June 26, 2017

VIA ELECTRONIC FILING

Kimberly D. Bose, Secretary
Nathaniel J. Davis, Sr., Deputy Secretary
Federal Energy Regulatory Commission
888 First Street NE
Washington, DC 20426

**Re: Fisheries and Habitat Monitoring Plan – 2016 Annual Report
License Article 410**

Dear Secretary Bose:

Enclosed is Public Utility District No. 1 of Snohomish County's Fisheries and Habitat Monitoring Plan Annual Report for 2016 pursuant to License Article 410 for the Jackson Hydroelectric Project. The draft report was provided to the Aquatic Resource Committee for a 30-day review and comment period; no comments were received. Consultation documentation is included in the report's Appendix H.

If you have any questions on the Fisheries and Habitat Monitoring Plan Annual Report for 2016, please contact Keith Binkley, Natural Resources Manager, at (425) 783-1769 or KMBinkley@snopud.com.

Sincerely,

/s/ Tom DeBoer

Tom DeBoer
Assistant General Manager of Generation, Power, Rates and Transmission Management
TADeBoer@snopud.com
(425) 783-1825

Enclosed: FHMP Annual Report 2016

cc: Aquatic Resource Committee

Henry M. Jackson Hydroelectric Project

(FERC No. 2157)

License Article 410: Fisheries and Habitat Monitoring Plan – 2016 Annual Report

Snohomish County PUD

Public Utility District No. 1

Everett, WA

June 2017

Final – This document has been prepared for the District. It has been peer-reviewed by the District for accuracy and formatting based on information known at the time of its preparation and with that understanding is considered complete by the District. The document may be cited as:

District. 2017. License Article 410: Fisheries and Habitat Monitoring Plan 2016 Annual Report, Henry M. Jackson Hydroelectric Project, FERC No. 2157. June 2017.

Table of Contents

List of Figures

1. INTRODUCTION

Public Utility District No. 1 of Snohomish County (the District) received a license on September 2, 2011 (License) from the Federal Energy Regulatory Commission (FERC) for the Henry M. Jackson Hydroelectric Project (Project) (FERC 2011). License Article 410 approved the Fisheries and Habitat Monitoring Plan (FHM Plan) filed with the FERC on September 2, 2010, with modification. Per Section 4.1 of the FHM Plan, the District is to prepare a report by June 30 of each year detailing the monitoring efforts of the previous calendar year.

This FHM Plan Annual Report covers activities conducted in calendar year 2016. Appendices A, B, and C contain water temperature data. Appendix A contains mean daily temperature in graphical format and Appendix B contains the same data in tabular format. Appendix C contains seven-day average of the daily maximum water temperature (7-DAD Max) in tabular format. Appendix D is the Smolt Outmigration Report. Appendix E is the Riverine Habitat Survey Report conducted by Stillwater Sciences. Appendix F is the Side Channel Maintenance Technical Memo. Appendix G contains data from the Side Channel Supplemental Assessments. This Annual Report was provided to the Aquatic Resources Committee (ARC) [consisting of the City of Everett, City of Sultan, Snohomish County, Washington Department of Ecology, Washington Department of Fish and Wildlife (WDFW), Tulalip Tribes, U.S. Forest Service, National Marine Fisheries Service, U.S. Fish and Wildlife Service and American Whitewater] for a 30-day review and comment period; no comments were received. Consultation documentation is included in Appendix H.

2. MONITORING OF FISH HABITAT IN THE SULTAN RIVER

2.1. Riverine Habitat Monitoring

As articulated in the FHM Plan and as prescribed in the Process Flow Plan, Marsh Creek Slide Modification Plan, Side Channel Enhancement/Large Woody Debris Plan, and the Side Channel Ramping Rate Evaluation Report, the District is required to conduct a habitat survey after a high flow event or other major event causing changes in habitat conditions. The flow event of November 18, 2015, warranted a post-event habitat survey. The District contracted for subsequent data collection during summer 2016. Detailed quantitative monitoring of physical habitat was conducted to document high flow induced changes in the lower, alluvial portion of the Sultan River as well as habitat changes attributable to the large scale side channel enhancement project and placement of engineered log jams. This work was conducted by Stillwater Sciences and built upon their prior surveys conducted in 2014 and prior to license issuance in 2007, and 2010. The results of this monitoring of aquatic habitat conditions in the lower Sultan River are presented in Appendix E.

2.2. Water Temperature Monitoring

Water temperature was continuously monitored at 12 locations within the Project area during 2016 (Figure 1). Monitoring at 9 of these locations was conducted by the District. The remaining monitoring was conducted by the U.S. Geological Survey (USGS) through a cooperative agreement. These 12 locations, in order from upstream to downstream, include:

- South Fork Sultan River, upstream of Culmback Dam, near river mile (RM) 18.2 (USGS Gage No. 12137290);
- Sultan River, within the bypass reach immediately downstream of Culmback Dam, at RM 15.8;
- Sultan River, at the base of the Sultan River Canyon Trail, at RM 15.5;
- Sultan River, within the bypass reach, near RM 14.3;
- Sultan River, within the bypass reach, near RM 11.3;
- Sultan River, within the bypass reach immediately upstream of the Diversion Dam, near RM 9.8;
- Sultan River, immediately downstream of the Diversion Dam, near RM 9.6 (USGS Gage No. 12137800);
- Sultan River, upstream of the Powerhouse, near RM 4.9;
- Sultan River, downstream of the Powerhouse, near RM 4.4 (USGS Gage No. 12138160),
- Sultan River, near the confluence with the Skykomish River, at RM 0.2;
- Skykomish River, upstream of the confluence with the Sultan River, at RM 14.1; and
- Skykomish River, downstream of the confluence with the Sultan River, at RM 13.2.

Water temperature monitoring at RM 14.3 and 11.3 in the Sultan River is part of the Water Temperature Conditioning Plan monitoring program; the other sites represent requirements under the original FHM Plan or subsequent revisions.

In general, water temperatures in the Sultan Basin during 2016 were much cooler than 2015 and were consistent with those collected during 2008 and 2009 by CH2M Hill and presented in the Water Quality Final Technical Report (CH2M Hill 2009). Figures depicting water temperatures during 2016 are presented in Appendix A. A tabulation of all mean daily temperature data for 2016 is presented in Appendix B. The seven-day average of the daily maximum temperature (7-DAD Max) is presented in Appendix C. Data gaps are attributed to malfunctioning equipment or equipment lost due to vandalism.

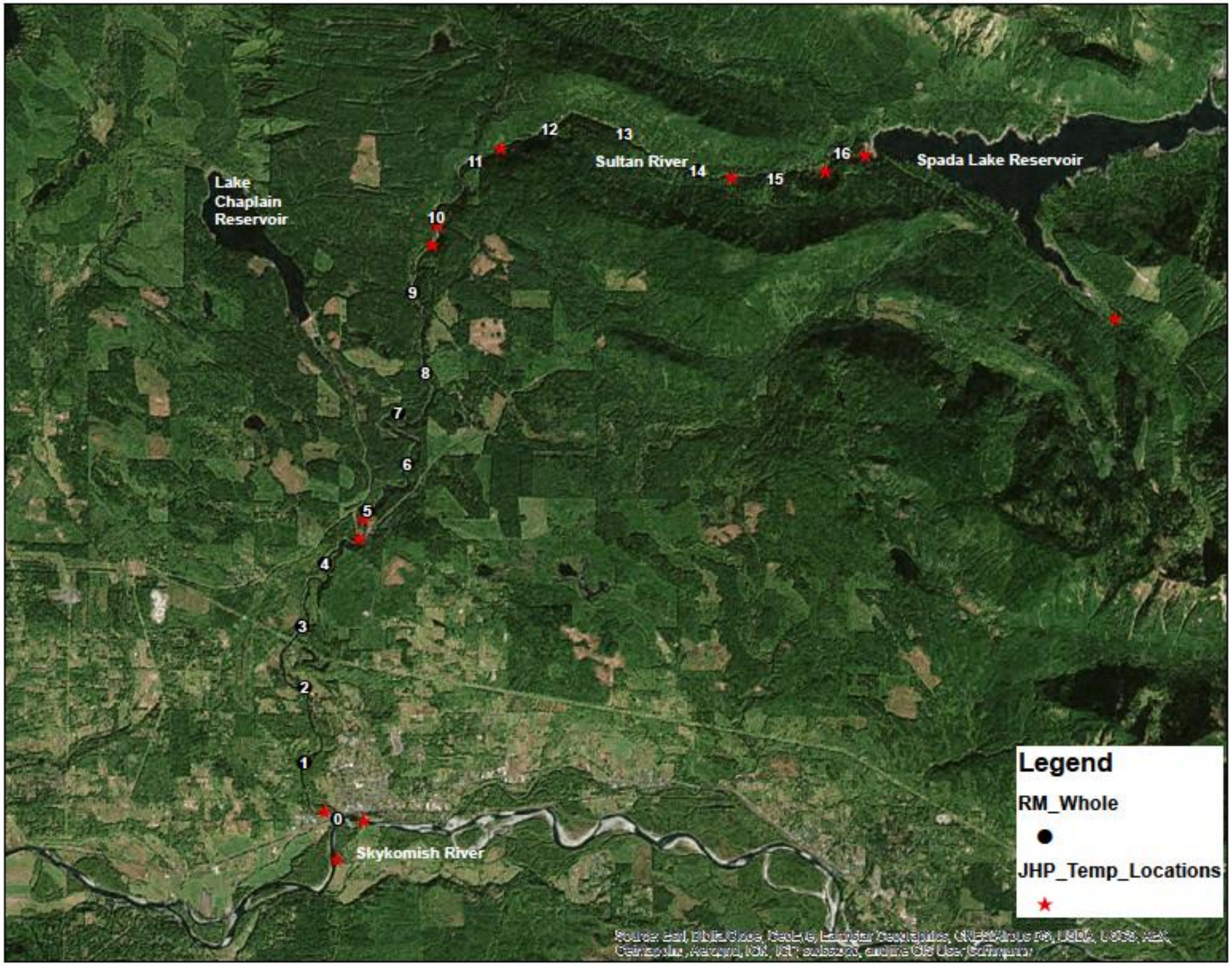


Figure 1. Locations of water temperature monitoring, Sultan watershed.

3. MONITORING OF FISH POPULATIONS IN THE SULTAN RIVER

3.1. Spawner Abundance, Distribution, and Timing in the Sultan River

In the Sultan River, steelhead and Chinook salmon escapement surveys are conducted during the spring and fall, respectively. These surveys are conducted, as conditions allow, within four index areas located downstream of the Diversion Dam (RM 9.7) (Figure 2). During 2016, water visibility and flow conditions were generally favorable during both the spring and fall surveys. Spring surveys were used to develop an escapement estimate of 130 steelhead based on the direct observation of 44 redds and expanded count of 81 redds. Of the 44 redds observed in index areas, 3 (6.8 percent) were observed in the Diversion Dam Index Area (DDIA).

Fall surveys occurred between September and October 2016. These surveys were used to generate an escapement estimate of 687 Chinook based on field observations and extrapolation of 275 redds. Of the 208 redds observed in index areas, none were observed in the DDIA. Both the steelhead and Chinook escapement estimates were developed cooperatively with WDFW.

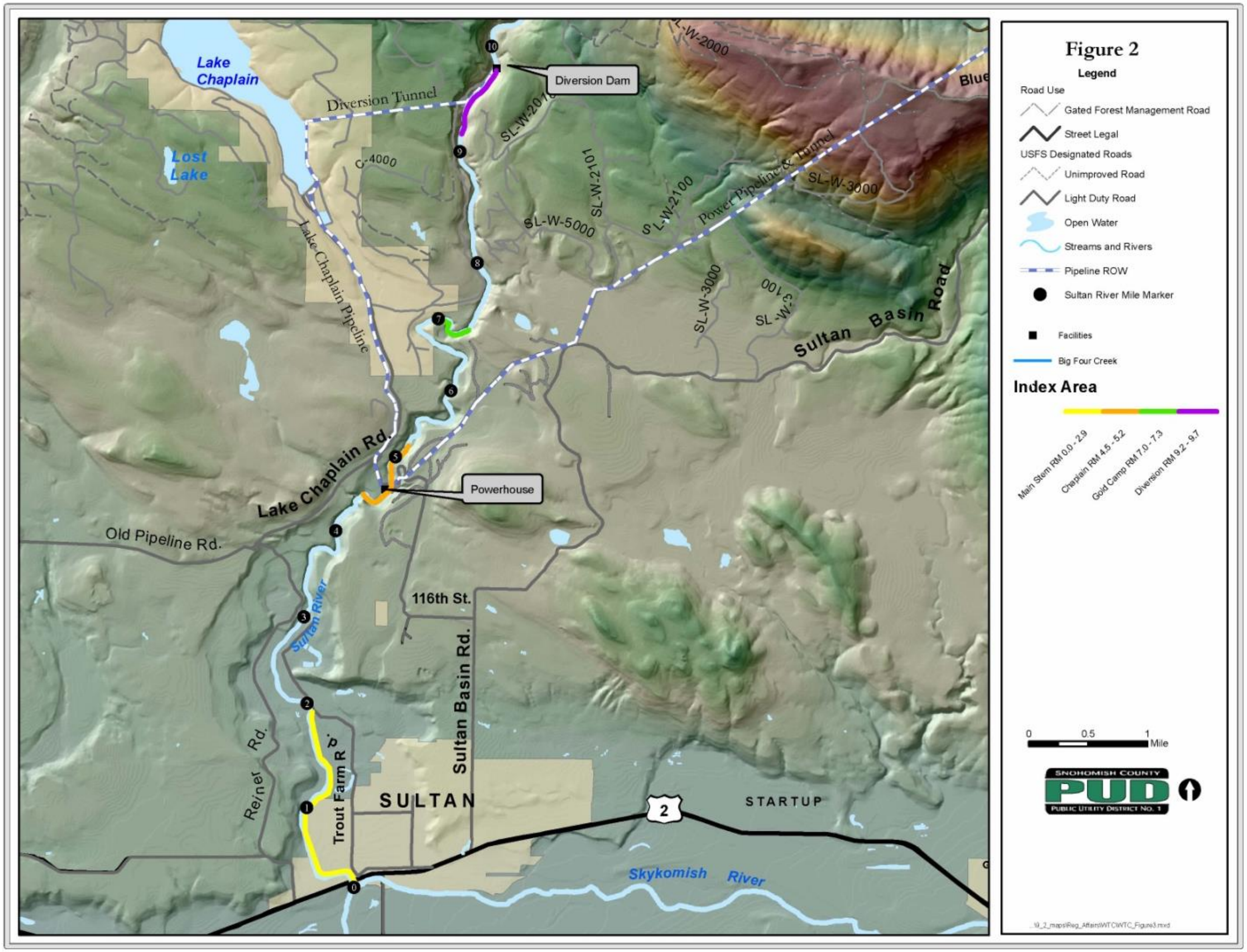


Figure 2. **Locations of steelhead and salmon escapement surveys, Sultan River.**

3.2. Flow Ceiling, Implemented for Chinook Salmon

A flow ceiling of 550 cfs is implemented annually between September 15 and October 15 in Reach 1 of the Sultan River, located downstream of the Powerhouse (RM 4.5). This ceiling ensures that areas used by spawning Chinook salmon remain wetted through the incubation and emergence periods should flows from the Project approach the minimum instream flow of 300 cfs. During 2016, mean daily discharge downstream of the Powerhouse averaged 505 cfs during the ceiling period. There were three separate, precipitation induced, deviations to the flow ceiling. There was no dewatering of Chinook salmon redds during late 2016 or early 2017.

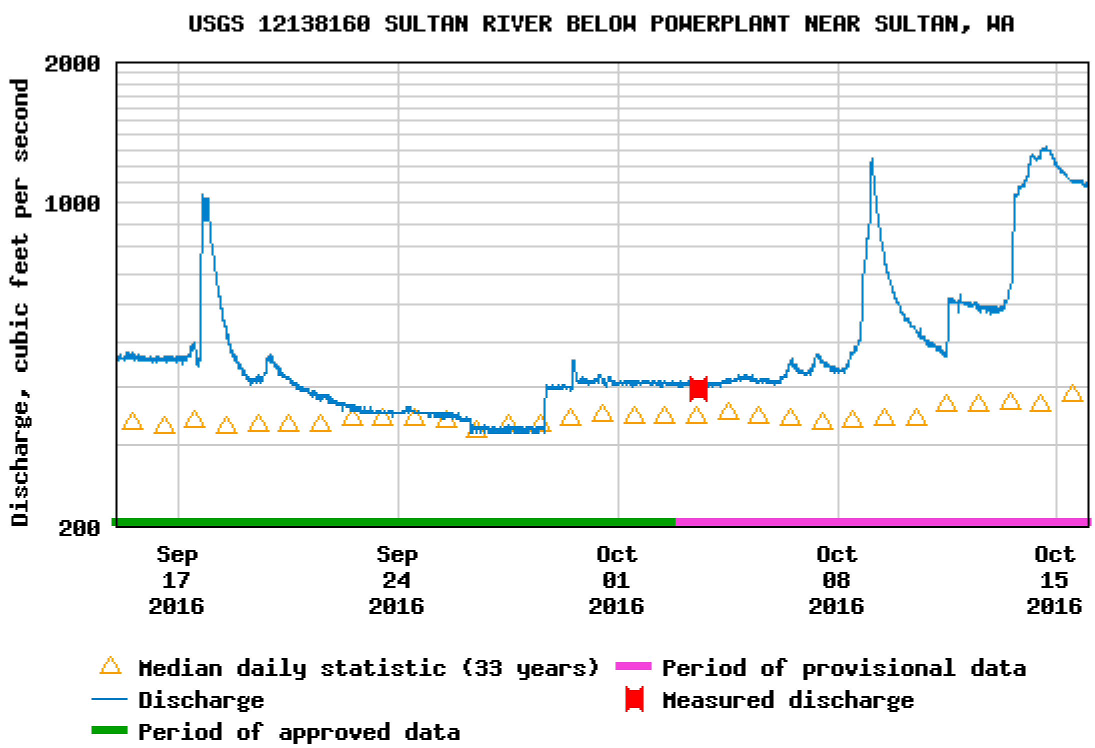


Figure 3. Mean Daily Discharge in the Sultan River downstream of the Powerhouse between September 15 and October 15, 2016.

3.3. Juvenile Production in the Sultan River

The fifth year of smolt trapping to estimate the outmigration of juvenile salmonids and production within the Sultan River was initiated on January 18, 2016. This effort involves operation of a five-foot diameter rotary screw trap positioned in the lower Sultan River near RM 0.2, just upstream of the confluence with the Skykomish River. Sampling during 2016 continued until June 30. A report presenting the results of the 2016 sampling season is presented in Appendix D.

4. SIDE CHANNEL MAINTENANCE AND MONITORING

Since construction, the District has completed a series of detailed flow and aquatic habitat surveys in the constructed side channels in the lower Sultan River. These side channels (SC) – SC1, SC2, SC3, and SC4 – had each undergone varying degrees of construction during summer 2012 to restore and/or enhance salmonid habitat. The primary objective of the District's surveys was to assess flow behavior and distribution and to determine whether additional downramping rate restrictions were necessary to prevent juvenile fish stranding in these side channels.

In addition to the aforementioned detailed survey effort, qualitative monitoring to assess the performance of both constructed and modified side channels, as well as the engineered log jams, was initiated after construction was completed in 2012 and has been conducted annually since. During survey efforts in 2016, dewatering of a portion of SC1 was documented. This dewatering was attributed to the distribution of flow at a split in the stream channel upstream of the dewatered section. The District obtained permits and subsequently modified the elevation of the channel in a 350 foot section of SC1. This adjustment restored the proper distribution of flow ensuring that all portions of the side channels remain wetted. A technical memorandum (Appendix F) describes in detail the background and maintenance steps taken to maintain side channel flow.

Qualitative fish populations surveys (snorkel and minnow traps) were conducted during summer 2016, to document species presence, size, relative abundance, and habitat utilization of the newly constructed side channels as identified in Section 3.2.1 of the FHM Plan. Data results for these supplemental assessments are included in Appendix G.

5. FUTURE MONITORING

The 2016 calendar year marks the fifth calendar year under the License. Monitoring methodologies employed in 2016 were consistent with those identified in the FHM Plan. Monitoring of physical habitat and water quality conditions will continue through 2017. Spawner abundance, distribution, and timing monitoring and juvenile production (smolt trap) monitoring will take place per the FHM Plan.

6. REFERENCES

FERC. 2011. Order Issuing New License, Project No. 2157-188. 136 FERC ¶ 62,188. September 2, 2011. Available at: http://www.snopud.com/Site/Content/Documents/relicensing/License/20110902LICENSE.pdf

APPENDIX A

2016 Water Temperature Figures

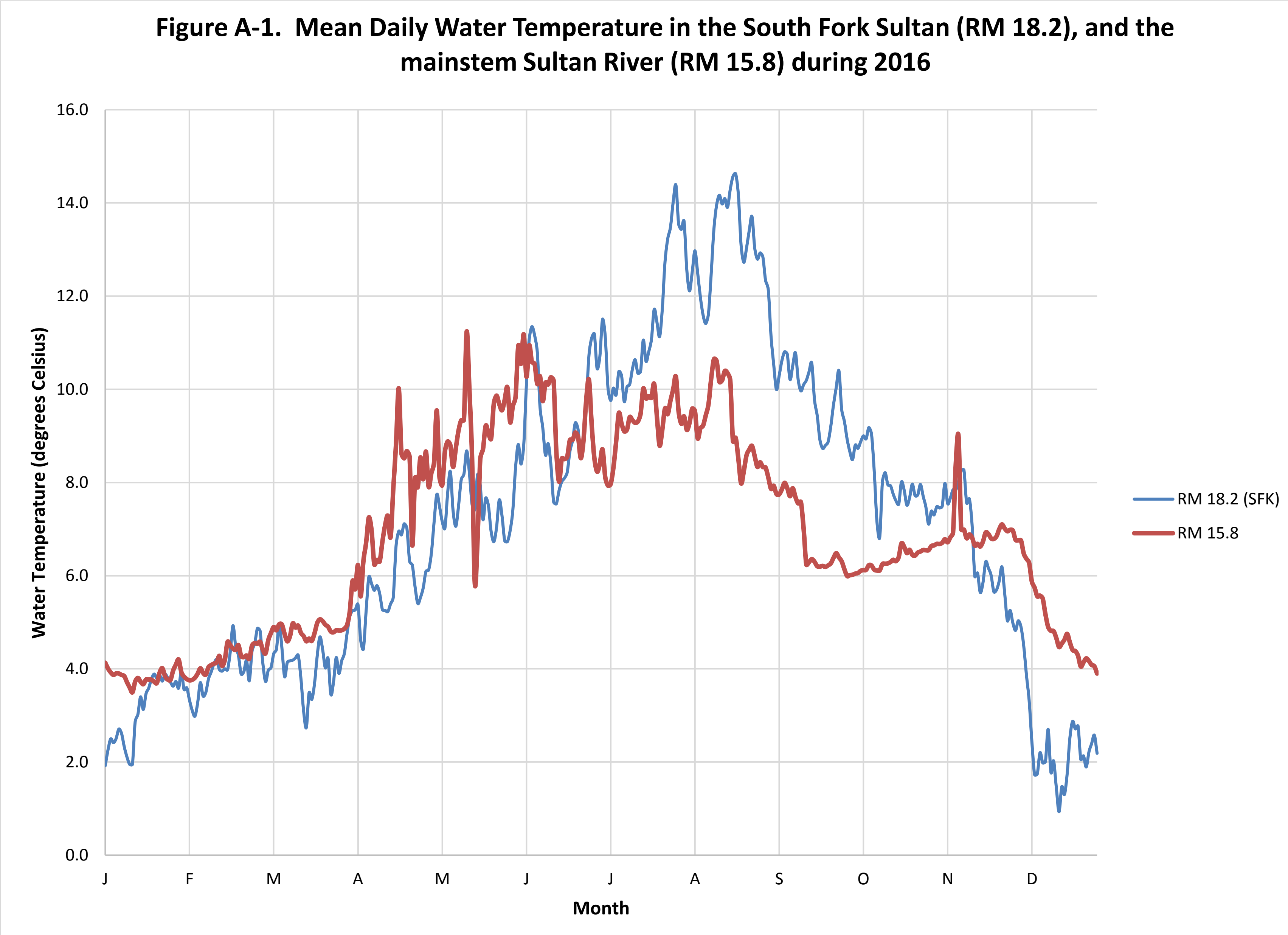


Figure A-1. Mean Daily Water Temperature in the South Fork Sultan (RM 18.2), and the mainstem Sultan River (RM 15.8) during 2016
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Water Temperature (degrees Celsius)
J
F
M
A
M
J
J
A
S
O
N
D
Month
RM 18.2 (SFK)
RM 15.8

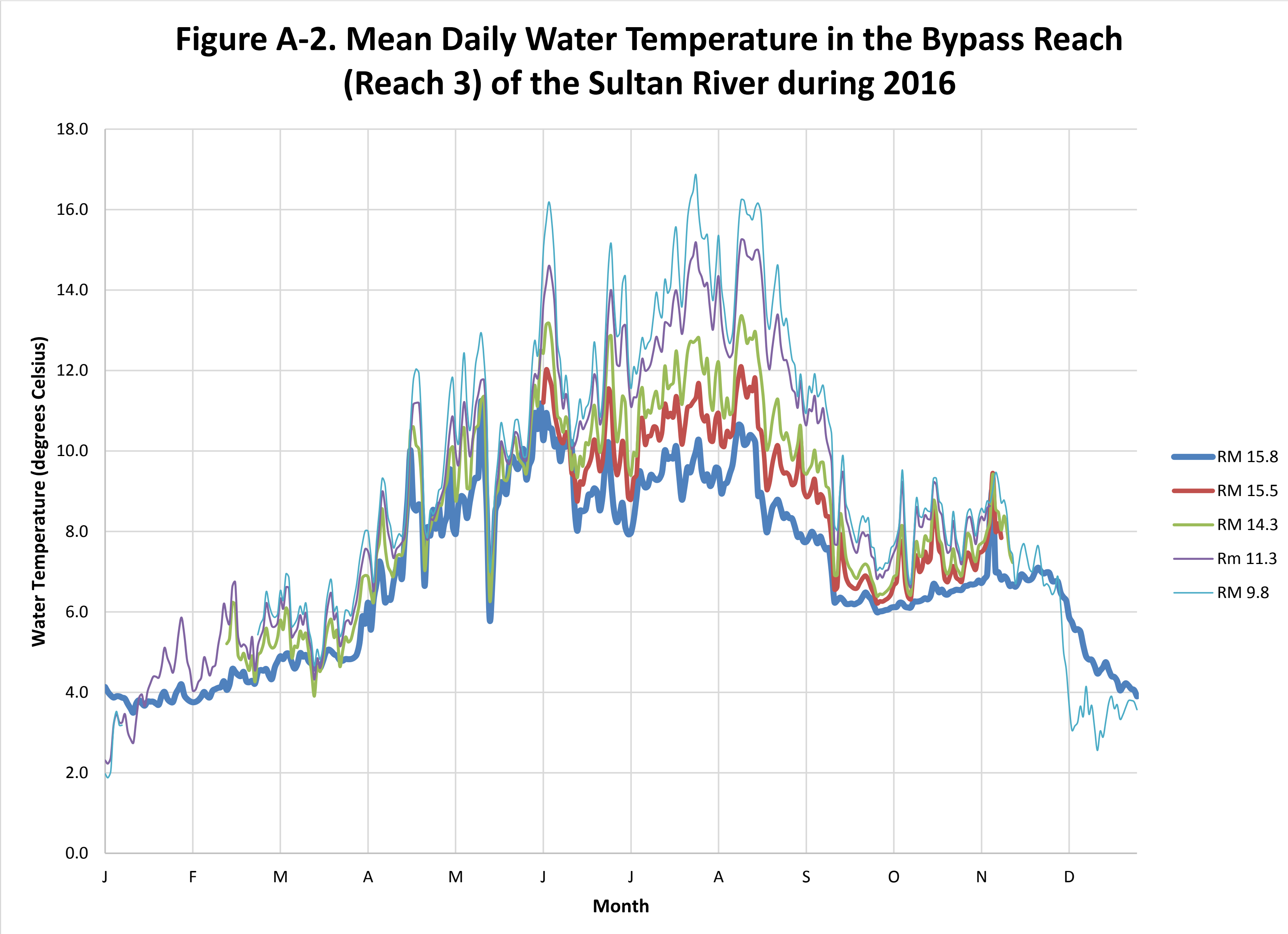


Figure A-2. Mean Daily Water Temperature in the Bypass Reach (Reach 3) of the Sultan River during 2016
Water Temperature (degrees Celsius)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Month
RM 15.8
RM 15.5
RM 14.3
Rm 11.3
RM 9.8

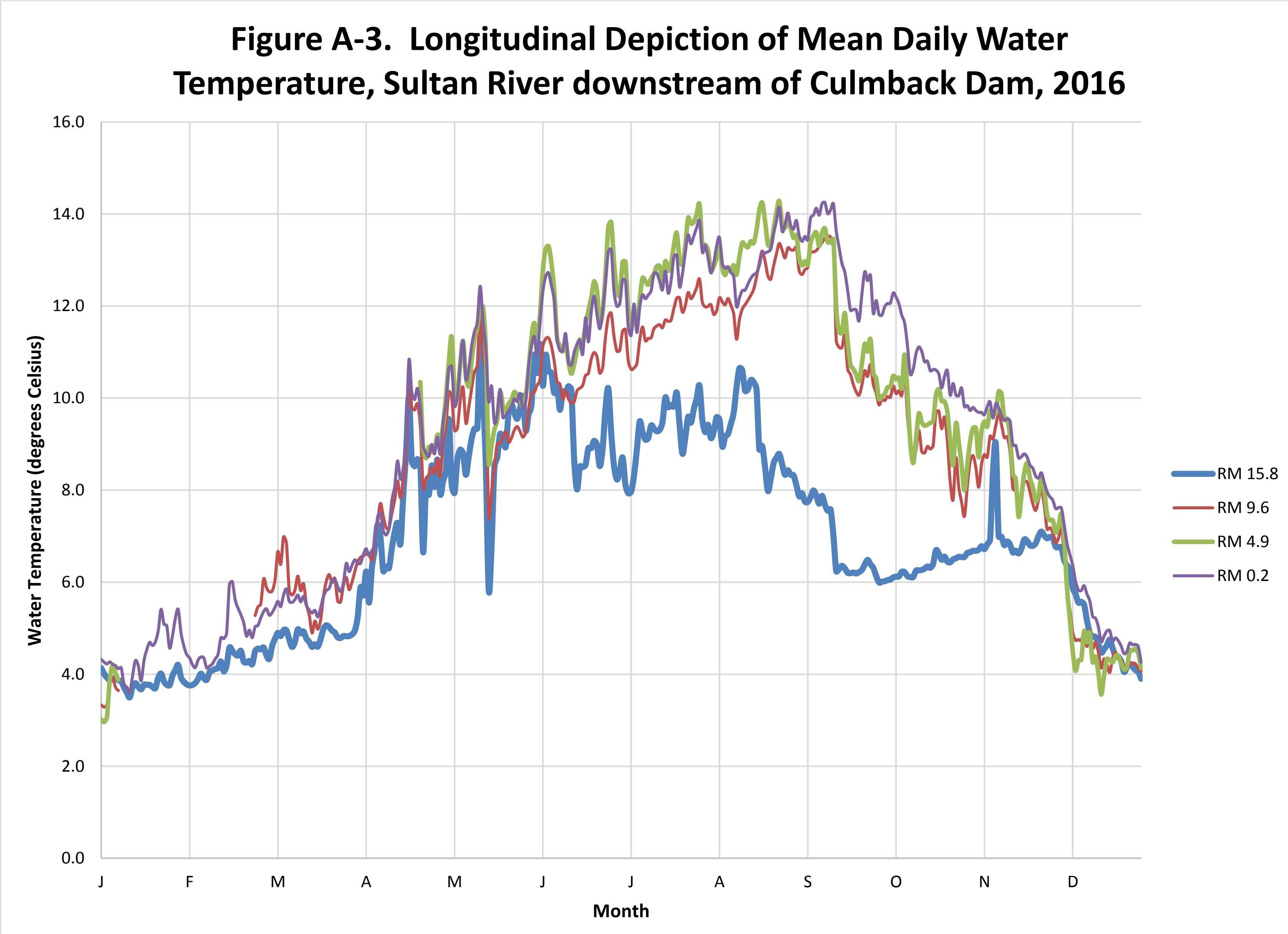


Figure A-3. Longitudinal Depiction of Mean Daily Water Temperature, Sultan River downstream of Culmback Dam, 2016
Water Temperature (degrees Celsius)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Month
RM 15.8
RM 9.6
RM 4.9
RM 0.2

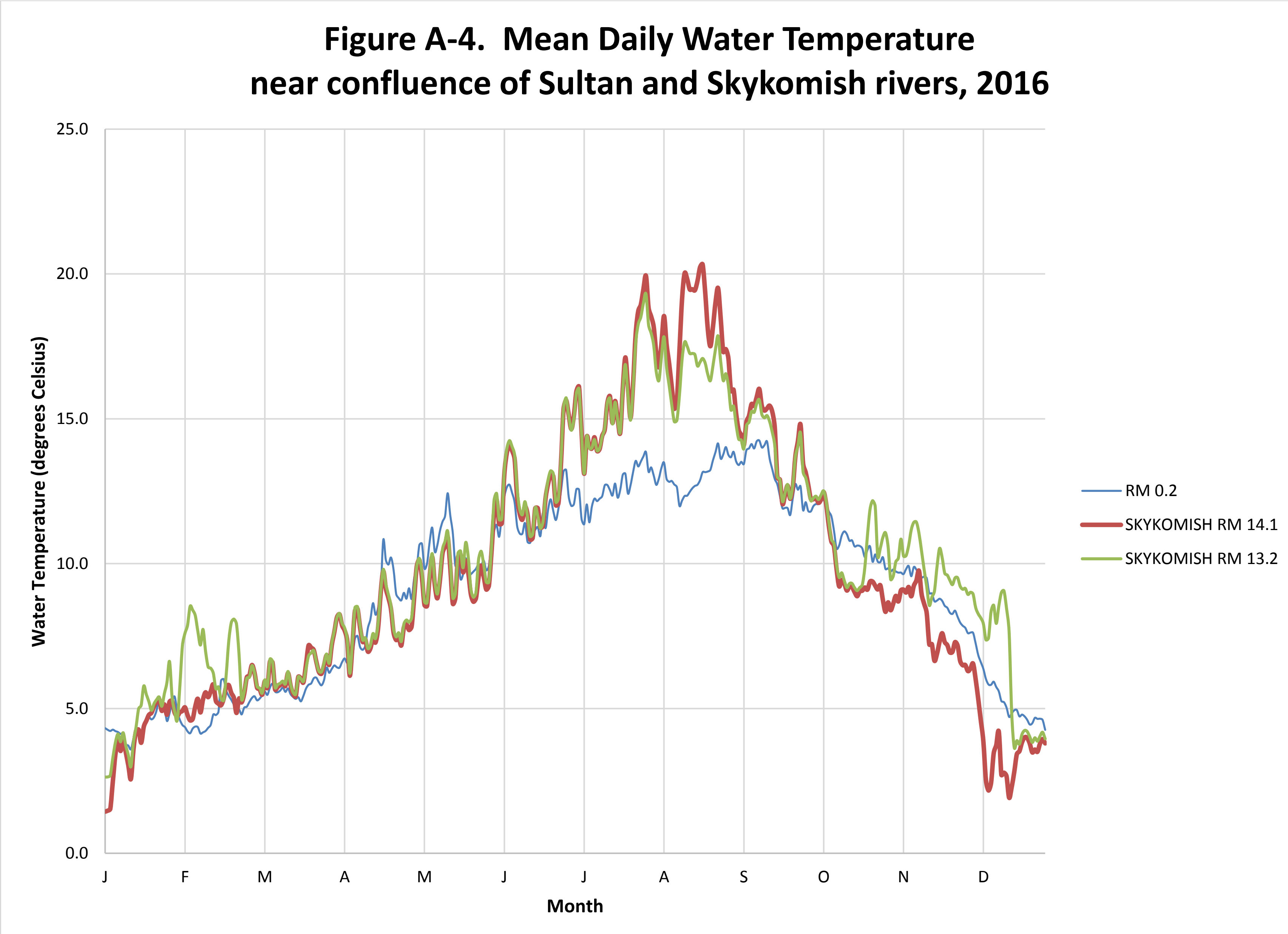


Figure A-4. Mean Daily Water Temperature
near confluence of Sultan and Skykomish rivers, 2016
Water Temperature (degrees Celsius)
25.0
20.0
15.0
10.0
5.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Month
RM 0.2
SKYKOMISH RM 14.1
SKYKOMISH RM 13.2

APPENDIX B

2016 Mean Daily Water Temperature Data in Tabular Format

	Sultan River										Skykomish River	
DATE	**RM 18.2 (SFK)**	**RM 15.8**	**RM 15.5**	**RM 14.3**	**RM 11.3**	**RM 9.8**	**RM 9.6**	**RM 4.9**	**RM 4.4**	**RM 0.2**	**RM 14.1**	**RM 13.2**
1/1	1.9	4.1			2.3	2.0	3.3	3.0	4.3	4.3	1.4	2.6
1/2	2.3	4.0			2.2	1.9	3.3	3.0	4.2	4.3	1.5	2.6
1/3	2.5	3.9			2.4	2.0	3.3	3.1	4.1	4.2	1.5	2.7
1/4	2.4	3.9			3.2	3.2	3.8	3.9	4.1	4.3	2.5	3.3
1/5	2.5	3.9			3.5	3.5	3.9	4.2	4.1	4.2	3.4	3.8
1/6	2.7	3.9			3.3	3.2	3.7	4.0	4.0	4.2	3.9	4.1
1/7	2.6	3.9			3.3	3.2	3.6	3.9	4.0	4.1	3.5	3.8
1/8	2.3	3.8			3.5					4.1	4.0	4.2
1/9	2.1	3.7			3.0					3.8	3.5	3.7
1/10	1.9	3.6			2.8					3.7	3.0	3.4
1/11	2.0	3.5			2.7					3.6	2.6	3.0
1/12	2.9	3.7			3.3					4.0	3.6	3.8
1/13	3.0	3.8			3.9					4.3	4.2	4.4
1/14	3.4	3.7			3.9					4.2	4.3	5.0
1/15	3.1	3.7			3.7					3.9	3.8	5.1
1/16	3.5	3.8			4.0					4.3	4.4	5.8
1/17	3.6	3.8			4.2					4.5	4.6	5.5
1/18	3.8	3.8			4.4					4.7	4.8	5.2
1/19	3.9	3.7			4.4					4.6	4.8	4.9
1/20	3.8	3.7			4.4				4.7	4.7	5.1	5.2
1/21	3.9	3.9			4.7				5.0	4.9	5.2	5.3
1/22	3.7	4.0			5.1				5.5	5.4	5.3	5.4
1/23	3.9	3.8			4.9				5.1	5.1	4.9	5.1
1/24	3.8	3.8			4.7				5.0	5.0	5.1	5.5
1/25	3.7	3.8			4.5				4.5	4.6	4.8	5.9
1/26	3.6	4.0			4.9				4.8	4.8	5.2	6.6
1/27	3.7	4.1			5.5				5.2	5.2	5.3	5.4
1/28	3.6	4.2			5.9				5.5	5.4	4.9	4.9
1/29	3.9	3.9			5.4				4.9	4.9	4.7	4.6
1/30	3.6	3.8			4.8				4.6	4.6	4.9	5.8
1/31	3.6	3.8			4.5				4.4	4.4	4.9	7.2

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
2/1	3.3	3.8			4.0				4.3	4.4	5.0	7.6
2/2	3.1	3.8			4.1				4.1	4.2	4.8	7.9
2/3	3.0	3.8			4.3				4.1	4.1	4.6	8.5
2/4	3.3	3.9			4.4				4.3	4.3	4.6	8.4
2/5	3.7	4.0			4.9				4.3	4.4	5.1	8.2
2/6	3.4	3.9			4.7				4.3	4.4	5.3	7.7
2/7	3.5	3.9			4.4				4.1	4.1	4.9	7.2
2/8	3.8	4.0			4.6				4.1	4.2	5.3	7.7
2/9	3.9	4.1			4.7				4.2	4.2	5.6	7.0
2/10	4.1	4.1			5.2				4.3	4.3	5.4	6.4
2/11	4.2	4.1			5.6				4.4	4.4	5.6	6.4
2/12	4.0	4.3			6.2				4.8	4.8	5.8	6.2
2/13	4.0	4.1		5.2	5.9				4.8	4.8	5.3	5.7
2/14	4.0	4.2		5.3	5.7				5.0	4.9	5.2	5.7
2/15	4.0	4.6		6.2	6.6				6.8	6.0	5.1	5.3
2/16	4.4	4.5		6.2	6.7				6.6	6.0	5.3	5.3
2/17	4.9	4.4		4.9	5.4				5.8	5.6	5.8	6.2
2/18	4.5	4.4		4.8	5.1				5.5	5.4	5.8	7.3
2/19	4.3	4.5		5.0	5.2				5.3	5.3	5.5	8.0
2/20	3.9	4.3		4.7	5.1				5.1	5.1	5.4	8.1
2/21	3.9	4.3		4.5	4.8				4.8	4.8	4.8	7.9
2/22	4.2	4.3		4.9	5.4				4.9	5.0	5.3	6.9
2/23	3.7	4.2		4.3	4.5				4.7	4.8	5.2	5.3
2/24	4.4	4.5		4.9	5.1	5.4	5.3		4.8	5.0	5.5	5.6
2/25	4.5	4.6		5.0	5.4	5.7	5.5		4.9	5.1	6.1	6.0
2/26	4.9	4.5		5.2	5.6	5.9	5.5		5.0	5.2	6.1	6.1
2/27	4.8	4.6		5.6	6.2	6.5	6.1		5.2	5.4	6.5	6.5
2/28	4.1	4.4		5.2	5.9	6.2	5.9		5.2	5.4	6.2	6.2
2/29	3.7	4.3		5.1	5.6	5.9	5.8		5.1	5.3	5.7	5.8

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
3/1	4.0	4.6		5.1	5.6	5.9	5.8		5.2	5.3	5.7	5.7
3/2	4.0	4.8		5.4	5.7	5.9	6.0		5.3	5.5	5.5	5.5
3/3	4.3	4.9		5.8	6.3	6.5	6.7		5.4	5.6	5.9	6.0
3/4	4.4	4.8		5.6	6.1	6.3	6.4		5.3	5.5	5.7	5.8
3/5	5.0	5.0		6.1	6.6	6.9	7.0		5.5	5.7	6.6	6.7
3/6	4.5	5.0		5.9	6.6	6.8	6.8		5.7	5.9	6.6	6.6
3/7	3.8	4.7		4.9	5.4	5.6	5.8		5.4	5.6	5.7	5.7
3/8	4.1	4.6		5.1	5.5	5.7	5.7		5.4	5.6	5.7	5.8
3/9	4.2	4.7		5.1	5.6	5.9	5.8		5.4	5.6	5.8	5.9
3/10	4.2	5.0		5.5	5.9	6.1	6.1		5.6	5.7	5.9	5.9
3/11	4.2	4.9		5.3	5.7	5.9	5.8		5.4	5.6	5.8	5.8
3/12	4.3	4.9		5.5	6.0	6.2	6.0		5.5	5.7	6.2	6.3
3/13	3.8	4.8		5.0	5.4	5.6	5.5		5.3	5.5	5.8	5.8
3/14	3.1	4.7		4.5	5.0	5.3	5.3		5.2	5.4	5.5	5.6
3/15	2.7	4.6		3.9	4.3	4.7	4.9		5.1	5.3	5.4	5.5
3/16	3.5	4.6		4.6	4.8	5.1	5.2		5.2	5.4	6.1	6.1
3/17	3.3	4.6		4.5	4.6	4.8	5.0		5.1	5.2	6.0	6.0
3/18	3.7	4.8		4.8	4.9	5.1	5.2		5.2	5.4	5.9	5.9
3/19	4.3	5.0		5.3	5.7	6.1	5.7		5.4	5.7	6.5	6.4
3/20	4.7	5.1		5.7	6.2	6.6	6.0		5.6	5.8	7.2	6.8
3/21	4.4	5.0		5.8	6.5	6.8	6.2		5.7	5.9	7.1	6.9
3/22	4.0	4.9		5.4	5.8	6.0	6.0		5.9	6.0	7.0	7.0
3/23	4.2	4.9		5.5	6.0	6.1	6.1		6.0	6.1	6.6	6.6
3/24	3.5	4.8		4.6	5.2	5.4	5.6		5.9	5.9	6.3	6.3
3/25	3.7	4.8		5.0	5.4	5.6	5.6		5.7	5.8	6.2	6.3
3/26	4.2	4.8		5.4	5.7	6.0	5.9		5.9	6.0	6.5	6.6
3/27	3.9	4.8		5.3	5.8	6.0	6.1		6.4	6.4	6.8	6.9
3/28	4.2	4.8		5.3	5.7	5.9	5.8		6.1	6.2	6.5	6.6
3/29	4.3	4.9		5.6	6.0	6.3	6.0		6.1	6.4	7.2	7.2
3/30	4.8	4.9		5.9	6.3	6.7	6.2		6.3	6.5	7.6	7.7
3/31	5.1	5.2		6.2	6.8	7.3	6.4		6.2	6.4	8.1	8.1

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
4/1	5.2	5.9		6.8	7.2	7.7	6.5		6.3	6.4	8.3	8.3
4/2	5.3	5.7		6.9	7.6	8.0	6.6		6.7	6.6	7.9	7.9
4/3	5.4	6.2		6.9	7.5	8.0	6.6		6.7	6.7	7.7	7.8
4/4	4.6	5.6		6.5	7.2	7.4	6.6		6.7	6.6	7.3	7.4
4/5	4.4	6.3		6.3	6.5	6.7	6.5		6.6	6.7	6.1	6.2
4/6	5.2	6.7		7.4	7.5	7.8	6.9		6.7	6.8	7.1	7.3
4/7	6.0	7.3		7.7	8.1	8.5	7.3		7.2	7.4	8.4	8.5
4/8	5.8	7.0		8.6	9.0	9.3	7.7		7.2	7.5	8.4	8.5
4/9	5.7	6.2		7.7	8.6	9.2	7.4		6.9	7.1	7.8	7.9
4/10	5.8	6.3		7.2	8.0	8.4	7.2		6.8	7.0	7.3	7.4
4/11	5.6	6.3		7.0	7.7	8.1	7.2		7.0	7.2	7.4	7.4
4/12	5.3	6.7		6.9	7.3	7.6	7.5		7.6	7.8	7.0	7.1
4/13	5.3	7.1		7.4	7.6	7.8	7.8		7.8	8.1	7.1	7.2
4/14	5.2	7.3		7.4	7.6	7.9	8.2		8.4	8.6	7.4	7.6
4/15	5.4	6.8		7.4	7.7	7.9	7.8		8.0	8.2	7.3	7.4
4/16	5.5	7.9		7.8	7.9	8.2	8.2		8.3	8.5	7.8	8.0
4/17	6.6	8.8		8.8	8.9	9.3	8.8		8.9	9.1	9.0	9.1
4/18	7.0	10.0		10.5	10.2	10.6	10.3		10.3	10.8	9.7	9.8
4/19	6.9	8.6		10.6	11.1	11.7	9.8		9.9	10.1	9.1	9.3
4/20	7.1	8.5		10.1	11.2	12.0	9.7		9.4	10.0	8.8	8.9
4/21	7.0	8.7		10.0	11.2	11.9	9.9		9.6	10.2	8.4	8.5
4/22	6.3	8.5		9.1	10.1	10.5	9.4	10.3	9.4	9.8	7.6	7.7
4/23	6.2	6.6		7.1	8.1	8.1	8.0	8.9	8.6	9.0	7.4	7.5
4/24	5.8	8.1		7.8	7.8	7.8	8.3	8.7	8.4	8.8	7.5	7.6
4/25	5.4	7.9		8.1	8.3	8.5	8.3	8.9	8.3	8.7	7.2	7.3
4/26	5.5	8.5		8.3	8.3	8.4	8.5	8.8	8.6	9.0	7.8	7.9
4/27	5.7	8.1		8.3	8.5	8.6	8.4	8.9	8.4	8.8	7.9	8.1
4/28	6.1	8.7		8.6	8.7	9.0	8.7	9.2	8.7	9.1	7.7	8.0
4/29	6.1	7.9		8.7	8.9	9.1	8.3	9.1	8.4	8.8	7.8	8.1
4/30	6.5	8.2		9.0	9.2	9.8	9.0	9.4	8.9	9.5	8.8	9.0

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
5/1	7.1	8.4		9.3	9.8	10.7	9.4	10.0	9.4	9.9	9.9	9.9
5/2	7.7	9.5		10.0	10.5	11.5	10.1	10.8	10.1	10.6	10.1	10.2
5/3	7.5	8.1		10.1	10.8	11.8	10.0	11.3	10.0	10.7	9.5	9.7
5/4	7.2	7.9		8.8	10.0	10.5	9.3	10.2	9.5	9.8	8.6	8.7
5/5	7.0	8.7		9.2	9.6	10.2	9.3	10.0	9.5	10.0	8.5	8.7
5/6	7.8	8.9		10.3	10.5	11.5	9.9	10.7	10.1	10.7	9.5	9.7
5/7	8.2	8.8		10.6	11.2	12.4	10.2	11.2	10.6	11.2	10.2	10.3
5/8	7.4	8.3		9.1	10.6	11.1	9.5	10.5	9.9	10.4	9.3	9.4
5/9	7.1	8.7		9.1	9.9	10.5	9.8	10.3	10.0	10.6	8.8	9.0
5/10	7.5	9.1		10.2	10.3	11.2	10.2	10.8	10.4	11.1	9.4	9.6
5/11	8.1	9.3		10.6	11.1	12.1	10.6	11.3	10.8	11.4	10.4	10.5
5/12	8.2	9.3		10.7	11.4	12.5	10.7	11.5	11.0	11.6	10.6	10.8
5/13	8.7	11.2		11.2	11.8	12.9	11.8	12.0	11.8	12.4	10.9	11.1
5/14	8.2	10.0		11.3	11.8	12.3	10.9	12.0	11.3	11.7	9.9	10.1
5/15	7.5	8.5		9.1	10.5	11.0	10.4	11.0	10.7	11.0	8.6	8.8
5/16	7.4	5.8		6.3	7.2	7.1	7.4	8.6	9.1	9.9	8.8	9.0
5/17	8.2	6.8		7.1	7.7	8.0	8.0	9.0	9.2	10.3	10.2	10.4
5/18	7.9	8.5		8.8	8.9	9.1	8.5	9.3	8.9	9.5	10.3	10.4
5/19	7.2	8.7		9.1	9.4	9.8	9.0	9.5	9.1	9.6	9.7	9.9
5/20	7.7	9.2		10.2	10.2	10.7	9.0	10.1	9.3	10.2	10.1	10.7
5/21	7.5	9.1		9.3	10.0	10.4	9.2	9.8	9.3	9.6	9.7	10.2
5/22	6.9	8.9		9.3	9.7	10.0	9.3	9.7	9.3	9.6	8.9	9.1
5/23	6.7	9.7		9.5	9.7	9.8	9.0	9.9	9.4	9.7	8.7	8.8
5/24	7.0	9.9		10.1	10.0	10.2	9.1	10.0	9.4	9.8	8.8	9.0
5/25	7.6	9.7		10.3	10.5	10.7	9.3	10.1	9.5	10.0	9.5	10.1
5/26	7.3	9.5		9.9	10.4	10.8	9.4	10.1	9.5	9.9	9.9	10.4
5/27	6.7	9.8		9.7	10.0	10.3	9.3	10.0	9.5	10.1	9.5	10.0
5/28	6.7	10.0		9.6	9.8	9.9	9.1	9.8	9.4	9.8	9.1	9.4
5/29	7.0	9.3		9.4	9.8	9.9	9.3	10.0	9.7	9.9	9.2	9.4
5/30	7.4	9.6		10.1	10.4	10.7	9.8	10.6	10.1	10.7	10.4	10.5
5/31	8.3	9.8		11.0	11.4	12.1	10.1	11.3	10.4	11.1	11.7	12.2

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
6/1	8.8	10.9		11.6	11.9	12.7	10.1	11.6	10.7	11.3	12.2	12.4
6/2	8.4	10.5		11.1	11.8	12.4	10.3	11.2	10.5	10.9	11.4	11.5
6/3	8.8	11.2		12.5	12.4	13.4	10.4	11.8	10.8	11.7	11.4	11.5
6/4	10.1	10.3	11.2	12.4	13.6	15.0	11.1	12.8	11.5	12.3	13.1	13.2
6/5	11.1	10.9	12.0	13.1	14.2	15.7	11.3	13.2	11.8	12.6	13.8	14.0
6/6	11.3	10.6	11.8	13.2	14.6	16.2	11.3	13.3	11.8	12.7	14.1	14.2
6/7	11.2	10.5	11.6	12.8	14.3	15.7	11.1	12.9	11.6	12.4	13.9	14.0
6/8	10.8	10.1	10.9	11.9	13.6	14.7	10.8	12.3	11.4	12.1	13.6	13.7
6/9	9.6	10.3	10.6	10.9	12.2	12.7	10.4	11.3	10.7	11.3	12.3	12.5
6/10	9.2	9.7	10.3	10.8	11.7	12.3	10.3	11.1	10.6	11.0	11.7	11.9
6/11	8.6	10.1	10.2	10.5	11.1	11.3	10.0	11.0	10.4	11.0	11.5	11.7
6/12	8.8	10.1	10.5	10.9	11.4	11.9	10.2	11.2	10.7	11.4	12.0	12.1
6/13	8.4	10.3	10.4	10.5	11.0	11.2	10.0	10.8	10.3	10.8	11.7	11.6
6/14	7.6	10.2	9.5	9.5	10.1	10.1	9.9	10.5	10.3	10.7	10.8	10.9
6/15	7.5	8.7	9.4	9.9	10.1	10.5	9.9	10.7	10.4	11.0	10.9	11.0
6/16	7.8	8.0	8.7	9.3	10.3	10.8	10.2	11.1	10.5	11.2	11.9	11.9
6/17	8.0	8.5	9.2	9.9	10.7	11.3	10.2	11.3	10.6	11.3	11.9	11.6
6/18	8.1	8.5	9.2	9.6	10.5	10.8	10.3	11.2	10.7	11.0	11.2	11.2
6/19	8.2	8.6	9.5	10.2	10.7	11.1	10.5	11.6	11.2	11.7	11.3	11.4
6/20	8.7	8.9	9.6	10.2	10.9	11.2	10.5	11.9	10.6	11.2	12.2	12.3
6/21	8.9	8.9	9.9	10.5	11.2	11.7	10.8	12.2	11.3	11.9	12.8	12.9
6/22	9.3	9.1	10.3	11.1	11.9	12.7	11.0	12.5	11.5	12.2	13.1	13.2
6/23	9.1	9.0	10.0	10.6	11.6	12.0	10.9	12.3	11.4	11.8	13.0	13.1
6/24	8.5	8.5	9.5	10.0	10.7	10.8	10.5	11.6	11.1	11.5	12.0	12.1
6/25	8.8	8.9	9.8	10.3	11.0	11.4	10.7	11.9	11.2	11.9	12.1	12.2
6/26	9.7	9.8	10.7	11.6	12.1	12.9	11.3	12.7	11.7	12.5	13.5	13.6
6/27	10.7	10.2	11.5	12.8	13.4	14.5	11.8	13.7	12.4	13.2	15.3	15.4
6/28	11.1	9.2	11.3	12.9	14.0	15.2	11.8	13.8	12.5	13.2	15.6	15.7
6/29	11.2	8.5	10.0	11.2	13.1	13.8	11.3	13.0	11.8	12.3	15.1	15.1
6/30	10.4	8.2	9.4	10.2	12.2	12.9	11.0	12.3	11.4	12.0	14.6	14.6

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
7/1	10.7	8.4	9.7	10.6	12.1	12.9	11.0	12.2	11.4	12.0	15.1	15.0
7/2	11.5	8.7	10.2	11.4	13.1	14.2	11.5	13.0	11.8	12.6	16.0	15.9
7/3	11.1	8.1	9.9	11.2	13.1	14.3	11.5	13.0	11.8	12.6	16.1	16.0
7/4	10.0	7.9	8.9	9.7	11.9	12.4	10.8	11.9	11.2	11.5	14.5	14.5
7/5	9.8	8.0	8.8	9.4	11.1	11.6	10.6	11.5	10.9	11.4	13.1	13.1
7/6	10.0	8.3	9.3	10.0	11.3	12.1	10.7	11.9	11.2	12.0	14.4	14.4
7/7	9.9	8.9	9.4	9.9	11.3	11.9	10.7	11.6	11.0	11.4	14.0	14.0
7/8	10.4	9.5	10.7	11.3	11.7	12.3	11.3	12.1	11.4	12.0	14.0	14.0
7/9	10.3	9.3	10.8	11.6	12.3	12.8	11.5	12.6	11.8	12.2	14.4	14.3
7/10	9.7	9.1	10.2	10.8	12.0	12.5	11.2	12.5	11.7	12.2	13.9	13.9
7/11	10.0	9.1	10.4	11.0	12.0	12.7	11.3	12.5	11.7	12.2	14.0	14.0
7/12	10.1	9.4	10.4	10.9	12.2	12.8	11.3	12.6	11.8	12.3	14.4	14.4
7/13	10.4	9.3	10.6	11.3	12.5	13.4	11.5	12.7	11.9	12.7	14.6	14.7
7/14	10.6	9.3	10.6	11.5	12.8	13.9	11.6	12.9	12.0	12.7	15.5	15.6
7/15	10.3	9.3	10.3	11.1	12.6	13.5	11.6	12.9	12.0	12.5	15.8	15.7
7/16	10.4	9.5	10.5	11.1	12.5	13.3	11.5	12.5	11.8	12.4	14.9	14.8
7/17	11.1	10.0	11.2	12.1	13.2	14.3	11.7	13.0	12.0	12.8	15.6	15.6
7/18	10.6	9.8	10.8	11.6	13.2	13.9	11.7	12.8	11.8	12.3	15.0	15.0
7/19	10.8	9.9	10.9	11.6	13.1	14.1	11.7	12.9	12.0	12.5	14.5	14.5
7/20	11.1	9.8	10.8	11.7	13.7	15.1	11.9	13.3	12.3	13.1	16.0	16.0
7/21	11.7	10.1	11.4	12.5	14.0	15.6	12.2	13.6	12.1	13.1	17.1	16.9
7/22	11.4	9.4	10.9	11.8	13.5	14.4	12.2	13.0	12.1	12.4	16.1	15.8
7/23	11.1	8.8	10.2	11.2	12.9	13.6	11.9	12.9	12.1	12.7	15.0	15.0
7/24	11.7	9.1	10.5	11.8	13.4	14.5	12.0	13.3	12.3	13.2	16.2	16.1
7/25	12.7	9.6	11.1	12.4	14.2	15.7	12.3	13.9	12.6	13.5	17.9	17.6
7/26	13.2	9.5	11.1	12.7	14.7	16.2	12.2	13.8	12.4	13.4	18.7	18.3
7/27	13.5	9.8	11.2	12.7	14.9	16.5	12.3	13.8	12.4	13.5	18.9	18.5
7/28	14.0	10.0	11.3	12.8	15.2	16.9	12.4	14.0	12.5	13.7	19.5	19.0
7/29	14.4	10.3	11.7	12.8	14.5	15.9	12.6	14.2	12.9	13.9	19.9	19.3
7/30	13.6	9.5	10.9	12.2	14.3	15.3	12.1	13.3	12.2	13.2	18.8	18.2
7/31	13.4	9.3	10.7	11.9	14.1	15.3	12.0	13.3	12.2	13.3	18.5	18.0

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
8/1	13.6	9.4	10.9	12.3	14.2	15.4	12.0	13.2	12.2	13.0	18.2	17.5
8/2	12.6	9.1	10.3	11.3	13.5	14.4	12.0	12.8	12.0	12.7	17.3	16.6
8/3	12.1	9.3	10.2	11.0	13.0	13.7	11.8	12.9	12.2	12.9	16.8	16.3
8/4	12.5	9.6	10.8	11.9	13.7	14.5	11.9	13.1	12.4	13.3	17.6	17.1
8/5	13.0	9.5	10.9	12.2	14.3	15.4	12.2	13.3	12.6	13.5	18.5	17.8
8/6	12.5	8.9	10.2	11.3	13.3	14.1	12.1	12.8	12.3	12.9	17.6	16.8
8/7	12.0	9.2	10.1	10.8	12.7	13.5	12.0	12.7	12.3	12.8	16.9	16.1
8/8	11.6	9.2	10.5	11.3	12.4	12.9	12.2	12.8	12.3	12.9	16.1	15.5
8/9	11.4	9.4	10.3	10.9	12.3	12.7	12.0	12.8	12.3	12.7	15.3	14.9
8/10	11.6	9.7	10.5	11.0	12.5	13.0	11.8	12.9	11.9	12.6	15.6	15.0
8/11	12.5	10.2	11.3	12.2	13.5	14.1	11.3	12.7	11.1	12.0	17.4	15.8
8/12	13.4	10.6	11.8	13.0	14.6	15.5	11.7	13.1	11.3	12.2	19.1	17.0
8/13	14.0	10.6	12.1	13.4	15.2	16.2	11.9	13.4	11.5	12.3	20.0	17.6
8/14	14.2	10.2	11.7	13.2	15.2	16.2	12.0	13.3	11.7	12.3	19.8	17.5
8/15	14.0	10.2	11.3	12.7	14.9	15.9	12.1	13.3	11.7	12.5	19.5	17.3
8/16	14.1	10.4	11.6	12.8	14.8	15.9	12.2	13.4	11.9	12.6	19.5	17.3
8/17	13.9	10.3	11.5	12.8	14.8	15.7	12.4	13.4	12.0	12.7	19.4	17.2
8/18	14.3	10.2	11.8	13.0	15.0	16.0	12.6	13.7	12.2	12.7	19.8	16.8
8/19	14.6	8.9	10.6	12.3	15.0	16.2	12.9	14.1	12.5	12.9	20.2	17.0
8/20	14.6	9.0	10.5	11.9	14.5	15.9	13.2	14.3	12.8	13.2	20.3	17.1
8/21	14.2	8.5	10.0	11.2	13.7	14.7	13.0	13.8	12.8	13.2	19.4	16.9
8/22	13.1	8.0	9.0	10.0	12.5	13.4	12.7	13.3	12.5	13.2	18.1	16.5
8/23	12.7	8.2	9.2	10.2	12.0	13.0	12.6	13.3	12.7	13.2	17.5	16.3
8/24	13.0	8.6	9.7	10.8	12.6	13.6	12.9	13.7	12.9	13.6	18.2	16.8
8/25	13.4	8.7	10.0	11.1	13.1	14.2	13.1	14.0	13.1	13.9	19.0	17.4
8/26	13.7	8.8	10.1	11.3	13.4	14.6	13.4	14.3	13.4	14.1	19.5	17.9
8/27	13.0	8.6	9.6	10.5	12.6	13.6	13.2	13.8	13.3	13.6	18.5	17.0
8/28	12.8	8.3	9.4	10.3	12.3	13.1	13.0	13.7	13.2	13.8	17.3	16.3
8/29	12.9	8.4	9.5	10.5	12.3	13.3	13.3	13.9	13.5	14.0	17.4	16.6
8/30	12.8	8.3	9.4	10.2	12.0	12.8	13.2	13.7	13.4	13.8	17.1	16.1
8/31	12.3	8.3	9.2	9.8	11.5	12.3	13.2	13.5	13.4	13.7	16.0	15.3

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
9/1	12.1	8.1	9.2	9.9	11.4	12.1	13.3	13.5	13.5	13.9	16.0	15.4
9/2	11.1	7.9	9.6	10.2	11.1	11.4	12.8	13.0	13.2	13.5	15.2	14.8
9/3	10.5	7.9	10.3	10.6	11.7	11.9	12.7	12.9	13.0	13.4	14.6	14.3
9/4	10.0	7.8	9.1	9.5	10.9	11.2	12.8	13.0	13.2	13.5	14.4	14.3
9/5	10.3	7.7	8.9	9.4	10.6	10.9	12.8	12.9	13.2	13.4	14.1	14.0
9/6	10.6	7.9	8.9	9.5	11.0	11.6	13.2	13.4	13.6	13.9	14.9	14.8
9/7	10.8	8.0	9.1	9.7	11.0	11.5	13.2	13.5	13.6	14.0	15.1	14.9
9/8	10.8	7.9	9.3	10.0	11.4	11.9	13.2	13.6	13.7	14.1	15.5	15.3
9/9	10.2	7.7	8.7	9.5	10.7	11.4	13.3	13.3	13.6	14.0	15.4	15.2
9/10	10.5	7.9	8.9	9.7	10.8	11.5	13.4	13.6	13.8	14.2	15.8	15.5
9/11	10.8	7.7	8.8	9.7	11.1	11.6	13.5	13.7	13.8	14.3	16.0	15.7
9/12	10.2	7.5	8.4	9.1	10.4	11.1	13.5	13.4	13.7	14.0	15.4	15.2
9/13	10.0	7.6	8.4	9.1	10.0	10.7	13.5	13.4	13.8	14.1	15.3	15.0
9/14	10.1	7.0	7.7	8.3	9.7	10.4	13.3	13.5	13.8	14.2	15.4	15.1
9/15	10.2	6.2	6.6	6.9	7.7	8.2	11.3	12.0	12.8	13.6	15.5	14.9
9/16	10.4	6.3	6.6	6.9	7.7	8.0	11.1	11.4	12.5	13.3	15.3	14.5
9/17	10.6	6.4	7.9	8.4	9.0	9.1	11.1	11.4	12.2	12.9	14.7	14.1
9/18	9.8	6.3	7.3	8.1	9.5	9.9	11.4	11.9	12.2	12.7	13.0	13.0
9/19	9.4	6.2	6.9	7.4	8.4	8.7	10.6	11.2	11.7	12.3	12.9	12.9
9/20	8.9	6.2	6.7	7.1	8.1	8.5	10.5	10.7	11.4	11.9	12.1	12.1
9/21	8.7	6.2	6.6	7.0	7.8	8.2	10.3	10.6	11.4	11.9	12.4	12.4
9/22	8.8	6.2	6.6	6.9	7.6	7.9	10.1	10.5	11.4	11.9	12.7	12.7
9/23	8.9	6.2	6.6	6.8	7.5	7.7	10.1	10.4	11.3	11.7	12.2	12.2
9/24	9.2	6.3	6.7	7.0	7.8	8.2	10.3	10.7	11.5	12.3	12.6	12.7
9/25	9.7	6.4	6.8	7.1	8.0	8.4	10.6	11.2	11.9	12.7	13.7	13.7
9/26	10.0	6.5	6.9	7.2	7.9	8.2	10.5	11.0	11.7	12.6	14.2	14.1
9/27	10.4	6.4	6.8	7.1	7.9	8.3	10.7	11.3	12.0	12.7	14.8	14.5
9/28	9.6	6.3	6.6	6.8	7.4	7.6	10.3	10.5	11.4	11.8	13.5	13.2
9/29	9.3	6.1	6.4	6.7	7.3	7.6	10.1	10.4	11.5	12.1	13.2	13.0
9/30	8.9	6.0	6.2	6.4	6.8	7.0	9.9	10.0	11.1	11.8	12.7	12.6

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
10/1	8.7	6.0	6.3	6.4	6.9	7.1	10.0	10.0	11.1	11.8	12.2	12.2
10/2	8.5	6.0	6.3	6.4	6.9	7.1	9.9	10.1	11.1	12.0	12.2	12.3
10/3	8.8	6.0	6.3	6.5	7.0	7.2	10.0	10.2	11.3	12.1	12.3	12.3
10/4	8.7	6.1	6.3	6.6	7.1	7.2	10.0	10.2	11.2	12.1	12.1	12.2
10/5	8.9	6.1	6.4	6.7	7.3	7.6	10.3	10.5	11.4	12.3	12.2	12.4
10/6	9.0	6.1	6.7	6.9	7.5	7.7	10.1	10.4	11.3	12.2	12.5	12.5
10/7	8.9	6.1	6.8	6.9	7.7	7.9	10.2	10.4	11.2	12.0	12.0	12.1
10/8	9.2	6.2	7.6	7.7	8.2	8.2	10.1	10.2	10.9	11.8	11.3	11.4
10/9	9.0	6.2	7.7	8.1	9.2	9.5	10.5	10.9	11.1	11.6	10.8	10.8
10/10	8.2	6.1	6.7	7.0	7.8	8.1	9.6	10.1	10.4	11.1	10.6	10.7
10/11	7.2	6.1	6.4	6.5	6.8	7.0	9.0	9.0	9.9	10.5	9.8	10.0
10/12	6.8	6.1	6.3	6.4	6.6	6.7	8.7	8.6	10.1	10.6	9.2	9.5
10/13	8.0	6.2	7.1	7.2	7.7	7.7	8.9	9.1	10.2	11.0	9.4	9.7
10/14	8.2	6.3	7.4	7.8	8.6	8.8	9.3	9.7	10.2	11.1	9.3	9.4
10/15	8.0	6.3	7.0	7.4	8.1	8.4	8.8	9.5	10.3	11.0	9.1	9.2
10/16	7.9	6.3	7.1	7.4	8.1	8.4	8.8	9.4	10.2	10.8	9.2	9.3
10/17	7.7	6.3	7.5	7.9	8.4	8.6	8.9	9.4	10.4	10.8	9.2	9.3
10/18	7.6	6.3	7.2	7.8	8.3	8.5	8.9	9.5	10.3	10.6	9.0	9.2
10/19	7.5	6.4	7.3	7.8	8.3	8.5	9.0	9.5	10.3	10.6	8.9	9.1
10/20	8.0	6.7	8.6	8.8	9.2	9.3	9.7	10.1	10.3	10.6	9.0	9.2
10/21	7.8	6.6	8.2	8.5	9.2	9.3	9.7	10.2	10.2	10.5	9.1	9.3
10/22	7.5	6.5	7.5	7.8	8.5	8.8	9.3	9.9	10.0	10.2	9.2	9.9
10/23	7.7	6.6	7.4	7.7	8.4	8.7	9.6	9.9	10.2	10.5	9.1	11.0
10/24	8.0	6.4	6.8	7.1	7.8	8.1	9.1	9.7	10.3	10.6	9.4	11.9
10/25	7.7	6.4	6.7	6.9	7.5	7.7	8.2	9.1	9.8	10.1	9.4	12.2
10/26	7.7	6.5	6.9	7.1	7.6	7.7	7.8	8.5	10.0	10.3	9.2	12.0
10/27	8.0	6.5	7.1	7.6	8.3	8.5	8.7	9.5	9.7	10.1	9.1	10.2
10/28	7.7	6.5	6.9	7.1	7.7	7.9	8.1	9.0	9.7	10.1	9.3	10.5
10/29	7.5	6.5	6.8	7.0	7.4	7.6	7.7	8.5	9.9	10.2	8.7	10.9
10/30	7.1	6.5	6.8	6.9	7.2	7.3	7.4	8.0	9.5	9.8	8.3	11.1
10/31	7.4	6.6	7.2	7.4	7.8	7.9	8.1	8.6	9.5	9.8	8.7	10.6

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
11/1	7.3	6.6	7.5	7.9	8.3	8.5	8.6	9.1	9.4	9.7	8.4	9.5
11/2	7.5	6.7	7.4	7.9	8.4	8.6	8.8	9.3	9.5	9.8	8.6	9.6
11/3	7.5	6.7	7.2	7.4	8.0	8.3	8.5	9.4	9.5	9.7	8.9	10.1
11/4	7.5	6.7	7.1	7.3	7.7	7.9	8.1	8.7	9.4	9.7	8.7	10.2
11/5	8.0	6.8	7.5	7.6	8.2	8.3	8.6	9.3	9.4	9.7	9.1	10.8
11/6	7.5	6.7	7.5	7.7	8.4	8.6	8.8	9.5	9.4	9.6	9.1	10.3
11/7	7.7	6.8	7.6	7.8	8.3	8.5	8.7	9.4	9.6	9.8	9.0	10.3
11/8	7.8	6.9	7.8	8.0	8.6	8.8	9.2	9.7	9.6	9.9	9.2	10.6
11/9	7.8	8.4	8.3	8.3	8.6	8.7	9.1	9.7	9.4	9.6	8.9	11.2
11/10	8.0	9.0	9.5	9.4		9.0	9.4	9.7	9.7	9.9	9.2	11.4
11/11	8.3	7.0	8.0	8.6		9.5	9.7	10.1	9.5	9.8	9.4	11.4
11/12	8.3	7.0	8.2	8.5		9.2	9.4	10.1	9.4	9.6	9.8	11.0
11/13	7.6	6.8	7.8	8.0		8.7	9.1	9.5	9.4	9.5	9.0	10.4
11/14	7.6	6.9		8.4		8.8	9.2	9.6	9.3	9.6	8.6	9.8
11/15	7.1	6.8		8.0		8.4	8.8	9.2	9.3	9.5	8.3	9.2
11/16	6.0	6.6		7.4		7.6	8.0	8.3	8.8	9.0	7.2	8.6
11/17	6.1	6.7		7.2		7.4	8.0	8.2	8.8	9.0	7.2	8.8
11/18	5.6	6.6				6.7	7.5	7.4	8.6	8.7	6.6	9.0
11/19	5.8	6.7				7.1	7.8	7.9	8.6	8.7	6.9	9.9
11/20	6.3	6.9				7.5	8.2	8.4	8.6	8.8	7.3	10.5
11/21	6.2	6.9				7.7	8.2	8.6	8.5	8.7	7.6	10.2
11/22	6.0	6.8				7.4	8.0	8.3	8.4	8.5	7.3	9.7
11/23	5.7	6.8				7.1	7.7	8.1	8.3	8.5	7.2	9.6
11/24	5.7	6.8				7.0	7.6	7.8	8.1	8.3	6.9	9.4
11/25	5.9	7.0				7.4	7.8	7.9	8.1	8.3	7.0	9.3
11/26	6.2	7.1				7.6	8.0	8.3	8.2	8.4	7.3	9.5
11/27	5.6	7.0				7.2	7.7	8.0	8.0	8.2	7.2	9.5
11/28	5.0	7.0				6.7	7.1	7.5	7.8	8.0	6.6	9.2
11/29	5.3	7.0				6.7	7.2	7.3	7.7	7.9	6.5	9.1
11/30	5.0	7.0				6.6	7.1	7.3	7.6	7.8	6.5	9.1

	Sultan River										Skykomish River	
DATE	RM 18.2 (SFK)	RM 15.8	RM 15.5	RM 14.3	RM 11.3	RM 9.8	RM 9.6	RM 4.9	RM 4.4	RM 0.2	RM 14.1	RM 13.2
12/1	4.8	6.8				6.4	6.9	7.1	7.4	7.6	6.3	8.9
12/2	5.0	6.8				6.6	7.0	7.2	7.5	7.6	6.4	9.0
12/3	4.9	6.8				6.9	7.2	7.5	7.5	7.6	6.5	9.0
12/4	4.5	6.5				6.2	6.6	6.9	7.1	7.2	6.0	8.5
12/5	3.9	6.4				5.0	5.7	5.9	6.7	6.8	5.3	8.3
12/6	3.3	6.3				4.6	5.4	5.2	6.6	6.6	4.6	8.1
12/7	2.4	5.9				3.7	4.9	4.5	6.4	6.4	3.9	7.9
12/8	1.7	5.7				3.1	4.7	4.1	6.0	6.0	2.5	7.4
12/9	1.7	5.6				3.2	4.8	4.3	5.9	5.8	2.2	7.4
12/10	2.2	5.6				3.3	4.7	4.3	5.7	5.8	2.4	8.3
12/11	2.0	5.5				3.7	4.9	4.9	5.8	5.9	3.4	8.6
12/12	2.0	5.2				3.4	4.6	4.7	5.6	5.7	3.7	7.9
12/13	2.7	4.9				4.1	5.0	4.9	5.5	5.6	4.2	8.5
12/14	1.8	4.8				3.5	4.6	4.3	5.3	5.3	2.7	9.0
12/15	2.0	4.8				3.7	4.7	4.4	5.2	5.2	2.8	9.1
12/16	1.4	4.7				3.1	4.5	4.0	5.1	5.0	2.7	8.5
12/17	0.9	4.5				2.6	4.1	3.6	4.8	4.7	1.9	7.6
12/18	1.5	4.5				3.0	4.3	4.0	4.8	4.8	2.3	4.9
12/19	1.3	4.6				2.9	4.2	4.3	5.2	4.9	2.8	3.6
12/20	1.8	4.8				3.3	4.0	4.3	4.8	4.9	3.4	3.9
12/21	2.5	4.6				3.7	4.3	4.3	4.7	4.7	3.5	3.8
12/22	2.9	4.4				3.9	4.5	4.4	4.9	4.8	3.8	4.1
12/23	2.7	4.4				3.6	4.3	4.4	4.8	4.7	4.0	4.2
12/24	2.8	4.3				3.7	4.3	4.2	4.8	4.6	4.0	4.2
12/25	2.1	4.0				3.3	4.2	4.1	4.7	4.4	3.8	4.0
12/26	2.1	4.1				3.4	4.2	4.1	4.8	4.5	3.5	3.8
12/27	1.9	4.2				3.6	4.2	4.5	5.2	4.7	3.6	4.0
12/28	2.2	4.2				3.8	4.2	4.5	5.8	4.6	3.5	3.9
12/29	2.4	4.1				3.8	4.2	4.6	6.0	4.6	3.8	4.0
12/30	2.6	4.1				3.8	4.1	4.4	5.3	4.6	3.9	4.2
12/31	2.2	3.9				3.6	4.1	4.1	5.4	4.3	3.8	4.0

APPENDIX C

2016 Seven-Day Average of the Daily Maximum (7-DAD Max) Water Temperature in Tabular Format

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
1/1	2.0	4.2			3.2	3.1	3.9	3.9	4.5	4.6	2.8	3.6
1/2	2.2	4.1			3.1	3.0	3.8	3.8	4.4	4.5	2.8	3.5
1/3	2.4	4.1			3.0	2.9	3.7	3.8	4.3	4.4	2.8	3.5
1/4	2.6	4.0			3.1	3.0	3.8	3.8	4.2	4.4	3.0	3.6
1/5	2.6	4.0			3.2					4.3	3.3	3.9
1/6	2.6	3.9			3.4					4.3	3.6	4.0
1/7	2.5	3.9			3.4					4.2	3.8	4.1
1/8	2.5	3.8			3.3					4.1	3.8	4.1
1/9	2.6	3.8			3.3					4.1	3.9	4.1
1/10	2.7	3.8			3.4					4.1	3.9	4.1
1/11	2.8	3.8			3.5					4.2	4.0	4.4
1/12	2.9	3.8			3.6					4.1	4.0	4.5
1/13	3.1	3.8			3.7					4.2	4.1	4.7
1/14	3.3	3.8			3.9					4.3	4.3	5.0
1/15	3.6	3.8			4.1					4.5	4.6	5.3
1/16	3.7	3.8			4.2					4.6	4.7	5.4
1/17	3.8	3.8			4.3					4.7	4.8	5.5
1/18	3.8	3.8			4.4					4.8	4.9	5.5
1/19	3.9	3.9			4.6					5.0	5.1	5.5
1/20	4.0	3.9			4.7					5.1	5.2	5.4
1/21	4.0	3.9			4.8					5.2	5.3	5.5
1/22	4.0	3.9			4.8					5.2	5.3	5.6
1/23	4.0	4.0			4.9				5.2	5.2	5.3	5.9
1/24	4.0	4.0			5.1				5.3	5.3	5.3	5.9
1/25	4.1	4.1			5.3				5.3	5.3	5.4	5.9
1/26	4.1	4.1			5.3				5.2	5.2	5.3	5.8
1/27	4.1	4.1			5.4				5.2	5.2	5.3	6.0
1/28	4.0	4.1			5.3				5.1	5.0	5.2	6.2
1/29	3.9	4.0			5.3				5.0	5.0	5.2	6.4
1/30	3.8	4.0			5.1				4.9	4.9	5.2	6.6
1/31	3.8	4.0			5.0				4.7	4.8	5.1	7.0

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
2/1	3.7	3.9			4.7				4.5	4.6	5.0	7.5
2/2	3.7	3.9			4.7				4.4	4.5	5.1	7.9
2/3	3.7	3.9			4.7				4.3	4.4	5.1	8.2
2/4	3.7	3.9			4.7				4.3	4.4	5.2	8.2
2/5	3.8	4.0			4.8				4.3	4.4	5.3	8.2
2/6	3.9	4.1			4.9				4.3	4.4	5.4	8.1
2/7	4.1	4.1			5.0				4.3	4.5	5.5	7.8
2/8	4.2	4.2			5.2				4.3	4.5	5.7	7.5
2/9	4.2	4.2			5.4				4.4	4.6	5.8	7.3
2/10	4.3	4.2			5.6				4.5	4.6	5.8	6.9
2/11	4.3	4.3			5.8				4.7	4.8	5.8	6.7
2/12	4.3	4.4			6.0				5.1	5.0	5.7	6.4
2/13	4.4	4.4			6.3				5.5	5.3	5.7	6.1
2/14	4.5	4.5			6.4				5.7	5.4	5.7	6.1
2/15	4.5	4.5			6.4				5.9	5.6	5.7	6.3
2/16	4.6	4.5		5.7	6.2				6.0	5.6	5.7	6.5
2/17	4.6	4.6		5.6	6.0				6.0	5.7	5.7	6.8
2/18	4.6	4.6		5.4	5.9				5.9	5.7	5.7	7.1
2/19	4.7	4.5		5.3	5.8				5.6	5.5	5.7	7.4
2/20	4.6	4.5		5.0	5.5				5.3	5.4	5.8	7.5
2/21	4.5	4.5		5.0	5.4				5.1	5.3	5.7	7.4
2/22	4.6	4.5		5.1	5.5				5.0	5.3	5.9	7.3
2/23	4.7	4.6		5.2	5.6				5.0	5.3	6.0	7.0
2/24	4.8	4.6		5.3	5.7				5.0	5.3	6.1	6.8
2/25	4.8	4.6		5.4	5.9				5.0	5.4	6.3	6.6
2/26	4.8	4.6		5.4	5.9				5.1	5.5	6.4	6.4
2/27	4.8	4.7		5.6	6.0	6.4	6.1		5.1	5.5	6.4	6.4
2/28	4.7	4.7		5.6	6.1	6.4	6.2		5.2	5.6	6.3	6.4
2/29	4.7	4.7		5.7	6.2	6.5	6.3		5.3	5.6	6.3	6.3

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
3/1	4.6	4.8		5.7	6.3	6.5	6.4		5.3	5.6	6.2	6.2
3/2	4.6	4.8		5.8	6.3	6.6	6.6		5.4	5.7	6.3	6.3
3/3	4.7	4.9		6.0	6.4	6.7	6.8		5.5	5.8	6.4	6.4
3/4	4.7	5.0		5.9	6.4	6.7	6.8		5.6	5.8	6.3	6.4
3/5	4.7	4.9		5.9	6.4	6.7	6.8		5.6	5.9	6.4	6.4
3/6	4.7	5.0		5.9	6.4	6.7	6.7		5.6	5.9	6.4	6.5
3/7	4.7	5.0		5.8	6.3	6.6	6.7		5.6	5.9	6.4	6.5
3/8	4.7	5.0		5.8	6.3	6.6	6.6		5.7	6.0	6.4	6.5
3/9	4.6	5.0		5.7	6.2	6.5	6.4		5.6	5.9	6.3	6.4
3/10	4.5	4.9		5.5	6.0	6.3	6.2		5.5	5.9	6.2	6.2
3/11	4.4	4.9		5.5	5.9	6.2	6.1		5.5	5.8	6.2	6.2
3/12	4.2	4.9		5.3	5.7	6.0	5.9		5.5	5.8	6.1	6.2
3/13	4.2	4.9		5.3	5.7	6.0	5.9		5.5	5.8	6.2	6.3
3/14	4.1	4.9		5.3	5.6	5.9	5.8		5.4	5.7	6.3	6.4
3/15	4.1	4.8		5.2	5.5	5.8	5.7		5.4	5.7	6.4	6.5
3/16	4.1	4.8		5.3	5.6	5.9	5.7		5.4	5.8	6.6	6.6
3/17	4.3	4.9		5.4	5.7	6.1	5.8		5.4	5.8	6.8	6.7
3/18	4.5	4.9		5.6	5.9	6.4	5.9		5.5	5.9	7.0	6.9
3/19	4.6	5.0		5.8	6.1	6.5	6.0		5.6	6.0	7.3	7.2
3/20	4.7	5.0		5.8	6.2	6.6	6.1		5.7	6.1	7.4	7.2
3/21	4.7	5.0		5.9	6.3	6.7	6.2		5.9	6.1	7.3	7.1
3/22	4.7	5.0		5.9	6.3	6.7	6.2		5.9	6.2	7.3	7.2
3/23	4.7	5.0		5.9	6.3	6.6	6.2		6.0	6.3	7.3	7.2
3/24	4.6	5.0		5.8	6.3	6.6	6.3		6.1	6.4	7.2	7.2
3/25	4.6	5.0		5.8	6.2	6.5	6.2		6.2	6.5	7.2	7.2
3/26	4.7	5.0		5.9	6.3	6.6	6.3		6.3	6.6	7.3	7.3
3/27	4.9	5.0		6.1	6.5	6.9	6.4		6.3	6.8	7.5	7.6
3/28	5.2	5.2		6.4	6.7	7.2	6.5		6.4	7.0	7.9	7.9
3/29	5.5	5.4		6.8	7.1	7.6	6.7		6.5	7.1	8.2	8.2
3/30	5.6	5.5		7.1	7.4	8.0	6.8		6.6	7.2	8.4	8.4
3/31	5.9	5.9		7.4	7.7	8.4	6.9		6.8	7.4	8.6	8.6

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
4/1	6.0	6.1		7.6	7.9	8.6	7.0		6.8	7.4	8.7	8.7
4/2	5.9	6.3		7.7	7.9	8.6	7.1		6.9	7.4	8.4	8.5
4/3	6.0	6.6		7.9	8.1	8.7	7.2		7.0	7.4	8.4	8.4
4/4	6.2	6.9		8.1	8.3	8.9	7.4		7.3	7.6	8.4	8.5
4/5	6.3	7.2		8.4	8.6	9.2	7.6		7.5	7.8	8.4	8.5
4/6	6.4	7.2		8.5	8.8	9.4	7.7		7.5	7.9	8.4	8.5
4/7	6.4	7.1		8.4	8.8	9.3	7.7		7.5	7.8	8.4	8.4
4/8	6.4	7.2		8.4	8.8	9.4	7.9		7.6	8.0	8.4	8.4
4/9	6.5	7.2		8.4	8.9	9.6	8.0		7.7	8.2	8.5	8.5
4/10	6.5	7.3		8.4	8.9	9.5	8.1		7.9	8.3	8.4	8.5
4/11	6.3	7.1		8.2	8.8	9.3	8.2		7.9	8.4	8.2	8.3
4/12	6.1	7.0		8.0	8.5	8.9	8.1		7.9	8.4	8.0	8.1
4/13	6.1	7.3		8.0	8.4	8.9	8.3		8.1	8.7	8.0	8.1
4/14	6.4	7.8		8.5	8.7	9.2	8.7		8.6	9.1	8.4	8.5
4/15	6.7	8.4		9.2	9.3	9.8	9.2		9.1	9.6	8.8	8.9
4/16	7.0	8.8		9.9	10.0	10.7	9.5		9.4	10.1	9.1	9.2
4/17	7.4	9.0		10.4	10.7	11.4	9.9		9.6	10.5	9.4	9.5
4/18	7.6	9.4		10.8	11.2	12.0	10.2		9.9	10.9	9.6	9.7
4/19	7.7	9.7		11.1	11.5	12.4	10.6		10.2	11.2	9.7	9.8
4/20	7.7	9.7		11.0	11.6	12.4	10.6		10.2	11.2	9.5	9.6
4/21	7.4	9.5		10.7	11.3	12.0	10.4		10.0	11.0	9.2	9.3
4/22	7.1	9.2		10.2	10.8	11.5	10.1		9.7	10.7	8.7	8.8
4/23	6.8	9.1		9.8	10.2	10.9	9.9		9.5	10.5	8.6	8.7
4/24	6.5	9.0		9.3	9.6	10.2	9.6		9.3	10.2	8.4	8.5
4/25	6.3	8.8		9.1	9.2	9.7	9.3	9.9	9.1	9.8	8.2	8.4
4/26	6.3	8.7		8.9	9.0	9.5	9.0	9.6	8.9	9.6	8.1	8.3
4/27	6.4	8.8		9.2	9.1	9.8	9.1	9.7	8.9	9.8	8.5	8.7
4/28	6.8	8.9		9.6	9.5	10.4	9.4	10.1	9.2	10.2	9.0	9.2
4/29	7.3	9.3		10.0	10.0	11.0	9.8	10.4	9.6	10.6	9.5	9.6
4/30	7.6	9.2		10.2	10.4	11.5	10.0	10.7	9.8	10.8	9.8	9.8

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
5/1	7.8	9.2		10.3	10.7	11.8	10.1	10.9	9.9	10.9	9.9	10.0
5/2	8.0	9.2		10.5	10.8	12.1	10.2	11.1	10.1	11.1	10.1	10.2
5/3	8.5	9.3		11.0	11.3	12.7	10.6	11.5	10.4	11.7	10.5	10.5
5/4	8.7	9.5		11.3	11.6	13.1	10.8	11.8	10.7	12.1	10.6	10.7
5/5	8.6	9.5		11.1	11.6	13.0	10.8	11.8	10.7	12.0	10.5	10.6
5/6	8.4	9.2		10.8	11.4	12.7	10.6	11.7	10.6	12.0	10.4	10.5
5/7	8.5	9.4		11.0	11.5	12.8	10.7	11.8	10.7	12.3	10.4	10.6
5/8	8.8	9.6		11.6	11.8	13.2	11.0	12.1	11.0	12.8	10.7	10.9
5/9	9.1	9.8		12.0	12.1	13.7	11.2	12.4	11.2	13.2	11.1	11.3
5/10	9.2	10.2		12.1	12.3	13.8	11.6	12.6	11.6	13.3	11.2	11.4
5/11	9.1	10.5		12.0	12.2	13.7	11.6	12.7	11.7	13.2	11.3	11.5
5/12	9.1	10.6		12.0	12.2	13.6	11.6	12.7	11.8	13.2	11.0	11.2
5/13	9.1	10.1		11.5	11.8	13.0	11.3	12.6	11.8	12.9	10.9	11.1
5/14	9.1	9.9		10.9	11.2	12.4	11.1	12.3	11.5	12.7	11.0	11.2
5/15	8.9	9.7		10.4	10.8	11.8	10.7	11.9	11.1	12.2	10.9	11.1
5/16	8.6	9.6		9.9	10.4	11.3	10.4	11.5	10.9	11.8	10.7	10.9
5/17	8.4	9.2		9.8	10.2	10.9	9.8	11.1	10.3	11.5	10.6	11.0
5/18	8.2	8.8		9.4	10.0	10.6	9.6	10.7	9.9	11.1	10.5	10.9
5/19	8.2	8.7		9.3	9.8	10.4	9.5	10.5	9.8	11.0	10.5	11.0
5/20	8.0	9.4		9.7	10.1	10.8	9.7	10.4	9.6	10.8	10.5	10.9
5/21	7.8	9.7		10.1	10.3	11.0	9.6	10.4	9.7	10.6	10.2	10.6
5/22	7.8	9.8		10.3	10.5	11.2	9.7	10.5	9.7	10.7	10.1	10.8
5/23	7.8	9.9		10.3	10.6	11.1	9.7	10.5	9.7	10.6	10.1	10.8
5/24	7.5	9.9		10.1	10.5	11.0	9.8	10.4	9.8	10.5	9.9	10.6
5/25	7.4	10.1		10.2	10.4	10.8	9.7	10.4	9.8	10.5	9.8	10.4
5/26	7.5	10.1		10.2	10.4	10.8	9.6	10.5	9.8	10.6	9.9	10.5
5/27	7.8	10.1		10.5	10.7	11.3	9.8	10.8	10.0	11.0	10.3	11.0
5/28	8.1	10.1		10.9	11.1	11.9	10.1	11.1	10.2	11.4	10.9	11.7
5/29	8.4	10.3		11.1	11.4	12.2	10.2	11.4	10.4	11.7	11.2	11.9
5/30	8.6	10.6		11.4	11.6	12.5	10.4	11.6	10.6	11.8	11.5	12.1
5/31	9.0	10.8		12.0	12.2	13.2	10.5	11.9	10.8	12.2	11.9	12.4

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
6/1	9.7	10.9		12.7	13.0	14.3	10.9	12.5	11.2	12.8	12.7	13.1
6/2	10.5	11.1		13.6	13.8	15.5	11.3	13.2	11.6	13.4	13.4	13.9
6/3	11.1	11.2		14.1	14.4	16.2	11.4	13.6	11.8	13.8	13.9	14.3
6/4	11.5	11.4		14.3	14.8	16.6	11.5	13.9	12.0	13.9	14.1	14.3
6/5	11.7	11.3		14.3	15.0	16.8	11.6	14.0	12.1	14.0	14.3	14.5
6/6	11.8	11.2		14.2	15.1	16.9	11.7	14.1	12.2	14.1	14.4	14.6
6/7	11.8	11.0	12.2	13.8	14.8	16.5	11.7	13.9	12.1	13.9	14.3	14.5
6/8	11.3	10.9	12.0	13.3	14.2	15.6	11.4	13.4	11.9	13.4	13.9	14.1
6/9	10.8	10.7	11.6	12.7	13.7	14.9	11.2	13.0	11.6	13.1	13.7	13.9
6/10	10.3	10.7	11.2	12.1	13.0	13.9	11.0	12.5	11.3	12.6	13.2	13.5
6/11	9.6	10.6	10.8	11.4	12.2	12.9	10.8	12.0	11.1	12.2	12.7	12.9
6/12	9.1	10.6	10.5	11.1	11.8	12.4	10.7	11.7	10.9	12.1	12.5	12.7
6/13	8.9	10.3	10.3	11.0	11.6	12.3	10.6	11.7	10.9	12.3	12.5	12.7
6/14	8.8	10.1	10.3	10.9	11.6	12.2	10.6	11.8	10.9	12.5	12.6	12.7
6/15	8.7	9.8	10.1	10.8	11.5	12.2	10.7	11.8	10.9	12.4	12.6	12.6
6/16	8.7	9.6	10.0	10.8	11.5	12.2	10.8	12.0	11.1	12.4	12.6	12.5
6/17	8.8	9.4	10.0	10.8	11.5	12.2	10.9	12.1	11.2	12.5	12.6	12.6
6/18	9.1	9.3	10.1	11.0	11.7	12.6	11.0	12.4	11.4	12.7	13.0	13.0
6/19	9.4	9.1	10.3	11.2	12.0	12.9	11.2	12.6	11.6	12.9	13.3	13.3
6/20	9.5	9.2	10.4	11.3	12.2	13.0	11.2	12.8	11.7	12.9	13.4	13.4
6/21	9.5	9.2	10.4	11.2	11.9	12.7	11.2	12.7	11.8	12.7	13.2	13.4
6/22	9.6	9.3	10.5	11.4	12.1	12.9	11.4	12.9	11.9	13.0	13.5	13.7
6/23	9.9	9.5	10.8	11.7	12.4	13.3	11.5	13.1	12.0	13.3	13.8	14.0
6/24	10.4	9.8	11.1	12.3	12.9	14.0	11.8	13.4	12.1	13.8	14.4	14.6
6/25	10.8	9.8	11.4	12.8	13.5	14.7	11.9	13.7	12.3	14.0	14.9	15.1
6/26	11.1	9.8	11.3	12.7	13.5	14.7	11.9	13.7	12.3	13.8	15.0	15.2
6/27	11.3	9.6	11.2	12.6	13.6	14.8	11.9	13.8	12.3	13.9	15.3	15.5
6/28	11.8	9.6	11.4	12.9	14.0	15.3	12.0	14.0	12.4	14.0	15.9	16.0
6/29	12.3	9.5	11.5	13.1	14.3	15.7	12.0	14.2	12.5	14.2	16.4	16.6
6/30	12.4	9.2	11.3	12.8	14.3	15.7	12.0	14.2	12.5	14.1	16.7	16.8

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
7/1	12.1	8.8	10.8	12.2	13.9	15.2	11.8	13.8	12.3	13.6	16.5	16.6
7/2	11.7	8.6	10.2	11.5	13.2	14.4	11.6	13.4	12.0	13.1	16.0	16.1
7/3	11.5	8.5	10.2	11.3	13.0	14.2	11.4	13.2	11.9	13.2	16.1	16.2
7/4	11.4	8.6	10.2	11.2	12.9	14.0	11.4	13.1	11.8	13.1	16.1	16.1
7/5	11.2	8.8	10.3	11.2	12.7	13.9	11.4	13.0	11.9	13.1	15.9	15.9
7/6	10.9	8.9	10.3	11.2	12.5	13.6	11.5	12.8	11.8	12.9	15.6	15.6
7/7	10.6	9.0	10.2	11.0	12.2	13.1	11.4	12.6	11.7	12.7	15.2	15.2
7/8	10.6	9.2	10.5	11.2	12.3	13.2	11.5	12.7	11.8	13.0	15.2	15.3
7/9	10.7	9.4	10.8	11.5	12.5	13.5	11.6	12.9	11.9	13.2	15.4	15.5
7/10	10.7	9.6	11.0	11.6	12.7	13.7	11.8	13.0	12.1	13.3	15.4	15.5
7/11	11.1	9.6	11.2	12.0	13.1	14.3	12.0	13.3	12.3	13.7	15.8	15.9
7/12	11.0	9.6	11.1	11.9	13.2	14.5	12.0	13.4	12.3	13.8	16.0	16.2
7/13	11.1	9.6	11.1	11.9	13.3	14.6	12.0	13.5	12.3	13.8	16.2	16.3
7/14	11.5	9.8	11.4	12.3	13.6	15.0	12.1	13.6	12.5	14.0	16.6	16.7
7/15	11.5	9.9	11.3	12.3	13.6	15.1	12.2	13.6	12.5	13.9	16.7	16.8
7/16	11.6	9.9	11.5	12.4	13.9	15.4	12.2	13.7	12.5	13.9	16.7	16.8
7/17	11.7	10.0	11.5	12.5	14.2	15.8	12.2	13.9	12.6	14.0	17.0	17.1
7/18	11.9	10.2	11.6	12.7	14.4	16.0	12.2	14.1	12.6	14.1	17.2	17.2
7/19	12.1	10.2	11.7	12.9	14.5	16.3	12.3	14.0	12.6	13.9	17.2	17.2
7/20	12.2	10.1	11.6	12.9	14.5	16.2	12.4	14.1	12.6	14.0	17.3	17.2
7/21	12.3	10.0	11.6	12.9	14.6	16.3	12.4	14.2	12.6	14.1	17.4	17.4
7/22	12.9	10.0	11.8	13.2	15.0	16.8	12.4	14.6	12.8	14.5	18.0	17.9
7/23	13.4	10.0	11.9	13.5	15.4	17.2	12.5	14.8	12.9	14.8	18.7	18.6
7/24	13.9	10.0	12.1	13.8	15.5	17.4	12.6	14.9	12.9	14.8	19.1	18.9
7/25	14.2	9.9	12.1	13.9	15.7	17.6	12.8	15.0	13.0	14.9	19.5	19.2
7/26	14.8	10.0	12.4	14.2	16.0	17.8	12.9	15.3	13.3	15.4	20.1	19.8
7/27	15.2	10.1	12.5	14.4	16.2	18.1	13.0	15.4	13.3	15.5	20.6	20.3
7/28	15.4	10.1	12.5	14.4	16.2	18.1	13.0	15.4	13.3	15.5	20.9	20.5
7/29	15.5	10.1	12.4	14.3	16.1	18.0	13.0	15.2	13.3	15.4	20.8	20.4
7/30	15.2	10.1	12.2	14.0	15.8	17.7	13.0	14.9	13.2	15.2	20.5	20.0
7/31	14.8	10.0	11.9	13.6	15.3	17.1	12.9	14.6	13.1	15.0	20.1	19.6

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
8/1	14.6	9.9	11.8	13.4	15.2	16.7	12.7	14.4	13.1	14.9	19.9	19.4
8/2	14.4	9.8	11.5	13.2	15.3	16.7	12.6	14.3	13.0	14.8	19.7	19.2
8/3	14.3	9.7	11.5	13.0	15.3	16.5	12.6	14.3	13.0	14.9	19.5	19.0
8/4	13.9	9.6	11.4	12.7	15.0	16.1	12.6	14.1	13.0	14.7	19.1	18.5
8/5	13.4	9.6	11.2	12.4	14.6	15.6	12.5	13.9	12.9	14.5	18.7	18.2
8/6	13.2	9.6	11.2	12.2	14.4	15.2	12.5	13.9	12.9	14.4	18.3	17.8
8/7	13.1	9.6	11.2	12.2	14.4	15.0	12.5	13.8	12.9	14.3	18.1	17.5
8/8	13.1	9.7	11.3	12.2	14.3	15.0	12.5	13.7	12.7	14.0	18.1	17.2
8/9	13.2	10.0	11.5	12.3	14.4	15.0	12.4	13.7	12.4	13.7	18.2	17.1
8/10	13.5	10.2	11.8	12.7	14.8	15.4	12.4	13.8	12.3	13.6	18.7	17.3
8/11	14.0	10.4	12.0	13.2	15.4	15.9	12.4	14.0	12.2	13.6	19.2	17.6
8/12	14.6	10.7	12.3	13.5	16.0	16.5	12.5	14.1	12.2	13.6	19.8	18.0
8/13	15.2	10.9	12.6	13.9	16.6	17.2	12.6	14.4	12.2	13.6	20.6	18.6
8/14	15.7	11.0	12.8	14.3	17.2	17.8	12.7	14.6	12.3	13.7	21.2	19.0
8/15	15.9	11.0	12.9	14.4	17.4	18.0	12.9	14.7	12.5	13.7	21.5	19.0
8/16	16.0	10.7	12.7	14.2	17.4	18.1	13.1	14.8	12.7	13.8	21.6	18.9
8/17	16.1	10.5	12.4	14.0	17.2	18.0	13.3	14.9	12.9	13.8	21.6	18.7
8/18	16.0	10.2	12.1	13.6	16.8	17.7	13.5	14.8	13.1	13.9	21.5	18.5
8/19	15.7	9.8	11.7	13.1	16.2	17.2	13.7	14.7	13.2	14.0	21.2	18.4
8/20	15.5	9.5	11.3	12.7	15.8	16.8	13.7	14.7	13.4	14.1	20.9	18.3
8/21	15.3	9.3	11.0	12.5	15.4	16.5	13.7	14.8	13.5	14.3	20.8	18.3
8/22	15.1	9.0	10.7	12.2	15.1	16.2	13.8	14.9	13.6	14.6	20.7	18.5
8/23	14.9	8.9	10.7	12.1	14.8	16.0	13.8	15.0	13.7	14.8	20.5	18.7
8/24	14.5	8.9	10.4	11.8	14.3	15.6	13.8	14.8	13.7	14.8	20.2	18.7
8/25	14.3	8.8	10.4	11.7	14.1	15.3	13.8	14.8	13.7	15.0	19.9	18.6
8/26	14.4	8.9	10.5	11.8	14.2	15.5	13.7	14.9	13.8	15.2	19.9	18.7
8/27	14.3	8.9	10.4	11.7	14.0	15.3	13.8	14.9	13.8	15.1	19.7	18.5
8/28	14.0	8.8	10.3	11.4	13.6	14.9	13.9	14.7	13.9	14.9	19.2	18.0
8/29	13.7	8.7	10.0	11.1	13.1	14.3	13.9	14.5	13.8	14.7	18.6	17.5
8/30	13.2	8.5	9.9	10.8	12.6	13.7	13.7	14.2	13.8	14.4	17.8	16.8
8/31	12.8	8.4	10.0	10.8	12.6	13.4	13.6	14.1	13.7	14.5	17.1	16.4

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
9/1	12.3	8.3	10.0	10.6	12.3	13.0	13.5	13.9	13.7	14.4	16.7	16.1
9/2	11.9	8.2	9.8	10.4	11.9	12.5	13.5	13.7	13.6	14.2	16.1	15.5
9/3	11.6	8.1	9.7	10.3	11.8	12.3	13.4	13.7	13.6	14.3	15.7	15.4
9/4	11.3	8.1	9.7	10.2	11.7	12.2	13.4	13.6	13.6	14.3	15.6	15.3
9/5	11.2	8.0	9.8	10.3	11.8	12.3	13.3	13.7	13.6	14.5	15.6	15.5
9/6	11.2	8.1	9.7	10.3	11.9	12.4	13.4	13.8	13.7	14.7	15.8	15.8
9/7	11.3	8.1	9.5	10.2	11.8	12.4	13.5	14.0	13.9	15.0	16.1	16.1
9/8	11.4	8.0	9.5	10.3	11.9	12.6	13.6	14.1	13.9	15.2	16.3	16.4
9/9	11.4	8.0	9.5	10.4	11.9	12.7	13.7	14.3	14.1	15.4	16.6	16.7
9/10	11.4	8.0	9.5	10.4	11.8	12.6	13.8	14.3	14.1	15.5	16.7	16.8
9/11	11.4	8.0	9.4	10.3	11.8	12.7	13.9	14.4	14.2	15.7	16.9	17.0
9/12	11.4	7.8	9.0	9.9	11.2	12.1	13.6	14.3	14.2	15.6	16.9	16.9
9/13	11.4	7.5	8.6	9.4	10.7	11.5	13.3	13.9	14.0	15.4	16.8	16.7
9/14	11.2	7.3	8.6	9.4	10.6	11.3	13.0	13.6	13.7	15.0	16.6	16.3
9/15	11.0	7.1	8.5	9.2	10.3	11.0	12.7	13.2	13.5	14.7	16.1	15.9
9/16	10.8	6.8	8.2	8.8	9.9	10.5	12.3	12.9	13.2	14.4	15.6	15.4
9/17	10.6	6.6	7.9	8.4	9.5	10.1	11.9	12.4	12.8	14.0	15.1	14.9
9/18	10.3	6.4	7.6	8.2	9.1	9.6	11.4	11.9	12.4	13.6	14.7	14.5
9/19	10.0	6.4	7.6	8.1	9.1	9.5	11.3	11.6	12.2	13.4	14.3	14.1
9/20	9.7	6.4	7.6	8.1	9.0	9.4	11.1	11.4	12.0	13.0	13.8	13.8
9/21	9.6	6.3	7.1	7.6	8.6	9.1	10.9	11.3	11.9	13.0	13.6	13.6
9/22	9.6	6.3	6.9	7.4	8.3	8.8	10.8	11.2	11.8	13.1	13.8	13.8
9/23	9.8	6.4	7.0	7.5	8.3	8.8	10.9	11.2	11.8	13.1	14.1	14.1
9/24	10.1	6.4	7.0	7.5	8.3	8.8	10.9	11.3	11.9	13.2	14.4	14.4
9/25	10.2	6.4	7.0	7.4	8.2	8.7	10.9	11.2	11.9	13.1	14.5	14.4
9/26	10.3	6.4	6.9	7.3	8.2	8.7	10.9	11.2	11.9	13.1	14.6	14.4
9/27	10.3	6.4	6.9	7.3	8.1	8.6	10.9	11.2	11.9	13.3	14.7	14.5
9/28	10.2	6.4	6.8	7.2	8.0	8.4	10.8	11.1	11.9	13.1	14.5	14.3
9/29	10.0	6.3	6.7	7.1	7.8	8.2	10.7	10.9	11.7	13.0	14.3	14.1
9/30	9.8	6.2	6.6	6.9	7.6	8.0	10.6	10.8	11.6	12.8	13.9	13.7

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
10/1	9.5	6.2	6.5	6.8	7.5	7.8	10.5	10.6	11.5	12.6	13.4	13.3
10/2	9.3	6.1	6.5	6.8	7.4	7.8	10.5	10.6	11.5	12.8	13.2	13.2
10/3	9.3	6.1	6.5	6.8	7.4	7.8	10.5	10.5	11.5	12.7	13.0	13.0
10/4	9.2	6.1	6.6	6.9	7.5	7.9	10.4	10.6	11.5	12.6	12.8	12.8
10/5	9.4	6.2	7.1	7.3	8.0	8.3	10.5	10.6	11.4	12.6	12.6	12.7
10/6	9.5	6.2	7.5	7.7	8.4	8.7	10.6	10.7	11.4	12.4	12.3	12.4
10/7	9.4	6.2	7.6	7.8	8.5	8.8	10.5	10.7	11.3	12.3	12.1	12.2
10/8	9.2	6.2	7.6	7.8	8.5	8.8	10.4	10.6	11.2	12.2	11.8	11.9
10/9	8.9	6.2	7.6	7.8	8.4	8.6	10.1	10.3	11.0	11.9	11.4	11.5
10/10	8.7	6.3	7.7	7.9	8.5	8.6	10.0	10.1	10.8	11.7	10.9	11.0
10/11	8.6	6.3	7.8	8.0	8.6	8.7	9.8	10.0	10.7	11.6	10.5	10.6
10/12	8.3	6.3	7.4	7.7	8.3	8.5	9.6	9.9	10.6	11.5	10.1	10.3
10/13	8.1	6.3	7.1	7.4	8.0	8.2	9.3	9.6	10.5	11.4	9.9	10.0
10/14	8.0	6.3	7.2	7.5	8.1	8.3	9.2	9.5	10.5	11.3	9.6	9.8
10/15	8.0	6.3	7.4	7.6	8.3	8.5	9.2	9.5	10.5	11.2	9.4	9.6
10/16	8.1	6.4	7.5	7.8	8.5	8.7	9.2	9.6	10.5	11.2	9.3	9.5
10/17	8.1	6.5	7.8	8.0	8.7	8.9	9.3	9.8	10.5	11.1	9.3	9.4
10/18	8.0	6.5	7.9	8.2	8.8	9.0	9.4	9.9	10.5	11.0	9.2	9.4
10/19	8.0	6.5	8.0	8.3	8.9	9.0	9.5	9.9	10.5	10.8	9.3	9.5
10/20	7.9	6.6	8.1	8.3	8.9	9.1	9.6	10.1	10.4	10.8	9.3	9.8
10/21	8.0	6.6	7.9	8.2	8.9	9.1	9.7	10.1	10.4	10.8	9.3	10.2
10/22	8.0	6.6	7.9	8.1	8.8	9.0	9.6	10.1	10.3	10.7	9.4	10.6
10/23	8.1	6.6	7.9	8.1	8.8	9.0	9.5	10.0	10.3	10.7	9.4	11.0
10/24	8.1	6.6	7.7	7.9	8.6	8.8	9.3	9.9	10.2	10.6	9.4	11.2
10/25	8.0	6.6	7.4	7.7	8.4	8.6	9.1	9.7	10.1	10.5	9.5	11.4
10/26	8.0	6.6	7.3	7.5	8.2	8.5	8.9	9.5	10.1	10.5	9.4	11.5
10/27	8.0	6.6	7.2	7.4	8.1	8.3	8.6	9.2	10.0	10.4	9.3	11.5
10/28	7.8	6.6	7.3	7.5	8.1	8.2	8.4	9.1	9.9	10.3	9.2	11.3
10/29	7.8	6.7	7.4	7.6	8.2	8.3	8.5	9.1	9.8	10.2	9.0	10.9
10/30	7.7	6.7	7.3	7.6	8.2	8.3	8.5	9.2	9.7	10.1	9.0	10.6
10/31	7.6	6.7	7.3	7.6	8.1	8.3	8.5	9.1	9.7	10.1	9.0	10.6

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
11/1	7.6	6.7	7.3	7.6	8.1	8.3	8.5	9.1	9.7	10.0	8.9	10.5
11/2	7.7	6.7	7.5	7.7	8.3	8.4	8.6	9.2	9.6	9.9	8.9	10.5
11/3	7.7	6.8	7.6	7.9	8.4	8.6	8.8	9.4	9.6	9.9	9.0	10.4
11/4	7.8	6.8	7.7	7.9	8.5	8.7	8.9	9.5	9.6	9.9	9.1	10.4
11/5	7.9	6.8	7.7	7.9	8.5	8.7	8.9	9.6	9.6	10.0	9.2	10.5
11/6	8.0	7.3	8.0	8.1	8.6	8.7	9.0	9.6	9.6	9.9	9.3	10.8
11/7	8.1	7.8	8.3	8.4		8.9	9.2	9.7	9.6	10.0	9.4	10.9
11/8	8.2	7.8	8.5	8.7		9.1	9.4	9.9	9.7	10.0	9.5	11.1
11/9	8.3	7.8	8.6	8.8		9.2	9.4	10.0	9.7	10.0	9.6	11.1
11/10	8.3	7.8	8.6	8.9		9.2	9.5	10.0	9.7	10.0	9.6	11.1
11/11	8.2	7.9		8.9		9.3	9.5	10.0	9.6	9.9	9.5	11.1
11/12	8.1	7.8		9.0		9.3	9.5	9.9	9.6	9.9	9.3	10.9
11/13	7.8	7.4		8.8		9.1	9.3	9.8	9.5	9.8	9.2	10.5
11/14	7.6	6.9		8.4		8.8	9.1	9.5	9.4	9.6	8.8	10.2
11/15	7.2	6.9				8.4	8.8	9.2	9.2	9.4	8.4	9.8
11/16	6.8	6.8				8.1	8.6	8.9	9.1	9.3	8.0	9.7
11/17	6.6	6.9				7.9	8.4	8.7	9.0	9.2	7.8	9.7
11/18	6.4	6.8				7.7	8.3	8.6	8.8	9.1	7.6	9.8
11/19	6.3	6.8				7.6	8.1	8.4	8.7	8.9	7.5	9.8
11/20	6.2	6.8				7.5	8.1	8.3	8.6	8.8	7.4	9.9
11/21	6.1	6.9				7.4	8.0	8.3	8.5	8.7	7.4	10.0
11/22	6.1	6.9				7.5	8.0	8.3	8.4	8.7	7.4	10.0
11/23	6.2	7.0				7.6	8.0	8.4	8.4	8.6	7.4	9.9
11/24	6.1	7.0				7.6	8.0	8.3	8.3	8.5	7.4	9.7
11/25	6.0	7.0				7.4	7.9	8.2	8.2	8.4	7.3	9.6
11/26	5.9	7.0				7.3	7.8	8.1	8.1	8.3	7.1	9.5
11/27	5.8	7.0				7.3	7.7	7.9	8.0	8.2	7.0	9.4
11/28	5.7	7.0				7.2	7.6	7.8	7.9	8.1	6.9	9.3
11/29	5.6	7.0				7.1	7.5	7.7	7.8	8.0	6.8	9.3
11/30	5.4	7.0				6.9	7.3	7.6	7.7	7.9	6.7	9.2

DATE	RM 18.2 (SFK) 7 Day Avg Max	RM 15.8 7 Day Avg Max	RM 15.5 7 Day Avg Max	RM 14.3 7 Day Avg Max	RM 11.3 7 Day Avg Max	RM 9.8 7 Day Avg Max	RM 9.6 7 Day Avg Max	RM 4.9 7 Day Avg Max	RM 4.4 7 Day Avg Max	RM 0.2 7 Day Avg Max	Skykomish Above 7 Day Avg Max	Skykomish Below 7 Day Avg Max
12/1	5.2	6.9				6.8	7.2	7.5	7.6	7.8	6.6	9.1
12/2	5.0	6.8				6.6	7.0	7.3	7.5	7.6	6.4	9.0
12/3	4.7	6.7				6.3	6.8	7.0	7.3	7.4	6.2	8.8
12/4	4.4	6.6				6.0	6.5	6.7	7.1	7.3	5.9	8.7
12/5	4.0	6.4				5.5	6.2	6.3	7.0	7.0	5.4	8.5
12/6	3.5	6.3				5.0	5.9	5.8	6.7	6.8	4.8	8.3
12/7	3.2	6.1				4.5	5.6	5.4	6.5	6.5	4.3	8.2
12/8	2.9	5.9				4.1	5.3	5.1	6.3	6.3	3.9	8.2
12/9	2.6	5.8				3.9	5.1	4.9	6.1	6.2	3.7	8.2
12/10	2.6	5.6				3.9	5.0	4.8	5.9	6.0	3.6	8.3
12/11	2.4	5.4				3.8	5.0	4.8	5.8	5.8	3.5	8.4
12/12	2.5	5.3				3.9	5.0	4.8	5.6	5.7	3.5	8.7
12/13	2.5	5.2				4.0	4.9	4.8	5.5	5.6	3.6	8.9
12/14	2.3	5.0				3.8	4.8	4.7	5.4	5.5	3.5	8.9
12/15	2.2	4.8				3.7	4.7	4.6	5.3	5.3	3.3	8.5
12/16	2.1	4.8				3.7	4.7	4.5	5.2	5.2	3.1	7.9
12/17	2.0	4.7				3.5	4.6	4.4	5.1	5.1	3.0	7.2
12/18	2.0	4.7				3.5	4.5	4.3	5.1	5.1	3.1	6.5
12/19	2.2	4.7				3.5	4.5	4.4	5.0	5.0	3.2	5.8
12/20	2.3	4.6				3.6	4.4	4.4	5.0	5.0	3.4	5.1
12/21	2.5	4.6				3.8	4.5	4.5	5.0	4.9	3.7	4.5
12/22	2.6	4.5				3.8	4.5	4.5	5.0	4.9	3.9	4.3
12/23	2.7	4.5				3.9	4.4	4.5	5.0	4.8	4.0	4.2
12/24	2.7	4.4				3.9	4.4	4.5	5.0	4.8	4.0	4.2
12/25	2.7	4.3				3.9	4.4	4.6	5.2	4.8	4.0	4.3
12/26	2.7	4.2				3.9	4.4	4.6	5.4	4.8	4.0	4.3
12/27	2.7	4.2				3.9	4.4	4.6	5.4	4.8	4.0	4.3
12/28	2.6	4.1				3.9	4.3	4.5	5.5	4.7	4.0	4.2
12/29	2.5	4.1				3.8	4.2	4.5	5.6	4.6	3.9	4.1
12/30	2.3	4.0				3.7	4.1	4.3	5.7	4.5	3.7	4.0
12/31	2.1	3.8				3.4	3.9	4.1	5.6	4.2	3.5	3.7

APPENDIX D

Smolt Outmigration Report, Sultan River

Smolt Out-Migration Report
Sultan River

Annual Monitoring Report 2016

SNOHOMISH COUNTY
PUD
PUBLIC UTILITY DISTRICT NO. 1

Table of Contents

List of Figures

List of Tables

1. Introduction

In 2012, Public Utility District No. 1 of Snohomish County (the District) began monitoring the out-migration of juvenile salmonids (smolts) as a measure (index) of reproductive success in the Sultan River near Sultan, Washington. This monitoring is one component of the Fisheries and Habitat Monitoring Plan (FHMP), as outlined in Article 410 of the License issued by the Federal Energy Regulatory Commission (FERC) on September 2, 2011, for the continued operation of the Jackson Hydroelectric Project (Project). This report presents the results of the fifth year (Year 5) of operation of the rotary screw trap (smolt trap) located on the lower Sultan River. Year 5 is the fifth of six consecutive years of initial operation, as outlined in the FHMP. Beginning in 2018 and extending to the end of the 45-year License term, the District will continue to operate the smolt trap for 2 out of every 6 years, as determined by the Aquatic Resource Committee (ARC).

The FHMP also stipulates that, subject to the results of monitoring, the District will commence operation of the smolt trap on February 1 and continue operations through June 30 of each sampling year. The District will operate the trap between 30 and 40 percent of the hours in any given week during the sampling year, except during severe flow events; and scheduled to fish for four day and four night periods per week, with each fishing period lasting a minimum of six hours. During periods when few fish are emigrating, the frequency of trapping can be reduced to fewer days per week. The FHMP also stipulates that the trap will be located in the lower mile of the Sultan River and that the District will collect, compile, analyze and report the following trap data by species and life stage: number captured, size distribution, timing (diel and seasonal), fish population estimates and trap efficiency.

2. Methods

2.1 Trap description, location, and operation

The Sultan River smolt trap, manufactured by E.G. Solutions, is 5 feet in diameter and designed to sample out-migrating fish over a range of flow conditions (discharge, depth, and velocity). The trap is seasonally positioned in the Sultan River at a location approximately 0.2 miles upstream of the confluence with the Skykomish River (Figure 1).

Figure 1. Aerial photograph depicting the location of the Sultan River smolt trap.

During 2016, the trap was operated from January 18 to June 30, fishing 65 percent of the total hours during that time period (67 percent of the day hours and 63 percent of the night hours). Table 1 summarizes total hours and percentage of time fished, by statistical week.

Table 1. Number and percentage of hours operated by week, Sultan River smolt trap, 2016.

Statistical Week[1]	Sample Block Start Date	Hours Operated	Percent Hours Operated
3	1/18	99	59
4	1/24	96	57
5	1/31	129	76
6	2/7	128	76
7	2/14	Did not operate trap due to high flow	
8	2/22	103	61
9	2/28	128	76
10	3/6	118	70
11	3/13	127	75
12	3/20	128	76
13	3/27	70	42
14	4/3	125	75
15	4/10	124	74
16	4/17	158	94
17	4/25	96	57
18	5/1	126	75
19	5/8	114	68
20	5/15	118	70
21	5/22	123	73
22	5/31	73	43
23	6/6	71	42
24	6/13	89	53
25	6/21	75	45
26	6/27	72	60

[i]Throughout this report, weekly data is presented in terms of statistical weeks. A table including statistical weeks and corresponding months is included as Appendix A.

During operation, the trap was constantly monitored for cone revolutions and directly observed through video surveillance. Site visits occurred at a minimum of once per day and more frequently depending on operating conditions. The number of cone revolutions per minute was recorded at the beginning and end of each trapping period (set). Discharge information from upstream of the trapping site was obtained from the U.S. Geological Survey Gaging Station No. 12138160 (Sultan River below Power Plant; River Mile 4.5).

At the end of each set, captured fish were enumerated and sorted by species and life history stage. Steelhead/rainbow trout were classified as smolt, parr, or young of the year (YOY). Smolts exhibit silvery body coloring, thin shape, blackened fin margins, and deciduous scales while parr retain their freshwater coloration (parr marks) (Loch et al., 1988). Young of the year were identified based on size (< 40 mm) and standard identification keys (Pollard et al., 1997).

Throughout the sampling season, on a weekly basis, a subsample of fish were measured for length (fork length in millimeters). Prior to measurement, fish were anesthetized with Tricaine Methanesulfonate (MS-222). Prior to release, fish were placed in a freshwater tank and allowed to recover.

2.2 Estimating Total Migration

In order to estimate total out-migration, the capture efficiency (percentage of total out-migrating fish captured) of the trap was determined through a series of tests conducted over the range of operating conditions. Capture efficiency tests were performed by releasing marked groups of hatchery Chinook and wild pink salmon. A total of 3,750 hatchery Chinook2 were released in batches of 750 fish during weeks 11, 14, 15, 19, and 24. These fish were 80-90 mm in length and were adipose fin-clipped prior to release. A total of 2,858 pink salmon were captured at the trap and marked with Bismarck Brown dye prior to their release. These fish were released in weeks 9, 10, 11, 12, 14, and 15. Catches of wild Chinook, chum, and coho salmon were insufficient, in terms of sample size, precluding their use for efficiency trials.

Efficiency tests were conducted at various discharges in order to determine efficiency under a range of conditions. The release site for all efficiency tests was Reese Park, approximately 0.3 miles upstream of the trap. This distance was great enough to allow for mixing of fish across the stream channel and within the water column, but short enough to reduce the likelihood of predation that would result in the loss of fish before they have an opportunity to arrive at the trap. In order to be assured that marked fish and unmarked fish have the same probability of capture, the trap operated continuously for a minimum of 72 hours after each release to allow all marked fish to migrate past the trap.

A modified Peterson mark-recapture approach was used to estimate total migration for the season (Volkhardt et al., 2007).

The following 5 assumptions must be met in order to achieve an estimate:

1) The population is closed;
2) All fish (marked and unmarked) have an equal opportunity of capture;
3) Marking does not affect catchability;
4) Marked fish mix at random with unmarked fish; and
5) All marks are detected and reported.

Peterson's equation is slightly biased. Therefore, we used Seber's adjustment (Seber, 1982) to Peterson's equation because it assumes that the second sampling is done without replacement.

[2] Hatchery fish were obtained from the Wallace River Hatchery.

Because we did not sample all hours during the season, we've modified Seber's equation to adjust for our sampling effort. Our modified Seber's estimator is as follows:

$$U_{2016} = \left(\frac{u_{2016} + 1}{p_{2016}}\right)\left(\frac{M_{2016} + 1}{m_{2016} + 1}\right)$$

Where
U_{2016} = Estimated number of fish migrating past the trap including hours not fished
u_{2016} = Number of fish captured at the trap
p_{2016} = Percent of hours fished
M_{2016} = Number of fish marked and released during efficiency trials
m_{2016} = Number of marked fish captured during efficiency trials
An approximate variance estimate of U_{2016} is as follows:

$$\widehat{Var}(U_{2016}) = \frac{(u_{2016} + 1)(M_{2016} + 1)(u_{2016} - m_{2016})(M_{2016} - m_{2016})}{p_{2016}{}^{2}(m_{2016} + 1)^{2}(m_{2016} + 2)}$$

and an approximate 95% confidence interval is

$$U_{2016} \pm 1.96\sqrt{\widehat{Var}(U_{2016})}$$

2.3 Egg-to-Migrant Survival (Chinook salmon)

Once the total number of out-migrating Chinook was estimated, egg-to-migrant survival was estimated through data collected during spawning surveys.

Egg-to-migrant survival is estimated by:

$$S_{2016} = \left(\frac{E_{2015}}{U_{2016}}\right)$$

Where

S_{2016} = Chinook egg-to-migrant survival in 2016

U_{2016} = Estimate of 2016 Chinook juvenile migration

E_{2015} = Number of Chinook eggs deposited in gravel in 2015

The number of Chinook eggs deposited in the gravel is calculated by multiplying the number of redds estimated during fall spawner surveys by the average number of eggs per female from Wallace River Hatchery data. Spawner surveys for chum and coho did not occur in the Sultan River in 2015, and therefore it is not possible to generate egg-to-migrant survival for these species. Typically the river is too turbid to get accurate fish counts during their respective spawning seasons.

2.4 Emergence Timing (Chinook salmon)

Numerous publications estimate that Chinook emerge from the gravel after accumulating 900 Celsius (C) thermal units (Kraus, 1999). Accumulated Thermal Units (ATUs) are calculated by determining mean daily temperature on the day of egg deposition and subsequent days until 900 ATUs are accumulated and emergence occurs. The District collects temperature data at several locations on the Sultan River. These temperature data were used in conjunction with spawner survey data to estimate the date that Chinook would have emerged from the gravel. This analysis provided insight into the stage of development at the time of several high flow events that occurred in late 2015 and early 2016.

3. Results and Discussion

3.1 Catch

A total of 18,507 fish were captured during the 2016 sampling year (Table 2). Although scales were not collected, all Chinook were age 0+ based on size and identification keys (Pollard et al., 1997).

Table 2. Total fish captured by species and life stage, Sultan River smolt trap, 2016.

Species	Total
Chinook Salmon (0+)	950
Pink Salmon	15,958
Chum Salmon	610
Coho Salmon (0+)	106
Coho Salmon (1+)	456
Steelhead/Rainbow Trout	92
Cutthroat Trout	12
Dace unidentified	199
Sculpin unidentified	71
Lamprey unidentified	38
Peamouth	11
Sucker unidentified	3
Mountain Whitefish	1

3.2 Out-Migration Timing

Out-migration timing was determined using weekly catch data (Table 3). Data were converted to catch per unit effort (CPUE) to evaluate timing throughout the season (Figure 2). In 2016, the highest Chinook CPUE occurred during the first week of the season and decreased during the following weeks, which is not consistent with the patterns observed in prior sampling years. Chum, pink, as well as Chinook CPUE decreased dramatically during the first week of April (week 14) and remained very low the remainder of the season. This is in sharp contrast to timing for years 2012-15 (Figure 3) in which Chinook, chum, and pink display a more prolonged out-migration period and CPUE did not drop as dramatically. This contrast in timing is likely the result of three high water events that occurred in late 2015 and early 2016. The highest of these flows occurred on November 17, 2015 when peak discharge of 7,320 cubic feet per second (cfs) was recorded at the U.S. Geological Survey Gaging Station No. 12138160 (Sultan River below Power Plant; River Mile 4.5).

Table 3. Number of salmon and trout caught by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Sample Block Start Date	Salmon					Trout	
		Chinook	Pink	Coho (1+)	Coho (0+)	Chum	Rainbow	Cutthroat
3	18-Jan	125	37	3	1	2	1	0
4	24-Jan	48	28	0	0	1	5	0
5	31-Jan	72	120	1	2	5	0	0
6	7-Feb	56	214	4	0	13	2	0
7	14-Feb	Did not operate trap due to high flow						
8	22-Feb	20	230	2	0	3	2	0
9	28-Feb	78	1,207	3	16	54	2	0
10	6-Mar	39	1,801	1	9	82	0	0
11	13-Mar	35	1,777	1	4	131	0	0
12	20-Mar	81	2,302	5	12	100	0	2
13	27-Mar	53	2,621	4	7	83	2	0
14	3-Apr	141	4,924	7	22	123	6	2
15	10-Apr	23	673	15	1	11	4	3
16	17-Apr	8	13	83	1	2	5	2
17	25-Apr	10	10	19	2	0	1	0
18	1-May	9	0	149	0	0	7	0
19	8-May	48	1	79	4	0	7	0
20	15-May	29	0	34	9	0	7	1
21	22-May	16	0	37	1	0	3	0
22	1-Jun	1	0	1	1	0	0	0
23	6-Jun	24	0	4	5	0	0	0
24	13-Jun	25	0	2	3	0	3	1
25	21-Jun	1	0	1	4	0	21	1
26	27-Jun	8	0	1	2	0	14	0
Season Total		950	15,958	456	106	610	92	12

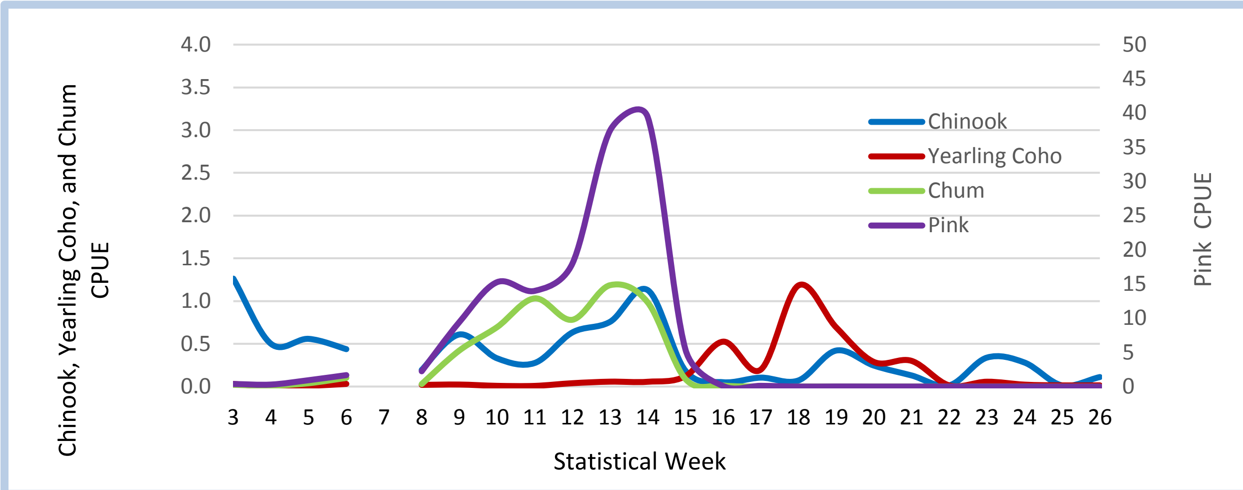


Figure 2. Catch per unit effort by week of Chinook, yearling coho (1+), chum, and pink salmon, Sultan River smolt trap, 2016.

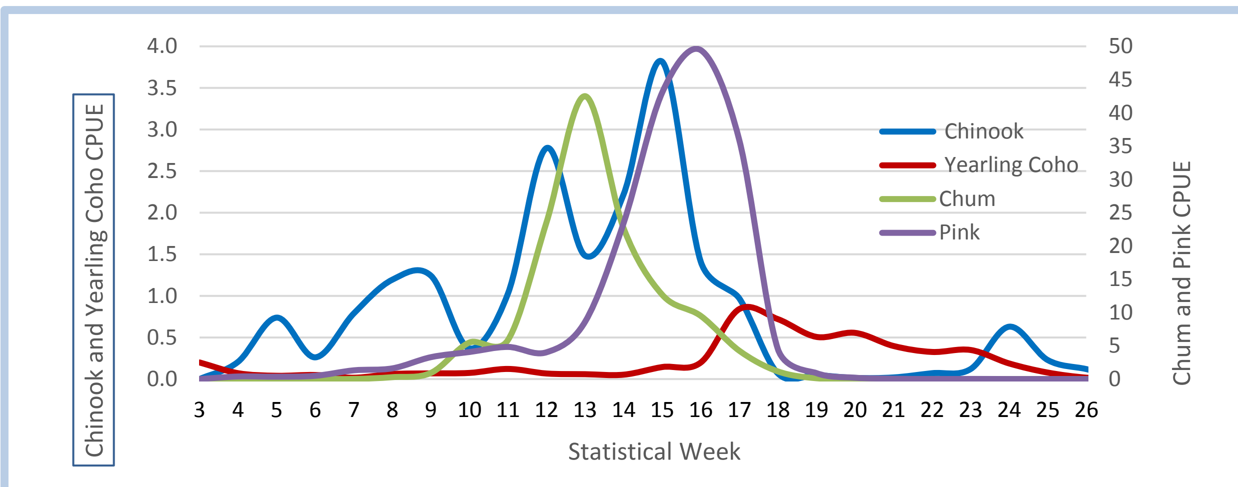


Figure 3. Average catch per unit effort by week of Chinook, yearling coho (1+), chum, and pink salmon, Sultan River smolt trap, 2012-16.

3.3 Total Out-migration

In order to estimate total out-migration, groups of hatchery Chinook and wild pink salmon were used to assess capture efficiency throughout the season. Table 4 summarizes results of efficiency trials by species.

Table 2. Summary of mark-recapture tests of capture efficiency for hatchery Chinook and wild pink salmon, Sultan River smolt trap, 2016.

Fish Used	Total Marked and Released	Total Recaptured	Percent Trap Efficiency
Hatchery Chinook	3,750	109	2.9
Wild Pink	2,858	38	1.3

A modified Peterson mark-recapture approach was used to determine capture efficiency and estimate total migration of Chinook, yearling coho, pink, and chum salmon. This method accounts for hours not fished during the season.

The hatchery Chinook efficiency rate of 2.9% was used to estimate total migration for Chinook and yearling coho (Tables 5 and 6). Since the catch size for yearling coho was insufficient to be used for efficiency trials, hatchery Chinook were used as a surrogate. Chinook and yearling coho were comparable in size (average fork length 85 mm and 101 mm, respectively) and exhibit similar swimming speed (Davis *et al*., 1963, Griffiths *et al*., 1972). The pink salmon efficiency rate of 1.3% was used for pink and chum estimates (Tables 7 and 8). Pink and chum salmon exhibit similar migratory patterns (Pennell and Barton, 1996) and are similar in size (36-42 mm) therefore, it was determined that using the pink salmon efficiency rate for the chum migration estimate was more suitable than using the hatchery Chinook efficiency rate.

Table 3. Chinook migration estimate, 95% confidence level, and variance, Sultan River smolt trap, 2016.

Chinook Migration Estimate	Fish Used for Efficiency Test	95% Confidence Level		Migration Variance
52,294	Hatchery Chinook (2.9%)	60,850	42,919	2.09E+07

Table 4. Yearling coho (1+) migration estimate, 95% confidence level, and variance, Sultan River smolt trap, 2016.

Yearling Coho Migration Estimate	Fish Used for Efficiency Test	95% Confidence Level		Migration Variance
24,294	Hatchery Chinook (2.9%)	27,991	20,274	3.87E+06

Table 5. Chum migration estimate, 95% confidence level, and variance, Sultan River smolt trap, 2016.

Chum Migration Estimate	Fish Used for Efficiency Test	95% Confidence Level		Migration Variance
71,508	Pink (1.3%)	90,610	49,013	1.13E+08

Table 6. Pink migration estimate, 95% confidence level, and variance, Sultan River smolt trap, 2016.

Pink Migration Estimate	Fish Used for Efficiency Test	95% Confidence Level		Migration Variance
1,872,164	Pink (1.3%)	2,385,908	1,246,913	8.19E+10

The Peterson mark-recapture approach is based on five assumptions. These assumptions must be met, or accommodated, in order to ensure an unbiased abundance estimate. A determination was made that all five assumptions were satisfied.

1. <u>The population is closed with no immigration or emigration.</u>
This assumption was satisfied because all fish that passed the trap were migrating from only the Sultan River. Because we were far enough upstream (0.2 miles) from the mouth, we do not believe any fish that passed the trap were emigrating from the Skykomish River.

2. All fish (marked and unmarked) have an equal opportunity of capture.
In order to be assured that marked fish and unmarked fish have the same probability of capture, the trap was fished continuously for a minimum of 72 hours after each release. All efficiency releases were at a site 0.3 miles upstream of the trap. This distance was great enough to allow for mixing of fish across the stream channel and within the water column, but short enough to reduce the likelihood of predation that would result in the loss of fish before they have an opportunity to arrive at the trap.

3. Marking does not affect catchability
After marking wild pink salmon with Bismarck Brown, the fish were held in aerated totes for a minimum of one hour prior to release. The fish showed no unusual behavior or stress as a result of marking. The Wallace Hatchery Chinook were adipose fin-clipped at the hatchery. These fish were held in aerated totes when being transferred from the hatchery to the release site on the Sultan River. Water temperature was constantly monitored in the aerated totes.

4. The fish do not lose their marks.
The use of Bismarck Brown for pinks and the adipose fin-clip for hatchery Chinook satisfied this assumption.

5. All recovered marks are detected and reported.
Bismarck Brown marked pinks and adipose fin-clipped hatchery Chinook were easily detected and recorded immediately.

3.4 Egg-to-Migrant Survival (Chinook salmon)

During the fall of 2015, a total of 156 Chinook redds were estimated during spawner surveys in the Sultan River upstream of the trap site. Assuming an out-migrant estimate of 52,294 fish, the egg-to-migrant survival for brood year 2015 was 7.4%. This is the lowest survival since the trap began operating in 2012 (Table 9) and is likely the result of the three high water events that occurred in late 2015 and early 2016. While the highest of these flows occurred on November 17, 2015 when peak discharge of 7,320 cubic feet per second (cfs), two other high flows occurred on December 10, 2015 (4,290 cfs) and February 15, 2016 (2,910 cfs). It is well documented that the survival of salmon eggs and embryos can be influenced by physical factors such as stream flooding, streambed scour and fill, and fine sediment deposition (DeVries, 1997). A peak flow of similar to the November event would likely result in significant scour (Stillwater Sciences, Meridian Environmental, 2008). The smaller events, while not as severe, may still have resulted in some level of scour and also quite possibly displaced some fish downstream shortly after emergence and prior to complete yolk absorption when swimming ability is reduced (Thomas *et al*., 1969).

3.5 Emergence Timing (Chinook salmon)

In order to estimate at what date Chinook fry emerged, Sultan River temperature data were analyzed along with data collected during spawning surveys. Surveys indicated that Chinook began spawning around September 9 in 2015. Mean daily temperature data indicate that eggs from these early spawning Chinook would have attained 900 Celsius ATUs and developed to emergence by approximately December 19. This analysis therefore indicates that no emergence had occurred prior to the high flow event on November 17.

Table 7. Estimated number of Chinook salmon eggs deposited in gravel (based on fall spawning surveys), estimated total out-migration, calculated egg-to-migrant survival rate, and recorded peak flow during incubation (August 15-February 15).

Year of Trap Operation	Chinook Redds (Year)	Number of Eggs Deposited in Gravel	Chinook Migration	Percent Egg-to-Migrant Survival	Peak Flow during egg incubation (cfs)
2016	156 (2015)	703,560	52,294	7.4	7,320
2015	146 (2014)	658,460	231,397	35.1	3,520
2014	184 (2013)	829,840	124,770	15.0	3,800
2013	390 (2012)	1,758,900	443,789	25.2	2,290
2012	53 (2011)	239,030	45,986	19.2	3,360

3.6 Fork Lengths

Chinook

Chinook fork lengths averaged 41.1 mm through Week 15 (mid-April). Beginning in Week 16, Chinook lengths increased rapidly, averaging 64.9 mm during the last eleven weeks of the season. This considerable difference in length is an indicator that some Chinook migrate past the trap soon after emergence and others stay in the river and grow larger prior to migrating. Also, the lower end of the size range did not exceed 40 mm until Week 20 (mid-May), indicating protracted emergence and/or slow growth for some fish.

Yearling coho (1+)

Fork lengths averaged 88.3 mm through week 9. Lengths increased rapidly beginning in week 10 and averaged 101.3 mm from week 10 through the end of the season. The cause of this increase in length beginning in week 10 (early March) is likely due to the fact that during the winter months, feeding virtually ceases and growth stops. Fish begin feeding in early spring, which results in a rapid increase in growth (Groot *et al*., 1991).

Chum

Chum lengths averaged 40.3 mm and showed little variation throughout the season. This small variation in length is an indicator that the vast majority of chum spend minimal time in the river and migrate past the trap soon after emergence.

Steelhead/Rainbow Trout

The first steelhead smolt was captured in week 14. Smolt fork lengths averaged 160.8 mm for the season. The first YOY rainbow trout was captured in week 24. Young of the year fork lengths averaged 29.4 mm (Table 10).

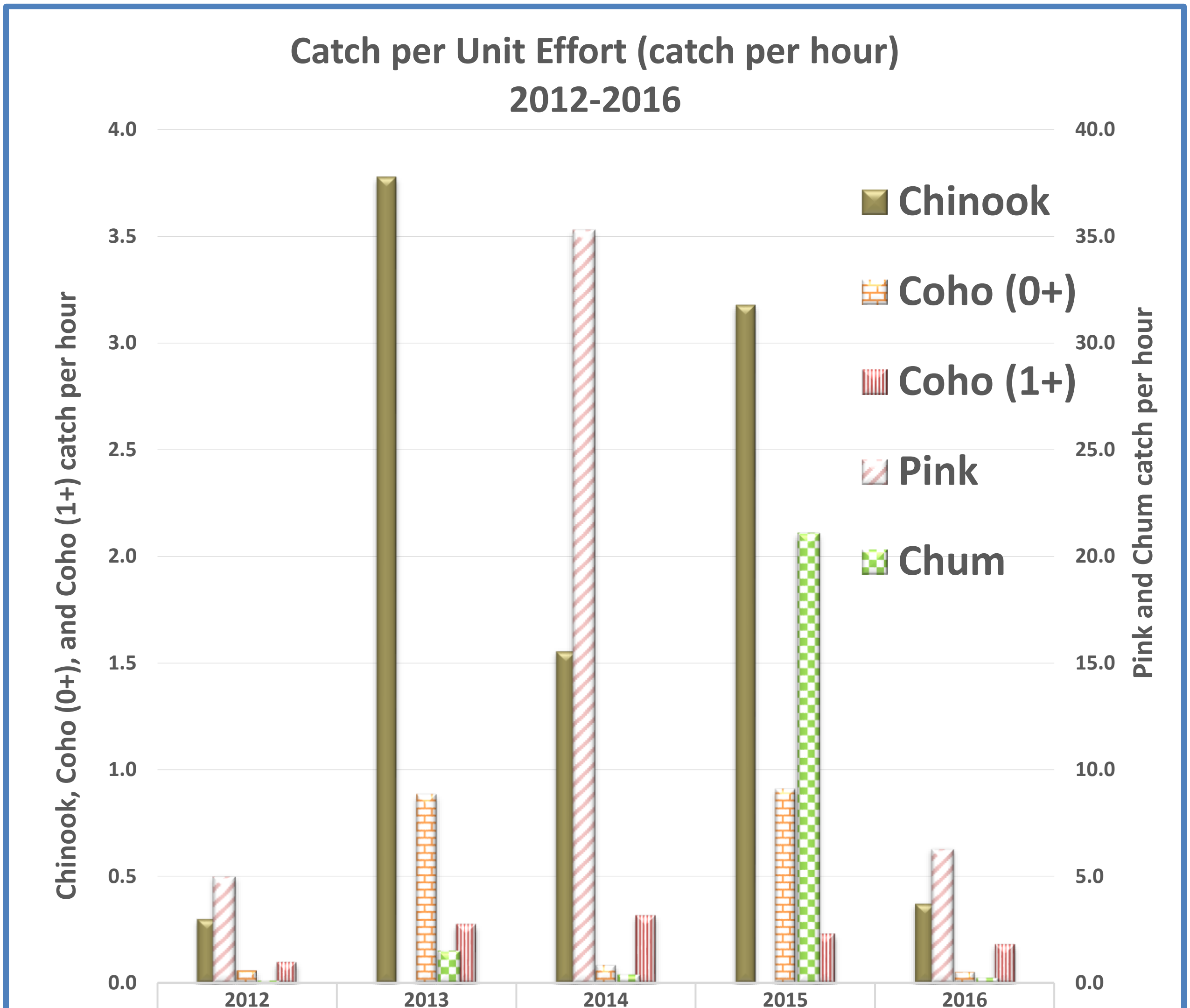
Table 10. Fork length (mm) of steelhead/rainbow trout smolt, parr, and young of the year (YOY) by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Smolt fork length (mm)	Parr fork length (mm)	Young of Year fork length (mm)
3		78	
4		83,86,97,142,210	
5			
6		68,121	
7	Did not operate trap due to high flow		
8		145,151	
9		79,109	
10		73,78,104,122,128,130	
11			
12			
13			
14	130		
15		90,93,100,148	
16	194,168	68,110,123	
17		78	
18	146,159,160,168,168,181	132	
19	132,148,160,166,188	82,91	
20	138,147,158,174	86,95,98	
21	158,165,168	78	
22			
23			
24			29,30,30
25			27,27,28,28,28,28,29,29,29,29,30,30,30,30,30,30,30,30,31,31,32
26			25,25,25,27,28,28,28,29,29,30,30,30,30,35

Additional information regarding fork lengths is included in Appendix B.

3.7 Catch per Unit Effort for 2012-2016

The smolt trap has been in the same location during the first five years of operation and in all likelihood will continue to be operated in the same location in future years. Figure 4 summarizes CPUE (catch/hour) for Chinook, sub-yearling coho (0+), yearling coho (1+), chum, and pink salmon for 2012-2016.



	2012	2013	2014	2015	2016
Chinook	0.3	3.8	1.6	3.2	0.4
Coho (0+)	0.1	0.9	0.1	0.9	0.1
Coho (1+)	0.1	0.3	0.3	0.2	0.2
Pink	5.1	0.0	35.3	0.0	6.4
Chum	0.1	1.5	0.4	21.1	0.2

Figure 4. Catch per Unit Effort of Chinook, sub-yearling coho (0+), yearling coho (1+), chum, and pink salmon during 2012-16, Sultan River smolt trap.

4. Summary

This report presents the results of the fifth year of operation of the rotary screw trap located on the Sultan River. In 2016, the trap was operated from January 18 to June 30 and fished 65% of the total hours during that time period.

Chinook egg-to-migrant survival in 2016 was 7.4% which is the lowest survival since the trap began operating in 2012. The previous low was 15.0% in 2014. The likely cause of this low survival was three high water events that occurred during the period of egg incubation in late 2015 and early 2016. The highest of these flows occurred on November 17, 2015 when a peak discharge of 7,320 cfs was recorded and likely resulted in scour of Chinook redds.

Chinook, chum, pink, and yearling coho salmon production estimates were made using a modified Peterson mark-recapture approach. An estimated 52,294 Chinook, 71,508 chum, 1,872,164 pink, and 24,294 yearling coho migrated during the trapping period. These estimates are substantially lower than the 2012-2015 average for all species except yearling coho. The reason for this may be that when the November 17 flow occurred, Chinook, chum, and pink had not emerged from the gravel while the yearling coho were long since out of the gravel and able to find refuge in off channel habitat.

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Appendix A

Statistical Weeks and Corresponding Months

Statistical Weeks	Corresponding Months
1-5	January
6-9	February
10-13	March
14-17	April
18-22	May
23-26	June

Appendix B

Fork Lengths

Chinook

Table B-1. Mean fork length (mm), standard deviation (SD), minimum and maximum length, number sampled, number captured, and percent sampled of Chinook by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Mean	SD	Min	Max	Sampled	Captured	Percent Sampled
3	40.2	1.49	37	43	24	125	19
4	40.3	1.47	37	44	39	48	81
5	40.7	2.12	37	45	23	72	32
6	40.4	1.26	39	43	10	56	18
7	Did not operate trap due to high flow						
8	41.8	1.56	40	44	9	20	45
9	40.3	1.34	38	44	29	78	37
10	41.0	1.63	38	44	10	39	26
11	40.3	1.25	39	43	16	35	46
12	40.6	1.28	38	43	20	81	25
13	40.2	0.98	38	41	11	53	21
14	40.8	2.11	38	47	16	141	11
15	41.2	1.47	40	44	6	23	26
16	53.7	11.79	43	67	6	8	75
17	45.7	8.46	40	69	10	10	100
18	54.8	13.64	41	75	9	9	100
19	60.7	10.25	39	78	48	48	100
20	59.0	9.34	43	76	29	29	100
21	77.5	16.17	55	103	16	16	100
22	55.0		55	55	1	1	100
23	68.8	7.50	58	85	24	24	100
24	69.1	7.08	59	80	17	25	68
25	89.0		89	89	1	1	100
26	79.6	10.98	68	100	8	8	100
Season Summary	50.6	14.3	37	103	383	950	40

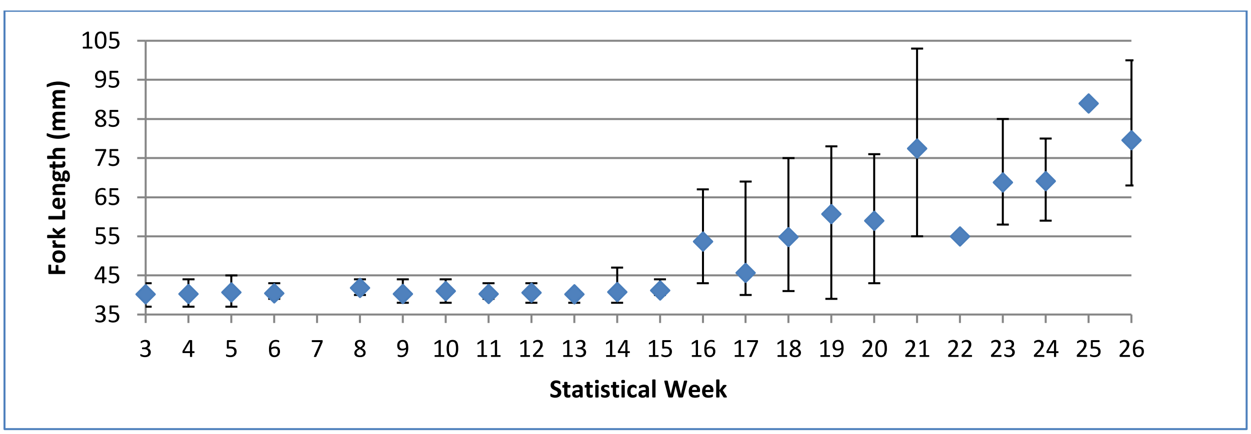

Figure B-1. Range (mean, minimum, and maximum) of Chinook fork lengths (mm), by statistical week, Sultan River smolt trap, 2016.

Yearling coho (1+)

Table B-2. Mean fork length (mm) standard deviation (SD), minimum and maximum length, number sampled, number captured, and percent sampled of yearling coho (1+) by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Mean	SD	Min	Max	Sampled	Captured	Percent Sampled
3	94.0	1.73	92	95	3	3	100
4						0	
5	75.0		75	75	1	1	100
6	80.8	5.62	75	88	4	4	100
7	Did not operate trap due to high flow						
8	89.0	2.83	87	91	2	2	100
9	78.3	0.58	78	79	3	3	100
10	115.0		115	115	1	1	100
11	101.0		101	101	1	1	100
12	101.6	16.86	73	117	5	5	100
13	87.5	10.38	78	100	4	4	100
14	108.4	15.00	83	120	7	7	100
15	101.7	12.13	78	115	15	15	100
16	102.6	6.10	88	117	56	83	67
17	104.6	9.54	92	136	19	19	100
18	104.3	8.73	81	124	73	149	49
19	101.7	9.90	87	126	44	79	56
20	98.8	11.17	82	132	29	34	85
21	94.4	8.79	78	115	35	37	95
22	103.0		103	103	1	1	100
23	97.5	2.38	95	100	4	4	100
24	98.0		97	97	1	1	100
25	92.0		92	92	1	1	100
26	97.0		97	97	1	1	100
Season Summary	100.7	12.4	75	136	310	455	68

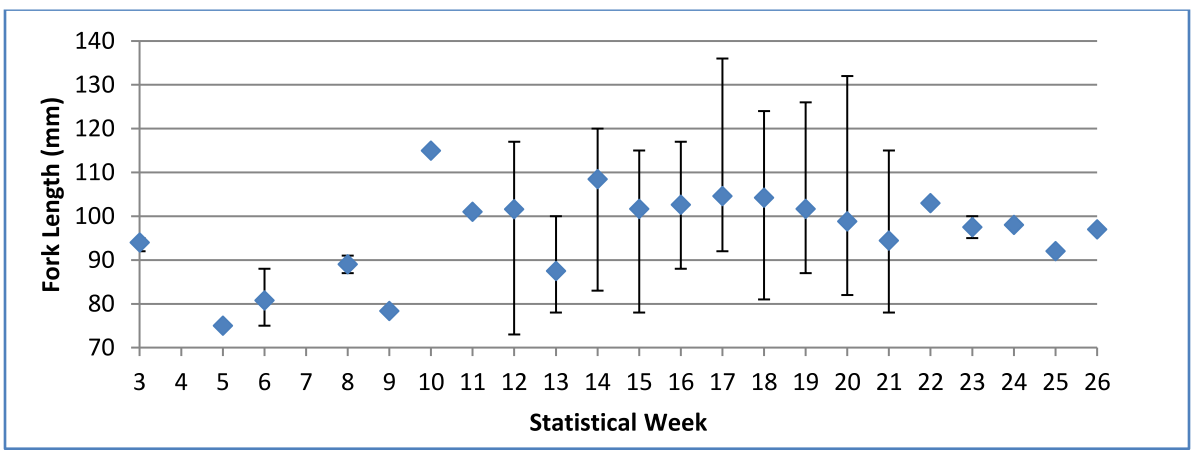

Figure B-2. Range (mean, minimum, maximum) of yearling coho (1+) fork lengths (mm) by statistical week, Sultan River smolt trap, 2016.

Chum

Table B-3. Mean fork length (mm), standard deviation (SD), minimum and maximum length, number sampled, number captured, and percent sampled of chum by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Mean	SD	Min	Max	Sampled	Captured	Percent Sampled
3	36.5	0.71	36	37	2	2	100
4	38.0		38	38	1	1	100
5	37.0		37	37	1	5	20
6	40.0	1.79	38	43	6	13	46
7	Did not operate trap due to high flow						
8	41.8	1.79	40	44	5	3	16
9	39.5	1.73	38	42	4	54	7
10	41.0	0.94	40	42	10	82	12
11	40.5	1.25	38	43	53	131	40
12	39.8	1.47	37	43	16	100	16
13	40.5	1.54	37	43	19	83	23
14	39.9	1.56	38	42	12	123	10
15	39.0	1.73	38	41	3	11	27
16	41.5	0.71	41	42	2	2	100
17						0	
18						0	
19						0	
20						0	
21						0	
22						0	
23						0	
24						0	
25						0	
26						0	
Season Summary	40.3	1.54	36	44	134	610	22

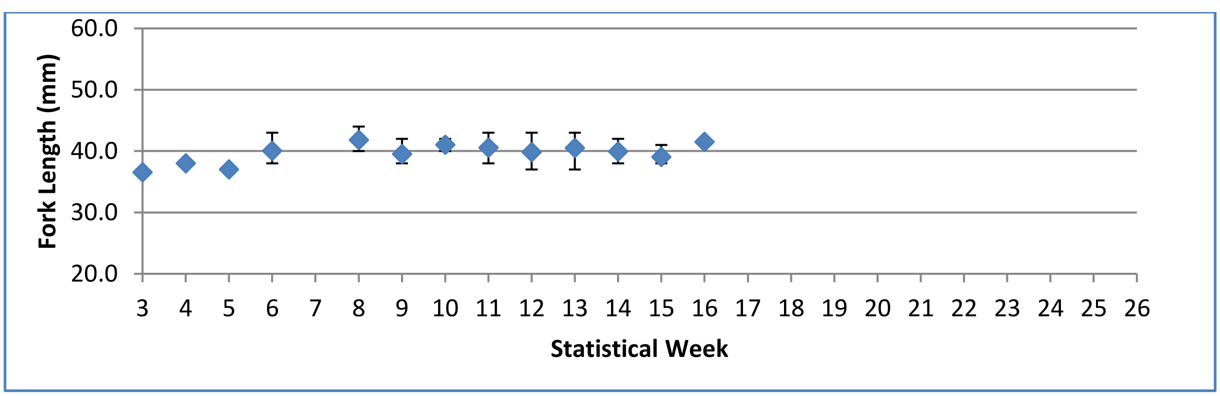

Figure B-3. Range (mean, minimum, maximum) of chum fork lengths (mm) by statistical week, Sultan River smolt trap, 2016.

Steelhead/Rainbow Trout

Table B-4. Mean fork length (mm), standard deviation (SD), minimum and maximum length, number sampled, number captured, and percent sampled of steelhead/rainbow trout by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Mean	SD	Min	Max	Sampled	Captured	Percent Sampled
3	78		78	78	1	1	100
4							
5						0	
6	94.5	37.48	68	121	2	2	100
7	Did not operate trap due to high flow						
8	148	4.24	145	151	2	2	100
9	94	21.21	79	109	2	2	100
10	105.8	25.27	73	130	6	6	100
11						0	
12						0	
13					0	2	0
14	130		130	130	1	1	100
15	107.8	27.16	90	148	4	4	100
16	132.6	49.5	68	194	5	5	100
17	78		78	78	1	1	100
18	159.1	16.05	132	181	7	7	100
19	138.1	39.26	82	188	7	7	100
20	128	34.71	86	174	7	7	100
21	163.7	5.13	158	168	3	3	100
22						0	
23						0	
24	29.7	0.58	29	30	3	3	100
25	29.3	1.32	27	32	21	21	100
26	28.5	2.65	25	35	14	14	100
Season Summary	86.6	56.69	25	210	91	93	98

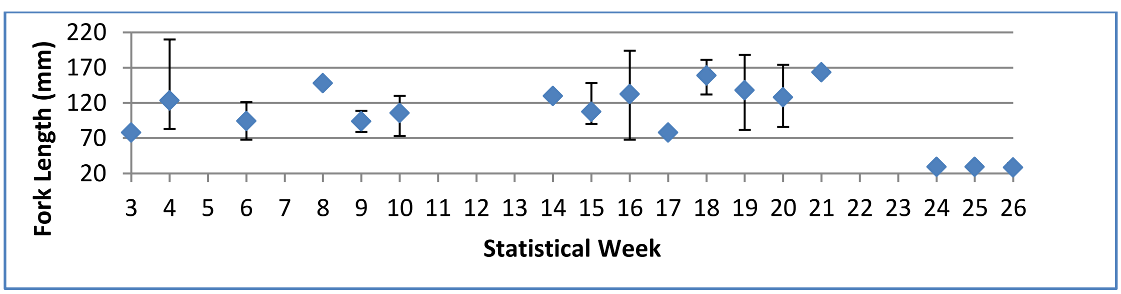

Figure B-4. Range (mean, minimum, maximum) of steelhead/rainbow trout fork lengths (mm) by statistical week, Sultan River smolt trap, 2016.

Cutthroat Trout

The first cutthroat trout was captured in week 12.

Table B-5. Mean fork length (mm), standard deviation (SD), minimum and maximum length, number sampled, number captured, and percent sampled of cutthroat trout by statistical week, Sultan River smolt trap, 2016.

Statistical Week	Mean	SD	Min	Max	Sampled	Captured	Percent Sampled
12	113.0	42.43	83	143	2	2	100
13						0	
14	89.5	0.71	89	90	2	2	100
15	120.7	6.66	115	128	3	3	100
16	124.0	57.98	83	165	2	2	100
17						0	
18						0	
19						0	
20	105.0		105	105	1	1	100
21						0	
22						0	
23						0	
24	170.0		170	170	1	1	100
25	215.0		215	215	1	1	100
26						0	
Season Summary	125.4	41.17	83	215	12	12	100

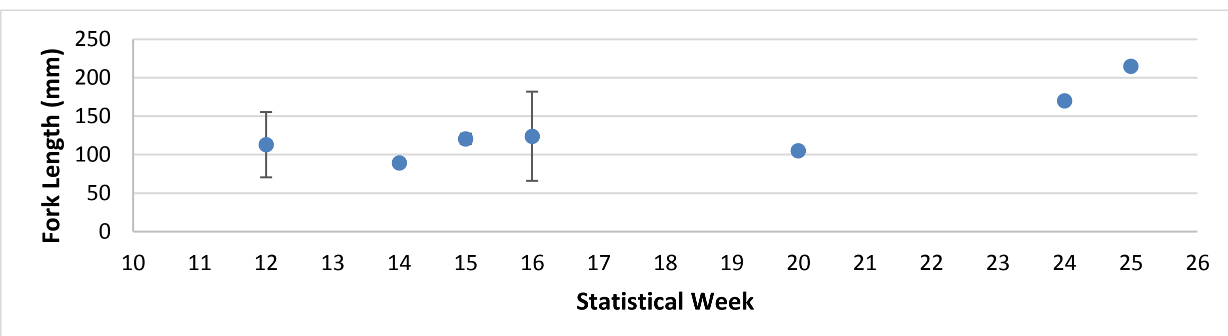

Figure B-5. Range (mean, minimum, maximum) of cutthroat trout fork lengths (mm) by statistical week, Sultan River smolt trap, 2016.

APPENDIX E

Riverine Habitat Survey, Sultan River

FINAL REPORT ◦ DECEMBER 2016

Sultan River
Riverine Habitat Monitoring

PREPARED FOR

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Suggested citation:
Stillwater Sciences. 2016. Sultan River riverine habitat monitoring. Prepared by Stillwater Sciences, Portland, Oregon for Snohomish County Public Utility District No.1, Portland, Oregon.

Cover photos: Clockwise from top left: Pool feature formed by installed wood at the head of Side Channel 4; gravel accumulation at outlet of Side Channel 2; riffle near the head of Side Channel 1; outlet of a newly formed pool in Side Channel 3.

Table of Contents

Tables

Figures

Appendices

EXECUTIVE SUMMARY

Stillwater Sciences conducted a field habitat survey of the lower 2.7 miles of the Sultan River in July 2016, including four side channels (all of which had been previously surveyed). The study was undertaken to determine if any habitat changes have occurred due to a significant high-flow event that occurred in November 2015. The 2016 survey was the second such resurvey conducted since issuance of the new license for the Henry M. Jackson Hydroelectric Project (Project) in 2011. The project is operated by the Public Utility District No. 1 of Snohomish County (the District) and these habitat surveys are required by the Fisheries and Habitat Monitoring Plan under Article 410 of the license.

Surveys conducted in 2007 and 2010, as part of the relicensing of the Project, provided the baseline data that have allowed post-2011 resurveys to determine the effects of subsequent high-flow events, of which the first occurred in March 2014 (Stillwater Sciences 2015). Table ES-1 lists each reach and the year they were each surveyed.

Riverine habitat attributes recorded for this study included instream unit subtype (e.g., pools, riffles, glides, islands), measurements of wetted unit surface area dimensions (length and width), unit margin features (lengths of undercut banks and bar edges), and the distribution and characterization of large woody debris (LWD). Subsequent to the 2007 and 2010 surveys, engineered LWD structures were installed in 2012 along the margins of the mainstem and side channels, along with other channel enhancements in all four side channels.

Table ES-1. Reaches surveyed and the year the survey was conducted.

Reach	Surveyed in 2007	Surveyed in 2010	Resurveyed in 2014	Resurveyed in 2016
Mainstem	Yes	No	Yes	Yes
Side Channel 1	No	Yes (partially)	Yes	Yes
Side Channel 2	No	Yes	Yes	Yes
Side Channel 3	Yes	No	Yes	Yes
Side Channel 4	No	No	Yes	Yes
		LWD INSTALLATIONS ↑ 2012	↑ HIGH FLOW MARCH 2014	↑ HIGH FLOW NOVEMBER 2015

As in 2014, the results of the 2016 study indicate that natural processes of wood recruitment and channel evolution have thus far resulted in modest changes to habitat attributes in the mainstem of the Sultan River since the baseline surveys were conducted. Although the mainstem is largely unchanged, the side channels have been transformed into more variable reaches with frequent pools and pool-riffle-glide complexes. This represents a marked improvement over their previous composition of primarily glide habitat dotted with some low-gradient riffles and a few small pools. Since 2012, high flows have reworked and modified the channels. This has led to a system that overall expresses a somewhat more dynamic, “natural” trajectory. For this survey, the largest positive changes observed since the 2014 survey occurred in Side Channels 2 and 4 (SC2 and SC4).

While the presence of engineered LWD structures and LWD in the mainstem river and along the side channels has successfully stabilized the inlet to side channels, one small area in the mainstem and a longer section of Side Channel 1 (SC1) that had flowing water in 2014 at the 320 cubic feet per second (cfs) mainstem discharge were dry at a similar discharge in 2016. This change was most evident in SC1 and comprised 594 feet (ft) of dry channel with marsh and isolated interspersed pools.

In summary, little measurable change can be documented in the mainstem as a result of this survey. However, the study results indicate that installations have initiated changes in habitat features and improved channel complexity, in terms of variability of depths and flow, in the side channels following high flows. Pool habitat has significantly increased, both in terms of the amount of surface area pools encompass and the overall number of pools observed in the study area. Based on relatively consistent results to date, future high flows are expected to interact with the installations and result in even greater side-channel habitat complexity in the future.

1 STUDY OBJECTIVES AND DESCRIPTION

The objective of this habitat survey was to delineate in-river habitat units and to conduct an in-river large woody debris (LWD) inventory in the Sultan River's lower 2.7 miles, including four previously identified side channels (Figure 1). The mainstem and Side Channel (SC) 3 were surveyed as part of Jackson Hydroelectric Project (Project) relicensing in 2007 and reported in *Revised Study Plan 18: Riverine, Riparian, and Wetland Habitat Assessment* (hereafter referenced as RSP 18) by Public Utility District No. 1 of Snohomish County (the District). In 2010, habitat was surveyed in SC1 and SC2 and a geomorphic assessment was conducted to inform wood placement and channel enhancement feasibility. Construction occurred in 2012, with inlet and outlet enhancements and boulder placement associated with the four side channels (SC1, SC2, SC3, and SC4). Enhancements included multiple log structures and individual logs in the side channels and eight large engineered LWD structures in the mainstem.

Follow-up habitat surveys, triggered by high-flow events (termed "process flows"), are required by the Fisheries and Habitat Monitoring Plan under Article 410 for the continued operation of the Project. Resurveys were conducted following two high-flow events that have since occurred:

- March 2014 (with a peak discharge of 4,940 cubic feet per second [cfs] at U.S. Geological Survey [USGS] Gage No. 12138160, corresponding to a 3- to 4-year event);
- November 2015 (with a peak discharge of 7,320 cfs at USGS Gage No. 12138160, corresponding to about a 7-year event).

The primary purpose for resurveying is to identify any significant changes that have occurred following the November 2015 high-flow event that could affect fish habitat in the lower Sultan River. This study thus evaluates habitat changes that have occurred as a result of the constructed habitat enhancements and their interaction with two high-flow events. This study also provides analysis of current conditions compared with baseline information previously compiled for the mainstem and side channels of this reach of the Sultan River. Per License Article 410, the frequency of these surveys is greatest between Year 1 and 10 of the new license and is reduced over the remainder of the license term.

2 BACKGROUND INFORMATION

As part of the formal relicensing process for Culmback Dam in 2007, RSP 18 was conducted to address Federal Energy Regulation Commission (FERC) requirements for a detailed description of aquatic and terrestrial resources of the Project-related environment between Culmback Dam and the mouth of the Sultan River.

The Sultan River below Culmback Dam is a highly confined, steep channel over 13 miles of its 16-mile length to its confluence with the Skykomish River The canyon that confines the river creates a high-energy environment that significantly affects the nature of instream habitats found within it. At approximately river mile (RM) 3.3, however, the river transforms into an alluvial valley where the channel widens and gravels from upstream sources deposit and accumulate. This survey was conducted on the lowermost, low-gradient alluvial portion of the watershed (Figure 1) from the power line crossing at RM 2.7 to the confluence of the Sultan and Skykomish rivers.

The Sultan River below Culmback Dam currently provides spawning and rearing habitat for numerous species of resident and anadromous salmonids.[1] The reach between the Culmback Dam and the Diversion Dam (RM 9.7) historically has supported self-sustaining stocks of resident rainbow trout (*O. mykiss*) and mountain whitefish (*Prosopium williamsoni*). Anadromous species, including Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), coastal cutthroat trout *(O. clarki)* and steelhead trout (*O. mykiss*), are utilizing spawning and rearing habitats within the river downstream of the Diversion Dam, which until recently was a barrier to upstream passage. Bull trout (*Salvelinus confluentus*) have not been observed spawning in the Sultan River but are known to use the lower river as rearing/foraging habitat.. Each of these fish species depend on aquatic habitats that are affected by Project operations, and it is thus important to collect information on habitats within the affected reach on an ongoing basis.

[1] Volitional fish passage through the sluiceway gate at the Diversion Dam at RM 9.7 was completed in October 2016, allowing unimpeded fish access to habitats upstream of the Diversion Dam for the first time since 1929.

Figure 1. Overview map of Study Area, spanning the lowermost 2.7 miles of the Sultan River upstream of its confluence with the Skykomish River (bottom right portion of the image). The four side channels covered by this survey are labeled.

3 METHODS

3.1 Study Area Description and River Reach Delineation

RSP 18 broke the river into three "operational reaches" and four "survey reaches," each of which contained multiple habitat units identified by Natural Sequence Order (NSO) or "unit" numbers. The present Study Area for the 2016 survey covers the lower mainstem Sultan River from the Bonneville Power Administration (BPA) power lines at RM 2.7, including four side channels within the reach, to its confluence with the Skykomish River. The 2016 survey took place wholly within Operational and Survey Reach 1, as defined in RSP 18. Habitat unit numbers previously assigned to the mainstem and side channels have not been altered except in the case where a habitat unit has changed. Maps illustrating habitat units are included in Appendix A for 2014 and in Appendix B for 2016.

3.2 Riverine Habitat Mapping and Large Woody Debris Survey

Methods used to quantify in-river habitat units and associated LWD for the 2016 survey were identical to those utilized in 2014, 2010, and 2007. These methods were selected to provide repeatable identification of habitat types, dimensions, and locations, as well as documentation of associated LWD.

The classification schemes used to identify specific habitat unit types, substrate sizes, and LWD attributes are given in Tables 1 and 2. Because some of the side channels had habitat types not included in the pre-existing classification scheme, some additional habitat types (i.e., isolated pools and marshy areas) were added in the field at the time of the survey.

Table 1. Riverine (instream) habitat types.

Habitat types	Pool
	Riffle
	Cascade
	Rapid
	Glide
	Island
	Side Channel
	Undercut Banks
	Backwater Areas
	Bar Edges

Table 2. Large woody debris (LWD) attributes.

LWD jam	Number of Pieces
	Dimension (length, width, height)
	Channel Position (bank, mid-channel, bar)
	Percent of Channel Width
	Largest Piece Size
LWD piece	Length
	Diameter
	Decay Class
	Species Class (conifer, deciduous)
	Rootwad (yes, no)
	Anchoring (bed bank)
	Channel Position (bank, mid-channel, bar)

3.2.1 Delineation of in-river habitat units

The in-river habitat unit classification system and field methods from RSP 18 were used for this survey. The classification system and field methods were adapted from those commonly used in Washington State (Pleus et al. 1999, Schuett-Hames et al. 1999). They provide consistency for unit type identification and for recording unit dimensions. Habitat attributes recorded include unit type (e.g., pools, riffles), measurements of wetted unit surface area dimensions (length and width), unit margin features (lengths of undercut banks and bar edges), and LWD characteristics. Example habitat unit field data collection forms and respective criteria for identification are provided in Appendix C.

The habitat and LWD assessments were conducted in July 2016 within the Study Area. The assessment involved a field survey (or census) by a two-person crew and was conducted moving upstream from the mouth of the Sultan River to RM 2.7. Flows during the survey (317–357 cfs) were maintained by dam releases to match the discharge experienced during the initial surveys in 2014 (313–320 cfs) and 2007 (319 cfs). Prior to enhancements, SC1 and SC2 were only activated at higher flows; therefore, the 2010 survey of these two side channels was conducted at a higher discharge (Table 3).

Table 3. Discharge at time of each survey as measured by USGS Gage No. 12138160, "Sultan River below Powerplant near Sultan, WA."

Year of survey	Flow (cfs)
2007	319
2010	561 to 802
2014	313 to 320
2016	317 to 357

Habitat unit delineation and measurement of habitat features are best conducted at similar flows in order to improve the reliability of direct comparisons between measurements on different dates. At different flows, bank edges can be inundated or revealed (changing the measurement of bar edges and undercut banks), and wetted widths and depths will obviously be altered.

The field crew surveyed each unit semi-sequentially to identify habitat unit boundaries and associated attributes. For the mainstem, data were collected in a hierarchical manner to first identify or confirm previous habitat unit boundaries, to verify or assign a habitat subtype, and to define the unit's position within the lateral channel (Table 4). These first-order, reach-scale data were recorded using the same alphanumeric coding system as in RSP 18 that assigned: (1) a unique numeric data identifier (NSO unit number); (2) a primary habitat unit type (pool, riffle, or other); (3) a habitat subtype (riffle, pool, subsurface flow, obscured, or other [Pleus et al. 1999]); and (4) a ranking that defined the degree to which the unit occupied the wetted channel. The latter included primary main channel units (Category 1), secondary main channel habitat units (i.e., units that did not span the entire river channel) (Category 2), and side channel habitat units separated from the main channel by an island (Category 3). Islands (Category 3) were identified according to Schuett-Hames et al. (1999), who defined the minimum length of an island unit being at least two times the bankfull channel width with the terrestrial area vegetated by perennial plants two meters or greater in height.

Subsequent data, including unit subtype and dimension measurements, were recorded for each habitat unit. Length, average depth (except in pool habitat units), and three wetted width measurements were either verified from the previous study or recorded for each habitat unit that were either newly delineated (as in the side channels) or re-delineated where habitat units had changed since the last survey. Habitat unit subtypes were designated for the "pool" and "riffle" primary units according to the criteria given in Table 4. Additional information was recorded for pools, including maximum depth, residual pool depth, and the dominant factor forming the pool according to the criteria given in Table 5 (Pleus et al. 1999).

Table 4. Criteria used to identify primary and subtypes and associated field code acronyms. (Subtype designations and definitions are adapted from Flosi et al. 1998 and Edelen 2005.)

Primary habitat unit type	Habitat unit subtype	Criteria for identification
Riffle (R)	Low-gradient Riffle (LGR)	Shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient <4% is usually cobble-dominated.
	High Gradient Riffle (HGR)*	Relatively higher-gradient than low-gradient riffles and dominant bed material is cobble instead of gravel.
	Rapid (RPD)	Steep sections of moderately deep, swift, and very turbulent water. Amount of exposed substrate is relatively high. Gradient is >4%, and substrate is boulder dominated. In Flosi et al. (1998) these are termed "high gradient riffles."
	Glide (GLD)	Wide uniform channel bottom. Flow with low to moderate velocities, lacking pronounced turbulence. Substrate usually consists of cobble, gravel, and sand.
	Cascade (CAS)	The steepest riffle habitat, consisting of alternating small waterfalls and small shallow pools. Substrate is usually bedrock and boulders.

Primary habitat unit type	Habitat unit subtype	Criteria for identification
Pool (P)	Main Channel Pool (MCP)	Large pools formed by mid-channel scour. Water velocity is slow, and the substrate is highly variable.
	Lateral Scour Pool (SCP)	Formed by flow impinging against a partial channel-bank obstruction.
	Pool Complex (CPX)**	Series of pools separated by other habitat units (typically very short riffles) not as long as the wetted width (and thus not delineated as separate habitat units).
	Backwater	A pool off the channel (either main channel or side channel) with no obvious flow-through.
	Intermittent Pool**	Series of pools separated by dry areas.
	Isolated Pool**	A pool surrounded by dry channel.
Other (OT)	Island (ISL)	Bars or land segments within the stream channel that are relatively stable, usually vegetated, and normally surrounded by water.
	Subsurface flow (SUB)*	That portion (part or all) of the water that infiltrates the stream bed and moves horizontally through and below it. It may or may not return to the stream channel at some point downstream.
	Alcove** (ALC)	An off-channel area with no obvious flow-through. Differs from a backwater pool in being more uniform depth (no obvious concavity).
	Dry Channel**	Stream channel dry at the flows experienced during the survey.
	Marsh**	Portions of the stream channel that are wet, muddy and heavily vegetated, with no discernible flow.

* These habitat subtypes were not observed in the 2016 survey.
** These habitat subtypes were added in the 2016 survey.

Table 5. List of pool-forming factors and associated field codes (Pleus et al. 1999). Definitions for individual LWD pieces versus debris jams are according to Schuett-Hames et al. (1999).

Field code	Pool-forming factor
1	LWD log(s)
2	LWD rootwad(s)
3	LWD jam
4	Roots of standing tree(s) or stump(s)
5	Boulder(s)
6	Bedrock
7	Channel bedform
8	Resistant bank
9	Artificial bank
10	Beaver dam
11	Other/Unknown

3.2.2 In-river LWD inventory

Survey methods to characterize and enumerate LWD within the Study Area followed methods refined for the Timber Fish and Wildlife Monitoring Program (Schuett-Hames et al. 1999). Deviations from survey methods included consolidating LWD into size categories and characterizing LWD in debris jams by tallying individual pieces and rootwads, as was done in 2007 and 2014. Example field data collection forms and criteria are provided in Appendix C.

For the field survey, LWD was defined as dead logs, limbs, or rootwads partially or entirely located within the bankfull channel. LWD was enumerated according to a minimum size and length criteria. Individual downed logs and rootwads tallied had a minimum length of two meters and a mid-point diameter of twenty centimeters or greater. Total length for each piece was recorded, and a diameter class was assigned. Diameter classes were defined as (1) ≥20 centimeters (cm) to <40 cm, (2) ≥40 cm to <60 cm, and (3) ≥60 cm. The location of LWD, either primarily (greater than 50%) within the wetted channel (zone 1) or within the bankfull channel width (zone 2), was also recorded based on the wetted channel conditions present. Additional LWD data attributes recorded were:

- anchor feature (root system, boulder, pinned, or unstable [Schuett-Hames et al. 1999]);
- species class (conifer, deciduous, or unknown);
- decay class (1-5, [Robison and Beschta 1990 cited in Schuett-Hames et al.1999]); and
- the presence or absence of an intact rootwad.

In addition to individual pieces of LWD, debris jams were recorded on base maps and their dimensions estimated. The criteria for identifying debris jams was the accumulation of ten or more pieces of interlocked LWD (including rootwads) where at least ten pieces were ≥20 cm (8 inches [in]) in diameter and >1.8 meters (m) (6 ft) in length, and the majority of the debris jam was located within the bankfull channel (Schuett-Hames et al. 1999). Attribute data recorded for debris jams included a tally of all pieces and rootwads meeting the criteria described above, and approximate length, width, and height dimensions. Specific diameter and length measurements were recorded for the most prominent individual piece within each jam. All LWD locations were identified by recording the associated habitat unit NSO in addition to other data described above. The location and characteristics of engineered log structures and single-placed logs were noted separately from the naturally occurring LWD.

3.2.3 Characterization of river channel substrate

Wolman pebble counts (Wolman 1954) were conducted using the standard methodology in the same mainstem habitat unit as in 2007 and 2014 (habitat unit 89), and one count was conducted in each of the side channels in the same units as in 2014. No pebble counts were conducted in SC3 during the 2014 survey and therefore no comparative SC3 pebble counts were conducted in 2016. Pebble count results are typically summarized by the intermediate diameter of the median particle size, D_{50} (Wolman 1954). D_{50} values lying between 20 and 60 millimeters (mm), and having less than 10% of particles smaller than 0.85 mm in diameter (i.e., $D_{10} > 0.85$ mm), are considered suitable substrate size for spawning of anadromous fish (Kondolf and Wolman 1993, Kondolf 2000). In addition to the value of D_{50}, we also calculated D_{16} (the particle size that 16% of all particles are smaller than) and D_{84} (the particle size that 84% of all particles are smaller than).

3.3 Deviations from RSP 18/Monitoring Plan

There were no significant deviations from the RSP 18 measurement methods, although the same enhancements employed in 2014 to facilitate current and future uses were also employed for the 2016 survey. These include a Google Earth .kmz file, with all habitat units delineated and field photographs from the 2010, 2014, and 2016 surveys embedded. Global positioning system (GPS) coordinates for the wetted width measurements of the side channels are provided with the geographic information system (GIS) data to ensure repeatability with future efforts.

4 RESULTS

4.1 Survey Results: Riverine Habitat and Large Woody Debris

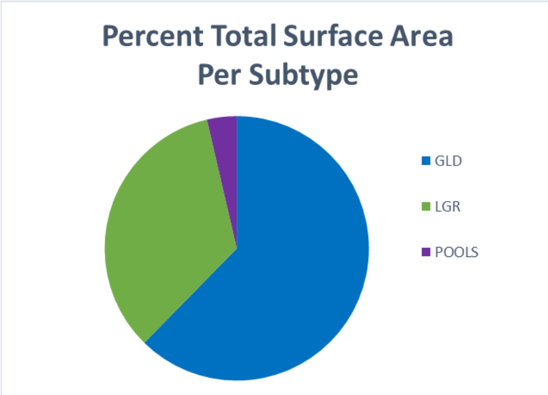
4.1.1 Habitat unit composition

A total of 230 in-river habitat units were surveyed within the Study Area (Table 6). This is an increase of 119 units, essentially twice the number of units identified in 2014, indicating that the study reach comprises complexly changing channels. Habitat subtypes not previously observed were identified in the study reach. The newly identified subtypes include isolated pools, intermittent pools, pool complexes, alcoves, marshes, and dry channels. Isolated and intermittent pools are recorded within using the subtype category of "Pool (other)". Maps illustrating 2016 habitat units are included in Appendix B, although the spatial distribution of these habitats is best viewed using the maps and interactive .kmz file provided with this report.

Though the mainstem units remained largely unchanged in the last two years, with only limited boundary shifts and unit additions, the side channels have undergone significant changes. Since 2014, SC1 has evolved from a channel containing 18 distinct units (primarily main channel pools, low-gradient riffles, and glides) to one that is now made up of 93 units including 35 main channel pools, stretches of dry channels and isolated pools and pool complexes, as well as a marsh, islands, and riffles (glides and low gradient). Similarly, since 2014, SC4 has been transformed from essentially one long glide (with a small pool and riffle) to a variable pool-riffle-glide reach providing a mixture of flows and depth.

Tables 6 and 7 provide summary statistics for habitat unit types and subtypes by reach. In 2016, low-gradient riffles, glides, and channel-spanning pools were the most abundant habitat unit subtypes; in total they accounted for 81% of all habitat units surveyed (Table 6). In terms of combined average percent surface area per subtype, glides and low-gradient riffles accounted for the majority of the surface area, mostly due to the presence of long and wide glides and riffles along the mainstem's length and the prevalence of these subtypes in each of the side channels. Pools (including main channel, lateral scour, isolated, intermittent, backwater, and complexes) accounted for a combined average 21.5% (Table 7), which is a significant increase from 2014 when pools accounted for <5%.

Figure 2 provides two alternative representation of the relative proportion of the primary habitat types and subtypes. The first graph (left) displays the total surface area per type/subtype across all reaches (i.e., mainstem and side channels) as a percent of the study reach total surface area (from Table 6). The second graph (right) displays the sum of each type/subtype's average percent surface area as calculated for each side channel and the mainstem individually (from Table 7).



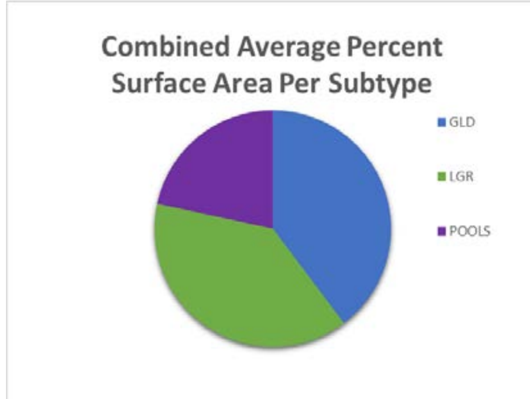


Figure 2. 2016 survey percent total surface area and combined average percent surface area per subtype. Habitat subtypes are as listed in Table 5: glide (GLD), low-gradient riffle (LGR), POOLS (including pool complexes and main channel, lateral scour, backwater, intermittent, and isolated pools).

Table 6. Composition of surveyed riverine habitat units by river reach and side channels of the lowermost 2.7 miles of the Sultan River.

Habitat		Process reach ID and side channel						Total number of habitat units	Percent of total habitat units
Primary unit type	**Subtype**	**Mainstem (unit category 1)***	**Mainstem (unit category 2 & 3)***	**SC1**	**SC2**	**SC3**	**SC4**		
Pool	Main channel pool	2	4	35	8	3	10	62	27.0%
	Lateral scour pool	-	-	1	2	-	-	3	1.3%
	Pool complex	-	-	3	-	-	-	3	1.3%
	Backwater	1	-	-	-	-	-	1	0.4%
	Pool (other)	-	-	12	-	-	-	12	5.2%
Riffle	Low-gradient riffle	14	17	12	8	9	5	65	28.3%
	Rapid	1	-	-	-	-	-	1	0.4%
	Glide	13	4	23	7	7	7	61	26.5%
Other	Island	5	7	3	-	1	-	16	7.0%
	Alcove	-	1	-	-	-	-	1	0.4%
	Marsh	-	-	1	-	-	-	1	0.4%
	Dry channel	1	-	3	-	-	-	4	1.7%
Total		**37**	**33**	**93**	**25**	**20**	**22**	**230**	**100%**

* Mainstem (unit category 1) includes primary mainstem channel units. Mainstem (unit categories 2 and 3) include secondary habitat units that did not span the entire mainstem river channel and side channel habitat units separated from the main channel by an island.

Table 7. Percent total surface area by riverine habitat unit, by river reach and side channels in the Study Area.

Habitat		Process reach ID and side channel						Combined average % surface area
Primary unit type	**Sub-type**	**Mainstem (unit category 1)***	**Mainstem (unit categories 2 & 3)***	**SC1**	**SC2**	**SC3**	**SC4**	
Pool	Main channel	<1	9	36.3	15.3	11.5	44.3	19.4
	Lateral scour			<1	2.3			<1
	Backwater	<1						<1
	Pool complex			5.1				<1
	Pool (other)			4.8				<1
Riffle	Low gradient	31	70.1	17.2	43.9	40.3	27.7	38.4
	Rapid	1.8						<1
	Glide	67.1	20	35.5	38.4	48.2	28.1	39.6
Other	Alcove							<1
	Marsh			<1				<1

* Mainstem (unit category 1) includes primary main channel units. Mainstem (unit categories 2 and 3) includes secondary main channel habitat units (units that did not span the entire river channel) and side channel habitat units separated from the main channel by an island.

For this study, wetted width data for units surveyed previously were visually compared to current conditions and re-measured with a laser rangefinder. The average wetted width for pools in the side channels ranged from 5.6 to 31.2 ft. Wetted widths in 2014 ranged from 11.2 to 31.9 ft, not because wetted widths decreased for previously surveyed pools but rather because new, smaller pools have formed since 2014. For riffles and glides in the mainstem and the four side channels, the average wetted width ranged from 10.3 ft for low-gradient riffles in SC1 to 109.5 ft for glides in the main channel (Table 8). These widths are largely unchanged from 2014.

The lengths of individual habitat units within the total Study Area range between 9 ft and 1,695 ft, with rapid and glide habitat units being the longest and intermittent and isolated pools measuring the shortest (Table 9). Glides were longest in the main channel with a median length of 616 ft. The sole rapid in the Study Area within the mainstem was 485 ft long. In SC2, average unit lengths are generally smaller than the other reaches, contributing to the side channel's complexity as measured by the spatial variability of habitat.

Table 8. Average wetted width (ft) by surveyed riverine habitat unit within the Study Area.

Habitat		Process reach ID and side channel					
Primary unit type	**Subtype**	**Mainstem (unit category 1)**	**Mainstem (unit categories 2 & 3)**	**SC1**	**SC2**	**SC3**	**SC4**
Pool	Main channel pool	14.7	31.1	12.5	21.0	31.2	19.2
	Lateral scour pool	-	-	14.0	13.3	-	-
	Pool complex			16.0			
	Backwater	-	-	5.6	-	-	-
	Pool (other)	-	-	14.3	-	-	-
Riffle	Low-gradient riffle	95.7	26.3	10.3	27.0	41.7	22.2
	High gradient riffle	-	-	-	-	-	-
	Glide	109.5	32.2	10.7	28.1	46.8	20.2

Table 9. Average unit length (ft) by surveyed subtype within the Study Area.

Habitat		Process reach ID and side channel						
Primary unit type	**Subtype**	**Mainstem (unit category 1)***	**Mainstem (unit categories 2 & 3)***	**SC1**	**SC2**	**SC3**	**SC4**	**Total average unit length (ft)**
Pool	Main channel	56	101	50	62	103	65	57
	Lateral scour	-	-	29 [1]	40	-		36
	Pool complex	-	-	66	-	-		66
	Backwater	129 [1]	-	-	-	-		129 [1]
	Pool (other)	-	-	32	-	-		32
Riffle	Low gradient	386	159	70	92	132	70	176
	Rapid	485 [1]	-	-	-	-		485 [1]
	Glide	755	195	76	94	145	55	236

Habitat		**Process reach ID and side channel**						
Primary unit type	**Subtype**	**Mainstem (unit category 1)***	**Mainstem (unit categories 2 & 3)***	**SC1**	**SC2**	**SC3**	**SC4**	**Total average unit length (ft)**
Other	Island	490	239	55	-	230[1]		282
	Alcove		48 [1]					48 [1]
	Marsh			43 [1]				43 [1]
	Dry channel	58 [1]		275				221
Total average unit length (ft)		339	169	80	67	153	63	157

* Mainstem (unit category 1) includes primary main channel units. Mainstem (unit categories 2 and 3) includes secondary main channel habitat units (units that did not span the entire river channel) and side channel habitat units separated from the main channel by an island.

[1] Indicates measurement of a single unit (i.e., not an average value).

4.1.1.1 Additional pool habitat unit attributes

Where possible, the apparent primary factor responsible for each pool's formation was recorded during field survey efforts, as specified in the study plan. Within the Study Area, 45% of the pools were either formed or were constructed adjacent to engineered wood (Table 10). Two of the eight large engineered log structures had pools formed or created in front of them. For the remaining pools, channel bedform (18%), resistant bank (18%), or LWD (l8%) were primary factors in their formation.

Table 10. Primary pool-forming factors for habitat units surveyed in the Study Area.

Pool-forming factor	Process reach ID and side channel						Total
	Mainstem (category 1)*	Mainstem (categories 2 & 3)*	SC1	SC2	SC3	SC4	
Roots of standing trees or stumps (Field code 4)	-	-	-	-	-	-	0
Boulder(s) (Field code 5)	0	0	0	0	0	1	1
Bedrock (Field code 6)	-	-	-	-	-	-	0
Channel Bedform (Field code 7)	0	2	0	4	3	1	10
Resistant Bank (Field code 8)	0	0	0	5	0	0	5
Artificial Bank (Field code 9)	-	-	-	-	-	-	0
LWD (logs) (Field Code 1)	0	1	0	0	0	0	1
Engineered Log Structure Associated	2	1	0	1	0	1	5
Total	**2**	**4**	**0**	**10**	**3**	**3**	**22**

* Mainstem (category 1) includes primary main channel units. Mainstem (categories 2 and 3) includes secondary main channel habitat units (units that did not span the entire river channel) and side channel habitat units separated from the main channel by an island.

Residual pool depth measurements for a given stream provide the number and spatial distribution of deep pool habitats that can support aquatic life, even through annual low-flow periods. Residual pool depth is the maximum wetted depth minus the wetted pool crest depth (Lisle 1987). In all cases, the average residual pool depth was 1.5 ft, with the first quartile measuring 0.96 ft. Median residual pool depths were comparable between reaches, ranging from 1.25 ft (SC1) to 3.4 ft (SC3). Residual depths were most variable in the mainstem (Figure 3). The smaller channels in the mainstem (categories 2 and 3) have greater residual pool depth because their downstream controls tend to be much shallower than the large mainstem pools[2]. SC3 is a natural channel and not recently constructed, which may explain its deeper residual pool depth than those measured in SC1, SC2 and SC4.

[2] Residual pool depths in the large mainstem portions of the river may be slightly less accurate. In some locations, low visibility or inability to wade to the deepest portion of the pool made it difficult to locate maximum depth accurately, in which case the field crew estimated the maximum depth.

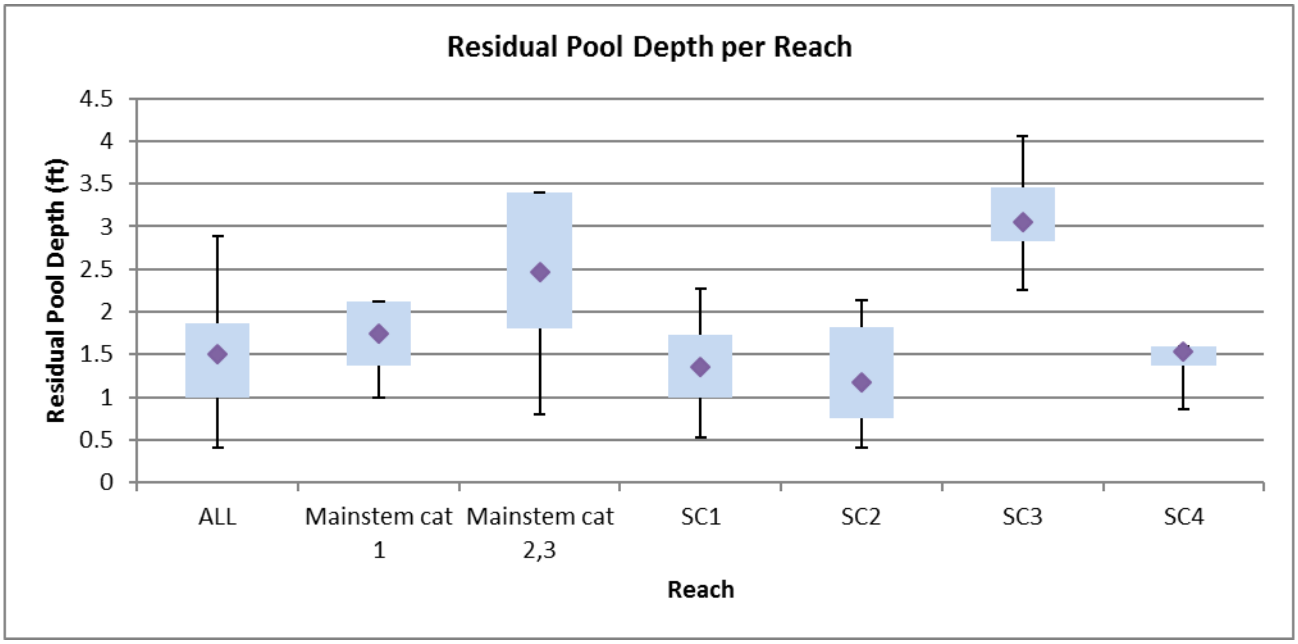


Figure 3. Box-and-whisker plots of surveyed residual pool depth by survey reach. The boundary of a box closest to zero indicates the 25th percentile, the diamond within a box marks the median, and the boundary of a box farthest from zero indicates the 75th percentile. Box whiskers indicate the minimum and maximum values.

4.1.1.2 Bar edge and undercut habitat attributes

Bar edge habitat is used by emergent juvenile salmon during spring and early summer rearing periods because of their conditions of low velocity and shallow depth, and juvenile salmon are found primarily in low-gradient riffle and glide habitats (Figure 4). Bar edge and undercut bank habitats were estimated as the percent of the unit length on either the right or left edges of each habitat unit. Results were calculated as cumulative averages for both sides of the stream (i.e., left and right combined).

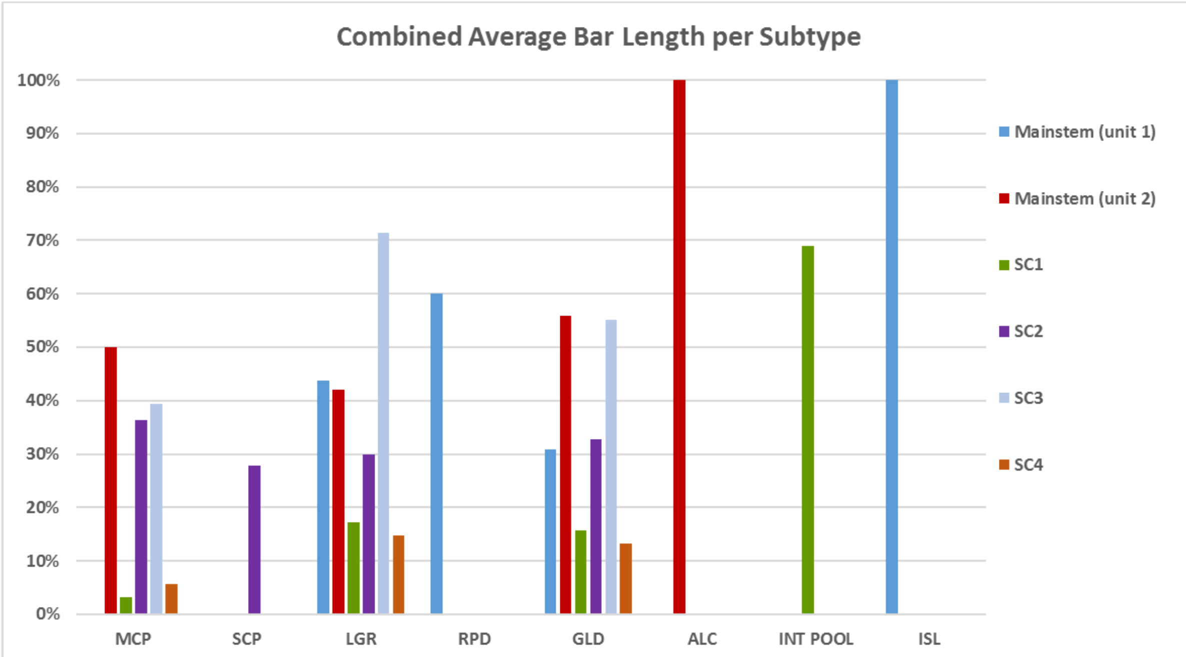


Figure 4. Average length (expressed as a percent) of bar edge per subtype by reach in the lowermost 2.7 miles of the Sultan River, including side channels. Habitat subtypes are as listed in Table 5: Main channel pool (MCP), lateral scour (SCP), low-gradient riffle (LGR), rapid (RPD), glide (GLD), alcove (ALC), intermittent pool (INT POOL), and island (ISL).

Within the total surveyed Study Area, measured bar edge habitat appears to constitute approximately 30% of stream length, and is most abundant in SC3 (55% of total stream length) (Table 11). Uncertainties in the accuracy and the replicability of this parameter, however, raise questions about the accuracy of these measurements in this and other surveys (see Section 5.4 for a more complete discussion).

Table 11. Average combined lengths of left and right bar edges for each reach per subtype (ft).

Habitat		Process reach ID and side channel											
Primary unit type	Subtype	Mainstem (category 1)		Mainstem (categories 2 & 3)		SC1		SC2		SC3		SC4	
		Avg length (ft)	% of total	Avg length (ft)	% of total	Avg length (ft)	% of total	Avg length (ft)	% of total	Avg length (ft)	% of total	Avg length (ft)	% of total
Pool	Main channel	0	0%	203	50%	58	3%	122	38%	124	40%	38	6%
	Lateral scour	0	0%	0	0%	0	0%	26	32%	0	0%	0	0%
	Intermittent	0	0%	0	0%	212	68%	0	0%	0	0%	0	0%
Riffle	Low-gradient riffle	2,636	47%	1,066	40%	153	18%	216	29%	834	70%	48	14%
	Rapid	291	60%	0	0%	0	0%	0	0%	0	0%	0	0%
	Glide	3,001	31%	454	58%	275	16%	227	34%	561	55%	54	14%
Other	Alcove	0	0%	48	100%	0	0%	0	0%	0	0%	0	0%
	Marsh	0	0%	0	0%	43	100%	0	0%	0	0%	0	0%

Undercut banks associated with habitat units provide refuge—cover and habitat complexity for fish and other aquatic organisms. Undercut banks are much less common than bar edges, but they were nonetheless present within all of the reaches. Across all reaches, undercut bank features were present in only 4% of total stream length, and so a detailed accounting of their locations is not provided here. They were predominantly found alongside glides (7% of total main channel pool stream length in the study area). The fraction of undercut habitat within each reach relative to twice the reach's total length (to account for the two banks) was measured as approximately 20% in SC2 and 16% in SC4, but <5% in the mainstem and the other two side channels.

4.1.2 Results: large woody debris (LWD) survey

The density of LWD can be presented using a variety of metrics. For this report, density of LWD is presented as pieces per mile of stream channel (Table 12). Only naturally occurring LWD was tallied (see Section 4.1.2.3 below for a discussion of the LWD in engineered wood structures). In some locations it was unclear whether the wood occurred naturally or had been placed as part of stream enhancement. Where the origin of the wood was ambiguous, it was assumed to be "natural" LWD. Maps indicating the distribution of LWD by habitat unit are included as Appendix D.

4.1.2.1 LWD—individual pieces

Data collected for individual LWD pieces included categories of piece diameter, length estimates, species type, and decay class. For purposes of the survey, individual LWD pieces were tallied separate from pieces occurring within debris jams. Nearly half (46%) of all individual LWD pieces were downed trees of a small diameter class (20 to 40 cm); 41% were of medium diameter (>40–60 cm) and 13% were of large diameter (>60 cm).

Table 12. LWD density per mile in the Study Area[1].

Survey reach	Length (mi)	LWD density per mile: individual pieces only	LWD density per mile: individual pieces and debris jam pieces
Mainstem	2.7	42	70
SC1	0.6	73	73
SC2	0.4	43	105
SC3	0.4	35	35
SC4	0.3	30	30

[1] In addition, 16 wood pieces were rootwads and are not included in these tallies.

The position of LWD within the bankfull channel was also recorded. Wood was classified on whether it was primarily (greater than 50%) in the wetted channel (Zone 1) or within the bankfull width (Zone 2). LWD pieces in the wetted channel were also further differentiated if any part of the LWD extended to mid-channel. The position of LWD within the channel is relevant to understanding how LWD contributes to habitat complexity by affecting channel hydraulics at different river discharges (Ralph et al. 1994, Montgomery et al. 1995). Within the Study Area, most (76%) of individual LWD pieces tallied were primarily within the wetted river channel (Zone 1), with 42% of those extending into mid-channel. The remaining 24% of the individual LWD pieces were primarily in Zone 2.

Tree species type and decay class were identified for all individual LWD pieces. Throughout the total surveyed Study Area, species composition was 61% unknown species (classified as such due to a lack of bark or otherwise identifying features), 18% coniferous species, and 21% deciduous species. Using a decay class scale of 1 to 5, where 1 indicates the lowest state of decay and 5 indicates the highest state of decay, less than half (37%) of individual LWD pieces were within decay classes 1 to 3, indicating that they are of fairly recent (i.e., the last few decades) origin.

4.1.2.2 LWD—jams

Within the Study Area, there were five natural debris jams within the wetted portion of the river channel at the time of the survey. This includes a jam in habitat unit 36, a jam in habitat unit 93 at the mouth of SC4 (accumulated against an engineered structure), a jam on the tip of an island in habitat unit 81, a jam at habitat unit 58, and a jam in SC2 (unit 2-16). The jams in habitat unit 36 and 93 were also present in 2014.

4.1.2.3 LWD—engineered wood

A large amount of engineered LWD was installed as bank-side structures in the mainstem, and as single logs to multi-log structures in each of the side channels. The 2014 report tallied the structures present. During the 2016 survey, the focus in regard to engineered wood was to document instances of scour at, and natural wood accumulation against, the engineered wood. When scour forms at installed structures or natural LWD accumulates, the increased channel complexity can be utilized by juvenile salmonids. Table 13 illustrates those structures that have either contributed to scour or had an accumulation of additional natural wood. Other structures that have not resulted in either still provide habitat and may result in the formation of pools or larger wood accumulations in the future.

Table 13. Engineered structures that have caused scour or accumulated natural LWD.

NSO #	# of logs in engineered structure*	Scour dimensions		Natural accumulation (# of logs)**	Comments
		Length (ft)	Max depth (ft)		
93a	15	30	3.9	12	Natural accumulation against a log structure at the head of SC4.
89	20	35	2.5	0	Scour at engineered structure. Large natural log near (but not against) the engineered structure contributed to the scour.
80	15	8	2.5		At the mouth of SC1. Pool small and was not habitat typed as its own unit.
79	15	10	2.5		Not certain that this scour caused by engineered structure.
79a	12	36	3.1		This jam formed unit 79a.
69	10	20	2		Located at the head of unit 69. Did not type the scour as a separate pool unit.
47	3			3	Accumulated 3 large logs as well as smaller debris.

NSO #	# of logs in engineered structure*	Scour dimensions		Natural accumulation (# of logs)**	Comments
		Length (ft)	Max depth (ft)		
SC2-4	3			5	This is a one-log structure on the left bank and a two-log structure on the right bank, with five logs and smaller debris accumulated against them. Scour just starting to form.
SC2-10	1	72	2.3	1	This forms unit SC2-10. Has one log and some smaller debris accumulation.
SC2-13	2	40	2.8	3	Forms pool SC2-13A.
SC2-14	3			8	This is a one-log structure on the right bank and a two-log structure on the left bank, with eight logs and smaller debris accumulated against them.
SC2-15A	1	111	2.7		Caused about one-half of the scour forming unit SC2-15a.
SC2-15A	2			1	Two structures, each of one log. One on right bank, one on left.
SC4-1D	3	52	2.7	3	These structures form pool SC4-1D.
SC4-1D	2			2	
SC4-1F	1	63	1.75		Forms unit SC4-1F, with some influence from a mid-channel boulder.
SC4-1G	2	24	1.95		Forms unit SC4-1H.
SC4-1I	7	51	2.7		A series of structures, one with one log and three with two logs form unit SC4-1J.
SC4-1N	4	51	2.6		Forms unit SC4-1N.
SC4-1O	1	10	3		This small scour is included in glide unit 1O.
SC4-1R	5	201	3		Two structure, one with two logs, one with three form unit SC4-1R.
SC4-1T	1	8	2.5		Not delineated as a separate pool.
SC1-2E	1	36	1.55		Forms unit SC1-2E.
SC1-2J	1	7	.75		Within a larger glide unit. Both areas of scour too small to delineate individually.
SC1-2J	1	6	1		
SC1-2M	3	27	2.2		Three structures totaling three logs form pool SC1-2J.
SC1-2O	11	81	2.32		Four separate structures form pool SC1-2O.
SC1-2Q	4	6	1.5		Four log structure forming small pool at downstream end of a glide.
SC1-2Y	1	8	0.5		Small amount of scour at one of five structures in SC1-2Y.

NSO #	# of logs in engineered structure*	Scour dimensions		Natural accumulation (# of logs)**	Comments
		Length (ft)	Max depth (ft)		
SC1-2Y	2			5	Accumulation on a left bank structure in SC1-2Y.
SC1-2Y	6	10	1.5		Multi-log structure forming a small scour pool.
SC1-2Y	2	12	1		Mid-channel structure with a small amount of scour.
SC1-3A	1	50	2.2	4	Accumulation against a log structure forms unit SC1-3a.
SC1-3B	4			2	No noticeable scour.
SC1-2AA	4	33	1.6		Forms unit SC1-2AA. Accumulation of small debris against a mid-channel structure.
SC1-6A	3	27	1.9		Forms unit SC1.6A, but barely extends into wetted channel at low flow.
SC1-11A	3	63	1.6		Forms SC1-11A.
SC1-11D	2	24	1.15		Forms SC1-11D.
SC1-11G	1	25	1.5		Forms SC1-11G.
SC1-11I	1	24	1.4		Forms SC1-11I.

* Numbers of logs in debris structures are approximate. Exact numbers are difficult to count due to overlap and burial in bank.

** Natural accumulation is the number of logs that meet the criteria for LWD. In many cases structures had also accumulated smaller debris.

In general, engineered wood is beginning to influence morphology—both forming pools and accumulating additional woody debris. Table 14 summarizes the number of pools formed and the debris accumulated in each reach.

Table 14. Changes in morphology due to engineered wood.

Survey reach	# of structures influencing morphology	Pools formed	LWD pieces accumulated
Mainstem	6	6	12
SC1	18	16	11
SC2	6	3	18
SC3	1	0	3
SC4	9	8	5

4.1.3 Characterization of river channel substrate

Sediment sizes are typically reported as percentiles of the intermediate diameter of sediment clasts on a bar or the bed of the river, notated as "D" with a subscript representing the percentage of particles smaller than that size (so, for example, D_{50} is the 50th percentile, or median substrate size) (Wolman 1954). Results from Wolman pebble counts are presented in Table 15.

Table 15. Approximate size distribution (in mm) of river substrate material from sample sites throughout the Study Area.

Reach*	Unit number containing sample	Stream substrate particle size (mm)		
		D_{16}	D_{50}	D_{84}
Mainstem	89	10	53	96
SC1	11	4	27	83
SC2	16	16	50	110
SC4	1	10	31	70

* Because pebble counts have not previously been conducted in SC3, there would be no historical data to compare, and thus no pebble counts were conducted in SC3 in 2016.

The pebble counts indicated that the gravel patches assessed were all suitable for spawning (i.e., D_{50} between 20 to 60 mm). Although Wolman counts cannot discriminate particles below 4 mm diameter, the reported sizes of D_{16} strongly suggest that the other grain-size criterion for suitable spawning (i.e., no more than 10% finer than 0.85 mm) was also met.

5 DISCUSSION

5.1 Riverine Habitat Characteristics

The primary objective of this 2016 study was to identify any significant changes that have occurred and that could affect fish habitat since the previous studies in the lower 2.7 miles of the mainstem Sultan River and its four side channels.

When comparing the 2016 to data from 2007, 2010, and 2014, the following general observations were made:

- A total of 230 in-river habitat units were surveyed within the Study Area. This is a substantial increase of 119 units, essentially twice the number of units identified in 2014. This is not an artifact of changes in sampling methodology but rather an expression of greater spatial diversity in habitat units, indicating that the recent high-flow event, stream enhancements, and other natural processes are facilitating geomorphic and hydrologic changes that could contribute to an increase in complexity in the study area. The majority of these changes occurred in the side channels.
- Habitat subtypes not previously observed were identified and defined for inclusion in the current (and any future) survey. These "new" subtypes are intermittent and isolated pools, dry channels, alcoves, and marshes. Conversely, the previously observed habitat type of subsurface flow habitat was no longer present in 2016.
- The percent of total surface area of each subtype in the Study Area in both 2014 and 2016 was not greatly changed from what existed in in 2007, but some systematic trends have become evident. In particular, glide habitat is being converted into more complex habitat, particularly pool-riffle-glide complexes, and substantially more island habitat has been created (Table 16).

Table 16. Comparison of percent total surface area of habitat subtypes for 2007, 2014, and 2016.

Year	Habitat subtype			
	Glide	Low-gradient riffle	Islands	Pools
2007	66	29	6	<1
2014	55	25	16	4.3
2016	47	26	23	2.9

- There was a substantial loss of measured bar edge habitat between 2014 and 2016. The mainstem and SC4 had the greatest apparent loss of bar edge. Compared to the bar edge measured in 2014, only 80% left bar edge and 55% right bar edge remained in 2016. This unusual result is discussed in greater detail below (Section 5.4); it is judged unlikely to reflect an actual change in riverine habitat but instead highlights an inherently noisy and unreliable parameter for repeat measurements over time. As such, it is advised to omit this parameter from future surveys.
- Compared to 2014, there is an increase in the average combined length (left and right) of undercut banks present in the side channels. In 2014 for SC2, undercut habitat accounted for 12% of the total cumulative perimeter length and in 2016 it accounted for 20% (Table 17). Mainstem undercut habitat remained largely unchanged.

Table 17. Comparison of combined left and right undercut banks as a percentage of total cumulative perimeter length per reach in 2014 and 2016.

Reach	Percent total cumulative perimeter length of undercut banks (combined left and right)	
	2014	2016
Mainstem (unit 1)	0%	2%
Mainstem (units 2,3)	1%	3%
SC1	4%	4%
SC2	12%	20%
SC3	0%	1%
SC4	0%	12%

5.1.1 Main channel

Mainstem habitat unit changes constituted ~10% of total bank length, along with localized changes in the vicinity of the engineered log structures. Specifically, the following changes were noted:

- undercut lengths decreased by 113 ft on the left bank and increased by 609 ft on the right bank; and
- average wetted widths were largely unchanged from previous studies, indicating the storm event experienced by the river system was not so extreme as to cause measurable bank erosion.

5.1.2 Side channels

The four side channels vary in their complexity, with SC1 having the most varied and generally smaller individual habitat units. The enhancement of the side channels has led to increased numbers of distinct habitat units, even during low flows, as outlined in the Results section. There has been a gain of 636 ft in low-flow stream channel length since 2014 (Table 18) spread amongst all side channels except SC4, adding the potential for greater habitat complexity and refugia. In SC1, however, there are now stretches of dry channel, and some glides and riffles have been transformed into a series of intermittent, isolated, and complex pools that have locally reduced aquatic habitat and connectivity.

Table 18. Side channel length comparisons from 2010, 2014, and 2016 data.

Side channel	2007 and 2010 lengths (ft)	2014 digitized lengths (ft)	Change, 2007/ 2010–2014	2016 digitized lengths (ft)	Change, 2014–2016
SC1	2,512	5,744	+3,232	5,995	+251
SC2	1,735	1,722	-13	1,802	+80
SC3	2,202	2,350	+148	2,740	+390
SC4	No Data	1,467	–	1,382	-85

SC1

SC1 was previously surveyed for habitat in 2010 before enhancements were made to the channel. The 2010 survey did not include the southerly extension (units SC1-1 and SC1-2 of the 2014 survey). In 2014, after enhancements were made, SC1 was substantially lengthened but still largely uniform, consisting mostly of glides with smaller amounts of pools and riffles (Figure 5). The pools mostly appear to have been constructed or have formed at installed large woody debris. There were some deeper areas beginning to form at large wood structures within the glides, and the 2014 report anticipated that habitat complexity would increase with additional high-flow events.

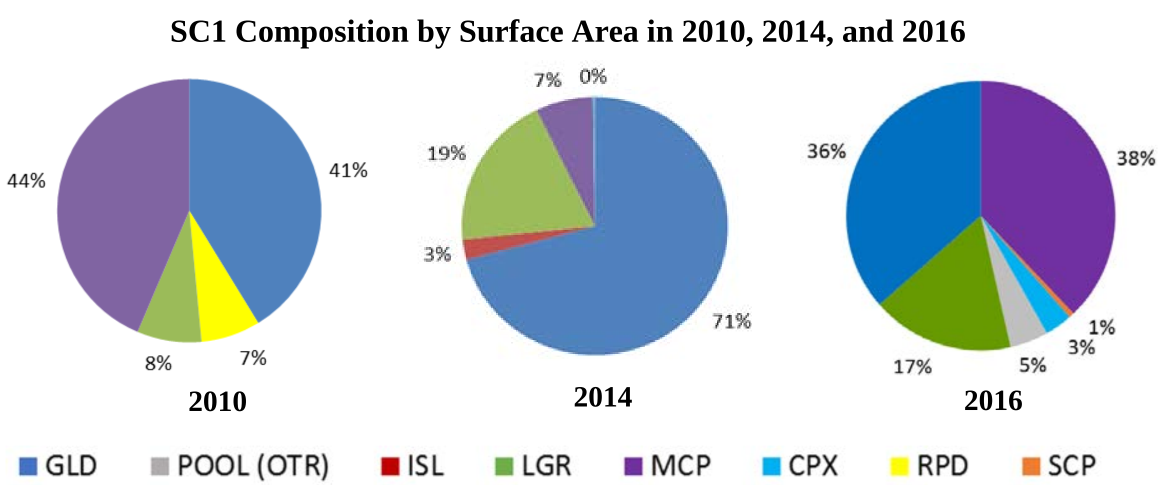


Figure 5. Comparison of SC1 composition by surface area in 2010, 2014, and 2016. Habitat subtypes are as listed in Table 5: Glide (GLD), Intermittent and isolated pools POOL (OTR), high gradient riffle (HGR), island (ISL), low-gradient riffle (LGR), main channel pool (MCP), pool complexes (CPX), rapid (RPD), and lateral scour (SCP).

Since 2014, SC1 has evolved from a relatively homogenous channel that comprised 18 units (primarily main channel pools, low-gradient riffles, and glides) to one that is now made up of 93 units including 35 pools, stretches of dry channels and isolated pools, as well as a marsh, islands, and glides and low-gradient riffles.

Though more complex in terms of number of distinct units that constitute the channel, the ability for SC1 to maintain cool-water refugia and channel connectivity has been compromised due to the decreasing depths and channel widths, and the stretches of dry channels and intermittent pools (which were observed to contain small fish) (Figure 6). The decreases in average wetted widths in this channel were mainly observed in glides and main channel pools, with average wetted widths for these subtypes decreasing from 2016 to 2014 by 4.4 and 4.9 ft, respectively. Average depths in SC1 were shallower (0.61 ft in 2016 compared to 0.94 ft in 2014), which could potentially affect the channel's ability to maintain cool water temperatures and support native fish. Water temperatures during these lower flow periods are unknown, but the presence of isolated pools could lead to mortality either through thermal stress or avian predation.

Discharge from the mainstem into the inlet of SC1 during the habitat assessment of 2016 was little different from 2014 and does not explain these results. What has changed between these two surveys is the split of flow at near the midpoint of the side channel (at SC1-5), where a short segment of channel returns flow to the mainstem river while the side channel itself continues for more than 1,000 ft farther before rejoining the Sultan River. Although this distributary network has increased the total length of side channels it has also allowed for the natural redistribution of water between the branches, which at present favors the shorter return segment back to the mainstem at low flows and a consequent reduction in wetted area and an increase in areas of dry channel and marsh downstream of the split along the other segment.

Over SC1 as a whole, there was a net gain of 140 ft in undercut bank length. Some collapsed banks were observed, indicating that undercutting was supplying sediment to the channel. In these still-young side channels, morphological change to the banks can be expected to continue, and the contribution of sediment from those changes is apparently exceeding the ability of flows to fully remove that introduced sediment during a single high-flow event.

Figure 6. SC1 downstream of the distributary split in SC1-5 was locally dry in 2016 (left); in 2014, the channel was wet in its entirety (right) from the head to its outlet.

SC2

SC2 is more structurally complex than SC1, with generally smaller and less uniform habitat units. Since 2014, the channel has evolved from a somewhat variable channel that contained 15 distinct subtype units to an even more diverse stretch containing 25 subtype units, with changes in habitat mostly occurring in the side channel's upper reaches. LWD structures accumulated additional large wood and retained spawning gravels as predicted in 2014 and, as a result, additional pools (mainly main channel pools) have formed since the last survey.

When comparing 2014 and 2016 by surface area, results show an increase in pool and riffle habitat and a decrease in glide habitat (Figure 7). Other changes include:

- the subsurface unit at unit numbered SC1-9 is now classified as a dry channel due to the lack of visible standing water or discharge;
- stream length in the channel increased by 80 ft overall;
- average wetted widths for the lateral scour pools decreased from 31.9 ft in 2014 to 13.3 ft in 2016;
- depths in the channel in 2016 are on average half those observed in 2014, despite similar discharges during both measurements. This could be due to infilling or changes at the inlet that reduced discharge through the channel; and
- undercut lengths increased on both banks from the 2014 survey, with an additional 282 ft observed on the left and 15 additional ft observed on the right banks.

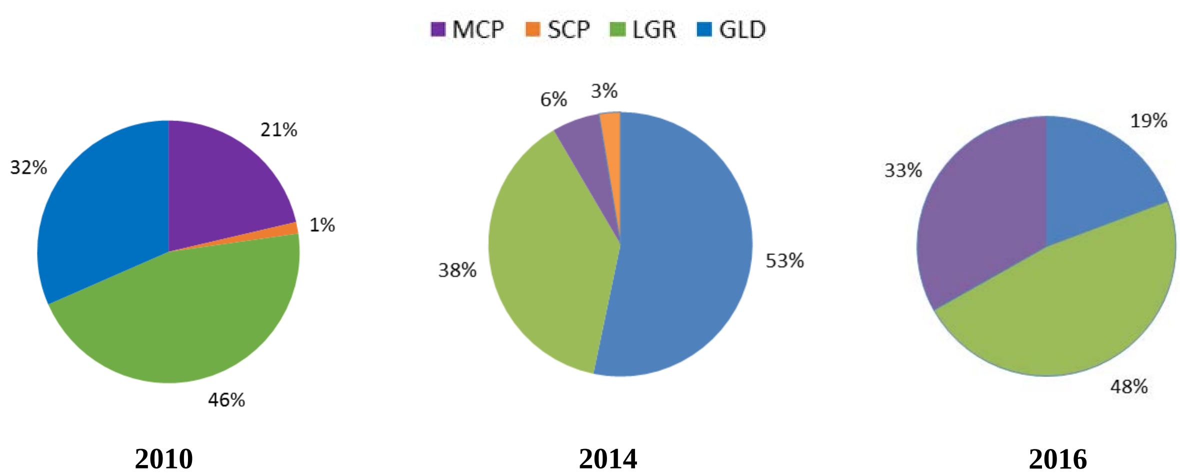


Figure 7. Comparison of SC2 composition by surface area in 2010, 2014, and 2016.

Figure 8. NSO SC2-15 was classified as a 274-ft-long glide in 2014 (left); as of the 2016 survey, it had become a shorter 45-ft glide surrounded by a large main channel pool and riffle (right).

SC3

The fraction of surface area per subtype in this side channel was unchanged between 2010 and 2014 (Figure 9). Between 2014 and 2016 relative areas were also similar, except for the loss of the island subtype previously measured, but with 20 distinct habitat subtypes in 2016 compared to 17 in 2014.

Additional changes in SC3 since 2014 include:

- the stream length increased by 390 ft (16%), likely due to increasing meander;
- average wetted width for main channel pools doubled, from 15.5 ft in 2014 to 31.2 ft in 2016; and
- undercut banks were not observed in any unit on the left bank and were observed to be present in only 34 ft of the right bank.

The effects of these changes on habitat and the resulting fish carrying capacity are likely inconsequential in aggregate.

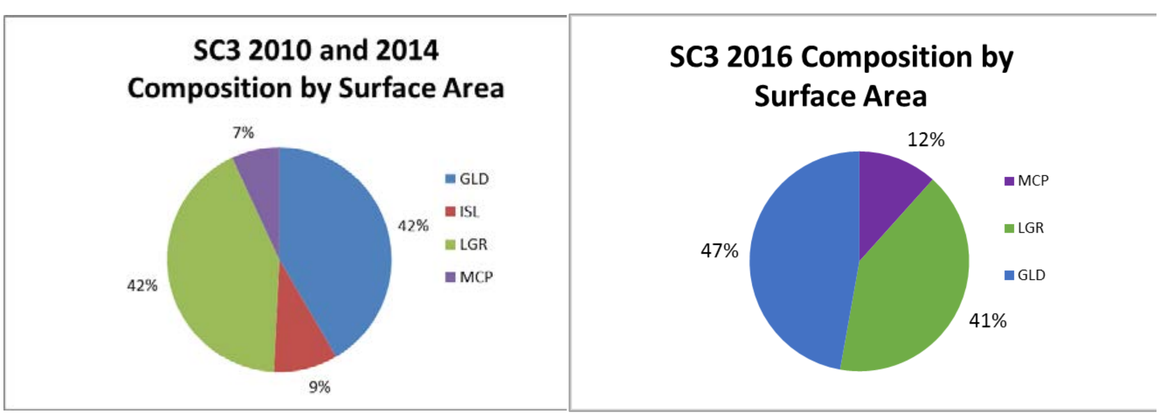


Figure 9. SC3 composition by surface area in 2010, 2014, and 2016.

SC4

The observed changes to SC4 were the most dramatic, and beneficial to fish habitat, of any side channel in the Study Area. Since 2014, SC4 has been transformed from essentially one long glide (with a small pool at its mouth and one riffle) to a variable pool-riffle-glide reach (Figure 10). Depths in SC4 now range from 0.8 to 2.7 ft, compared to 2014 when depths ranged from only 0.9 to 1.2 ft. The mixture of flows and depths derived from the more variable habitat now present is key to sustaining fish and invertebrate species. Undercut habitat also increased since 2014, by 392 ft on the left and 72 ft on the right banks.

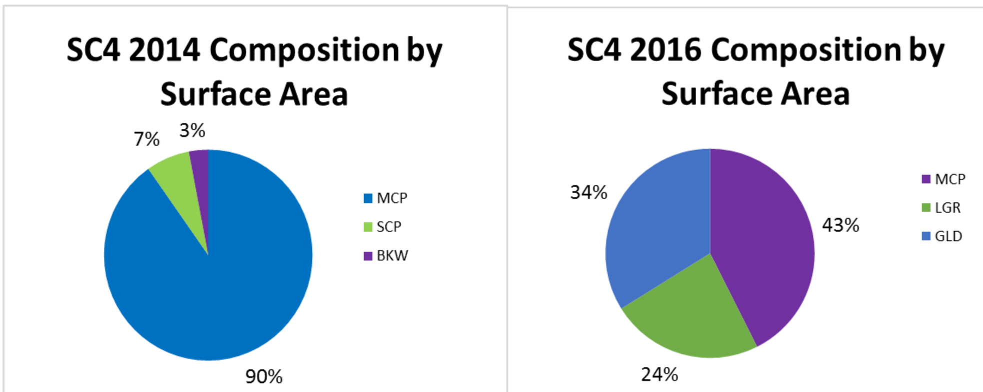


Figure 10. SC4 composition by surface area in 2014 and 2016.

In summary, the changes to habitat in this reach are positive, insofar as diversity of habitat supports the requirement of having variable and proximal freshwater habitats for the range of salmonid life stages, including those used for spawning, juvenile rearing, and migration of adults.

5.2 Large Woody Debris Characteristics

The total amount of LWD (number of logs) was remarkably similar between 2014 (216 pieces) and 2016 (214 pieces). Some obvious recruitment was observed (large trees in the channel due to bank erosion), and some wood was likely washed downstream out of the system by the high flows. There were some shifts in LWD distribution that can be best compared on the distribution maps and GIS layers from 2007, 2010, and 2014. In terms of number of pieces per mile, the amount of naturally occurring LWD was higher in the mainstem and SC2 (if debris jam pieces are included), and lower elsewhere (Table 19).

Most of the wood is individual pieces, with five jams (an increase of three jams over 2014). All jams were in the mainstem, except for one in SC2. The wood present was reported to be more decayed in 2016 than 2014, with 63% of the LWD classified in decay classes 4 or 5 in 2016, vs 43% in 2014, and 22% in 2007. It would not be expected that LWD (especially conifers) would visibly decay to that degree in two years, suggesting that this parameter may be subject to significant observer variability from year-to-year. Regardless of actual decay status, however, reaches with LWD offer more complex habitat than reaches that are completely lacking in LWD.

Table 19. LWD density per mile in the Study Area.

Survey reach	Length (mi)	LWD density per mile, individual pieces only		LWD density per mile, individual pieces plus debris jam pieces	
		2014	2016	2014	2016
Mainstem	2.7	36	42	53	70
SC1	0.6	83	73	83	73
SC2	0.4	68	43	68	105
SC3	0.4	55	35	55	35
SC4	0.3	17	30	17	30

The engineered log structures and LWD placed in 2012 were designed to provide habitat complexity, divert water into the side channels, retain gravel, provide bank habitat at varying flows, and roughen the flood plain. The engineered structures represent a significant increase in LWD in the mainstem over levels observed in 2007 and have begun to contribute to habitat complexity through the formation of pools and the accumulation and retention of natural LWD, which either may be limited in availability (due to the upstream dam) or flushed downstream and lost from the system, or both. The contribution to habitat complexity from the engineered LWD has increased significantly since 2014. This is especially noticeable in SC1 and SC4, as noted in the Section 4 (Results) above.

The structures and logs in the side channels are continuing to provide cover for fish over a range of flows. Structures have accumulated additional large wood and have led to the formation of additional pools and other habitat types since 2014. The structures are also well-positioned to serve as a catalyst for habitat change (e.g., accumulation of additional wood, retention of gravel, and increasing habitat complexity in the side channels) in the future.

5.3 Sediment Characteristics

Only one pebble count was conducted in 2007 in the Study Reach, and its location was revisited for 2014 and 2016 (Table 20). Additional pebble counts were conducted in 2014 in SC1, SC2, and SC4, which were again reproduced in 2016. The purpose of the 2016 study was to re-create previous surveys to assess habitat changes. Because there was no pre-existing particle size data for SC3, a pebble count was not conducted there in either 2014 or 2016, as there would not have been any comparisons to make.

The results of the mainstem pebble count indicate that while the D_{50} particle was very similar in size in 2016 to the 2014 result, the D_{16} particle was smaller and the D_{84} particle was larger, indicating a wider range of particle sizes in the reach (Table 20).

Table 20. Comparison of approximate size distribution (in mm) of river substrate in the Study Reach for 2007, 2014 and 2016.

Year	Unit number	Stream substrate particle size (mm)		
		D_{16}	D_{50}	D_{84}
2007*	89	23	39	63
2014		22	51	84
2016		10	53	96

* The size distributions for this site were erroneously reported in RSP 22; values reported here were recalculated from the raw field data.

This result generally held true in SC1 and SC4: similar median particle size with a wider range in 2016 when compared to 2014. SC2 had results that were quite similar across the size distribution, although all representative particle classes were somewhat smaller in 2016 vs 2014, as was the overall particle size range (Table 21).

Table 21. Comparison of approximate size distribution (in mm) of river substrate in the side channels between 2014 and 2016.

Year	Unit number	Stream substrate particle size (mm)		
		D_{16}	D_{50}	D_{84}
SC1				
2014	11	3	23	50
2016	11-I	4	27	83
SC2				
2014	16	25	62	129
2016	16	16	50	110
SC4				
2014	1	5	23	49
2016	1Q	10	31	70

The variations seen could be the result of a number of factors and are well within the reported range of interannual variability, although none of them influence the underlying conclusion that the riffle substrates have been of a suitable size range for spawning throughout the nine years that sampling has occurred.

5.4 Variability and Uncertainty in Bar Edge Habitat Measurements

The reported changes in bar edge habitat over time (as noted in Section 5.1) are not readily explained by physical changes to the channel, despite the apparent magnitude of loss between 2014 and 2016. They likely represent not only actual changes in some bar edges but also the difficulty in applying a uniform criterion for their identification. Beechie et al. (2005) identified the boundary between edge units (such as bar edge habitat) and midchannel units by "a visible current shear line, the edge units having lower velocity…bars [edge habitat] had a shallow, low-gradient interface with the shore" (p. 719). This is not a very precise definition, particularly when observed at low flows when the velocity of the flow is low and so a "shear line" may be obscure or absent altogether. We also note that this habitat type is not common in most such characterizations (e.g., Frissell et al. 1986, Hawkins et al. 1993)

In this survey, the changes in the bar edges in the mainstem Sultan River recorded between 2014 and 2016 are particularly uncertain, based on comparison of the tabulated data with field photos and airphotos. This disparity is likely to have resulted in large part from the inaccuracies inherent in making long-distance observations, given that crossing the mainstem from one side to the other was typically precluded by the water depth over most habitat units. We also note that there was no spatial pattern to recorded differences between the two years, with apparent reductions spread from the top to the bottom of the study reach, and with no particular area being more or less affected. A true geomorphic basis for these differences would almost certainly have expressed some spatial variability, since bank and bar formation is not uniform through any reach of a river.

For all of these reasons, the seemingly dramatic reduction in this habitat unit is most likely a consequence of trying to measure an intrinsically ambiguous parameter, prone to observational differences from one year to another even with the same observer, and one whose defining characteristics are poorly expressed during the very flow conditions that are required for other, more critical elements of the survey. Thus, we recommend that this parameter be abandoned in future years' surveys.

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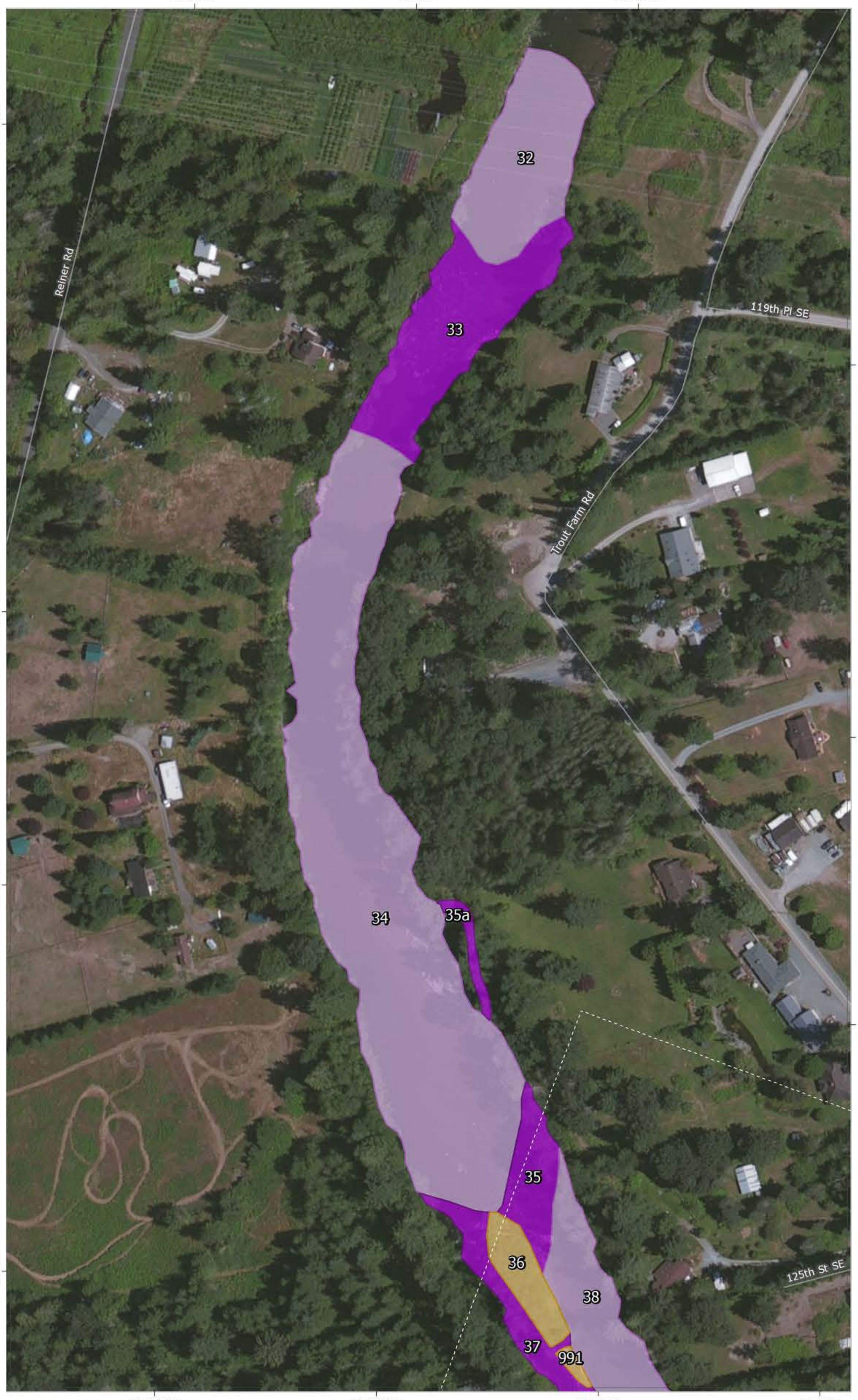
Appendices

Appendix A

Maps Illustrating 2014 Habitat Units

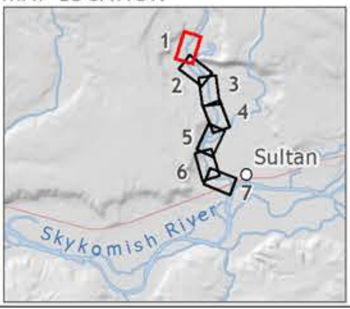


SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

Glide | Low-gradient riffle | Rapid
Island | Main channel pool | Subsurface flow

MAP LOCATION



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DATA SOURCES
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Roads: ESRI 2014

Stillwater Sciences
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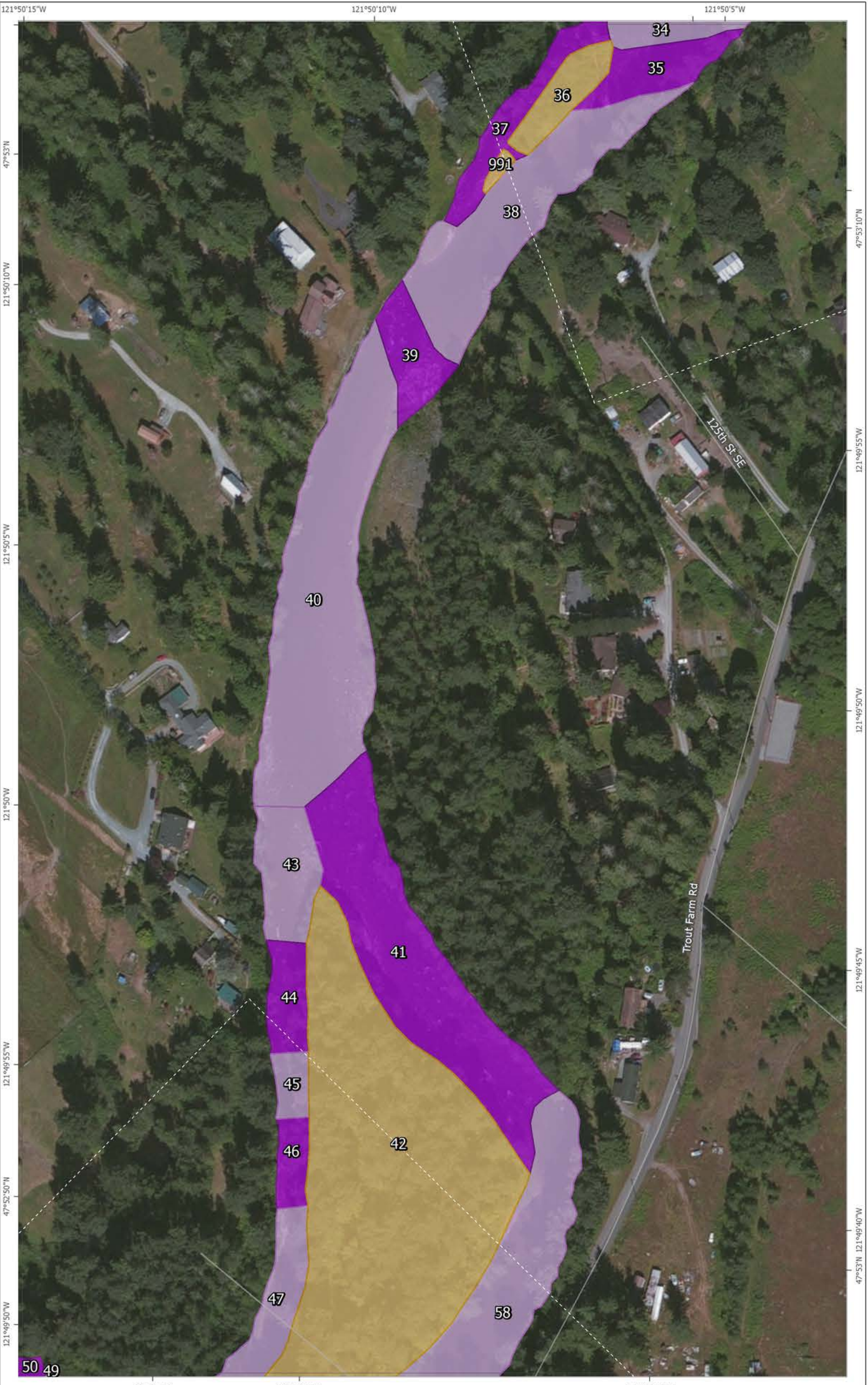
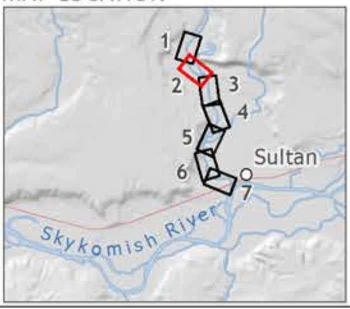


SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

- Glide
- Low-gradient riffle
- Rapid
- Island
- Main channel pool
- Subsurface flow

MAP LOCATION



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1:2,100 1 in = 175 feet

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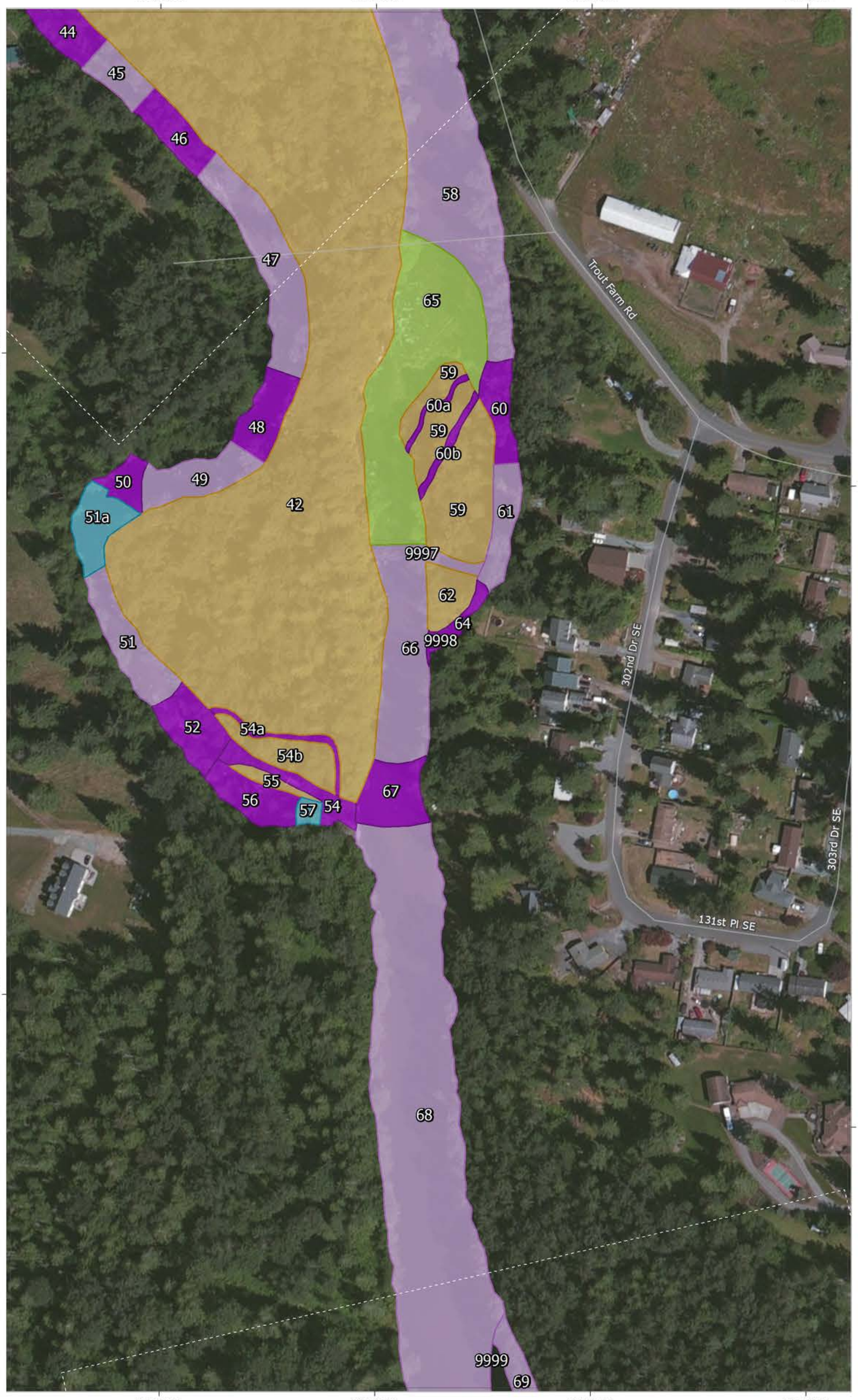
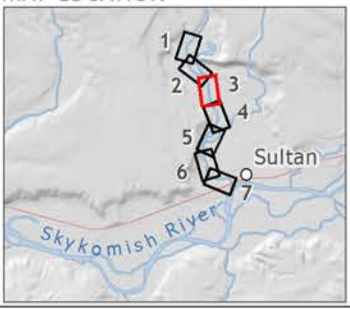


SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

MAP LOCATION



Glide	Low-gradient riffle	Rapid
Island	Main channel pool	Subsurface flow

0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

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SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

MAP LOCATION

Glide | Low-gradient riffle | Rapid

Island | Main channel pool | Subsurface flow

0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

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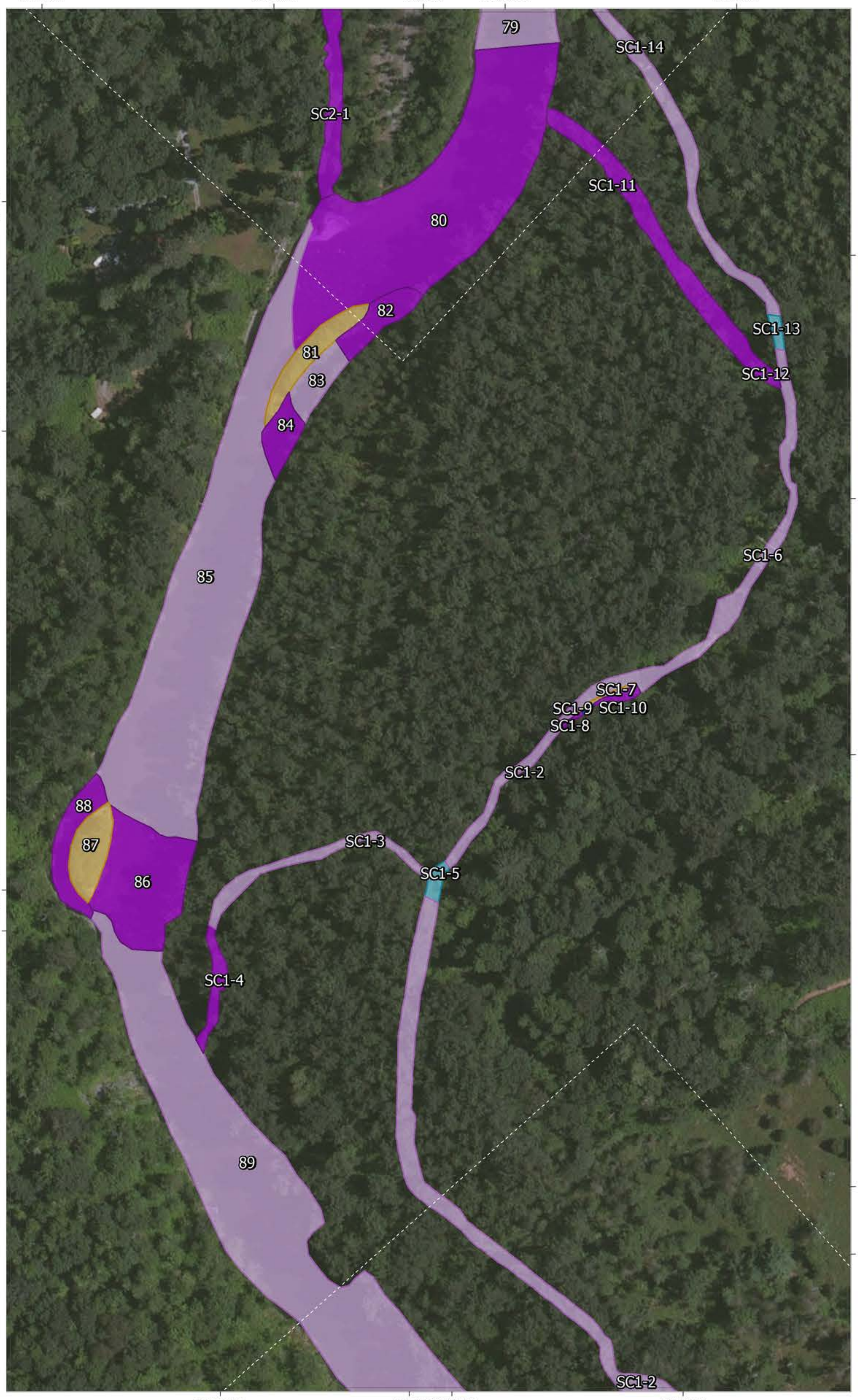
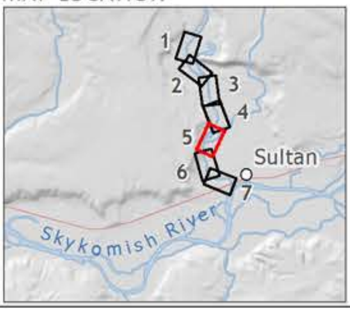


SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

Glide | Low-gradient riffle | Rapid
Island | Main channel pool | Subsurface flow

MAP LOCATION



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Roads: ESRI 2014

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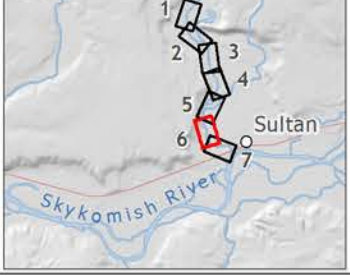
SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

- Glide
- Low-gradient riffle
- Rapid
- Island
- Main channel pool
- Subsurface flow

MAP LOCATION



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1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
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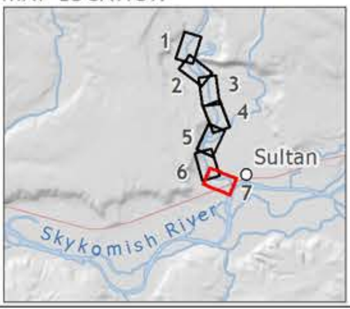
SULTAN RIVER LARGE WOODY DEBRIS

Habitat Types

Glide | Low-gradient riffle | Rapid
Island | Main channel pool | Subsurface flow

MAP LOCATION

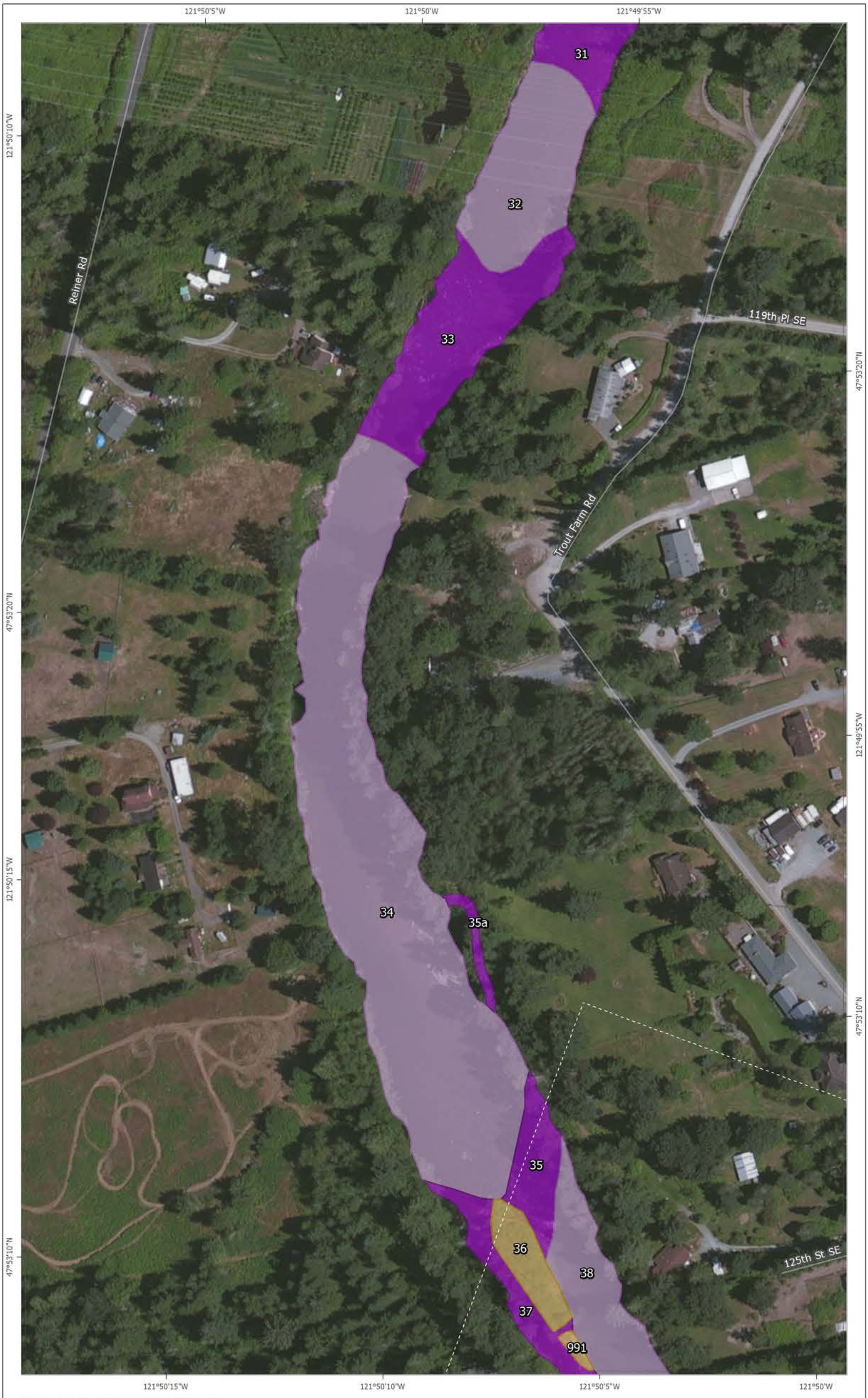


0 100 200 400 Feet
0 25 50 100 Meters
1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

Appendix B
Maps Illustrating 2016 Habitat Units



SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Low-gradient riffle

MAP LOCATION

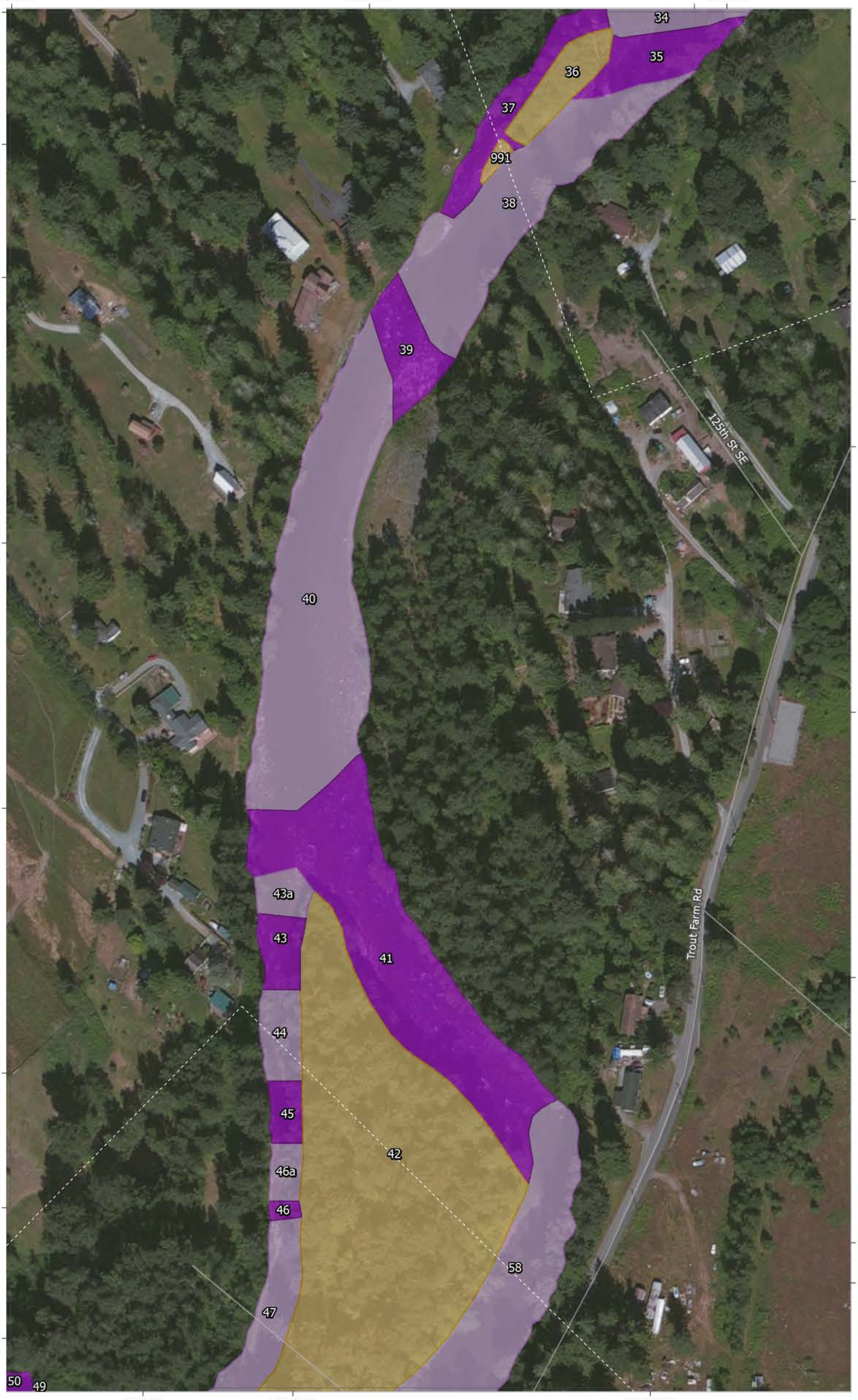
0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

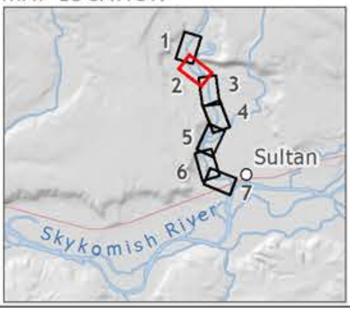


SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Low-gradient riffle

MAP LOCATION



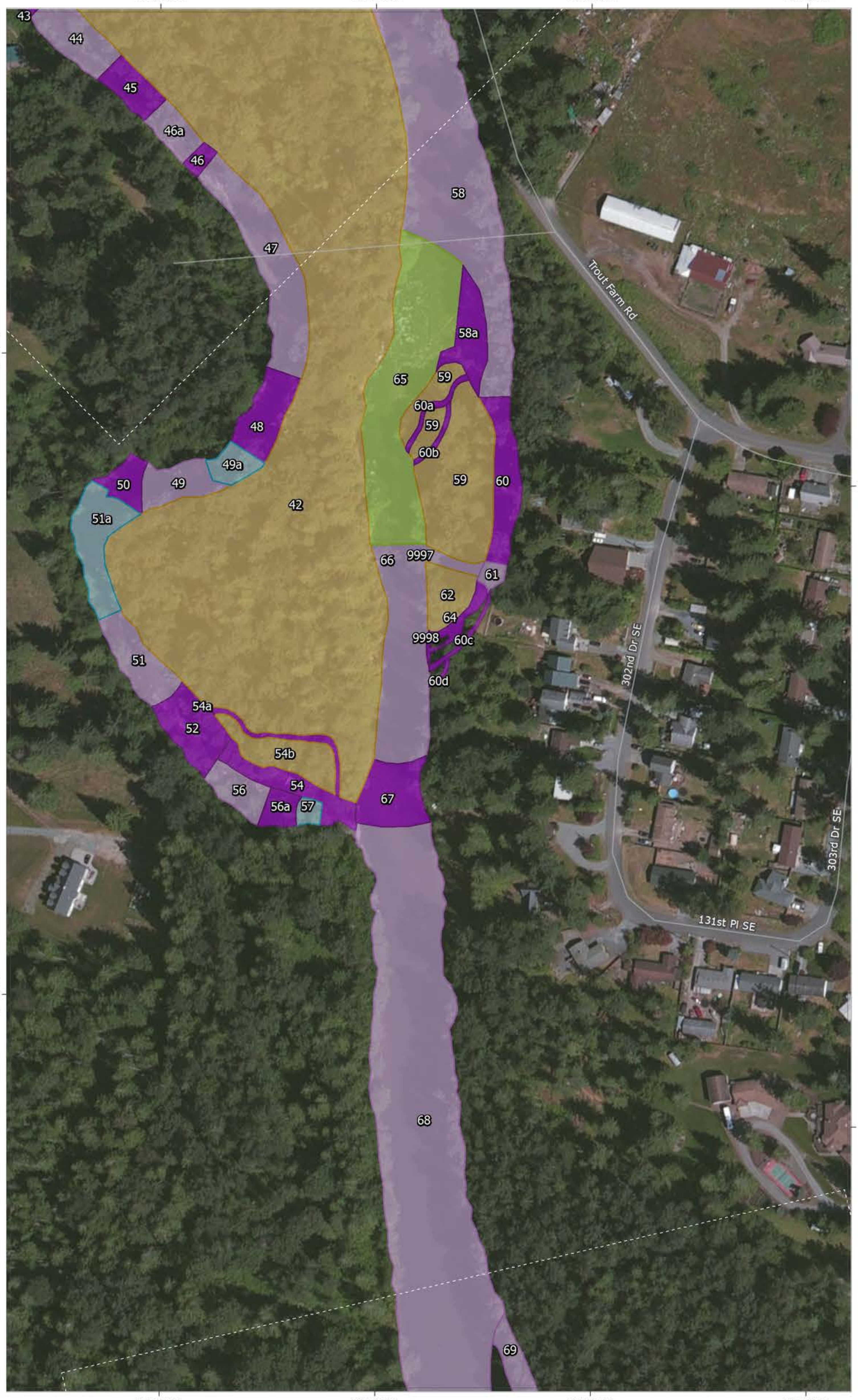
0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

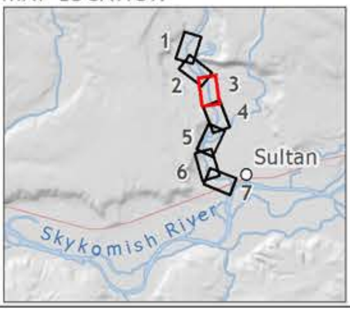


SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Main channel pool
- Low-gradient riffle
- Rapid

MAP LOCATION



0 100 200 400 Feet
0 25 50 100 Meters
1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

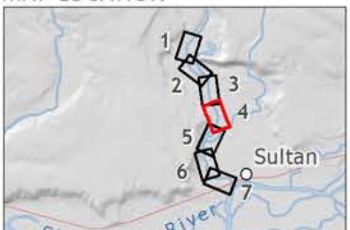
Stillwater Sciences
www.stillwatersci.com

SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Main channel pool
- Low-gradient riffle

MAP LOCATION



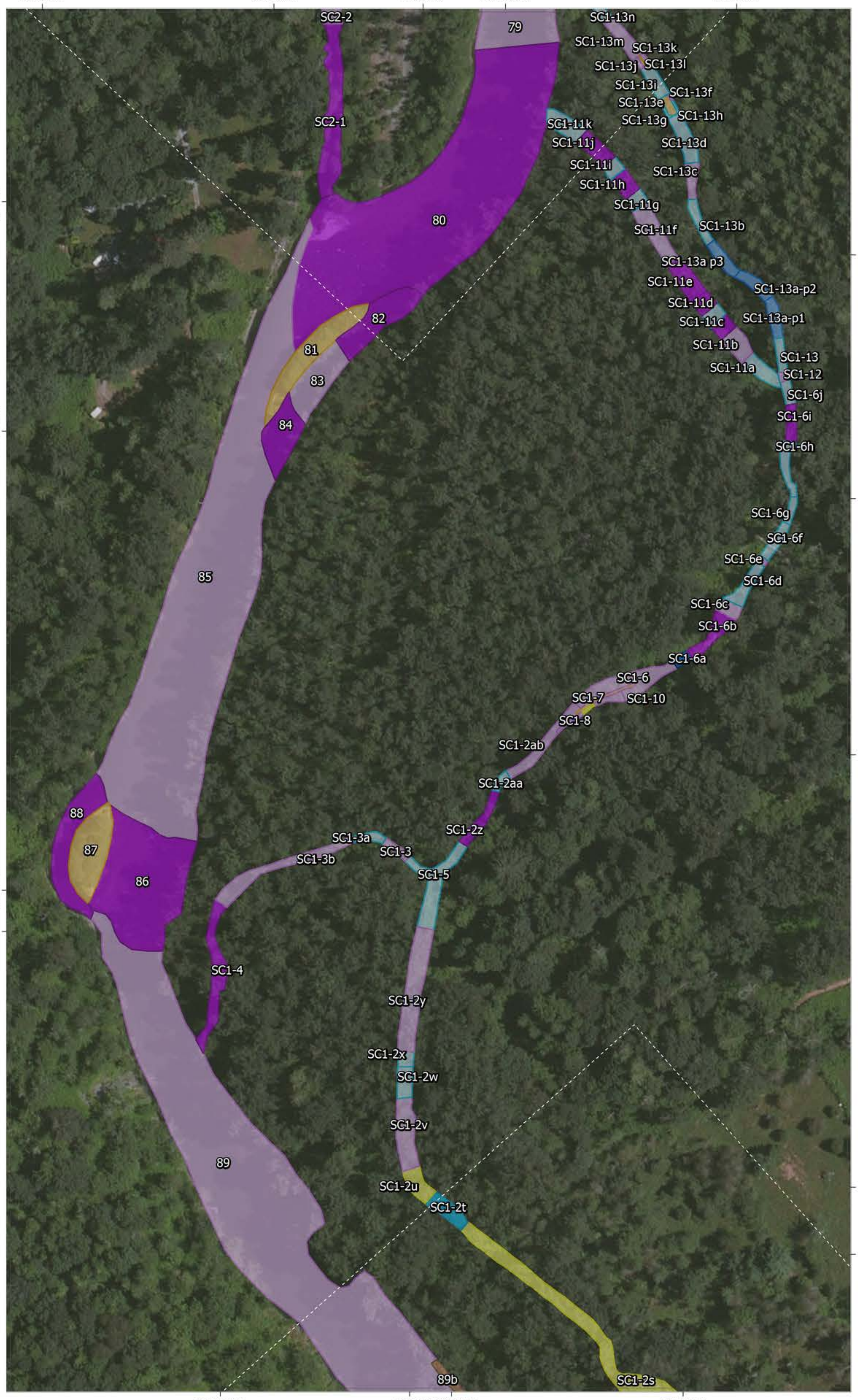
0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

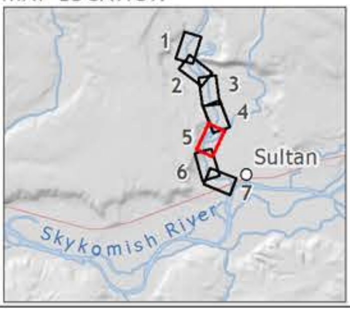


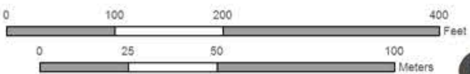
SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Main channel pool
- Isolated pool
- Pool complex
- Scour pool
- Low-gradient riffle
- Dry

MAP LOCATION

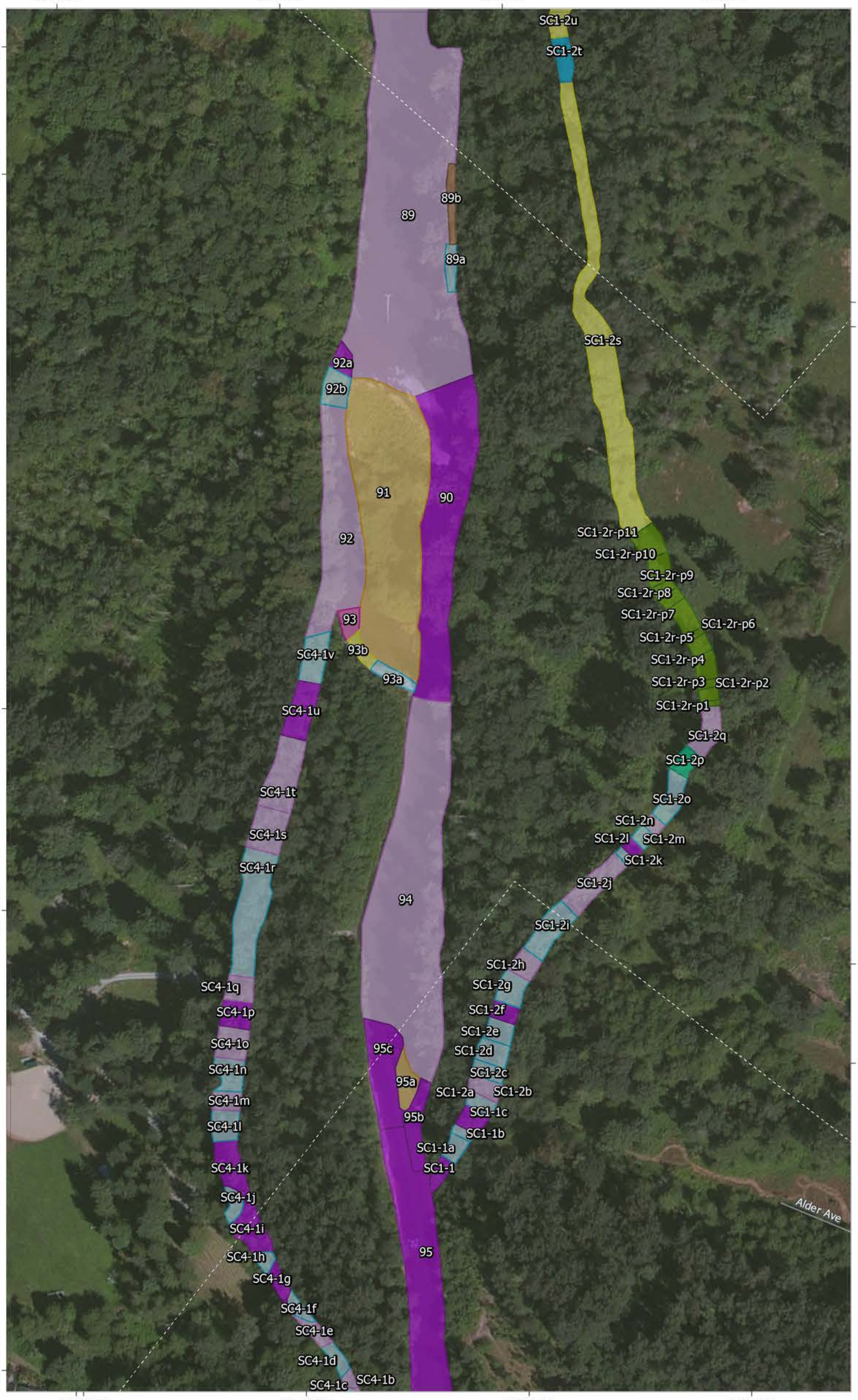




1:2,130 1 in = 178 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

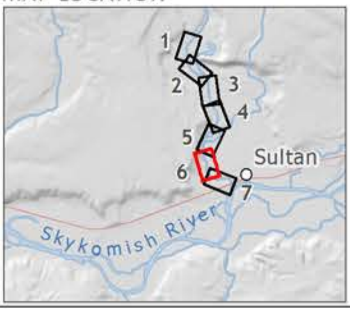


SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Main channel pool
- Intermittent pool
- Isolated pool
- Low-gradient riffle
- Marsh
- Alcove
- Backwater
- Dry

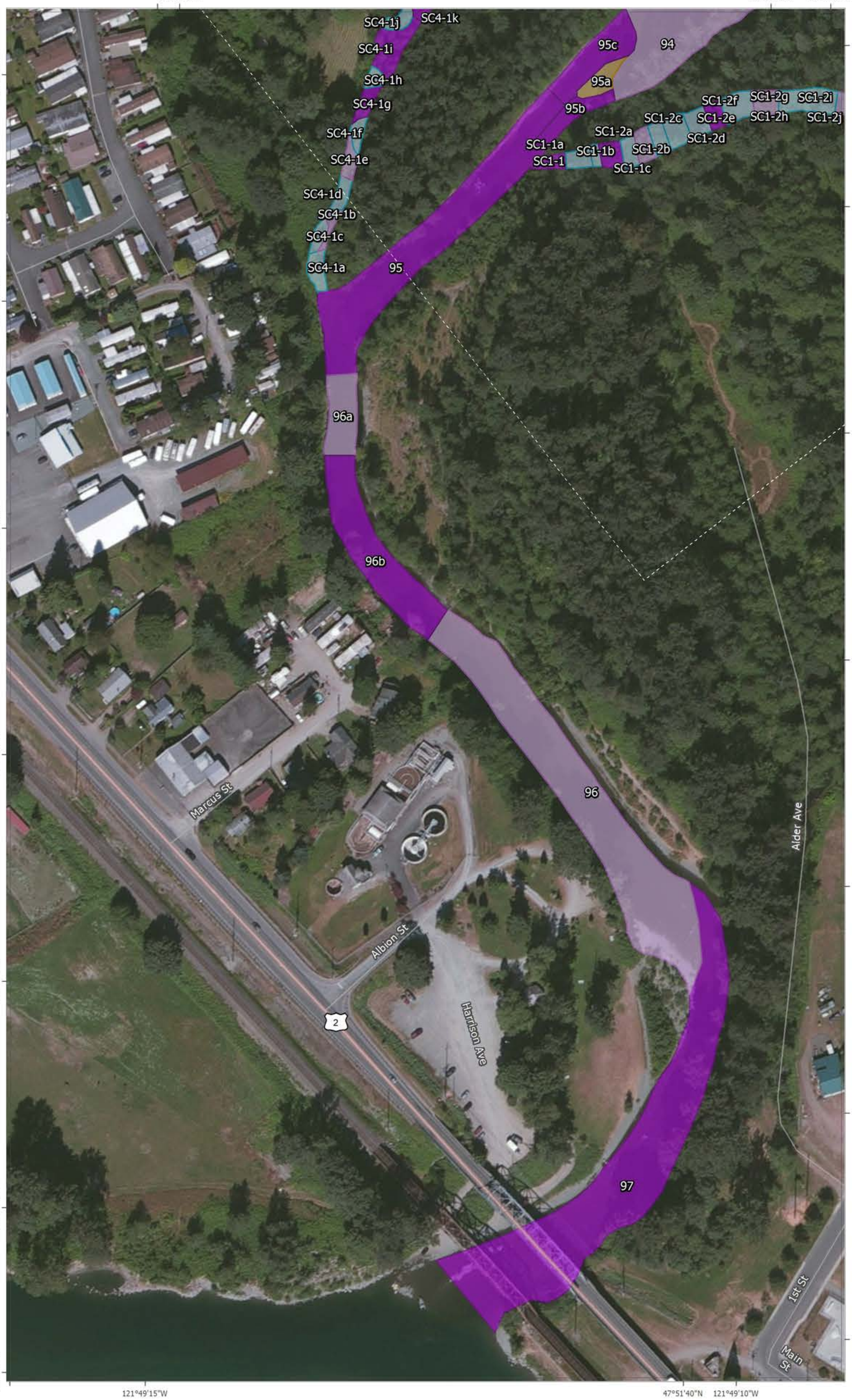
MAP LOCATION



0 100 200 400 Feet
0 25 50 100 Meters
1:2,100 1 in = 175 feet

Stillwater Sciences
www.stillwatersci.com

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

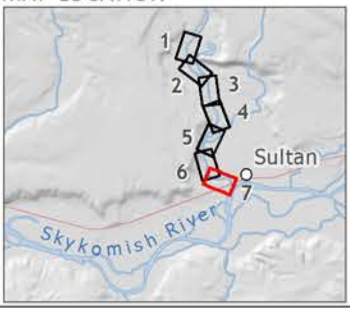


SULTAN RIVER HABITAT UNITS

Habitat Types (labeled with NSO ID)

- Glide
- Island
- Main channel pool
- Low-gradient riffle

MAP LOCATION



0 100 200 400 Feet
0 25 50 100 Meters
1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

Appendix C

Field Data Sheets

Sultan River In-River Habitat Survey

Reach ____________________

NSO (cont) ____________________

BFW Criteria ____________________

Date ____________________

Form # ________ of ________

Crew ____________________

Recorder ____________________

QC

Date ____________________

QC'er ____________________

				Dimensions					**Pool Data**				**Bar Edges**		**Undercut bank**				
nso	**core** unit type	**sub** unit type	unit **category**	length (ft)	avg. depth(ft)	wet width1	wet width2	wet width3	Pool Out Depth	Pool Form Fact	Pool Max Depth	Dive (Y/N)	bar % left bank	bar % right bank	uc % left bank	uc width (ft)	uc % right bank	uc width (ft)	comments

Reaches

Operational Reaches

A	RM 0.0 - 2.7	Confluence with Skykomish River upstream to BPA transmission line crossing
B	RM 2.7 - 4.3	BPA transmission line crossing upstream to Jackson Powerhouse

Process Reaches

C	RM 4.3 - 9.7	Jackson Powerhouse upstream to City of Everett Diversion Dam
D	RM 9.7 - 16.5	City of Everett Diversion Dam upstream to Culmback Dam

Habitat Unit Codes

Core Unit Types

Riffle	R
Pool	P
Sub-surface flow	SSF
Wetland	W
Obscured	OB
Other	OT

Sub - unit types (Calif. salmonid stream restoration manual)

Pool	MCP	main channel pool	(e.g. trench pool, mid-channel pool, channel conf. pool, step pool)
	SCP	scour pool	(e.g. corner pool, scour enhanced by root wad - log - boulder)
	BKW	backwater pool	
Riffle	LGR	Low gradient riffle	
	HGR	High gradient riffle	
	GLD	Glide	
	CAS	Cascade	

Pool forming features (TFW pg 24)

1	LWD log(s)	7	channel bedform
2	LWD rootwad(s)	8	resistant bank
3	LWD jam	9	artificial bank
4	roots of standing trees or stump(s)	10	beaver dam
5	Boulder(s)	11	other / unknown
6	Bedrock		

Unit Category

1 primary units: dominant units in the mainchannel
2 secondary units: sub-dominant units within the main channel that span less than 50% of the wetted channel width along less than half their channel length
3 side channel units: units in smaller clearly defined channels that are separated from main low flow channel (say by an island for example)

LWD Single Pieces

Date ____________________

Reach ____

NSO (cont) ____

BFW ____

Form # ________ of ________

Crew ____________________

Recorder ______________

	Diameter											KEY PIECES	
NSO	Rtwd diam ≥ 20cm	Small >20 to <40cm	Med ≥40 to <60cm	Large >60cm	Length (ft)	Zone 1 or 2	Mid-chan (Y/N)	Rtwd (Y/N)	Anchor R / P / B / U	Species Conf / Dec / Unk	Decay Class (1 - 5)	Key Piece #	Piece Diam (cm)

QC'D BY ______________ **DATE:** ______________

Sultan River LWD SURVEY
Debris Jams

Reach ____________________

NSO (cont) ____________________

BFW Criteria ____________________

Date ____________________ QC

Form # __________ of __________ OC'er ____________________

Recorder ____________________ Date ____________________

LWD DEBRIS JAMS

						DJ Largest Piece			DJ Dimensions		
NSO	Jam #	Lowest Zone (1or2)	Mid-Chan (Y/N)	Tally Rtwd diam ≥ 20cm	Tally Pieces Approx ≥20 cm	Key Piece#	Diam (cm)	Length (ft)	DJ Length (ft)	DJ Width (ft)	DJ Height (ft)

LWD Hab Survey Codes
Descriptions

ZONE 1 defined as the portion of the bankfull channel that is wetted at the time of the survey, regardless of whether the water is flowing or stagnant

ZONE 2 defined as the area between the bankfull channel edge on both banks, below an imaginary line that connects those points, above the wetted gravel bars channel surface, and includes areas such as dry

ZONE 3 the area vertically above Zone 2, the bankfull channel

ZONE 4 area outside of the bankfull channel and Zone 3

LWD Log Criteria

1 dead
2 the root system (if present) no longer supports the weight of the stem / bole
3 minimum diameter of 0.1 meters along 2 meters of its length, AND
4 minimum 0.1 meter of length extending into the bankfull channel

LWD Rootwad Criteria

1 dead
2 root system detached from original position
3 minimum diameter of 0.2 meters with a total length <2 meters; AND,
4 minimum 0.1 meter of length extending into the bankfull channel

LWD Jam Identification

1 minimum 10 qualifying pieces of LWD either physically touching at one or more points, or associated with jam structure
2 minimum 0.1 meter of one LWD piece's length extending into the bankfull channel

KEY PIECE CRITERIA
See pg 17 and Appendix C of TFW Large Woody Debris Survey Manual

Sultan River Habitat Survey Wolmann Pebble Count

Date ____________
Reach ____________
NSO ____________ BFW (m) ________
FeatureID ____________

	size (mm)	Count	Total #
Mud Silt	<2		
Fine Sand	<2		
Sand	2 - 4		
G	4 - 6		
R	6 - 8		
A	8 - 12		
V	12 - 16		
E	16 - 22		
L	22 - 32		
S	32 - 45		
	45 - 64		
C	64 - 90		
O	90 - 128		
B	128 - 180		
B	180 - 256		
B	256 - 362		
L	362 - 512		
D	512 - 1024		
R	1024 - 2048		
S	2048 - 4096		
Bdrck	Bedrock		

Total =

Comments:

Date ____________
Reach ____________
NSO ____________ BFW (m) ________
Feature# ____________

	size (mm)	Count	Total #
Mud Silt	<2		
Fine Sand	<2		
Sand	2 - 4		
G	4 - 6		
R	6 - 8		
A	8 - 12		
V	12 - 16		
E	16 - 22		
L	22 - 32		
S	32 - 45		
	45 - 64		
C	64 - 90		
O	90 - 128		
B	128 - 180		
B	180 - 256		
B	256 - 362		
L	362 - 512		
D	512 - 1024		
R	1024 - 2048		
S	2048 - 4096		
Bdrck	Bedrock		

Total =

Comments:

Sultan River Hab Survey
Aerial Photo Mapping: Landmark / Photo / Comments Log

Date: ____

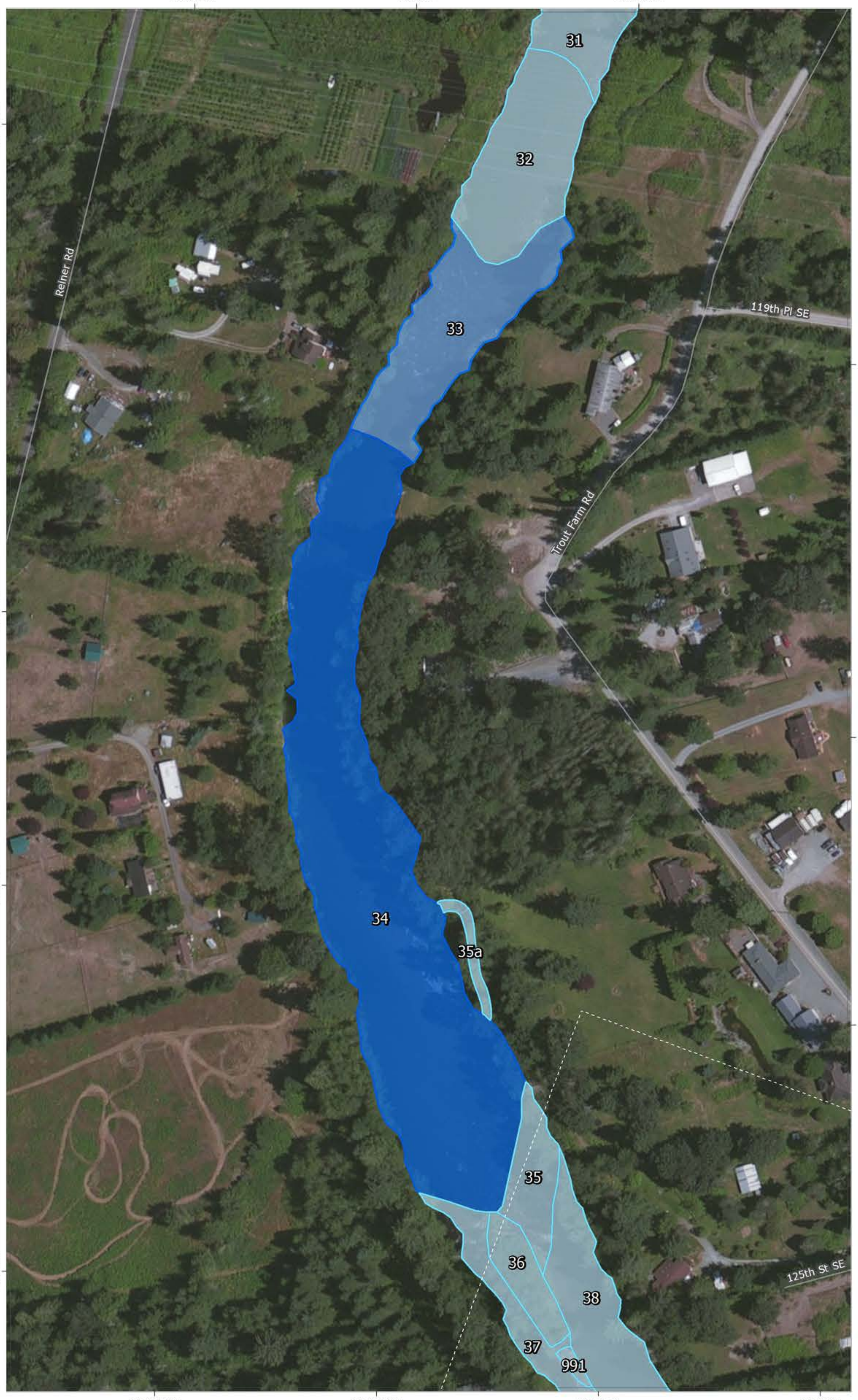
River Reach: ______________________________________

Form _____of _____

Comments	**NSO**	**ID / Item#**	**Photo#**	**GPS ID Info**

Appendix D

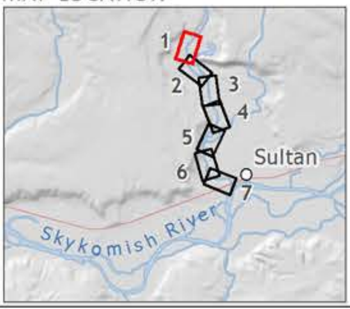
Maps Illustrating Large Woody Debris



SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

MAP LOCATION



LWD count by Habitat Unit

0 | 2 - 3 | 8 -10

1 | 4 - 7

0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

LWD count by Habitat Unit

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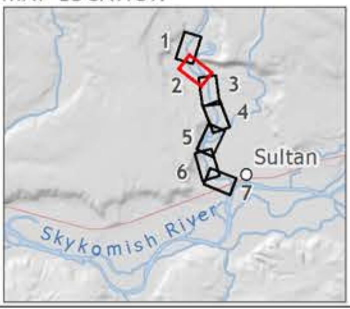
1 | 4 - 7

MAP LOCATION



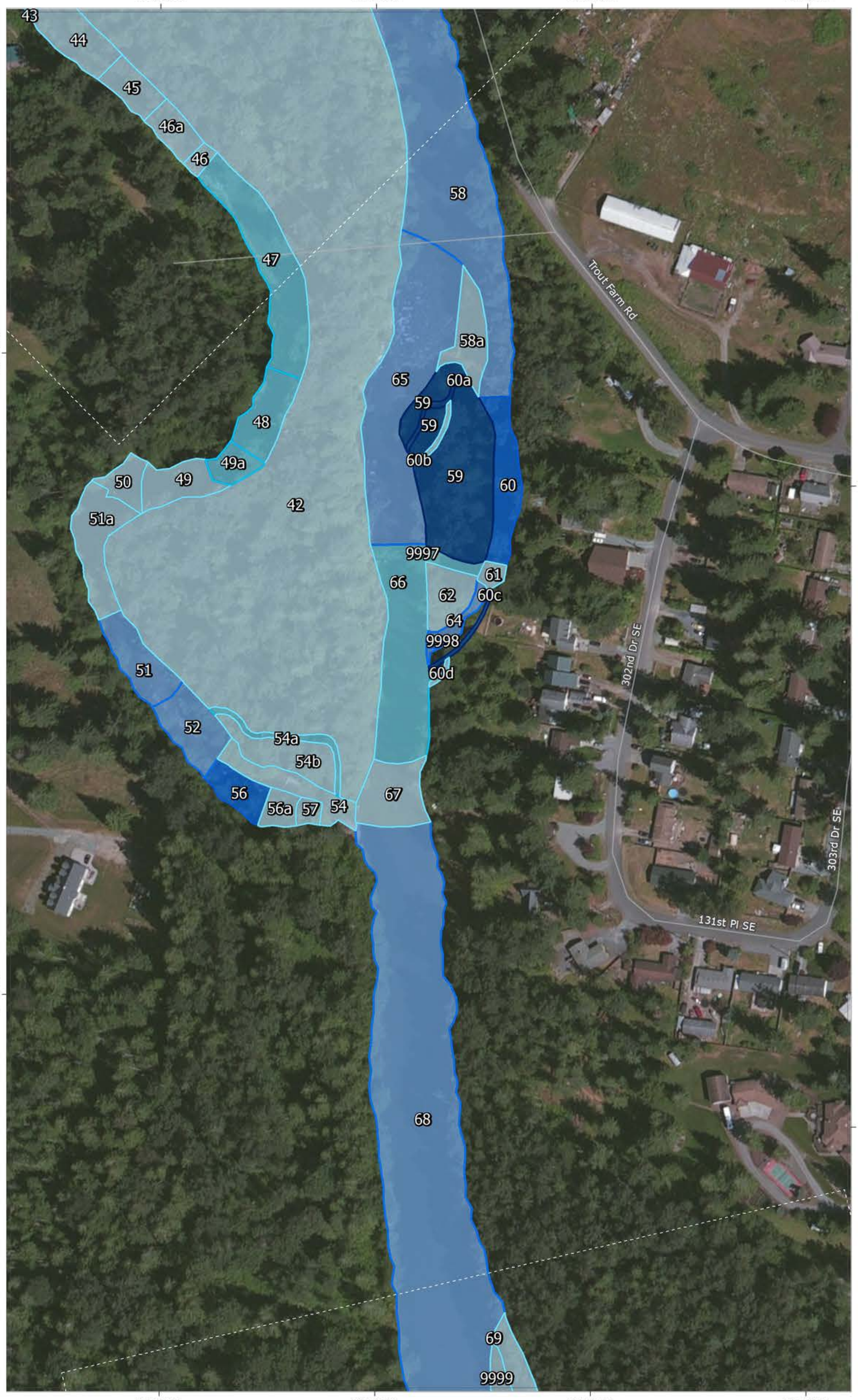
0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

Stillwater Sciences
www.stillwatersci.com

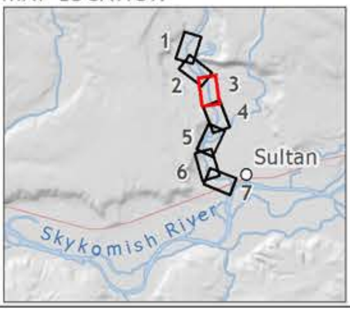
DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014



SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

MAP LOCATION



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Stillwater Sciences
www.stillwatersci.com

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

PAGE 4 OF 7

MAP LOCATION

LWD count by Habitat Unit

0 | 2 - 3 | 8 -10

1 | 4 - 7

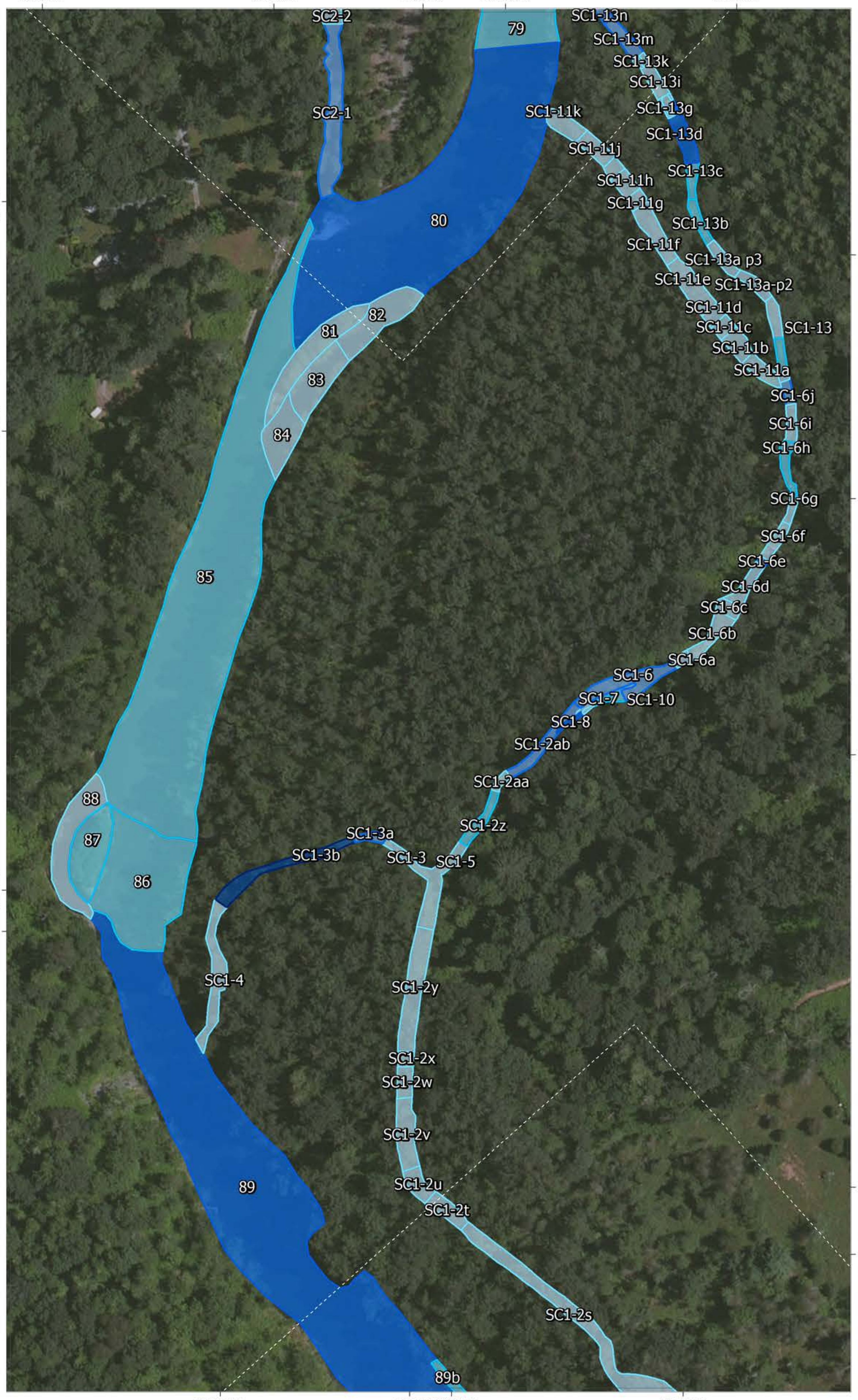
0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

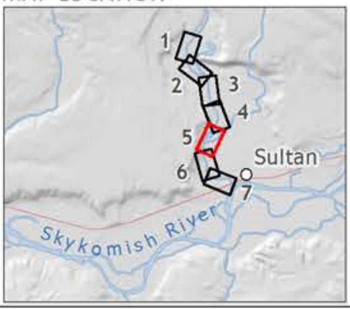
Stillwater Sciences
www.stillwatersci.com



SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

MAP LOCATION



LWD count by Habitat Unit

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0 100 200 400 Feet
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1:2,130 1 in = 178 feet

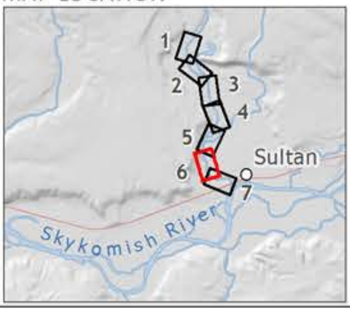
DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

Stillwater Sciences
www.stillwatersci.com

SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

MAP LOCATION



LWD count by Habitat Unit

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www.stillwatersci.com

DATA SOURCES
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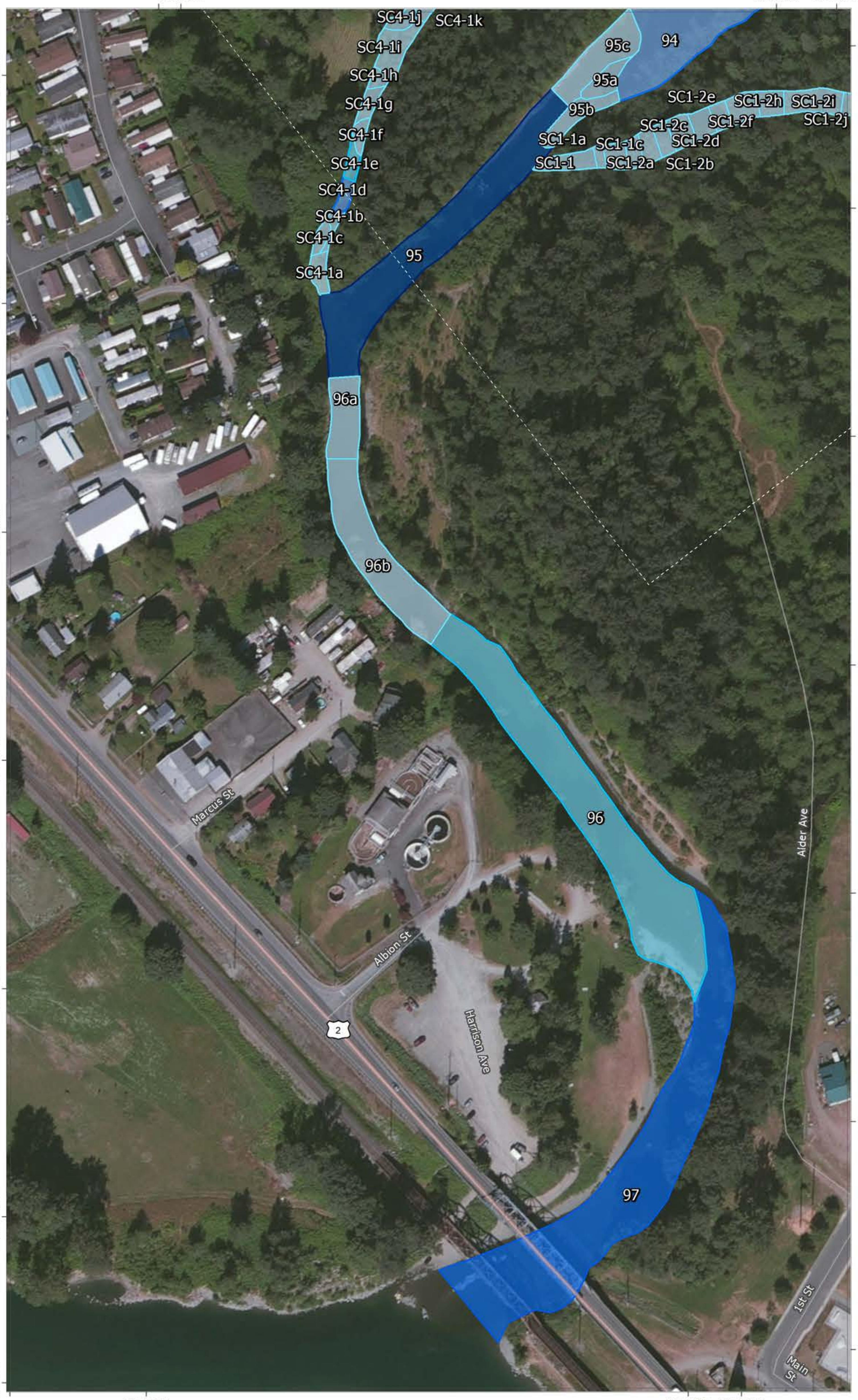
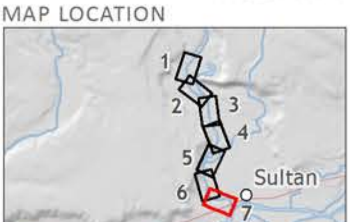
Roads: ESRI 2014



SULTAN RIVER LARGE WOODY DEBRIS

Large Woody Debris (LWD)

MAP LOCATION



LWD count by Habitat Unit

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1 | 4 - 7

0 100 200 400 Feet

0 25 50 100 Meters

1:2,100 1 in = 175 feet

Stillwater Sciences
www.stillwatersci.com

DATA SOURCES
Imagery: ESRI World Mapping Service
Roads: ESRI 2014

APPENDIX F

Side Channel Maintenance – Technical Memo detailing 2016 actions

TECHNICAL MEMO

TO: **Jackson Hydroelectric Project (FERC No. 2157) file**

FROM: **Keith Binkley, Natural Resources Manager**

DATE: **December 14, 2016**

RE: **License Article 404: Side Channel Enhancements, Maintenance 2016**

Introduction

This memo was prepared to document specific maintenance actions taken during 2016 to ensure that the objectives of the Plan for Side Channel Enhancement and Large Woody Debris Placement (SCE/LWD Plan) continue to be met under License Article 404.

The SCE/LWD Plan has a number of objectives to advance the overall goal of enhancing adult and juvenile salmon habitats in the lower river. These objectives include:

1. *Provide for adult holding and spawning habitat in the main river channel over a range of hydrologic flow conditions.*
2. *Expand the range of hydrologic flow conditions over which side channels receive inflow from the main river by manipulating the hydraulic inlet controls to ensure inflows at a mainstem minimum flow of 300 cfs.*
3. *Use LWD structures to increase both adult and juvenile habitat availability in the mainstream and side channels.*
4. *Ensure that the overall design of LWD structures takes advantage of natural river geomorphic processes that promote their long-term effectiveness and sustainability.*
5. *Provide for maintenance of existing adult spawning habitat and expand potential off-channel refuge and summer rearing habitat in side channels for native salmon and trout species.*
6. *Develop and implement a long-term monitoring program to track overall performance of these enhancement measures.*

Potential maintenance actions are identified through routine monitoring, as described below:

> *Structure Performance - Engineered log structures are routinely inspected for structural integrity and signs of degradation / changes in form, orientation, or function. Racking of additional woody debris is noted and in instances where it negatively impacts the functioning of the structure, it is removed. Observations are recorded and photo documented.*

To date, no maintenance actions have been taken at any of the eight engineered log structure installations in the lower river.

> *Physical Habitat Measurements - Side channel habitats are monitored seasonally to qualitatively assess functionality over the full range of flow conditions with focused surveys conducted when mainstem flows drop below 400 cfs. This information defines flow connectivity and the relationship between mainstem and side channel flow.*

> *Monitoring includes a pedestrian (walking) habitat survey along the length of each channel including photo documentation of observed changes, as appropriate.*
>
> *Consistent with the Fisheries and Habitat Monitoring Plan, during Year 1 through Year 10, if there is a high flow event or other major event causing change, the District will perform a comprehensive quantitative habitat survey of the lower river including side channel habitats. Under the current license, comprehensive surveys have been conducted in 2014 and again in 2016 with baseline surveys conducted in 2007 and 2010.*

During the 2016 comprehensive survey (Stillwater 2016), dewatering of a portion of one side channel, under low flow conditions, was documented and quantified. This area was also identified during a ramping rate evaluation conducted at the same time. The documentation and subsequent resolution of this issue is the focus of this report.

Prior to 2016, maintenance actions have been minor and included:

- fence repair along conservation easement areas,
- contouring of pedestrian trails, near bridges, to maintain appropriate access as stipulated in the Americans with Disabilities Act,
- re-seeding of landowner properties, and
- placement of wood from Culmback Dam.

None of these minor actions warranted detailed reporting.

Table 1. Habitat surveys conducted in the Sultan River since issuance of the current license in 2011.

Date	Action
September 2012	Completion of Side Channel Construction Project
2013	Annual Pedestrian Surveys, Initial Side Channel Habitat Surveys for Evaluation of Downramping Rates
2014	Annual Pedestrian Surveys, Comprehensive Riverine Habitat Survey
2015	Annual Pedestrian Surveys, Revised Ramping Rate Evaluation
2016	Annual Pedestrian Surveys, continuation of Revised Ramping Rate Evaluation, Comprehensive Riverine Habitat Survey

Identification of Maintenance Issue or Concern

The routing and distribution of flow within the Side Channel 1 (SC 1) complex has been closely monitored since the completion of the construction of side channel enhancements. The SC 1 complex has two inlets and two outlets (Figure 1). A second inlet, referred to as the “new” or “redundant” inlet, was created to ensure water delivery in the event that the original inlet became blocked or compromised. The original “old” inlet is adjacent to a large wetland where beaver have been observed. Historically, beaver activity has resulted in flow reductions within SC 1 under low flows. Since construction, no significant flow related problems have been identified at the inlets other than the occasional damming of the channel by people during the summer.

Monitoring by District staff has indicated that the distribution of flow between the two outlets to SC 1 has evolved since construction. This was not unexpected because the confluence of the two outlets is a dynamic area. In addition, a small log jam is present at this location. The distribution of flow is also variable over the range of river flows leading further to the evolution of the area. During initial project construction, an intentional “plug” was created (installed) in the newly constructed outlet, near cross section (XS) 8 and XS-9 (Figure 1), as a measure to protect against the complete routing of all flow down the new channel. Over time, sedimentation and changes at the log jam lead to the routing of a proportionately lesser amount of flow down the new outlet. This situation was not problematic at mainstem flows above 400 cfs but was concerning at flows below 400 cfs, especially during the summer when groundwater levels tend to be lower.

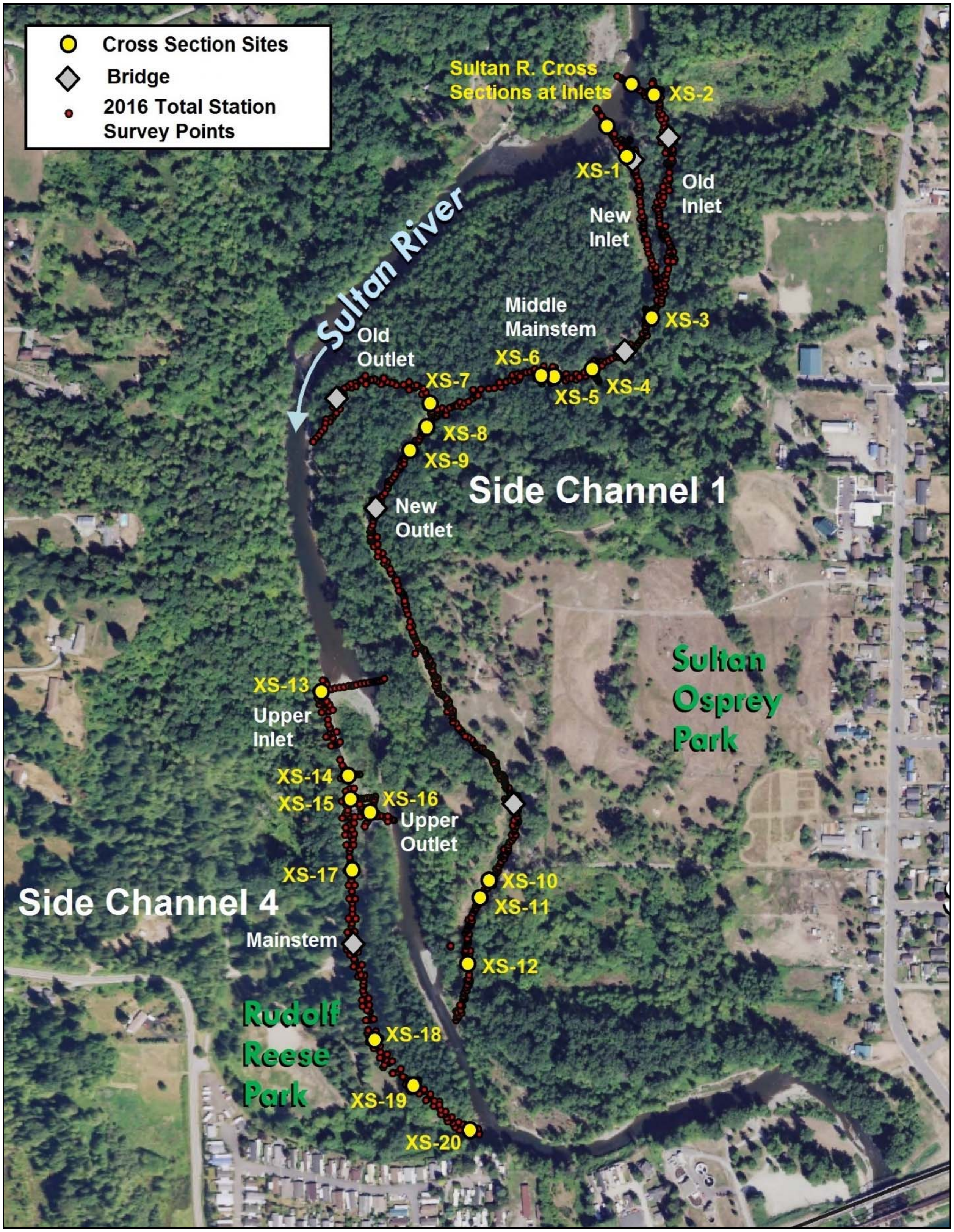

Figure 1. Map of the lower Sultan River, including the old and new outlets to Side Channel 1.

In addition to the observed changes in flow distribution, evolution of the channel also resulted in changes in habitat. Since 2014, SC 1 has evolved from a channel that contained 18 units (primarily main channel pools, low gradient riffles, and glides) to one that is now made up of 93 units including 35 pools, stretches of dry channels and isolated pools, as well as a marsh, islands, and glides and low gradient riffles.

Though more complex in terms of number of distinct units that constitute the channel, the ability for SC 1 to maintain channel connectivity has been compromised due to the decreasing depths and channel widths, and the observed stretches of dry channels and intermittent pools. The following photo was taken in the new outlet to SC 1 in July 2016 when mainstem flow of the Sultan River was approximately 320 cfs. (Figure 2).

Figure 2. Photo taken in July, 2016 depicting dry reach in new outlet to Side Channel 1.

Upon documentation of the severity of the dewatering issue under low-flow conditions, the District implemented a timely resolution of the situation prior to closing of the typical annual in-water work window. The sequence of events leading up to channel modification and those conducted afterward are outlined in Table 2. The cooperation of the Washington Department of Fish and Wildlife (WDFW) was critical to the immediate resolution of this issue.

Table 2. Chronological sequence of events during 2016

Date	Action
July 10	Reduction in plant output (generation) to decrease river flows and replicate flow conditions present during prior survey conducted in 2014
July 11-15	Dewatering documented during surveys[1]
July 22	WDFW notified of issue and intent to remediate
July 28	On-site meeting with WDFW Habitat Biologist
August 8	Formal submission of plans to modify channel, under Hydraulic Project Approval (HPA) 122550
August 25	HPA issued by WDFW. In-water work window during 2016 through September 30
September 21	Pre-project survey
September 26-28	Construction - excavation/removal of “plug” (1,150 cubic yards of material)
October 3	Post construction measurements of flow distribution
October 16	Notification to ARC of immediate actions taken and intent to document by survey
October 19	Post construction site visit with WDFW
November 9	Post project topographic / bathymetric survey of project area

Methods

Pre Measurements

The approach to resolving the identified dewatering issue was to remove or modify the intentional “plug” installed during initial construction. A review of as-built set with the Project Engineer indicated that this could be accomplished through removal of approximately 8 inches of material within the upper 300 feet of the new channel. The channel was surveyed and staked prior to excavation and monitored continually through the process to ensure that the area was not over excavated.

Implementation of Best Management Practices / Erosion Control Measures

Construction was scheduled to coincide with a period of reduced generation and discharge so as to provide favorable flow conditions within the side channel work area and to minimize potential issues with turbidity. Ironically, while mainstem flows were identical to those during the summer survey, no dewatering of the channel was evident at the time of construction. This is likely attributable to recharge of the groundwater aquifer since the summer survey. With the increased amount of water present at the site, temporary actions were taken to reduce the volume and route a greater portion of the flow down the old channel. At this time, in order to control erosion, straw bales were placed in the channel at the downstream end of the work area.

Excavation

As stated previously, surveying during the excavation process assured that final target channel elevations were achieved. In order to avoid the presence of a homogenous channel, additional excavation was done in select areas, primarily near existing large wood installations, to increase hydraulic diversity and complexity and to make the channel more fish friendly. The primary

[1] Two separate “low flow” habitat surveys were conducted this week. One of the surveys was for the purpose of evaluating ramping rates and the other was a post significant high flow assessment. Issue of dewatering in the new SC 1 outlet was documented and quantified during both surveys.

purpose of this short 300-foot section of channel is to convey water further downstream consistent with desired flow split although utilization of this area by spawning adults and rearing juveniles has been readily evident since construction.

Post Measurements

A detailed topographic / bathymetric survey of the entire modified area was completed after construction was complete. This survey provided the basis for documenting finished channel elevations, updating of the longitudinal profile, updating of cross sections at two survey locations, and the calculation of volume of material removed during excavation. Several flows greater than 2,000 cfs in the main channel of the river had occurred between the time construction was completed on September 28 and the date of this survey on November 9. (Figure 3).

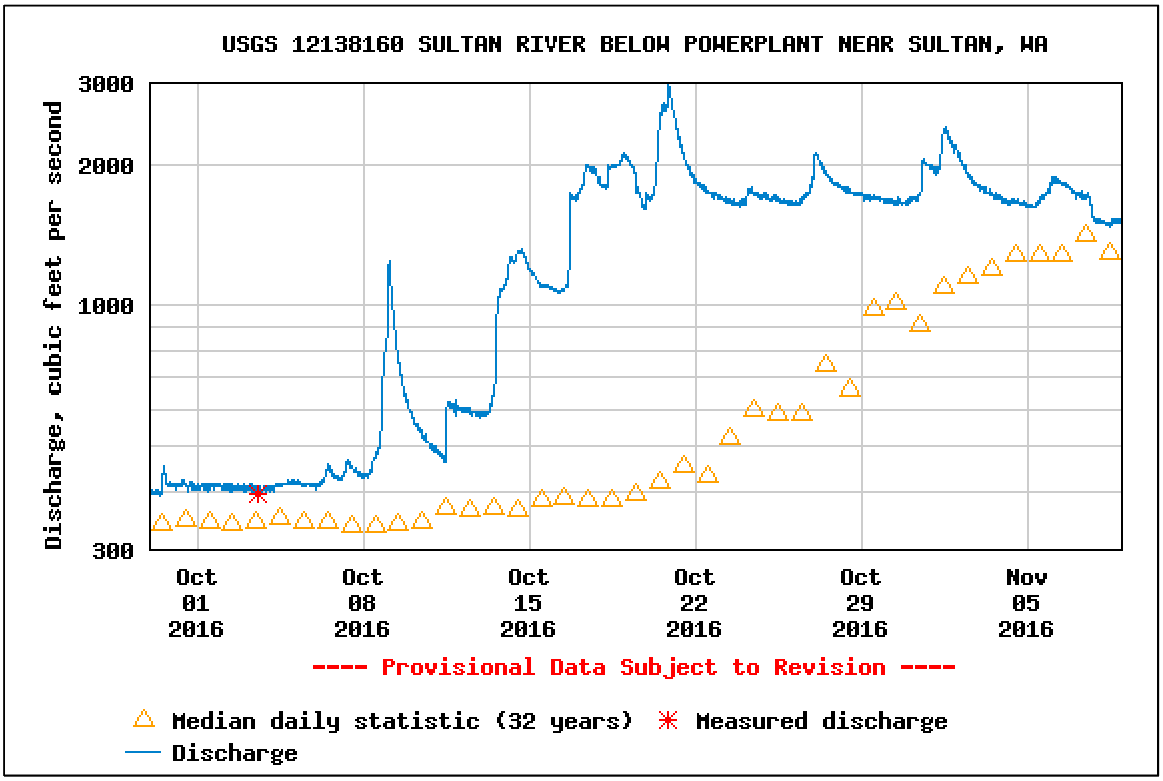

Figure 3. Hydrograph of the lower Sultan River depicting flows experienced prior to post construction topographic survey.

Results

Dewatering of sections of the new SC 1 outlet was directly related to diminished connectivity with upper portions of the side channel and the distribution of flow at the confluence of the new and old channels. The potential for this issue was noted at the time of initial construction and identified for monitoring. Flow measurements within both channels have been obtained since 2013 (Table 3). The measurements indicate a general pattern of a reduced percentage of flow being routed down the new SC 1 outlet (Table 3). The observed variability in the trend was most likely attributed to the racking of wood at the jam present at the confluence of the two channels. Aggradation of the channel within the new SC 1 outlet was also likely a contributing factor to the observed dewatering.

Table 3. Flow measurements at the confluence of the new and old outlets (pre-modification vs. current*)

Date	Mainstem Flow (cfs)	Side Channel 1 Total Flow (cfs), at confluence	Flow (cfs) and (percentage of total) routed down Old Outlet	Flow and (percentage of total) routed down New Outlet
6/25/13	342	12.3	8.5 (69)	3.7 (31)
10/1/13	447	9.8	6.1 (62)	3.8 (38)
11/14/13	1370	63.2	27.3 (43)	35.9 (57)
7/11/14	376	11.5	9.2 (80)	2.3 (20)
4/30/15	380	10.8	9.4 (87)	1.4 (13)
5/12/15	421	14.0	9.5 (68)	4.5 (32)
5/26/15	324	7.7	6.5 (85)	1.2 (15)
7/21/16	340	6.9	6.7 (96)	0.3 (4)
10/3/16*	404	6.6	1.9 (28)	4.7 (72)

The distribution of flow observed at the confluence on 10/3/16 (Table 3) is reflective of the channel modifications made within the upper portion of the new outlet and demonstrates the initial success at resolution of the dewatering issue. Figure 4 quantifies changes in channel elevation and updates the longitudinal profile for habitat related purposes. Similarly, modified changes at Cross Sections 8 and 9 are documented in Figures 5 and 6, respectively.

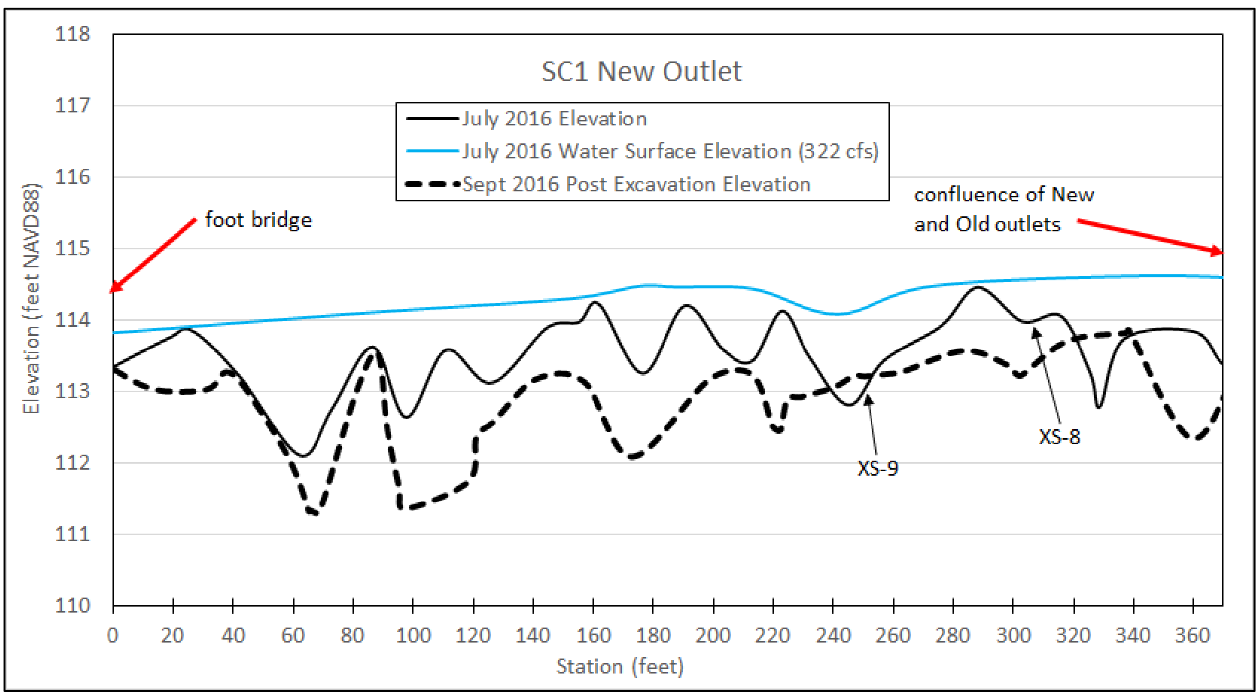

Figure 4. SC 1 New Outlet profile from confluence with Old Outlet to foot-bridge downstream.

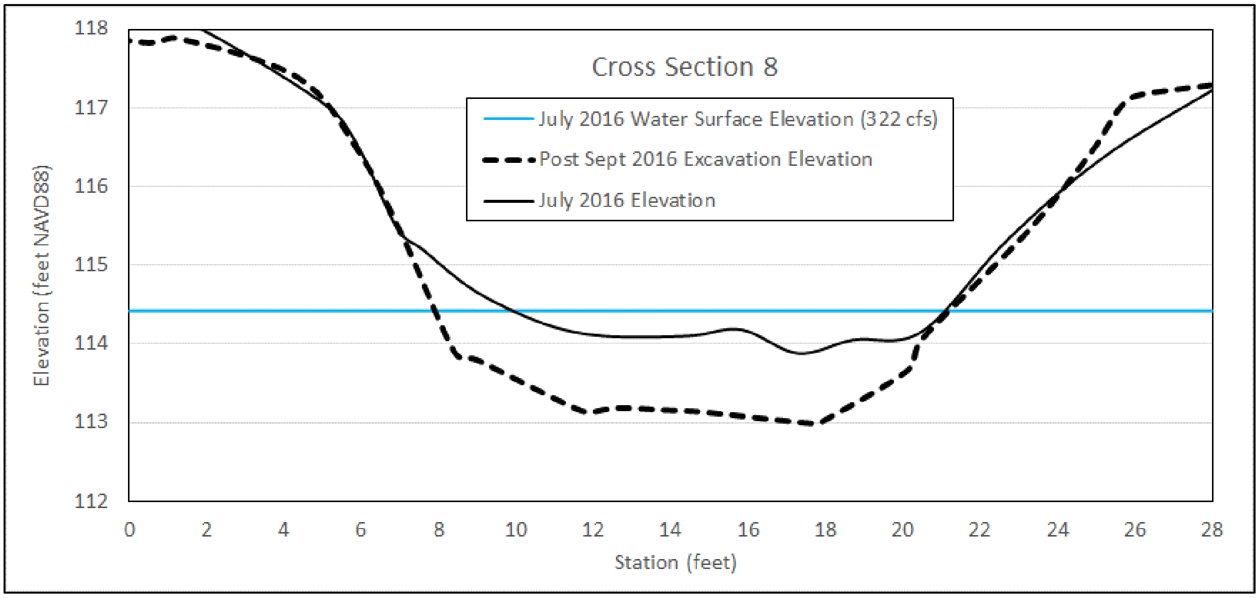

Figure 5. SC 1 Ramping Rate Study Cross Section 8 near the upstream end of the New Outlet.

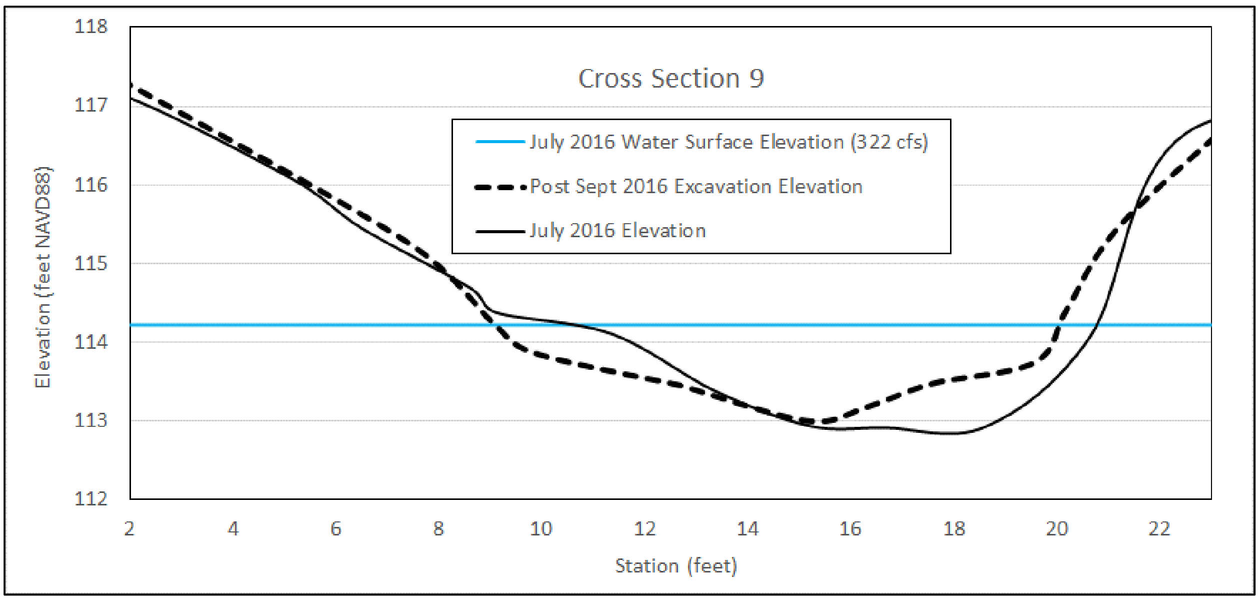

Figure 6. SC 1 Ramping Rate Study Cross Section 9 near the upstream end of the New Outlet.

APPENDIX G

Side Channel Supplemental Assessments

Jackson - Sultan River, Results of Snorkel Survey Summer 2016

Site			Date	Discharge (cfs)		Coho	Avg Size	Trout	Avg Size
				Mainstem	Side Channel	Number		Number	
Side Channel #1 (historic)	Just upstream of confluence with redundant	VISUAL SURFACE (too shallow)	25-Jul	350	~4	123	75	12	120
Side Channel #1 (historic)	u/s of middle bridge	VISUAL SURFACE (too shallow)	25-Jul	350	~7	38	75	0	
Side Channel #1 (historic)	below middle bridge, start u/s of jam	VISUAL SURFACE (too shallow)	25-Jul	350	~7	27	75	4	120
Side Channel #1 (redundant)	entire channel	VISUAL SURFACE (too shallow)	25-Jul	350	~3	46	75	1	120
							75		120
Side Channel #2	u/s of fjord	Snorkel	25-Jul	350	~10	29	75	7	120
Side Channel #2	further upstream	Snorkel	25-Jul	350	~10	18	75	0	
Side Channel #2	further but before RB inflow	Snorkel	25-Jul	350	~10	37	75	6	120
Side Channel #3	d/s of "s" near lower boulder placement	Snorkel	27-Jul	346	~25	6	75	0	
Side Channel #3	u/s of "s"	Snorkel	27-Jul	346	~25	3	75	0	
Side Channel #3	near LWD on LB	Snorkel	27-Jul	346	~25	4	75	1	120
Side Channel #4		Snorkel	1-Aug	320	~65	21	75	0	

Jackson - Sultan River, Results of 2016 Minnowing Trapping Efforts

Trap #	Site	Date Deployed	Date Checked and Removed	Description	Number Fish Captured				
					coho	rainbow	cutthroat	sculpin	dace
Trap 1	Side channel #1 (historic)	25-Jul	27-Jul	20' downstream inlet	2				
Trap 2	Side channel #1 (redundent)	25-Jul	27-Jul	15' downstream inlet	0			1	
Trap 3	Side channel #1 (historic)	25-Jul	27-Jul	50' upstream middle bridge	4	1		1	
Trap 4	Side channel #1 (historic)	25-Jul	27-Jul	30' downstream middle bridge	1				
Trap 5	Side channel #1 (extension)	27-Jul	29-Jul	250' upstream outlet	2				
TOTAL					**9**	**1**	**0**	**2**	**0**
Trap 6	Side channel #2	27-Jul	29-Jul	80' downstream inlet	1	1			
Trap 7	Side channel #2	25-Jul	27-Jul	150' downstream inlet	5				2
Trap 8	Side channel #2	25-Jul	27-Jul	300' downstream inlet	3	2		3	1
Trap 9	Side channel #2	25-Jul	27-Jul	200' upstream outlet	1	1			
Trap 10	Side channel #2	25-Jul	27-Jul	100' upstream outlet					
TOTAL					**10**	**4**	**0**	**3**	**3**
Trap 11	Side channel #3	27-Jul	29-Jul	150' downstream inlet	1	1			
Trap 12	Side channel #3	27-Jul	29-Jul	250' downstream inlet	2				1
Trap 13	Side channel #3	27-Jul	29-Jul	300' upstream outlet	0				
Trap 14	Side channel #3	27-Jul	29-Jul	200' upstream outlet	1				
Trap 15	Side channel #3	27-Jul	29-Jul	40' upstream outlet	1	3			
TOTAL					**5**	**4**	**0**	**0**	**1**
coho ~ 75 mm									
all rainbow and cutthroat > 100 mm				**Total All Side Channels**	**24**	**9**	**0**	**5**	**4**

APPENDIX H

Consultation Documentation

McDonnell, Andrew

From: Presler, Dawn
Sent: Wednesday, May 17, 2017 1:29 PM
To: 'Wright, Lindsy'; 'Vacirca, Richard -FS'; 'Anne Savery'; ''brock.applegate@dfw.wa.gov' (brock.applegate@dfw.wa.gov)'; ''James (ECY) Pacheco' (JPAC461@ECY.WA.GOV)'; 'Ken Walker'; ''Jim Miller'; 'Thomas O'Keefe'; 'Rustay, Michael'
Cc: Binkley, Keith; McDonnell, Andrew
Subject: JHP (FERC No. 2157) - draft Fisheries and Habitat Monitoring Annual Report for 30day review
Attachments: 2016 FHMP Annual Report DRAFT.pdf

Dear ARC,

Attached for your review is the Draft 2016 Annual Report for the Fisheries and Habitat Monitoring Plan. Please take the next 30 days to review and provide comments, if any, back to me with a cc: to Keith Binkley by June 16. Thanks.

Dawn Presler
Sr. Environmental Coordinator
(425) 783-1709

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