Flow Summary for Gaging Stations on the Willapa River and Selected Tributaries

Abstract

Between May and October 2001, the Washington State Department of Ecology conducted a streamflow assessment on the mainstem and South Fork of the Willapa River, as well as on Fork Creek, a mainstem tributary.

The streamflow monitoring was conducted in support of a temperature total maximum daily load (TMDL) study. The purpose of the study was to characterize the water temperature in the basin and establish load and wasteload allocations for the heat sources to meet water quality standards for surface water temperature.

Continuous stage height recorders and staff gages were installed; four to six discharge measurements were taken at each site. Discharge rating curves were developed for each site by relating various stage height values to corresponding discharge measurements. Applying these rating curves over the range of stage height enabled a continuous record of discharge to be developed at each site.

During the study, streamflow in the Willapa River basin followed a general pattern of dry season decline, with the exception of several small storm events throughout the study period, and one large storm event in August which resulted in peak flows for the entire water year.

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Introduction

Between May and October 2001, the Environmental Assessment Program of the Washington State Department of Ecology (Ecology) conducted a streamflow assessment on the mainstem and South Fork of the Willapa River, as well as on Fork Creek, a mainstem tributary, in support of a temperature total maximum daily load (TMDL) study developed by the Environmental Assessment Program. The purpose of the study was to characterize the water temperature in the basin and establish load and wasteload allocations for the heat sources to meet water quality standards for surface water temperature. The study was initiated because of the 303(d) listings of river segments which are water quality limited for temperature (Stohr 2001).

Sites

The Willapa River drains into Willapa Bay located in Pacific County in southwestern Washington State. The climate in the basin is heavily influenced by its proximity to the Pacific Ocean, with cool, wet winters and mild summers. Annual precipitation ranges from 80 inches in the lowlands to 120 inches in the higher elevations, and occurs primarily between the months of October and June (Stohr 2001).

For this study, Ecology established continuous stage height recorders at four locations in the basin; two on the mainstem Willapa River, one on the South Fork Willapa River, and one on Fork Creek, a tributary to the mainstem. On the mainstem, the uppermost station was located at the Highway 6 crossing, just below the town of Lebam, at river mile 34.0 (Figure 1, Site 1). The lower station on the mainstem was located at Oxbow Road, at river mile 25.6 (Site 2). On the South Fork, the station was located just below the City of Raymond's South Fork Water Treatment Plant, at river mile 4.7 (Site 3). On Fork Creek, a mainstem tributary that enters the Willapa River at river mile 31.1, the station was located just above the mouth at the Willapa Salmon Hatchery (Site 4).

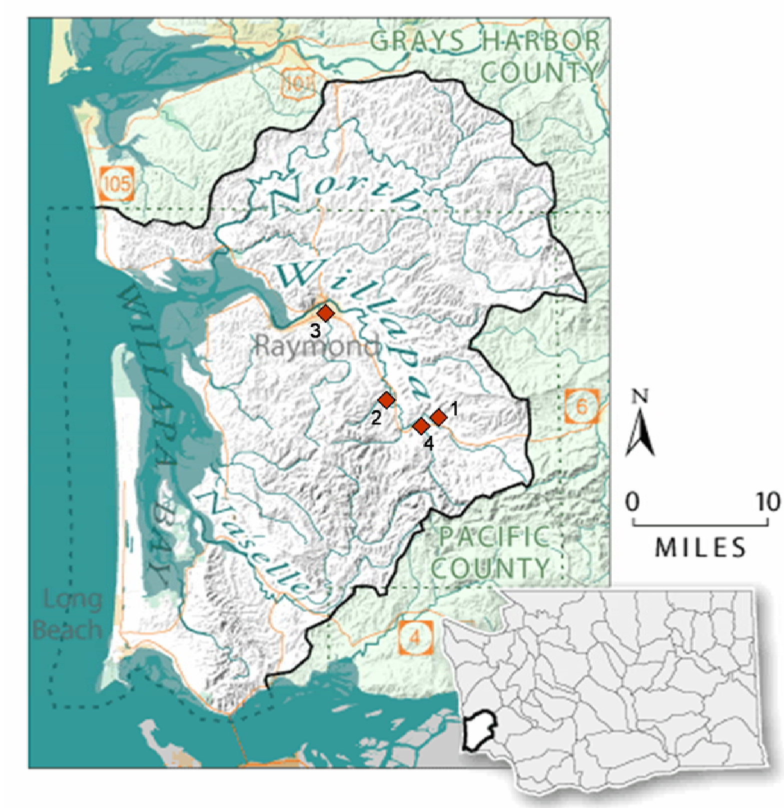

Figure 1: Map of Willapa TMDL study sites.

Methods

Each of the four continuous gaging stations was equipped with a pressure transducer and datalogger that recorded stage height and temperature at 15-minute intervals from May to October 2001. Four to six wading discharge measurements were taken at each station to establish rating curves used to calculate the average daily discharges.

Discharge measurements were made following the United States Geological Survey (USGS) mid-section method. Ecology has made minor modifications to the USGS method to accommodate its measurement equipment (Hopkins, 1999). The flow measurement cross sections were established by driving re-bar into opposing banks perpendicular to the streamflow. This allowed field staff to return to the same cross-section at different stage heights and added to the reliability of the measured discharge data. In general, the cross-sections were divided into approximately 20 cells so that no more than 10% of the total discharge passed through any single cell. The width of the individual cells varied in keeping with the 10% discharge criteria. Velocity measurements were taken at 60% of the stream depth when the total stream depth was less than 1.5 feet and at 20% and 80% of the stream depth when the depth was greater than 1.5 feet (Hopkins, 1999). The instream velocity measurements were taken using a standard USGS top set wading rod fitted for Swoffer type optical sensors and propellers. Stream discharge was calculated in the office using an in-house specialized discharge calculation software program.

Quality Assurance

Quality assurance measures were taken in this study to address both error in stage height record produced by the dataloggers, and error inherent in instream discharge measurements.

Discharge Measurements

Because the largest potential source of error involved with a discharge measurement is in the velocity measurement itself, site selection and equipment calibration are of high importance. In this study, the measured cross-sections were rated between excellent and poor. Based on physical conditions encountered at each site, an excellent cross-section assumes an error of up to 2% and a poor cross-section assumes an error of over 8%. Depending on the selected cross-section, a minimum of the assigned error is assumed and carried forward to the final discharge calculation. An additional source of error in velocity measurements is the calibration of the Swoffer instruments. The ideal calibration value of a Swoffer propeller is 186. The Swoffer propellers used during this project were pre- and post-calibrated with values ranging from 184 to 186. A calibration rating of 186 means that for every 186 revolutions of the propeller, 10 feet of water have passed the measurement point. A calibration value of 184 underestimates the discharge measurement by one percent. Once a rating curve was established, discharge measurements were tracked by comparing the measured discharge values to the predicted discharge values at the same stage. The combination of propeller variations, poor cross-sections, and high bottom roughness due to low-flow conditions contributed to the measured and predicted discharge differences ranging from 0.1% to over 25%. This range of difference between the measured and the predicted discharge demonstrates the ability of the rating curves to predict stream discharge for each site.

Pressure Transducers and Staff Gages

Based on manufacturer specifications, the theoretical precision of the pressure transducers is less than or equal to 0.02% of the full-scale output. For the transducers used by Ecology, this precision is considered linear from 0 to 15 psi, or 0 to 34.6 feet (Fletcher, 2.6). During the study period, the accuracy of each transducer was addressed by using staff gage versus transducer regressions. The r^2 values for the regressions of transducer against staff gage readings ranged from 0.959 to 0.997.

Results

This study was designed as a summer low-flow assessment of the Willapa River basin. One significant rainfall event occurred during the study period: during August 22-24. For many rivers in Western Washington, this rainfall event resulted in the peak streamflow for the entire water year. Due to time constraints and the travel time involved to reach the study sites, flows were not measured during this storm event. All discharge data that is greater than two times the highest measured flow at each of the stations is considered to be only an estimate of stream discharge.

Site 1: Willapa River at Lebam

The average daily discharge for Site 1 ranged from 8.3 cubic feet per second (cfs) in mid-August to over 110 cfs during a storm event in late-August. Peak flow during the study period was over 270 cfs on August 23rd (Figure 2). Daily discharge averages are presented in Appendix A, Table 1. The rating curve encompassed only 23% of the range of discharge, with flow measurements ranging from 9.5 to 52 cfs (Figure 3). However, discharge exceeded the rating curve only about 5% of the time over the duration of the study (Figure 4). Within the range of measured flows, the fit of the rating curve was very good. A linear regression of river stage against discharge had an r^2 value of 0.997 (Figure 5). Four of the five discharge measurements conducted at Site 1 were within 5% of the flow predicted by the rating curve. One discharge measurement was not used in the development of the rating curve because of a poor fit. This was most likely due to an erroneous reading of depth to water surface from the reference point established on the highway bridge. The linear regression of tape down readings against pressure transducer readings was quite strong, with an r^2 value of 0.997 (Figure 6). The overall trend in streamflow at Site 1 reflects a typical dry-period decline in discharge, with the exception of a few small storm events, and one large storm event in late-August.

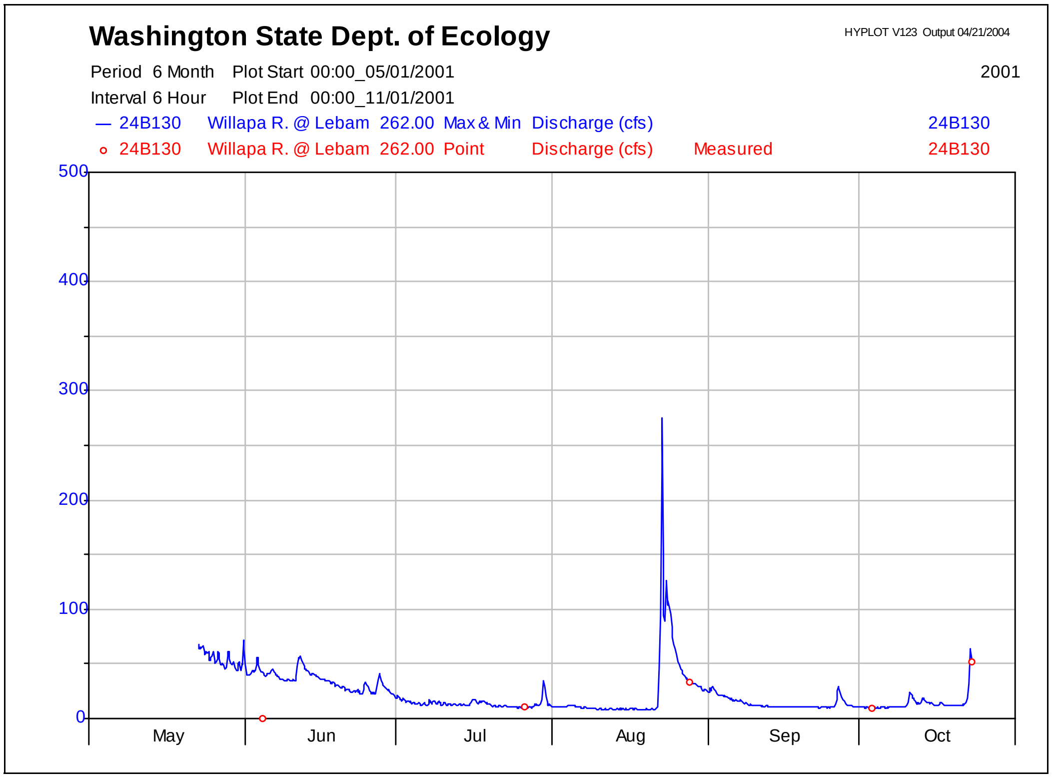

Figure 2: Discharge hydrograph for Site 1.

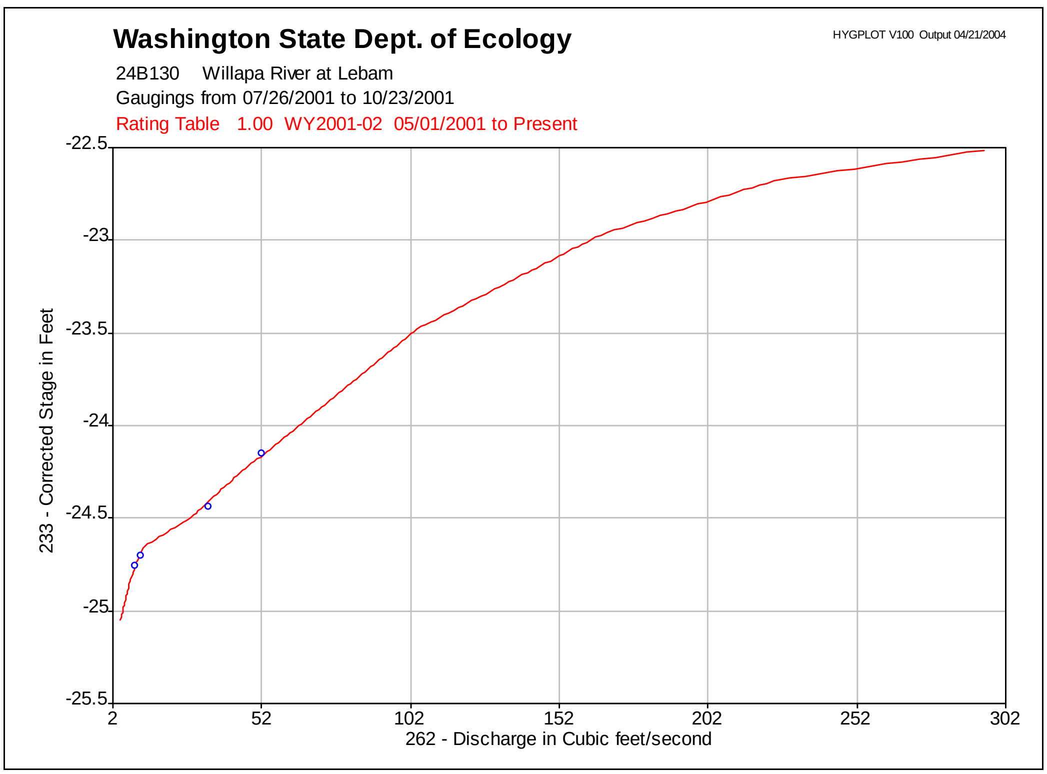

Figure 3: Discharge rating curve for Site 1.

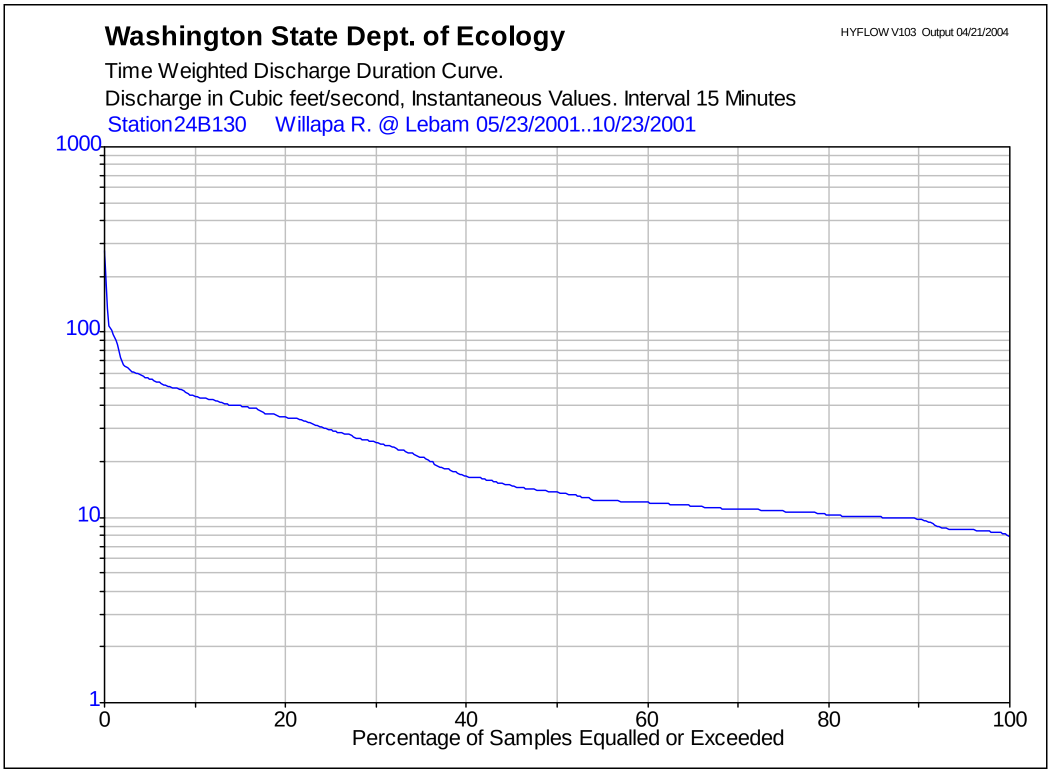

Figure 4: Flow exceedence graph for Site 1.

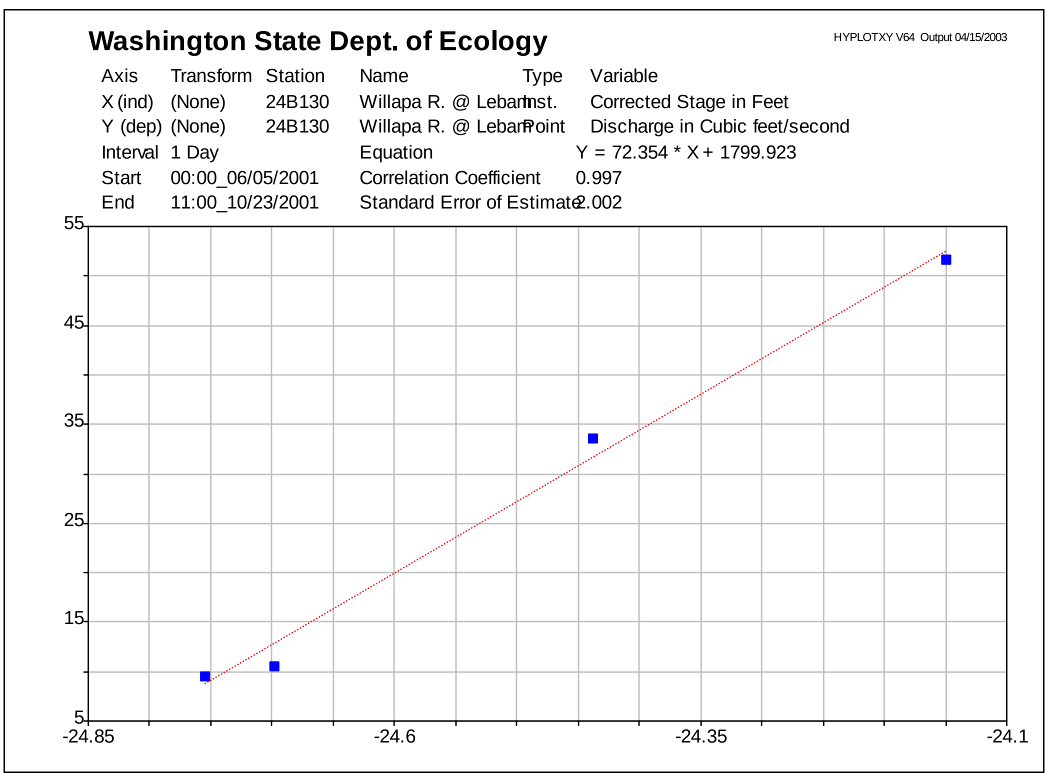

Figure 5: Linear regression of stage versus discharge for Site 1.

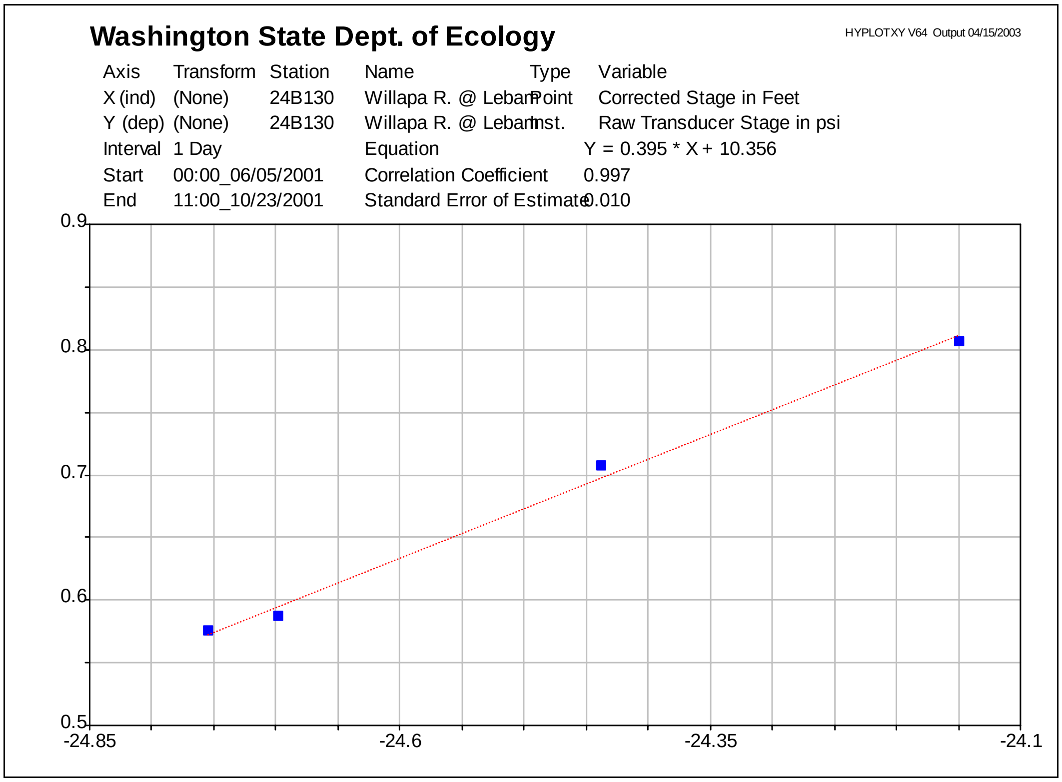

Figure 6: Linear regression of tape down versus pressure transducer readings for Site 1.

Site 2: Willapa River at Oxbow

The average daily discharge for Site 2 ranged from under 30 cfs in mid-August to almost 600 cfs in mid-May. Peak flow during the study period was over 1,200 cfs on August 22nd (Figure 7). Daily discharge averages are presented in Appendix A, Table 2. The rating curve encompassed only 20% of the range of discharge, with flow measurements ranging from 37 to 237 cfs (Figure 8). However, discharge exceeded the rating curve only about 8% of the time over the duration of the study (Figure 9). Within the range of measured flows, the fit of the rating curve was very good. A linear regression of river stage against discharge had an r^2 value of 0.993 (Figure 10). All five discharge measurements conducted at Site 2 were within 5% of the flow predicted by the rating curve. The linear regression of tape down readings against pressure transducer readings was quite strong, with an r^2 value of 0.997 (Figure 11). The overall trend in streamflow at Site 2 reflects a typical dry-period decline in discharge, with the exception of a few small storm events, and one large storm event in late-August.

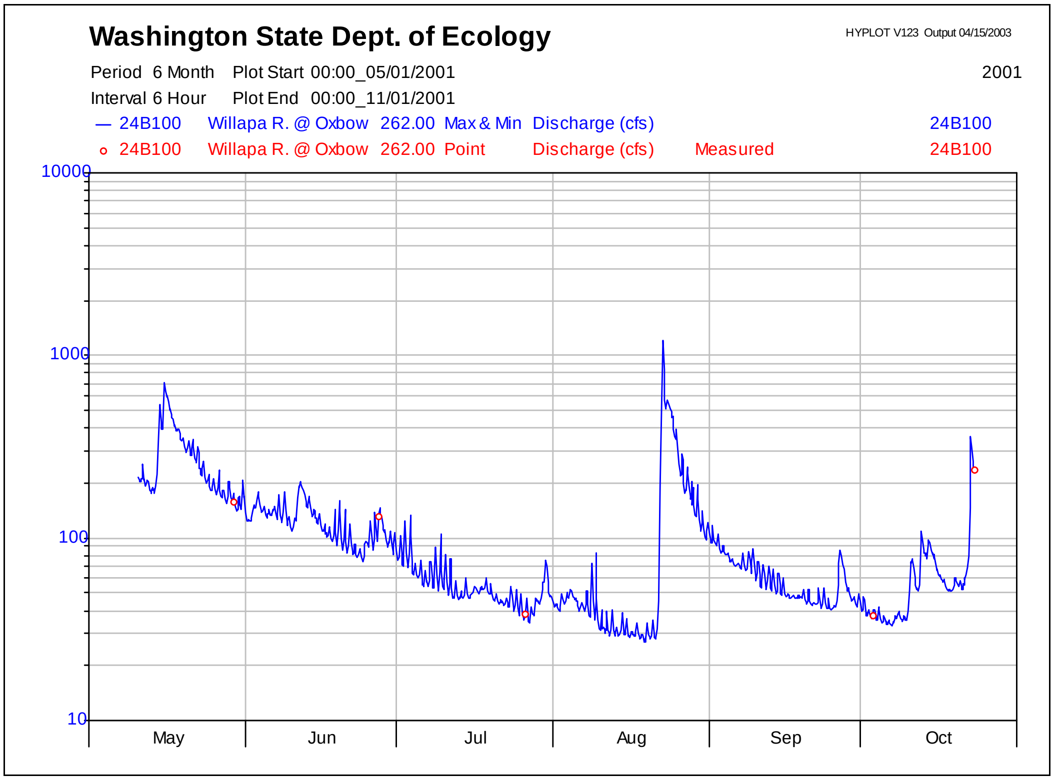

Figure 7: Discharge hydrograph for Site 2.

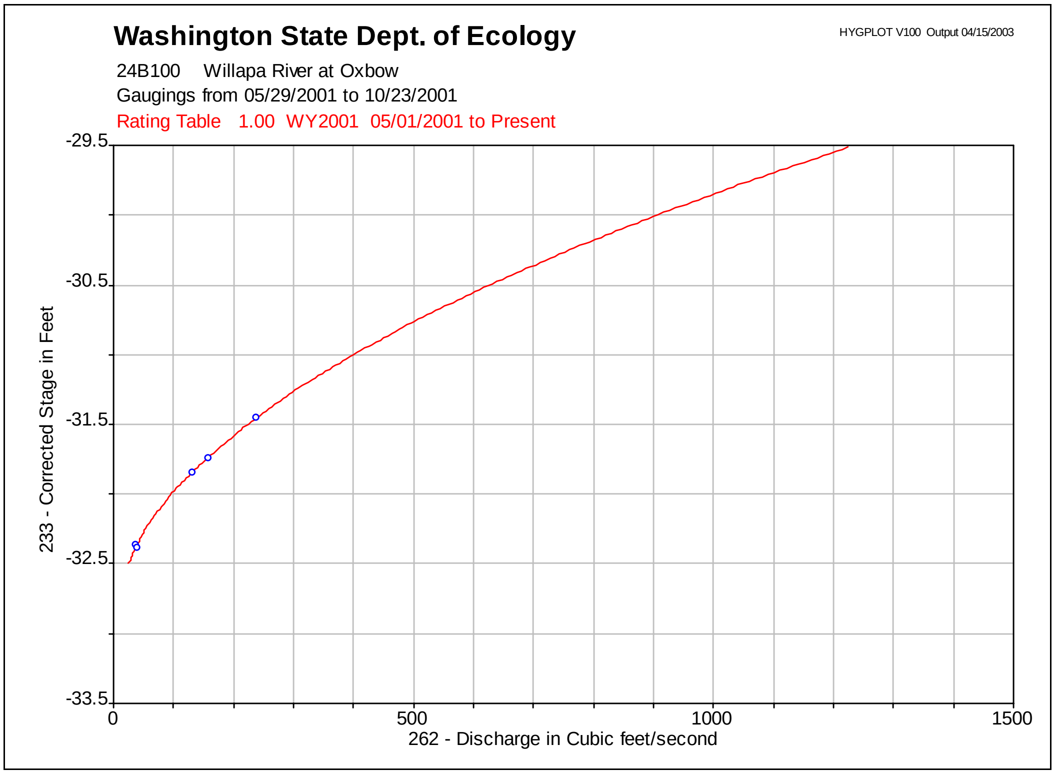

Figure 8: Discharge rating curve for Site 2.

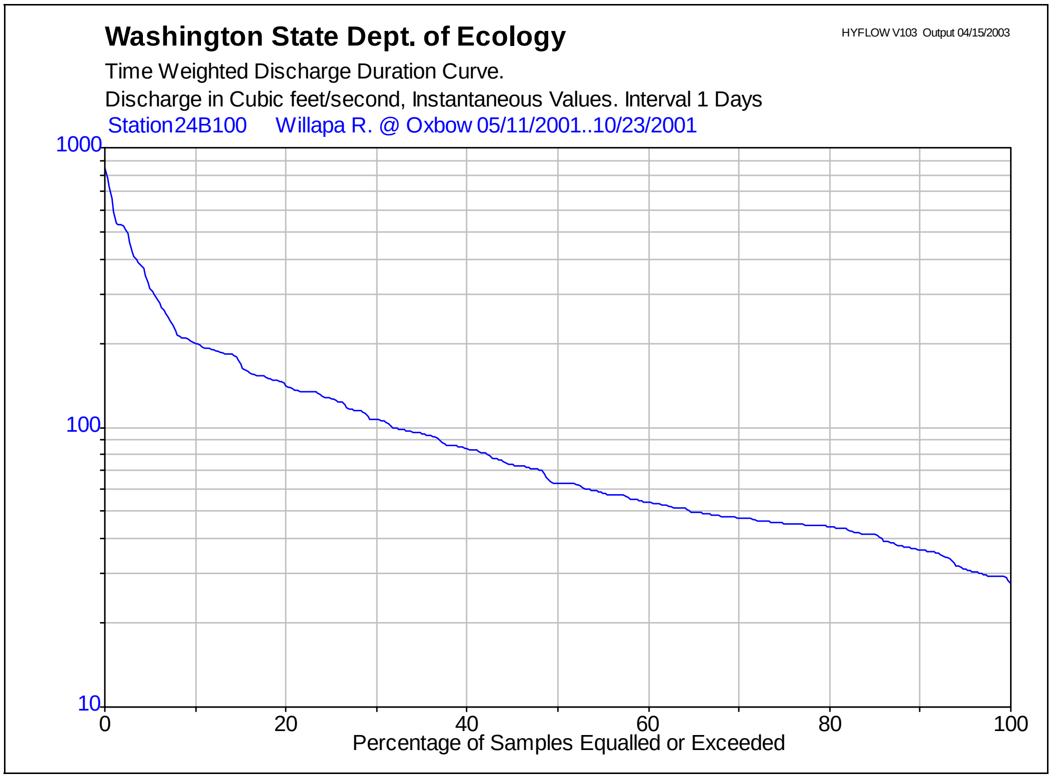

Figure 9: Flow exceedence graph for Site 2.

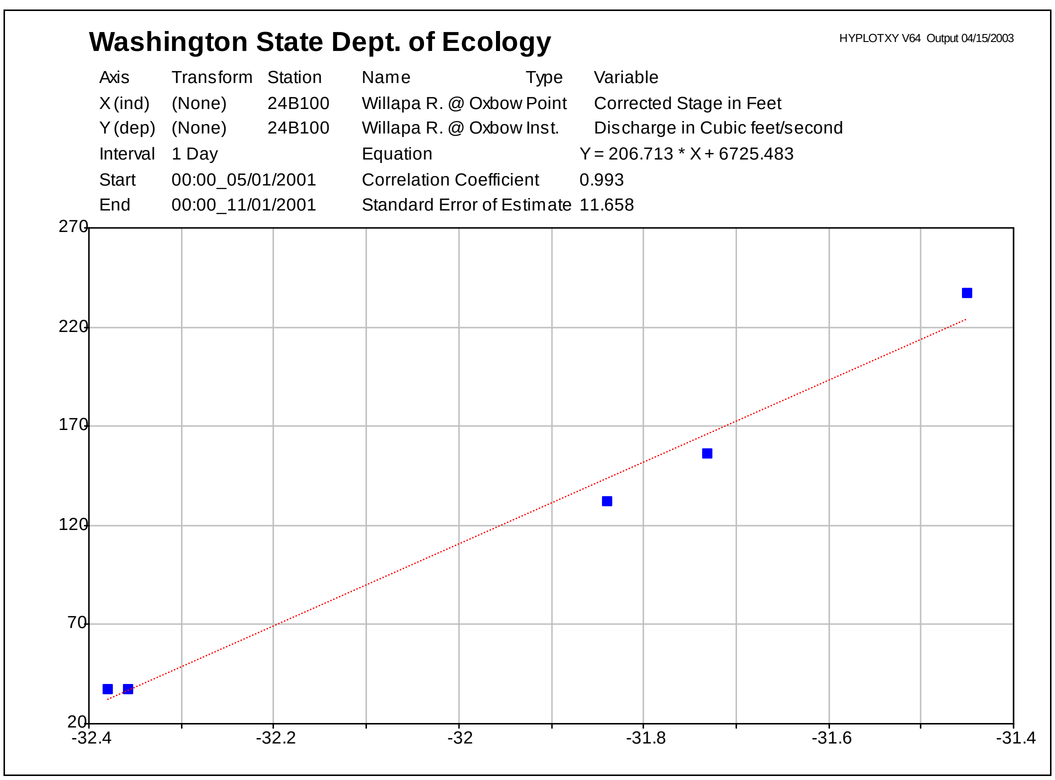

Figure 10: Linear regression of stage versus discharge for Site 2.

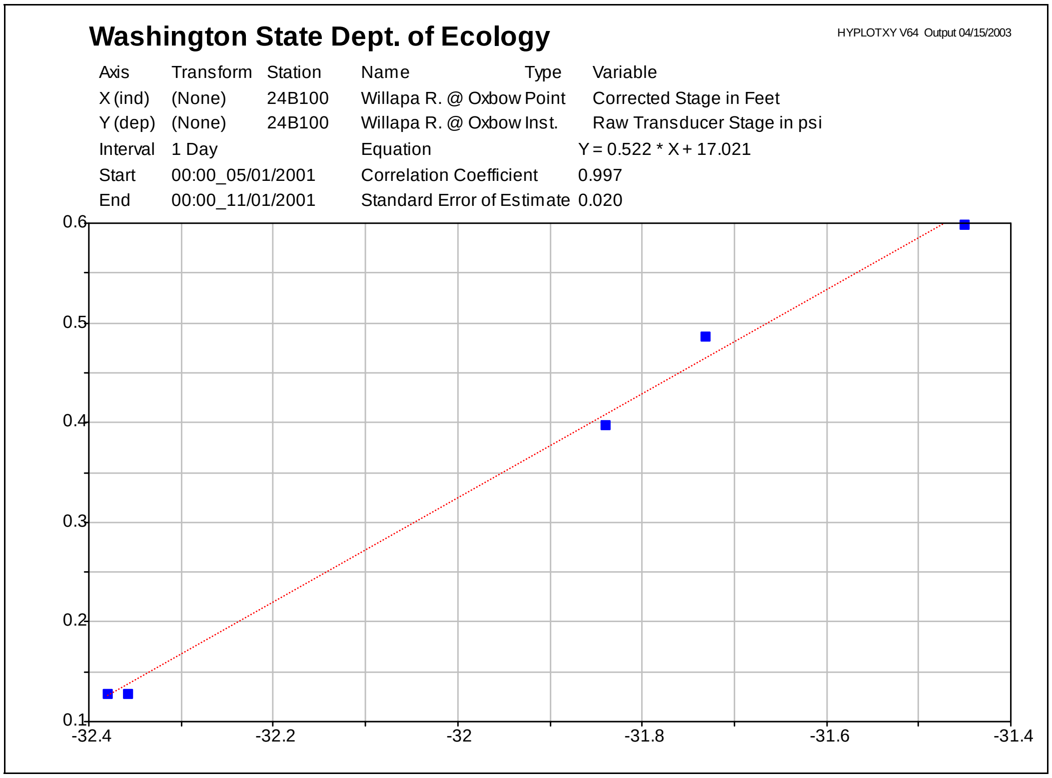

Figure 11: Linear regression of tape down versus pressure transducer readings for Site 2.

Site 3: S.F. Willapa River at South Fork Water Treatment Plant

The average daily discharge for Site 3 ranged from under 30 cfs in early-October to over 300 cfs in mid-May. Peak flow during the study period was nearly 740 cfs during a storm event on August 22nd (Figure 12). Daily discharge averages are presented in Appendix A, Table 3. The station was located downstream of a water supply withdrawal for the City of Raymond. Daily withdrawal totals are presented in Appendix B.

The rating curve encompassed only 12% of the range of discharge, with flow measurements ranging from 29 to 87 cfs (Figure 13). Discharge at this site exceeded the rating curve approximately 18% of the time (Figure 14), resulting in nearly 5% of the discharge data being qualified as estimates. Within the range of measured flows, the fit of the rating curve was very good. A linear regression of river stage against discharge had an r^2 value of 0.993 (Figure 15). All five discharge measurements conducted at Site 3 were within 5% of the flow predicted by the rating curve. The linear regression of staff gage readings against pressure transducer readings was fairly strong, with an r^2 value of 0.959 (Figure 16). The overall trend in streamflow at Site 3 reflects a typical dry-period decline in discharge, with the exception of a few small storm events and one large storm event in late-August.

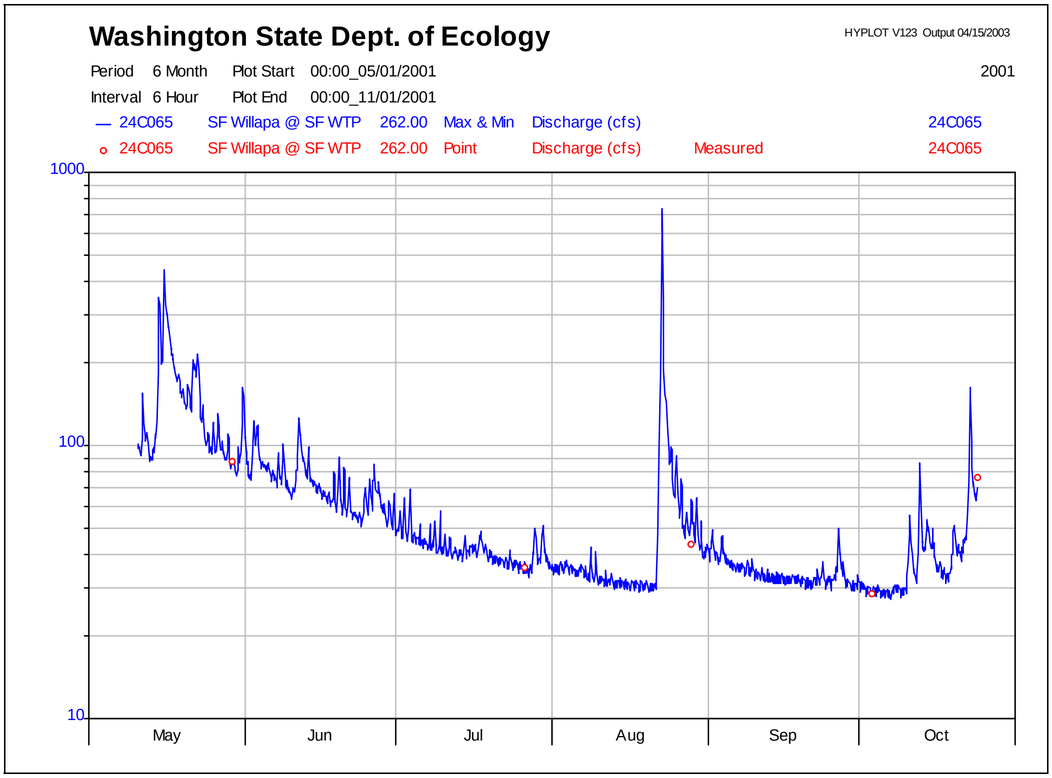

Figure 12: Discharge hydrograph for Site 3.

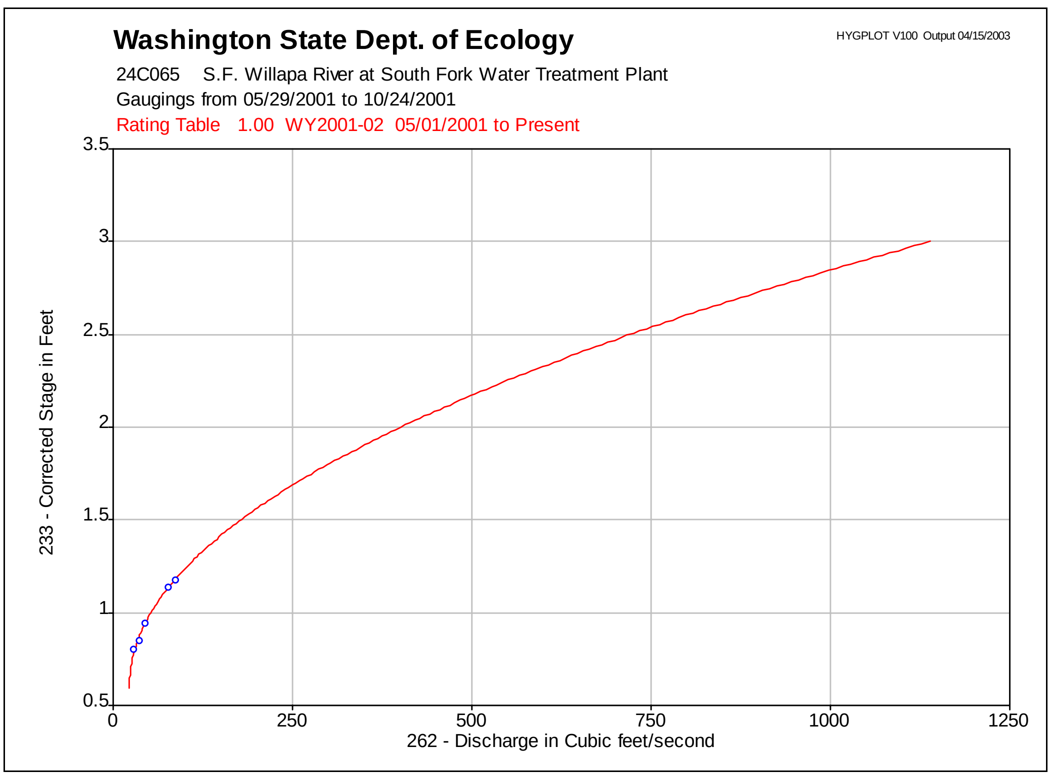

Figure 13: Discharge rating curve for Site 3.

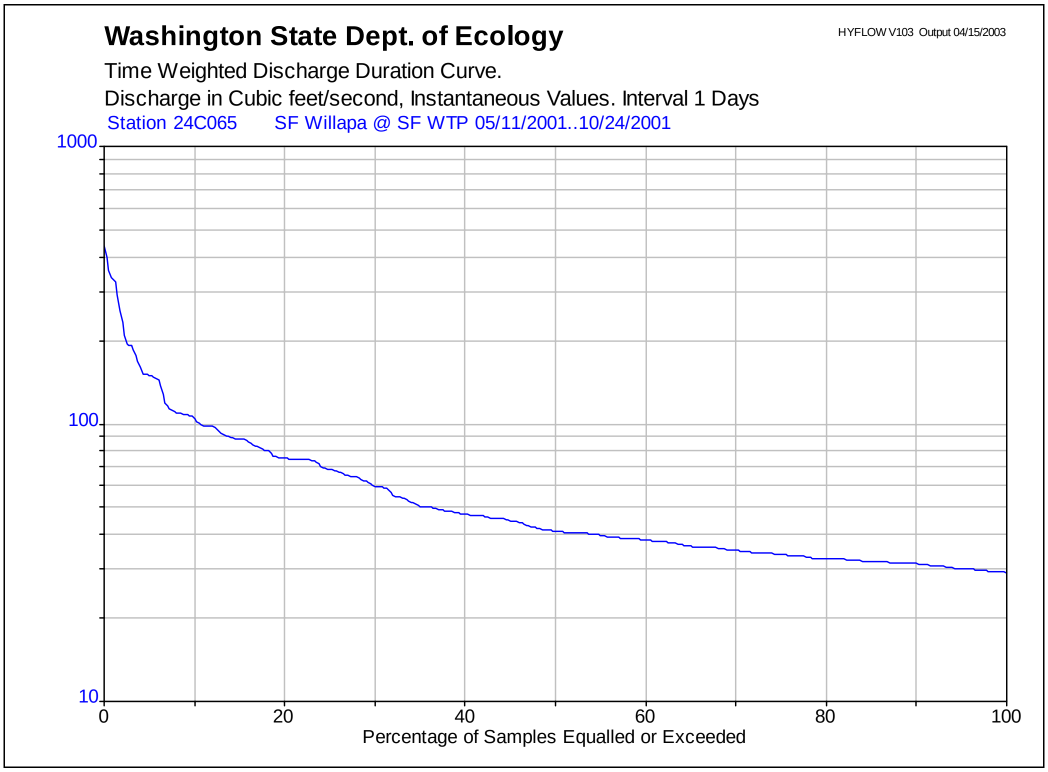

Figure 14: Flow exceedence graph for Site 3.

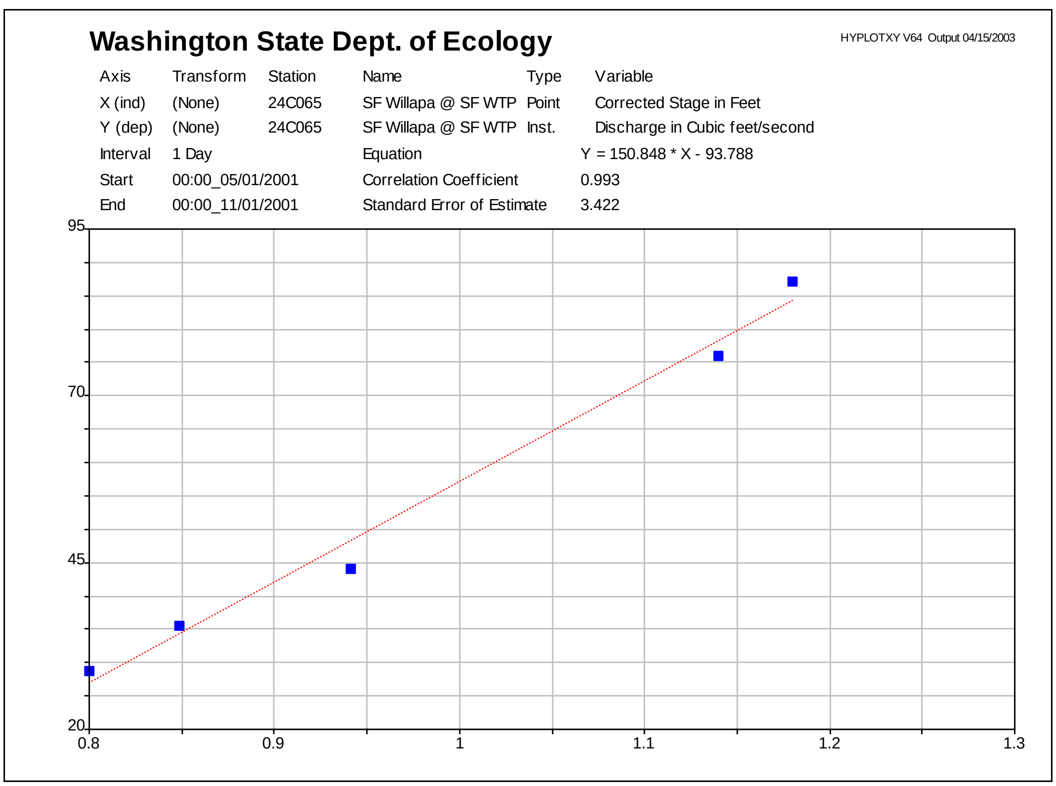

Figure 15: Linear regression of stage versus discharge for Site 3.

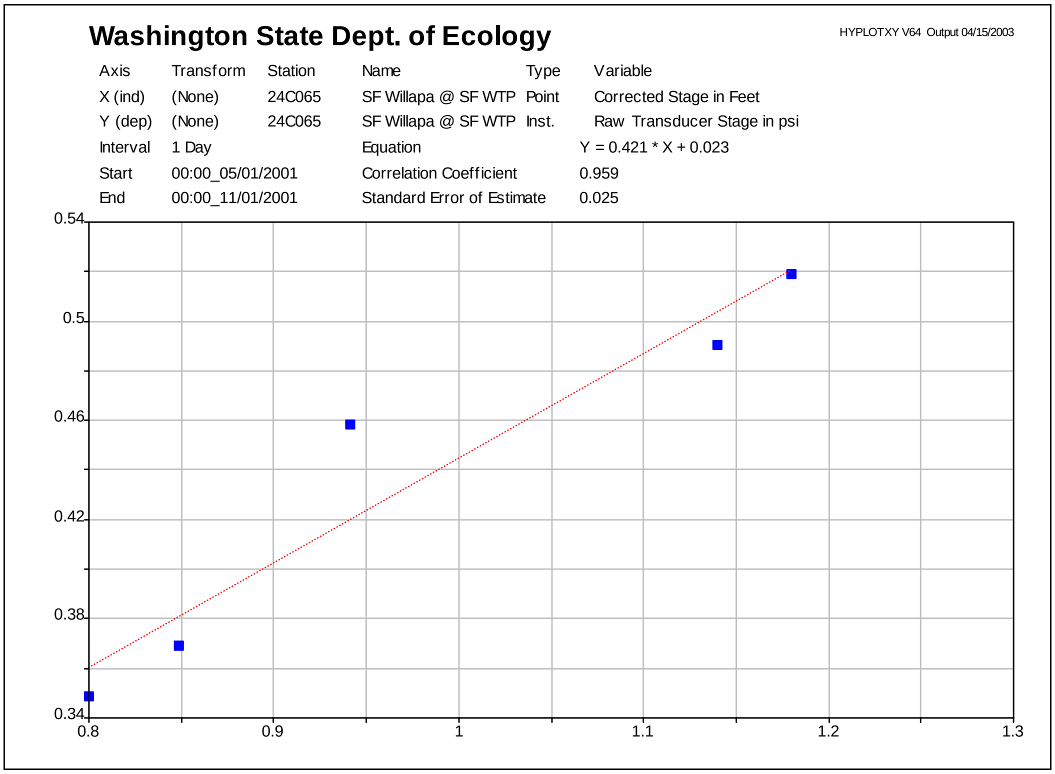

Figure 16: Linear regression of staff gage versus pressure transducer readings for Site 3.

Site 4: Fork Creek Near Mouth

The average daily discharge for Site 4 ranged from under 5 cfs in mid-August to over 320 cfs during a storm event in late-August. Peak flow during the study period was nearly 670 cfs on August 22nd (Figure 17). Daily discharge averages are presented in Appendix A, Table 4. The Washington State Department of Fish and Wildlife (WDFW) operates a salmon hatchery near the mouth of Fork Creek. The stream-gaging station at this site was located downstream of one of the water intakes for the hatchery. WDFW continuously withdraws 6.7 cfs from Fork Creek through this intake.

The rating curve for Site 4 encompassed only 15% of the range of discharge, with flow measurements ranging from 6.8 to 98 cfs (Figure 18). However, discharge exceeded the rating curve only about 2% of the time over the duration of the study (Figure 19). Within the range of measured flows, the fit of the rating curve was fairly good. A linear regression of river stage against discharge had an r^2 value of 0.987 (Figure 20). Only one of the six discharge measurements conducted at Site 4 was within 5% of the flow predicted by the rating curve, but four of the discharge measurements were within 10%. The linear regression of tape down readings against pressure transducer readings was very strong, with an r^2 value of 0.997 (Figure 21). The overall trend in streamflow at Site 4 reflects a typical dry-period decline in discharge, with the exception of a few small storm events and one large storm event in late-August.

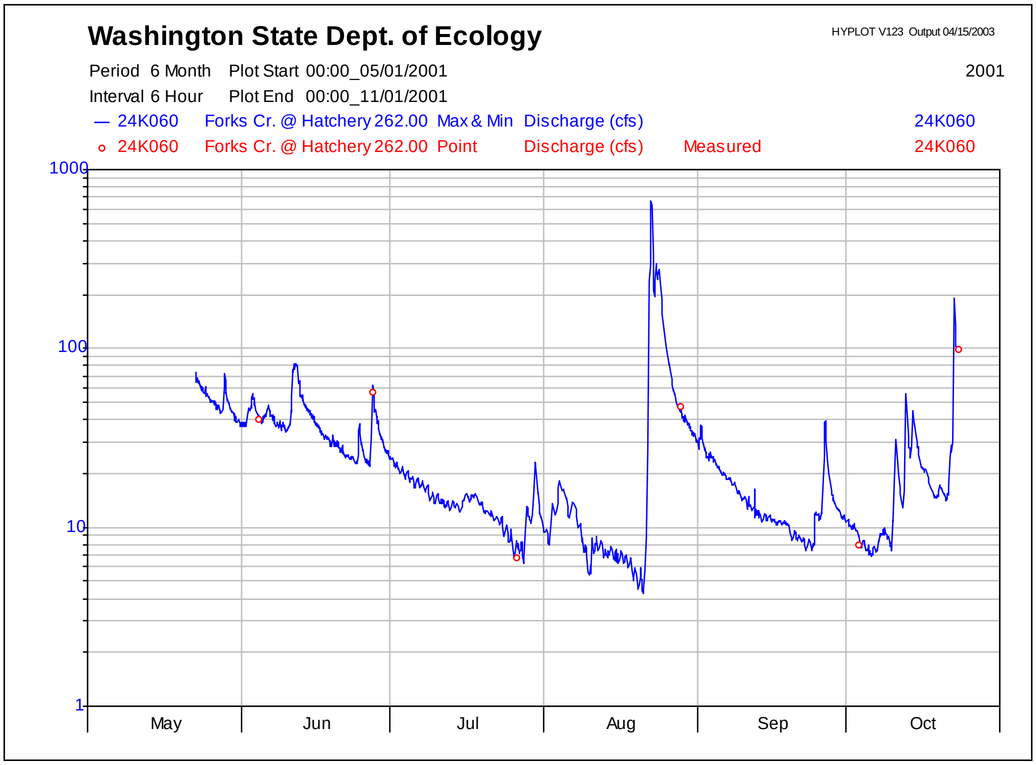

Figure 17: Discharge hydrograph for Site 4.

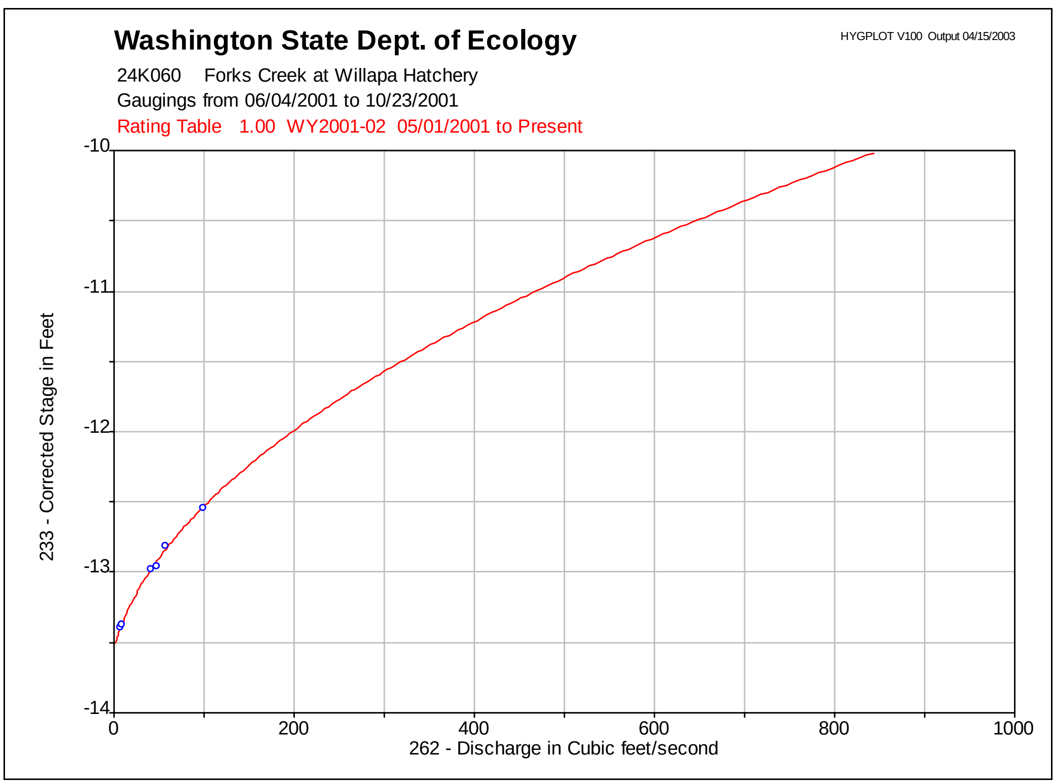

Figure 18: Discharge rating curve for Site 4.

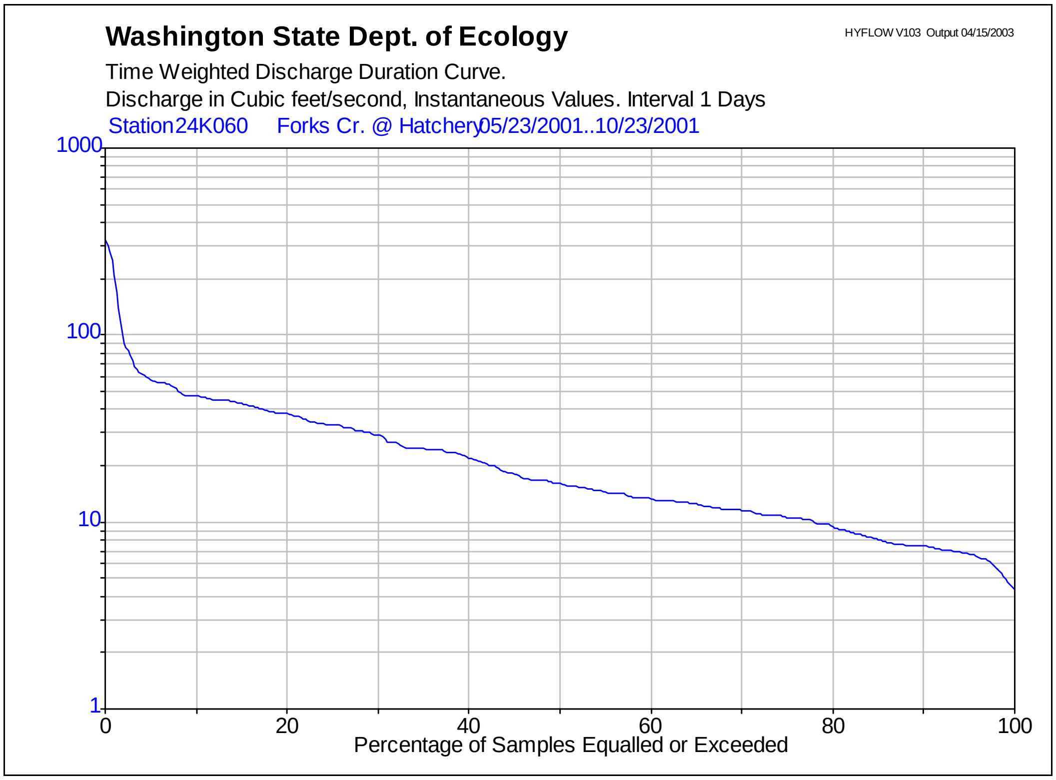

Figure 19: Flow exceedence graph for Site 4.

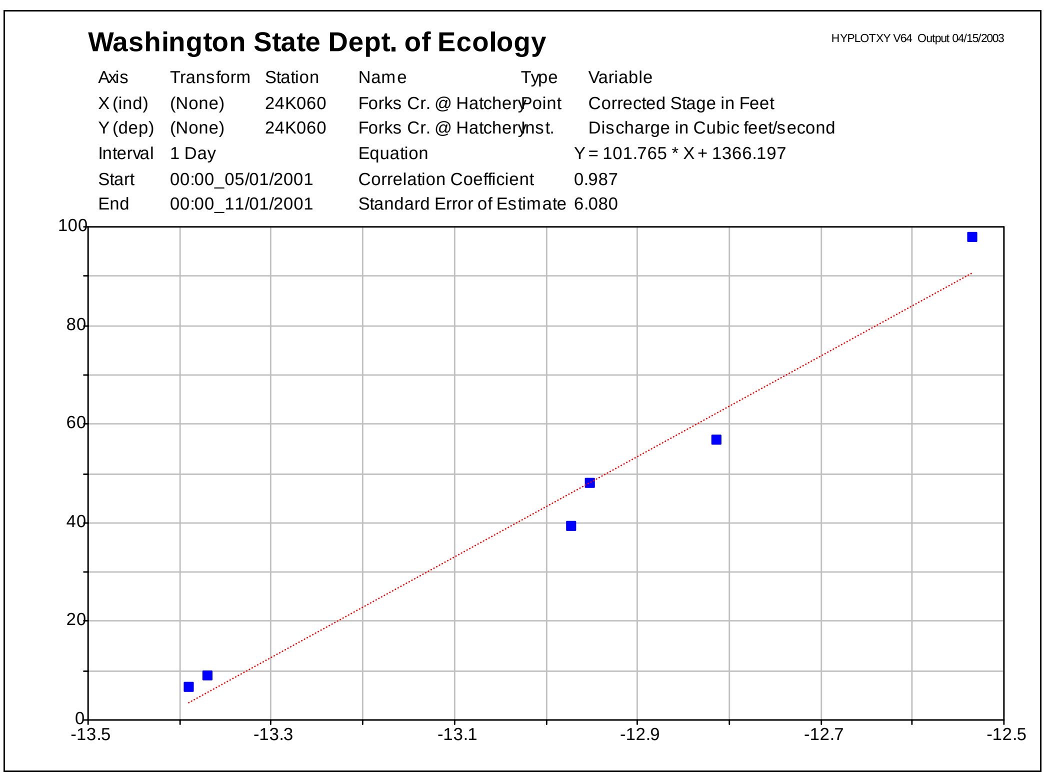

Figure 20: Linear regression of stage versus discharge for Site 4.

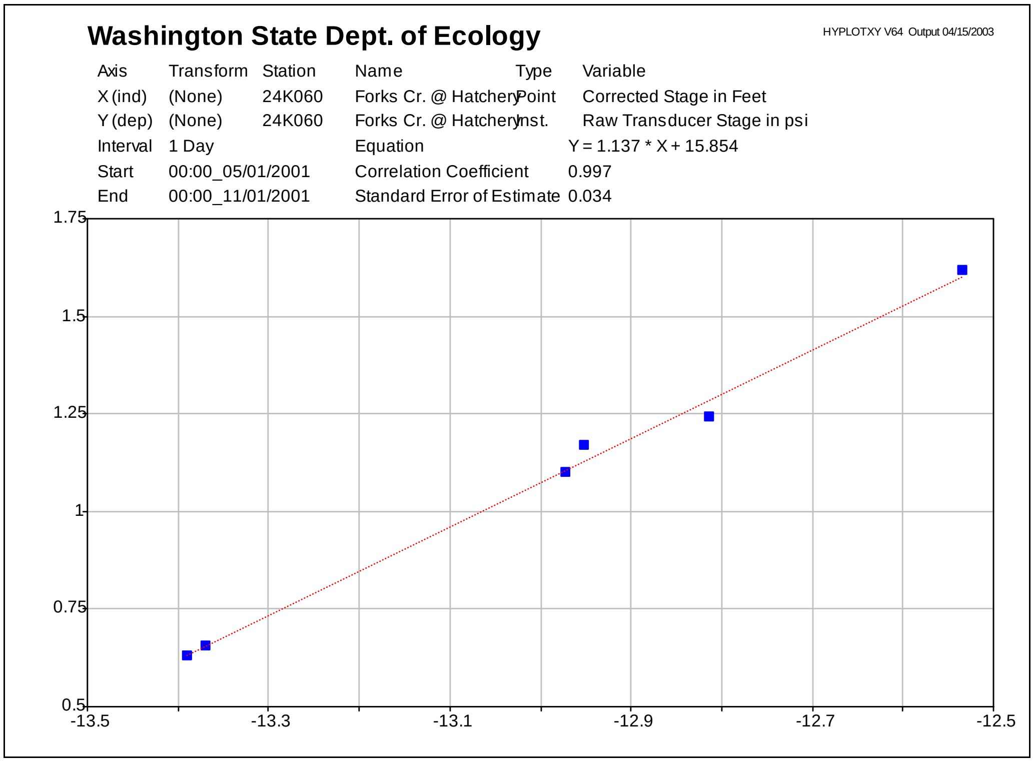

Figure 21: Linear regression of tape down versus pressure transducer readings for Site 4.

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Hopkins, Brad. 1999. *Determination of Instantaneous Flow Measurements on Rivers and Streams*. Washington State Department of Ecology, Olympia, Washington. Draft Paper. P.6.

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Appendix A: Average Daily Discharge Tables for 2001

Table 1: Average Daily Discharge for Site 1 – Willapa R. at Lebam

Day	May	Jun	Jul	Aug	Sep	Oct
1	[]	41.0	18.9	11.0	26.2	10.1
2	[]	42.3	17.3	10.8	25.0	10.0
3	[]	49.7	15.6	10.8	21.2	9.94
4	[]	41.9	14.2	11.7	20.1	9.92
5	[]	40.6	13.7	11.2	17.9	10.0
6	[]	43.0	12.9	10.1	16.4	9.97
7	[]	38.8	13.6	9.95	15.7	10.4
8	[]	35.7	15.0	9.39	13.6	11.0
9	[]	35.2	13.9	8.90	12.3	11.1
10	[]	34.6	12.9	8.56	11.8	13.3
11	[]	47.2A	12.8	8.47	11.5	20.5
12	[]	50.7A	12.4	8.57	11.2	14.9
13	[]	43.2	12.4	8.44	11.0	16.8
14	[]	40.3	12.2	8.63	10.8	15.0
15	[]	38.2	12.6	8.55	10.7	13.3
16	[]	35.9	16.5	8.60	10.7	12.1
17	[]	34.3	14.8	8.58	10.8	13.3
18	[]	32.1	15.7	8.26	11.1	12.0
19	[]	29.9	13.0	8.38	11.1	11.8
20	[]	27.9	11.4	8.52	10.7	12.1
21	[]	26.0	11.3	8.63	10.3	12.4
22	[]	24.9	11.2	111J	10.2	26.5A
23	64.8A	24.7	10.8	106J	10.1	[]
24	59.3A	26.8	10.4	93.3J	10.0	[]
25	56.6A	28.3	10.1	63.1A	10.4	[]
26	54.7A	22.9	9.91	46.3	18.9	[]
27	48.9	33.2	9.88	37.9	20.7	[]
28	53.5A	30.7	11.6	33.8	13.1	[]
29	50.5	25.5	12.8	31.0	11.4	[]
30	46.7	21.5	24.9	28.1	10.6	[]
31	53.3A		12.6	25.8		[]
Mean	54.3A	34.9A	13.5	24.9J	13.8	13.0A
Median	53.5A	34.9A	12.8	10.1J	11.3	12.1A
Max.Daily Mean	64.8A	50.7A	24.9	111J	26.2	26.5A
Min.Daily Mean	46.7	21.5	9.88	8.26	10.0	9.92
Inst.Max	71.1A	57.0A	34.1	273J	29.7	63.4A
Inst.Min	43.9	18.6	9.44	7.94	9.84	9.80
Missing Days	22	0	0	0	0	9

------------------ Notes -------------------
All recorded data is continuous and reliable except where the following tags are used....
A ... Above Rating, reliable extrapolation
J ... Estimated Data
[ ] Data Not Recorded

Table 2: Average Daily Discharge for Site 2 – Willapa R. at Oxbow

Day	May	Jun	Jul	Aug	Sep	Oct
1	[]	126	84.6	43.1	102	42.2
2	[]	138	88.5	43.9	95.8	38.5
3	[]	165	85.3	46.3	85.7	38.1
4	[]	143	66.9	49.7	80.9	37.4
5	[]	135	64.7	46.0	74.9	35.3
6	[]	139	58.5	42.1	71.1	34.3
7	[]	142	62.0	45.0	73.3	34.8
8	[]	147	64.5	48.0	73.4	37.4
9	[]	124	70.3	43.7	74.2	36.1
10	[]	117	62.1	33.9	67.0	45.7
11	218	162	58.2	32.8	62.1	67.4
12	199	181	50.2	32.7	61.5	57.8
13	181	155	48.0	30.4	59.0	89.9
14	283	137	51.1	31.6	55.5	87.5
15	458	126	47.6	30.9	53.1	79.4
16	599	112	51.8	29.6	48.3	64.4
17	458	105	51.9	30.6	47.3	57.9
18	390	111	53.7	28.8	47.2	52.2
19	346	114	51.0	29.6	48.2	55.5
20	315	106	46.8	30.4	46.6	56.0
21	301	95.5	44.6	30.7	43.8	56.3
22	277	86.4	44.5	579	46.9	134
23	235	81.3	46.7	579	46.3	[]
24	209	82.9	45.0	483	42.4	[]
25	194	102	42.1	344	41.2	[]
26	193	109	39.3	241	59.6	[]
27	175	123	36.8	198	72.6	[]
28	176	112	42.6	174	52.2	[]
29	167	97.3	45.8	148	46.0	[]
30	151	90.7	64.2	122	44.9	[]
31	157		49.2	109		[]
Mean	271	122	55.4	121	60.8	56.3
Median	218	120	51.1	43.9	57.2	53.9
Max.Daily Mean	599	181	88.5	579	102	134
Min.Daily Mean	151	81.3	36.8	28.8	41.2	34.3
Inst.Max	706	202	134	1210	117	359
Inst.Min	137	74.2	34.1	27.0	40.4	33.1
Missing Days	10	0	0	0	0	9

------------------ Notes ------------------
All recorded data is continuous and reliable
except where the following tags are used...
[ ] Data Not Recorded

Table 3: Average Daily Discharge for Site 3 – S.F. Willapa at Willapa Water Treatment Plant

Day	May	Jun	Jul	Aug	Sep	Oct
1	[]	87.2	50.4	35.6	42.4	30.7
2	[]	95.0	51.9	35.9	40.2	29.6
3	[]	104	52.6	36.5	41.2	29.5
4	[]	85.6	46.1	35.7	39.0	29.6
5	[]	82.8	46.2	34.7	36.8	29.0
6	[]	77.6	44.5	35.1	36.3	28.9
7	[]	78.2	44.8	34.7	35.9	29.1
8	[]	82.4	45.2	34.5	35.8	30.2
9	[]	70.9	45.5	35.2	35.8	29.3
10	[]	68.0	42.5	32.3	33.9	34.4
11	114	97.3	42.2	32.3	33.8	41.0
12	106	90.3	40.5	31.9	33.5	37.7
13	91.8	81.6	39.9	31.0	33.0	52.5
14	162	73.5	41.0	31.6	33.0	46.5
15	246	69.7	41.1	31.2	32.6	43.4
16	306	66.5	41.9	31.1	32.6	36.7
17	217	63.9	44.0	31.0	32.6	34.7
18	180	66.4	42.4	30.8	32.4	33.0
19	155	69.0	39.8	30.6	32.0	41.3
20	148	65.2	38.6	30.3	31.5	43.0
21	166	62.2	37.9	32.3	31.4	41.8
22	187	56.3	37.8	266	33.0	69.9
23	127	54.7	37.4	175	33.4	89.9
24	103	58.6	36.7	91.8	31.8	[]
25	102	65.1	36.1	74.5	31.7	[]
26	107	70.8	35.4	61.5	35.9	[]
27	96.8	67.5	35.1	50.8	37.9	[]
28	95.3	58.5	43.1	53.50	31.8	[]
29	85.9	55.0	39.4	51.7	30.9	[]
30	85.5	54.6	42.8	44.4	31.4	[]
31	115		36.8	40.9		[]
Mean	143	72.6	41.9	51.8	34.5	39.6
Median	115	69.3	41.9	35.1	33.2	34.7
Max.Daily Mean	306	104	52.6	266	42.4	89.9
Min.Daily Mean	85.5	54.6	35.1	30.3	30.9	28.9
Inst.Max	438	126	68.8	738	50.0	163
Inst.Min	77.6	47.5	32.9	28.9	29.2	27.3
Missing Days	10	0	0	0	0	8

------------------ Notes -------------------
All recorded data is continuous and reliable
except where the following tags are used...
[ ] Data Not Recorded

Table 4: Average Daily Discharge for Site 4 – Fork Cr. at Willapa Salmon Hatchery

Day	May	Jun	Jul	Aug	Sep	Oct
1	[]	37.8	23.6	9.30	32.2	10.5
2	[]	43.8	21.8	10.6	27.6	10.0
3	[]	50.0	20.4	13.0	25.0	8.90
4	[]	41.8	19.5	17.0	23.4	8.02
5	[]	40.8	18.2	14.1	21.1	7.46
6	[]	44.7	17.7	12.5	19.5	7.41
7	[]	40.1	17.0	12.3	18.5	8.24
8	[]	37.2	16.0	9.37	17.0	9.42
9	[]	36.6	14.6	7.17	15.4	8.64
10	[]	36.9	14.3	6.67	14.2	13.9
11	[]	67.9	13.8	7.85	13.1	21.1
12	[]	68.2	13.4	7.82	12.7	19.5
13	[]	51.2	13.4	7.09	11.8	35.5
14	[]	45.0	13.1	7.34	11.4	34.8
15	[]	40.3	13.2	6.88	11.2	27.9
16	[]	36.2	14.8	6.77	10.8	21.5
17	[]	33.1	14.7	6.58	10.6	19.0
18	[]	30.7	14.7	5.99	10.5	15.7
19	[]	29.7	13.3	5.38	9.88	15.4
20	[]	28.6	12.2	4.94	9.01	15.8
21	[]	26.2	11.8	7.39	8.70	16.4
22	[]	24.9	11.1	323	8.20	69.7
23	63.9	24.0	10.5	252	8.01	[]
24	57.9	28.3	9.48	224	9.42	[]
25	52.8	27.5	8.51	119	11.6	[]
26	49.2	23.0	7.63	74.5	25.2	[]
27	46.0	45.8	7.36	54.6	21.2	[]
28	56.7	38.5	11.0	44.7	14.4	[]
29	49.2	30.0	11.6	40.1	12.4	[]
30	42.3	26.0	17.8	36.3	11.3	[]
31	38.9		11.4	32.3		[]
Mean	50.8	37.8	14.1	44.7	15.2	18.4
Median	49.2	37.0	13.4	10.6	12.5	15.6
Max.Daily Mean	63.9	68.2	23.6	323	32.2	69.7
Min.Daily Mean	38.9	23.0	7.36	4.94	8.01	7.41
Inst.Max	72.1	82.4	24.9	669	39.5	190
Inst.Min	36.9	21.9	6.32	4.26	7.46	6.91
Missing Days	22	0	0	0	0	9

------------------ Notes ------------------
All recorded data is continuous and reliable
except where the following tags are used...
[ ] Data Not Recorded

Appendix B: Daily Water Withdrawals for the City of Raymond South Fork Water Treatment Plant

Day	May		June		July		August		September		October	
	*KGPD**	*CFS*[†]	*KGPD*	*CFS*	*KGPD*	*CFS*	*KGPD*	*CFS*	*KGPD*	*CFS*	*KGPD*	*CFS*
1	541	0.84	575	0.89	682	1.06	872	1.35	690	1.07	578	0.89
2	520	0.80	634	0.98	687	1.06	553	0.86	576	0.89	639	0.99
3	678	1.05	517	0.80	841	1.30	481	0.74	601	0.93	723	1.12
4	512	0.79	542	0.84	480	0.74	691	1.07	565	0.87	562	0.87
5	787	1.22	656	1.02	613	0.95	573	0.89	650	1.01	560	0.87
6	468	0.72	500	0.77	745	1.15	561	0.87	690	1.07	620	0.96
7	938	1.45	607	0.94	714	1.10	781	1.21	460	0.71	594	0.92
8	436	0.67	591	0.91	707	1.09	590	0.91	727	1.12	588	0.91
9	579	0.90	747	1.16	759	1.17	819	1.27	671	1.04	662	1.02
10	575	0.89	367	0.57	717	1.11	550	0.85	595	0.92	726	1.12
11	491	0.76	598	0.93	786	1.22	774	1.20	707	1.09	483	0.75
12	688	1.06	623	0.96	679	1.05	664	1.03	681	1.05	575	0.89
13	505	0.78	612	0.95	618	0.96	717	1.11	780	1.21	734	1.14
14	562	0.87	646	1.00	641	0.99	674	1.04	742	1.15	556	0.86
15	608	0.94	374	0.58	729	1.13	661	1.02	697	1.08	578	0.89
16	555	0.86	560	0.87	600	0.93	817	1.26	741	1.15	604	0.93
17	569	0.88	721	1.12	539	0.83	397	0.61	697	1.08	531	0.82
18	554	0.86	781	1.21	670	1.04	711	1.10	533	0.82	596	0.92
19	652	1.01	569	0.88	633	0.98	568	0.88	586	0.91	755	1.17
20	409	0.63	620	0.96	783	1.21	851	1.32	701	1.08	382	0.59
21	746	1.15	633	0.98	470	0.73	414	0.64	599	0.93	602	0.93
22	691	1.07	671	1.04	717	1.11	716	1.11	730	1.13	494	0.76
23	695	1.08	694	1.07	759	1.17	581	0.90	519	0.80	723	1.12
24	512	0.79	442	0.68	670	1.04	844	1.31	633	0.98	579	0.90
25	787	1.22	662	1.02	524	0.81	400	0.62	787	1.22	647	1.00
26	399	0.62	624	0.97	839	1.30	705	1.09	394	0.61	530	0.82
27	512	0.79	652	1.01	672	1.04	726	1.12	780	1.21	610	0.94
28	817	1.26	768	1.19	557	0.86	865	1.34	392	0.61	581	0.90
29	472	0.73	451	0.70	483	0.75	529	0.82	453	0.70	610	0.94
30	610	0.94	745	1.15	670	1.04	828	1.28	631	0.98	641	0.99
31	570	0.88			583	0.90	600	0.93			537	0.83

*KGPD = Thousand gallons per day
[†]CFS = Cubic feet per second