Salmonberry River Temperature Monitoring

STEP Project Progress Report 2010

Volunteer Jena Lemke placing a data logger in Bathtub Creek, May 2010.

Summary: Water temperature loggers were placed at 10 sites in the summers of 1994-1997, 2004, 2007, and 2008, and at 14 sites in 2009-2010. The lowest seven miles of the mainstem regularly exceed DEQ's core cold water habitat standard. The site at the mouth exceeded the EPA/DEQ core cold water habitat temperature standard for 76 days in 2009. Four of the seven monitored tributaries have recorded seven-day average daily maximum temperatures above the DEQ standard. The EPA/DEQ spawning temperature standard is exceeded in most years as far upstream as river mile 12. The spawning standard applies to the main stem before June 15 and after September 15.

Prepared By Ian Fergusson

11/1/2010

1. Introduction

The Salmonberry River is known for its run of wild winter steelhead, regarded as one of the healthiest runs on the West Coast. The Salmonberry also supports Chinook salmon, coho salmon, cutthroat trout, and rainbow trout (an isolated population in the North Fork headwaters). The South Fork of the Salmonberry has been designated as "Salmon Anchor Habitat" by the Oregon Department of Forestry. Relatively healthy watersheds such as the Salmonberry are critical to long-term survival of salmonids, and ongoing monitoring is essential.

A STEP project was started in 1993, with the goal being long-term monitoring of winter steelhead spawning and summer water temperatures. Spawning surveys have been conducted every year; temperature monitoring has occurred in the summers of 1993 through 1997, 2004, and 2007-2010.

During the period we have been monitoring the Salmonberry, two major weather events have reshaped the landscape. In February 1996 a severe rain-on-snow event occurred. Of the monitored sites, Wolf Creek and Kinney Creek suffered debris torrents that removed miles of riparian vegetation. By contrast, Pennoyer Creek, the North Fork, and the South Fork suffered relatively little damage. Other tributaries, notably Tunnel Creek and Bathtub Creek, also suffered debris torrents. The main stem was channelized. The Port of Tillamook Bay Railroad was severely damaged; repairs required about $12 million.

In December of 2007 a severe 3-day rain event occurred. Most of the tributaries that were slowly recovering from the 1996 flood were scoured again. In addition, the South Fork was damaged, as was the lowest mile of the North Fork. The main stem was much channelized, and deep pools were filled in. Observers who have seen the results of both events agree that the 2007 flood was worse. The POTB Railroad was damaged to such an extent that repairs will not be attempted; the estimate exceeded $50 million.

2. Acknowledgements

Numerous organizations have provided support for this project over the years. The Oregon Department of Fish and Wildlife North Coast District Office is the STEP sponsor. The STEP Advisory Committee approved a grant in 2008 that allowed the purchase of additional data loggers. Oregon Department of Environmental Quality has provided valuable technical assistance. Marty and Joyce Sherman started the project, and have remained involved throughout. Volunteers, without whom there would be no data, have come from Americorps, Clark-Skamania Flyfishers, Native Fish Society, Northwest Steelheaders, Oregon Trout, Rainland Flycasters, Sierra Club, and Trout Unlimited.

3. Equipment and Methodology

Until 2008, ODFW provided Onset Hobo® temperature loggers, with resolution of 0.1° C. Accuracy is unknown, but is probably ±0.5° C. Beginning in 2008, we used NexSens® model 1921G loggers purchased by ODFW for dedicated use by the project team, with resolution of 0.5® C and accuracy of ±1° C. In 2008 the project was awarded a STAC mini-grant, and we purchased 10 additional NexSens® model 1921G loggers. These were deployed at additional sites beginning in 2009. See "5. Locations".

Data loggers are placed following standard protocols (OWEB, 1999; Dunham et al, 2005). Turbulent, well-mixed sites are selected. Placement is as close to the thalweg as possible. Data loggers are shielded from direct sunlight by white PVC housings. They are anchored with a rock and duct tape, and secured with cable to a log, root wad, or to a second rock. A plastic plant nursery tag, inscribed "Temperature monitor attached-please do not disturb" with permanent marker, is attached to the anchor end of the cable (away from the data logger). This tag is visible in the cover photo, which also illustrates the use of a second rock as an upstream anchor.

Since 2004, when the data suggested that several sites had become dewatered, sites in small tributaries are visited at least once during August to check water levels. On one occasion (Kinney Creek, 2009, Fig. 1) it was necessary to move a logger to a different location farther upstream. On other occasions loggers have been moved in late summer to make sure the logger is in the deepest possible position at the site.

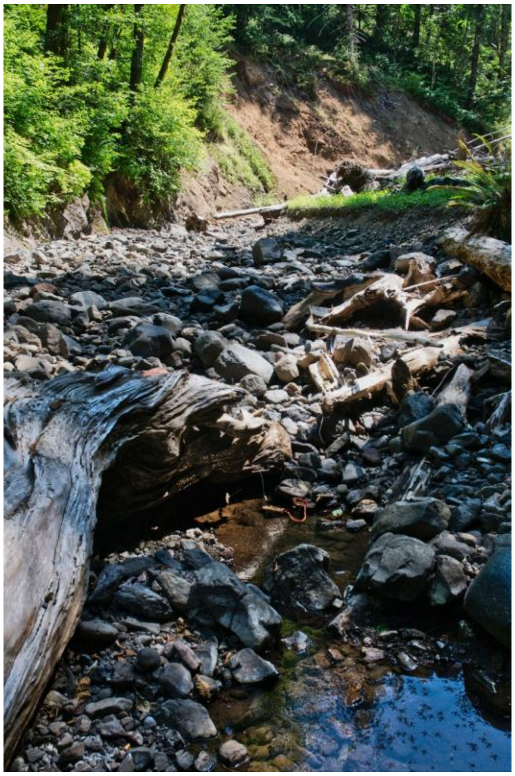


Fig. 1. Kinney Creek site, 8/1/2009. The orange cord is attached to a handheld thermometer placed inside the logger housing. The thermometer registered 15°C at 1:55 PM; the data logger record showed 15.5°C at 2:00 PM. This site is where subsurface flow emerges at the end of a large alluvial deposit from the 2007 debris torrent.

The Hobo® loggers were encased in a waterproof white plastic housing provided by the manufacturer. NexSens® loggers have a small black and clear waterproof plastic housing; we encase these further in white PVC pipe, with both ends of the pipe open and the sides drilled with holes to ensure adequate water flow (Fig. 2). A test over two hot days in August 2008 revealed a maximum of 1°C difference between shielded and unshielded loggers, when deployed in shallow water fully exposed to the sun. With careful site selection, this condition should not occur, but late summer conditions in small tributaries may be nearly this extreme. As standard procedure, we deploy all the NexSens® loggers in the white PVC pipe, regardless of site, to avoid any possibility of direct solar radiation affecting the measurements.

Fig. 2. A NexSens® data logger in the standard waterproof housing, lower right, and another in the same housing but further encased in a section of PVC pipe. This photo is from a test comparing temperatures recorded by shielded and unshielded loggers.

From 1994 through 1997, the data loggers recorded the temperature every 2.4 hours. In 2004 and 2007, the sampling frequency was every 3.2 hours. In 2008 and later the frequency was every 2.0 hours. Dunham et al (2005) presented a chart that can be used to determine the probability of underestimating the maximum daily temperature, for a given sampling frequency and daily range in temperature. It appears that the probability of underestimating the daily maximum temperature (and overestimating the daily minimum) in a stream with the Salmonberry's typical daily range is about 1% for a 2-hour sampling interval, and 2% for a 3-hour interval.

The NexSens® data loggers are limited to 2048 observations per deployment, and a 1-hour interval would mean limiting collection to 85 days. For the summer of 2011, we will test 1-hour vs. 2-hour intervals, perhaps by deploying two loggers in the same tube, with one recording at 2-hour intervals and the other at 1-hour intervals but with log start date delayed until later in the summer. Test sites will probably be ones that have typically shown the greatest rate of daily change in the past, which would provide the highest probability of missing the daily high or low.

4. Quality Control and Data Storage

Handheld thermometers (alcohol in glass tubes) with 1°C graduations are used to check temperatures at placement and retrieval. They are also used in midsummer checks. With handheld, non-certified thermometers and two-hour reading intervals, this process is of limited value. Beginning in 2010, the handheld thermometers were checked against a NIST-traceable digital thermometer provided by DEQ.

In 2008 and 2009, pre- and post-deployment accuracy checks were conducted, using ice baths, as described in Dunham et al. (2005). The temperature of a slurry of ice and water is presumed to be 0°C, and this characteristic can be used to check accuracy, making sure each data logger reads within the published accuracy range (in the case of the NexSens® loggers, ±1°C).

In 2010, cool (5-15°C) and warm (15-25°C) water baths were utilized for the accuracy checking, using a NIST-traceable thermometer provided by DEQ, and following the procedures in OWEB (1999).

All procedures are being changed to comply with the quality assurance requirements for OWEB/DEQ "A" quality data. A quality assurance plan will be produced. With the current set of data loggers, the "A" level quality standard cannot be met, as "A" level requires instrument accuracy of ±0.5°C. Nevertheless, we intend to meet all other requirements so that all procedures are in place when the current loggers are replaced. The data will meet "B" level standards and should be eligible for uploading to DEQ's LASAR database following DEQ approval.

After downloading, data are checked for anomalies. The most likely is a period of extreme highs and lows, corresponding to a period when the site was dewatered and the logger was recording air temperatures. This occurred at three sites in 2004. In this case, the data were retained and marked, but not used in reporting. A related situation occurs when a stream comes close to dewatering, when a high proportion of the surface flow is made up of groundwater percolating out. This situation shows up in the data as relatively cool temperatures with little daily variation. In those cases, data are used in reporting.

Data are stored in Microsoft Excel spreadsheets on the hard drive of a personal computer, and backed up to an external hard drive. Both drives are stored at the author's home (contact ian.fergusson@comcast.net). Data are uploaded to the ODFW Data Clearinghouse (https://nrimp.dfw.state.or.us/dataclearinghouse/default.aspx?p=1) annually. Reports can also be found at that site.

5. Locations

14 sites are monitored: seven main stem sites (three were added in 2009) and seven tributary sites (two were added in 2009). One site, on the North Fork, is monitored with two separate data loggers, for redundancy. In Table 1, "River Mile" refers to main stem sites only, and measurement begins at the river mouth. "Miles from Divide" refers to the hydrologic length of the primary stream channel down to the monitoring site, tracing the primary channel from the closest point on the topographic divide. National Geographic TOPO® software was used.

Table 1. Salmonberry River temperature monitoring sites.

Number	Site Name	River Mile (Main stem)	Miles From Divide	Stream Order	Site Established
1	Main stem above Pennoyer Cr.	13.9	5.4	2nd	1994
2	Pennoyer Cr.		3.2	2nd	1994
3	Wolf Cr.		4.6	3rd	1994
4	Main stem below Wolf Cr.	11.7	7.6	4th	1994
5	Kinney Cr.		2.6	3rd	1994
6	Main stem above North Fork	8.5	10.8	4th	2009
7	North Fork (main)		8.6	4th	1994
8	North Fork (backup)		8.6	4th	2009
9	Main stem below North Fork	8.2	11.1	5th	1994
10	Bathtub Cr.		2.1	2nd	2009
11	South Fork		3.4	3rd	1994
12	Main stem below South Fork	6.5	12.7	5th	2009
13	Belfort Cr.		2.1	2nd	1994
14	Main stem below Belfort Cr.	3	16.3	5th	1994
15	Main stem above mouth	0.3	19.2	5th	2009

The map in Appendix A shows monitor locations, keyed to the numbers in Table 1.

We do not have complete data for each site for each year. Over the course of the project, 5 monitors have been lost. Occasional battery failures have occurred. Some data are missing for unknown reasons. All data from the 4 sites monitored in 1993 are unusable, as the launching process tagged the beginning dates as 1/1/1980. Since the begin date represents the date the device was turned on in the ODFW office (date unknown), and field notes relating to placement and retrieval dates were lost, there is no way to associate the 1993 temperatures with exact dates.

In 2004, 3 monitors (upper main stem, Kinney Cr., and South Fork) recorded temperatures so high relative to other sites and other years that the data are suspect and were not included in the analysis. The likely explanation is that they were placed in areas where the water went underground, and the monitors were recording air temperatures.

Table 2. Data availability by year.

Name	1994	1995	1996	1997	2004	2007	2008	2009	2010
Mainstem Above Pennoyer Cr.	X	X	X	X		X	X	X	X
Mainstem Below Wolf Cr.	X	X	X	X		X	X	X	X
Mainstem above North Fork								X	X
Mainstem Below North Fork	X	X	X	X		X	X	X	X
Mainstem Below South Fork								X	X
Mainstem Below Belfort Cr.	X	X	X	X			X	X	X
Mainstem At Mouth								X	X
Pennoyer Creek	X	X	X	X	X	X	X	X	X
Wolf Creek	X	X	X	X	X		X	X	X
Kinney Creek	X	X		X		X	X	X	X
North Fork	X	X	X	X	X		X	X	X
North Fork backup								X	X
Bathtub Creek								X	X
South Fork	X	X	X			X	X	X	X
Belfort Creek	X	X		X		X	X	X	X

X=good data; solid box = missing or suspect data

6. Objectives and Criteria

The primary reasons for gathering temperature data are to determine if summer water temperatures meet the requirements for salmonid spawning and rearing, and whether any discernible temperature trends exist.

Oregon DEQ has designated the Salmonberry main stem and all tributaries as "core cold-water habitat" (http://www.deq.state.or.us/wq/rules/div041/fufigures/figure230a.pdf). The DEQ/EPA "Core Cold Water Habitat" standard (16^{o} C), is defined as the upper limit for core juvenile salmonid rearing habitat (except for bull trout). The pertinent wording in the Oregon Administrative Rules (340-041-0028 (4) (b)) is "*The seven-day-average maximum temperature of a stream identified as having core cold water habitat use…may not exceed 16.0 degrees Celsius (60.8 degrees Fahrenheit)*."

The EPA/DEQ salmonid spawning criterion is 13^{o} C (55.4^{o} F; governed by OAR 340-041-0028 (4) (a)). This standard applies to the Salmonberry main stem and the tributaries shown on DEQ's salmon and steelhead spawning use map (http://www.deq.state.or.us/wq/rules/div041/fufigures/figure230b.pdf). Relevant spawning use periods for the Salmonberry are Sep 1 – Jun 15 for the main stem, Oct 15 – Jun 15 for Bathtub Creek and Wolf Creek, and Nov 1- Jun 15 for Kinney Creek, South Fork, and North Fork. Since we generally deploy the monitors from late May or early June through mid-September, there is little overlap with designated spawning periods. However, violations of the standard within those limited periods might indicate a need to extend the monitoring periods.

The seven-day moving average of the daily maximum temperatures (abbreviated 7DADM) helps avoid the results being unduly affected by the maximum temperature of a single day. The 7DADM reflects an average of maximum temperatures that fish are exposed to over a week-long period. It is calculated as the average of the current day and the previous six days.

7. Results Relative to EPA/DEQ Standards

A. Cold Water Habitat Standard

Table 2. Salmonberry River Main Stem: number of days in excess of DEQ Core Cold Water Habitat Standard (16^{o}C; 60.8^{o}F), and maximum recorded 7DADM

		RM 13.9	RM 11.7	RM 8.5	RM 8.2	RM 6.5	RM 3	RM 0.3
		Above Pennoyer	**Below Wolf**	**Above N Fork**	**Below N Fork**	**Below S Fork**	**Below Belfort**	**Above Mouth**
1994	**Days > 16^{o}C**	0	0	M	0	M	**26**	M
	Max 7DADM	14.1	15.9	M	15.5	M	**17.9**	M
1995	**Days > 16^{o}C**	0	0	M	0	M	**23**	M
	Max 7DADM	13.5	15.7	M	15.9	M	**17.8**	M
1996	**Days > 16^{o}C**	0	**6**	M	**7**	M	**51**	M
	Max 7DADM	14.1	**16.4**	M	**16.9**	M	**19.4**	M
1997	**Days > 16^{o}C**	0	**6**	M	0	M	**47**	M
	Max 7DADM	13.8	**16.3**	M	15.9	M	**18.5**	M
2004	**Days > 16^{o}C**	M	M	M	M	M	M	M
	Max 7DADM	M	M	M	M	M	M	M
2007	**Days > 16^{o}C**	0	0	M	0	M	M	M
	Max 7DADM	13.3	15.2	M	15.4	M	M	M
2008	**Days > 16^{o}C**	0	0	M	**2**	M	**33**	M
	Max 7DADM	14.2	15.5	M	**16.2**	M	**18.1**	M
2009	**Days > 16^{o}C**	0	**15**	**27**	**20**	**29**	**61**	**76**
	Max 7DADM	16.0	**17.6**	**19**	**18.4**	**19.6**	**21.6**	**23.3**
2010	**Days > 16^{o}C**	0	0	0	0	**20**	**33**	**52**
	Max 7DADM	14.3	15.6	15.7	15.4	**16.7**	**17.9**	**19.6**

It is clear that even in a relatively cool summer such as 2010, the lowest 7 miles of the main stem routinely exceed the core cold-water habitat standard.

Table 3. Salmonberry River Tributaries: number of days in excess of DEQ Core Cold Water Habitat Standard (16°C; 60.8°F), and maximum recorded 7DADM

		Penn. Cr	Wolf Cr	Kinney Cr	North Fork	Bathtub Cr	South Fork	Belfort Cr
1994	**Days > 16°C**	0	0	0	0	M	0	0
	Max 7DADM	14.3	14.4	12.6	15.1	M	13	12.9
1995	**Days > 16°C**	0	0	0	0	M	0	0
	Max 7DADM	14.2	14.3	13	15.3	M	13.2	13.2
1996	**Days > 16°C**	0	**12**	M	**3**	M	0	M
	Max 7DADM	14.8	**16.9**	M	**16.2**	M	13.7	M
1997	**Days > 16°C**	0	**15**	**11**	0	M	M	0
	Max 7DADM	14.2	**16.8**	**16.2**	15.5	M	M	13.1
2004	**Days > 16°C**	0	0	M	0	M	M	M
	Max 7DADM	14.5	14.7	M	13.7	M	M	M
2007	**Days > 16°C**	0	M	0	M	M	0	0
	Max 7DADM	13.7	M	15.4	M	M	13.2	13.5
2008	**Days > 16°C**	0	0	0	0	M	0	0
	Max 7DADM	14.1	15.4	15	15.3	M	14.1	14.9
2009	**Days > 16°C**	0	**13**	**5**	**18**	**9**	0	0
	Max 7DADM	15.9	**17.4**	**16.3**	**18.4**	**17.0**	15.3	15.9
2010	**Days > 16°C**	0	**3**	0	0	0	0	0
	Max 7DADM	14	**16.1**	14.8	15.8	15.4	13.9	14.2

Wolf Creek, Kinney Creek, and Bathtub Creek were all scoured by large debris flows in February 1996 and again in December 2007. See Appendix B for other presentations of the temperature data relative to the core cold water habitat standard.

B. Salmonid Spawning Standard

Relevant spawning use periods are Sep 1 – Jun 15 for the main stem; Oct 15 – Jun 15 for Bathtub Creek and Wolf Creek, and Nov 1- Jun 15 for Kinney Creek, South Fork, and North Fork. Our monitoring periods overlap these only slightly; nevertheless, the 13°C standard is exceeded routinely in the main stem, and rarely in the tributaries.

Table 4. Salmonberry River Main Stem - Days DEQ Spawning Standard exceeded (before 6/15 and after 9/1)

	Total Number of Days DEQ Spawning Standard (13°C; 55.4°F) Exceeded													
	Above Pennoyer		**Below Wolf**		**Above N Fork**		**Below N Fork**		**Below S Fork**		**Below Belfort**		**Above Mouth**	
Year	**≤ 6/15**	**≥ 9/1**	**≤ 6/15**	**≥ 9/1**	**≤ 6/15**	**≥ 9/1**	**≤ 6/15**	**≥ 9/1**	**≤ 6/15**	**≥ 9/1**	**≤ 6/15**	**≥ 9/1**	**≤ 6/15**	**≥ 9/1**
1994 (6/6-9/24)	0	0	0	**4**	M	M	0	**4**	M	M	0	**24**	M	M
1995 (4/24-9/23)	0	0	0	**21**	M	M	0	**23**	M	M	0	**23**	M	M
1996 (6/3-9/21)	0	0	0	**14**	M	M	0	**17**	M	M	**4**	**19**	M	M
1997 (5/25-9/24)	0	0	0	**16**	M	M	0	**16**	M	M	**5**	**18**	M	M
2004 (5/29-9/18)	M	M	M	M	M	M	M	M	M	M	M	M	M	M
2007 (6/4-9/8)	0	0	0	**8**	M	M	0	**8**	M	M	M	M	M	M
2008 (6/1-9/5)	0	0	0	**5**	M	M	0	**4**	M	M	0	**5**	M	M
2009 (5/30-9/12)	0	**5**	0	**6**	**4**	**10**	**2**	**10**	**4**	**10**	**10**	**12**	**11**	**12**
2010 (4/26-9/18)	0	0	0	0	0	0	M	M	0	**14**	0	**14**	0	**14**

M=missing data

Table 5. Salmonberry River Tributaries - Days DEQ Spawning Standard exceeded (before 6/15 only)

Total Number of Days DEQ Spawning Standard (13°C; 55.4°F) Exceeded							
Year	Penn. Cr	Wolf Cr	Kinney Cr	North Fork	Bathtub Cr	South Fork	Belfort Cr
1994 (6/6-9/24)	n/a	0	0	0	M	0	n/a
1995 (4/24-9/23)	n/a	0	0	0	M	0	n/a
1996 (6/3-9/21)	n/a	0	M	0	M	0	n/a
1997 (5/25-9/24)	n/a	0	0	0	M	M	n/a
2004 (5/29-9/18)	n/a	0	M	0	M	M	n/a
2007 (6/4-9/8)	n/a	M	0	M	M	0	n/a
2008 (6/1-9/5)	n/a	0	0	0	M	0	n/a
2009 (5/30-9/12)	n/a	6	0	0	4	0	n/a
2010 (4/26-9/18)	n/a	0	0	0	0	0	n/a

M=missing data; n/a=spawning standard does not apply

8. Effect of North Fork on Main Stem Temperatures

The North Fork enters at about river mile 8.3, and contributes about the same amount of water as the main stem does at that point. If either source (North Fork or upper main stem) is significantly different in temperature, this difference should be visible at the station just downstream of the North Fork. The site in the main stem just upstream of the North Fork was established in 2009; the sites in the North Fork and just downstream of the North Fork were established in 1994. The site in the North Fork is more than one mile above the mouth. Temperatures might be cooler there than at the mouth, as the usual pattern is for temperatures to increase in a downstream direction. However, there could be significant groundwater inputs in the lower mile, and three permanent tributaries enter the North Fork between the monitoring station and the mouth.

Table 6 shows temperatures at the upstream and downstream sites beginning in 2009, the first year temperatures were recorded at the site immediately above the North Fork. The dates selected are those on which the highest 7DADM for the year was recorded. The North Fork appears to provide a slight cooling effect.

Table 6. Main stem temperatures above and below the North Fork

	Maximum 7DADM	
Period	Above NF	Below NF
2009 (7 days ending 8/3)	19.0	18.4
2010 (7 days ending 8/18)	15.7	15.4

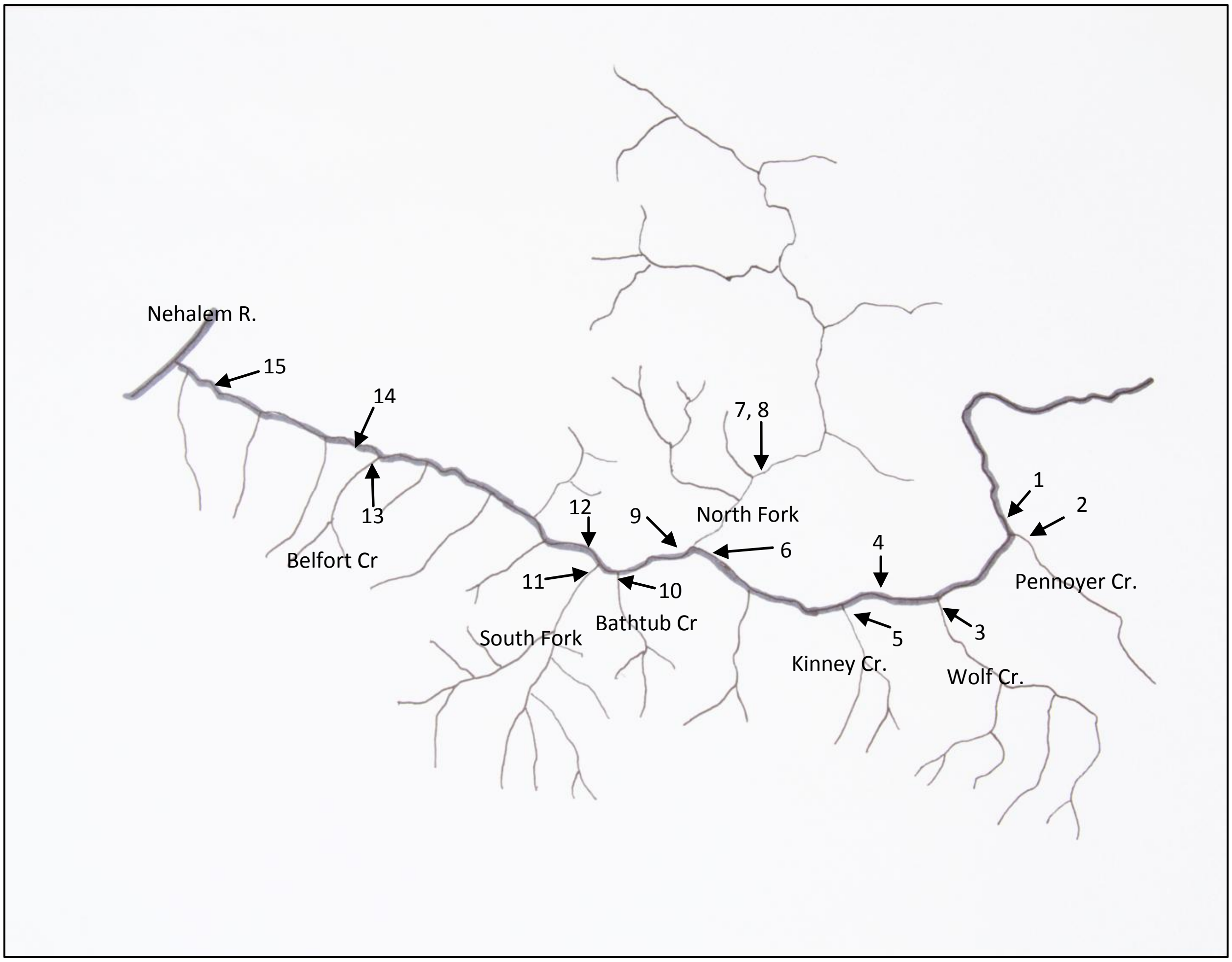
Citations

Dunham, J., G. Chandler, B. Rieman, and D. Martin. 2005. Measuring stream temperature with digital data loggers: a user's guide. Gen. Tech. Rep. RMRS-GTR-150WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Oregon DEQ website water quality rules section (http://www.deq.state.or.us/wq/rules/div041tblsfigs.htm).

Oregon Watershed Enhancement Board, 1999. Water Quality Monitoring Technical Guidebook (http://www.oregon.gov/OWEB/docs/pubs/wq_mon_guide.pdf).

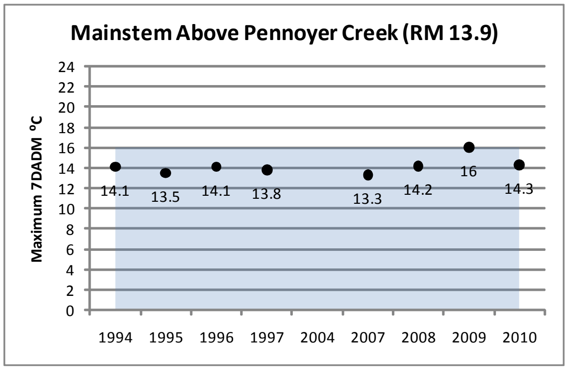
Appendix A. Site Locations

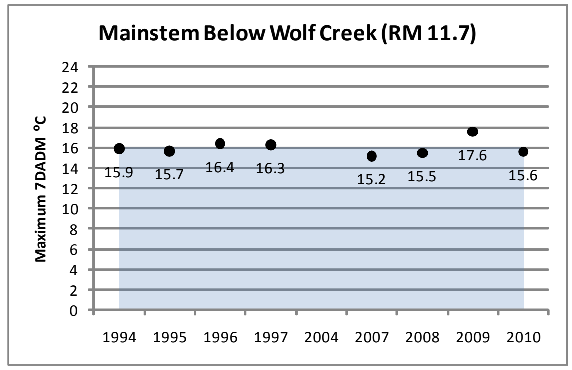


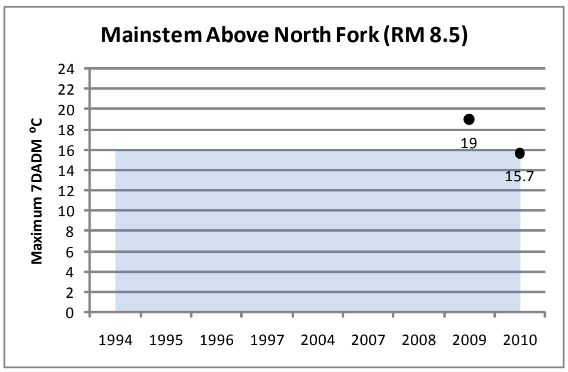
Salmonberry River main stem is shown as a bold line. One inch=1.4 miles.

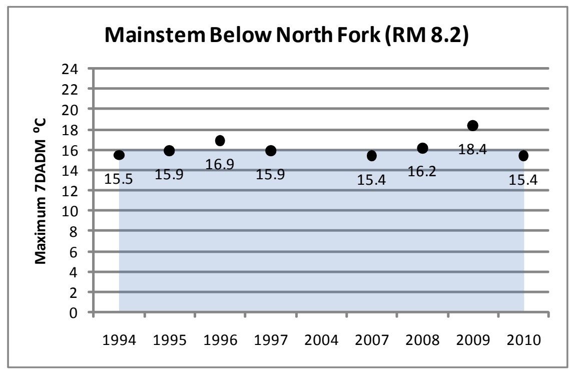
Appendix B. Maximum 7DADM by Site and Year

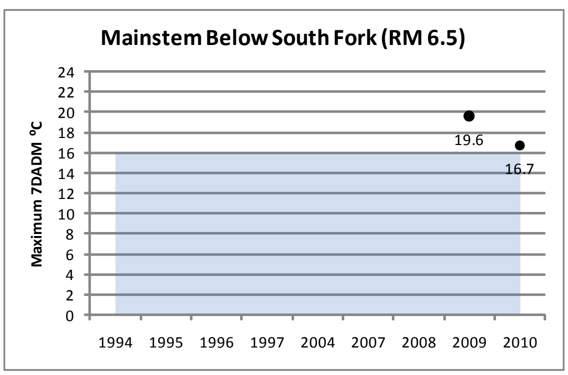
The shaded area in the following charts represents temperatures at or below the 16^{o}C standard.

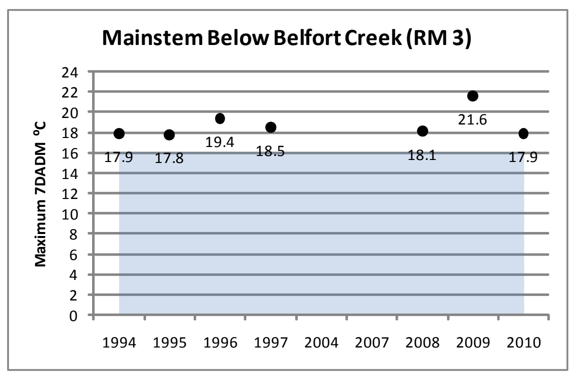


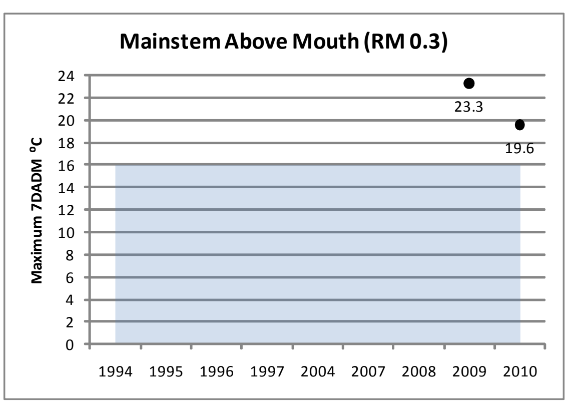


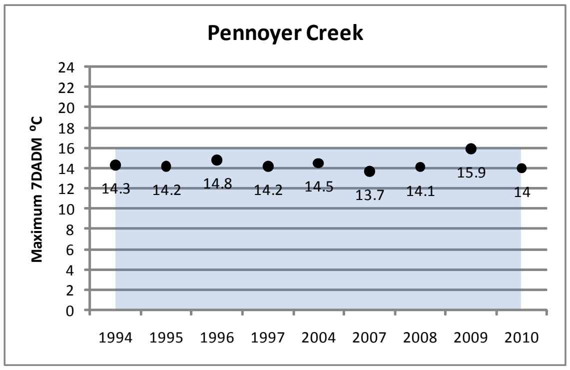











Pennoyer Creek
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
14.3
14.2
14.8
14.2
14.5
13.7
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14
1994
1995
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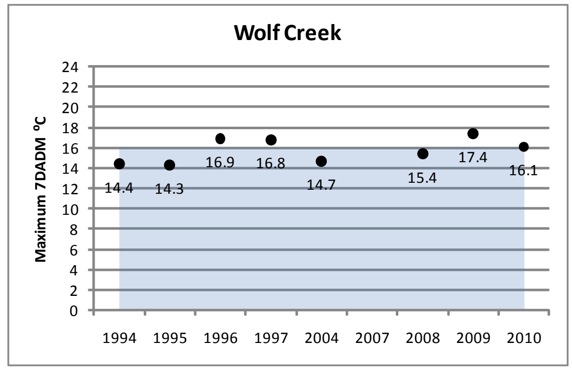
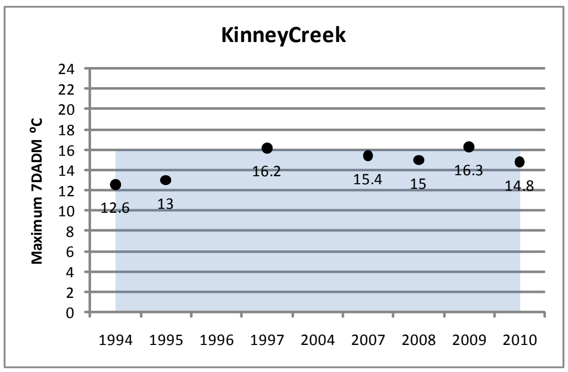
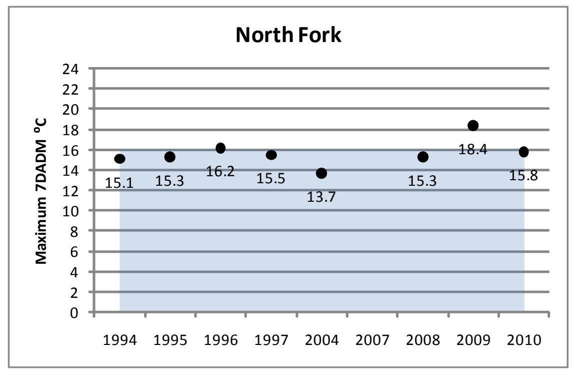
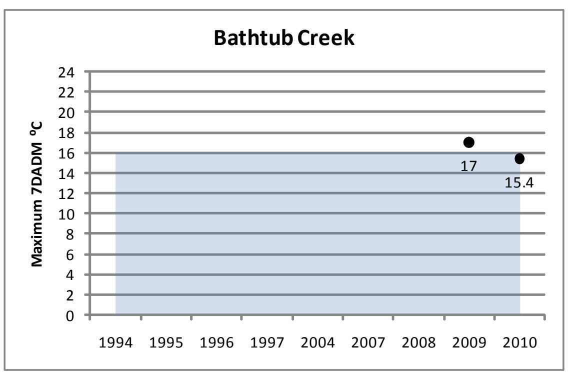
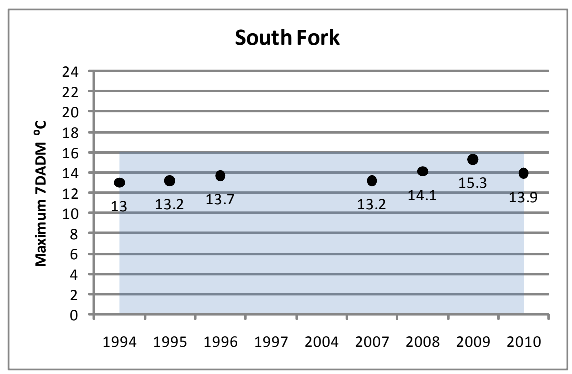
2009
2010

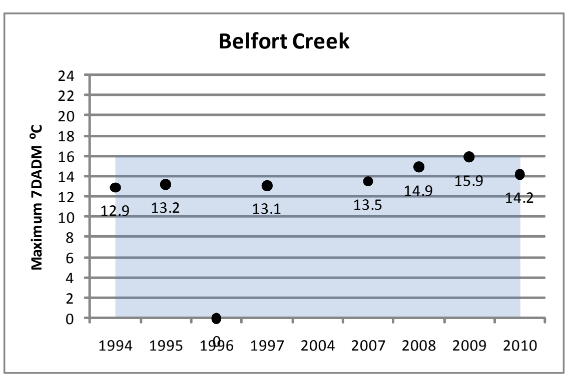

Wolf Creek
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
14.4
14.3
16.9
16.8
14.7
15.4
17.4
16.1
1994
1995
1996
1997
2004
2007
2008
2009
2010


KinneyCreek
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
12.6
13
16.2
15.4
15
16.3
14.8
1994
1995
1996
1997
2004
2007
2008
2009
2010


North Fork
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
15.1
15.3
16.2
15.5
13.7
15.3
18.4
15.8
1994
1995
1996
1997
2004
2007
2008
2009
2010


Bathtub Creek
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
17
15.4
1994
1995
1996
1997
2004
2007
2008
2009
2010


South Fork
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
13
13.2
13.7
13.2
14.1
15.3
13.9
1994
1995
1996
1997
2004
2007
2008
2009
2010


Belfort Creek
Maximum 7DADM °C
24
22
20
18
16
14
12
10
8
6
4
2
0
12.9
13.2
0
13.1
13.5
14.9
15.9
14.2
1994
1995
1996
1997
2004
2007
2008
2009
2010