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The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2009

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

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Abstract —Water temperatures were monitored on the Trinity and lower Klamath rivers from April to October 2009 to evaluate the influence of a DRY water year schedule from Lewistown Dam on downstream water temperature objectives specified in the Trinity River Record of Decision. The North Coast Region Basin Plan temperature objective of 15.6 °C at Douglas City was exceeded 33 days between July 1 and September 15. Warm air temperatures and release water temperatures are assumed to be the causative factors for failing to meet the objective. The temperature objective of 13.3 °C at the North Fork Trinity River was met at all times, in part due to operational changes at Trinity Dam involving the use of the deeper auxiliary outlet to attain colder water for release to meet temperature criteria..

During the spring, the water temperature regime of the lower Trinity River generally fell within the "Optimal" or "Marginal" thermal regime for salmonid smolts. However, there were two brief periods near May 18 and May 30 where water temperatures exceeded the "Marginal" criterion and entered the "Unsuitable" criterion for smolts. Despite not meeting the objective all the time, the prescribed flow did result in increased temperature differences between the Trinity River and the Klamath River, indicating that Lewiston Dam releases helped in moderating water temperatures during a time when water temperatures of the Klamath River were increasing.

The most pronounced influence of Lewiston Dam releases on downstream temperatures occurred from August 25 to August 31 when a pulse flow with a peak release of 2,767 cfs from Lewiston Dam was used to support the ceremonial needs of the Hoopa Valley Tribe. During this time, the Trinity River averaged 2.9 °C colder than the Klamath River at the confluence with the Trinity River. A peak difference of 4.4 °C was recorded on August 26, a time when flow from Lewiston Dam represented a dominant flow source to the Klamath River. The large differential resulted in a temperature reduction of 2.0 °C below the confluence and between 1.0 and 1.5 °C difference at the Terwer Gage of the lower Klamath River.

INTRODUCTION

The Trinity River Restoration Program (TRRP) was reauthorized with the signing of the Record of Decision (ROD) of the Final Trinity River Mainstem Fishery Restoration Environmental Impact Statement in December of 2000 (USDOI 2000). Since this time, the TRRP has moved in earnest towards the over-arching goal of restoring the natural production of salmon and steelhead below Lewiston Dam. An important component of the TRRP is the application of an Adaptive Environmental Assessment and Management (AEAM) program. As part of this program, monitoring is used to evaluate progress towards achieving restoration objectives, and improved understanding of the river response to various management actions (e.g. dam releases or gravel augmentation). In support of the AEAM program, this report assesses the influences that Lewiston Dam releases had on the downstream thermal environment, and in particular whether or not the water temperature objectives as identified in the ROD were achieved (Table 1).

This report presents the temperature monitoring information collected for WY2009 and is the eighth consecutive year for which a report of this type has been written for the Trinity River Restoration Program. Reports describing the thermal regimes for the years 2002 to 2008 (Zedonis 2003, Zedonis 2004, Zedonis 2005, Zedonis and Turner 2006, and Zedonis and Turner 2007, Zedonis and Turner 2008, and Zedonis 2009) are available in electronic format from the Trinity River Restoration Program or the Arcata Fish and Wildlife Office of the U.S. Fish and Wildlife Service (http://www.fws.gov/arcata/fisheries).

STUDY AREA

The Trinity River, located in northwest California, is the largest tributary to the Klamath River (Figure 1). This tributary is regulated by Trinity and Lewiston Dams constructed in the early 1960s. Trinity Dam created Trinity Reservoir that can store up to 2.45 million acre-feet of water. Located immediately below Trinity Dam, Lewiston Dam forms Lewiston Reservoir, which serves as a re-regulating reservoir for flow to the Trinity River and diversion to the Sacramento River Basin. From Lewiston Dam, the Trinity River flows for approximately 180 river kilometres (rkm) before joining the Klamath River at

Weitchpec, CA. From Weitchpec, the Klamath River flows for 70 rkm 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, operated by the U.S. Geological Survey (USGS), the California Department of Water Resources, and from probes deployed by the Arcata Fish and Wildlife Office (AFWO) and Yurok Tribe (Table 2). 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. The use of the data filtering process has been used in prior years (2004 thru 2008) following discovery that resultant data were generally accurate when compared to independent certified thermistors (Zedonis 2003).

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). A copy of the AFWO protocol is available upon request. 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 obtained from the CDEC. These data were also labeled "preliminary and subject to revision" and were reviewed and corrected using the same standards established for water temperature downloads. 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 the USGS website (http://water.usgs.gov). Some of the flow data may be considered provisional and subject to change.

RESULTS AND DISCUSSION

Hydrology

In water year 2009, approximately 465 thousand acre-feet (TAF) of water was released from Lewiston Dam to the Trinity River. This total accounted for the prescribed flow of 453 TAF to support a flow prescription for a Dry water year (Figure 2), and approximately 12 TAF in late August to support the biennial Hoopa Valley Tribal Boat Dance ceremony that occurs in odd years.

Contributions of flow from Lewiston Dam to the lower Trinity River and Klamath River varied through the year (Figure 2; also see Appendix A for daily information). During the early part of April the contributions of flow from Lewiston Dam to the lower river gauges were quite small (e.g. 2 to 3 %) due to low base flows (e.g. 300 cubic feet per second (cfs)) and the larger contributions of flow from the abundant tributaries located above downstream gauges. In contrast, by late April and early May, peak spring flow releases from Lewiston Dam resulted in a substantially greater contribution of flow to the lower Trinity River as well as the lower Klamath River. In the most extreme case, Lewiston Dam releases comprised up to 35% of total flow at the Klamath gauge in early May (see Appendix A).

Spring flow from Lewiston Dam generally followed a Dry water year schedule as prescribed in the ROD (Figure 3). Exceptions included several multiple-day benches of stabilized flow releases after the peak release of 4,375 cfs that occurred on May 5. These benches occurred to support ongoing geomorphological and aquatic habitat evaluations by the TRRP (J. Polos, Pers. Comm.).

In early July the flow schedule ramped down to a summer base flow of 450 cfs. Lewiston Dam releases remained at the 450 cfs base flow though the end of the water year, with the exception of a pulse flow in late August to support the Hoopa Valley Tribal Boat Dance Ceremony. This pulse flow occurred from August 23 to August 27 with flows peaking at 2,650 cfs on August 24. Similar to past pulse flow events in support of the Tribal ceremonies (e.g.WY 2003, 2005, 2007), there was a marked influence on flow

at all downstream gages of the river system (Figure 2, Appendix A). The peak flow of the August 2009 Boat Dance pulse flow event was about 1000 cfs greater than experienced in previous years and as such, had a greater influence. The greatest influence occurs at the time of peak pulse flow arrival, which is dependent upon distance traveled (See Zedonis 2003). The magnitude of the flow increase was sufficient enough to make the Trinity River the dominant flow source to the Klamath River below the confluence.

Water Temperatures of the Mainstem Trinity River

Lewiston Gauge (rkm 178.2)

From April to mid-October, water temperatures of Lewiston Dam releases remained between 7.7 and 11.8 ˚C (Figure 4). The warmest release temperatures occurred between mid-June and mid-August, coinciding with typical warming trends and times of decreasing flows out of Lewiston Reservoir. Reduced flows through Lewiston Reservoir result in increased hydraulic residence time of water in the reservoir that warms before release to the Trinity River. In contrast, some of the coldest release temperatures occurred during times of high flow, most notably early and late May. The August pulse flow resulted in a 0.5 to 0.7 ˚C reduction in water temperature from Lewiston Dam.

In early October, water temperatures from Lewiston Dam were also reduced but the reasons for this reduction were atypical for this time of the year. In 2009, the Central Valley Operations Division of the USBR utilized the auxiliary outlet works of Trinity Dam, which allowed water to be drawn from a deeper and colder stratum of the reservoir than typically used. This was deemed a necessary step to ensure that downstream temperature objectives were met. The influence of this operational change, as well as concomitant cooler air temperatures, was substantial and successful at reducing the release temperature at Lewiston Dam.

Douglas City Gauge (rkm 148.5)

Water temperatures ranged between 8.4 and 16.5 ˚C from April to mid-October (Figure 5). Water temperatures at this site also exhibited an inverse relationship of flow from Lewiston Dam. Inverse relationships were most notable during high flow periods in early May and early and late August.

Water temperatures failed to meet the Regional Water Quality Control Board temperature objectives (North Coast Regional Water Quality Control Board, 1994) at this location for a total of 33 days from July 1 thru August 20. A maximum exceedance of 0.9 ˚C over the 15.6˚C objective occurred on July 28.

Reasons for exceeding the objective are likely several-fold. First, the average temperatures of water released from Lewiston Dam during July 2 thru August 20, increased to near 11.1˚C, which is approximately 1.1 ˚C warmer than what is typically needed in an average year to meet the objective (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). This increase in water temperature was likely due to an increase in air temperature, and the synergistic effect of warm releases from Trinity Dam and increased hydraulic residence time in Lewiston Reservoir caused by decreased trans-basin exports (Figure 4) and reduced flow from Lewiston Reservoir (Figure 5). After August 20, the water temperature objectives for this location were met.

Trinity above the North Fork Trinity (rkm 117.6)

Average daily water temperatures of the Trinity River above the North Fork Trinity were warmer in comparison to the upstream Douglas City site, but followed a similar trend (Figure 6). Similar to the Douglas City site, water temperatures above the North Fork Trinity showed an inverse relationship with flow. Average daily temperatures peaked at 20.4 ˚C on July 28. The pulse flow in late August was at least partially responsible for a temperature reduction from approximately 18 ˚C to 13 ˚C. Following the peak, average daily water temperatures continued to decrease thereafter to sufficiently meet the temperature objective of not exceeding 13.3 ˚C (Table 1). Reasons for meeting the objectives at this location included cooler air temperatures and responsive operational changes by the USBR to utilize the auxiliary bypass at Trinity Dam to achieve colder release temperatures from Lewiston Dam.

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

Water temperatures in this region were also influenced by Lewiston Dam releases. As Lewiston Dam releases were reduced and air temperatures increased water temperatures

increased (Figure 7). Typically in July and August average daily water temperatures in the lower part of the Trinity River range between 23 to 25 °C.

During the August pulse, the average daily water temperatures were reduced by 4 to 5 ˚C at Big French Creek. Similarly, water temperatures at Hoopa (rkm 20.0), which are used here to represent the lower Trinity River site at rkm 0.1 where limited data exist, were also reduced by a substantial amount (3 to 4 ˚C) but slightly less that the upstream site. This reduced influence at the lower river site is believed to be largely due to the dampening influence of accreted flow from tributaries such as the South Fork, New River, Willow Creek, etc.

The springtime temperature objectives of meeting at least the marginal temperature regime for smolts of the lower Trinity River (U.S. Fish and Wildlife Service and Hoopa Valley Tribe. 1999) were generally met although a few exceptions are noted (Figure 8). The exceptions include a brief period around May 18 and another around May 29 when water temperatures entered the "unsuitable" temperature range for smolts, in part, from warm air temperatures (Figure 9), but also likely from reductions in flow.

Water Temperatures of the Klamath River above and below the Trinity River Confluence

From mid-April to mid-October, the average daily water temperatures at Hoopa (representing Weitchpec on the Trinity for purposes of this report) were variable compared to the Klamath River above the confluence with the Trinity River at rkm 70.2 (Figure 10, See Appendix A for daily information). From April 15 to May 16, water temperatures of the Klamath River at rkm 70.2 were on average 0.5 °C colder than the Trinity River entering the Klamath River even though the peak releases of 4,375 cfs from Lewiston Dam occurred within this time period. From May 17 to July 7, this relationship changed and on average the Trinity River was approximately 0.8 °C colder than the Klamath River. From July 8 to August 24, the average water temperature of the Trinity and Klamath were similar (i.e. Trinity ~ 0.2°C colder than the Klamath). From August 25 to August 31 the trend changed and the Trinity River was colder due to the pulse flow from Lewiston Dam. Compared to the Klamath River above the Trinity River confluence, the pulse flow reduced the average daily water temperature of the Trinity

River at Hoopa (rkm 20.0) by 2.9 °C (Appendix A). The peak difference in temperature occurred on August 26 when the Trinity River was 4.4 °C colder than the Klamath River (Figure 10). This difference correspondingly altered the thermal regime of the mainstem Klamath River downstream of its confluence with the Trinity River. About 1.5 km downstream of the confluence (i.e. rkm 68.7), the average daily water temperatures of the river were reduced by as much as 2.0 °C during the pulse flow event. A similar but less pronounced influence was observed in the lower Klamath River at Terwar (rkm 13.0), where average daily water temperatures were reduced by about 1 to 1.5 °C. We believe this less pronounced influence is likely an influence of the cooler coastal meteorology and tributary water sources within this area. From August 27 through the end of the water year, Trinity temperatures remained cooler than the Klamath by an average of 0.6 °C (see Appendix A).

ACKNOWLEDGEMENTS

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PERSONAL COMMUNICATIONS

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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 (USDOI 2000 and USFWS et.al., 2000)	• Lewiston to Weitchpec (rkm 178.2 to 0.1)	Normal and Wetter Water Years: • April 22 to May 22 • May 23 to June 4 • June 5 to July 9 Dry and Critically Dry Water Years: • April 22 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 Centigrade

Table 2. Water temperature monitoring sites of the Trinity River (TR) and the Klamath River (KR) below Weitchpec in 2009. 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 Gauge (LWS)	178.2	California Data Exchange Center (CDEC)	(U.S. Geological Survey /and U.S. Bureau of Reclamation)
TR above Rush Ck (TRRC1)	173.0	FWS	Fish and Wildlife Service (FWS)
TR@ Limkiln Gulch Gauge (TLK)	158.7	CDEC	USGS
TR @ Douglas City Gauge (TRDC2)	148.5	CDEC	USGS
TR above Canyon Ck (TRCN1)	127.4	FWS	FWS
TR abv N.F. Trinity R. (NFH)	117.6	CDEC	USGS
TR abv Big French Creek (TRBF1)	94.2	FWS	FWS
TR @ Burnt Ran. Trans Sta (TRBR1)	76.4	FWS	FWS
TR abv S. Fork Trinity R. (TRSF1)	50.6	FWS	FWS
TR @ Willow Creek Trap (TRWC1)	34.1	FWS	FWS
TR @ Hoopa Gauge (HPA)	20.0	CDEC	USGS/Dept. Of Water Resources
TR @ Weitchpec (TRWE1)	0.1	FWS/YTEP/USBR	FWS/YTEP/USBR
Mainstem Klamath River			
KR at Weitchpec (KRWE1) [b]	70.2	YTEP	Yurok Tribe
KR below Weitchpec (KBW3)	68.7	YTEP/FWS	FWS/Yurok Tribe
KR above Terwer (KRTG2) [a]	13.0	YTEP/FWS	FWS/Yurok Tribe
Trinity River Tributary Sites			
Canyon Ck (CNTR1)	127.3 + 0.1	FWS	FWS
N. F. Trinity R (NFTR1)	116.7 + 0.1	FWS	FWS
Big French Ck (BFTR1)	94.1 + 0.1	FWS	FWS
S. F. Trinity R (SFTR1)	50.5 + 0.1	FWS	FWS

'a = Data is available from multiple sources
'b = This site is located immediately above the confluence of the Trinity River and refers to the distance from the Klamath River mouth.
'c = River kilometer of mainstem Trinity River + the distance up the tributary

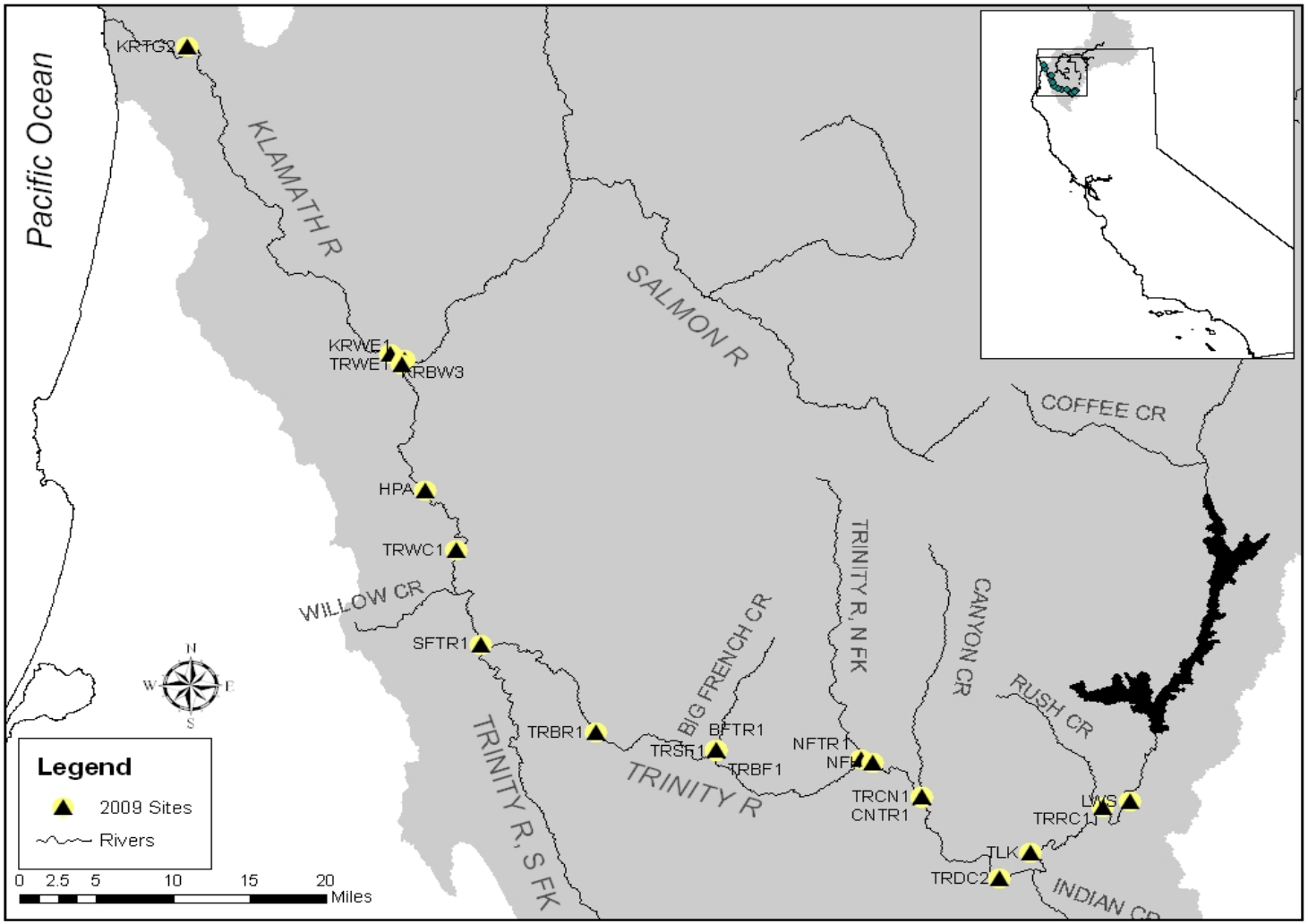


Figure 1. Location of water temperature monitoring sites of the Trinity River and lower Klamath River in 2009. See Table 2 for site information.

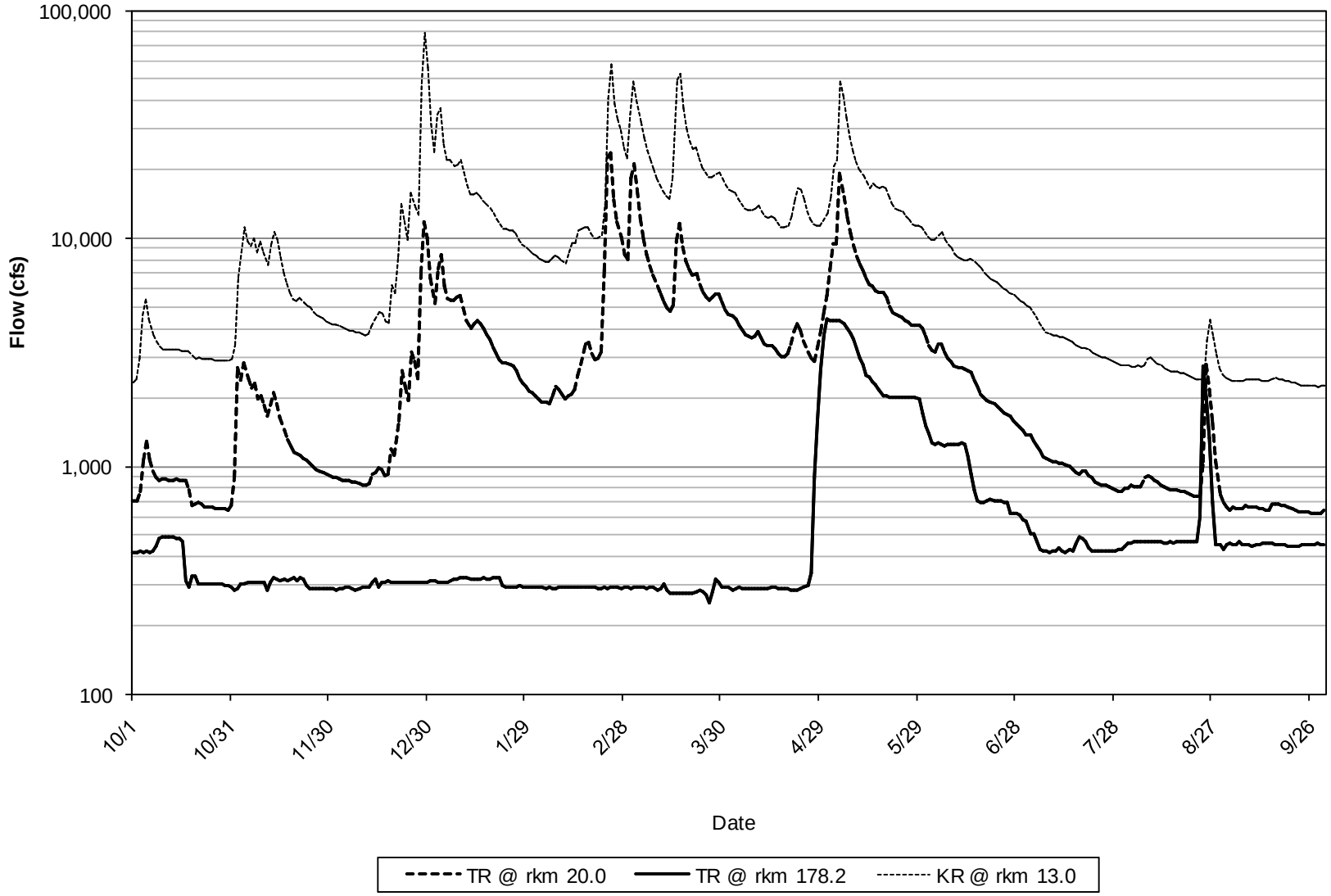


Figure 2. Average daily flow of the Trinity River (TR) at Lewiston gauge (rkm 178.2) and Hoopa gauge (rkm 20.0), and the Klamath River (KR) at the Terwar Gauge (rkm 13.0) in 2009. US Geological Survey gauge data, preliminary and subject to revision.

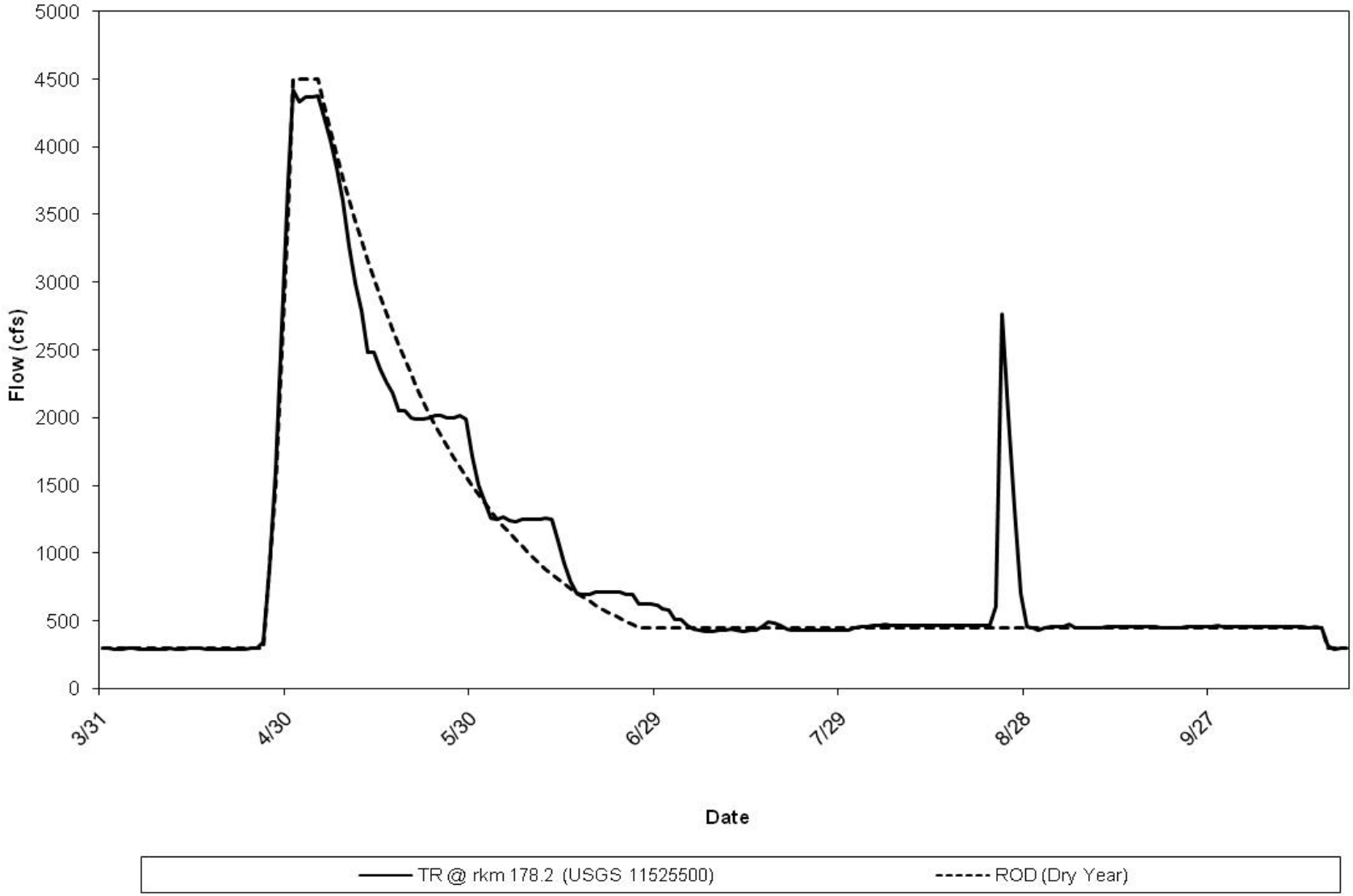
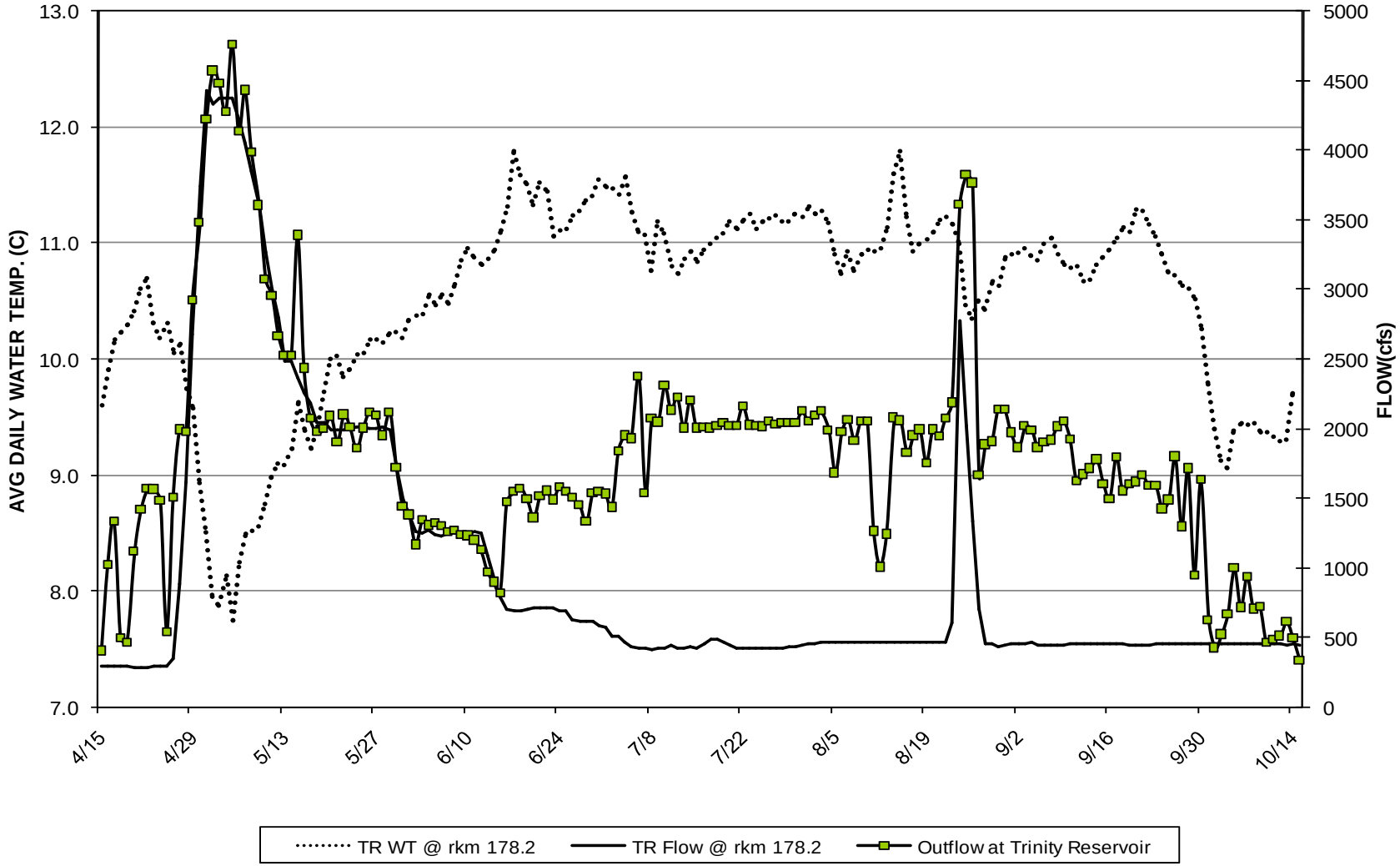


Figure 3. Spring and early summer flow releases from Lewiston Dam (rkm 178.2) on the Trinity River (TR) in 2009 compared to the flow schedule for a Dry hydrologic water year identified in the Record of Decision (USDOI 2000).



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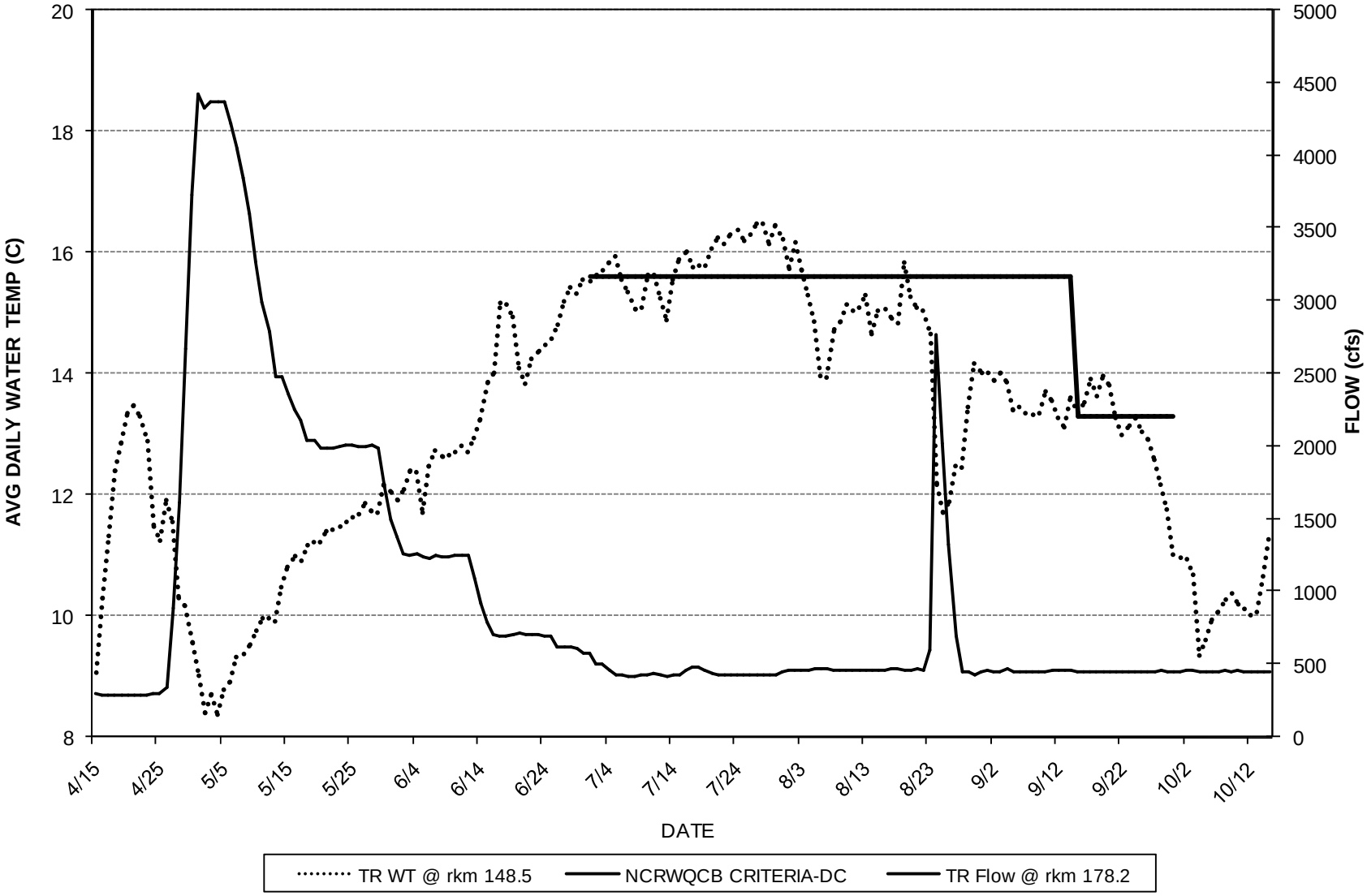


Figure 5. Comparison of average daily water temperatures (WT) of the Trinity River (TR) at Douglas City gauge (rkm 148.5) in 2009 and the water temperature objective of the North Coast Regional Water Quality Control Board (NCRWQCB Criteria-DC).

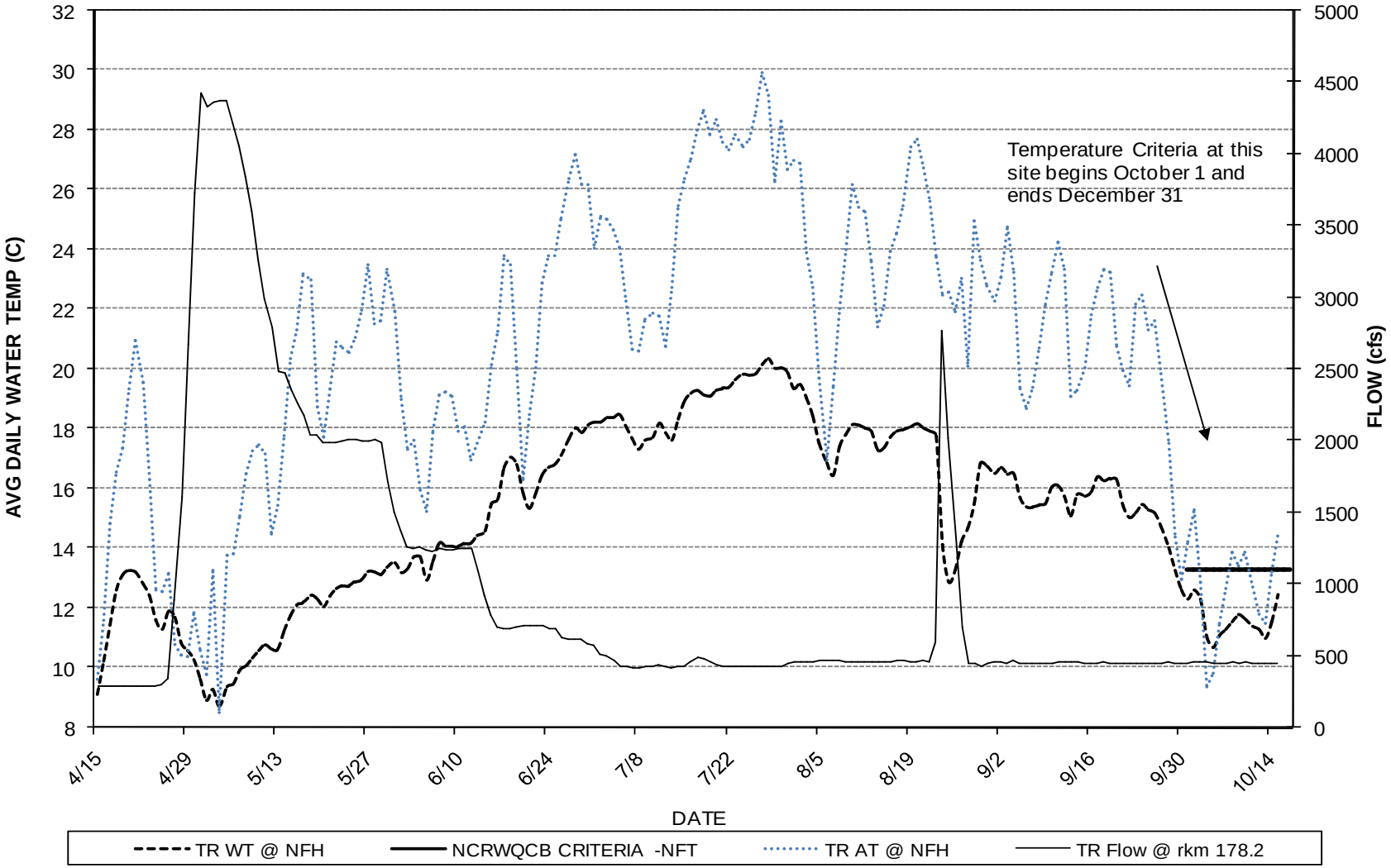


Figure 6. Comparisons of average daily water temperatures (WT) of the Trinity River (TR)above the confluence of the North Fork Trinity River (rkm 117.6) in 2009 and the water temperature objective of the North Coast Regional Water Quality Control Board (NCRWQCB-NFT). Air temperature (AT) data are from the North Fork at Helena site.

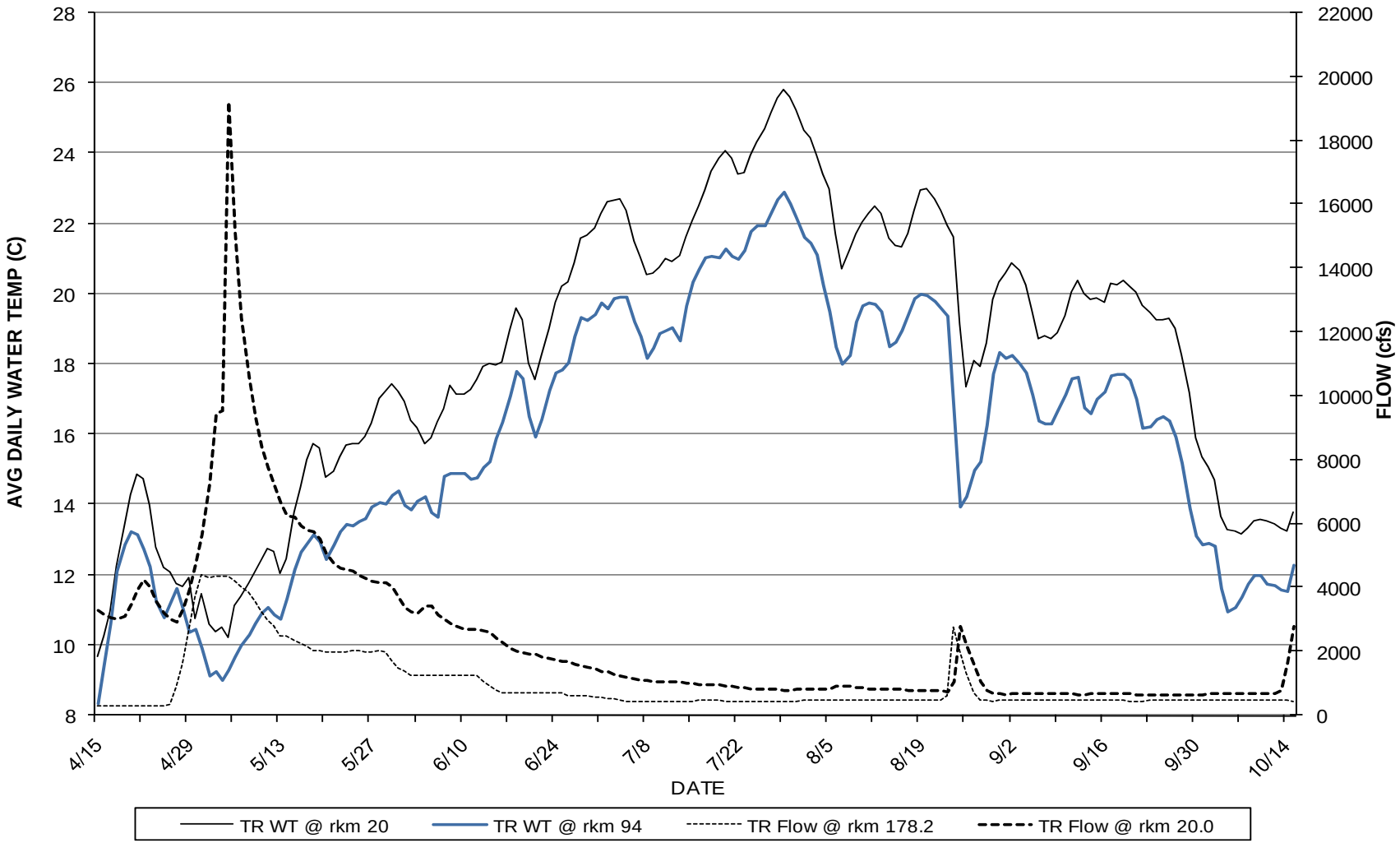


Figure 7. Comparisons of average daily water temperatures of the Trinity River (TR) above Big French Creek (rkm 94) and the Hoopa Gage (rkm 20.0) and flow at Lewiston (rkm 178.2) and Hoopa (rkm 20.0) in 2009. Note: we do not have complete records for water temperature for the Trinity River site at Weitchpec so the Hoopa site is used. Comparisons of average daily water temperatures at rkm 20 and 0.01 revealed they were quite similar (Appendix B).

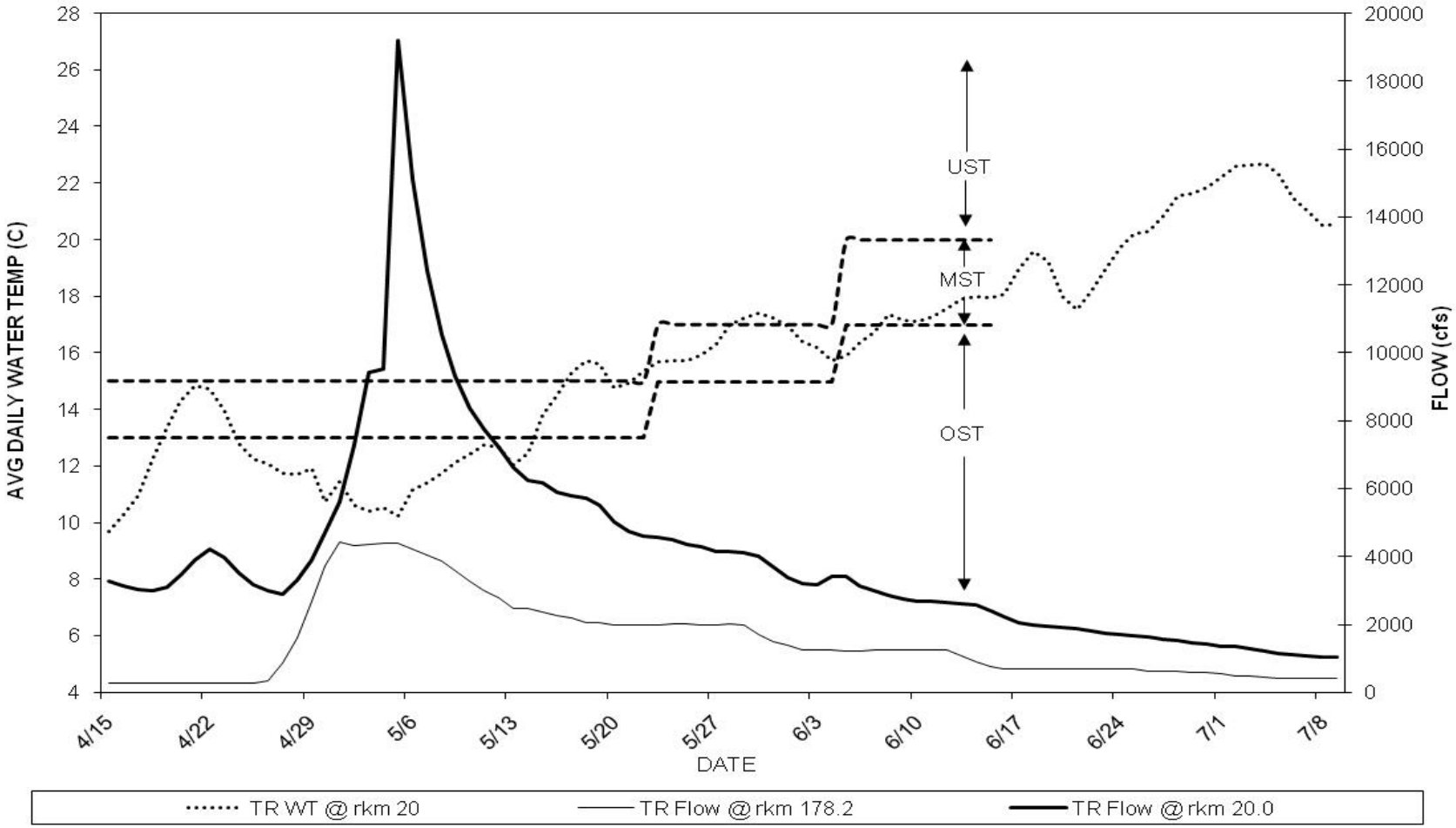


Figure 8. Average daily water temperatures (WT) of the Trinity River (TR) at Hoopa in 2009 and how they compare to the spring-time temperature objectives established by the Record of Decision (USDOI 2000 and USFWS et al., 2000). Comparisons of water temperatures at rkm 20.0 and 0.1 for times of overlapping data suggest that Hoopa site is a good surrogate (Appendix B). Smolt objectives: UST = unsuitable smolt temperatures; MST = marginal smolt temperatures, OST = optimal smolt temperatures. Optimal smolt temperatures were sought from April 22 to July 9 in 2009.

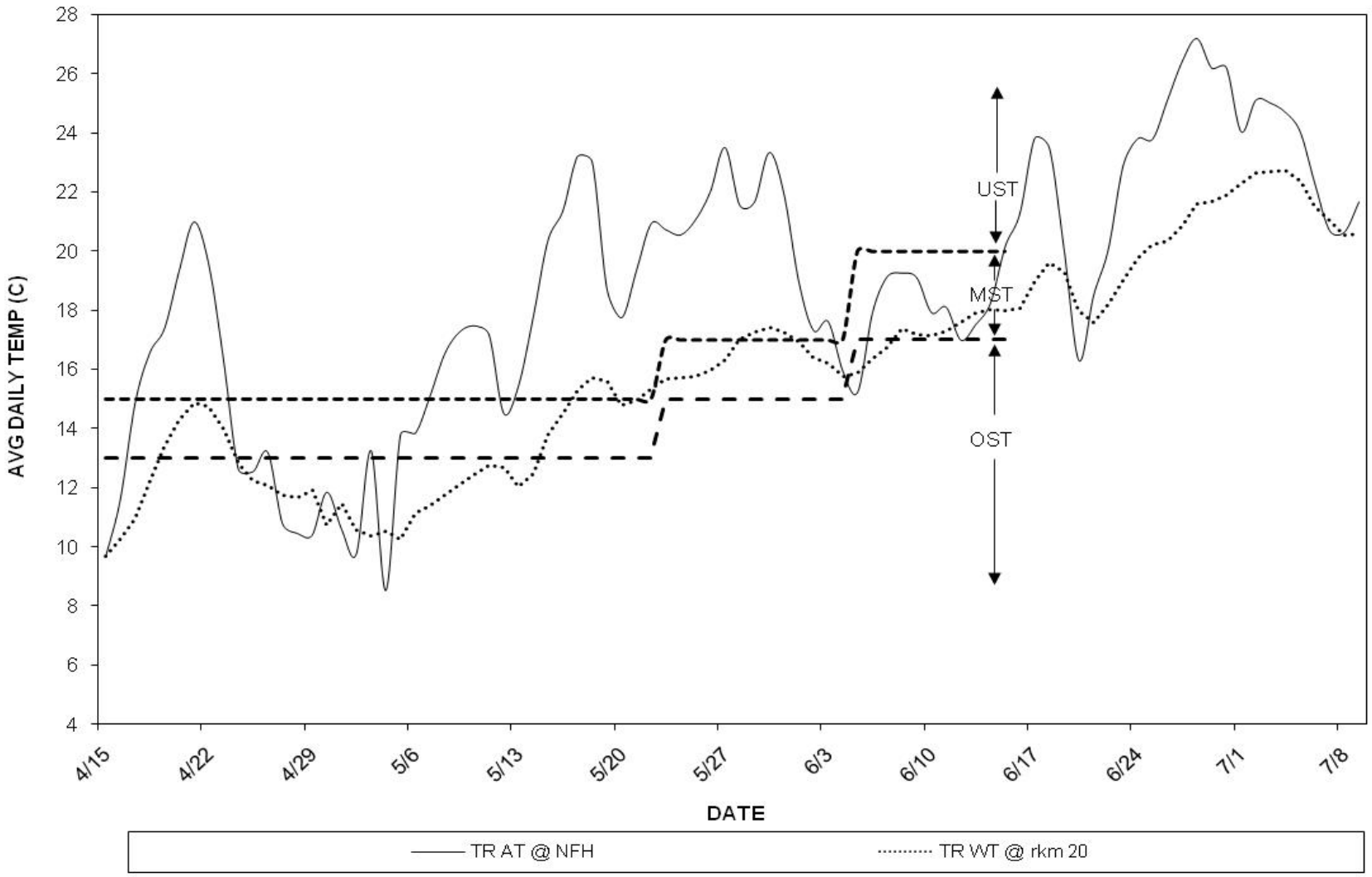


Figure 9. Air temperature (AT) and its influence on water temperature (WT) of the Trinity River (TR) at Hoopa from April 22 to July 9, 2009. Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures; OST = Optimally suitable temperatures.

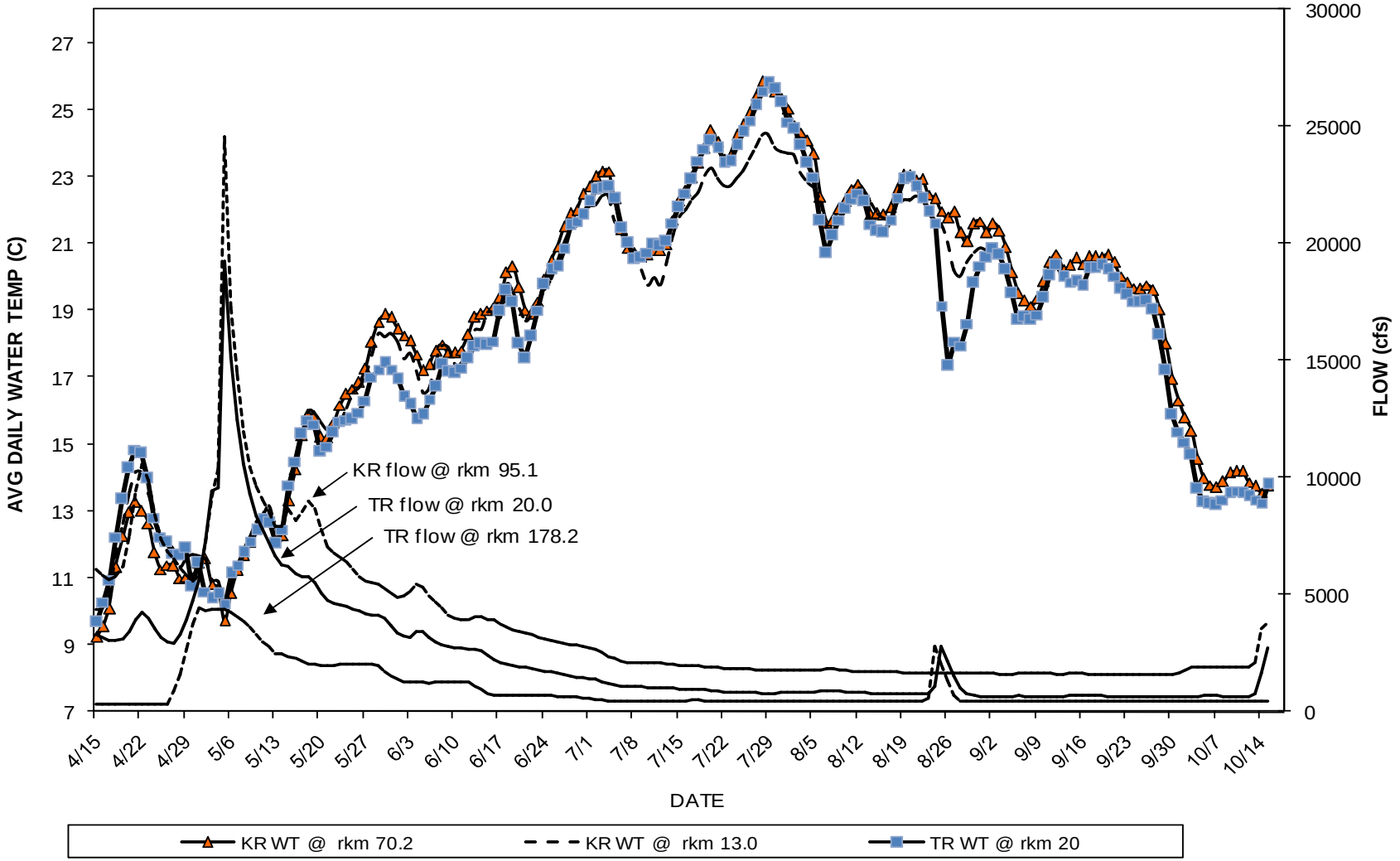


Figure 10. Comparison of water temperatures (WT) of the Trinity River (TR) at Hoopa (rkm 20) and the Klamath River (KR) above (rkm 70.2) and below (rkm 13.0)) the confluence of the Trinity River relative to stream flow in 2009. See Appendix A for daily information.

Appendix C. Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2009. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer

	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 Klamath Gage (%)[b]		Trinity R.	Klamath R. Sites			Trinity R.	Klamath R. Sites	
Date	Lewiston rkm 178.6	Hoopa rkm 20.0	Iron Gate rkm 305.5	Orleans rkm 95.1	Klamath rkm 13.0	Lewiston Dam rkm 178.6	Iron Gate Dam rkm 305.5	TR rkm 20	WE rkm 70.2	KBW rkm 68.7	KAT rkm 13.0	TR rkm 20	KBW rkm 68.7	KAT rkm 13.0
04/15/09	294	3287	1597	6090	12200	2	13	9.7	9.2	10.0	10.1	-0.4	-0.8	-0.8
04/16/09	292	3142	1593	5793	11700	2	14	10.3	9.5	9.9	10.1	-0.7	-0.3	-0.5
04/17/09	289	3024	1598	5620	11200	3	14	10.9	10.1	10.1	10.4	-0.9	-0.1	-0.3
04/18/09	288	3007	1595	5748	11100	3	14	12.2	11.3	10.8	11.6	-0.9	0.5	-0.3
04/19/09	289	3107	1597	6198	11400	3	14	13.4	12.2	11.7	12.6	-1.1	0.6	-0.4
04/20/09	287	3442	1599	7523	12500	2	13	14.3	13.0	12.4	13.5	-1.3	0.6	-0.6
04/21/09	287	3900	1594	9461	14700	2	11	14.8	13.2	12.9	14.2	-1.6	0.3	-0.9
04/22/09	286	4218	1596	10542	16700	2	10	14.7	13.0	13.1	14.1	-1.7	0.0	-1.1
04/23/09	288	3984	1597	9890	16400	2	10	14.0	12.6	12.9	13.5	-1.3	-0.3	-0.9
04/24/09	295	3531	1599	8419	14800	2	11	12.8	11.8	12.4	12.8	-1.0	-0.6	-1.0
04/25/09	298	3186	1591	7356	13100	2	12	12.2	11.3	11.9	12.0	-1.0	-0.6	-0.8
04/26/09	342	2993	1602	6816	12100	3	13	12.1	11.4	11.7	12.1	-0.7	-0.3	-0.7
04/27/09	887	2904	1594	6492	11600	8	14	11.7	11.3	11.7	11.8	-0.4	-0.3	-0.5
04/28/09	1610	3303	1600	6157	11400	14	14	11.7	11.0	11.4	11.3	-0.7	-0.4	-0.4
04/29/09	2674	3910	1596	5799	11400	23	14	11.9	11.0	11.4	11.6	-0.9	-0.3	-0.6
04/30/09	3734	4717	1597	5547	11900	31	13	10.7	11.0	11.4	11.7	0.3	-0.4	-0.7
05/01/09	4420	5642	1505	5854	12800	35	12	11.4	11.5	11.5	11.6	0.0	0.0	-0.2
05/02/09	4328	7297	1502	7239	15200	28	10	10.6	11.6	11.5	11.6	1.0	0.1	0.0
05/03/09	4367	9430	1634	9198	20600	21	8	10.4	10.8	10.9	10.9	0.4	-0.1	-0.1
05/04/09	4369	9530	1632	10369	22100	20	7	10.5	10.7	11.0	10.9	0.2	-0.3	-0.2
05/05/09	4375	19217	1763	24573	49000	9	4	10.2	9.7	10.5	10.2	-0.5	-0.7	-0.5
05/06/09	4219	15142	1608	17250	42600	10	4	11.1	10.5	10.5	10.7	-0.6	0.0	-0.2
05/07/09	4052	12454	1573	14450	33800	12	5	11.4	11.2	10.9	11.4	-0.2	0.3	-0.1
05/08/09	3849	10563	1525	11933	28100	14	5	11.8	11.7	11.2	11.8	-0.1	0.5	-0.2
05/09/09	3603	9333	1483	10457	24400	15	6	12.1	12.1	11.5	12.2	0.0	0.6	-0.2
05/10/09	3264	8373	1431	9627	21900	15	7	12.4	12.5	11.8	12.7	0.1	0.7	-0.2
05/11/09	2995	7755	1427	9043	20100	15	7	12.7	12.8	12.0	12.8	0.1	0.8	0.0
05/12/09	2793	7215	1428	8558	18900	15	8	12.7	12.8	12.3	13.1	0.2	0.6	-0.3
05/13/09	2484	6651	1424	7911	17600	14	8	12.0	12.2	12.2	12.5	0.2	0.0	-0.3
05/14/09	2479	6237	1423	7937	16700	15	9	12.4	12.3	12.1	12.3	-0.2	0.2	0.0
05/15/09	2359	6199	1423	8667	17500	13	8	13.8	13.3	12.6	13.4	-0.5	0.7	-0.1
05/16/09	2258	5915	1431	8193	16800	13	9	14.5	14.2	13.4	14.4	-0.2	0.9	-0.2
05/17/09	2182	5784	1427	8559	16500	13	9	15.3	15.3	14.2	15.3	0.0	1.1	-0.1
05/18/09	2045	5745	1431	9019	16900	12	8	15.7	15.9	14.9	16.0	0.2	1.0	-0.1
05/19/09	2046	5510	1437	8662	16600	12	9	15.6	15.8	15.1	15.9	0.2	0.7	-0.1
05/20/09	1992	5036	1434	7764	15400	13	9	14.8	15.2	14.9	15.6	0.4	0.3	-0.4
05/21/09	1988	4735	429	7016	14200	14	3	14.9	15.2	14.7	15.4	0.3	0.5	-0.2
05/22/09	1987	4613	1426	6741	13500	15	11	15.3	15.6	15.0	15.6	0.3	0.6	0.1
05/23/09	1996	4568	1429	6590	13200	15	11	15.7	16.2	15.4	15.7	0.5	0.8	0.5
05/24/09	2010	4503	1430	6413	13000	15	11	15.7	16.5	15.6	16.1	0.8	0.9	0.4
05/25/09	2010	4364	1420	6086	12500	16	11	15.7	16.7	15.8	16.5	0.9	0.9	0.1
05/26/09	1995	4281	1431	5781	12000	17	12	15.9	16.9	16.0	16.7	0.9	0.9	0.2
05/27/09	1994	4165	1432	5542	11600	17	12	16.3	17.3	16.2	17.1	1.0	1.0	0.2
05/28/09	2010	4139	1435	5486	11400	18	13	17.0	18.1	16.8	17.7	1.0	1.3	0.4
05/29/09	1985	4131	1443	5448	11300	18	13	17.2	18.6	17.3	18.3	1.4	1.3	0.3
05/30/09	1716	4008	1437	5264	11100	15	13	17.4	18.9	17.6	18.2	1.5	1.3	0.7

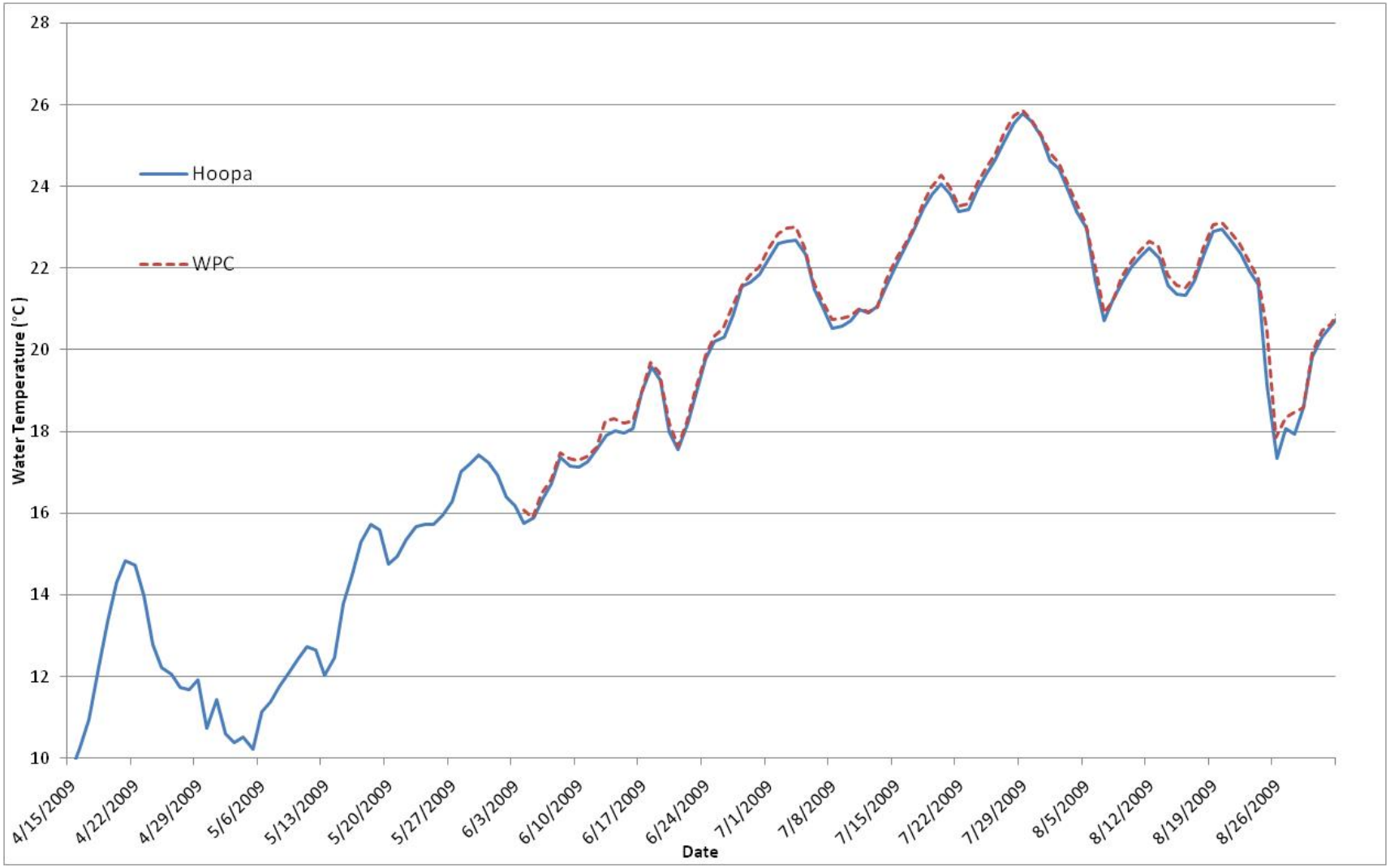
Appendix A. (Continued). Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2009. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer,

	Flow (CFS)							Average Daily Water Temperatures (^{o}C)				Differences in Water Temps (^{o}C) of the Klamath R. at RKm 70.2 and:		
	Trinity R.		Klamath R.			Contributions of Flow to the Klamath Gage (%)[b]		Trinity R.	Klamath R. Sites			Trinity R.	Klamath R. Sites	
Date	Lewiston rkm 178.6	Hoopa rkm 20.0	Iron Gate rkm 305.5	Orleans rkm 95.1	Klamath rkm 13.0	Lewiston Dam rkm 178.6	Iron Gate Dam rkm 305.5	TR rkm 20	WE rkm 70.2	KBW rkm 68.7	KAT rkm 13.0	TR rkm 20	KBW rkm 68.7	KAT rkm 13.0
05/31/09	1499	3700	1448	5079	10600	14	14	17.2	18.8	17.7	18.3	1.6	1.1	0.5
06/01/09	1381	3374	1546	4872	10100	14	15	16.9	18.5	17.5	18.1	1.5	0.9	0.4
06/02/09	1258	3208	1548	4949	9820	13	16	16.4	18.2	17.3	17.6	1.8	0.9	0.7
06/03/09	1250	3184	1554	5137	9910	13	16	16.2	18.1	17.2	17.7	1.9	0.9	0.4
06/04/09	1265	3409	1568	5427	10300	12	15	15.7	17.7	16.9	17.2	1.9	0.8	0.5
06/05/09	1240	3406	1565	5285	10700	12	15	15.9	17.2	16.6	16.6	1.3	0.6	0.6
06/06/09	1228	3146	1568	4956	9910	12	16	16.3	17.4	16.6	16.7	1.0	0.7	0.7
06/07/09	1249	2992	1563	4687	9440	13	17	16.7	17.8	17.0	17.4	1.1	0.8	0.4
06/08/09	1244	2872	1544	4399	9020	14	17	17.4	18.0	17.3	17.9	0.6	0.7	0.1
06/09/09	1244	2765	1541	4137	8570	15	18	17.2	17.7	17.4	17.9	0.6	0.4	-0.1
06/10/09	1246	2694	1547	3974	8250	15	19	17.1	17.7	17.2	17.4	0.6	0.5	0.3
06/11/09	1255	2698	1557	3938	8080	16	19	17.3	17.8	17.3	17.4	0.5	0.5	0.4
06/12/09	1250	2659	1570	3903	8070	15	19	17.6	18.3	17.4	17.9	0.7	0.8	0.4
06/13/09	1090	2635	1572	4071	8050	14	20	17.9	18.8	18.0	18.4	0.9	0.8	0.4
06/14/09	922	2575	1573	4080	8110	11	19	18.0	18.9	18.1	18.4	0.9	0.8	0.5
06/15/09	790	2397	1565	3937	7890	10	20	18.0	19.0	18.3	18.9	1.0	0.7	0.1
06/16/09	704	2246	1554	3894	7640	9	20	18.1	19.1	18.3	18.9	1.0	0.7	0.2
06/17/09	692	2071	1559	3753	7350	9	21	19.0	19.4	18.6	18.8	0.4	0.8	0.6
06/18/09	693	1998	1558	3618	7040	10	22	19.6	20.1	19.9	19.8	0.5	0.3	0.3
06/19/09	706	1938	1560	3489	6830	10	23	19.3	20.3	20.0	19.5	1.1	0.4	0.8
06/20/09	711	1913	1560	3411	6660	11	23	18.0	19.7	19.2	19.1	1.7	0.4	0.6
06/21/09	708	1880	1551	3332	6560	11	24	17.6	19.0	18.6	18.7	1.4	0.4	0.3
06/22/09	708	1809	1546	3262	6380	11	24	18.2	18.9	18.7	18.9	0.7	0.2	0.0
06/23/09	707	1758	1541	3179	6210	11	25	19.0	19.3	19.2	19.2	0.3	0.1	0.0
06/24/09	694	1718	1544	3098	6040	11	26	19.8	19.9	19.9	19.6	0.1	0.0	0.3
06/25/09	692	1679	1548	3033	5880	12	26	20.2	20.5	20.4	19.9	0.3	0.1	0.6
06/26/09	623	1651	1547	2971	5760	11	27	20.3	20.9	20.8	20.5	0.6	0.1	0.4
06/27/09	619	1567	1545	2921	5640	11	27	20.9	21.5	21.3	21.0	0.6	0.1	0.5
06/28/09	618	1519	1303	2866	5470	11	24	21.6	21.9	21.9	21.4	0.3	0.0	0.5
06/29/09	614	1482	1545	2818	5340	11	29	21.7	22.0	22.0	21.5	0.3	0.0	0.5
06/30/09	582	1440	1543	2755	5240	11	29	21.8	22.5	22.3	21.8	0.6	0.1	0.6
07/01/09	574	1374	1448	2709	5090	11	28	22.3	22.7	22.7	22.1	0.5	0.0	0.6
07/02/09	507	1361	1325	2637	4980	10	27	22.6	23.0	23.0	22.2	0.4	0.0	0.9
07/03/09	504	1279	1209	2506	4780	11	25	22.7	23.2	23.1	22.4	0.5	0.0	0.7
07/04/09	465	1221	1087	2370	4500	10	24	22.7	23.2	23.2	22.4	0.5	0.0	0.7
07/05/09	432	1166	1035	2251	4260	10	24	22.3	22.3	22.5	21.6	0.0	-0.2	0.7
07/06/09	424	1104	1193	2155	4020	11	30	21.5	21.4	21.8	21.5	-0.1	-0.4	-0.1
07/07/09	421	1082	1035	2115	3870	11	27	21.0	20.9	21.2	21.2	-0.2	-0.3	-0.3
07/08/09	416	1059	1034	2099	3800	11	27	20.5	20.7	21.0	20.8	0.2	-0.3	-0.1
07/09/09	425	1047	1033	2097	3760	11	27	20.6	20.6	20.8	20.2	0.0	-0.2	0.4
07/10/09	426	1043	1039	2086	3730	11	28	20.7	20.7	20.9	19.8	-0.1	-0.2	0.9
07/11/09	438	1027	1036	2081	3700	12	28	21.0	20.8	20.9	20.0	-0.2	-0.1	0.8
07/12/09	426	1027	1038	2063	3690	12	28	20.9	20.8	20.9	19.8	-0.1	-0.1	1.0
07/13/09	419	1013	1037	2036	3640	12	28	21.1	21.0	21.1	20.5	-0.1	-0.1	0.5
07/14/09	428	991	1038	2020	3580	12	29	21.6	21.7	21.7	21.3	0.1	0.0	0.4
07/15/09	425	966	1033	1993	3500	12	30	22.1	22.3	22.3	21.8	0.2	-0.1	0.5

Appendix A. (Continued). Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2009. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer,

	Flow (CFS)							Average Daily Water Temperatures (^{o}C)				Differences in Water Temps (^{o}C) of the Klamath R. at RKm 70.2 and:		
	Trinity R.		Klamath R.			Contributions of Flow to the Klamath Gage (%)[b]		Trinity R.	Klamath R. Sites			Trinity R.	Klamath R. Sites	
Date	Lewiston rkm 178.6	Hoopa rkm 20.0	Iron Gate rkm 305.5	Orleans rkm 95.1	Klamath rkm 13.0	Lewiston Dam rkm 178.6	Iron Gate Dam rkm 305.5	TR rkm 20	WE rkm 70.2	KBW rkm 68.7	KAT rkm 13.0	TR rkm 20	KBW rkm 68.7	KAT rkm 13.0
07/16/09	457	938	1038	1970	3410	13	30	22.5	22.6	22.7	22.0	0.1	-0.1	0.5
07/17/09	485	926	1035	1951	3330	15	31	22.9	23.0	23.0	22.3	0.0	-0.1	0.6
07/18/09	481	951	1035	1936	3300	15	31	23.5	23.4	23.5	22.5	-0.1	-0.1	0.9
07/19/09	463	951	1036	1908	3280	14	32	23.8	23.9	23.9	23.0	0.0	-0.1	0.8
07/20/09	441	913	1037	1890	3230	14	32	24.1	24.4	24.4	23.3	0.3	0.0	1.1
07/21/09	425	888	1032	1872	3160	13	33	23.8	24.0	24.0	22.9	0.2	0.0	1.1
07/22/09	425	844	1033	1862	3090	14	33	23.4	23.5	23.6	22.7	0.1	0.0	0.8
07/23/09	425	837	1033	1851	3050	14	34	23.4	23.6	23.6	22.7	0.2	0.0	0.9
07/24/09	426	827	1030	1846	3020	14	34	23.9	24.3	24.2	22.9	0.3	0.1	1.3
07/25/09	426	818	1030	1832	2980	14	35	24.3	24.6	24.5	23.2	0.2	0.0	1.4
07/26/09	426	810	1031	1818	2940	14	35	24.7	24.9	24.9	23.5	0.2	0.1	1.4
07/27/09	426	800	1030	1803	2900	15	36	25.1	25.4	25.4	23.9	0.3	0.0	1.6
07/28/09	425	789	1030	1797	2860	15	36	25.5	25.8	25.9	24.2	0.3	0.0	1.6
07/29/09	429	777	1030	1783	2820	15	37	25.8	25.8	25.8	24.3	0.0	0.0	1.6
07/30/09	428	772	1031	1777	2770	15	37	25.6	25.5	25.5	23.9	-0.1	0.0	1.7
07/31/09	446	799	1029	1773	2770	16	37	25.2	25.3	25.3	23.8	0.1	0.0	1.6
08/01/09	458	799	1027	1767	2760	17	37	24.6	25.0	25.0	23.7	0.4	0.0	1.3
08/02/09	457	823	1027	1758	2740	17	37	24.4	24.5	24.5	23.6	0.1	0.0	0.9
08/03/09	463	813	1027	1777	2740	17	37	23.9	24.3	24.2	23.1	0.4	0.1	1.2
08/04/09	463	809	1026	1762	2750	17	37	23.4	24.1	23.9	22.8	0.7	0.1	1.3
08/05/09	468	812	1032	1750	2720	17	38	23.0	23.7	23.5	22.6	0.7	0.1	1.0
08/06/09	467	892	1036	1796	2760	17	38	21.7	22.4	22.4	22.2	0.7	0.0	0.2
08/07/09	466	913	1031	1831	2960	16	35	20.7	21.6	21.5	21.4	0.9	0.2	0.2
08/08/09	464	887	1030	1815	2990	16	34	21.2	21.7	21.6	21.4	0.4	0.1	0.3
08/09/09	463	864	1029	1791	2900	16	35	21.7	22.0	22.0	21.8	0.3	0.0	0.2
08/10/09	463	846	860	1766	2830	16	30	22.0	22.3	22.3	22.0	0.2	0.0	0.2
08/11/09	463	827	853	1736	2750	17	31	22.3	22.6	22.6	22.4	0.3	0.0	0.3
08/12/09	462	811	853	1717	2680	17	32	22.5	22.8	22.8	22.7	0.3	0.0	0.1
08/13/09	461	795	852	1714	2630	18	32	22.3	22.5	22.7	22.5	0.2	-0.2	0.0
08/14/09	463	785	852	1709	2610	18	33	21.6	21.9	22.0	22.2	0.3	-0.2	-0.3
08/15/09	462	788	853	1709	2610	18	33	21.4	21.9	21.9	21.9	0.5	0.0	0.0
08/16/09	463	786	855	1698	2600	18	33	21.3	21.9	21.8	21.7	0.5	0.0	0.1
08/17/09	465	775	857	1691	2570	18	33	21.7	22.1	22.0	21.7	0.4	0.0	0.4
08/18/09	465	770	855	1682	2550	18	34	22.4	22.6	22.6	22.2	0.2	0.0	0.4
08/19/09	464	763	854	1666	2520	18	34	22.9	23.1	23.1	22.3	0.1	0.0	0.8
08/20/09	463	751	830	1658	2470	19	34	23.0	23.1	23.1	22.3	0.1	0.0	0.8
08/21/09	467	741	855	1644	2440	19	35	22.7	22.9	22.9	22.4	0.2	0.0	0.4
08/22/09	464	739	862	1645	2420	19	36	22.4	22.9	22.8	22.3	0.6	0.1	0.6
08/23/09	600	735	1030	1640	2410	25	43	21.9	22.5	22.4	22.0	0.5	0.1	0.5
08/24/09	2767	1052	1030	1640	2410	115	43	21.6	22.4	22.2	21.7	0.7	0.2	0.7
08/25/09	2018	2784	1030	1638	3570	57	29	19.1	22.0	21.4	21.6	2.8	0.6	0.4
08/26/09	1329	2166	1030	1636	4380	30	24	17.3	21.8	19.8	21.0	4.4	2.0	0.7
08/27/09	697	1547	1030	1632	3660	19	28	18.1	21.9	20.2	20.2	3.9	1.8	1.8
08/28/09	453	1042	1030	1629	3100	15	33	17.9	21.3	20.2	20.0	3.4	1.1	1.3
08/29/09	449	752	1031	1648	2690	17	38	18.6	21.1	20.3	20.4	2.5	0.8	0.6
08/30/09	428	689	1030	1647	2500	17	41	19.8	21.6	20.9	20.7	1.8	0.7	0.9

Appendix A. (Continued). Water temperature and flow comparisons of the Trinity River (rkm 20.0) and the mainstem Klamath River above and below the confluence of the Trinity River, April 15 to October 15, 2009. Station locations: TR = Trinity River, WE = Klamath River at Weitchpec, KBW = Klamath Below Weitchpec, and KAT = Klamath at Terwer,

	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 Klamath Gage (%)[b]		Trinity R.	Klamath R. Sites			Trinity R.	Klamath R. Sites	
Date	Lewiston rkm 178.6	Hoopa rkm 20.0	Iron Gate rkm 305.5	Orleans rkm 95.1	Klamath rkm 13.0	Lewiston Dam rkm 178.6	Iron Gate Dam rkm 305.5	TR rkm 20	WE rkm 70.2	KBW rkm 68.7	KAT rkm 13.0	TR rkm 20	KBW rkm 68.7	KAT rkm 13.0
08/31/09	448	662	1029	1635	2450	18	42	20.3	21.7	#N/A	20.9	1.3	#N/A	0.8
09/01/09	458	645	1029	1622	2390	19	43	20.6	21.3	#N/A	20.8	0.7	#N/A	0.5
09/02/09	454	658	1030	1617	2380	19	43	20.9	21.6	#N/A	#N/A	0.7	#N/A	#N/A
09/03/09	453	652	1038	1611	2370	19	44	20.7	21.4	#N/A	#N/A	0.7	#N/A	#N/A
09/04/09	467	648	1038	1611	2350	20	44	20.2	20.9	#N/A	#N/A	0.6	#N/A	#N/A
09/05/09	448	654	1030	1613	2350	19	44	19.5	20.1	#N/A	#N/A	0.6	#N/A	#N/A
09/06/09	449	668	1028	1623	2400	19	43	18.7	19.5	#N/A	#N/A	0.8	#N/A	#N/A
09/07/09	449	662	1030	1626	2410	19	43	18.8	19.3	#N/A	#N/A	0.5	#N/A	#N/A
09/08/09	447	663	1031	1628	2410	19	43	18.7	19.1	#N/A	#N/A	0.4	#N/A	#N/A
09/09/09	448	658	1028	1628	2410	19	43	18.9	19.3	#N/A	#N/A	0.5	#N/A	#N/A
09/10/09	450	652	1028	1620	2400	19	43	19.4	19.9	#N/A	#N/A	0.5	#N/A	#N/A
09/11/09	455	650	1223	1616	2380	19	51	20.0	20.4	#N/A	#N/A	0.4	#N/A	#N/A
09/12/09	457	640	1032	1611	2350	19	44	20.4	20.7	#N/A	#N/A	0.3	#N/A	#N/A
09/13/09	456	643	1030	1609	2350	19	44	20.0	20.2	#N/A	#N/A	0.2	#N/A	#N/A
09/14/09	457	681	1029	1621	2420	19	43	19.8	20.4	#N/A	#N/A	0.5	#N/A	#N/A
09/15/09	453	685	1030	1619	2440	19	42	19.9	20.6	#N/A	#N/A	0.7	#N/A	#N/A
09/16/09	452	678	1028	1619	2420	19	42	19.7	20.4	#N/A	#N/A	0.6	#N/A	#N/A
09/17/09	453	673	1026	1611	2390	19	43	20.3	20.6	#N/A	#N/A	0.3	#N/A	#N/A
09/18/09	454	668	1026	1610	2380	19	43	20.3	20.6	#N/A	#N/A	0.4	#N/A	#N/A
09/19/09	447	666	1028	1600	2360	19	44	20.4	20.6	#N/A	#N/A	0.2	#N/A	#N/A
09/20/09	447	648	1027	1599	2340	19	44	20.2	20.7	#N/A	#N/A	0.4	#N/A	#N/A
09/21/09	445	641	1023	1589	2330	19	44	20.0	20.4	#N/A	#N/A	0.4	#N/A	#N/A
09/22/09	447	632	1023	1574	2290	20	45	19.7	20.0	#N/A	#N/A	0.4	#N/A	#N/A
09/23/09	452	627	1025	1573	2260	20	45	19.5	19.8	#N/A	#N/A	0.4	#N/A	#N/A
09/24/09	451	627	1029	1574	2250	20	46	19.3	19.7	#N/A	#N/A	0.4	#N/A	#N/A
09/25/09	451	626	1027	1579	2260	20	45	19.2	19.6	#N/A	#N/A	0.4	#N/A	#N/A
09/26/09	450	623	1032	1579	2250	20	46	19.3	19.8	#N/A	#N/A	0.5	#N/A	#N/A
09/27/09	452	623	1039	1580	2240	20	46	19.0	19.6	#N/A	#N/A	0.6	#N/A	#N/A
09/28/09	459	623	1039	1586	2230	21	47	18.3	19.0	#N/A	#N/A	0.8	#N/A	#N/A
09/29/09	452	624	1038	1588	2240	20	46	17.2	18.0	#N/A	#N/A	0.8	#N/A	#N/A
09/30/09	452	635	750	1607	2260	20	33	15.9	16.9	#N/A	#N/A	1.1	#N/A	#N/A
10/01/09	452	641	1327	1623	2310	20	57	15.4	16.3	#N/A	#N/A	0.9	#N/A	#N/A
10/02/09	454	648	1323	1783	2360	19	56	15.0	15.8	#N/A	#N/A	0.7	#N/A	#N/A
10/03/09	457	648	1328	1873	2690	17	49	14.7	15.4	#N/A	#N/A	0.7	#N/A	#N/A
10/04/09	454	650	1330	1884	2740	17	49	13.7	14.5	14.4	#N/A	0.9	0.2	#N/A
10/05/09	453	665	851	1898	2790	16	31	13.3	14.0	13.8	#N/A	0.7	0.2	#N/A
10/06/09	453	668	1321	1898	2820	16	47	13.2	13.8	13.6	#N/A	0.5	0.1	#N/A
10/07/09	452	666	1327	1895	2800	16	47	13.2	13.7	13.6	#N/A	0.6	0.1	#N/A
10/08/09	454	660	1330	1884	2790	16	48	13.3	13.9	13.7	#N/A	0.5	0.1	#N/A
10/09/09	452	659	1320	1889	2770	16	48	13.5	14.2	14.0	#N/A	0.6	0.2	#N/A
10/10/09	455	656	1327	1873	2760	16	48	13.6	14.2	14.0	#N/A	0.6	0.2	#N/A
10/11/09	450	654	1333	1879	2730	16	49	13.5	14.2	14.0	#N/A	0.7	0.2	#N/A
10/12/09	451	654	1332	1892	2760	16	48	13.4	13.9	13.8	#N/A	0.4	0.0	#N/A
10/13/09	449	782	1333	2062	2950	15	45	13.3	13.8	13.8	#N/A	0.4	0.0	#N/A
10/14/09	451	1635	1326	3527	4770	9	28	13.2	13.6	13.6	#N/A	0.3	-0.1	#N/A
10/15/09	444	2747	1326	3773	7960	6	17	13.8	13.7	13.8	#N/A	0.0	-0.1	#N/A

Appendix B. Comparison of water temperatures at Hoopa gage (rkm 20.0) of the Trinity River and the terminus of the Trinity River (WPC, rkm 0.1). Graph is provided to illustrate how similar water temperatures can be at these locations. Note: that the Hoopa site (dotted line) is slightly cooler than the terminus of the Trinity River.