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The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2004

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Abstract. Water temperatures of the Trinity River below Lewiston Dam and the Klamath River below the confluence of the Trinity River were monitored between April 15 and October 15 to evaluate the influence of prescribed flow releases from Lewiston Dam on downstream water temperature objectives. The flow prescription for the time period of April 15 to July 9 was successful at maintaining a relatively cool river, but it was not sufficient to prevent exceeding the optimal temperature objective at Weitchpec (178 kilometers below Lewiston Dam) in April, early-and mid-May, and mid-June through July 9 during periods of warm ambient air temperatures. The prescribed flow was responsible for maintaining the thermal regime of the Trinity River up to 3.9 ˚C colder than the Klamath River and also acted to decrease water temperatures of the Klamath River below the confluence by up to 2.2 ˚C. The flow prescription for 450 cfs or greater from July 1 and October 15 were adequate to meet the temperature objectives of the Basin Plan of the North Coast Regional Water Quality Control Board from July 1 through October 15.

INTRODUCTION

Flow and water temperatures of the Trinity River mainstem changed appreciably when the Trinity River Division (TRD) of the Central Valley Project was completed and the Trinity River was dammed in 1963 at a location 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 acts to moderate extremes in water temperatures throughout the year. During the fall and winter months, water temperatures in the vicinity of Lewiston Dam have become warmer and from early summer to early fall, water temperatures have become cooler when compared to pre-dam conditions.

Areas further downstream 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 the 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 the TRD, the controlled lower river flow has resulted in a thermal regime that is typically warmer and more susceptible to change due to ambient air temperatures.

In 1991, the North Coast Regional Water Quality Control Board (NCRWQCB) formally adopted water temperature objectives for the 64 kms 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 throughout the 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 2004, Lewiston Dam releases included a constant flow of 2,000 cfs from June 10 to July 9 to meet the spring-time criteria.

In the late summer 2004, about 37 thousand acre-feet of additional water was released from Lewiston Dam to augment flow of the Klamath River to potentially avert another large-scale die-off of adult Chinook salmon in the lower Klamath River similar to that observed in 2002. Flow augmentation included releases that ranged from 1,700 to 1,000 cfs from August 23 to September 11, when dam releases would typically be 450 cfs. Although no specific temperature criteria were targeted for this time period, it was predicted that the flow augmentation release reduced temperatures of the Trinity River and lower Klamath River based on similar releases in past years (Zedonis 2004).

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 had on water temperatures of the Trinity River below Lewiston Dam and the lower Klamath River below Weitchpec from mid-April to mid-October in 2004.

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 for the 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. 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, namely air temperatures and hydrology. Estimates of river flow at several sites on the Trinity and Klamath rivers were obtained from CDEC and U.S. Geological Survey (http://water.usgs.gov) websites.

RESULTS

Hydrology

In water year (WY) 2004 approximately 768 thousand acre-feet (TAF) of water was released from Lewiston Dam to the Trinity River. The total was comprised of 647 TAF to support base flow conditions for a Normal water year, including peak spring flows of about 6,000 cfs, base summer/early fall flows of 450 cfs, and base winter and spring flow of 300 cfs (Figure 2). It also included about 84 TAF that the U.S. Bureau of Reclamation released in February to reduce storage in Trinity Reservoir for dam safety purposes, and 37 TAF for flow augmentation to the Klamath River during the late summer to potentially avert another large-

scale die-off of adult Chinook salmon in the lower Klamath River similar to that observed in 2002.

Due to dry hydrologic conditions in the Klamath River basin from May through July, the contribution of flow from the Trinity River to the lower Klamath River was relatively large (Figure 2). Beginning in May, flow at Hoopa was largely comprised of flow from Lewiston Dam, which indicated relatively little flow contributions from the tributaries between Lewiston and Hoopa. During April and May, the largest contributions from tributaries between these gages accounted for about 3,500 cfs. Similar to the spring months, releases from Lewiston Dam comprised a high percentage of total flow of the lower Trinity River and the lower Klamath River during early July and late August to early September, when tributary contributions were decreased.

Contributions of flow from the Trinity River to the total flow of the Klamath River at the Klamath gage site varied throughout the spring and early summer (Appendix A) and late summer and early fall (Appendix B). For example, on June 10 and July 9 Lewiston Dam releases represented 27% and 37% of the flow at Klamath (rkm 10.8). From mid-July to August 23, base summer flow releases of 450 cfs from Lewiston Dam accounted for 15 to 20 % of the total flow at Klamath. From August 23 to September 16, a time when additional flows were released from both Lewiston and Iron Gate Dams, contributions of flow from Lewiston became more prominent increasing to a peak of greater than 50 % on or about August 23 and steadily decreased thereafter.

A comparison of the spring flows that occurred in 2004 with those recommended in the ROD for Normal and Wet water years is shown in Figure 3. This graphic illustrates that the peak flow of approximately 6,000 cfs occurred about nine days later than originally identified in the ROD and closely mimicked that of the Wet water year type until late July.

Peak flows of the Klamath River at Iron Gate Dam (rkm 305.4) and Orleans (rkm 95.1), and at Klamath (rkm 10.8) occurred in mid-February, although the magnitude of change that occurred at Iron Gate Dam was much smaller than at Orleans and Klamath gages

located further downstream in the watershed (Figure 4). Flow at the Orleans gage, representing flow of the Klamath River prior to mixing with the Trinity River, ranged from 9,000 to 16,000 cfs during April and May and steadily decreased to a minimum of 1,400 cfs in late August.

Water Temperatures of the Mainstem Trinity River

Lewiston Gage (rkm 178.2)

From April to October water temperatures of Lewiston Dam releases remained between 8 and 11.6 ˚C (Figure 5). The warmest release temperatures coincided with times of increased hydraulic residence time of water in Lewiston Reservoir. The effect of increased hydraulic residence time is perhaps best illustrated in late August and mid-September, when relatively a relatively small volume of water was being channeled through Lewiston Reservoir resulting in increased water temperatures (Figure 5). During this time, the water temperature of Lewiston Dam releases increased to a maximum 11.6 ˚C. On August 23 flow from Lewiston Dam increased to approximately 1,660 cfs and diversions through the Carr Tunnel increased to reduce water temperatures of releases to the Trinity River by 1.0 to 1.5 ˚C.

Douglas City Gage (rkm 148.5)

Prior to the peak flow that occurred in mid-May, average daily water temperatures at the Douglas City gage reached 13.2 ˚C (Figure 6). From May 5 to July 9 when dam releases were generally at or above 2,000 cfs, water temperatures were reduced to less than 12.0 ˚C. From July 10 to July 25 dam releases decreased to 450 cfs and average daily water temperatures increased to a maximum of just over 15.0 ˚C, but stayed below 15.6 ˚C maximum average daily temperature objective of the North Coast Regional Water Quality Control Board (NCRWQCB). On August 23, average daily water temperatures decreased from 15.1 to 11.3 ˚C in response to increased flow releases from Lewiston Dam. Upon returning to base flows of 450 cfs on September 15, water temperatures increased slightly but remained below the NCRWQCB objectives.

Pear Tree Gulch (rkm 117.6)

Average daily water temperatures at Pear Tree Gulch were generally elevated in comparison to the Douglas City site. Increased flow from Lewiston Dam that occurred from mid- May to July 10 and August 23 to September 13 resulted in a notable decrease in the water temperature at

this site (Figure 7). From mid-May to July 9, the average daily water temperature was less than 13.5 ˚C. Following the spring release, water temperatures increased to a maximum of 18.5˚C on July 27.

The increased flow from Lewiston Dam that occurred from August 24 to September 16 also reduced water temperatures measured at Pear Tree Gulch (Figure 7). On or about August 23, water temperatures at this site decreased from 18.0 to below 13.0 ˚C and remained near 13.0 ˚C until mid-September when flows were reduced to 450 cfs. From mid-September to early October temperatures were generally less than 14 ˚C, with the exception of September 14 to 18 when temperatures were between 14 and 15 ˚C. During the first 5 days of October, water temperatures were as warm as 13.6˚C, which is slightly greater than the NCRWQCB temperature objective of 13.3 ˚C.

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

Similar to temperature monitoring sites between Lewiston (rkm 178.2) and Pear Tree Gulch (rkm 117.6), Lewiston Dam releases that occurred from mid-May to July 15 and from August 24 to September 16 had a distinct influence on water temperatures in this region of river (Figure 8). The release of 6,000 cfs from Lewiston that occurred in mid-May resulted in average daily water temperatures less than 14 ˚C. Following the down-ramping of flow to 2,000 cfs, water temperatures steadily warmed to 18.0˚C on June 17 at Weitchpec. The Lewiston Dam release of 2,000 cfs that occurred from June 17 to July 9 resulted in average daily water temperatures at Weitchpec between 17.8 and 19.6˚C. When Lewiston Dam releases were reduced to 450 cfs in mid-July, the average daily water temperatures of the entire reach increased rapidly, with the lower most site (TR @ rkm 0.1) exhibiting the greatest increase (24.3 ˚C). From mid-July to August 22, water temperatures at this lower most site were between 21 to 24 ˚C. From August 23 to 26, when Lewiston Dam releases were again increased, water temperatures decreased to below 19.0˚C. From August 27 to October 15 water temperatures were generally below 18.0˚C.

The spring time temperature criteria were not always met from April 15 to July 9 (Figure 9). Periodically the average daily water temperature at Weitchpec exceeded the optimal criteria and fell into the marginal zone, but never entered the unsuitable zone. Time periods that the average daily water temperatures exceeded the optimal temperature criteria

included April, early-and mid-May, and mid-June through July 9. Graphical examination of air and water temperature data revealed a positive association between the warmest time periods and times of temperature exceedence (see Figure 10).

Water Temperatures of the Klamath River

Spring and Early Summer

Average daily water temperatures of the Trinity River at Weitchpec were colder than the Klamath River from June 10 to mid-July (Figure 11, Appendix A). In mid-June, the Trinity River was between 1.0 to 1.5 ˚C colder than the Klamath and reached a maximum temperature difference of 3.9 ˚C on July 6. From July 9 to July 20, the Trinity River steadily warmed and temperature differences decreased as flow was reduced from Lewiston Dam. When 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, significant reductions in temperature were observed in the lower reaches of the Klamath River (Figure 11). The relative difference in water temperatures between the Klamath River at Weitchpec (rkm 70.2) and downstream sites (i.e., rkm 62.0 and 10.8) ranged between 0.3 and 1.7 ˚C from June 10 to June 30 and 1.2 to 2.2˚C from July 1 to July 9. The greatest temperature reductions occurred from July 5 to 8 when: 1) the Trinity River water was coldest relative to the Klamath River; 2) flow contributions from the Trinity River was greatest, and 3) ambient air temperatures were relatively high (Figure 12).

Late Summer Pulse Flow

The increased flow from Lewiston Dam that occurred from August 23 to September 12 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 on about August 24, water temperatures of the Trinity River were 0.5 ˚C colder than the Klamath River. During the period of increased flow at Weitchpec between August 26 to September 15, water temperatures of the Trinity River became 1.8 to 3.5 ˚C colder than the Klamath River. Again, the greatest reductions in temperature in the lower Klamath River occurred when the Trinity River was coldest relative to the Klamath River, and air

temperatures were warmest (Figure 14). Upon returning to base summer flows of 450 cfs after September 15, water temperatures of the Trinity River became less than 0.7 ˚C colder than the Klamath River.

The increased flow that occurred from August 23 to September 12 decreased water temperatures in the Klamath River at sites below the confluence (Figure 14, Appendix B) compared to sites on the Klamath River above the confluence. Prior to the arrival of the pulse flow (August 15 to August 22), differences in water temperature between the Klamath River located above the confluence and below the confluence at rkm 62.0 and rkm 10.8 were less than 0.2 and 1.7 ˚C. In contrast, during the pulse flows arrival (August 26 to September 15) water temperatures were further reduced at these sites. The greatest temperature change occurred from about August 26 through the first week in September, a time period when the water temperatures of the Trinity River were coolest relative to temperatures measured in the Klamath River above the confluence with the Trinity River. During this time, water temperatures at rkm 62.0 and rkm 10.8 were up to 1.6˚C colder than those measured in the Klamath River above the confluence. After the pulse flow (September 16 to September 30) water temperature differences between rkm 70.2 and downstream sites lessened to generally less than 0.2 ˚C at rkm 62.0 and 0.8 ˚C at rkm 10.8.

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 meteorologic 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). When hydraulic residence time in Lewiston Reservoir is increased, water temperatures increase. These colder releases generally result in cooler temperatures in downriver reaches. 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 releases and ambient

meteorological conditions become increasingly important to river temperatures with increasing distance downriver.

For all practical purposes, the NCRWQCB temperature objectives appear to have been met at all times during the summer and early fall. Only in early October was exceedence of the objective at the confluence of the North Fork Trinity River confluence possibly in question. During this time the average daily temperature was exceeded by 0.3 ˚C, a magnitude that probably falls within the error of the instrumentation used to measure temperatures. Examination of probable causes for approaching the objective was warm ambient meteorological conditions. Other factors implicated in not meeting this objective in 2002 (Zedonis 2003) and 2003 (Zedonis 2004) included a flow magnitude less than 450 cfs from Lewiston Dam and dam release temperatures greater than 10.0 ˚C, both of which were adequate in 2004.

The reasons for periodically exceeding the Trinity River ROD optimal temperature criteria from April to July at Weitchpec included warm air temperatures and relatively small contributions of flow from Lewiston Dam and tributaries (Figures 9 and 10). In combination, these factors acted synergistically to allow for rapid heat gain. The marked increase in average daily water temperature from 9.8 to 14.5 ˚C that occurred at Weitchpec from April 21 to 27 is a good example. During this time, average daily air temperatures were above normal and flow contributions from tributaries and Lewiston Dam were relatively small, allowing for rapid heat gain. Increasing flow from Lewiston Dam to levels greater than those that occurred (e.g.300 cfs) would have helped moderate water temperature extremes and prevent exceedance of the temperature criteria.

The increased Lewiston Dam releases that occurred from August 23 to September 12 had a large influence on water temperatures in both the Trinity and Klamath rivers. Compared to the spring and early summer releases, increased flows that occurred during this time period had a greater effect on downstream reaches. In this case, temperature differences between the Trinity River and Klamath River were as great as 3.9 ˚C. This difference can most likely be attributed to relatively little accretion of warmer water from tributaries during this time of the year and relatively fast travel-time of dam released water to the lower Trinity and Klamath Rivers.

Although Lewiston Dam releases influenced the water temperatures of the Klamath River below the confluence, coastal meteorology also played a role. Cooler air temperatures in this region of the basin helped direct river water temperatures to a new and cooler equilibrium during the summer months. The cooling effect is best illustrated in mid-August (Figure 14) when water temperatures at rkm 10.8 are colder than at the upriver site located at rkm 70.2. During this time, flow conditions were stable and air temperatures at Klamath (rkm 10.8) where colder than the upriver site.

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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) • Lewiston to DouglasCity (rkm 178.2 to 148.5) • Lewiston to the Confluence of the North Fork Trinity River Confluence (rkm 178.2 to 117.6)	All Years • July 1 to September 15 • September 15 to September 30 • October 1 to December 31	≤ 15.5 ≤ 13.3 ≤ 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: • April 15 to May 22 • May 23 to June 4 • June 5 to July 9 Dry and Critically Dry Water Years: • April 15 to May 22 • May 23 to June 4 • June 5 to June 15	 ≤ 13.0 ≤ 15.0 ≤ 17.0 ≤ 15.0 ≤ 17.0 ≤ 20.0

1 = Average daily water temperature in degrees Centrigrade

Table 2. Water temperature monitoring sites of the Trinity River and the Klamath River below Weitchpec, 2004. Note: Not all data presented here is presented in the report but is 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	Hoopa Valley Tribe (HVT)
TR @ Douglas City Gage (DGC)	148.5	CDEC	HVT
TR above Canyon Ck (TCN)	127.4	FWS	FWS
TR @ Pear Tree Gulch Gage (PTG)	117.6	CDEC	US. Bureau of Reclamation
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) [d]	50.6	FWS	FWS
TR @ Willow Ck Trap Site (WLC)	37.0	FWS	FWS
TR @ Hoopa Gage (HPA)	20.0	CDEC	US Geological Survey
TR @ Weitchpec (TR)	0.1	FWS	FWS/Yurok Tribe
Mainstem Klamath River			
KR abv. Trinity R (WE) [b]	70.2	FWS	FWS/Yurok Tribe
KR above Tully Ck (TC)	62.0	FWS	FWS/Yurok Tribe
KR @ Coon Creek Falls (KCC)[c]	57.6	Yurok Tribe	Yurok Tribe
KR above Pecwan Ck (KPC) [c]	42.3	Yurok Tribe	Yurok Tribe
KR above Blue Ck (KBC)	26.5	FWS	Yurok/FWS
KR @ Terwer (TG)	10.8	FWS	FWS/Yurok Tribe
Trinity River Tributary Sites			
Rush Ck (RSH)	173.0 + 1.5	FWS	FWS
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 = Probes lost to vandalism

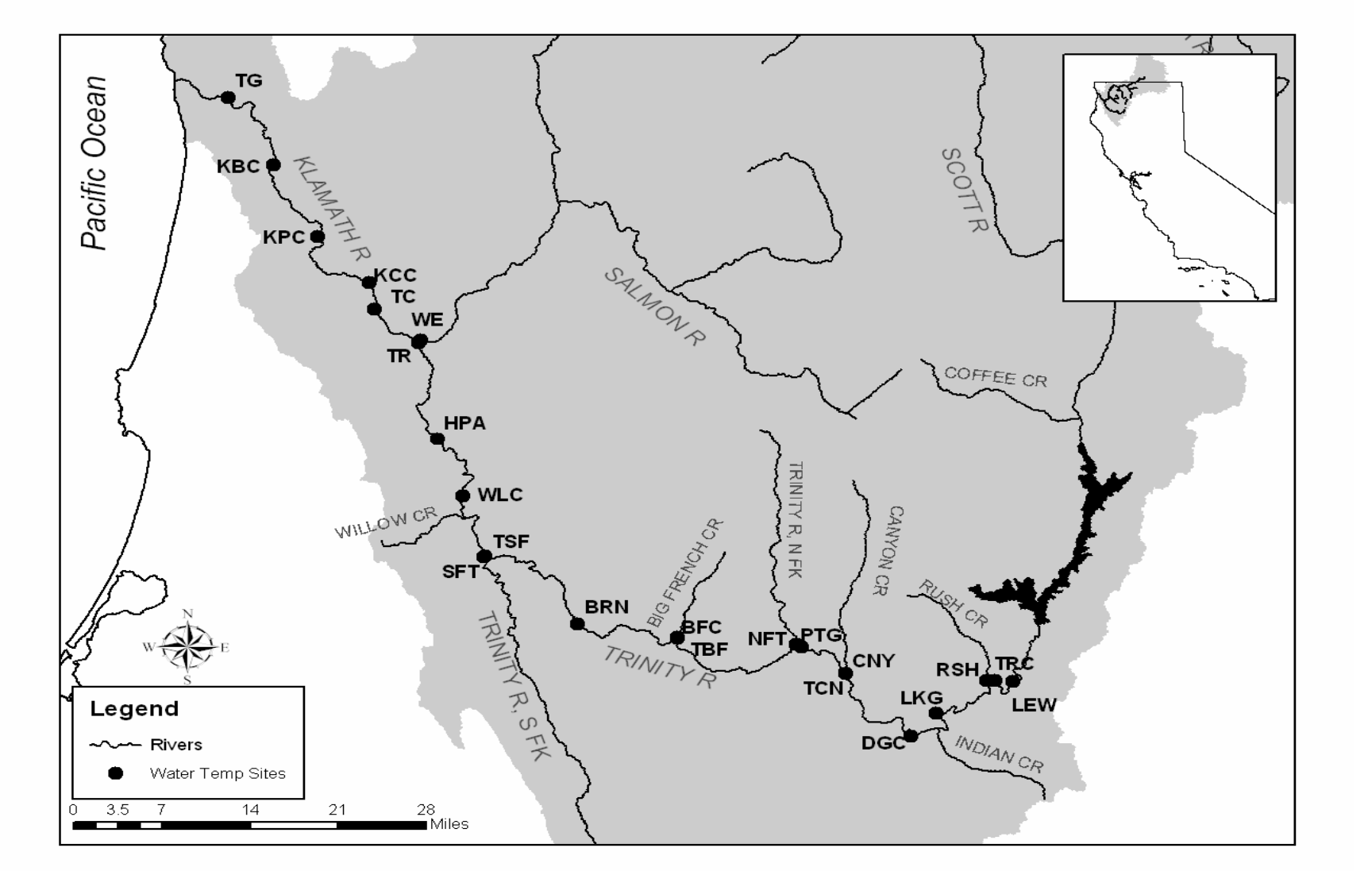

Figure 1. Location of water temperature monitoring sites of the Trinity River and lower Klamath River in 2004. See Table 2 for site descriptions.

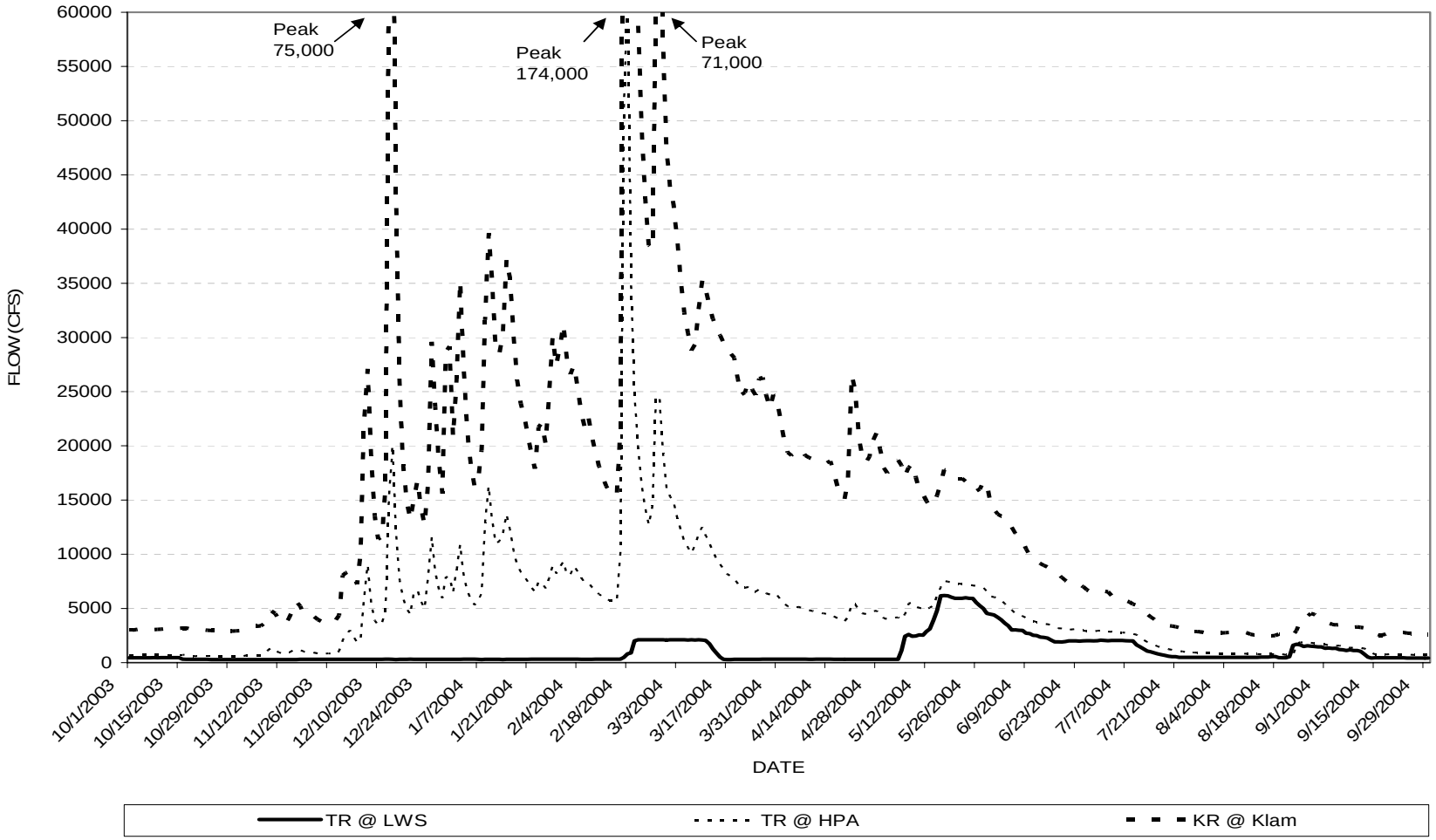

Figure 2. Average daily flow of the Trinity River at Lewiston gage (LWS; rkm 178.2) and Hoopa gage (HPA; rkm 20.0) , and the Klamath River at the Klamath Gage (Klam; rkm 10.8) in 2004. US Geological Survey gage data, preliminary and subject to revision.

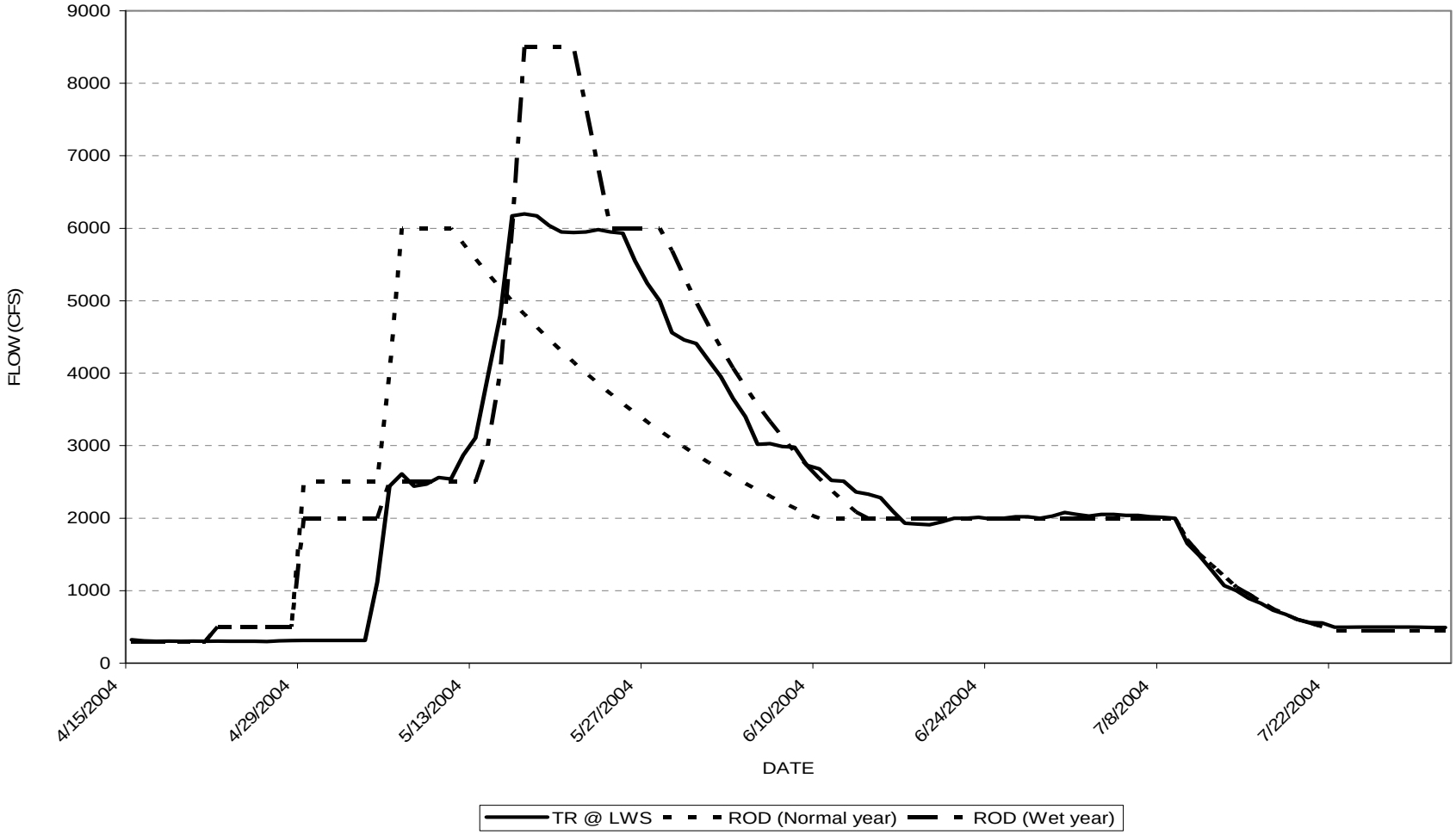

Figure 3. Spring and early summer flow releases from Lewiston Dam in 2004 compared flow schedules of Normal and Wet hydrologic years of the Record of Decision (USFWS et.a., 2000).

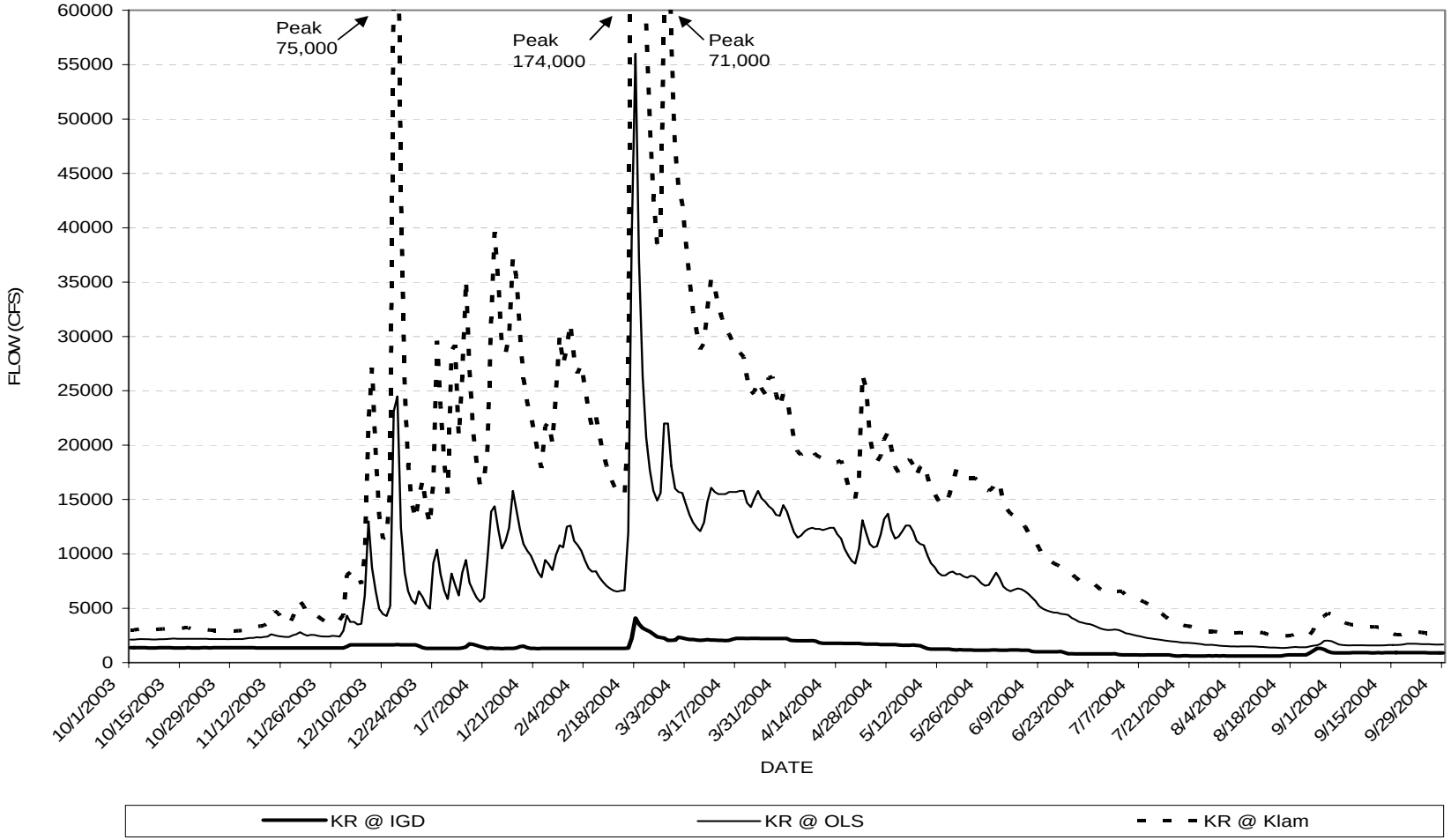

Figure 4. Average daily flow of the Klamath River at Iron Gate Dam (IGD; rkm 305.4), Orleans gage (OLS; rkm 95.1) and the Klamath River at the Klamath Gage (Klam; rkm 10.8). U.S. Geological Survey gage data, preliminary and subject to revision.

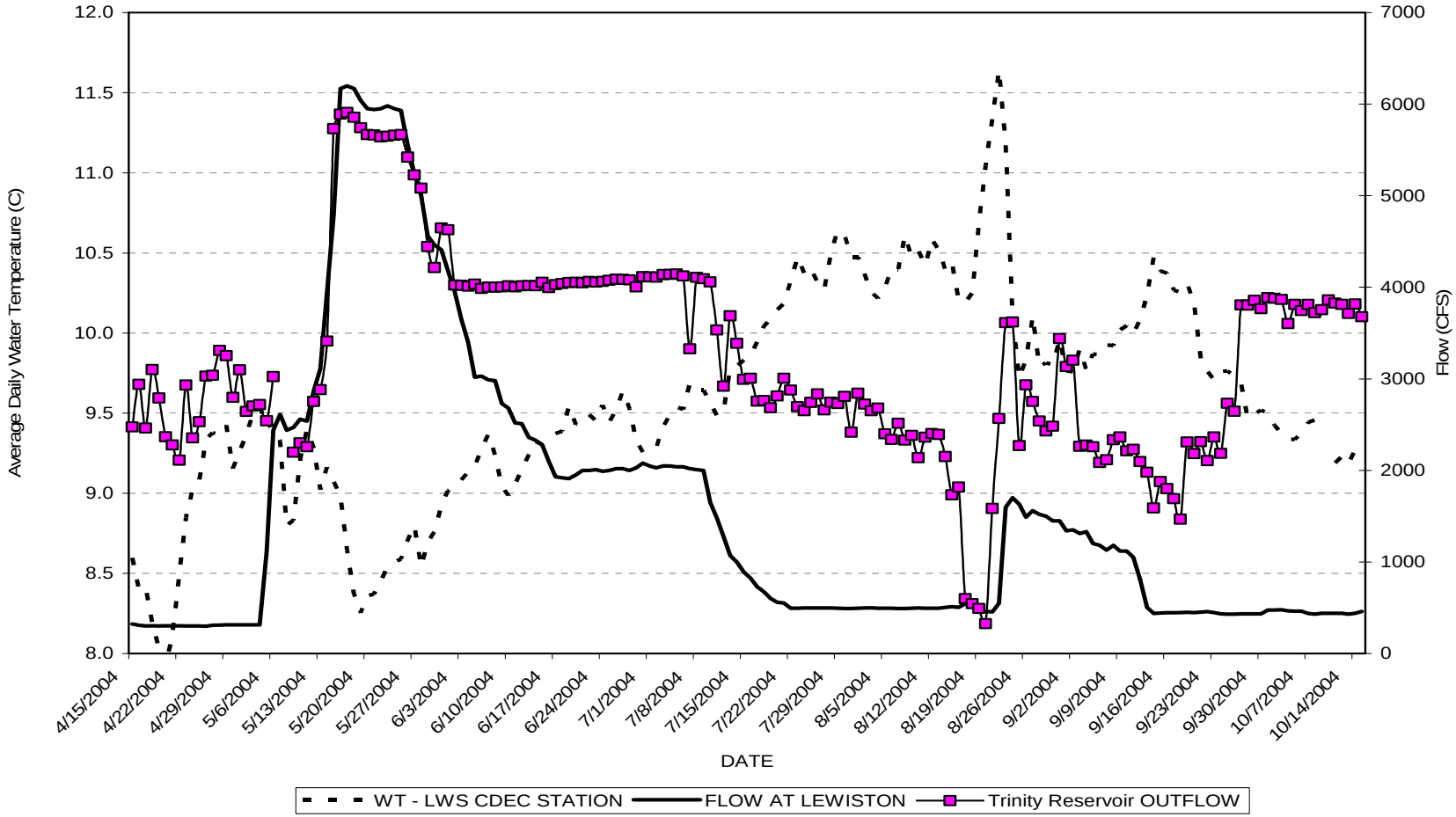

Figure 5. Average daily water temperature (WT) and flow of the Trinity River at Lewiston (LWS) gage (rkm 178.2) and Trinity Reservoir outflow, 2004. Trinity Reservoir outflow is used for releases to the Trinity River as well as diversions to the Sacramento River basin. The area between lines representing Trinity Reservoir outflow and flow at Lewiston represent an estimate of the flow being diverted to the Sacramento River basin

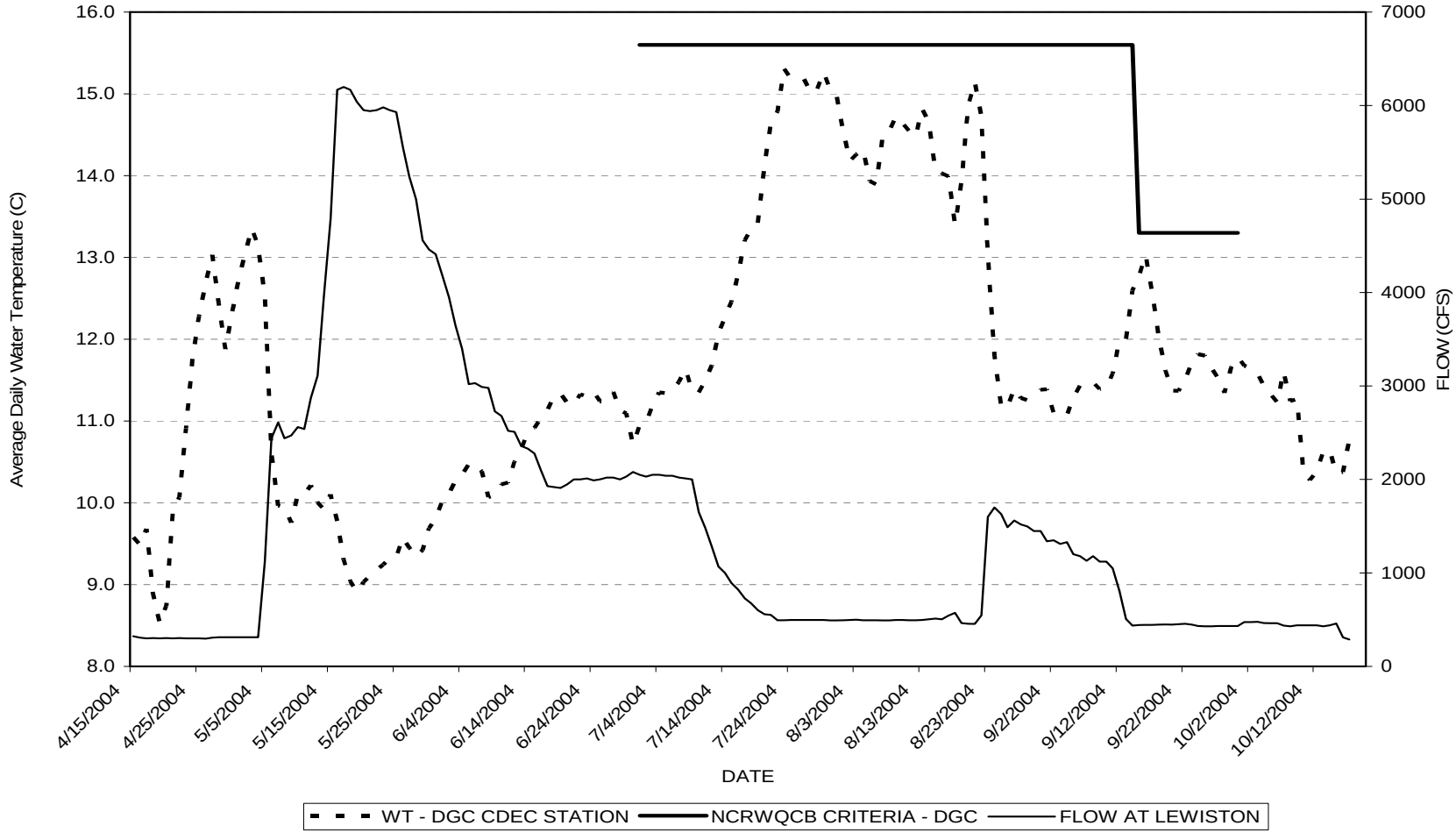

Figure 6. Average daily water temperatures (WT) of the Trinity River at the Douglas City gage (DGC: rkm 148.5) and flow at Lewiston in 2004. Comparisons of water temperature data and the North Coast Regional Water Quality Control Board water temperature objectives.

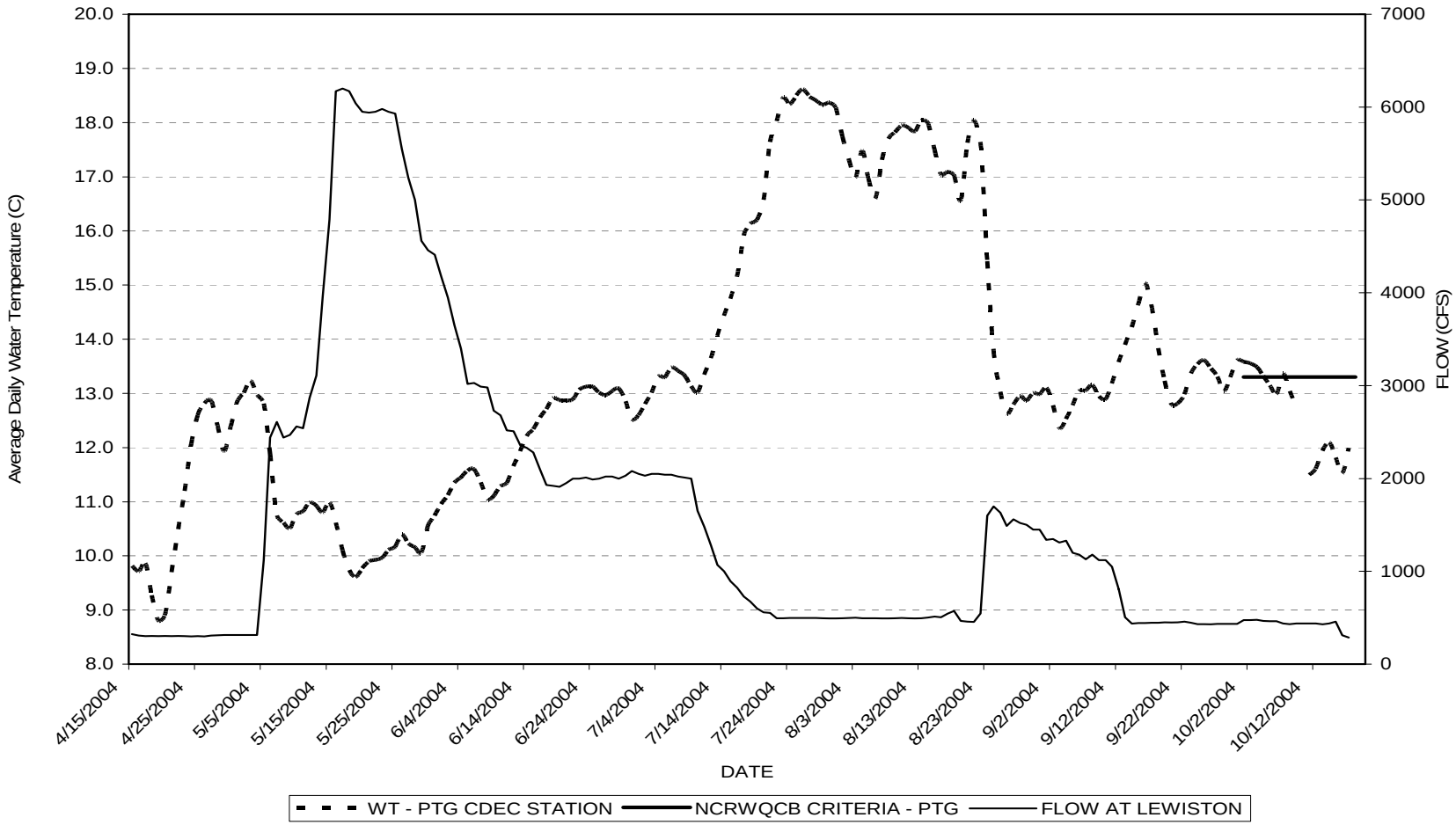

Figure 7. Average daily water temperatures (WT) of the Trinity River at the Pear Tree Gulch (PTG; rkm 117.6) gage and flow at Lewiston in 2004. Comparison of water temperatures and the North Coast Regional Water Quality Control Board temperature objectives after October 1.

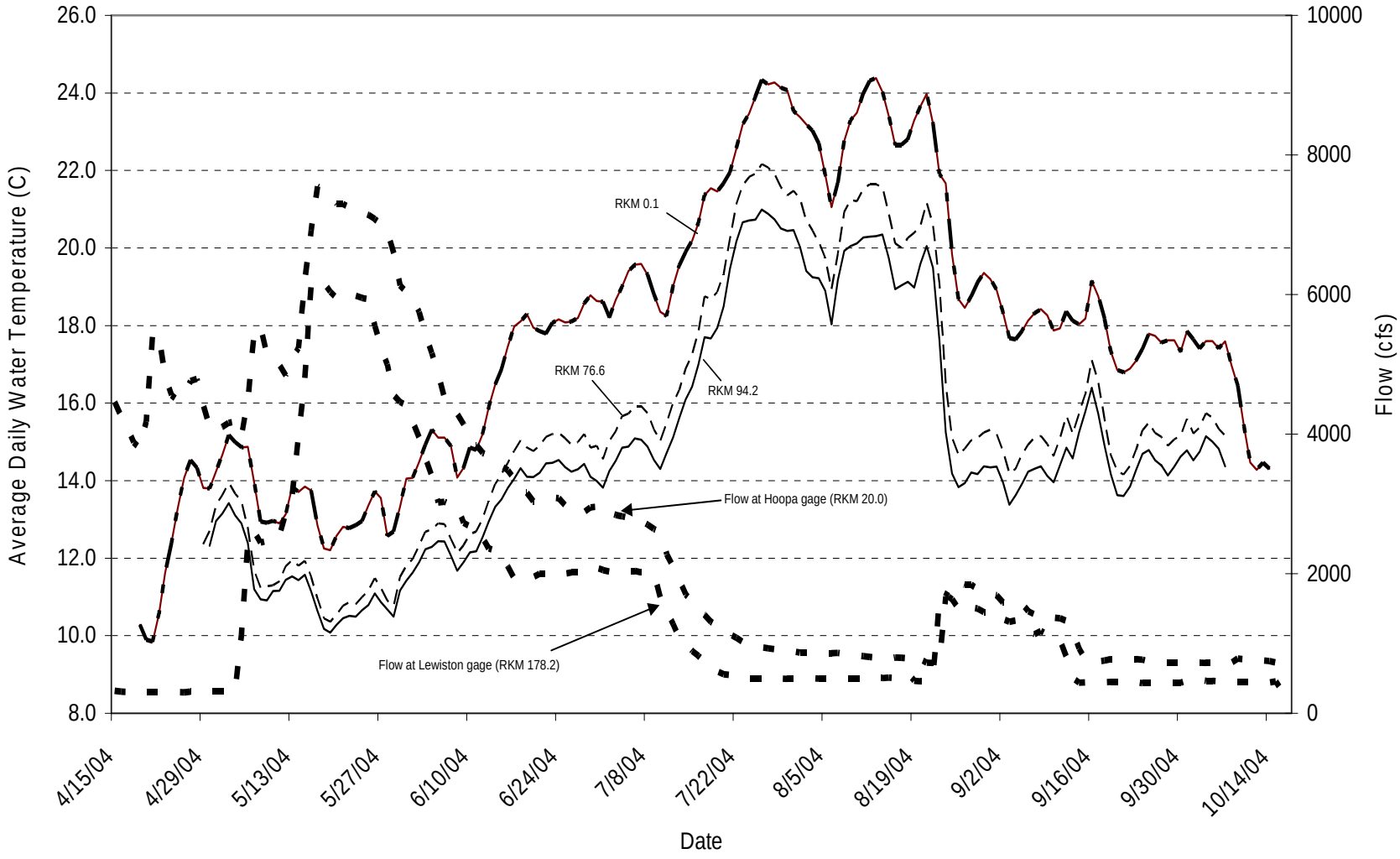

Figure 8. Average daily water temperatures of the Trinity River immediately above Big French Creek (rkm 94.2), Burnt Ranch Transfer Station (rkm 76.4), Weitchpec (rkm 0.1), and flow of the Trinity River at Lewiston and Hoopa gages, 2004.

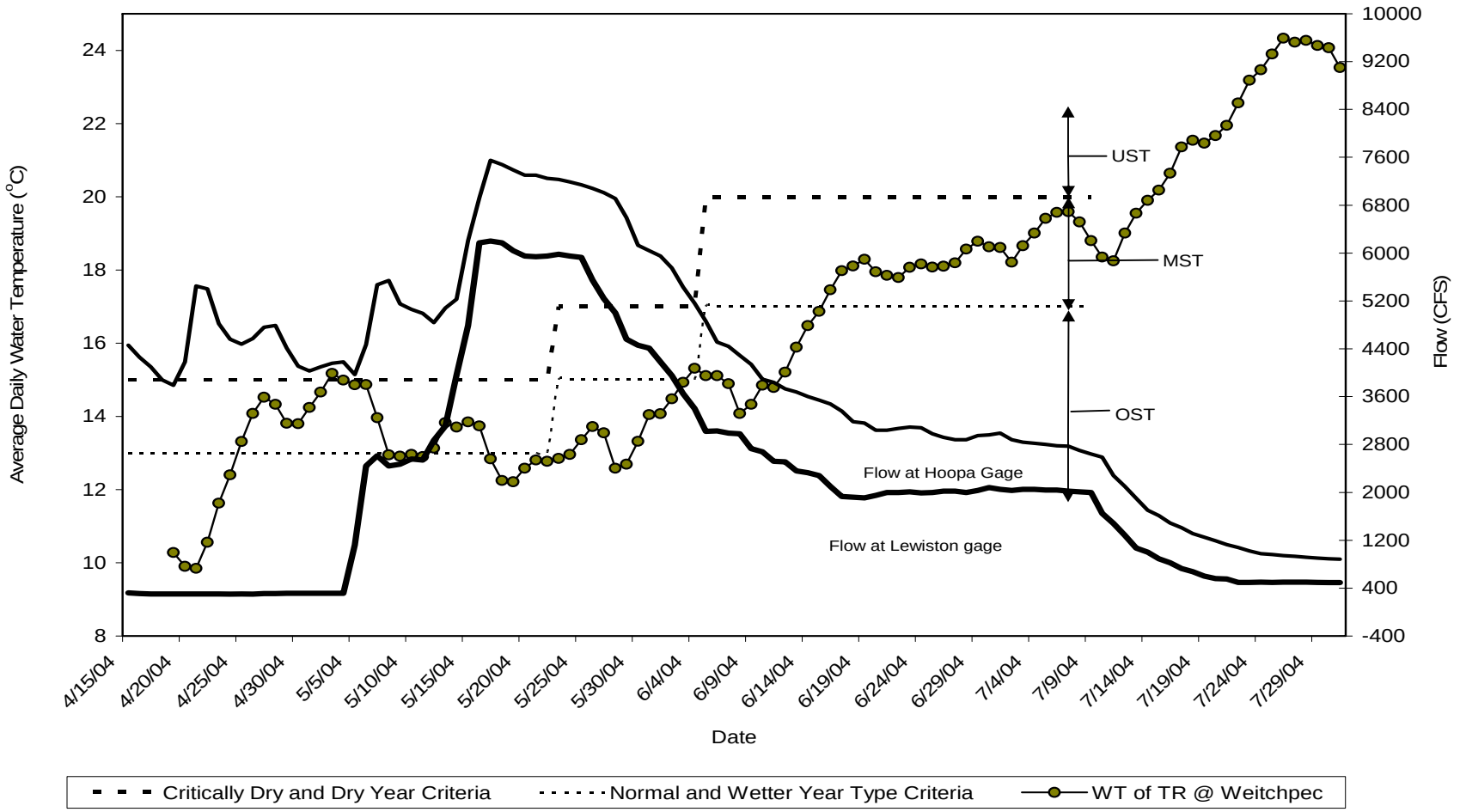

Figure 9. Average daily water temperatures (WT) of the Trinity River at Weitchpec in 2004, and how they compare to the spring-time temperature criteria established by the Record of Decision (USFWS et al., 2000). Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures, OST = Optimally suitable temperatures.

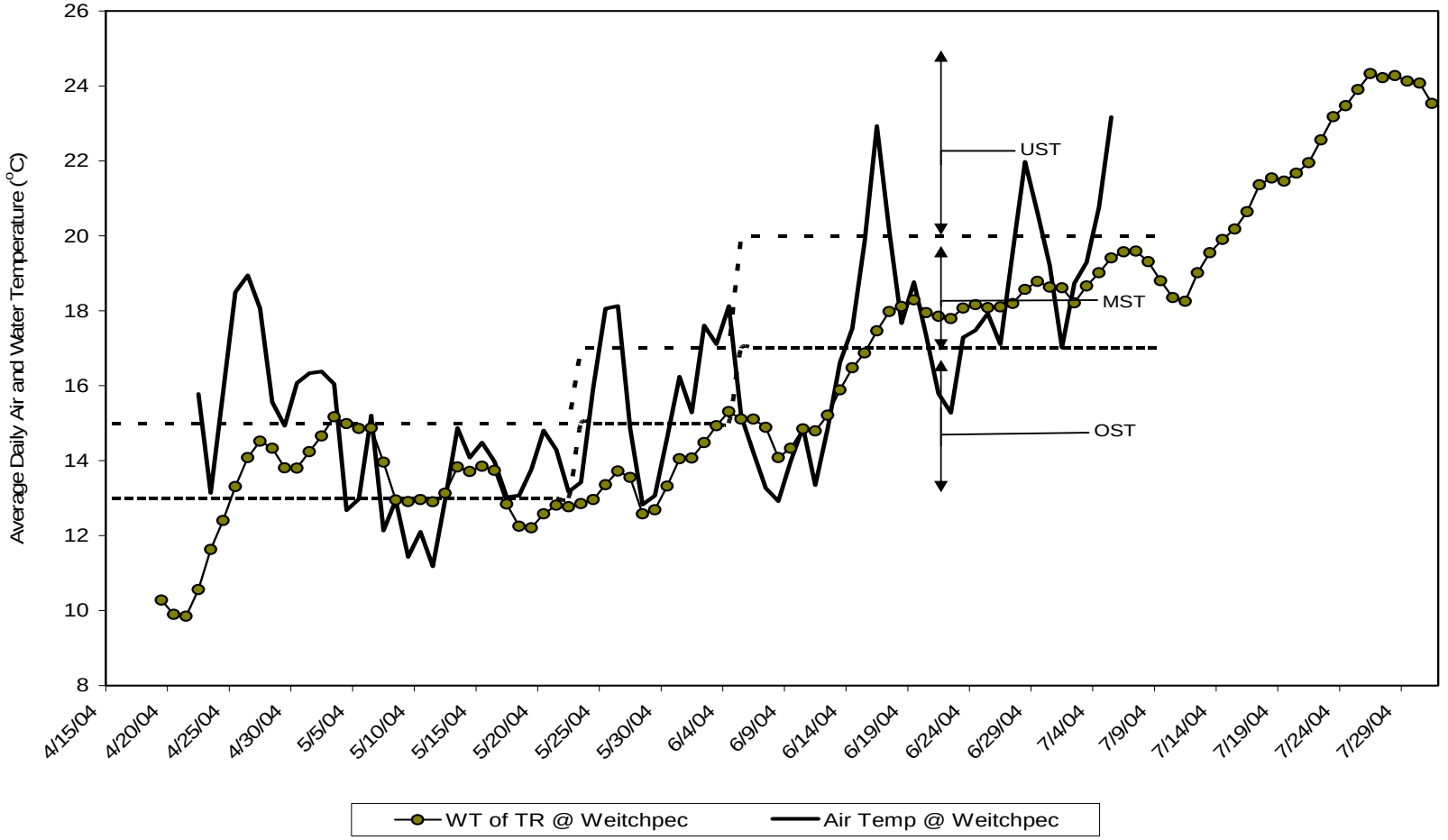

Figure 10. Air temperature and its influence on water temperature (WT) of the Trinity River at Weitchpec from April 15 to July 30, 2004. Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures; OST = Optimally suitable temperatures

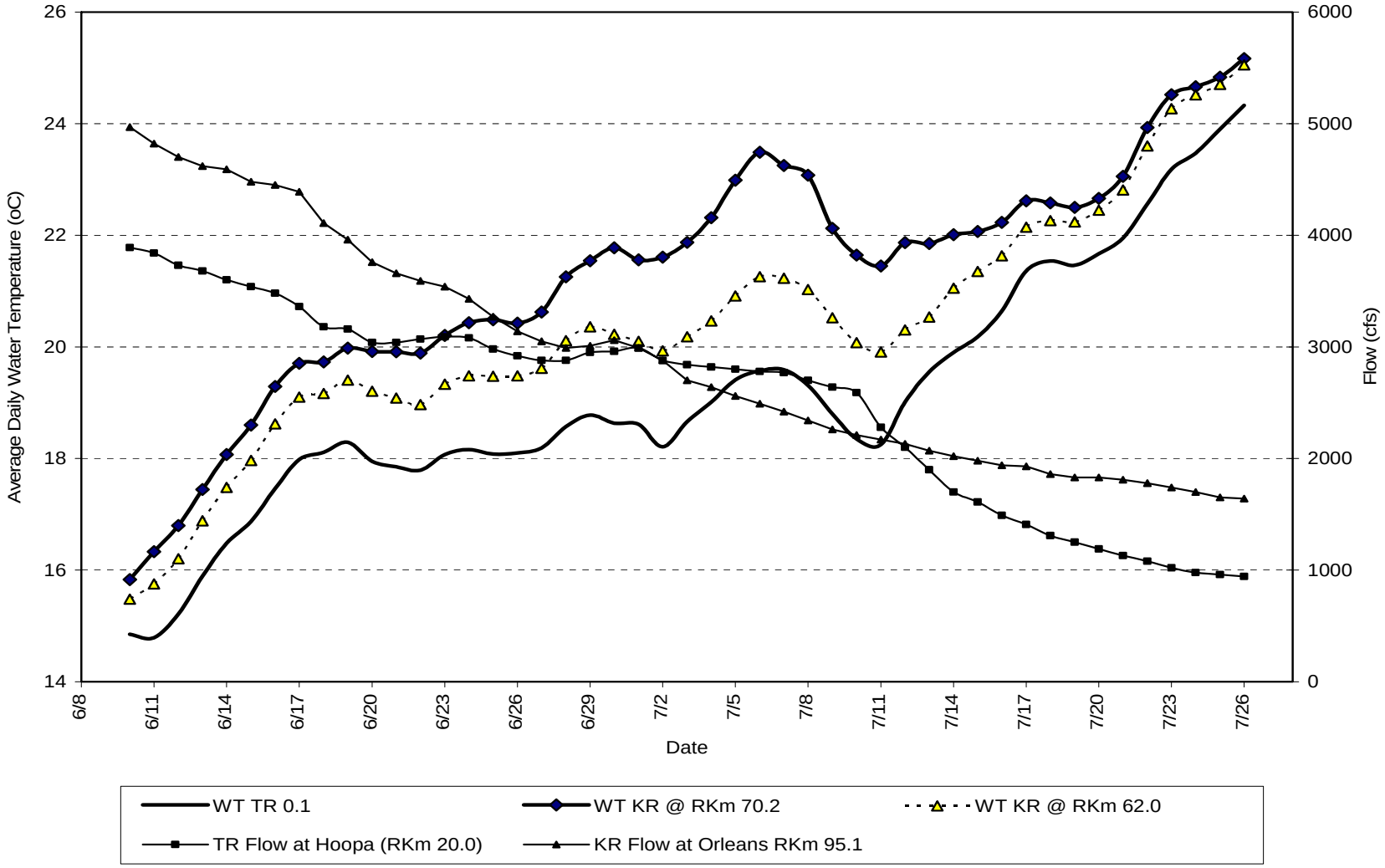

Figure 11. Comparison of water temperatures (WT) of the Trinity River at Weitchpec (rkm 0.1) and the Klamath River above (rkm 70.2) and below (rkm 62.0) the confluence of the Trinity River from June 10 to July 26, 2004.

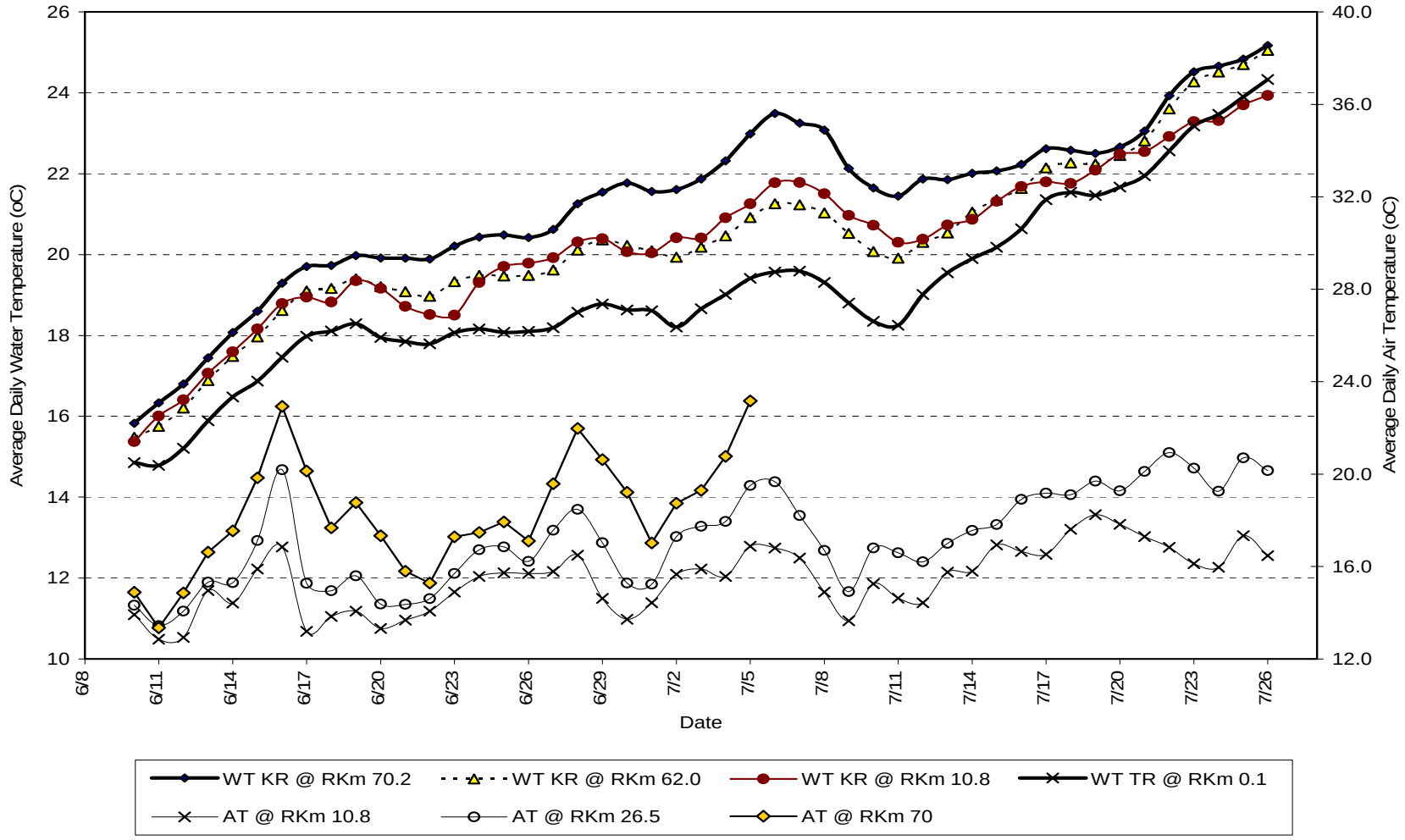

Figure 12. Comparison of average daily water temperatures (WT) of the Trinity River at Weitchpec (rkm 0.1) and the Klamath River above (rkm 70.2) and below the confluence of the Trinity River (rkm 62.0 and 10.8) and air temperatures (AT) from three stations located at or below Weitchpec from June 10 to July 26, 2004.

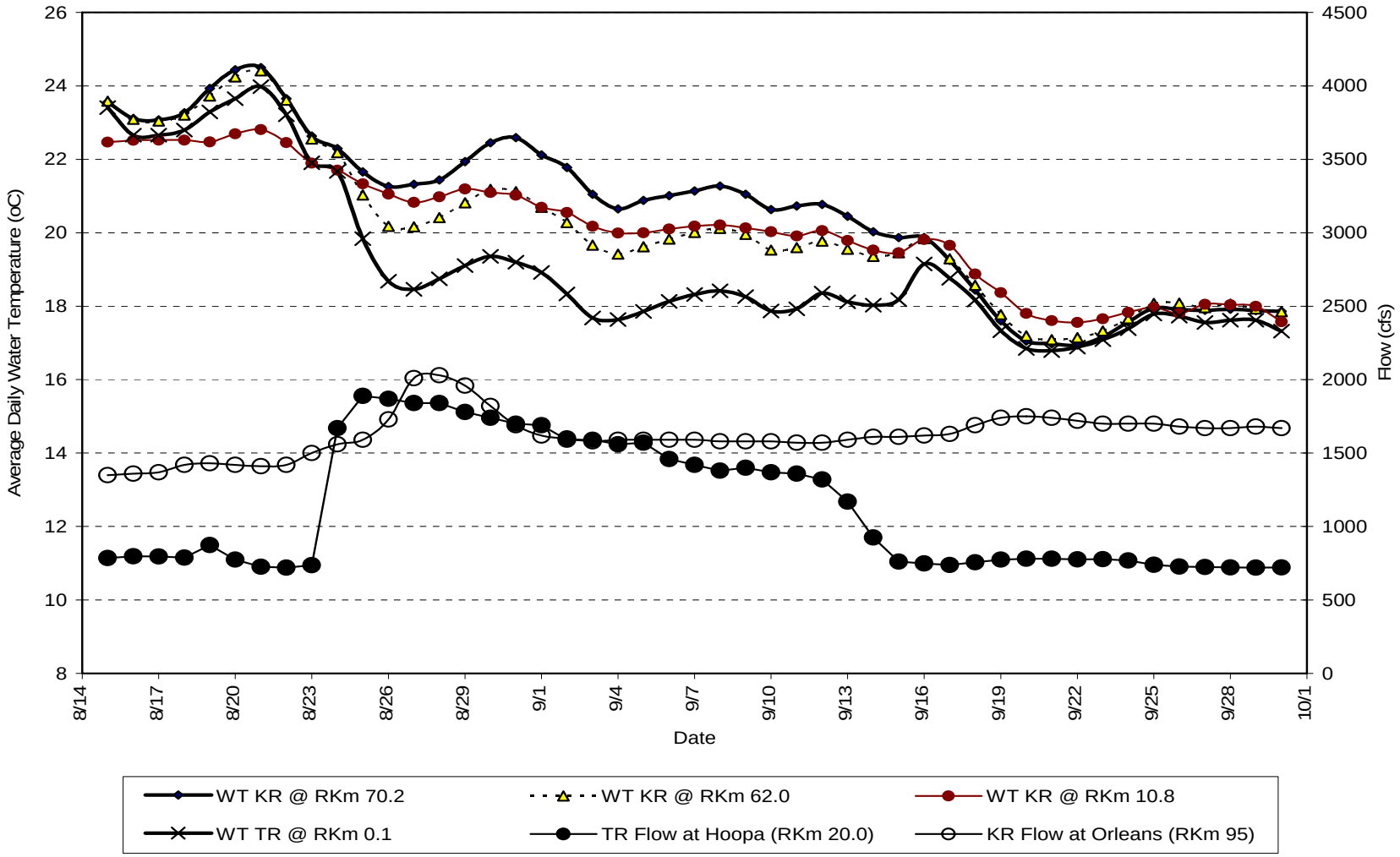

Figure 13. Comparison of average daily water temperatures (WT) of the Trinity River at Weitchpec (rkm 0.1) and the Klamath River above (rkm 70.2) and below the confluence of the Trinity River (rkm 62.0 and 10.8) from August 15 to September 30, 2004.

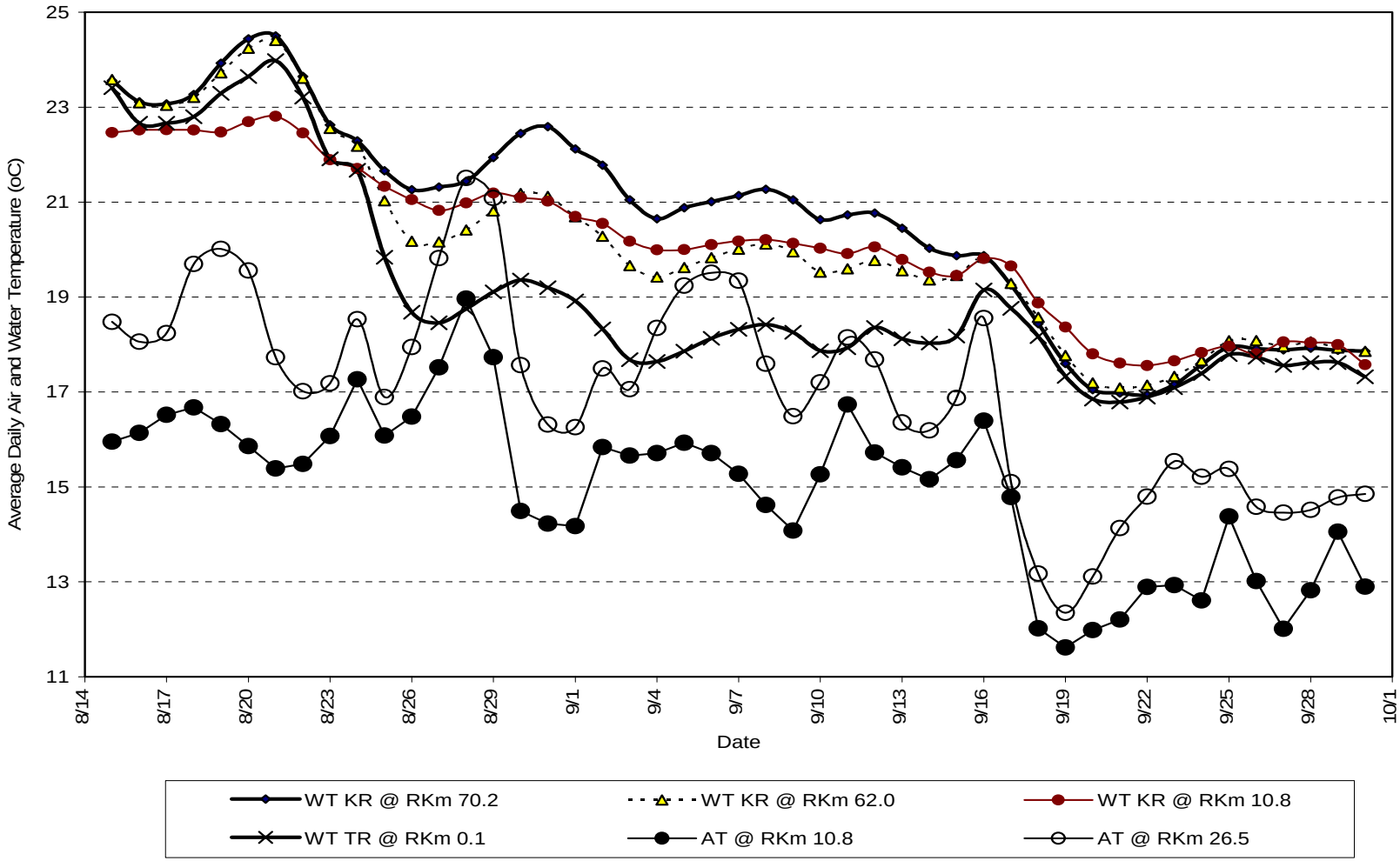

Figure 14. Comparison of average daily water temperatures (WT) of the Trinity River at Weitchpec (rkm 0.1) and the Klamath River above (rkm 70.2) and below the confluence of the Trinity River (rkm 62.0 and 10.8) and air temperatures (AT) at rkm 26.5 and 10.8 from August 15 to September 30, 2004.

Appendix A. Average daily water temperatures and flow of the Klamath and Trinity Rivers from June 10 to July 26, 2004

		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		
Date	Flow Description	Lewiston rkm 178.6	Hoopa rkm 20.0	Iron Gate rkm 305.4	Orleans rkm 95.1	Turwar rkm 10.8	Lewiston Dam rkm 178.6	Iron Gate Dam rkm 305.4	TR rkm 0.1	WE rkm 70.2	TC rkm 62.0	KBC rkm 26.5	TG rkm 10.8	TR rkm 0.1	TC rkm 62.0	KBC rkm 26.5	TG (km 10.8
6/10		2680	3890	1010	4970	9870	27	10	14.9	15.8	15.5	15.5	15.4	1.0	0.3	0.4	0.5
6/11		2520	3840	1010	4820	9560	26	11	14.8	16.3	15.8	16.0	16.0	1.5	0.6	0.4	0.3
6/12		2510	3730	1010	4700	9330	27	11	15.2	16.8	16.2	16.4	16.4	1.6	0.6	0.4	0.4
6/13		2360	3680	1010	4620	9140	26	11	15.9	17.4	16.9	17.0	17.1	1.6	0.6	0.4	0.4
6/14		2330	3600	1010	4590	8970	26	11	16.5	18.1	17.5	17.6	17.6	1.6	0.6	0.5	0.5
6/15		2280	3540	1020	4480	8840	26	12	16.9	18.6	18.0	18.2	18.2	1.7	0.6	0.4	0.4
6/16	>	2100	3480	915	4450	8670	24	11	17.5	19.3	18.6	18.8	18.8	1.8	0.7	0.4	0.5
6/17		1930	3360	820	4390	8530	23	10	18.0	19.7	19.1	19.2	18.9	1.7	0.6	0.5	0.8
6/18		1920	3180	810	4110	8150	24	10	18.1	19.7	19.2	19.1	18.8	1.6	0.6	0.6	0.9
6/19		1910	3160	808	3960	7850	24	10	18.3	20.0	19.4	19.6	19.4	1.7	0.6	0.4	0.6
6/20		1950	3040	807	3760	7590	26	11	18.0	19.9	19.2	19.4	19.2	2.0	0.7	0.5	0.8
6/21		2000	3040	802	3660	7360	27	11	17.9	19.9	19.1	18.8	18.7	2.1	0.8	1.1	1.2
6/22		2000	3070	805	3590	7340	27	11	17.8	19.9	19.0	18.7	18.5	2.1	0.9	1.2	1.4
6/23		2010	3090	808	3540	7330	27	11	18.1	20.2	19.3	18.9	18.5	2.1	0.9	1.3	1.7
6/24		1990	3080	802	3430	7230	28	11	18.2	20.4	19.5	19.6	19.3	2.3	0.9	0.8	1.1
6/25		2000	2980	807	3270	7010	29	12	18.1	20.5	19.5	19.7	19.7	2.4	1.0	0.7	0.8
6/26		2020	2920	805	3140	6730	30	12	18.1	20.4	19.5	19.8	19.8	2.3	0.9	0.6	0.6
6/27		2020	2880	805	3050	6570	31	12	18.2	20.6	19.6	20.0	19.9	2.4	1.0	0.7	0.7
6/28		2000	2880	803	2990	6450	31	12	18.6	21.3	20.1	20.3	20.3	2.7	1.1	0.9	0.9
6/29		2030	2950	805	3010	6470	31	12	18.8	21.5	20.4	20.4	20.4	2.8	1.2	1.1	1.1
6/30		2080	2960	815	3060	6580	32	12	18.6	21.8	20.2	20.4	20.1	3.1	1.5	1.4	1.7
7/1		2050	2990	740	2990	6570	31	11	18.6	21.6	20.1	20.3	20.0	3.0	1.5	1.3	1.5
7/2		2030	2880	713	2880	6530	31	11	18.2	21.6	19.9	20.5	20.4	3.4	1.7	1.2	1.2
7/3		2050	2840	716	2700	6170	33	12	18.7	21.9	20.2	20.6	20.4	3.2	1.7	1.2	1.5
7/4		2050	2820	711	2640	6060	34	12	19.0	22.3	20.5	20.9	20.9	3.3	1.9	1.4	1.4
7/5		2040	2800	710	2560	5950	34	12	19.4	23.0	20.9	21.4	21.3	3.6	2.1	1.6	1.7
7/6		2040	2780	710	2490	5840	35	12	19.6	23.5	21.3	21.9	21.8	3.9	2.2	1.6	1.7
7/7		2020	2770	707	2420	5710	35	12	19.6	23.3	21.2	21.8	21.8	3.7	2.0	1.5	1.5
7/8		2010	2700	707	2340	5590	36	13	19.3	23.1	21.0	21.5	21.5	3.8	2.1	1.6	1.6
7/9	< 2000 cfs or Greater Release from Lewiston Dam	2000	2640	710	2260	5390	37	13	18.8	22.1	20.5	20.9	21.0	3.3	1.6	1.2	1.2
7/10		1650	2590	712	2210	5290	31	13	18.4	21.6	20.1	20.6	20.7	3.3	1.6	1.0	0.9
7/11		1480	2280	717	2170	5050	29	14	18.3	21.4	19.9	20.2	20.3	3.2	1.5	1.2	1.1
7/12		1280	2100	719	2130	4730	27	15	19.0	21.9	20.3	20.5	20.4	2.9	1.6	1.3	1.5
7/13		1070	1900	714	2070	4480	24	16	19.6	21.9	20.5	21.0	20.7	2.3	1.3	0.9	1.1
7/14		1000	1700	712	2020	4200	24	17	19.9	22.0	21.1	21.2	20.9	2.1	1.0	0.8	1.1
7/15		892	1610	711	1980	4000	22	18	20.2	22.1	21.4	21.5	21.3	1.9	0.7	0.6	0.8
7/16		823	1490	660	1940	3840	21	17	20.6	22.2	21.6	21.8	21.7	1.6	0.6	0.4	0.5
7/17	< Down Ramp >	728	1410	621	1930	3720	20	17	21.4	22.6	22.1	22.0	21.8	1.3	0.5	0.6	0.8
7/18		674	1310	624	1860	3590	19	17	21.5	22.6	22.3	22.1	21.8	1.0	0.3	0.4	0.8
7/19		602	1250	629	1830	3430	18	18	21.5	22.5	22.2	22.4	22.1	1.0	0.3	0.1	0.4
7/20		560	1190	633	1830	3380	17	19	21.7	22.7	22.5	22.6	22.5	1.0	0.2	0.0	0.2
7/21		552	1130	622	1810	3330	17	19	22.0	23.1	22.8	22.8	22.5	1.1	0.2	0.2	0.5
7/22		495	1080	614	1780	3220	15	19	22.6	23.9	23.6	23.4	22.9	1.4	0.3	0.5	1.0
7/23		495	1020	616	1740	3130	16	20	23.2	24.5	24.3	24.0	23.3	1.3	0.2	0.5	1.2
7/24		498	977	615	1700	2990	17	21	23.5	24.7	24.5	24.2	23.3	1.2	0.1	0.5	1.4
7/25		497	960	619	1650	2930	17	21	23.9	24.8	24.7	24.3	23.7	0.9	0.1	0.5	1.1
7/26	< Base Flow >	498	944	627	1640	2880	17	22	24.3	25.2	25.1	24.6	23.9	0.8	0.1	0.6	1.2

b = contributions do not reflect travel time differences.

Appendix B. Average daily water temperature and flow of the Klamath and Trinity Rivers from August 15 to September 30, 2004.

		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		
Date	Flow Description	Lewiston rkm 178.6	Hoopa rkm 20.0	Iron Gate rkm 305.4	Orleans rkm 95.1	Turwar rkm 10.8	Lewiston Dam rkm 178.6	Iron Gate Dam rkm 305.4	TR rkm 0.1	WE rkm 70.2	TC rkm 62.0	KBC rkm 26.5	TG rkm 10.8	TR rkm 0.1	TC rkm 62.0	KBC rkm 26.5	TG (km 10.8
8/15		513	786	623	1350	2450	21	25	23.4	23.6	23.6	23.4	22.5	0.1	0.0	0.1	1.1
8/16	< Before Pulse[a] >	505	797	678	1360	2460	21	28	22.7	23.1	23.1	23.1	22.5	0.4	0.0	0.0	0.6
8/17		545	796	694	1370	2490	22	28	22.7	23.1	23.0	23.0	22.5	0.4	0.0	0.0	0.5
8/18		573	789	710	1420	2510	23	28	22.8	23.3	23.2	23.0	22.5	0.5	0.1	0.2	0.7
8/19		466	874	710	1430	2630	18	27	23.3	23.9	23.7	23.3	22.5	0.6	0.2	0.6	1.5
8/20		458	775	710	1420	2660	17	27	23.7	24.4	24.2	23.7	22.7	0.8	0.2	0.8	1.7
8/21		456	726	712	1410	2490	18	29	24.0	24.5	24.4	23.8	22.8	0.5	0.1	0.7	1.7
8/22		548	719	717	1420	2440	22	29	23.2	23.7	23.6	23.2	22.5	0.4	0.0	0.4	1.2
8/23		1600	737	713	1500	2540	63	28	21.9	22.6	22.6	22.5	21.9	0.7	0.1	0.1	0.7
8/24		1700	1670	896	1560	2960	57	30	21.7	22.3	22.2	22.2	21.7	0.6	0.1	0.0	0.6
8/25		1630	1890	1080	1590	3880	42	28	19.8	21.7	21.0	21.6	21.3	1.8	0.6	0.1	0.3
8/26		1490	1870	1320	1730	4130	36	32	18.7	21.3	20.2	20.9	21.1	2.6	1.1	0.3	0.2
8/27		1560	1840	1320	2010	4260	37	31	18.5	21.3	20.2	20.8	20.8	2.9	1.2	0.5	0.5
8/28		1520	1840	1210	2030	4530	34	27	18.8	21.4	20.4	21.0	21.0	2.7	1.0	0.4	0.5
8/29		1500	1780	1040	1960	4440	34	23	19.1	21.9	20.8	21.3	21.2	2.8	1.1	0.6	0.7
8/30	< During Pulse[a] >	1450	1740	929	1820	4210	34	22	19.4	22.5	21.2	21.4	21.1	3.1	1.3	1.1	1.4
8/31		1450	1700	911	1690	3950	37	23	19.2	22.6	21.1	21.3	21.0	3.4	1.5	1.3	1.6
9/1		1340	1690	908	1620	3770	36	24	18.9	22.1	20.7	20.9	20.7	3.2	1.4	1.2	1.4
9/2		1350	1590	908	1600	3630	37	25	18.3	21.8	20.3	20.6	20.6	3.5	1.5	1.2	1.2
9/3		1310	1590	908	1580	3520	37	26	17.7	21.1	19.7	20.1	20.2	3.4	1.4	0.9	0.9
9/4		1330	1560	909	1590	3480	38	26	17.6	20.7	19.4	19.9	20.0	3.0	1.2	0.7	0.7
9/5		1200	1570	913	1590	3500	34	26	17.9	20.9	19.6	20.0	20.0	3.0	1.3	0.9	0.9
9/6		1180	1460	913	1590	3460	34	26	18.1	21.0	19.8	20.2	20.1	2.9	1.2	0.8	0.9
9/7		1130	1420	913	1590	3350	34	27	18.3	21.1	20.0	20.3	20.2	2.8	1.1	0.8	1.0
9/8		1180	1380	913	1580	3310	36	28	18.4	21.3	20.1	20.4	20.2	2.9	1.1	0.9	1.1
9/9		1120	1400	913	1580	3280	34	28	18.3	21.1	20.0	20.2	20.1	2.8	1.1	0.8	0.9
9/10		1120	1370	912	1580	3300	34	28	17.9	20.6	19.5	20.0	20.0	2.8	1.1	0.6	0.6
9/11		1050	1360	911	1570	3250	32	28	17.9	20.7	19.6	19.9	19.9	2.8	1.1	0.8	0.8
9/12		808	1320	913	1570	3220	25	28	18.4	20.8	19.8	20.1	20.1	2.4	1.0	0.7	0.7
9/13		506	1170	910	1590	3180	16	29	18.1	20.5	19.6	19.8	19.8	2.3	0.9	0.7	0.7
9/14		437	925	913	1610	2920	15	31	18.0	20.0	19.4	19.6	19.5	2.0	0.7	0.4	0.5
9/15		443	761	913	1610	2670	17	34	18.2	19.9	19.5	19.4	19.5	1.7	0.4	0.4	0.4
9/16		445	748	917	1620	2540	18	36	19.2	19.9	19.8	20.1	19.8	0.7	0.0	-0.2	0.1
9/17		446	738	921	1630	2550	17	36	18.8	19.3	19.3	19.6	19.7	0.5	0.0	-0.3	-0.4
9/18		447	757	919	1690	2620	17	35	18.2	18.4	18.6	18.8	18.9	0.3	-0.1	-0.4	-0.4
9/19	< After Pulse[a] >	451	775	919	1740	2810	16	33	17.3	17.6	17.8	18.1	18.4	0.3	-0.2	-0.5	-0.8
9/20		448	780	915	1750	2860	16	32	16.9	17.1	17.2	17.7	17.8	0.2	-0.1	-0.6	-0.8
9/21		452	780	913	1740	2830	16	32	16.8	17.0	17.1	17.4	17.6	0.2	-0.1	-0.4	-0.6
9/22		458	776	913	1720	2800	16	33	16.9	16.9	17.1	17.4	17.6	0.1	-0.2	-0.5	-0.6
9/23		447	777	913	1700	2780	16	33	17.1	17.2	17.3	17.6	17.7	0.1	-0.2	-0.4	-0.5
9/24		432	769	913	1700	2730	16	33	17.4	17.6	17.7	17.8	17.8	0.2	-0.1	-0.3	-0.3
9/25		431	740	913	1700	2700	16	34	17.8	18.0	18.1	17.9	18.0	0.2	-0.1	0.1	0.0
9/26		430	727	912	1680	2660	16	34	17.7	17.9	18.1	18.1	17.8	0.2	-0.2	-0.2	0.1
9/27		433	724	912	1670	2620	17	35	17.6	17.9	18.0	18.1	18.1	0.3	-0.1	-0.2	-0.2
9/28		433	721	911	1670	2590	17	35	17.6	17.9	18.1	18.2	18.0	0.3	-0.1	-0.2	-0.1
9/29		433	720	909	1680	2590	17	35	17.6	17.9	17.9	17.9	18.0	0.3	0.0	0.0	-0.1
9/30		433	721	908	1670	2590	17	35	17.3	17.9	17.9	17.7	17.6	0.5	0.0	0.1	0.3

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

Region 8
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