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Lewiston Dam Releases and Their Influence on Water Temperatures of the Trinity and Klamath Rivers, California

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U.S. Fish and Wildlife Service
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, California 95521
(707) 822-7201
FAX (707) 822-8411

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Author: Paul Zedonis
(paul_zedonis@fws.gov)

A Report to the
Trinity River Restoration Program
P.O. Box 1300
Weaverville, CA 96093

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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 (U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999). Prior to the TRD, the water temperatures of the river were largely dependent on mainstem flow quantity. Today, the Trinity River below Lewiston Dam 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 the 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, the spring-time snowmelt portion of the hydrograph provided abundant snowmelt runoff throughout the Trinity River that acted to moderate warm temperatures. Since the TRD, the controlled lower river flow has resulted in the Trinity River becoming warmer during the spring and early summer.

Establishment of water temperature objectives in the Trinity River basin reaffirm the relative importance of the need to improve or maintain cold water thermal regimes throughout the river to restore salmonid populations. In 1991, the North Coast Regional Water Quality Control Board (NCRWQCB) formally adopted temperature objectives for the first 64 kilometers of river below Lewiston Dam. These objectives were intended to assure that adequate areas of suitable temperatures were available for the protection of adult spring and fall-run salmon that migrate and hold in the upper basin in the early summer and spawn in the fall and winter (Table 1).

The signing of the Record of Decision (ROD) for the Trinity River Environmental Impact Statement (EIS) by the Secretary of the Interior in December of 2000 supported the NCRWQCB 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 2000). Unlike the NCRWQCB objectives, which target an area immediately below Lewiston Dam and are the same for all water year types, the ROD's spring-time objectives are intended to improve the thermal regime along the entire Trinity River from Lewiston Dam to Weitchpec for emigrating salmon and steelhead smolts, and vary with water year type designation (Table 1). In June 2000, the Hoopa Valley Tribe formally adopted the spring-time temperature criteria of the ROD in their Water Quality Control Plan (Hoopa Valley Tribe 2000).

The recommended dam releases during the spring vary with water year designation (See U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999 for more details). In Normal and wetter water years, peak dam releases ranging between 6,000 and 11,000 cubic feet per second (cfs) are recommended whereas in Dry and Critically Dry years peaks up to 4,500 cfs are recommended. Variable peak releases are intended to restore various attributes of a healthy river channel (USFWS 2000). A common feature of spring hydrographs of Normal and wetter water years is a bench of 2000 cfs that follows the downramp from peak releases and extends until July 9th. This bench was established to maintain near optimal water temperatures of the mainstem Trinity River to Weitchpec for emigrating salmonid smolts (Table 1). In contrast, the spring hydrographs of Dry and Critically Dry years feature reduced dam releases that are intended to result in warmer thermal conditions of the Trinity River. Warmer conditions in these year types were recommended so that temperature differences between the Trinity River and the Klamath River are small enough to avoid any negative effects to salmonids departing or entering the Trinity River (See U.S. Fish and Wildlife Service and Hoopa Valley Tribe 1999, Chapter 5.5 and Appendix L for more details).

In water year (WY) 2003 (interim flow year while the Supplemental EIS is being prepared), approximately 556 thousand acre-feet (TAF) of water was released from Lewiston Dam to the Trinity River. This total was approximately 100 TAF greater than the Dry Year allocation of 453 TAF originally allotted pursuant to a Court Order by Judge Oliver Wanger. Two events resulted in additional water being released to the Trinity River: 1) very wet hydrologic conditions during April that prompted unforeseen safety-of-dam releases to the Trinity River in late April and early May, and 2) a Court-approved allotment of 38 TAF (volume actually released) for use in a 24-day increase in Lewiston Dam releases that occurred from late August and early September to potentially avert another large-scale die-off of adult salmon in the lower Klamath River similar to that observed in 2002.

In recognition of the wet hydrologic conditions of WY 2003 and that the allotted Dry year allocation would not be sufficient to accomplish all the objectives of the Wet water year designation (especially geomorphic work associated with recommended peak flows), spring-time dam releases were distributed to match a portion of the spring and early hydrograph of a Wet water year type (Figure 1). In this case, dam releases mimicked recommended flow patterns of a Wet hydrologic year type by releasing 2000 cfs from mid June through July 9, followed by a gradual recession to summer base flows of 450 cfs.

An important component of the Adaptive Environmental Assessment and Management (AEAM) program of the Trinity River Restoration Program is to monitor and evaluate management actions identified in the Record of Decision. One such item is the effect of dam releases on water temperatures of the Trinity River. The primary objectives of this study were to: 1) empirically describe the effects of Lewiston Dam releases on water temperatures of the mainstem Trinity River and Klamath River below Weitchpec from mid April to mid October; and 2) describe the thermal regimes of several large tributaries that enter the mainstem Trinity River below Lewiston Dam.

METHODS

Hydrology

River flows can be an important variable in water quality investigations. For this study, flow information was required for determining pulse flow travel-time and water temperature evaluations. Estimates of river flow at several sites along the Trinity and Klamath Rivers were obtained from internet websites. Gages along the Trinity River included: Lewiston (RKm 178.2), Burnt Ranch (RKm 78.5) and Hoopa (RKm 20.0). Gages along the Klamath River included: Iron Gate (RKm 305.4), Orleans (RKm 95.1) and Terwer (RKm 10.8). The California Data Exchange Center (http://cdec.water.ca.gov) and U.S. Geological Survey (http://water.usgs.gov) websites proved to be most useful in downloading preliminary flow information.

Air Temperature

Because air temperature plays a significant role in the thermodynamics of river systems and may explain up to 95 percent of the variance in water temperature (Crisp and Howson 1982), air temperature data are included as part of the analyses presented in this report. Hobo Pro Series ® Air temperature-relative humidity probes were installed in radiation shields and placed at Weitchpec (RKm 70.2) and Terwer (RKm 10.8). The sensor deployed at RKm 70.2 was attached to a tree located near the Yurok Tribe's Weitchpec office, where lateral distance from the water's edge and elevation above the water surface was estimated to be 80 meters and 30 meters, respectively. The sensor placed at RKm 10.8 was placed between 3 and 5 meters above water surface and within

10 meters of the water's edge. Both sensors passed post-field season quality control evaluations, which indicated that collected data was probably accurate.

Water Temperature

Water temperature data were collected from gage stations and Service-owned probes that were deployed throughout the Trinity River Basin and the lower Klamath River (Figure 2, Table 2). Internet resources, in particular the California Data Exchange Center (CDEC), proved most uesful in obtaining data from telemetered stations. A weakness of data obtained from these sites is that data are labeled "preliminary and subject to revision" meaning the accuracy of the data is unknown. Additionally, these data required filtering for "erroneous" data.

Temperature probes manufactured by Onset Computer Corporation ® and Hydrolab DataSondes^{tm} were used to collect hourly water temperature data at additional locations along the Trinity River and the Klamath River below Weitchpec (Table 2). Prior to and after deployment, each probe was subjected to a performance test to verify it was recording to within the manufacturer's accuracy specification of ± 0.2 degrees Celsius (˚C). In all cases, the instrumentation proved to be accurate and reliable. Monitoring results are reported for the time period of mid-April to October.

The influence of Trinity River flow on water temperatures of Klamath River below Weitchpec was determined through comparative analysis of water temperature data collected above and below the confluence at Weitchpec. Water temperatures of the Klamath River (RKm 70.2) served as a control site to compare water temperatures of four sites located below the confluence of the Trinity River. It was believed that the Weitchpec site served as a good control because it represented local meteorologic conditions and was not influenced in any way by the Trinity River. The relative difference between the control and downstream sites was used as an estimate of the relative influence of the Trinity River on water temperatures of the Klamath River.

RESULTS

Hydrology

Average daily flows of the Trinity River at Lewiston (RKm 178.2), Burnt Ranch (RKm 78.5), and Hoopa (RKm 20.0) during the spring and summer of 2003 are presented in Figure 3. Releases from

Lewiston Dam to the Trinity River, as estimated by the Lewiston Gage, peaked at approximately 2,500 cfs from May 1 through May 24th. Following this peak, releases were reduced to 2,000 cfs where they were held until July 9th. From July 9th to July 15th releases were gradually reduced to base summer flows of approximately 450 cfs where they remained until August 25th. From August 25 to September 15 releases were again increased to a maximum of 1,800 cfs. On September 16th flow was reduced to 450 cfs and remained there until October 16th. From October 16th until the following year, releases were maintained at 300 cfs.

The contributions of Lewiston Dam releases to total flow of the lower Trinity River and lower Klamath River were relatively small during the spring compared to certain time periods in the summer (Figure 3). Flow accretion between the Burnt Ranch and Hoopa gages was indicative of the significant amount of rainfall that occurred during the month of April. In late April, flow from Lewiston was approximately 2,000 to 2,500 cfs, whereas flow at the Hoopa gage located approximately 155 kilometers downstream was nearly 20,000 cfs. Tributaries below the Burnt Ranch gage such as the South Fork Trinity River, which drains the largest sub-basin in the Trinity River Basin, contributed substantial flow to the mainstem in this lower river reach. For example, preliminary flow information obtained from CDEC for the Hyampom gage on the South Fork Trinity River indicated that the South Fork was contributing just over 7,000 cfs to the mainstem Trinity River in late April and early May. In contrast to the spring months, releases from Lewiston Dam comprised a much high proportion 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 reduced.

Flow of the Klamath River at Orleans (RKm 95.1) ranged from 11,000 to 16,000 cfs during April and May (Figure 3). During the following months river flow steadily decreased and by late August flow was at its minimum of 1,900 cfs. On or near July 8 and August 25, flow of the Trinity River at Hoopa was similar in magnitude to the Klamath River at Orleans. Flow contributions from Lewiston Dam were largely responsible for increased contributions to total flow of the lower Klamath River at these times.

Contributions of flow from Lewiston Dam to the total flow of the Klamath River at Terwer gage varied throughout the spring, summer and early fall. From early May to mid July, the 2,500 and 2,000 cfs releases from Lewiston Dam represented an increasingly greater fraction of the total flow at the Terwer gage mainly due to decreasing contributions from tributaries. For example, on May 1 and July 9 Lewiston Dam releases represented approximately 6 and 31 percent of the flow at

Terwer, respectively. From mid July to August 23, base summer flow releases of 450 cfs from Lewiston Dam accounted for approximately 14 percent of the total flow at Terwer. From August 24 to September 16, contributions of flow from Lewiston Dam became more prominent increasing to a peak of approximately 40 percent.

Travel time of the Late Summer Pulse from Lewiston Dam

The time required for the initial flow increase from Lewiston Dam to influence downstream gages varied with distance (Table 3). Increased flows from Lewiston Dam on the August 24 were first identified at Burnt Ranch, Hoopa and Terwer gaging stations approximately 20, 30, and 44 hours later, respectively. Similarly, the peak release from Lewiston Dam (i.e. 1,800 cfs) that occurred on August 25th was estimated to require 16, 27 and 41 hours to reach the Burnt Ranch, Hoopa, and Terwer gages, respectively.

Water Temperatures of the Mainstem Trinity River

Lewiston Gage (RKm 178.2)

At the onset of the peak spring release of 2500 cfs in early May, the average daily water temperatures at this location were reduced from 10.3 ˚C to near 9.0 ˚C (Figure 4). From early May to late July, water temperatures generally increased and the maximum average daily value of 11.3 ˚C occurred on July 25th. This peak coincided with the approximate time that dam releases were reduced to base summer flows on July 23. On August 25th flow from Lewiston Dam was increased to approximately 1,800 cfs, and water temperatures at this site were subsequently reduced by approximately 0.5 ˚C. From August 25 to mid-October, water temperatures remained below 9.7 ˚C.

Douglas City Gage (RKm 148.5)

Prior to the peak flow that occurred in early May, average daily water temperatures at the Douglas City gage reached 10.5 ˚C (Figure 5). From May 5 to July 9 when dam releases were generally at or above 2000 cfs, water temperatures did not exceed 12.0 ˚C. From July 10 to July 25 releases continued to decrease to 450 cfs and water temperatures continued to increase to a maximum of 17.3 ˚C. The warmest water temperatures that occurred from July 22 to August 1 exceeded the North Coast Regional Water Quality Control Board (NCRWQCB) objective of 15.6 ˚C.

From early August through mid September water temperatures declined and were generally below the NCRWQCB temperature objectives (Figure 5). The coolest temperatures coincided with the increased releases that occurred from August 25 to mid September. Water temperatures were reduced sharply from ~14.0 to ~ 11.0 ˚C on or about August 25th.

Pear Tree Gulch (RKm 117.6)

Average daily water temperatures at this site were generally elevated in comparison to the Douglas City site. Increased flow from Lewiston Dam that occurred from May 1 to July 10 and August 25 to September 16 resulted in a notable change in the water temperature at this site (Figure 6). From May to July 9, the average daily water temperature was less than 14.0 ˚C. Following the spring release, water temperatures increased to a maximum of 20.4 ˚C on July 24. Similar to the Douglas City site, the maximum temperature coincided with warm releases and reduced flow from Lewiston Dam.

The increased flow from Lewiston Dam that occurred from August 24 to September 16 also coincided with reduced water temperatures (Figure 6). On or about August 25, water temperatures at this site decreased from 17.0 to 13.0 ˚C and remained below 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. During the first 7 days of October water temperatures ranged from 13.5 to 14.1˚C, slightly greater than the NCRWQCB temperature objective of 13.3 ˚C.

Lewiston to Pear Tree Gulch (RKm 178.2 to 117.6)

Average daily water temperatures of the Trinity River from Lewiston (RKm 178.2) to Pear Tree Gulch (RKm 117.6) are represented by data collected by five probes (Figure 7). In combination, these data provide a regional perspective on variations in water temperatures.

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

Average daily water temperatures of the Trinity River between Big French Creek (RKm 94.2) and Weitchpec (RKm 0.1) are also represented by data collected by five different probes (Figure 8). Similar to temperature monitoring sites between RKm 178.2 to 117.6, Lewiston Dam releases that occurred from June to July 15 and from August 24 to September 16 also coincided with reduced water temperatures in this reach. The Lewiston Dam release of 2,000 cfs that occurred from June to July 9 coincided with average daily water temperatures at Weitchpec between 16.0 and 18.0˚C and a maximum temperature of ~ 19.0 ˚C. When Lewiston Dam releases were reduced to 450 cfs in mid-July, the average daily water temperatures of the entire reach increased rapidly. The lower most site (Weitchpec @ RKm 0.1) exhibited the greatest increase (24.3 ˚C).

Water Temperatures of Tributaries to the Trinity River

Water temperatures of tributaries below Lewiston Dam were quite variable (Figure 9). The South Fork Trinity River was one of the warmest tributaries. From April to mid July, average daily water temperatures of the South Fork Trinity River were up to 8.0 ˚C warmer than all other tributaries. During this same time period, the other tributaries were generally within 2 to 3 ˚C of each other.

From July to October the thermal regimes of tributaries were increasingly dissimilar. Big French Creek and Rush Creek, which are smaller in size than others, exhibited the most stable and similar thermal regime through the monitoring period. These two streams also exhibited the coolest water temperatures during the late summer and early fall. As compared to Big French Creek and Rush Creek, Canyon Creek and the North Fork Trinity River exhibited warmer summer time water temperatures.

Spring-time Objectives at Weitchpec

The temperature objectives for meeting optimal thermal conditions at Weitchpec were not always met from April 15 to July 9 (Figure 10). Periodically water temperatures exceeded the optimal criteria and fell into the marginal zone, but never entered the unsuitable zone. Example time periods where average daily water temperatures exceeded the optimal criteria included May 21-22, May 29 to June 10 and June 26 to July 9. In late June, the upper optimal criterion of 17.0 ˚C was exceeded by 2.0 ˚C. Examination of air temperature data during the times revealed a strong positive association between warmest time periods and times of criteria exceedence (Figure 11).

Water Temperature Differences of the Klamath and Trinity Rivers at Weitchpec and Downstream Sites during the Spring and Early Summer

Water temperatures of the Trinity River at Weitchpec were colder than the Klamath River from June 10 to mid July, but the largest differences occurred in late June through mid July (Figure 12, Table 4). Prior to mid-June, the water temperature of the Trinity River was typically less than 0.7 ˚C colder than the Klamath River. From June 19 to July 9 the Trinity River was between 1.3 and 2.7 ˚C colder than the Klamath River and the greatest difference occurred on or about July 9. When Lewiston Dam releases decreased from 2,000 cfs to ~ 450 cfs from July 9 to July 20, the Trinity River was initially 2.6 ˚C colder than the Klamath River but thereafter differences decreased to ~ 1.5 ˚C. When Lewiston Dam releases were 450 cfs from July 21 to July 26, the Trinity River was generally less than 0.9˚C colder than the Klamath River.

Comparisons of water temperatures above and below the confluence from mid June to mid early July also revealed temperature reductions also occurred at monitoring sites below the Klamath-Trinity confluence (Table 4; Figure 12). The relative difference in water temperatures between the control site on the Klamath River at Weitchpec (RKm 70.2) and downstream sites on the Klamath River (RKm 62.0, 26.5 and 10.8) ranged between 0.2 and 1.2 ˚C from June 10 to June 30 and 0.9 to 1.8˚C from July 1 to July 15. The greatest temperature reductions occurred from July 10 to 12 when Trinity River water was coldest relative to the Klamath River and contributed nearly 50 percent of the flow of the lower Klamath River. Temperature reductions at RKm 26.5 and 10.8 generally followed a similar trend to RKm 62.0, but at times exhibited greater reductions possibly due to cooler ambient conditions (i.e. air temperature) of the coastal region (Figure 13).

Water Temperature Differences of the Klamath and Trinity Rivers at Weitchpec and Downstream Sites During the Late Summer Pulse Flow

The increased flow releases from Lewiston Dam that occurred from August 24 to September 17 coincided with reduced water temperatures of the lower Trinity River and the Klamath River (Figure 14; Table 5). Prior to the pulse flows arrival at Weitchpec (approximately August 25), water temperatures of the Trinity River were 0.8 ˚C colder than the Klamath River. During the time of arrival at Weitchpec (August 27 to September 18), water temperatures of the Trinity River became from 1.4 and 4.0 ˚C colder than the Klamath River. The period of greatest difference occurred from September 1 to September 4 and coincided with times when air temperatures were warmest (Figure 15). After September 17 the Trinity River was less than 1.0 ˚C colder than the Klamath River.

The increased in flow that occurred from August 24 to September 17 also coincided with reduced water temperatures of the Klamath River below the confluence (Figure 14, Table 5). Prior to the arrival of the pulse flow, the differences in water temperature between the control site located above the confluence with the Trinity River (RKm 70.2) and a site much further downstream (RKm 10.8) were less than 0.7 ˚C and average daily water temperature between these sites was between 22.2 and 22.9 ˚C. In comparison, during the arrival of the increased flow (August 27 to September 10) the water temperatures of the Klamath River at RKm 62.0, 42.3, 26.5 and 10.8 decreased by as much as 2.0 ˚C and daily averages were reduced to near 21 ˚C. From September 10 to September 30, water temperatures of sampling locations between RKm 70.2 and 10.8 were very similar and average daily water temperatures were less than 20.0 ˚C.

DISCUSSION

Water temperatures of the river below Lewiston Dam are influenced by the temperature of the water released from the dam as well as the magnitude of release and ambient meteorologic conditions. Typically the coldest dam releases are associated with short hydraulic residence time (i.e. rapid flushing) 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 is increased, released water temperatures increase. These colder releases generally result in cooler temperatures in downstream 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 downstream.

Exceedence of the NCRWQCB temperature objectives at Douglas City from July 22 to August 1 are explained by two observations. First, water released from Lewiston Dam was fairly warm (approximately 11.3 ˚C). Second, the magnitude of flow was approximately 380 cfs or approximately 70 cfs less than what was recommended by the Flow Evaluation (USFWS and Hoopa Valley Tribe 1999). Previous examination of water temperature and flow information over 5 years (1992 through 1997) shows that the Regional Board temperature objectives were usually met under a variety of meteorological conditions when release temperatures were less than 10 ˚C and the dam release was near 450 cfs (USFWS and Hoopa Valley Tribe 1999). Thus, had the released water temperature been 10 ˚C and flow near 450 cfs it is likely the temperature objective would have been met.

The probable cause for exceeding the NCRWQCB temperature objective by approximately 1.0 ˚C at the North Fork Trinity River from October 1 to October 7 was warm ambient meteorological conditions. During this time, dam release water temperatures were maintained at less than 9.7 ˚C and dam releases followed the prescribed flow recommendation of 450 cfs, both of which have generally been adequate to meet the objective. At nearly 68 kilometers below Lewiston Dam, however, water at the North Fork has had a greater travel time that allows more time for heating during warm meteorologic conditions.

The water temperature objectives of average daily temperatures being "optimal" from April to early July at Weitchpec were not always met. In particular, from June to early July the objective was exceeded on several occasions. It was at this time that the average daily temperatures at Weitchpec exceeded the upper optimal threshold of 17˚C by 1 to 2˚C, but remained within the "marginal" zone (17.0 to 20.0 ˚C). The primary reasons for periodically exceeding the spring-time objectives was probably warm air temperatures and warm tributary inflow. As is shown in Figure 11, times that the objective was exceeded corresponded well to the time of warming air temperatures. Additionally, contributions of warmer water from larger tributaries (e.g. South Fork Trinity River) helped warm the colder water of the mainstem. For example, on June 8 the South Fork Trinity River contributed approximately 18% (800 cfs) of the total Trinity River flow below the Burnt Ranch gage and at 19 ˚C the water was 3.1 ˚C warmer than the mainstem Trinity River (15.9 ˚C). Using a proportional mixing formula, this contribution of warm water from the South Fork Trinity River increased the mainstem Trinity River temperature by approximately 0.5 ˚C degrees.

The increased Lewiston Dam releases that occurred from August 24 to September 17th also had a significant influence on water temperatures of the Trinity and Klamath Rivers. As compared to the spring and early summer releases, increased flow that occurred at this time had a much greater effect on downstream reaches. This greater effect can probably be attributed mainly to relatively little accretion of warmer water from tributaries that are typically at a minimum during this time of the year and relatively fast travel-time for the release (e.g. approximately 44 hours to Weitchpec).

Although Lewiston Dam releases influenced the water temperatures of the Klamath River below the confluence, changing meteorology of the coastal region also influenced water temperatures. In particular, the cooler air temperatures (and probably higher relative humidity) of the coastal region cooled the Klamath River during the summer months. The cooling effect is best illustrated during late July (Figure 13) and late August (Figure 15) when flow fluctuations were not occurring and air temperatures at Terwer (RKm 10.8) where considerably colder than Weitchpec (RKm 70.2) and water temperatures of the Klamath River at RKm 10.8 were coldest.

RECOMMENDATIONS

The water temperature data that were collected for this study supported a comprehensive assessment of the effect of Lewiston Dam releases on the thermal regime of the Trinity River, and the Klamath River from its confluence with the Trinity River to the Pacific Ocean. It is recommended that a temperature-monitoring network similar to the one used in 2002 and 2003 be maintained in the future, and that the Trinity River Restoration Program evaluate the content of this report to see where additional monitoring sites may be needed, if any. This monitoring network provides important empirical data necessary for construction of predictive water temperature models.

Water temperature modeling of the Trinity River system continues to be an important tool for evaluating water management options and should be continued. In the past, modeling served as an important tool to assist in development of dam release schedules and will likely continue to serve an important role in the Trinity River Restoration Program. Continued collection of complete and accurate water temperature data records will be essential for empirical evaluations of the effects of dam releases on water temperatures as well as accurate modeling.

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PERSONAL COMMUNICATIONS

Patton, Tom. U.S. Bureau of Reclamation, Central Valley Operations, November 17, 2003

Table 1. Water temperature objectives of the Trinity River.

Objective	Target Area	Dates	Criteria[a]
NCRWQCB	• Lewiston to Douglas City[b]	July 1 to Sept 15	≤ 15.5
	• Lewiston to Douglas City[b]	Sept 15 to Sept 30	≤ 13.3
	• Lewiston to the Confluence of the North Fork Trinity River Confluence[c]	Oct 1 to Dec 31	≤ 13.3
Spring-Time Objectives[d]	• Lewiston to Weitchpec[e]	Normal and Wetter Water Years:	
		• April 15 to May 22	≤ 13.0
		• May 23 to Jun 4	≤ 15.0
		• June 5 to Jul 9	≤ 17.0
		Dry and Critically Dry Water Years:	
		• April 15 to May 22	≤ 15.0
		• May 23 to Jun 4	≤ 17.0
		• June 5 to Jun 15	≤ 20.0

‘a = Average daily criteria in degrees Celsius
‘b = Compliance determined from data collected at the Douglas City gage
‘c = Compliance determined from data collected at the Pear Tree Gulch gage
‘d = Criteria adopted in the Trinity River EIS Record of Decision of December 2000, and the Hoopa Valley Tribe Water Quality Control Plan in 2000.
‘e = Compliance determined from data collected at Weitchpec gage

Table 2. Water temperature monitoring locations of the Trinity River Basin and the Klamath River below Weitchpec, 2003.

Water Temperature Monitoring Locations of 2003			
Mainstem Sites			
Site	**Location (RKm)**	**Source**	**Operator**
TR @ Lewiston Gage	178.2	California Data Exchange Center (CDEC)	California Department of Water resources
TR above Rush Ck[c]	173.0	Tidbit	Fish and Wildlife Service (FWS)
TR@ Limkiln Gulch Gage	158.7	CDEC	Hoopa Valley Tribe (HVT)
TR @ Douglas City Gage	148.5	CDEC	HVT
TR above Canyon Ck	127.4	FWS	FWS
TR @ Pear Tree Gulch Gage	117.6	CDEC	US. Bureau of Reclamation
TR above Big French Creek	94.2	FWS	FWS
TR @ Burnt Ranch Trans Sta.	76.4	FWS	FWS
TR above S. Fork Trinity R.	50.6	FWS	FWS
TR @ Willow Creek Trap Site	37.0	FWS	FWS
TR @ Hoopa Gage	20.0	CDEC	US Geological Survey
TR @ Weitchpec	0.1	FWS	FWS/Yurok Tribe
KR immediately abv. Trinity R.	70.0	FWS	FWS/Yurok Tribe
KR above Tully Ck	62.0	FWS	FWS/Yurok Tribe
KR @ Coon Creek Falls [c]	57.6	FWS	FWS
KR above Pecwan Ck	42.3	FWS	FWS
KR above Blue Ck	26.5	FWS	FWS
KR @ Terwer	10.8	FWS	FWS/Yurok Tribe
Tributary Sites			
Swift Ck [c]	Abv Trinity Res.	FWS	FWS
Coffee Ck [c]	Abv Trinity Res.	FWS	FWS
Stuarts Fork [c]	Abv Trinity Res.	FWS	FWS
Rush Ck	173.0 + 1.5	FWS	FWS
Canyon Ck	127.3 + 0.1	FWS	FWS
N. F. Trinity R.	116.7 + 0.1	FWS	FWS
Big French Ck	94.1 + 0.1	FWS	FWS
S. F. Trinity R.	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 available from USFWS for this site, but is not presented within this report.

Table 3. Estimates of travel time for the late summer pulse flow at several gages along the Trinity River and the lower Klamath River, August 2003.

Gage Location	Gage Basin	Distance to the Pacific Ocean (River Kilometer)	Travel Time Estimates based on Stream Gage Information [a]			
			Date and Time of Initial Flow Increase	Cumulative Travel Time (hr)	Date and Time of Peak Release (1810 cfs)	Cumulative Travel Time (hr)
Lewiston	Trinity River	248.7	8/24 @ 15:00	0	8/25 @ 01:00	0
Burnt Ranch	Trinity River	148.7	8/25 @ 11:00	+20	8/25 @ 17:00	+16
Hoopa	Trinity River	95.2	8/25 @ 22:00	+31	8/26 @ 04:00	+27
Terwer [b]	Klamath River	10.8	8/26 @ 11:00	+44	8/26 @ 18:00	+41

‘a –Estimates are based on graphical interpretation and do not represent times of temperature change.

‘b – Data may be slightly biased from the influence of tidal cycles.

Table 4. Comparison of average daily water temperatures of the Klamath and Trinity River at Weitchpec and sites below the confluence from June 10 to July 26, 2003.

Date	Lewiston Dam Release Description	Flow (CFS) Trinity Sites		Flow (CFS) Klamath Sites			Average Daily Water Temperatures (°C) Trinity River Site		Klamath R. Sites					Differences in Water Temps of the Klamath R. (RKm 70.2) and Downstream Sites:			
		LWS (RKm 178.6)	HPA (RKm 20.0)	IG (RKm 305.4)	OLS (RKm 95.1)	TER (RKm 10.8)	RKm 0.1	Difference (KR @ RKm 70.2 - TR @ RKm 0.1)	RKm 70.2	RKM 62.0	RKM 42.3	RKM 26.5	RKM 10.8	RKM 62.0	RKM 42.3	RKM 26.5	RKM 10.8
6/10	< 2000 cfs Release from Lewiston Dam >	1980	5000	1510	9180	15883	17.3	0.4	17.6	17.5	-	-	17.9	0.2	-	-	-0.3
6/11		1980	4700	1400	8340	14704	16.9	0.7	17.6	17.3	-	-	17.0	0.3	-	-	0.6
6/12		1980	4550	1350	7680	13865	16.6	0.7	17.3	-	-	-	-	-	-	-	-
6/13		1990	4410	1340	7080	13104	16.6	0.3	17.0	-	-	-	-	-	-	-	-
6/14		1980	4290	1360	6750	12562	-	-	17.2	16.9	-	-	17.0	0.3	-	-	0.2
6/15		1980	4180	1370	6380	12067	-	-	17.3	17.0	-	-	17.3	0.4	-	-	0.0
6/16		1990	4150	1260	6090	11674	-	-	18.1	17.6	-	-	17.8	0.5	-	-	0.3
6/17		1990	4200	1220	5940	11500	-	-	19.1	18.5	-	-	18.1	0.6	-	-	1.0
6/18		1980	4220	1220	-	11396	-	-	19.2	18.5	-	-	18.5	0.7	-	-	0.7
6/19		1990	4100	1220	5660	11209	16.9	2.0	18.9	18.0	-	-	18.0	0.9	-	-	0.9
6/20		1980	3990	1210	5460	10748	16.5	1.9	18.4	17.6	-	-	17.9	0.8	-	-	0.5
6/21		1990	3830	1110	5220	10222	16.5	1.5	18.0	17.4	-	-	18.0	0.6	-	-	0.1
6/22		1990	3730	1050	4920	9853	16.4	1.6	18.0	17.3	-	-	17.7	0.7	-	-	0.3
6/23		1980	3660	1050	4570	9332	16.2	1.7	17.9	17.2	-	-	-	0.7	-	-	-
6/24		1980	3580	1050	4450	8923	16.3	1.5	17.8	17.1	-	17.5	-	0.7	-	0.3	-
6/25		1980	3530	1050	4330	8687	16.9	1.3	18.2	17.6	-	17.9	-	0.6	-	0.3	-
6/26		1980	3490	1000	4180	8412	17.7	1.5	19.2	18.5	-	18.8	-	0.7	-	0.4	-
6/27		1990	3510	1010	4070	8309	18.3	2.0	20.3	19.4	-	19.7	-	0.9	-	0.6	-
6/28		1990	3530	1010	3960	8248	18.9	2.4	21.3	20.2	-	20.4	-	1.1	-	0.8	-
6/29		1990	3530	1010	3920	8192	19.0	2.6	21.5	20.3	-	20.4	-	1.2	-	1.1	-
6/30		1990	3430	1010	3840	7778	18.9	2.4	21.3	20.2	-	20.3	20.3	1.1	-	0.9	1.0
7/1		1990	3320	1010	3720	7405	18.2	2.5	20.7	19.5	-	20.0	20.0	1.1	-	0.7	0.7
7/2		1990	3260	1010	3610	7169	17.8	2.3	20.1	19.0	-	19.4	19.7	1.0	-	0.6	0.4
7/3		2020	3220	1010	3540	6999	18.1	1.7	19.7	18.8	-	19.2	19.4	0.9	-	0.5	0.3
7/4		2010	3210	1010	3510	6905	18.0	1.9	19.9	19.0	-	19.3	19.4	0.9	-	0.6	0.5
7/5		2010	3170	1010	3420	6766	18.2	2.2	20.4	19.3	-	19.5	19.5	1.1	-	0.9	0.8
7/6		2000	3150	1010	3340	6657	18.4	2.4	20.9	19.6	-	19.7	19.7	1.2	-	1.1	1.2
7/7		1990	3140	1010	3280	6585	18.5	2.6	21.1	19.8	-	19.4	19.3	1.3	-	1.8	1.8
7/8		2000	3110	1010	3260	6520	18.5	2.6	21.1	-	-	20.0	19.9	-	-	1.1	1.2
7/9		2010	3040	1010	3200	6403	18.7	2.7	21.4	-	-	20.3	20.5	-	-	1.1	0.9
7/10	< Down Ramp >	1860	2990	969	3120	6219	18.9	2.6	21.5	20.2	-	20.5	20.5	1.4	-	1.0	1.0
7/11		1570	2830	843	3060	6105	18.9	2.6	21.5	20.2	-	20.7	20.8	1.3	-	0.8	0.6
7/12		1320	2600	755	3000	5778	19.2	2.6	21.7	20.4	-	20.8	20.9	1.3	-	0.9	0.8
7/13		1180	2360	747	2910	5413	19.8	2.2	22.0	20.9	-	21.2	21.3	1.0	-	0.8	0.7
7/14		1050	2180	746	2750	5094	19.9	2.0	21.8	20.9	-	21.2	21.2	1.0	-	0.7	0.6
7/15		906	2050	734	2690	4855	20.1	1.8	21.9	21.0	-	20.7	20.6	0.9	-	1.2	1.3
7/16		793	1940	723	2660	4707	20.4	1.6	22.0	21.2	-	21.3	21.0	0.8	-	0.7	1.0
7/17		708	1800	731	2640	4497	20.5	1.7	22.2	21.3	-	21.4	21.3	0.9	-	0.9	0.9
7/18		630	1680	731	2600	4318	21.2	1.4	22.6	22.0	-	21.8	21.7	0.7	-	0.8	0.9
7/19		585	1550	731	2580	4139	21.8	1.3	23.0	22.4	-	-	22.1	0.6	-	-	0.9
7/20		511	1480	731	2540	3997	21.9	1.5	23.4	22.7	-	-	22.4	0.7	-	-	1.0
7/21	< Base Flow >	439	1390	731	2490	3879	22.6	1.6	24.2	23.4	-		22.7	0.7	-	-	1.5
7/22		385	1310	731	2460	3734	23.5	1.3	24.8	24.2	-	23.8	23.3	0.6	-	1.0	1.6
7/23		388	1220	736	2460	3616	24.2	0.9	25.2	24.7	-	24.2	23.7	0.5	-	0.9	1.5
7/24		404	1180	739	2410	3505	24.3	0.7	25.1	24.4	-	24.0	23.6	0.6	-	1.1	1.5
7/25		453	1180	749	2380	3452	23.9	0.8	24.8	24.1	-	23.6	23.0	0.7	-	1.2	1.8
7/26		492	1160	735	2410	3475	23.7	0.9	24.6	24.0	-	23.7	23.1	0.5	-	0.9	1.4

Table 5. Comparison of average daily water temperatures of the Klamath and Trinity River at Weitchpec and sites below the confluence from August 15 to September 30, 2003.

Date	Pulse Flow Description	Flow (CFS) Trinity R. LWS (RKm 178.6)	Flow (CFS) Trinity R. HPA (RKm 20.0)	Flow (CFS) Klamath R. IG (RKm 305.4)	Flow (CFS) Klamath R. OLS (RKm 95.1)	Flow (CFS) Klamath R. TER (RKm 10.8)	Average Daily Water Temperatures (°C) Trinity R. Site RKm 0.1	Difference (KR @ RKm 70.2 - TR @ RKm 0.1)	Klamath R. Sites RKm 70.2	Klamath R. Sites RKm 62.0	Klamath R. Sites RKm 42.3	Klamath R. Sites RKm 26.5	Klamath R. Sites RKm 10.8	Differences in Water Temps of the Klamath R. (RKm 70.2) and Downstream Sites: RKM 62.0	RKM 42.3	RKM 26.5	RKM 10.8
8/15	< Before Pulse[a] >	462	975	995	2270	3129	21.7	0.3	22.0	21.8	22.2	22.2	-	0.2	-0.2	-0.2	-
8/16		466	960	995	2230	3055	21.6	0.4	22.0	21.8	22.1	22.0	-	0.3	-0.1	0.0	-
8/17		463	951	995	2220	3021	21.6	0.6	22.3	22.0	22.2	22.1	-	0.3	0.1	0.2	-
8/18		465	941	995	2210	2993	22.1	0.7	22.7	22.5	22.7	22.5	-	0.3	0.1	0.2	-
8/19		461	925	995	2190	2953	22.7	0.5	23.2	22.9	23.0	22.8	22.5	0.3	0.2	0.4	0.7
8/20		465	910	997	2180	2907	23.0	0.5	23.6	23.3	23.4	23.1	22.7	0.2	0.1	0.4	0.9
8/21		466	899	1000	1960	2855	22.8	0.8	23.6	23.2	23.3	23.0	22.5	0.4	0.2	0.6	1.1
8/22		467	893	1000	1960	2819	21.9	0.7	22.7	22.2	22.5	22.2	22.2	0.4	0.2	0.5	0.5
8/23		466	900	1000	1960	2854	21.6	1.1	22.7	22.2	22.3	22.1	21.8	0.5	0.4	0.6	0.9
8/24		721	909	1000	1980	2884	22.1	0.8	22.9	22.5	22.7	22.5	22.2	0.3	0.2	0.4	0.7
8/25	< During Pulse[a] >	1810	942	1000	1980	2872	22.1	0.8	22.9	22.6	22.8	22.6	22.4	0.3	0.1	0.3	0.5
8/26		1700	1980	995	1950	3206	21.9	0.7	22.5	22.2	22.4	22.4	22.5	0.3	0.1	0.1	0.1
8/27		1570	1980	996	1930	3777	19.6	2.9	22.4	21.1	21.8	21.9	22.0	1.3	0.6	0.5	0.4
8/28		1460	1860	999	1910	3687	18.9	3.6	22.6	20.7	21.1	21.0	20.9	1.9	1.5	1.5	1.7
8/29		1480	1740	1000	1880	3550	18.9	3.3	22.1	20.6	20.9	21.0	21.0	1.6	1.2	1.2	1.1
8/30		1440	1750	1000	1890	3523	19.1	3.4	22.5	20.8	21.1	21.0	20.9	1.7	1.4	1.5	1.5
8/31		1430	1720	1000	1880	3515	19.2	3.6	22.8	21.0	21.3	21.2	21.1	1.8	1.5	1.6	1.7
9/1		1410	1700	1170	1870	3490	19.3	3.7	23.0	21.2	21.6	21.5	21.4	1.8	1.4	1.5	1.6
9/2		1380	1680	1190	1870	3457	19.2	3.9	23.1	21.2	21.6	21.7	21.6	1.9	1.4	1.4	1.4
9/3		1330	1640	1190	1990	3532	18.4	4.0	22.4	20.6	21.1	21.0	21.0	1.8	1.4	1.5	1.4
9/4		1290	1640	1190	2000	3571	18.2	4.0	22.3	20.4	20.6	20.6	20.6	1.9	1.6	1.6	1.6
9/5		1300	1620	1190	2050	3573	18.7	3.8	22.5	20.8	20.9	20.5	20.4	1.7	1.6	2.0	2.1
9/6		1290	1630	1190	2050	3581	18.9	3.4	22.2	20.6	20.6	20.3	20.1	1.7	1.7	1.9	2.1
9/7		1230	1580	1190	2020	3515	18.1	3.3	21.4	20.0	20.3	20.1	19.8	1.4	1.1	1.4	1.6
9/8		1210	1550	1190	1980	3503	17.2	3.3	20.5	19.0	19.4	19.4	19.6	1.5	1.1	1.1	1.0
9/9		1150	1560	1190	2000	3585	16.4	3.1	19.4	18.2	18.6	18.6	18.8	1.3	0.8	0.8	0.6
9/10		1140	1580	1190	2130	3751	16.3	2.9	19.2	17.9	18.3	18.5	18.7	1.3	0.9	0.7	0.5
9/11		1120	1530	1190	2110	3658	17.4	2.3	19.7	-	18.9	19.0	19.1	-	0.7	0.7	0.6
9/12		1090	1490	1190	2070	3533	18.2	1.9	20.1	-	19.6	19.7	19.9	-	0.4	0.4	0.2
9/13		1060	1440	1190	2030	3443	18.3	1.7	20.0	-	19.7	19.8	19.8	-	0.3	0.3	0.2
9/14		1050	1390	1190	2000	3348	18.0	1.7	19.7	-	19.5	19.6	19.8	-	0.3	0.2	0.0
9/15		999	1360	1190	2000	3284	17.6	2.0	19.7	-	19.2	19.3	19.4	-	0.4	0.4	0.3
9/16		659	1320	1190	2000	3257	16.8	2.1	18.9	-	18.6	18.6	18.8	-	0.4	0.4	0.1
9/17		465	1130	1190	2000	3191	16.3	2.1	18.4	-	17.9	18.0	18.1	-	0.5	0.4	0.3
9/18	< After Pulse[a] >	468	864	1190	2000	2945	16.4	1.4	17.9	-	17.8	17.8	17.9	-	0.1	0.1	-0.1
9/19		459	833	1190	2000	2790	16.9	1.0	17.9	17.5	17.8	17.9	18.0	0.3	0.0	0.0	-0.2
9/20		452	802	1350	2000	2783	17.4	1.1	18.4	18.1	18.3	18.3	18.4	0.4	0.1	0.1	0.0
9/21		449	793	1360	2020	2775	17.8	1.1	18.8	18.5	18.8	18.8	18.8	0.3	0.1	0.0	0.0
9/22		446	783	1380	2110	2888	18.0	1.0	19.0	18.7	18.9	19.1	19.2	0.3	0.0	-0.1	-0.3
9/23		445	776	1390	2140	2894	18.2	1.1	19.2	18.9	19.1	19.1	19.2	0.3	0.1	0.2	0.0
9/24		446	764	1380	2150	2897	18.4	0.9	19.3	-	19.2	19.0	19.0	-	0.1	0.3	0.3
9/25		448	759	1370	2160	2892	18.5	0.8	19.3	-	19.2	19.1	19.0	-	0.1	0.2	0.3
9/26		449	749	1370	2130	2923	18.6	0.7	19.3	19.1	19.3	18.9	19.0	0.2	0.0	0.4	0.3
9/27		445	748	1360	2110	2946	18.5	0.6	19.1	19.0	19.1	-	18.8	0.2	0.0	-	0.3
9/28		441	745	1360	2130	2911	18.4	0.6	18.9	18.8	19.0	-	18.9	0.2	-0.1	-	0.0
9/29		441	735	1360	2100	2898	18.4	0.5	18.9	18.8	19.0	-	19.1	0.1	-0.1	-	-0.2
9/30		445	740	1360	2090	2876	18.1	0.6	18.6	18.5	18.8	-	18.6	0.1	-0.1	-	0.0

a = pulse flow timing varies with gage location.

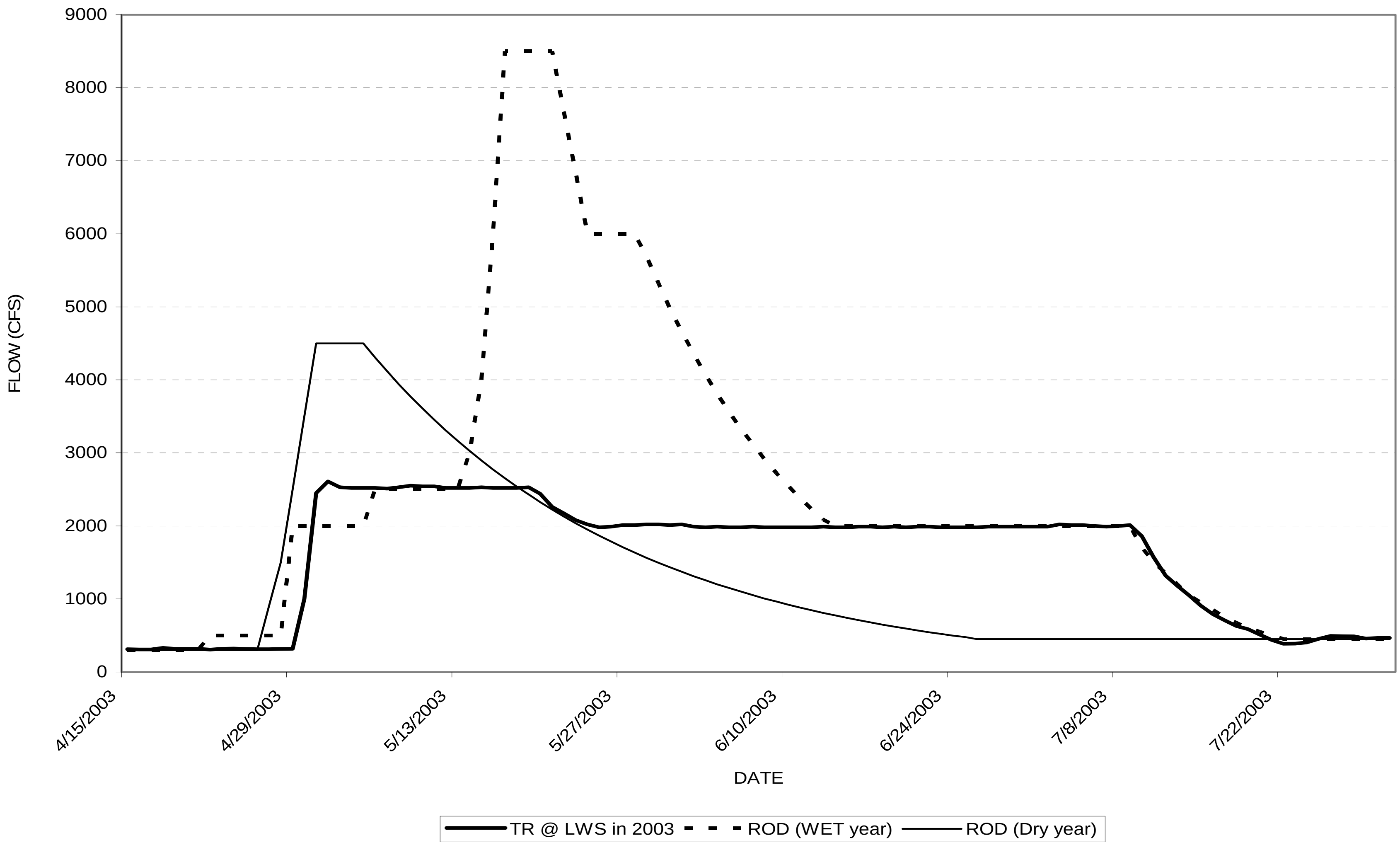

Figure 1. Spring and early summer flow from Lewiston Dam in 2003 and Lewiston Dam flow schedules of Wet and Dry hydrologic years of the 2000 Record of Decision.

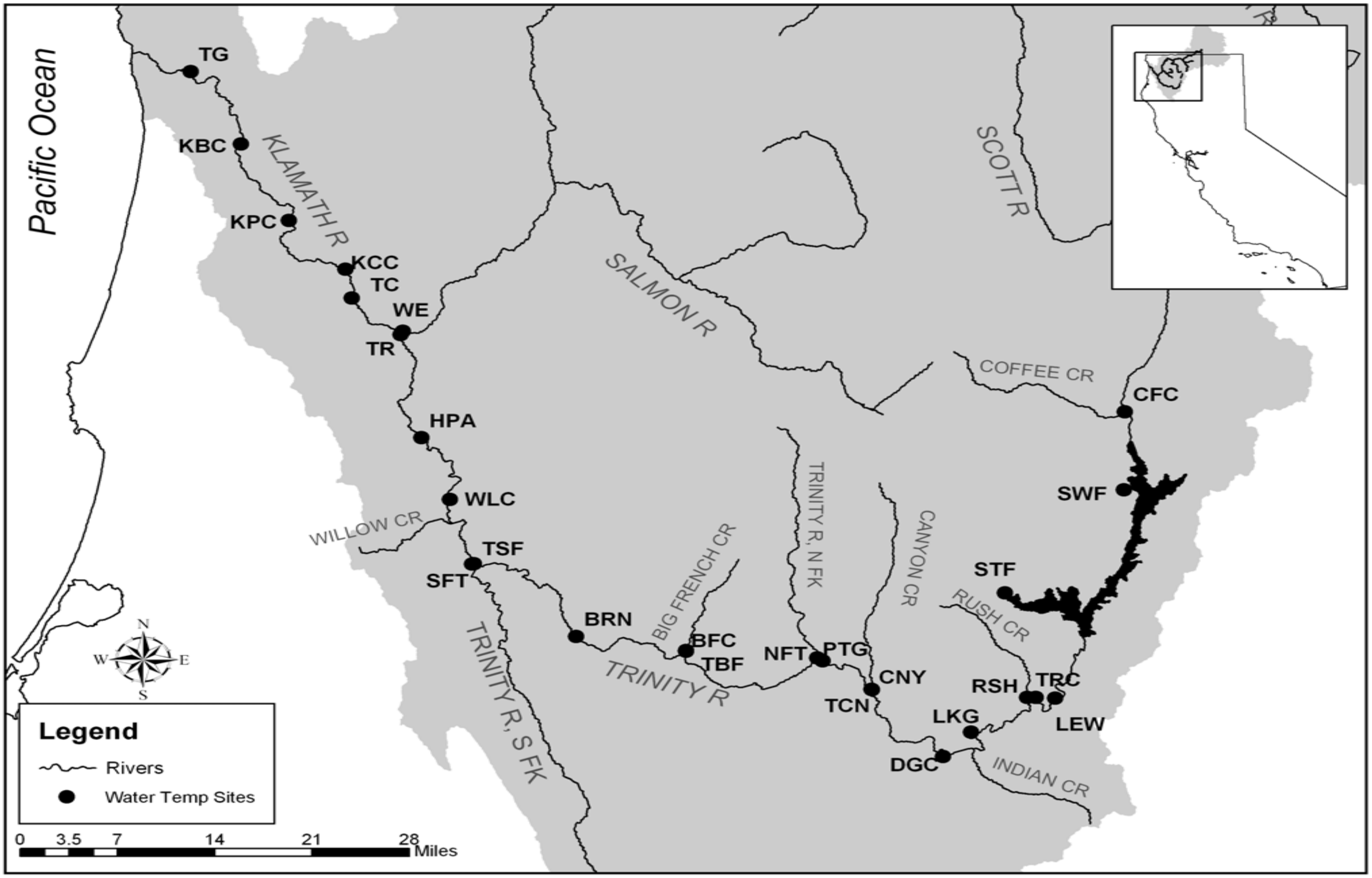

Figure 2. Water temperature monitoring sites in 2003.

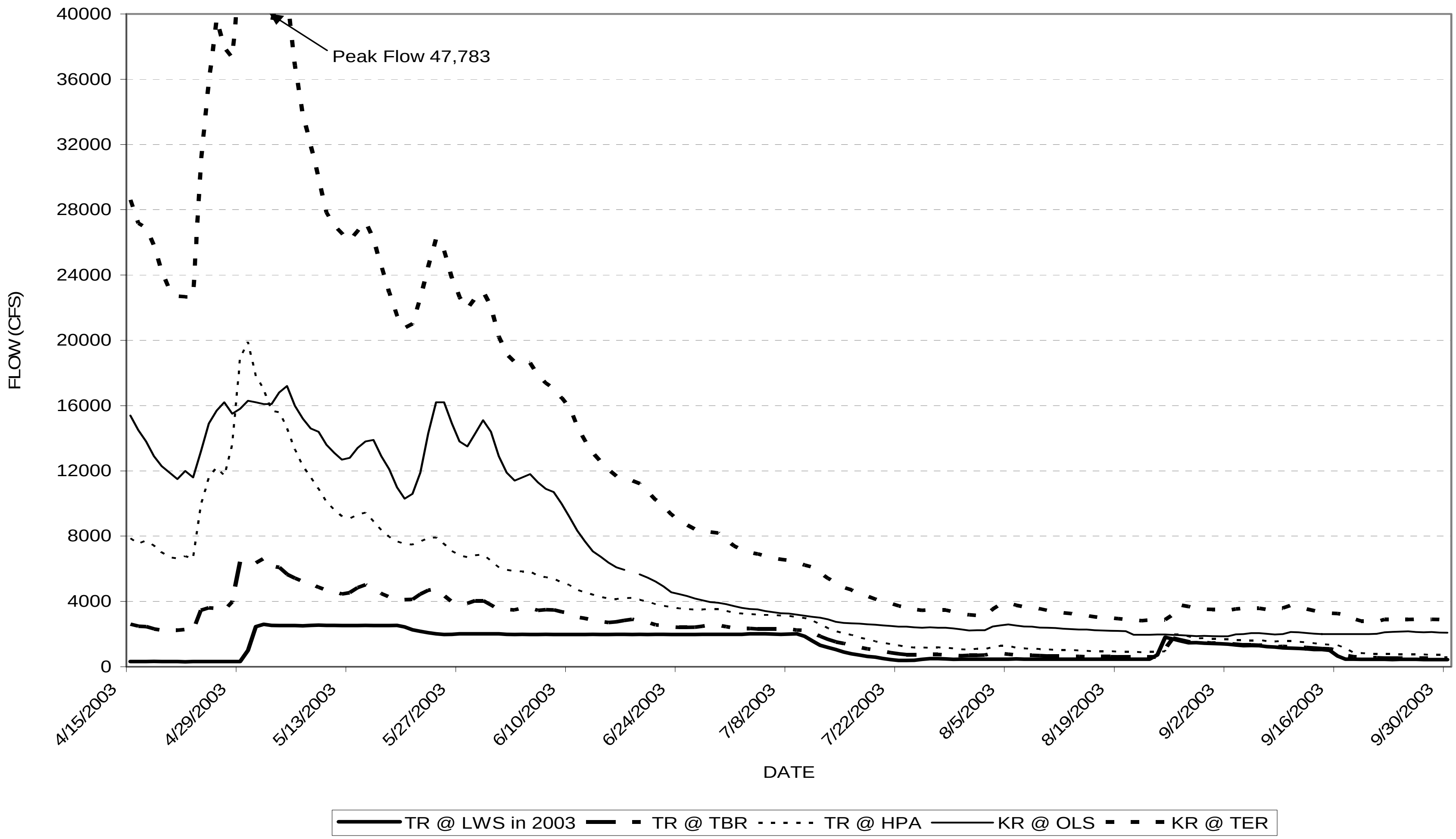

Figure 3. Average daily flow of the Trinity River at Lewiston gage (LWS; RKm 178.2), Burnt Ranch gage (TBR; RKm 78.5) and Hoopa gage (HPA; RKm 20.0) and flow of the Klamath River at Orleans gage (OLS; RKm 95.1) and Terwer gage (TER; RKm 10.8). USGS gage data, preliminary and subject to revision.

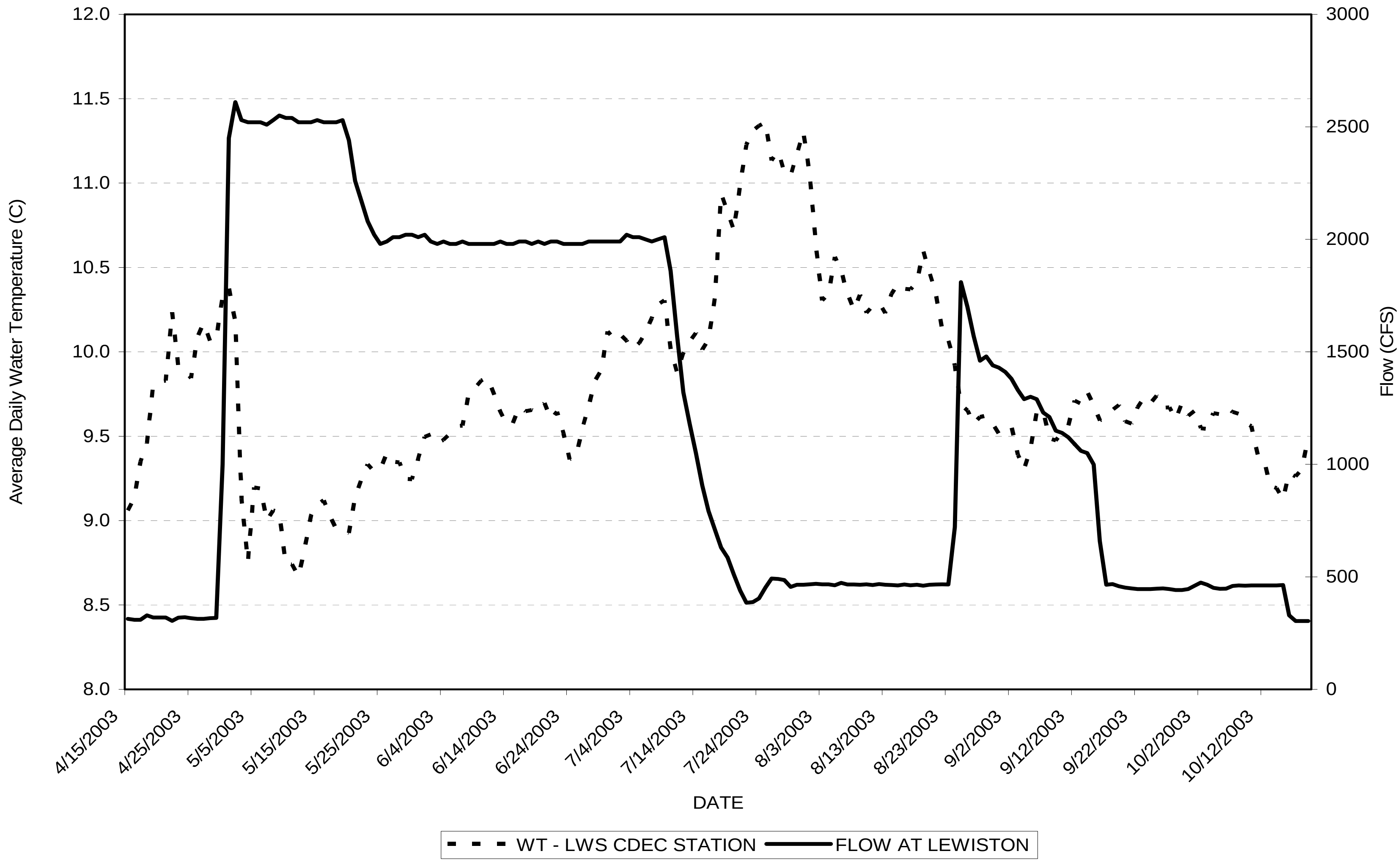

Figure 4. Average daily water temperature and flow of the Trinity River at Lewiston gage in 2003.

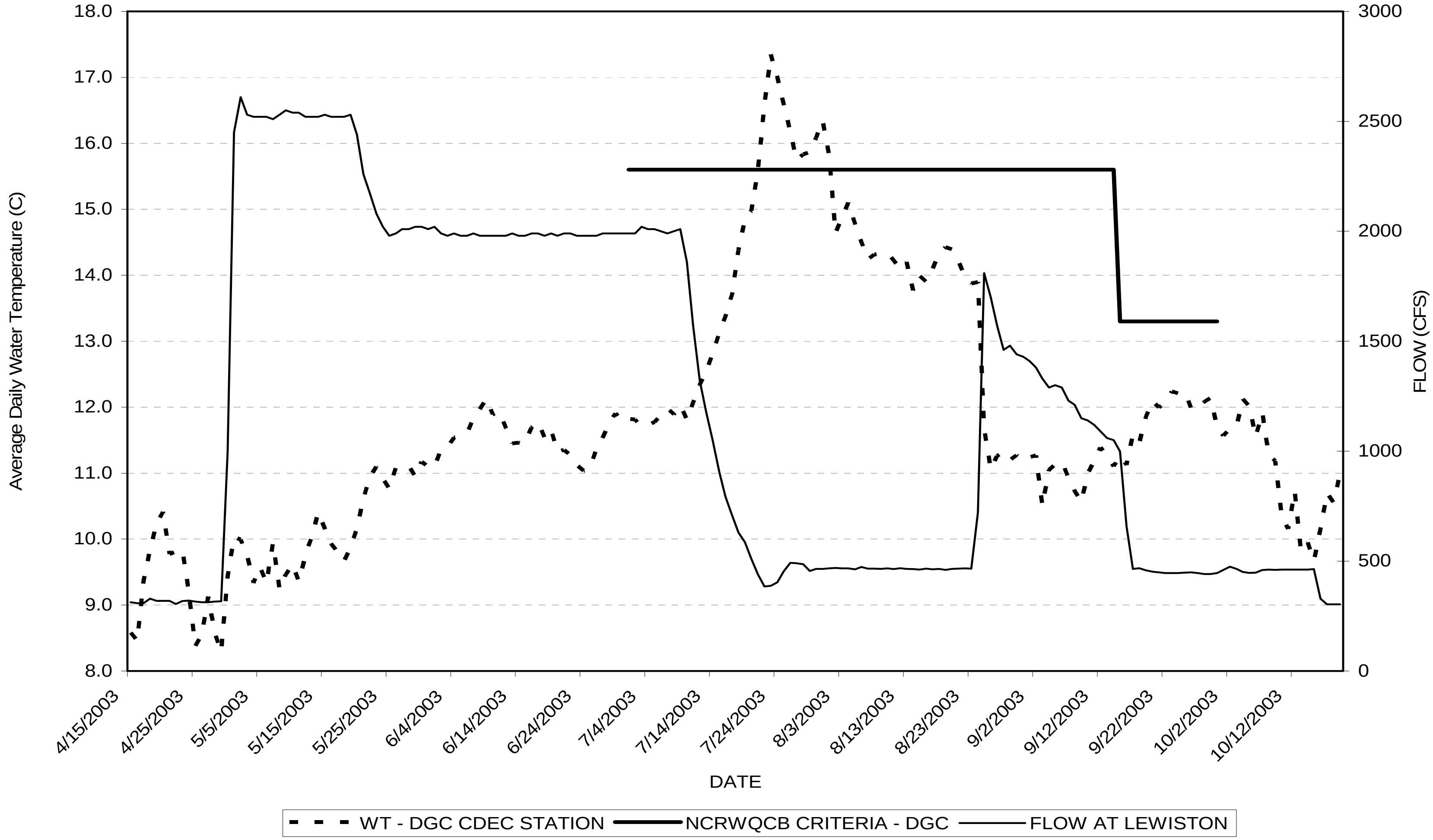

Figure 5. Average daily water temperatures of the Trinity River at the Douglas City gage and flow at Lewiston in 2003. Comparisons of water temperature data and the North Coast Regional Water Quality Control Board water temperature objectives.

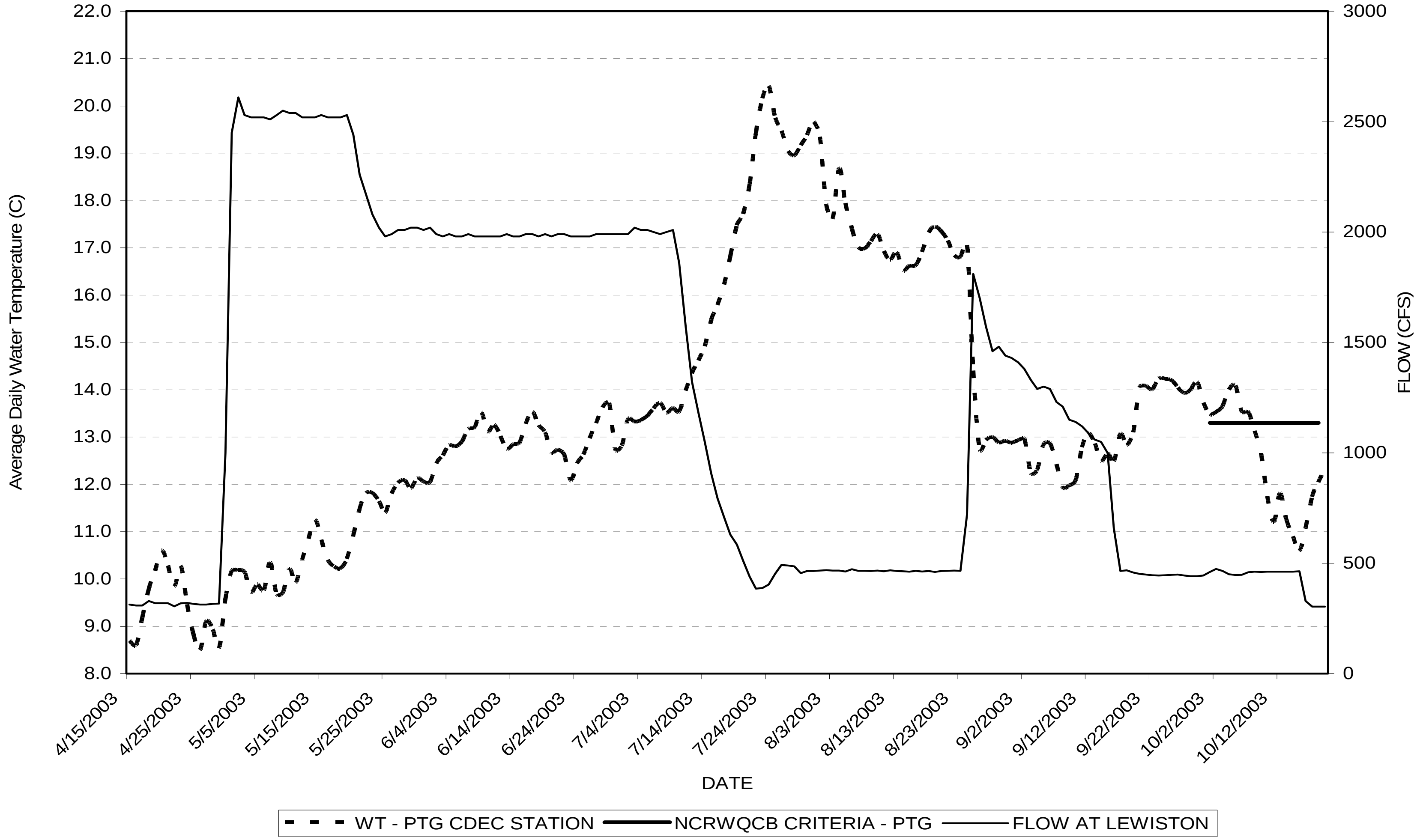

Figure 6. Average daily water temperatures of the Trinity River at the Pear Tree Gulch gage and flow at Lewiston in 2003. Comparison of water temperatures and the North Coast Regional Water Quality Control Board temperature objectives after October 1.

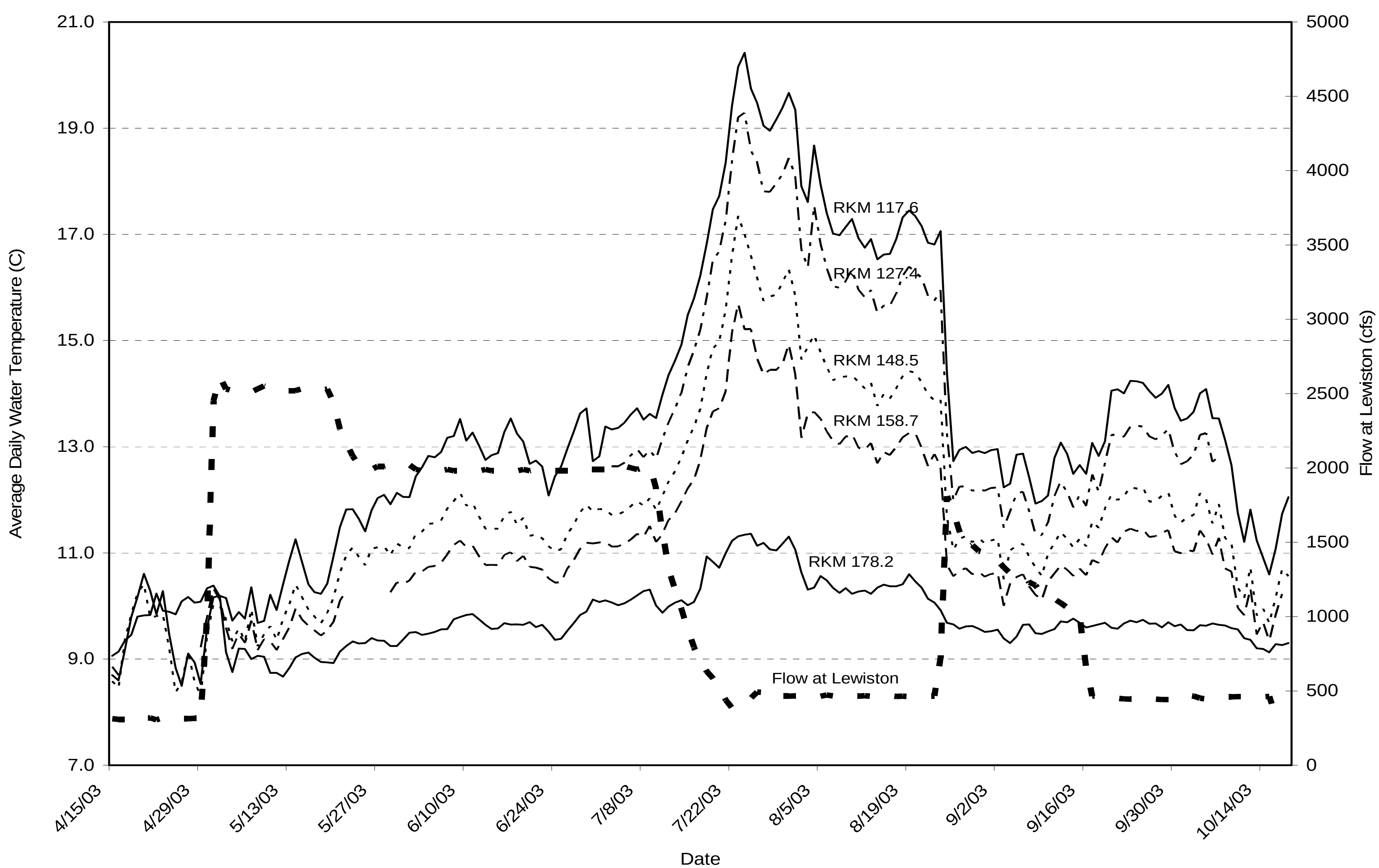

Figure 7. Average daily water temperatures of the Trinity River from Lewiston gage (RKm 178.2) to Pear Tree Gulch gage (RKm 117.6), and flow at Lewiston gage, 2003.

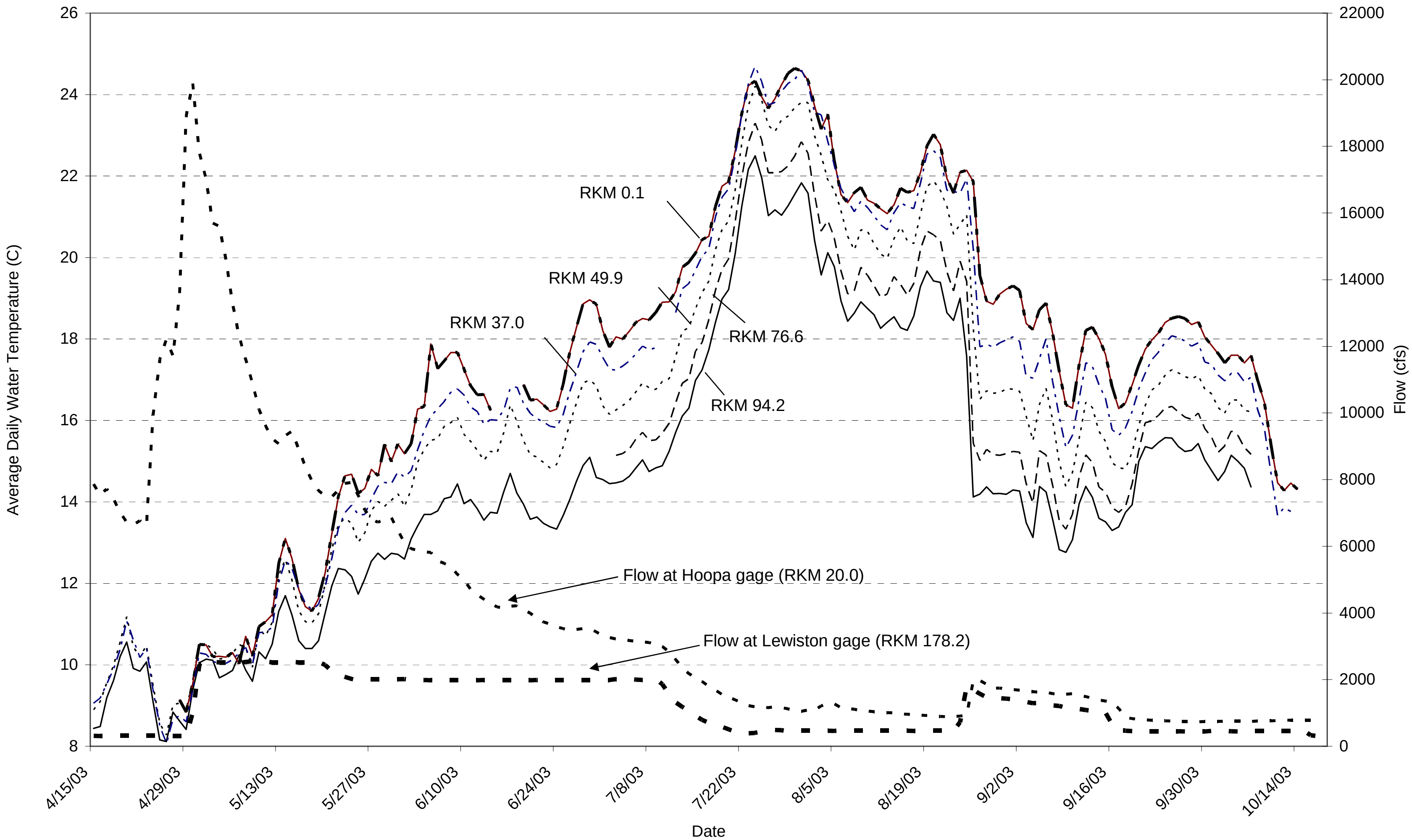

Figure 8. Average daily water temperatures of the Trinity River from immediately above Big French Creek (RKm 94.2) to Weitchpec (RKm 0.1), and flow of the Trinity River at Lewiston and Hoopa gages, 2003.

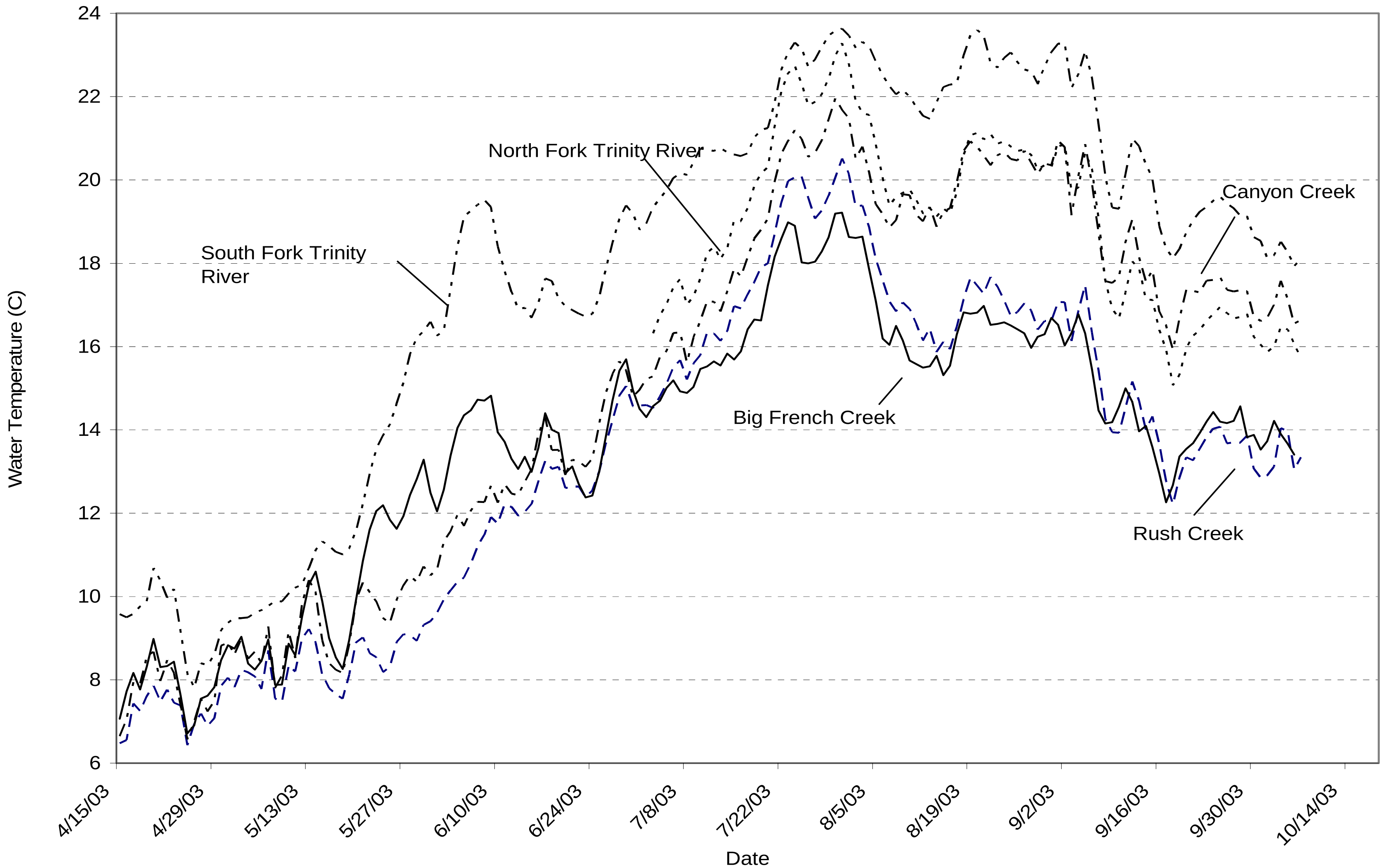

Figure 9. Average daily water temperatures of five tributaries to the Trinity River, 2003.

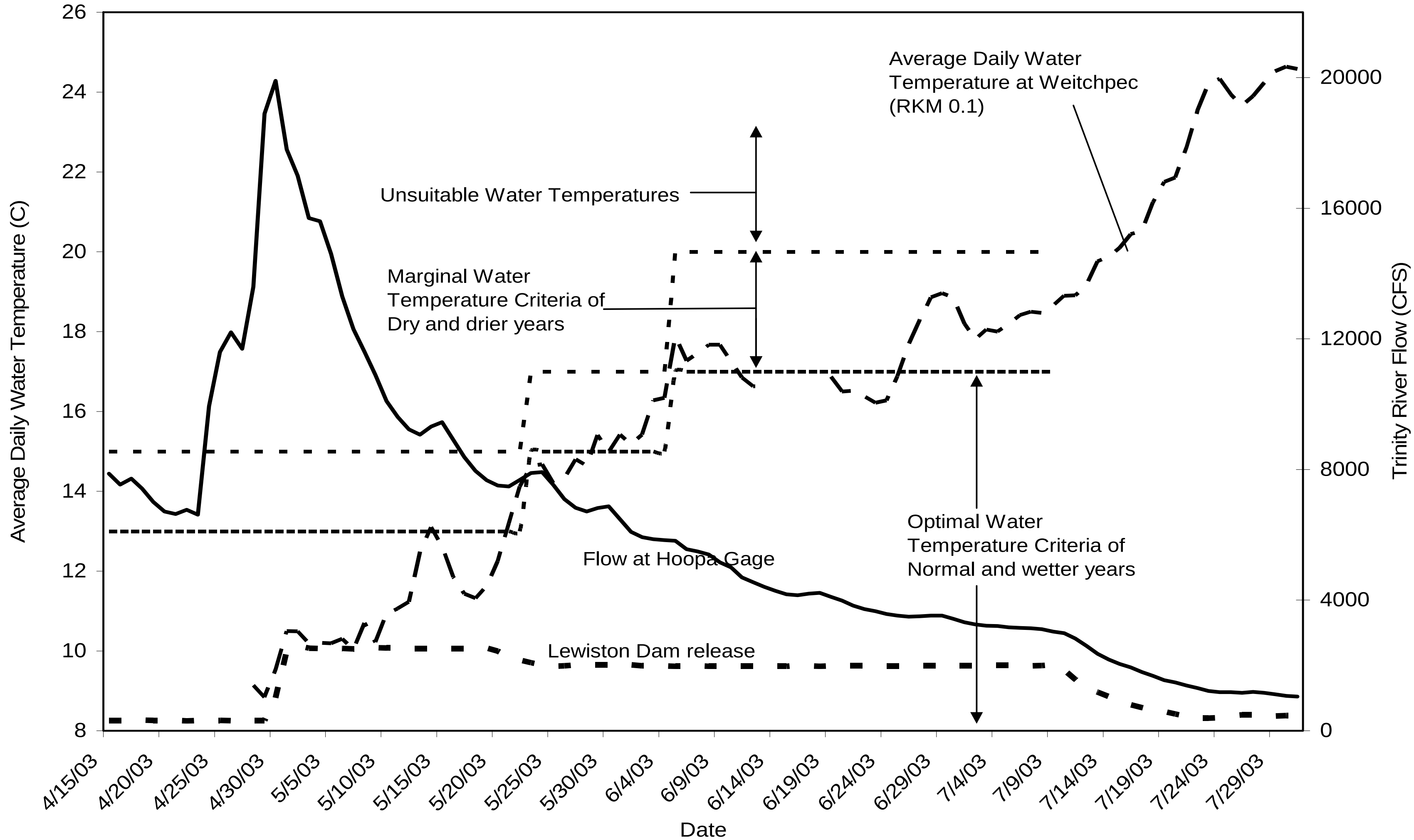

Figure 10. Comparison of water temperatures and flow of the Trinity River at Weitchpec (RM 0.1) and the spring-time temperature objectives, 2003.

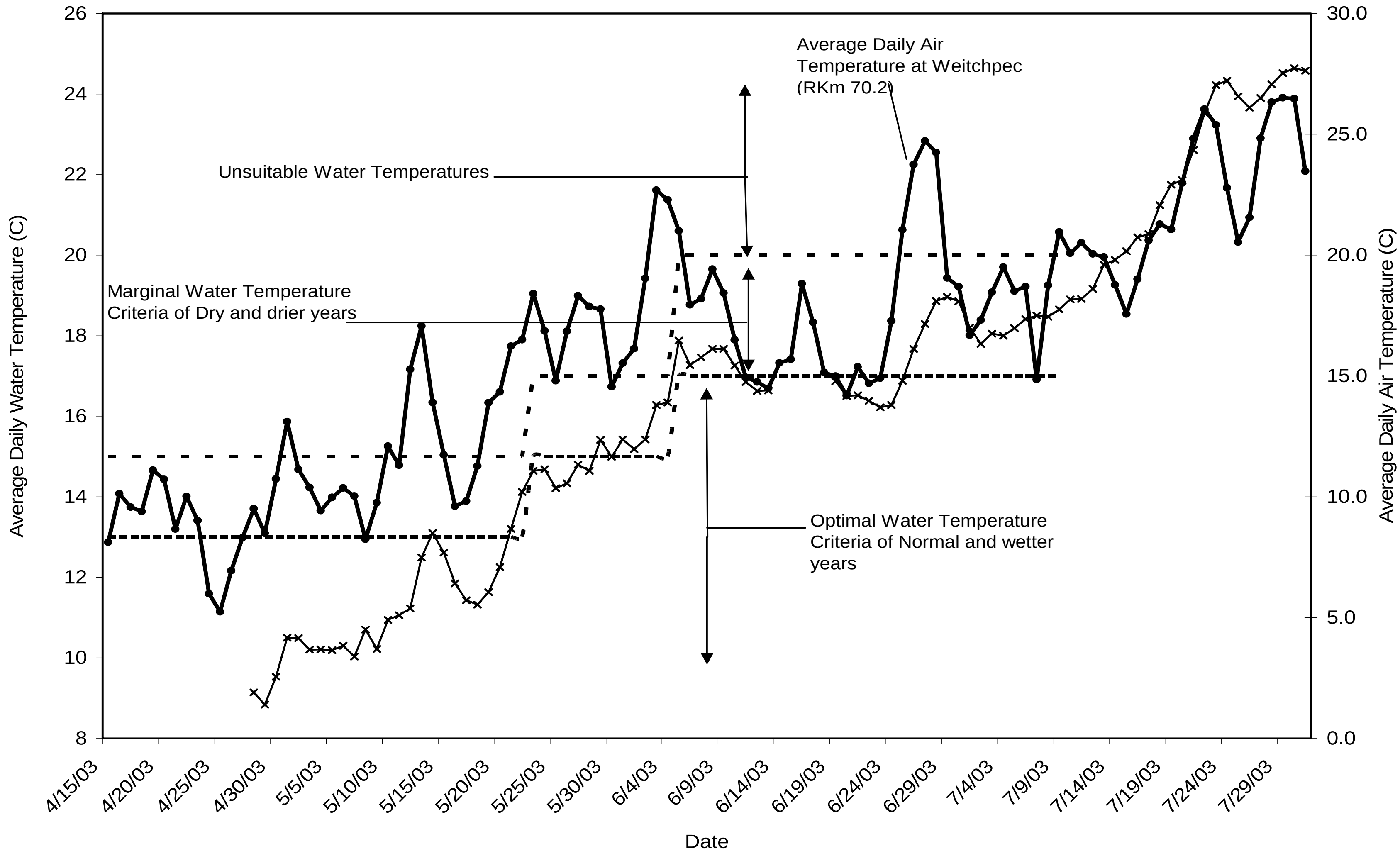

Figure 11. Air temperature and its influence on water temperature of the Trinity River at Weitchpec during the spring of 2003.

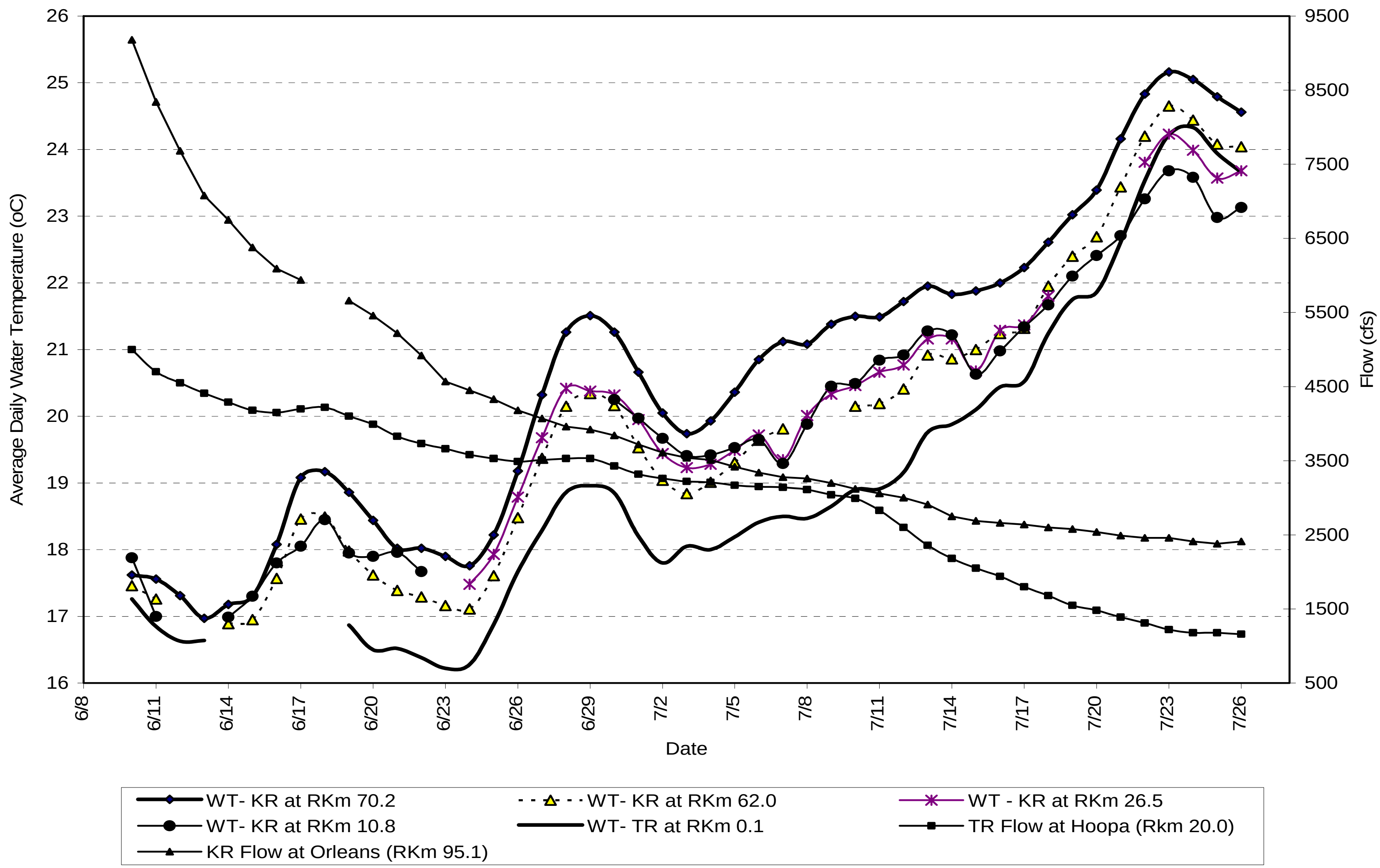

Figure 12. Influence of river flow on water temperatures (WT) of the lower Trinity River and the Klamath River below the confluence. June 10 to July 26, 2003.

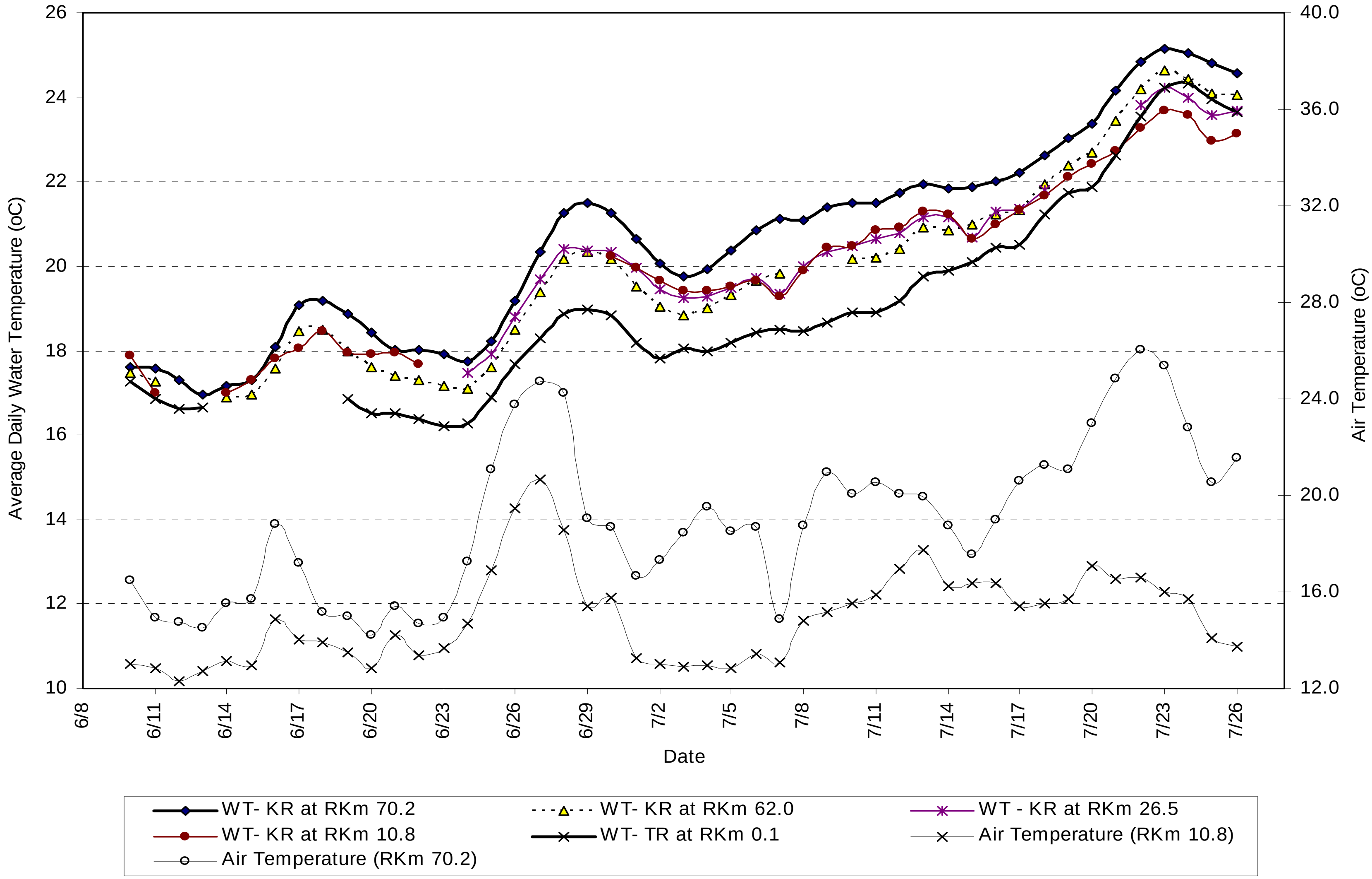

Figure 13. Influences of air temperature on water temperatures (WT) of the Trinity River and Klamath River below the confluence, June 10 to July 26, 2003.

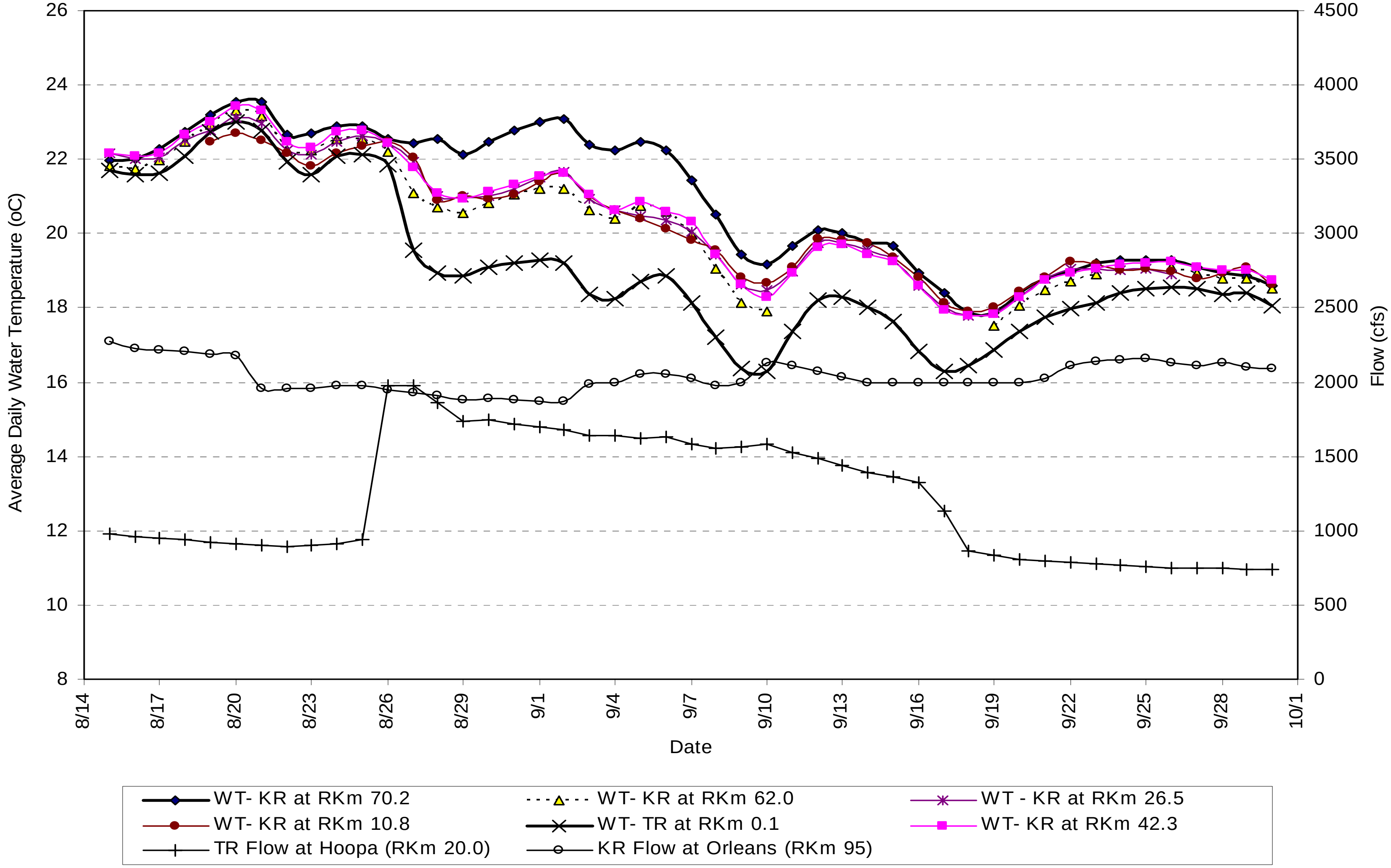

Figure 14. Influence of river flow on water temperatures (WT) of the lower Trinity River and the Klamath River below the confluence. August 15 to September 30, 2003.

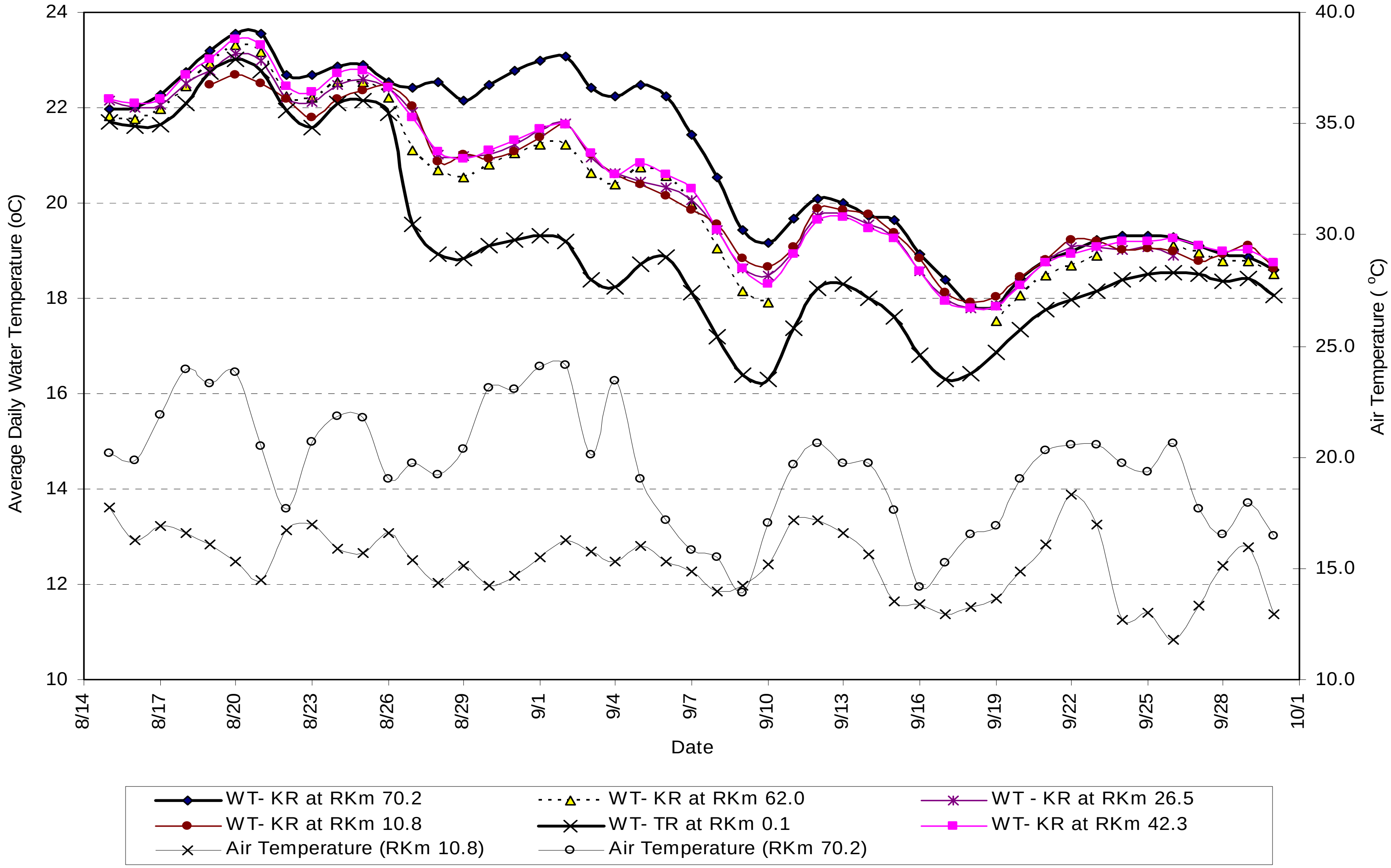

Figure 15. Influence of air temperature on water temperatures (WT) of the lower Trinity River and the Klamath River below the confluence. August 15 to September 30, 2003.

Region 1
U.S. Fish & Wildlife Service
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, California 95521

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