## U.S. Fish & Wildlife Service

Arcata Fisheries Data Series Report Number DS2006-08

# The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2005

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March 2006

Funding for this study was provided by the Bureau af Reclaimation and U. S. Fish and Wildlife Service through the Trinity River Restoration Program.



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Key words: Trinity River, Lewiston Dam, flow, water temperature

The correct citation for this report is:

Zedonis, P. and R. Turner. 2006. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2005. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2006-08, Arcata, California.

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# The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2005

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*Abstract* Water temperatures were monitored on the Trinity and Lower Klamath rivers from April to October 2005 to evaluate the influence of prescribed flow releases from Lewistown Dam on downstream water temperature objectives specified in the Trinity River Record of Decision. Flow from Lewiston Dam (2000 + cfs) that closely followed the prescribed flows for a "Normal" water year type were successful at cooling the mainstem Trinity River, but were insufficient to prevent exceeding the desired "Optimal" smolt temperature objective of 17.0 ˚C at Weitchpec from late June through early July. During this time, average daily water temperatures at Weitchpec were less than 18.6 ˚C, representing "Marginal" thermal regime for Chinook salmon smolts. Although the temperature objective was not met in late June and early July, the release of 2,000+ cfs from Lewistown Dam resulted in the greatest difference in average daily water temperatures between the Lower Klamath (20.2 ˚C) and Trinity (17.7 ˚C) rivers of 2.5 ˚C.

Basin Plan objectives of the North Coast Regional Water Quality Control Board were not always met during summer 2005 despite the flow magnitude from Lewiston Dam followed prescribed guidelines of 450 cfs from July through mid October The objective of not exceeding 15.6° C (average daily temperature) was exceeded by up to 0.8 ˚C at the Douglas City compliance point for 22 consecutive days in July and early August. A warm weather pattern and relatively warm water being released from Lewiston Dam (11 to 12 ˚C) contributed to the failure to meet the objective all the time.

A one-day pulse flow of 1,610 cfs from Lewiston Dam on August 29 to support the ceremonial needs of the Hoopa Valley Tribe's White Deerskin Dance temporarily reduced water temperatures of the Trinity and Klamath rivers. Prior to the arrival of the pulse flow at Weitchpec, the average daily water temperature of the Trinity River was 21.1 ˚C, 0.4 ˚C cooler than the Klamath River (rkm 70.2). During the pulse flow arrival on August 30 and 31, average daily water temperature of the Trinity River at Weitchpec was 19.5 ˚C, 1.8 ˚C colder than the Klamath River (rkm 70.2). For two days following the pulse flow arrival, water temperatures at Weitchpec continued to be cooler than the Klamath River, indicating a delayed effect of the coldwater pulse. Several days after the pulse flow, water temperatures of the Trinity River remained less than 0.9 ˚C colder than the Klamath River. Comparison of water temperatures of the Klamath River

above (rkm 70.2) and below (rkm 68.7) the confluence of the Trinity River indicated that the pulse flow reduced the water temperature of the Klamath River by up to 0.8 ˚C.

# INTRODUCTION

Flow and water temperatures of the Trinity River mainstem changed when the Trinity River Division (TRD) of the Central Valley Project was completed and the Trinity River was dammed in 1963, about 178 kilometers (kms) upriver from the confluence with the Klamath River at Weitchpec (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). The Trinity River below Lewiston Dam now receives water from a large impoundment that moderates extremes in water temperatures throughout the year. Water temperatures in the vicinity of Lewiston Dam have become warmer in the fall and winter months and cooler from early summer to early fall compared to pre-dam temperatures.

Further downstream, river temperatures have also been affected, most notably during the spring and early summer months (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). Prior to the TRD, water temperatures in the Trinity River during spring and early summer were primarily influenced by snowmelt. Snowmelt provided a coldwater source as well as increased flow to the river. In combination, these factors allowed the Trinity River to maintain a relatively cool thermal regime. Since completion of the TRD, the thermal regime of the Trinity River is typically warmer than existed historically and is more responsive to change induced by ambient air temperatures due decreased volume and associated thermal mass.

In 1991, the North Coast Regional Water Quality Control Board (NCRWQCB) formally adopted water temperature objectives for the 64 km of Trinity River immediately below Lewiston Dam (Table 1). These objectives were intended to assure that adequate areas of suitable temperatures were available for the protection of adult spring and fall-run Chinook salmon that migrate and hold in the river below the dam in summer and spawn in the fall and winter. Since these objectives were adopted, flows of 450 cubic feet per second (cfs) from Lewiston Dam have been used to meet the criteria during the summer and early fall (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999).

The Record of Decision (ROD) for the Trinity River Environmental Impact Statement (EIS) signed by the Secretary of the Interior in December of 2000 supported the NCRWQCB temperature objectives and improvement of the thermal regime of the river during the spring and early summer (hereafter referred to as the spring-time objectives)

(USFWS et al. 2000). Unlike the NCRWQCB objectives, which target the 64-km reach immediately below Lewiston Dam and are the same for all water year types, the spring-time objectives vary with water year type and are intended to improve the thermal regime for salmon and steelhead smolt emigration on the Trinity River between Lewiston Dam to Weitchpec (Table 1). In a Normal water year type as experienced in 2005, Lewiston Dam releases included a constant flow of 2,000 cfs from June 8 to July 9 to meet the spring-time criteria.

An important component of the Adaptive Environmental Assessment and Management program of the Trinity River Restoration Program is to monitor and evaluate restoration activities for their intended purpose. This includes examination of the effects of Lewiston Dam releases on downstream water temperatures. This report focused on evaluating the influence of water released from Lewiston Dam on water temperatures of the Trinity River below Lewiston Dam and the lower Klamath River below Weitchpec from mid-April to mid-October in 2005.

## STUDY AREA

The Trinity River, located in northwest California, is the largest tributary to the Klamath River (Figure 1). The Trinity River is regulated by Trinity and Lewiston Dams. From Lewiston Dam, the Trinity River flows for approximately 180 kilometers before joining the Klamath River at Weitchpec. From Weitchpec, the Klamath River flows for 70 kilometers before entering the Pacific Ocean.

## METHODS

The influence of Lewiston Dam releases on downstream water temperature was assessed using water temperature data collected by telemetered stations and from probes deployed by the Arcata Fish and Wildlife Office (AFWO). Data from telemetered stations were downloaded from the California Data Exchange Center (CDEC) website available at http://cdec.water.ca.gov. Data obtained from the CDEC site are labeled “preliminary and subject to revision”, meaning the accuracy of the data is unknown. To correct for possible errors, we conducted graphic evaluations to identify erroneous data points that were later deleted.

AFWO used temperature probes manufactured by Onset Computer Corporation® to collect hourly water temperature data from April to October. Prior to and after deployment, each probe was subjected to a performance test to verify it was recording within the manufacturer's accuracy specification of ± 0.2 degrees Celsius (˚C). In all tests, the instruments proved to be accurate and reliable.

Assessing the influences of Lewiston Dam releases on water temperatures of the Trinity River and lower Klamath River was accomplished by comparing environmental factors known to affect water temperature, primarily air temperatures and hydrology. Air temperature data were collected by AFWO using Onset® probes that met similar standards established for water temperature. Estimates of river flow at several sites on the Trinity River (Lewiston –rkm 178.2; and Hoopa – rkm 20.0) and Klamath River (Iron Gate - rkm 305.5; Orleans - rkm 95.1; and Klamath - rkm 13.0) were obtained from the CDEC and U.S. Geological Survey (http://water.usgs.gov) websites.

## RESULTS

### Hydrology

In water year (WY) 2005 approximately 651 thousand acre-feet (TAF) of water was released from Lewiston Dam to the Trinity River. This total was comprised of 647 TAF to support base flow conditions for a Normal water year that included a peak spring flow of about 7,000 cfs, base summer/early fall flows of 450 cfs, and base winter and spring flow of 300 cfs (Figure 2). Additionally, 4 TAF of flow was released from Lewiston Dam to support the ceremonial needs of the Hoopa Valley Tribe's White Deerskin Dance that occurred on August 28 and 29.

Due to wet hydrologic conditions in the Klamath River basin from March through May, the contribution of flow from Lewiston Dam to the lower Trinity River (Hoopa gauge; rkm 20.0) and the Klamath River (Klamath gauge – rkm 13.0) was relatively small, including the peak release of 7,000 cfs in mid May (Figure 2). Only in early July (during the 2000 cfs bench) and late August (during the White Deerskin Boat Dance) was the majority of flow at Hoopa derived from Lewiston Dam. Similarly, it was during these times that Lewiston releases resulted in significant change in flow at the Klamath gauge (Appendixes A and B).

Spring flows in 2005 were graphically compared to those recommended in the ROD for a Normal water year (Figure 3). Peak flow was increased from a planned 6,000 cfs to 7,000 cfs. This increase was scheduled to allow for collection of empirical data for flow and geomorphology models of the Trinity River Restoration Program (Joe Polos pers. comm.). To accommodate this short-term higher peak release and remain within the water budget, less water was used during mid-to-late May through application of a faster down-ramping of the hydrograph. From June 10 to July 9, Lewiston Dam releases of 2,000 cfs persisted as prescribed in the Normal WY flow schedule.

Outside of a December storm, spring storms resulted in peak flows of the Klamath River at Iron Gate Dam (rkm 305.4), Orleans (rkm 95.1), and at Klamath (rkm 10.8) from March into June (Figure 4). Flow at the Orleans gage, representing flow of the Klamath River prior to mixing with the Trinity River, peaked at over 30,000 cfs during the mid-May storms and except for a June freshet, steadily decreased to a minimum of 1,900 cfs in late September.

## <u>Water Temperatures of the Mainstem Trinity River</u>

*Lewiston Gage (rkm 178.2)*

From April to October, water temperatures of Lewiston Dam releases remained between 8 and 12.5 ˚C (Figure 5). The warmest release temperatures coincided with typical warming trends and times of decreased flows out of Trinity and Lewiston reservoirs, resulting in increased hydraulic residence time of water in Lewiston Reservoir. The effect of increased hydraulic residence time is best illustrated in late April and during mid-July when flows were reduced to base flows of 450 cfs (Figure 5). During these times, water temperature of Lewiston Dam releases increased to a maximum 12.5 ˚C. On August 29, flow from Lewiston Dam increased to approximately 1,610 cfs, reducing temperature of releases to the Trinity River by about 0.5˚C.

***Douglas City Gage (rkm 148.5)***

Prior to the peak flow that occurred in mid-May, the average daily water temperatures at the Douglas City gage reached 12.2 ˚C (Figure 6). From May 5 to July 9 when dam releases were generally at or above 2,000 cfs, water temperatures were maintained at less than 12.5 ˚C. From

July 10 to July 22 dam releases decreased to 450 cfs and average daily water temperatures increased to levels that exceeded the 15.6 ˚C average daily temperature objective of the NCRWQCB. Daily average temperature measured during this period was over 16.4 ˚C and the objective was exceeded for 22 consecutive days. After August 9, temperatures decreased below the NCRWQCB objectives.

*Pear Tree Gulch/ Trinity above the North Fork Trinity (rkm 117.6)*

Average daily water temperatures above the North Fork Trinity were generally elevated in comparison to the Douglas City site. Increased flow from Lewiston Dam that occurred from late April to mid-July and the two day increase in flows in August for the Hoopa Tribe's White Deerskin Boat Dance resulted in a notable decrease in the water temperature at this site (Figure 7). From mid-May to July 9, average daily water temperature was less than 14.3 ˚C. Following the spring release, water temperatures increased to a maximum of 19.4˚C on August 6. The water temperature on October 1 exceeded the NCRWQCB criteria of 13.3 ˚C by 0.3 ˚C, but was below the criteria for the remainder of the sampling period.

*Above Big French Creek to Weitchpec (rkm 94.2 to 0.1)*

Water temperatures in this region of the river were also influenced by Lewiston Dam releases, but to a lesser degree than the upstream reaches (Figure 8). Within this reach, the temperature signature of Trinity Dam flow releases appeared to be masked by the influences of large flow contributions from tributaries. From April to mid-May, water temperatures of this reach remained below 13.0 ˚C. By late May, water temperatures increased steadily, but showed variation consistent with variability in weather conditions. By mid July, water temperatures of the Weitchpec site exceeded 22.0 ˚C, which persisted until mid August. Beginning in mid August, water temperatures of the Trinity River began to decline due to cooler air temperatures, shortened day length, and the short duration pulse flow from Lewiston Dam for the Hoopa Tribe's White Deerskin Dance that occurred on August 29.

The spring time temperature criteria for the Normal WY were not always met from April 20 to July 9 (Figure 9). The average daily water temperature at Weitchpec exceeded the optimal criteria and fell into the marginal zone for four days in early May, on May 27 and from June 27 to July 9, but never reached the unsuitable zone. Graphical examination of air and water temperature data revealed a positive association between the warmest time periods and times of temperature exceedence (Figure 10).

## **Water Temperatures of the Klamath River**

### ***Spring and Early Summer***

Average daily water temperatures of the Trinity River at Weitchpec were nearly always colder than the Klamath River during the sampling period (Figure 11, Appendix A). In early July, the Trinity River was more than 2˚C colder than the Klamath and reached a maximum temperature difference of 2.5 ˚C on July 4. From July 9 to July 22, the Trinity River steadily warmed and temperature differences decreased as flow was reduced from Lewiston Dam. After Lewiston Dam releases were reduced to base summer flows of 450 cfs from July 21 to July 26, the Trinity River became less than 1.4˚C colder than the Klamath River.

During periods when the Trinity River was notably colder than the Klamath River, reductions in temperature were observed in the lower reaches of the Klamath River (Figures 11 and 12). The relative difference in water temperatures between the Klamath River at Weitchpec (rkm 70.2) and downstream sites (i.e., rkm 68.7, 26.5 and 13.0) ranged between 1.2˚C from June 10 to June 30 and 0.6 to 1.7˚C from July 1 to July 9. The greatest temperature reductions occurred from July 1 to 9 when: 1) the Trinity River water was coldest relative to the Klamath River; and 2) flow contributions from the Trinity River to the Klamath River were greatest (Figure 11).

### *Late Summer Pulse Flow*

Increased flow from Lewiston Dam that occurred on August 29 also resulted in reduced water temperatures of the Trinity River at Weitchpec and the lower Klamath River (Figure 13, Appendix B). Prior to the pulse flow arrival at Weitchpec (same day as release), water temperatures of the Trinity River were 21.1 ˚C, 0.4 ˚C colder than the Klamath River at rkm 70.2. During the pulse flow arrival on August 30 and 31, water temperatures of the Trinity River at Weitchpec were 19.5 ˚C, 1.8 ˚C colder than the Klamath River (rkm 70.2). For two days following the pulse flow arrival, water temperatures at Weitchpec continued to be cooler than the Klamath River, indicating a delayed effect of the coldwater pulse.

Several days after the pulse flow, water temperatures of the Trinity remained less than 0.9 ˚C colder than the Klamath River.

The short pulse flow also briefly influenced water temperatures of the Klamath River at rkm 68.7 below the confluence (Figure 13, Appendix B). At the time of peak influence (August 31), water temperature at this site was 0.8 ˚C colder than the Klamath River measured immediately above the Trinity River. The effect of the pulse on sites further downstream on the Klamath River was not readily apparent, although it likely affected the thermal regime slightly.

## DISCUSSION

Water temperatures of the Trinity River below Lewiston Dam are influenced by the temperature of water released from Trinity Reservoir, hydraulic residence time in Lewiston Reservoir, the magnitude of the release to the river, and ambient meteorological conditions throughout the basin. Typically, the coldest dam releases are associated with short hydraulic residence time of water stored in Lewiston Reservoir. Short hydraulic residence times generally result from high volume releases into the Trinity River alone or in combination with large diversions to the Sacramento River basin through the Carr Tunnel (Zedonis 1997). However, the magnitude of the influence can vary substantially with distance from the dam. River temperatures closest to the dam are influenced primarily by the temperature of the water released from the dam. Magnitude of dam releases and tributary inflows and ambient meteorological conditions become increasingly important to river temperatures with increasing distance downriver.

The NCRWQCB temperature objectives were not always met in 2005. The temperature objective of 15.6 ˚C at Douglas City was exceeded for 22 days (July 19 to August 10). During this time, water temperatures were up to 0.8 ˚C greater than the objective. The main reasons for not meeting the objective included relatively warm releases (11 to 12 ˚C) from Lewiston Dam and warm meteorological conditions. A flow of 450 cfs from Lewiston Dam with a temperature of 10.0 ˚C is typically required to meet the objective in all but extremely warm time periods (USFWS and Hoopa Valley Tribe 1999). As mentioned above, a management action to decrease the release temperature to this level would have either reduced the number of days the 15.6 ˚C temperature objective at Douglas City was exceeded or resulted in near 100 % compliance.

The temperature criterion for spring time objectives was exceeded from late June to early July. At this time, flow from Lewiston Dam was 2,000 cfs, flow contributions from tributaries were high and warm, dam releases were warming, and air temperatures were relatively high. The overall effect of these conditions is that Lewiston Dam releases did not have as great an influence on the thermal regime of the lower portion of the Trinity River. In order to meet this criterion, flow release from Lewiston Dam would have had to have been increased to a volume greater than 2,000 cfs, to a quantity that is best addressed thru modeling.

## ACKNOWLEDGEMENTS

We would like to thank Nicholas Hetrick, Joe Polos, and Randy Brown of the Arcata Fish and Wildlife Office of the U.S. Fish and Wildlife Service for providing comments on an earlier draft of this report

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04. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA 95521. 34 pp.

Table 1. Water temperature objectives for the Trinity River, California.

| Source | Target Area | Dates | Temperature Objective[1] |
|---|---|---|---|
| Basin Plan for the North Coast Region (Regional Water Quality Control Board, 1994) | • Lewiston to Douglas City (rkm 178.2 to 148.5) | All Years<br>• July 1 to September 15 | ≤ 15.5 |
| | • Lewiston to DouglasCity (rkm 178.2 to 148.5) | • September 15 to September 30 | ≤ 13.3 |
| | • Lewiston to the Confluence of the North Fork Trinity River Confluence (rkm 178.2 to 117.6) | • October 1 to December 31 | ≤ 13.3 |
| Spring-Time Objectives of the Record of Decision for the Trinity River EIS/EIR (USFWS et.al., 2000) | • Lewiston to Weitchpec (rkm 178.2 to 0.1) | Normal and Wetter Water Years:<br>• April 15 to May 22 | ≤ 13.0 |
| | | • May 23 to June 4 | ≤ 15.0 |
| | | • June 5 to July 9 | ≤ 17.0 |
| | | Dry and Critically Dry Water Years:<br>• April 15 to May 22 | ≤ 15.0 |
| | | • May 23 to June 4 | ≤ 17.0 |
| | | • June 5 to June 15 | ≤ 20.0 |

1 = Average daily water temperature in degrees Centigrade

Table **2**. Water temperature monitoring sites of the Trinity River and the Klamath River below Weitchpec, 2005. Note: Not all data identified in this table are presented in the report but are available upon request.

| **Water Temperature Monitoring Sites** | | | |
|---|---|---|---|
| **Mainstem Trinity River** | | | |
| **Site Name (abbreviation)** | **Location (rkm)** | **Data Source** | **Operator** |
| TR @ Lewiston Gage (LWS) | 178.2 | California Data Exchange Center (CDEC) | California Department of Water resources |
| TR above Rush Ck (TRC) | 173.0 | FWS | Fish and Wildlife Service (FWS) |
| TR@ Limkiln Gulch Gage (LKG) | 158.7 | CDEC | U.S. Geological Survey (USGS) |
| TR @ Douglas City Gage (DGC) | 148.5 | CDEC | USGS |
| TR above Canyon Ck (TCN) | 127.4 | FWS | FWS |
| TR @ Pear Tree Gulch Gage (PTG) | 117.6 | CDEC | US. Bureau of Reclamation (USBR) |
| TR above Big French Creek (TBF) | 94.2 | FWS | FWS |
| TR @ Burnt Ran. Trans Sta (BRN) | 76.4 | FWS | FWS |
| TR above S. Fork Trinity R. (TSF) | 50.6 | FWS | FWS |
| TR @ Willow Ck Trap Site (WLC) | 37.0 | FWS | FWS |
| TR @ Hoopa Gage (HPA)[d] | 20.0 | CDEC | US Geological Survey |
| TR @ Weitchpec (TR) | 0.1 | FWS | FWS/Yurok Tribe |
| **Mainstem Klamath River** | | | |
| KR above Trinity R (WE) [b] | 70.2 | FWS | FWS/Yurok Tribe |
| KR below Weitchpec (KBW) | 68.7 | FWS | FWS/Yurok Tribe |
| KR above Blue Ck (KBC) | 26.5 | FWS | Yurok/FWS |
| KR above Terwer (KAT) | 10.8 | FWS | FWS/Yurok Tribe |
| **Trinity River Tributary Sites** | | | |
| Rush Ck (RSH) | 173.0 + 0.4 | CDEC | USBR/ USGS |
| Canyon Ck (CNY) | 127.3 + 0.1 | FWS | FWS |
| N. F. Trinity R (NFT) | 116.7 + 0.1 | FWS | FWS |
| Big French Ck (BFC) | 94.1 + 0.1 | FWS | FWS |
| S. F. Trinity R (SFT) [d] | 50.5 + 0.1 | FWS | FWS |

‘a = River kilometer of mainstem Trinity River + the distance up the tributary
‘b = This site is located immediately above the confluence of the Trinity River and refers to the distance from the Klamath River mouth.
‘c = Data is not available from USFWS but may be available from Yurok Tribe.
‘d = No data collected here in 2005. flow data only

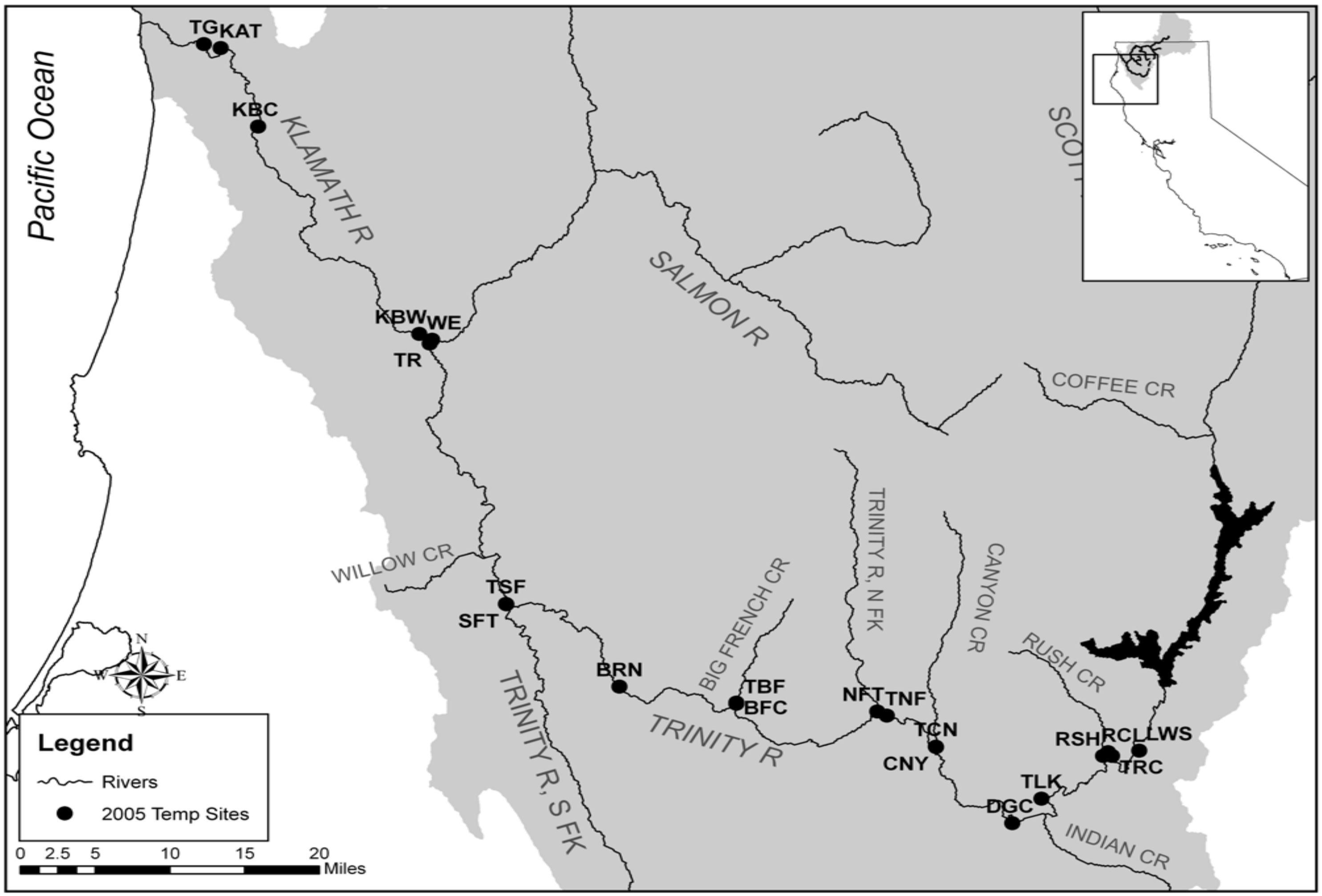


Figure 1. Location of water temperature monitoring sites of the Trinity River and lower Klamath River in 2005. See Table 2 for site descriptions.

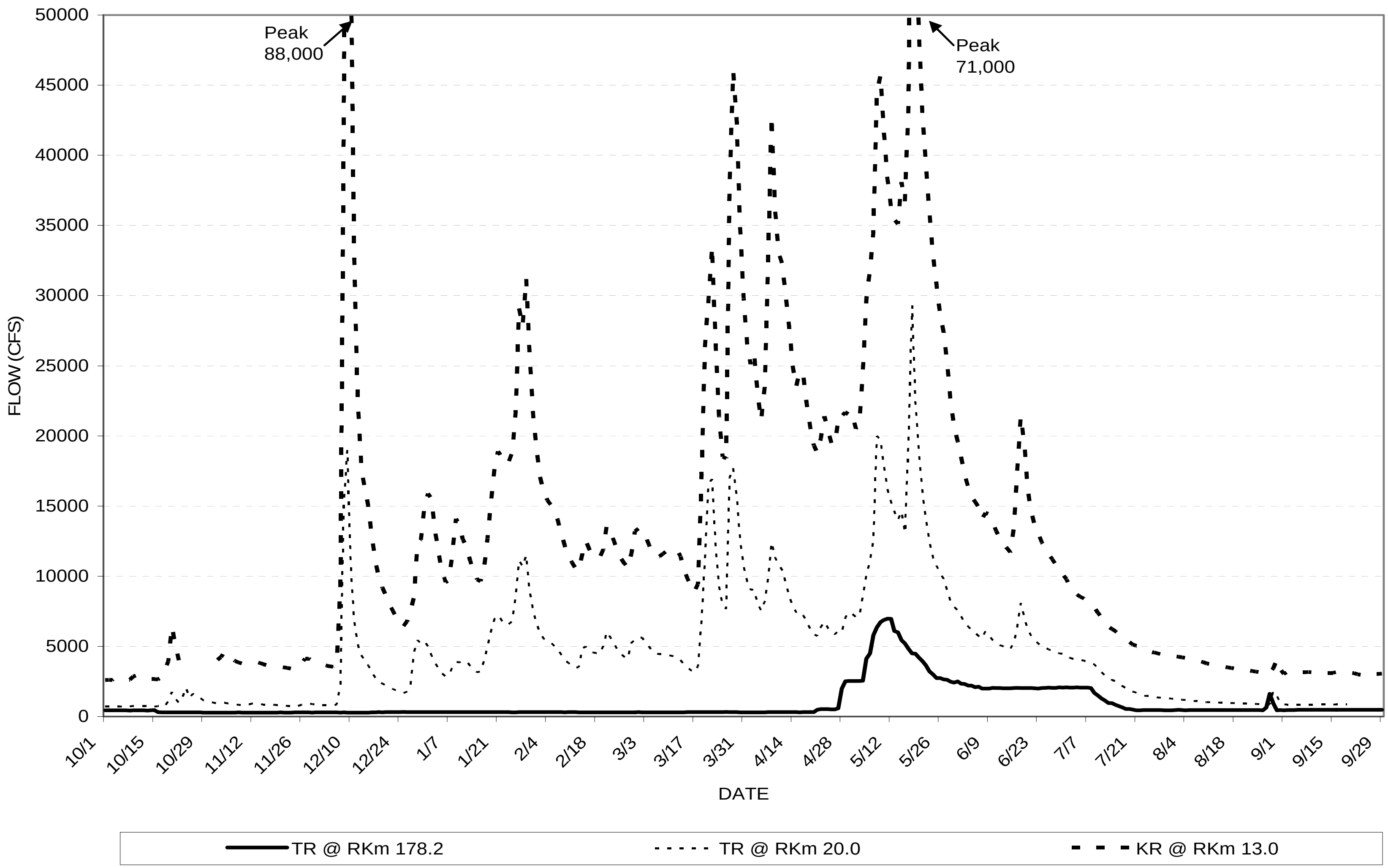


Figure 2. Average daily flow of the Trinity River (TR) at Lewiston gage (rkm 178.2) and Hoopa gage (rkm 20.0) , and the Klamath River 9KR) at the Klamath Gage (rkm 13.0) in 2005. US Geological Survey gage data, preliminary and subject to revision.

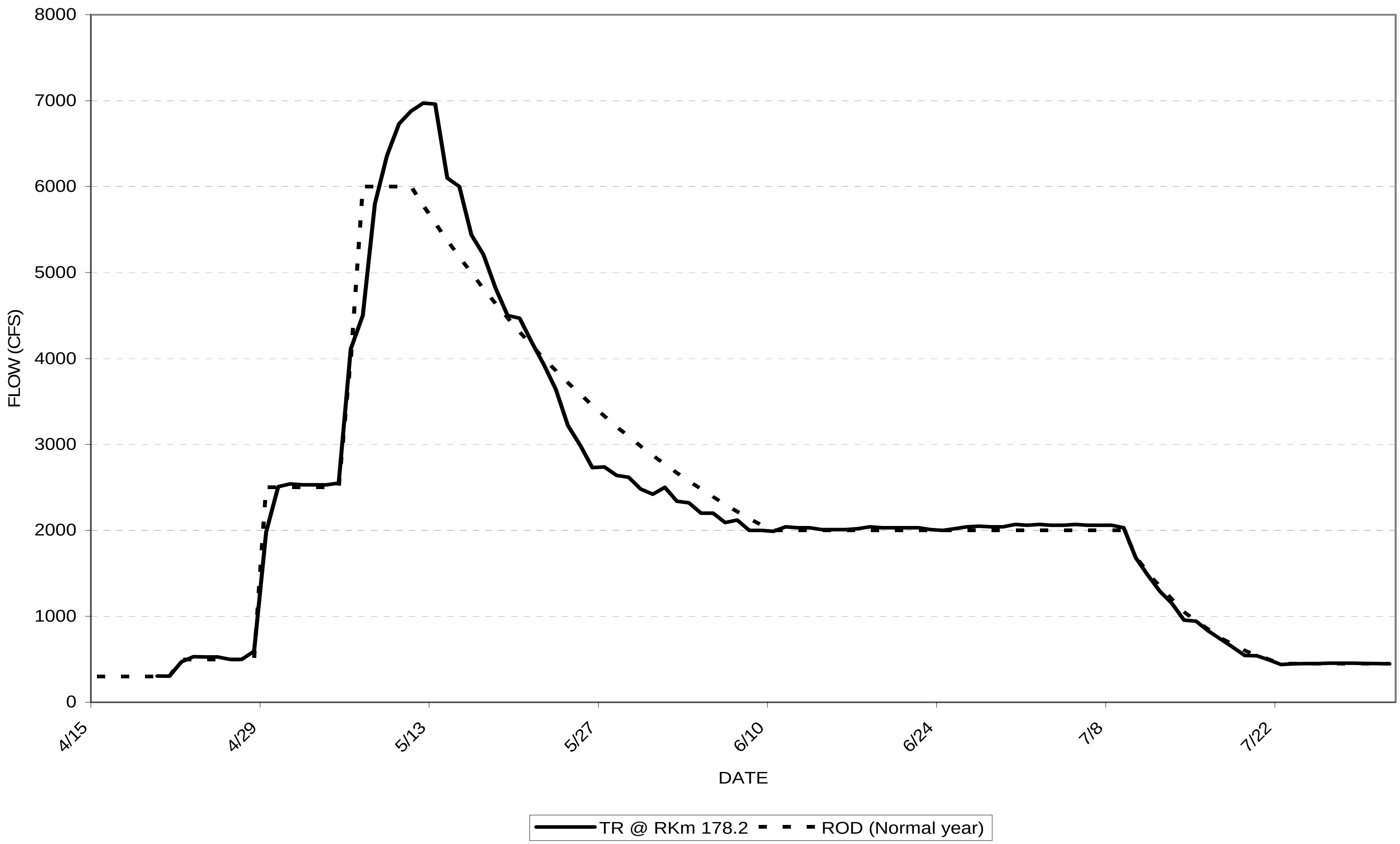


Figure 3. Spring and early summer flow releases from Lewiston Dam (rkm 178.2)on the Trinity River (TR) in 2005 compared flow schedules for a Normal hydrologic water year identified in the Record of Decision (ROD) (USFWS et.al., 2000).

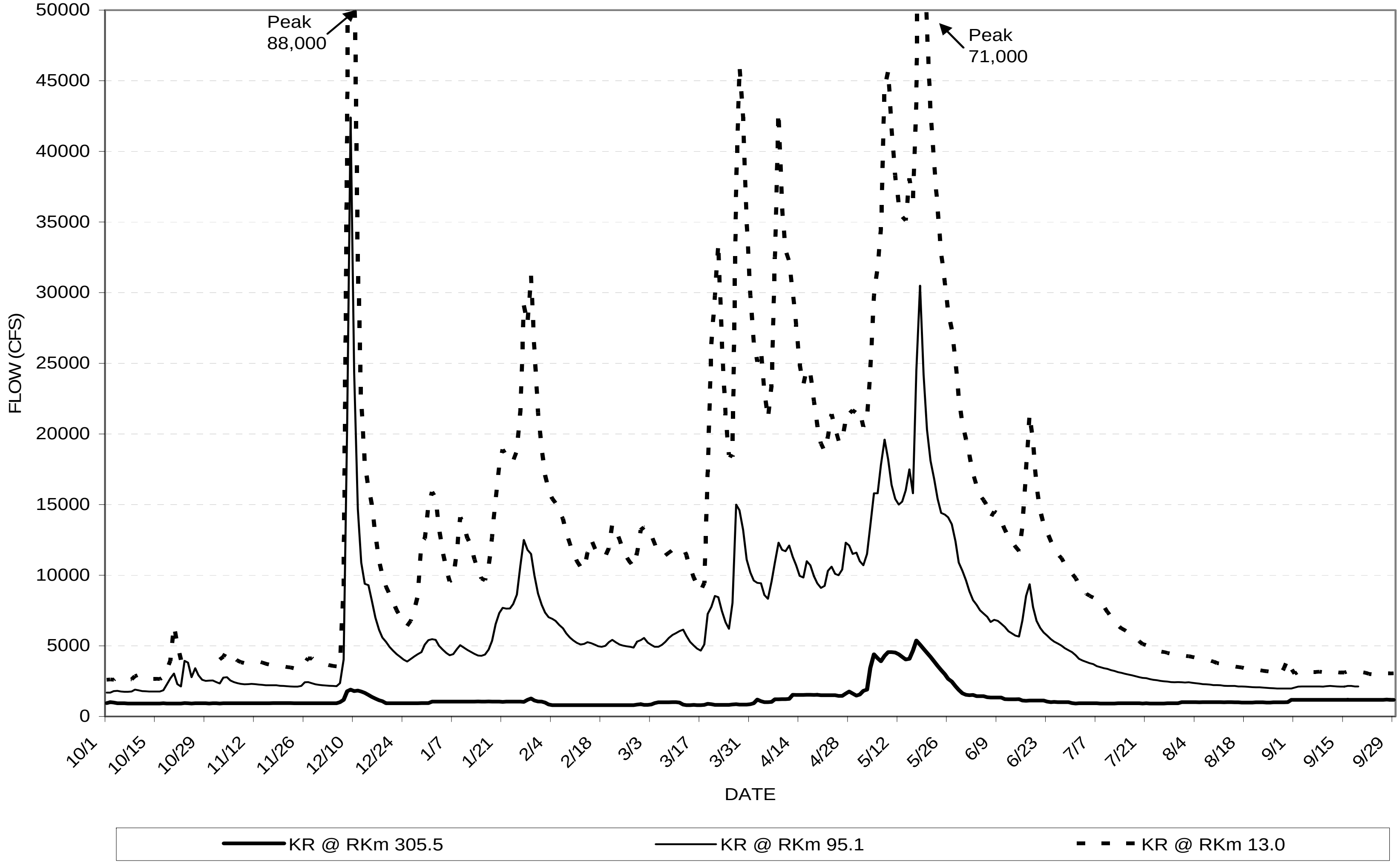


Figure 4. Average daily flow of the Klamath River (KR) at Iron Gate Dam (rkm 305.5), Orleans gage (rkm 95.1) and at Klamath (rkm 13.0). U.S. Geological Survey gage data, preliminary and subject to revision.

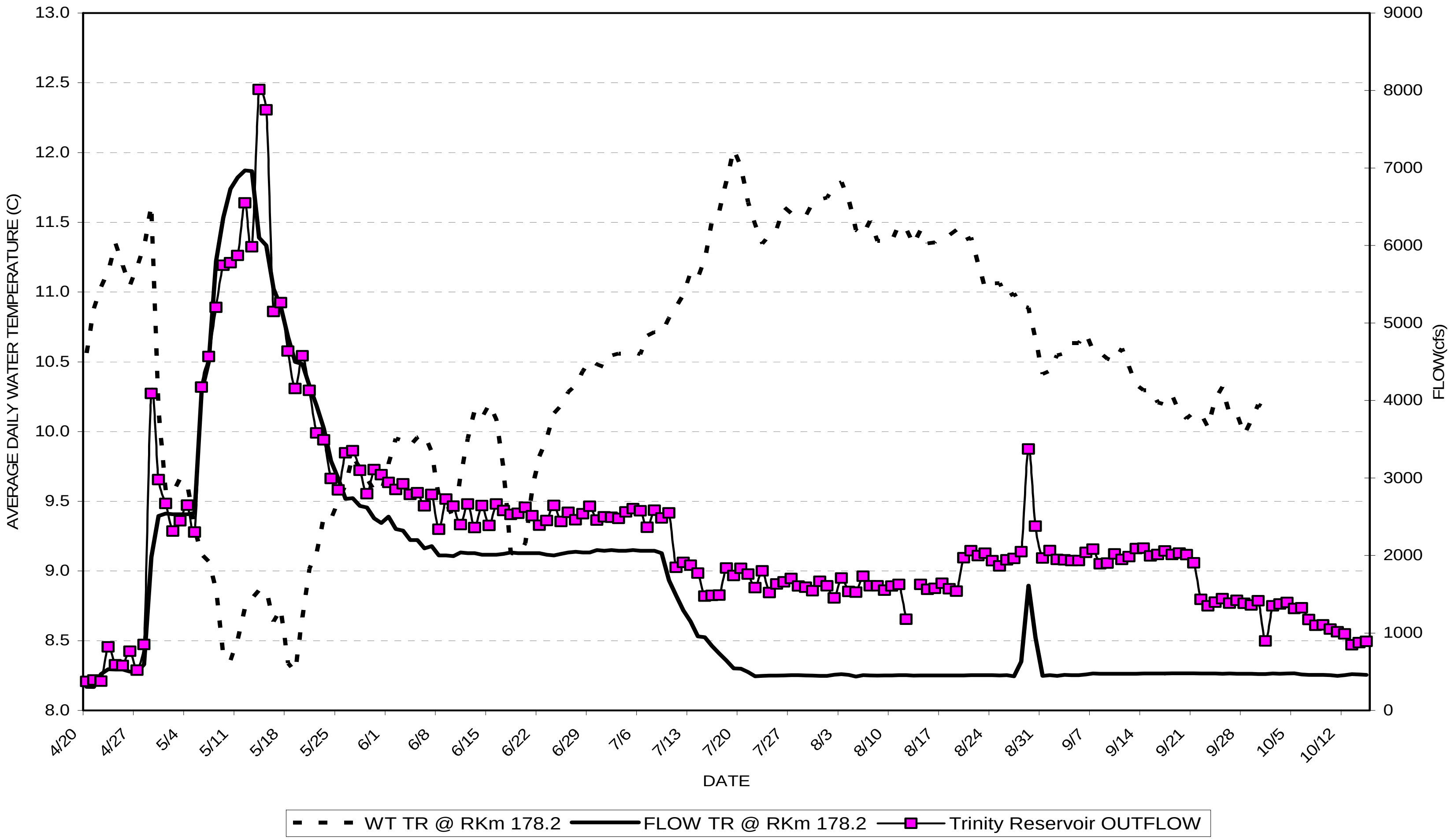


Figure 5. Water temperature (WT) and flow of the Trinity River at Lewiston (rkm 178.2) and Trinity Reservoir outflow in 2005. Trinity Reservoir outflow is used for releases to the Trinity River and diversions to the Sacramento River basin. The area between lines representing Trinity Reservoir outflow and flow at Lewiston represent an estimate of the flow diverted to the Sacramento River Basin

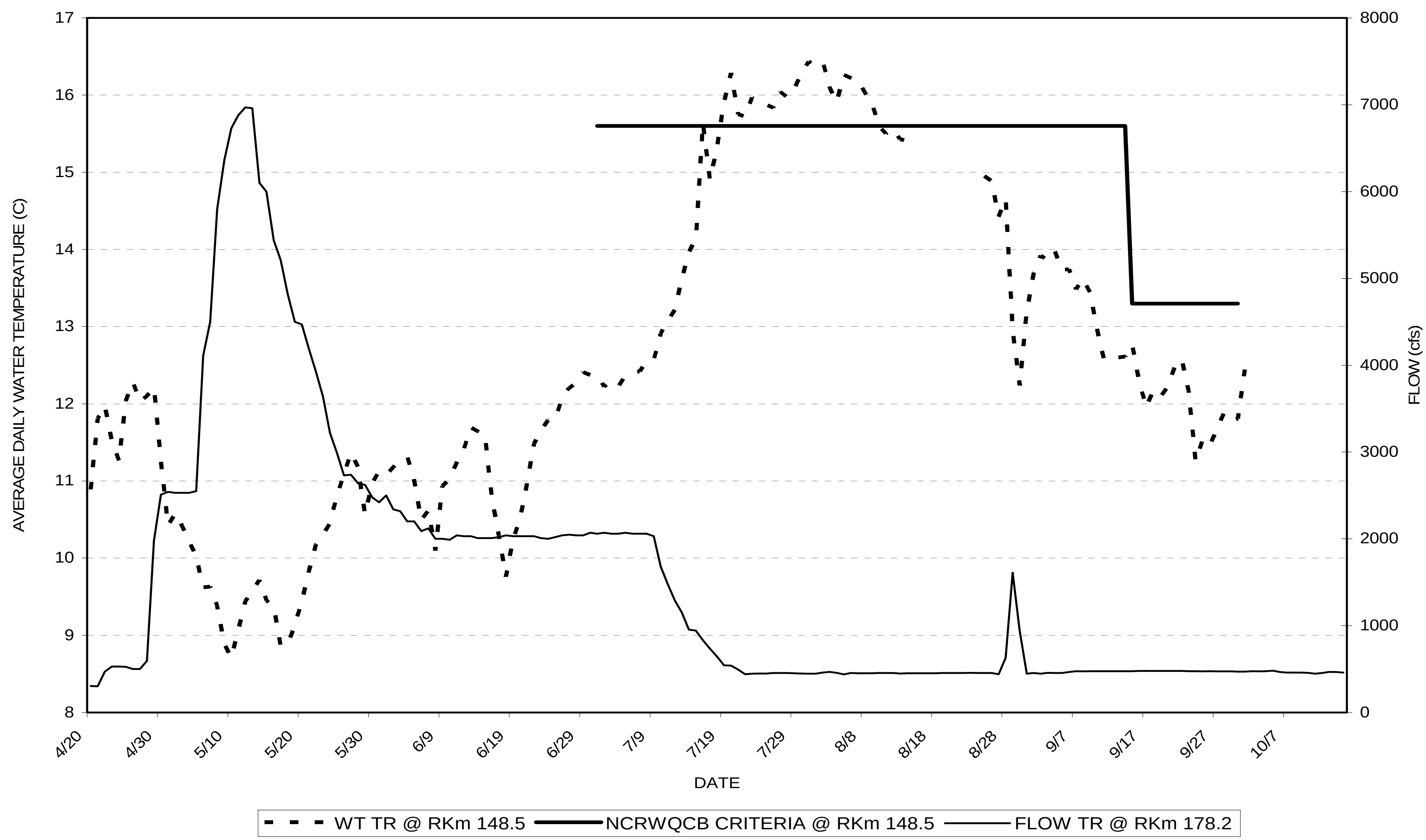


Figure 6. Average daily water temperatures (WT) of the Trinity River at the Douglas City gage (rkm 148.5) and flow at Lewiston (rkm 178.2) in 2005. Comparisons of water temperature data and the North Coast Regional Water Quality Control Board water temperature objectives.

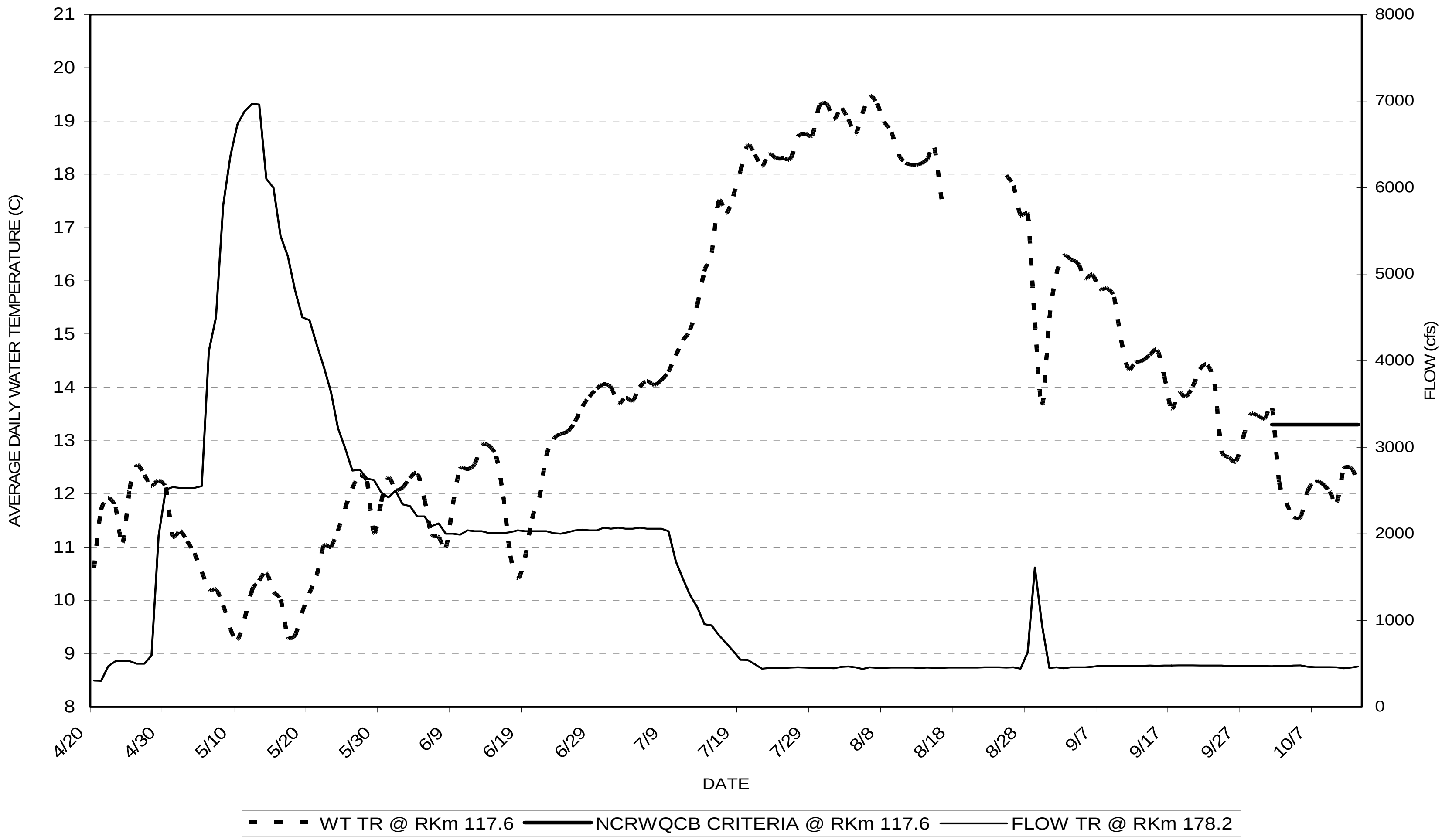


Figure 7. Average daily water temperatures (WT) of the Trinity River near the confluence of the North Fork Trinity River (rkm 117.6) and flow at Lewiston (rkm 178.2) in 2005 and North Coast Regional Water Quality Control Board water temperature objectives after October 1.

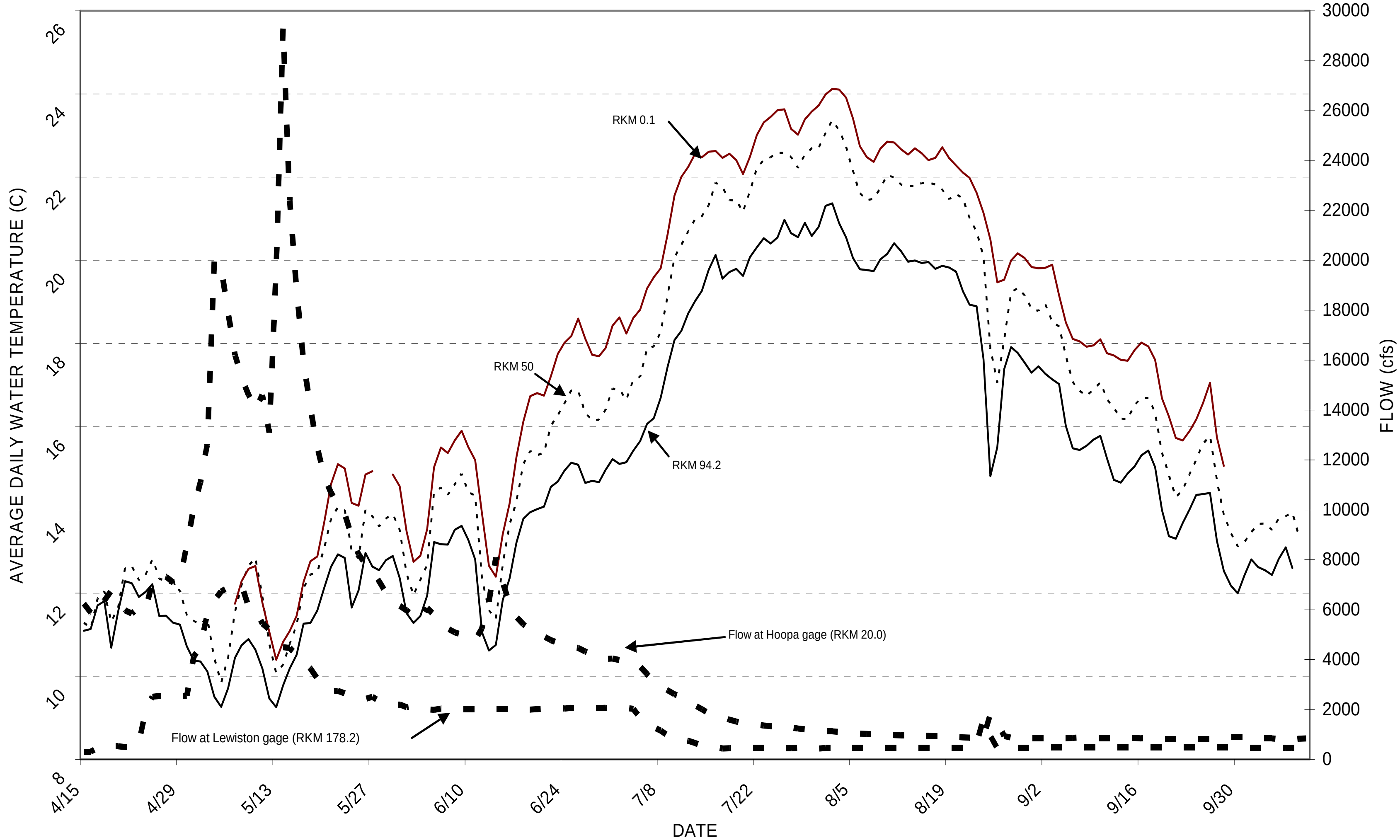


Figure 8. Average daily water temperatures of the Trinity River immediately above Big French Creek (rkm 94.2), immediately above the South Fork Trinity River (rkm 50.0), and Weitchpec (rkm 0.1), and flow data from Lewiston (rkm 178.2) and Hoopa (rkm 20.0) in 2005.

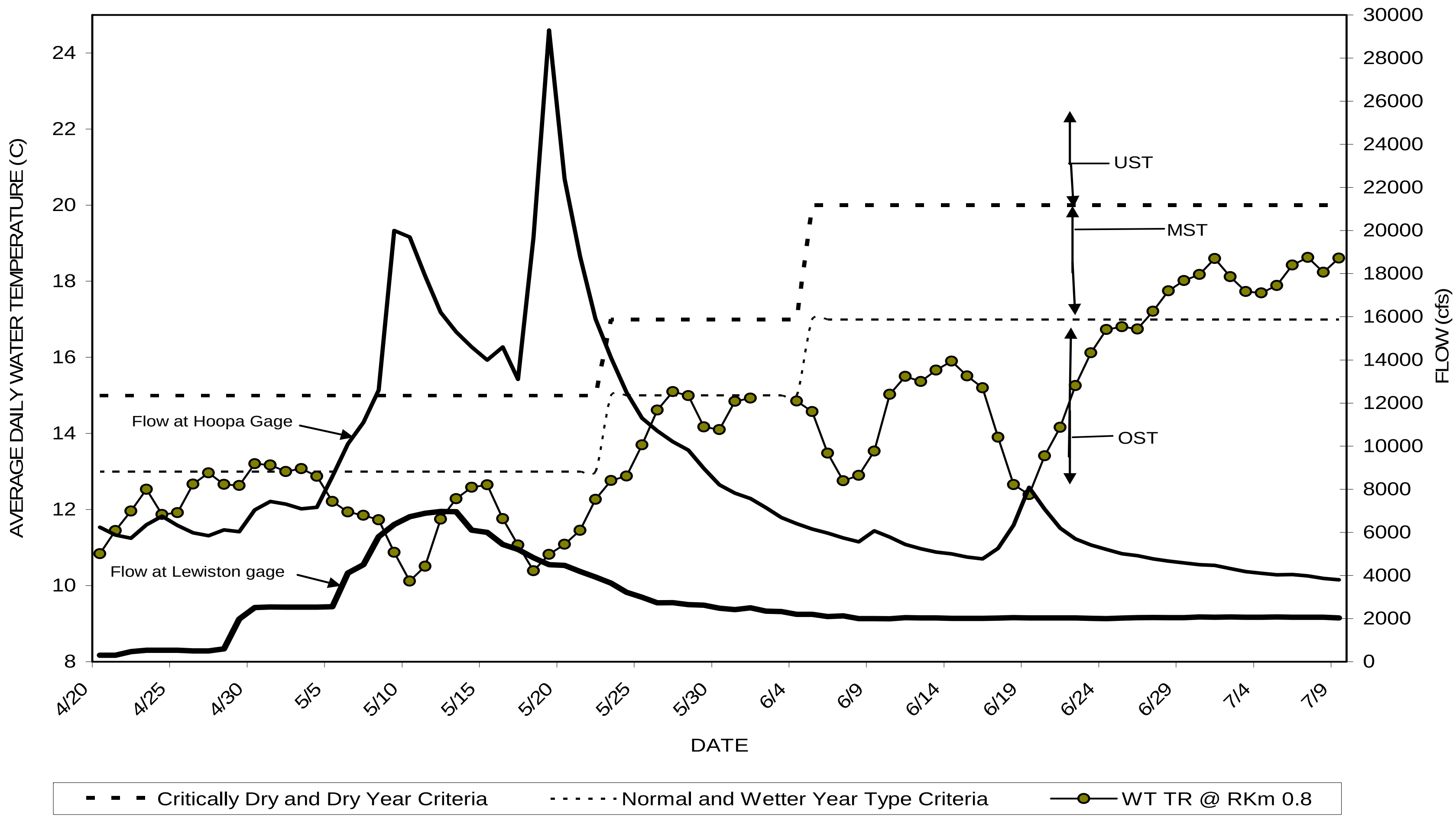


Figure 9. Average daily water temperatures (WT) of the Trinity River at Weitchpec in 2005 and how they compare to the spring-time temperature criteria established by the Record of Decision (USFWS et al., 2000). Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures, OST = Optimally suitable temperatures.

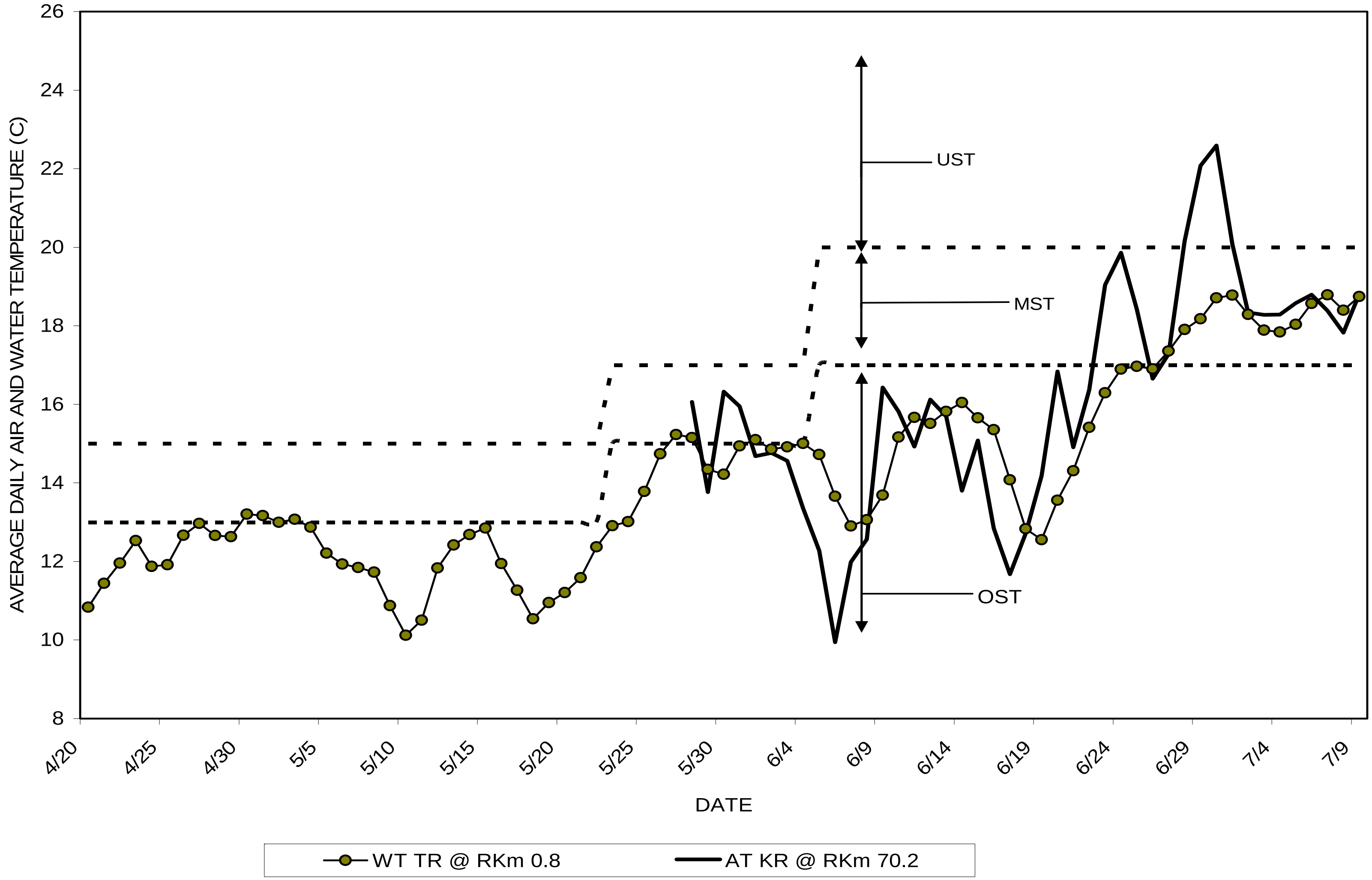


Figure 10. Air temperature (AT) and its influence on water temperature (WT) of the Trinity River at Weitchpec from April 15 to July 9, 2005. Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures; OST = Optimally suitable temperatures

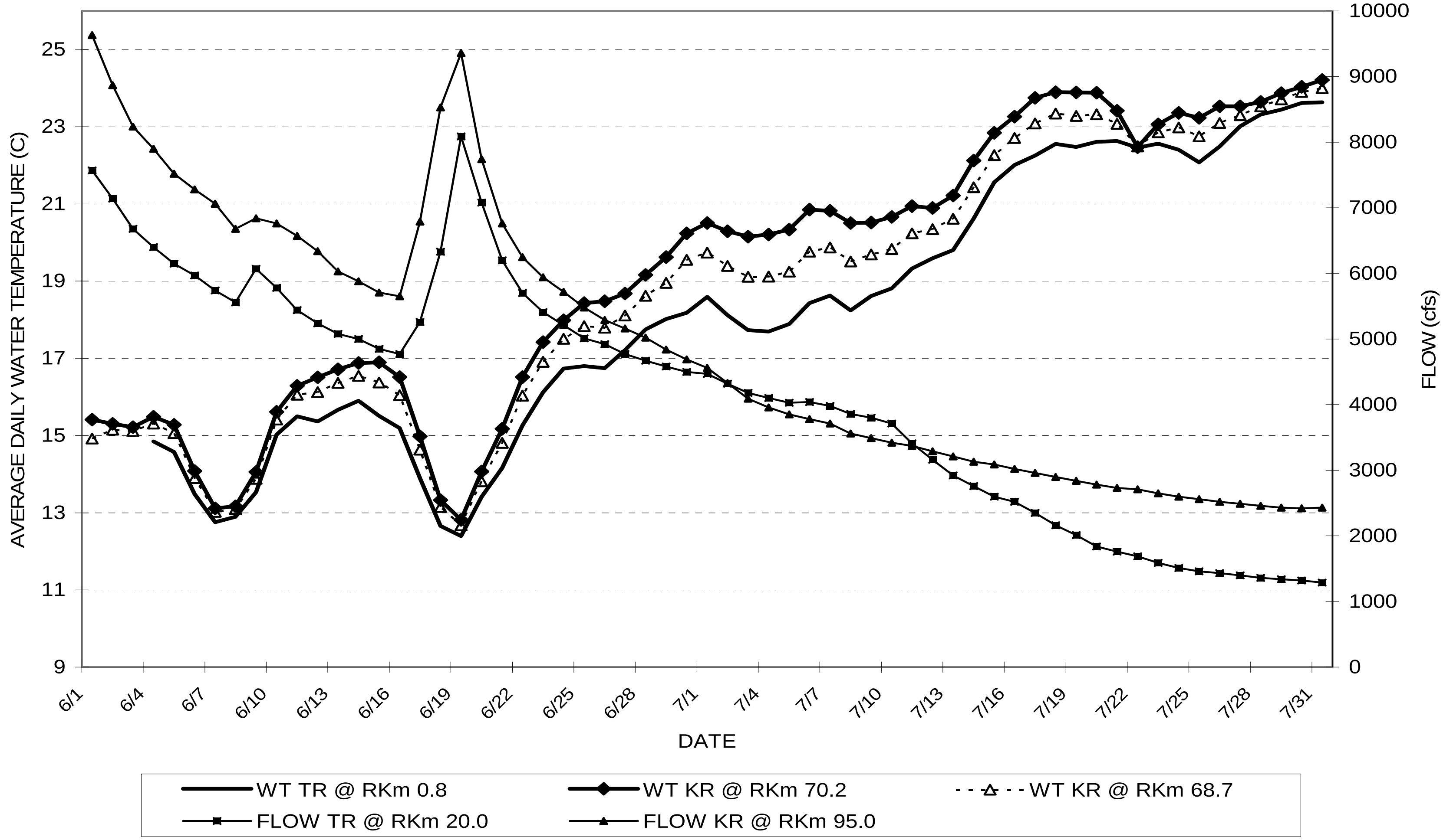


Figure 11. Comparison of water temperatures (WT) of the Trinity River (TR) at Weitchpec (rkm 0.1) and the Klamath River (KR) above (rkm 70.2) and below (rkm 68.7) the confluence and flow of the Trinity River (rkm 20.0) and the Klamath River (rkm 95.0) in 2005.

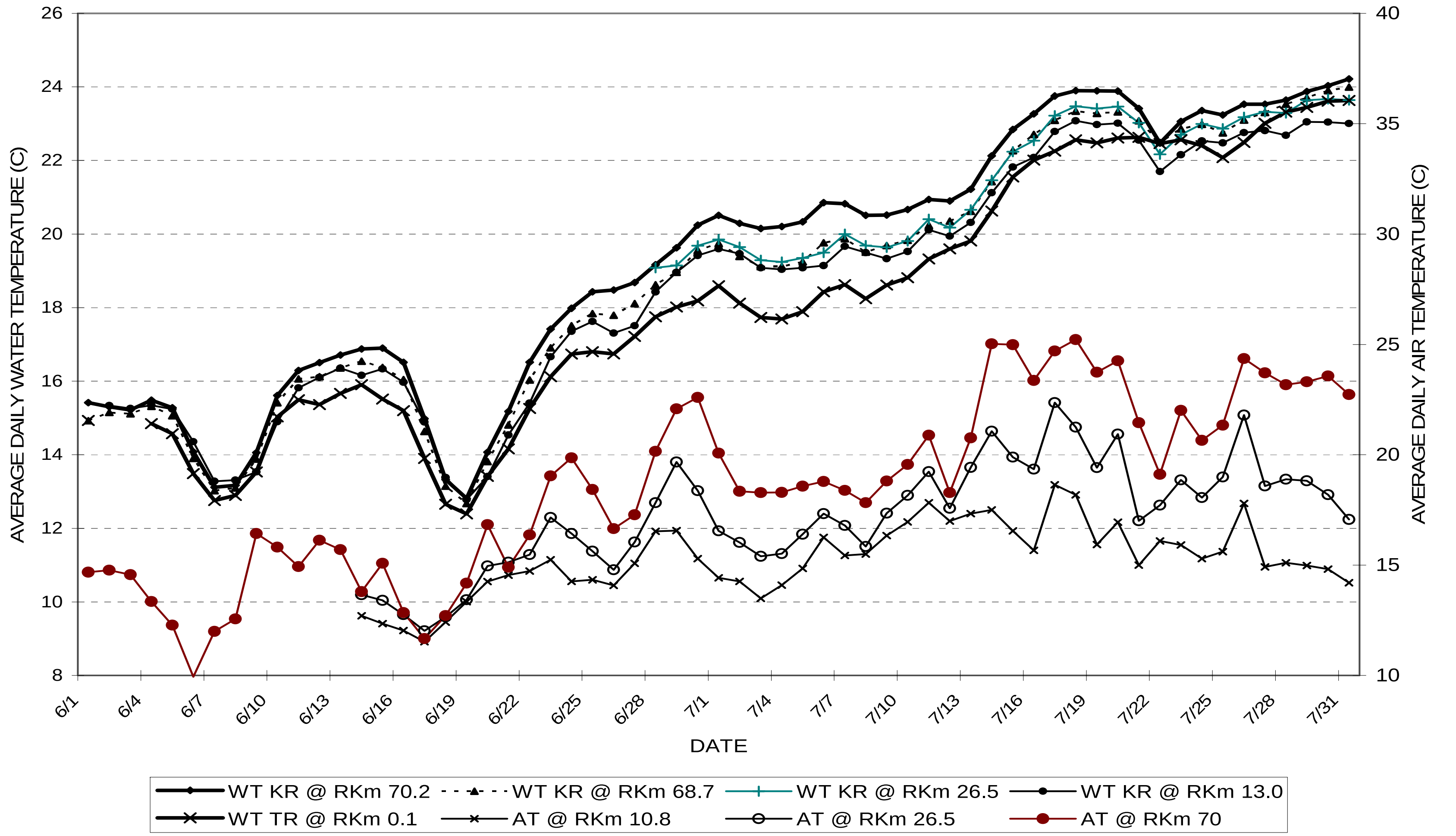


Figure 12. Comparison of average daily water temperatures (WT) of the Trinity River (TR) at Weitchpec (rkm 0.1) and the Klamath River (KR) above (rkm 70.2) and below the confluence of the Trinity River (rkm 68.7 and 13.0) and air temperatures (AT) from three stations located at or below Weitchpec, 2005.

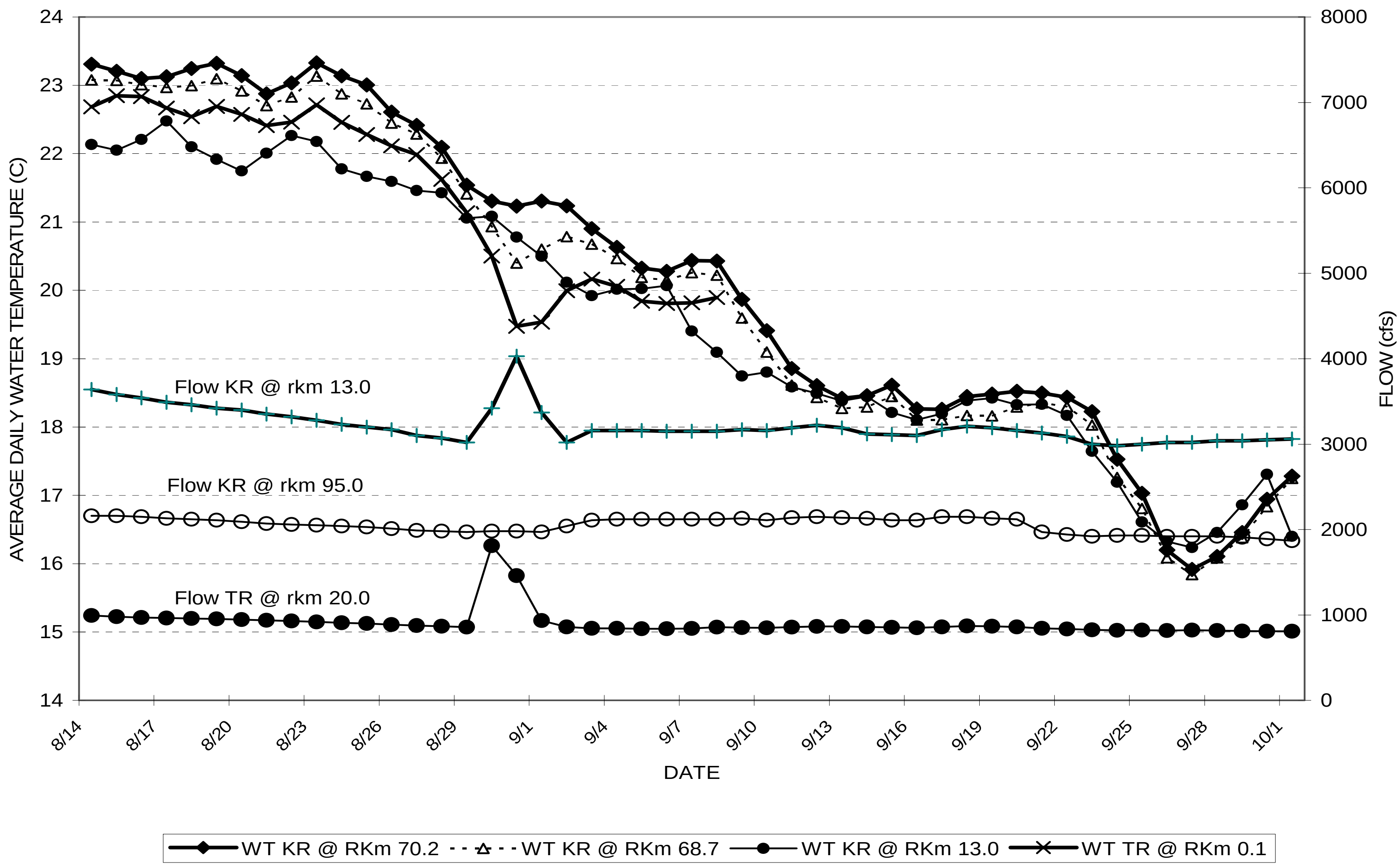


Figure 13. Comparison of flow and average daily water temperatures (WT) of the Trinity River (TR) at Weitchpec (rkm 0.1) and the Klamath River (KR) above (rkm 70.2) and below the confluence of the Trinity River (rkm 68.7 and 13.0) in August and September, 2005.

# Appendix A. Average daily water temperatures and flow of the Klamath and Trinity Rivers from June 10 to July 26, 2005

| | | Flow (CFS) | | | | | | | Average Daily Water Temperatures (°C) | | | | | Differences in Water Temps (°C) of the Klamath R. at RKm 70.2 and: | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Trinity R. | | Klamath R. | | | Contributions of Flow to the Turwar Gage (%)[b] | | Trinity R. | Klamath R. Sites | | | | Trinity R. | Klamath R. Sites | | |
| | Flow | Lewiston | Hoopa | Iron Gate | Orleans | Turwar | Lewiston Dam | Iron Gate Dam | TR | WE | KBW | KBC | KAT | TR | KBW | KBC | KAT |
| Date | Description | rkm 178.6 | rkm 20.0 | rkm 305.5 | rkm 95.1 | rkm 13.0 | rkm 178.6 | rkm 305.5 | rkm 0.8 | rkm 70.2 | rkm 68.7 | rkm 26.5 | rkm 13.0 | rkm 0.8 | rkm 68.7 | rkm 26.5 | rkm 13.0 |
| 6/10 | | 1990 | 5780 | 1340 | 6760 | 14400 | 14 | 9 | 15.03 | 15.61 | 15.41 | | 14.89 | 0.6 | 0.2 | | 0.7 |
| 6/11 | | 2040 | 5440 | 1340 | 6570 | 13800 | 15 | 10 | 15.50 | 16.29 | 16.06 | | 15.82 | 0.8 | 0.2 | | 0.5 |
| 6/12 | | 2030 | 5240 | 1220 | 6340 | 13200 | 15 | 9 | 15.36 | 16.51 | 16.12 | | 16.10 | 1.1 | 0.4 | | 0.4 |
| 6/13 | | 2030 | 5080 | 1210 | 6030 | 12700 | 16 | 10 | 15.67 | 16.71 | 16.36 | | 16.35 | 1.0 | 0.4 | | 0.4 |
| 6/14 | | 2010 | 5000 | 1210 | 5880 | 12300 | 16 | 10 | 15.90 | 16.88 | 16.54 | | 16.16 | 1.0 | 0.3 | | 0.7 |
| 6/15 | | 2010 | 4850 | 1210 | 5710 | 12000 | 17 | 10 | 15.51 | 16.90 | 16.37 | | 16.34 | 1.4 | 0.5 | | 0.6 |
| 6/16 | < 2000 cfs or Greater Release from Lewiston Dam > | 2010 | 4770 | 1220 | 5650 | 11700 | 17 | 10 | 15.20 | 16.51 | 16.05 | | 15.97 | 1.3 | 0.5 | | 0.5 |
| 6/17 | | 2020 | 5260 | 1130 | 6790 | 13400 | 15 | 8 | 13.90 | 14.98 | 14.63 | | 14.89 | 1.1 | 0.3 | | 0.1 |
| 6/18 | | 2040 | 6330 | 1110 | 8530 | 17400 | 12 | 6 | 12.65 | 13.33 | 13.15 | | 13.38 | 0.7 | 0.2 | | -0.1 |
| 6/19 | | 2030 | 8090 | 1120 | 9360 | 21400 | 9 | 5 | 12.39 | 12.81 | 12.67 | | 12.78 | 0.4 | 0.1 | | 0.0 |
| 6/20 | | 2030 | 7080 | 1120 | 7740 | 19400 | 10 | 6 | 13.41 | 14.07 | 13.81 | | 13.41 | 0.7 | 0.3 | | 0.7 |
| 6/21 | | 2030 | 6200 | 1120 | 6760 | 16200 | 13 | 7 | 14.16 | 15.18 | 14.81 | | 14.54 | 1.0 | 0.4 | | 0.6 |
| 6/22 | | 2030 | 5700 | 1120 | 6250 | 14600 | 14 | 8 | 15.26 | 16.52 | 16.03 | | 15.40 | 1.3 | 0.5 | | 1.1 |
| 6/23 | | 2010 | 5410 | 1120 | 5940 | 13600 | 15 | 8 | 16.12 | 17.42 | 16.91 | | 16.66 | 1.3 | 0.5 | | 0.8 |
| 6/24 | | 2000 | 5210 | 1050 | 5720 | 13000 | 15 | 8 | 16.74 | 17.98 | 17.51 | | 17.35 | 1.2 | 0.5 | | 0.6 |
| 6/25 | | 2020 | 5010 | 1020 | 5480 | 12400 | 16 | 8 | 16.80 | 18.43 | 17.83 | | 17.62 | 1.6 | 0.6 | | 0.8 |
| 6/26 | | 2040 | 4920 | 1030 | 5290 | 11900 | 17 | 9 | 16.74 | 18.48 | 17.79 | | 17.31 | 1.7 | 0.7 | | 1.2 |
| 6/27 | | 2050 | 4770 | 1020 | 5160 | 11500 | 18 | 9 | 17.21 | 18.68 | 18.11 | | 17.51 | 1.5 | 0.6 | | 1.2 |
| 6/28 | | 2040 | 4670 | 1020 | 5020 | 11200 | 18 | 9 | 17.75 | 19.16 | 18.62 | 19.08 | 18.42 | 1.4 | 0.5 | 0.1 | 0.7 |
| 6/29 | | 2040 | 4580 | 1020 | 4840 | 10800 | 19 | 9 | 18.02 | 19.63 | 18.96 | 19.15 | 18.96 | 1.6 | 0.7 | 0.5 | 0.7 |
| 6/30 | | 2070 | 4500 | 1020 | 4690 | 10400 | 20 | 10 | 18.18 | 20.24 | 19.55 | 19.68 | 19.42 | 2.1 | 0.7 | 0.6 | 0.8 |
| 7/1 | | 2060 | 4470 | 941 | 4560 | 10100 | 20 | 9 | 18.60 | 20.51 | 19.74 | 19.85 | 19.60 | 1.9 | 0.8 | 0.7 | 0.9 |
| 7/2 | | 2070 | 4320 | 921 | 4330 | 9770 | 21 | 9 | 18.12 | 20.29 | 19.39 | 19.64 | 19.47 | 2.2 | 0.9 | 0.6 | 0.8 |
| 7/3 | | 2060 | 4180 | 923 | 4090 | 9260 | 22 | 10 | 17.73 | 20.15 | 19.11 | 19.29 | 19.08 | 2.4 | 1.0 | 0.9 | 1.1 |
| 7/4 | | 2060 | 4100 | 923 | 3960 | 8930 | 23 | 10 | 17.69 | 20.21 | 19.12 | 19.24 | 19.04 | 2.5 | 1.1 | 1.0 | 1.2 |
| 7/5 | | 2070 | 4030 | 931 | 3850 | 8670 | 24 | 11 | 17.89 | 20.33 | 19.25 | 19.35 | 19.08 | 2.4 | 1.1 | 1.0 | 1.3 |
| 7/6 | | 2060 | 4040 | 926 | 3780 | 8530 | 24 | 11 | 18.43 | 20.85 | 19.76 | 19.49 | 19.14 | 2.4 | 1.1 | 1.4 | 1.7 |
| 7/7 | | 2060 | 3980 | 927 | 3710 | 8420 | 24 | 11 | 18.63 | 20.82 | 19.87 | 20.00 | 19.67 | 2.2 | 1.0 | 0.8 | 1.2 |
| 7/8 | | 2060 | 3860 | 925 | 3560 | 8140 | 25 | 11 | 18.24 | 20.51 | 19.51 | 19.69 | 19.50 | 2.3 | 1.0 | 0.8 | 1.0 |
| 7/9 | | 2030 | 3800 | 921 | 3490 | 7910 | 26 | 12 | 18.61 | 20.52 | 19.69 | 19.64 | 19.33 | 1.9 | 0.8 | 0.9 | 1.2 |
| 7/10 | < Down Ramp > | 1680 | 3710 | 918 | 3420 | 7780 | 22 | 12 | 18.81 | 20.67 | 19.83 | 19.81 | 19.52 | 1.9 | 0.8 | 0.9 | 1.1 |
| 7/11 | | 1480 | 3410 | 917 | 3370 | 7390 | 20 | 12 | 19.32 | 20.94 | 20.24 | 20.41 | 20.12 | 1.6 | 0.7 | 0.5 | 0.8 |
| 7/12 | | 1290 | 3160 | 917 | 3290 | 7040 | 18 | 13 | 19.59 | 20.90 | 20.35 | 20.17 | 19.94 | 1.3 | 0.5 | 0.7 | 1.0 |
| 7/13 | | 1150 | 2920 | 918 | 3210 | 6660 | 17 | 14 | 19.81 | 21.22 | 20.62 | 20.66 | 20.31 | 1.4 | 0.6 | 0.6 | 0.9 |
| 7/14 | | 956 | 2760 | 924 | 3130 | 6410 | 15 | 14 | 20.62 | 22.12 | 21.43 | 21.46 | 21.12 | 1.5 | 0.7 | 0.7 | 1.0 |
| 7/15 | | 944 | 2600 | 925 | 3090 | 6230 | 15 | 15 | 21.56 | 22.84 | 22.26 | 22.24 | 21.82 | 1.3 | 0.6 | 0.6 | 1.0 |
| 7/16 | | 832 | 2520 | 928 | 3020 | 6080 | 14 | 15 | 22.01 | 23.26 | 22.71 | 22.54 | 22.08 | 1.3 | 0.6 | 0.7 | 1.2 |
| 7/17 | | 736 | 2350 | 928 | 2960 | 5910 | 12 | 16 | 22.25 | 23.75 | 23.09 | 23.22 | 22.79 | 1.5 | 0.7 | 0.5 | 1.0 |
| 7/18 | | 644 | 2160 | 930 | 2900 | 5690 | 11 | 16 | 22.56 | 23.90 | 23.34 | 23.47 | 23.08 | 1.3 | 0.6 | 0.4 | 0.8 |
| 7/19 | | 544 | 2010 | 928 | 2840 | 5490 | 10 | 17 | 22.48 | 23.89 | 23.28 | 23.41 | 22.98 | 1.4 | 0.6 | 0.5 | 0.9 |
| 7/20 | | 541 | 1840 | 927 | 2780 | 5310 | 10 | 17 | 22.61 | 23.88 | 23.32 | 23.47 | 23.01 | 1.3 | 0.6 | 0.4 | 0.9 |
| 7/21 | < Base Flow > | 495 | 1760 | 920 | 2730 | 5110 | 10 | 18 | 22.63 | 23.41 | 23.08 | 23.02 | 22.55 | 0.8 | 0.3 | 0.4 | 0.9 |
| 7/22 | | 440 | 1690 | 924 | 2710 | 5030 | 9 | 18 | 22.46 | 22.47 | 22.49 | 22.17 | 21.70 | 0.0 | 0.0 | 0.3 | 0.8 |
| 7/23 | | 448 | 1590 | 918 | 2650 | 4940 | 9 | 19 | 22.56 | 23.06 | 22.86 | 22.70 | 22.15 | 0.5 | 0.2 | 0.4 | 0.9 |
| 7/24 | | 450 | 1510 | 918 | 2600 | 4790 | 9 | 19 | 22.41 | 23.36 | 22.98 | 23.00 | 22.53 | 1.0 | 0.4 | 0.4 | 0.8 |
| 7/25 | | 450 | 1460 | 918 | 2560 | 4690 | 10 | 20 | 22.07 | 23.23 | 22.75 | 22.86 | 22.47 | 1.2 | 0.5 | 0.4 | 0.8 |
| 7/26 | | 454 | 1430 | 922 | 2520 | 4610 | 10 | 20 | 22.49 | 23.53 | 23.10 | 23.18 | 22.76 | 1.0 | 0.4 | 0.4 | 0.8 |

b = contributions do not reflect travel time differences.

Appendix B. Average daily water temperature and flow of the Klamath and Trinity Rivers from August 21 to October 6, 2005.

| | | Flow (CFS) | | | | | Contributions of Flow to the Klamath Gage (%)[b] | | Average Daily Water Temperatures (°C) | | | | | Differences in Water Temps (°C) of the Klamath R. at RKm 70.2 and: | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Trinity R. | | Klamath R. | | | | | Trinity R. | Klamath R. Sites | | | | Trinity R. | Klamath R. Sites | | |
| Date | Flow Description | LWS (RKm 178.6) | HPA (RKm 20.0) | IG (RKm 305.5) | OLS (RKm 95.1) | Klam (RKm 10.8) | Lewiston Dam | Iron Gate Dam | RKm 0.8 | RKm 70.2 | RKm 68.7 | RKm 26.5 | RKm 13.0 | RKm 0.8 | RKm 68.7 | RKm 26.5 | RKm 13.0 |
| 8/21 | | 455 | 938 | 983 | 2070 | 3350 | 14 | 29 | 22.41 | 22.87 | 22.70 | 22.32 | 21.75 | 0.5 | 0.2 | 0.6 | 1.1 |
| 8/22 | | 456 | 928 | 990 | 2060 | 3320 | 14 | 30 | 22.46 | 23.04 | 22.83 | 22.54 | 22.01 | 0.6 | 0.2 | 0.5 | 1.0 |
| 8/23 | | 457 | 919 | 991 | 2050 | 3280 | 14 | 30 | 22.72 | 23.33 | 23.14 | 22.78 | 22.26 | 0.6 | 0.2 | 0.5 | 1.1 |
| 8/24 | < Before Pulse[a] > | 456 | 908 | 991 | 2040 | 3230 | 14 | 31 | 22.46 | 23.14 | 22.88 | 22.65 | 22.18 | 0.7 | 0.3 | 0.5 | 1.0 |
| 8/25 | | 454 | 900 | 985 | 2030 | 3200 | 14 | 31 | 22.28 | 23.01 | 22.73 | 22.39 | 21.78 | 0.7 | 0.3 | 0.6 | 1.2 |
| 8/26 | | 456 | 886 | 985 | 2010 | 3170 | 14 | 31 | 22.11 | 22.61 | 22.45 | 22.23 | 21.67 | 0.5 | 0.2 | 0.4 | 0.9 |
| 8/27 | | 442 | 875 | 989 | 1990 | 3100 | 14 | 32 | 21.99 | 22.41 | 22.29 | 22.15 | 21.59 | 0.4 | 0.1 | 0.3 | 0.8 |
| 8/28 | | 631 | 868 | 991 | 1980 | 3070 | 21 | 32 | 21.62 | 22.09 | 21.93 | 21.88 | 21.46 | 0.5 | 0.2 | 0.2 | 0.6 |
| 8/29 | < During Pulse[a] > | 1610 | 858 | 995 | 1970 | 3020 | 53 | 33 | 21.14 | 21.54 | 21.41 | 21.67 | 21.43 | 0.4 | 0.1 | -0.1 | 0.1 |
| 8/30 | | 945 | 1810 | 990 | 1980 | 3420 | 28 | 29 | 20.50 | 21.31 | 20.93 | 21.33 | 21.06 | 0.8 | 0.4 | 0.0 | 0.2 |
| 8/31 | | 448 | 1460 | 1010 | 1980 | 4030 | 11 | 25 | 19.47 | 21.23 | 20.40 | 21.22 | 21.08 | 1.8 | 0.8 | 0.0 | 0.1 |
| 9/1 | | 456 | 934 | 1180 | 1970 | 3370 | 14 | 35 | 19.54 | 21.31 | 20.60 | 20.97 | 20.78 | 1.8 | 0.7 | 0.3 | 0.5 |
| 9/2 | | 446 | 859 | 1180 | 2040 | 3020 | 15 | 39 | 20.00 | 21.24 | 20.79 | 20.81 | 20.50 | 1.2 | 0.5 | 0.4 | 0.7 |
| 9/3 | | 458 | 843 | 1180 | 2110 | 3160 | 14 | 37 | 20.17 | 20.90 | 20.68 | 20.50 | 20.12 | 0.7 | 0.2 | 0.4 | 0.8 |
| 9/4 | | 456 | 844 | 1180 | 2120 | 3160 | 14 | 37 | 20.06 | 20.63 | 20.47 | 20.35 | 19.92 | 0.6 | 0.2 | 0.3 | 0.7 |
| 9/5 | | 456 | 839 | 1180 | 2120 | 3160 | 14 | 37 | 19.84 | 20.33 | 20.19 | 20.40 | 20.02 | 0.5 | 0.1 | -0.1 | 0.3 |
| 9/6 | | 466 | 838 | 1170 | 2120 | 3150 | 15 | 37 | 19.81 | 20.28 | 20.15 | 20.25 | 20.03 | 0.5 | 0.1 | 0.0 | 0.3 |
| 9/7 | | 476 | 840 | 1180 | 2120 | 3150 | 15 | 37 | 19.82 | 20.44 | 20.26 | 20.27 | 20.07 | 0.6 | 0.2 | 0.2 | 0.4 |
| 9/8 | | 473 | 856 | 1180 | 2120 | 3150 | 15 | 37 | 19.89 | 20.43 | 20.22 | 19.89 | 19.40 | 0.5 | 0.2 | 0.5 | 1.0 |
| 9/9 | | 475 | 851 | 1170 | 2130 | 3170 | 15 | 37 | 19.14 | 19.87 | 19.59 | 19.42 | 19.09 | 0.7 | 0.3 | 0.4 | 0.8 |
| 9/10 | | 475 | 848 | 1180 | 2110 | 3160 | 15 | 37 | 18.55 | 19.41 | 19.10 | 19.12 | 18.74 | 0.9 | 0.3 | 0.3 | 0.7 |
| 9/11 | | 475 | 856 | 1170 | 2140 | 3190 | 15 | 37 | 18.17 | 18.86 | 18.61 | 19.03 | 18.80 | 0.7 | 0.2 | -0.2 | 0.1 |
| 9/12 | | 475 | 866 | 1170 | 2150 | 3220 | 15 | 36 | 18.09 | 18.61 | 18.43 | 18.73 | 18.59 | 0.5 | 0.2 | -0.1 | 0.0 |
| 9/13 | | 475 | 864 | 1180 | 2140 | 3190 | 15 | 37 | 17.97 | 18.42 | 18.27 | 18.64 | 18.49 | 0.4 | 0.1 | -0.2 | -0.1 |
| 9/14 | | 477 | 859 | 1180 | 2130 | 3120 | 15 | 38 | 17.99 | 18.46 | 18.29 | 18.52 | 18.38 | 0.5 | 0.2 | -0.1 | 0.1 |
| 9/15 | | 476 | 854 | 1180 | 2110 | 3110 | 15 | 38 | 18.13 | 18.61 | 18.45 | 18.65 | 18.44 | 0.5 | 0.2 | 0.0 | 0.2 |
| 9/16 | | 478 | 849 | 1180 | 2110 | 3100 | 15 | 38 | 17.82 | 18.26 | 18.10 | 18.37 | 18.21 | 0.4 | 0.2 | -0.1 | 0.1 |
| 9/17 | < After Pulse[a] > | 478 | 860 | 1180 | 2150 | 3170 | 15 | 37 | 17.75 | 18.26 | 18.11 | 18.31 | 18.10 | 0.5 | 0.2 | -0.1 | 0.2 |
| 9/18 | | 480 | 871 | 1170 | 2150 | 3210 | 15 | 36 | 17.66 | 18.44 | 18.17 | 18.47 | 18.20 | 0.8 | 0.3 | 0.0 | 0.2 |
| 9/19 | | 480 | 869 | 1180 | 2130 | 3190 | 15 | 37 | 17.62 | 18.48 | 18.16 | 18.55 | 18.38 | 0.9 | 0.3 | -0.1 | 0.1 |
| 9/20 | | 480 | 859 | 1180 | 2120 | 3160 | 15 | 37 | 17.84 | 18.52 | 18.29 | 18.63 | 18.42 | 0.7 | 0.2 | -0.1 | 0.1 |
| 9/21 | | 479 | 843 | 1180 | 1,970 | 3130 | 15 | 38 | 18.07 | 18.50 | 18.35 | 18.59 | 18.33 | 0.4 | 0.1 | -0.1 | 0.2 |
| 9/22 | | 478 | 836 | 1180 | 1,940 | 3090 | 15 | 38 | 17.96 | 18.44 | 18.30 | 18.55 | 18.33 | 0.5 | 0.1 | -0.1 | 0.1 |
| 9/23 | | 477 | 825 | 1180 | 1,920 | 3000 | 16 | 39 | 17.68 | 18.22 | 18.03 | 18.32 | 18.17 | 0.5 | 0.2 | -0.1 | 0.1 |
| 9/24 | | 477 | 820 | 1180 | 1,930 | 2980 | 16 | 40 | 16.75 | 17.53 | 17.26 | 17.79 | 17.65 | 0.8 | 0.3 | -0.3 | -0.1 |
| 9/25 | | 474 | 823 | 1180 | 1,930 | 3000 | 16 | 39 | 16.30 | 17.03 | 16.81 | 17.26 | 17.19 | 0.7 | 0.2 | -0.2 | -0.2 |
| 9/26 | | 476 | 818 | 1180 | 1,920 | 3020 | 16 | 39 | 15.77 | 16.20 | 16.09 | 16.65 | 16.61 | 0.4 | 0.1 | -0.5 | -0.4 |
| 9/27 | | 474 | 822 | 1180 | 1,920 | 3020 | 16 | 39 | 15.69 | 15.92 | 15.84 | 16.43 | 16.33 | 0.2 | 0.1 | -0.5 | -0.4 |
| 9/28 | | 474 | 818 | 1190 | 1,920 | 3040 | 16 | 39 | 15.93 | 16.11 | 16.09 | 16.34 | 16.24 | 0.2 | 0.0 | -0.2 | -0.1 |
| 9/29 | | 473 | 813 | 1180 | 1,910 | 3040 | 16 | 39 | 16.18 | 16.46 | 16.38 | 16.63 | 16.46 | 0.3 | 0.1 | -0.2 | 0.0 |
| 9/30 | | 472 | 808 | 1180 | 1,890 | 3050 | 15 | 39 | 16.61 | 16.94 | 16.83 | 17.01 | 16.86 | 0.3 | 0.1 | -0.1 | 0.1 |
| 10/1 | | 471 | 810 | 1340 | 1,870 | 3060 | 15 | 44 | 17.11 | 17.28 | 17.25 | 17.46 | 17.31 | 0.2 | 0.0 | -0.2 | 0.0 |
| 10/2 | | 476 | 818 | 1360 | 1,990 | 3140 | 15 | 43 | 15.80 | 16.42 | 16.24 | 16.57 | 16.40 | 0.6 | 0.2 | -0.2 | 0.0 |
| 10/3 | | 474 | 864 | 1350 | 2,140 | 3490 | 14 | 39 | 15.10 | 15.69 | 15.54 | 15.97 | | 0.6 | 0.2 | -0.3 | |
| 10/4 | | 477 | 891 | 1350 | 2,190 | 3750 | 13 | 36 | 14.51 | 14.73 | 14.65 | 15.55 | | 0.2 | 0.1 | -0.8 | |
| 10/5 | | 481 | 890 | 1350 | 2,130 | 3710 | 13 | 36 | | | | 14.92 | | | | | |
| 10/6 | | 466 | 888 | 1350 | 2,100 | 3620 | 13 | 37 | | | | | | | | | |

a = pulse flow timing varies with gage location.
b = contributions do not reflect travel time issues.