Section 4 - Temperature Evaluation

General

This section evaluates potential effects that a water storage and release project may have on the temperatures of Fifteenmile Creek during the periods when water temperatures are high. Information on the existing system water temperatures was taken from the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (TMDL), Appendix A, Figure 10 on page 18, dated December 2008. Corresponding stream flow data are derived from Table 2, on page 25, of the same document. Figure 4-1 identifies the locations of the flow and temperature monitoring sites.

A second calculation was made using flow and temperature information from data recorded in 2014. The temperature of the water from near the diversion point of the Orchard Ridge Ditch was used as the ambient temperature of the water to be added to the flow at the station below Dufur and also the station near the mouth of Fifteenmile Creek. Figure 4-2 shows the 2014 flows for the three locations and Figure 4-3 shows the temperature recorded at each of the sites. Although there is a significant amount of temperature data collected, it is not possible to evaluate the impacts that stored water would have on the stream temperature, as this data does not have corresponding flow data associated with it. The analysis requires that flow and temperature data be correlated so impacts can be assessed. Future data gathering efforts should include both flow and temperature.

The evaluation primarily considers using stored water to replace live flows normally diverted for irrigation. The increased in-stream flows are added to measured stream flows at the upstream measured water temperature. The release of stored water directly to the stream is also discussed, but concern over the predictability of stored water temperature during the late season makes this option less desirable.

The temperature evaluation was completed using a simple mass balance model.

Mass Balance Model

The purpose of the model is to provide an approximation of the possible changes in stream flow temperatures that water storage and release could cause. The model uses available temperature and flow data for the existing conditions on Fifteenmile Creek. It makes a simplified basic assumption that the same amount of energy will be imparted to the creek flows from the air, sun, and other environmental factors independent of the volume of water in the creek. The additional water that may be added to the stream flows from the project and its temperature was then estimated and added to the creek water. A linear mass balance was used to estimate the resulting water temperature for the creek flows at different locations in Fifteenmile Creek.

The mass balance equation used for the temperature calculations is:

$$T_{mix} = \frac{(Q_{up} \times T_{up}) + (Q_{in} \times T_{in})}{(Q_{up} + Q_{in})}$$

Where:

T_{mix} = The calculated final temperature of the water after combining the existing flow with the added flow.

Q_{up} = Flow in cubic feet per second (cfs) of the stream prior to addition of flow to the stream.

T_{up} = Temperature of the water in the stream prior to addition of flow.

Q_{in} = The flow (cfs) added to the existing stream flow.

T_{in} = The temperature of the water added to the stream.

Existing Stream Flow and Temperatures

The earliest available data from the TMDL were used for the existing stream flow and temperature conditions. Fifteenmile Creek flow measurements were taken on August 2, 2002, and the water temperature for the same date was used from the figure and table noted above in the TMDL. For the purposes of this Study, the water temperature in Fifteenmile Creek from below Ramsey Creek is of concern due to existing water rights that remove water from the stream. In the TMDL, there were three sites where both the temperature and flow data were collected at nearly the same location (see Figure 4-1). Table 4-1 lists the three locations and summarizes the flow and temperature at each of the locations. These flow and temperature data were used as the base in the mass balance equation calculations that will show the calculated effect of adding flow to the stream.

TABLE 4-1
MEASURED TEMPERATURE AND FLOW DATA

Location	Flow (cfs)	Temperature (°C)	Temperature (°F)
Upstream of Eightmile Creek	3.1	19.6	67.3
Downstream of Standard Hollow (Emerson Loop Road)	1.0	24.4	75.9
Upstream of Ramsey Creek	6.7	16.7	62.1

Note: Data from Appendix A of the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL, dated December 2008.

Evaluation of Water Temperature Model

The temperature evaluation considers two possible methods of stream flow augmentation. The first method includes allowing live flows that would normally be diverted for irrigation to remain in the stream, with stored water being delivered directly to irrigators from the storage reservoir without introducing any stored water into the stream. The temperature of the water in the system will be the ambient upstream water temperature. The second method includes the release of stored water into the stream system from the storage reservoir.

The amount of water that could be available for flow augmentation from a reservoir was determined by using data provided by the Oregon Water Resources Department (OWRD). According to the information received from OWRD, the estimated surface water available for storage from Fifteenmile Creek would be 4,274 acre-feet. The 4,274 acre-feet is the estimated amount of water that could be available for

storage using the mean daily flows and the water availability basis. The availability numbers are based on the 50 percent exceedance flows in Fifteenmile Creek. When considering ecological flows, the total storage amount is estimated to be reduced to 1,921 acre-feet.

The higher volume of 4,274 acre-feet of available storage is evaluated for the modeling of the stream temperatures. Twenty-five percent of the water stored will be assumed to be used for stream flow augmentation. Twenty-five percent of 4,274 acre-feet is 1,069 acre-feet. According to the stream temperature data in the TMDL, the stream temperature rises above the desired rearing/migration temperature of 18°C around June 1 and continues to be above the desired temperature through the end of September, or approximately 122 days. With 1,069 acre-feet available for stream augmentation, 8.9 acre-feet per day could be released, which converts to a steady flow of approximately 4.4 cfs. Table 4-2 shows the calculated resultant temperature if the water added to the stream is from the live flow that would remain in the stream instead of being diverted for irrigation purposes. Since the water added comes from the stream, the temperature of the water is equal to the ambient temperature of the existing water, 16.7°C, in Fifteenmile Creek above Ramsey Creek.

TABLE 4-2
USING OWRD AVAILABLE STORAGE (TOTAL OF 4,274 ACRE-FEET AVAILABLE FOR STORAGE)

Location	Total Mixed Flow (cfs)	Mixed Temperature (°C)	Mixed Temperature (°F)
Upstream of Eightmile Creek	7.5	17.9	64.2
Downstream of Standard Hollow (Emerson Loop Road)	5.5	18.2	64.7
Upstream of Ramsey Creek	11.1	16.7	62.1
Assumed Temperature of Water Left in Stream		16.7	62.1

Note: Addition of 25 percent (1,069 acre-feet) of the water stored to Fifteenmile Creek at a location near the Ramsey Creek confluence. Temperature of the additional water is equal to the ambient temperature of the water in the stream at the measurement site above Ramsey Creek since it is water that will be left in the stream and not diverted for irrigation.

When the lower total storage volume of 1,921 acre-feet is utilized, there is less water available to release in stream during critical summer seasons. Twenty-five percent of 1,921 acre-feet is 480 acre-feet available for stream augmentation. This would be a minimum that would need to be used to augment flow if state funding were used, but more stored water could be used for that purpose. With the available 480 acre-feet being divided equally over 122 days, a steady flow of 2.0 cfs could be available for stream flow exchange. Table 4-3 provides the results of the mass balance calculations for adding a flow of 2.0 cfs to the creek at ambient stream water temperatures.

TABLE 4-3
OWRD WATER AVAILABILITY MINUS FLOWS FROM THE BASIN INVESTIGATION REPORT'S OPTIMUM MINUS THE MONTH OF MARCH (TOTAL OF 1,921 ACRE-FEET AVAILABLE FOR STORAGE)

Location	Total Mixed Flow (cfs)	Mixed Temperature (°C)	Mixed Temperature (°F)
Upstream of Eightmile Creek	5.1	18.5	65.3
Downstream of Standard Hollow (Emerson Loop Road)	3.0	19.3	66.7
Upstream of Ramsey Creek	8.7	16.7	62.1
Assumed Temperature of Water Left in Stream		16.7	62.1

Note: The Oregon Department of Fish and Wildlife suggests no water be stored in March.

The amount of water available and the temperature of the water introduced into the stream for augmentation determine how much benefit stored water will have to the stream. According to the simplified basic mass balance calculations, the greater the amount of water available for stream augmentation and the lower the temperature of the water introduced into the stream, the greater the benefit will be to the stream.

2014 Flow and Temperature Data

Temperature and flow data from the 2014 irrigation season provides an additional and more current look at the effects of adding water to the creek at ambient water temperatures. Figure 4-2 shows the flow in Fifteenmile Creek at three locations: near the mouth, below Dufur, and above Dufur at OWRD Station 14103996 (located near the diversion point for the Orchard Ridge Ditch). Figure 4-3 shows the water temperature data for the same three locations, the Rearing and Migration temperature target, the Core Cold Water Habitat temperature target, and the Salmon and Steelhead Spawning target temperature.

Using the previously discussed mass balance temperature calculation formula, the resultant temperature was calculated for the site below Dufur and the site near the mouth of Fifteenmile Creek. The total amount used for in-stream flow augmentation was 1,300 acre-feet to match a possible amount available from senior water right holders in the valley. This produces an in-stream flow rate increase of about 5 cfs. A mean 5 cfs flow was added to the existing flow in the stream between June 20 and October 1 at the two lower locations with the temperature of the added flow being equal to the ambient temperature at the upper site. Figure 4-3 shows the calculated resultant temperature for each location.

For the summer and fall of 2014, if a steady flow of 5 cfs could be added to the existing flow, the resulting calculated water temperature is shown on Figure 4-3. The calculated water temperature is shown with the dark red and dark blue solid lines. From the calculations, the water temperature at the site below Dufur could be kept below the Rearing and Migration temperature and the water temperature at the site near the mouth could also be lowered significantly.

Reservoir Water Temperature

Based on available stream temperature data, surface water is anticipated to range between near freezing to roughly 5°C during anticipated storage periods (November 1 to April 30). The water stored during the first six months of the water year will have the maximum thermal benefits.

Using this, the maximum thermal benefit may best be achieved for the stream via reservoir discharge to the stream, because recovery of stored water and stream flow enhancement is more controlled and does not rely on natural return flows that may not provide the optimal thermal benefit to the stream. Options should be developed during design of possible improvements to use either creek water or stored water for in-stream flow augmentation, depending on maximum thermal benefit.

Surface water temperature within the study area ranges from frozen (0°C) in the middle and upper elevations during mid-winter to 28°C or more during mid-summer. During anticipated periods of maximum diversion to storage, November 1 to April 30, surface water temperature is generally near

freezing to roughly 5°C. Table 4-4 shows the result of mass balance calculations for the addition of 12°C water to the stream from a reservoir. The releasing of water from a reservoir into the creek concerns the Oregon Department of Environmental Quality, and if this option were to be considered, the temperature (and other water quality parameters) of the water released from the reservoir into the stream would need to be carefully monitored to avoid releasing water that is warmer than the ambient temperature of the natural stream water.

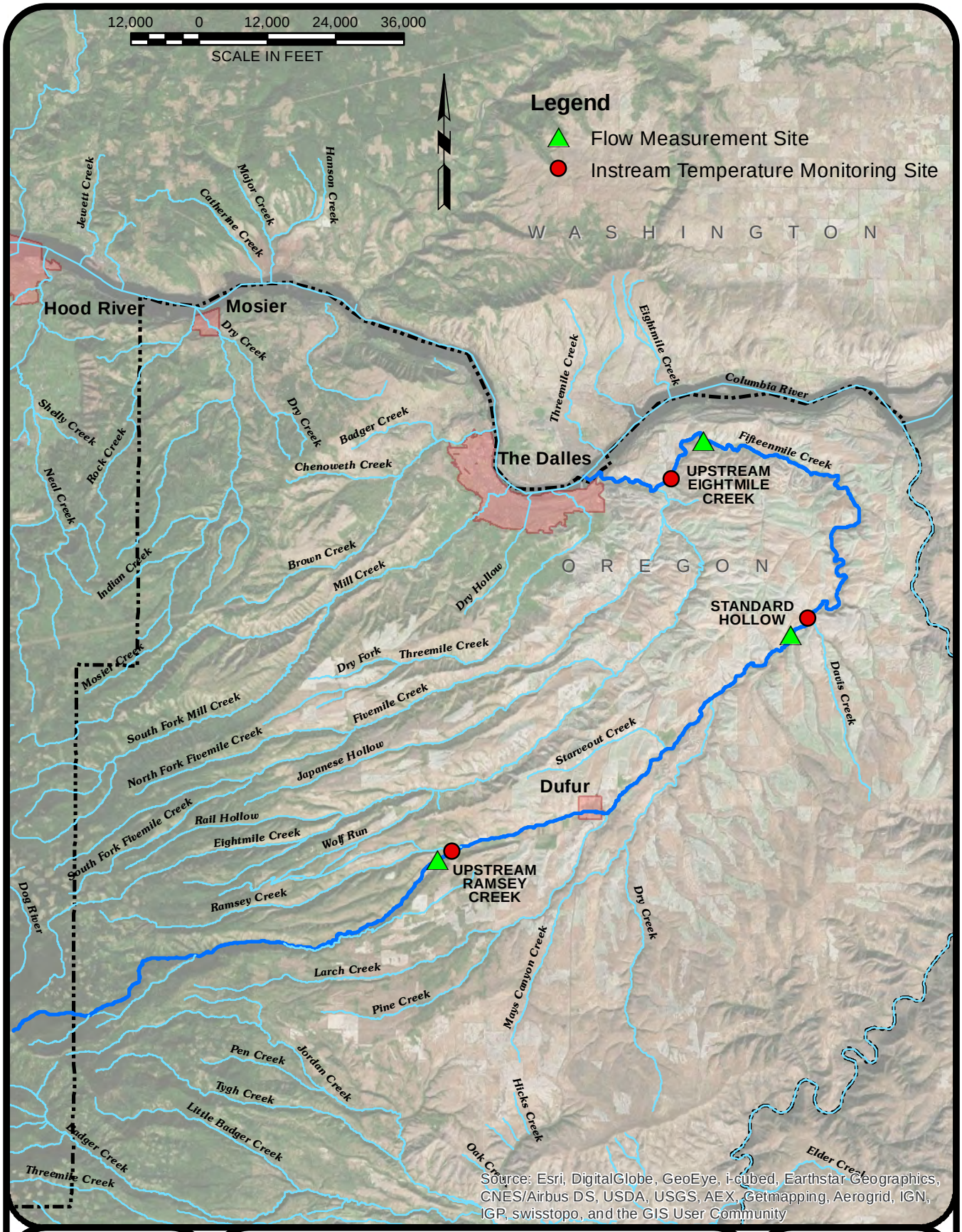
TABLE 4-4
USING RESERVOIR WATER (TOTAL OF 4,274 ACRE-FEET AVAILABLE FOR STORAGE)

Location	Total Mixed Flow (cfs)	Mixed Temperature (˚C)	Mixed Temperature (˚F)
Upstream of Eightmile Creek	7.5	15.1	59.2
Downstream of Standard Hollow (Emerson Loop Road)	5.5	14.3	57.8
Upstream of Ramsey Creek	11.1	14.8	58.7
Assumed Temperature of Water Out of Reservoir		12.0	53.6

Note: Addition of 25 percent (1,069 acre-feet) of the water stored to Fifteenmile Creek at a location near the Ramsey Creek confluence. Temperature of the stored water is assumed to be 12˚C (53.6˚F).

Summary

Evaluation of the existing temperatures and flows for the current conditions of Fifteenmile Creek shows that after approximately June 15 the water temperature rises significantly above the desired habitat temperatures. With the addition of the flow from the storage reservoir project, the mass balance model shows the water temperature can be significantly reduced to provide water temperatures that are near and, in some cases, below the desired upper limit for desired habitat conditions. An important fact to consider is that the data used for stream temperature and flow consisted of information from a very limited data set. The mass balance model calculates the results of adding water to the stream for the specific days and times where both the flow and temperature data are available, but more information is needed to make more accurate predictions of the effect of adding water to the stream at different times of the year. The mass balance calculations with the information available show the temperature of the water introduced into the stream has the potential to significantly decrease the stream temperature.



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FIFTEENMILE CREEK WATERSHED ABOVEGROUND STORAGE FEASIBILITY STUDY

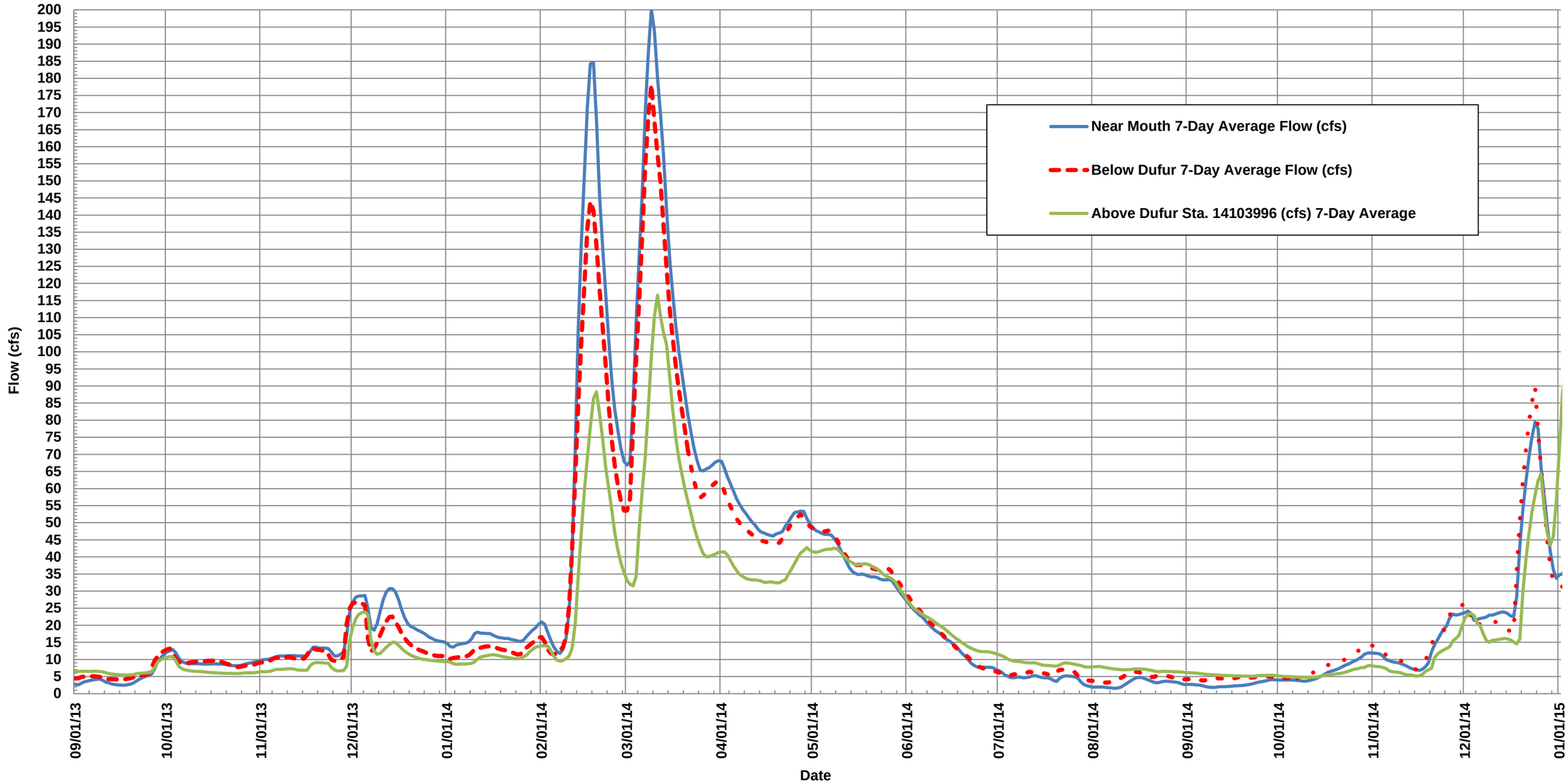
TEMPERATURE MONITORING AND FLOW MEASUREMENT SITES

FIGURE

4-1

\\LGSVR6\gisprojects\WascoCounty_SWCD\597-03_FifteenmileWaterStorFeasibility\TempMonitorLocations.mxd, 3/9/2015, 10:59:38 AM

Fifteenmile Creek Flow - 2014



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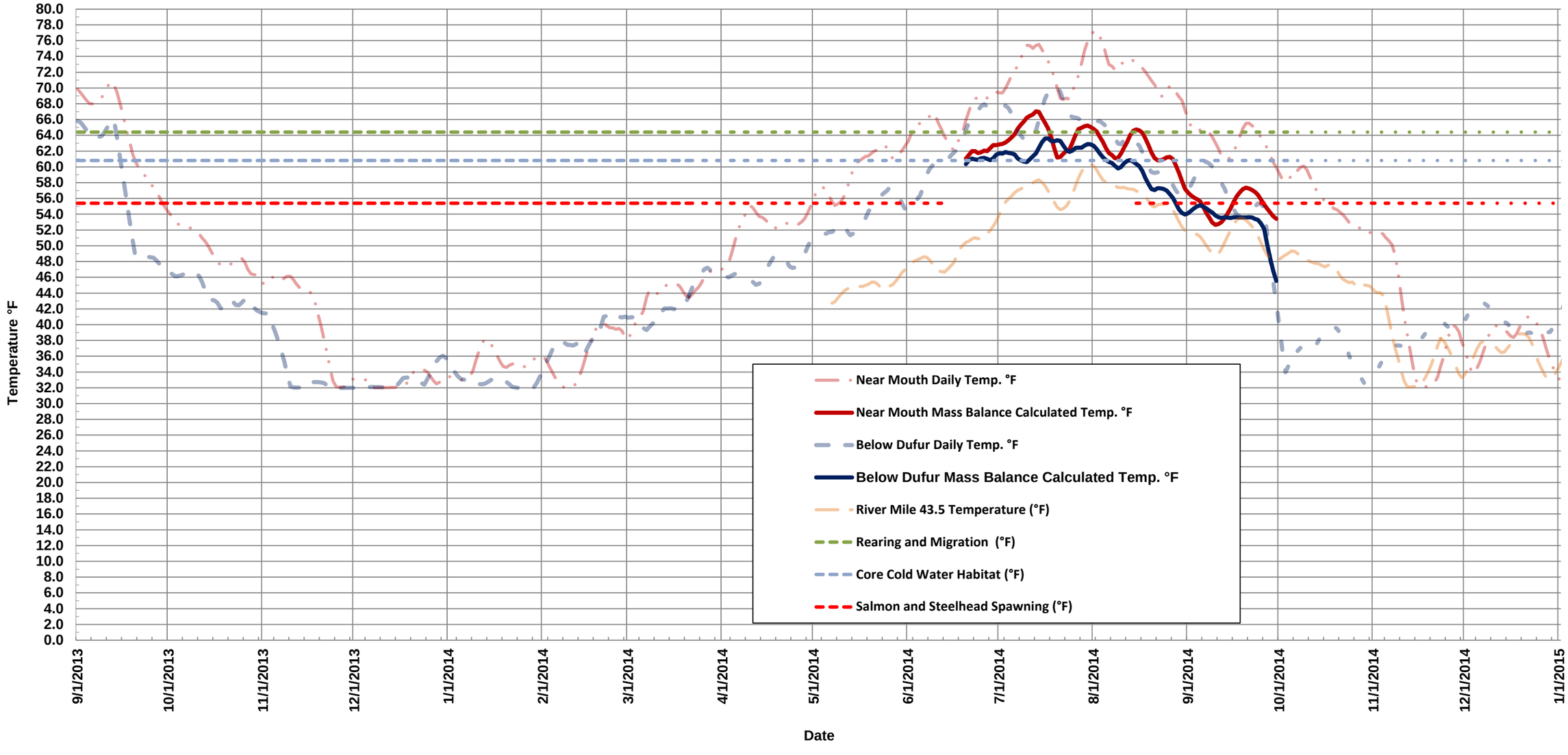
WASCO COUNTY SOIL AND WATER CONSERVATION DISTRICT
FIFTEENMILE CREEK WATERSHED ABOVEGROUND STORAGE FEASIBILITY STUDY

FIFTEENMILE CREEK FLOW - 2014

FIGURE

4-2

Fifteenmile Creek Temperature - 2014



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FIFTEENMILE CREEK WATERSHED ABOVEGROUND STORAGE FEASIBILITY STUDY

FIFTEENMILE CREEK TEMPERATURE - 2014

FIGURE

4-3