U.S. Fish & Wildlife Service

Arcata Fisheries Data Series Report Number DS2008-01

The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2007

Paul Zedonis And Randy Turner

U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, CA 95521
(707) 882-7201

January 2008

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

The Arcata Fish and Wildlife Office Fisheries Program reports its study findings through two publication series. The **Arcata Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency databases. The **Arcata Fisheries Technical Reports** publishes scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional fisheries journals.

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

The correct citation for this report is:

Zedonis, P. and R. Turner. 2008. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA. April to October, 2007. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2008-01, Arcata, California.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Arcata Fisheries Data Series Report Number DS 2008-01

The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2007

Paul Zedonis and Randy Turner
U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office
1655 Heindon Road, Arcata, CA 95521
paul_zedonis@fws.gov

Abstract —Water temperatures were monitored on the Trinity and Lower Klamath rivers from April to October 2007 to evaluate the influence of prescribed flow releases from Lewistown Dam on downstream water temperature objectives specified in the Trinity River Record of Decision. A Dry water year schedule was implemented and was fully successful at meeting the summer temperature objectives of the North Coast Regional Water Quality Control Board Objectives at Douglas City and the North Fork Trinity River. The Dry year schedule was not fully successful at meeting at least "Marginal" smolt temperature criteria at Weitchpec. Exceedence of the 17.0 °C criterion occurred from May 30 to June 5 and was due to warm air temperatures. The greatest exceedence occurred on June 3 when the water temperature was 1.8 ˚C above the criterion of 17 ˚C. Despite not meeting the criterion, these flows did result in increased temperature differences between the Trinity River and the Klamath River, which indicated that these flows moderated water temperatures during a time when water temperatures of the Klamath River were increasing. A 2-day pulse flow from Lewiston Dam in late August used to support the ceremonial needs of the Hoopa Valley Tribe reduced water temperatures of the Trinity River at Weitchpec by 1 to 2 °C, which resulted in an increased temperature differential with the 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 Environmental Impact Statement in December of 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.

This report represents the sixth 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 2006 (Zedonis 2003, Zedonis 2004, Zedonis 2005, Zedonis and Turner 2006, and Zedonis and Turner 2007) 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 km before joining the Klamath River at Weitchpec. From Weitchpec, the Klamath River flows for 70 km 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), and the Yurok and Hoopa Valley Tribes. 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. Unfortunately, the flow data obtained from many of these websites is also preliminary and subject to change.

RESULTS AND DISCUSSION

Hydrology

In water year 2007, approximately 458 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, and roughly 4 TAF for a 2-day pulse flow

to support the ceremonial needs of the Hoopa Valley Tribe (Figure 2). Limitations on precise flow control from Lewiston Dam accounts for the remaining 1 TAF.

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 detailed information). During the winter and early spring, contributions of flow from Lewiston dam to lower river gauges were quite small due to low base flows (e.g. 300 cfs) and the larger contributions of flow from the abundant tributaries located above downstream gauges. In contrast, the peak flow of 4,600 cfs that occurred in early May as well as the 2-day pulse of 1,000+ cfs in late August resulted in a substantially greater contribution of flow to the lower Trinity River (i.e. Hoopa gauge) as well as the lower Klamath River (i.e. Klamath gauge).

Spring flow from Lewiston Dam followed a Dry water year schedule remarkably well as prescribed in the ROD (Figure 3). Unlike previous years, there were no modifications made to the spring schedule.

Water Temperatures of the Mainstem Trinity River

Lewiston Gauge (rkm 178.2)

From April to October, water temperatures of Lewiston Dam releases remained between 7.5 and 10.8 ˚C (Figure 4). 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 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 May during the peak release of 4,600 cfs.

Douglas City Gauge (rkm 148.5)

Water temperatures ranged between 8.2 and 15.7 ˚C from April to mid-October (Figure 5). Water temperatures at this site were largely influenced by an inverse relationship of flow from Lewiston Dam and water temperature, as well as typical summertime weather patterns. Inverse relationships are most notable from early May through July as well as during the 2-day pulse in late August. During these times as well as periods of steady flow, the temperature objectives of the NCRWQCB were for all practical purposes met. Unlike past years, the water temperature

criterion was not exceeded in 2007 due to relatively low release temperatures from Lewiston Dam and only moderately warm ambient air temperatures. In past years, these factors have to varying "degrees" been warmer to result in exceedence of the criterion (see Zedonis 2004)

Trinity above the North Fork Trinity (rkm 117.6)

Average daily water temperatures above the North Fork Trinity were slightly warmer in comparison to the upstream Douglas City site but followed a similar trend (Figure 6). Similar to the Douglas City site, water temperatures showed an inverse relationship with flow. Average daily temperatures peaked at 20.3 ˚C on July 6. Following the peak in July, average daily water temperatures continued to decrease thereafter. In all cases, including the start of October, the NCRWQCB objective of 13.3 ˚C was met. Again, the probable reason for meeting the criterion in 2007 was a combination of adequate flow release volume and water temperature and relatively low ambient air temperatures.

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. Within this reach, the temperature influence of Lewiston Dam releases are somewhat diluted during the spring by relatively large flow contributions from tributaries (e.g. South Fork Trinity River, New River, etc). However, there were still times, in particular early May when a release of ~4,600 cfs from Lewiston Dam was partly responsible for a 4 to 5° C reduction in water temperatures in this reach (Figure 7). As Lewiston dam releases were reduced and air temperatures increased water temperatures also increased, reaching a peak of over 24 °C in early July. The pulse flow in late August also resulted in a substantial reduction in water temperatures in this reach, with the greatest reduction occurring at the top of this reach. Variations in daily average water temperature during periods of steady summer flow indicate that meteorological factors heavily influenced water temperatures during these times.

The springtime temperature criteria for smolts of the lower Trinity River were generally met except for May 30 to June 5 when water temperatures exceeded the "marginal" zone

and entered the "unsuitable" range (Figure 8). The greatest exceedence occurred on June 3 when the water temperature was 1.8 ˚C above the criterion of 17 ˚C. The time of exceedance corresponded to a time of increasing air temperatures (Figure 9).

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

From mid-April to mid October, the average daily water temperatures of the Klamath River were generally warmer than the Trinity River mouth (Figure 10, See Appendix A for more detail). The Klamath River was generally between 1.0 and 1.6 °C warmer than the Trinity River from May 26 to June 6. Beyond this time period, water temperature of the Trinity River were typically less than 0.8 °C colder than the Klamath River except from August 28 to September 3 when temperature differences increased due to the increased flow of cold water from Lewiston Dam to support the ceremonial needs of the Hoopa Valley Tribe. During this increase in flow, water temperatures of the Trinity River were reduced by 1 to 2 °C that resulted in increased temperature differences (up to 2.6°C) between the two waterways. As in previous odd numbered years when this ceremony occurs, we again found the pulse flow to reduce water temperatures of the Trinity River and that the greatest temperature difference occurred 1 to 2 days following the release from Lewiston Dam (e.g. see Zedonis 2004).

ACKNOWLEDGEMENTS

We would like to thank Nicholas Hetrick and Joe Polos 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. We also would like to thank Ken Fetcho of the Yurok Tribe Environmental Program who provided water temperature data for several site along the lower Trinity River and Klamath River. The Trinity River Restoration Program provided funding to support field studies and report completion.

REFERENCES

North Coast Regional Water Quality Control Board. 1994. Basin Plan for the North Coast Region, Santa Rosa, CA.

Zedonis P.1997. A water temperature model of the Trinity River, U. S. Fish and Wildlife Service, Arcata, CA 95521. 97 pp.

Zedonis, P. 2003. Lewiston Dam releases and their influence on water temperatures of the Trinity River, CA, WY 2002. Report AFWO-F-04-03. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA 95521. 16 pp.

Zedonis, P. 2004. Lewiston Dam releases and their influence on water temperatures of the Trinity and Klamath Rivers, CA; April to October, 2003. Report AFWO-F01-04. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, CA 95521. 34 pp.

Zedonis, P. 2005. The influence of Lewiston Dam releases on water temperatures of the Trinity and Klamath Rivers, CA; April to October, 2004. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR2005-03, Arcata, California. 31 pp.

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 DS2006-08, Arcata, California. 29 pp

Zedonis, P. and R. Turner. 2007. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2006. U. S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2007-01, Arcata, California.

.

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 Centigrade

Table 2. Water temperature monitoring sites of the Trinity River and the Klamath River below Weitchpec in 2007. 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 (TRLW2)	178.2	California Data Exchange Center (CDEC)	California Department of Water resources
TR above Rush Ck (TRRC1)	173.0	FWS	Fish and Wildlife Service (FWS)
TR@ Limkiln Gulch Gauge (TRLK1)	158.7	CDEC	U.S. Geological Survey (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. (TRNF1)	117.6	CDEC	US. Bureau of Reclamation (USBR)
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 (TRHP1)	20.0	USGS	USGS
TR @ Weitchpec (TRWE1)[a]	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 Blue Ck (KRBC1)	26.5	YTEP/FWS	Yurok/FWS
KR above Terwer (KRTG2)	13.0	YTEP/FWS	FWS/Yurok Tribe
Trinity River Tributary Sites			
Rush Ck (RCTR2)	173.0 + 0.4[c]	CDEC	USBR/ USGS
Canyon Ck (CNTR1)	127.3 + 0.1	FWS	FWS
N. F. Trinity R (NFTR1)	116.7 + 0.1	FWS	FWS
Big French Ck (BFC)	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

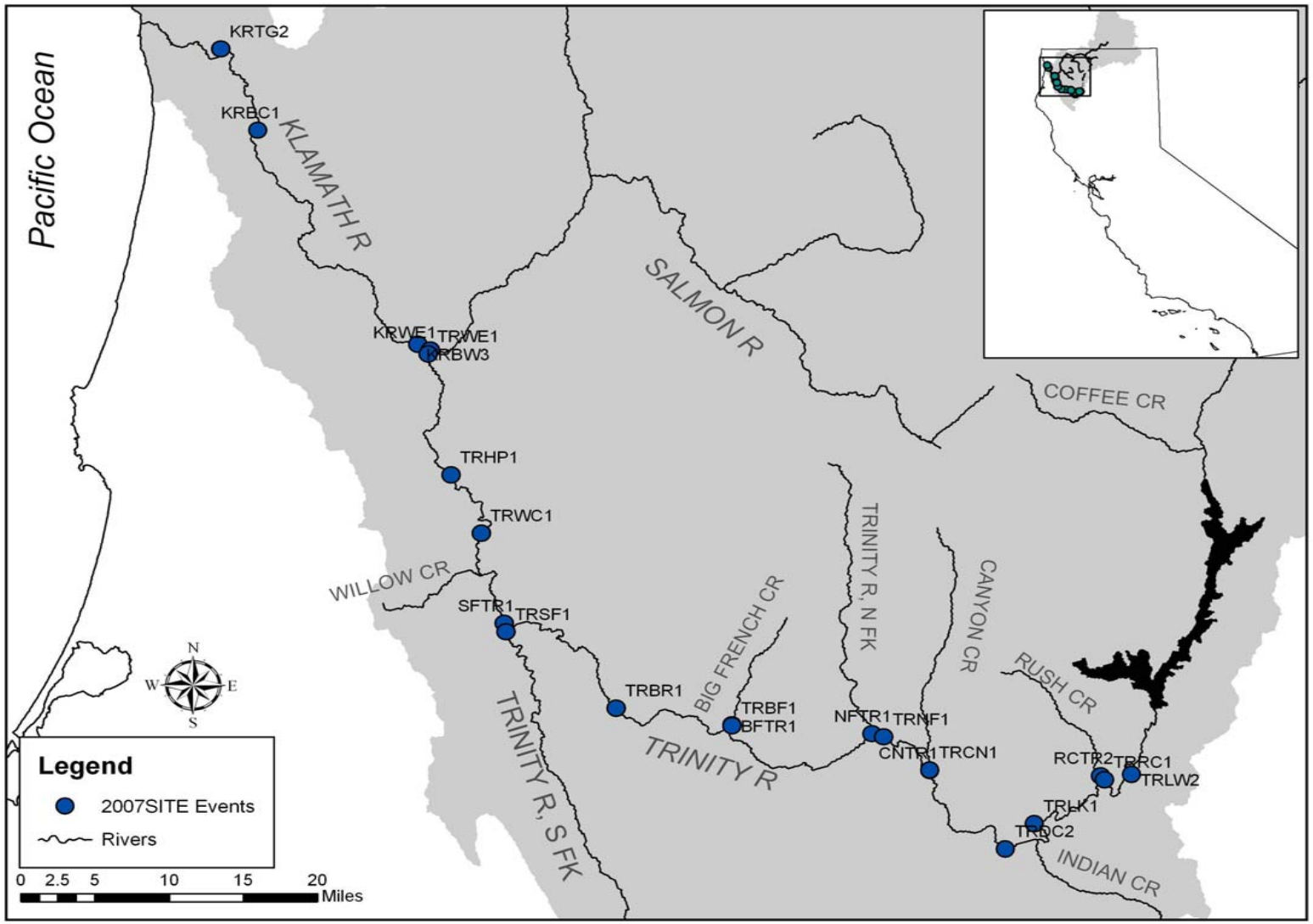

Figure 1. Location of water temperature monitoring sites of the Trinity River and lower Klamath River in 2007. See Table 2 for site descriptions.

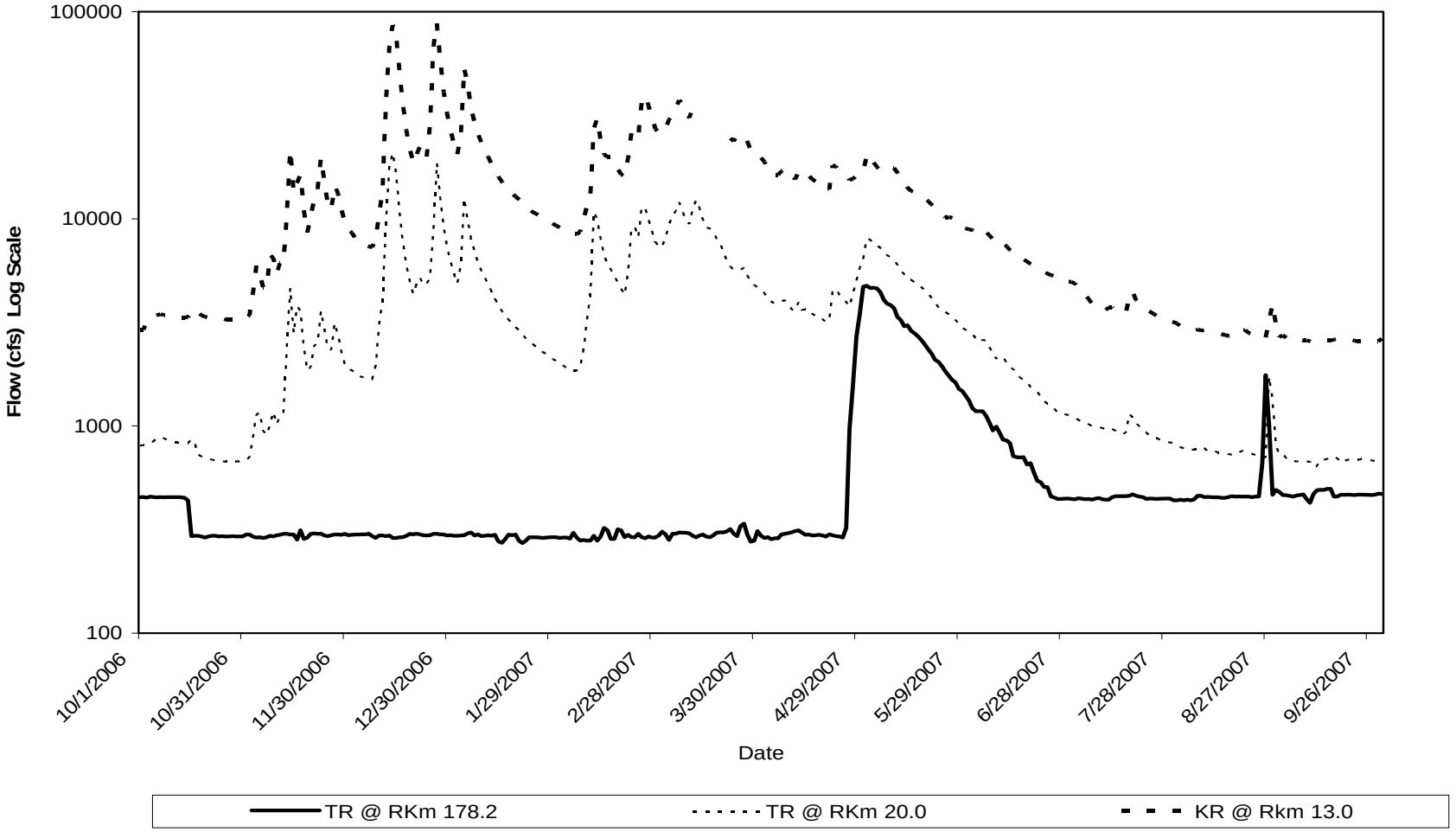

Figure 2. Average daily flow of the Trinity River (TR) at Lewiston gauge (RKm 178.2) and Hoopa gauge (RKm 20.0), and the Klamath River at the Klamath Gauge (RKm 13.0) in 2007. US Geological Survey gauge data, preliminary and subject to revision.

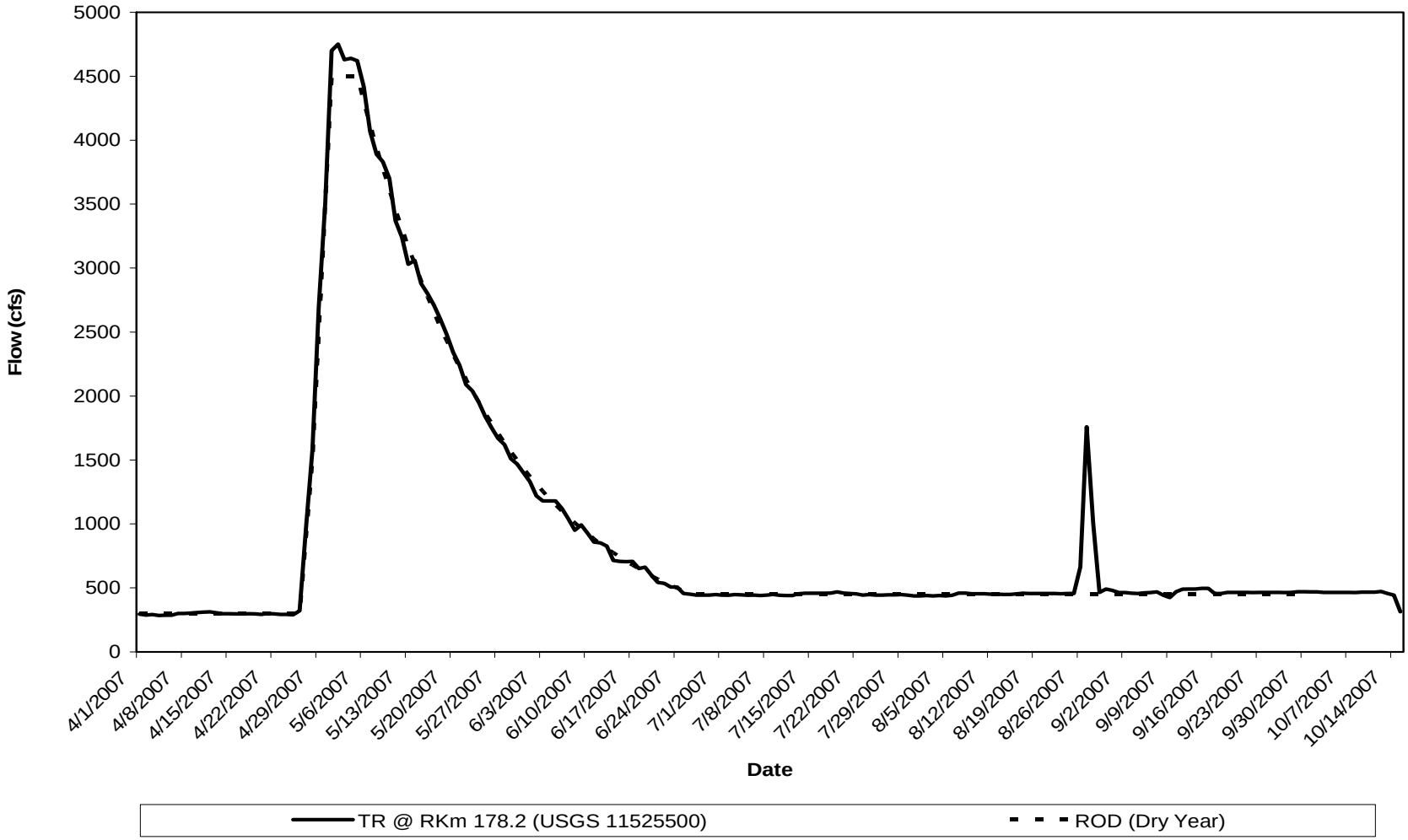

Figure 3. Spring and early summer flow releases from Lewiston Dam (rkm 178.2) on the Trinity River (TR) in 2007 compared to the flow schedule for a Dry hydrologic water year identified in the Record of Decision (ROD) (USFWS et.al., 2000).

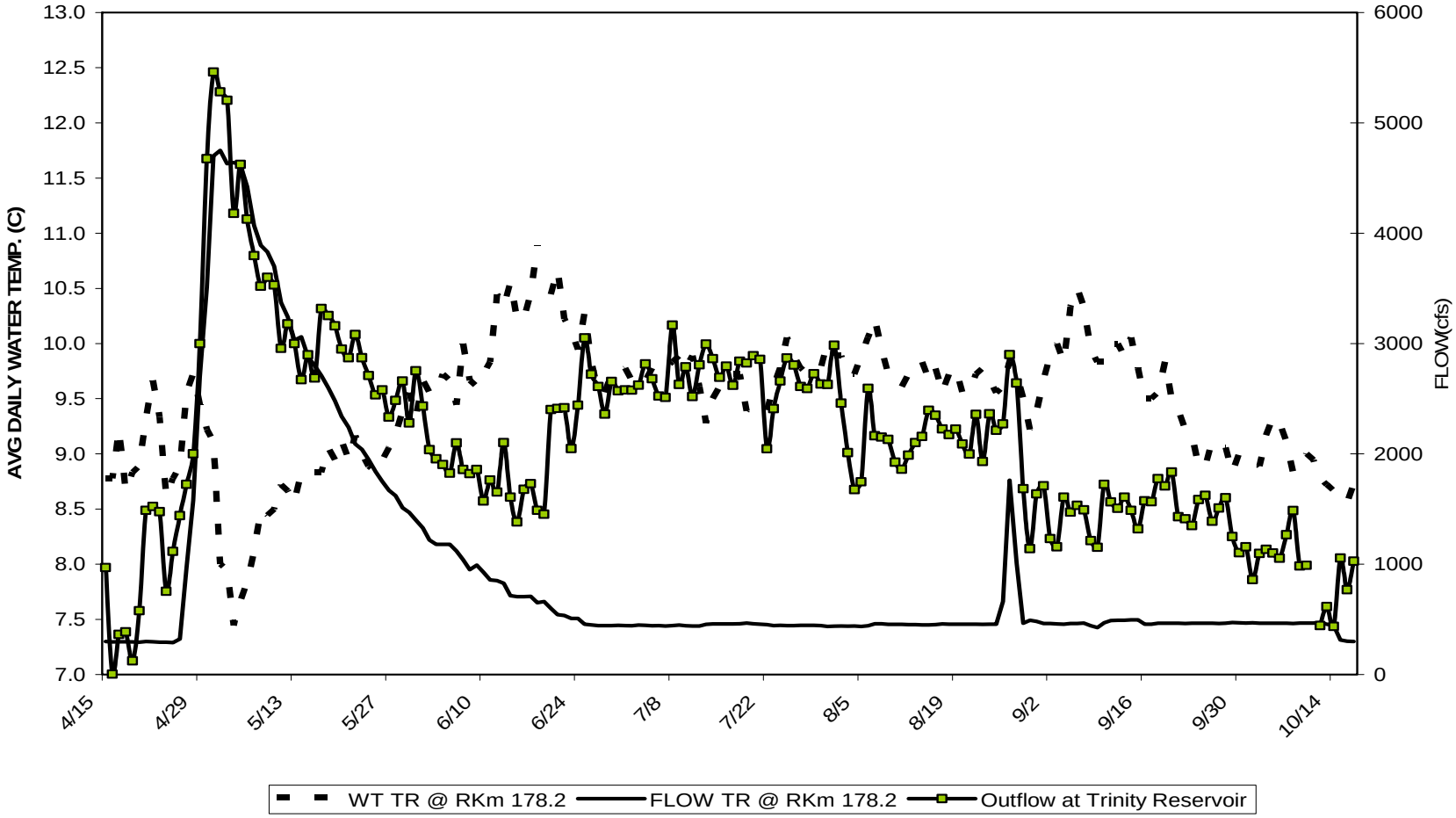

Figure 4. Water temperature (WT) and flow of the Trinity River at Lewiston (RKm 178.2) and Trinity Reservoir outflow in 2007. Trinity Reservoir outflow supplies water to the Trinity River and diversions to the Sacramento River basin. The area between lines representing Trinity Reservoir outflow and flow at Lewiston represent an estimate of flow diverted to the Sacramento River Basin.

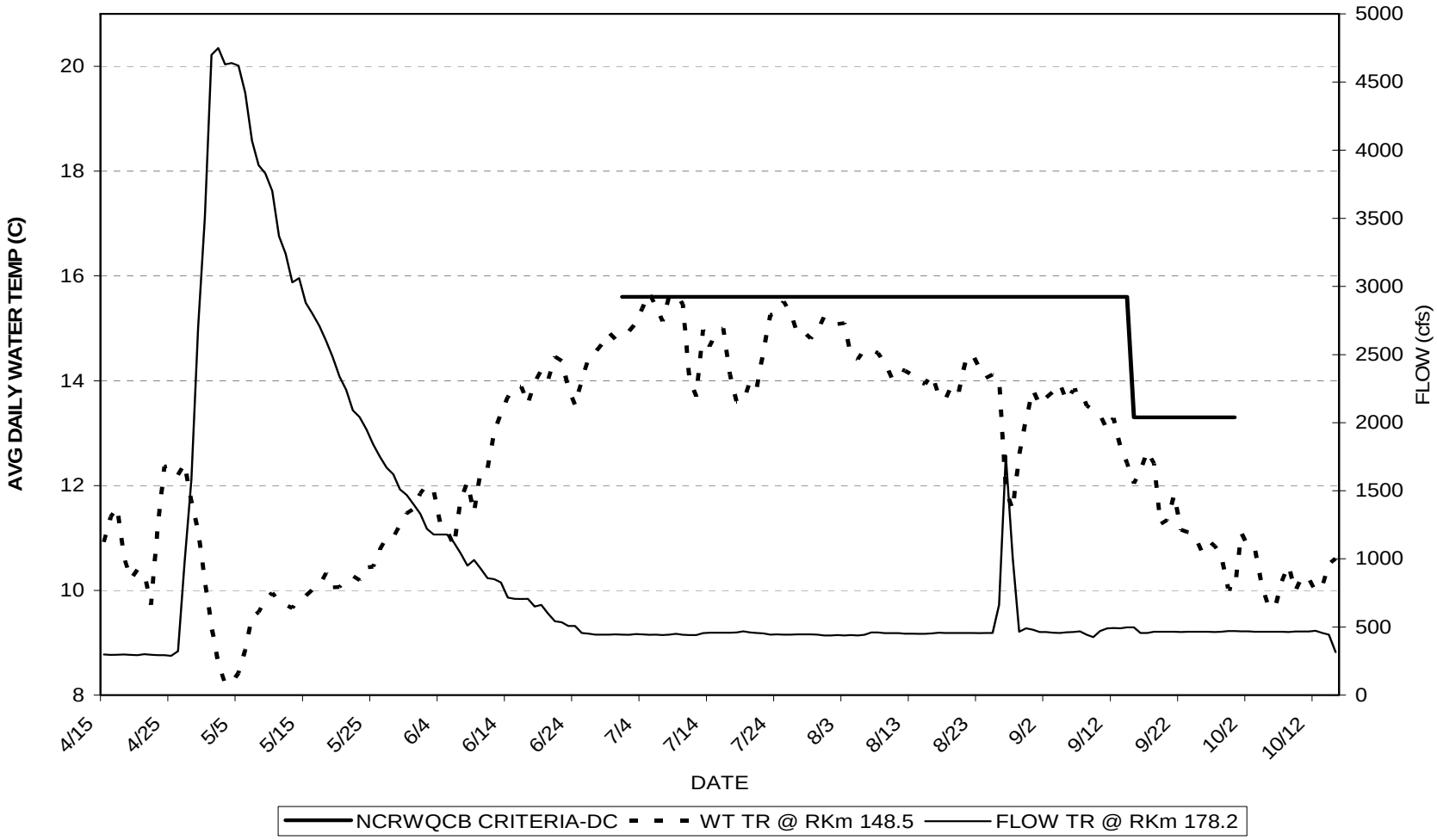

Figure 5. Comparison of average daily water temperatures (WT) of the Trinity River at Douglas City gauge (RKm 148.5) and the water temperature criteria of the North Coast Regional Water Quality Control Board in 2007. The criteria are not to be exceeded.

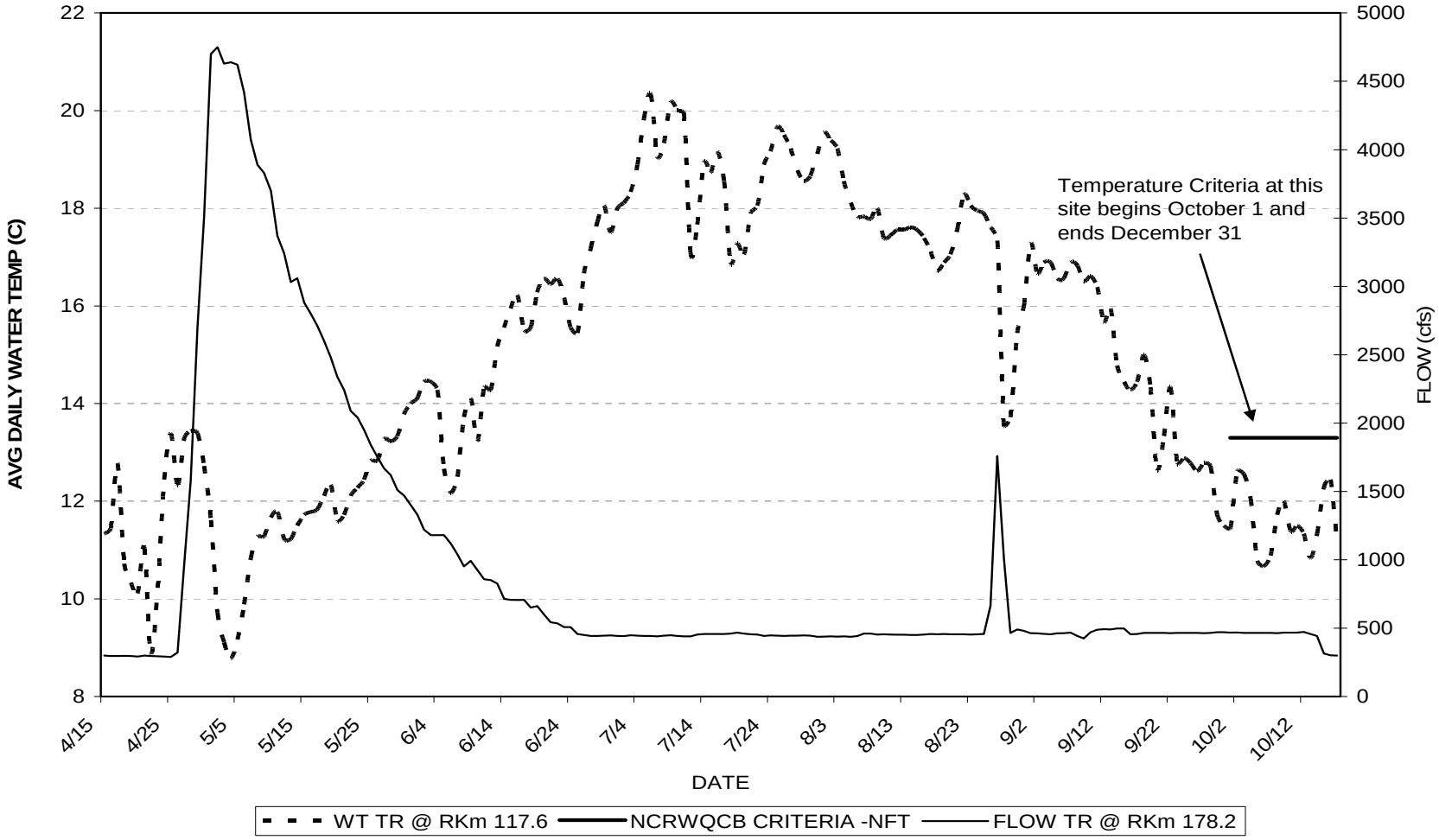

Figure 6. Comparisons of average daily water temperatures (WT) of the Trinity River above the confluence of the North Fork Trinity River (RKm 117.6) and the water temperature criteria of the North Coast Regional Water Quality Control Board in 2007. The criterion is not to be exceeded.

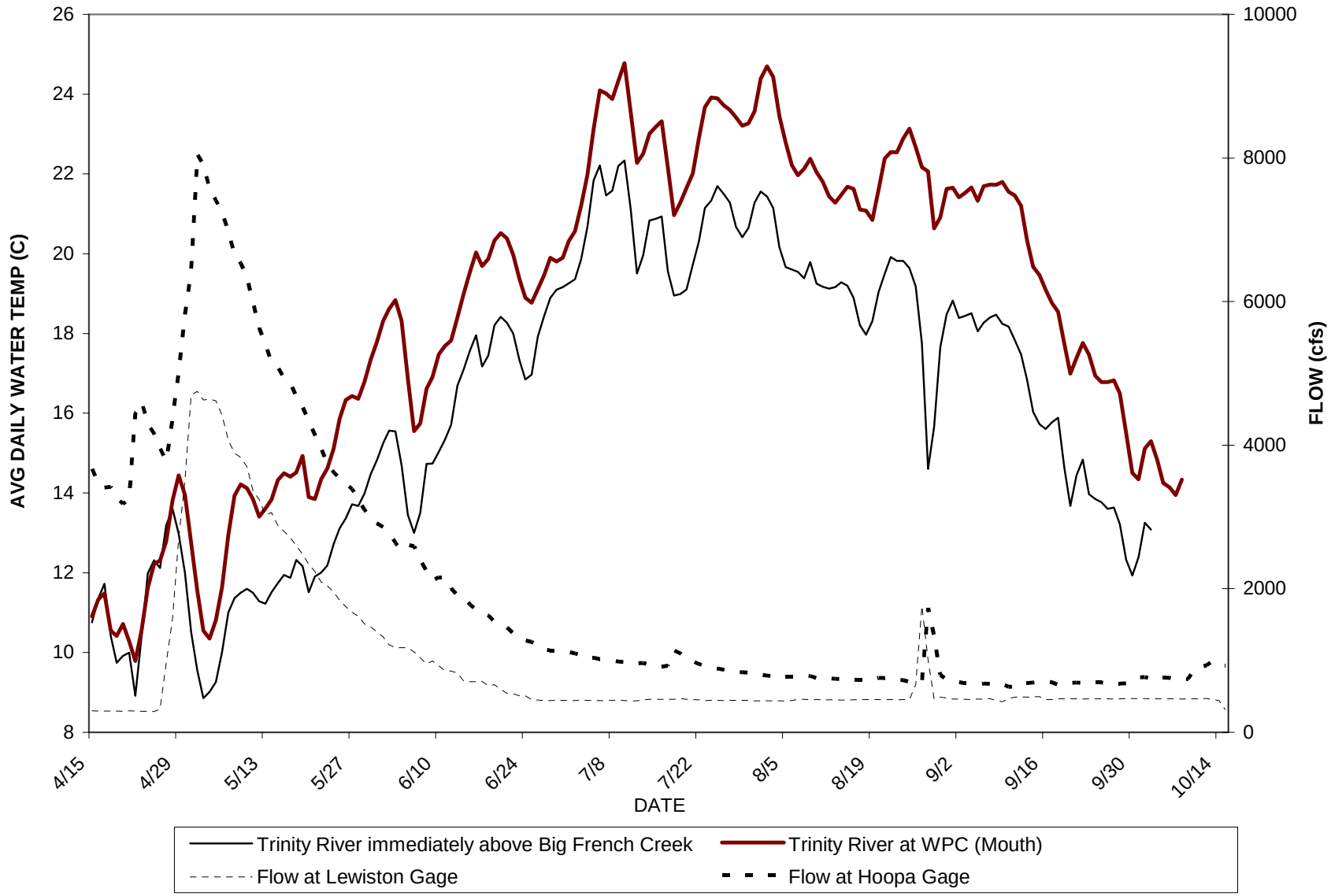

Figure 7. Average daily water temperatures of the Trinity River immediately above Big French Creek (RKm 94.2) and Weitchpec (RKm 0.1), and flow data from Lewiston (RKm 178.2) and Hoopa (RKm 20.0) in 2007.

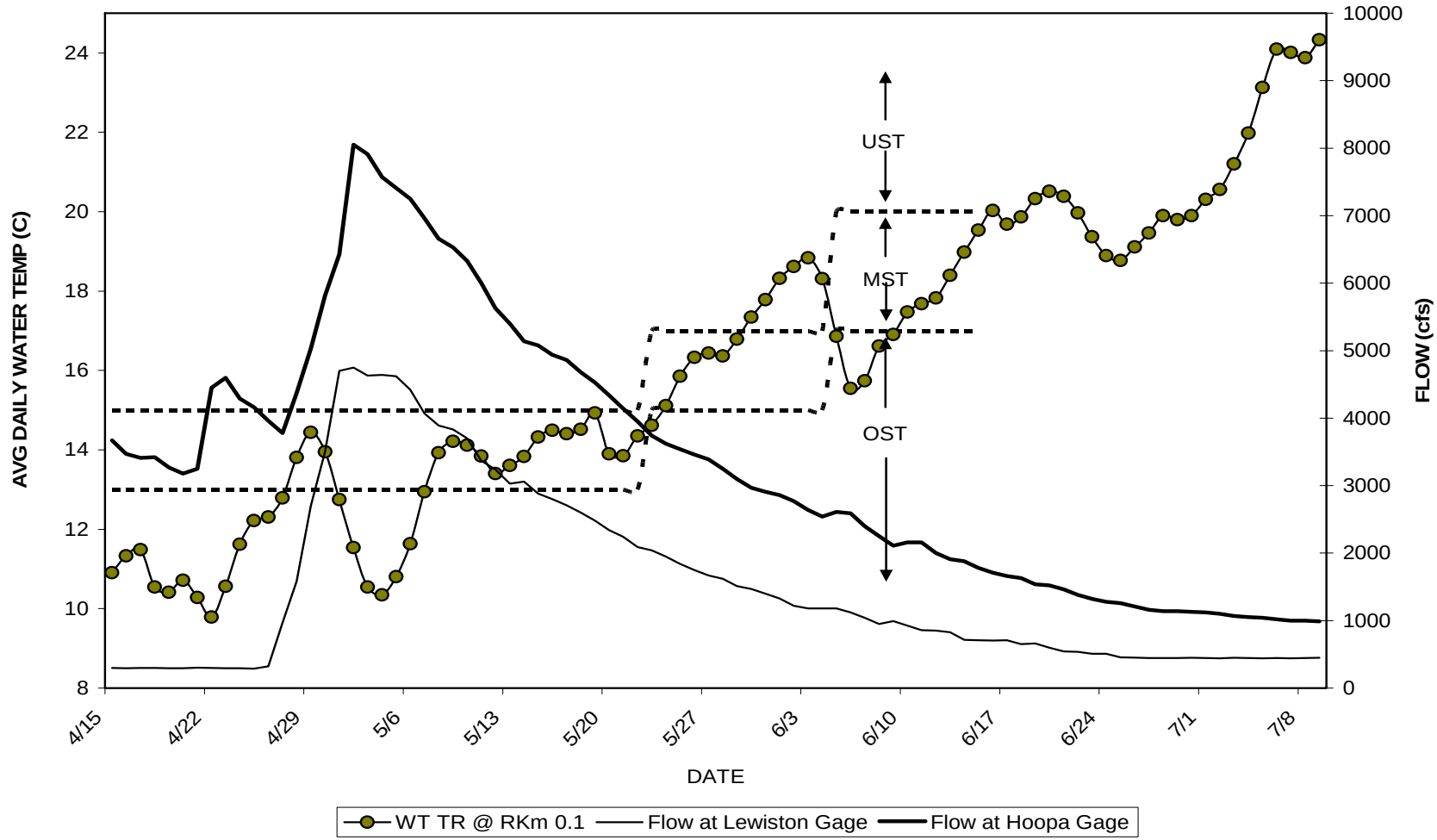

Figure 8. Average daily water temperatures (WT) of the Trinity River at Weitchpec in 2007 and how they compare to the spring-time temperature criteria established by the Record of Decision (USFWS et al., 2000). Smolt criteria: UST = unsuitable smolt temperatures; MST = marginal smolt temperatures, OST = optimal smolt temperatures. Marginal smolt temperatures were sought from April to June 15 in 2007.

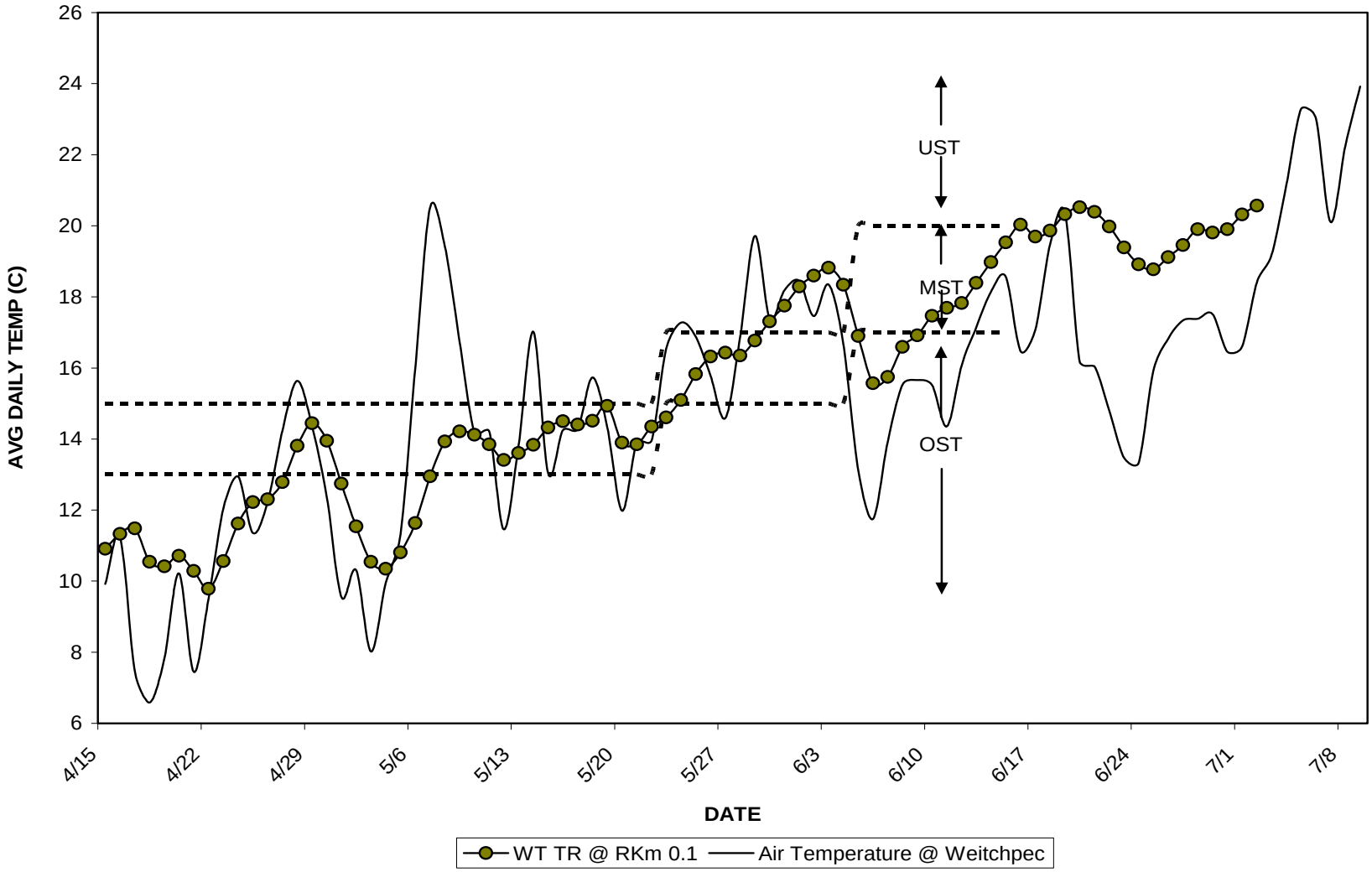

Figure 9. Air temperature and its influence on water temperature (WT) of the Trinity River at Weitchpec from April 15 to July 9, 2007. Smolt criteria: UST = Unsuitable temperatures; MST = Marginally suitable temperatures; OST = Optimally suitable temperatures.

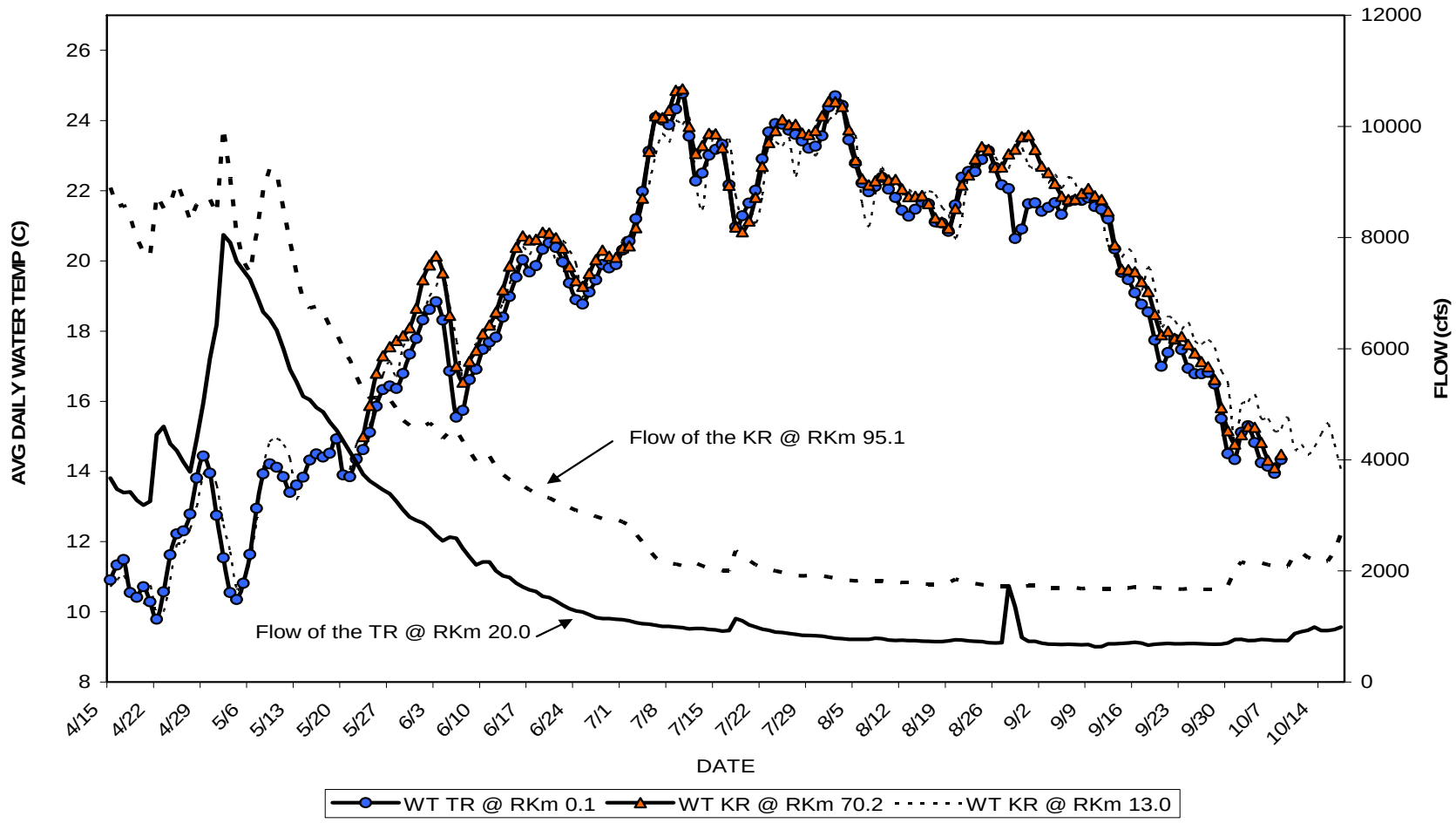

Figure 10. Comparison of water temperatures (WT) of the Trinity River (TR) at Weitchpec (RKm 0.1) and the Klamath River (KR) above (RKm 70.2) and below (RKm 13.0)) the confluence of the Trinity River in 2007. See Appendix A for specific daily information.

Appendix A. Table of water temperatures and flows of the Trinity River (RKm 0.1) and the mainstem Klamath River above and below the confluence of the Trinity River and the Klamath River, April 15 to October 15, 2007.

	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		
	Lewiston	Hoopa	Iron Gate	Orleans	Klamath	Lewiston Dam	Iron Gate Dam	TR	WE	KBW	KBC	KAT	TR	KBW	KBC	KAT
Date	rkm 178.6	rkm 20.0	rkm 305.5	rkm 95.1	rkm 13.0	rkm 178.6	rkm 305.5	rkm 0.1	rkm 70.2	rkm 68.7	rkm 26.5	rkm 13.0	rkm 0.1	rkm 68.7	rkm 26.5	rkm 13.0
4/15/07	299	3670	2440	8900	16200	2	15	10.9	–	–	–	10.7	--	--	--	--
4/16/07	296	3470	2430	8550	15500	2	16	11.3	–	–	–	10.9	--	--	--	--
4/17/07	297	3410	2360	8590	15200	2	16	11.5	–	–	–	11.0	--	--	--	--
4/18/07	298	3420	2320	8360	15300	2	15	10.5	–	–	–	10.7	--	--	--	--
4/19/07	296	3270	2250	7980	14500	2	16	10.4	–	–	–	10.4	--	--	--	--
4/20/07	293	3180	2020	7730	14100	2	14	10.7	–	–	–	10.2	--	--	--	--
4/21/07	300	3250	2000	7660	13900	2	14	10.3	–	–	–	10.8	--	--	--	--
4/22/07	297	4450	2040	8760	18100	2	11	9.8	–	–	–	9.9	--	--	--	--
4/23/07	294	4600	2180	8520	17900	2	12	10.6	–	–	–	10.0	--	--	--	--
4/24/07	293	4290	2460	8590	17000	2	14	11.6	–	–	–	10.9	--	--	--	--
4/25/07	289	4160	2390	8980	16800	2	14	12.2	–	–	–	11.9	--	--	--	--
4/26/07	322	3960	2080	8680	16300	2	13	12.3	–	–	–	12.0	--	--	--	--
4/27/07	966	3780	1990	8300	15400	6	13	12.8	–	–	–	12.4	--	--	--	--
4/28/07	1580	4370	1820	8590	15600	10	12	13.8	–	–	–	13.0	--	--	--	--
4/29/07	2700	5030	1790	8720	16200	17	11	14.4	–	–	–	13.9	--	--	--	--
4/30/07	3510	5820	1730	8690	17000	21	10	14.0	–	–	–	14.0	--	--	--	--
5/1/07	4700	6430	1600	8430	17100	27	9	12.7	–	–	–	13.6	--	--	--	--
5/2/07	4750	8050	1470	9980	19900	24	7	11.5	–	–	–	12.5	--	--	--	--
5/3/07	4630	7910	1410	9070	20500	23	7	10.5	–	–	–	11.7	--	--	--	--
5/4/07	4640	7570	1410	8070	18700	25	8	10.4	–	–	–	10.7	--	--	--	--
5/5/07	4620	7410	1410	7580	17800	26	8	10.8	–	–	–	10.9	--	--	--	--
5/6/07	4420	7250	1410	7360	17100	26	8	11.6	–	–	–	11.4	--	--	--	--
5/7/07	4070	6960	1500	8080	17200	24	9	12.9	–	–	–	12.6	--	--	--	--
5/8/07	3890	6660	1690	8850	17700	22	10	13.9	–	–	–	14.1	--	--	--	--
5/9/07	3830	6530	1880	9240	17700	22	11	14.2	–	–	–	14.8	--	--	--	--
5/10/07	3700	6330	1750	9160	17600	21	10	14.1	–	–	–	14.9	--	--	--	--
5/11/07	3370	6000	1620	8520	16700	20	10	13.8	–	–	–	14.8	--	--	--	--
5/12/07	3240	5630	1490	7940	15700	21	9	13.4	–	–	–	14.4	--	--	--	--
5/13/07	3030	5400	1430	7360	14900	20	10	13.6	–	–	–	13.2	--	--	--	--
5/14/07	3060	5140	1420	6860	14100	22	10	13.8	–	–	–	14.1	--	--	--	--
5/15/07	2880	5080	1430	6730	13600	21	11	14.3	–	–	–	–	--	--	--	--
5/16/07	2800	4940	1420	6760	13500	21	11	14.5	–	–	–	–	--	--	--	--
5/17/07	2710	4860	1420	6650	13300	20	11	14.4	–	–	–	–	--	--	--	--
5/18/07	2600	4680	1420	6400	12900	20	11	14.5	–	–	–	–	--	--	--	--
5/19/07	2480	4530	1420	6270	12500	20	11	14.9	–	–	–	–	--	--	--	--
5/20/07	2340	4340	1420	6000	12200	19	12	13.9	–	–	–	–	--	--	--	--
5/21/07	2240	4140	1410	5800	11700	19	12	13.8	–	–	–	14.1	--	--	--	--
5/22/07	2090	3950	1420	5500	11300	18	13	14.3	–	–	–	14.8	--	--	--	--
5/23/07	2040	3740	1420	5250	10800	19	13	14.6	15.0	–	–	15.0	0.4	--	--	0.0
5/24/07	1950	3620	1420	5110	10400	19	14	15.1	15.9	–	–	15.3	0.8	--	--	0.6
5/25/07	1840	3540	1420	5120	10200	18	14	15.9	16.8	–	–	16.0	0.9	--	--	0.8
5/26/07	1750	3460	1420	5130	10200	17	14	16.3	17.3	–	–	16.7	1.0	--	--	0.5
5/27/07	1670	3390	1410	5090	10100	17	14	16.4	17.6	–	–	17.1	1.1	--	--	0.4
5/28/07	1620	3250	1420	4920	9800	17	14	16.4	17.7	–	–	16.7	1.4	--	--	1.0
5/29/07	1510	3100	1420	4710	9420	16	15	16.8	17.9	–	–	17.5	1.1	--	--	0.3
5/30/07	1470	2970	1420	4620	9080	16	16	17.3	18.1	–	–	17.8	0.8	--	--	0.3

Appendix A. Cont.

	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 0.1	WE rkm 70.2	KBW rkm 68.7	KBC rkm 26.5	KAT rkm 13.0	TR rkm 0.1	KBW rkm 68.7	KBC rkm 26.5	KAT rkm 13.0
5/31/07	1400	2910	1470	4600	8980	16	16	17.8	18.7	–	–	17.9	0.9	--	--	0.8
6/1/07	1330	2860	1570	4590	8890	15	18	18.3	19.5	–	–	18.5	1.1	--	--	1.0
6/2/07	1220	2770	1550	4660	8840	14	18	18.6	19.9	–	–	19.0	1.3	--	--	0.9
6/3/07	1180	2640	1540	4560	8720	14	18	18.8	20.1	–	–	19.3	1.3	--	--	0.9
6/4/07	1180	2540	1550	4380	8370	14	19	18.3	19.7	–	–	19.7	1.3	--	--	0.0
6/5/07	1180	2610	1550	4510	8400	14	18	16.9	18.5	–	–	18.7	1.6	--	--	-0.3
6/6/07	1120	2590	1560	4530	8660	13	18	15.6	17.0	16.0	–	17.7	1.5	1.0	--	-0.7
6/7/07	1040	2400	1560	4330	8310	13	19	15.7	16.5	16.5	–	16.6	0.8	0.0	--	-0.1
6/8/07	951	2250	1550	4150	7930	12	20	16.6	17.1	16.9	–	17.0	0.5	0.2	--	0.2
6/9/07	992	2110	1550	3980	7570	13	20	16.9	17.4	17.7	–	17.7	0.5	-0.2	--	-0.2
6/10/07	927	2160	1550	4080	7520	12	21	17.5	17.9	17.5	–	17.4	0.4	0.5	--	0.5
6/11/07	858	2160	1560	4070	7620	11	20	17.7	18.2	18.2	–	17.4	0.5	0.0	--	0.7
6/12/07	852	2000	1550	3870	7370	12	21	17.8	18.5	18.3	–	18.3	0.7	0.2	--	0.2
6/13/07	827	1910	1540	3730	7040	12	22	18.4	19.2	18.8	–	18.8	0.8	0.4	--	0.4
6/14/07	715	1880	1540	3640	6850	10	22	19.0	19.9	19.5	–	19.3	0.9	0.4	--	0.5
6/15/07	707	1780	1540	3600	6700	11	23	19.5	20.4	20.0	–	19.8	0.8	0.4	--	0.6
6/16/07	706	1710	1540	3530	6530	11	24	20.0	20.7	20.7	–	20.4	0.7	0.0	--	0.3
6/17/07	708	1660	1540	3460	6380	11	24	19.7	20.6	20.5	–	20.2	0.9	0.1	--	0.4
6/18/07	651	1630	1540	3390	6220	10	25	19.9	20.6	20.6	–	20.6	0.7	0.0	--	0.0
6/19/07	662	1540	1540	3350	6060	11	25	20.3	20.8	20.6	–	20.8	0.5	0.2	--	0.0
6/20/07	599	1520	1540	3310	5920	10	26	20.5	20.8	21.0	–	20.8	0.3	-0.2	--	0.0
6/21/07	543	1460	1540	3250	5840	9	26	20.4	20.7	20.8	–	20.0	0.3	-0.1	--	0.7
6/22/07	535	1380	1540	3190	5670	9	27	20.0	20.4	20.6	–	20.6	0.4	-0.3	--	-0.2
6/23/07	508	1320	1540	3140	5530	9	28	19.4	19.8	20.1	–	20.3	0.5	-0.3	--	-0.5
6/24/07	508	1280	1540	3090	5440	9	28	18.9	19.4	19.7	–	19.9	0.5	-0.2	--	-0.5
6/25/07	457	1260	1540	3070	5340	9	29	18.8	19.3	19.3	–	19.0	0.5	0.0	--	0.3
6/26/07	451	1210	1540	3040	5280	9	29	19.1	19.6	19.6	–	19.6	0.5	0.1	--	0.0
6/27/07	444	1160	1530	2980	5130	9	30	19.5	20.0	19.8	–	19.9	0.6	0.3	--	0.1
6/28/07	444	1140	1540	2940	5030	9	31	19.9	20.3	20.5	–	20.2	0.4	-0.1	--	0.1
6/29/07	445	1140	1540	2940	5010	9	31	19.8	20.1	20.3	–	20.1	0.3	-0.2	--	0.1
6/30/07	447	1130	1540	2920	4980	9	31	19.9	20.1	20.0	–	19.9	0.2	0.1	--	0.2
7/1/07	444	1120	1460	2880	4960	9	29	20.3	20.4	20.5	–	20.6	0.1	-0.1	--	-0.2
7/2/07	442	1100	1340	2820	4870	9	28	20.6	20.4	20.7	–	20.7	-0.1	-0.2	--	-0.3
7/3/07	448	1070	1210	2660	4690	10	26	21.2	20.9	21.1	–	21.1	-0.3	-0.1	--	-0.2
7/4/07	446	1050	1080	2510	4510	10	24	22.0	21.8	21.7	–	21.6	-0.2	0.1	--	0.2
7/5/07	443	1040	1020	2370	4310	10	24	23.1	23.1	22.8	–	22.2	0.0	0.3	--	0.9
7/6/07	444	1020	1020	2230	4100	11	25	24.1	24.1	24.2	–	23.0	0.0	0.0	--	1.1
7/7/07	441	1000	1020	2170	3890	11	26	24.0	24.1	24.7	–	23.6	0.1	-0.6	--	0.5
7/8/07	445	1000	1020	2140	3850	12	26	23.9	24.3	24.5	–	23.4	0.4	-0.2	--	0.9
7/9/07	449	987	1020	2120	3770	12	27	24.3	24.9	25.1	–	24.0	0.5	-0.3	--	0.9
7/10/07	443	978	1020	2090	3710	12	27	24.8	24.9	25.4	–	23.9	0.1	-0.5	--	1.0
7/11/07	441	955	1020	2090	3610	12	28	23.6	23.8	25.4	–	24.1	0.3	-1.5	--	-0.3
7/12/07	441	963	1020	2140	3730	12	27	22.3	23.1	23.0	–	22.3	0.8	0.1	--	0.8
7/13/07	454	965	1030	2090	3730	12	28	22.5	23.3	23.3	–	21.5	0.8	0.0	--	1.8
7/14/07	458	948	1030	2040	3630	13	28	23.0	23.6	23.7	–	23.1	0.6	-0.1	--	0.5
7/15/07	458	938	1030	2020	3550	13	29	23.2	23.6	24.2	–	23.6	0.4	-0.6	--	0.1

Appendix A. Cont.

	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 0.1	WE rkm 70.2	KBW rkm 68.7	KBC rkm 26.5	KAT rkm 13.0	TR rkm 0.1	KBW rkm 68.7	KBC rkm 26.5	KAT rkm 13.0
7/16/07	458	913	1030	2000	3500	13	29	23.3	23.2	24.0	–	23.1	-0.1	-0.8	--	0.2
7/17/07	458	928	1030	2000	3510	13	29	22.2	22.2	23.6	–	23.5	0.0	-1.4	--	-1.3
7/18/07	460	1140	1030	2360	4160	11	25	21.0	21.0	21.7	–	21.9	0.0	-0.8	--	-0.9
7/19/07	468	1100	1030	2260	4430	11	23	21.3	20.8	21.1	–	21.2	-0.5	-0.3	--	-0.4
7/20/07	460	1030	1030	2190	4040	11	25	21.6	21.1	21.4	–	21.7	-0.5	-0.3	--	-0.6
7/21/07	456	992	1020	2110	3900	12	26	22.0	21.8	22.0	–	21.1	-0.2	-0.2	--	0.7
7/22/07	453	949	1020	2060	3750	12	27	22.9	22.7	22.6	–	21.9	-0.2	0.1	--	0.8
7/23/07	444	930	1020	2030	3630	12	28	23.7	23.4	23.8	–	23.4	-0.3	-0.4	--	-0.1
7/24/07	447	900	1020	2000	3560	13	29	23.9	23.7	24.1	–	23.4	-0.2	-0.4	--	0.3
7/25/07	445	888	1020	1970	3480	13	29	23.9	24.0	24.4	–	23.3	0.1	-0.4	--	0.7
7/26/07	444	874	1020	1930	3400	13	30	23.7	23.9	24.5	–	23.5	0.2	-0.6	--	0.4
7/27/07	446	857	1030	1920	3340	13	31	23.6	23.9	24.2	–	22.4	0.3	-0.3	--	1.5
7/28/07	446	842	1030	1910	3270	14	31	23.4	23.6	24.2	–	23.4	0.2	-0.6	--	0.2
7/29/07	447	836	1030	1920	3230	14	32	23.2	23.6	24.0	–	23.7	0.4	-0.4	--	-0.1
7/30/07	445	832	1030	1920	3200	14	32	23.3	23.7	24.0	–	23.0	0.5	-0.2	--	0.7
7/31/07	437	825	1030	1910	3170	14	32	23.6	24.1	24.3	–	23.6	0.6	-0.2	--	0.5
8/1/07	438	805	1030	1890	3130	14	33	24.4	24.5	25.0	–	24.0	0.2	-0.4	--	0.5
8/2/07	441	789	1030	1870	3040	15	34	24.7	24.5	25.3	–	24.2	-0.2	-0.7	--	0.4
8/3/07	438	781	1030	1850	2970	15	35	24.4	24.4	25.2	–	24.3	0.0	-0.8	--	0.1
8/4/07	441	770	1030	1830	2920	15	35	23.4	23.7	24.6	–	23.8	0.3	-0.9	--	-0.1
8/5/07	437	768	1030	1820	2900	15	36	22.8	22.9	23.8	–	23.6	0.1	-1.0	--	-0.7
8/6/07	442	769	1030	1830	2890	15	36	22.2	22.3	23.1	–	21.6	0.1	-0.8	--	0.7
8/7/07	460	770	1030	1830	2920	16	35	22.0	22.2	22.5	–	21.0	0.2	-0.3	--	1.2
8/8/07	460	790	1030	1820	2890	16	36	22.1	22.3	22.4	–	21.9	0.2	-0.1	--	0.4
8/9/07	454	781	1030	1820	2900	16	36	22.4	22.4	22.9	–	22.7	0.1	-0.5	--	-0.2
8/10/07	455	754	1030	1810	2870	16	36	22.0	22.3	22.9	–	22.1	0.3	-0.6	--	0.3
8/11/07	454	749	1030	1800	2840	16	36	21.8	22.3	22.8	–	22.4	0.5	-0.5	--	-0.1
8/12/07	452	753	1030	1790	2800	16	37	21.4	22.0	22.6	–	21.9	0.6	-0.5	--	0.2
8/13/07	452	745	1030	1790	2800	16	37	21.3	21.8	22.3	–	22.0	0.6	-0.5	--	-0.2
8/14/07	450	742	1030	1780	2770	16	37	21.5	21.8	22.2	–	21.9	0.4	-0.4	--	0.0
8/15/07	450	736	1030	1770	2750	16	37	21.7	21.9	22.4	–	21.9	0.2	-0.5	--	0.0
8/16/07	453	731	1030	1760	2710	17	38	21.6	21.6	22.4	–	22.0	0.0	-0.7	--	-0.4
8/17/07	458	728	1030	1760	2700	17	38	21.1	21.2	22.0	–	21.9	0.1	-0.7	--	-0.7
8/18/07	456	728	1030	1760	2710	17	38	21.1	21.1	21.7	–	21.5	0.0	-0.6	--	-0.4
8/19/07	457	741	1030	1790	2760	17	37	20.8	20.9	21.6	–	21.3	0.1	-0.6	--	-0.4
8/20/07	456	759	1030	1850	2890	16	36	21.6	21.5	21.3	–	20.7	-0.1	0.2	--	0.8
8/21/07	456	756	1030	1820	2900	16	36	22.4	22.2	22.3	–	21.3	-0.2	-0.1	--	0.9
8/22/07	456	740	1030	1790	2810	16	37	22.5	22.4	22.9	–	22.5	-0.1	-0.5	--	0.0
8/23/07	454	733	1030	1770	2770	16	37	22.5	22.9	23.2	–	22.7	0.4	-0.3	--	0.2
8/24/07	456	726	1030	1750	2810	16	37	22.9	23.3	23.7	–	23.0	0.4	-0.4	--	0.3
8/25/07	457	707	1030	1740	2760	17	37	23.1	23.2	23.9	–	23.1	0.0	-0.7	--	0.1
8/26/07	663	702	1030	1730	2700	25	38	22.7	22.7	23.4	–	23.0	0.0	-0.8	--	-0.3
8/27/07	1760	707	1030	1720	2660	66	39	22.2	22.7	23.1	–	22.7	0.5	-0.4	--	0.0
8/28/07	1010	1730	1030	1720	3200	32	32	22.1	23.0	23.1	–	22.6	1.0	-0.1	--	0.4
8/29/07	465	1350	1040	1720	3860	12	27	20.6	23.2	22.8	–	23.2	2.5	0.3	--	0.0
8/30/07	491	800	1040	1720	3100	16	34	20.9	23.5	22.6	–	23.2	2.6	1.0	--	0.3

Appendix A. Cont.

	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		
	Lewiston	Hoopa	Iron Gate	Orleans	Klamath	Lewiston Dam	Iron Gate Dam	TR	WE	KBW	KBC	KAT	TR	KBW	KBC	KAT
Date	rkm 178.6	rkm 20.0	rkm 305.5	rkm 95.1	rkm 13.0	rkm 178.6	rkm 305.5	rkm 0.1	rkm 70.2	rkm 68.7	rkm 26.5	rkm 13.0	rkm 0.1	rkm 68.7	rkm 26.5	rkm 13.0
8/31/07	481	731	1040	1730	2690	18	39	21.6	23.6	23.6	–	22.7	2.0	0.0	--	0.9
9/1/07	464	731	1040	1730	2740	17	38	21.7	23.2	23.4	–	22.6	1.5	-0.3	--	0.5
9/2/07	463	700	1030	1700	2670	17	39	21.4	22.7	23.0	–	22.5	1.3	-0.3	--	0.2
9/3/07	459	681	1040	1700	2590	18	40	21.5	22.5	22.8	–	22.2	1.0	-0.3	--	0.3
9/4/07	456	679	1040	1700	2590	18	40	21.7	22.2	22.8	–	22.5	0.6	-0.6	--	-0.3
9/5/07	462	674	1040	1700	2590	18	40	21.3	21.8	22.2	–	22.1	0.5	-0.3	--	-0.2
9/6/07	464	678	1040	1710	2600	18	40	21.7	21.7	22.3	–	22.4	0.1	-0.6	--	-0.6
9/7/07	468	676	1040	1700	2590	18	40	21.7	21.8	22.3	–	22.2	0.0	-0.5	--	-0.5
9/8/07	443	672	1040	1680	2590	17	40	21.7	21.9	22.1	–	21.6	0.2	-0.1	--	0.3
9/9/07	425	674	1040	1690	2560	17	41	21.8	22.1	22.4	–	21.8	0.3	-0.3	--	0.2
9/10/07	470	633	1040	1680	2530	19	41	21.5	21.9	22.1	–	21.6	0.3	-0.2	--	0.2
9/11/07	490	638	1050	1680	2550	19	41	21.5	21.8	21.9	–	21.3	0.3	-0.2	--	0.5
9/12/07	492	685	1050	1680	2580	19	41	21.2	21.4	21.7	–	20.5	0.2	-0.3	--	1.0
9/13/07	491	687	1050	1680	2580	19	41	20.3	20.5	21.2	–	20.1	0.1	-0.7	--	0.3
9/14/07	497	693	1050	1680	2580	19	41	19.7	19.8	20.2	–	20.1	0.1	-0.5	--	-0.3
9/15/07	497	705	1050	1690	2580	19	41	19.5	19.7	19.9	–	20.3	0.3	-0.2	--	-0.6
9/16/07	456	714	1050	1710	2610	17	40	19.1	19.7	20.0	–	20.1	0.6	-0.3	--	-0.4
9/17/07	457	697	1050	1700	2630	17	40	18.8	19.4	19.7	–	19.2	0.7	-0.2	--	0.2
9/18/07	466	664	1040	1710	2600	18	40	18.5	19.1	19.5	–	19.8	0.6	-0.3	--	-0.7
9/19/07	465	679	1030	1700	2580	18	40	17.7	18.5	19.0	–	19.2	0.7	-0.5	--	-0.7
9/20/07	466	685	1030	1690	2590	18	40	17.0	17.9	18.1	–	18.2	0.9	-0.2	--	-0.3
9/21/07	465	693	1020	1690	2600	18	39	17.4	18.0	18.0	–	18.4	0.6	0.0	--	-0.4
9/22/07	464	688	1020	1680	2580	18	40	17.8	17.8	18.3	–	18.3	0.0	-0.5	--	-0.5
9/23/07	466	685	1020	1670	2560	18	40	17.5	17.9	18.0	–	18.1	0.4	-0.2	--	-0.2
9/24/07	466	691	1020	1680	2560	18	40	16.9	17.6	18.0	–	18.2	0.7	-0.3	--	-0.6
9/25/07	465	691	1020	1680	2560	18	40	16.8	17.4	17.6	–	17.7	0.6	-0.2	--	-0.3
9/26/07	465	687	1020	1670	2560	18	40	16.8	17.1	17.5	–	17.6	0.3	-0.4	--	-0.5
9/27/07	464	681	1020	1670	2540	18	40	16.8	17.0	17.4	–	17.7	0.2	-0.4	--	-0.8
9/28/07	466	679	1020	1670	2540	18	40	16.5	16.6	17.2	–	17.5	0.1	-0.6	--	-0.9
9/29/07	471	684	1020	1700	2560	18	40	15.5	15.8	16.4	–	16.9	0.3	-0.6	--	-1.0
9/30/07	470	702	1200	1730	2640	18	45	14.5	15.2	15.9	–	16.5	0.7	-0.7	--	-1.4
10/1/07	468	763	1340	2000	3060	15	44	14.3	14.8	14.8	–	14.8	0.4	0.0	--	0.0
10/2/07	469	769	1340	2160	3340	14	40	15.1	15.0	15.1	–	15.9	-0.1	-0.1	--	-0.9
10/3/07	466	743	1340	2120	3300	14	41	15.3	15.3	15.4	–	16.0	0.0	-0.1	--	-0.7
10/4/07	466	748	1330	2120	3330	14	40	14.8	15.3	15.7	–	16.2	0.4	-0.4	--	-0.9
10/5/07	465	762	1330	2140	3400	14	39	14.2	14.8	15.2	–	15.5	0.6	-0.4	--	-0.7
10/6/07	466	758	1330	2110	3350	14	40	14.1	14.3	14.9	–	15.5	0.2	-0.6	--	-1.2
10/7/07	465	749	1330	2090	3290	14	40	13.9	14.1	14.5	–	15.2	0.2	-0.4	--	-1.0
10/8/07	464	746	1330	2080	3270	14	41	14.3	14.5	14.6	–	15.2	0.2	-0.1	--	-0.7
10/9/07	467	742	1330	2080	3290	14	40	–	–	15.0	–	15.5	--	--	--	--
10/10/07	467	868	1340	2300	3840	12	35	–	–	14.7	–	14.6	--	--	--	--
10/11/07	467	908	1330	2330	4120	11	32	–	–	14.7	–	14.8	--	--	--	--
10/12/07	472	931	1320	2240	3880	12	34	–	–	14.4	–	14.5	--	--	--	--
10/13/07	457	986	1320	2200	3820	12	35	–	–	14.2	–	14.7	--	--	--	--
10/14/07	444	927	1320	2150	3720	12	35	–	–	14.8	–	15.1	--	--	--	--
10/15/07	315	928	1320	2180	3630	9	36	–	–	15.0	–	15.4	--	--	--	--