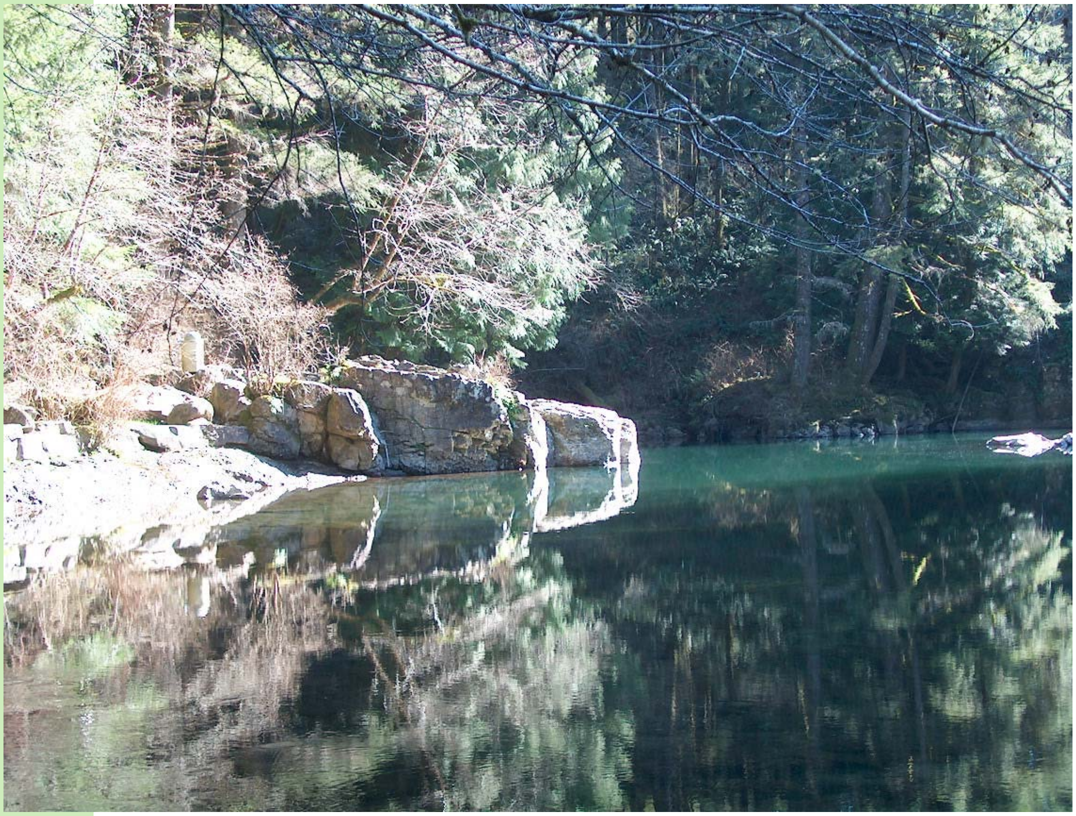

Streamflow Summary for Gaging Stations on the East Fork Lewis River, 2005-06

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Cover photo: E.F. Lewis River above Moulton Falls (photo by Chuck Springer).

Streamflow Summary for Gaging Stations on the East Fork Lewis River, 2005-06

by
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Waterbody Numbers: WA-27-2020, WA-27-2030

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Abstract

From June 2005 to November 2006, the Washington State Department of Ecology (Ecology) conducted a streamflow assessment on the East Fork Lewis River.

The assessment was conducted in support of a temperature and fecal coliform Total Maximum Daily Load (TMDL) study. The purpose of the TMDL study was to (1) characterize water temperatures and fecal coliform concentrations in the East Fork Lewis River basin, and (2) establish loading capacity, and load and wasteload allocations, for heat and fecal coliform sources in the watershed. These allocations will be set in order for the East Fork Lewis River to meet Washington State water quality standards.

Continuous stage height (water surface elevation) recorders and staff gages were installed at two sites for this study.

1. The lower site, which was impacted by the Columbia River tidal bulge, collected tide-impacted stage height data until the station was flooded in December 2005.
2. At the upper site, 11 discharge measurements were taken over the duration of the study, and a discharge rating curve was developed by relating the stage heights to their corresponding discharges. A continuous discharge record was developed for this site by applying the rating curve over the range of stage heights encountered.

In addition to the two sites established in support of the TMDL study, data were used from one long-term Ecology streamflow monitoring site and one U.S. Geological Survey streamflow monitoring site.

Potential error of streamflow data collected from the three Ecology monitoring sites ranged from ±14% to ±30%.

Introduction

From June 2005 to November 2006, the Environmental Assessment (EA) Program of the Washington State Department of Ecology (Ecology) conducted a streamflow assessment on the East Fork (E.F.) Lewis River.

This monitoring was conducted in support of a temperature and fecal coliform Total Maximum Daily Load (TMDL) study developed by the EA Program. The purpose of the TMDL study was to (1) characterize water temperatures and fecal coliform concentrations in the E.F. Lewis River basin, and (2) establish loading capacity, and load and wasteload allocations, for heat and fecal coliform sources in the watershed. These allocations will be set in order for the East Fork Lewis River to meet Washington State water quality standards.

The TMDL study was initiated because of federal Clean Water Act 303(d) listings of E.F. Lewis River segments which are water quality impaired for temperature and fecal coliform (Bilhimer, Sullivan, and Brock, 2005).

Sampling Sites

The E.F. Lewis River is a tributary to the mainstem Lewis River. The E.F. Lewis flows west from its headwaters in the Gifford Pinchot National Forest to its confluence with the mainstem Lewis River near the town of La Center. The E.F. Lewis River basin covers an area of 212 square miles. Land use in the basin is predominantly suburban and rural density residential development in the lower watershed, and forestry in the upper watershed.

For this streamflow study, Ecology established continuous stage height recorders at Site 1 and 2 on the E.F. Lewis River. Data from sites 3 and 4 were also used.

1. E.F. Lewis River near La Center (Site 1): The lower station was located on a Clark County greenbelt parcel upstream of Paradise Point State Park, at river mile 1.8 (Figure 1, Site 1). The purpose of this station was to monitor the influence of the Columbia River tidal bulge on the E.F. Lewis. However, the station was flooded during a large storm event in December 2005, and was not re-established.

2. E.F. Lewis River at Sunset Campground (Site 2): The upper station was located at the Gifford Pinchot National Forest boundary, at river mile 32.5.

3. E.F. Lewis River near Dollar Corner (Site 3): Data from a long-term streamflow monitoring site at Daybreak Park, northwest of the town of Battle Ground, at river mile 10.1, were also used for the TMDL study.

4. E.F. Lewis River at Heisson USGS Gage (Site 4): Data from the U.S. Geological Survey station E.F. Lewis River at Heisson, at river mile 20.3, were also used for the TMDL study. Average daily discharges for this station are presented in Appendix C.

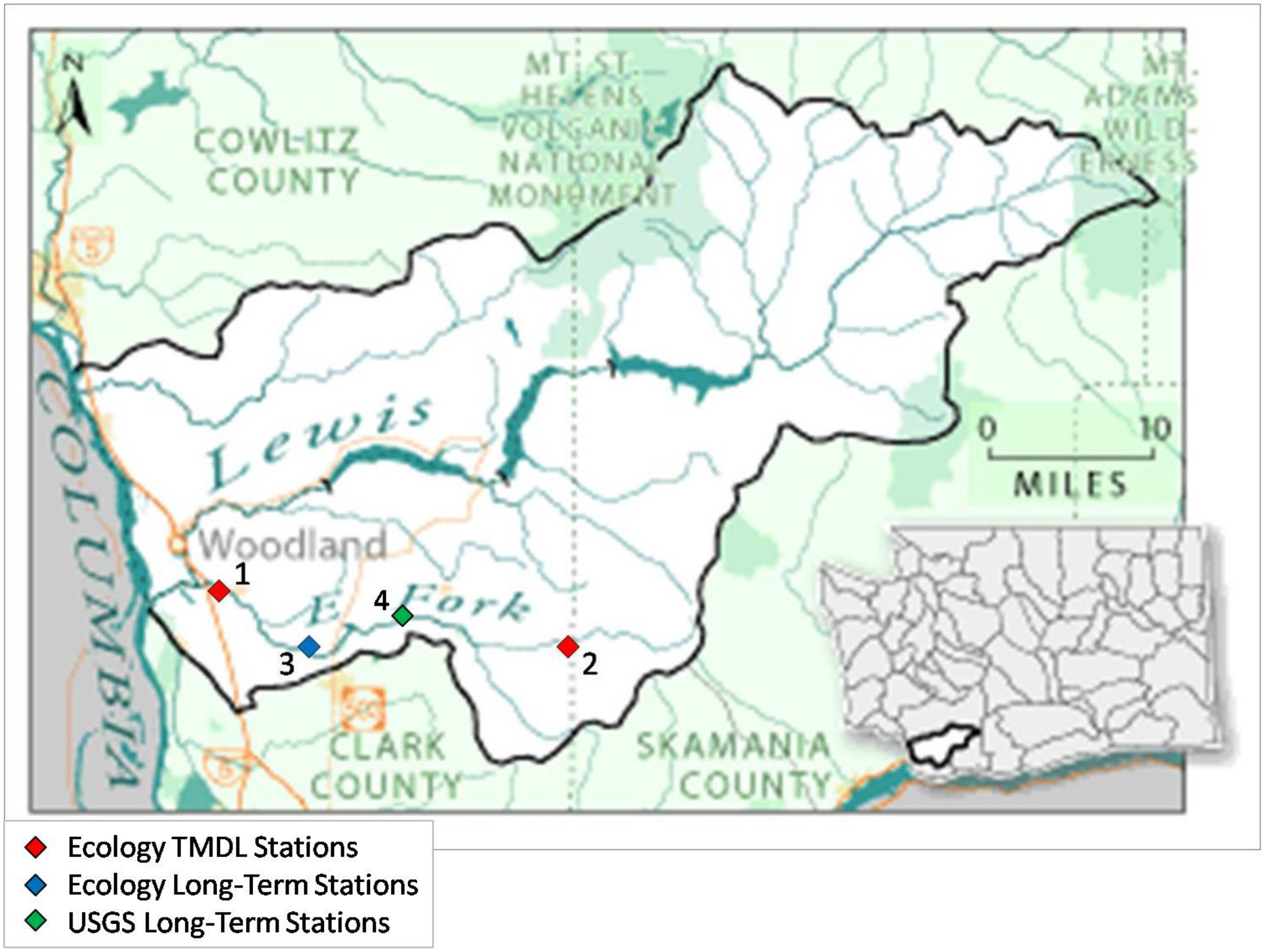

Figure 1. Map of E.F. Lewis River Basin Study Sites.

Methods

Each of the continuous gaging stations was equipped with a pressure transducer and datalogger that recorded water surface elevation (stage height) and water temperature at 15-minute intervals from June 2005 to November 2006.

Eleven discharge measurements were taken at Site 2 to establish a discharge rating curve, which models the relationship between stage and discharge. This rating curve was then used to calculate the average daily discharge for Site 2.

Discharge Measurements

Most discharge measurements were made following the U.S. Geological Survey (USGS) mid-section method (Rantz et al., 1982a, 1982b). Ecology has made minor modifications to the USGS method to accommodate its measurement equipment (Butkus, 2005). The flow measurement cross-sections were established by driving re-bar into opposing banks such that the cross-sections were perpendicular to the streamflow at each site. 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. 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 using the USGS mid-section method with a specialized discharge calculation software program developed by Ecology (Butkus, 2005).

One of the discharge measurements at Site 2 was made using an Acoustic Doppler Current Profiler (ADCP) mounted on a durable plastic trimaran vessel. ADCPs use Doppler technology to determine a continuous profile of depth and velocity across the river channel. Four to eight measurements are made by towing or walking the ADCP vessel across the chosen transect, which must be between one and 15 feet deep and have moderate velocities (less than six feet per second). The results of these transects are then averaged (Shedd, Springer, and Clishe, 2008). The continuous profiling capability of ADCPs make them an extremely accurate instrument for measuring discharge, since water column velocities and cross-sectional area are measured more thoroughly than can be done using current meters. However, depths at this site were usually too shallow for the ADCP to be applicable.

Stage Height Records

Submersible pressure transducers were installed to continuously monitor stage height at each site. A primary gage index (PGI) was also installed at each site. The PGI is a readable device, such as a staff gage, wire weight gage, or reference point from a bridge. The stage heights observed from the PGI are used to develop the rating curve and calibrate the datalogger at the site. The dataloggers at each site were calibrated to the PGI at the time of installation, and were subsequently recalibrated as necessary.

Pressure transducers are inherently prone to drift, with the degree varying from instrument to instrument. Drift is essentially a migration of the instrument from its original calibration, and materializes as a difference between observed and logged stage height values. This instrument drift results in erroneous stage height values that, when applied to the discharge rating curve for a station, produce erroneous discharge values. These erroneous stage height values are typically corrected by applying time-weighted adjustments to the continuous data set, which pivot on the stage height values observed on the PGI by staff in the field.

The adjusted stage height values are then applied to the discharge rating curve for the site, yielding a more accurate record of discharge. The time-weighted adjustments are based on the assumption that instrument drift occurs gradually and evenly over time, which under conditions such as sedimentation and biofouling is generally true (Freeman et al., 2004).

Error Assessments

Error estimates were calculated for each site for the two primary sources of error: pressure transducer drift and the discharge rating curve. The error estimates were calculated for each site for the 2005-06 study period as a whole, and for the low-flow period of July through September 2005 and 2006 separately.

Error introduced by pressure transducer drift was quantified using the following calculation:

$$\frac{1}{n}\sum_{1}^{n}\left(\frac{\left|Q_{rec}-Q_{obs}\right|}{Q_{obs}}\right)$$

where

Q_{rec} is the corresponding discharge for the recorded stage values.

Q_{obs} is the corresponding discharge for the observed stage height values.

Error in the discharge rating curve is quantified using the following calculation:

$$\frac{1}{n}\sum_{1}^{n}\left(\frac{\left|Q_{pred}-Q_{adj}\right|}{Q_{pred}}\right)$$

where

Q_{pred} is the discharge predicted by the rating curve.

Q_{adj} is the measured discharge plus or minus the maximum potential error, based on the professional quality rating of each discharge measurement.

Error due to pressure transducer drift and error inherent in the discharge rating curve are mutually exclusive sources of error, and are thus treated as additive.

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Quality Assurance

Quality assurance measures were taken during this study to address (1) error inherent in the instream discharge measurements, and (2) error in stage height records produced by the dataloggers.

Discharge Measurements

Because the largest potential source of error in a discharge measurement is in the velocity measurement, site selection and equipment calibration are of high importance. In this study, the measured cross-sections were qualitatively rated from excellent to poor, based on physical conditions encountered during each measurement.

- An *excellent* cross-section, which lies in a straight channel segment with laminar flow and fairly fine-grained substrate, assumes an error of up to 2%.

- A *good* cross-section, which generally lies in a straight channel segment with predominantly laminar flow and courser-grained substrate, assumes an error of up to 5%.

- A *fair* cross-section, which may contain sections of angular flow, turbulence, or near-bank eddies, assumes an error of up to 8%.

- A *poor* cross-section, which lies in proximity to bends in the stream channel with predominantly turbulent flow and cobble or boulder substrate, 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 and rating curve development.

An additional source of error in velocity measurements is the calibration of the Swoffer instruments. The ideal calibration setting of a Swoffer propeller is 186, which means that for every 186 revolutions of the propeller, 10 lineal feet of water has passed the measurement point. The Swoffer meters tend to be temperature sensitive, and the calibration setting of a meter can change over the course of a discharge measurement. The calibration settings for Swoffer meters used during this project were checked before and after each discharge measurement, with values ranging from 184 to 187. A calibration value of 184 overestimates the discharge measurement by 1.0%. Similarly, a calibration value of 187 underestimates the discharge measurement by 0.5%.

Once a discharge rating curve was established for Site 2, discharge measurements were tracked by comparing the measured discharge values to the discharge values predicted by the rating curve at the same stage. The combination of propeller variations, turbulent flow conditions at high flows, and high bottom roughness at low flows contributed to the measured and predicted discharge differences for individual flow measurements ranging from 0.2% to 12%. This range of differences between measured and predicted discharge demonstrates the ability of the rating curve to predict stream discharge for Site 2.

Stage Height Records

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 pounds per square inch (psi), or 0 to 34.6 feet (Fletcher, T., 1994).

During the 2005-06 study period, the accuracy of each pressure transducer was addressed by using staff gage versus pressure transducer regressions. The correlation coefficient (r) values for the regression of raw pressure transducer readings against the final data set, which had been adjusted to the discrete observed stage height values, were 1.0 (a perfect correlation) for Site 1, 0.98 for Site 2, and 0.99 for Site 3. These correlations provide an indication of the severity of pressure transducer drift (discussed above in *Methods* section) at each site.

Results

Results for the three Ecology sites are as follows:

Site 1: E.F. Lewis River near La Center

Site 1 was monitored for tide level from June 2005 until the station was destroyed by flooding in December 2005. An arbitrary datum based on a staff gage established at the site was used to monitor the tide-impacted stage height. No discharge measurements were made at the site, and a discharge rating curve was not developed due to the tidal influence on the stage-discharge relationship (Figure 2).

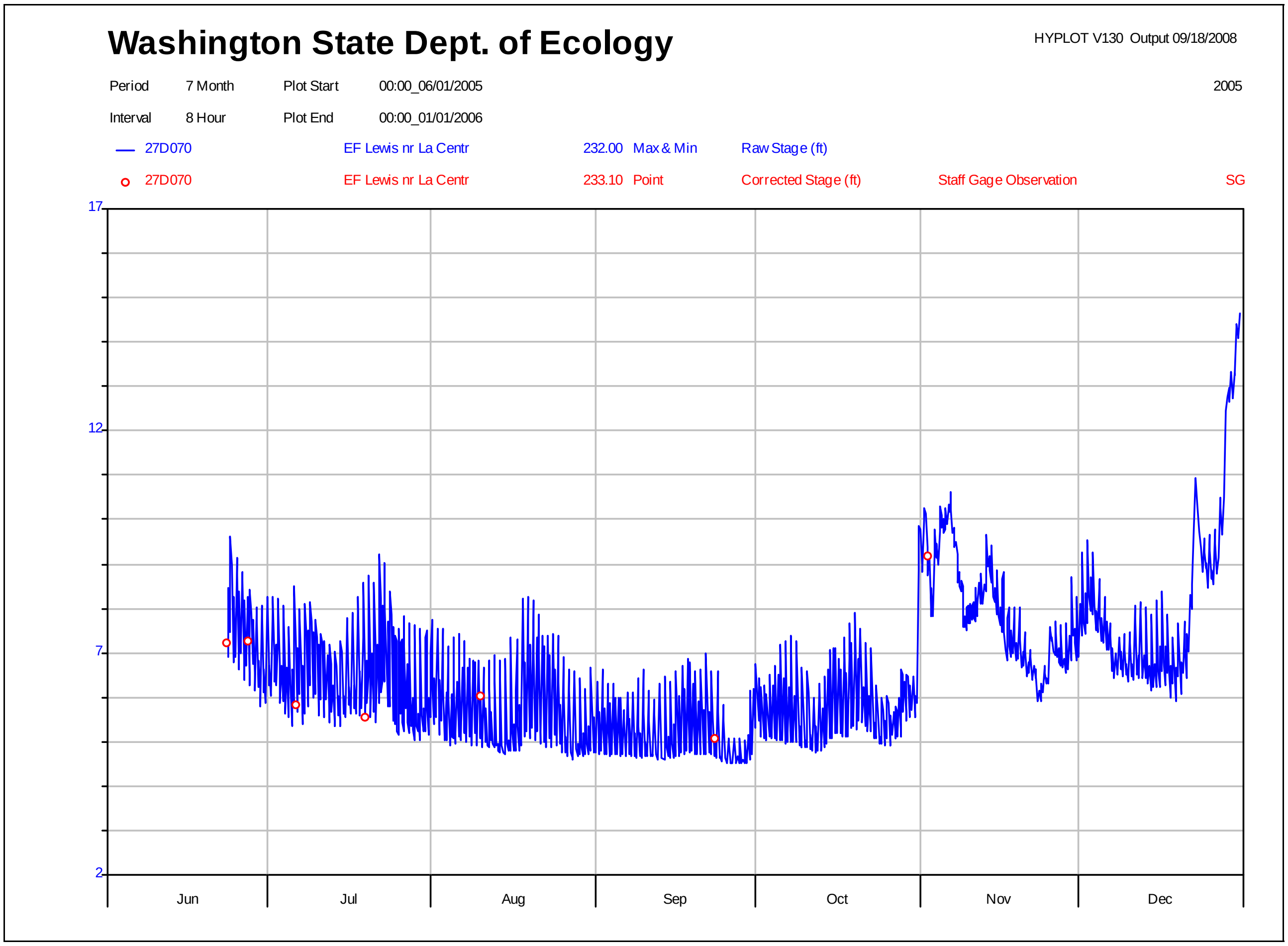

Figure 2. Tide-impacted stage height for Site 1, June 1 – December 31, 2005.

Site 2: E.F. Lewis River at Sunset Campground

The average daily discharge for Site 2 ranged from 12.7 cubic feet per second (cfs) in September 2005 to 1,000 cfs during a large storm event in January 2006. Peak streamflow during the study was greater than 1,240 cfs (Figure 3). Since high flow modeling was not done for this site, the true peak flow is not known. Daily discharge averages are presented in Appendix A. The measured range of discharge for this site encompassed less than 30% of the range of discharge encountered, with flow measurements ranging from 13.6 to 689 cfs (Figure 4). However, those flows that exceeded the measured range occurred only 5% of the time. 1% of flows were less than the lowest measured flow, and 4% of flows were higher than the highest measured flow (Figure 5).

Within the measured range of flows, the fit of the rating curve was fair. Ten of the 11 discharge measurements taken at Site 2 were within 10% of the flow predicted by the rating curve, and six of those ten measurements were within 5%. High flows were the most difficult to measure accurately at this site.

In January 2006, a large storm event (the largest of the 2005-06 study period) caused a moderate amount of scour at this site, causing a shift in the stage-discharge relationship that affected low flows. This shift was reflected in the rating curve for the site, and applied for the remainder of the study period.

Time-weighted adjustments were performed on the continuous data to correct for pressure transducer drift. A linear regression of pre- versus post-adjusted continuous discharge data showed a correlation coefficient (r) of 0.981 and a standard error of 39.9 cfs (27% of the mean flow for the study). This regression indicated considerable pressure transducer drift at this site (Figure 6). During the low-flow period, the same regression showed more extreme transducer drift, yielding a correlation coefficient (r) of 0.991 and a standard error of 11.2 cfs (44% of mean flow for the low-flow period).

Overall, the potential error for discharge data for this site is estimated to be ±30%. Of this, 18% of the error is from the continuous stage data, and 13% is from the rating. During the low-flow periods of July through September 2005 and 2006, the potential error in the continuous data was higher at 24%, whereas the potential error in the rating curve was slightly lower at 12%. The 6% difference in the continuous data error is attributable to a brief period in early July 2005 when an erroneous field calibration of the datalogger produced large differences between the raw and adjusted data sets.

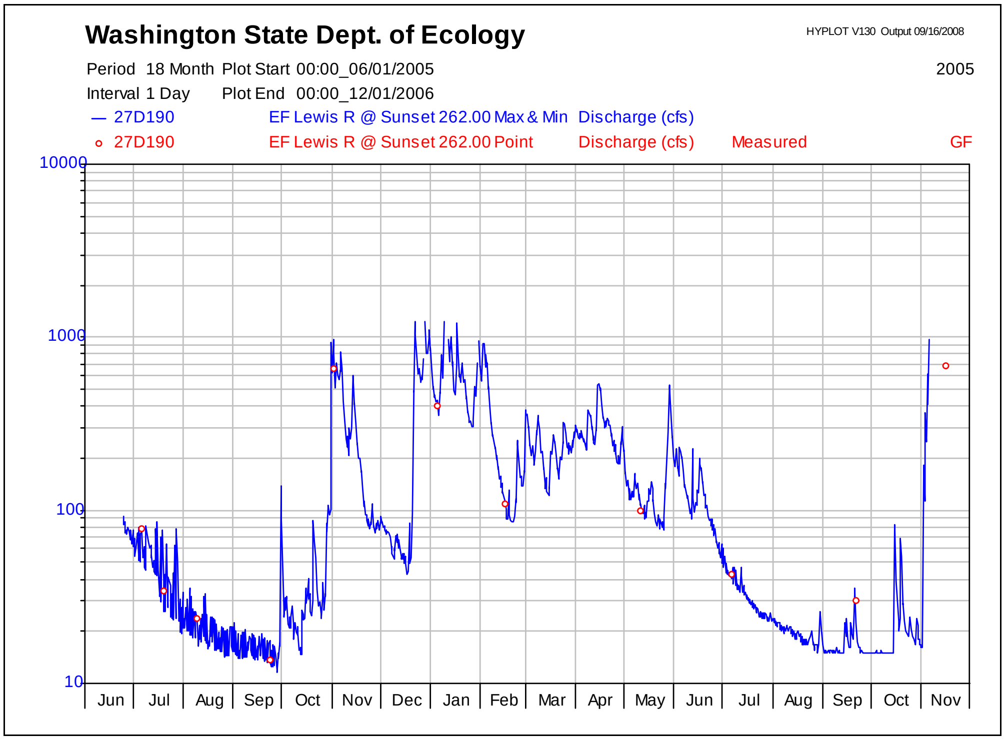

Figure 3: Discharge hydrograph for Site 2 June 1, 2005 – October 31, 2006.

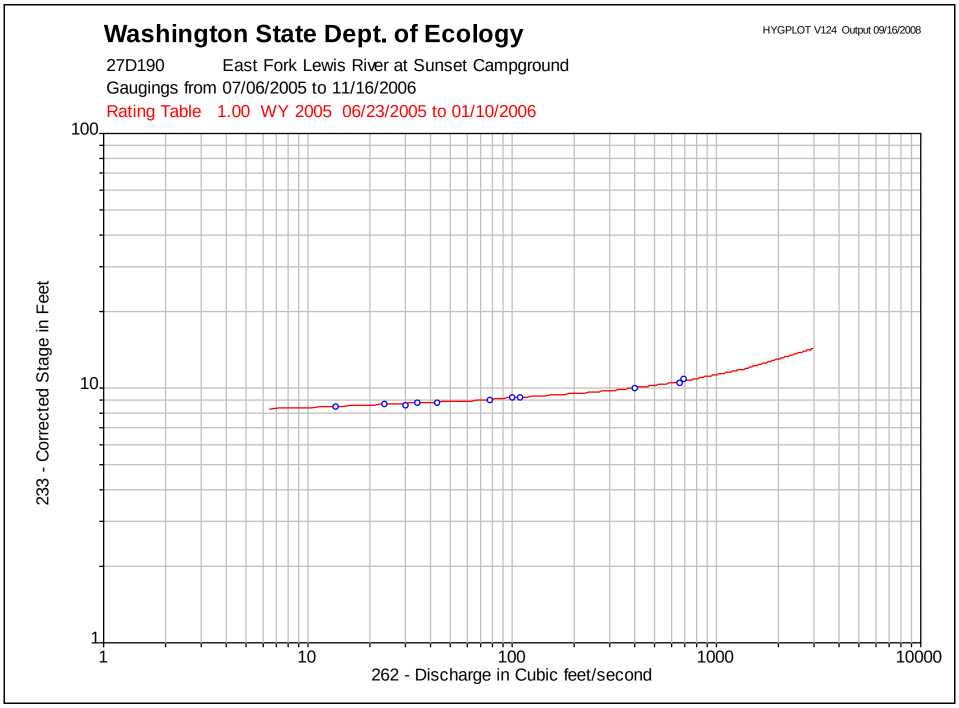

Figure 4: Discharge rating curve for Site 2, June 1, 2005 – October 31, 2006.

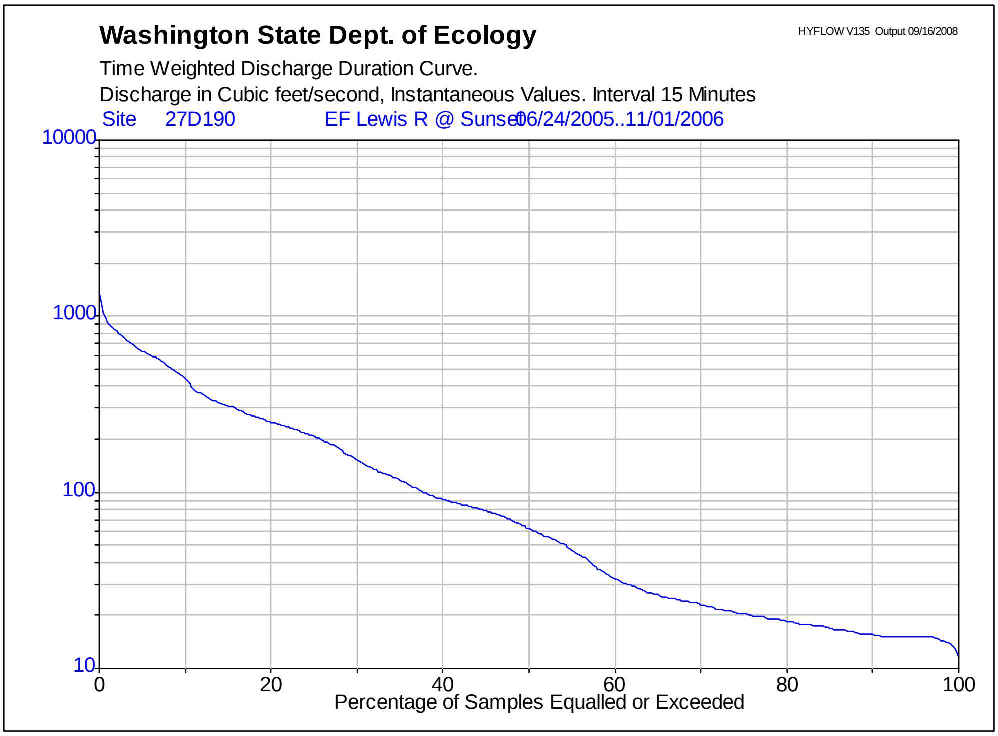

Figure 5: Discharge exceedance graph for Site 2, June 1, 2005 – October 31, 2006.

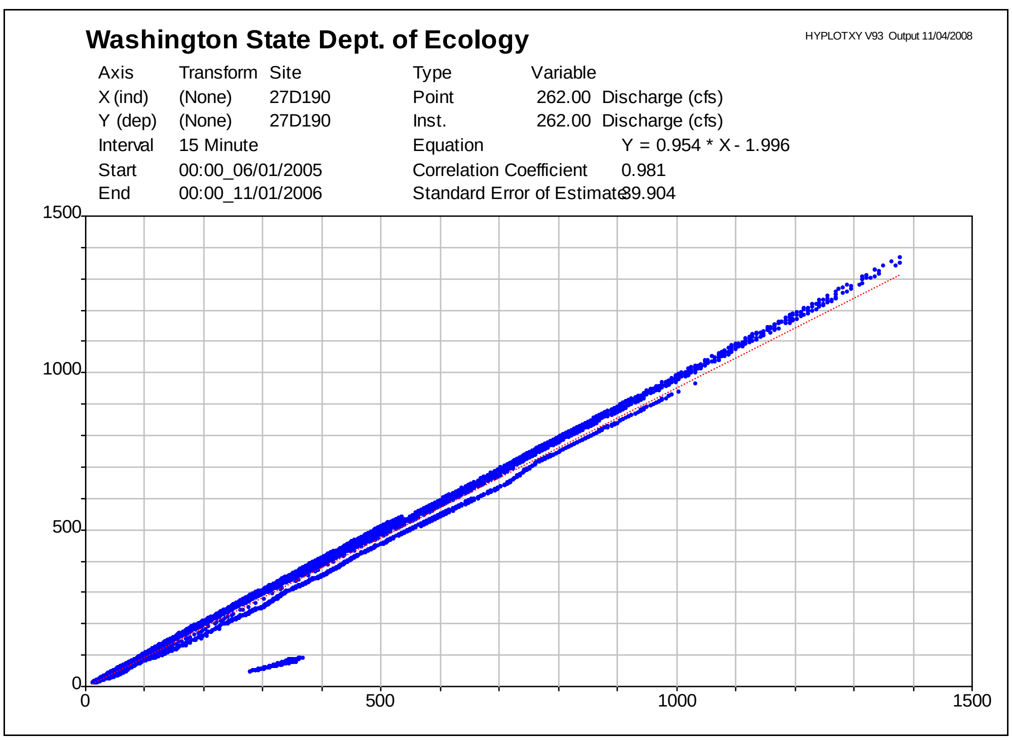

Figure 6: Linear regression of pre- versus post-adjusted discharge data for Site 2, June 1, 2005 – October 31, 2006.

Site 3: E.F. Lewis River near Dollar Corner

The average daily discharge for Site 3 ranged from 60.6 cfs in August and September 2006 to 10,700 cfs during a large storm event in January 2006. Peak streamflow during the study is estimated to be 13,600 cfs (Figure 7). Daily discharge averages are presented in Appendix B. The measured range of discharge for this site encompassed less than 45% of the range of discharge encountered, with flow measurements ranging from 68.4 to 5,970 cfs (Figure 8). However, those flows that exceeded the measured range occurred only 12% of the time. 11% of flows were less than the lowest measured flow, and 1% of flows were higher than the highest measured flow (Figure 9).

Within the measured range of flows, the fit of the rating curve was excellent. All 12 discharge measurements taken at Site 3 were within 5% of the flow predicted by the rating curve.

In January 2006, a large storm event (the largest of the 2005-06 study period) caused a moderate amount of fill at this site, causing a shift in the stage-discharge relationship that affected low flows. This shift was reflected in the rating curve for the site, and applied for the remainder of the study period.

Time-weighted adjustments were performed on the continuous data to correct for pressure transducer drift. A linear regression of pre- versus post-adjusted continuous discharge data showed a correlation coefficient (r) of 0.998 and a standard error of 22.6 cfs (3% of the mean flow for the study), indicating minor pressure transducer drift at this site (Figure 10). During the low-flow period, the same regression showed similar results, with a correlation coefficient (r) of 0.995 and a standard error of 3.1 cfs (3% of mean flow for the low-flow period).

Overall, the potential error for discharge data for this site is estimated to be ±14%. Of this, 5% of the error is from the continuous stage data, and 9% is from the rating. During the low-flow periods of July through September 2005 and 2006, the potential error in the continuous stage data was less at 2.5%, while the potential error in the rating curve stayed the same. Much of the raw data from July 2005 was missing from the data set, so potential error estimates could not be calculated for this period.

At the time of publication of this report, data for this station was still under review. While the author does not anticipate substantial changes to the data set, it is considered provisional and subject to change.

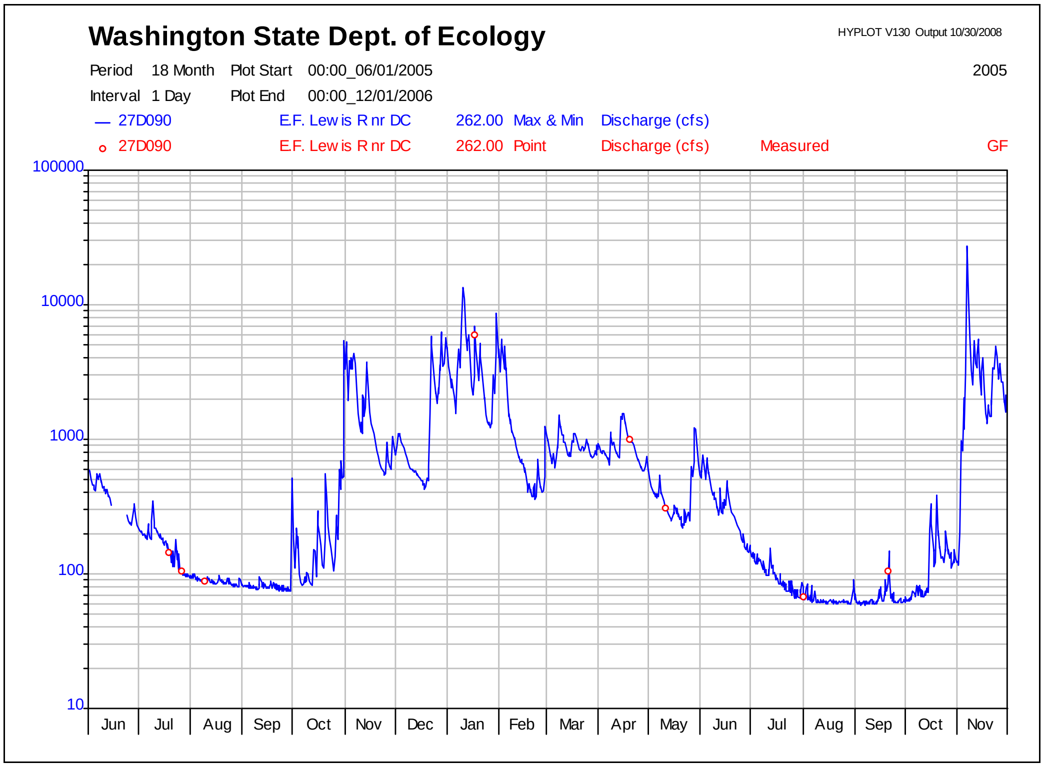

Figure 7: Discharge hydrograph for Site 3, June 1, 2005 – November 30, 2006.

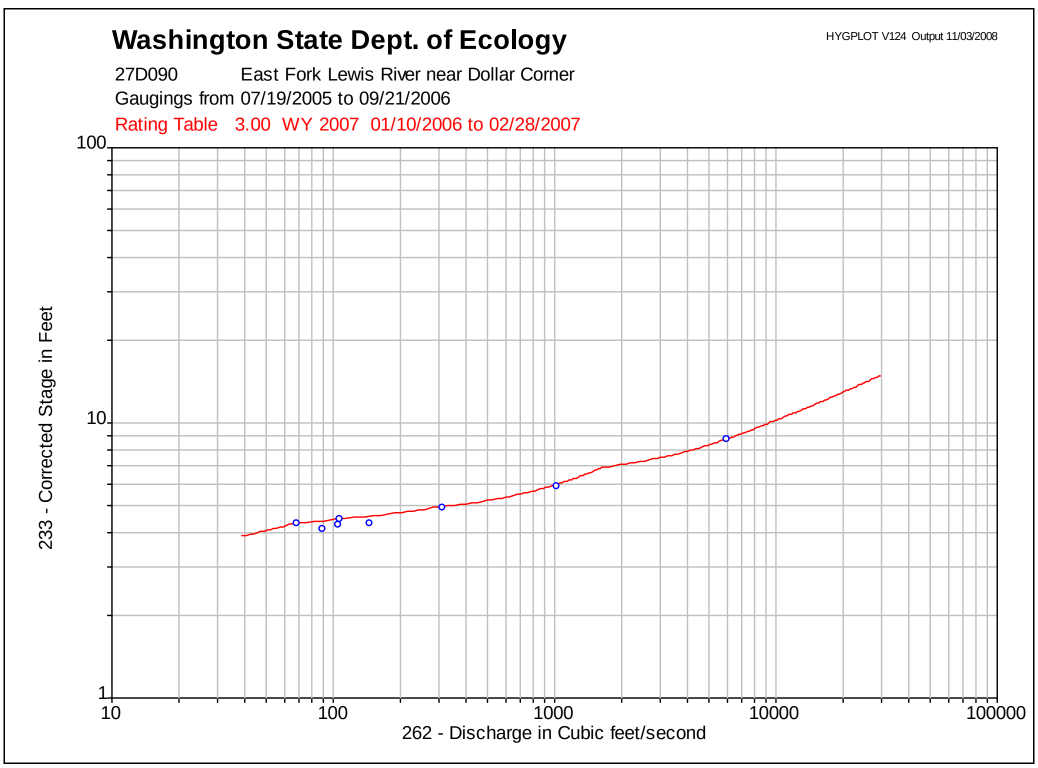

Figure 8: Discharge rating curve for Site 3, July 19, 2005 – November 30, 2006.

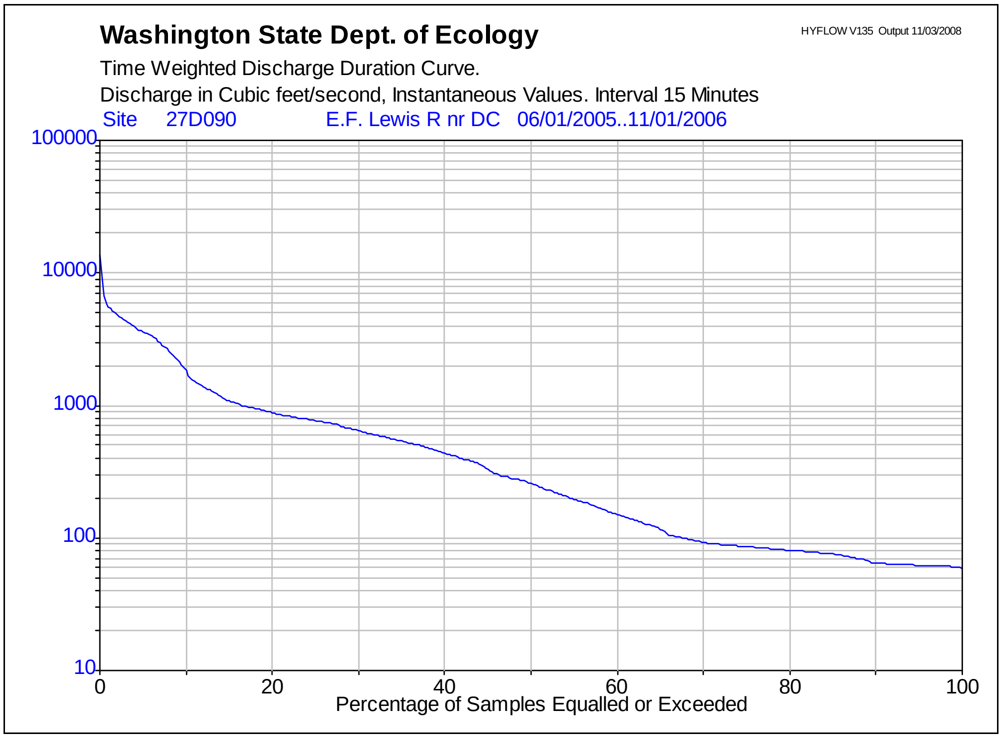

Figure 9: Discharge exceedance graph for Site 3, June 1, 2005 – November 30, 2006.

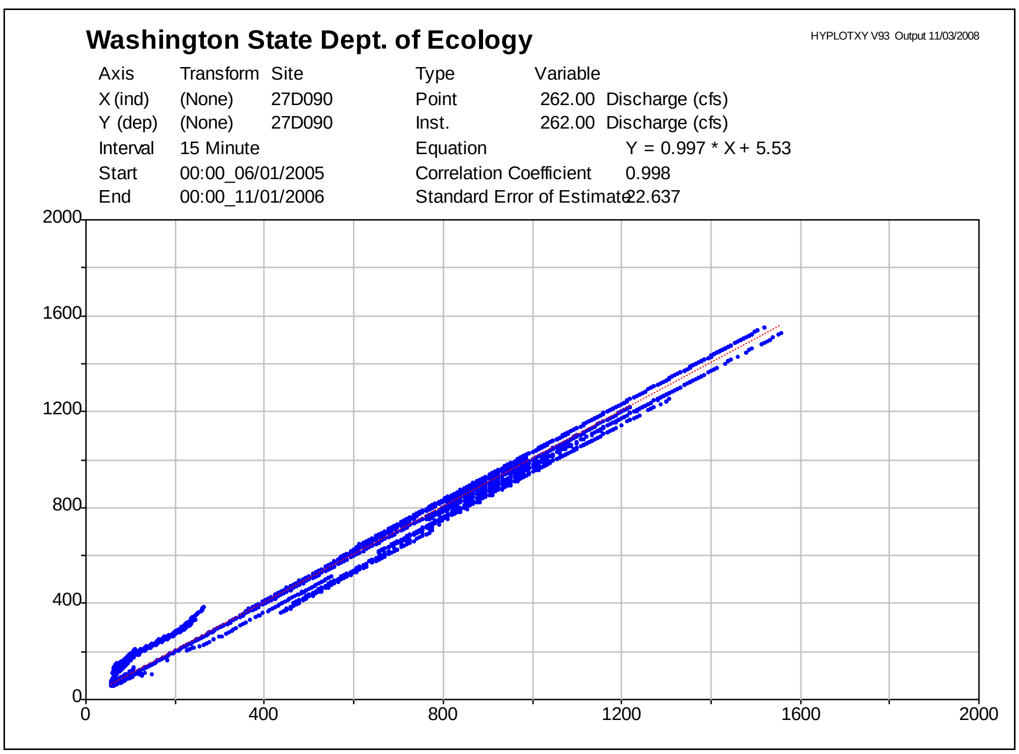

Figure 10: Linear regression of pre- versus post-adjusted discharge data for Site 3, June 1, 2005 – November 30, 2006.

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Appendices

Appendix A: Average Daily Discharge for Site 2 – E.F. Lewis River at Sunset Campground

	2005							2006										
Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	60.6	21.9	18.3	46.1	794A	88.5	764A	615	365	300	193	193	51.8	23.2B	16.1U	15.0U	16.4J
2	[]	58.3	23.4	16.7	26.3	626A	82.4	573	745A	329	280	155	200	48.2	22.8B	15.3U	15.0U	37.7J
3	[]	60.0	23.7	15.5	28.8	577	79.1	474	786A	275	269	134	167	45.7	22.4B	15.2U	15.0U	179J
4	[]	58.7	24.4	14.8	25.1	647	75.2	445	741A	223	270	122	205	43.8	22.0B	15.2U	15.0U	379J
5	[]	57.6	23.0	15.6	22.0	602	74.0	393	594	211	259	121	211	43.0	21.6B	15.2U	15.0U	543J
6	[]	65.3	21.9	16.1	22.3	756A	72.2	413	448	196	247	123	188	42.2	21.0B	15.2U	15.0U	[ ]D
7	[]	53.3	21.5	16.2	24.0	536	65.5	632A	355	252	232	144	154	41.5	20.6B	15.1U	15.0U	[ ]D
8	[]	58.1	21.4	16.6	19.6	368	57.5	669A	295	311	306	144	128	39.9	20.2B	15.2U	15.0U	[]
9	[]	74.1	19.9	15.6	21.3	291	55.9	728A	247	318	370	129	114	38.2	20.8B	15.7U	15.0U	[]
10	[]	63.4	18.6	16.3	20.0	246	63.7	[ ]?	214	255	329	114	103	36.0	20.9B	15.5U	15.0U	[]
11	[]	58.7	20.1	16.9	17.3	231	69.2	[ ]?	189	196	279	103	95.4	35.1	20.6B	15.0U	15.0U	[]
12	[]	52.0	20.7	16.1	15.5	273	64.7	802A	165	158	251	99.6	114	40.2	20.3B	15.0U	15.0U	[]
13	[]	47.8	23.1	15.2	21.4	468	57.7	931A	150	143	254	95.6	104	37.4	19.5B	15.0U	15.0U	[]
14	[]	52.3	22.9	15.4	24.5	494	54.1	822A	136	133	409	91.5	105	34.2	18.7B	19.0U	15.0U	[]
15	[]	53.6	20.2	15.2	28.4	359	54.0	581A	119	127	527	102	123	32.5	18.6B	20.1B	31.0U	[]
16	[]	38.7	16.9	15.3	30.6	285	51.8	492	109	180	462	123	161	31.4	19.0B	20.6B	60.9J	[]
17	[]	40.7	20.4	16.6	33.5	220	44.0	1000A	94.1	235	374	131	179	30.3B	19.6B	16.9B	28.7J	[]
18	[]	41.4	20.8	16.0	30.2	181	67.4	697A	105	260	331	124	160	29.8B	18.5B	19.3B	21.2J	[]
19	[]	30.7	19.4	15.4	26.1	153	59.1	569	90.8	229	315	104	133	29.0B	17.5B	19.7B	51.9J	[]
20	[]	29.9	18.5	14.9	68.9	119	67.2	639	86.4	200	318	90.4	113	28.2B	17.2B	20.2B	37.4J	[]
21	[]	36.6	17.7	14.6	57.9	98.6	221	627	88.1	164	319	84.5	98.7	26.8B	17.2B	29.2J	25.3J	[]
22	[]	33.4	16.8	14.7B	44.0	91.5	854A	504	103	184	297	87.5	90.8	26.6B	17.3B	19.5J	21.4J	[]
23	[]	28.7	16.5	14.5B	31.1	85.0	761A	407	156	221	257	83.0	86.1	26.1B	17.5B	16.9J	19.6J	[]
24	86.8	26.8	17.8	13.4B	27.1	82.8	634	351	222	294	234	83.2	81.4	25.3B	18.1B	15.4U	20.9J	[]
25	80.1	28.3	17.1	14.1B	25.4	95.5	589	332	173	300	222	80.8	76.2	24.9B	17.8B	15.0U	22.8J	[]
26	73.9	33.2	16.3	14.8B	34.0	85.9	581	313	150	251	205	125	71.8	24.7B	16.8B	15.0U	19.8J	[]
27	76.0	38.9	16.4	12.8B	28.3	77.5	671A	312	152	234	193	166	65.4	24.4B	16.2B	15.0U	18.4J	[]
28	70.3	29.9	16.6	12.7B	69.3	78.4	[ ]?	460	305	222	214	447	61.4	24.1B	15.7U	15.0U	17.4J	[]
29	67.5	23.9	17.8	15.3	85.9	82.1	924A	508		227	269	442	57.1	23.7B	16.0U	15.0U	20.6J	[]
30	66.9	22.5	18.2	73.0	99.5	80.9	874A	[ ]?		247	248	319	55.3	24.6B	21.8B	15.0U	19.2J	[]
31		23.7	17.7		586A		992A	761A		281		236		24.3B	18.4B		17.2J	
Mean	74.5	44.5	19.7	17.3B	52.9A	303A	280A	579A	273A	233	295	148	123	33.3B	19.3U	16.8U	21.4U	231J
Median	73.9	41.4	19.9	15.4B	28.3A	238A	73.1A	571A	169A	229	275	123	114	31.4B	19.0U	15.2U	17.4U	179J
Max.Daily Mean	86.8	74.1	24.4	73.0B	586A	794A	992A	1000A	786A	365	527	447	211	51.8B	23.2U	29.2U	60.9U	543J
Min.Daily Mean	66.9	22.5	16.3	12.7B	15.5A	77.5A	44.0A	312A	86.4A	127	193	80.8	55.3	23.7B	15.7U	15.0U	15.0U	16.4J
Inst.Max	92.6	86.1	35.6	139B	942A	967A	1240A	1240A	919A	382	544	525	232	60.7B	26.2U	35.6U	82.5U	976J
Inst.Min	61.1	19.2	14.3	11.6B	14.8A	73.9A	42.9A	302A	85.1A	121	185	77.5	49.9	23.0B	15.0U	15.0U	15.0U	16.1J

------------------- Notes -------------------

All recorded data is continuous and reliable
except where the following tags are used...

? ... Unreliable Estimate
A ... Above Rating, reliable extrapolation
B ... Below rating, reliable extrapolation
D ... Instrument Damaged
J ... Estimated Data
U ... Unknown flow, less than value shown
[ ] Data Not Recorded

Appendix B: Average Daily Discharge for Site 3 – E.F. Lewis River near Dollar Corner

	2005							2006									
Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	545~	213~	94.0~	82.6B	277*	4390*	789*	4110J	3790~	1030~	897~	549~	536~	142~	69.6B	64.8B	62.6B
2	522~	207~	96.1~	81.3B	153*	3220*	1010*	3280J	4130~	938~	832~	474~	674~	138~	66.4B	61.1B	63.0B
3	476~	203~	94.6~	81.3B	187*	2720*	1080*	2670J	4140~	807~	804~	425~	560~	130~	70.7B	60.6B	63.7B
4	441~	194~	92.5~	80.5B	145*	3670*	1010*	2390J	4070~	711~	796~	394~	599~	128~	65.7B	60.6B	64.3B
5	446~	186~	90.5B	81.5B	91.7*	3540*	909*	1790J	2710~	685~	755~	385~	610~	126~	64.4B	60.6B	68.3B
6	524~	203~	89.8B	80.1B	83.7*	4120*	824*	2360J	1670~	642~	726~	382~	532~	126~	65.9B	61.0B	70.7~
7	531~	192~	89.8B	79.5B	89.5*	3010*	751*	4010J	1400~	843~	676~	418~	469~	121~	63.4B	61.1B	73.3~
8	516~	189~	89.9B	78.9B	88.0*	1900*	687*	4060J	1280~	1050~	881~	463~	412~	112~	63.6B	61.0B	74.6~
9	465~	301~	89.2B	78.4B	98.0	1410*	634*	4430J	1060~	1290~	973~	372~	374~	106~	62.6B	61.5B	75.1~
10	426~	225~	88.3B	80.6B	94.1*	1210*	605*	10700J	941~	1150~	909~	330~	335~	102~	63.0B	62.1B	71.1~
11	414~	214~	90.3B	87.8B	87.8*	1310*	591*	8230J	845~	991~	801~	307~	294~	102~	63.2B	61.7B	70.3~
12	400~	199~	89.0B	82.8B	83.3*	1570*	580*	5160J	761~	891~	767~	293~	286~	111~	63.0B	61.6B	71.1~
13	376~	190~	89.0B	81.3B	107*	3010*	562*	5510J	715~	803~	738~	274~	329~	132~	62.9B	61.5B	73.1~
14	348~	185~	86.9B	79.7B	106*	2980*	537*	4900J	674~	779~	1150~	262~	302~	105~	62.2B	62.4B	76.8~
15	[]	176~	85.6B	79.1B	161*	1950*	518*	3200J	608~	773~	1470~	267~	330~	98.6~	61.7B	71.3B	96.4~
16	[]	167~	85.5B	79.4B	218*	1460*	499*	2450J	560~	871~	1420~	300~	370~	93.7~	62.2B	71.9~	282~
17	[]	164~	88.3B	82.5B	179*	1210*	474*	5510J	492~	1010~	1220~	295~	402~	89.4~	63.4B	66.8B	189~
18	[]	157~	92.6B	82.1B	145*	1030*	445J	4140~	433~	1060~	1090~	290~	351~	87.7~	63.4B	65.8B	130~
19	[]	147~	88.2B	79.9B	138*	885*	481J	3100~	425~	978~	1010~	268~	308~	85.6~	62.1B	79.6~	237~
20	[]	138~	86.2B	78.7B	394*	780*	513J	4130~	392~	891~	981~	249~	278~	83.1~	61.7B	80.4~	273~
21	[]	131~	85.3B	79.1B	290*	699*	904J	3650~	401~	834~	941~	228~	258~	80.9~	60.7B	111~	179~
22	[]	137~	85.2B	77.6B	202*	635*	3650J	2570~	404~	850~	866~	270~	241~	78.1~	61.6B	81.3B	144~
23	[]	150~	86.5B	77.3B	167*	585*	3570J	1680~	410~	839~	783~	258~	226~	80.7~	61.7B	64.8B	128~
24	266~	119~	87.1B	78.1B	144*	554*	2450J	1430~	586~	944~	727~	275~	214~	78.8~	62.6B	63.3B	131~
25	245~	109~	84.8B	77.3B	115*	746*	1980J	1310~	471~	951~	681~	267~	198~	77.2~	62.7B	61.7B	182~
26	234~	103~	82.3B	76.5B	229*	764*	2100J	1260~	419~	862~	644~	432~	181~	73.7B	62.1B	61.6B	155~
27	272~	101~	81.7B	76.0B	196*	658*	2880J	1330~	468~	786~	602~	567~	168~	70.5B	61.3B	61.8B	142~
28	295~	98.9~	81.5B	77.0B	402*	605*	5050J	2470~	888~	751~	599~	1110~	161~	70.6B	60.6B	61.9B	134~
29	248~	98.1~	82.2B	75.5B	490*	782*	4200J	2860~		753~	662~	1040~	156~	70.2~	60.6B	62.2B	118~
30	226~	97.2~	88.6B	168B	587*	800*	4670J	6620A		793~	653~	774~	150~	70.8B	64.1B	62.7B	140~
31		95.8~	85.1B		3280*		5210J	4600~		855~		603~		77.5~	76.7B		128~
Mean	391~	164~	88.0B	82.7B	291*	1740*	1620J	3740J	1250~	884~	868~	414~	343~	98.4B	63.7B	66.3B	122B
Median	414~	167~	88.3B	79.6B	153*	1260*	824J	3280J	695~	855~	802~	330~	318~	93.7B	62.9B	62.0B	118B
Max.Daily Mean	545~	301~	96.1B	168B	3280*	4390*	5210J	10700J	4140~	1290~	1470~	1110~	674~	142B	76.7B	111B	282B
Min.Daily Mean	226~	95.8~	81.5B	75.5B	83.3*	554*	445J	1260J	392~	642~	599~	228~	150~	70.2B	60.6B	60.6B	62.6B
Inst.Max	593~	352~	101B	512B	5420*	5290*	6340J	13600J	5490~	1530~	1550~	1220~	769~	157B	90.5B	148B	384B
Inst.Min	218~	92.8~	79.9B	73.9B	82.1*	544*	425J	1210J	359~	615~	579~	219~	144~	65.3B	59.2B	58.7B	61.9B

------------------ Notes -------------------
All recorded data is continuous and reliable
except where the following tags are used...
* ... Data estimated based on other stations
B ... Below rating, reliable extrapolation
J ... Estimated Data
[ ] Data Not Recorded
~ ... Provisional data

Appendix C: Average Daily Discharge for Site 4 – E.F. Lewis River at Heisson

	2005							2006									
Day	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1	532	223	97.5	62.7	255	2650	477	2600	2470	1060	831	498	495	146	78.1	51.0	42.2
2	502	212	97.5	60.6	138	1820	590	2140	2670	953	764	434	605	140	77.0	44.6	42.2
3	453	203	94.0	60.4	155	1580	633	1830	2620	805	742	395	502	134	74.6	43.3	42.2
4	412	191	89.6	58.6	130	2040	592	1700	2530	696	734	376	568	135	71.9	43.8	42.7
5	435	182	86.4	57.5	95.6	1960	537	1400	2070	679	694	372	572	131	70.4	44.0	46.5
6	504	224	86.1	56.6	81.3	2250	490	1690	1630	641	660	370	503	131	66.7	44.0	44.2
7	521	190	85.6	55.2	90.0	1690	444	2470	1300	860	607	411	446	125	65.5	43.5	45.7
8	504	202	85.1	53.4	88.1	1170	401	2520	1090	1130	858	430	398	117	63.4	44.2	45.1
9	449	298	83.7	53.0	103	888	369	3120	930	1330	914	363	370	111	64.4	44.9	45.3
10	412	241	81.8	60.2	96.3	756	352	6850	816	1100	845	331	341	109	66.0	46.1	41.6
11	399	224	83.3	76.0	86.6	811	343	5220	726	914	736	319	311	108	65.1	43.9	40.2
12	385	204	81.3	59.4	78.3	1010	335	3340	649	802	689	309	315	123	63.9	42.3	40.3
13	360	192	79.0	55.5	99.6	1660	321	3600	606	719	668	290	337	129	62.0	41.9	39.8
14	335	181	74.6	53.4	106	1630	305	3250	570	703	1270	276	327	109	58.7	48.9	39.9
15	314	171	73.4	52.8	140	1170	291	2360	516	701	1630	289	353	101	57.2	59.2	82.9
16	314	161	73.2	53.0	175	912	279	2050	474	830	1510	321	394	96.9	58.4	59.9	200
17	468	153	84.4	62.3	144	744	264	3390	444	983	1240	318	399	93.0	61.5	52.1	104
18	407	146	85.9	56.2	122	630	246	2810	415	1040	1060	309	357	90.3	59.9	58.6	70.6
19	397	139	77.2	53.0	119	548	282	2300	386	934	957	283	324	88.6	55.3	67.8	177
20	349	134	72.5	50.9	296	485	321	2850	362	826	906	257	294	85.7	53.2	67.3	152
21	326	129	71.1	49.4	213	433	699	2570	373	766	876	233	272	80.5	52.2	107	89.6
22	322	152	70.3	47.6	157	391	2600	2070	418	796	792	279	250	83.2	53.7	70.6	69.5
23	301	141	71.3	48.1	132	360	2220	1650	488	785	705	263	232	89.7	54.0	55.6	62.1
24	276	126	69.8	46.5	117	338	1670	1380	603	923	652	280	216	83.3	57.5	49.4	70.1
25	263	122	64.4	46.6	109	464	1460	1250	494	903	609	266	199	80.7	57.6	45.8	93.5
26	251	116	61.0	45.9	180	468	1530	1190	450	795	573	460	187	81.2	53.7	44.4	70.6
27	287	111	60.5	45.0	151	397	1940	1270	492	709	533	530	176	80.6	50.0	43.7	63.2
28	291	107	59.9	45.4	287	367	3300	2080	995	686	548	1160	168	79.4	48.1	42.9	59.7
29	259	105	65.5	44.2	325	467	2620	2270		698	620	1030	161	79.5	46.5	42.6	63.4
30	239	103	78.3	231	377	488	2870	4100		731	599	725	155	80.0	65.6	42.7	69.3
31		99.4	66.4		2230		3230	2890		798		558		84.5	65.4		59.7
Mean	376	167	77.8	60.0	222	1020	1030	2590	985	848	828	411	341	103	61.2	51.2	69.6
Median	373	161	78.3	53.4	132	783	490	2360	604	802	739	331	332	96.9	61.5	44.8	59.7
Max.Daily Mean	532	298	97.5	231	2230	2650	3300	6850	2670	1330	1630	1160	605	146	78.1	107	200
Min.Daily Mean	239	99.4	59.9	44.2	78.3	338	246	1190	362	641	533	233	155	79.4	46.5	41.9	39.8
Inst.Max	578	331	101	582	3280	3170	4040	7920	3240	1670	1730	1290	710	158	86.0	130	256
Inst.Min	225	95.0	57.0	43.0	76.0	331	234	1100	354	602	516	229	142	76.0	44.0	41.0	39.0

----------------- Notes -------------------
All recorded data is continuous and reliable