Umpqua Basin Watershed Council

Cow Creek Watershed Temperature Study 2000

Procedure, results and preliminary analysis

Prepared by InSight Consultants
PO Box 10, Yoncalla, OR 97499
insight@rosenet.net

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- UBWC Technical Advisory Committee members for technical review.
- Supplemental Data Contributors:
  - Medford BLM
  - Roseburg BLM
  - US Forest Service, Umpqua National Forest
  - Oregon Department of Forestry
  - David Parker- Woodford Creek
- The Temperature Analysis Macro Version 1.1 developed by Medford DEQ was used to develop the seasonal statistics.

Kent Smith
Consultant, InSight Consultants
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The following disclaimer applies to all BLM data used in this document:

Cow Creek Watershed Temperature Study - Summer of 2000

Summary

Temperature data from 89 continuously sampling data loggers was obtained from monitoring sites throughout the Cow Creek Watershed during the summer of 2000. The seasonal maximums from the various sites ranged between 82.5 and 57.3 °F with an average of 67.0 °F. The 7-day maximums lagged the seasonal maximums by an average of 1.4 degrees with a maximum difference of 4.9 °F. The maximum ΔT (difference between daily maximum and minimum values) value ranged from 2.7 to 18.5°F with an average of 7.9 °F.

The temperature profile of the main stem of Cow Creek is dominated by the effect of the Galesville Reservoir that introduces cold water and higher flows during summer releases and causes an abrupt decrease in stream temperature. This effect appears to diminish further downstream and, at the mouth of Cow Creek, the temperatures are similar to the South Umpqua directly above the confluence.

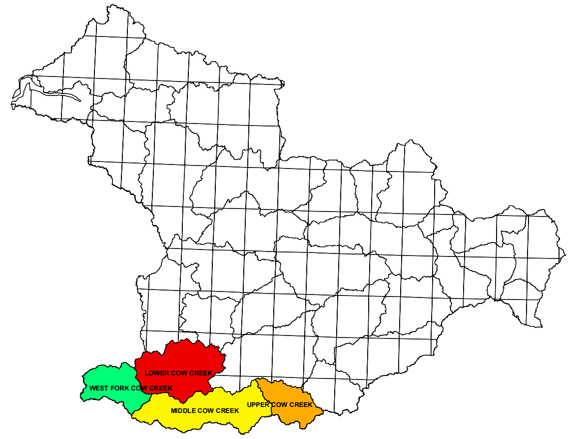
Analysis of the data with respect to the location in the watershed indicated that the tributary streams tended to be in the order of 10 °F cooler than Cow Creek with smaller streams typically cooler than larger streams. Charting the data with respect to the distance from the source ridge of each stream indicated that the maximum temperature of the coldest streams tended to increase on a logarithmic scale at the rate of 10 degrees for every multiple of ten miles. The data cluster above this line suggests that many of the similarly sized tributary streams have the potential to be at cooler temperatures.

Objective and scope of the study:

This study was sponsored by the Umpqua Basin Watershed Council (UBWC) and is part of an ongoing project to characterize the summer stream temperature regime in the interior watersheds of the Umpqua River Basin with an emphasis on the seasonal maximum temperatures. This particular study measured stream temperatures within the Cow Creek watershed from the mouth located near Riddle to the South Fork located 75 miles upstream on the Umpqua National Forest. Stream temperature data was collected simultaneously at 30-minute intervals from 88 sites located throughout the watershed.

A preliminary analysis using statistics from the data was completed to examine the range of seasonal and daily variability in the data as well as the spatial distribution of the temperature patterns and the effect of stream size on stream temperature. It is expected that this data and analysis will provide a basis for addressing site specific temperature related issues, aquatic habitat evaluation, a Temperature Management Plan for the watershed and further study.

Study Area:



Geographical Characteristics

The Cow Creek Watershed is a subbasin of the South Umpqua River system and is located at the southern end of the Umpqua Basin. The watershed is about 500 square miles with elevation ranging from 630 feet to about 4700 feet at the eastern edge. The watershed is located in the Umpqua Interior Foothill ecoregion.

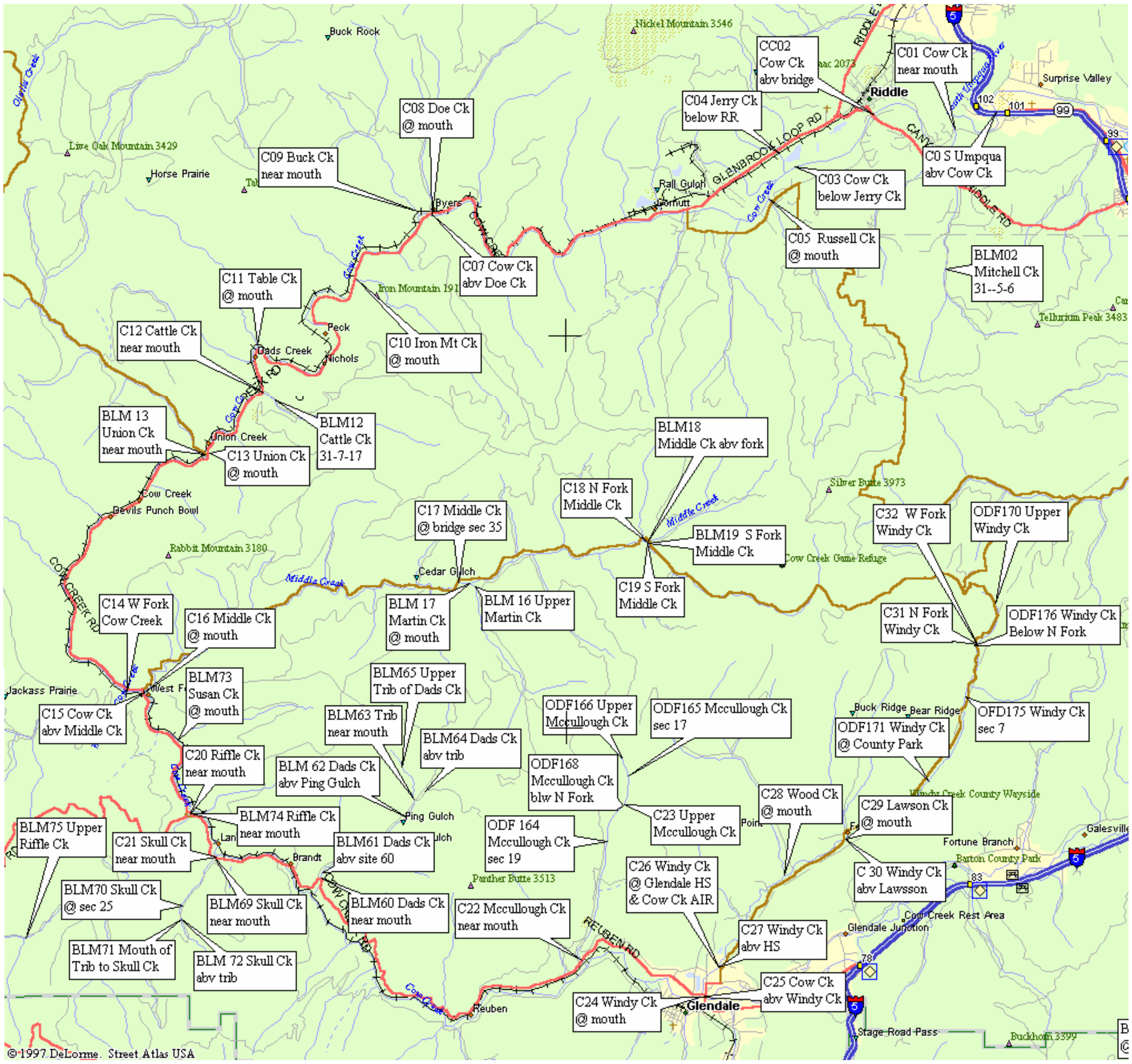
Description of the study:

Site Selection:

Thirty-nine UBWC stream temperature site locations were selected to obtain a representative sample of the various types of streams throughout the watershed. An emphasis was made to include the smaller streams to better understand their temperature characteristics and how they affect the larger streams. Sites on the main streams were often paired with a site at the mouth of a contributing tributary.

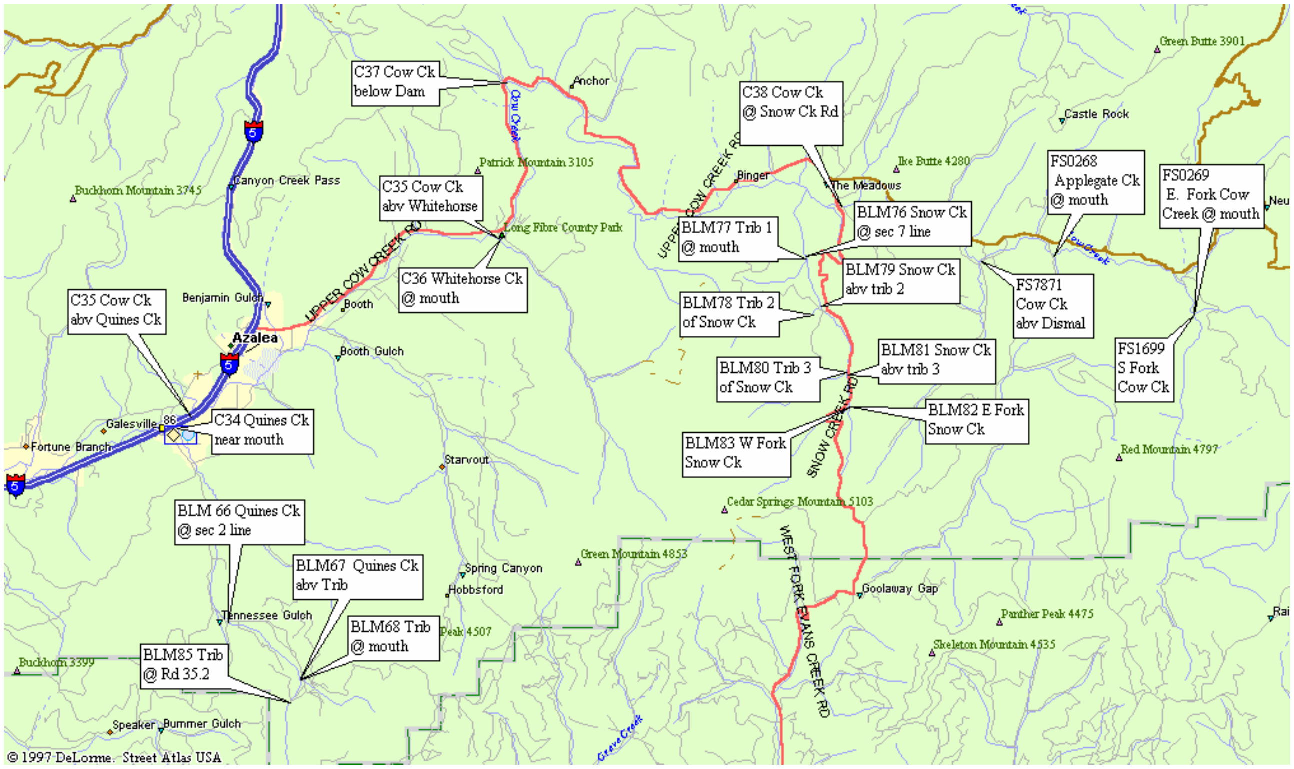
Data were also obtained from fifty sites from other sources for a total of eighty-nine stream temperature sites. Only one site was located in the West Fork drainage since data had been previously collected for that area. Air and stream temperature was also measured at Mill, Pass, Calapooya, North Myrtle, and Windy Creeks to provide a reference control sample of the entire central Umpqua basin.

The locations of all of the monitoring sites are shown on Maps 1(a) and 1(b). Site Data Sheets containing temperature data and other site related information are included in Appendix A. Digital picture computer files are also available for each site that show the upstream and downstream riparian condition as well as the data logger site location. A VHS video is also available that shows additional details of each UBWC site.
Elevation and the associated channel gradients are important parameters that affect the energy of the stream as well as the local climatic regime. To help provide a three-dimensional perspective, Chart 1 shows the relative elevation of the sites plotted against the stream miles measured from the mouth of Cow Creek. The point labels denote the monitoring site number.



Map 1(a) Temperature Monitoring Sites in the Western Portion of the Cow Creek Watershed

The elevation chart shows that all of the sites in this study were less than 1000 feet in elevation with the highest sites located in the upper Camp Creek area. The channel gradient for Paradise, Camp and Mill Creek appeared to follow similar patterns. The upper portion of the Mill/ Lake curve represents Lake Creek located above Loon Lake with a significantly lower channel gradient. This break indicates a geological change from coastal mountains to a plateau area. The gradient of the larger Umpqua River is also low as expected for a river of this size.



Map 1(b) Temperature Monitoring Sites in the Eastern Portion of the Cow Creek Watershed

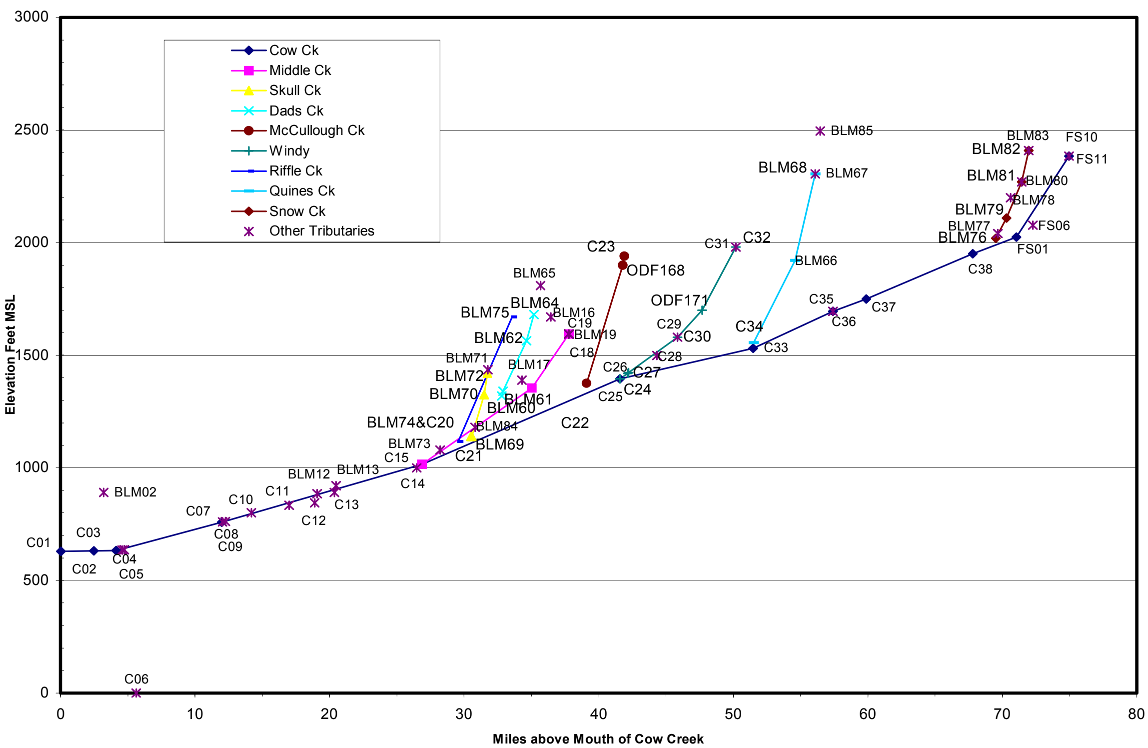


Chart 1 Site elevation with respect to river mile

Deployment and Collection:

The 39 UBWC “StowAway® Tidbit®” data logger units were deployed in the Cow Creek Watershed between June 13 and June 28 and collected between September 16 and September 18, 2000. A field audit was conducted between July 28 and August 2 to obtain a temperature check and to assure that each data logger was properly submerged.

The units were set to record the temperature at 30-minute intervals and typically about 4,000 temperature measurements were collected at each site. Permission was obtained from landowners to access sites located on private property. An attempt was made to place the temperature logger device to assure that it was measuring a representative sample of the active steam at the site. However, on the main portion of Cow Creek it was more difficult to place a unit directly in active flow portion of the channel at a point where it would remain submerged as the flow recedes. In the small streams the challenge was to select sites with good circulation and enough water volume to keep the unit submerged. In spite of best efforts, some of the logger units were exposed by receding flows and do not have a complete seasonal record. These sites are clearly identified in the data record.

Documentation:

A camcorder was used to document the exact sensor location and general characteristics of each UBWC deployment site. Digital picture files for each site were also produced that show the downstream and upstream views as well as the sensor location. Copies of these files are available through the Umpqua Basin Watershed Council.

A VHS recording entitled “Cow Creek Stream Temperature 2000– Field Notes” is also available for viewing or copying. The emphasis of this video was to document the location of each sensor unit and the general site characteristics. However, some segments contain other observations including fish presence.

A data sheet was developed for each UBWC site that describes some of the site characteristics and is located in Appendix A. Stream distances to the mouth and source ridge were obtained from digitized streams on mapping software. Elevation data were determined by interpolation of 40-ft contours on computerized USGS quad maps. These maps also verified the site coordinates location data that was measured in the field with GPS equipment. Local distance measurements at the site were estimated visually.

Several shade related observations were recorded: Vegetation altitude and density as well as the topographic altitude were taken for the riparian zones on each side of the stream. Wetted stream width, bank-full width, average depth, and bank-full depth were also recorded. Depth of unit at time of audit and time of removal was measured with a tape measure to provide an indication of the submerged state of the unit. Angle measurements for topographic and vegetation altitude were measured with a hand-held clinometer. The water circulation in the vicinity of the data logger was noted to provide an indication of thermal mixing. The circulation was rated “good” if there was obvious, visible flow around the logger unit. A “fair” rating meant that the unit was in a pool with obvious infow and outflow but without easily discernable circulation in the vicinity of the unit. A “poor” circulation rating meant that there was no discernable flow through the pool or around the submerged unit.

The site data sheets also chart the temperature data, which show graphically all of the recorded stream temperature data as well as the seven-day-average-of the daily maximum and the daily mean. The seven-day moving average value is plotted in the center of the seven-day interval and the daily mean is plotted each day at noon. A horizontal line is also plotted to depict the 64 °F temperature standard. The data at the end of the record file was trimmed off to assure that no out-of-water temperature information was included in the statistical analysis.

Accuracy Checks:

To assure that the logger units were operating properly, accuracy checks were made on all of the UBWC instruments before deployment and after retrieval. A NIST calibrated Traceable© reference thermometer was used to check each sensor at two different temperatures. Several readings were taken over a period of time to trace the response of the unit to an abrupt change in temperature. Chart 2 shows the results from a typical

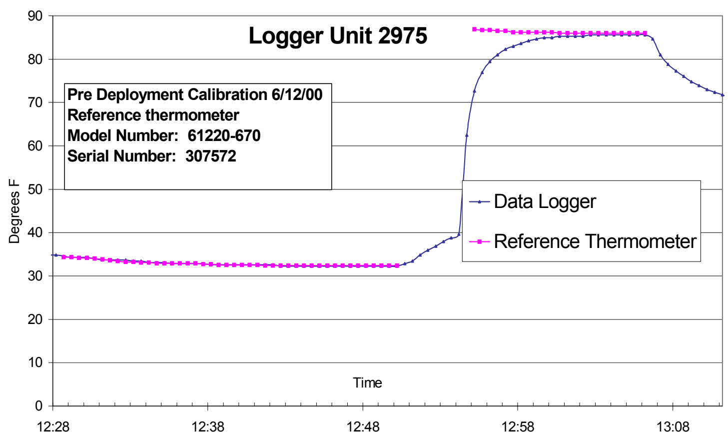


Chart 2 Typical accuracy check for a Tidbit® unit.

accuracy test. Note that the temperature time response of the units in stirred water is about six minutes. Tables 1 and 2 in Appendix B (Data Accuracy Information) shows the results of these tests. All of the units were within +0.1° and –0.4°C of the reference thermometer after thermal equilibrium was reached.

A field audit was also conducted on all of the UBWC sites using a Traceable reference thermometer to measure the water temperature at the site near the data logger. The recorded value was later compared with the corresponding data logger value. This method is not as accurate as the direct calibration method since the water temperature was, in some cases, changing rapidly and the logger units do not respond to the changes as rapidly as the reference thermometer. With two exceptions the field measurements were within -.9°F within the reference standard. Since the accuracy of the sensors under controlled conditions was consistently better than +/- 0.5 °F, both before and after the field deployment, it is reasonable to assume that the larger deviations in the field audit data were caused by other factors and should not be attributed to the data loggers.

Preliminary Analysis

There are many factors that influence stream temperature and understanding the conditions and processes that cause variability over time and distance is essential for a sound temperature management program. The following analysis examines the variability in the data from several perspectives with the objective of introducing the reader to some basic concepts and methods for extracting useful information from the data.

Between Season Variability

Each year the summer weather patterns cause a unique characteristic temperature pattern that is generally apparent in all of the stream temperature data within the Umpqua River Basin. Chart 3 compares the 1998, 1999, and 2000 results at a site in the Elk Creek watershed located in the north central portion of the county. Notice that the maximum values for this site were over 5 degrees warmer in 1998. In 1998 there was a distinctive peak and most of the sites monitored had a seasonal maximum on 7/27. In 1999 and 2000 there wasn't a distinctive peak and there was more variability in the date of the seasonal maximum. In 2000 most of the sites experienced a seasonal maximum between 7/31 and 8/8.

Within Season Variability

The differences in the temperature patterns between sites during the same time period may be due to the variability of the local weather conditions and local site factors such as stream orientation, streamflow depth and velocity, groundwater temperature and flow, and shade

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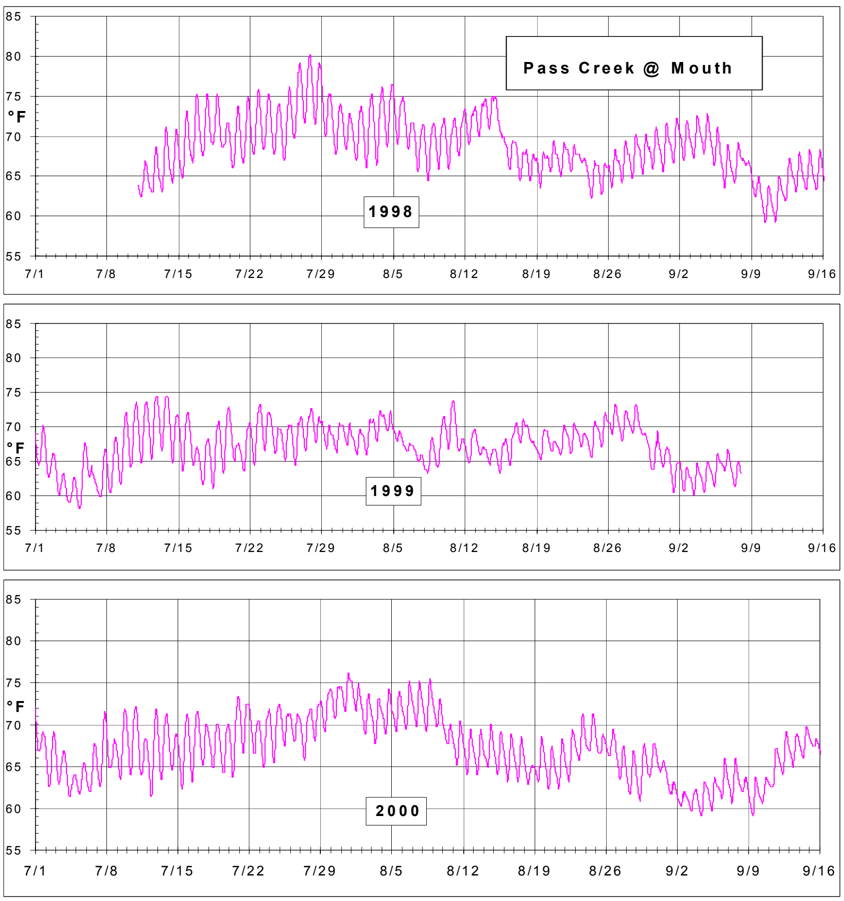


Chart 3 Comparison of 1998 –2000 seasonal stream temperature patterns for central Douglas County. (Data from Pass Creek @ mouth /Elk Creek

conditions.

Since maximum temperatures are a central issue for this analysis, the variability of the air temperature during the warmest part of the season is of interest. Chart 4 shows the summer air temperatures measured along shaded reaches of streams at five different locations in the Umpqua Basin. A comparison of the data shows that the seasonal maximum air temperatures at these locations were very similar. On the warm days the sky was probably uniformly clear across the basin and it appears that each shaded riparian environment responded to the solar input in a similar manner. There appears to be more variability on some of the cooler days, which suggests that a non-uniform cloud distribution may have been a factor.

This result suggests that most of the stream temperature variability between the sites during the maximum heating period for the summer 2000 season is due to variations in local site conditions other than air temperature. Analysis of the similarities and differences of these data and site characteristics can provide some insight to the processes and conditions that are influencing the variability in stream temperature.

Typical Temperature Patterns

Chart 5 shows a typical pattern for the year 2000 summer season for Middle Creek at the mouth. Note the similarity of the pattern with the year 2000 data in Chart 3 from the Elk Creek watershed and the air temperatures in Chart 4. While the general shape is similar, the amplitude and vertical displacement may vary considerably between streams. The daily

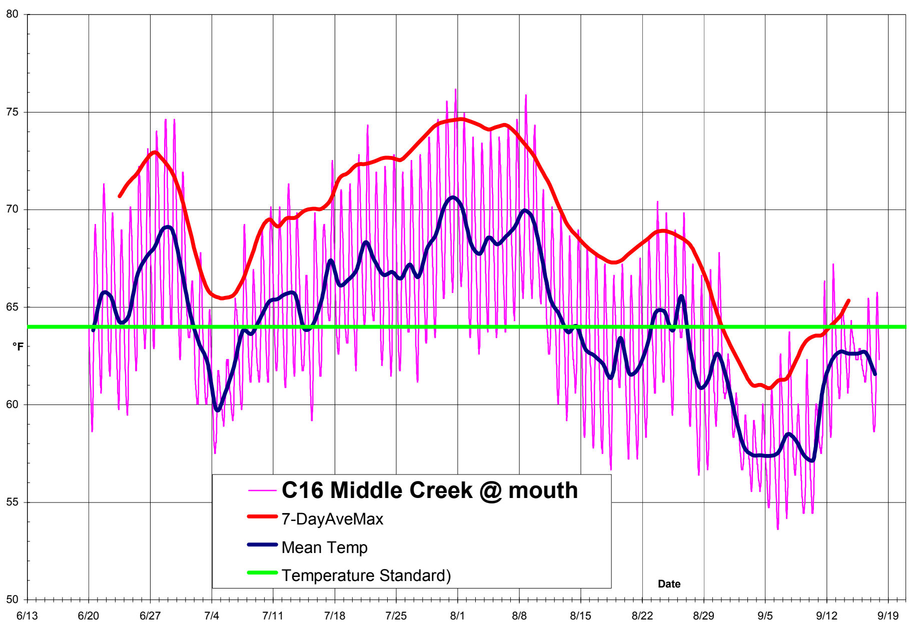


Chart 5 Typical Temperature Patterns in the Cow Creek Watershed

mean, 7-day average maximum and the 64 °F standard are also shown.

Atypical patterns
To better interpret the temperature patterns it is helpful to look at some atypical temperature patterns from the study and examine the differences in site conditions that affected these patterns.

Chart 6 shows data from the mouth of Table Creek, a small tributary of Cow Creek that went dry during the study. Notice that as the flow receded the daily maximum decreased until the creek went completely dry. This result is somewhat surprising since shallower water is generally associated with higher water temperatures from solar heating. Apparently groundwater and/or evaporation effects are dominating the heating process in this case. However, once the water is gone, the unit produces a typical air-temperature pattern. The peaks at the right end of the pattern indicate temperatures experienced during transport.

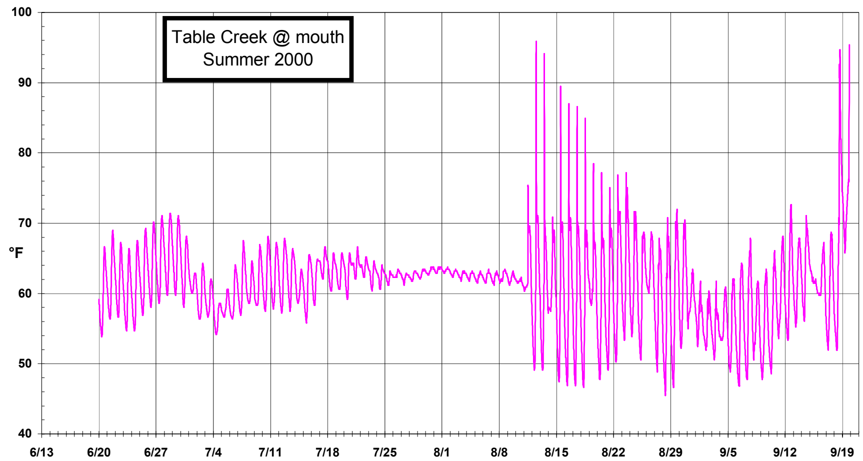


Chart 6 Table Creek transition to a dry streambed

The air temperature data was trimmed from the record used to develop seasonal statistics. As mentioned previously, the Galesville Reservoir has a very pronounced effect on the longitudinal temperature profile for Cow Creek. Chart 7 shows the temperature pattern before the water enters the reservoir and Chart 8 shows how deep-water releases from the reservoir dominate the temperature profile immediately below the dam. Chart 9 shows the pattern about 2.5 miles downstream where the diurnal solar pattern is superimposed on the release pattern. By the time the water reaches Galesville, most of the seasonal pattern is restored but the temperatures remain lower than those immediately above the reservoir.

Chart 10 shows the temperature near the mouth of Cow Creek located 60 stream miles below the dam. It is interesting to note that the pattern for the South Umpqua River (Chart 11) as measured at a point above the confluence with Cow Creek is nearly identical with the Cow Creek pattern. This suggests that both systems may have reached some type of thermal equilibrium with the surrounding environment.

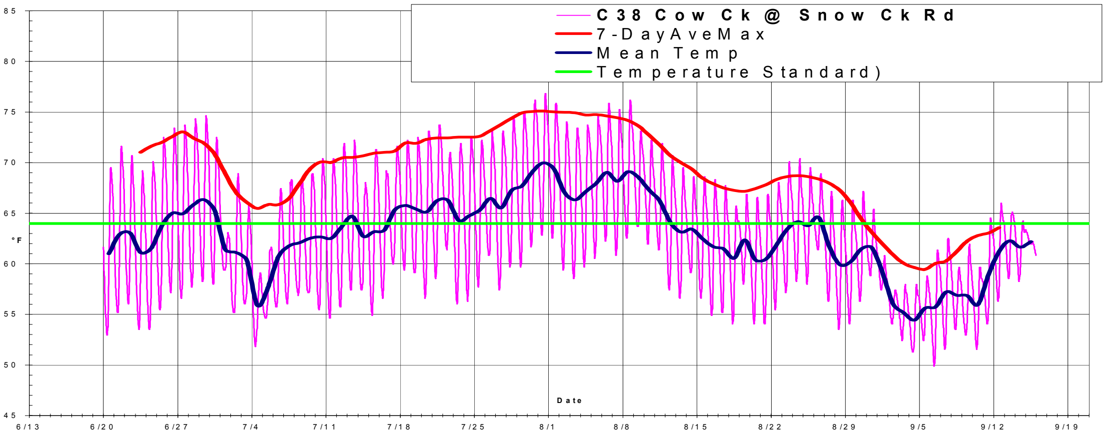


Chart 7 Cow Creek above the reservoir

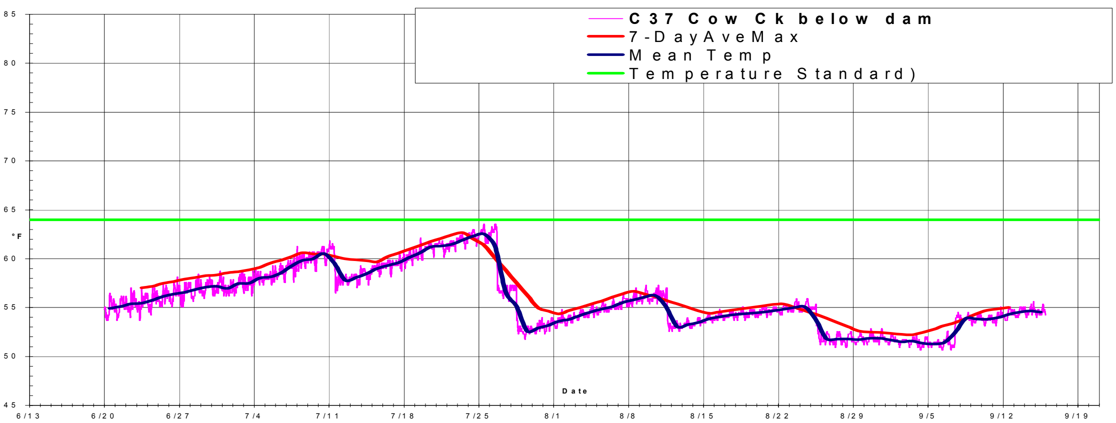


Chart 8 Cow Creek directly below dam

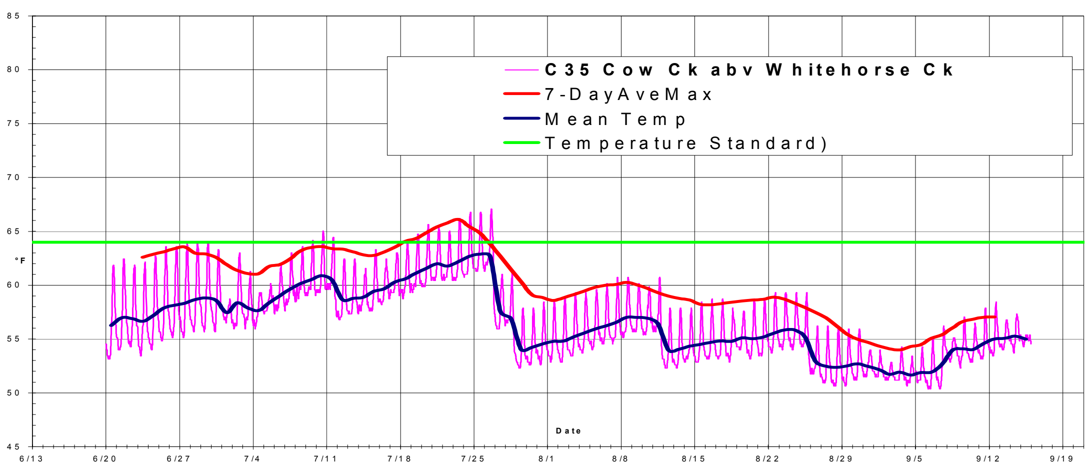


Chart 9 Cow Creek 2.5 miles downstream above Whitehorse Creek

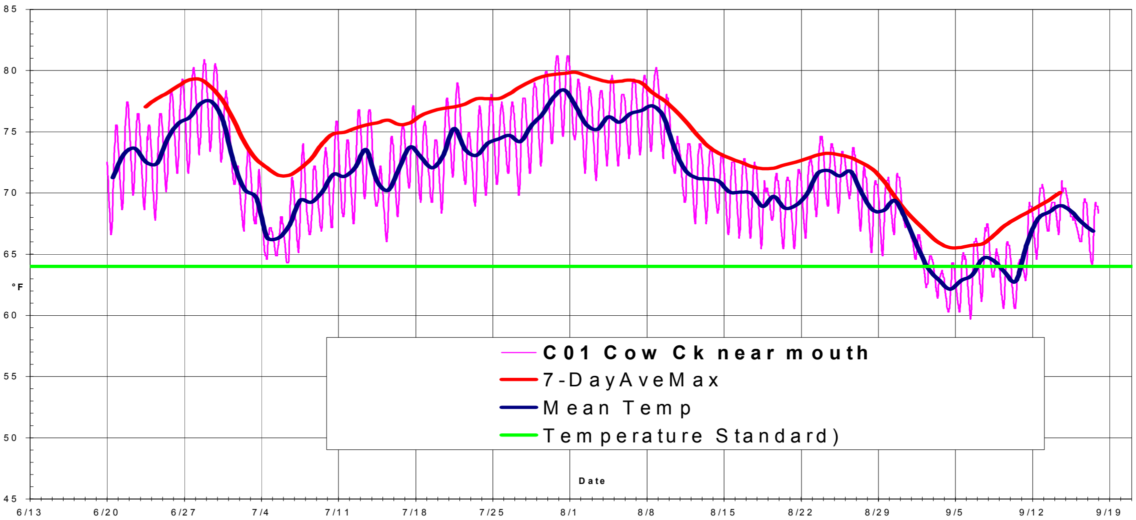


Chart 10 Cow Creek near mouth 60 miles below dam

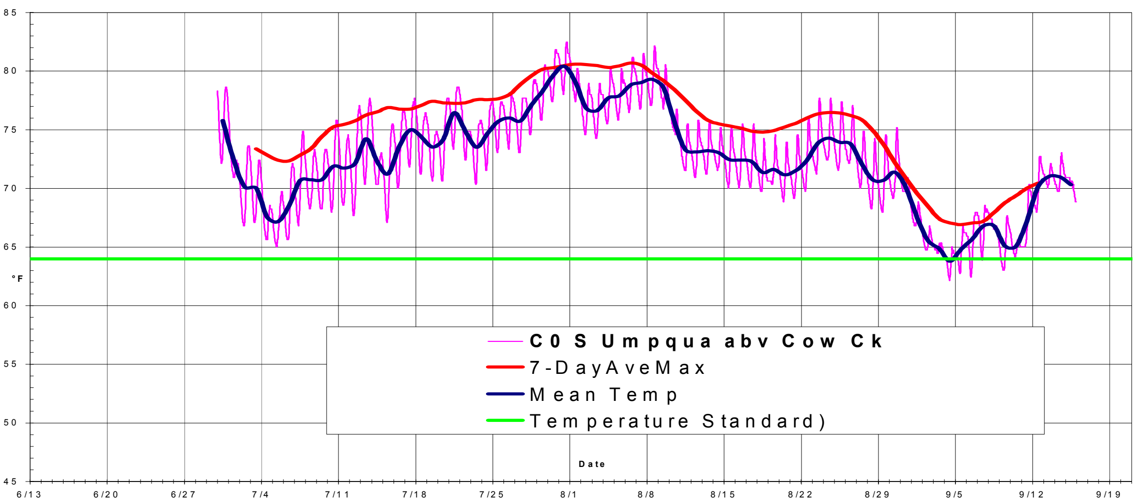


Chart 11 South Umpqua River above Cow Creek confluence

Site Temperature Statistics

Statistics provides the means to reduce the data to more manageable form. Two sets of statistics were generated from the data:

(1) The seasonal statistics show the extreme values and averages for the season. In particular, they show when and where the highest temperatures occurred within the period of record for the site.

(2) Statistics for a given day were also created to show how the various sites responded to similar solar input under prevailing streamflow conditions.

Table 1(A) Seasonal Statistical Summary

Site Name	Start	Stop	Seasonal Max		Seasonal Min		Seasonal Max ΔT		7-Day averages			
	Date	Date	Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
BLM02 Mitchell Ck @ sec 6	05/01/00	09/25/00	08/08/00	69.5	05/11/00	45.2	06/27/00	8.9	08/06/00	68.3	61.1	7.2
BLM12 Cattle 31-7-17	05/01/00	10/26/00	08/08/00	68.3	10/24/00	42.7	06/01/00	10.6	08/01/00	66.9	60.5	6.4
BLM13 Union Ck near mouth	05/01/00	10/28/00	07/31/00	70.7	10/24/00	43.5	06/24/00	10.8	08/01/00	69.5	60.4	9.1
BLM16 Upper Martin Ck	05/01/00	10/12/00	08/08/00	63.9	05/11/00	43.7	05/19/00	6.4	08/06/00	62.4	57.3	5.2
BLM17 Martin 31-7-35	05/01/00	10/12/00	07/31/00	68.9	05/11/00	43.7	06/01/00	10.6	08/01/00	67.7	59.9	7.7
BLM18 Middle 31-6-29	05/01/00	10/12/00	07/31/00	70.1	05/11/00	43.7	06/27/00	13.5	08/01/00	68.5	58.2	10.2
BLM19 S Fork Middle	05/01/00	10/12/00	08/08/00	71.0	10/05/00	43.4	06/27/00	14.0	08/01/00	69.3	57.1	12.2
BLM60 Dads Ck near mouth	06/14/00	09/28/00	08/08/00	66.6	09/24/00	45.4	08/29/00	8.1	08/07/00	65.0	58.2	6.8
BLM61 Dads Ck abv BLM60	06/28/00	10/24/00	08/08/00	65.0	10/24/00	41.9	06/28/00	8.2	08/07/00	63.6	58.1	5.5
BLM62 Dads Ck abv Ping Gulch	06/14/00	09/28/00	08/08/00	65.2	09/24/00	45.8	06/20/00	9.3	08/01/00	64.1	57.2	6.9
BLM63 Trib near mouth	06/14/00	07/24/00	06/28/00	65.6	07/04/00	50.6	06/27/00	9.9	06/27/00	64.0	54.7	9.3
BLM64 Dads Ck abv Trib	06/14/00	09/28/00	08/08/00	59.7	09/24/00	49.7	09/24/00	4.2	08/06/00	59.0	56.0	3.0
BLM65 Upper Trib	06/14/00	09/28/00	08/08/00	61.1	09/24/00	48.8	08/28/00	3.7	08/06/00	60.2	57.3	2.9
BLM66 Quines Ck @ Sec 2 line	06/13/00	09/18/00	08/08/00	65.8	09/06/00	50.2	06/20/00	7.3	08/02/00	64.5	59.2	5.3
BLM67 Quines Ck abv Trib	06/13/00	09/18/00	08/08/00	60.6	09/04/00	48.8	06/20/00	4.2	08/07/00	59.7	57.1	2.7
BLM68 Mouth of Trib to Quines Ck	06/13/00	09/18/00	08/08/00	63.7	09/04/00	49.4	06/25/00	5.3	08/07/00	62.8	59.0	3.8
BLM69 Mouth of Skull Ck	06/14/00	09/11/00	08/08/00	66.1	09/06/00	51.4	06/21/00	7.1	08/07/00	65.0	60.6	4.4
BLM70 Skull Ck @ Sec 25	06/14/00	09/11/00	08/08/00	64.9	09/06/00	50.2	08/06/00	5.4	08/06/00	63.5	58.5	5.0
BLM71 Mouth of trib to Skull	06/14/00	09/11/00	08/08/00	62.4	09/06/00	50.6	07/27/00	3.3	08/07/00	61.3	58.7	2.6
BLM72 Skull Ck abv Trib	06/14/00	09/11/00	08/08/00	63.0	09/06/00	51.5	06/28/00	3.4	08/07/00	62.2	59.9	2.3
BLM73 Susan Ck @ mouth	06/30/00	09/28/00	07/31/00	71.2	09/24/00	50.6	07/12/00	8.9	08/01/00	70.0	62.7	7.3
BLM74 Riffle Ck @ mouth	06/30/00	09/20/00	08/08/00	69.8	09/06/00	51.3	07/15/00	9.3	08/01/00	68.5	60.7	7.8
BLM75 Upper Riffle Ck	06/30/00	09/20/00	08/08/00	66.6	09/06/00	52.7	07/15/00	7.1	08/02/00	65.9	60.1	5.9
BLM76 Snow Ck @ sec 7 line	06/22/00	10/05/00	07/31/00	64.9	10/05/00	44.9	06/27/00	8.4	08/03/00	63.8	56.5	7.2
BLM77 Trib 1 Snow Ck	06/22/00	09/19/00	08/09/00	59.3	09/10/00	47.9	06/27/00	4.8	08/07/00	58.6	55.6	3.1
BLM78 Trib 2 Snow Ck	06/22/00	10/05/00	08/08/00	58.3	10/04/00	43.9	08/28/00	5.3	08/07/00	57.6	54.2	3.5
BLM79 Snow Ck abv Trib 2	06/23/00	10/05/00	08/08/00	60.9	10/05/00	44.7	06/24/00	6.1	08/07/00	60.0	56.2	3.7
BLM80 Trib 3 Snow Ck	06/22/00	10/05/00	08/08/00	58.6	10/04/00	44.1	06/24/00	4.5	08/07/00	57.8	54.5	3.3
BLM81 Snow Ck abv Trib 3	06/22/00	10/05/00	08/08/00	59.4	10/05/00	44.8	06/24/00	4.5	08/07/00	58.7	55.4	3.2
BLM82 E Fork Snow Ck	06/22/00	10/05/00	08/08/00	57.3	10/04/00	44.2	08/28/00	3.6	08/07/00	56.7	54.4	2.4
BLM83 W Fork Snow Ck	06/22/00	10/05/00	08/08/00	59.1	10/04/00	46.0	09/24/00	3.6	08/07/00	58.4	55.7	2.7
BLM84 Rattail Ck @ mouth	07/01/00	09/20/00	08/09/00	64.4	09/06/00	51.1	07/27/00	4.8	08/07/00	63.6	60.2	3.4
BLM85 Trib @ road 35.2	06/13/00	09/18/00	08/08/00	58.8	06/13/00	48.5	07/27/00	3.1	08/07/00	58.0	55.8	2.1
C0 S Umpqua abv Cow Ck	06/30/00	09/15/00	07/31/00	82.5	09/04/00	62.2	07/12/00	9.4	08/06/00	80.7	76.1	4.6
C01 Cow Ck near mouth	06/20/00	09/17/00	07/31/00	81.2	09/06/00	59.7	07/20/00	9.4	08/01/00	79.9	72.9	7.0
C02 Cow Ck abv Canyonville Bridge	06/20/00	09/17/00	07/31/00	82.3	09/06/00	58.7	06/27/00	11.1	08/01/00	80.9	71.9	9.0
C03 Cow Ck blw Jerry Ck	06/20/00	09/17/00	07/31/00	82.1	09/06/00	58.5	06/28/00	10.5	08/01/00	80.5	71.5	9.0
C04 Jerry Ck below RR	06/20/00	09/17/00	08/08/00	73.9	09/10/00	52.0	07/27/00	12.9	08/06/00	72.0	60.5	11.4
C05 Russell Ck @ mouth	06/20/00	09/17/00	07/31/00	71.6	09/06/00	54.7	06/27/00	10.1	08/01/00	70.0	62.4	7.6
C06 Catching Ck near mouth	06/20/00	09/17/00	07/31/00	80.4	08/29/00	52.0	08/04/00	18.5	08/06/00	78.9	61.4	17.5
C07 Cow Ck abv Doe Ck	06/20/00	09/17/00	07/31/00	79.6	09/06/00	58.2	07/20/00	8.7	07/31/00	78.1	71.0	7.1
C08 Doe Ck @ mouth	06/20/00	09/17/00	08/08/00	68.7	09/06/00	51.4	06/27/00	8.0	08/01/00	67.2	60.7	6.6
C09 Buck Ck near mouth	06/20/00	09/17/00	08/08/00	70.5	09/06/00	52.2	06/27/00	9.8	08/01/00	68.9	61.9	7.0
C10 Iron Mt Ck @ mouth	06/20/00	09/17/00	08/08/00	68.7	09/06/00	51.1	06/27/00	9.1	08/06/00	67.1	59.8	7.3
C11 Table Ck @ mouth	06/20/00	08/10/00	06/28/00	71.4	06/20/00	53.9	06/24/00	12.9	06/27/00	69.8	58.0	11.8
C12 Cattle Ck near mouth	06/20/00	09/17/00	07/31/00	68.8	09/06/00	50.9	06/24/00	8.8	08/01/00	67.3	60.5	6.8
C13 Union Ck @ mouth	06/20/00	09/17/00	07/31/00	70.6	09/06/00	51.2	06/24/00	10.8	08/01/00	69.4	60.7	8.7
C14 W Fork Cow @ mouth	06/20/00	09/17/00	08/08/00	77.6	09/06/00	55.6	06/25/00	10.0	08/01/00	76.5	68.3	8.1

Seasonal Statistics:

Table 1(A-D) lists some seasonal statistics for the season of record for each site. Note that some sites had a truncated record as indicated by the “start” and “stop” dates. This statistical information is generally used to determine the range of values of all of the sites for the entire season. Of particular interest is the seasonal maximum of the seven-day running average of the daily maximum temperature because this value determines compliance with the Oregon State stream temperature standard. Chart 12(A-C) provides a visual comparison of the seasonal maximum, 7-day maximum and ΔT values. The dates of each record interval are indicated for each site on the chart.

Table 1(B) Continuation of Statistical Summary

Site Name	Lat	Long	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day max: Date	Max	Min	Agency
BLM02 Mitchell Ck @ sec 6	42° 54' 44.68"	123° 20' 20.14"	127	42	0	2594.5	228.5	0.0	08/08/00	69.5	62.0	Roseburg BLM
BLM12 Cattle 31-7-17	42° 52' 54.86"	123° 33' 23.75"	131	29	0	2645.5	280.5	0.0	07/31/00	68.3	62.0	Roseburg BLM
BLM13 Union Ck near mouth	42° 52' 0.16"	123° 34' 30.36"	130	54	3	2512.0	363.5	10.0	07/31/00	70.7	61.7	Roseburg BLM
BLM16 Upper Martin Ck	42° 49' 35.61"	123° 29' 12.85"	101	0	0	1625.0	0.0	0.0	08/08/00	63.9	58.5	Roseburg BLM
BLM17 Martin 31-7-35	42° 50' 12.82"	123° 29' 24.78"	131	32	0	2406.0	247.0	0.0	07/31/00	68.9	61.7	Roseburg BLM
BLM18 Middle 31-6-29	42° 50' 48.23"	123° 26' 3.48"	128	48	1	2171.0	297.0	0.5	07/31/00	70.1	59.9	Roseburg BLM
BLM19 S Fork Middle	42° 50' 47.3"	123° 26' 3.57"	134	53	3	2156.0	350.5	8.5	07/31/00	70.7	58.8	Roseburg BLM
BLM60 Dads Ck near mouth	42° 46' 2"	123° 32' 17"	94	11	0	1793.5	52.5	0.0	08/08/00	66.6	59.4	Medford BLM
BLM61 Dads Ck abv BLM60	42° 46' 9"	123° 32' 17"	80	4	0	1510.0	21.0	0.0	08/08/00	65.0	59.5	Medford BLM
BLM62 Dads Ck abv Ping Gulch	42° 46' 56"	123° 30' 41"	93	8	0	1651.5	33.0	0.0	07/30/00	65.2	58.0	Medford BLM
BLM63 Trib near mouth	42° 47' 15"	123° 30' 31"	41	4	0	794.0	13.5	0.0	06/28/00	65.6	55.9	Medford BLM
BLM64 Dads Ck abv Trib	42° 47' 18"	123° 30' 18"	87	0	0	1285.5	0.0	0.0	08/08/00	59.7	56.9	Medford BLM
BLM65 Upper Trib	42° 47' 43"	123° 30' 48"	77	0	0	1314.5	0.0	0.0	08/08/00	61.1	58.3	Medford BLM
BLM66 Quines Ck @ Sec 2 line	42° 44' 23"	123° 15' 36"	92	9	0	1928.0	74.0	0.0	07/30/00	65.6	60.1	Medford BLM
BLM67 Quines Ck abv Trib	42° 43' 39"	123° 14' 19"	59	0	0	922.0	0.0	0.0	08/08/00	60.6	57.8	Medford BLM
BLM68 Mouth of Trib to Quines Ck	42° 43' 40"	123° 14' 19"	86	0	0	1634.0	0.0	0.0	08/08/00	63.7	60.0	Medford BLM
BLM69 Mouth of Skull Ck	42° 46' 21"	123° 34' 22"	89	15	0	1877.0	97.5	0.0	08/08/00	66.1	61.2	Medford BLM
BLM70 Skull Ck @ Sec 25	42° 45' 43"	123° 34' 58"	81	3	0	1590.5	9.5	0.0	08/08/00	64.9	59.7	Medford BLM
BLM71 Mouth of trib to Skull	42° 45' 29"	123° 34' 60"	78	0	0	1490.0	0.0	0.0	08/08/00	62.4	59.5	Medford BLM
BLM72 Skull Ck abv Trib	42° 45' 30"	123° 34' 58"	80	0	0	1710.0	0.0	0.0	08/08/00	63.0	60.7	Medford BLM
BLM73 Susan Ck @ mouth	42° 48' 3"	123° 35' 3"	91	43	4	2013.0	424.5	10.5	07/31/00	71.2	63.8	Medford BLM
BLM74 Riffle Ck @ mouth	42° 47' 0"	123° 34' 48"	83	36	0	1827.0	303.0	0.0	07/31/00	69.8	61.9	Medford BLM
BLM75 Upper Riffle Ck	42° 45' 13"	123° 37' 57"	83	23	0	1879.0	144.5	0.0	07/31/00	66.6	60.5	Medford BLM
BLM76 Snow Ck @ sec 7 line	42° 48' 45"	123° 5' 51"	85	4	0	1365.0	9.0	0.0	07/31/00	64.9	57.7	Medford BLM
BLM77 Trib 1 Snow Ck	42° 48' 41"	123° 5' 55"	52	0	0	606.5	0.0	0.0	08/08/00	59.3	56.0	Medford BLM
BLM78 Trib 2 Snow Ck	42° 48' 1"	123° 5' 53"	35	0	0	319.0	0.0	0.0	08/08/00	58.3	54.7	Medford BLM
BLM79 Snow Ck abv Trib 2	42° 48' 11"	123° 5' 36"	70	0	0	997.0	0.0	0.0	08/08/00	60.9	56.7	Medford BLM
BLM80 Trib 3 Snow Ck	42° 47' 24"	123° 5' 15"	38	0	0	393.5	0.0	0.0	08/08/00	58.6	55.2	Medford BLM
BLM81 Snow Ck abv Trib 3	42° 47' 23"	123° 5' 15"	50	0	0	640.5	0.0	0.0	08/08/00	59.4	56.0	Medford BLM
BLM82 E Fork Snow Ck	42° 46' 58"	123° 5' 13"	19	0	0	247.0	0.0	0.0	08/08/00	57.3	54.8	Medford BLM
BLM83 W Fork Snow Ck	42° 46' 58"	123° 5' 14"	47	0	0	596.0	0.0	0.0	08/08/00	59.1	56.3	Medford BLM
BLM84 Rattail Ck @ mouth	42° 46' 19"	123° 34' 30"	77	2	0	1667.5	6.0	0.0	08/08/00	64.4	60.9	Medford BLM
BLM85 Trib @ road 35.2	42° 43' 24"	123° 14' 32"	40	0	0	575.0	0.0	0.0	08/08/00	58.8	56.3	Medford BLM
C0 S Umpqua abv Cow Ck	42° 56' 51.6"	123° 19' 21.18"	78	78	67	1871.5	1838.0	1385.5	08/08/00	82.2	77.1	UBWC
C01 Cow Ck near mouth	42° 56' 34.52"	123° 20' 9.37"	90	89	75	2159.5	2011.5	1299.0	07/30/00	81.2	74.0	UBWC
C02 Cow Ck abv Canyonville Bridge	42° 56' 45.88"	123° 21' 47.4"	90	90	72	2159.5	1978.5	1187.0	07/30/00	82.3	72.9	UBWC
C03 Cow Ck blw Jerry Ck	42° 56' 3.89"	123° 23' 19.52"	90	89	72	2159.5	1974.0	1177.5	07/31/00	82.1	73.1	UBWC
C04 Jerry Ck below RR	42° 56' 17.1"	123° 23' 32.57"	90	65	14	2038.5	575.0	64.0	08/08/00	73.9	62.4	UBWC
C05 Russell Ck @ mouth	42° 55' 37.03"	123° 23' 43.11"	90	72	7	2156.5	752.0	26.0	07/31/00	71.6	64.0	UBWC
C06 Catching Ck near mouth	42° 55' 11.9"	123° 24' 23.17"	90	79	41	2112.0	738.5	232.0	08/08/00	79.7	63.2	UBWC
C07 Cow Ck abv Doe Ck	42° 55' 26.1"	123° 30' 11.84"	90	85	65	2159.5	1870.5	992.5	07/31/00	79.6	72.5	UBWC
C08 Doe Ck @ mouth	42° 55' 27.53"	123° 30' 11.16"	90	30	0	2024.5	254.0	0.0	07/30/00	68.4	61.5	UBWC
C09 Buck Ck near mouth	42° 55' 28.83"	123° 30' 28.16"	90	51	3	2081.5	499.0	12.0	07/30/00	70.5	62.6	UBWC
C10 Iron Mt Ck @ mouth	42° 54' 29.77"	123° 31' 37.53"	90	31	0	1936.5	179.0	0.0	08/08/00	68.7	61.4	UBWC
C11 Table Ck @ mouth	42° 53' 35.02"	123° 33' 31.4"	52	30	4	1231.0	266.5	14.5	06/28/00	71.4	59.8	UBWC
C12 Cattle Ck near mouth	42° 52' 54.86"	123° 33' 23.75"	90	29	0	1970.5	257.0	0.0	07/31/00	68.8	61.9	UBWC
C13 Union Ck @ mouth	42° 52' 0.16"	123° 34' 30.36"	90	50	2	2011.0	387.0	5.0	07/31/00	70.6	61.8	UBWC
C14 W Fork Cow @ mouth	42° 48' 42.98"	123° 36' 0.95"	90	78	52	2159.5	1549.5	568.5	07/30/00	77.3	69.1	UBWC

Table 1(C) Continuation of Seasonal Statistical Summary

Site Name	Start	Stop	Seasonal Max		Seasonal Min		Seasonal Max ΔT		7-Day averages			
	Date	Date	Date	Value	Date	Value	Date	Value	Date	Max	Min	Δ T
C15 Cow Ck abv Middle Ck	06/21/00	09/17/00	07/31/00	75.1	09/06/00	55.6	06/25/00	8.5	07/30/00	73.9	66.8	7.1
C16 Middle Creek @ mouth	06/20/00	09/17/00	07/31/00	76.2	09/06/00	53.6	07/27/00	11.6	08/01/00	74.6	64.4	10.3
C17 Middle Ck @ sec 35 bridge	06/24/00	09/17/00	07/31/00	71.8	09/06/00	50.6	06/27/00	11.9	07/31/00	70.1	61.4	8.7
C18 N Fork Middle Ck	06/20/00	09/17/00	08/08/00	69.6	09/06/00	48.3	06/27/00	13.7	08/01/00	68.2	58.0	10.2
C19 S Fork Middle Ck	06/21/00	09/17/00	08/08/00	72.1	09/06/00	48.1	06/27/00	14.0	08/06/00	70.1	57.5	12.6
C20 Riffle Ck @ mouth	06/24/00	09/17/00	08/08/00	69.8	09/10/00	51.5	06/27/00	10.1	08/01/00	68.5	60.9	7.6
C21 Skull Ck @ mouth	06/24/00	09/17/00	08/01/00	67.9	09/10/00	51.4	08/02/00	7.2	07/31/00	66.7	60.0	6.7
C22 McCullough Ck near mouth	06/30/00	09/15/00	08/08/00	66.0	09/10/00	50.4	08/03/00	7.1	08/06/00	64.7	58.9	5.8
C23 Upper McCullough	06/30/00	09/15/00	08/08/00	62.9	09/04/00	48.8	07/24/00	5.4	08/06/00	61.8	57.5	4.3
C24 Windy Ck @ mouth	06/20/00	09/14/00	08/08/00	68.8	09/10/00	54.2	06/27/00	7.8	08/06/00	67.8	62.1	5.7
C25 Cow Ck abv Windy Ck	06/20/00	09/14/00	06/28/00	73.4	09/06/00	54.3	06/24/00	10.4	06/27/00	72.3	62.9	9.4
C26 Windy Ck @ Glendale HS	06/20/00	09/15/00	08/08/00	68.8	09/10/00	54.8	06/27/00	7.8	08/05/00	67.8	62.2	5.6
C27 Windy Ck abv HS	06/20/00	09/15/00	08/08/00	70.3	09/10/00	54.0	08/04/00	8.1	08/06/00	69.2	61.9	7.3
C28 Wood Ck @ mouth	06/20/00	09/15/00	08/08/00	64.9	09/06/00	51.1	06/20/00	7.3	08/07/00	63.9	59.3	4.6
C29 Lawson Ck @ mouth	06/20/00	09/14/00	08/08/00	67.9	09/06/00	50.9	07/27/00	10.0	08/06/00	67.1	59.5	7.6
C30 Windy Ck abv Lawson	06/20/00	09/14/00	08/01/00	68.4	09/10/00	52.5	06/20/00	8.7	08/03/00	67.4	60.7	6.7
C31 N Fork Windy Ck	06/20/00	09/15/00	08/08/00	61.8	09/04/00	49.5	07/27/00	4.5	08/07/00	60.6	57.5	3.1
C32 W. Fork Windy Ck	06/20/00	09/15/00	08/08/00	60.8	09/04/00	49.3	07/12/00	3.6	08/07/00	60.0	57.3	2.7
C33 Cow Ck abv Quines	07/31/00	09/15/00	08/08/00	63.0	09/06/00	50.3	08/03/00	7.0	08/08/00	61.8	55.9	5.8
C34 Quines Ck @ mouth	07/31/00	09/15/00	08/25/00	76.5	09/06/00	56.6	08/25/00	18.5	08/23/00	71.6	59.9	11.7
C35 Cow Ck abv Whitehorse Ck	06/20/00	09/15/00	07/26/00	67.1	09/07/00	50.4	07/26/00	9.8	07/23/00	66.1	60.1	6.0
C36 Whitehorse @ mouth	06/20/00	09/15/00	06/29/00	62.8	06/20/00	52.9	06/27/00	5.9	07/21/00	61.7	57.4	4.3
C37 Cow Ck below dam	06/20/00	09/15/00	07/26/00	63.6	09/07/00	50.6	07/26/00	7.1	07/23/00	62.7	60.2	2.5
C38 Cow Ck @ Snow Ck Rd	06/20/00	09/15/00	07/31/00	76.8	09/06/00	49.9	06/27/00	17.2	07/31/00	75.1	60.6	14.5
CP1 Woodford Ck 1	08/23/00	10/10/00	09/16/00	58.9	10/10/00	50.9	09/06/00	2.7	09/17/00	57.8	56.7	1.1
CP2 Woodford Ck 2	08/23/00	10/10/00	08/26/00	58.9	10/05/00	49.3	09/23/00	3.5	08/26/00	58.1	56.3	1.8
CP3 Woodford Ck 3	08/23/00	10/10/00	08/24/00	61.6	10/05/00	47.7	08/28/00	6.2	08/26/00	60.5	55.6	4.9
CP4 Woodford Ck 4	08/23/00	10/10/00	08/26/00	64.7	10/05/00	49.3	09/11/00	5.7	08/26/00	62.8	58.1	4.7
FS01 Cow Ck abv Dismal Ck	06/11/00	09/29/00	07/31/00	71.2	09/24/00	45.1	06/27/00	11.7	08/07/00	69.8	60.0	9.8
FS06 Applegate Ck @ mouth	06/11/00	09/29/00	07/31/00	66.9	09/24/00	45.2	06/27/00	9.9	08/01/00	65.6	58.1	7.5
FS10 E Fork Cow Ck@ mouth	06/11/00	09/29/00	08/08/00	61.6	06/11/00	45.9	06/13/00	5.0	08/07/00	60.8	57.3	3.5
FS11 S Fork Cow Ck @ mouth	06/11/00	09/29/00	08/08/00	61.4	06/11/00	46.0	06/20/00	5.9	08/06/00	60.7	56.4	4.3
ODF164 McCullough Ck sec 19	08/08/00	10/29/00	08/08/00	63.1	10/23/00	42.3	08/29/00	5.3	08/11/00	59.4	55.9	3.5
ODF165 McCullough Ck sec 17	08/08/00	10/29/00	08/08/00	60.3	10/23/00	44.6	08/28/00	3.4	08/11/00	57.6	55.3	2.2
ODF166 McCullough Ck abv site 165	08/08/00	10/29/00	08/08/00	59.9	10/23/00	45.1	08/29/00	2.8	08/11/00	57.3	55.3	2.0
ODF168 McCullough Ck blw N Fork	08/08/00	10/29/00	08/08/00	62.3	10/23/00	43.5	08/29/00	4.8	08/11/00	59.1	55.7	3.4
ODF170 Upper Windy Ck	08/09/00	10/29/00	08/09/00	60.1	10/23/00	45.3	08/28/00	3.6	08/12/00	57.4	54.9	2.6
ODF171 Windy Ck @ county park	08/09/00	10/29/00	08/09/00	63.9	10/24/00	43.9	08/22/00	3.9	08/12/00	60.9	58.1	2.8
ODF175 Windy Ck sec 7	08/09/00	10/29/00	08/09/00	62.5	10/23/00	43.1	08/22/00	5.0	08/12/00	59.5	56.2	3.3
ODF176 Windy Ck blw N Fork	08/09/00	10/29/00	08/09/00	60.9	10/23/00	42.9	09/24/00	4.2	09/17/00	57.9	55.5	2.4
CowAir Cow Ck AIR	06/20/00	09/15/00	08/08/00	89.7	08/28/00	39.4	08/28/00	40.3	08/06/00	86.4	53.0	33.4
Summary Statistics * Air Temperature not included												
Maximum:				**82.5**		**62.2**		**18.5**		**80.9**	**76.1**	**17.5**
Minimum:				**57.3**		**41.9**		**2.7**		**56.7**	**54.2**	**1.08**
Diffference:				**25.2**		**20.2**		**15.8**		**24.2**	**21.9**	**16.4**
Average:				**67.0**		**49.4**		**7.9**		**65.6**	**59.5**	**6.07**

Table 1(D) Continuation of Seasonal Statistical Summary

Site Name	Lat	Long	Days > 55 F	Days > 64 F	Days > 70 F	Hours > 55 F	Hours > 64 F	Hours > 70 F	Warmest day of 7-day max Date	Max	Min	Agency
C15 Cow Ck abv Middle Ck	42° 48' 43.58"	123° 35' 39.49"	89	78	39	2135.5	1435.5	333.5	07/31/00	75.1	67.9	UBWC
C16 Middle Creek @ mouth	42° 48' 43.82"	123° 35' 38.82"	90	76	38	2131.0	1121.0	257.5	07/31/00	76.2	65.8	UBWC
C17 Middle Ck @ sec 35 bridge	42° 50' 15.54"	123° 29' 40.9"	86	50	7	1913.5	564.0	30.5	07/31/00	71.8	63.6	UBWC
C18 N Fork Middle Ck	42° 50' 48.23"	123° 26' 3.48"	89	44	0	1661.5	294.0	0.0	07/30/00	69.6	59.2	UBWC
C19 S Fork Middle Ck	42° 50' 47.3"	123° 26' 3.57"	89	49	6	1685.5	360.5	11.5	08/08/00	72.1	59.5	UBWC
C20 Riffle Ck @ mouth	42° 46' 58.95"	123° 34' 48.51"	86	44	0	1903.0	372.5	0.0	07/31/00	69.8	62.2	UBWC
C21 Skull Ck @ mouth	42° 46' 23.25"	123° 34' 20.46"	86	21	0	1828.0	113.0	0.0	07/31/00	67.9	61.3	UBWC
C22 McCullough Ck near mouth	42° 44' 52.72"	123° 27' 19.44"	75	8	0	1553.0	50.5	0.0	08/08/00	66.0	60.5	UBWC
C23 Upper McCullough	42° 47' 5.02"	123° 26' 37.12"	64	0	0	1076.5	0.0	0.0	08/08/00	62.9	58.4	UBWC
C24 Windy Ck @ mouth	42° 44' 25.34"	123° 25' 3.87"	87	51	0	2071.5	446.5	0.0	08/08/00	68.8	63.2	UBWC
C25 Cow Ck abv Windy Ck	42° 44' 24.66"	123° 25' 3.53"	87	67	21	2069.5	922.5	113.0	06/28/00	73.4	63.9	UBWC
C26 Windy Ck @ Glendale HS	42° 44' 47.5"	123° 24' 45.02"	88	54	0	2109.5	418.0	0.0	08/08/00	68.8	63.2	UBWC
C27 Windy Ck abv HS	42° 44' 50.48"	123° 24' 43.42"	88	60	1	2089.5	458.0	2.0	08/08/00	70.3	63.0	UBWC
C28 Wood Ck @ mouth	42° 46' 3.9"	123° 23' 29.01"	85	7	0	1700.5	25.0	0.0	08/08/00	64.9	60.0	UBWC
C29 Lawson Ck @ mouth	42° 46' 39.04"	123° 22' 15.77"	87	31	0	1851.0	116.5	0.0	08/08/00	67.9	60.7	UBWC
C30 Windy Ck abv Lawson	42° 46' 38.42"	123° 22' 15.1"	87	36	0	1958.5	192.5	0.0	08/01/00	68.4	61.5	UBWC
C31 N Fork Windy Ck	42° 49' 21.22"	123° 19' 45.91"	73	0	0	1259.5	0.0	0.0	08/08/00	61.8	58.4	UBWC
C32 W. Fork Windy Ck	42° 49' 19.92"	123° 19' 46.58"	61	0	0	996.5	0.0	0.0	08/08/00	60.8	57.9	UBWC
C33 Cow Ck abv Quines	42° 46' 51.72"	123° 16' 16.61"	43	0	0	736.5	0.0	0.0	08/08/00	63.0	56.2	UBWC
C34 Quines Ck @ mouth	42° 46' 44.4"	123° 16' 24.65"	47	34	22	1127.5	409.5	64.5	08/25/00	76.5	58.0	UBWC
C35 Cow Ck abv Whitehorse Ck	42° 49' 3.62"	123° 11' 1.61"	82	12	0	1297.5	46.0	0.0	07/26/00	67.1	57.3	UBWC
C36 Whitehorse @ mouth	42° 49' 2.19"	123° 11' 1.77"	88	0	0	1978.0	0.0	0.0	07/19/00	62.2	57.7	UBWC
C37 Cow Ck below dam	42° 50' 51.84"	123° 10' 53.16"	59	0	0	1084.5	0.0	0.0	07/25/00	63.6	61.6	UBWC
C38 Cow Ck @ Snow Ck Rd	42° 49' 29.04"	123° 5' 22.12"	88	75	43	1966.0	857.5	290.5	07/31/00	76.8	62.8	UBWC
CP1 Woodford Ck 1	42° 45' 36"	123° 19' 48"	41	0	0	767.0	0.0	0.0	09/16/00	58.9	57.0	Parker
CP2 Woodford Ck 3	42° 45' 19"	123° 19' 37"	25	0	0	520.5	0.0	0.0	08/26/00	58.9	58.4	Parker
CP3 Woodford Ck 3	42° 44' 52"	123° 19' 18"	33	0	0	603.5	0.0	0.0	08/23/00	61.6	56.0	Parker
CP4 Woodford Ck 4	42° 44' 46"	123° 19' 12"	45	2	0	793.0	7.0	0.0	08/26/00	64.7	60.8	Parker
FS01 Cow Ck abv Dismal Ck	42° 48' 47.45"	123° 3' 1.66"	103	49	6	1974.0	277.0	10.5	08/08/00	70.9	60.5	Forest Service
FS06 Applegate Ck @ mouth	42° 48' 52.41"	123° 1' 47.36"	95	19	0	1834.0	112.5	0.0	07/30/00	66.9	59.1	Forest Service
FS10 E Fork Cow Ck@ mouth	42° 48' 11.25"	122° 59' 22.86"	74	0	0	1088.5	0.0	0.0	08/08/00	61.6	57.9	Forest Service
FS11 S Fork Cow Ck @ mouth	42° 48' 10.07"	122° 59' 23.79"	79	0	0	1021.0	0.0	0.0	08/08/00	61.4	57.2	Forest Service
ODF164 McCullough Ck sec 19	42° 46' 35.81"	123° 26' 49.72"	39	0	0	646.0	0.0	0.0	08/08/00	63.1	58.8	O DeptForesty
ODF165 McCullough Ck sec 17	42° 47' 31.38"	123° 26' 25.12"	30	0	0	481.0	0.0	0.0	08/08/00	60.3	57.5	O DeptForesty
ODF166 McCullough Ck abv site 165	42° 47' 45.61"	123° 26' 32.13"	28	0	0	457.0	0.0	0.0	08/08/00	59.9	57.3	O DeptForesty
ODF168 McCullough Ck blw N Fork	42° 47' 0.52"	123° 26' 39.47"	36	0	0	584.0	0.0	0.0	08/08/00	62.3	58.3	O DeptForesty
ODF170 Upper Windy Ck	42° 49' 54.81"	123° 19' 22.33"	35	0	0	556.0	0.0	0.0	08/09/00	60.1	57.8	O DeptForesty
ODF171 Windy Ck @ county park	42° 47' 25.41"	123° 20' 42.32"	41	0	0	827.0	0.0	0.0	08/09/00	63.9	61.0	O DeptForesty
ODF175 Windy Ck sec 7	42° 48' 37"	123° 19' 58.16"	40	0	0	712.0	0.0	0.0	08/09/00	62.5	59.3	O DeptForesty
ODF176 Windy Ck blw N Fork	42° 49' 18.73"	123° 19' 45.08"	34	0	0	534.0	0.0	0.0	09/19/00	59.5	56.3	O DeptForesty
CowAir Cow Ck AIR	42° 44' 47.5"	123° 24' 45.02"	88	82	74	1487.5	862.0	576.0	08/08/00	89.7	58.9	UBWC
Summary Statistics * Air Temperature not included												
Maximum:			134.0	90.0	75.0	2645.5	2011.5	1385.5		82.3	77.1	
Minimum:			19.0	0.0	0.0	247.0	0.0	0.0		57.3	54.7	
Diffference:			115.0	90.0	75.0	2398.5	2011.5	1385.5		25.0	22.4	
Average:			75.8	25.4	7.6	1506.2	303.2	92.1		66.9	60.6	

Chart 12(A) Seasonal Max, Min, and ΔT Values

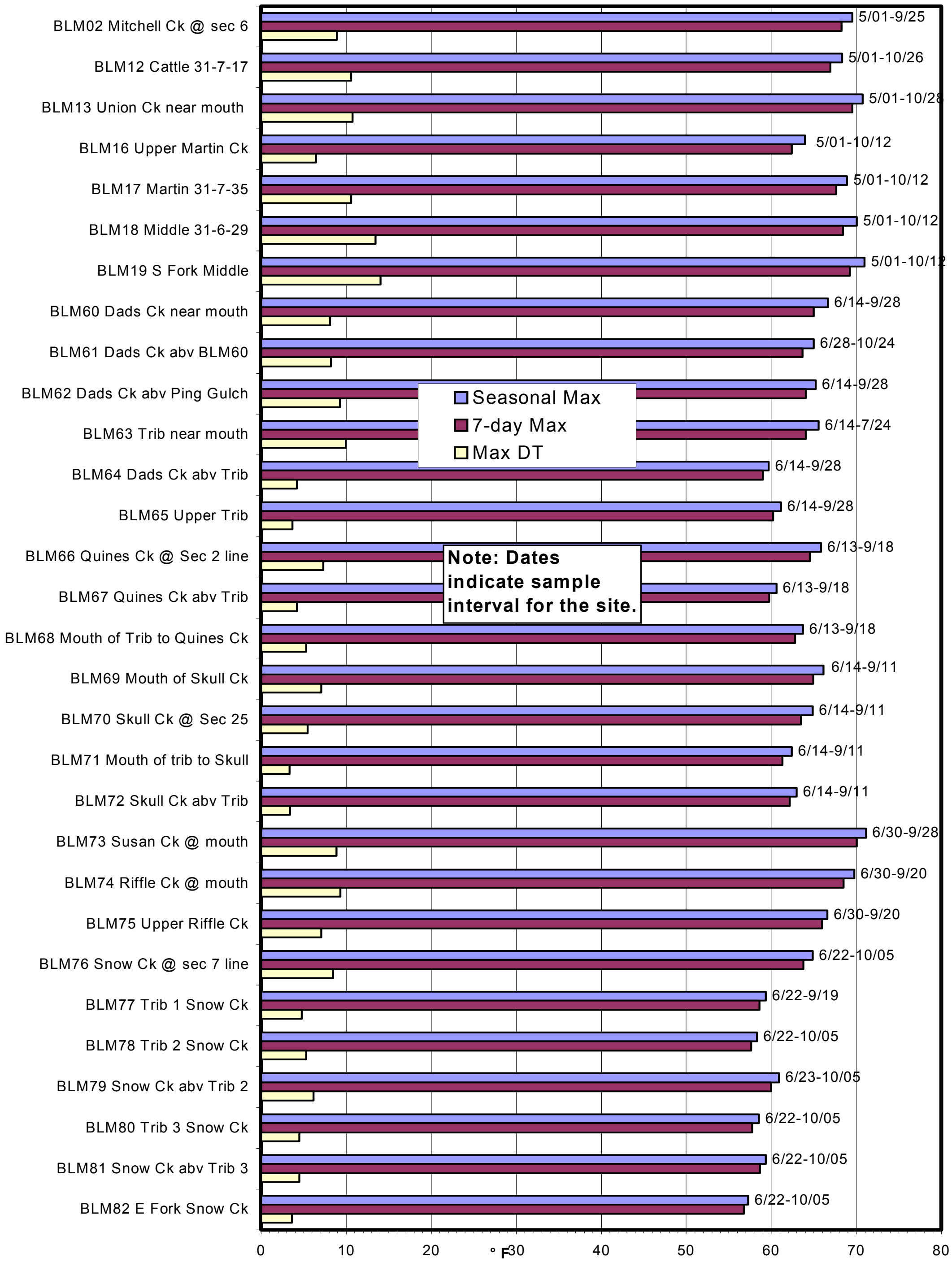


Chart 12(B) Seasonal Max, Min, and ΔT Values

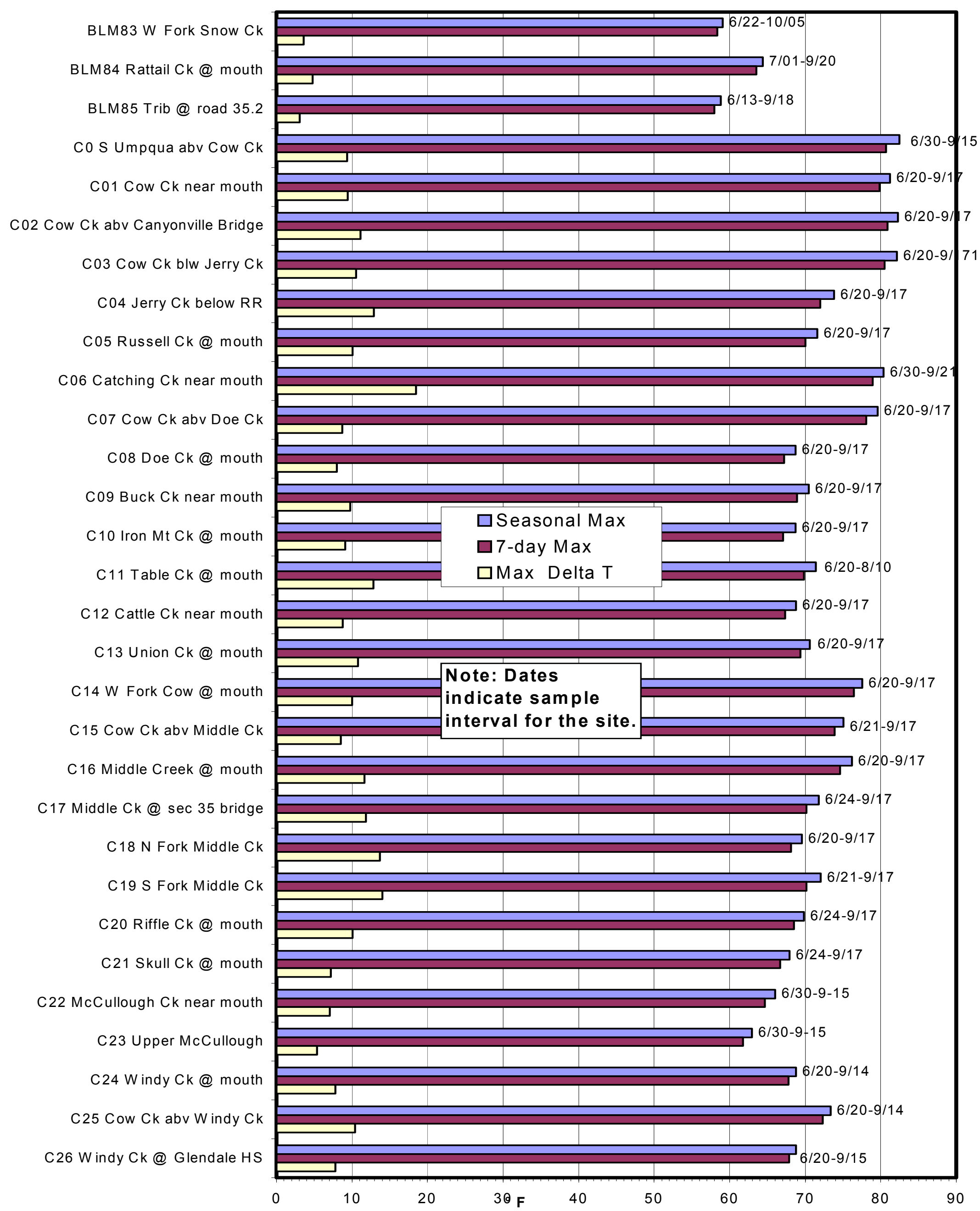
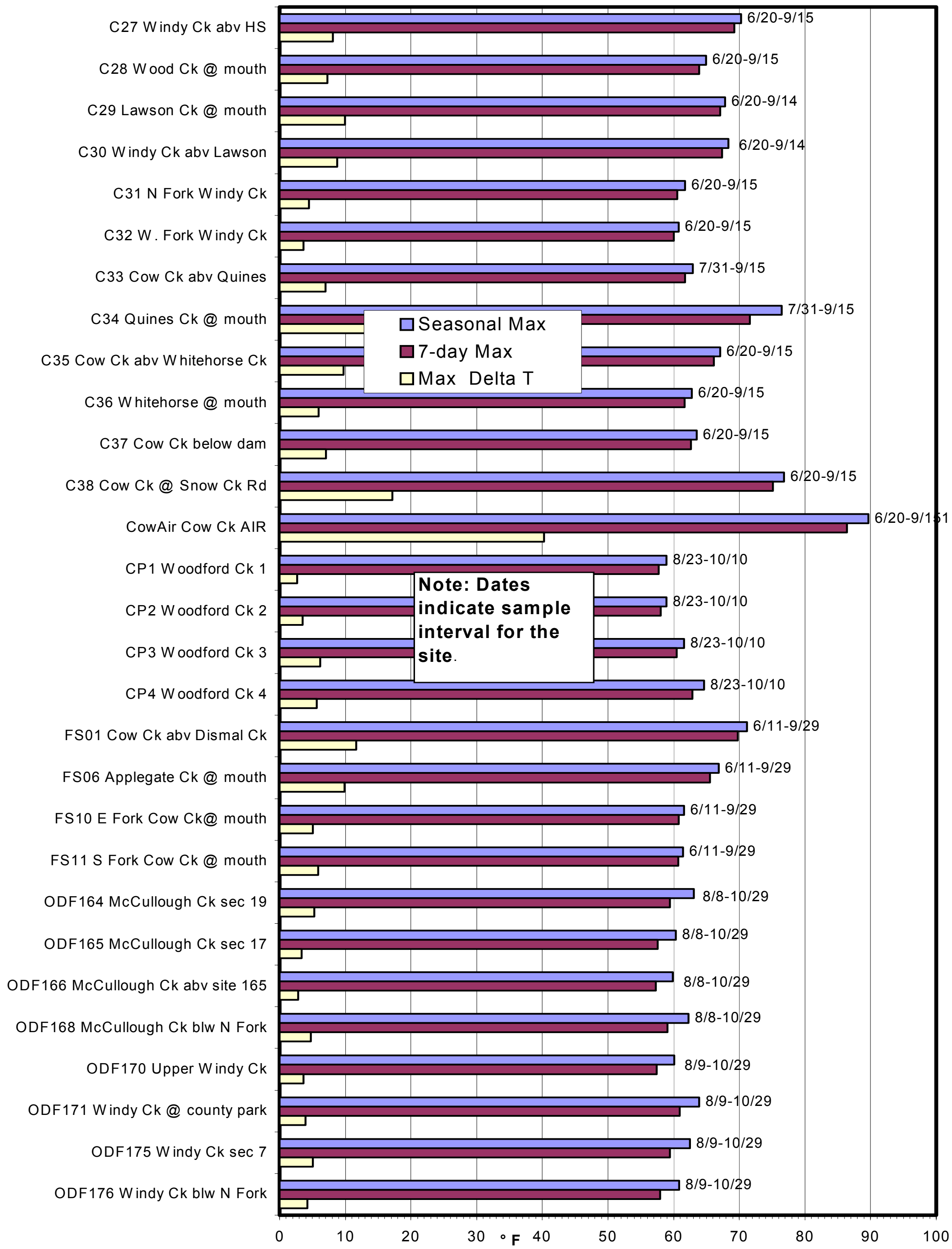


Chart 12(C) Seasonal Max, Min, and ΔT Values



Notes to Table 1 and Chart 12

- The seasonal maximum value is the highest daily temperature measured at a site.
- The maximum ΔT represents the largest observed difference between the daily maximum and minimum for the site.
- The 7-day maximum is the seasonal maximum of the 7-day running average of the daily maximum values. This statistic blends a time duration factor with the maximum value and is part of the Oregon State criteria for stream temperature.
- The "CowAir Cow Creek Air" entry is air temperature measured at the same site as C26 (Windy Creek @ Glendale HS).

Statistics for a Given Day:

The advantage of a synoptic study is that it provides the opportunity to compare how the streams respond simultaneously under similar conditions at exactly the same point in time. For this analysis, August 8, 2000 was selected since most of the sites had their seasonal maximum temperatures on that date. Table 2 provides some of the temperature statistics for that day. The maximum and minimum data represent the extreme values for the 24-hr period starting at midnight and the ΔT value is the difference between these values. The mean is the average of all of the readings (typically 48) over the 24-hr period. The simple average of the max and minimum values is also shown for comparison with the mean value of all of the readings. If the mean is lower than the simple average it indicates that there are more "cool" values than "hot" values and provides an indication of the relative duration of solar exposure for the day.

Heating rates were calculated from the temperature change measured between consecutive 30-minute readings. The maximum rates occurred during daytime heating and the negative minimum rates show the rate of nighttime cooling. In general, there appears to be a strong association between high ΔT and high rates of heating. Taking the difference between the maximum and minimum rates eliminates all of the heat flux that is constant throughout the 24-hour period. In other words, the rate difference is solely dependent on the diurnal effects under steady-state flow conditions.

The time data indicates the time of day that the maximum or minimum value first occurred. The time of minimum provides an indication of the time of day that the sun first starts to affect the water temperature - latter times suggest more morning shade. Likewise, the time of maximum indicates the point where the solar heating component is no longer greater than the heat loss component. Early PM time for the maximum suggests better afternoon shade.

The Paired Site column denotes sites that were located at the confluence of two streams - similar symbols denote the paired sites that are discussed in the next section.

Site Name	Max Temp °F	Min Temp °F	Mean Temp °F	Max +Min / 2 °F	ΔT °F	Rate of Heating: Max Rate °F / hr	Mim Rate °F / hr	Δ Ρατε °F / hr	Time of Min	Time of Max	Paired Sites
BLM02 Mitchell Ck @ sec 6	69.52	61.98	65.03	65.75	7.54	2.34	-1.18	1.16	4:00 PM	8:00 AM	
BLM12 Cattle 31-7-17	68.33	61.97	65.22	65.15	6.36	1.74	-0.58	1.16	2:00 PM	8:00 AM	
BLM13 Union Ck near mout	70.43	61.99	65.83	66.21	8.44	1.76	-1.16	0.6	5:30 PM	7:30 AM	
BLM16 Upper Martin Ck	63.93	58.50	60.75	61.22	5.43	1.72	-0.58	1.14	3:00 PM	7:30 AM	
BLM17 Martin 31-7-35	68.61	61.65	64.93	65.13	6.96	1.76	-1.16	0.6	4:30 PM	7:30 AM	
BLM18 Middle 31-6-29	69.76	60.48	64.74	65.12	9.28	2.32	-1.18	1.14	5:00 PM	8:00 AM	
BLM19 S Fork Middle	70.96	59.61	64.74	65.29	11.35	3.52	-1.22	2.3	3:00 PM	7:30 AM	
BLM60 Dads Ck near mouth	66.63	59.41	62.38	63.02	7.22	1.728	-0.612	1.116	5:00 PM	7:30 AM	
BLM61 Dads Ck abv BLM60	64.98	59.52	62.06	62.25	5.45	1.188	-0.612	0.576	5:00 PM	7:00 AM	
BLM62 Dads Ck abv Ping G	65.19	59.16	62.20	62.18	6.03	1.152	-0.612	0.54	5:00 PM	8:00 AM	
BLM64 Dads Ck abv Trib	59.70	56.89	58.16	58.30	2.81	0.576	-0.576	0	4:00 PM	6:30 AM	
BLM65 Upper Trib	61.14	58.28	59.73	59.71	2.86	0.612	-0.612	0	3:00 PM	7:00 AM	
BLM66 Quines Ck @ Sec 2	65.84	60.64	63.23	63.24	5.20	1.728	-0.612	1.116	5:30 PM	7:00 AM	
BLM67 Quines Ck abv Trib	60.62	57.78	59.06	59.20	2.84	0.576	-0.576	0	5:00 PM	5:30 AM	#
BLM68 Mouth of Trib to Qui	63.72	60.01	61.75	61.86	3.71	1.152	-0.612	0.54	3:00 PM	5:30 AM	#
BLM69 Mouth of Skull Ck	66.13	61.21	63.43	63.67	4.91	1.152	-0.612	0.54	5:30 PM	8:00 AM	
BLM70 Skull Ck @ Sec 25	64.87	59.70	62.22	62.29	5.17	1.728	-0.612	1.116	3:00 PM	8:00 AM	
BLM71 Mouth of trib to Skul	62.38	59.54	60.99	60.96	2.84	0.576	-0.576	0	6:30 PM	8:30 AM	%
BLM72 Skull Ck abv Trib	62.98	60.69	61.78	61.84	2.29	0.576	-0.576	0	6:00 PM	7:00 AM	%
BLM73 Susan Ck @ mouth	70.56	63.82	66.70	67.19	6.73	1.764	-0.612	1.152	6:00 PM	8:30 AM	
BLM74 Riffle Ck @ mouth	69.76	61.92	65.53	65.84	7.85	1.764	-0.612	1.152	5:00 PM	9:00 AM	
BLM75 Upper Riffle Ck	66.61	60.84	63.39	63.73	5.78	1.188	-0.612	0.576	5:00 PM	8:30 AM	
BLM76 Snow Ck @ sec 7 lir	64.56	57.70	60.59	61.13	6.86	2.268	-1.188	1.08	2:30 PM	7:00 AM	
BLM77 Trib 1 Snow Ck	59.34	55.99	57.45	57.67	3.35	0.576	-0.576	0	5:30 PM	7:00 AM	
BLM78 Trib 2 Snow Ck	58.32	54.70	56.52	56.51	3.62	1.116	-0.576	0.54	3:00 PM	7:00 AM	
BLM79 Snow Ck abv Trib 2	60.91	56.66	58.71	58.78	4.25	1.152	-0.576	0.576	5:30 PM	7:30 AM	
BLM80 Trib 3 Snow Ck	58.57	55.22	56.78	56.89	3.35	1.116	-0.576	0.54	4:30 PM	6:00 AM	&
BLM81 Snow Ck abv Trib 3	59.36	55.99	57.58	57.68	3.37	1.116	-0.576	0.54	3:00 PM	6:30 AM	&
BLM82 E Fork Snow Ck	57.31	54.79	56.00	56.05	2.52	0.576	-0.576	0	5:00 PM	7:00 AM	*
BLM83 W Fork Snow Ck	59.11	56.30	57.59	57.70	2.81	0.576	-0.576	0	4:00 PM	6:00 AM	*
BLM84 Rattail Ck @ mouth	64.38	60.94	62.52	62.66	3.44	0.612	-0.612	0	8:30 PM	9:30 AM	
BLM85 Trib @ road 35.2	58.82	56.30	57.62	57.56	2.52	0.576	-0.576	0	2:00 PM	6:30 AM	
C0 S Umpqua abv Cow Ck	82.16	77.07	79.31	79.62	5.09	1.28	-1.28	0	4:30 PM	7:30 AM	
C01 Cow Ck near mouth	80.25	73.40	77.13	76.83	6.85	1.88	-1.24	0.64	7:30 PM	8:30 AM	
C02 Cow Ck abv Canyonvill	81.63	72.30	76.78	76.97	9.33	1.88	-1.26	0.62	7:00 PM	8:00 AM	
C03 Cow Ck blw Jerry Ck	81.17	71.85	76.63	76.51	9.32	2.5	-1.26	1.24	4:30 PM	8:00 AM	
C04 Jerry Ck below RR	73.85	62.39	67.60	68.12	11.46	2.9	-1.82	1.08	4:30 PM	8:30 AM	
C05 Russell Ck @ mouth	70.69	62.82	66.69	66.76	7.87	2.32	-0.62	1.7	4:00 PM	8:00 AM	
C07 Cow Ck abv Doe Ck	78.95	71.56	75.24	75.26	7.39	1.26	-0.64	0.62	6:00 PM	8:30 AM	&*
C08 Doe Ck @ mouth	68.71	62.05	65.38	65.38	6.66	2.32	-0.58	1.74	5:30 PM	7:30 AM	&*
C09 Buck Ck near mouth	70.46	63.74	67.13	67.10	6.72	2.9	-1.2	1.7	3:00 PM	8:00 AM	
C10 Iron Mt Ck @ mouth	68.68	61.44	64.61	65.06	7.24	2.34	-0.6	1.74	6:00 PM	8:00 AM	
C11 Table Ck @ mouth	63.46	61.46	62.46	62.46	2.00	1.16	-0.58	0.58	4:00 PM	2:00 AM	
C12 Cattle Ck near mouth	68.52	61.86	64.92	65.19	6.66	1.74	-0.6	1.14	4:30 PM	7:30 AM	
C13 Union Ck @ mouth	69.99	62.12	65.94	66.06	7.87	1.76	-1.18	0.58	5:00 PM	8:00 AM	
C14 W Fork Cow @ mouth	77.57	69.34	73.31	73.46	8.23	2.48	-1.24	1.24	3:00 PM	9:30 AM	
C15 Cow Ck abv Middle Ck	74.13	67.00	70.27	70.57	7.13	1.8	-1.22	0.58	5:00 PM	7:30 AM	%#%
C16 Middle Creek @ mouth	75.87	65.46	69.95	70.67	10.41	2.4	-1.2	1.2	5:30 PM	10:00 AM	%#%
C17 Middle Ck @ sec 35 bri	71.48	63.27	67.31	67.38	8.21	2.32	-1.2	1.12	7:30 PM	8:30 AM	
C18 N Fork Middle Ck	69.57	60.61	64.49	65.09	8.96	1.74	-1.16	0.58	6:00 PM	8:00 AM	)(
C19 S Fork Middle Ck	72.08	59.53	64.93	65.81	12.55	3.5	-1.8	1.7	3:30 PM	8:00 AM	)(
C20 Riffle Ck @ mouth	69.82	62.23	65.66	66.03	7.59	1.76	-0.6	1.16	5:30 PM	8:30 AM	
C21 Skull Ck @ mouth	67.05	61.26	63.64	64.16	5.79	2.9	-1.18	1.72	2:00 PM	7:30 AM	
C22 McCullough Ck near m	66.01	60.52	63.31	63.27	5.49	2.9	-2.34	0.56	2:00 PM	7:30 AM	
C23 Upper McCullough	62.94	58.35	60.48	60.65	4.59	1.72	-0.58	1.14	6:00 PM	9:00 AM	
C24 Windy Ck @ mouth	68.75	63.23	65.93	65.99	5.52	1.18	-0.6	0.58	6:00 PM	7:30 AM	()
C25 Cow Ck abv Windy Ck	71.26	62.21	66.49	66.74	9.05	1.74	-1.2	0.54	7:30 PM	9:00 AM	()
C26 Windy Ck @ Glendale	68.76	63.24	65.50	66.00	5.52	1.18	-0.6	0.58	4:30 PM	7:30 AM	
C27 Windy Ck abv HS	70.28	63.01	66.05	66.65	7.27	1.74	-1.18	0.56	4:00 PM	7:00 AM	
C28 Wood Ck @ mouth	64.90	60.03	62.29	62.47	4.87	0.58	-0.58	0	6:00 PM	8:00 AM	
C29 Lawson Ck @ mouth	67.86	60.65	63.30	64.26	7.21	2.34	-1.16	1.18	3:30 PM	7:30 AM	%#
C30 Windy Ck abv Lawson	67.80	61.74	63.70	64.77	6.06	2.32	-2.32	2.84E-14	3:00 PM	7:30 AM	%#
C31 N Fork Windy Ck	61.75	58.35	59.80	60.05	3.40	0.58	-0.58	0	6:30 PM	7:00 AM	$
C32 W. Fork Windy Ck	60.77	57.93	59.48	59.35	2.84	1.14	-0.58	0.56	2:30 PM	8:00 AM	$
C33 Cow Ck abv Quines	62.95	56.17	59.63	59.56	6.78	1.14	-1.14	0	5:00 PM	8:00 AM	
C34 Quines Ck @ mouth	71.00	65.14	66.80	68.07	5.86	2.34	-1.2	1.14	4:30 PM	6:00 AM	
C35 Cow Ck abv Whitehors	60.72	55.11	57.00	57.92	5.61	1.7	-1.7	0	3:30 PM	4:00 AM	<>
C36 Whitehorse @ mouth	61.65	59.94	60.28	60.80	1.71	2.28	-1.14	1.14	10:30 AM	12:00 AM	<>
C37 Cow Ck below dam	57.02	55.08	55.81	56.05	1.94	1.66	-2.78	-1.12	4:30 PM	12:30 AM	
C38 Cow Ck @ Snow Ck Rd	76.20	62.53	69.12	69.37	13.67	3.02	-1.24	1.78	4:30 PM	8:00 AM	

Table 2 Selected Statistics from the 24-hour period on August 8, 2000.

Spatial Analysis of the Data

A basic objective of this project is to better understand the response pattern of the stream temperatures within the watershed. On a two dimensional chart, it is helpful to plot the "given day" statistics as a function of the stream distance from the mouth and also the stream distance from the source ridge. Each approach provides a different perspective for analysis.

Site Distance from the mouth of Cow Creek

This approach emphasizes the distance "up-the-river" from the mouth to a particular site and it provides the opportunity to compare the temperature of the mainstem stream with the corresponding temperature of a contributing tributary at the point of confluence. Chart 13 shows the maximum temperatures observed on 8/8/00 as a function of the site distance

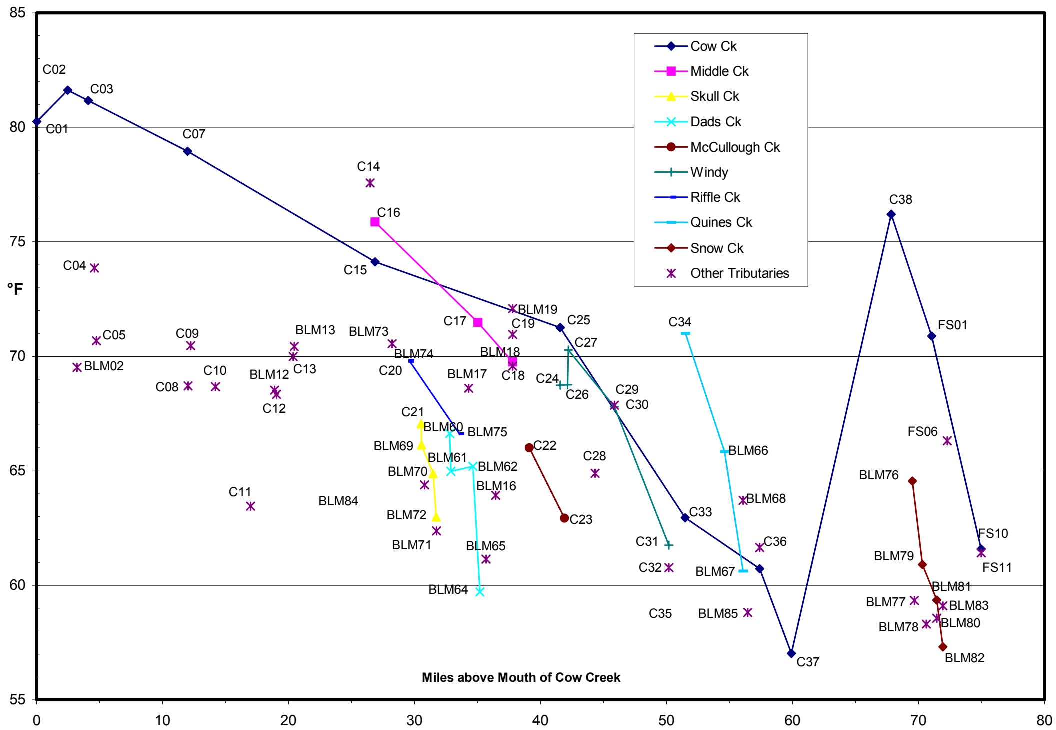


Chart 13 Maximum 8/8/2000 Temperatures by River Mile

from the mouth of Cow Creek. The "paired sites" listed in Table 3 are located at the same distance value and have the same elevation. For example, C24, Windy Creek at the mouth and C25, Cow Creek above Windy Creek are both 42 miles from the mouth of Cow Creek. However, the distance to the source of Windy Creek is less and the associated stream is smaller than Cow Creek at the point of confluence. In general the smaller tributaries have cooler temperatures while similar sized streams tend to have similar temperatures. Of course the smaller tributaries typically have less water, which may equate to reduced availability of quality habitat. Consequently, the relatively small mixing area with both cooler temperatures and ample water may represent rather scarce points with optimal habitat conditions for fish and other aquatic organisms.

Typically streams increase in temperature in downstream direction but, for Cow Creek, this pattern is disrupted between sites C37 and C38, which are located below and above the Galesville reservoir. Below the dam the stream resumes heating and, as shown previously, matches the temperature of the South Umpqua at the point of confluence (sites C0 and C1). Site C14 is at the mouth of the West Fork of Cow Creek and, being a smaller tributary, would normally be cooler than the larger stream. However, for this system, the larger stream is still cooler.

All of the other sites are relatively cooler with the smaller tributaries showing a general pattern of rapid downstream heating. However, it appears that local "hot spots" may occur with the temperature recovering further downstream. For example, Site C27 on Windy Creek is located about 300 feet above C26 but has a higher temperature than the downstream site. It was noted that site C27 is more exposed to direct sunlight than site C26.

The values of the minimum temperatures shown in Chart 14 are, of course, lower and tend to be more compressed. The average annual temperature of the basin is probably in the

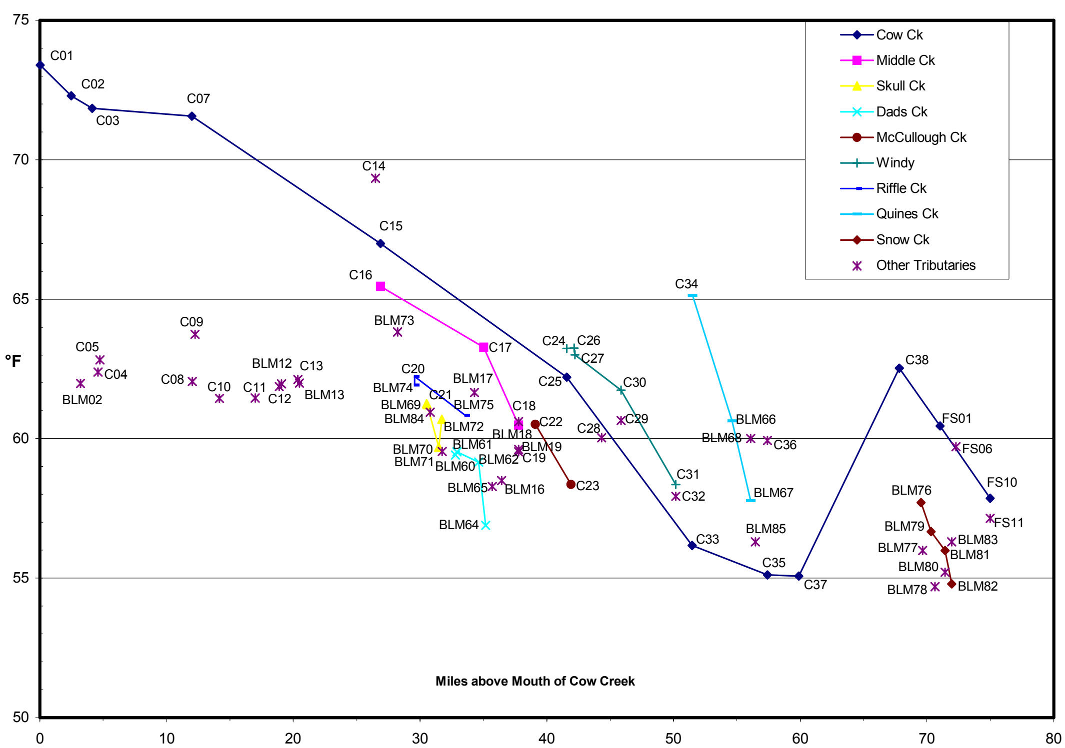


Chart 14 Minimum 8/8/2000 Temperatures by River Mile

low 50's and the extent that the minimum stream temperature is above that value represents the excess heat accumulated over the summer. Notice that the water temperature below the dam is near the expected minimum value.

Chart 15 shows the variation in ΔT between the sites. Since the solar radiation is the only variable that changes regularly on a daily basis, most of the ΔT value at a site is associated with changes in the amount of solar energy received by the stream. Vegetative shade, topographic shade, cloud cover, stream azimuth, and solar path influence the amount of

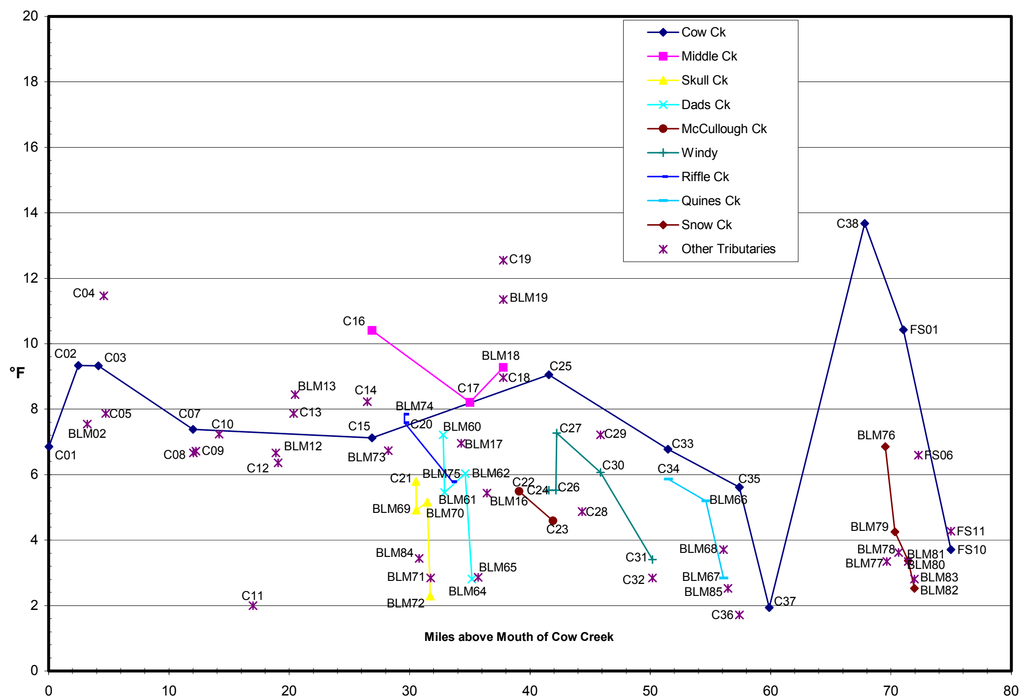


Chart 15 ΔT Temperature for 8/8/00 for distance from mouth of Cow Creek

solar energy received at the water surface on any give day. Sites with high ΔT are apparently receiving a higher net level of solar energy per unit volume of water throughout the day. The water at site C37, directly below the reservoir, has not had much time to receive solar input and consequently has a low ΔT while the water downstream at site C35 has had more exposure time to the sunlight. The temperature patterns for these sites were shown in Charts 8 and 9. Note that the site C11 value (Chart 6) is very similar to site C37, suggesting an influence by a large cool source in both cases.

As expected, the sites with high ΔT were typically noted to have high exposure to direct solar radiation within the immediate vicinity.

Site Distance from the source ridge

It was noted in the preceding discussion that streams generally get larger as they accumulate more water while moving down through the watershed. With increased flow, they generally get wider, deeper and flow faster. Also, the channel bank and bed characteristics change as well as the type and extent of riparian vegetation. Likewise, the proportional contribution of groundwater inflow also generally decreases. All of these effects can influence the stream temperature and generally contribute to increasing stream temperatures in the down stream direction.

Likewise, the quality of the fish habitat tends to be related to the size of the stream. The very small streams may be the coldest but they may not have a sufficient volume of water for adequate rearing during the summer months. The large streams have sufficient water but may get too warm. If temperature is limiting the health and development of the fish, there may be an optimum stream size range that has the right mix of water and temperature. If this proves to be the case, these areas should be identified and receive management emphasis.

Plotting the sites as a function of the distance to their respective ridgelines is a way to roughly sort the streams by size. For example, points 5 miles from the ridge of each stream will tend to have similar flows and channel characteristics. Of course, this relationship breaks down if the streams are in a significantly different geologic area or have different watershed geometry. For that reason, this type of comparison is effective only when made in the same geographic area and, even then, there may be considerable variability. It should be noted that this sorting does not directly account for differences in absolute elevation between sites but it does account, to some extent, for the relative vertical drop from the source ridge.

Charts 16 and 17 shows how the maximum and minimum temperatures observed on 8/8/00 varied as a function of the distance of the site from the stream's respective source ridgeline. The streams that are in the 5 to 15 mile range from their source may represent the best cool water summer habitat. Streams less than 5 miles may be cooler but may not have sufficient water. Streams located more than 15 miles from the source normally would be getting too warm but, because of the reservoir release, this portion of Cow Creek is relatively cool.

Since the streams associated with a particular ridge distance will tend to have similar size and flow characteristics, one would expect they would have similar temperatures if they had similar shade characteristics. It is readily apparent from Charts 16 and 17 that there is considerable temperature variability between sites at any given source distance. To the extent that these sites have similar size, shape and flow, most of the remaining variability can be associated with differences in shade. Consequently, the chart provides a "first cut" view of sites that may benefit from improved shade. However, it needs to be emphasized that there may be other factors that would cause a particular site to have elevated temperatures and a local field assessment would be required before a site-specific management plan could be developed.

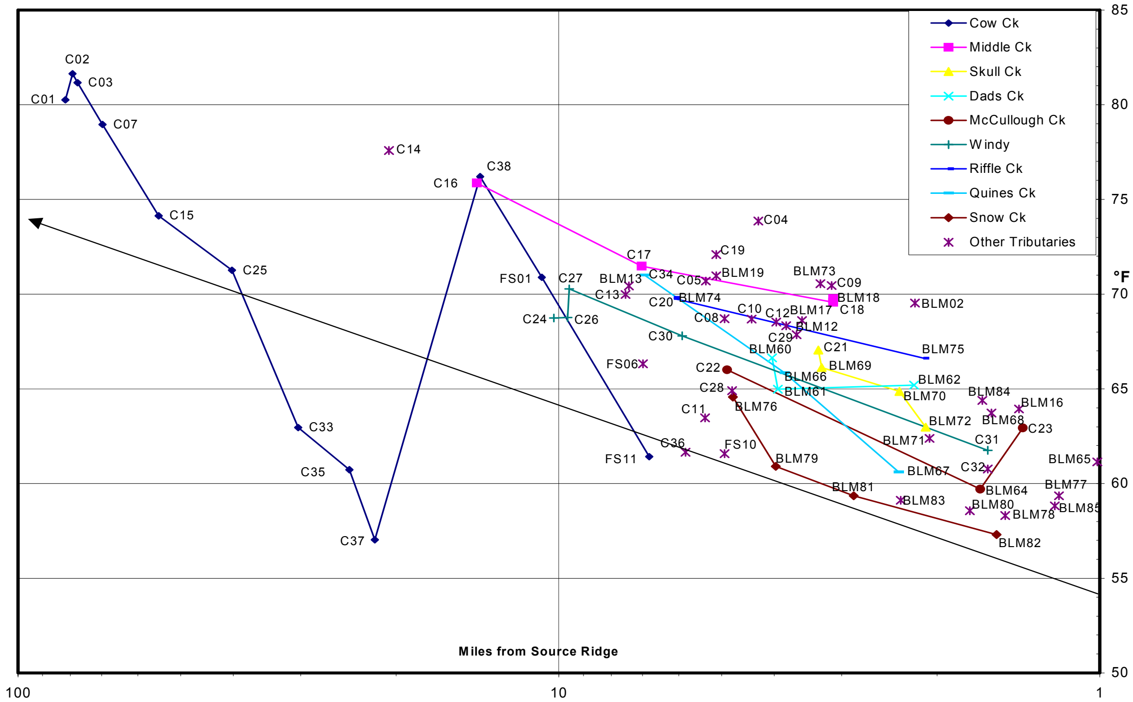


Chart 16 Maximum 8/8/2000 Temperatures by Distance From Source

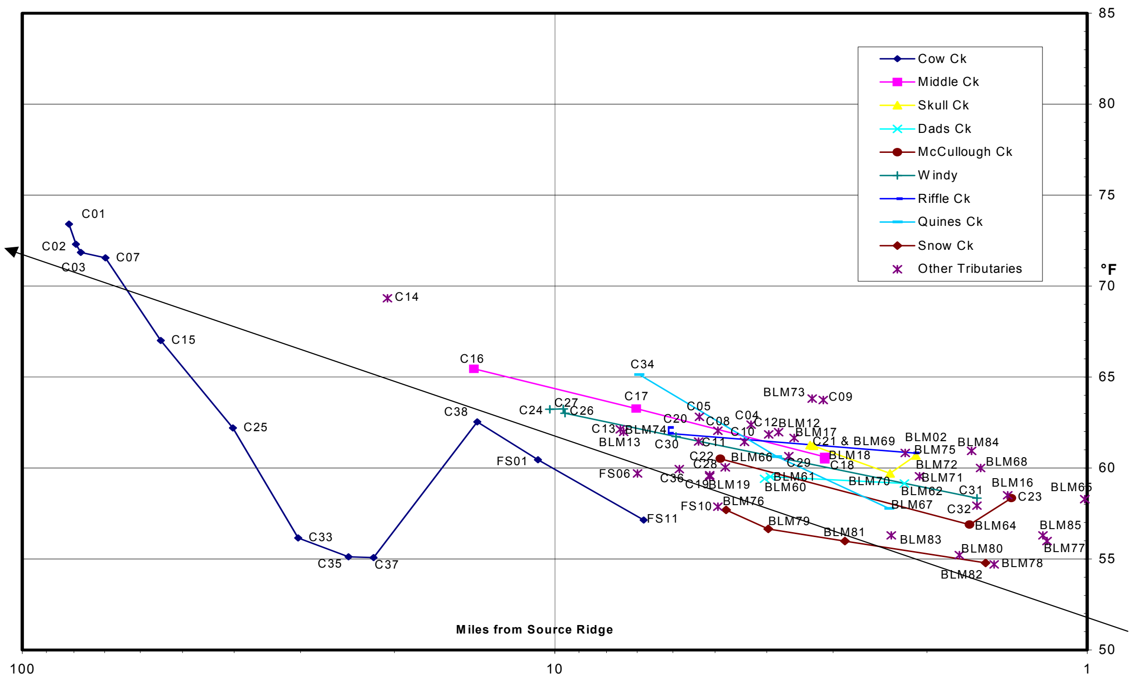


Chart 17 Minimum 8/8/00 Temperatures by Distance from the Source

The sites along the lower edge of the data cluster are of interest because they represent the best temperatures in the watershed under current conditions. The important implication is that shade management on the other sites, with temperatures located further above the line, may bring the maximum temperatures down to at least this level. The question remains open whether the line represents the best possible conditions and the lowest possible temperatures. Further analysis and modeling is needed to determine the expected temperatures under “ideal” watershed conditions. Nevertheless, it is apparent that there are streams in the 5 to 15 mile range with potentially good habitat that could be cooled as much as 10°F. Cold-water fish that are trying to survive in these areas would certainly benefit from this reduction in temperature.

Note that the distance is plotted on a logarithmic scale. Previous studies have noted that the lower edge of the data cluster (identified by the arrow) tends to have a characteristic slope for a given watershed. The equation for the lower edge of the max value cluster is:

$$T \sim 10 \log D + 54.$$

This means that the temperature for this line at mile 1 is 54°F and will increase by 10 °F for every distance multiple of 10.   Notice that the temperature slope of Cow Creek both above and below the reservoir is higher at about 45 °F for every distance multiple of 10. The maximum temperature for C14, West Fork Cow Creek suggests that this watershed may also have a higher rate of heating.

The minimum values tend to be less variable with similar slope. For reference the arrow shown on the chart has an equation:

$$T \sim 10 \log D + 52.$$

Since the rate of heat transfer is dependent on the difference in temperature between two bodies, the higher rate of heating of Cow Creek below the dam is probably a result of the exceptionally cold water adjusting to the local environment.

The corresponding ΔT values shown in Chart 18 indicate that the ΔT values tend to be somewhat higher in the 3 to 15 mile range. This result is consistent with the previous studies and it is thought that, for very small streams, the higher proportion of groundwater limits the daily temperature fluctuation. For the larger streams, the larger quantity of water (greater depth) generally limits the temperature increase generated by the solar radiation. However, the values for lower Cow Creek are higher than observed in other similarly sized streams. This effect may be related to the higher rate of heating discussed in the previous section.

As previously discussed, the 3-15 mile streams may be particularly important to the fishery resource during the summer season and shade management may be effective in lowering stream temperatures of the streams with high ΔT values in this zone.

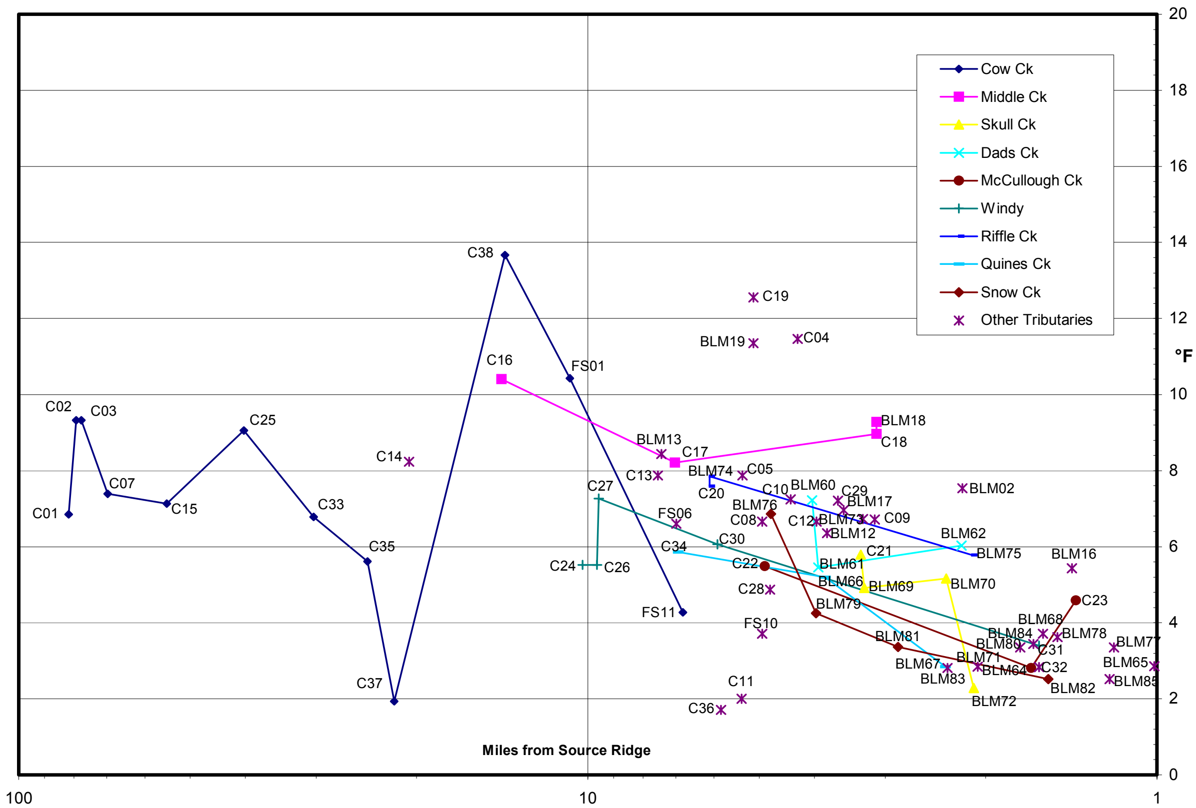


Chart 18 ΔT values for 8/8/00 by Distance From Source.

Conclusions

When the results of the Cow Creek study are combined with the previous studies several important points can be inferred.

Key Observations:

- For this collection of data, the zone of maximum temperatures below 64 °F extended from 0 to about 10 miles as shown in Chart 16. This is a longer distance than observed in previous studies.
- There is a general tendency for streams to heat in the downstream direction. However, downstream temperatures for individual streams can be colder than points upstream if conditions are significantly different. (Example: lower Windy Creek) The implication is that local conditions can significantly affect the local stream

temperature during low flow conditions but these conditions do not persist further downstream.
- The warmer sites appear to have a strong association with exposure to direct solar radiation (absence of shade) based on general observation.
- The low flow period represents an extreme condition in the stream channels. Surface flow velocities tend toward zero as the streams go dry. The resulting isolated pools apparently can remain relatively cool. Hyporheic (groundwater flow) circulation may be a contributing factor. The Table Creek site is a good example of possible groundwater influence. It was interesting to note that this effect was similar to that caused by the cold water release from the reservoir.
- Maximum ΔT values may tend to occur between 3 and 15 miles of the ridgeline.
- The rate of downstream heating (°F/mile) for the non-augmented streams appears to be similar to other streams in the Umpqua Basin.

Management Implications:

The small tributaries may be providing important thermal refuge areas for the cold-water fish species and other aquatic life if these areas have cooler temperatures and sufficient water. Pools in the smaller tributaries could also be beneficial if they maintain sufficient water and have cover. Since the watershed does support a population of cold-water fish, they would likely benefit from any temperature reductions at any point in the watershed and increasing stream shade may be the most direct way to obtain these reductions. A long-term management objective could be to achieve a full shade condition for all perennial streams in the watershed. However, it should be noted that a significant benefit could be realized by improving the effectiveness of the existing riparian shade. Assigning implementation priority to improving existing buffers would have the advantage of (1) faster results since vegetation is already established and (2) not requiring a land use change.

Recommended additional work:

- Inventory the stream shade in the watershed and use models to determine potential stream temperatures under various shade and flow conditions. In particular, determine the relative contributions of local conditions and upstream influence.
- Correlate fish presence data with the temperature data to identify the optimum habitat zones if they exist.
- Develop a temperature management plan for the Umpqua Basin
- Monitor the stream temperature at the 5 reference sites each year to provide a link between current conditions and the previous studies.
- Compile all of the data from the Stream Temperature Characterization Studies into a CD format along with analysis, site data, and site photos. Emphasis would be on comparison of regional heating patterns and identification of management potential.
- Manage the watershed for increased/ optimum shade to reduce the maximum summer heating.

Other Information

About the Data used for the analysis

The following provides source and accuracy information for the data used in the analysis:

Tidbit data loggers

Appendix B contains the specifications for the logger as well as results from the pre and post deployment accuracy checks and the field audit. The procedure was discussed in the "Accuracy Check" section of this report.

Stream Distance

The distance to the source ridge was measured using Terrain Navigator® mapping software from Maptech. The error between any two stations is estimated as +/- 0.2 miles.

Position

The longitude and latitude were measured using Terrain Navigator® mapping software from Maptech. Maximum error is estimated at +/- .1 minute.

Elevation

Elevation data for the monitoring sites were estimated from mapping software with USGS 1:24000 quad maps with 40-foot contours. The data values were interpolated directly from the contours and compared with mapped benchmark values. Error in elevation data is estimated at +/- 10 feet.

Field Materials and equipment

The following materials were used to conduct this study:

- 50 temperature loggers
- Camcorder
- Traceable thermometer
- Rebar wire
- Surgical tubing
- Hip waders
- Brush clippers

Further Information

For information on obtaining the following:

1. VHS Video "Field Notes" approximately 2.5 hr. Shows details of each sensor location and some general site characteristics.
2. .jpg picture files of each site.
3. Raw data files from each site.

Contact:

Umpqua Basin Watershed Council, 1758 N.E. Airport Road, Roseburg, Or 97470.
InSight Consultants, PO Box 10, Yoncalla OR 97499.

Conversion Tables

°C	°F
10.0	50.0
10.5	50.9
11.0	51.8
11.5	52.7
12.0	53.6
12.5	54.5
13.0	55.4
13.5	56.3
14.0	57.2
14.5	58.1
15.0	59.0
15.5	59.9
16.0	60.8
16.5	61.7
17.0	62.6
17.5	63.5
18.0	64.4
18.5	65.3
19.0	66.2
19.5	67.1
20.0	68.0
20.5	68.9
21.0	69.8
21.5	70.7
22.0	71.6
22.5	72.5
23.0	73.4
23.5	74.3
24.0	75.2
24.5	76.1
25.0	77.0
25.5	77.9
26.0	78.8
26.5	79.7
27.0	80.6
27.5	81.5
28.0	82.4
28.5	83.3
29.0	84.2
29.5	85.1
30.0	86.0

°F = (1.8 x °C) +32

°F	°C
50	10.0
51	10.6
52	11.1
53	11.7
54	12.2
55	12.8
56	13.3
57	13.9
58	14.4
59	15.0
60	15.6
61	16.1
62	16.7
63	17.2
64	17.8
65	18.3
66	18.9
67	19.4
68	20.0
69	20.6
70	21.1
71	21.7
72	22.2
73	22.8
74	23.3
75	23.9
76	24.4
77	25.0
78	25.6
79	26.1
80	26.7
81	27.2
82	27.8
83	28.3
84	28.9
85	29.4
86	30.0
87	30.6
88	31.1
89	31.7
90	32.2

°C = (°F-32) / 1.8

Miles	Kilometers
1	1.61
2	3.22
3	4.83
4	6.44
5	8.05
6	9.66
7	11.27
8	12.87
9	14.48

Miles	Kilometers
0.62	1
1.24	2
1.86	3
2.49	4
3.11	5
3.73	6
4.35	7
4.97	8
5.59	9

Acres	Hectares
1	0.40
2	0.81
3	1.21
4	1.62
5	2.02
6	2.43
7	2.83
8	3.24
9	3.64

Acres	Hectares
2.47	1
4.94	2
7.41	3
9.88	4
12.36	5
14.83	6
17.30	7
19.77	8
22.24	9