Salmonberry River Temperature Monitoring 1994-2007

A STEP Project

Spawning Steelhead, Main Stem Salmonberry River

Abstract: Recording water temperature monitors were placed at 10 sites in the summers of 1994-1997, 2004, and 2007. Significant temperature increases were recorded after the 1996 floods. Recent levels are closer to 1994-95. There are not enough observations to determine whether long-term warming is occurring. The lowest mainstem site exceeded the EPA "Core Juvenile Rearing Standard" for long periods (23 to 50 days) every year from 1994-1997. No data exist for this site after 1997. Four sites exceeded the EPA standard for 5-16 days in 1996/97; none of those sites exceeded the standard in other years. The lower main stem is of the most concern; three to eight miles of river are likely to regularly exceed the EPA core juvenile rearing standard.

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1. Introduction

The Salmonberry River is a tributary of the lower Nehalem River. It arises in Tillamook County just west of the Washington County line, about 6 miles northwest of the town of Timber. Approximately 17 miles long, it joins the Nehalem about 14 river miles above the Nehalem's head of tidewater.

The Salmonberry is the North Coast's most remote river. One road crosses the river at the mouth, and a few logging roads provide access to the upper river. The Port of Tillamook Bay operates a railroad that follows the river from its mouth to Pennoyer Creek in the upper watershed. This railroad provides foot access to the lower 14 miles of the river. At this writing the future of the railroad is uncertain, as the December 2007 storm caused extensive damage to the railroad in the Salmonberry canyon. Repairs and continued operation may not be economically feasible.

Much of the Salmonberry watershed was involved in the Tillamook Burns (1933, 1939, 1945), and as a result logging activity has been minimal until recently. Extensive clear cut harvesting is occurring on private timberlands, mostly in the Wolf Creek, Kinney Creek, and North Fork sub watersheds. The Oregon Department of Forestry is also conducting harvest operations.

The Salmonberry is known for its run of wild winter steelhead, regarded as one of the healthiest runs of those fish on the West Coast. Hatchery steelhead have never been stocked in the Salmonberry. The Salmonberry has a reputation for producing very large steelhead (20 pounds and more). It also has runs of fall Chinook salmon and sea-run cutthroat trout, resident cutthroat trout, and a small resident population of rainbow trout in the upper North Fork watershed. Very small numbers of juvenile coho salmon have been noted in Oregon Department of Fish and Wildlife (ODFW) electroshock surveys.

Every year since 1993 a team of volunteers has conducted winter steelhead spawning surveys in the Salmonberry, under a STEP (Salmon Trout Enhancement Program) project. This effort has been led the entire time by Marty and Joyce Sherman. The effort was initiated by the Oregon Trout Steelhead Committee, but has operated independently of Oregon Trout for many years.

Because of the importance of the Salmonberry in steelhead production, and the possibility of temperature changes due to increased timber harvest, ODFW provided the volunteer team with recording temperature monitors ("Hobo Temps") in 1993, 1994, 1995, 1996, 1997, 2004, and 2007 to monitor summertime temperatures at ODFW-selected locations within the watershed.

2. Methodology

The devices were duct-taped to rocks large enough to prevent movement and placed in locations deemed likely to remain fully watered throughout the summer. A typical placement in a small tributary (Pennoyer Creek) is shown.

There is no consensus within the volunteer team as to whether it is better to prominently flag the devices to facilitate retrieval, or conceal them to prevent tampering, which makes retrieval difficult. We have probably lost devices for both reasons.

Monitors were placed in late spring and retrieved in September, before any significant fall rains that might move poorly anchored devices. Monitors are calibrated to sample 10 times per day, at intervals of 2 h 24 m.

After the volunteer team retrieved the devices, they were delivered to ODFW in Tillamook for downloading. To our knowledge ODFW has not done any analysis of the data; however, in 2007 we were given copies (in Excel spreadsheet format) of all data collected to date so we could do our own analysis.

3. Locations

Four main stem sites and six tributary sites were monitored. Starting with the site highest in the watershed, they are:

1. Main stem above Pennoyer Cr., river mile (RM) 13.9. Steelhead redds have been observed in this stretch. There is a falls about 0.5 miles above this point, which presumably marks the upper limit of steelhead spawning.

2. Pennoyer Cr., RM 13.9. This is a small tributary with a barrier falls a short distance above its mouth. Occasional steelhead redds have been observed below the falls. Resident cutthroat trout are found above the falls.

3. Wolf Cr., RM 12.4. This is the third largest tributary of the Salmonberry, behind the North and South Forks. Although Wolf Creek is not regularly surveyed, ad-hoc surveys have noted considerable steelhead spawning activity, with redds observed as far as 2 miles upstream from the mouth. Wolf Creek was scoured by a massive debris flow in 1996 that began near the top of a ridge separating Wolf and Kinney Creeks, and travelled more than 3 miles along the entire length of Wolf Creek.

4. Main stem below Wolf Cr., RM 11.7. The site is within the area known as "Wolf Creek Flats" and is part of a standard steelhead spawning survey. This stretch typically has high numbers of steelhead redds and marks the upper limit of Chinook spawning activity.

5. Kinney Cr., RM 10.9. A small tributary, not regularly surveyed for spawners. On occasion steelhead redds have been observed in lower Kinney Cr. Much of Kinney Creek was scoured by debris flows in the 1996 floods.

6. North Fork, RM 8.3. The North Fork has a very large spawning run of steelhead. The Salmonberry's signature fish are the ones that ascend the daunting North Fork falls in April and go on to spawn well up the North Fork. Spawning Chinook have been observed in the lower North Fork (below the falls). Resident cutthroat trout occur above the falls, and resident rainbow trout are found in the headwaters. Steelhead redds have been documented 5 miles above the falls.

7. Main stem below North Fork, RM 8. This is within the "Enright" spawning survey reach, which has been surveyed by ODFW since the 1960's. Steelhead and Chinook salmon spawn within this reach.

8. South Fork, RM 6.7. The South Fork has a spawning run of steelhead, as well as cutthroat trout. The South Fork was designated as salmon "Anchor Habitat" under a 2003 agreement involving ODFW, Oregon Department of Forestry, and Oregon Trout. The volunteer team

regularly surveys the South Fork to document steelhead spawning activity. Steelhead redds have been documented not only in the main South Fork, but also in its main tributary, Ripple Creek, and in the upper South Fork up to 0.5 miles above Ripple Creek.

9. Belfort Creek, RM 3.1. This is a small tributary, too small for steelhead spawning, but may support cutthroat trout or other fish species.

10. Main stem below Belfort Cr., RM 3. Both steelhead and chinook spawn in this area.

See Appendix 1 for a map with site locations.

We do not have complete data for each site for each year. 1994 and 1995 are the only years with complete data. Over the course of the project, 4 monitors have been lost. Occasional battery failures occurred. Some data are missing for unknown reasons. All data from the 4 sites monitored in 1993 are unusable, as the download 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 reported temperatures so high relative to other locations 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 substantially underground, and the monitors were exposed to air temperatures. See Appendix 2.

The following table summarizes data availability for each location by year.

Table 1. Hobo Temp Locations

Location	1993	1994	1995	1996	1997	2004	2007
Main stem above Pennoyer	unusable	data	data	data	data	suspect	data
MS below Wolf Cr	not placed	data	data	data	data	battery	data
MS below North Fk	lost	data	data	data	data	missing	data
MS below Belfort	not placed	data	data	data	data	not placed	not placed
Pennoyer Cr	unusable	data	data	data	data	data	data
Wolf Cr	not placed	data	data	data	data	data	missing
Kinney Cr	not placed	data	data	battery	data	suspect	data
North Fork	unusable	data	data	data	data	data	lost
South Fork	not placed	data	data	data	lost	suspect	data
Belfort Cr	unusable	data	data	missing	data	lost	data

4. Objectives and Criteria

The primary reasons for gathering temperature data are to determine if summer water temperatures meet the requirements of anadromous fish and whether any discernible temperature trends exist.

For determining whether temperatures are suitable for anadromous fish, we elected to use the "EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards" (EPA document 910-B-03-002, April 2003).

A summary of EPA temperature considerations for salmon and trout (includes steelhead and coastal cutthroat) life stages appears in Table 2.

Table 2. EPA Temperature Considerations For Salmon and Trout Life Stages

Life Stage	Temperature Consideration	Temperature & Unit	°F Equiv., Rounded
Spawning and Egg Incubation	Spawning most frequently observed in the field	4-14 °C (daily avg.)	39-57
	Egg Incubation:		
	-good survival	4-12 °C (constant)	39-54
	-optimal range	6-10 °C (constant)	43-50
	Reduced Viability of Gametes in Holding Adults	> 13 °C (constant)	55
Juvenile Rearing	Lethal (1 week exposure)	23-26 °C (constant)	73-79
	Optimal Growth		
	-unlimited food	13-20 °C (constant)	55-68
	-limited food	10-16 °C (constant)	50-61
	Rearing Preference (Lab and Field Studies)	10-17 °C (constant); < 18 °C (7DADM)	50-63; <64
	Impairment to Smoltification	12-15 °C (constant)	54-59
	Impairment to Steelhead Smoltification	>12°C (constant)	54
	Disease Risk (lab studies)		
	-high	>18-20 °C (constant)	64-68
	-elevated	14-17 °C (constant)	57-63
	-minimized	12-13 °C (constant)	54-55
Adult Migration	Lethal (1 week exposure)	21-22 °C (constant)	70-72
	Migration Blockage and Delay	21-22 °C (average)	70-72
	Disease Risk (lab studies)		
	-high	>18-20 °C (constant)	64-68
	-elevated	14-17 °C (constant)	57-63
	-minimized	12-13 °C (constant)	54-55
	Adult Swimming Performance		
	-reduced	>20 °C (constant)	68
	-optimal	15-19 °C (constant)	59-66
	Overall Reduction in Migration Fitness due to Cumulative Stresses	>17-18 °C (prolonged exposures)	63-64

EPA suggests using a seven-day moving average of the daily maximum temperatures (7DADM) as a way of describing the maximum temperatures in a stream. This avoids 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.

EPA consolidated the considerations into a set of recommendations. The recommendations for salmonid uses during summer maximum conditions are these:

Salmon/Trout “Core” Juvenile Rearing: 16 °C (61 °F) 7DADM. Salmon adult holding prior to spawning may also be included in this use category.

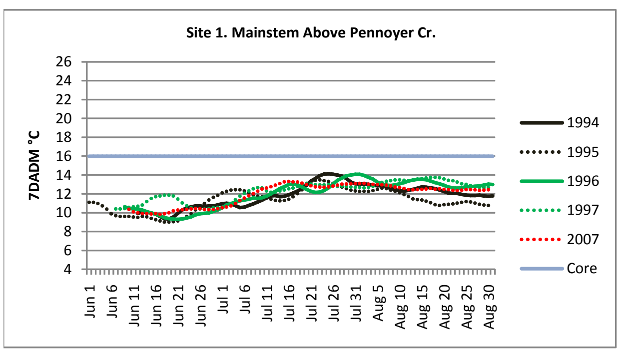
Salmon/Trout Migration plus Non-Core Juvenile Rearing: 18 °C (64 °F) 7DADM.

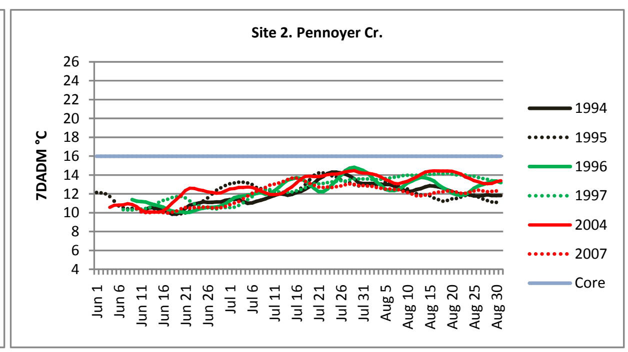
These temperature criteria do not represent absolute upper thresholds of tolerance; rather, they represent the upper limits of **optimum** temperatures for the use category. Short periods exceeding the standards do not necessarily mean a chronic problem is present. Longer periods above the standard, or temperatures well in excess of the standard, would indicate suboptimal conditions are developing that need to be addressed.

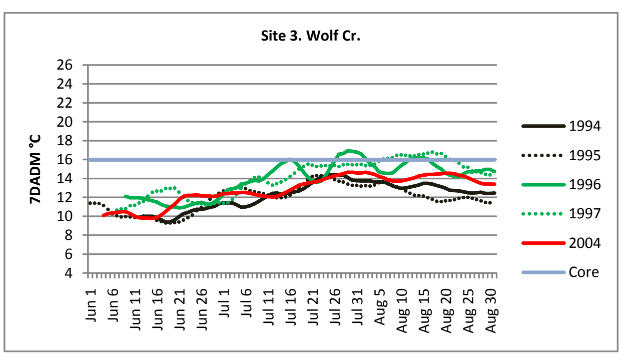
Of the two applicable categories, we think the Salmon/Trout “Core” Juvenile Rearing standard should be used and should apply to the entire Salmonberry watershed. The Salmonberry is a small river with a very well-distributed run of spawning steelhead, and a significant tributary (the South Fork) is designated as “Anchor Habitat”. There is also a late summer run of Chinook that may hold in the lower river prior to spawning, and the “Core” standard would apply to them as well.

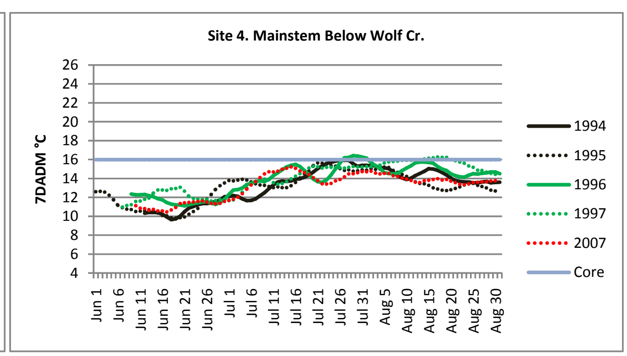
5. Results Relative to EPA “Core Juvenile Rearing” Standard

In the following charts, a “Core” benchmark line is included, representing the 16 °C (61 °F) “Core Juvenile Rearing” standard, and the 7DADM is plotted for each year where data exist for the location. The charts are presented in descending order of location in the watershed.



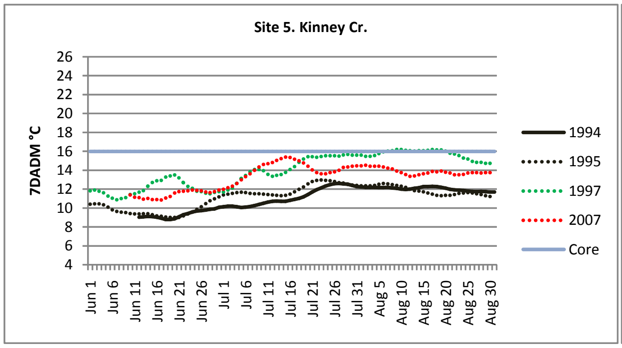


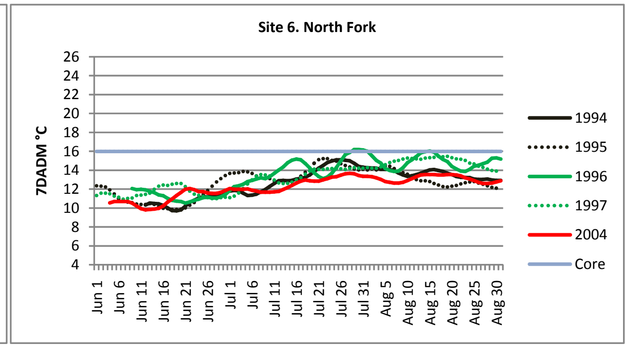




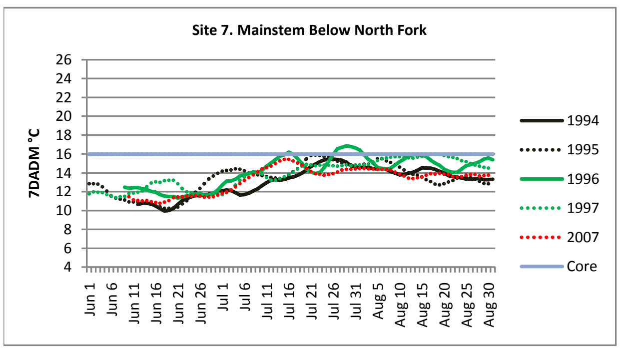
Wolf Creek exceeded the “Core Juvenile” standard Jul 26-Aug 2 and Aug 12-16 of 1996, and Aug 6-21 of 1997. This is almost certainly due to the extensive loss of streamside vegetation following the Feb 1996 debris flow. The main stem Salmonberry below Wolf Creek showed the effects of the warmer Wolf

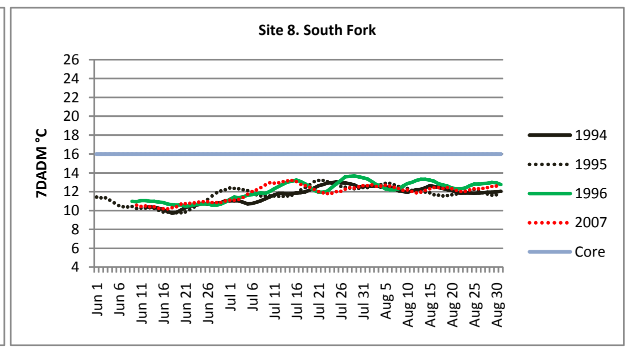
Creek water, slightly exceeding the “Core Juvenile” standard in 1996 and 1997. The standard was closely approached in 1994 and 1995.



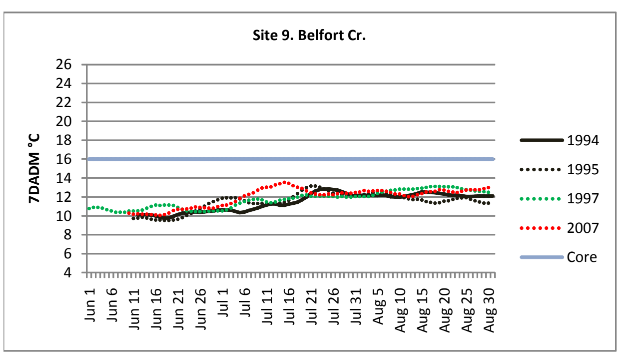


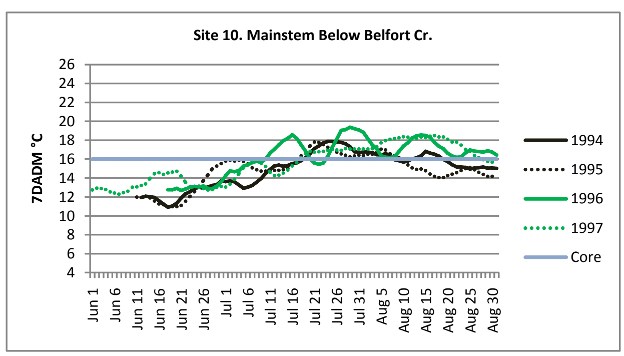
Kinney Creek also exceeded the “Core Juvenile” standard very slightly in 1997 (1996 missing due to battery failure). The North Fork slightly exceeded the core standard in 1996.





The main stem Salmonberry exceeded the core standard briefly in 1996 and reached it for much of August in 1997. In addition, the core standard was reached briefly, but not exceeded, in 1995. The South Fork remained well below the core standard for all years. The South Fork came through the 1996 floods relatively unscathed.





Belfort Creek also remained well below the core standard all measured years. It is uncertain what role Belfort Creek plays in salmonid life cycles, beyond contributing a small volume of cooler water to the lower main stem.

The main stem below Belfort Creek shows the cumulative effects of temperature regimes throughout the system. Even in the "baseline" years of 1994 and 1995, it exceeded the core juvenile rearing standard for 23 days (1994) and 27 days (1995). In 1996 and 1997 it exceeded the standard for much of the summer (81 and 78 days, respectively). Data are not present for any years after 1997. Presumed uses of the lower mainstem are: juvenile rearing, adult summer Chinook holding, sea-run cutthroat trout holding and migration. The location is out of the optimum range for all of those except for pass-through migration of cutthroat. In 1996 and 1997, this location also exceeded the non-core juvenile rearing standard (18°C.). It will be critical to keep monitoring this location. As there are 3 river miles below this point, and the next site on the main stem is 5 miles upstream from this point, there could be a long stretch of river that regularly exceeds the core standard.

Table 3 summarizes the number of days each site exceeded the Core Juvenile Rearing Standard. Clearly, the worst years were 1996 and 1997, and can be attributed to widespread flooding and riparian damage in February of 1996. The main stem below Belfort Creek is the only site of concern at this point.

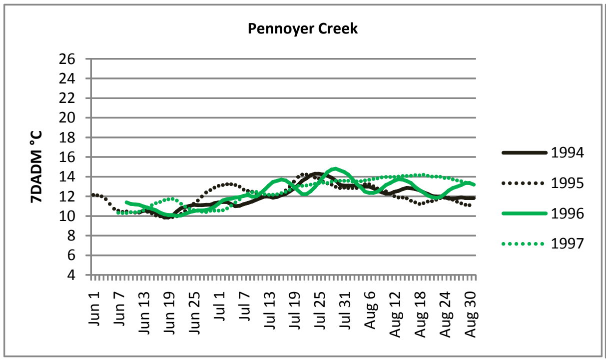
Table 3. Days Above Core Juvenile Rearing Standard (16 °C)

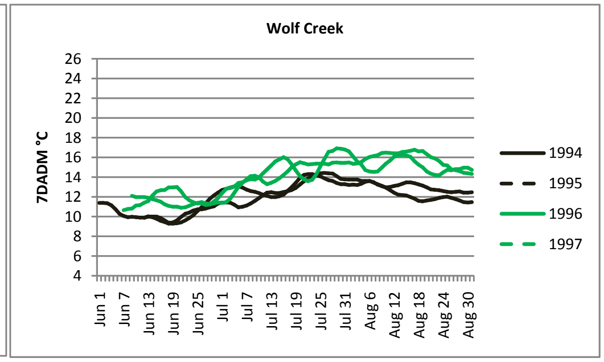
Location	1994	1995	1996	1997	2004	2007	Total
Mainstem Above Pennoyer Cr.	0	0	0	0	M	0	**0**
Pennoyer Cr.	0	0	0	0	0	0	**0**
Wolf Cr.	0	0	13	16	0	M	**29**
Mainstem Below Wolf Cr.	0	0	6	7	M	0	**13**
Kinney Cr.	0	0	0	14	M	0	**14**
North Fork	0	0	5	0	0	M	**5**
Mainstem Below North Fork	0	0	7	0	M	0	**7**
South Fork	0	0	0	M	M	0	**0**
Belfort Cr.	0	0	M	0	M	0	**0**
Mainstem Below Belfort Cr.	27	23	50	41	M	M	**141**
	27	**23**	**81**	**78**	**0**	**0**	**209**

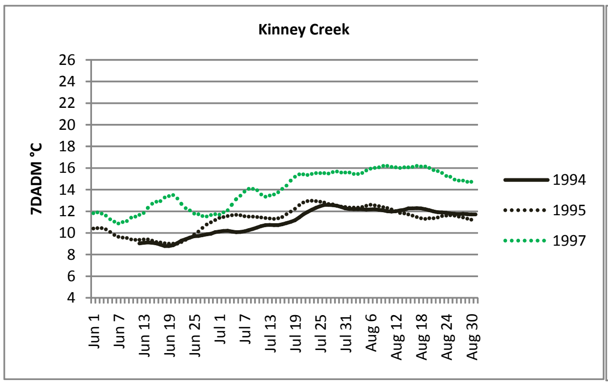
6. Effects of Major Debris Flows

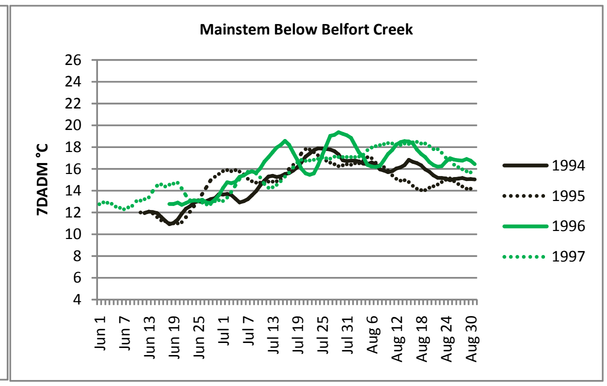
In February of 1996 a severe rain-on-snow event occurred in the Salmonberry watershed. Of the monitored sites, Wolf Creek and Kinney Creek suffered major debris flows that removed miles of riparian vegetation. By contrast, Pennoyer Creek suffered relatively little damage. These three tributaries in the Salmonberry headwaters provide an opportunity to see what effect the debris flows had on water temperatures.

Pennoyer Creek showed a slight elevation in temperatures in 1996 and 1997. Wolf Creek showed significant increases in temperatures in 1996 and 1997 due to the loss of riparian vegetation. Kinney Creek also showed elevated temperatures in 1997 (1996 missing due to battery failure) for the same reason. All sites monitored showed elevated temperatures in 1996 and 1997. The cumulative effects are seen in the data from the mainstem Salmonberry below Belfort Creek, 3 miles above the mouth.

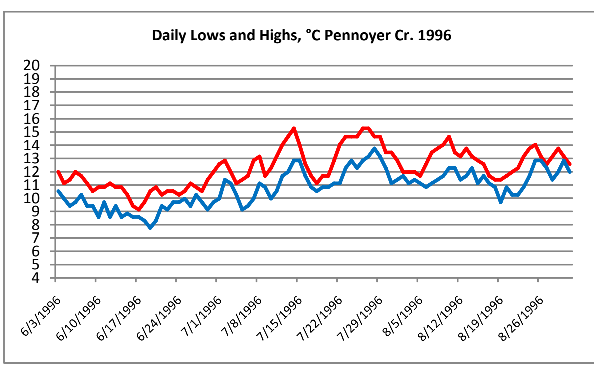


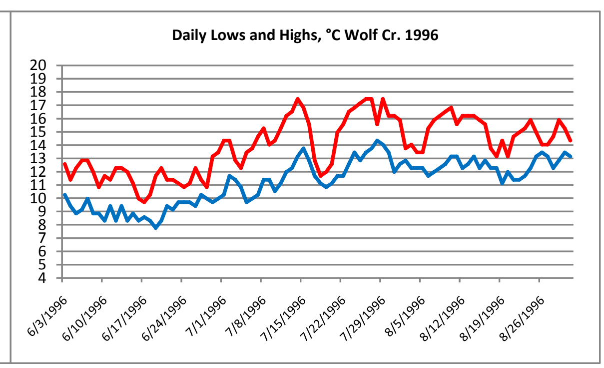


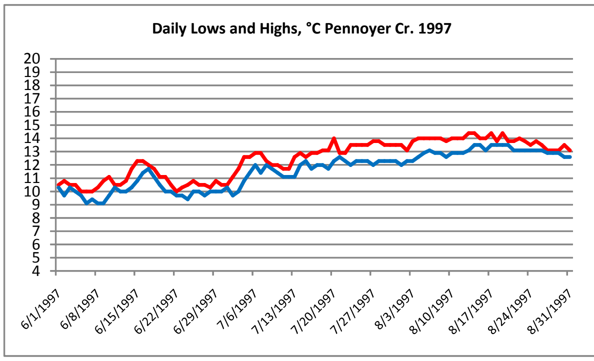


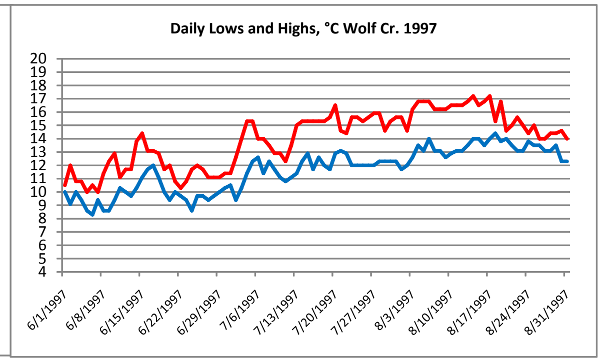


Daily high and low temperatures also show the effects of removing riparian vegetation. In the following charts, in 1996 Pennoyer Creek had higher lows and lower highs than Wolf Creek. There was less variation within a day in Pennoyer Creek, and less variation from one day to the next. Riparian vegetation reduces both heat gain and heat loss. The Cochran Pond, 1.5 miles upstream from the Pennoyer Creek site, also influences temperatures. Over the course of a typical summer, the pond probably causes a slight rise in Pennoyer Creek temperatures, but it would also serve to stabilize daily fluctuations.



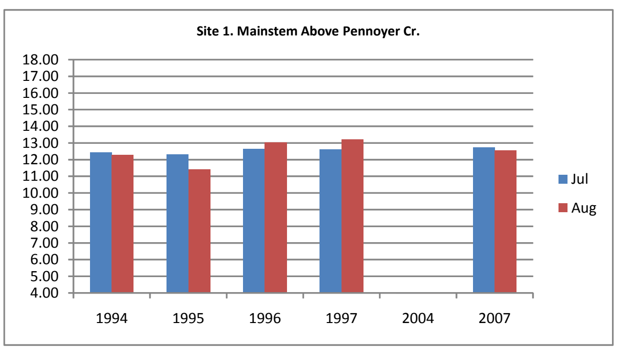


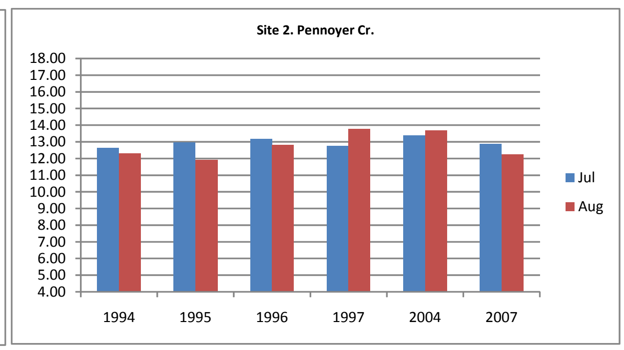




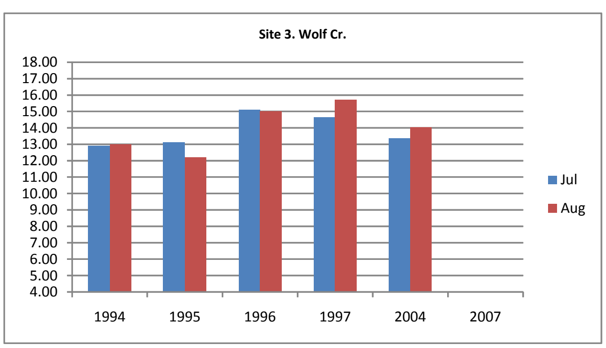
7. Temperature Trends

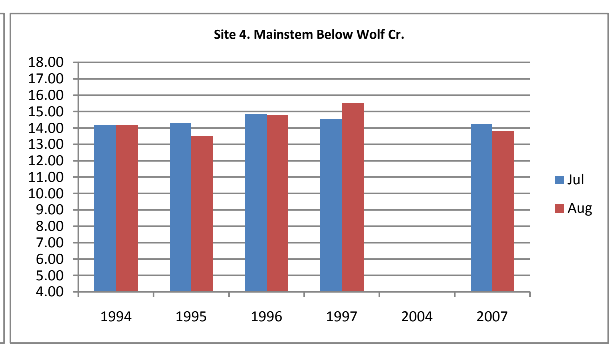
It is difficult to say whether temperatures are rising, falling, or fluctuating within normal variations. Missing data preclude coming up with any watershed-wide averages. Each site must be examined on its own. July and August were selected for illustration, as they are the months with the highest temperatures. Assuming that 1994 and 1995 were "normal" years, and 1996 and 1997 were aberrations due to unusually severe disturbances, we are left with looking at 2004 and 2007 to come up with conclusions. That is not enough data to arrive at any firm conclusions. Nevertheless, based on the data at hand, 4 sites may be warming, 4 appear stable (back to 1994/95 levels), and 2 are inconclusive. Site-by-site charts follow.



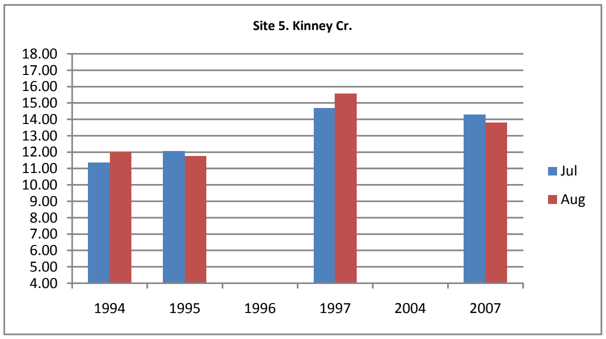


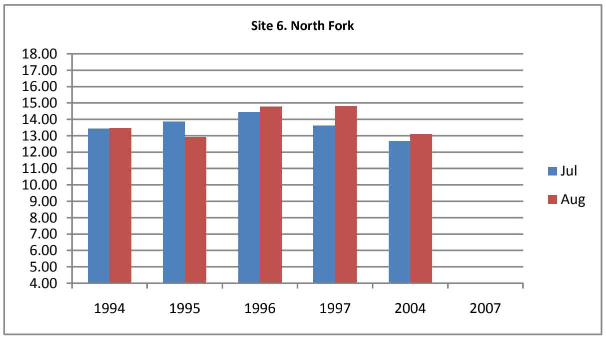
Site 1 may be warming. 2007 was warmer in both July and August than either 1994 or 1995. It may also be cooling from the effects of the 1996 disturbances. Site 2 is back to 1994/95 levels after interim warming. This is the only site with data for each year.



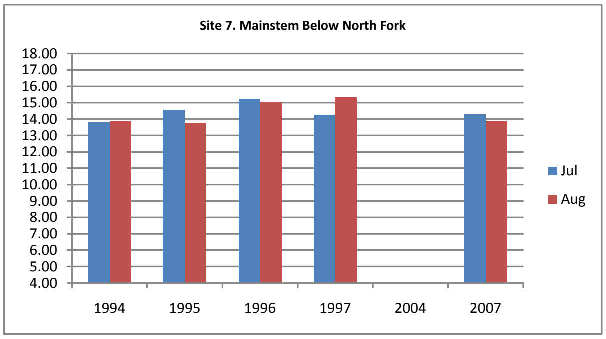


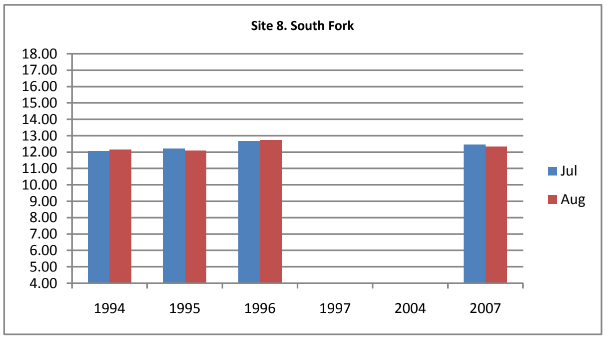
Site 3, Wolf Creek, is inconclusive. It appears to be cooling after the 1996 disturbances, but whether that also occurred in 2007 is unknown. Site 4, the main stem below Wolf Creek, has returned to 1994/95 levels, which would suggest that Wolf Creek may have as well.



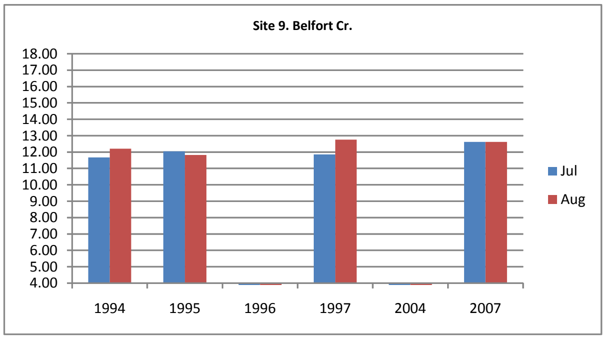


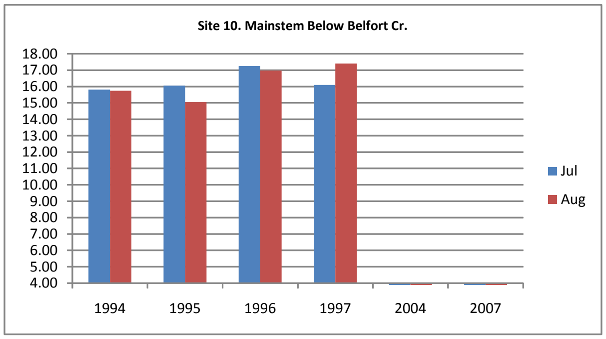
Site 5, Kinney Creek, was still considerably warmer in 2007 than 1994/95. By 2004 the North Fork was slightly cooler than 1994/95.





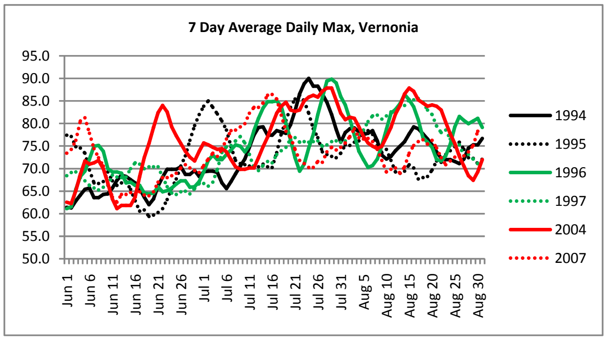
Site 7, like all the main stem sites, is missing 2004 data. It appears to have returned roughly to 1994/95 levels. Site 8, the South Fork, was slightly higher in 2007 than in 1994/95.

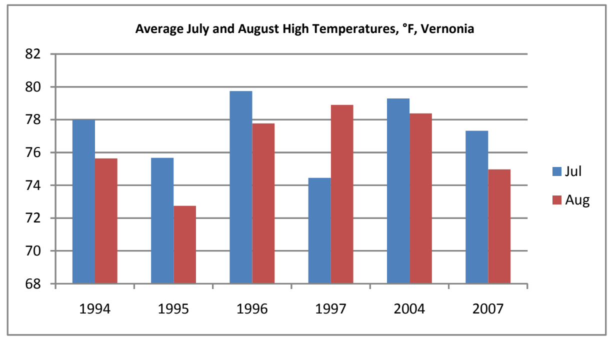




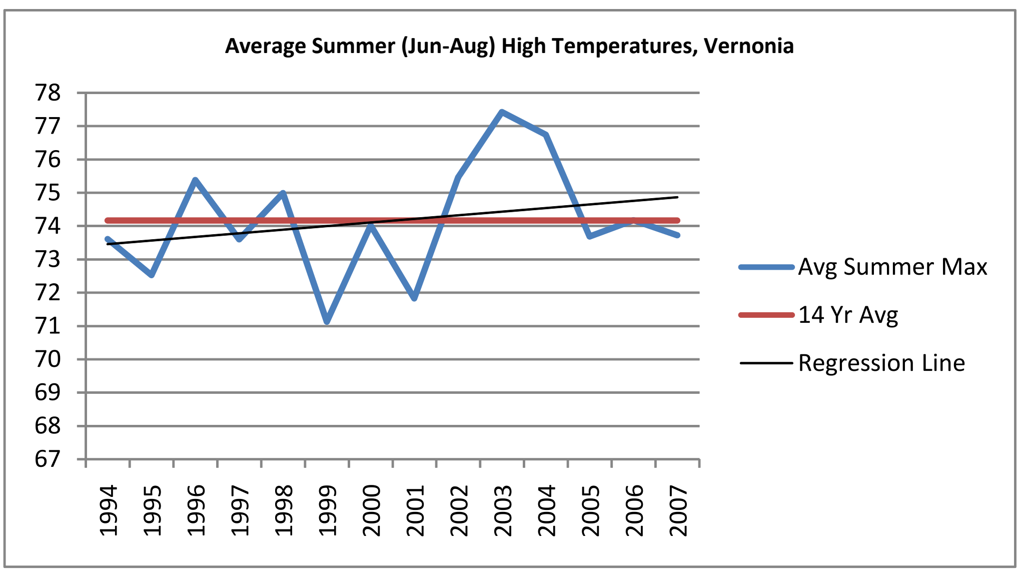
Site 9, Belfort Creek, looks to be warming. It is impossible to say what is happening at Site 10 due to missing data.

Data for the following charts came from the Oregon Climate Service for the weather station at Vernonia, which is the closest known station with data covering all the years in question. Source: http://www.ocs.oregonstate.edu , station 358884.





At Vernonia, 2004 was the warmest of the 6 years shown, with 1996 next and 1994 third. The pattern at Vernonia is similar to the pattern at Pennoyer Creek, though with more volatility (as expected, since air temperatures fluctuate more than water temperatures). Are temperatures at Vernonia increasing? Even with a 14-year history, it is hard to say. The regression line in the following chart would seem to indicate so, but examining the cycles, it is possible that in another few years the line would tilt down.



8. Recommendations

More frequent monitoring is necessary. This should be an ongoing project with monitoring done every year if possible. In order for that to happen, it will be necessary to gather organizational support to purchase a dedicated supply of Hobo Temps and provide the volunteer hours needed. The volunteer team should have the ability to launch the Hobo Temps and download the data, providing copies to ODFW.

Refresher training in Hobo Temp placement should be arranged to make sure the volunteer team follows standard protocols.

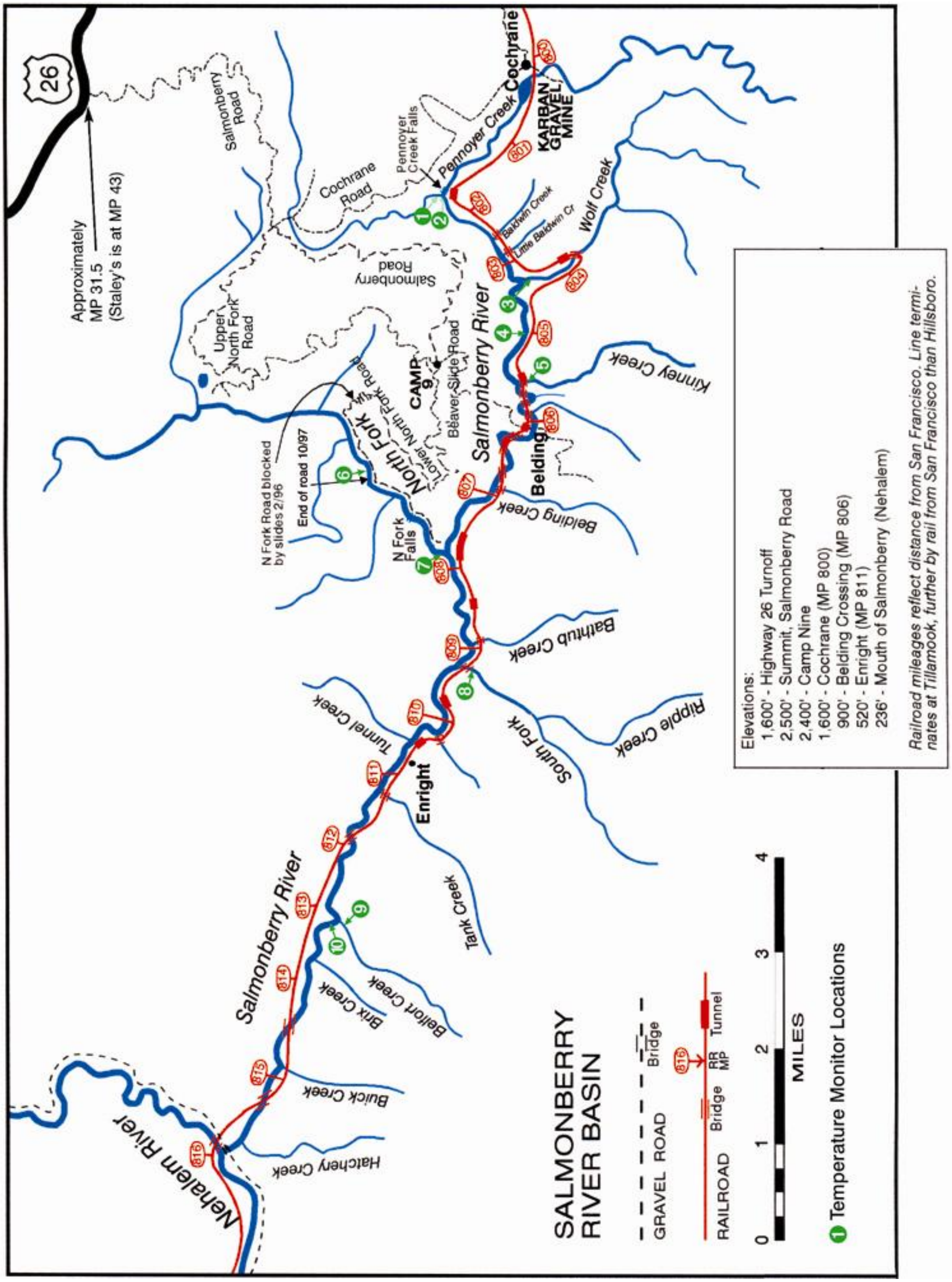
Mainstem sites will be critical. We have missed too much data in recent years, and any temperature changes affecting juvenile fish will first be noticeable in the mainstem. We recommend adding two main stem sites: one below the South Fork, and one below Belding Creek. This would give three sites below the North Fork and three above.

Of 60 opportunities to gather data (6 years X 10 sites), we lost 10 opportunities for various reasons, or 17%. We should be able to cut that rate of loss down to just an occasional case of equipment failure.

A site should be added to the North Fork for redundancy if nothing else. Ideally, this would be above the current site, which is at the parking area about one mile above the mouth. There is much summertime use of the North Fork at the current site (camping/picnicking), which increases the chance of loss or damage. The prime rearing habitat on the North Fork is probably the 3 miles or so above the current site, and it would be useful to add a site in that reach.

Since we are measuring based on a 7 day moving average, and would like to monitor June, July, and August, the devices should be placed no later than May 24.

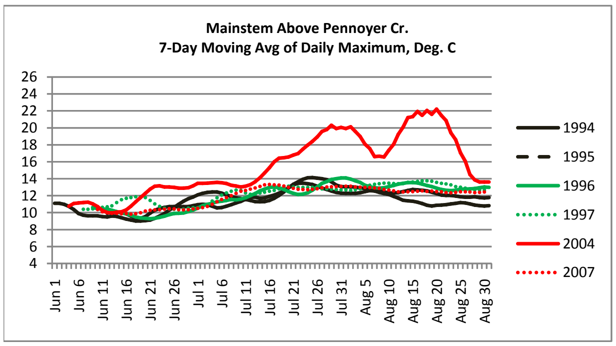
Appendix 1 – Site Map

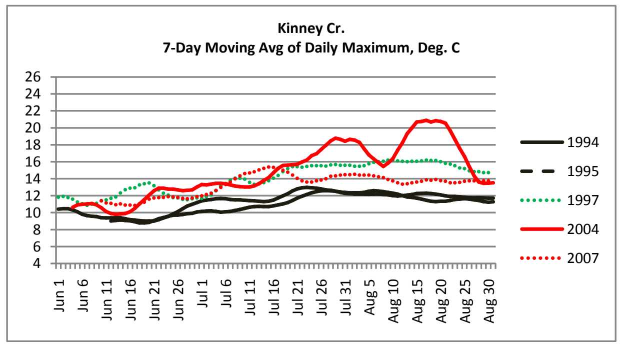


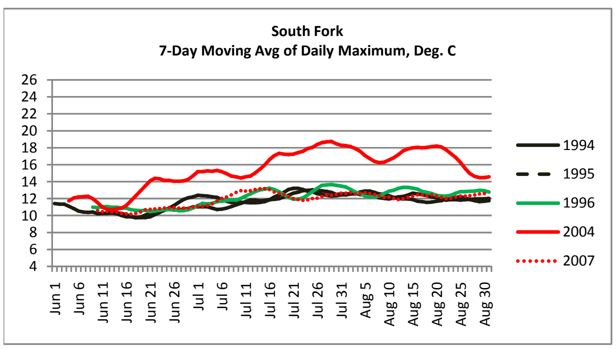
Appendix 2 – 2004 Data

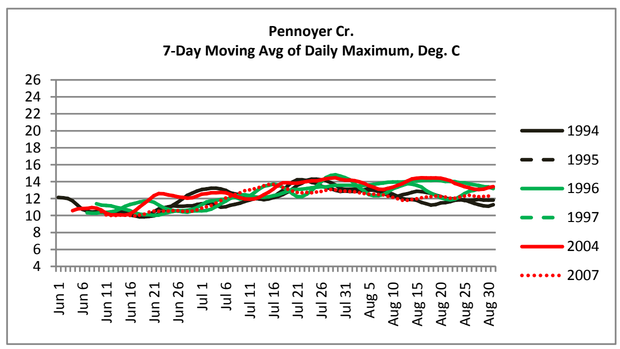
The following charts show why some of the 2004 data were considered aberrant and were not used in the analysis. The most likely explanation is that they were in locations that were entirely or substantially dewatered for long periods.

The main stem above Pennoyer Creek, Kinney Creek, and the South Fork all show very similar 2004 temperature patterns. Notice that the apparent temperature change suggests a disturbance of far greater magnitude than the 1996 debris flows. Also notice that 2007 temperatures at these sites fall right back in line with other years. Compare these sites to Pennoyer Creek, less than 100 yards away from the main stem site, which shows only slightly elevated 2004 temperatures.









Temperatures in Wolf Creek, severely affected by the 1996 debris flows, were only moderately elevated in 2004 relative to 1994-95, and were lower than 1996/1997. The North Fork shows a similar pattern.