SECTION D
RIPARIAN FUNCTION

INTRODUCTION

Louisiana-Pacific Corporation (L-P) conducted an assessment of riparian function in the Garcia River Watershed Analysis Unit (WAU) during the summer of 1998. In 2003, Mendocino Redwood Company updated some of the information of L-P's assessment. This report presents the updated riparian function module for the Garcia WAU.

This assessment is divided into two groups: 1) the potential of the riparian stand to recruit large woody debris (LWD) to the stream channel and 2) a canopy closure and stream temperature assessment. The LWD potential assessment evaluates short-term (the next 2-3 decades) LWD recruitment. It shows the current condition of the riparian stands for generating LWD for stream habitat or stream channel stability. Field observations of current LWD levels in the stream channels and the riparian stand's ability to recruit LWD are presented in relation to channel sensitivity to LWD in order to determine current instream needs. The canopy closure and stream temperature assessment presents current canopy closure conditions and how these are related to the stream temperature monitoring which has been conducted.

LARGE WOODY DEBRIS RECRUITMENT POTENTIAL AND INSTREAM DEMAND METHODS

Short-term LWD recruitment potential (next 20-30 years) was evaluated in designated stream segments within the Garcia WAU. Stream segments were designated in the stream channel condition assessment and are shown on map E-1(Stream Channel Condition Module). Generally, stream segments were designated on any watercourse with less than a 20 percent gradient. In this assessment, vegetation type, size and density is assumed to influence LWD recruitment with the best riparian vegetation being large conifer trees.

To determine the LWD recruitment potential, riparian stands were classified using year 2000 aerial photographs and field observations from the summer of 1998. The riparian stands were evaluated for a distance of approximately one tree height on either side of the watercourse. Riparian stands were evaluated separately for each side of the watercourse. The following vegetation classification scheme for the Mendocino Redwood Company (MRC) timber inventory was used to classify the riparian stands:

Vegetation Classes

RW- greater than 75% of the stand basal area in coast redwood.
RD- combination of Douglas-fir and coast redwood basal area exceeds 75% of the stand, but neither species alone has 75% of the basal area.
MH- mix of hardwood basal area exceeds 75% of the stand, but no one hardwood species has 75% of the basal area.
CH- mix of conifer and hardwood basal area exceeds 75% of the stand, but no one hardwood or conifer species has 75% of the basal area.
Br- Brush

Vegetation Size Classes
1 - <8inches dbh
2 - 8 to 15.9 inches dbh
3 - 16 to 23.9 inches dbh
4 - 24 to 31.9 inches dbh
5 - >32 inches dbh

The size class is determined by looking at the diameters of the trees in the riparian stand. The size class which exceeds 50% of the total basal area is the size class assigned to the stand.

Vegetation Density
O - 5-20% tree canopy cover range
L - 20-40% tree canopy cover range
M - 40-60% tree canopy cover range
D - 60-80% tree canopy cover range
E - >80% tree canopy cover

The codes for vegetation classification of riparian stand condition are based on the three classes listed above. The vegetation code is a string of the classes with the vegetation class first, the size class second, and the vegetation density last. For example, the vegetation code for a redwood stand with greater than 50% of the basal area with 16-23.9 inch dbh or larger and 60-80% canopy cover would be classified RW3D.

In this assessment, vegetation type, size and density is assumed to affect LWD recruitment to the stream channel with the best riparian vegetation being large conifer trees. The LWD recruitment potential ratings reflect this. The following table presents the vegetation classification codes for the different LWD recruitment potential ratings (Table D-2).

Table D-2. Description of LWD Recruitment Potential Rating by Riparian Stand Classification for the Garcia River WAU.

Vegetation Type	**Size and Density Classes**					
	Size Classes 1-2 (Young)		**Size Class 3 (Mature)**		**Size classes 4-5 (Old)**	
	Sparse (O, L)	**Dense (M, D, E)**	**Sparse (O, L, M)**	**Dense (D, E)**	**Sparse (O, L, M)**	**Dense (D, E)**
RW	Low	Low	Low	Moderate	Moderate	High
RD	Low	Low	Low	Moderate	Moderate	High
CH	Low	Low	Low	Moderate	Low	High
MH	Low	Low	Low	Low	Low	Moderate

LWD was inventoried in watercourses during the stream channel assessment. All "functional" LWD was tallied within the active channel and the bankfull channel for each sampled stream segment. Functional LWD was that LWD which was providing some habitat or morphologic function in the stream channel (i.e. pool formation, scour, debris dam, bank stabilization, or gravel storage). The minimum size requirement for functional LWD is 4 inch diameter and 10 foot length. LWD can be functional if the minimum size is not meet if a rootwad is attached. The LWD was classified by tree species class, either redwood, fir (Douglas-fir, hemlock, grand fir), hardwood (alder, tan oak, etc.), or unknown (if tree species is indeterminable). Length and diameter were recorded for each piece so that volume could be calculated.

LWD pieces are assigned attributes if they fell into certain categories. These categories are: if the LWD piece was part of a living tree, root associated (i.e. does it have a rootwad attached to it), was part of the piece buried within stream gravel or the bank, or associated with a restoration structure. By assigning these attributes, the number of pieces in a segment which, for example, have a rootwad associated with the LWD can be noted. This is important as these types of pieces can be more stable or have ecological benefits above that which a LWD piece alone may have.

Pieces that were partially buried were noted, as calculated volume for these pieces represents a minimum. There may likely be a significant amount of volume that is buried that we cannot measure. Also, these pieces are more stable in the channel during high flows. The percentage of total pieces which are partially buried was calculated for each stream segment. Some consideration was given as to what percentage (0-25%, 25-50%, 50-75% and 75-100%) of the LWD pieces in the stream were recently contributed (<10 years). The LWD is further classified as a key LWD piece if it meets the following size requirement:

Table D-3. Key LWD Piece Size Requirements (adapted from Bilby and Ward, 1989)

Bankfull width (ft)	Diameter (in)	Length (ft)
0-20	12	20
20-30	18	30
30-40	22	40
40-60	24	60

Debris jams (>10 pieces) were noted and total dimensions of the jam recorded. This volume was calculated and added to total LWD volume with a correction factor of 50%. In other words, 50% of the total volume of a debris jam was considered to be “air space.” Data was not recorded for individual pieces contained in debris jams. All volume estimates were seperated in two groups, one not considering jams and one including volume from jams. The percentage of total volume contained in debris jams was also calculated.

The quantity of LWD observed was normalized by distance, for comparison through time or to other similar areas, and was presented as a number of LWD pieces per 100 meters. This normalized quantity, by distance, was performed for functional and key LWD pieces within the active and bankfull channel. The key piece quantity in the bankfull channel (per 100 meters of channel) is compared to the target for what would be an appropriate key piece loading. The target for appropriate key piece loading was derived from Bilby and Ward (1989) and Gregory and Davis (1992) and presented in Table D-4.

Table D-4. Target for Number of Key Large Woody Debris Pieces in Watercourses of the Garcia WAU.

	# Key Pieces		
Bankfull Width (ft)	**Per 100 meters**	**Per 1000 feet**	**Per mile**
<15	6.6	20	106
15-35	4.9	15	79
35-45	3.9	12	63
>45	3.3	10	53

An in-stream LWD demand is identified in addition to the riparian stand recruitment potential, discussed previously. The in-stream LWD demand is an indication of what level of concern there is for in-stream LWD for stream channel morphology and fish habitat associations within the Garcia River WAU. The in-stream LWD demand is determined by stream segment considering the overall LWD recruitment, the stream segment LWD sensitivity rating (as determined in the Stream Channel and Fish Habitat Assessment for stream geomorphic units), and the level of LWD currently in the stream segment (on target or off target). Table D-5 shows how these three factors are used to determine the in-stream LWD demand.

Table D-5. In-stream LWD Demand

		Channel LWD Sensitivity Rating		
	LWD On Target / **LWD Off Target**	**LOW**	**MODERATE**	**HIGH**
Recruitment Potential Rating	**LOW**	LOW	MODERATE	HIGH
		MODERATE	HIGH	HIGH
	MODERATE	LOW	MODERATE	MODERATE
		MODERATE	HIGH	HIGH
	HIGH	LOW	MODERATE	MODERATE
		LOW	HIGH	HIGH

Low In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are sufficient for LWD function in these stream channel types.

Moderate In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are moderately sufficient for fish habitat and stream channel morphology requirements. Consideration must be given to these areas to improve the LWD recruitment potential of the riparian stand. These areas may also be considered for supplemental LWD or stream structures placed in the stream channel.

High In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are not sufficient for LWD function in these stream channel types. These areas must consider improvement of the LWD recruitment potential of the riparian stand. These areas should be the highest priority for supplemental LWD or stream structures placed in the stream channel.

Major streams and stretches of river within each Calwater Planning Watershed were further evaluated for meeting target conditions. Within each hydrologic watershed of the stream segment analyzed, the percentage of watercourses with low or moderate LWD demand and the percentage of watercourses with an appropriate number of key LWD pieces determine the overall quality rating of watercourse LWD in each stream or stream segment of a Calwater planning watershed. Under this scheme, LWD quality falls into the following categories:

ON TARGET – >80% of watercourses have low or moderate LWD demand, and >80% of stream segments have appropriate number of key LWD pieces.

MARGINAL – 50-80% of watercourses have low or moderate LWD demand, and stream segments have significant functional LWD and are approaching the number of key LWD pieces desired

DEFICIENT – <50% of watercourses have low or moderate LWD demand, and little functional or key LWD.

The percentages that define the break between each of the LWD quality ratings have the intent of realizing that streams and watersheds are dynamic. LWD loadings are naturally found to be variable. Therefore a target of 100% of stream segment meeting LWD quality demand would be inappropriate. However, it seems that if less than half of the watercourses (50%) do not meet LWD demand than a LWD deficiency is assumed.

We consider key LWD for determination of both instream LWD demand and overall LWD quality to help ensure that enough key LWD exists at both small (i.e., stream segment) and large (i.e., planning watershed) spatial scales.

LARGE WOODY DEBRIS RECRUITMENT POTENTIAL AND INSTREAM DEMAND RESULTS

The large woody debris recruitment potential and in-stream LWD demand for the Garcia WAU is illustrated in Map D-1. The large woody debris recruitment potential and in-stream LWD demand provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD. These areas must be monitored over time to ensure that the recruitment potential is improving and that large woody debris is providing the proper function to the watercourses.

Current LWD loading is shown in Table D-7. Only eight of the fourteen segments surveyed in the Garcia River WAU met the LWD target. The remainder of the segments fell below the LWD target. LWD loading was exceptionally low in the five mainstem Garcia River sites, lower Rolling Brook, and the lower South Fork Garcia segments. The best LWD habitat occurred in tributaries to the mainstem and South Fork Garcia.

Debris jams, where they occurred, contained a significant portion of the total LWD volume. In the Garcia River WAU, debris jams occurred in only two segments and contained up to 68% of the total volume of those segments (see Table D-7a and b). Although there can be a significant amount of LWD in a segment if it trapped in debris jams, the ecological function may not be accurately represented by the LWD numbers. LWD in debris jam might provide more habitat value if they were spread out in the stream as opposed to being piled up in one spot.

LWD species composition was largely redwood dominated (Table D-7b). This analysis was limited to pieces not contained within debris jams. 90% of all LWD pieces in the Garcia River WAU were redwood. The remainder of pieces consisted of an even mixture of fir, alder, hardwood, and unknown species. This may not be surprising as these streams flow through a redwood forest but it does show that the LWD currently found in the Garcia River is more stable as redwood breaks down more slowly in streams than hardwood species.

As shown in tables D-7 a and b, there is a need for large woody debris in most of the channel segments of the Garcia River WAU. Channel segments with LWD levels which are well below the target will need to be the priority for monitoring future recruitment and restoration work. Even the segments that met the target need LWD levels to be maintained to ensure LWD is providing fish habitat and morphological function in the stream channels.

Riparian LWD recruitment potential in the Garcia River WAU is generally low (See Map D-1). The majority of the riparian stands within the Garcia WAU are classified as low LWD recruitment potential. Past harvesting activities in riparian areas have resulted in many areas which contain open, small hardwood or mixed conifer/hardwood stands. Stream segments in the Garcia River WAU contained little LWD that was recently contributed to the stream. Nearly 90% of all LWD pieces had been in the stream channel for at least 10 years. The lack of recently contributed LWD is probably the result of the low recruitment potential of the current riparian stands.

The majority of the stream segments in the Garcia River WAU fall within the high in-stream LWD demand classification (Map D-1). The high in-stream LWD demand in the WAU is primarily due to stream channels that are moderately or highly responsive to LWD input adjacent to riparian stands with moderate to low LWD recruitment potential. Even in the smaller channels that met the LWD target, poor recruitment potential makes in-stream LWD demand high or moderate.

Table D-6 shows the instream LWD quality rating for major streams and sections of stream or river in individual Calwater planning watersheds. This quality rating will provide a tool to monitor the quality of the LWD in major streams over time. Currently the mainstem Garcia River and Rolling Brook have a deficient LWD quality rating, with the South Fork Garcia and Fleming Creek segments receiving a marginal rating.

Table D-6. Instream LWD Quality Ratings for Major Streams and Sections of Streams or Rivers in Calwater Planning Watersheds for the Gualala WAU.

Stream	**Calwater Planning Watershed**	**Instream LWD Quality Rating**
Garcia River	Rolling Brook	Deficient
Garcia River	South Fork Garcia	Deficient
Lee Creek	Rolling Brook	No data
Rolling Brook	Rolling Brook	Deficient
South Fork Garcia	South Fork Garcia	Marginal
Flemming Creek	South Fork Garcia	Marginal

Table D-7a. Large Woody Debris Piece Count in Selected Stream Segments of the Garcia WAU.

Stream Segment Name	ID#	Functional LWD Pieces w/o Debris Jams	Total # of Debris Jams	Functional LWD (#/100m) w/o Debris Jams	Key LWD Pieces w/o Debris Jams	Key LWD Pieces/100m w/o Debris Jams	Root Associated Piece Count		Root Associated Volume	
							#	%	Yd^3	%
Garcia River	2	50	0	5.4	0	0.0	12	24%	49.2	32%
Garcia River	3	15	0	1.9	1	0.1	0	53%	69.5	88%
Garcia River	4	38	0	3.9	0	0.0	0	16%	43.4	37%
Garcia River	5	24	0	3.3	1	0.1	0	52%	183.2	79%
Garcia River	6	21	0	2.4	1	0.1	7	33%	104.8	74%
Rolling Brook	19	18	0	5.6	1	0.3	3	17%	13.3	13%
Rolling Brook	20	26	0	10.6	4	1.6	2	8%	11.1	13%
Mill Creek	53	24	0	6.5	5	1.4	6	25%	60.7	52%
South Fork Garcia	83	17	0	3.8	0	0.0	2	12%	8.4	23%
South Fork Garcia	84	23	3	7.0	0	0.0	6	26%	29.2	17%
South Fork Garcia	85	54	0	17.8	3	1.0	17	31%	78.1	43%
South Fork Garcia	86	65	0	20.7	5	1.6	12	18%	81.3	33%
Unamed to(Sfk Garcia)	89	11	0	8.7	11	8.7	0	0%	0.0	0%
Unamed to SFk	90	24	0	10.7	12	5.4	1	4%	2.3	3%
South Fork Garcia	101	26	1	12.6	12	5.8	4	15%	24.4	21%
South Fork Garcia	102	28	1	10.6	19	7.2	6	21%	32.8	12%
South Fork Garcia	111	45	0	13.5	10	3.0	5	13%	32.7	24%
Unamed to(Garcia)	121	50	0	32.2	16	10.3	2	4%	12.3	7%
Unamed to(Garcia)	127	20	0	21.5	16	17.2	0	0%	0.0	0%
Unamed trib. (Bueler)	149	58	0	23.8	35	14.3	9	17%	63.0	17%
Unamed (Bueler)	150	27	0	17.5	10	6.5	2	7%	10.3	8%
Unamed to(Garcia)	155	7	0	4.6	2	1.3	0	0%	0.0	0%

Table D-7b. Large Woody Debris Volume in Selected Stream Segments of the Garcia WAU.

Stream Segment Name	ID#	Total Volume (yd^3) w/o Debris Jams	Total Volume (yd^3) w/ Debris Jams	Total Vol/100m (yd^3) w/o Debris Jams	Total Vol/100m (yd^3) w/ Debris Jams	Percent of Total Volume in Debris Jams	% of Vol in Key Pieces w/o Jams	% of Total Volume By Species w/o Jams				Recruitment Percent (>10 yrs)
								Redwood	Fir	Hardwood	Unknown	
Garcia River	2	155.5	155.5	16.8	16.8	0%	0%	94%	0%	6%	0%	95
Garcia River	3	78.7	78.7	9.7	9.7	0%	52%	94%	0%	0%	6%	95
Garcia River	4	115.8	115.8	11.9	11.9	0%	0%	88%	4%	8%	0%	95
Garcia River	5	231.4	231.4	33.2	33.2	0%	29%	19%	0%	0%	81%	99
Garcia River	6	140.9	140.9	16.2	16.2	0%	53%	96%	0%	4%	0%	99
Rolling Brook	19	100.9	100.9	31.3	31.3	0%	37%	100%	0%	0%	0%	90
Rolling Brook	20	82.9	82.9	33.8	33.8	0%	51%	94%	2%	4%	0%	80
Mill Creek	53	116.5	116.5	31.7	31.7	0%	68%	83%	3%	14%	0%	90
South Fork Garcia	83	36.1	36.1	8.1	8.1	0%	0%	93%	0%	7%	0%	90
South Fork Garcia	84	56.6	175.1	17.3	53.5	68%	0%	96%	0%	4%	0%	95
South Fork Garcia	85	180.4	180.4	59.6	59.6	0%	24%	85%	0%	15%	0%	95
South Fork Garcia	86	247.0	247.0	78.5	78.5	0%	65%	86%	7%	6%	0%	80
Unamed to(Sfk Garcia)	89	68.5	68.5	54.1	54.1	0%	100%	100%	0%	0%	0%	90
Unamed to SFk	90	83.1	83.1	37.1	37.1	0%	87%	99%	0%	1%	0%	90
South Fork Garcia	101	118.2	118.6	57.1	57.3	0%	80%	94%	6%	0%	0%	95
South Fork Garcia	102	121.0	269.1	45.9	102.1	55%	90%	100%	0%	0%	0%	90
South Fork Garcia	111	134.4	134.4	40.3	40.3	0%	63%	94%	3%	2%	0%	90
Unamed to(Garcia)	121	168.7	168.7	108.5	108.5	0%	67%	97%	3%	0%	0%	95
Unamed to(Garcia)	127	101.8	101.8	109.5	109.5	0%	94%	92%	0%	8%	0%	98
Unamed trib. (Bueler)	149	362.5	362.5	148.6	148.6	0%	89%	100%	0%	0%	0%	90
Unamed (Bueler)	150	135.8	135.8	87.8	87.8	0%	66%	76%	0%	0%	24%	98
Unamed to(Garcia)	155	10.2	10.2	6.7	6.7	0%	69%	73%	0%	27%	0%	99

STREAM CANOPY AND TEMPERATURE METHODS

Canopy closure over watercourses was estimated from year 2000 aerial photographs. Four canopy closure classes were determined using the aerial photographs. These classes are shown in table D-8. A map was produced for the Garcia WAU based on the aerial photograph interpretations.

Table D-8. Estimated levels of Stream Canopy Closure from Aerial Photographs.

Stream surface not visible	>90% shade
Stream surface visible or visible in patches	70-90% shade
Stream surface visible but banks are not visible	40-70% shade
Stream surface visible and banks visible at times	20-40% shade
Stream surface and banks visible	0-20% shade

In 1998 field measurements of canopy closure over select stream channels were performed. The field measurements were taken during the stream channel assessments in the Garcia WAU. The field measurements consisted of estimating canopy closure over a watercourse using a spherical densiometer. The densiometer estimates were taken at approximately 3-5 evenly spaced intervals along a sampled channel segment, typically a length of 20-30 bankfull widths. The results of the densiometer readings were averaged across the channel to represent the percentage of canopy closure for the channel segment. The stream canopy closure for the Garcia WAU is mapped in Map D-2.

Stream temperatures have been monitored in Class I streams in the Garcia River WAU, by Louisiana-Pacific Corp. in 1994-97 and MRC in 1999-2002. In summer 2001 this was expanded to include Class II stream temperatures as part of a herpetological study. Stream temperature monitoring used electronic temperature recorders (Stowaway, Onset Instruments) monitoring the water temperature at continuous 2 hour intervals. Stream temperatures are monitored during the summer months when the water temperatures are highest. The stream temperature recorders were typically placed in shallow pools (<2 ft. in depth) directly downstream of riffles. Map D-2 shows the temperature monitoring locations and Table D-9 describes the temperature monitoring locations.

Table D-9. Stream Temperature Monitoring Locations and Time Periods in the Garcia WAU.

Temperature Monitoring Station	Stream Channel Segment	River/Stream Name	Years Monitored
93-1	1	Garcia River	94, 95, 97, 99, 00, 01
93-2	19	Rolling Brook	95, 96, 97, 99, 00, 01, 02
93-4	83	South Fork Garcia	94, 95, 97, 99, 00, 01, 02
93-5	3	Garcia River	99, 00, 01, 02
93-6	6	Garcia River	97, 99
93-7	111	Fleming Creek	97, 00, 01, 02
93-8	89	South Fork Garcia	99, 01, 02
93-9	20	Rolling Brook	97
93-20*	20	Rolling Brook	01
93-21*	141	Lee Creek	01

*Class II Streams

Maximum weekly average temperatures (MWATs) and maximum weekly maximum temperatures (MWMTs) were calculated for the stream temperatures by taking a seven day average of the mean and maximum daily stream temperature.

A stream shade quality rating was derived for major tributaries or river segments within a Calwater planning watershed. The percentage of perennial watercourses in a stream segment's hydrologic watershed ranked as having "on-target" effective shade determines the overall quality of the stream's shade canopy. For streams or rivers that flow through several Calwater planning watersheds, the percentage of perennial watercourses in stream segments of that planning watershed ranked as having "on-target" effective shade determines the overall quality of the stream or river's shade canopy. MRC uses 2 sequential sets of criteria to determine if a watershed has "on-target" effective shade, the first based on stream temperature, the second on effective shade:

- If the MWAT value for stream temperature at the outlet of a streams major basin lies below 15°C, then we consider that current shade conditions provide "on-target" effective shade for all watercourses in that basin.

However, if the MWAT value, for the major basin of a stream, lies above 15°C then the percentage of effective shade determines the streams effective shade quality rating.

The percentage of effective shade required for an "on-target" rating varies by bankfull width of the watercourse:

- for watercourses with bankfull widths <30 feet, >90% effective shade.
- for watercourses with bankfull widths of 30-100 feet, >70% effective shade.
- for watercourses with bankfull widths of 100-150 feet, >40% effective shade.

We use the following categories of watercourse-shade rating to determine overall shade quality in each major stream or river/stream segment of a planning watershed:

ON TARGET – >90% of perennial watercourses that contribute to the stream have "on-target" effective shade

MARGINAL – 70-90% of perennial watercourses that contribute to the stream have "on-target" effective shade, or >70% of stream with greater than 70% canopy.

DEFICIENT – <70% of perennial watercourses that contribute to the stream have "on-target" effective shade or <70% canopy.

STREAM CANOPY AND TEMPERATURE RESULTS

Canopy closure over watercourses is generally favorable throughout the Garcia River WAU (Map D-2 and Table D-10). The mainstem Garcia River has poor canopy cover but this is to be expected of a wide, large channel. All tributaries have either >90% or 70-90% canopy cover.

Table D-10. 1998 Field Observations of Stream Canopy Closure for Select Stream Channel Segments in the Garcia River WAU.

Stream Name	Segment Number	Mean Shade Canopy
Garcia River	1	68
Garcia River	2	34
Garcia River	3	31
Garcia River	4	37
Garcia River	5	31
Garcia River	6	46
Rolling Brook	19	86
Rolling Brook	20	91
No Name Creek	53	84
South Fork Garcia	83	91
South Fork Garcia	84	85
South Fork Garcia	85	88
South Fork Garcia	86	92
South Fork Garcia	89	96
South Fork Garcia	90	91
Upper South Fork Garcia River	101	89
Upper South Fork Garcia River	102	86
Fleming Creek	111	94
Graphite Creek	149	77
Graphite Creek	150	67
Unnamed to Garcia River	155	80

Water temperatures in the South Fork Garcia, Fleming Creek, and Rolling Brook are within the preferred temperature ranges for salmonids. Even the maximum temperatures recorded during the entire summer at these sites are not near lethal levels for coho and steelhead ($23^{o}C$-$26^{o}C$). MWATs from the temperature sites in these smaller streams are well below the maximums for coho salmon ($17\text{-}18C^{o}$)(Brett, 1952 and Becker and Genoway, 1979). See Tables D-11, D-12 and D-13.

The mainstem Garcia water temperatures are above the preferred range for salmonids. It should be noted that the mainstem Garcia River water temperature cools after the water travels through the MRC lands (93-6 is at MRC property line upstream and 93-1 is at downstream property line). This is probably from cool water tributaries feeding the mainstem within MRC lands and proximity to the coast with lower air temperatures. See Tables D-11, D-12 and D-13.

Table D-11. Maximum Daily Temperatures in the Garcia WAU.

Station	1994	1995	1996	1997	1998	1999	2000	2001	2002
93-1	20.2	23.0	**	21.7	**	18.3	21.1	19.8	**
93-2	**	16.7	15.3	15.8	**	16.1	16.0	15.7	16.0
93-4	15.0	17.1	**	15.1	**	17.8	16.4	16.0	16.0
93-5	**	**	**	**	**	22.2	22.5	24.0	20.5
93-6	**	**	**	22.6	**	22.8	**	**	**
93-7	**	**	**	14.7	**	**	13.7	14.1	14.0
93-8	**	**	**	**	**	14.6	**	13.3	12.8
93-9	**	**	**	15.1	**	**	**	**	**
93-20	**	**	**	**	**	**	**	15.2	**
93-21	**	**	**	**	**	**	**	16.8	**

**Data not collected

Table D-12. Maximum Weekly Average Temperature (MWAT) in the Garcia WAU.

Station	1994	1995	1996	1997	1998	1999	2000	2001	2002
93-1	17.9	19.7	**	19.2	**	15.8	18.3	18.2	**
93-2	**	15.1	13.9	14.7	**	14.5	14.4	14.2	13.8
93-4	14.0	15.3	**	14.2	**	15.8	14.4	14.7	14.5
93-5	**	**	**	**	**	19.1	20.2	19.0	18.9
93-6	**	**	**	19.5	**	20.2	**	**	**
93-7	**	**	**	14.1	**	**	13.1	13.2	13.1
93-8	**	**	**	**	**	13.8	**	12.9	12.6
93-9	**	**	**	14.4	**	**	**	**	**
93-20	**	**	**	**	**	**	**	13.6	**
93-21	**	**	**	**	**	**	**	13.8	**

**Data not collected

Table D-13. Maximum 7-Day Moving Average of the Daily Maximum (MWMT) in the Garcia WAU.

Station	1994	1995	1996	1997	1998	1999	2000	2001	2002
93-1	20.0	22.3	**	21.3	**	17.8	20.7	19.5	**
93-2	**	16.3	14.9	15.6	**	15.5	15.4	15.5	14.7
93-4	14.8	16.7	**	14.8	**	16.8	16.1	15.9	15.7
93-5	**	**	**	**	**	21.5	21.9	22.4	20.2
93-6	**	**	**	22.1	**	22.4	**	**	**
93-7	**	**	**	14.7	**	**	13.5	13.8	13.7
93-8	**	**	**	**	**	14.3	**	13.2	12.7
93-9	**	**	**	14.9	**	**	**	**	**
93-20	**	**	**	**	**	**	**	14.7	**
93-21	**	**	**	**	**	**	**	16.3	**

**Data not collected

Canopy cover over the stream is generally good in the Garcia WAU. Only the segments of the mainstem Garcia have deficient stream shade quality ratings. The mainstem Garcia River is a large, wide channel where canopy cover is difficult to maintain (Table D-14). The tributaries in the South Fork Garcia are on target. The tributaries of Rolling Brook and Lee Creek are rated marginal mainly due to slightly lower than expected canopy on some of the upper reaches of these streams.

Table D-14. Stream Shade Quality Ratings for Major Streams and River/Stream Segments in Calwater Planning Watersheds for the Gualala WAU.

Stream	Calwater Planning Watershed	Shade Quality Rating
Garcia River	Rolling Brook	Deficient
Garcia River	South Fork Garcia	Deficient
Lee Creek	Rolling Brook	Marginal
Rolling Brook	Rolling Brook	Marginal
South Fork Garcia	South Fork Garcia	On Target
Flemming Creek	South Fork Garcia	On Target

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Appendix D

Garcia River Watershed Analysis Unit

Map D-1
Large Woody Debris Recruitment Potential and Demand

This map presents the large woody debris recruitment potential and in-stream large woody debris (LWD) demand for the streams on MRC lands in the Garcia WAU. This map provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. It is based on the streamside stand characteristics, amount of LWD in the stream and the sensitivity of the stream channel to LWD from aerial photograph interpretation of 2000 photographs and field observations in 1998. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD.

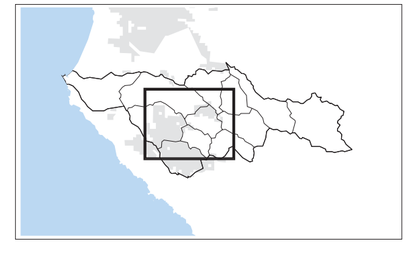
LWD Recruitment Potential Classes
- High
- Moderate
- Low

Instream LWD Demand
- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Garcia River Watershed Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 1



0 1/2 1 Mile

September 2003

Garcia River Watershed Analysis Unit

Map D-1
Large Woody Debris Recruitment Potential and Demand

This map presents the large woody debris recruitment potential and in-stream large woody debris (LWD) demand for the streams on MRC lands in the Garcia WAU. This map provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. It is based on the streamside stand characteristics, amount of LWD in the stream and the sensitivity of the stream channel to LWD from aerial photograph interpretation of 2000 photographs and field observations in 1998. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD.

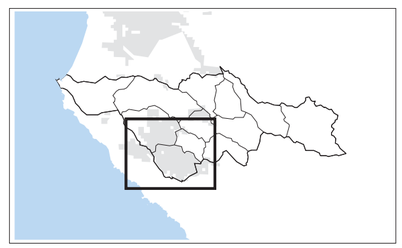
LWD Recruitment Potential Classes
- High
- Moderate
- Low

Instream LWD Demand
- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Garcia River Watershed Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 2



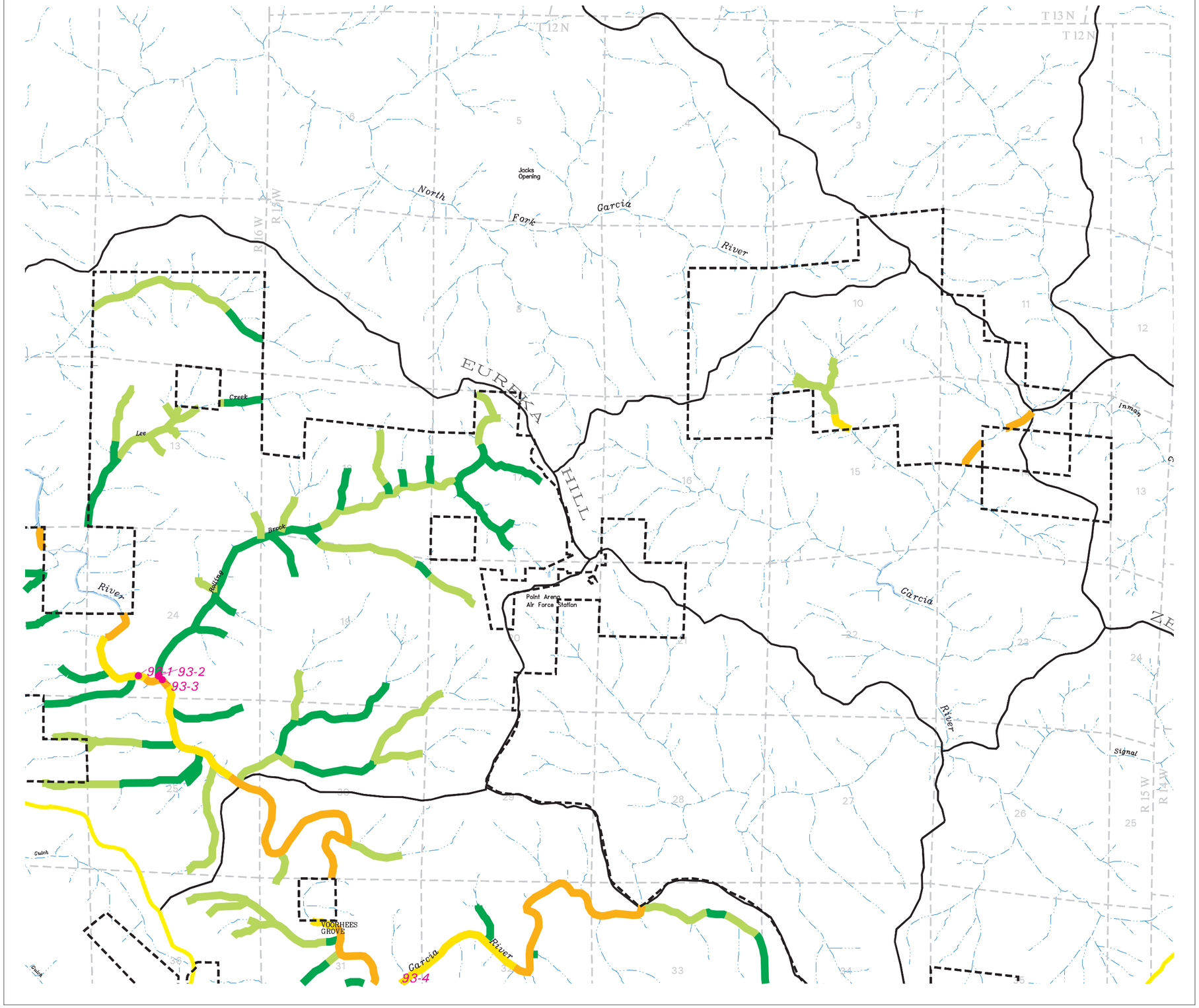
0 1/2 1 Mile

September 2003

Garcia River Watershed Analysis Unit

Map D-2
Stream Canopy Classification and Temperature Monitoring Locations

This map presents the canopy closure, over watercourses, for streams and rivers within the MRC ownership in the Garcia WAU. The canopy was estimated for five canopy closure classes from 2000 aerial photographs and 1998 field observations. The location of stream temperature monitoring locations is also presented, these locations are monitoring each year during summer.

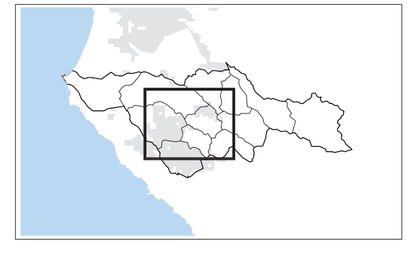


Stream Canopy Classes
- > 90%
- 70-90%
- 40-70%
- 20-40%
- 0-20%

- Temperature Monitoring Locations
- MRC Ownership
- Planning Watershed Boundary
- Garcia River Watershed Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 1



0 1/2 1 Mile

September 2003

Garcia River Watershed Analysis Unit

Map D-2
Stream Canopy Classification and Temperature Monitoring Locations

This map presents the canopy closure, over watercourses, for streams and rivers within the MRC ownership in the Garcia WAU. The canopy was estimated for five canopy closure classes from 2000 aerial photographs and 1998 field observations. The location of stream temperature monitoring locations is also presented, these locations are monitoring each year during summer.

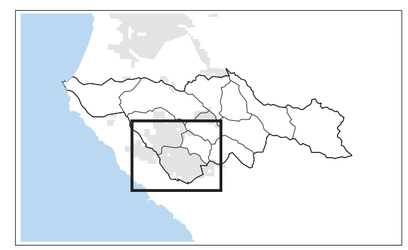
Stream Canopy Classes
- > 90%
- 70-90%
- 40-70%
- 20-40%
- 0-20%

- Temperature Monitoring Locations

- MRC Ownership
- Planning Watershed Boundary
- Garcia River Watershed Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 2



0 1/2 1 Mile

September 2003

Figure T93-01. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Garcia River (Site T93-01), Mendocino County, California.

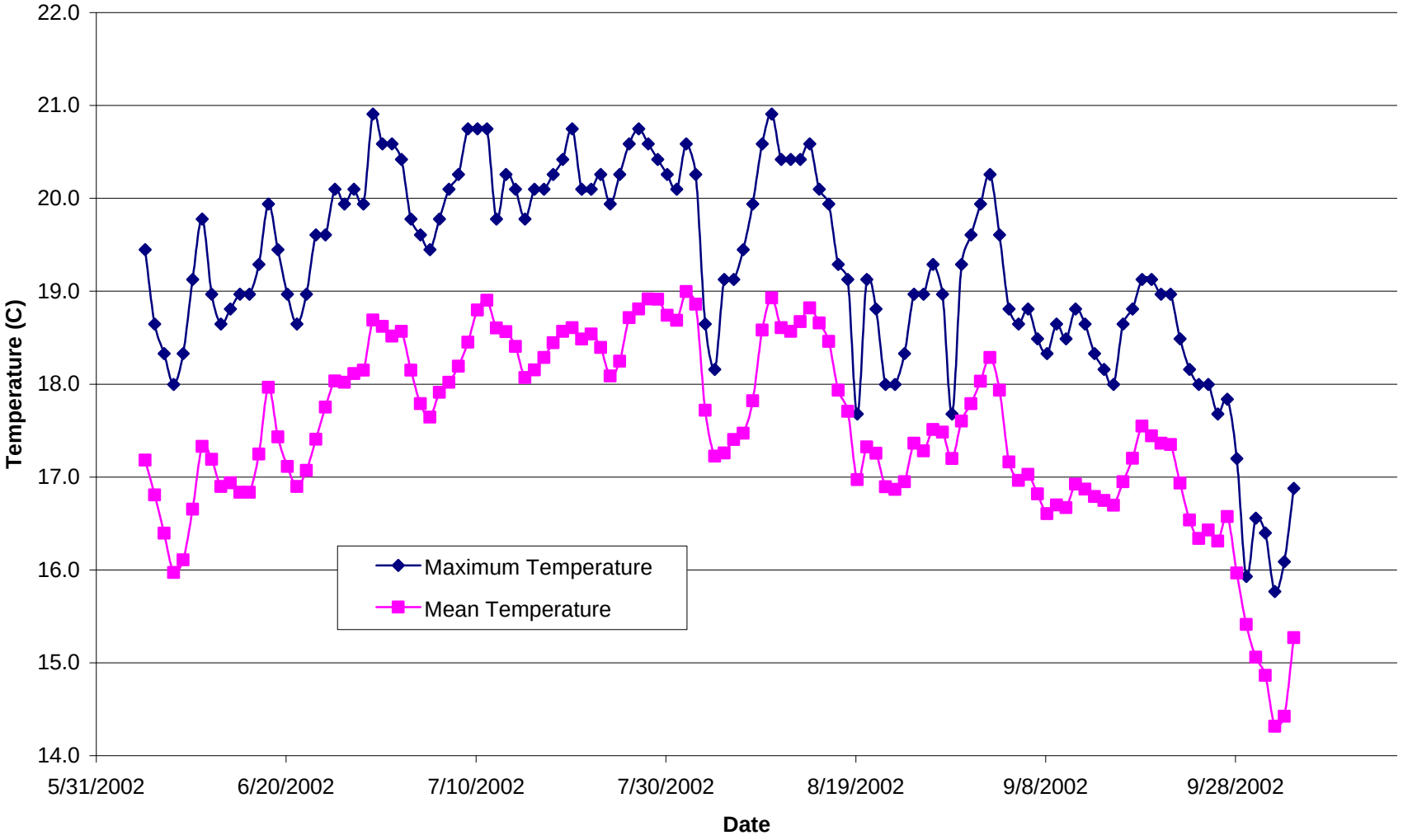


Figure T93-02. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Rolling Brook Creek (Site T93-02), Mendocino County, California.

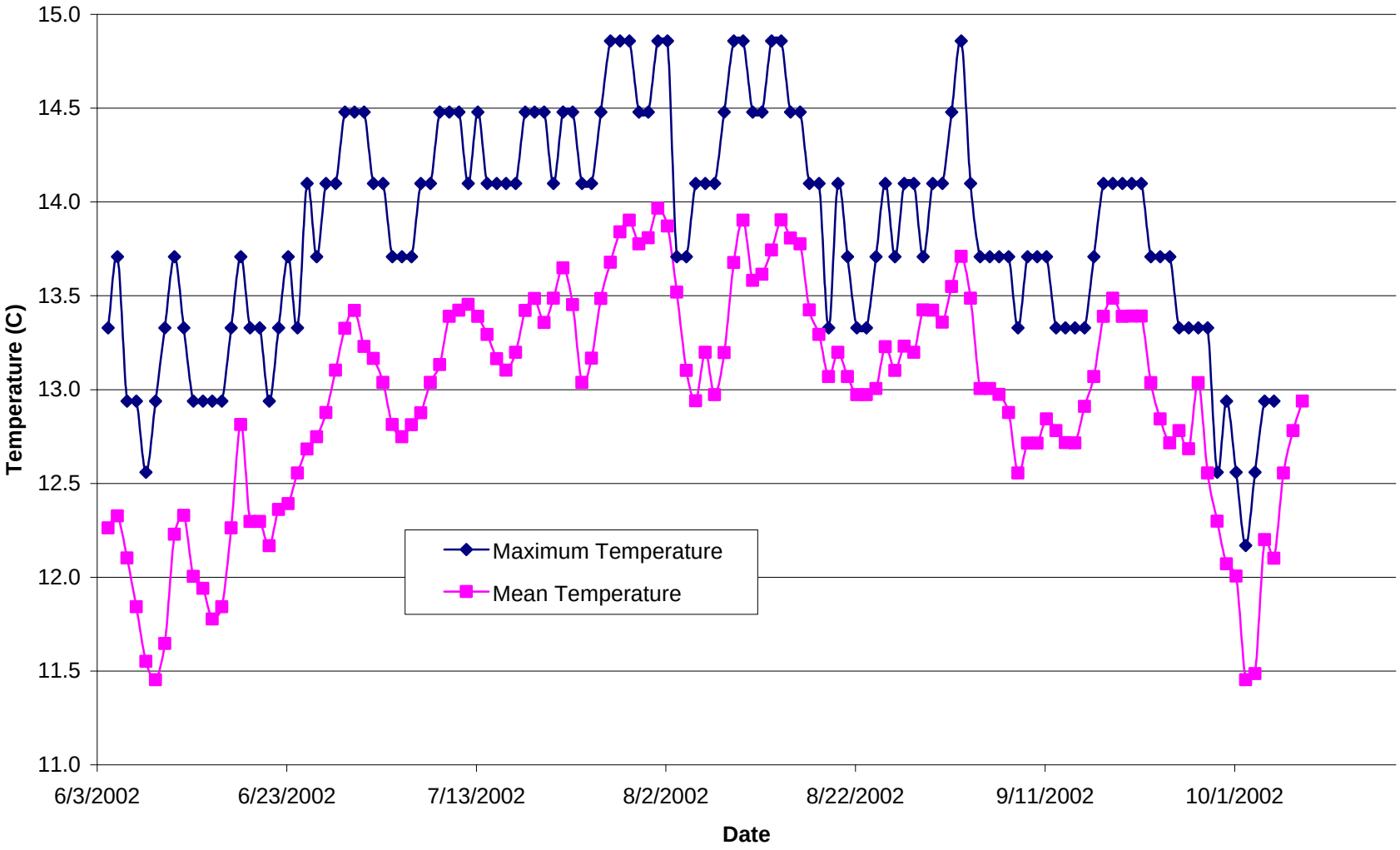


Figure T93-04. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2002 at South Fork Garcia River (Site T93-04), Mendocino County, California.

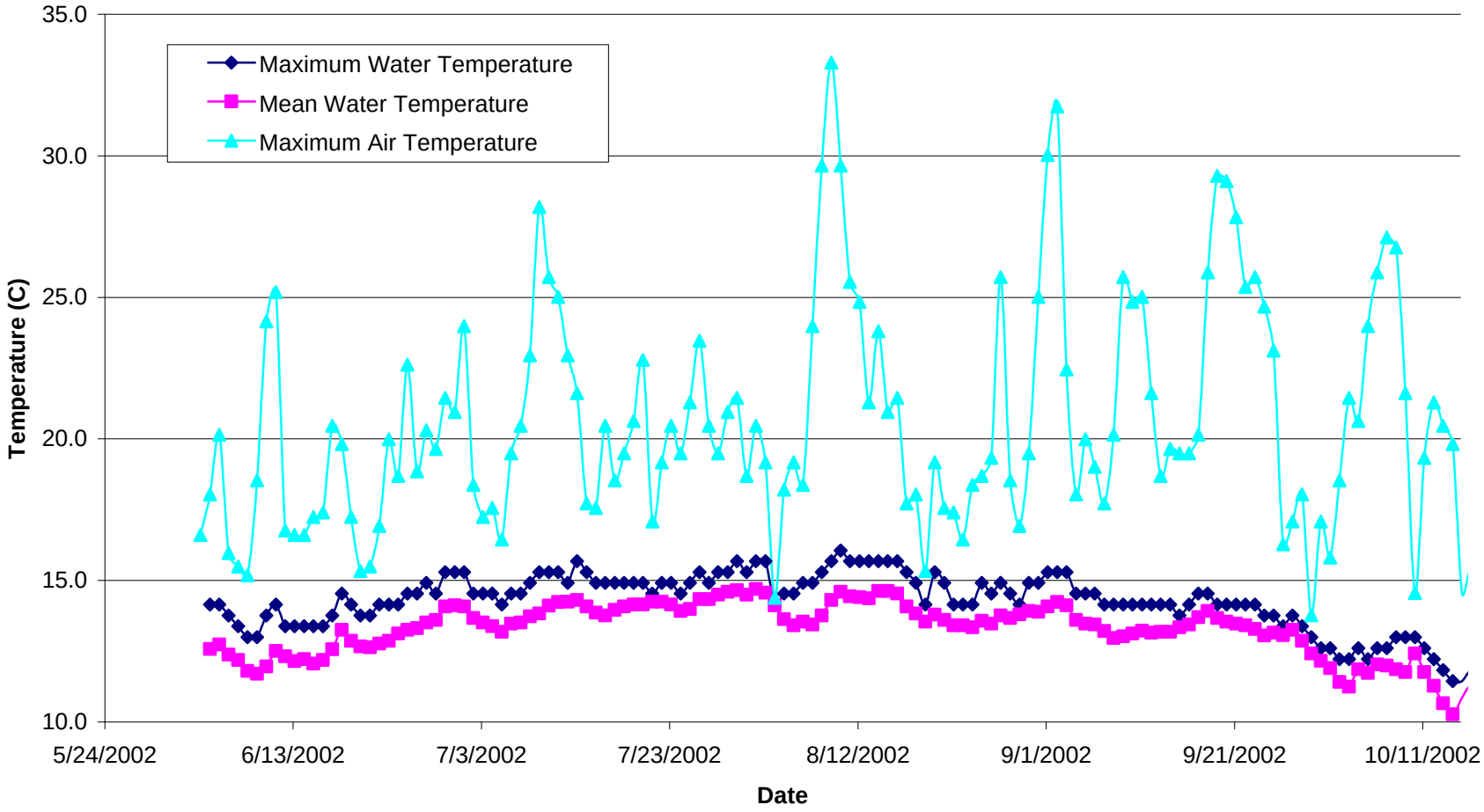


Figure T93-05 Mean and Maximum Daily Stream Temperatures During Summer 2002 at Garcia River (Site T93-05), Mendocino County, California.

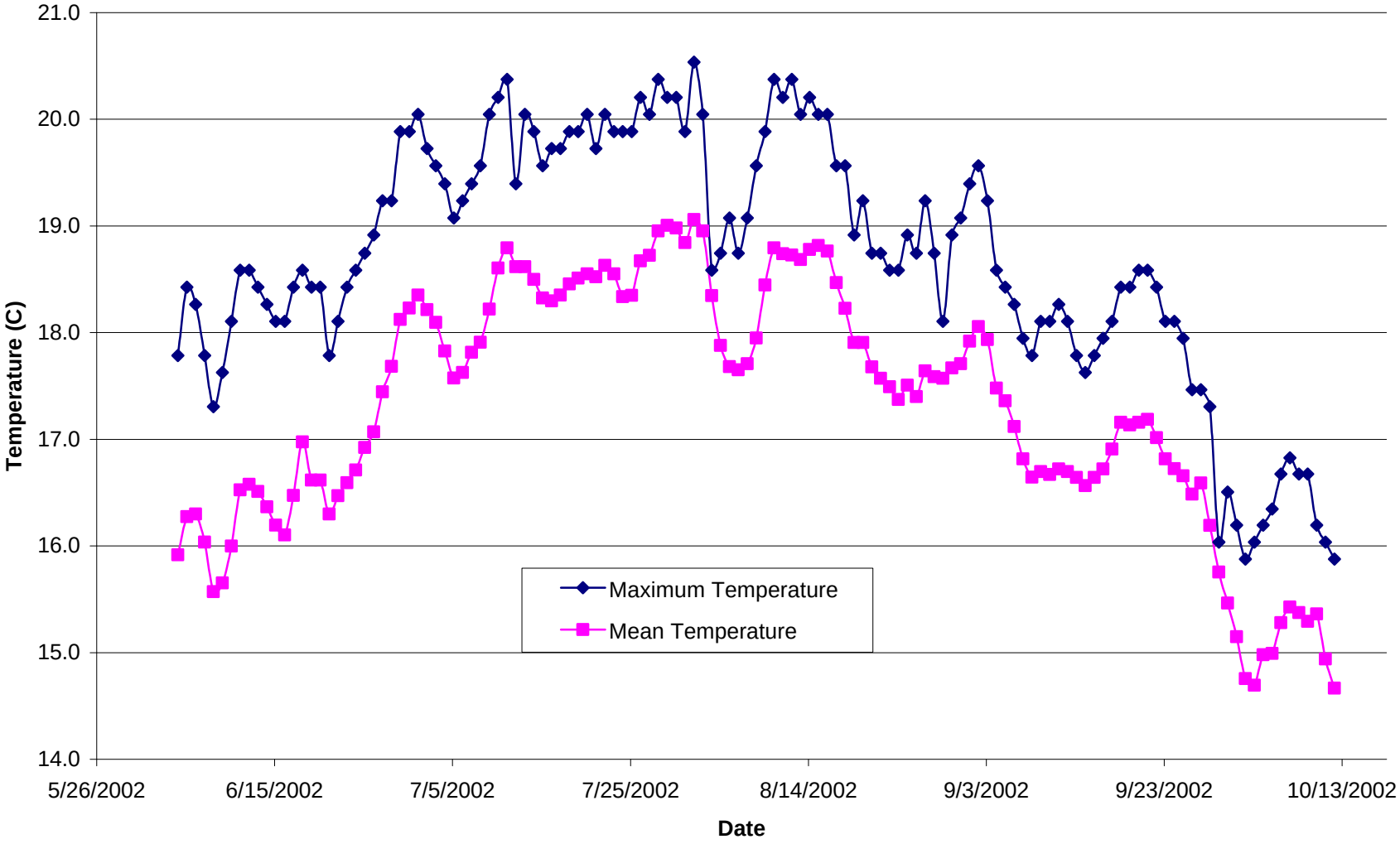


Figure T93-07. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Flemming Creek (Site T93-07), Mendocino County, California.

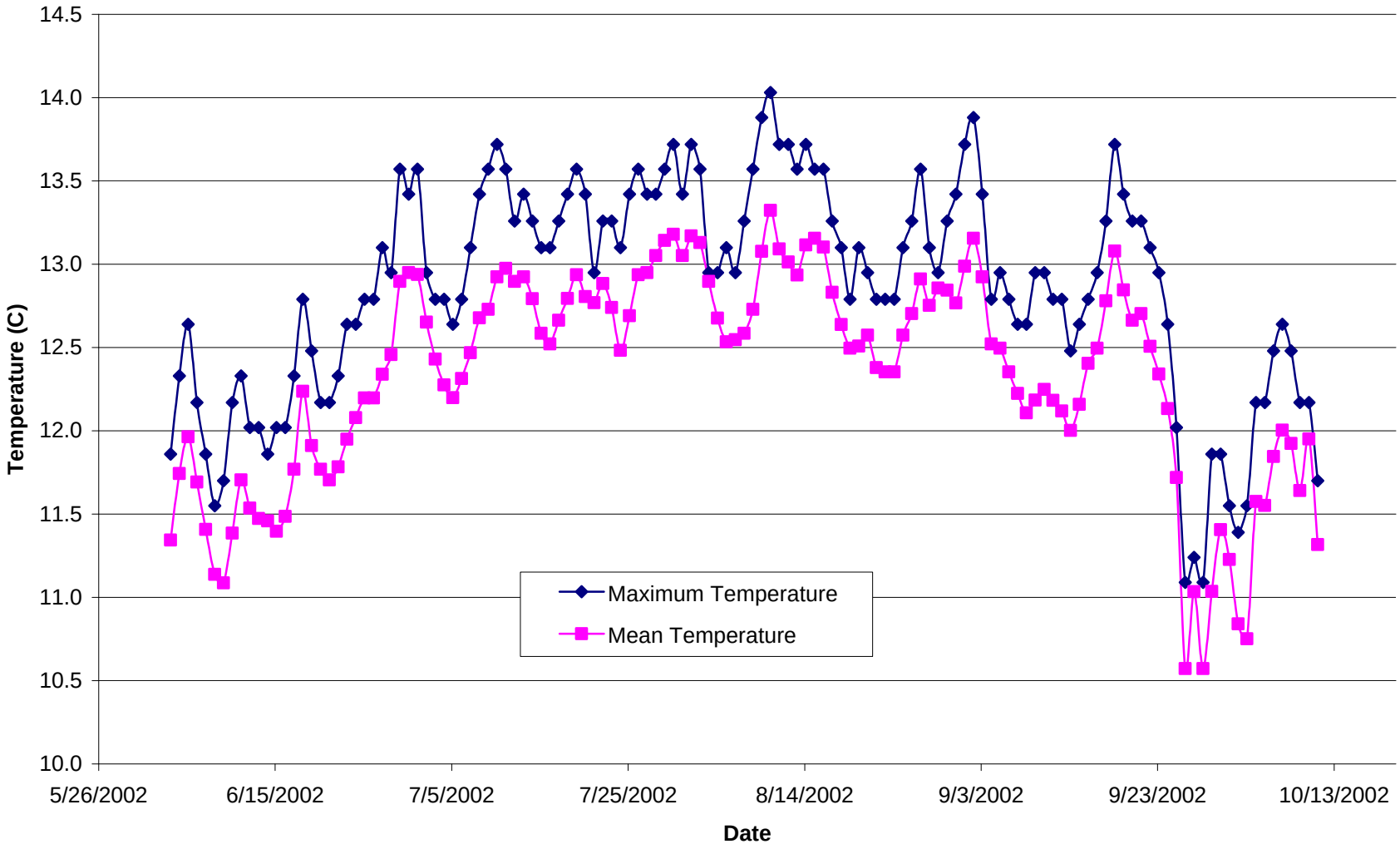


Figure T93-08. Mean and Maximum Daily Stream Temperatures During Summer 2002 at South Fork Garcia River (Site T93-08), Mendocino County, California.

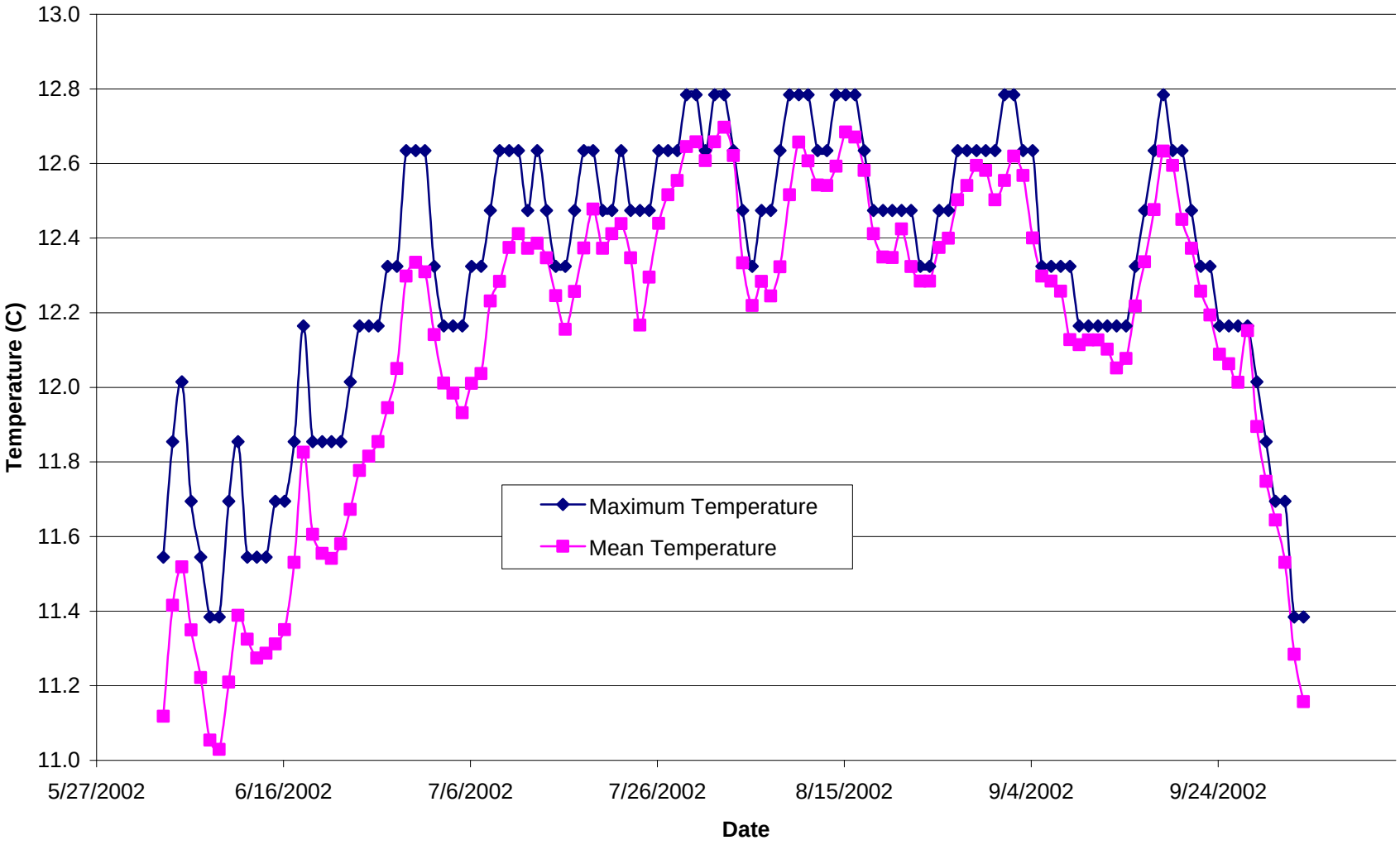


Figure 129. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Garcia River (Site 93-1), Mendocino County, California.

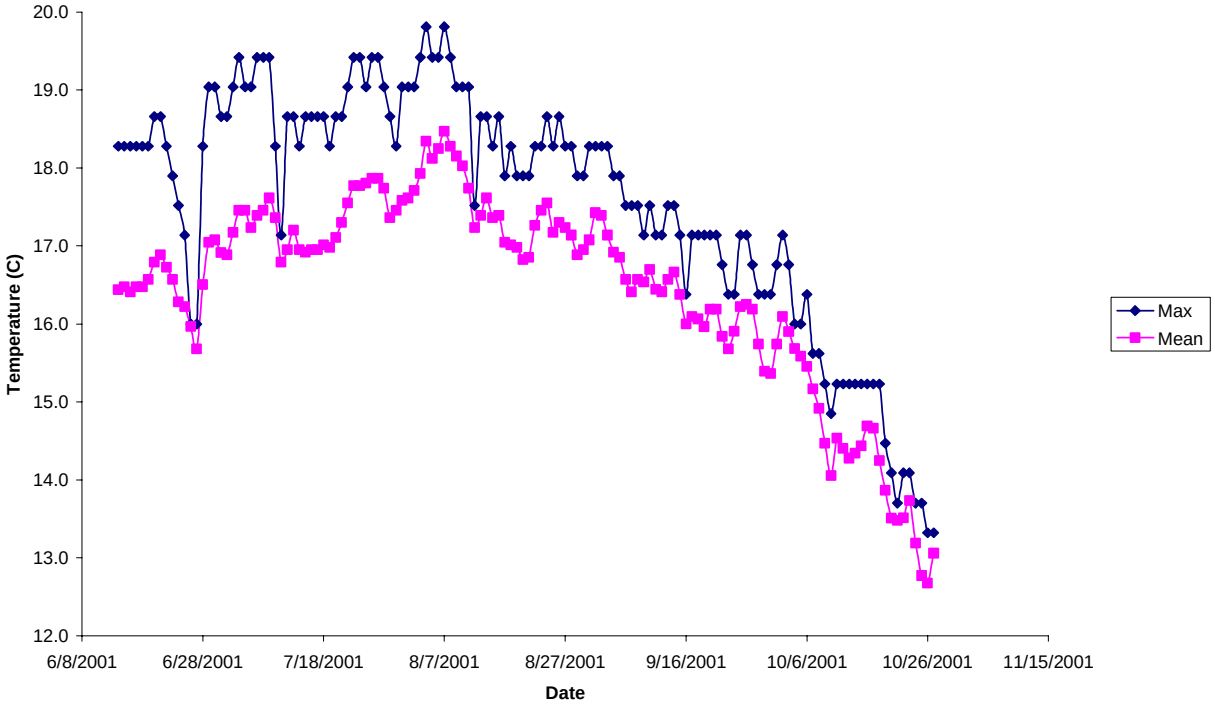
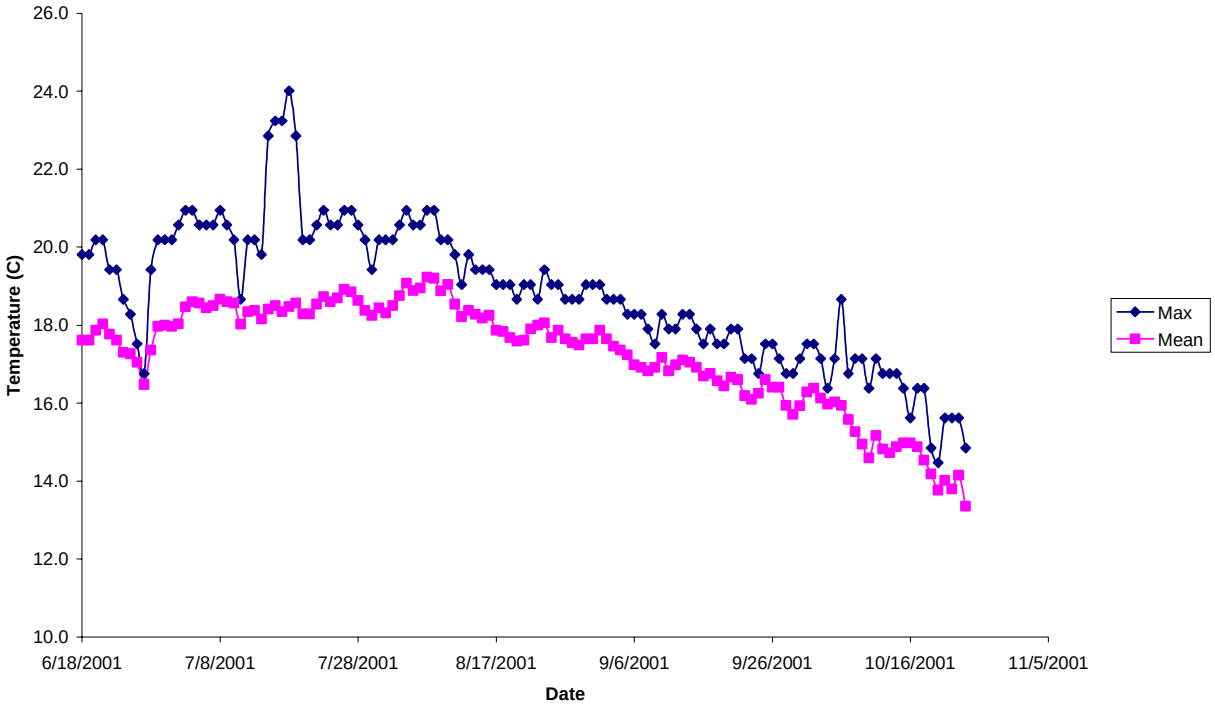


Figure 132. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Garcia River (Site 93-5), Mendocino County, California.



Mean and Maximum Daily Stream Temperatures During Summer 2001 at Garcia River (Site 93-6), Mendocino County, California.

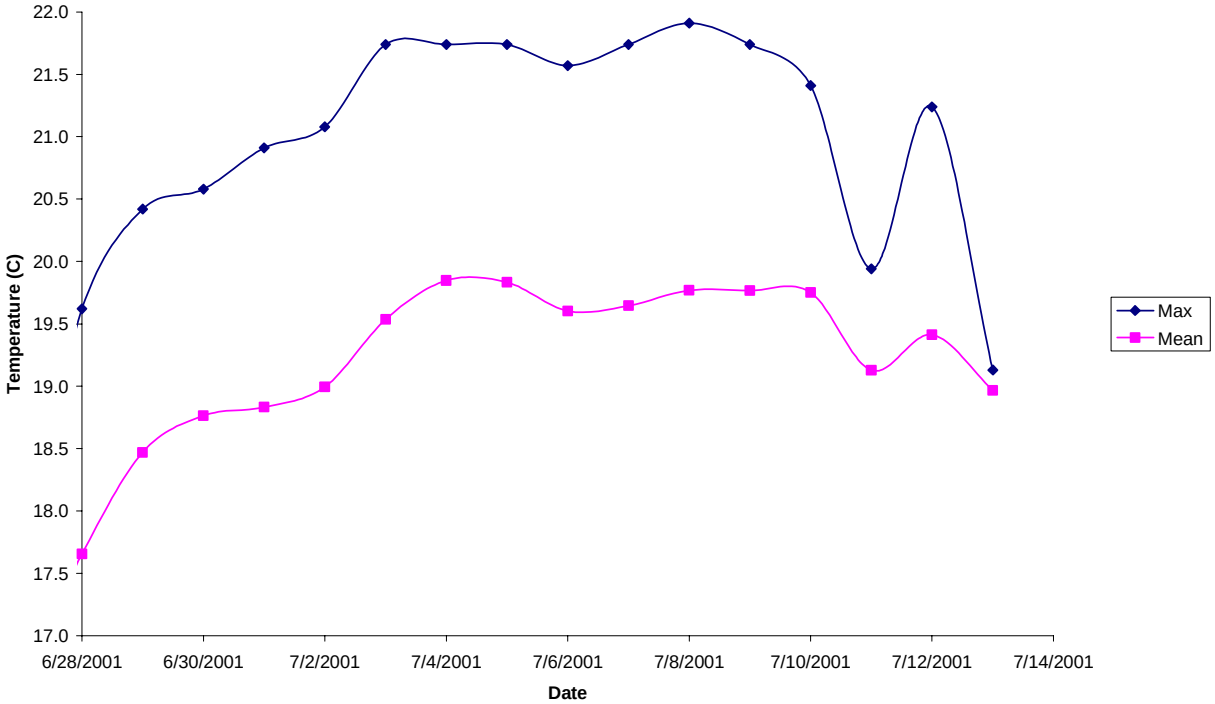


Figure 130. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Rolling Brook (Site 93-2), Mendocino County, California.

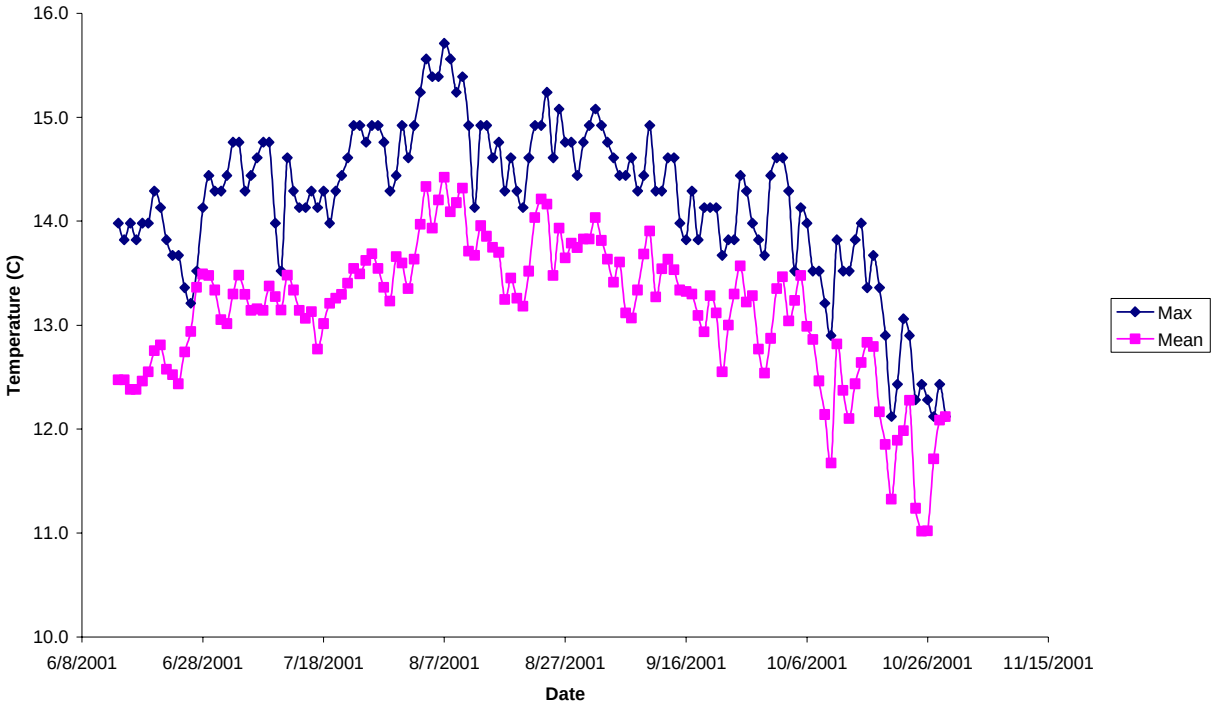


Figure 131. Mean and Maximum Daily Stream Temperatures During Summer 2001 at South Fork Garcia River (Site 93-4), Mendocino County, California.

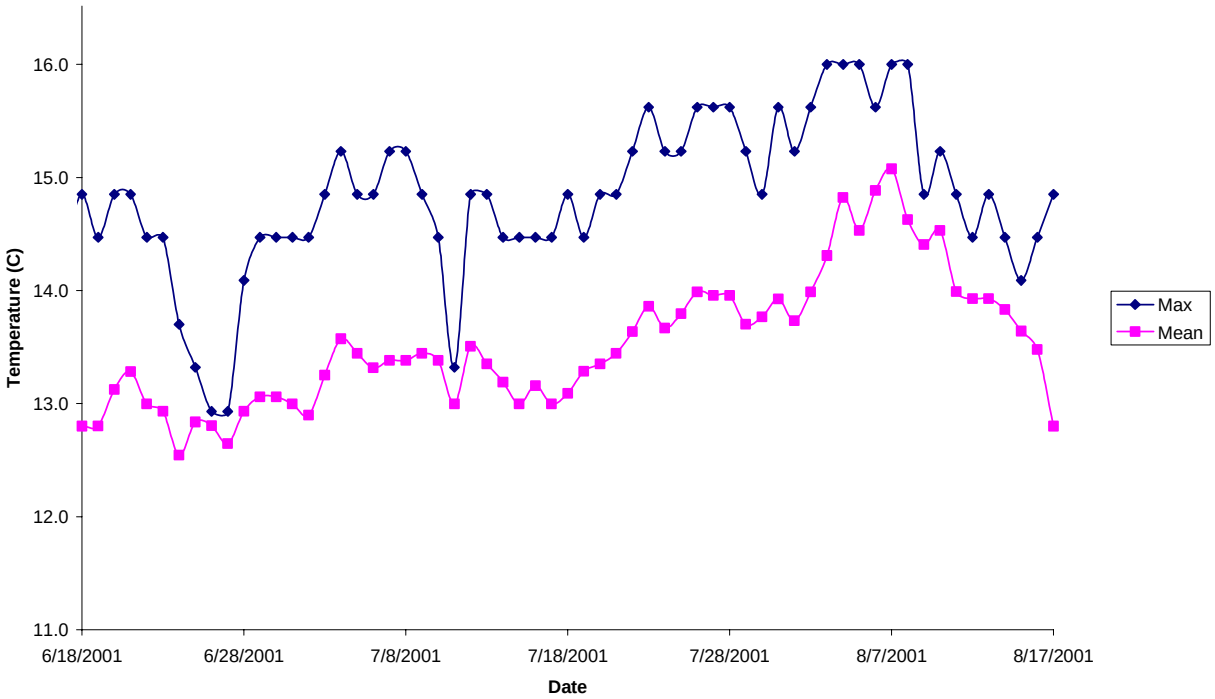


Figure 133. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Fleming Creek (Site 93-7), Mendocino County, California.

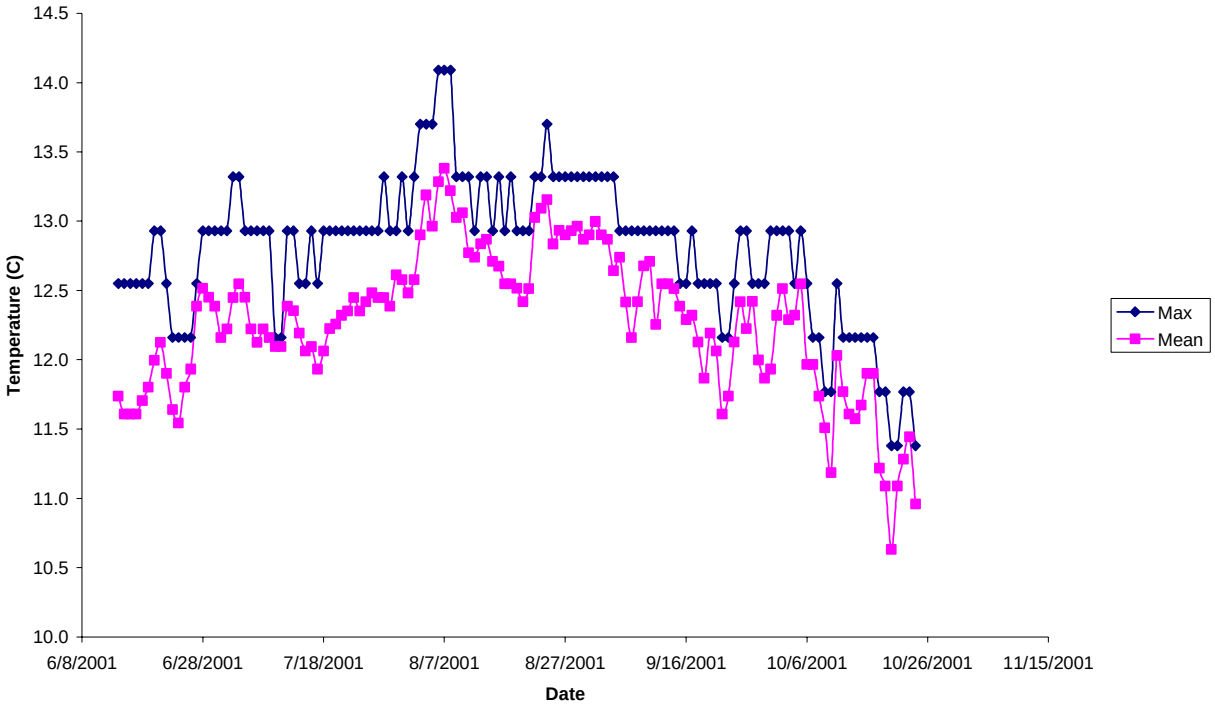


Figure 134. Mean and Maximum Daily Stream Temperatures During Summer 2001 at South Fork Garcia River (Site 93-8), Mendocino County, California.

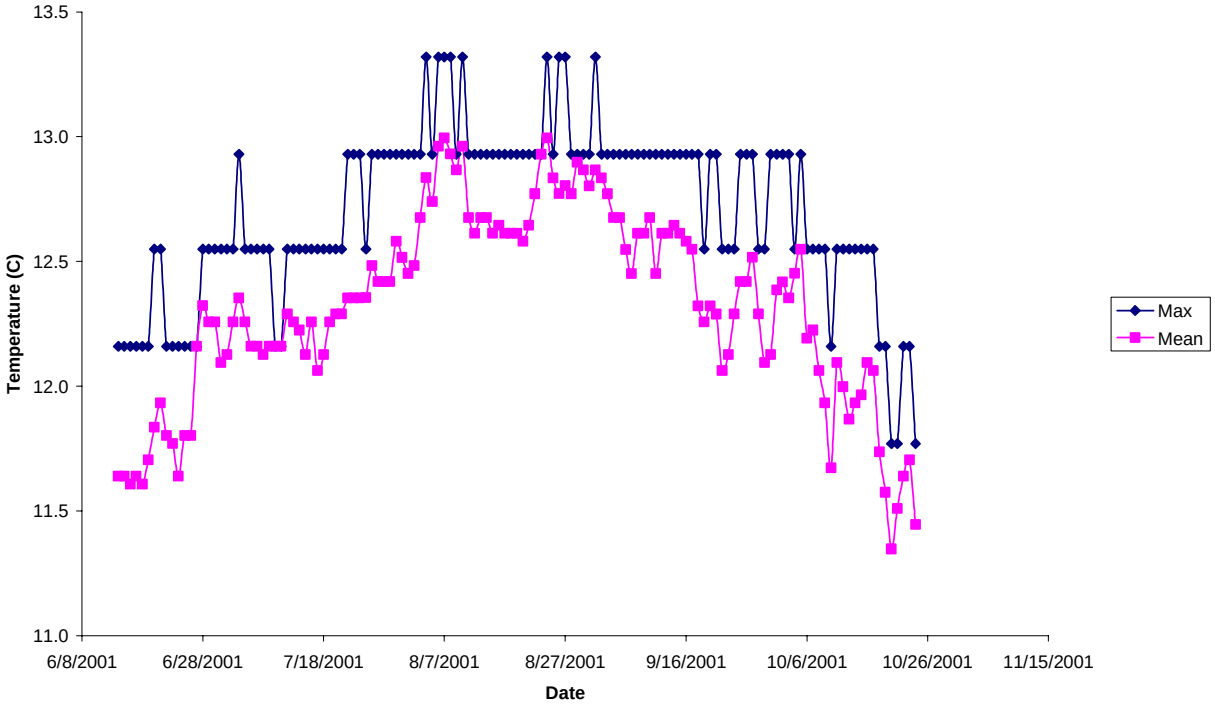


Figure 136. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Lee Creek (Site 93-21), Mendocino County, California.

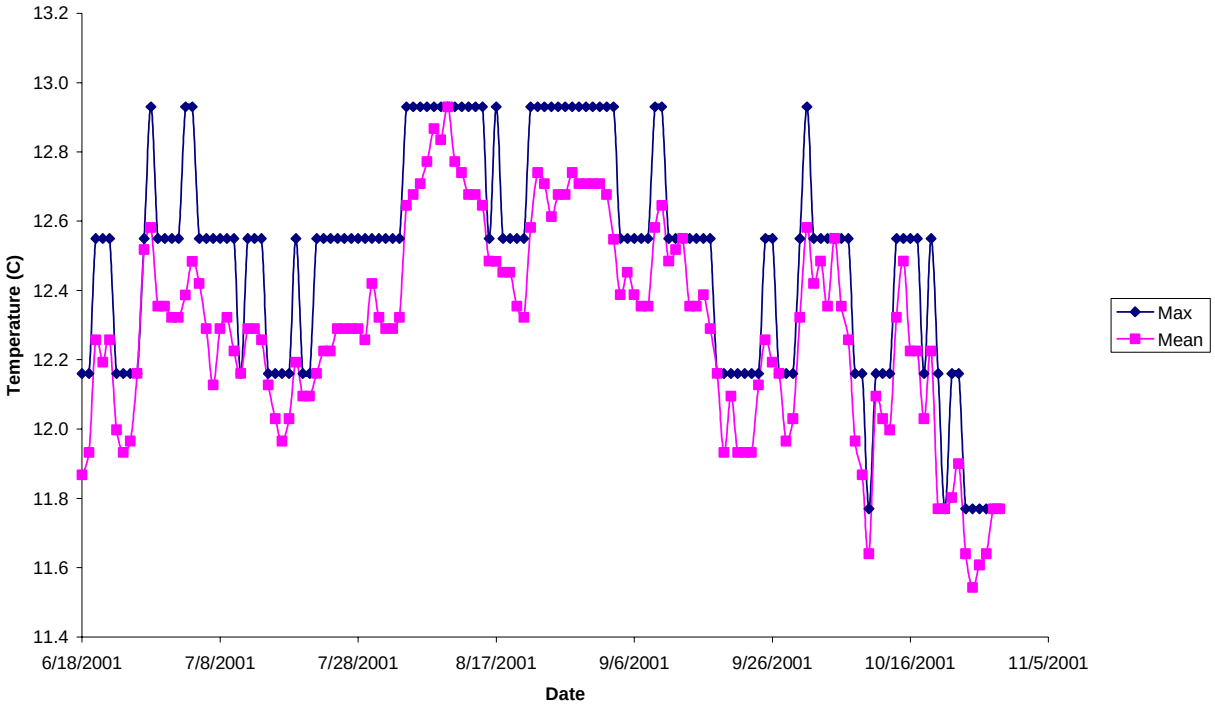


Figure 135. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Rolling Brook (Site 93-20), Mendocino County, California.

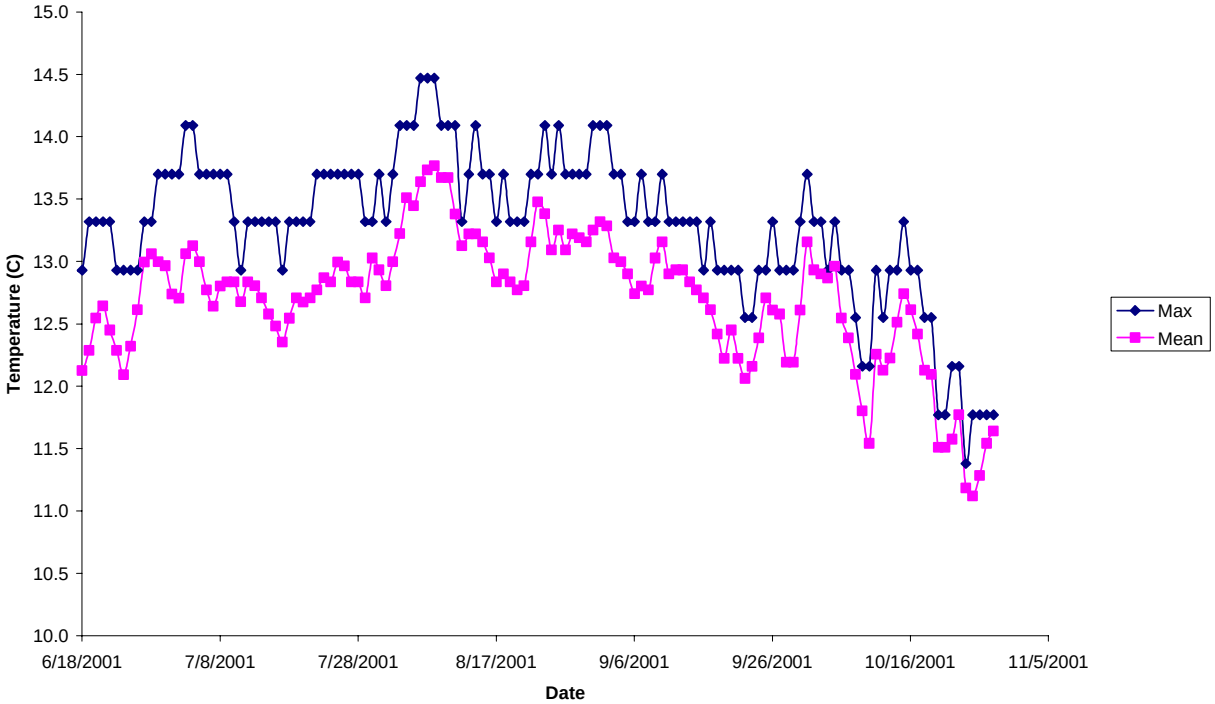


Figure 138. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Garcia River (Site 93-1), Mendocino County, California.

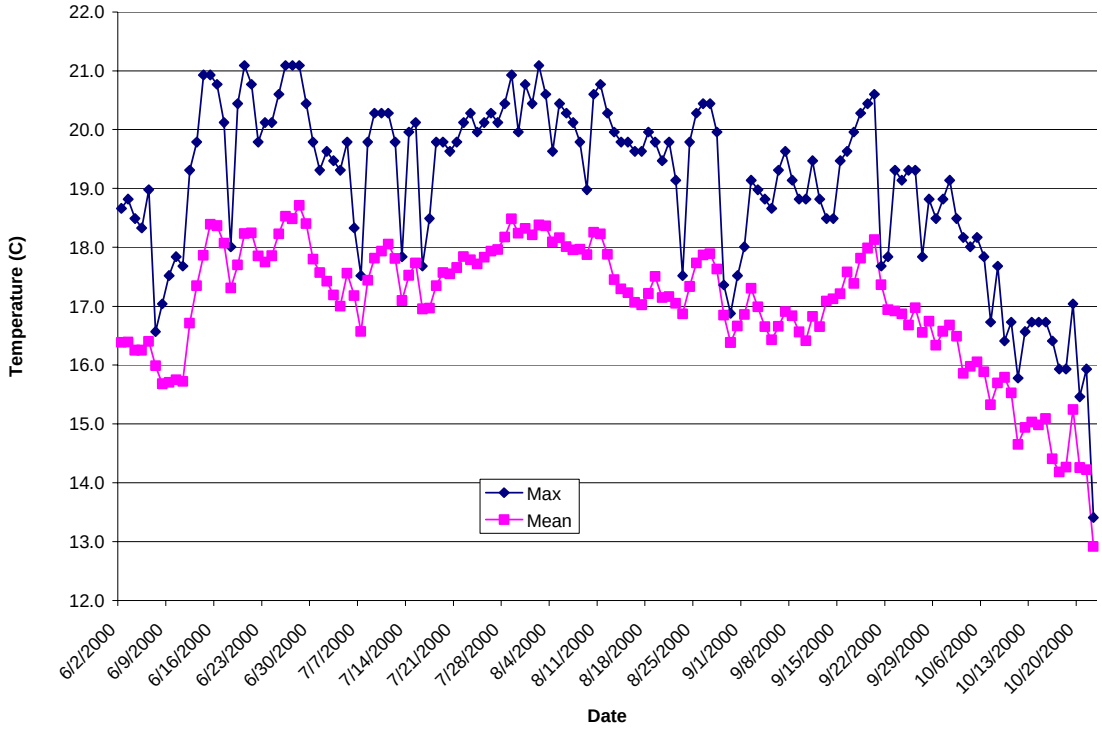


Figure 146. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Garcia River (Site 93-5), Mendocino County, California.

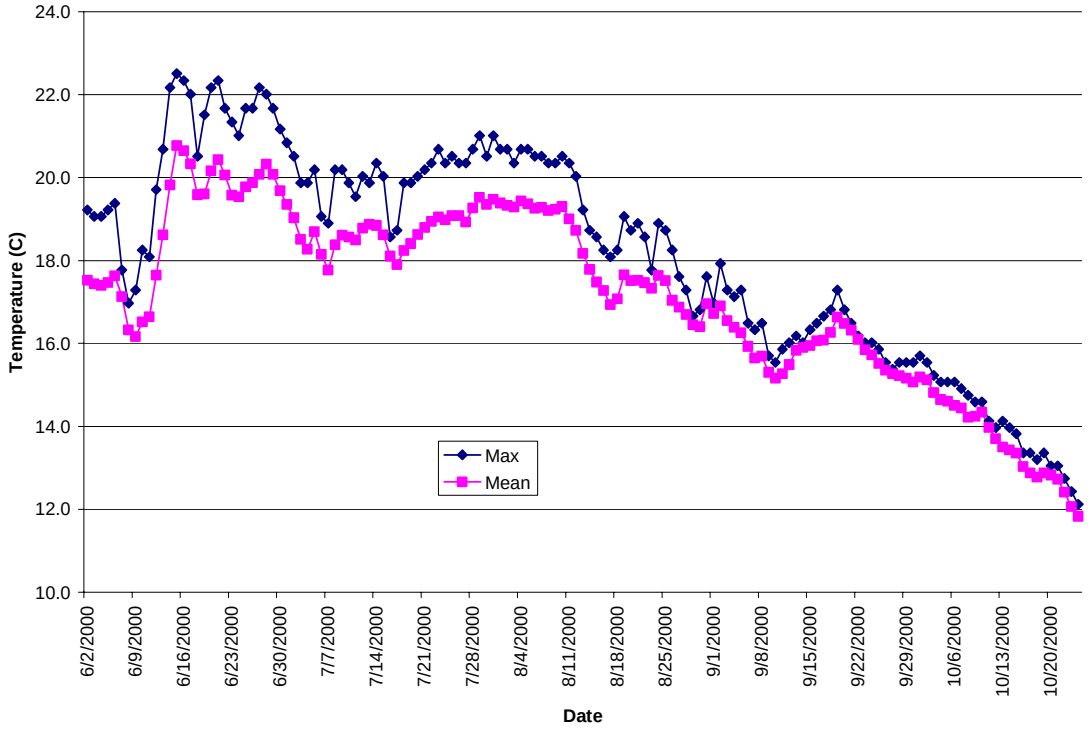


Figure 141. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Rolling Brook (Site 93-2), Mendocino County, California.

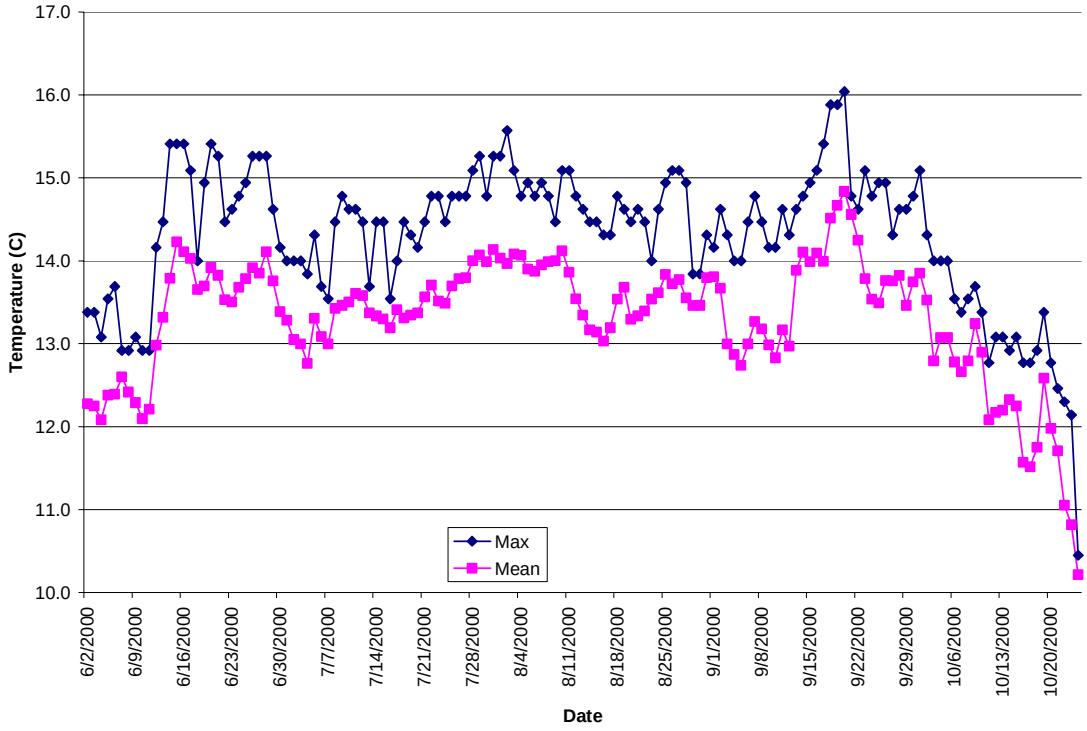


Figure 144. Mean and Maximum Daily Stream Temperatures During Summer 2000 at South Fork Garcia River (Site 93-4), Mendocino County, California.

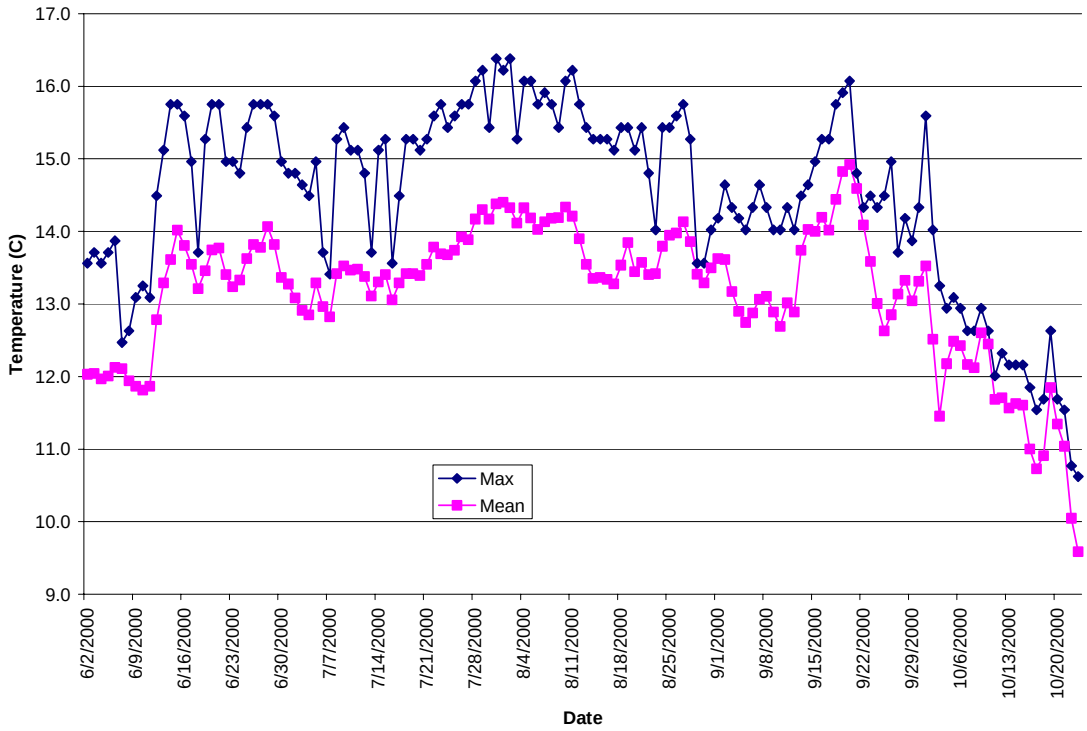


Figure 150. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Fleming Creek (Site 93-7), Mendocino County, California.

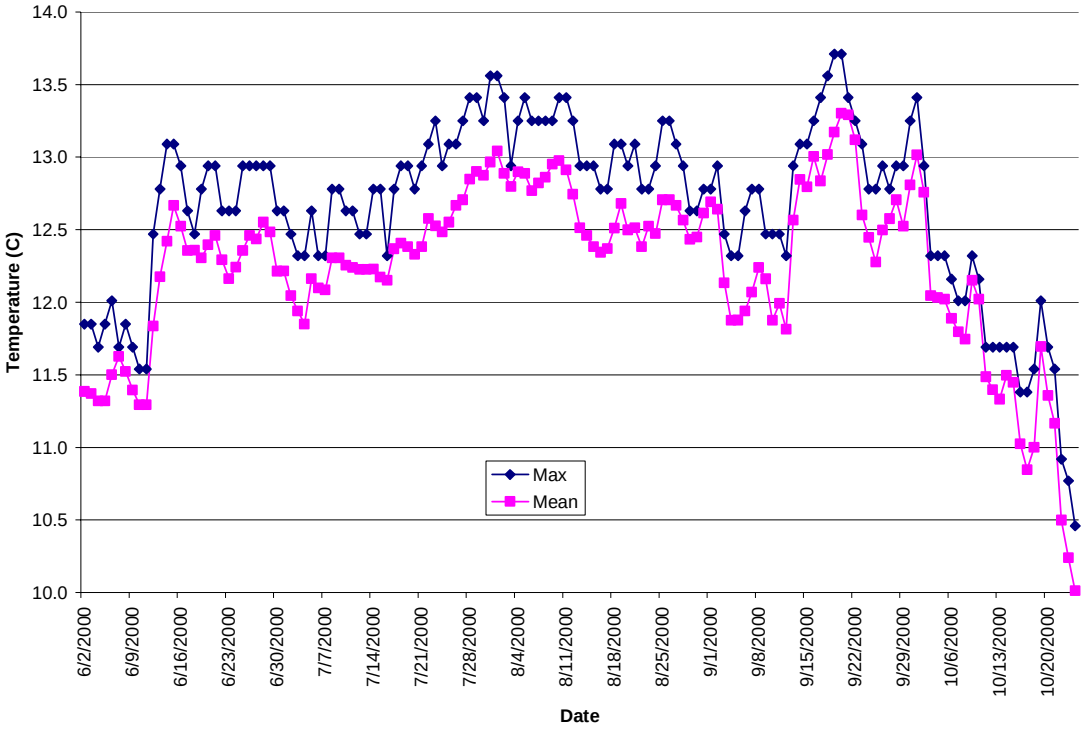


Figure 137. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Garcia River (Site 93-1), Mendocino County, California.

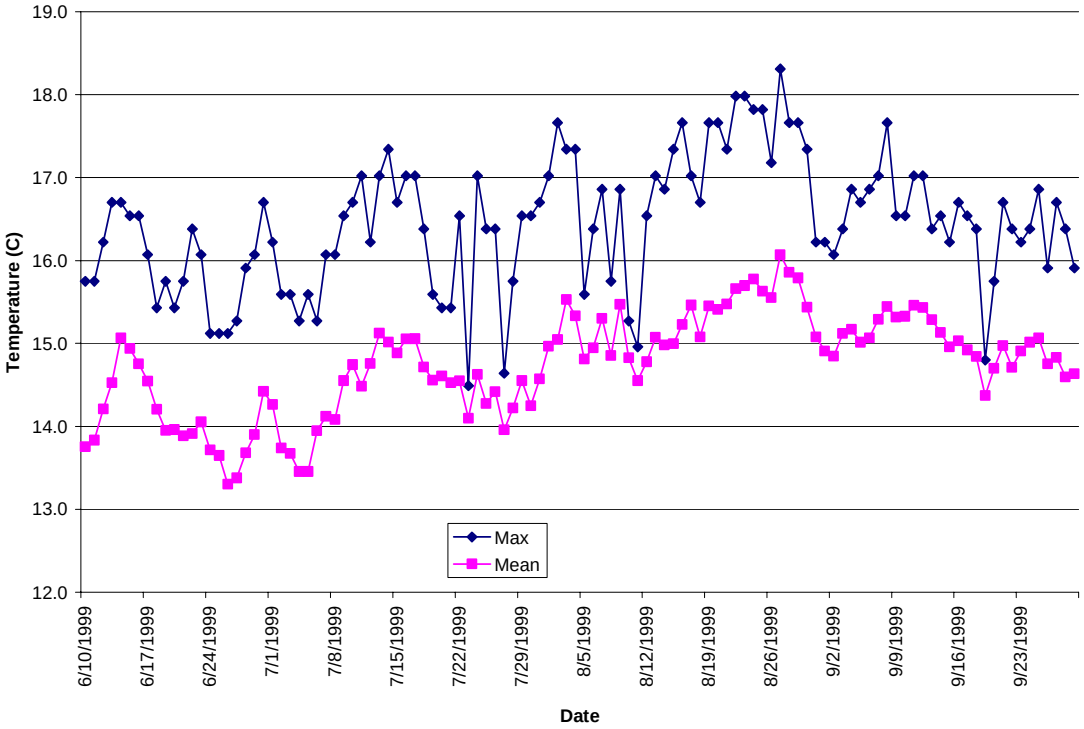


Figure 146. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Garcia River (Site 93-5), Mendocino County, California.

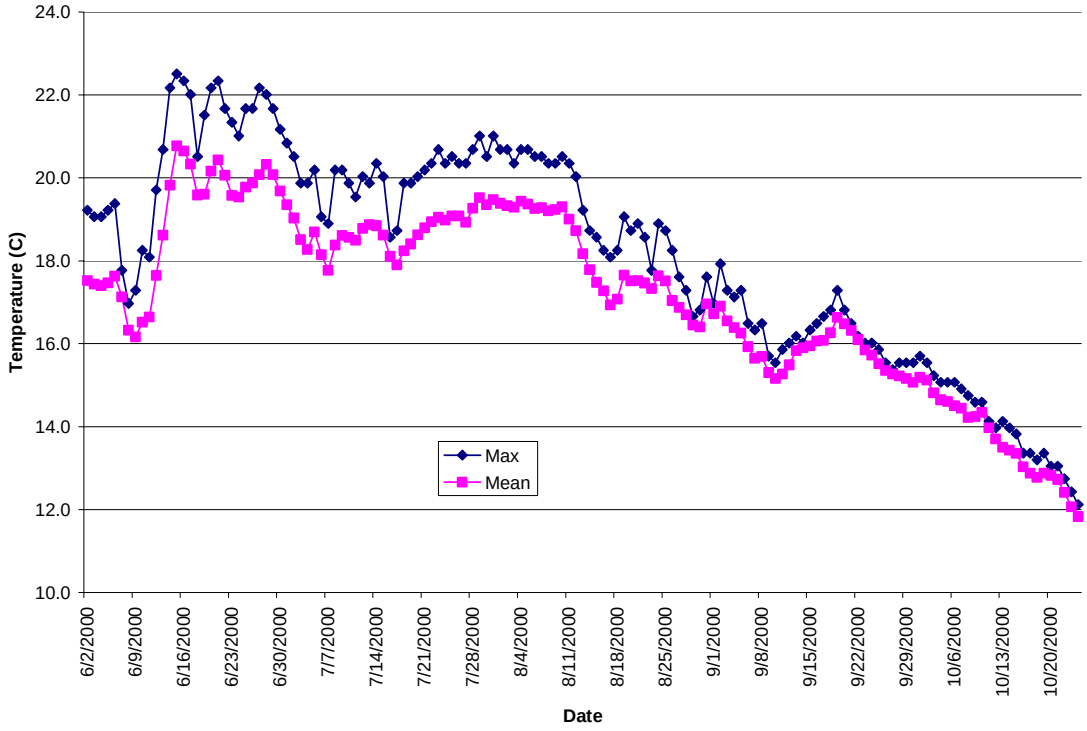


Figure 140. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Rolling Brook (Site 93-2), Mendocino County, California.

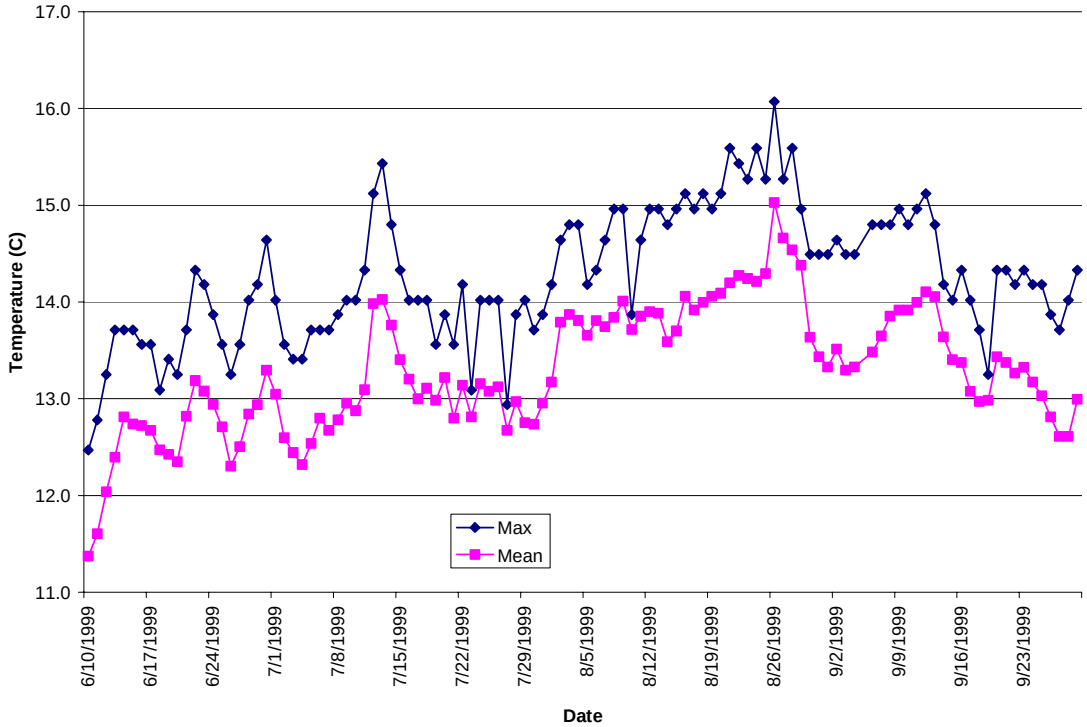


Figure 143. Mean and Maximum Daily Stream Temperatures During Summer 1999 at South Fork Garcia River (Site 93-4), Mendocino County, California.

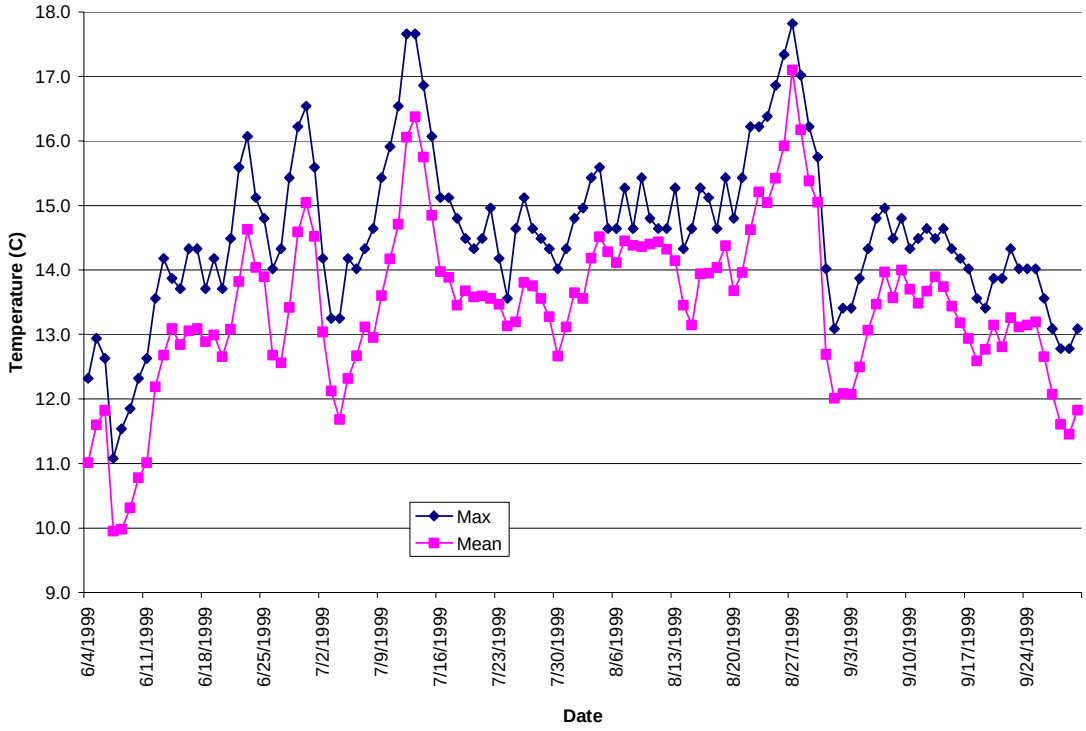


Figure 148. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Garcia River (Site 93-6), Mendocino County, California.

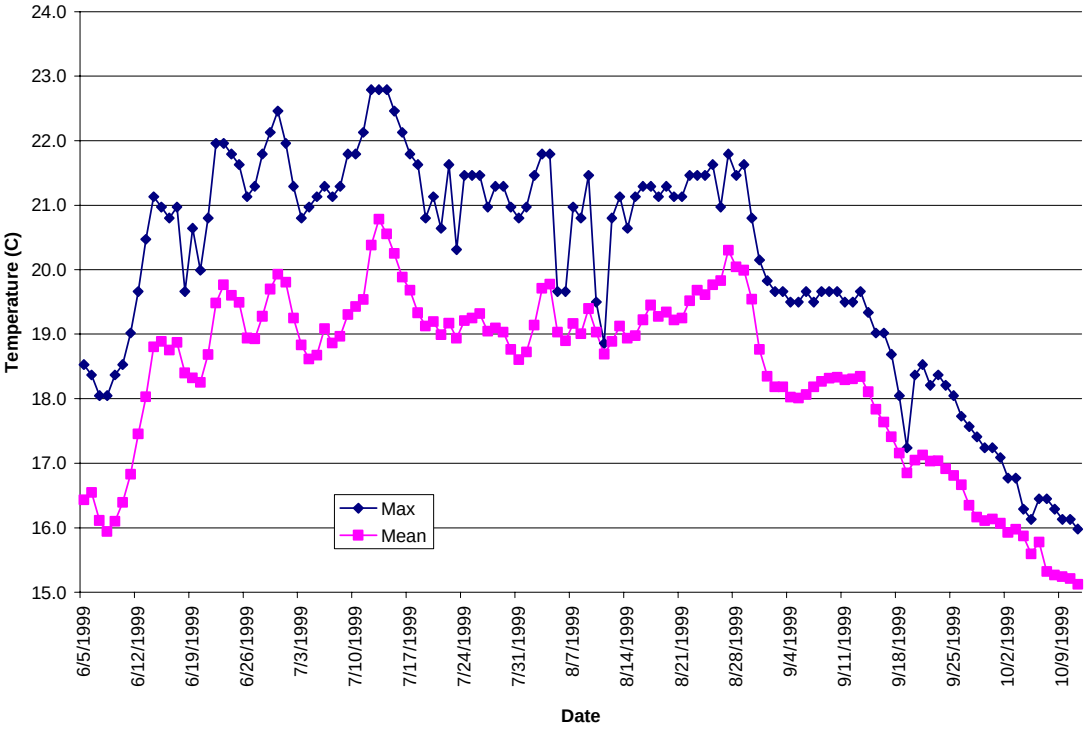


Figure 151. Mean and Maximum Daily Stream Temperatures During Summer 1999 at South Fork Garcia River (Site 93-8), Mendocino County, California.

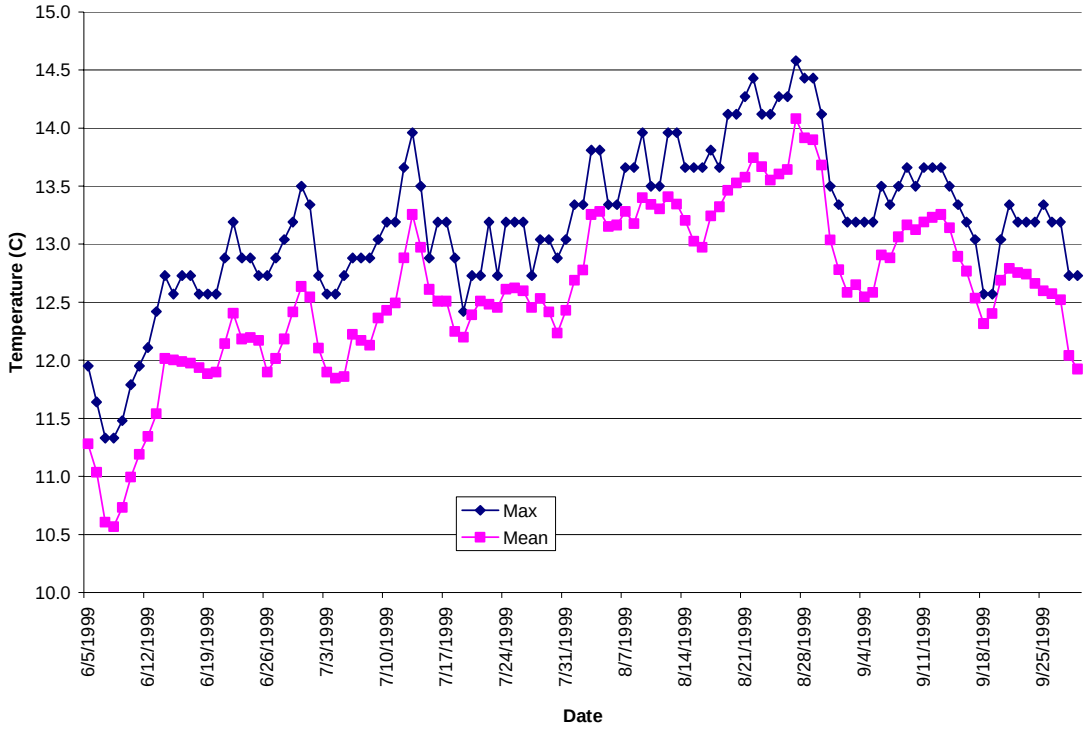


Figure 136. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Garcia River (Site 93-1), Mendocino County, California.

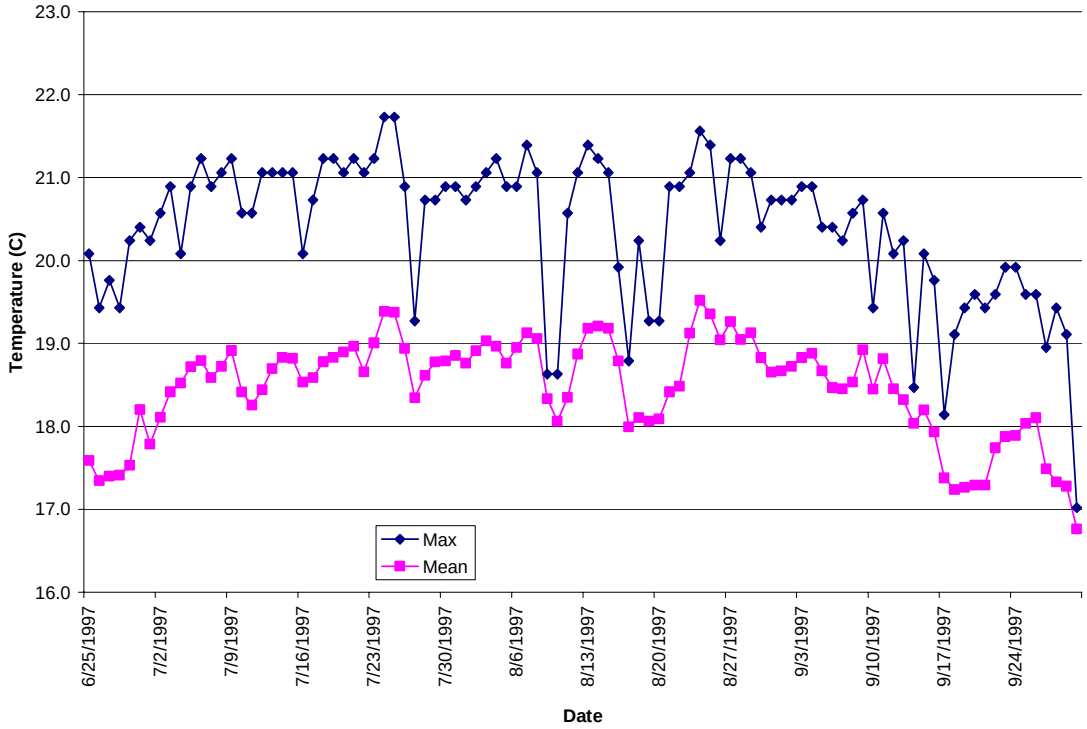


Figure 139. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Rolling Brook (Site 93-2), Mendocino County, California.

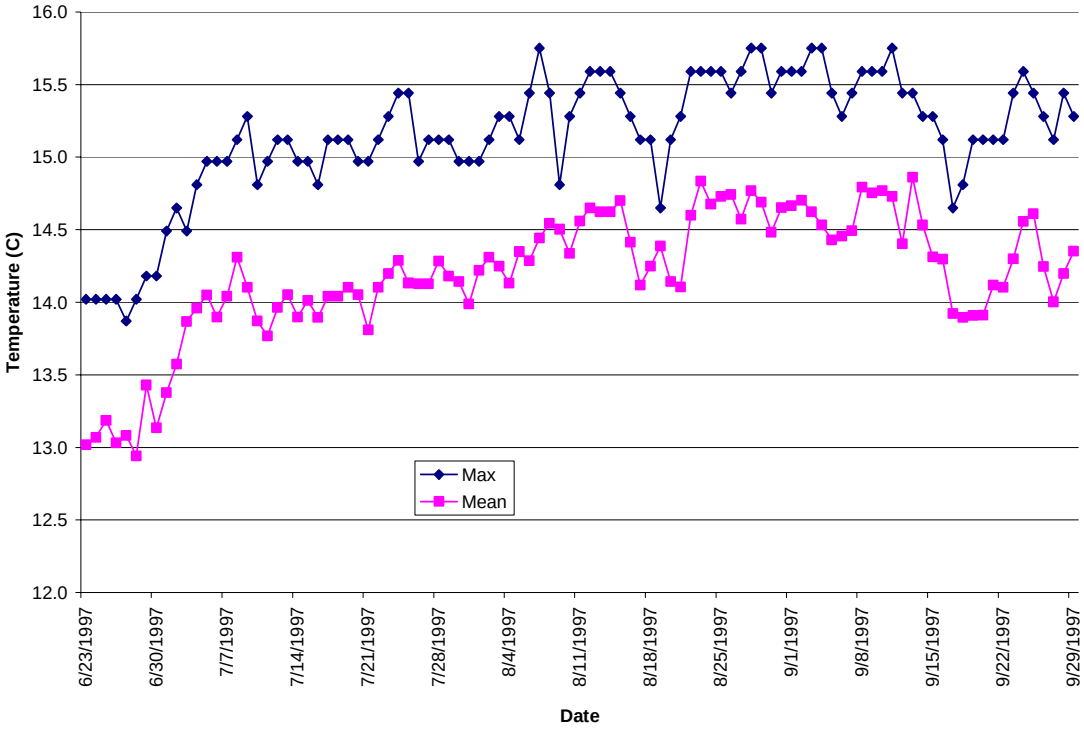


Figure 142. Mean and Maximum Daily Stream Temperatures During Summer 1997 at South Fork Garcia River (Site 93-4), Mendocino County, California.

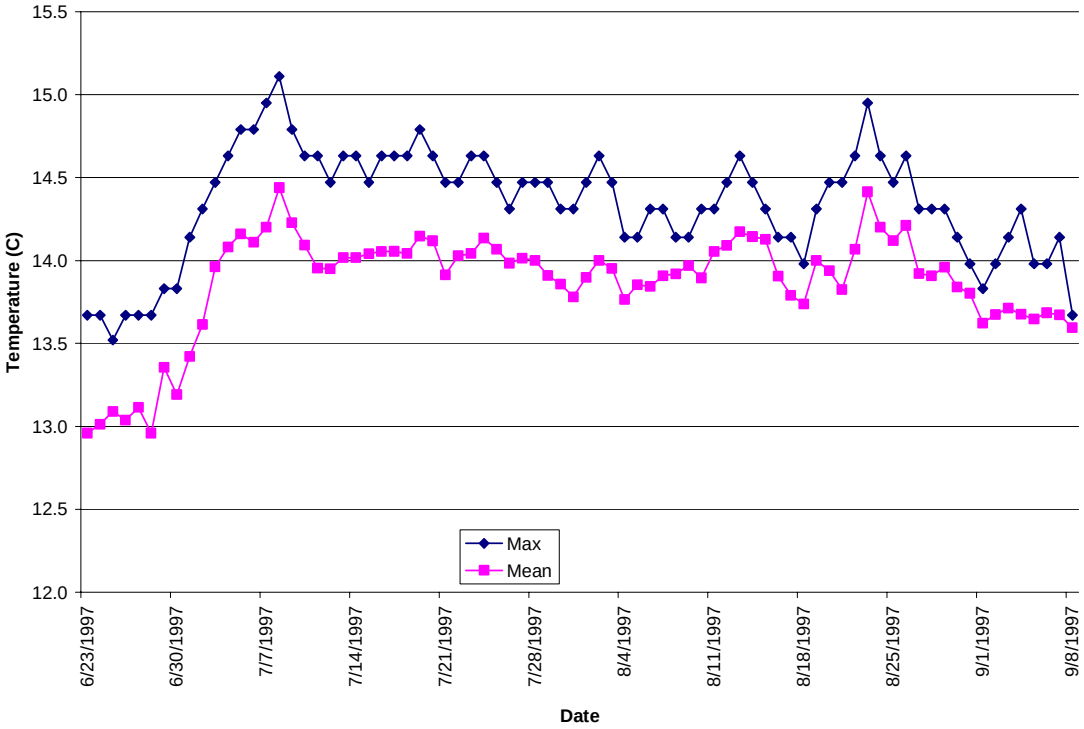


Figure 147. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Garcia River (Site 93-6), Mendocino County, California.

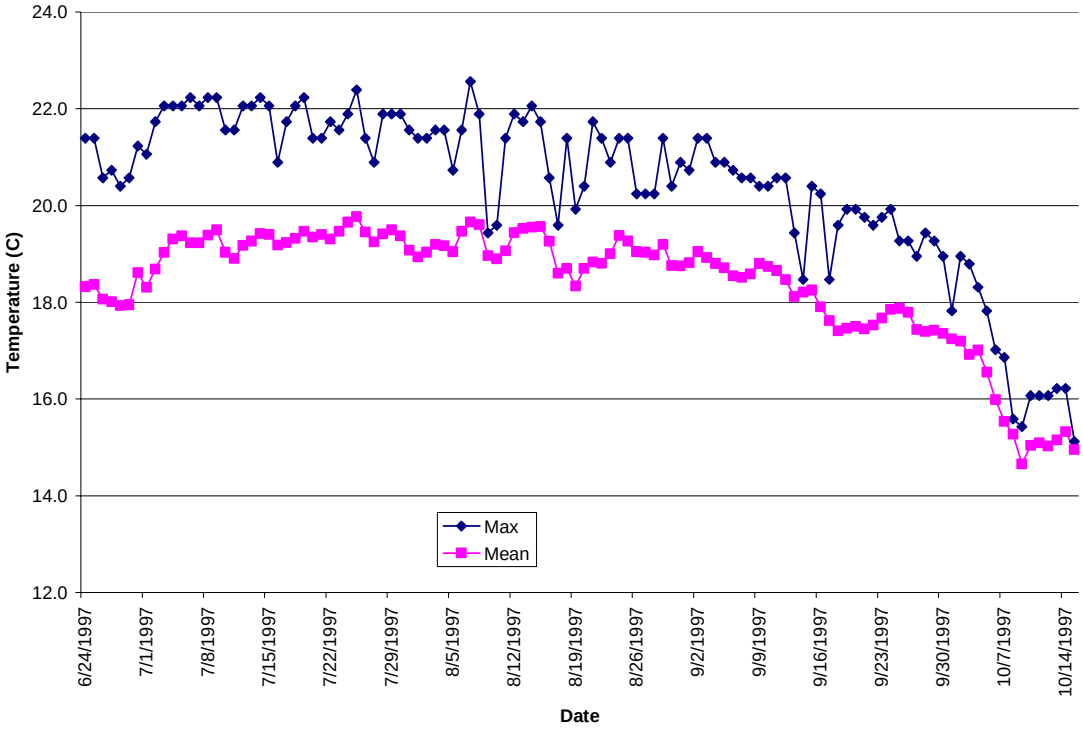


Figure 149. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Fleming Creek (Site 93-7), Mendocino County, California.

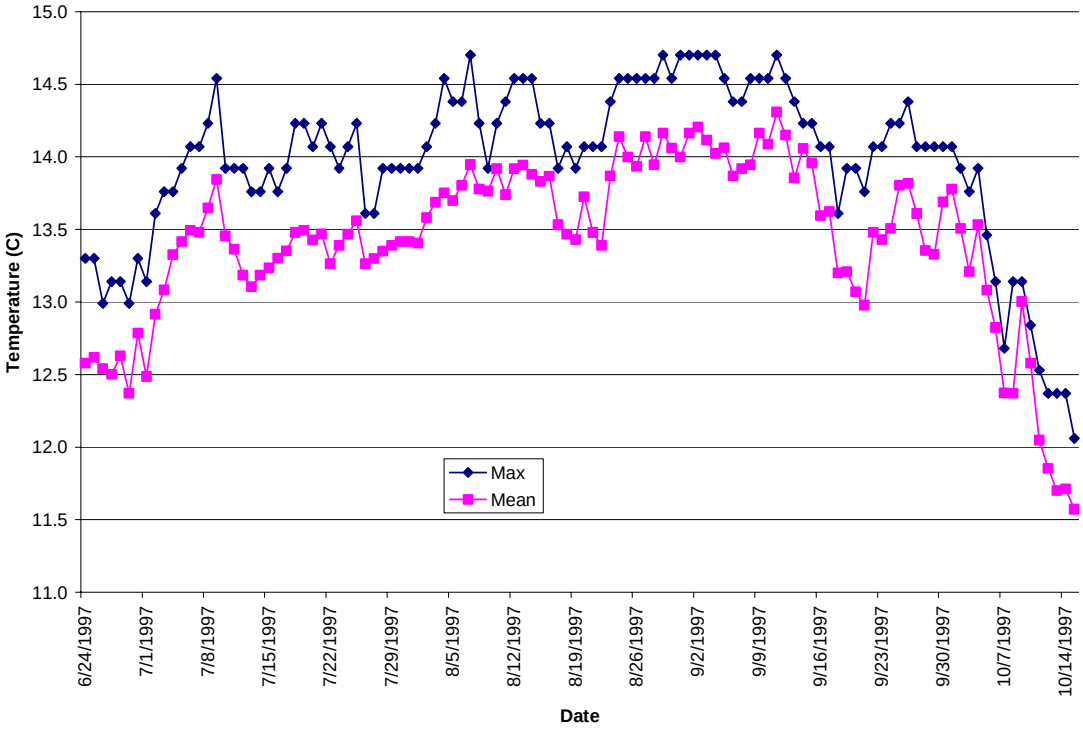


Figure 151a. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Rolling Brook (Site 93-9), Mendocino County, California

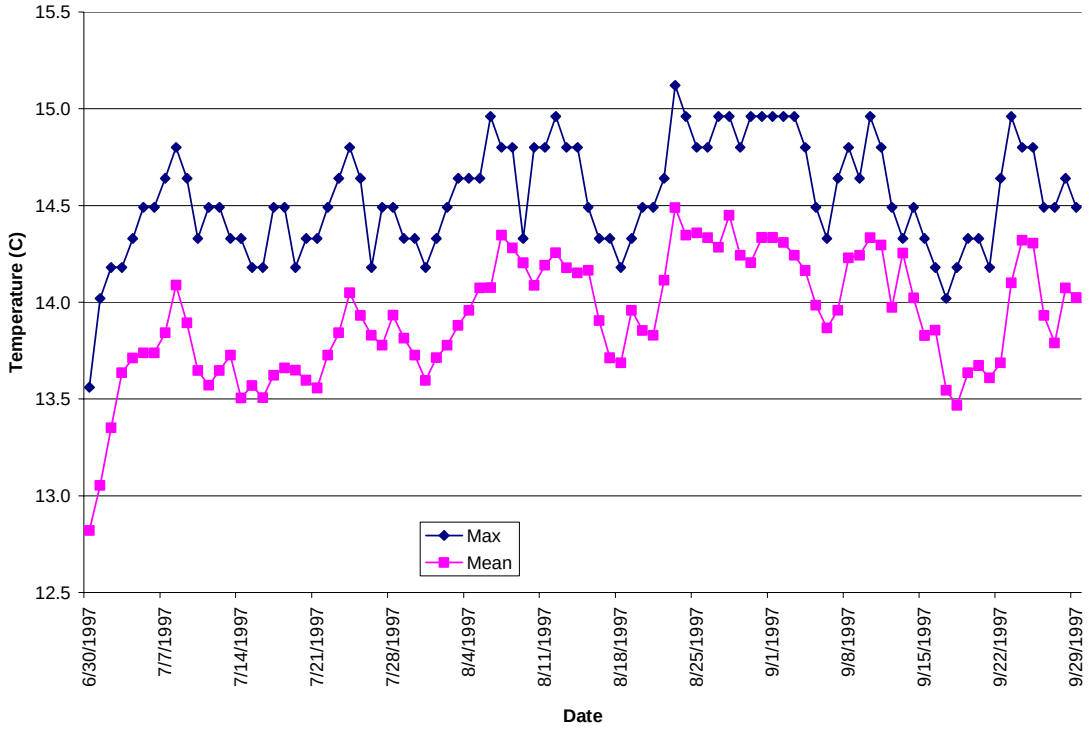


FIGURE 104. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1996) AT ROLLING BROOK (MAP NO. 23; MONITORING SITE NO. 93-2), MENDOCINO CO., CALIFORNIA.

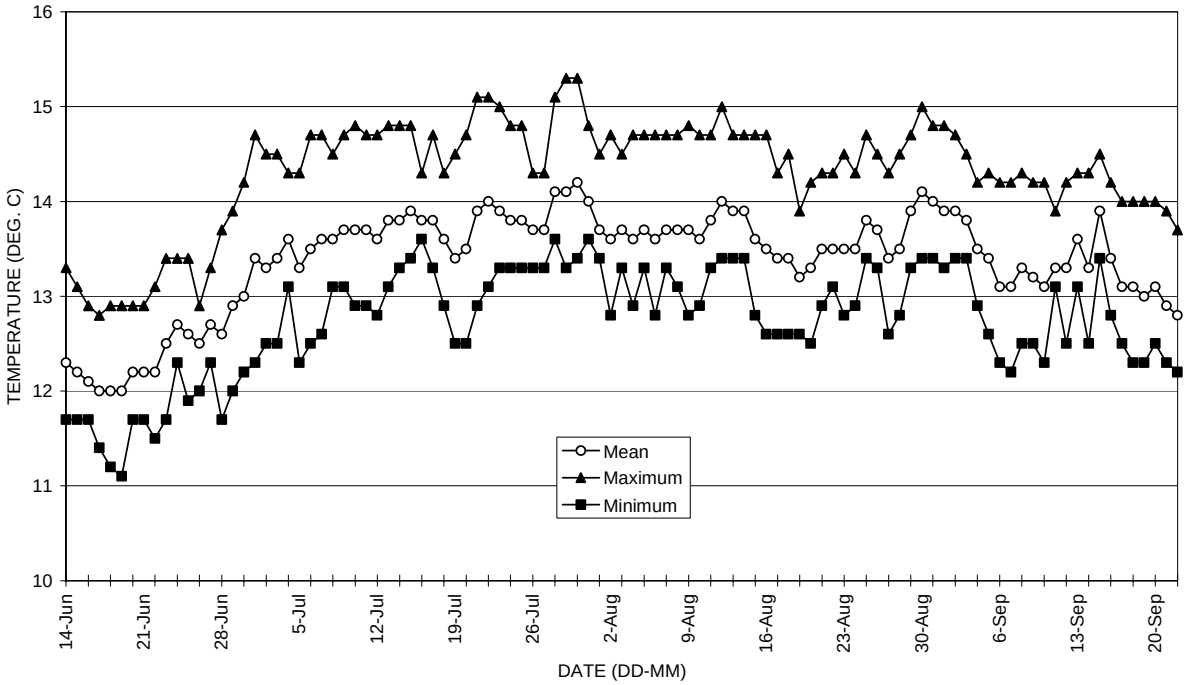


FIGURE 102. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JULY-SEPTEMBER 1995) AT GARCIA RIVER (MAP NO. 23; MONITORING SITE NO. 93-1), MENDOCINO CO., CALIFORNIA.

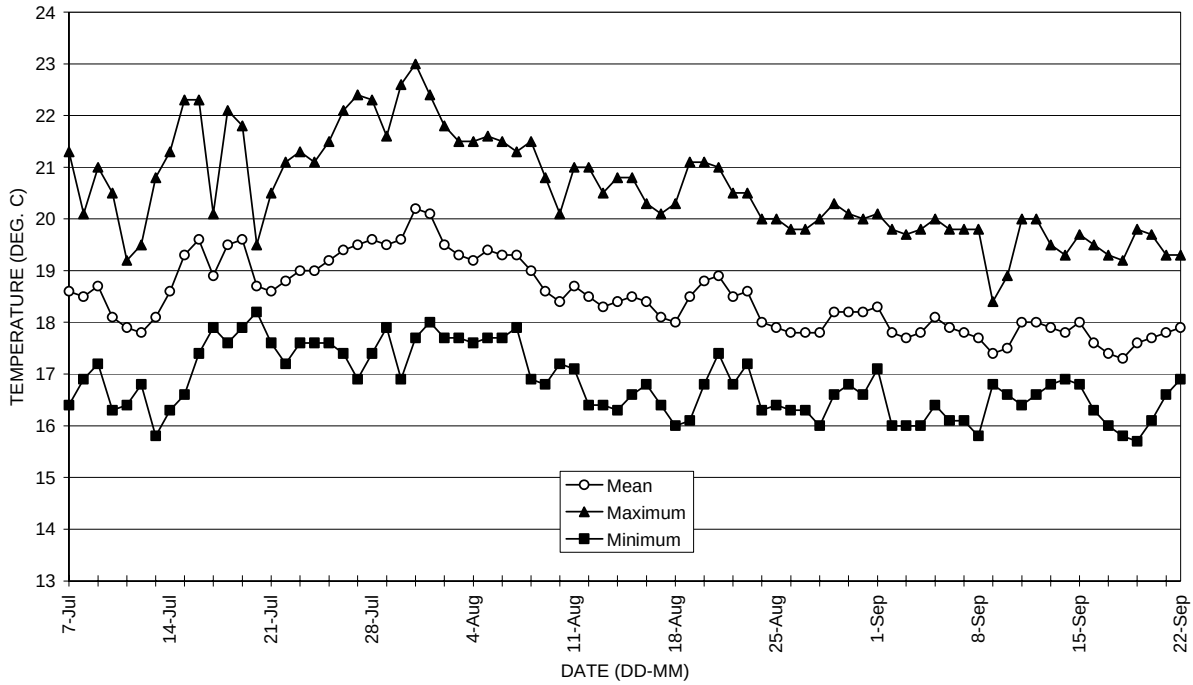


FIGURE 103. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JULY-SEPTEMBER 1995) AT ROLLING BROOK (MAP NO. 23; MONITORING SITE NO. 93-2), MENDOCINO CO., CALIFORNIA.

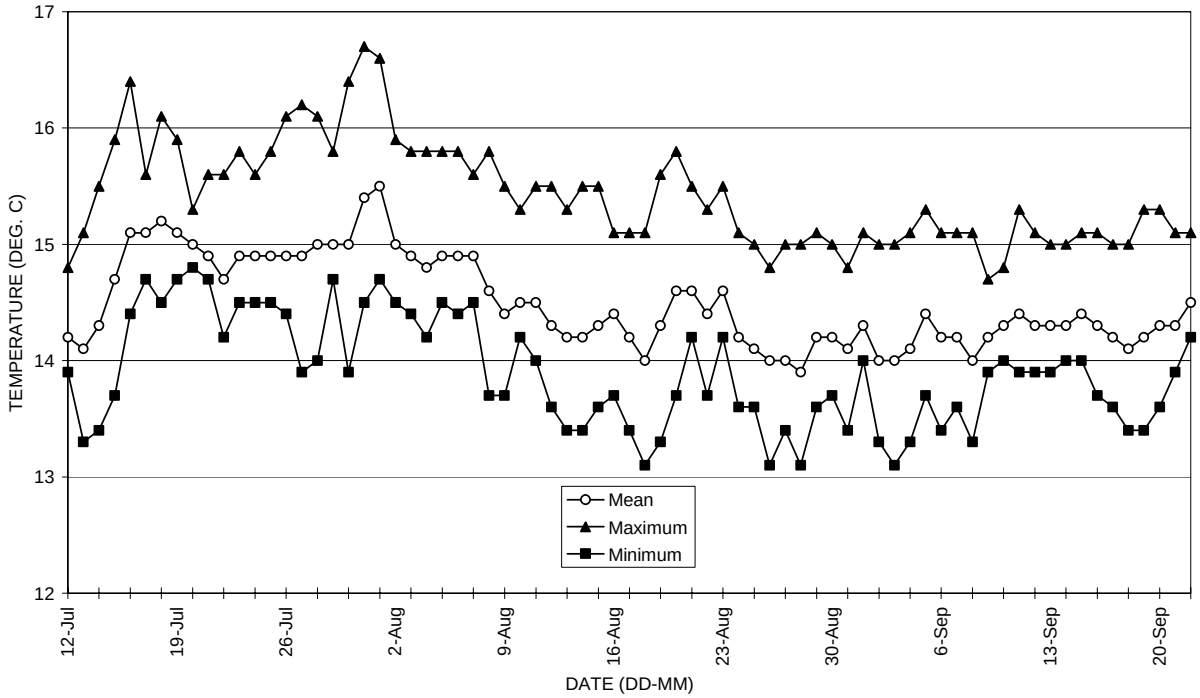


FIGURE 106. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JULY-SEPTEMBER 1995) AT SOUTH FORK GARCIA RIVER (MAP NO. 23; MONITORING SITE NO. 93-4), MENDOCINO CO., CALIFORNIA.

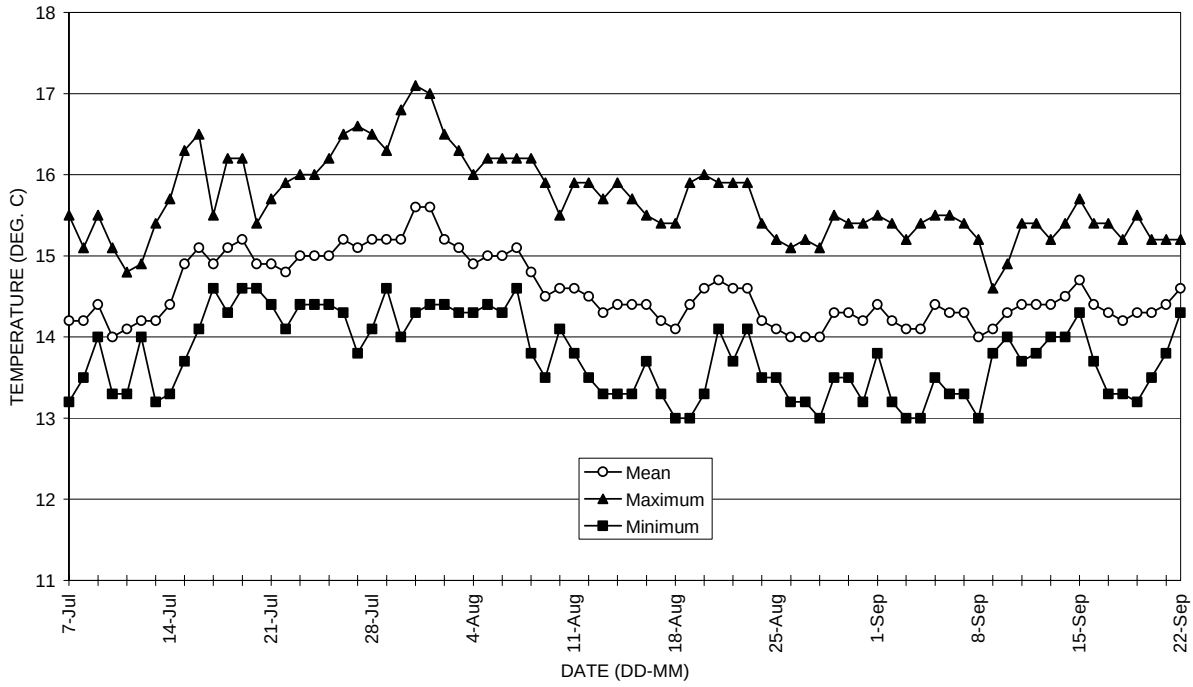


FIGURE 74. MEAN AND MAXIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT MAINSTEM GARCIA RIVER (FIGURE 1-G; MONITORING SITE NO. 31), MENDOCINO CO., CALIFORNIA.

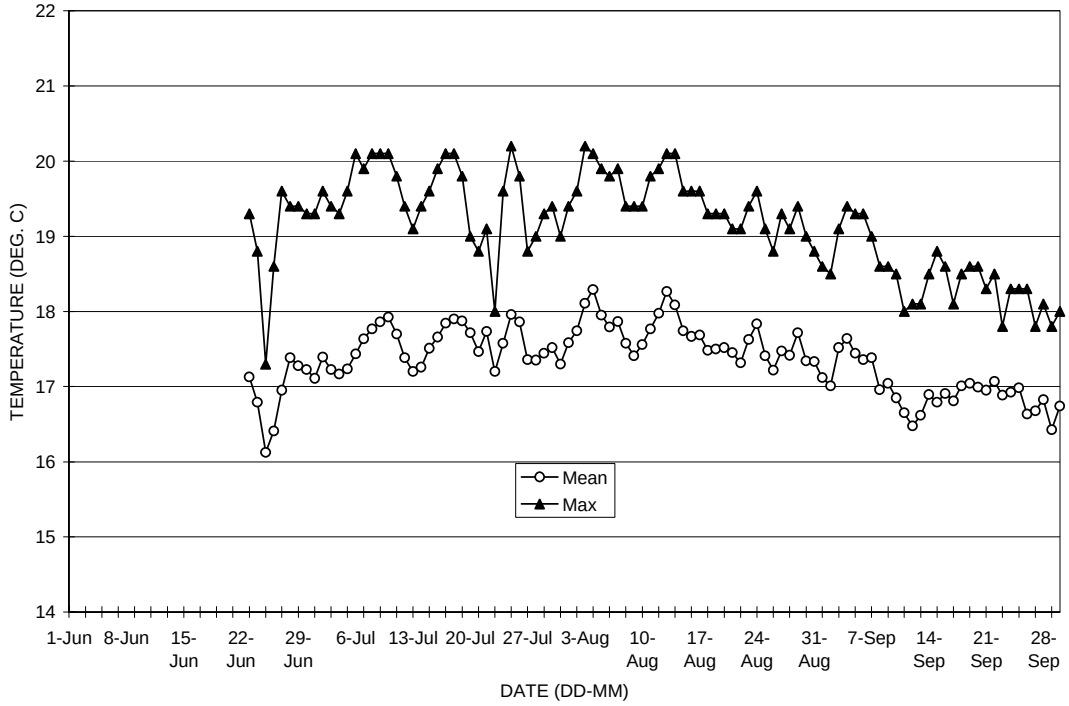


FIGURE 105. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT SOUTH FORK GARCIA RIVER (MAP NO. 23; MONITORING SITE NO. 93-4), MENDOCINO CO., CALIFORNIA.