APPENDIX D. GROUNDWATER PUMP TESTS

Groundwater pump tests were conducted at four test pits in 2008 to evaluate the presence of groundwater at potential project sites. At each site, soil and water samples were collected and analyzed. In this appendix, the four sites are described, and the results and analytical reports are presented.

1.0 Test Pit Descriptions

Test Pit 1

Test Pit 1 was located on the left bank of the Kalama River at RM 2.5 (Ledgett Property). The ground elevation was 23.7 feet. The excavation proceeded to a depth of 10 feet (Figures D1 and D2). The upper 4 feet consisted of fine grained silts and sand, from 4 to 6 feet there was a transition to gravel and below 6 feet river alluvium. The digging below 6 feet was very hard, as the material was compacted. Water was encountered at elevation 15.2 feet (7 feet below the ground surface). A groundwater pump test was conducted. Test results for the pump test, soil samples and water quality measurements are shown in Table D1 and Figure D7.

Figure D1. Test Pit 1 Excavation

Figure D2. Test Pit 1 Soils

Test Pit 2

Test Pit 2 was dug out in a low point of the open pasture owned by the Port of Kalama (Figure D3). The ground elevation was 19.6. The water level was 15.8. Excavation proceeded down to an approximate elevation of 13.6 feet (6 feet deep). Below elevation 15 feet, the excavated soil walls were collapsing, and it would have been very difficult to stabilize the slopes without a major excavation. Soil tests within this area indicate a much lower percentage of gravel compared to Test Pit 1.

Figure D3. Test Pit 2 Excavation

Test Pit 3

Test Pit 3 was dug within an existing swale on the right bank of the Kalama River downstream from Test Pit 1. The ground elevation was 15.0 feet and static water surface was at 12.6 feet.

The first three feet of excavation were very wet sandy loam. When the excavator bucket removed water from the pit, the groundwater recharge appeared to have a high iron content; the cobble removed were covered with iron rich sediment. This condition was confirmed by the water quality tests with a 35 part per million (ppm) iron reading. Similar to Test Pit 2, the soil walls were collapsing and it would have been very difficult to stabilize the slopes without a major excavation so a pump test was not completed.

Figure D4. Test Pit 3 Excavation Area

Test Pit 4

Test Pit 4 was dug within land owned by WDFW on the right bank floodplain at RM 0.4. The ground elevation was 12.5 feet, and the groundwater elevation was 7.5 feet. The excavation proceeded to a depth of 6.5 feet. There was no gravel, but a very consistent sand material after 2 to 3 feet of sandy loam was removed. A pump test was conducted at this site. Pumping started at a static water surface of 7.5 feet. The water level was pumped down 1.1 feet at a rate of 97 gallons per minute (gpm) over a time of 4 minutes. The drawdown rate, or the rate at which the water elevation dropped, exceeded the pumping rate and the hole was pumped dry. The adjacent water elevation in the Kalama River during pumping was 7.0 feet. This reach of the river is tidal with water elevations varying from 6 to 10 feet of elevation. Drawdown curve and results are shown in Table D1, and Figure D7.

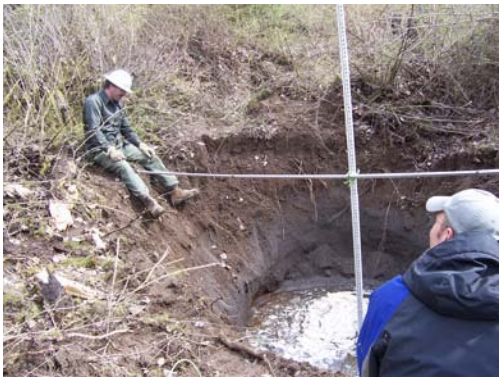


Figure D5. Test Pit 4 Excavation

Figure D6. Test Pit 4 Bottom of Hole

2.0 Results

The two parameters used to assess the flow potential are the drawdown index and the apparent velocity. The drawdown index is the pump rate divided by the drawdown rate. It is a measurement of how much water will flow into the hole relative to the rate water is going out. The apparent velocity is the inflow rate divided by the cross-sectional area of the hole contributing flow, at the point at which the pump rate is equal to the inflow rate (i.e. the water level has stabilized). Powers (1990) has published values for these two parameters on an empirical basis relative to the success of over 10 groundwater channels constructed in Washington State.

For the Lower Kalama River sites the low drawdown index, and the very slow recharge rates tends to indicate a low potential for the development of adult salmon spawning channels. The exception may be the area around Test Pit 4, as this is tidal and adult access could be provided at higher tides. Spawning gravel would have to be imported. The high quality groundwater and substrate does provide excellent opportunities for creation of year round off channel rearing for juvenile salmonids.

The drawdown and recharge curves of Figure D7 show that the test holes were drawn down very fast and took much longer to recharge. The soil was very compacted at Test Pit 1. Conditions for summer and fall (low flow periods) need to be monitored to check for water elevations. These low flow elevations need to be correlated to the surveyed project datum. Figure D8, shows the water levels for all the monitoring areas within the Lower Kalama and Columbia River.

	Sediment Classification (%)			Water Quality		Pump	Drawdown			Recharge				
	Gravel	Sand	Silt, Clay	DO (ppm)	Fe (ppm)	Rate (gpm)	Depth (ft)	Rate (gpm)	Time (min)	Depth (ft)	Rate (gpm)	Time (min)	Drawdown Index	Apparent Velocity (fpm)
TP1	79	20	1	4.1	9.7	60	1.5	70	7.8	1.5	32	17	0.46	NA
TP2	56	25	19			-	-	-	-	-	-	-	-	-
TP3	-	-	-	2.8	35	-	-	-	-	-	-	-	-	-
TP4	11	85	4	2.3	0.2	97	1.1	128	3.9	1.1	17	29	0.13	NA

Table D1. Lower Kalama River Groundwater Test Results for Test Pit 1 (TP1), Test Pit 2 (TP2), Test Pit 3 (TP3), and Test Pit 4 (TP4).

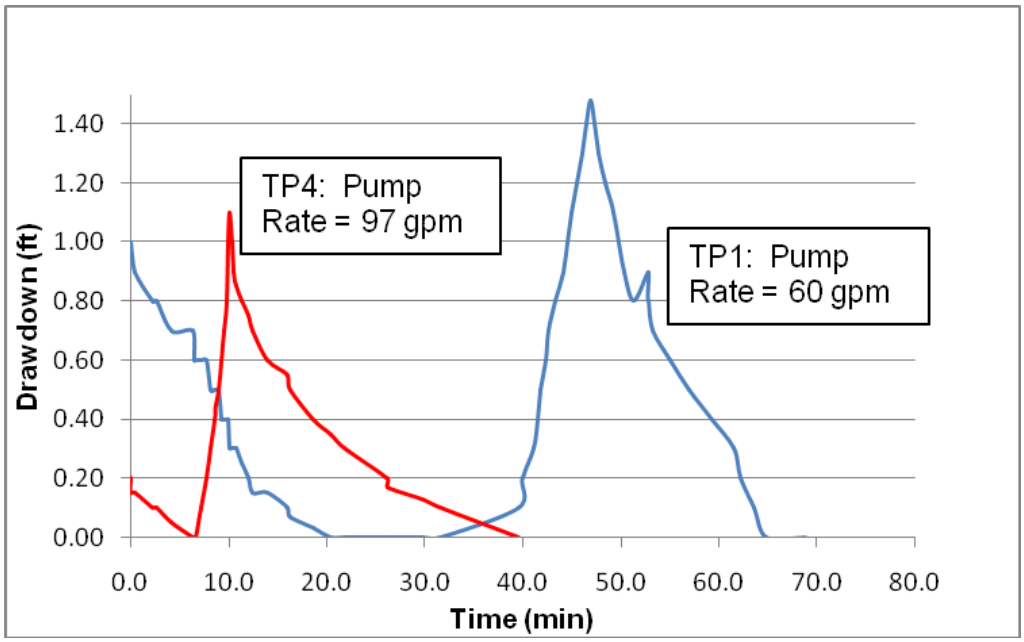


Figure D7. Lower Kalama River Test Pit 1 (TP1) and Test Pit 4 (TP4) drawdown and recharge curves superimposed to a common start time.

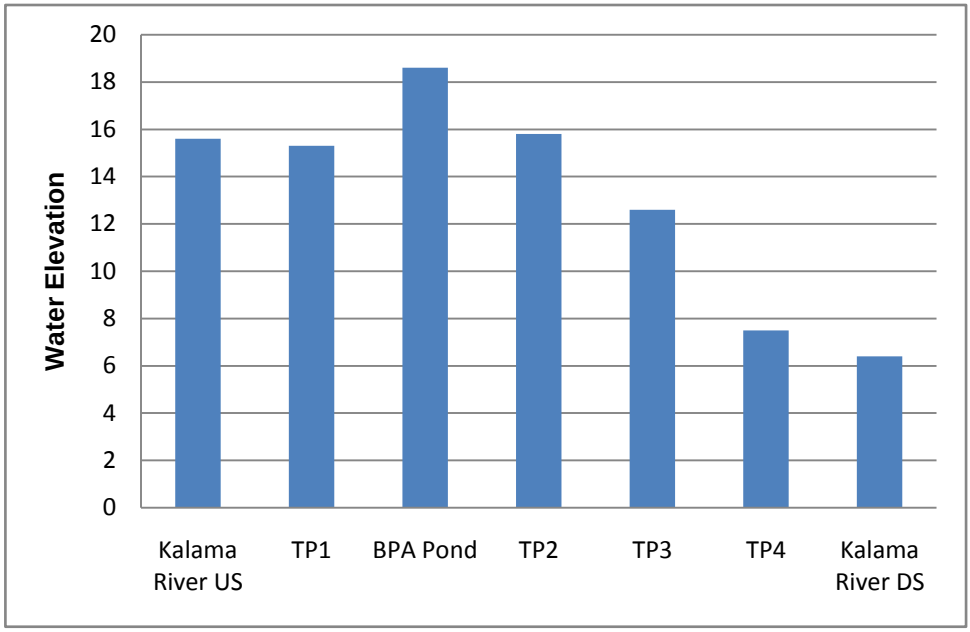
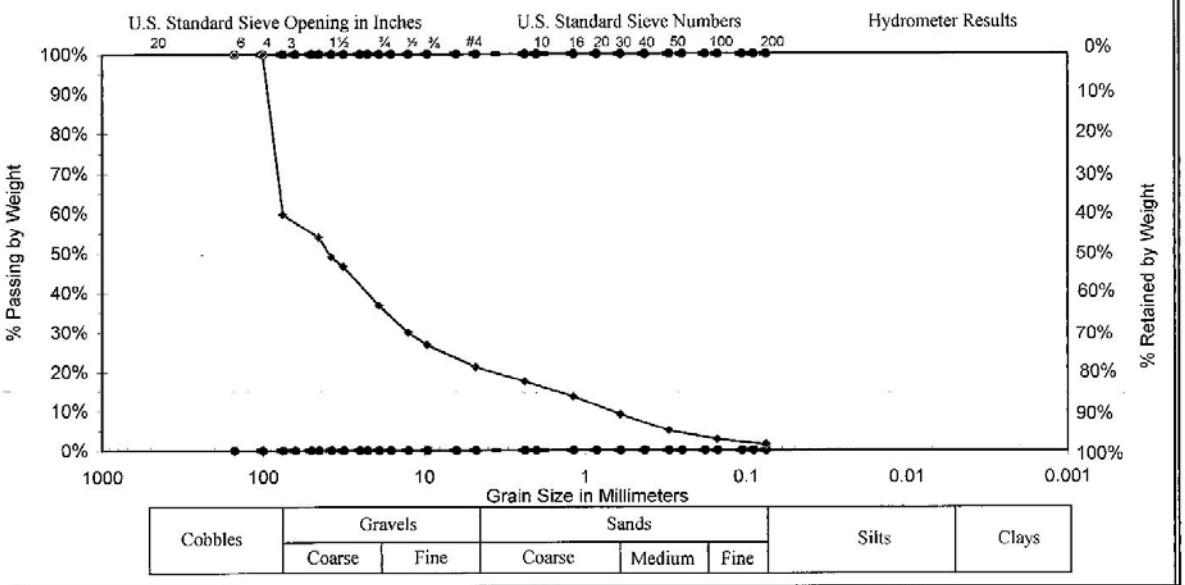


Figure D8. April 3 and 4, 2008 water surface elevations during the test pit period. Datum is Port Survey datum.

3.0 Soil Samples

Soil samples were analyzed by Geotechnical Testing Laboratory of Olympia Washington, in April of 2008. The analysis report follows.

GEOTECHNICAL TESTING LABORATORY



Date : 04/07/08
Sample #: 450
Sample ID: Gravel with Sand
Source: TP-1
Project: Lower Kalama
Client: Waterfall Engineers
ASTM#: C-136
Depth: NA

D_{10} = 0.74
D_{30} = 12.79
D_{60} = 75.29
C_C = 2.94
C_U = 102.06
Liquid Limit= 0.00
Plastic Limit= 0.00
Plasticity Index= 0.00

Classification
GW, Well-graded Gravel with Sand
Specifications
No Specs
% Moisture: #DIV/0!
Dust Ratio=
Fineness Modulus
7.60

% Gravel
78.94%
% Sand
19.65%
% Silt & Clay
1.42%
Sample Meets Specs
NA

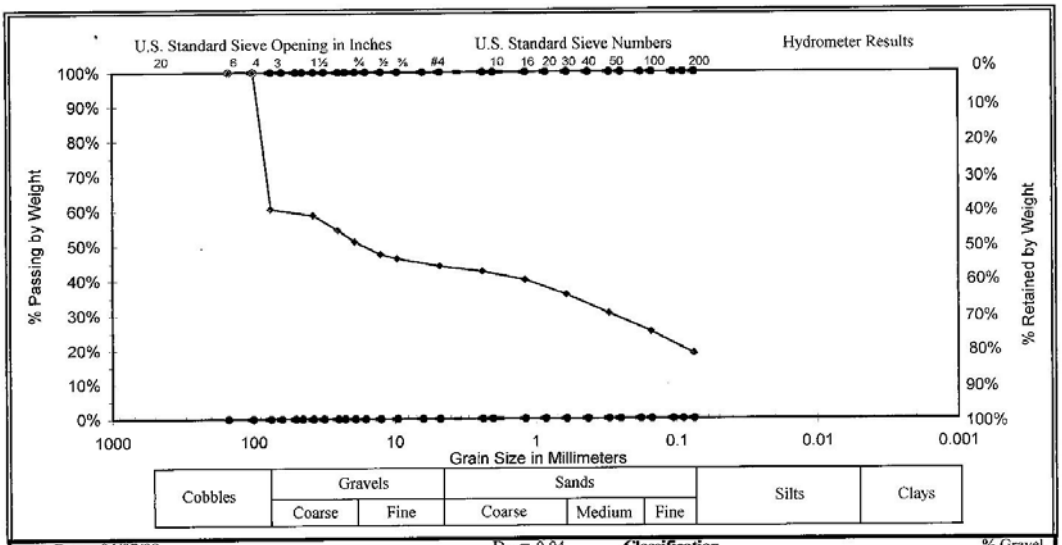
Coarse Section Sieve Size US	Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
6.00"	150.00		100.0%		
4.00"	100.00	100.0%	100.0%		
3.00"	75.00	59.5%	59.5%		
2.50"	63.00		57.2%		
2.00"	50.00		54.8%		
1.75"	45.00	53.8%	53.8%		
1.50"	37.50	48.9%	48.9%		
1.25"	31.50	46.5%	46.5%		
1.00"	25.00		41.3%		
7/8"	22.40		39.3%		
3/4"	19.00	36.6%	36.6%		
5/8"	16.00		33.4%		
1/2"	12.50	29.7%	29.7%		
3/8"	9.50	26.6%	26.6%		
1/4"	6.30		22.9%		

Fines Section Sieve Size US	Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
#4	4.750	21.1%	21.1%		
#8	2.360	17.4%	17.4%		
#10	2.000		16.2%		
#16	1.180	13.5%	13.5%		
#20	0.850		10.9%		
#30	0.600	8.9%	8.9%		
#40	0.425		6.5%		
#50	0.300	4.8%	4.8%		
#60	0.250		4.1%		
#80	0.180		3.1%		
#100	0.150	2.7%	2.7%		
#140	0.106		1.9%		
#170	0.090		1.7%		
#200	0.075	1.4%	1.4%		
#270	0.053				

Reported by: _____
Reviewed by: _____

10011 Blomberg St. SW, Olympia, WA 98512
Phone #: (360) 754-4612 Fax #: (360) 754-4848

GEOTECHNICAL TESTING LABORATORY



Date : 04/07/08
Sample #: 451
Sample ID: Silty Gravel with Sand
Source: TP-2
Project: Lower Kalama
Client: Waterfall Engineers
ASTM#: C-136
Depth: NA

D_{10} = 0.04
D_{30} = 0.29
D_{60} = 63.60
C_C = 0.03
C_U = 1598.37
Liquid Limit= 0.00
Plastic Limit= 0.00
Plasticity Index= 0.00

Classification
GM, Silty Gravel with Sand
Specifications
No Specs
% Moisture: 7.4%
Dust Ratio=
Fineness Modulus
5.65

% Gravel
55.93%
% Sand
25.22%
% Silt & Clay
18.85%
Sample Meets Specs
NA

Coarse Section Sieve Size US	Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
6.00"	150.00		100.0%		
4.00"	100.00	100.0%	100.0%		
3.00"	75.00	60.5%	60.5%		
2.50"	63.00		60.0%		
2.00"	50.00		59.4%		
1.75"	45.00		59.1%		
1.50"	37.50	58.8%	58.8%		
1.25"	31.50		56.7%		
1.00"	25.00	54.4%	54.4%		
7/8"	22.40		52.9%		
3/4"	19.00	51.1%	51.1%		
5/8"	16.00		49.4%		
1/2"	12.50	47.4%	47.4%		
3/8"	9.50	46.2%	46.2%		
1/4"	6.30		44.8%		

Fines Section Sieve Size US	Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
#4	4.750	44.1%	44.1%		
#8	2.360	42.5%	42.5%		
#10	2.000		41.8%		
#16	1.180	40.0%	40.0%		
#20	0.850		37.7%		
#30	0.600	35.9%	35.9%		
#40	0.425		32.7%		
#50	0.300	30.5%	30.5%		
#60	0.250		28.7%		
#80	0.180		26.2%		
#100	0.150	25.1%	25.1%		
#140	0.106		21.4%		
#170	0.090		20.1%		
#200	0.075	18.8%	18.8%		
#270	0.053				

Reported by: _____
Reviewed by: _____

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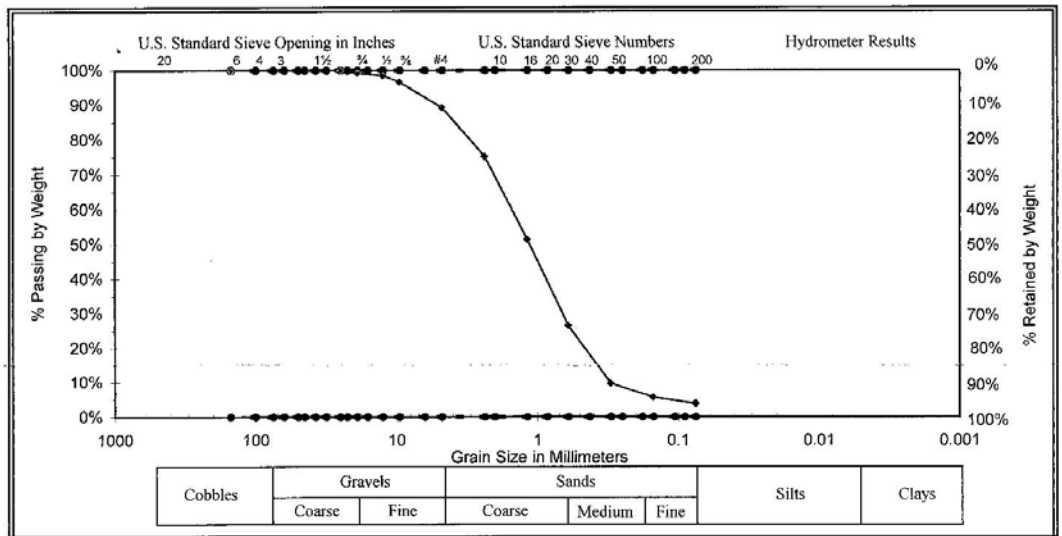

Date : 04/07/08	D_{10} = 0.31	**Classification**		% Gravel
Sample #: 452	D_{30} = 0.69	**SP. Poorly graded Sand**		10.82%
Sample ID: Sand	D_{60} = 1.61	**Specifications**		% Sand
Source: TP-4	C_C = 0.95	No Specs		85.37%
Project: Lower Kalama	C_U = 5.25	% Moisture: 15.2%		% Silt & Clay
Client: Waterfall Engineers	Liquid Limit= 0.00	Dust Ratio=		3.82%
ASTM#: C-136	Plastic Limit= 0.00	Fineness Modulus		Sample Meets Specs
Depth: NA	Plasticity Index= 0.00	3.47		**NA**

Coarse Section Sieve Size US	Metric	**Actual Cumulative Percent Passing**	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
6.00"	150.00		100.0%		
4.00"	100.00		100.0%		
3.00"	75.00		100.0%		
2.50"	63.00		100.0%		
2.00"	50.00		100.0%		
1.75"	45.00		100.0%		
1.50"	37.50		100.0%		
1.25"	31.50		100.0%		
1.00"	25.00	100.0%	100.0%		
7/8"	22.40		99.7%		
3/4"	19.00	99.2%	99.2%		
5/8"	16.00		98.9%		
1/2"	12.50	98.4%	98.4%		
3/8"	9.50	96.6%	96.6%		
1/4"	6.30		91.6%		

Fines Section Sieve Size US	Metric	**Actual Cumulative Percent Passing**	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
#4	4.750	89.2%	89.2%		
#8	2.360	75.1%	75.1%		
#10	2.000		67.8%		
#16	1.180	51.2%	51.2%		
#20	0.850		37.0%		
#30	0.600	26.3%	26.3%		
#40	0.425		16.6%		
#50	0.300	9.6%	9.6%		
#60	0.250		8.3%		
#80	0.180		6.4%		
#100	0.150	5.7%	5.7%		
#140	0.106		4.6%		
#170	0.090		4.2%		
#200	0.075	3.8%	3.8%		
#270	0.053				

Reported by: _____

Reviewed by: _____

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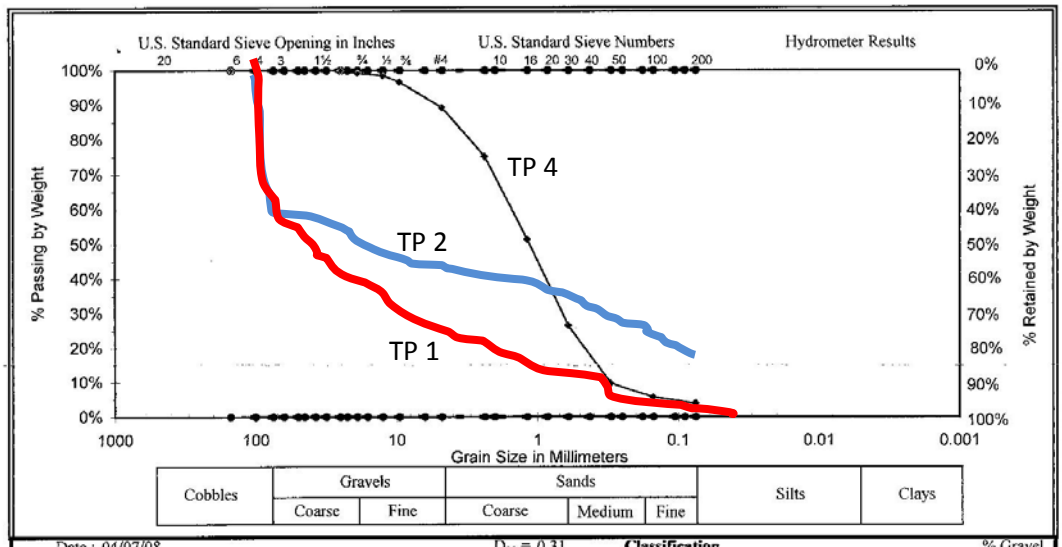

Date : 04/07/08
Sample #: 452
Sample ID: Sand
Source: TP-4
Project: Lower Kalama
Client: Waterfall Engineers
ASTM#: C-136
Depth: NA

D_{10} = 0.31
D_{30} = 0.69
D_{60} = 1.61
C_C = 0.95
C_U = 5.25
Liquid Limit= 0.00
Plastic Limit= 0.00
Plasticity Index= 0.00

Classification
SP. Poorly graded Sand
Specifications
No Specs
% Moisture: 15.2%
Dust Ratio=
Fineness Modulus
3.47

% Gravel
10.82%
% Sand
85.37%
% Silt & Clay
3.82%
Sample Meets Specs
NA

Coarse Section Sieve Size US	Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
6.00"	150.00		100.0%		
4.00"	100.00		100.0%		
3.00"	75.00		100.0%		
2.50"	63.00		100.0%		
2.00"	50.00		100.0%		
1.75"	45.00		100.0%		
1.50"	37.50		100.0%		
1.25"	31.50		100.0%		
1.00"	25.00	100.0%	100.0%		
7/8"	22.40		99.7%		
3/4"	19.00	99.2%	99.2%		
5/8"	16.00		98.9%		
1/2"	12.50	98.4%	98.4%		
3/8"	9.50	96.6%	96.6%		
1/4"	6.30		91.6%		

Fines Section Sieve Size US	Metric	Actual Cumulative Percent Passing	Interpolated Cumulative Percent Passing	Specs Max	Specs Min
#4	4.750	89.2%	89.2%		
#8	2.360	75.1%	75.1%		
#10	2.000		67.8%		
#16	1.180	51.2%	51.2%		
#20	0.850		37.0%		
#30	0.600	26.3%	26.3%		
#40	0.425		16.6%		
#50	0.300	9.6%	9.6%		
#60	0.250		8.3%		
#80	0.180		6.4%		
#100	0.150	5.7%	5.7%		
#140	0.106		4.6%		
#170	0.090		4.2%		
#200	0.075	3.8%	3.8%		
#270	0.053				

Reported by: _____
Reviewed by: _____

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4.0 Water Samples

Water samples were analyzed by Columbia Analytical Services Inc., in April of 2008. The analytical report follows.

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client :	Waterfall Engineering	**Service Request :**	K0802848
Project Name :	Lower Kalama Off Channel Design	**Date Collected :**	04/03/08
Project No. :	NA	**Date Received :**	04/03/08
Matrix :	Water	**Date Extracted :**	04/08/08

Dissolved Metals

Sample Name :	TP1 Ledge H (4/3)	**Units :**	ug/L (ppb)
Lab Code :	K0802848-002	**Basis :**	NA

Analyte	Analysis Method	MRL	Date Analyzed	Sample Result	Result Notes
Iron	6010B	20	04/16/08	9770	

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client :	Waterfall Engineering	**Service Request :**	K0802848
Project Name :	Lower Kalama Off Channel Design	**Date Collected :**	04/03/08
Project No. :	NA	**Date Received :**	04/03/08
Matrix :	Water	**Date Extracted :**	04/08/08

Dissolved Metals

Sample Name :	TP4 (4/3)	**Units :**	ug/L (ppb)
Lab Code :	K0802848-003	**Basis :**	NA

Analyte	Analysis Method	MRL	Date Analyzed	Sample Result	Result Notes
Iron	6010B	20	04/16/08	187	

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client :	Waterfall Engineering	**Service Request :**	K0802848
Project Name :	Lower Kalama Off Channel Design	**Date Collected :**	04/03/08
Project No. :	NA	**Date Received :**	04/03/08
Matrix :	Water	**Date Extracted :**	04/08/08

Total Metals

Sample Name :	TP3 (4/3)	**Units :**	ug/L (ppb)
Lab Code :	K0802848-004	**Basis :**	NA

Analyte	Analysis Method	MRL	Date Analyzed	Sample Result	Result Notes
Iron	6010B	20	04/16/08	35400	

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client :	Waterfall Engineering	**Service Request :**	K0802848
Project Name :	Lower Kalama Off Channel Design	**Date Collected :**	NA
Project No. :	NA	**Date Received :**	NA
Matrix :	Water	**Date Extracted :**	04/08/08

Total Metals

Sample Name :	Method Blank	**Units :**	ug/L (ppb)
Lab Code :	K0802848-MB	**Basis :**	NA

Analyte	Analysis Method	MRL	Date Analyzed	Sample Result	Result Notes
Iron	6010B	20	04/16/08	ND	

Comments:

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client : Waterfall Engineering
Project Name : Lower Kalama Off Channel Design
Project Number : NA
Sample Matrix : WATER

Service Request : K0802848
Date Collected : 04/02,03/08
Date Received : 04/02,03/08

Oxygen, Dissolved

Analysis Method : SM 4500-O G
Test Notes :

Units : mg/L
Basis : NA

Sample Name	Lab Code	MRL	Dilution Factor	Date/Time Analyzed	Result	Result Notes
TP1 Ledge H (4/2)	K0802848-001	-	1	04/02/08 17:30	4.11	
TP4 (4/3)	K0802848-003	-	1	04/03/08 17:00	2.31	
TP3 (4/3)	K0802848-004	-	1	04/03/08 17:00	2.81	

SM Standard Methods for the Examination of Water and Wastewater, 20th Ed., 1998.

Report By:CSKILLERN