Local Stream Temperature Variability in Three Streams in the South Umpqua Basin

August, 2006

InSight Consultants
PO Box 10
Yoncalla, OR 97499
www.yoncalla.net

Forward

Since 1999 extensive monitoring and analysis has been conducted within the Umpqua Basin with the objective of characterizing the spatial and temporal variability of the temperature of the streams. To accomplish this objective, more than three hundred monitoring sites were established with a typical distribution of about 10 square miles. The resulting data provided a better understanding of the spatial and temporal variability of the stream temperature at the stream scale level. A discussion of these results can be found in the UBWC document Umpqua Stream Temperature 2003.

This study complements the previous work by focusing on the local stream temperature variability at the reach level for three streams representative of the stream size classes found in the Basin.

Acknowledgements:

Grateful appreciation is extended to Sandy and Chris Lyon for their assistance with the field work for this project.

No funds were received for this project. All services were donated by Sandy, Chris and Kent Smith of Insight Consultants.

Additional Information:

A companion CD with the same title is available from Insight Consultants and contains an Excel workbook with all of the data; a 20 minute mpeg movie video showing the field conditions, some resident fish, and the deployment sites; a file of site photos; this report as well as the report Umpqua Stream Temperature 2003 mentioned above.

These reports can be also accessed and downloaded at www.yoncalla.net in the stream temperature section.

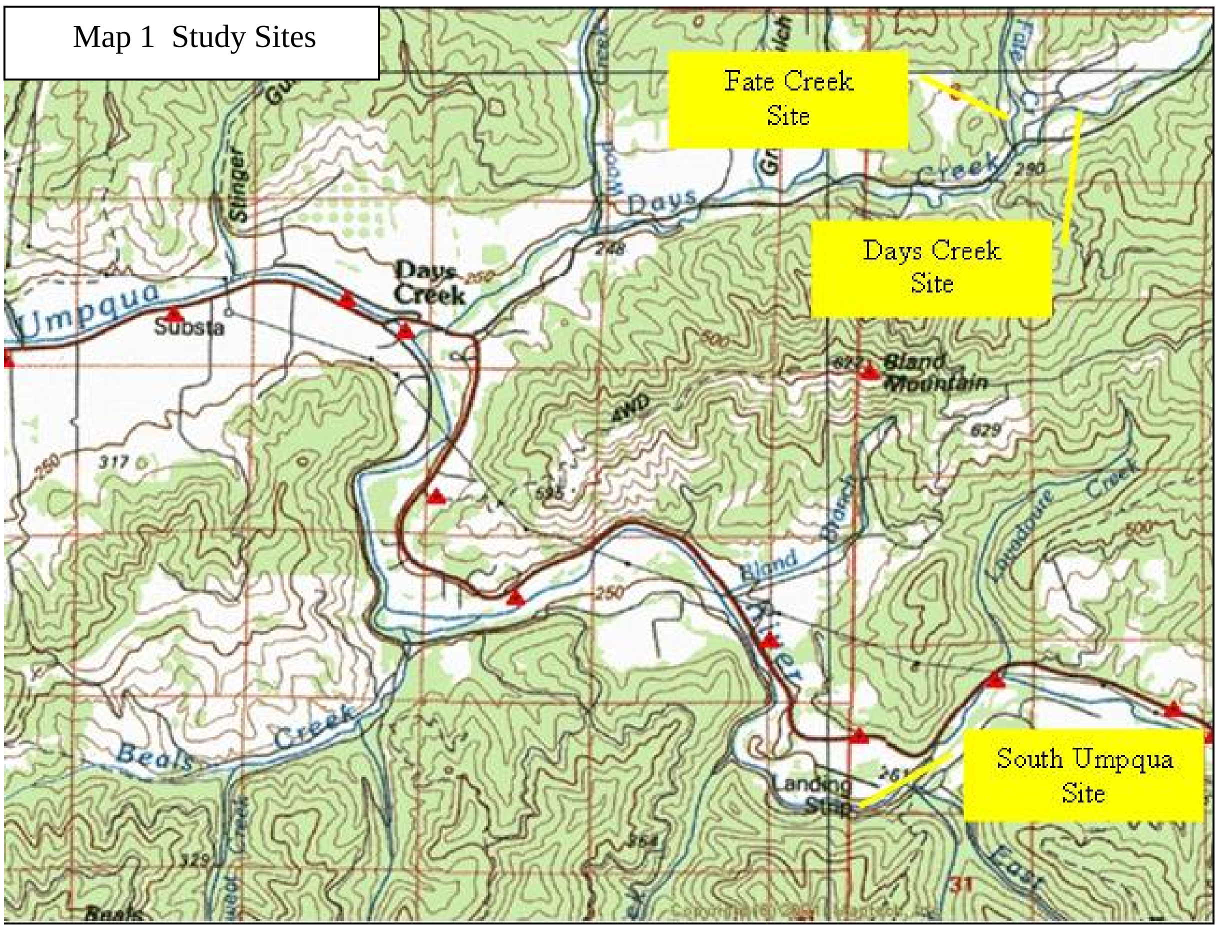
Comments and feedback are welcome. Please address them to:

Kent Smith
Watershed Consultant
Insight Consultants
PO Box 10, Yoncalla OR 97499
541-849-2724
www.yoncalla.net

Local Stream Temperature Variability in Three Streams in the South Umpqua Basin

The objective of this study was to examine at the reach level the stream temperature variability of three streams that are representative of the range of sizes found within the Umpqua Basin. Map 1 shows the general location of the sites selected.

Map 1 Study Sites



Fate Creek was the smallest stream selected with an area of about three square miles. Days Creek is representative of an intermediate sized stream and the South Umpqua site is typical of the large rivers in the Basin.

Days Creek

Days creek is a primary tributary of the South Umpqua River. At the sampling location above Fate Creek the distance to the furthest source ridge is 11.3 miles.

Photo 1 shows the study site looking downstream. The main channel enters from the left and on the right is a small, isolated inflow area that is supplied by hyporheic flow through the gravel bar shown in the foreground.

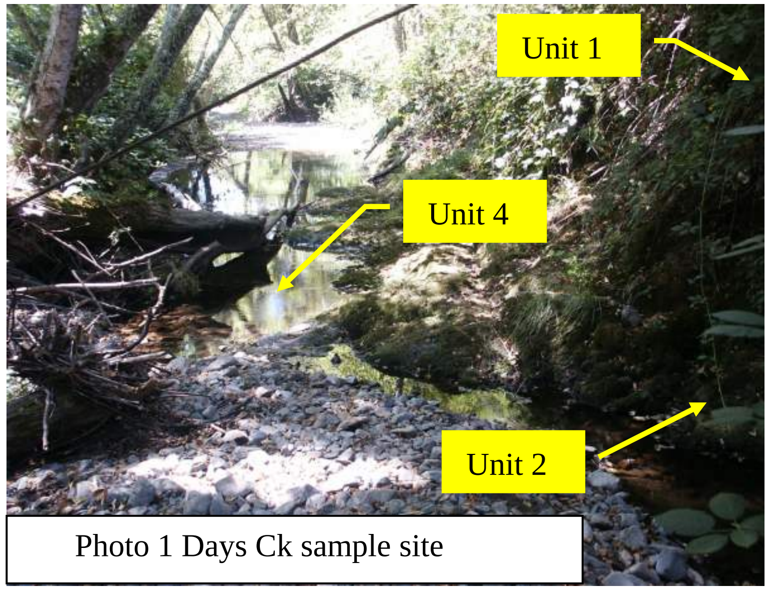


Photo 1 Days Ck sample site

Unit 1 measured air temperature of the site and is located in the vegetation about six feet above the water on the right edge of the photo. Unit 2 is located directly below it in the side supply channel.

Unit 3 is located in the main channel immediately upstream from the photo point and is not shown. Unit 4 is located in the pool located below the mouth of the side channel. Unit 5 is located at a depth of three feet in a larger pool about 100 feet upstream.

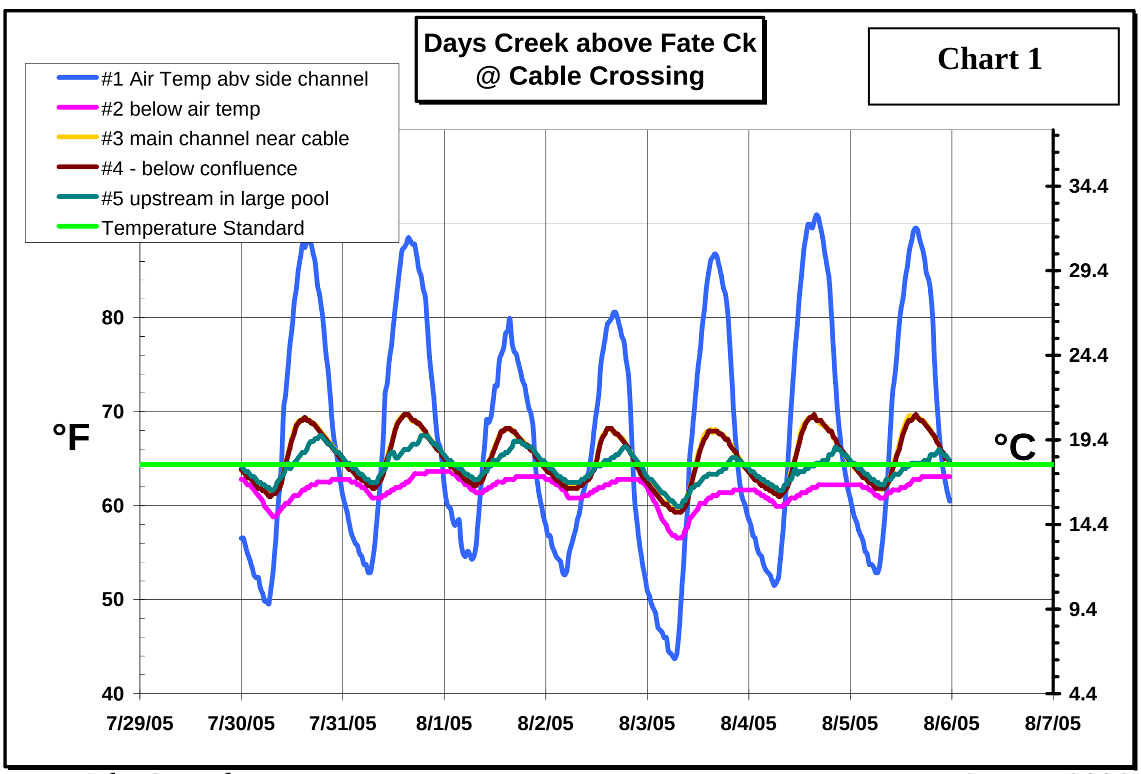


Chart 1

Chart 1 shows the temperature data measured at 30-minute intervals. Unit 1, air temperature, shows the typically larger fluctuation for air caused by its lower thermal mass. Note that units 3 and 4 essentially coincide, with the Unit 3 trace located behind the Unit 4 trace. These two sites appear to represent the prevailing or “bulk” temperature of the stream. Note also that their late-afternoon peak values are quite well synchronized with the air temperature, indicating immediate response to change in direct solar input. However, the morning minimum values lag about 90 minutes indicating that the warm air may be moving into the area before direct solar radiation affects the water units.

Unit 5, located upstream in a deeper pool follows the same pattern during the night hours but shows a truncated pattern during the daytime period. Apparently something is limiting the effect of direct solar radiation for this unit during the midday period. However, it is interesting that the nighttime response is very similar to the bulk temperature response suggesting that the night environmental conditions are affecting these sites in a similar manner.

Unit 2 located in the small side channel has the lowest temperatures. This area is supplied by hyporheic water seeping through the gravel bar that is creating a hydraulic head of about two feet. Note that the diurnal pattern is offset by about two hours because the supply water is delayed as it seeps through the gravel. The over-all lower temperature at this site may be due in part to groundwater inflow and also the “swamp cooler” evaporation effect that occurs as the water moves through the gravel. However, the relatively large offset response to the cold morning of July 3 suggests a strong surface influence.

Fate Creek

Fate Creek is a primary tributary of Days Creek with a water shed area of about 3 square miles. The distance to the furthest source ridge point is 3.2 miles. Photo 2, looking upstream, shows the pool area where some of the units were deployed.

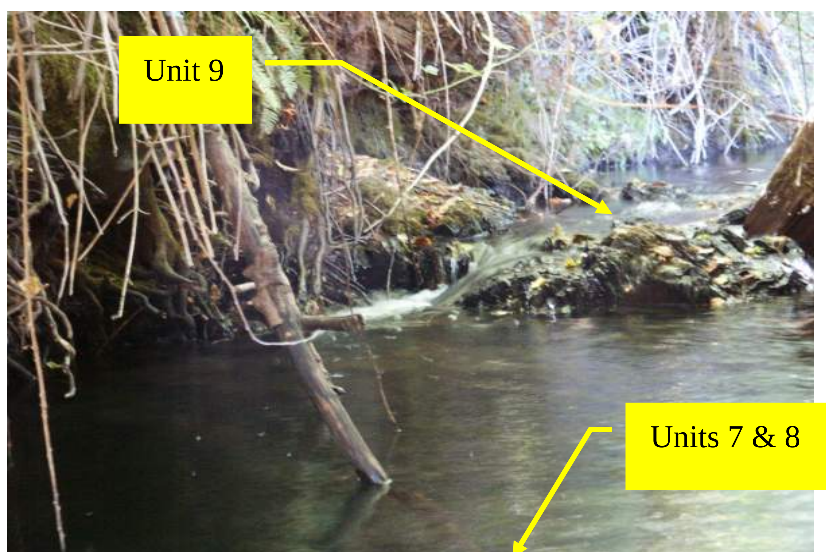
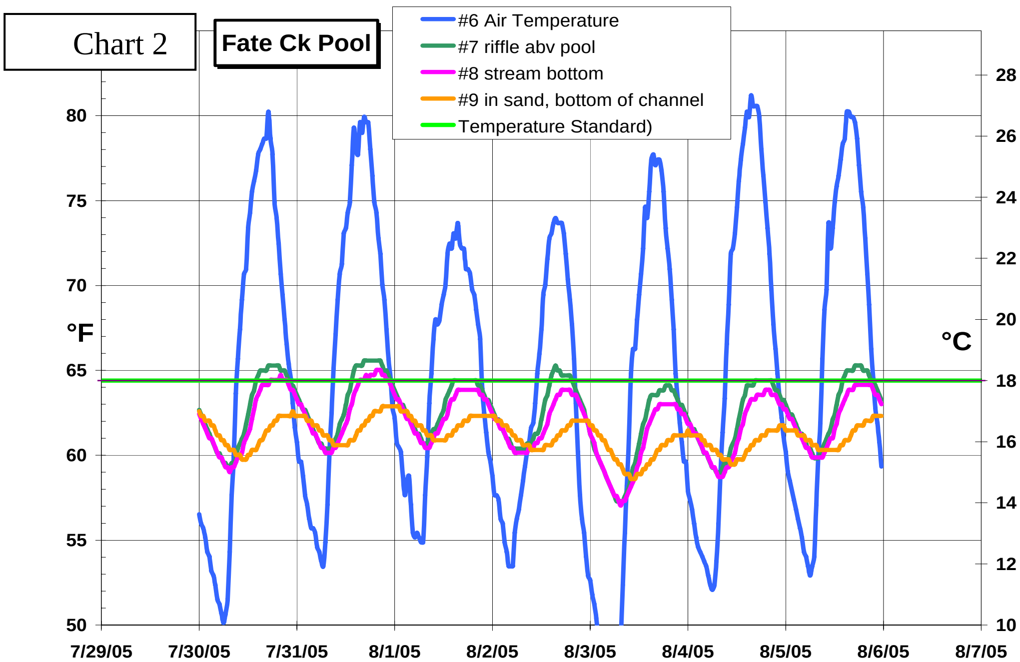


Photo 2 Fate Ck Site

Unit 6 (not shown) measured air temperature in the vicinity and was located about 6 feet above the pool. Unit 7 measured water temperature at the bottom of the pool and was attached to the stick shown in the photo. Unit 8 was buried about 6 inches in the bottom sand beneath Unit 7. Unit 9 was located in the riffle zone upstream of the pool.

Chart 2 shows that the peak temperature in the riffle (Unit 7) was slightly higher than that of the deep pool (Unit 8) but the night time response at the two sites was nearly identical. This suggests that the direct solar influence was greater in the shallower riffle site but that both locations responded the same way to the more uniform night conditions.

The unit buried in the sand bottom also shows the diurnal pattern but the peak values are also reduced and the time of the daily maximum and minimum values is delayed about 4 hours. This delay and the similar diurnal pattern suggest that water is slowly



flowing into the streambed at this location. If the streambed was experiencing upwelling at this point the expected pattern would be a flatter line because of the constant temperature of the inflowing groundwater.

It is interesting to note that the air temperature starts to increase at about 6:00 AM which corresponds to sunrise but the water temperature doesn't start to increase until about 8:30 AM. At sunrise convection currents probably bring in warm air but the shaded water isn't directly affected until later.

The cool night on July 2-3 caused a corresponding low value for the water temperature. This effect shows that both the local environment as well as direct solar radiation influences the stream and air temperature.

South Umpqua

Photo 3 is an upstream view that shows the location of the data loggers at the South Umpqua site. The alcove (Unit 11) appears to be associated with an upslope drainage zone that is thought to be supplying cool subsurface water. The water surface of the "bay" (Unit 12) is at a lower elevation than that of the alcove thus creating a hydraulic head across the intervening gravel bar. Unit 14 was originally buried about 8" in the saturated zone of the sandbar to record the hyporheic water temperature. However, during retrieval of the loggers, the unit was found lying on the surface of the sandbar, apparently dug up by an animal. The plot trace for Unit 14 in Chart 5 indicates that this event occurred during the first night at about 10:30 PM on 7/29/05.

Unit 13 is located in the bottom of the main channel thalweg located to the left of the photo. The river depth at this point was about 3 feet with good circulation.

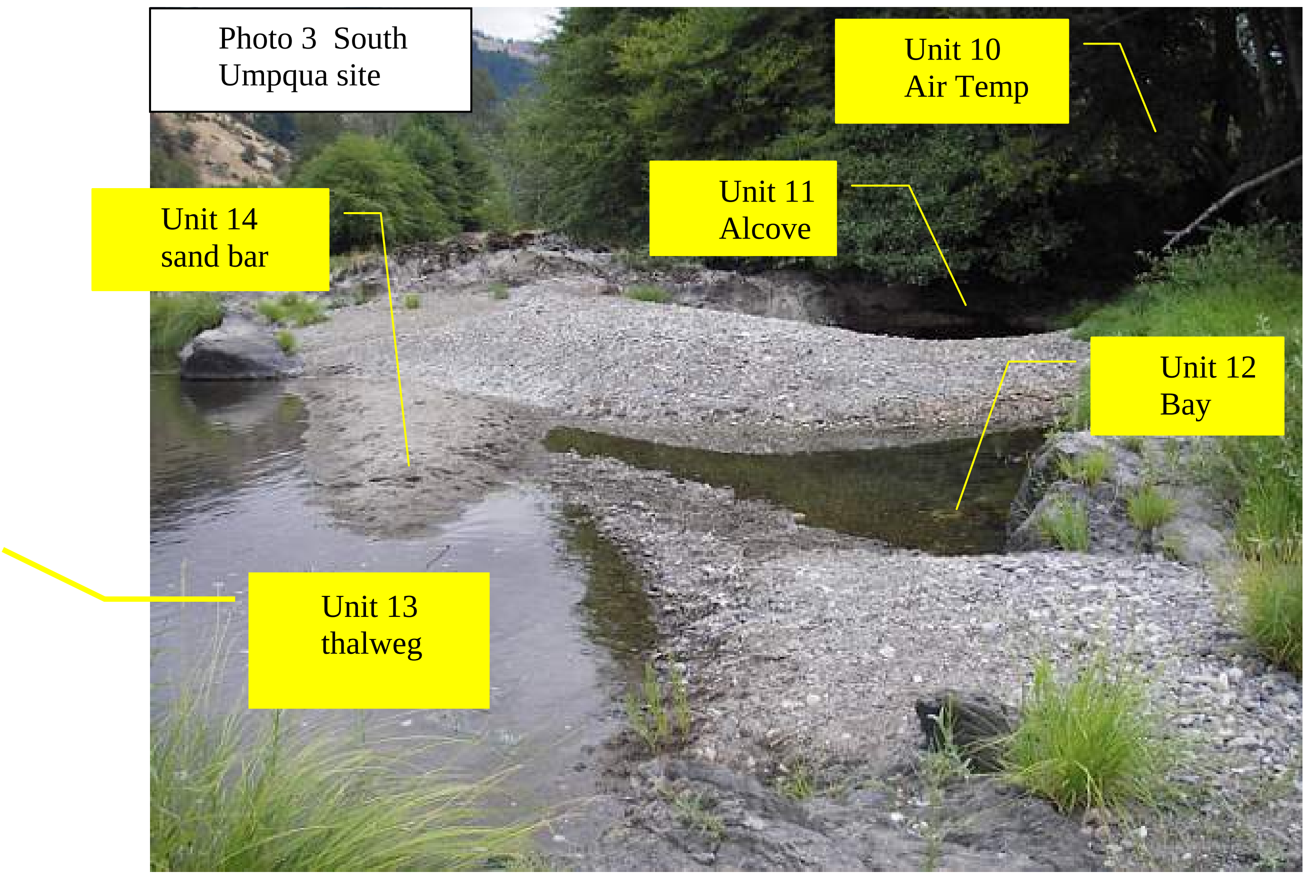
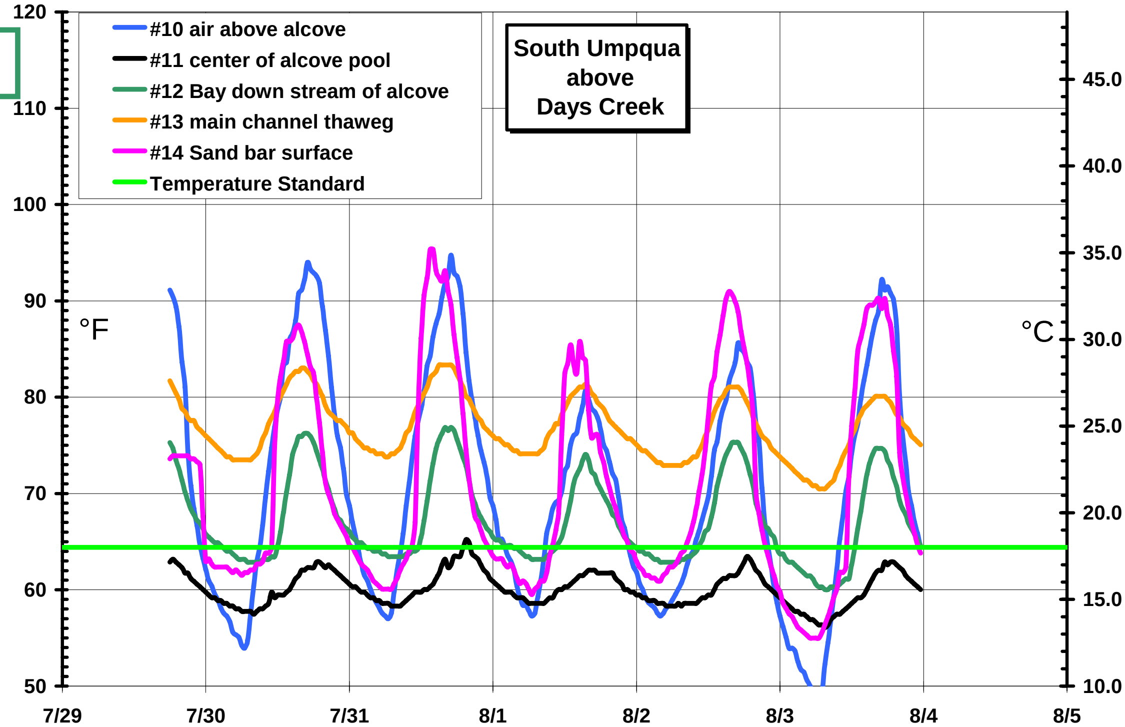


Chart 5 shows that the alcove water temperature (Unit 11) was about 20 °F cooler than the thalweg of the main channel. This is particularly significant since the high bulk temperature of the main channel is approaching the lethal range for cold-water fish. It should be noted that this particular alcove was isolated from the main channel and may not have been particularly beneficial to the fishery resource. However, it does show that isolated low temperature areas can exist along the main channel and may, in some cases, provide critical habitat for the fishery resource.

Chart5



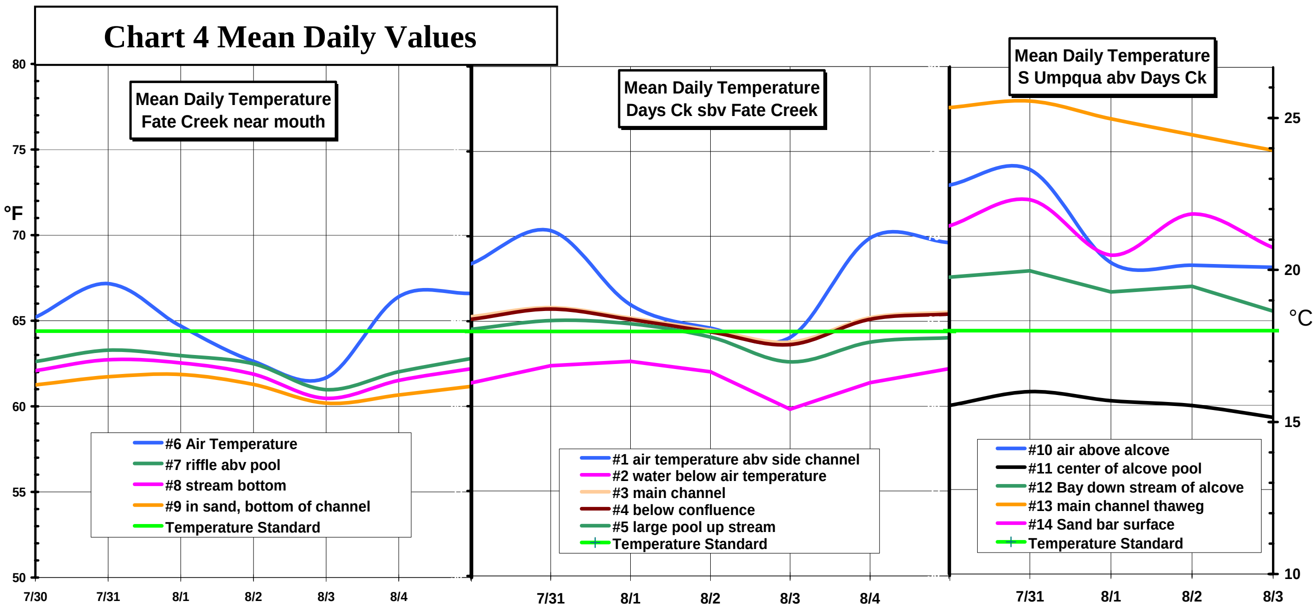
As previously mentioned, Unit 14 is measuring the surface temperature of the sandbar in contrast to Unit 10 that is suspended from a tree limb in a shaded environment. The higher minimum (nighttime) temperatures for Unit 14 is due to the higher heat capacity of the sandbar compared to the air measured by Unit 10. The irregular pattern of the peak daytime values of Unit 14 on 7/31 and 8/1 are probably the result of intermittent cloud cover disrupting the direct solar influx.

Unit 12 shows intermediate temperatures between the cool alcove and the warm channel. It should be noted however that spot testing of the river showed that the edges were often warmer than the main thalweg.

Notice that the stream temperatures in the thalweg (Unit 13) are notably elevated and the entire pattern is offset. Examination of the mean daily values can show this displacement effect more clearly.

Mean Daily Temperature Values

Examination of the daily mean values is helpful to assess the relative temperature effect on a daily basis. The graphs on Chart 4 allow a direct comparison of the mean daily values for between the sites.

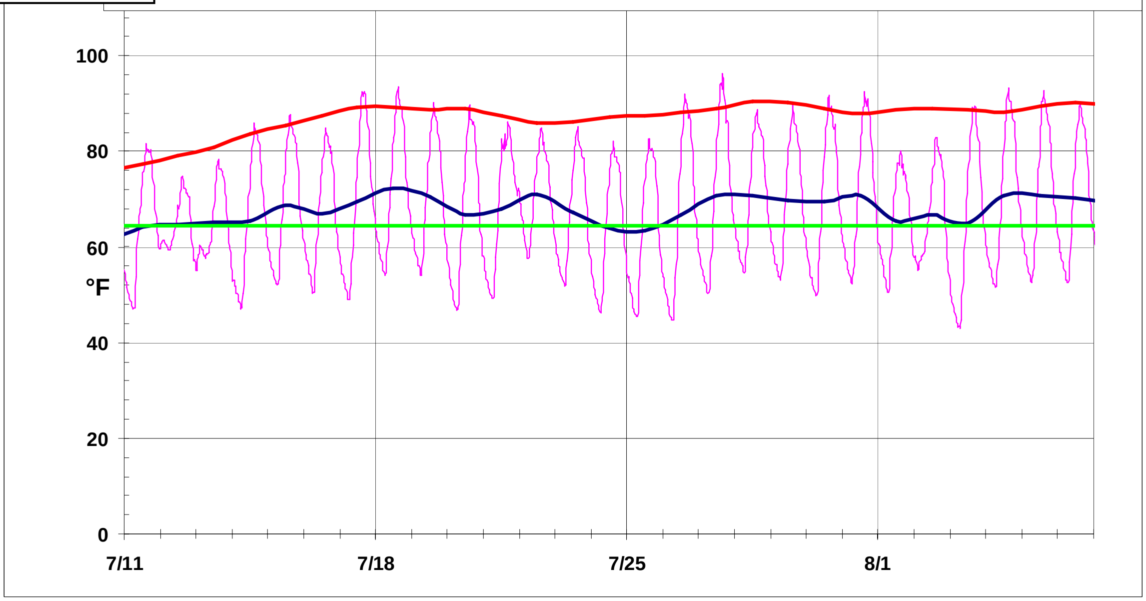


The set of curves for Fate Creek indicate that the temperature of the stream system tends to lag that of the surface air temperature. The tight grouping and the similarity of pattern of the water temperature data indicates that these points are responding in a similar way to the local thermal environment. .

The curves for Days Creek suggest that the net effective environment is about 4 °F warmer than that of Fate Creek. Note that the deep pool had a mean temperature about 1 °F below the bulk value while values of the unit in the seepage supplied zone were about 4 °F lower. It is also interesting to note the disparity in air temperature between the sites. The Fate Ck and Days Ck are located in the same vicinity.

As mentioned previously, the mean temperature of the South Umpqua site thalweg (Unit 13) is more than 5 °F above the mean temperature of the local environment. This contrasts with the other sites that tended to cluster around a common value. A higher temperature suggests that the water in the thalweg area has been heated by a source from another location and / or an earlier time. Chart 5 provides a possible explanation. It shows the air temperature site at Glendale where a seasonal maximum for temperature occurred the week prior to this study and mean temperatures during this time were 4-5 °F higher prior to 7/31 – the start of this study. It is likely that the high observed thalweg temperature is a result of that condition since the temperature of the large thermal mass such as the river will tend to lag the surface conditions.

Chart 5



This explanation is consistent with the low temperatures in the alcove (Unit 11) which is thought to be dominated by the large thermal mass of the ground water system.

Spatial Distribution Patterns

As mentioned in the beginning of this report, this study supplements a series of characterization studies done previously (See Umpqua Stream Temperature 2003). The previous studies indicated that stream temperature of the smaller streams (less than 12 miles from the source ridge) tend to be fairly consistent within a given stream reach and these values typically have a mean value similar to the local environment. These values are what are usually measured during monitoring and are sometimes referred to as the “bulk stream temperature.” However, this study also shows that relatively scarce zones can occur due to hyporheic or groundwater inflow.

Plots of the various summary statistics form the Umpqua Basin data show a consistent pattern that is a function of the distance from with headwater source point where the stream first emerges at the surface with a summer temperature of about 52 °F. As the stream progresses downstream the bulk temperature tends to warm as the stream becomes larger and the proportion of groundwater inflow diminishes. Chart 6 shows a summary of these data based on the annual 7-day maximum statistic for more than 300 sites. Basically, the bulk temperature of a stream at a given location will be either in the yellow or green zones. Streams that were in good condition with good riparian shade typically had values nearer to the blue zone. Conversely, abused and exposed streams will have temperatures that extend well into the yellow zone.

Experience has shown that the 7-day maximum statistic is typically within 2-3 degrees Fahrenheit of the season maximum. The maximum temperatures for 7/31/06 from this study are consistent with that range and can be compared with the previous study. Table 1 compares the minimum expected bulk temperature value against the 7/31/ maximum daily values. Even though these values are from different statistics, the comparison serves to give a good estimation of the relative status of the test sites. These values also are shown in Chart 6 as blue diamonds.

Table 1 Comparison of study data to rest of the Umpqua

Site	Distance to Ridge miles	Min Value from Chart 6 °F abv line	7/31 Max Value °F
Fate Ck	3.15	61	65.3
Days Ck	11.3	67	69.7
South Umpqua	56.9	74	83

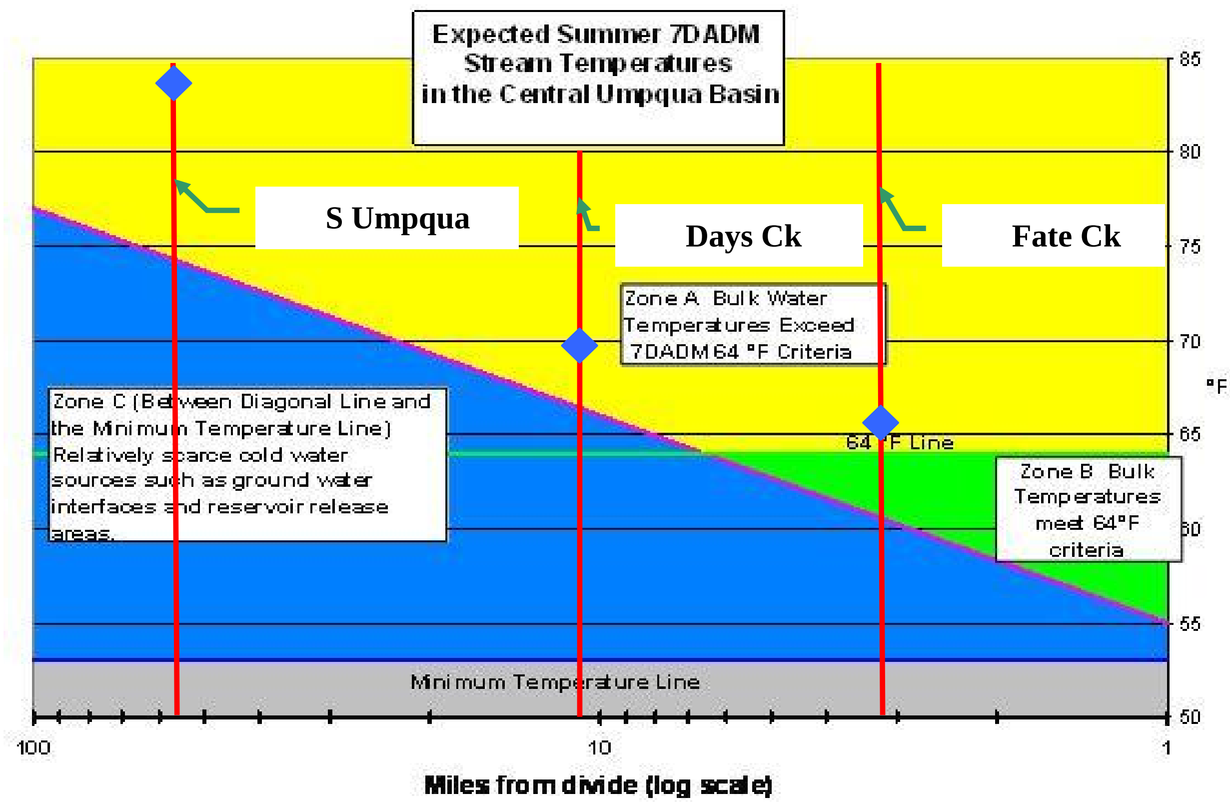


Chart 6 Distribution pattern for the Annual 7 Day Maximum Moving Average stream temperature for over 300 sites in the Umpqua Basin. The values typically fall within the green or yellow zones. The locations of the sites for this report are represented by the red vertical lines. The blue diamond markers show the maximum observed stream temperature for 7/31/05.

The red vertical lines indicate the location of the three test sites used in this study and the blue diamonds show the corresponding daily maximum values from 7/31/06. It is apparent from the slope the two small streams that these points are consistent with the previous study. The offset for the South Umpqua site is again the result of the high antecedent high temperatures and the thermal mass induced lag in the time series.

Management Implications

This study again confirms the concept that much of the Umpqua Basin has bulk summer stream temperatures that exceed the optimum for cold-water fish. Consequently, cold-water refuge sites such as the cold sites identified in this study may represent critical habitat, particularly in the larger stream systems. For example, fish that migrate in the summer may be able to travel during the cold portion of the night and seek refuge in the cold zones during the day. Or the cold zones may provide rearing habitat during a critical portion of the life cycle of some species.

In any event, if these areas are critical, they should be identified and, at a minimum, protected. The artificial development of alcoves is another option that would careful planning, monitoring and maintenance. In particular, special attention should be given to points on the river that are associated with upslope draws or drainage areas. “Dry” stream channels can be an important source of cold sub-surface flow into the main channel and should be identified for possible management. For example, more structural diversity could be very beneficial in these areas. In general it can be said that that additional stream structure and extra diversity it provides is usually beneficial with regard to creating cold-water refugia.

By understanding the dynamics of the heating processes in the river the restoration / conservation efforts can be directed where they will be most effective. The basic ecological principle for the stream temperature regime in the Umpqua is scarcity - similar to an arid desert where it makes more sense to invest management in the scarce oases than the abundant sand dunes.