	470
	Clay & some gravel w/b	23	493
	PUMP TEST:		
	Dim. 8"x493'		
	SWL: 162 ft.		
	DD: 252 ft.		
	Yield: 30 g.p.m.		
	Water Temp. 50°		
	(over)		

Turn up   Sheet of sheets

32

WELL LOG.—Continued No. /

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward		
	Type & size of pump: Berkley Submersible turbine pump		
	Type & size of motor or engine: 10 h.p.		
	CASING:		
	8" diam. from surface to ~~493~~ 481 ft. (open 12' ba[illegible]		
	Fe 0.3		
	CaCO₂ 180		
	pH 7.5		
	Cl low		

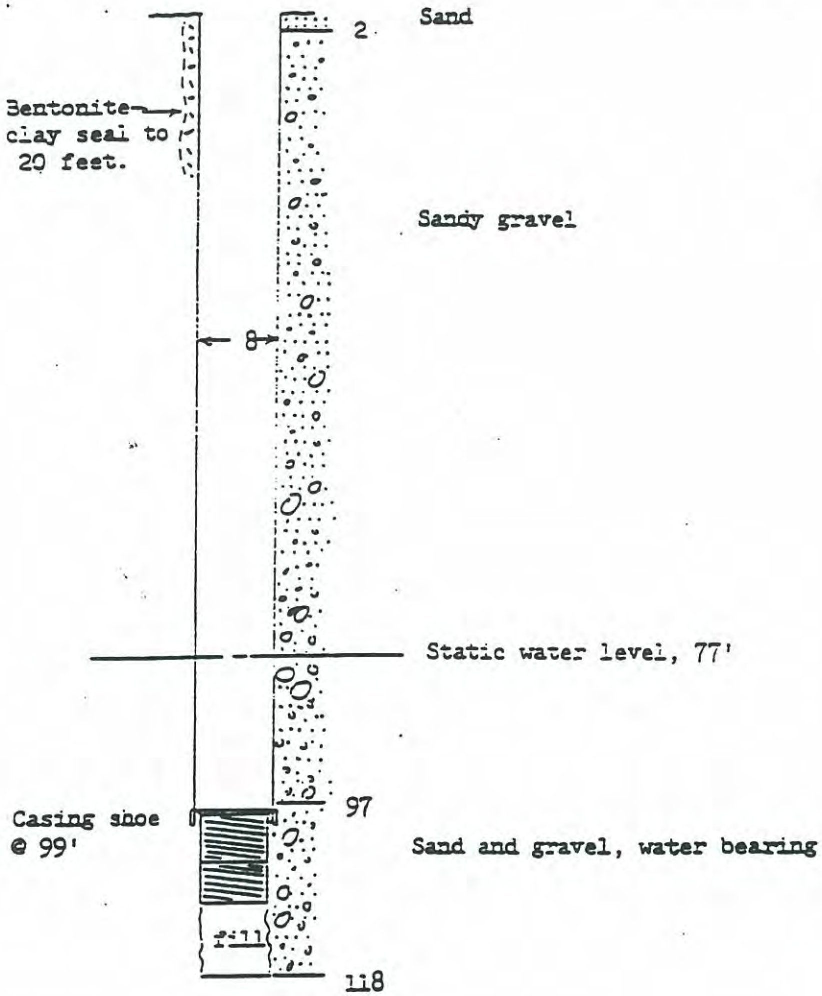
22/3E-31J: G. V. Fischer. Altitude 360 ft. Drilled by owner. 493' x 8". Cased to 481 ft., open hole below. SWL 162 ft. Dd 252 ft. at 30 gpm. Temperature 50°F. Hardness as $CaCO_3$: 180 ppm, iron 0.3 ppm, pH 7.5, low in chloride.

32

soil	13	13
clay, sand and gravel	183	196
sand, some water	20	216
clay, blue	183	399
sand, gravel, and clay, some water	41	440
sand, heavy, with clay	30	470
clay, some gravel, water-bearing	23	493

S. F. No. 1449—OS—6-61—2M.

Driller's Log



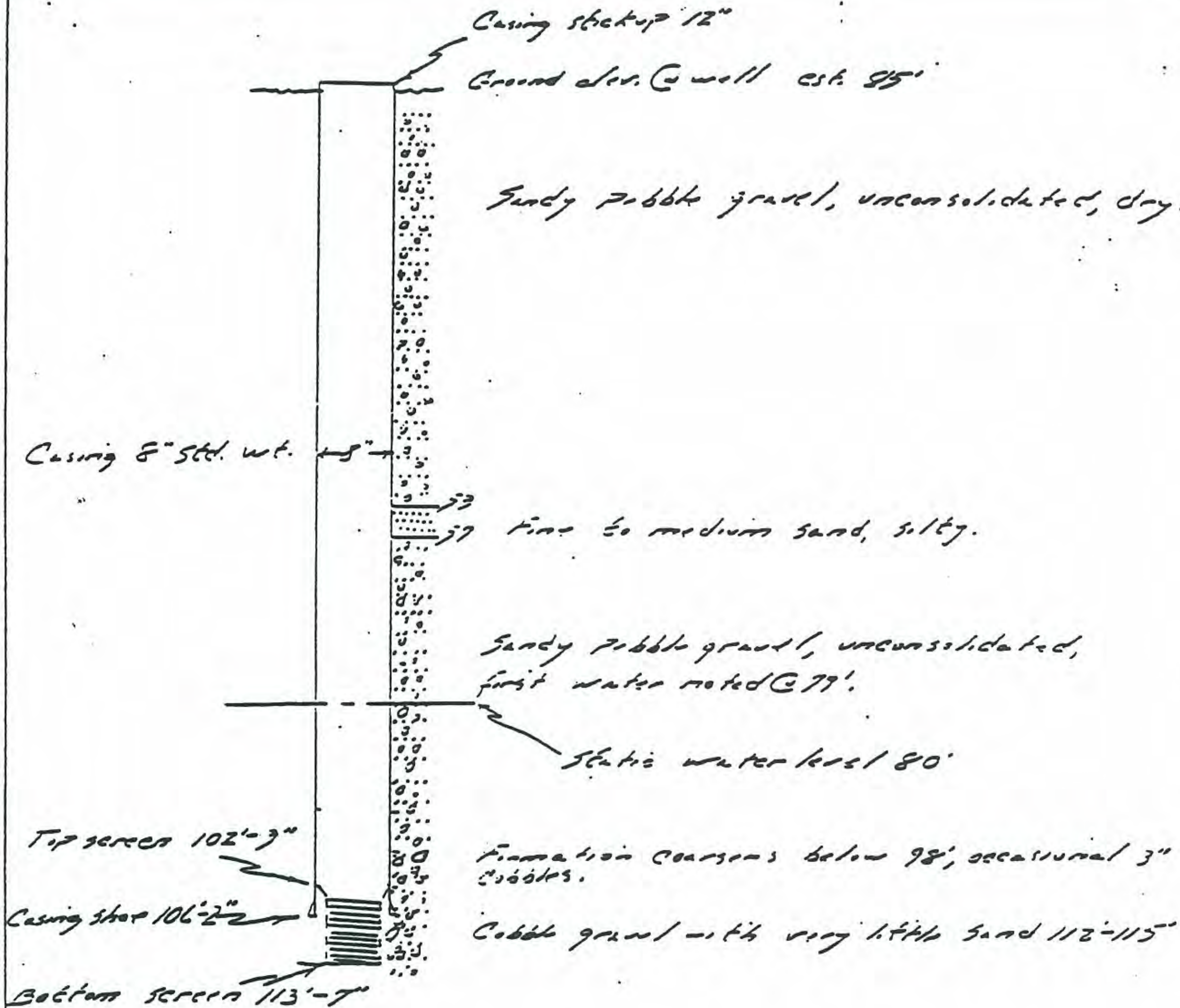
Johnson, stainlessscreen; .080" slot, 99' - 104'
.100" slot, 104' - 109', bail bottom, lead packer seal.

GOLD BEACH
Well No. 2

DATE 9/23/76 | SCALE 1" = 20'

R.J. Rongey Inc.

35



Screen Data

Make - Cook
Type - Stainless, wire wound
Size - 8" nom.
Length - 10'
Equipment - Bail bottom, lead packer.

WELL COMPLETION DATA GOLD BEACH WELL NO. 1	
DATE 5/27/65	SCALE 1" = 20'
Rongey / Associates	

34 Gold Beach #1	sandy pebble gravel, unconsolidated, dry.	53	102-114 Screen
	fine to medium sand, silty	57	
	sandy pebble gravel, unconsolidated, __?__ water __?__ at 79'	80	
	cobble gravel with very little sand	115	
35 Gold Beach #2	sandy gravel	97	99-109 Screen
	sand and gravel, water bearing	118	

FROM RITZI, 1983.

C 4597

40

STATE OF WASHINGTO
DEPARTMENT OF CONSERVATION AND DEVELOPMENT Appli. #5840

WELL LOG — No. ....../......-......

Date August 21, 19 63
Record by Driller
Source Driller's Record

Location: State of WASHINGTON
County King
Area
Map (SW¼NW¼)
Govt. Lot 2 ¼ sec. 21 T. 22 N., R. 3 E.

Diagram of Section

Drilling Co. Maxwells Pioneer Drillers
Address
Method of Drilling ...... Date Dec. 1, 19 60
Owner William Rueter
Address Hollymere Farm, Rt. 1, Box 113, Burton, Wn.
Land surface, datum ...... ft. above / below

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Brown sand		65
	Blue sand (very fine)	15	80
	Blue clay	63	143
	Streak of sand	1	144
	Blue sandy clay	246	390
	blue clay	5	395
	sandy clay	10	405
	Blue clay	3	408
	Sand	6	414
	Clay	2	416
	Sandy blue clay	34	450
	Grey sand, fine, dirty	15	465
	Sand	8	473
	Screened at 468.6 to 473'		

Turn up — Sheet ...... of ...... sheets

WELL LOG.—Continued — No. ....../......-......

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	Depth forward		
	Bailer test: 18 gpm at 155'		
	SWL: 82.5' on February 3, 1961		
	98' on July 10, 1963		
	(300 E & 500 N of W¼ cor 21)		
	22/3-21		

S. F. No. 7449—OS—6-61—2M

41

File Original with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's Copy

ENTERED

WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W108287
UNIQUE WELL I.D. # AEP 443
Water Right Permit No. 22-3E-22B

Former driller for Statewide

(1) **OWNER:** Name TOM MORRIS Address

(2) **LOCATION OF WELL:** County KING NW 1/4 NE 1/4 Sec 22 T 22 N.R. 3E WM

(2a) **STREET ADDRESS OF WELL:** (or nearest address)

TAX PARCEL NO.:

(3) **PROPOSED USE:** [X] Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) **TYPE OF WORK:** Owner's number of well (if more than one)
[X] New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method: ☐ Dug ☐ Cable [X] Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) **DIMENSIONS:** Diameter of well 6 inches
Drilled 422 feet. Depth of completed well 422 ft.

(6) **CONSTRUCTION DETAILS**
Casing Installed:
[X] Welded 6" Diam. from 0 ft. to 422 ft.
☐ Liner installed ___" Diam. from ___ ft. to ___ ft.
☐ Threaded ___" Diam. from ___ ft. to ___ ft.

Perforations: ☐ Yes [X] No
Type of perforator used
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.

Screens: ☐ Yes [X] No ☐ K-Pac Location
Manufacturer's Name
Type ___ Model No.
Diam. ___ Slot Size ___ from ___ ft. to ___ ft.
Diam. ___ Slot Size ___ from ___ ft. to ___ ft.

Gravel/Filter packed: ☐ Yes [X] No ☐ Size of gravel/sand
Material placed from ___ ft. to ___ ft.

Surface seal: [X] Yes ☐ No To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ___ Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: ___ H.P.

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ___ ft.
Static level 330 ft. below top of well Date 4/2/99
Artesian pressure ___ lbs. per square inch Date
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 30 gal./min. with 10 ft. drawdown after 2 hrs.
Airtest ___ gal./min. with ___ ft. drawdown after ___ hrs.
Artesian flow ___ g.p.m. Date
Temperature of water ___ Was a chemical analysis made? ☐ Yes ☐ No

(10) **WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION**
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered.

MATERIAL	FROM	TO
BROWN CLAYEY H.P.	0	12
BROWN GRAVELLY H.P.	12	65
BROWN SAND	65	82
BROWN SAND & GRAVEL	82	280
LARGE GRAVEL	280	300
BROWN PEAT	300	320
BROWN SAND & GRAVEL	320	400
GRAY SAND & GRAVEL	400	420

RECEIVED
JUN 2 1999
DEPT OF ECOLOGY

Work Started 3/29/99 Completed 4/2/99

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Type or Print Name L JOHNSON License No. 0220 (Licensed Driller/Engineer)

Trainee Name ___ License No.
Drilling Company STATEWIDE DRILLING Co.
(Signed) [signature] License No. 0220 (Licensed Driller/Engineer)
Address 1333 BEACON WAY S RENTON.
Contractor's Registration No. STATEDC136RG Date 4/3/99

(USE ADDITIONAL SHEETS IF NECESSARY)

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ECY 050-1-20 (11/98)

(42)

22/3E/22 M

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 030439

Water Right Permit No. ______

(1) OWNER: Name CLIFF ALTON (VASHON GRAVEL) Address SW 248th ST Vashon Wash

(2) LOCATION OF WELL: County KING — NW ¼ SW ¼ Sec. 22 T. 22 N., R. 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW. 248th ST VASHON

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned ☐ New well ☐ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☑ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 577 feet. Depth of completed well 577 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 8" Diam. from 0 ft. to 160 ft.
Welded ☑ 6" Diam. from 0 ft. to 572 ft.
Liner installed ☐
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name JOHNSON
Type STAINLESS Model No. ______
Diam. 6 Slot size .020 from 572 ft. to 577 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 405 ft. below top of well Date 12/4/90
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test 10 gal./min. with 2 ft. drawdown after 1 hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
GRAVEL	0	140
BLUE CLAY	140	162
BROWN GRAVELLY H.P.	162	410
BLUE SANDY SILT	410	520
BLUE CLAY	520	570
GRAVEL	570	577

RECEIVED
JAN 14 1991
DEPT. OF ECOLOGY

Work started ______, 19__. Completed 12/4, 19 90

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 1000 Benson Way S. Renton, WA 98055 772-5771

(Signed) [signature] (WELL DRILLER) License No. 0226

Contractor's Registration No. STATEDC136RC Date 12/4, 19 90

(USE ADDITIONAL SHEETS IF NECESSARY)

Date , 19

Driller [illegible] Hours Worked

Helper [illegible] Hours Worked

Drill No. [illegible] Drill Hours Worked

Job Name [illegible]MAN

Address [illegible]RY ISLAND

Size of Hole [illegible] Depth at Last Report 0

CASING USED	TOTAL LENGTH	LOG OF FORMATION	FT. DRILLED
Shoe	[illegible]	[illegible] Clay	0 - 30
10=	[illegible]	[illegible] Clay	30 - 35
10=	[illegible]	Gravelly Brown Clay	35 - 42
10=	[illegible]	Greyish Green Clay	42 - 52
10=	50-3	Silty Blue Clay (SEEP)	52 55
10=	[illegible]-3	Greyish Green Clay	55 72
10=	70-3	Silt with Blue Clay Binder	72 92
10=	80-3	TOTAL DEPTH	

Screen Used

Bailer Test

Water Level

Pump Test

Gas Taken

Remarks

KIRKLAND PUBLISHING CO., KIRKLAND, WASH.

Date , 19

Driller JAY Hours Worked

Helper KEN Hours Worked

Drill No. 22 W Drill Hours Worked 45

Job Name ROD WOODMAN

Address

Size of Hole Depth at Last Report

CASING USED	TOTAL LENGTH	LOG OF FORMATION	FT. DRILLED
10=	170-3	Blue Clay Silt Stone (water)	[illegible]
10=	180-3	Blue Clay	180-[illegible]
10=	190-3	Fine Sand Silty Water	235
10=	200-3		
10=	210-3		
10=	220-3		
10=	230-3		
5-8 3/4	235 11	TOTAL DEPTH	

Screen Used NO

Bailer Test 10+ G.P.M.

Water Level 130' DRAW DOWN 30'

Pump Test

Gas Taken

Remarks Bailed well tries to clean up still has a lot of fine powder silt in water. As clean as I can get it with a bailer. Customer wanted sand + gravel dumped in bottom for gravel pack. Dumped in about 3 [illegible] Buck[illegible]

KIRKLAND PUBLISHING CO. KIRKLAND, WASH.

45

(47)

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 098594
UNIQUE WELL I.D. # AEP 429
Water Right Permit No. 22-3-20K

(1) OWNER: Name WHIT CARHCART Address 911 NACHES Hy HTS Rd. Yakima

(2) LOCATION OF WELL: County KING NW 1/4 SE 1/4 Sec 20 T. 22 N., R 3E W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 86th Place SW - 1st access Rd. on rt. (gated) ≈100'N of Docktou Rd.

(3) PROPOSED USE: [X] Domestic [ ] Irrigation [ ] DeWater Industrial [ ] Test Well [ ] Municipal [ ] Other [ ]

(4) TYPE OF WORK: Owner's number of well (If more than one) ____
Abandoned [ ] New well [X] Deepened [ ] Reconditioned [ ] Method: Dug [ ] Cable [ ] Rotary [X] Bored [ ] Driven [ ] Jetted [ ]

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 163 feet. Depth of completed well 146 ft.

(6) CONSTRUCTION DETAILS:
Casing Installed: 6" Diam. from 0 ft. to 136 ft.
Welded [ ] ____" Diam. from ____ ft. to ____ ft.
Liner installed [ ] ____" Diam. from ____ ft. to ____ ft.
Threaded [ ]

Perforations: Yes [ ] No [X]
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes [X] No [ ]
Manufacturer's Name COOK
Type STAINLESS Model No. ____
Diam. 6 Slot size .012 from 134 ft. to 141 ft.
Diam. 6 Slot size .014 from 141 ft. to 146 ft.

Gravel packed: Yes [ ] No [X] Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes [X] No [ ] To what depth? 20 ft.
Material used in seal BENTONITE
Did any strata contain unusable water? Yes [ ] No [X]
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 91 ft. below top of well Date 11/25/98
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes [ ] No [ ] If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test 10 gal./min. with 15 ft. drawdown after 2 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes [ ] No [X]

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
BROWN CLAYEY H.P.	0	15
GRAY SILTY CLAY	15	70
BROWN SANDY H.P.	70	101
BROWN SILTY SAND	101	146
BROWN SAND	146	150
GRAY CLAY	150	163

RECEIVED
DEC 28 1998
DEPT OF ECOLOGY

Work Started ____, 19__. Completed 11/25, 1998

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME STATEWIDE DRILLING CO 1532 Beacon Way S Renton, WA 98055 772-6771 (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address ____
(Signed) [signature] (WELL DRILLER) License No. 0220

Contractor's Registration No. STATEDC136RA Date 11/25, 1998

(USE ADDITIONAL SHEETS IF NECESSARY)

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WATER WELL REPORT

State of Washington

OBW-5

~~File~~ No. R 27647

Unique Well Tag No. AEJ 916

Water Right Permit No. 22-3E-29R

1) OWNER:
Name: AESI c/o Jill Wheeler Complete Address: 911 5th Ave Suite 100 Kirkland wa 98033

2) LOCATION OF WELL: County King SE 1/4 SE 1/4 Sec 29 T 22 N R 3E WM

2a) STREET ADDRESS OF WELL (if known) Maury Island pit (Lonestar)

3) PROPOSED USE: [ ] Domestic [ ] Test Well [ ] Industrial monitoring [ ] DeWater [ ] Irrigation [X] Other [ ] Municipal

4) TYPE OF WORK: Owner's number of well (if more than one) OBW-5

[ ] Decommission [X] New well [ ] Deepened [ ] Reconditioned

METHOD: [ ] Dug [ ] Bored [ ] Cable [ ] Driven [X] Rotary [ ] Jetted

5) DIMENSIONS: Diameter of well 6 inches.
Drilled 260 feet. Depth of completed well 228 feet.

6) CONSTRUCTION DETAILS:
[X] Casing Installed 6 " Diam. from +2 ft. to 223 ft.
[ ] Liner Installed ____ " Diam. from ____ ft. to ____ ft.

Perforations: [ ] Yes [X] No
Type of perforator used ____

Screens: [X] Yes [ ] No
Manufacturer's name Johnson
Type Stainless Model No. ____
Diam. 6 Slot size .04 from 223 ft. to 228 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: [ ] Yes [X] No
Gravel placed from ____ ft. to ____ ft.

Surface seal: [X] Yes [ ] No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? [ ] Yes [X] No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

7) WATER LEVELS: Land surface elevation above mean sea level ____ ft.
Static level 181 ft. below top of well Date 2-16-99
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

8) WELL TESTS: Was a pump test made? [X] Yes [ ] No
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Bailer test 2 gal./min. with 35 ft. drawdown after 1 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? [X] No [ ] Yes

10) WELL LOG OR DECOMMISSION PROCEDURE DESCRIPTION

Formation: Described by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Clearly note water bearing zones and hydraulic characteristics.

MATERIAL	From	To
Fill	0	1
Topsoil	1	3
Brown silty clay	3	10
Brown sand, gravel & silt	10	46
Brown med sand & silt	46	110
Brown med to fine sand	110	170
Brown fine sand	170	207
Brown fine sand seepage	207	230
Brown silt & sand layered	230	235
Gray fine sand & water	235	240
Brown fine sand & water	240	

RECEIVED
FEB 22 1999
DEPT OF ECOLOGY

DRILLER'S COMMENTS (WORK STARTED): 1-25-99 / 2-16-99
Start and Finish time laps due to Geo physics testing.

Cut casing at 230', back filled w/ 3/8 chips to 229' from 260'

WELL CONSTRUCTION CERTIFICATION:
I constructed/supervised and accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are tue to my best knowledge and belief.

(Please print or type)
DRILLING COMPANY Aquatech Well Drilling & Pumps Inc
Address 2722 Butler Cr Rd Sedro Woolley Wa
WELL DRILLER NAME Brannon Hopke License No. 1825
SIGNATURE [signature]
TRAINEE NAME & LICENSE # ____
Contractor's Registration No. AQUATWDC410K4 Date 2-19-99, 19__

Decommission: [ ] Perforated Casing [ ] Removed Casing
Amount of sealant used ____
Type of sealant used (Attach add'l sheet if necessary) ____

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Second Copy - Owner's Copy
Third Copy - Driller's copy

ECY 050-1-20 (11/97)

WATER WELL REPORT

State of Washington

OBW-6

~~File No.~~ S.C. R 27647

Unique Well Tag No. AEJ 917

Water Right Permit No. 22-3E-29B

1) OWNER:
Name: AESI % Jill Wheeler Complete Address: 911 5th Ave Suite 100 Kirkland wa 98033

2) LOCATION OF WELL: County King NW 1/4 NE 1/4 Sec 29 T 22 N R 3E WM

2a) STREET ADDRESS OF WELL (if known) Maury Island pit (Lonestar)

3) PROPOSED USE: ☐ Domestic ☐ Test Well ☐ Industrial ☐ DeWater (resource protection) ☐ Irrigation ☒ Other ☐ Municipal

4) TYPE OF WORK: Owner's number of well (if more than one) OBW-6
☐ Decommission ☒ New well ☐ Deepened ☐ Reconditioned
METHOD: ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☒ Rotary ☐ Jetted

5) DIMENSIONS: Diameter of well 6 inches.
Drilled 240 feet. Depth of completed well 238 feet.

6) CONSTRUCTION DETAILS:
☒ Casing Installed 6" Diam. from +2 ft. to 238 ft.
☐ Liner Installed ___" Diam. from ___ ft. to ___ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ___

Screens: ☒ Yes ☐ No
Manufacturer's name Johnson
Type Stainless Model No. ___
Diam. 6 Slot size 6 from 233 ft. to 238 ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: ☐ Yes ☒ No
Gravel placed from ___ ft. to ___ ft.

Surface seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

7) WATER LEVELS: Land surface elevation above mean sea level ___ ft.
Static level 218.6 ft. below top of well Date 2-12-99
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (cap, valve, etc.)

8) WELL TESTS: Was a pump test made? ☒ Yes ☐ No
Yield: 35 gal./min. with 15 ft. drawdown after 1 hrs.
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water ___ Was a chemical analysis made? ☒ No ☐ Yes

10) WELL LOG OR DECOMMISSION PROCEDURE DESCRIPTION

Formation: Described by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Clearly note water bearing zones and hydraulic characteristics.

MATERIAL	From	To
Topsoil	0	2
Brown silty clay	2	7
Brown gravel, sand silt	7	20
Brown med to corse sand, gravel	20	50
Brown fine sand	50	70
Brown course sand & gravel	70	76
Brown med sand	76	130
Brown course sand & gravel	130	138
Brown fine sand	138	150
Brown corse sand & gravel	150	159
Brown fine sand	159	220
Brown fine sand & water	220	

RECEIVED
FEB 22 1999
DEPT OF ECOLOGY

DRILLER'S COMMENTS (WORK STARTED): 1-28 / 2-12-99
Start to finish time laps due to Geo physics testing.

WELL CONSTRUCTION CERTIFICATION:
I constructed/supervised and accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are tue to my best knowledge and belief.

(Please print or type)
DRILLING COMPANY Aquatech Well Drilling & Pumps Inc
Address 2722 Butler Cr Rd Sedro Woolley Wa
WELL DRILLER NAME Brannon Hopke License No. 1825
SIGNATURE [signature]
TRAINEE NAME & LICENSE # ___
Contractor's Registration No. AQUATWD040KY Date 2-19-99, 19__

Decommission: ☐ Perforated Casing ☐ Removed Casing
Amount of sealant used ___
Type of sealant used (Attach add'l sheet if necessary) ___

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File Original and First Copy with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's copy
ECY 050-1-20 (11/97)

WATER WELL REPORT

State of Washington

OBW-7

~~Tag~~ No. S.C. R 27643

Unique Well Tag No. AEI 915

Water Right Permit No. 22-3E-28E

1) OWNER: Name: AESI % Jill Wheeler Complete Address: 911 5th Ave Suite 100 Kirkland Wa. 98033

2) LOCATION OF WELL: County King SW 1/4 NW 1/4 Sec 28 T 22 N R 3E WM

2a) STREET ADDRESS OF WELL (if known) Maury Island Pit (Lonestar)

3) PROPOSED USE: ☐ Domestic ☐ Test Well ☐ Industrial ☐ Irrigation ☒ Other ☐ Municipal — resource protection ☐ DeWater

4) TYPE OF WORK: Owner's number of well (if more than one) OWW-7

☐ Decommission ☒ New well ☐ Deepened ☐ Reconditioned

METHOD: ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☒ Rotary ☐ Jetted

5) DIMENSIONS: Diameter of well 6 inches.

Drilled 300 feet. Depth of completed well 295 feet.

6) CONSTRUCTION DETAILS:

☒ Casing Installed 6 " Diam. from +2 ft. to 292 ft.

☐ Liner Installed ____ " Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No

Type of perforator used ____

Screens: ☒ Yes ☐ No

Manufacturer's name Johnson

Type Stainless Model No. ____

Diam. 6 Slot size 6 from 290 ft. to 295 ft.

Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: ☐ Yes ☒ No

Gravel placed from ____ ft. to ____ ft.

Surface seal: ☒ Yes ☐ No To what depth? 18 ft.

Material used in seal Bentonite

Did any strata contain unusable water? ☐ Yes ☒ No

Type of water? ____ Depth of strata ____

Method of sealing strata off ____

7) WATER LEVELS: Land surface elevation above mean sea level ____ ft.

Static level 263 ft. below top of well Date 2-17-99

Artesian pressure ____ lbs. per square inch Date ____

Artesian water is controlled by ____ (cap, valve, etc.)

8) WELL TESTS: Was a pump test made? ☒ Yes ☐ No

Yield: 2 gal./min. with 28 ft. drawdown after 1 hrs.

Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.

Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.

Artesian flow ____ g.p.m. Date ____

Temperature of water ____ Was a chemical analysis made? ☐ No ☐ Yes

WELL CONSTRUCTION CERTIFICATION:

I constructed/supervised and accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are tue to my best knowledge and belief.

(Please print or type)

DRILLING COMPANY Aquatech Well Drilling + pump Inc.

Address 2722 Butler Cr Rd Sedro Woolley

WELL DRILLER NAME Brannon Hopke License No. 1825

SIGNATURE [signature]

TRAINEE NAME & LICENSE # ____

Contractor's Registration No. AQUATWD040K4 Date 2-19-99, 19__

10) WELL LOG OR DECOMMISSION PROCEDURE DESCRIPTION

Formation: Described by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Clearly note water bearing zones and hydraulic characteristics.

MATERIAL	From	To
Fill	0	1
Brown silty clay & gravel	1	10
Brown gravel & sand	10	76
Brown coarse sand & gravel	76	105
Brown med sand	105	180
Brown fine silty sand	180	185
Brown fine sand & silt layered	185	205
Brown fine sand	205	260
Brown fine sand & water	260	

RECEIVED FEB 22 1999 DEPT OF ECOLOGY

DRILLER'S COMMENTS (WORK STARTED): 2-1-99/2-17-99

Start to finish time laps due to Geo physics testing.

Cut casing 295' back filled w/ 3/8 chips from 298' to 295

Decommission: ☐ Perforated Casing ☐ Removed Casing

Amount of sealant used ____

Type of sealant used (Attach add'l sheet if necessary) ____

File Original and First Copy with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's copy

ECY 050-1-20 (11/97)

WATER WELL REPORT

State of Washington

OBW-8

~~Tank No.~~ S.C. R 27644

Unique Well Tag No. AEJ 918

Water Right Permit No. 22-3E-28E

1) OWNER:
Name: AESI % Jill Wheeler Complete Address: 911 5th Ave Suite 100 Kirkland Wa 98033

2) LOCATION OF WELL: County King SW 1/4 NW 1/4 Sec 28 T 22 N R 3E WM

2a) STREET ADDRESS OF WELL (if known) Maury Island pit (Lone Star)

3) PROPOSED USE: resource protection ☐ DeWater ☐ Domestic ☐ Irrigation ☐ Test Well ☒ Other ☐ Industrial ☐ Municipal

4) TYPE OF WORK: Owner's number of well (if more than one) OBW-8
☐ Decommission ☒ New well ☐ Deepened ☐ Reconditioned
METHOD: ☐ Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted

5) DIMENSIONS: Diameter of well 6 inches.
Drilled 100 feet. Depth of completed well 98 feet.

6) CONSTRUCTION DETAILS:
☒ Casing Installed 6 " Diam. from +2 ft. to 94 ft.
☐ Liner Installed ____ " Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____

Screens: ☒ Yes ☐ No
Manufacturer's name Johnson
Type Stainless Model No. ____
Diam. 6 Slot size .06 from 93 ft. to 98 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: ☐ Yes ☒ No
Gravel placed from ____ ft. to ____ ft.

Surface seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

7) WATER LEVELS: Land surface elevation above mean sea level ____ ft.
Static level 67 ft. below top of well Date 2-4-99
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

8) WELL TESTS: Was a pump test made? ☒ Yes ☐ No
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Bailer test 10 gal./min. with 15 ft. drawdown after 1 hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☒ No ☐ Yes

10) WELL LOG OR DECOMMISSION PROCEDURE DESCRIPTION

Formation: Described by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Clearly note water bearing zones and hydraulic characteristics.

MATERIAL	From	To
Fill	0	1
Brown gravel, sand & silt	1	10
Brown med to carse sand	10	65
Brown med sand & water	65	90
Brown fine sand & water	90	

RECEIVED
FEB 22 1999
DEPT OF ECOLOGY

DRILLER'S COMMENTS (WORK STARTED): 2-3 / 2-4-99

Decommission: ☐ Perforated Casing ☐ Removed Casing
Amount of sealant used ____
Type of sealant used (Attach add'l sheet if necessary) ____

WELL CONSTRUCTION CERTIFICATION:
I constructed/supervised and accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are tue to my best knowledge and belief.

(Please print or type)

DRILLING COMPANY Aquatech Well Drilling & pumps Inc
Address 2722 Butler Cr Rd Sedro Woolley Wa
WELL DRILLER NAME Brannon Hoppe License No. 1825
SIGNATURE B. Hoppe
TRAINEE NAME & LICENSE # ____
Contractor's Registration No. AQUATWDOO4K4 Date 2-19-99, 19

Ecology is an Equal Opportunity and Affirmative Action employer. For special accomodation needs, contact the Water Resources Program at (360) 407-6600. The TDD number is (360) 407-6006.

File Original and First Copy with Department of Ecology
Second Copy - Owner's Copy
Third Copy - Driller's copy

ECY 050-1-20 (11/97)

WATER WELL REPORT
State of Washington

OBW-9

~~File No.~~ S.C. R27647
Unique Well Tag No. AEI 919
Water Right Permit No. 22-3E-28E

1) OWNER: Name: AESI c/o Jill Wheeler Complete Address: 911 5th Ave Suite 100 Kirkland Wa 98033

2) LOCATION OF WELL: County King SW 1/4 NW 1/4 Sec 28 T 22 N R 3E WM

2a) STREET ADDRESS OF WELL (if known) Maury Island pit (Lonestar)

3) PROPOSED USE: ☐ Domestic ☐ Test Well ☐ Industrial ☐ DeWater ☐ Irrigation ☒ Other: resource protection ☐ Municipal

4) TYPE OF WORK: Owner's number of well (if more than one) OBW-9
☐ Decommission ☒ New well ☐ Deepened ☐ Reconditioned
METHOD: ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☒ Rotary ☐ Jetted

5) DIMENSIONS: Diameter of well 6 inches.
Drilled 60 feet. Depth of completed well 42 feet.

6) CONSTRUCTION DETAILS:
☒ Casing Installed 6" Diam. from +2 ft. to 38 ft.
☐ Liner Installed ____" Diam. from ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____

Screens: ☒ Yes ☐ No
Manufacturer's name Johnston
Type Stainless Model No. ____
Diam. 6 Slot size .06 from 37 ft. to 42 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: ☐ Yes ☒ No
Gravel placed from ____ ft. to ____ ft.

Surface seal: ☒ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

7) WATER LEVELS: Land surface elevation above mean sea level ____ ft.
Static level 26 ft. below top of well Date 2-5-99
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

8) WELL TESTS: Was a pump test made? ☐ Yes ☐ No
Yield: 10 gal./min. with 12 ft. drawdown after 1 hrs.
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? ☐ No ☒ Yes

WELL CONSTRUCTION CERTIFICATION:
I constructed/supervised and accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are tue to my best knowledge and belief.

(Please print or type)
DRILLING COMPANY Aquatech Well Drilling & Pumps Inc.
Address 2722 Butler Cr Rd Sedro Woolley Wa
WELL DRILLER NAME Brannon Hopke License No. 1825
SIGNATURE [signature]
TRAINEE NAME & LICENSE # ____
Contractor's Registration No. AQUATWD040K4 Date 2-19-99, 19

10) WELL LOG OR DECOMMISSION PROCEDURE DESCRIPTION

Formation: Described by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Clearly note water bearing zones and hydraulic characteristics.

MATERIAL	From	To
Fill	0	3
Brown clay gravel & sand	3	12
Brown sand, gravel	12	20
Brown med sand	20	24
Brown sand & water	24	26
Brown sand wood (log) water	26	28
Brown sand - fine - water	28	50
Gray silt layer	50	51
Gray sand & water	51	

RECEIVED
FEB 22 1999
DEPT OF ECOLOGY

DRILLER'S COMMENTS (WORK STARTED): 2-4 / 2-5-99

Decommission: ☐ Perforated Casing ☐ Removed Casing
Amount of sealant used ____
Type of sealant used (Attach add'l sheet if necessary) ____

Ecology is an Equal Opportunity and Affirmative Action employer. For special accomodation needs, contact the Water Resources Program at (360) 407-6600. The TDD number is (360) 407-6006.

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ECY 050-1-20 (11/97)

71 (55)

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG Well #1 No. Appli. 5589

Date 5-24, 1960

Record by well driller

Source driller's record

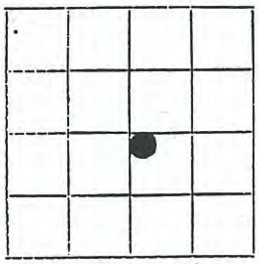

Diagram of Section

Location: State of WASHINGTON

County King

Area

Map Govt. Lot 2

¼ ¼ sec 22 T 22 N., R. 3 E.

Drilling Co. L. R. Gaudio Well Drilling Co.

Address Tacoma, Wash.

Method of Drilling Date 3-30, 1960

Owner Boise-Cascade Corp. Klinker Div.

Address Seattle, Wash.

Land surface, datum ft. above/below

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	Thickness (feet)	Depth (feet)
	Top soil-sand & gravel	30	30
	Sand with some gravel	26	56
	Sand - silty	9	65
	Clay, brown sandy	20	85
	Clay, blue	3	88
	Hardpan- brown	15	103
	Gravel- cemented	9	112
	Hardpan	13	125
	Clay, brown	3	128
	Hardpan, gray	12	140
	Hardpan, brown, sandy	31	171
	Sand, fine to med. silty	35	206
	Clay, sandy	19	225
	Sand, fine, silty w/b gravel at bottom	15	240
	Clay, blue	20	260
	" "	32	292
	(over)		

Turn up

Sheet of sheets

WELL LOG.—Continued No. 5589

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward	——	292
	Sand with gravel w/b	12	304
	Silty sand with gravel- gray	13	317
	Gravel & sand w/b alternating loose & tight layers	11	328
	Clayey hardpan	2	330
	Sand & gravel tight clay layers	7	337
	Gravel & sand	7	344
	Bottom of 12" I.D.Casing		348
	Clay, blue	74	418
	Clay, hard	17	435
	PUMP TEST:		
	Dim. 12"x348'		
	SWL: 203 ft.		
	DD: 26 ft.		
	Yield: 300 g.p.m.		
	Water Temp. 51°F		
	CASING:		
	12" diam. Std. casing from 0 to 348'		
	PERFORATIONS:		
	8 rows at 8" centers - 317 to 319'		
	8 " " 6" " 319 to 326		
	8 " " 8" " - 326 to 328		
	8 " " 12" " 328 to 334		
	8 " " 8" " 334 to 337		
	8 " " 6" " 337 to 344		

MW-1

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W103368
AF6 349

Water Right Permit No. ______

(1) OWNER: Name Lonestar Corporation Address c/o Pacific GWG / 2377 Eastlake Ave E, Seattle

(2) LOCATION OF WELL: County King SE ¼ SW ¼ Sec. 16 T. 22N N., R. 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW 240th Maury Island, WA

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) MW-1
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 204 feet. Depth of completed well 203' 6' ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 4 " Diam. from +1.5 ft. to 204 ft.
Welded ☑ ______ " Diam. from ______ ft. to ______ ft.
Liner installed ☐ ______ " Diam. from ______ ft. to ______ ft.
Threaded ☐

Perforations: Yes ☐ No ☑
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Cook Screens
Type Stainless steel Model No. ______
Diam. 5 Slot size .004 from 203.6 ft. to 198'6 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite Chips
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name N/A.
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 181.3' ft. below top of well Date 11/15/99
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest .25 gal./min. with stem set at 202 ft. for 1.0 hrs.
Artesian flow ______ g.p.m. Date 11/15/99
Temperature of water 56° Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Silty Sand	0	12
gray till w/gravels	12	23
Brown sand w/minor gravels	23	184
gray fine sand	184	204

RECEIVED
MAY 8 - 2000
DEPT OF ECOLOGY
NWRO-WR

Work started 11/9/99, 19. Completed 11/15/99, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME CASCADE DRILLING INC (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address P.O. BOX 1184, Woodinville, WA

(Signed) [signature] (WELL DRILLER) License No. 2426

Contractor's Registration No. CASCADI-088KK Date 11/15/99, 1999

(USE ADDITIONAL SHEETS IF NECESSARY)

9614

ECY 050-1-20 (10/87) -1329-

MW-2

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W103367
AFG 348
Water Right Permit No. ____

(1) OWNER: Name Lonestar Corp. c/o Pacific GWG Address 2377 Eastlake Ave E., Seattle

(2) LOCATION OF WELL: County King SE ¼ SW ¼ Sec 16 T. 22N N., R. 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW 240th Maury Island, WA

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) MW-2
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 72' feet. Depth of completed well 72 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +1.5 ft. to 70 ft.
Welded ☑ ____ " Diam. from ____ ft. to ____ ft.
Liner installed ☐
Threaded ☐ ____ " Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ☑
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Cook Screens
Type Stainless Steel Model No. ____
Diam. 5 Slot size 004 from 72 ft. to 67 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☑ No ☐ To what depth? 18 ft.
Material used in seal Bentonite Chips
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name N/A
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 38.3 ft. below top of well Date 11/16/99
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 1.5 gal./min. with stem set at 71 ft. for 1.0 hrs.
Artesian flow ____ g.p.m. Date 11/16/99
Temperature of water 56° Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Silty Sand w/minor gravel	0	11
~~grey~~ Brown sand w/minor gravel	11	40
gray fine sand	40	72'

RECEIVED
MAY 8 - 2000
NWRO-WR
DEPT OF ECOLOGY

Work started 11/15/99, 19. Completed 11/16/99, 19.

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Cascade Drilling, Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P.O. Box 1184
(Signed) [signature] (WELL DRILLER) License No. 2426
Contractor's Registration No. CASCAD1-088KK Date 11/16, 1999

(USE ADDITIONAL SHEETS IF NECESSARY)

9614

MW-3

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. W103366
AFG 347
Water Right Permit No. ______

(1) OWNER: Name Lonestar Corp. c/o Pacific GWG Address 2377 Eastlake Ave E - Seattle

(2) LOCATION OF WELL: County King SE ¼ SW ¼ Sec 16 T. 22 N., R. 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW 240th, Maury Island, WA

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater ☐ Industrial ☐ Test Well ☐ Municipal ☐ Other

(4) TYPE OF WORK: Owner's number of well (if more than one) MW-3
☐ Abandoned ☑ New well ☐ Deepened ☐ Reconditioned
Method: ☐ Dug ☐ Cable ☑ Rotary ☐ Bored ☐ Driven ☐ Jetted

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 77 feet. Depth of completed well 73.5 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +2 ft. to 77 ft.
☑ Welded ______" Diam. from ______ ft. to ______ ft.
☐ Liner installed
☐ Threaded ______" Diam. from ______ ft. to ______ ft.

Perforations: ☐ Yes ☑ No
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: ☑ Yes ☐ No
Manufacturer's Name Cook
Type SS Model No. ______
Diam. 5 Slot size .006 from 68.5 ft. to 73.5 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: ☐ Yes ☑ No Size of gravel ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: ☑ Yes ☐ No To what depth? 18 ft.
Material used in seal Bentonite Chips
Did any strata contain unusable water? ☐ Yes ☑ No
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name N/A
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 44.9 ft. below top of well Date 11/17/99
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☑ No If yes, by whom? ______
Yield: ______ gal./min. with ______ ft. drawdown after ______ hrs.
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest 12 gal./min. with stem set at 72 ft. for 1 hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water 56° Was a chemical analysis made? ☐ Yes ☑ No

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Silty Sand	0	7
Brown fine Sand	7	22
gray till	22	28
~~[illegible]~~ brown Sand w/minor gravel	28	77

RECEIVED
MAY 8 - 2000
NWRO-WR
DEPT OF ECOLOGY

Work started 11/10/99, 19. Completed 11/17/99, 19.

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Cascade Drilling, Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P.O. Box 1184
(Signed) [signature] (WELL DRILLER) License No. 2426
Contractor's Registration No. CASCADI-088KK Date 11/17, 1999

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329- 3

9614

MW-4

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W103364

Water Right Permit No. AFG-345

(1) OWNER: Name Lonestar Corporation c/o Pacific GWG Address 2377 Eastlake Ave E. Seattle

(2) LOCATION OF WELL: County King SE ¼ SW ¼ Sec 16 T 22 N., R 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW 240th, Maury Island, WA

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) MW-4
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 178' feet. Depth of completed well 115'10" ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6 " Diam. from +2 ft. to 178' ft.
Welded ☑ ____ " Diam. from ____ ft. to ____ ft.
Liner installed ☐ ____ " Diam. from ____ ft. to ____ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☒ No ☒
Manufacturer's Name Cook
Type SS Model No. ____
Diam. 5" Slot size .064 from 116 ft. to 114 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☐ No ☒ To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name N/A
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level ____ ft.
Static level 102.4' ft. below top of well Date 11/24/99
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest 1/2 gal./min. with stem set at 114 ft. for 1.0 hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water 56° Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
fill	0	6
Brown Silty Sand w/ minor gravel	6	21
Brown Sand	21	126
Gray Sand w/ minor Silt	126	178

RECEIVED
MAY 8 - 2000
DEPT OF ECOLOGY
NWRO-WR

Work started 11/22/99, 19__. Completed 11/24/99, 19__

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Cascade Drilling, Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P.O. Box 1184
(Signed) [signature] (WELL DRILLER) License No. 2426
Contractor's Registration No. CASCAD1-088KK Date 12/24, 19 99

(USE ADDITIONAL SHEETS IF NECESSARY)

9614

ECY 050-1-20 (10/87) -1329-

MW-5 (mon well)

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W103365

Water Right Permit No. AFG 346

(1) OWNER: Name Lonestar Corp % Pacific GWG Address 2377 Eastlake Ave E, Seattle

(2) LOCATION OF WELL: County King SE ¼ SW ¼ Sec 16 T 22 N., R 3E W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) SW 240th, Maury Island, WA

(3) PROPOSED USE: ☑ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) MW-5
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☐ Rotary ☑ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 157.2 feet. Depth of completed well 157.2' ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +2 ft. to 157' ft.
Welded ☑ ___" Diam. from ___ ft. to ___ ft.
Liner installed ☐ ___" Diam. from ___ ft. to ___ ft.
Threaded ☐

Perforations: Yes ☐ No ☑
Type of perforator used ___
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Cook Screens
Type SS Model No. ___
Diam. 5" Slot size .006 from 157.2' ft. to 152.2' ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ___
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☑ No ☐ To what depth? 18' ft.
Material used in seal Bentonite Chips
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

(7) PUMP: Manufacturer's Name N/A
Type: ___ H.P. ___

(8) WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 110.4 ft. below top of well Date 11/19/99
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom? ___
Yield: ___ gal./min. with ___ ft. drawdown after ___ hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ___
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest 20 gal./min. with stem set at 156 ft. for 1.0 hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water 56° Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
fill	0	8
gray till	8	19
brown sand w/minor gravel	19	105
gray silty sand	105	107
brown sand	107	157

RECEIVED MAY 8 - 2000 DEPT OF ECOLOGY
NWRO-WR

Work started 11/18/99, 19. Completed 11/19, 1999

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Cascade Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)

Address P.O. Box 1184

(Signed) [signature] (WELL DRILLER) License No. 2426 (~~2626~~)

Contractor's Registration No. CASCAD-088KK Date 11/19, 1999

(USE ADDITIONAL SHEETS IF NECESSARY)

9614

ECY 050-1-20 (10/87) -1329-

Appendix C

GPS Survey Results

Pacific Groundwater Group

W&H PACIFIC
3350 Monte Villa Parkway
Bothell, Washington 98021

December 2, 1999

Mr. Crispin Prahl
Pacific Groundwater Group
2377 Eastlake Avenue East
Seattle, Washington 98102

Re: GPS Survey for Water Wells – Maury Island, Washington
WHP File No. 3-2214-0001-00100

Dear Crispin:

The following information is being sent per your November 30, 1999 e-mail.

The attached sheet lists personnel, equipment used, datum, and the method used to establish the well locations. Also attached is a listing of the wells, including 3D coordinates.

We hope this satisfies your request as stated in your e-mail. If you have any questions, please call me at (425) 951-4862, or Larry Signani at (425) 951-4864.

Sincerely,

W&H PACIFIC, INC.

Megan Ayres-Dodson

Megan Ayres-Dodson
GPS Specialist

Attachments: As referenced above

MAD:cya
I:\PROJECT\22140001\WORD\Prahl.doc

MAURY ISLAND WELLS
NOVEMBER 1999

Horizontal Datum: NAD 83/91
Vertical Datum: NAVD'88
Units: US Feet

Williams #1
Locate: North rim lid
Northing 143863.2 Easting 1242578.6 Elevation 94.2

Cornutt #3
Locate: Top North edge casing
Northing 140516.0 Easting 1240318.6 Elevation 150.7

Hamilton #4
Locate: Top nipple 1" diameter pipe
Northing 141922.9 Easting 1242501.3 Elevation 189.3

Williams #4B
Locate: North rim top lid
Northing 141944.2 Easting 1242383.4 Elevation 187.8

Wolff #5
Locate: North rim top lid
Northing 145818.1 Easting 1246047.8 Elevation 115.1

Silkett #6
Locate: North rim top lid
Northing 145487.7 Easting 1245808.2 Elevation 101.6

Farcy #8
Locate: North rim top lid
Northing 144742.5 Easting 1244138.3 Elevation 130.3

Williams, E #10
Locate: North rim
Northing 145106.9 Easting 1244956.4 Elevation 113.4

McKallor #11
Locate: North rim top lid
Northing 144622.4 Easting 1243381.0 Elevation 98.0

Sandy Shores #31
Locate: North edge access portal
Northing 135435.6 Easting 1238779.8 Elevation 307.4

Hillcrest #32
Locate: South edge access portal
Northing 132055.5 Easting 1236203.9 Elevation 364.4

Gold Beach 2 #34
Locate: North side access portal pipe (lower side with cap off)
Northing 140289.9 Easting 1246331.4 Elevation 105.5

Gold Beach 1 #35
Locate: North side access portal
Northing 140208.9 Easting 1246340.3 Elevation 103.5

Reuter #40
Locate: North edge access portal (bottom PVC pipe)
Northing 144087.6 Easting 1243070.5 Elevation 110.0

Alton #42
Locate: North rim top lid
Northing 142558.2 Easting 1247402.5 Elevation 410.2

Hartman #44
Locate: Northwesterly side top 6" diameter pipe
Northing 145301.1 Easting 1244914.80 Elevation 96.1

Edmunds #45
Locate: North side access portal
Northing 145615.5 Easting 1247120.9 Elevation 169.7

Sheldon #46
Locate: North rim top lid
Northing 143597.6 Easting 1242337.7 Elevation 99.8

Carhart #47
Locate: North rim top lid
Northing 141293.6 Easting 1241283.2 Elevation 182.6*
* Does not meet project specifications due to poor satellite visibility

Ferguson #48s
Locate: Top PVC pipe (0.32' above sewer lid)
Northing 139157.0 Easting 1238939.4 Elevation 47.8

OBW-9
Locate: North rim 2" PVC pipe
Northing 137422.5 Easting 1242521.5 Elevation 41.1

MW-1
Locate: North rim top pipe
Northing 139340.7 Easting 1241350.3 Elevation 265.2

MW-2
Locate: North rim
Northing 137403.8 Easting 1242510.6 Elevation 41.1

MW-3 (Alwood)
Locate: North rim top pipe
Northing 138310.9 Easting 1238613.1 Elevation 100.2

MW-4 (King County)
Locate: North rim top pipe
Northing 139497.7 Easting 1239997.8 Elevation 168.1

MW-5 (Hamilton)
Locate: North rim top lid
Northing 141276.6 Easting 1242332.0 Elevation 199.4

Appendix D

Appendix D

Recharge Estimation for the Maury Groundwater Flow Model

Pacific Groundwater Group

Appendix D
Recharge Estimation for the Maury Groundwater Flow Model

1 Method

A proprietary spreadsheet model developed by Pacific Groundwater Group was used, in conjunction with GIS analysis, to estimate monthly and annual recharge within the model domain. The spreadsheet model is based on algorithms used in the "Deep Percolation Model" developed by the USGS (Bauer, 1996 and Bauer & Vaccaro, 1987). PGG's model employs a daily water budget to track soil moisture, perched conditions over till, runoff, snow-pack storage, and interception loss. The model estimates daily potential evapotranspiration using either the Blaney-Criddle (SCS, 1970) or Priestly-Taylor (1972) method, and calculates actual evapotranspiration as a function of soil texture and available moisture in the root zone. All water passing through the root zone is considered to be shallow recharge. When a till layer is included, the model tracks an overlying, perched water table and allows for both downward vertical seepage through the till ("deep recharge") and shallow "perched subflow" above the till. If the water table reaches the land surface, potential recharge is rejected and routed to the runoff term. Runoff is also modeled based on a fixed percentage of precipitation. Running the model for consecutive identical years allows simulation of a cyclic steady state. The model can be calibrated to all known terms, including runoff, saturation above the till, deep recharge, perched subflow, and snow-pack storage.

GIS was used to identify six "recharge classes" based on unique combinations of land cover and surficial geology. Land cover was broken into three categories (grass, mixed trees, and mine sites) and was digitized from areal photographs of the island. Mixed trees were modeled as half coniferous and half deciduous trees. Residential development, generally of low density, was grouped into the "grass" category. Surficial geology maps of the island (Booth, 1991) and the site (AESI, 1999a) were combined in the GIS, and a simple division was made between areas underlain by lower permeability units (predominantly till (***Qvt***), but also ***Qpvu*** interglacial deposits) and by advance outwash (***Qva***). The following defines the six recharge classes:

	grass land cover	**forest land cover**	**mine site**
underlying till	1	2	3
underlying outwash	4	5	6

In addition, recharge classes comprised entirely of barren soil (Class 7) and coniferous trees (Class 8) were defined for simulation of the mine during excavation and after reclamation, respectively. In both cases, underlying till was considered absent.

The recharge analysis also considered the water-holding capacities of existing soils, however there were insufficient variations between existing soil types to warrant delineation of additional recharge classes. Alderwood and Everett soils, the two most prominent types on the island, have very similar available water capacity (AWC) profiles. The major discriminating factor is that Alderwood soils are underlain by a consolidated till stratum, typically encountered 24 to 40 inches below land surface (SCS, 1973). Because PGG's model simulates the presence of till independent of soil properties, a "composite soil" was defined to represent the AWC profiles of both soils. The following summarizes the AWC profiles of the three soil types:

Everett		Alderwood		Composite	
Depth Range	AWC	Depth Range	AWC	Depth Range	AWC
0-17 in	0.08-0.1	0-27 in	0.09-0.11	0-17 in	0.08-0.11
17-32 in	0.06-0.08	Below 27 in	Till	17-27 in	0.06-0.11
32-60 in	0.02-0.04			27-32 in	0.06-0.08
				32-60 in	0.02-0.04

For each depth range, the modeled AWC value is the midpoint of the AWC range. It should be noted that the AWC variation between Everett and Alderwood soils is small relative to the overall possible, as siltier soils typically have AWC values ranging from 0.20 to 0.40. The mine sites were assumed to have poorly developed soils (or soils have been removed), with textures dominated by the sand and gravel for which the mine was developed. A typical value of AWC for sandy soils, 0.08, was used for the mine sites. A specific yield of 0.37 was assumed for all soils.

Plant potential evapotranspiration (ET) was calculated with the method of Blainey-Criddle. Grass was assigned a root depth of 24 inches in accordance with the USGS Deep Percolation Model used for to southwest King County (Woodward et al, 1995), and coniferous and mixed trees were assigned a depth of 36 inches. Soil evaporation was calculated for barren portions of the mine sites (down to a depth of 12 inches) with the method of Priestly-Taylor (1972). Mine areas were assumed to be 2/3 vegetated and 1/3 barren. Recharge simulations for grass and bare soil were combined in this ratio to yield estimates for the mine sites.

For recharge classes with till sub-strata, depth to till was assumed to be 3 feet and the minimum depth to seasonal water table was assumed to be 1 foot. Due to the coarse textures and high permeabilities of predominant soils, runoff was believed to be relatively minor and specified as a fixed, small percentage of precipitation (10%). This runoff allocation was also based on local reports and direct field observations that little surface flow exists over most of Maury Island during large storm events. Permeabilities reported for Alderwood soils (above till) range from 2 to 6.3 inches/hour, with equal or greater permeabilities reported for Everett soils (SCS, 1973).

Interception was not explicitly modeled because the Blaney-Criddle equation does not require specification of interception parameters. However, interception loss is known to be high in forests of the Pacific Northwest during wintertime, when advective loss of intercepted moisture can dominate evapotranspiration (Bauer & Mastin, 1997; pers. comm., Black, 1999). During the drier months (May through September), crop factors can be derived for conifers by multiplying the crop factor for grass by the ratio of Priestly Taylor "alpha" values measured for conifers and grass (0.73 and 1.26, respectively). The "alpha" parameter was developed for dry leaf transpiration based on stomatal resistance. Current methods of ET estimation have not fully developed suitable means for estimating advective losses during winter months. For these months, the best recourse for estimating forest ET is believed to be use of high-end, measured crop factors (pers. comm, Black, 1999). In this case, Blaney-Criddle crop factors for alfalfa were used between November and March, and for grass during April and October. Alfalfa has one of the highest crop factors, and grass is also relatively high (Dunne & Leopold, 1978).

Monthly precipitation averages were derived for Maury Island based on linear regression analysis between short-term precipitation records on Vashon and Maury Islands, and concurrent records from Seatac Airport (about 8 miles to the northeast), and long-term records from Seatac Airport. Spatially uniform precipitation was assumed across all of Maury Island. An average-year, representative monthly precipitation record was synthesized for Maury Island by multiplying long-term average monthly values from Seatac Airport by a factor of 1.2. Monthly precipitation averages were divided into equal daily values for input to the recharge model. The following table shows the climatic input data for the model:

Month	Precipitation (inches)	Avg. Daily Max Temp (°F)	Avg Daily Min Temp (°F)
Jan	6.45	43.5	33.3
Feb	4.78	47.6	35
Mar	4.24	52.5	36.6
Apr	2.79	59.5	40.3
May	2.04	65.5	44.2
Jun	1.80	70.5	48.3
Jul	0.91	73.2	50.7
Aug	1.37	74.1	51.7
Sep	2.25	68.4	49.3
Oct	3.87	59.3	44.7
Nov	6.99	50.7	39.6
Dec	7.08	46	36.5
Annual	44.6	59.4	42.5

Temperature values were obtained from a station at Vashon Cove on Vashon Island. Comparison between long-term (1931-1998) statistics for Seatac Airport and the shorter record available for Vashon Cove (1931-1954) showed relatively little difference between the monthly averages of daily temperature for the two sites. Monthly averages of maximum daily temperatures were typically within one degree Fahrenheit, whereas monthly average minimum daily temperatures for the two sites were more variable with Seatac averaging 1.6 degrees warmer. Differing periods of record may contribute to this apparent temperature difference, however a comparison of Seatac temperature statistics for 1931-1998 and 1961-1990 records suggested insignificant variation between the period averages. Alternatively, differing geographic factors may contribute to the temperature difference (e.g., island versus mainland characteristics). Available data were insufficient to distinguish the cause of this temperature difference, and its magnitude is considered relatively small for the purpose of calculating ET.

Solar radiation data, required for the Priestly-Taylor method, were obtained from measurements made at the Seatac station. The data are maintained and reported by the National Renewable Energy Laboratory (NREL) as part of the National Solar Radiation Database, and represent a period of 1961-1990. Maximum observed daily clear sky solar radiation was not measured, but was derived from measured extraterrestrial solar radiation by applying a ratio of 0.73 (after Giles and others, 1984). The radiation data are presented below. The recharge model employed a Priestly-Taylor alpha coefficient of 1.0. While a value of 1.26 is considered standard for wet surfaces, evaporation from soils (E_s) is less than evaporation from free surfaces (E_o). E_s/E_o ratios reported in the literature range from 60% to 90% (Jensen et al, 1990). Sensitivity analysis showed that varying the alpha coefficient by ± 0.27 around 1.0 resulted in PET values which varied by +27% and –15%, however resulting recharge values varied by only +6% and –3%.

Month	Extraterrestrial solar radiation ($MJ\ m^{-2}\ d^{-1}$)	Maximum observed daily clear sky solar radiation ($MJ\ m^{-2}\ d^{-1}$)	Daytime incoming solar radiation ($MJ\ m^{-2}\ d^{-1}$)
January	10.99	8.02	3.54
February	16.53	12.07	5.96
March	24.49	17.88	10.18
April	32.82	23.96	14.70
May	39.14	28.57	19.16
June	41.88	30.57	20.91
July	40.51	29.58	21.84
August	35.30	25.77	18.56
September	27.71	20.23	13.57
October	19.42	14.18	8.00
November	12.66	9.25	4.19
December	9.54	6.96	2.89

Actual soil evaporation and plant evapotranspiration were calculated as a function of daily soil moisture availability, soil texture, and potential ET based on functions employed in the USGS DPM (Bauer & Vaccaro, 1987). In general, reduced soil moisture reduces evaporation and transpiration because the remaining moisture is held with greater tension in the soil and unsaturated hydraulic conductivities are reduced.

A GIS approach was used to calculate the proportion of each of the six recharge classes present in every active, layer-1 model cells. The model grid was exported to ArcView, and each model cell was made into a polygon. Model polygons were overlain on the recharge-class polygons, and the spatial percentages of each class were exported to a database. The database was then used to calculate weighted averages of recharge for each model cell based on the spatial percentage and recharge values calculated for each class. Averages were calculated on both annual and monthly bases. The database also included features to impose time lags for recharge originating at the land surface to reach the water table and to limit recharge in the ***Qpvu*** deposits based on their permeability. Specifically:

- monthly recharge values *for all cells* could be lagged by integer multiples of one month; or monthly recharge values *for each cell* could be lagged according to depth to water from land surface; and
- annual recharge values for layer-1 model cells occupied by ***Qpvu*** interglacial deposits could be set to the K_v value for ***Qpvu***, with monthly values normalized to the annual value..

A digital map of water-level elevation in the ***Qva*** deposits (layer 1) was prepared in Surfer and imported into Groundwater Vistas to estimate depth to water for each active model cell. Time lags (integer multiples of one month) were estimated for each model cell based on the depth to water and the linear lag/depth relationship (20.35 ft/month) discussed in Section 7 of the Hydrogeologic Impact Assessment report ("the main report"). Annual recharge to layer-1 ***Qpvu*** cells was maintained at the model K_v value used in each calibration run, and monthly values were scaled proportional to the monthly variation predicted for Class 2 recharge (mixed trees on till).

2 Recharge Estimation Results

PGG's recharge model was used to estimate monthly and annual recharge for each recharge class. Soil property, plant, climatic and other pertinent data were input, and the model was run for each recharge class independently. For classes with no underlying till a single model run allowed definition of the daily, monthly, and annual soil-moisture water balance. For classes with underlying till multiple runs were required during which the vertical permeability (K_v) of the till and the "Darcy flow coefficient" of the perched aquifer (a composite term for horizontal permeability (K_h) times gradient (i) per unit-width) were adjusted to calibrate to site conditions. These two values were adjusted so that their combination allowed the seasonal perched water table to come within one foot of the land surface during the wettest period of the year. Site reconnaissance, monitoring, and other inquiries suggest that standing water is uncommon on most parts of the study area - an observation consistent with the relatively high permeability of island soils, including the till.

K_v and the Darcy flow coefficient were also adjusted to control the distribution between downward infiltration through the till and lateral perched subflow. For grass and tree covered areas, a K_v value of 0.009 feet/day (2.1×10^{-6} cm/sec) was selected to allow all of the shallow recharge from the root zone (about 24 inches/year) to pass through the till over the coarse of a year. Till infiltration of 24 inches/year is relatively high among reported values. A recent USGS summary of 28 studies for which infiltration through till was estimated showed a range of 1.5 to 37.4 in/yr (Bauer & Mastin, 1997). Those studies for which rigorous methods were employed[1] showed an average of 13.6 in/yr over a combined area of 251 square miles. Site-verified data on which to base K_v for the till are currently unavailable.

Model sensitivity to the assumption that perched subflow is insignificant and shallow recharge is fully accommodated by downward seepage through the till was evaluated. If perched subflow represents a significant pathway for recharge, water accumulated over the till body in the center of the island would move downslope on the till surface and would eventually discharge into adjacent unsaturated outwash deposits where the till pinches out. Figure 5-1 of the main report shows the surficial distribution of till and the land-surface topography that would likely control flow directions for perched subflow. A portion of the recharge originating above till near the mine site would move as perched subflow in a northwesterly direction and discharge to the outwash deposits along the edge of the till about 1,500 feet southeast of Dockton Springs. The perched subflow would essentially create a "subsurface waterfall" where discharge off the till contributes a "line source" to the water table after moving downward through almost 200 feet of vadose zone.

Darcy calculations were performed to evaluate quantities of shallow recharge that could potentially be redistributed due to perched subflow above the till. As presented in Table D-1, the calculations assumed a maximum saturated thickness of 1 to 2 feet above the till, consistent with a typical soil thickness over till of 27 inches representative of Alderwood soils (SCS, 1973).

[1] Defined here as a predictive or calibrated numerical model, or a USGS water resource investigation.

Based on the gradient equal to the slope of the land surface and hydraulic conductivity values representative of Alderwood soils (SCS, 1973) and sandy materials, flow across the top of the till was estimated to range from 0.003 to 0.018 gpm per linear foot perpendicular to the flow path. For a flow tube with a length of 2,000 feet oriented parallel to the topograpghic gradient, this rate of perched subflow represents only a small portion (about 2 to 11 percent) of the maximum rate of winter recharge estimated above the till. The limiting factor to the amount of flow moving through the shallow perched zone is the hydraulic capacity of this zone. The capacities calculated on Table D-1 suggest that the downward seepage through the till must be capable of accommodating the bulk of recharge, because the perched zone cannot do so.

The recharge "line-source" expected along the downslope (northwest) boundary of the surficial till unit could be impacted by mine excavation. Because water accumulating above the till could flow laterally downslope towards this "subsurface waterfall", removal of till from contributing areas could reduce the amount of water available to the perched flow system. Where till is removed from the mine site, the portion of recharge supplying shallow perched flow to the northwest would be redistributed to areas directly beneath the site. Investigative MODFLOW model simulations were performed to evaluate the significance of such a redistribution of recharge. The steady-state calibration for Scenario B was run with a 11,600-foot long line source positioned along the northwest edge of the till body mapped in the center of the island (see Figure 5-1). The line source was modeled using a flux of approximately 0.01 gpm per linear foot for an upslope till catchment of 2,000-foot length, and proportional fluxes for larger and smaller till catchments. The total modeled inflow along the line source was approximately 90 gpm, about 2 percent of the total recharge inflow to the model.

The MODFLOW simulation predicted that addition of the line source would cause localized water table mounding in the Principal Aquifer of 2 to 3 feet relative to groundwater levels on more distant parts of the island. A second simulation was performed where fluxes along 4,000 feet of the line source directly downslope of the mine were reduced and redistributed to model cells within the mine excavation area. This simulation represents the removal of till at the mine site with the associated redistribution of recharge. The model predicts discharge from all springs to increase slightly. Modeled discharges at Dockton and Ferguson Springs showed predicted increases of 0.4 percent or less, and modeled discharge at Spring E showed an increase on the order of 1.4 percent. Redistribution of modeled recharge caused localized declines in predicted water levels along the line source of 0.2 feet or less, however water-level rises were predicted for most other areas of the model. Predicted rises are highest in till-excavated portions of the mine footprint, where values generally range from 0.2 to 0.3 feet (although a localized increase of 0.6 feet was noted). Predicted water-level rise diminishes with distance from the Qva trough.

Given the relatively small impacts predicted due to redistribution of recharge and considering that little is actually known about the shallow perched system, no further analysis was performed regarding this phenomenon. Analysis presented in the main body of this report distributes recharge from the root zone (or shallow underlying till) without addition of a line source along the edge of the till.

The following table shows the monthly and annual estimates of recharge predicted by the spreadsheet model. Recharge through till is presented for classes 1-3, whereas recharge at the bottom of the root zone is presented for classes 4-8. Output from the recharge spreadsheet model for each recharge class is provided in Tables D-2 through D-8. Figure 7-1, in the main body of the report, provides a graphical representation of estimated recharge over time.

Class	Class	Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grass + Till	1	24.07	3.63	3.34	3.68	3.44	2.40	0.00	0.00	0.00	0.00	0.78	3.29	3.52
Trees + Till	2	25.57	3.83	3.52	3.87	3.62	2.03	0.00	0.00	0.00	0.00	1.51	3.48	3.72
Mine + Till	3	24.01	3.64	3.34	3.66	3.42	1.90	0.00	0.00	0.00	0.00	1.22	3.30	3.53
Grass + Outwash	4	24.10	5.38	3.71	2.62	0.44	0.00	0.00	0.00	0.00	0.00	0.78	5.36	5.81
Trees + Outwash	5	25.85	5.46	3.79	2.78	0.71	0.00	0.00	0.00	0.00	0.00	1.51	5.62	5.97
Mine + Outwash	6	25.06	5.50	3.77	2.60	0.37	0.00	0.00	0.00	0.00	0.00	1.22	5.60	6.00
Barren + Outwash	7	27.04	5.75	3.90	2.57	0.22	0.00	0.00	0.00	0.00	0.00	2.11	6.11	6.38
Conifers + Outwash	8	23.75	5.26	3.54	2.40	0.43	0.00	0.00	0.00	0.00	0.00	1.18	5.22	5.72

Note: all values are in inches.

The model predictions show very little difference among recharge estimates within class groupings overlying till and those overlying outwash. Although potential ET differs significantly for each land-cover grouping, variables such as root zone depth tend to reduce differences in recharge estimates. Model predictions of month-to-month recharge patterns *between* the two groupings, however, do show a significant difference. Figure 7-1 shows that predicted recharge is more "flashy" for the outwash grouping. The till perching layer reduces the maximum monthly rate of recharge, but sustains the duration of recharge two months longer into the dryer early-spring months (April and May).

For the point of comparison, it should be noted that a previous study by Carr/Associates (1983) specifically addresses the issues of water balance and recharge estimation for Vashon and Maury Islands. The study presents an estimate of "water surplus" (precipitation minus ET) that is quite consistent with the recharge estimates discussed above. Carr estimated 20 in/yr surplus for 40 in/yr rainfall; whereas PGG estimated 24 in/yr shallow recharge for 45 in/yr rainfall. Carr's study, however, assumes that between 56 to 76 percent of this surplus (28 to 38 percent of total rainfall) is lost as direct runoff to streams. Without data to support this assumption, estimation of percent surplus going to groundwater recharge (through outwash *or* till) versus that going to direct runoff to streams cannot be substantiated. On Maury Island, field observations and previous site-related investigations indicate that surface streams, and thus direct runoff, are noticeably absent within the study area. As previously mentioned, our analysis assumes that direct runoff plays only a small role in the overall water balance for Maury Island.

The predicted cell-by-cell recharge estimates were imported to Groundwater Vistas. Annual averages were used for steady-state calibration, and monthly averages were used for transient simulation based on monthly stress periods.

3 References

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Table D-1 Evaluation of Peched Aquifer Capability to Transmit Water

	SCS High K, 2-ft thick	SCS High K, 1-ft thick	SCS Low K, 2-ft thick	Sandy K, 2-ft Thick
Width of flow tube (ft)	1	1	1	1
Length of flow tube above till body (birdseye) (ft)	2000	2000	2000	2000
Area of flow tube above till body (birdseye) (ft^2)	2000	2000	2000	2000
Length of flow tube above till body (ground surface) (ft)	2110	2110	2110	2110
Elevaton (head) drop over flow tube distance (ft)	130	130	130	130
Gradient of flow tube	0.062	0.062	0.062	0.062
Maximum Infiltration to land surface (in/mo)*	6.4	6.4	6.4	6.4
Maximum Infiltration to land surface (ft/d)	0.0175	0.0175	0.0175	0.0175
Maximum Recharge below root zone (in/mo)**	6.0	6.0	6.0	6.0
Maximum Recharge below root zone (ft/d)	0.0164	0.0164	0.0164	0.0164
Maximum Recharge to flow tube (ft^3/d)	32.8	32.8	32.8	32.8
Perched saturated thickness (ft)	2	1	2	2
Perched hydraulic conductivity (in/hr)	6	6	2	14.1
Perched hydraulic conductivity (ft/d)	12	12	4	28.2
Perched hydraulic conductivity (cm/sec)	4.2E-03	4.2E-03	1.4E-03	1.0E-02
Perched flux rate (ft^3/d)	1.5	0.7	0.5	3.5
Proportion of Total Recharge Above Till	5%	2%	2%	11%
Perched Discarge Along Edge of Till (gpm/ft)	0.008	0.004	0.003	0.018
Perched Discharge per 200' Model Cell (gpm)	1.5	0.8	0.5	3.6

* Based on "infiltration" term from recharge estimation spreadsheets.
** Based on "infiltration" term minus "actual ET" term from recharge estimation spreadsheets.

Location of Land Surface Profile Used for Flow Tube

Table D-2 Recharge / Water Balance for the Maury Island: Category 1 - Grass with Till - No Perched Subflow

Vegetation Data	
Type of Land Cover	grass
Rooting Depth	24 in
Priestly Taylor "Alpha"	N/A
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data	
Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data		
Avg. Soil Available Water Capacity (AWC)	0.09	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till Layer	3	feet, based on field observations.
Thickness of Till Layer	20	feet.
Vertical Hydraulic Conductivity of Till	0.009	ft/day, based on empirical adjustment
Specific Yield of Perched Aquifer	0.33	based on typical value ranges.
Darcy Flow Coefficient for Perched Aquifer	0.00001	based on empirical adjustment.

Method of Estimating Potential Evapotranspiration: Blaney Criddle (BC)

Priestly Taylor Canopy Interception: Not Modeled

Snowpack: Not Modeled

Till Perching: Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	0.49	0.57	0.73	0.85	0.90	0.92	0.92	0.92	0.87	0.79	0.67	0.55	0.77
Blaney Criddle % of Annual Light (d)	0.064	0.065	0.082	0.091	0.103	0.105	0.106	0.097	0.084	0.076	0.064	0.061	1.00
Priestly Taylor Net Radiation (RN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potential Evapotranspiration (PET)	0.42	0.61	1.22	2.11	3.21	4.04	4.51	4.32	3.01	1.82	0.91	0.56	26.75
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	1.17	2.24	3.60	2.95	0.76	0.00	0.00	0.00	10.72
Actual Evapotranspiration (AET)	0.42	0.61	1.22	2.11	2.68	2.13	1.28	1.13	1.36	1.66	0.91	0.56	16.06
Shallow Recharge (RS)*	3.64	3.35	3.68	3.45	2.40	0.00	0.00	0.00	0.00	0.78	3.29	3.52	24.10
Perched Subflow (PS)*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Deep Recharge (RD)*	3.63	3.34	3.68	3.44	2.40	0.00	0.00	0.00	0.00	0.78	3.29	3.52	24.07

ANNUAL	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
SUMMARY	44.63	N/A	N/A	44.63	4.46	40.17	26.75	16.06	24.10	0.03	24.07

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Table D-3 Recharge / Water Balance for the Maury Island: Category 2 - Mixed Trees with Till - No Perched Subflow

Vegetation Data	
Type of Land Cover	mixed trees
Rooting Depth	36 in
Priestly Taylor "Alpha"	N/A
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data	
Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data		
Avg. Soil Available Water Capacity (AWC)	0.08	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till Layer	3	feet, based on field observations.
Thickness of Till Layer	20	feet.
Vertical Hydraulic Conductivity of Till	0.0095	ft/day, based on empirical adjustment
Specific Yield of Perched Aquifer	0.33	based on typical value ranges.
Darcy Flow Coefficient for Perched Aquifer	0.00001	based on empirical adjustment.

Method of Estimating Potential Evapotranspiration: Blaney Criddle (BC) **Priestly Taylor Canopy Interception:** Not Modeled **Snowpack:** Not Modeled **Till Perching:** Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	0.40	0.49	0.63	0.74	0.70	0.74	0.74	0.67	0.52	0.55	0.49	0.40	0.59
Blaney Criddle % of Annual Light (d)	0.064	0.065	0.082	0.091	0.103	0.105	0.106	0.097	0.084	0.076	0.064	0.061	1.00
Priestly Taylor Net Radiation (RN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potential Evapotranspiration (PET)	0.35	0.53	1.06	1.83	2.49	3.27	3.63	3.16	1.80	1.27	0.66	0.40	20.44
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Average Soil Moisture in Soil Profile (SW)	8.17	9.08	8.64	6.58	3.33	2.04	1.32	1.00	1.66	2.79	4.02	6.24	4.54
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	0.45	1.47	2.71	1.80	0.00	0.00	0.00	0.00	6.43
Actual Evapotranspiration (AET)	0.35	0.53	1.06	1.83	2.49	2.24	1.71	1.14	0.96	1.21	0.66	0.40	14.56
Shallow Recharge (RS)*	3.84	3.52	3.87	3.63	2.03	0.00	0.00	0.00	0.00	1.51	3.48	3.72	25.60
Perched Subflow (PS)*	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Deep Recharge (RD)*	3.83	3.52	3.87	3.62	2.03	0.00	0.00	0.00	0.00	1.51	3.48	3.72	25.57

ANNUAL SUMMARY	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
	44.63	**N/A**	**N/A**	**44.63**	**4.46**	**40.17**	**20.44**	**14.56**	**25.60**	**0.03**	**25.57**

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Table D-4 Recharge / Water Balance for the Maury Island: Category 3 - Barren with Till - Till Leakage Limited to 24 in/yr

Vegetation Data	
Type of Land Cover	barren
Rooting Depth	12 in
Priestly Taylor "Alpha"	1
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data	
Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data		
Avg. Soil Available Water Capacity (AWC)	0.08	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till Layer	3	feet, based on field observations.
Thickness of Till Layer	20	feet.
Vertical Hydraulic Conductivity of Till	0.009	ft/day, based on empirical adjustment
Specific Yield of Perched Aquifer	0.33	based on typical value ranges.
Darcy Flow Coefficient for Perched Aquifer	0.001	based on empirical adjustment.

Method of Estimating Potential Evapotranspiration: Priestly Taylor (PT)

Priestly Taylor Canopy Interception: Not Modeled

Snowpack: Not Modeled

Till Perching: Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Blaney Criddle % of Annual Light (d)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Priestly Taylor Net Radiation (RN)	0.24	1.85	4.81	8.32	11.74	13.25	13.72	11.11	7.08	3.03	0.65	-0.13	6.33
Potential Evapotranspiration (PET)	0.06	0.42	1.28	2.33	3.64	4.19	4.61	3.77	2.21	0.89	0.17	0.00	23.56
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Soil Moisture in Root Zone (SW)	0.96	0.95	0.92	0.88	0.47	0.31	0.27	0.29	0.43	0.89	0.95	0.96	0.69
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	1.60	2.39	3.70	2.40	0.00	0.00	0.00	0.00	10.09
Actual Evapotranspiration (AET)	0.06	0.42	1.28	2.33	2.30	1.74	0.85	1.20	1.88	0.89	0.17	0.00	13.12
Shallow Recharge (RS)*	4.38	4.05	4.31	3.71	0.95	0.00	0.00	0.00	0.00	2.11	3.48	4.05	27.04
Perched Subflow (PS)*	0.71	0.71	0.67	0.33	0.02	0.00	0.00	0.00	0.00	0.00	0.17	0.48	3.08
Deep Recharge (RD)*	3.67	3.34	3.65	3.39	0.93	0.00	0.00	0.00	0.00	2.10	3.32	3.56	23.96

ANNUAL SUMMARY	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
	44.63	N/A	N/A	44.63	4.46	40.17	23.56	13.12	27.04	3.08	23.96

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Table D-5 Recharge / Water Balance for the Maury Island: Category 4 - Grass with no Till

Vegetation Data	
Type of Land Cover	grass
Rooting Depth	24 in
Priestly Taylor "Alpha"	N/A
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data	
Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data		
Avg. Soil Available Water Capacity (AWC)	0.09	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till (Not Used in Model)	100	
Till Thickness (Not Used in Model)	20	
Vertical Hydraulic Conductivity of Till	N/A	
Specific Yield of Perched Aquifer	N/A	
Darcy Flow Coefficient for Perched Aquifer	N/A	

Method of Estimating Potential Evapotranspiration: Blaney Criddle (BC)
Priestly Taylor Canopy Interception: Not Modeled
Snowpack: Not Modeled
Till Perching: Not Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	0.49	0.57	0.73	0.85	0.90	0.92	0.92	0.92	0.87	0.79	0.67	0.55	0.77
Blaney Criddle % of Annual Light (d)	0.064	0.065	0.082	0.091	0.103	0.105	0.106	0.097	0.084	0.076	0.064	0.061	1.00
Priestly Taylor Net Radiation (RN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potential Evapotranspiration (PET)	0.42	0.61	1.22	2.11	3.21	4.04	4.51	4.32	3.01	1.82	0.91	0.56	26.75
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	1.17	2.24	3.60	2.95	0.76	0.00	0.00	0.00	10.72
Actual Evapotranspiration (AET)	0.42	0.61	1.22	2.11	2.68	2.13	1.28	1.13	1.36	1.66	0.91	0.56	16.06
Shallow Recharge (RS)*	5.38	3.71	2.62	0.44	0.00	0.00	0.00	0.00	0.00	0.78	5.36	5.81	24.10
Perched Subflow (PS)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep Recharge (RD)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ANNUAL SUMMARY	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
	44.63	N/A	N/A	44.63	4.46	40.17	26.75	16.06	24.10	N/A	N/A

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Table D-6 Recharge / Water Balance for the Maury Island: Category 5 - Mixed Trees with no Till

Vegetation Data

Type of Land Cover	mixed trees
Rooting Depth	36 in
Priestly Taylor "Alpha"	N/A
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data

Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data

Avg. Soil Available Water Capacity (AWC)	0.08	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till (Not Used in Model)	100	
Till Thickness (Not Used in Model)	20	
Vertical Hydraulic Conductivity of Till	N/A	
Specific Yield of Perched Aquifer	N/A	
Darcy Flow Coefficient for Perched Aquifer	N/A	

Method of Estimating Potential Evapotranspiration: Blaney Criddle (BC) **Priestly Taylor Canopy Interception:** Not Modeled **Snowpack:** Not Modeled **Till Perching:** Not Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	0.40	0.49	0.63	0.74	0.70	0.74	0.74	0.67	0.52	0.55	0.49	0.40	0.59
Blaney Criddle % of Annual Light (d)	0.064	0.065	0.082	0.091	0.103	0.105	0.106	0.097	0.084	0.076	0.064	0.061	1.00
Priestly Taylor Net Radiation (RN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potential Evapotranspiration (PET)	0.35	0.53	1.06	1.83	2.49	3.27	3.63	3.16	1.80	1.27	0.66	0.40	20.44
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Average Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Average Soil Moisture in Soil Profile (SW)	2.92	2.92	2.90	2.87	2.60	2.03	1.31	1.00	1.65	2.78	2.91	2.92	2.40
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	0.45	1.47	2.71	1.80	0.00	0.00	0.00	0.00	6.43
Actual Evapotranspiration (AET)	0.35	0.53	1.06	1.83	2.29	2.19	1.70	1.13	0.96	1.21	0.66	0.40	14.31
Shallow Recharge (RS)*	5.46	3.79	2.78	0.71	0.00	0.00	0.00	0.00	0.00	1.51	5.62	5.97	25.85
Perched Subflow (PS)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep Recharge (RD)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ANNUAL SUMMARY	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
	44.63	N/A	N/A	44.63	4.46	40.17	20.44	14.31	25.85	N/A	N/A

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Recharge / Water Balance for the Maury Island: Category 6b - Barren with no Till

Vegetation Data	
Type of Land Cover	barren
Rooting Depth	12 in
Priestly Taylor "Alpha"	1
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data	
Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data		
Avg. Soil Available Water Capacity (AWC)	0.08	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till (Not Used in Model)	100	
Till Thickness (Not Used in Model)	20	
Vertical Hydraulic Conductivity of Till	N/A	
Specific Yield of Perched Aquifer	N/A	
Darcy Flow Coefficient for Perched Aquifer	N/A	

Method of Estimating Potential Evapotranspiration: Priestly Taylor (PT)
Priestly Taylor Canopy Interception: Not Modeled
Snowpack: Not Modeled
Till Perching: Not Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Blaney Criddle % of Annual Light (d)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Priestly Taylor Net Radiation (RN)	0.24	1.85	4.81	8.32	11.74	13.25	13.72	11.11	7.08	3.03	0.65	-0.13	6.33
Potential Evapotranspiration (PET)	0.06	0.42	1.28	2.33	3.64	4.19	4.61	3.77	2.21	0.89	0.17	0.00	23.56
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	1.60	2.39	3.70	2.40	0.00	0.00	0.00	0.00	10.09
Actual Evapotranspiration (AET)	0.06	0.42	1.28	2.33	2.30	1.74	0.85	1.20	1.88	0.89	0.17	0.00	13.12
Shallow Recharge (RS)*	5.75	3.90	2.57	0.22	0.00	0.00	0.00	0.00	0.00	2.11	6.11	6.38	27.04
Perched Subflow (PS)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep Recharge (RD)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ANNUAL SUMMARY	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
	44.63	N/A	N/A	44.63	4.46	40.17	23.56	13.12	27.04	N/A	N/A

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Recharge / Water Balance for the Maury Island: Category 5x - Conifers with no Till

Vegetation Data	
Type of Land Cover	mature conifers
Rooting Depth	36 in
Priestly Taylor "Alpha"	N/A
Average Annual Fractional Foliar Cover	N/A
Average Annual Foliar Interception Capacity	N/A

Weather Station Data	
Nearest Weather Station	Seatac Airport
Average Precipitation	37.2 in/yr
Avg Annual Temperature	59.2 °F
Latitude	47.45 °N
Longitude	-121.72 °W
Elevation	400 feet msl

Soil and Water Data		
Avg. Soil Available Water Capacity (AWC)	0.08	inch/inch within root zone, based on SCS soil d
Ratio of Site:Weather-Station Precipitation	120%	of official station, based on PGG linear regress
Resulting "Effective" Precipitation (P)	44.6	in/yr (annual average)
Portion of "P" going to immediate runoff*	10%	of effective precipitation, based on high perme
Rate of Snow Ablation (SA)	N/A	
Snowmelt Rate Coefficieint	N/A	
Depth to Till (Not Used in Model)	100	
Till Thickness (Not Used in Model)	20	
Vertical Hydraulic Conductivity of Till	N/A	
Specific Yield of Perched Aquifer	N/A	
Darcy Flow Coefficient for Perched Aquifer	N/A	

Method of Estimating Potential Evapotranspiration: Blaney Criddle (BC)

Priestly Taylor Canopy Interception: Not Modeled

Snowpack: Not Modeled

Till Perching: Not Modeled

RECHARGE CALCULATOR:

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
Evaporation Estimates													
Monthly Temp (T, °F)	38.4	41.3	44.6	49.9	54.9	59.4	62.0	62.9	58.9	52.0	45.2	41.3	50.9
Monthly Temp (T, °C)	3.6	5.2	7.0	9.9	12.7	15.2	16.6	17.2	14.9	11.1	7.3	5.1	10.5
Blaney Criddle Crop Factor (k)	0.63	0.73	0.86	0.85	0.52	0.53	0.53	0.53	0.50	0.80	0.78	0.64	0.66
Blaney Criddle % of Annual Light (d)	0.064	0.065	0.082	0.091	0.103	0.105	0.106	0.097	0.084	0.076	0.064	0.061	1.00
Priestly Taylor Net Radiation (RN)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Potential Evapotranspiration (PET)	0.55	0.78	1.44	2.11	1.85	2.32	2.59	2.48	1.73	1.85	1.06	0.65	19.40
Water Balance													
Effective Precipitation (P)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Interception Loss (IL)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowpack Storage (SS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	- - -
Snowpack Ablation (SA)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Snowmelt (SM)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AvailableThroughfall (ATF)	6.46	4.79	4.25	2.80	2.04	1.80	0.91	1.37	2.26	3.88	7.00	7.09	44.63
Runoff (RO)	0.65	0.48	0.42	0.28	0.20	0.18	0.09	0.14	0.23	0.39	0.70	0.71	4.46
Infiltration (I)	5.81	4.31	3.82	2.52	1.84	1.62	0.82	1.23	2.03	3.49	6.30	6.38	40.17
Soil Moistue Deficit (PET-P)	0.00	0.00	0.00	0.00	0.00	0.52	1.68	1.11	0.00	0.00	0.00	0.00	3.31
Actual Evapotranspiration (AET)	0.55	0.78	1.44	2.11	1.85	2.12	1.74	1.24	1.09	1.79	1.06	0.65	16.41
Shallow Recharge (RS)*	5.26	3.54	2.40	0.43	0.00	0.00	0.00	0.00	0.00	1.18	5.22	5.72	23.75
Perched Subflow (PS)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Deep Recharge (RD)*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ANNUAL SUMMARY	P	IL	SM	ATF	RO	I	PET	AET	RS	PS	RD
	44.63	N/A	N/A	44.63	4.46	40.17	19.40	16.41	23.75	N/A	N/A

NOTES:
All values used in the Evaporation Estimates, Water Balance, and Annual Summary are in inches unless otherwise noted.
Abbreviations used in the annual summary are defined in the Evaporation Estimates and Water Balance.
* Modeled runoff consists of the sum of the fixed percentage of effective precipitation going to runoff and any infiltration rejected when saturation reaches the land surface.
** Shallow recharge is water that flows either to the shallow water table or through the bottom of the root zone (infiltration minus actual evapotranspiration from soil).
Deep recharge is water that flows through the till layer. Perched subflow is lateral, saturated flow above the till layer to adjacent discharge points.

Appendix E

Appendix E

Maury Island Vadose Zone Modeling with Hydrus-2D

Pacific Groundwater Group

Appendix E
Maury Island Vadose Zone Modeling with Hydrus-2D

1 Method Overview

A variably saturated flow model of the unsaturated zone overlying the water table at the proposed mine site was developed. The model was used to analyze lagging and dampening of the recharge pulse between the land surface and the water table under two conditions:

1. Current condition: 300 feet from land surface to water table.
2. Excavated condition: 15 feet from land surface to water table.

PGG reviewed grain size analyses of soil samples obtained from the proposed mine site during investigative drilling to characterize sedimentary texture. Two models were developed using the variably saturated, finite element flow model "Hydrus-2D" to simulate each thickness of vadose zone (Simunek, 1999). This appendix describes characterization of sedimentary texture in the vadose zone, design of the variably saturated flow model, and the modeling approach.

2 Characterization of Sedimentary Texture

Grain size analyses were summarized from 34 samples from wells on or near the proposed mine site. Thirty samples were collected by AESI during the drilling of on-site wells OBW-1 and OBW-2 (AESI, 1998). AESI's samples were obtained during air rotary drilling from the settling cyclone. The two wells penetrated between 244 and 305 feet of vadose zone before intercepting the water table. Four samples were analyzed by PGG following the drilling of additional project wells. The samples were collected from relatively finer-grained intervals using Shelby tubes. Rosa Environmental Laboratories of Seattle, Washington analyzed the samples for grain-size distribution and various saturated and unsaturated parameters.

PGG's Shelby tube samples were generally collected from the finer-grained sedimentary layers encountered while drilling. Drive samples were initially used to evaluate for possible perched water intervals during drilling process. No perched water was observed. The four Shelby tube samples described in this appendix were selected for laboratory analysis because they were collected from a variety of elevations above the water table.

The grain size analyses for all 34 samples were performed down to the USDA upper limit grain-size for silt (75 micron mesh); thus, silt and clay were lumped into one category. Review of the AESI data showed silt/clay contents generally ranging from 1.5 to 12 percent, whereas PGG's data showed three samples with silt/clay contents ranging from 9 to 20 percent. The fourth PGG sample (83% silt/clay) was disregarded as it was obtained from a silt lens encountered in the vertical profile. A summary of the grain-size analyses is presented in Table E-1.

Based on the available data and considering the multiple objectives of PGG's samples (i.e., perched water identification *and* physical property testing), a "representative vadose zone profile" was constructed with silt/clay contents ranging from 2 to 12 percent. Hydrus-2D supports the U. S. Soil Salinity Laboratory's "neural network" computer program "Rosetta" to estimate soil-moisture characteristic curves and hydraulic conductivity distributions based on grain-size distributions.

Rosetta draws upon the USDA's "UNSODA" soil property database[1] to derive relationships between easily measured grain-size (and other) information and the key parameters required to approximate soil-moisture characteristic curves and unsaturated hydraulic conductivity distributions using the methods of van Genuchten (1980) and Mualem (1976). Because Rosetta requires separation of silt and clay contents, PGG reviewed grain-size data from 153 soil samples characterized as "sand" in the UNSODA database to approximate a general, representative relationship between silt and clay contents. Figure E-1 shows that while overall correlation was poor, a definite linearly increasing relationship could be discerned. Based on this relationship, PGG divided the silt/clay fraction into 60% silt and 40% clay. The following table shows the sand, silt, and clay contents of the representative vadose zone profile.

Interval Bottom Depth (ft)	120	138	156	174	192	210	228	246	264	282	300
Percent Sand	98	97	96	95	94	93	92	91	90	89	88
Percent Silt	1.2	1.8	2.4	3	3.6	4.2	4.8	5.4	6	6.6	7.2
Percent Clay	0.8	1.2	1.6	2	2.4	2.8	3.2	3.6	4	4.4	4.8

3 Design of Hydrus-2D Model

The Hydrus-2D model was setup to simulate a 300-foot vertical profile of the vadose zone. The profile analysis requires only a one-dimensional simulation, and Hydrus-2D's finite element grid was set up to most closely approximate a purely 1-D solution. Two columns of nodes were specified with a horizontal separation of 15 cm (6 inches). The upper 150 cm (6 feet) of the profile was assigned relatively detailed nodal definition, with vertical nodal spacings gradually increasing from 1 cm (0.4 inches) at the land surface to 5 cm (2 inches). Below this, vertical spacings were transitioned to a maximum value of 15 cm (6 inches). Eleven soil property zones occupied the vertical profile, with silt and clay content increasing with depth as shown in the table above. The top two nodes (representing the land surface) were assigned the specified flux boundaries. The bottom two nodes were assigned the "free drainage" boundary condition, which simulates a unit vertical hydraulic gradient. "Observation nodes" were specified every 50 feet in the vertical profile, from which hydrographs of water content (or head) vs. time could be extracted. Time-series data for volumetric flow rates exiting the bottom of the model domain at the free drainage boundary nodes could also be extracted.

Modeled hydraulic properties for the eleven soil property zones were generated with Rosetta, based on the percentages of sand, silt and clay discussed in Section 2 of this appendix. Rosetta provides estimates of five parameters used to generate the soil moisture characteristic curve: saturated water content, residual water content, "alpha", "N", and "M" (van Genuchten, 1980). Rosetta sets "M" equal to 1-1/N, as recommended. Rosetta also provides an estimate of saturated hydraulic conductivity and a factor "L" used to relate the characteristic curve to the unsaturated hydraulic conductivity curve (Mualem, 1976). An "L" value of 0.5 is typically recommended, and was used in this analysis. Table E-2 presents the hydraulic parameters used generated by Rosetta for the eleven soil types.

Modeled specified flux boundaries at the land surface were assigned PGG estimates of monthly recharge for mine land-cover with no underlying till as described in Appendix D. Because the goal of the modeling exercise is to evaluate time lag as a function of depth, average monthly recharge

[1] The UNSODA database catalogs soil properties based upon rigorous and detailed textural and hydraulic property testing from 790 soil samples.

values for non-till covered areas are preferred. The non-till recharge schedule exhibits sharper peaks and troughs than the till recharge schedule, and thus will be better for discerning time lag. In addition, the proposed mine site is less than half-covered with till, and would have zero till cover if ultimately excavated.

The model design was modified to represent the post-excavation scenario. A total thickness of 480 cm (15.7 feet) was simulated, with the same detailed nodal spacing retained in the top 150 cm (6 feet) and 15 cm spacing below. Hydraulic properties were set uniformly to those used in the bottom 18 feet of the base-case (300-foot) scenario. The top of the domain was assigned the same recharge stresses applied to the specified flux nodes as in the base-case scenario. Observation points were placed at the top, middle, and bottom of the flow domain.

4 Modeling Approach

Hydrus-2D was first used run a base-case scenario for comparison with the post-excavation scenario. The base case simulated the entire 300-foot thickness of vadose zone with the model setup described above. First, a steady-state water-content distribution was simulated by applying the annual average recharge rate to the top of the model. Several different initial conditions were used to establish that local minima did not prevent arrival at a unique solution. A transient simulation was then performed in order to reach a "cyclic steady state" of annual water-content fluctuation. Monthly stress periods were be used, and monthly recharge estimates were applied to the top of the model over a twenty-year time period. Hydrographs of water content vs. time were used to determine that recurrent water content fluctuations occur at the observation points from year-to-year (thus a cyclic steady state has been reached). Soil hydraulic conductivity values were adjusted (doubled relative to those presented above) to evaluate the sensitivity of the model to this parameter. In doing so, the soil moisture characteristic curves remained unaltered but the simulated unsaturated hydraulic conductivity distributions shifted proportionally with saturated hydraulic conductivity (based on the method of Mualem (1976)).

5 References

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van Genuchten, M. Th. 1980. "A Closed Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils." *Soil Science Society of America Journal*, 44, 892

Table E-1 Summary of Soil Samples Used to Construct Representative Soil Texture Profile

Well ID	Sample Depth (feet)	Sample Elevation (feet)	Saturation	% Gravel (>4mm)	% Sand (0.074-4mm)	% Silt+Clay (<0.074mm)	Soil Description
AESI OBW-1	15	277	vadose zone	36.9	57.4	5.7	damp, grayish brown, gravelly SAND with trace silt
AESI OBW-1	35	257	vadose zone	37	59.9	3.1	damp, grayish brown, gravelly SAND with trace silt
AESI OBW-1	55	237	vadose zone	48.8	38.9	12.3	damp, tan to brown, sandy GRAVEL with few silt
AESI OBW-1	75	217	vadose zone	59	37.2	3.8	damp, tan to brown, sandy GRAVEL with trace silt
AESI OBW-1	110	182	vadose zone	5.3	91.6	3.1	damp, grayish tan SAND with trace gravel & silt
AESI OBW-1	130	162	vadose zone	10.8	87.5	1.7	damp, grayish tan SAND with few gravel & trace silt
AESI OBW-1	150	142	vadose zone	3.1	94.2	2.7	damp, grayish tan SAND with trace gravel & silt
AESI OBW-1	170	122	vadose zone	5.6	92.9	1.5	damp, grayish tan SAND with trace gravel & silt
AESI OBW-1	190	102	vadose zone	0.1	93.9	6	damp, grayish tan SAND with trace silt
AESI OBW-1	210	82	vadose zone	0.1	96.8	3.1	damp, grayish tan SAND with trace silt
AESI OBW-1	230	62	vadose zone	0	96.2	3.8	damp, grayish tan SAND with trace silt
AESI OBW-1	250	42	saturated	0	91.9	8.1	damp, grayish tan SAND with few silt
AESI OBW-1	270	22	saturated	0.6	83.4	16	wet, grayish tan SAND with silt
AESI OBW-1	300	-8	saturated	0	49.3	50.7	wet, gray, sandy SILT
AESI OBW-2	15	334	vadose zone	55.5	40.2	4.3	wet, tan to brown, sandy GRAVEL with trace silt
AESI OBW-2	40	309	vadose zone	60.7	37	2.3	wet, tan to brown, sandy GRAVEL with trace silt
AESI OBW-2	60	289	vadose zone	57.1	39.9	3	moist, tan to brown, sandy GRAVEL with trace silt
AESI OBW-2	70	279	vadose zone	36.8	61	2.2	moist, tan to brown, gravelly SAND with trace silt
AESI OBW-2	85	264	vadose zone	77.7	19.8	2.5	moist, tan to brown, sandy GRAVEL with trace silt
AESI OBW-2	120	229	vadose zone	1	97.5	1.5	damp, grayish tan SAND with trace gravel & silt
AESI OBW-2	140	209	vadose zone	8.3	90.1	1.6	damp, grayish tan SAND with few gravel & trace silt
AESI OBW-2	160	189	vadose zone	10.2	88.4	1.4	damp, grayish tan SAND with few gravel & trace silt
AESI OBW-2	200	149	vadose zone	0.1	97.3	2.6	damp, grayish tan SAND with trace silt
AESI OBW-2	220	129	vadose zone	5.4	92.6	2	damp, grayish tan SAND with trace gravel & silt
AESI OBW-2	240	109	vadose zone	0	98.4	1.6	damp, grayish tan SAND with trace silt
AESI OBW-2	260	89	vadose zone	0	98.3	1.7	damp, grayish tan SAND with trace silt
AESI OBW-2	280	69	vadose zone	0	62.8	37.2	damp, grayish tan SAND with silt
AESI OBW-2	300	49	vadose zone	0	91.9	8.1	damp, grayish tan SAND with few silt
PGG MW-1	79	181	vadose zone	0	91.2	8.8	dry to moist, brown, silty, medium SAND
PGG MW-1	159	101	vadose zone	0	88.8	11.2	dry to moist, brown, silty, fine to medium SAND
PGG MW-1	179	81	vadose zone	0	17.4	82.6	wet , brown, very sandy SILT*
PGG MW-4	40	120	vadose zone	0.3	80	19.7	dry to moist, brown, silty, fine to medium SAND

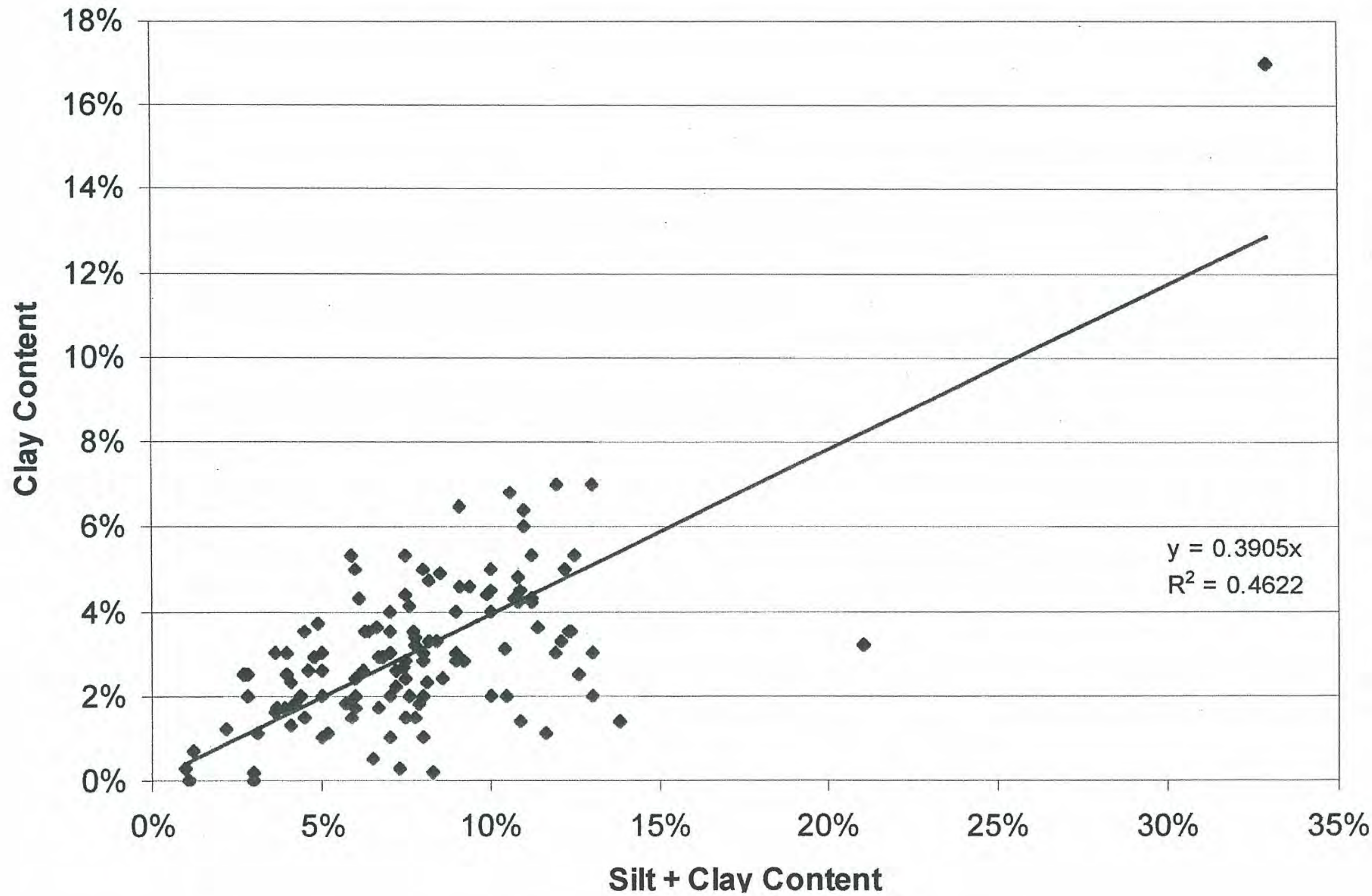
* represents rare silty zone above WT

Table E-2 Summary of Hydraulic Parameters Used for Soils in the Hydrus-2D Model

Sand Content	Silt Content	Clay Content	Saturated Water Content	Residual Water Content	"alpha" (1/cm)	"N"	Saturated Hydraulic Conductivity (cm/sec)
98%	1.2%	0.8%	37.7%	5.1%	0.0342	4.00	1.3E-02
97%	1.8%	1.2%	37.8%	5.1%	0.0342	3.80	1.1E-02
96%	2.4%	1.6%	37.8%	5.1%	0.0341	3.60	9.9E-03
95%	3.0%	2.0%	37.8%	5.1%	0.0342	3.41	8.6E-03
94%	3.6%	2.4%	37.8%	5.1%	0.0342	3.22	7.4E-03
93%	4.2%	2.8%	37.8%	5.1%	0.0344	3.04	6.3E-03
92%	4.8%	3.2%	37.9%	5.0%	0.0345	2.87	5.4E-03
91%	5.4%	3.6%	37.9%	5.0%	0.0348	2.71	4.6E-03
90%	6.0%	4.0%	37.9%	4.9%	0.035	2.55	3.9E-03
89%	6.6%	4.4%	37.9%	4.9%	0.0353	2.42	3.3E-03
88%	7.2%	4.8%	38.0%	4.8%	0.0356	2.29	2.8E-03

Note: saturated hydraulic conductivity values were doubled during sensitivity analysis.

Figure E-1 Comparison of Clay vs. Silt+Clay Content from UNSODA Database



Appendix F

Appendix F

Formulation of General Head Boundaries for the Maury Groundwater Flow Model

Pacific Groundwater Group

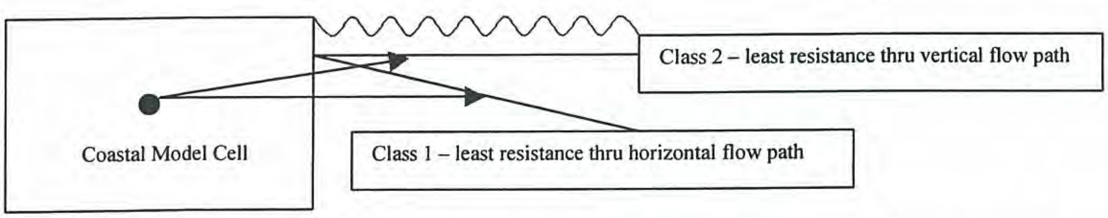
Appendix F
Formulation of General Head Boundaries

General head boundaries were used to represent the hydraulic connection between the lower permeability interglacial deposits (***Qpvu*** aquitard) and surrounding marine bodies. In layer 2, all cells seaward of the coast were defined as inactive. The adjacent (inland) active cells all have a connection with the sea, however the thickness and permeability of the intervening sediments varies among different stretches of coastline. General head boundaries simulate hydraulic connection between the center of a model cell and a distant constant head condition by specifying:

1. the distance to the constant head condition;
2. the value of constant head condition (e.g., 10 feet mean sea level); and
3. the cross-sectional area and hydraulic conductivity of the materials which lie between the model cell and the constant head condition.

MODFLOW calculates flow to/from the constant head condition as directly proportional to the difference between head at the model cell and the distant constant head value. Aquifer storage between these two points is not taken into account using the general head boundary condition.

Two different classes of hydraulic connection were identified for formulation of the general head condition based on bathymetry (topography of the ocean floor). In class 1, a predominantly horizontal pathway provides the least resistance for groundwater discharge to the sea. In this case, the sea floor dips steeply away from the coast, and penetrates much of the ***Qpvu*** aquitard. In class 2, discharge is estimated to occur more through vertical movement up through the sea floor sediments. This occurs where the sea floor is relatively shallow and does not penetrate much of the ***Qvpu*** thickness. The following schematic diagram demonstrates the distinction to these two classes.



Each coastal cell in layer 2 was assigned to one of these two classes. In addition, for the purpose of calculation, each cell was assigned to one of three "types" depending on whether the coastal exposure occurred along a model row direction, column direction, or on two sides of the model cell. Cell dimensions, bottom and top elevations, "classes", "types", and distances between model cells and sea floor exposures were maintained in a central speadsheet for calculation of boundary condition parameters.

Analysis of the model grid showed that the midpoint elevation of the saturated portion of layer 2 ranged from –35 to –185 feet mean sea level (msl). It was assumed that the average midpoint elevation was –100 feet. For Class 1 cells, the distance to the marine exposure (i.e., to the constant head) was approximated by the distance from the coast to the –100 foot bathymetric contour plus half the cell's row (or column) width. For Class 2 cells, the distance to the marine exposure was approximated by the hypotenuse of the vertical distance between the sea floor elevation and the average midpoint elevation and the horizontal distance of half the row (or column) width.

Cross sectional areas were assumed equal to the row (or column) width times the saturated thickness of layer 2. Where marine exposure occurred on both the row and column face of a cell, the two cross sectional areas were summed. Hydraulic conductivity values for class 1 cells were assumed equal to the horizontal hydraulic conductivity of layer 2. Hydraulic conductivity values for class 2 cells were assumed equal to the vertical hydraulic conductivity of model layer 2. Head values were defined based on the saltwater heads at the assumed depth of the aquifer/seawater interface.

Three reaches of general head boundaries were defined, as shown in the following table. Based on the assumptions described above, spreadsheet analysis was performed to assign general head boundary parameters for all cells. Example calculations from the general head boundary conditions spreadsheet are shown on Table F-1.

Reach #	Location	Connection	Distance
1	Lower 2/3 of SE Coast	Horizontal	600 ft
2	Upper 1/3 of SE Coast, N Coast, S Coast	Horizontal	1300 ft
3	W Coast	Vertical	75 ft

Table F-1 Example of General Head Boundary Calculation Spreadsheet

Kh in ft/d	0.61	Kh in cm/s	2.2E-04	Kz iin ft/d	0.0061	Kz in cm/s	2.2E-06

Row	Column	Row Width	Column Width	Final Revised L1-Bot	Final L2 Bottom	Layer 2 Midpoint	Layer 2 Saturated Thickness	Layer 2 Exposed Face	Layer 2 Coastal Reach	Distance	Width	K in ft/d	Head
1	21	500	200	-10	-250	-130	240	3	3	193	700	0.006	0.625
1	22	500	200	-10	-250	-130	240	1	3	261	200	0.006	0.625
1	23	500	200	-10	-260	-135	250	3	3	193	700	0.006	0.625
1	62	500	500	10	-350	-175	350	2	3	261	500	0.006	0.625
1	71	500	600	80	-300	-150	300	2	2	1600	500	0.609	2.5
2	19	500	200	0	-240	-120	240	1	3	261	200	0.006	0.625
2	20	500	200	0	-240	-120	240	1	3	261	200	0.006	0.625
2	24	500	200	-10	-250	-130	240	1	3	261	200	0.006	0.625
2	25	500	200	-10	-250	-130	240	3	3	193	700	0.006	0.625
2	62	500	500	50	-340	-170	340	2	3	261	500	0.006	0.625
2	72	500	600	50	-290	-145	290	3	2	1575	1100	0.609	2.5
3	17	500	300	20	-230	-115	230	3	3	214	800	0.006	0.625
3	18	500	300	20	-230	-115	230	3	1	800	800	0.609	2.5
3	25	500	200	-10	-240	-125	230	2	3	125	500	0.006	0.625
3	51	500	300	0	-320	-160	320	3	3	214	800	0.006	0.625
3	52	500	300	0	-330	-165	330	1	3	261	300	0.006	0.625
3	53	500	300	0	-340	-170	340	1	3	261	300	0.006	0.625
3	54	500	300	0	-340	-170	340	1	3	261	300	0.006	0.625
3	55	500	300	0	-340	-170	340	1	3	261	300	0.006	0.625
3	56	500	400	0	-350	-175	350	3	3	237	900	0.006	0.625
3	61	500	500	0	-330	-165	330	3	3	261	1000	0.006	0.625
3	72	500	600	120	-280	-140	280	2	2	1600	500	0.609	2.5
4	11	500	400	0	-200	-100	200	3	3	237	900	0.006	0.625
4	12	500	300	0	-200	-100	200	1	3	261	300	0.006	0.625
4	13	500	300	0	-210	-105	210	1	3	261	300	0.006	0.625
4	14	500	300	10	-210	-105	210	1	3	261	300	0.006	0.625
4	15	500	300	10	-210	-105	210	1	3	261	300	0.006	0.625
4	16	500	300	40	-210	-105	210	1	3	261	300	0.006	0.625

NOTES:

Exposed Face: 1 = exposed along column width; 2 = exposed along row width; 3 = exposed along both faces.

Coastal Reach: 1 = Southern 1/3 of SE Coast; 2 = N, S, and SE Coast Remainder; 3 = W Coast.

Appendix G

Appendix G

Review Comments from Dr. Thomas Harter for Three Interim Modeling Reports

Pacific
Groundwater
Group

Department of Land, Air, and Water Resources
University of California at Davis
9240 S. Riverbend Ave.
Parlier, CA 93648
(559) 646-6569
thharter@ucdavis.edu

Crispin Prahl,
Senior Hydrogeologist
Pacific Groundwater Group
2377 Eastlake Ave. East
Seattle, WA 98105

February 15, 2000

Re: Reviews #1 and # 2 of Maury Island Gravel Mining Impact Study

Dear Mr. Prahl:

Enclosed please find my technical and scientific reviews of the conceptual modeling approach taken by PGG for (1.) recharge estimation, modeling of flow in the unsaturated zone, and (2.) modeling of groundwater flow (hydrogeologic impact assessment).

Sincerely,

Thomas Harter, Ph.D.

Maury Island Gravel Mining Impact Study:
Review #1: Recharge and Unsaturated Flow Modeling Approach

The following discussion of the technical and scientific approach chosen by PGG for estimating recharge rates and the movement of moisture through the unsaturated (vadose) zone is based on a written report entitled "Interim Recharge Evaluation Summary", submitted January 13, 2000; a written report entitled "Maury Island Vadose Zone Model: Preliminary Design Report", submitted February 6, 2000; a complete set of computer files used for recharge estimation and unsaturated zone flow modeling; and extensive personal communications with Peter Schwartzman at PGG.

The objective of this review is to ensure that the approach chosen by PGG is scientifically and technically defensible and represents an unbiased effort that is reasonably exhaustive to achieve the objectives of the hydrogeologic impact assessment (Task 8. in the PGG project). The objectives of the assessment are "*to develop useful models that accurately portray recharge processes and the groundwater flow system. Also, to calibrate a groundwater flow model to best estimates of recharge, aquifer properties, and measured groundwater levels, and to use this model to assess the hydrogeologic impacts of altered recharge patterns associated with gravel-pit development/reclamation alternatives.*" [PGG Project Design, 1999]. Specifically, the modeling efforts are designed to perform predictive simulations to evaluate:

- *differences between impacts from the preferred mine development and reclamation conditions*
- *changes in groundwater flow patterns that could place domestic wells downgradient from the mine site*
- *potential mounding beneath the gravel pit that could allow groundwater levels to intersect the proposed mine floor elevation*
- *potential changes in spring discharge associated with the preferred mine alternatives*

[PGG Project Design]

For purposes of this Maury Island assessment, the most critical groundwater aquifer of interest is the uppermost, unconfined aquifer, particularly in the vicinity of the proposed project site. As is typical on islands of this size, the groundwater flow system is driven primarily by permeability of the aquifer material and by the temporal and spatial distribution of recharge from the land surface. On Maury Island, the depth to the water table of the unconfined aquifer is as much as 300 feet and a considerable time lag has been observed between the occurrence of recharge near the land surface and the change in water levels in the unconfined aquifer due to the time necessary for recharge water to travel through the (mostly sandy) deep vadose zone (the unsaturated sediments above the water table of the unconfined aquifer). The overall modeling approach to assess the hydrogeologic impact of the proposed project therefore consists of three distinct conceptual stages, each implemented with its own computer model:

1. **Recharge Model:** Characterize the recharge rate to the deeper vadoze zone from the island's surface soils and the potential for perched horizontal flow above the (near-surface) till layer (pre- and post-project implementation);
2. **Deep Vadose Zone Model:** Characterize the time lag necessary for recharge water to travel from the near-surface area through the deep vadose zone the aquifer below and define the temporal recharge pattern to the unconfined aquifer below based on the deep vadose zone input calculated in stage 1. (pre- and post-project implementation)
3. **Groundwater Model:** Characterize the groundwater flow system before and after project implementation utilizing the recharge patterns determined from stage 2.

Review #1 covers the conceptual and technical implementation of the model design for stage 1. and stage 2.

1-1.: Recharge Model

Computation of the amount of recharge to the unconfined aquifer is critical for a good understanding of the groundwater flow patterns on Maury Island. Recharge from precipitation is the natural driving force in Maury Island's distinct groundwater dynamics. Just as precipitation varies throughout the year, the recharge rate to the deep vadose zone below the surface soil layer varies with time. Since no direct measurements exist of that deep recharge rate, the most common, and scientifically proven technique for the estimation of that recharge rate is to calculate it as the difference between the amount of precipitation (input) and the amount of runoff (to rivers) and evapotranspiration (to the atmosphere from the land surface). Adequate knowledge of precipitation, runoff, and evapotranspiration is therefore necessary to calculate recharge to below the soil horizon (and into the deep vadose zone).

On Maury Island, a limited amount of measurements are available for precipitation and runoff and no direct measurements of evapotranspiration (ET) exist. Precipitation is derived based on records from Vashon and Maury Island as well as complementary data from Seatac Airport. The use of linear correlation between the island records and the Seatac airport records as a means to extend the short-term precipitation record of Maury Island is technically the best available approach and entirely appropriate within the scope of this assessment.

The amount of runoff from the island (other than spring flow) is known to be relatively small, but has not been measured in the past. Based on experience in similar watersheds, observations on Maury Island, and the existing coarse soil texture (high infiltration capacity), the assumption that approximately 10% of the effective precipitation is converted to runoff seems justified. Even if actual runoff were as little as 5% or as much as 15% of the total precipitation, it would have only a small effect on the amount of deep recharge computed.

The amount of evapotranspiration (including losses from interception) is the most critical variable for estimating deep recharge, since approximately half of the average precipitation is lost to ET. Evapotranspiration is controlled by a number of factors such as temperature, sunshine, root depth, plant type, soil field capacity, soil wilting point, etc. While climate variables can be safely assumed to be the same for the entire island, plant land cover and soil types vary across the study area. The proposed division into three major land covers (grass land, forest land, and mine site) is a reasonable distinction given the scope of the study although the land cover analysis does not distinguish between deciduous trees and evergreen conifers. Given the data available for the two major soil series on Maury Island and the overall similarity in their (relatively low) available water content, it is also prudent design to consider one composite soil profile that only distinguishes between those sites that are underlain by a shallow till layer and those that are not. This results in six major ET classifications and, hence, six recharge classes, which are mapped by GIS overlay of the soil and land cover maps: three land covers by two soil series.

The computation of the actual ET for the six recharge classes using Blaney-Criddle (1970) and Priestley-Taylor (1972) is more than sufficient for the proposed modeling efforts (see discussion in Maidment, 1992). The preliminary results show that annual actual ET varies little between the different land cover units. Hence, the annual amount of groundwater recharge across the island is relatively uniform. However, the presence of a shallow till layer significantly dampens the month to month variations observed in in the recharge to the deep vadose zone below the till layer, when compared to soils with no till layer.

The shallow till layer must also be considered for its potential to spatially redistribute some of the recharge. The presence of the till layer may result in a very shallow, perched aquifer just beneath the land surface, if the low vertical hydraulic conductivity of the till layer temporarily prevents sufficient seepage into the deeper vadose zone. If, in addition, a significant horizontal gradient and high hydraulic conductivity exist within the perched aquifer, significant horizontal movement may occur across the till layer. This situation may occur, for example, above the till layer at and surrounding the project site in the central part of the island (see Surficial Geological Map, AESI, 1999). The recharge model allows for computation of a shallow perched aquifer, based on a simple mass balance procedure, when tracking moisture flow through the vertical soil and till profile.

Whether or not perching occurs and whether or not perched groundwater experiences significant horizontal flow is primarily a function of the vertical conductivity of the till, and the horizontal K of the overlying soils material. From several simplified considerations, the critical hydraulic conductivity values for vertical K in the till and horizontal K in the overlying soils can be derived (see Figure 1):

1. Vertical K in the till: perching over a significant period of time (more than 1 month) will occur when the vertical hydraulic conductivity is smaller than the monthly shallow recharge from the soil above during the season with the highest precipitation (winter). From the recharge to the deep vadose zone predicted for the no-till model, it appears that the highest recharge rates during the winter months are approximately 5 to 6 inches per month (1/60th ft/d). Hence, vertical K values much smaller than 0.01 ft/d would result in significant perching. Values as small as 0.001 - 0.005 ft/d are plausible vertical K values for till.

2. Horizontal K in the soil layer above the till: Significant horizontal movement of water will only occur when water is perched on top of the till. However, since ponding of water is not observed at the land surface, the perched water table does not exceed thicknesses of approximately 3 feet (the average thickness of the soil layer) and is unlikely to exceed even 2 feet on an average winter month (no field measurements seem currently available). Hence, if water is perched, the Darcian flux horizontally across the till layer must provide sufficient flow for recharge water to be transported away from the till, otherwise water would pond at the land surface. For purposes of this assessment, horizontal movement of water would only be significant - if at all - if the horizontal movement of perched water would result in a significant redistribution of the recharge water to groundwater. The horizontally moving water would discharge over the downslope edge of the till layer. There, the discharge would provide localized high recharge rates into the deeper unsaturated zone and the aquifer. A potentially significant amount would be any discharge over the edge of the till representing more than 10% of the recharge to the contributing area.

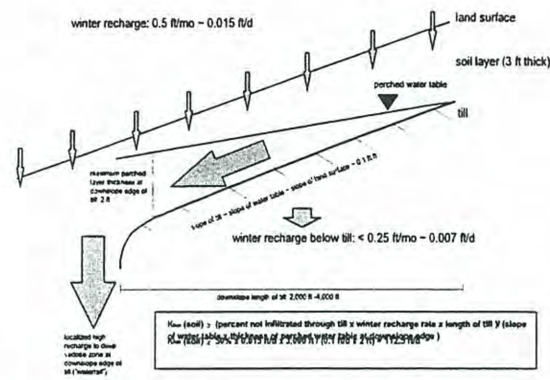


Figure 1: Simplified cross-section through shallow soil and till layer illustrating the potential horizontal redistribution of recharge. Values given are approximate.

The central area of the island that is covered with till is approximately 2,000 to 4,000 feet wide and slopes to the W and N. The land surface slopes at approximately 10%. These numbers are approximate but sufficient for illustration. If 10% of the annual recharge (approximately 2 feet) onto the till layer is to be moved across the edge of the till, then 0.1 x 2 feet x 2,000 ft length x 1ft width = 400 ft^3 of water must be discharged per foot downslope perimeter of the till every year or approximately 1 ft^3/d. At a 10% slope and 2 ft perched thickness, this is achieved with a hydraulic conductivity of 5 ft/d. This estimate, however, is low, because it assumes constant recharge throughout the year. During the winter month, when most recharge occurs, water must be transported rapidly across the till to avoid perching to the land surface (which has not been observed). If at least half of the winter month's shallow recharge (0.5 ft/month) is discharged across the edge of the till layer, then 0.5 x 0.5 ft/month x 2,000 ft length x 1 ft width = 500 ft^3 of water must be discharged per foot downslope perimeter of the till each winter month or approximately 20 ft^3/d. At a 10% slope and 2 ft perched thickness, this discharge (at the downslope edge of the till) is achieved with a hydraulic conductivity on the order of 100 ft/d (Darcy's law). Whether this is a potentially reasonable hydraulic conductivity within the project area, should be clarified in the project report.

If such high K is indeed conceivable, a significant amount of the recharge above the central till layer on Maury Island may move laterally across the shallow till layer and create a localized high aquifer recharge along the downslope perimeter of the till ("perimeter recharge"). The downslope perimeter is located on the west and northside of the central Maury Island till layer. The proposed project would remove a significant portion of the central till, thereby not only creating a temporal shift in recharge, but potentially also redistributing recharge that previously may have discharged predominantly further to W of the mining site at the downgradient edge of the till. The spatial shift in recharge distribution, if it indeed occurs, could potentially result in an eastward translocation of the water table divide with resulting shallower water table gradient and less groundwater discharge towards the westside of the island - at least locally. For the springs in the Dockton area, this could be considered a "worst-case" scenario. It would therefore be appropriate to clarify, whether significant horizontal movement across the till layer is possible, based on an evaluation of the soil layer hydraulic conductivity. If it is indeed a possible scenario, the potential for spatial redistribution of recharge from the till to its perimeter should be considered in the assessment (as indicated in the "Interim Recharge Evaluation Summary", p. 6).

1-2: Deep Vadose Zone Model

The review of the "Vadose Zone Model" is primarily based on the "Maury Island Vadose Zone Model Preliminary Design Report" submitted in January 2000; and personal communications (for clarification) between Peter Schwartzman and myself.

For the purposes of this review, "deep vadose zone" refers to the unsaturated zone between the water table and the bottom of the soil root zone or shallow till layer. The purpose of the vadose zone model is to estimate the monthly rate of recharge at the bottom of the unsaturated zone (water table), given the monthly rate of recharge from the shallow soil zone or till layer as defined by the "recharge model" (see above). In comparison to the the annual recharge cycle at the bottom of the root zone, the recharge cycle at the water table will be even more dampened. Most importantly, however, it will occur significantly later. The time lag between recharge into the deep vadose zone at the top and recharge to the water table at the bottom ("time lag") is related to dynamics of water flow in the vadose zone. The key question to answer with respect to the proposed project and the hydrogeologic assessment is: what is the relationship between time lag and depth to water table (or thickness of the deep vadose zone)? And how is it altered by the proposed removal of a significant portion of the vadose zone at the project site? The largest alteration of the time lag would occur, if the time lag is strongly depth dependent (e.g., increases linearly with depth). The proposed project would have the least impact, if most of the time lag occurs near the bottom 10' - 20' of the vadose zone (which will not be removed) due to the siltier sediments found there.

To answer these questions and to obtain a realistic estimate of water table recharge under the proposed project alternative, PGG is implementing a vadose zone model. The vadose zone model is based on the hydrodynamic flow principle governing water flow through the unsaturated (or vadose) zone. It works similar to a groundwater flow model in that the flow rate is governed by the hydraulic conductivity and the potentiometric gradient. However, unlike in groundwater, the hydraulic conductivity is not only a function of the sediment texture, but also of the moisture content and can therefore change over time. The moisture content, in turn, is a function of the (unsaturated) water potential (which defines the potentiometric gradient).

Hence, adequate knowledge of the relationship between hydraulic conductivity and moisture content ("hydraulic conductivity curve"), and between moisture content and water potential ("moisture retention curve") is critical to perform good estimation of the flow processes in the unsaturated zone. The two "curves" can be measured on sediment samples in the laboratory. They can also be reasonably well estimated from the grain size distribution ("sediment texture") of the sediment samples. A common approach is to measure the sediment texture and the moisture retention curve, and to estimate the unsaturated hydraulic conductivity curve from those measurements and measurement of the saturated hydraulic conductivity.

This is the approach taken by PGG. In addition, PGG has relied on borehole profiles describing the vertical distribution of sediment textures. The sedimentary stratigraphy in the unsaturated zone generally exhibits gradually finer sediments with depth. The coarsest, sandiest sediments are near the top of the deep vadose zone. Most of the siltier, clayier sediments are found near the bottom.

A vertical distribution of unsaturated hydraulic properties in the vadose zone is defined based on this generalized sedimentary architecture: Consistent with a number of borehole profiles, the silt and clay content near the bottom of the vadose zone is estimated to be 12%. At the top of the vadose zone it is estimated to be approximately 2%. Given the range of measured data, these estimates are appropriate approximations of the overall hydraulic properties in the vadose zone within the modeling area. Locally, there may be significant variations in clay and silt content (as indicated by the data that PGG obtained during drilling of two additional on-site wells). However, such small scale variations will be dampenend out over relatively short vertical distances. The impact of such small scale heterogeneity becomes negligible with respect to the behavior of the overall flow patterns in the underlying aquifer.

The % clay fraction is perhaps the most important fraction with respect to estimating the relationship between depth to water table and time lag observed between rainfall (recharge into the shallow soil) and recharge to the aquifer (as measured by well water levels). Available samples did not distinguish between the clay and silt fraction. PGG therefore utilized the USDA "UNSODA" database to determine the ratio of % silt to % clay in soil samples with similar textural properties as those sampled on Maury Island. While the ratio of silt to clay measured in typical sand samples varies, the bandwidth of the % silt : % clay ratio is relatively small, as shown in PGG's "Maury Island Vadose Zone Model, Preliminary Design Report": from about 85:15 to about 55:45. The value chosen based on the mean ratio, 60:40, is an appropriate value. It can later be confirmed or revised depending on whether the modeled time lag is consistent with measured time lags (reported in Carr, 1983). Carr's data suggest that the time lag to 50' is likely to be from 1 month to 3 months. The time lag to 100' should be on the order of 2 to 5 months. The time lag to 150' should be on the order of 4 to 7 months.

If the silt:clay ratio were significantly smaller (more clay), the time lag would increase, but be less depth dependent (since a good portion of the time lag is associated with only the lowest portion of the vadose zone). Hence, with a smaller silt:clay ratio, the removal of the upper portion of the vadose zone by the proposed project would be predicted to have less of an impact on the water table than if the silt:clay ratio were estimated to be larger. For purposes of the assessment, the "worst case" would be the smallest reasonable clay content (silt:clay = 0.85:0.15), in which case the time lag is strongly depth dependent and the largest difference would be observed between the current time lag and the time lag after project implementation. Whichever ratio is chosen for the model, the data collected by Carr (1983) seem to suggest a well defined outcome against which the model can be adjusted.

The saturated hydraulic conductivity (and, to some extent, the hydraulic conductivity curve) is the second model variable that will have a strong control onto the predicted time lag for a given depth. Measurements of this variable are available and the sensitivity of this variable to the predicted time lag results can be implemented using the proposed model. Again, Carr's data will provide a reasonable validation target.

The Hydrus-2D software used for implementing the vadose zone model is an internationally recognized software package that has been tested and validated in various research studies. Since the flow in the vadose zone is predominantly vertical, it is reasonable to setup the model domain as a one-dimensional, vertical column (although the software also allows two-dimensional simulations). Due to the nature of unsaturated flow, lateral movement is likely to be negligible with respect to defining the existing or future recharge patterns on the island (with the exception discussed under "recharge model").

The boundary conditions are mostly consistent with the conceptual model: a specified flux at the top represents the recharge rate defined by the "recharge model". The bottom boundary condition is suggested to be a "free drainage" boundary condition, which is appropriate to estimate the time lag to the top of the capillary fringe above the water table. Alternatively, a water table boundary condition (constant head) could be defined to estimate the time lag directly at the water table. Given the large depth of the vadose zone (300') relative to thickness of the capillary fringe.(~ 2-10'), the two boundary conditions will give similar results. However, for simulating the recharge underneath the future project, the water table boundary condition should be used at the bottom of the model domain (the current design suggests use of a free drainage boundary).

Grid discretization is appropriate for the choice of model parameters and consistent with general unsaturated zone flow modeling (see, e.g, Harter and Yeh, 1998). The modeling approach outlined in the design report is consistent with the overall objective of the vadose zone model, namely to determine the time lag and rate of recharge to water table based on the results from the "recharge model" and a thorough stratigraphic and hydrostratigraphic characterization of the vadose zone. I emphasize that, based on our modeling experiments with a variety of very heterogeneous vadose zones, I concur with PGG's suggestion that small scale heterogeneities in the stratigraphy of the Maury Island sediments (thin, non-extensive silt lenses within the sandier sediment packages) are irrelevant to estimating the time lag and recharge rate to the water table aquifer.

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Maury Island Gravel Mining Impact Study:
Review #2 of the Groundwater Modeling Approach

This review investigates the conceptual and technical-scientific merit of the groundwater flow model. The review is based on the PGG "Design Summary for the Maury Island Groundwater Flow Model" submitted in January 2000; on a number of geologic, bathymetric, topographic, land cover, soils, and hydrogeologic maps submitted with the report; on actual groundwater model files for Groundwater Vistas that have been submitted to me; and on personal communication with Peter Schwartzman and Crispin Prahl for clarification and additional background information.

The purpose of the groundwater flow model is to determine the impact of the proposed project on the groundwater flow dynamics of Maury Island. Specifically, the modeling efforts are designed to perform predictive simulations to evaluate:

- *differences between impacts from the preferred mine development and reclamation conditions*
- *changes in groundwater flow patterns that could place domestic wells downgradient from the mine site*
- *potential mounding beneath the gravel pit that could allow groundwater levels to intersect the proposed mine floor elevation*
- *potential changes in spring discharge associated with the preferred mine alternatives*

[PGG Project Design]

The groundwater model is primarily driven by two variables: the hydraulic conductivity (and its spatial distribution across the island and with depth), and the annually cyclical recharge rate at the water table (and its spatial distribution across the island). Other hydrogeologic parameters that influence the groundwater flow pattern on Maury Island are the geologic structure of the sediments (the sequence and shape of various geologic layers), the porosity of the sediments, and the geographic extent of the island, which define the boundary conditions of the groundwater system on Maury Island..

The recharge rate to the water table is estimated based on the recharge model and the vadose zone model, which have been discussed in the previous sections of this review. Here, I will focus on the conceptual model of the hydrogeology and its implementation in MODFLOW.

A good description of the island geology from borehole logs is a prerequisite to estimating the spatial distribution of aquifer hydraulic conductivity across the island . PGG relied on a number of existing reports describing the major sedimentary units on the island. The geologic documents were prepared by J. R. Carr / Associates, 1983; Derek Booth, USGS, 1991; and Terra Associates, 1999, to which I also had access.

The conceptual model proposed by PGG is essentially a six layer model, of which only three are an explicit part of the groundwater model. The upper three layers are modeled separately by the recharge and vadose zone models. The six model layers conform with the six most important stratigraphic units on the island:

1. the root zone or soil that has developed within the top 3-5 feet of the land surface,
2. a shallow lodgement till of the Vashon drift, "Qvt", (only in some parts of the island),
3. relatively thick advance outwash deposits of the Vashon drift, "Qva", consisting of gravels, sands and silty sands.
    - 3a. In the upper part, Qva is unsaturated (see "vadose zone model"),
    - 3b. while its lower portion forms the unconfined (water table) aquifer underlying the project site and a majority of Maury Island. It is the uppermost layer of the groundwater system underneath Maury Island (layer 1 of the groundwater model)
4. The Qva aquifer is bounded from below by thick, mostly lower permeable pre-Vashon interglacial deposits, "Qvp", which form a regional aquitard

(layer 2 of the groundwater model). The aquitard crops out at the periphery of Maury Island. In the central part of the island near and around the project site, the aquitard surface is located underneath sea-level such that the Qva aquifer is in direct hydraulic communication with the ocean. The bottom of the aquitard is several hundred feet below sea-level.

5. A deep, confined aquifer underneath the Qvp aquitard has been documented by few well logs (layer 3 of the groundwater model).

The primary concern of the assessment are changes in the unconfined Qva aquifer flow dynamics, particularly in the vicinity of the proposed project. The groundwater model must be able to resolve the particular subsurface hydraulics that will develop as a result of the mining activity. The proposed layering of the groundwater model into (from top to bottom) an unconfined aquifer (Qva), an aquitard (Qvp), and a conceptual deep aquifer that is here implemented as a constant head boundary (from below) is therefore appropriate. The lateral model discretization of 200 ft. at and nearby the proposed project site is adequate for modeling changes in recharge patterns on the island due to the proposed activities.

5. The proposed model submitted is somewhat inconsistent in the assignment of model layers relative to the conceptual three layers: Near the island margins, the model's top layer is assigned to the aquitard rather than the unconfined aquifer, supposedly because the Qva aquifer has been eroded away. This should have no significant effect on the modeling results. However, a more elegant model implementation is achieved by assigning top layer cells to Qva only and by inactivating layer 1 of the groundwater model, where is does not exist on the island. Layer 2 in its entirety, then, represents the interglacial deposits, Qvp, with significantly lower hydraulic conductivity than the much sandier Qva. Flow in the aquitard is primarily vertically downwards due to the post-development drawdown of water levels in the deep aquifer. Assigning geologic layers directly to model layers will make layer 2 cells become surface cells near the perimeter of the island, where the top layer has been eroded away. Currently, layer 2 (aquitard) is described as being modeled as confined. However, it should be modeled as variably confined/ unconfined aquifer.

Hydraulic properties of the groundwater model: The design summary designates a reasonable range of expected hydraulic conductivity, *K*, and specific yield, S_y, values for the groundwater model. The hydraulic conductivity will be the most important variable to be adjusted during calibration (calibration variable), since actual measurement of *K* from pumping tests or textural data yields only order-of-magnitude estimates of the actual value of *K*. If the groundwater model calibration is used, as here, to refine these initial estimates of *K*, such that simulated groundwater levels match actually measured groundwater levels (calibration target), then it is important to consider the sensitivity and uniqueness of the calibrated *K* map to the calibration target.

Under conditions of island groundwater flow, where a mounding of groundwater occurs underneath the island, with slopes towards the ocean around it, infinite combinations of recharge rates and hydraulic conductivity will produce the same groundwater levels: small hydraulic conductivity (slow lateral flow) combined with small recharge will produce as high a groundwater mound as a large hydraulic conductivity and a large recharge rate. Under the latter scenario, lateral flow out of the groundwater mound is rapid, but the high recharge rate keeps the groundwater mound at a significant thickness.

In this study, recharge rates are estimated separately. Hence, calibration will be able to determine regional *K* values of the Qva and Qvp formations without much ambiguity. The model will determine four *K* values that will be uniform across the island: Horizontal and vertical hydraulic conductivity in the Qva unit (layer 1), and horizontal and vertical hydraulic conductivity in the Qvp unit (layer 2). In light of the significant lack of spatially distributed pumping test data, and the relatively uniform appearance of textural variability in sediment outcrops, it is reasonable to assume that the K values for the Qva and Qvp units are uniform across the project area. In Qva, the horizontal K value is the most critical due to the mostly lateral flow out of the central groundwater mound on the island, while in Qvp, the vertical K value is most critical, due to the predominantly vertical aquitard flow conditions. Some non-uniqueness may occur in calibrating the vertical K of Qvp together with the horizontal K of Qva. This means that several different combinations of these K values may produce a good fit of simulated to measured water levels. Calibration should address this issue. Calibration will also provide insight into whether the assumption of uniformity for the K values is appropriate or should be modified.

Boundary conditions: Boundary conditions are relatively well defined due, primarily, to the well defined extent of the freshwater aquifer within the island. The model boundaries represent various flow conditions and flow controls along the ocean-land boundary around the island. I would not expect large flows to occur (under non-developed conditions) across most of the boundaries, although they are appropriately designed to handle such lateral flows.

Known spring flows along the perimeter of the island are modeled as MODFLOW "drains", imitating the seepage conditions at the springs. Spring discharge is controlled by the water level in the unconfined aquifer (a variable computed by the model), and by the hydraulic properties of the spring, collectively referred to as "conductance" (a parameter defined as input to the model). It is common practice to determine the spring conductance through calibration. The final value of the calibration should be checked against the physical dimensions of the spring and its hydraulic properties relative to those of the aquifer.

Implementation of the Calibration: Unconfined water levels on the island vary by approximately 2-3 feet between annual lows and highs. This is a relatively small amount compared to the significant spatial water level changes across the island. It is therefore appropriate to begin the calibration process with a steady-state model, i.e., a model that neglects the temporal changes in water levels. This allows the modeler to more narrowly define possible ranges of K values such that the model simulates reasonably accurate the overall spatial pattern of the groundwater mound underneath the island (as defined by water level measurements). The transient calibration is a "fine-tuning" tool to ensure that annual changes in groundwater levels caused by the seasonably varying recharge rate are reasonably well reproduced by the groundwater model. The transient calibration is also need to calibrate the specific yield and storage coefficient of the Qva and Qvp units.

In conclusion, I find that the proposed groundwater model is a technically and scientifically sound representation of the Maury Island hydrogeology for the purposes defined in the introduction.

Department of Land, Air, and Water Resources
University of California at Davis
9240 S. Riverbend Ave.
Parlier, CA 93648
(559) 646-6569
thharter@ucdavis.edu

Crispin Prahl,
Senior Hydrogeologist
Pacific Groundwater Group
2377 Eastlake Ave. East
Seattle, WA 98105

April 16, 2000

Re: Review #3 of Maury Island Gravel Mining Impact Study

Dear Mr. Prahl:

Enclosed please find my technical and scientific review of the calibration and predictive modeling implemented with the recharge, vadose zone, and groundwater models for the Maury Island Gravel Mining Project. Your team has done an outstanding job characterizing and modeling the hydrogeology of this island. The work is meticulously implemented. I cannot think of any better approaches to meet the objectives of this study. I sincerely hope you consider publishing this study in an international journal, such as Ground Water. It is certainly worth the efforts.

I very much appreciate the trust you have put into my abilities to provide technical and scientific review and guidance in this project.

Sincerely,

Thomas Harter, Ph.D.

Maury Island Gravel Mining Impact Study:
Review #3: Groundwater Model Calibration and Predictive Simulation of Impact

This review is based on material submitted electronically by Crispin Prahl during final report preparation (April 14, 2000). These materials contained a draft of the final report of the hydrogeologic impact assessment (DHIA) including appendices D, E, and F and including several tables and figures. The review is also based on extensive discussions between myself, Peter Schwartzman, and Crispin Prahl during the model calibration and during the preparation of the predictive simulations.

As with the earlier reviews, the objective of this review is to ensure that the model calibration and predictive simulation approach chosen by PGG is scientifically and technically defensible and represents an unbiased effort that is reasonably exhaustive to achieve the objectives of the hydrogeologic impact assessment (Task 8. in the PGG project).

The objectives of the impact assessment are "*to develop useful models that accurately portray recharge processes and the groundwater flow system. Also, to calibrate a groundwater flow model to best estimates of recharge, aquifer properties, and measured groundwater levels, and to use this model to assess the hydrogeologic impacts of altered recharge patterns associated with gravel-pit development/reclamation alternatives.*" [PGG Project Design, 1999]. Specifically, the modeling efforts are designed to perform predictive simulations that will assess:

- *differences between impacts from the preferred mine development and reclamation conditions*
- *changes in groundwater flow patterns that could place domestic wells downgradient from the mine site*
- *potential mounding beneath the gravel pit that could allow groundwater levels to intersect the proposed mine floor elevation*
- *potential changes in spring discharge associated with the preferred mine alternatives*

[PGG Project Design]

The overall modeling approach for the hydrogeologic impact assessment is an integrated assessment of percolation at the land surface (recharge), of the water transfer through the unsaturated zone (vadose zone model), and of groundwater flow dynamics (groundwater model):

1. **Recharge Model:** Characterize the recharge rate to the deeper vadoze zone from the island's surface soils and the potential for perched horizontal flow above the (near-surface) till layer (pre- and post-project implementation);
2. **Vadose Zone Model:** Characterize the time lag necessary for recharge water to travel from the near-surface area through the deep vadose zone the aquifer below and define the temporal recharge pattern to the unconfined aquifer below based on the deep vadose zone input calculated in stage 1. (pre- and post-project implementation)
3. **Groundwater Model:** Characterize the groundwater flow system before and after project implementation utilizing the recharge patterns determined from stage 2.

In reviews #1 and #2, I provided comments on the conceptual and modeling implementation of these three model components and the technical defensibility of the overall approach.

This review focuses on the implementation of the groundwater model calibration and the predictive simulations.

Groundwater Model Calibration

The groundwater model developed by PGG is based upon the conceptual understanding of Maury Island physiography (section 4 of the DHIA), geology (section 5 of the DHIA), and groundwater flow system dynamics (section 6 of the DHIA). The conceptual and technical model approach taken by PGG is scientifically appropriate for meeting the objectives of the study, as outlined in my previous two reviews.

In building a somewhat simplified computer model of a natural system such as groundwater aquifers, it is generally not possible to provide exact estimates of all the parameters that drive such a computer model everywhere in space and time. For example, groundwater flow and groundwater elevations on Maury Island are sensitive to the amount and spatio-temporal distribution of recharge and to the spatial distribution of aquifer geometry and aquifer hydraulic conductivity. Few actual measurements of these parameters actually exist.

In the Maury Island computer model, recharge was estimated based on the difference between precipitation and evapotranspiration in a given month. Precipitation, evapotranspiration, and related parameters in turn were estimated based on records at nearby weather stations and scientific evidence of plant water use in similar circumstances. Aquifer geometry was estimated based on a handful of well logs and drilling logs. And the hydraulic conductivity was estimated from the composition of the glacial outwash sediments and pumping tests outside the study area in locations with similar aquifer material.

Boundary conditions of the groundwater model are an other critical part of the model input. In the Maury Island study, these are primarily defined based on the physical boundaries of the island.

Among those input parameters, water level elevations that are part of boundary conditions, recharge, and aquifer thicknesses can be estimated to accuracies of 10-30% and better. In contrast, the regional hydraulic conductivity of the various groundwater units are, at best, estimated within 1 to 2 orders of magnitude accuracy. Hydraulic conductivity is therefore by far the least well known parameter. If all other input parameters are known to significantly higher accuracy, hydraulic conductivity can be determined by 'calibration'.

Calibration is the process of adjusting (not well known) input parameters of the computer model until the output is in reasonable agreement with reality (that is, with actually measured observations). The input parameters that are adjusted are called 'calibration parameters' and the output that is observed for comparison to reality is referred to as 'calibration target'.

When calibrating a groundwater model, it is paramount to minimize the number of calibration parameters. The larger the number of calibration parameters, the more likely it is that the same results can be achieved by more than one particular combination of calibration parameters.

In the Maury Island study, the least known input parameters are the hydraulic conductivities of the principal aquifer and the hydraulic conductivity of the underlying aquitard. In contrast, a scientifically advanced, and technically accurate method has been presented to provide reasonable estimates of recharge prior to calibration of groundwater model (see review 1 and 2). Independently estimating the recharge is a key to successfully calibrating this model. It is reasonable to assume that boundary conditions and aquifer geometry are known well enough with respect to groundwater model sensitivity (when compared to hydraulic conductivity) that they should not be included in the calibration process.

The principle of parsimony further dictates that the principle aquifer be modeled with a single regional, large-scale value of hydraulic conductivity. Too little is known to justify much subregional differentiation: The number of water level and spring discharge observation on Maury Island is to few, and there is a decided lack of detailed hydraulic conductivity measurement. Furthermore, for meeting the objectives of the study, such detailed analysis is unnecessary.

The PGG study correctly identifies the key calibration variables (horizontal hydraulic conductivity of the principal aquifer including the conductances for modeling the springs, and vertical hydraulic conductivity of the aquitard). The DHIA provides reasonable minimum and maximum values by which the calibration of these parameters is constrained.

The chosen calibration targets (well water level measurements, spring discharge measurements) are also reasonably exhaustive of reliable water level and groundwater discharge measurements available for Maury Island.

Despite the significant efforts to constrain the groundwater model with as many independent measuremenets and estimates of input data as possible, a significant dilemma remains: There is no unique combination of hydraulic conductivity in the principal aquifer and vertical hydraulic conductivity in the underlying aquitard, which satisfies the observations. Rather, there are numerous combinations of these two parameters, which will all result in a similar good fit to the water level distributions (that is, satisfy the calibration target requirements; see section 8.2.1 of the DHIA).

The calibration therefore results in more than 1 plausible groundwater model ('scenario') for Maury Island. PGG correctly identified two key scenarios and added a third one to explain one significant local anomaly in water level data. These scenarios represent the extreme ends of the possible parameter combinations: Scenario A represents that with high permeability in the principal aquifer and low vertical permeability in the underlying aquitard, while scenario C represents the low principial aquifer conductivity with the large vertical conductivity in the aquitard. Since all scenarios are equally likely given the available data, *ALL* of these scenarios must be included in the predictive simulations as done here.

The steady-state calibration to a single month's worth of observation data is scientifically justified in light of the small seasonal water level changes and the large spatial water level changes across the island. The results of the steady-state calibrations for each of the three scenarios are in exellent agreement with measured water levels and spring discharges, considering that the model does not distinguish subregional variations in hydraulic conductivity (with the exception of the low K zone in scenario B), considering the accuracy of the measured data, and considering the objectives of the study.

The purpose of the transient model calibration is to adjust those parameters that have the most significant impact on the seasonal variation in water levels. These parameters are the specific yield (effective porosity) of the principal aquifer and the hydraulic conductivity of the unsaturated zone, which determines the time necessary for recharge to travel from below the root zone to the water table of the principal aquifer (recharge delay time, time-lag). The specific yield is known with relatively high accuracy and an appropriate range is chosen in the study (28% and 20%).

As explained in the report, the model does not account for the diffusion of the recharge pulse (dampening) as it travels through the unsaturated zone. The vadose zone model is merely used to determine the recharge delay time. Model recharge to the water table is therefore subject to larger seasonal variations than actual recharge on the island. This is a valid simplification of reality, because the objective of the study is to predict the largest possible water level variations that would occur as a result of the project. Any predictions of future water levels with such a simplified model are likely to overestimate future water level and spring discharge variations. If modeled future impact is less than significant with this simplified tool, then it is scientifically unlikely that actual future impact will be more than significant.

The transient calibration shows that regardless of the choice of these parameters, predicted seasonal variations are larger than those observed over the relatively short observation period 1999-2000. Furthermore, annual variations in precipitation apparently cause much larger temporal changes in water levels than those caused by the strong seasonality of winter rains and summer dry periods.

Within the limits of the modeling approach and of the short record of transient observations, transient calibration is therefore not feasible. In other words, within the prescribed range of specific yield and recharge delay times (time lag variation), no one parameter combination fits measured data better than others.

The comparison of actual and modeled transient (seasonal) water level fluctuations, however, serve as an important sensitivity analysis and provides further confidence in the model construct as a suitable predictor of future conditions: predicted seasonal water level changes are at least as large and of similar magnitude as observed in reality. The sensitivity analysis also provides a parameter set that can be considered "worst case" for purposes of the study: the shortest reasonable recharge delay time causes the largest seasonal spikes and troughs in local recharge to groundwater and presumably the largest possible changes in water levels and spring discharge. Section 8.3 of the DHIA (transient calibration) appropriately discusses the implications of these efforts. The applied procedures are technically correct and scientifically more than appropriate.

Predictive Simulations

For the predictive simulations, the initial step is to seek out a "worst case" scenario (among all possible scenarios) to determine the worst possible impacts from the proposed project. I find that the selected worst case scenario is an appropriate selection of parameters for such a prediction: minimizing recharge delay time underneath the proposed project. If the worst case scenario shows significant impacts, then additional data would need to be collected to further constrain the worst case scenario and to provide more realistic simulations. However, if the impact under the worst case scenario is considered insignificant for purposes of the project, no further modeling is needed.

The model representation of future project phases and reclamation is entirely appropriate within the context of this project and includes sufficient detail for assessing future impacts of the proposed project.

The predictive worst case simulations are properly carried out for all three scenarios from the steady-state calibration and for the two end-points of the plausible range of specific yield values.

The modeled impacts described in section 8.4 of the DHIA should therefore be considered as the technically best estimate of "worst case" impact. The scientific basis upon which these predictions are made is rather extensive and extremely qualified. The high level of complexity prescribed in the approach for developing the three model components (recharge, vadose zone, and groundwater model), the exhaustive detail provided in the model, the extensive model calibration, and the broad definition of plausible groundwater model scenarios provide a scientifically high degree of confidence in the model predictions, and hence, in the hydrogeologic impact assessment. From an academic and scientific point of view, the objectives of this study have been met with meticulous work and outstanding technical and scientific rigor.