SECTION D
RIPARIAN FUNCTION

INTRODUCTION

Mendocino Redwood Company conducted an assessment of riparian function in the Hollow Tree Creek Watershed Analysis Unit (WAU) during the summer of 1999. 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 and 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. The goal of these evaluations is to provide baseline information on the current LWD loading in the channel and current status of riparian stand function in the Hollow Tree Creek WAU.

LARGE WOODY DEBRIS AND INSTREAM DEMAND

Methods

Short-term LWD recruitment potential (next 20-30 years) was evaluated in designated stream segments within the Hollow Tree WAU. Stream segments were designated in the stream channel condition assessment and are shown on map E-1 (Stream Channel Condition Module). Generally, all stream segments were evaluated 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 1996 aerial photographs and field observations from the summer of 1999. 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 diameter breast height (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 Hollow Tree 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 is that which is providing some habitat or morphologic function in the stream channel (i.e. pool formation, scour, debris dam, bank stabilization, or gravel storage). There was a 4 inch diameter (10 centimeter) and 10 foot length (3.3 m) minimum size requirement for functional LWD. However, rootwads are counting as functional LWD though they often do not meet the length requirement. The LWD is 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 associated with an accumulation of 3 pieces or more was recorded and the number of LWD accumulations in the stream survey reach was tallied. LWD pieces were also assigned attributes if they fall into certain categories. These categories are: the LWD piece was part of a living tree, root associated (i.e. does it have a rootwad attached to it), part of the piece buried within stream gravel or the bank, or associated with a stream habitat enhancement structure. By assigning these attributes, the number of pieces in a segment which, for example, have a rootwad associated with the LWD can be calculated. This is important as these associations of the LWD provide context on the stability or ecological benefits that the LWD may possess.

Pieces that were partially buried were noted, as dimension for not accurately known. There may likely be a significant amount of volume that is buried that we cannot measure. Also, these pieces may be more stable in the channel during high flows. The percentage of total pieces that 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, defined as aggregates of LWD with >10 pieces, and debris accumulations, defined as aggregates of LWD with between 3-10 pieces, were noted. Total number of pieces and number of key pieces in each debris jam was noted. Species and dimensions were recorded as could be best determined for individual pieces contained in debris jams. All volume estimates and piece counts were separated in two groups, one not considering jams and one considering all LWD pieces in the segment, debris jams included. The percentage of total volume and total pieces per segment that was 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 is presented as a number of LWD pieces per 328 feet (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 328 feet or 100 meters) is compared to the target for what would be an appropriate key piece loading. The target for appropriate key piece loading is 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 Hollow Tree WAU.

Bankfull Width (ft)	# Key Pieces		
	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 was 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 aquatic habitat associations within the Hollow Tree WAU. The in-stream LWD demand was 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	LOW	MODERATE	HIGH
		MODERATE	MODERATE	HIGH	HIGH
	MODERATE	LOW	LOW	MODERATE	MODERATE
		MODERATE	MODERATE	HIGH	HIGH
	HIGH	LOW	LOW	MODERATE	MODERATE
		LOW	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 the 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.

Results and Discussion

The large woody debris recruitment potential and in-stream LWD demand for the Hollow Tree Creek 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-6 a, b, and c. Only six channel segments in tributaries to Hollow Tree Creek met the LWD target. LWD levels in streams of the Hollow Tree Creek WAU are low.

Table D-6(a). Large Woody Debris Piece Counts in Select Stream Segments of the Hollow Tree WAU.

Stream Segment Name	ID#	LWD Pieces w/o Debris Jams	LWD Pieces w/ Debris Jams	Debris Accum.	LWD (#/328ft.) w/o Debris Jams	LWD (#/328ft.) w/ Debris Jams	LWD Pieces w/o Debris Jams	LWD Pieces w/ Debris Jams	LWD Pieces/328ft. w/o Debris Jams	LWD Pieces/328ft. w/Debris Jams	LWD Pieces in Debris Jams
Hollow Tree	RL3	14	18	0	3.0	3.9	1	1	0.2	0.2	22%
Hollow Tree	RL4	1	1	0	0.2	0.2	0	0	0.0	0.0	0%
Bond Creek	RM109	36	36	0	16.1	16.1	5	5	2.2	2.2	0%
Bond Creek	RM110	59	59	1	22.6	22.6	5	5	1.9	1.9	0%
Hollow Tree	RM3	12	12	0	2.8	2.8	0	0	0.0	0.0	0%
Walters Creek	RM43	21	21	0	7.3	7.3	6	6	2.1	2.1	0%
Lost Pipe Creek	RM48	8	8	0	6.8	6.8	2	2	1.7	1.7	0%
Hollow Tree	RM5	5	5	0	1.3	1.3	1	1	0.3	0.3	0%
Bear Creek	RM54	31	69	3	38.7	86.1	9	37	NA	NA	55%
Hollow Tree	RM6	15	15	0	5.4	5.4	1	1	0.4	0.4	0%
Redwood Creek	RM68	59	59	0	38.1	38.1	4	4	NA	NA	0%
Redwood Creek	RM69	48	48	1	30.5	30.5	5	5	3.2	3.2	0%
SF Redwood Creek	RM88	51	51	1	33.8	33.8	22	22	NA	NA	0%
Doctors' Creek	RU12	13	40	0	9.8	30.1	5	11	3.8	8.3	68%
Hollow Tree	RU2	19	19	0	5.8	5.8	0	0	0.0	0.0	0%
Waldron Creek	RU25	29	29	2	13.2	13.2	14	14	6.4	6.4	0%
Hollow Tree	RU4	42	42	0	31.0	31.0	1	1	0.7	0.7	0%
Hollow Tree	RU5	28	28	0	16.7	16.7	6	6	3.6	3.6	0%
Bear Wallow	RU57	18	18	0	9.5	9.5	9	9	4.8	4.8	0%
Butler Creek	RU6	32	32	0	14.2	14.2	1	1	0.4	0.4	0%
Huckleberry Creek	RU64	44	62	0	15.3	21.6	6	10	2.1	3.5	29%
Little Bear Wallow	RU65	28	28	0	24.4	24.4	1	1	0.9	0.9	0%
Huckleberry Creek	RU7	20	20	0	8.7	8.7	2	2	0.9	0.9	0%
Michaels Creek	RU8	26	26	0	10.2	10.2	1	1	0.4	0.4	0%
Lynch Creek	RU9	30	30	0	43.5	43.5	3	3	4.4	4.4	0%

Table D-6(b). Large Woody Debris Volume from Select Stream Segments of the Hollow Tree Creek WAU.

Stream Segment Name	ID#	LWD Volume (yd^3) w/o Debris Jams	LWD Volume (yd^3) w/ Debris Jams	LWD volume (yd^3/328 ft) w/o Debris Jams	LWD volume (yd^3/328 ft) w/ Debris Jams	% of Total Volume in Debris Jams	% of Total Volume in Key Pieces	Percent of Total Volume by Species (w/ Debris Jam LWD)					% Current Recruitment (<10 yrs)
								Redwood	Fir	Alder	Hardwood	Unknown	
Hollow Tree	RL3	28.7	43.9	6.2	9.5	35%	21%	47%	9%	3%	16%	25%	95
Hollow Tree	RL4	0.2	0.2	0.0	0.0	0%	0%	100%	0%	0%	0%	0%	0
Bond Creek	RM109	92.1	92.1	41.3	41.3	0%	57%	94%	1%	0%	0%	5%	10
Bond Creek	RM110	107.5	107.5	41.1	41.1	0%	41%	77%	0%	0%	0%	22%	20
Hollow Tree	RM3	10.4	10.4	2.4	2.4	0%	0%	0%	27%	6%	37%	30%	100
Walters Creek	RM43	29.3	29.3	10.2	10.2	0%	63%	43%	0%	0%	0%	57%	90
Lost Pipe Creek	RM48	18.8	18.8	15.9	15.9	0%	70%	49%	42%	0%	0%	10%	0
Hollow Tree	RM5	11.9	11.9	3.0	3.0	0%	66%	14%	66%	0%	0%	20%	75
Bear Creek	RM54	127.0	230.7	158.3	287.7	45%	80%	75%	0%	0%	0%	25%	90
Hollow Tree	RM6	15.1	15.1	5.5	5.5	0%	35%	77%	0%	22%	0%	1%	70
Redwood Creek	RM68	115.6	115.6	74.7	74.7	0%	35%	59%	1%	0%	9%	30%	80
Redwood Creek	RM69	64.0	64.0	40.6	40.6	0%	22%	36%	6%	0%	55%	3%	30
SF Redwood Crk	RM88	107.0	107.0	70.9	70.9	0%	74%	79%	1%	0%	1%	19%	75
Doctors' Creek	RU12	36.0	70.1	27.1	52.7	49%	70%	94%	0%	0%	0%	6%	10
Hollow Tree	RU2	45.1	45.1	13.8	13.8	0%	0%	75%	22%	0%	2%	0%	10
Waldron Creek	RU25	66.0	66.0	30.1	30.1	0%	87%	86%	0%	0%	3%	11%	15
Hollow Tree	RU4	54.4	54.4	40.2	40.2	0%	10%	88%	0%	0%	2%	9%	20
Hollow Tree	RU5	31.0	31.0	18.5	18.5	0%	67%	54%	37%	0%	2%	7%	NA
Bear Wallow	RU57	26.0	26.0	13.8	13.8	0%	67%	66%	0%	0%	2%	32%	30
Butler Creek	RU6	49.9	49.9	22.1	22.1	0%	15%	91%	0%	0%	0%	9%	5
Huckleberry Crk	RU64	73.6	98.6	25.6	34.3	25%	71%	89%	0%	0%	1%	10%	20
Little Bear Wallow	RU65	21.2	21.2	18.4	18.4	0%	13%	76%	3%	0%	1%	21%	40
Huckleberry Crk	RU7	26.0	26.0	11.3	11.3	0%	48%	91%	0%	0%	0%	9%	20
Michaels Creek	RU8	37.5	37.5	14.8	14.8	0%	15%	96%	0%	0%	0%	3%	10
Lynch Creek	RU9	75.4	75.4	109.4	109.4	0%	37%	77%	2%	0%	0%	22%	10

Table D-6(c). Large Woody Debris Attributes for Selected Streams of the Hollow Tree WAU.

		LWD Pieces						LWD Volume					
		Root Assoc.		Buried		Alive		Root Assoc.		Buried		Alive	
Segment Name	ID#	#	percent	#	percent	#	percent	Yd^3	percent	Yd^3	percent	Yd^3	percent
Hollow Tree	RL3	4	22%	3	17%	0	0%	6.3	14%	1.4	3%	0.0	0%
Hollow Tree	RL4	1	100%	0	0%	0	0%	0.2	100%	0.0	0%	0.0	0%
Bond Creek	RM109	3	8%	2	6%	0	0%	11.3	12%	9.0	10%	0.0	0%
Bond Creek	RM110	8	14%	13	22%	1	2%	33.2	31%	29.3	27%	1.0	1%
Hollow Tree	RM3	9	75%	0	0%	0	0%	7.3	70%	0.0	0%	0.0	0%
Walters Creek	RM43	0	0%	3	14%	1	5%	0.0	0%	2.1	7%	0.3	1%
Lost Pipe Creek	RM48	0	0%	1	13%	0	0%	0.0	0%	1.8	10%	0.0	0%
Hollow Tree	RM5	0	0%	1	20%	1	20%	0.0	0%	0.3	2%	7.9	66%
Bear Creek	RM54	1	1%	9	13%	0	0%	2.8	1%	14.0	6%	0.0	0%
Hollow Tree	RM6	8	53%	1	7%	1	7%	3.3	22%	0.2	1%	5.2	35%
Redwood Creek	RM68	5	8%	20	34%	0	0%	9.7	8%	53.5	46%	0.0	0%
Redwood Creek	RM69	4	8%	5	10%	0	0%	38.8	61%	3.0	5%	0.0	0%
SF Redwood Creek	RM88	7	14%	8	16%	0	0%	14.8	14%	6.9	6%	0.0	0%
Doctors' Creek	RU12	3	8%	2	5%	1	3%	20.4	29%	5.5	8%	0.8	1%
Hollow Tree	RU2	0	0%	0	0%	2	11%	0.0	0%	0.0	0%	2.6	6%
Waldron Creek	RU25	1	3%	6	21%	0	0%	1.3	2%	17.2	26%	0.0	0%
Hollow Tree	RU4	2	5%	3	7%	6	14%	1.2	2%	12.9	24%	6.5	12%
Hollow Tree	RU5	2	7%	3	11%	0	0%	11.8	38%	3.8	12%	0.0	0%
Bear Wallow	RU57	0	0%	2	11%	0	0%	0.0	0%	0.2	1%	0.0	0%
Butler Creek	RU6	3	9%	2	6%	0	0%	0.1	0%	3.7	7%	0.0	0%
Huckleberry Creek	RU64	2	3%	8	13%	0	0%	31.4	32%	4.6	5%	0.0	0%
Little Bear Wallow	RU65	3	11%	7	25%	0	0%	9.0	43%	2.4	12%	0.0	0%
Huckleberry Creek	RU7	0	0%	0	0%	0	0%	0.0	0%	0.0	0%	0.0	0%
Michaels Creek	RU8	0	0%	0	0%	2	8%	0.0	0%	0.0	0%	2.0	5%
Lynch Creek	RU9	5	17%	3	10%	2	7%	31.7	42%	2.2	3%	5.4	7%

Debris jams were sparse in the Hollow Tree Creek WAU. Jams, where they occurred, were shown to be a significant portion of the total number of pieces and total volume. In the WAU, debris jams occurred in four segments and contained up to 68% of the total number of pieces and 49% of the total volume (see Tables D-6a and b). In the case of segment RU12 (Doctors Creek), debris jams actually affected whether or not the segment met the LWD target. It was only with adding in the key pieces that were contained in debris jams that the segment exceeded the LWD target. Although there obviously can be a significant amount of LWD trapped in debris jams, the ecological function may not be accurately represented by numbers alone. All of the pieces in a debris jam may actually have more habitat value if they were spread out in the stream as opposed to being piled up in one spot.

Debris accumulations (>3 pieces) were sparse in the Hollow Tree Creek WAU and didn't constitute a large portion of the total LWD volume. Up to one-third of the pieces in any given segment were partially buried. This indicates that we are unable to quantify a significant portion of the LWD volume which may eventually be useful to the stream. Root associated pieces constituted up to 53% of the total piece count and up to 100% of the total volume in any given segment.

LWD species composition was largely redwood dominated (Table D-6b). Almost 70% of all the pieces in the Hollow Tree Creek WAU were redwood. This may not be surprising as these streams flow through a redwood forest but it does show that the LWD currently found in these streams is more stable as redwood breaks down more slowly in streams than hardwood species.

As shown in tables D-6a and b and map D-1, there is a need for large woody debris in most of the channel segments of the Hollow Tree Creek 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 segment that met the targets need LWD levels to be maintained to ensure LWD is providing fish habitat and morphological function in the stream channels.

Riparian recruitment potential is, in general, poor in the Hollow Tree Creek WAU (See Map D-1). The entire mainstem of Hollow Tree Creek and many of its tributaries fall into the low recruitment potential category. Exceptions are Redwood, Bear, Mule and Middle Creeks where riparian stands were considered decent. Past harvesting activities in riparian areas have resulted in many areas which contain open, small hardwood or mixed conifer/hardwood stands. These types of areas will have to be managed in a more responsible manner in order to provide for future stream channel habitat.

Currently, nearly all of the stream segments in the Hollow Tree Creek WAU are in the high and moderate in-stream LWD demand classification (Map D-1). Though not quantified in the survey, a portion of the LWD present in the Hollow Tree Creek WAU is the result of restoration work. The high in-stream LWD demand in the WAU are primarily due to low levels of LWD in the stream channels compounded by many riparian stands with moderate to low LWD recruitment potential.

Table D-7 shows the instream LWD quality rating for major streams and sections of stream or river in individual Calwater planning watersheds for the Hollow Tree WAU. This quality rating will provide a tool to monitor the quality of the LWD in major streams over time. Currently the majority of the streams have a marginal LWD quality rating, with a few streams currently receiving a deficient rating. None of the major streams in the Hollow Tree WAU received an on target rating.

Table D-7. Instream LWD Quality Ratings for Major Streams and Sections of Streams in Calwater Planning Watersheds for the Hollow Tree WAU.

Major Stream	Stream LWD Rating
Hollow Tree Creek (Lower Hollow Tree PWS)	Deficient
Hollow Tree Creek (Middle Hollow Tree PWS)	Deficient
Hollow Tree Creek (Upper Hollow Tree PWS)	Deficient
Mill Creek	Marginal
South Fork Creek	Marginal
Walters Creek	Marginal
Bear Creek	Marginal
Redwood Creek	Marginal
Bond Creek	Marginal
Michaels Creek	Deficient
Waldron Creek	Marginal
Bear Wallow Creek	Marginal
Huckleberry Creek	Marginal
Butler Creek	Marginal
Jack of Hearts Creek	No Data

CANOPY CLOSURE AND STREAM TEMPERATURE

Methods

Canopy closure, over watercourses, was estimated from 1996 aerial photographs. Four canopy closure classes were determined using aerial photographs. These classes are shown in Table D-8. A map depicting the canopy closure over streams, by closure class, was produced for the Hollow Tree Creek WAU based on the aerial photograph interpretations.

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

Stream surface not visible	>90% shade
Stream surface slightly 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	0-40% shade

During summer 1999, field measurements of canopy closure over select stream channels were performed. The field measurements were taken during the stream channel assessments in the Hollow Tree Creek 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 channel sample 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 streamside canopy closure over streams for the Hollow Tree Creek WAU is mapped in Map D-2.

Stream temperature has been monitored in the Hollow Tree Creek WAU, by Louisiana-Pacific Corp., 1994-97 and MRC in 1999-2003. In summer 2001 this was expanded to include Class II streams temperatures as part of a herpetological study. Stream temperature monitoring involved

use of electronic temperature recorders (Stowaway, Onset Instruments) monitoring the water temperature continuously at 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 a and b describes the temperature monitoring locations.

Table D-9a. Class I Stream Temperature Monitoring Locations and Years Monitored for the Hollow Tree Creek WAU (see map D-2).

Temperature Monitoring Station	Stream Channel Segment Number	Stream Name	Years Monitored
41-1	RL2	Lower Hollow Tree	94, '95, '99, '00, '01, '02, '03
41-2	RM67	Redwood Creek	94, '95, '99, '00, '01, '02, '03
41-2A	Air	Redwood Creek	'02, '03
41-3	RM109	Bond Creek	96, '97, '99, '00, '01, '02, '03
41-4	RM6	Hollow Tree@Bond	99, '00, '01, '02, '03
41-5	RU8	Michaels Creek	94, '96, '99, '00, '01, '02, '03
41-6	RU7	Huckleberry Creek	94, '95, '99, '00, '01, '02, '03
41-7	RU4	Upper Hollow Tree	94, '95, '99, '00, '01, '03
41-8	RM42	Walters Creek	1997
41-9	RU25	Waldron Creek	1997
41-10	RU57	Bear Wallow Creek	'02, '03
41-11	RU65	Little Bear Wallow Creek	2002
55-01	n/a	Jack of Hearts Creek	'01, '02, '03

Table D9b. Class II Stream Temperature Monitoring Locations for Summer 2001.

Temperature Monitoring Station	Stream Channel Segment Number	Stream Name	Years Monitored
41-20	RU28	Tributary to Waldron Creek	2001
41-21	RM77	Tributary to Redwood Creek	2001
41-22	RM8	Middle Creek	2001

Daily temperatures are shown for each temperature monitoring site and year and are presented in graphs in Appendix D. Maximum weekly average temperatures (MWATs) and maximum weekly maximum temperatures 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 segments hydrologic watershed ranked as having "on-target" effective shade determines the overall quality of the stream's shade canopy. For streams of 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 (for North Branch Navarro the major basin is the Navarro River) 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 over each watercourse in the hydrologic watershed or planning watershed for streams and rivers that flow through a planning watershed 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 <16 feet, >90% effective shade.
- for watercourses with bankfull widths of 16-50 feet, >70% effective shade.
- for watercourses with bankfull widths of 50-100 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.

Results and Discussion

Canopy closure over watercourses is generally very good throughout the Hollow Tree Creek WAU (Map D-2 and Table D-10). The canopy closure map shows almost all Class I and II streams with a high streamside shade classification (>90% cover)(Map D-2). An obvious exception is lower mainstem Hollow Tree Creek (below Walters Creek) where canopy cover over the watercourse is low. This entire stretch has 0-40% canopy cover.

Table D-10. 1999 Field Observations of Canopy Closure for Select Stream Channel Segments in the Hollow Tree Creek WAU.

Stream Name	Segment Number	Mean Canopy Closure
Hollow Tree	RM5	55
Lost Pipe Creek	RM48	92
Hollow Tree	RM3	48
Lynch Creek	RU9	87
Doctors' Creek	RU12	98
Hollow Tree	RM6	89
Butler Creek	RU6	92
Hollow Tree	RU5	96
Hollow Tree	RU4	96
Hollow Tree	RU2	85
Bond Creek	RM110	96
Bond Creek	RM109	96
Michaels Creek	RU8	81
Waldron Creek	RU25	88
Hollow Tree	RL4	58
Hollow Tree	RL3	58
Redwood Creek	RM68	90
Redwood Creek	RM69	86
Huckleberry Creek	RU64	92
Huckleberry Creek	RU7	85
Bear Wallow	RU57	92
Little Bear Wallow	RU65	90
Bear Creek	RM54	86
SF Redwood Creek	RM88	93
Walters Creek	RM43	81

Stream temperatures in the lower mainstem of Hollow Tree Creek are outside the range for rearing salmonids. Temperatures are exceptionally high at the lower Hollow Tree site (41-1), which has instantaneous maximum temperatures that approach the lethal levels of coho salmon ($23C^{o}$) and steelhead trout ($26C^{o}$). MWAT values recorded at this site for every year on record exceed the maximums for coho salmon ($17\text{-}18C^{o}$)(Brett, 1952 and Becker and Genoway, 1979). Temperatures at the remaining sites in the Hollow Tree WAU are within the ranges for coho salmon and steelhead trout. See Tables D-11, D-12 and D-13.

Table D-11. Maximum Daily Temperature for each year and station in the Hollow Tree Creek WAU in degrees Celsius.

Station No.	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
41-1	22.2	21.9	**	**	**	22.7	23.4	21.6	19.4	21.8
41-2	15.8	15.8	**	**	**	15.9	16.4	16.1	15.6	17.1
41-2Air	**	**	**	**	**	**	**	**	21.3	24.8
41-3	**	**	18.2	18.1	**	16.7	17.0	16.8	16.9	18.0
41-4	**	**	**	**	**	19.1	19.4	19.1	18.1	20.1
41-5	20.6	**	18.1	**	**	17.7	18.4	16.6	16.8	18.1
41-6	16.1	15.9	**	**	**	13.8	16.8	15.6	15.8	17.4
41-7	19.6	18.0	**	**	**	13.4	17.5	17.1	**	18.4
41-8	**	**	**	18.3	**	**	**	**	**	**
41-9	**	**	**	17.6	**	**	**	**	**	**
41-10	**	**	**	**	**	**	**	**	15.6	17.1
41-11	**	**	**	**	**	**	**	**	14.1	**
55-01	**	**	**	**	**	**	**	16.2	17.1	17.9

**Data not collected

Table D-12. Maximum Weekly Average Temperature (MWAT) for each station in the Hollow Tree Creek WAU in degrees Celsius.

Station No.	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
41-1	19.9	19.2	**	**	**	19.1	19.9	18.8	18.2	19.9
41-2	14.3	14.3	**	**	**	14.7	15.0	14.5	14.4	16.1
41-2Air	**	**	**	**	**	**	**	**	16.2	18.6
41-3	**	**	16.2	16.0	**	15.2	15.1	14.7	15.4	16.5
41-4	**	**	**	**	**	16.5	16.9	16.4	15.7	17.9
41-5	16.5	**	16.0	**	**	15.3	15.9	14.4	14.6	16.2
41-6	14.5	14.4	**	**	**	13.0	14.6	13.6	14.5	16.0
41-7	16.4	15.7	**	**	**	12.6	14.9	14.8	**	16.4
41-8	**	**	**	16.3	**	**	**	**	**	**
41-9	**	**	**	15.4	**	**	**	**	**	**
41-10	**	**	**	**	**	**	**	**	14.1	15.5
41-11	**	**	**	**	**	**	**	**	12.5	**
55-01	**	**	**	**	**	**	**	13.9	15.2	16.5

**Data not collected

Table D-13. 7-Day Moving Average of the Daily Maximum (MWMT) for each station of the Hollow Tree Creek WAU in degrees Celsius.

Station No.	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
41-1	21.9	21.4	**	**	**	21.3	22.3	20.7	18.7	21.1
41-2	15.4	15.3	**	**	**	15.4	15.5	15.5	15.3	16.7
41-2Air	**	**	**	**	**	**	**	**	19.6	23.1
41-3	**	**	17.4	17.2	**	16.2	16.2	15.9	16.4	17.4
41-4	**	**	**	**	**	18.0	18.5	18.0	17.2	19.2
41-5	20.2	**	17.4	**	**	16.9	17.5	15.9	16.1	17.5
41-6	15.8	15.4	**	**	**	13.4	15.6	14.5	15.3	16.7
41-7	19.0	17.6	**	**	**	13.0	16.4	16.3	**	16.7
41-8	**	**	**	18.1	**	**	**	**	**	**
41-9	**	**	**	16.3	**	**	**	**	**	**
41-10	**	**	**	**	**	**	**	**	15.1	16.4
41-11	**	**	**	**	**	**	**	**	13.4	**
55-01	**	**	**	**	**	**	**	15.5	16.7	17.5

**Data not collected

Class II temperatures are presented in Table D-14. Temperatures in these streams are cooler due to smaller size and greater canopy closure.

Table D-14. Class II Stream Temperature Data for the Hollow Tree WAU.

Stream Name	Station Number	Maximum	MWAT
Tributary to Waldron Crk.	41-20	12.9	12.5
Tributary to Redwood Crk.	41-21	14.1	13.4
Middle Creek	41-22	16.4	13.5

The data shows stream temperatures outside the preferred range for the mainstem of Hollow Tree Creek. Many of the tributaries of Hollow Tree are within a preferred range of temperature for salmonids. The canopy cover is favorable in these streams; it is difficult to attribute any high stream temperature to inadequate stream shading from the streamside vegetation. The high temperatures may instead be due to high air temperatures that result from the inland position of the watershed. Air temperature appears to correlate with stream temperature fluctuations in Hollow Tree WAU. The maximum, MWAT, and MWMT air temperature at Redwood Creek (Site 41-2A) is greater than 2 degrees Celsius lower in 2002 than in 2003. The stream temperatures are lower in 2002 as well.

The lower Hollow Tree site (41-1) has high stream temperatures and very low canopy closure levels. The canopy shade ratings in Hollow Tree WAU show many on target ratings, a few streams exhibiting marginal ratings and lower Hollow Tree Creek with a deficient rating (Table D-15).

Table D-15. Stream Temperature and Stream Shade Quality Ratings for Major Streams and River/Stream Segments in Calwater Planning Watersheds for the Hollow Tree WAU.

Stream	Stream Canopy Shade Rating
Hollow Tree Creek (lower)	Deficient
Hollow Tree Creek (middle)	Marginal
Hollow Tree Creek (upper)	Marginal
Mill Creek	No Data
South Fork Creek	On Target
Walters Creek	Marginal
Bear Creek	On Target
Redwood Creek	On Target
Bond Creek	Marginal
Michaels Creek	Marginal
Waldron Creek	Marginal
Bear Wallow Creek	On Target
Huckleberry Creek	On Target
Butler Creek	On Target
Jack of Hearts Creek	No Data

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Bilby, R.E. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in Western Washington. Transactions of the American Fisheries Society 118: pp. 368-378.

Brett, J.R. 1952. Temperature tolerances in young Pacific salmon, (Oncorhynchus). Journal of Fishery Resources Board Canada 9:268-323.

Gregory, K.J, and R.J. Davis. 1992. Coarse woody debris in stream channels in relation to river channel management in woodland areas. Regulated Rivers: Research and Management 7: pp. 117-136.

Louisiana-Pacific Corporation. 1997. Sustained Yield Plan. Report submitted to the California Department of Forestry. Sacramento, CA.

Appendix D

Hollow Tree Creek 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 within MRC lands in the Hollow Tree 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 1996 photographs and field observations in 1999. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD.

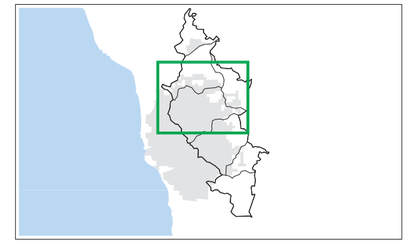
LWD Recruitment Potential Classes
- High
- Moderate
- Low

Instream LWD Demand
- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Hollow Tree Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 1



0 1/2 1 Mile

December 2003

Hollow Tree Creek 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 Hollow Tree WAU. The canopy was estimated for four canopy closure classes from 2000 aerial photographs and 1999 field observations. The location of stream temperature monitoring locations is also presented, these locations are monitoring each year during summer.

41-2
41-21
41-3
41-4
41-5
41-20
41-7
41-6

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

Temperature Monitoring Locations

MRC Ownership
Planning Watershed Boundary
Hollow Tree Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 2

0 1/2 1 Mile

December 2003

Hollow Tree Creek Watershed Analysis Unit

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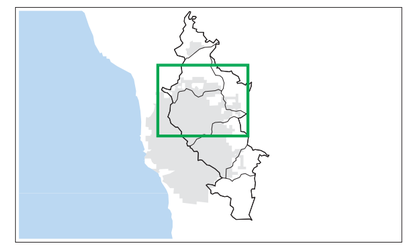
Stream Canopy Classes
- > 90%
- 70-90%
- 40-70%
- 0-40%

- Temperature Monitoring Locations
- MRC Ownership
- Planning Watershed Boundary
- Hollow Tree Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 1



0 1/2 1 Mile

December 2003

Hollow Tree Creek Watershed Analysis Unit

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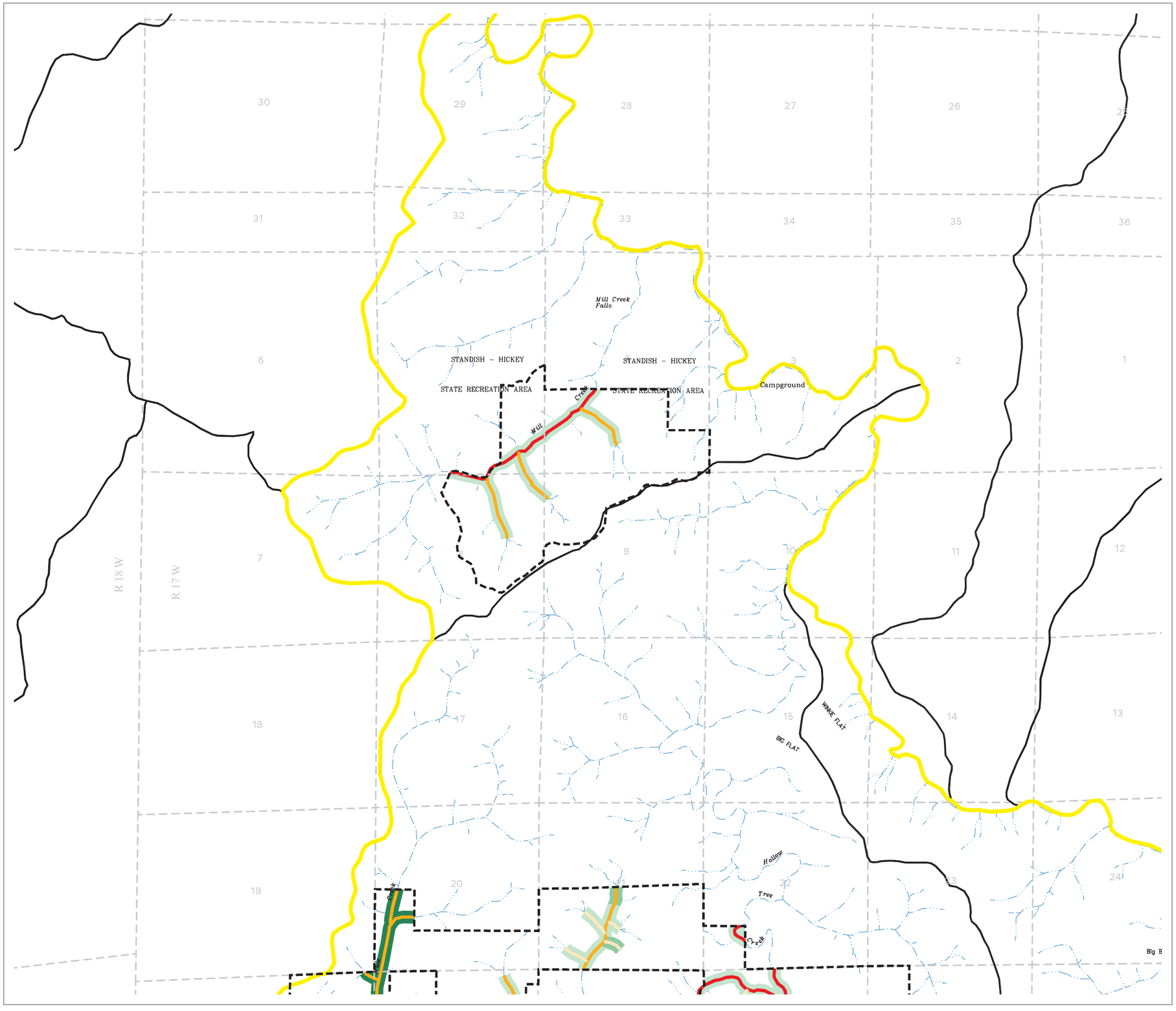


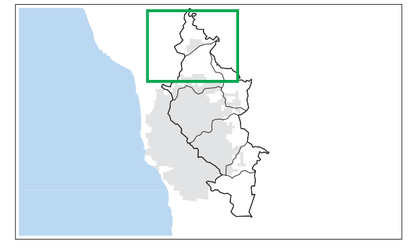
LWD Recruitment Potential Classes
- High
- Moderate
- Low

Instream LWD Demand
- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Hollow Tree Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 3



0 1/2 1 Mile

December 2003

Hollow Tree Creek Watershed Analysis Unit

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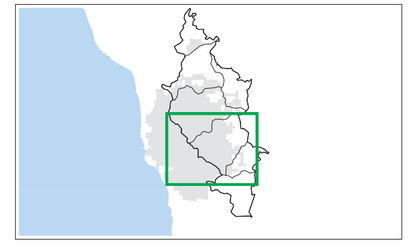
LWD Recruitment Potential Classes
- High
- Moderate
- Low

Instream LWD Demand
- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Hollow Tree Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 2



0 1/2 1 Mile

December 2003

Hollow Tree Creek Watershed Analysis Unit

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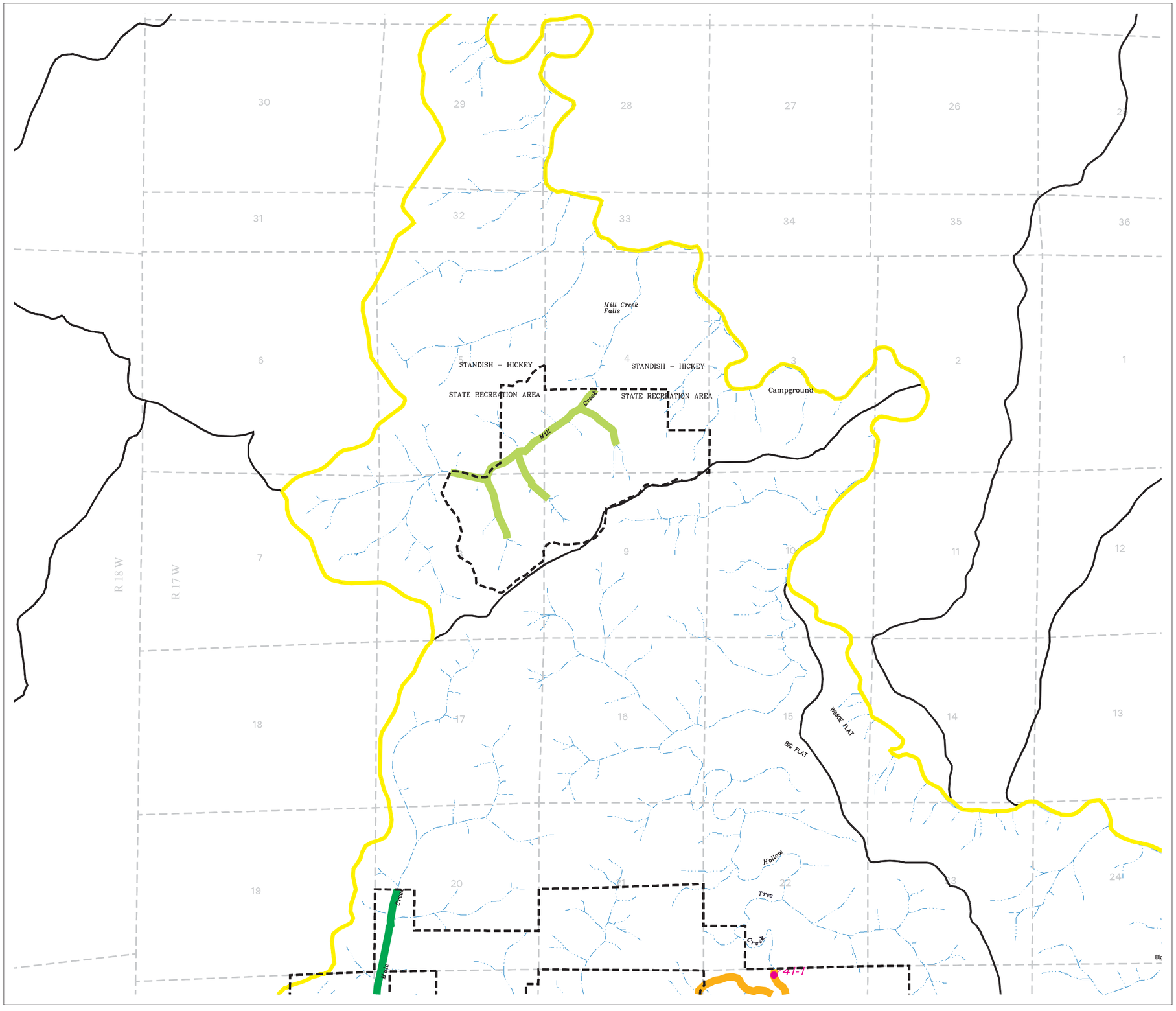
Stream Canopy Classification and Temperature Monitoring Locations

This map presents the canopy closure, over watercourses, for streams and rivers within the MRC ownership in the Hollow Tree WAU. The canopy was estimated for four canopy closure classes from 2000 aerial photographs and 1999 field observations. The location of stream temperature monitoring locations is also presented, these locations are monitoring each year during summer.

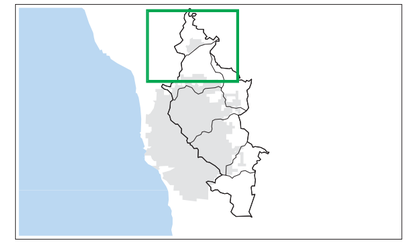


Stream Canopy Classes
- > 90%
- 70-90%
- 40-70%
- 0-40%

- Temperature Monitoring Locations
- MRC Ownership
- Planning Watershed Boundary
- Hollow Tree Creek Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 3



0 1/2 1 Mile

December 2003

Figure T41-01. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Hollow Tree Creek (Site T41-01), Mendocino County, California.

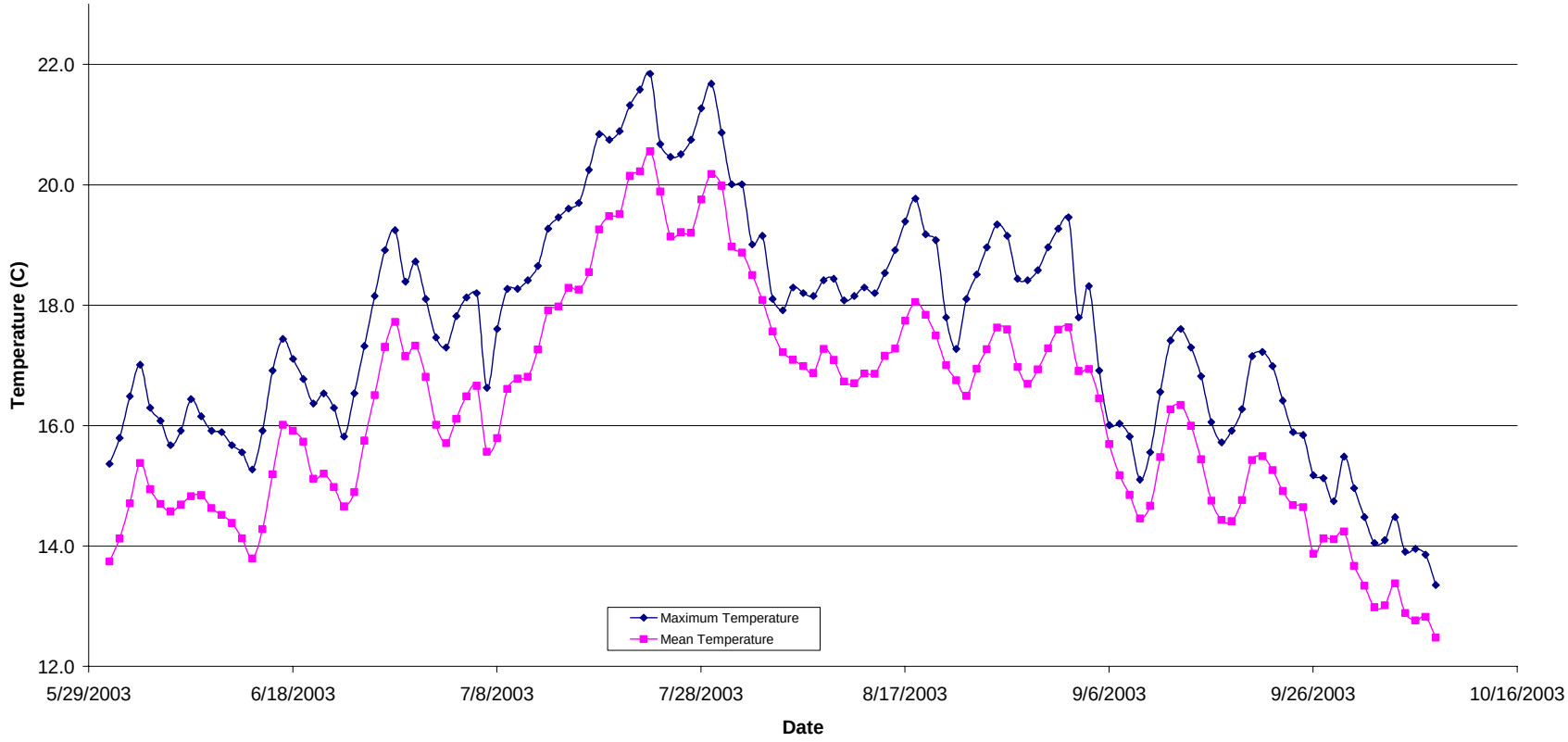


Figure T41-02. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2003 at Redwood Creek (Site T41-02), Mendocino County, California.

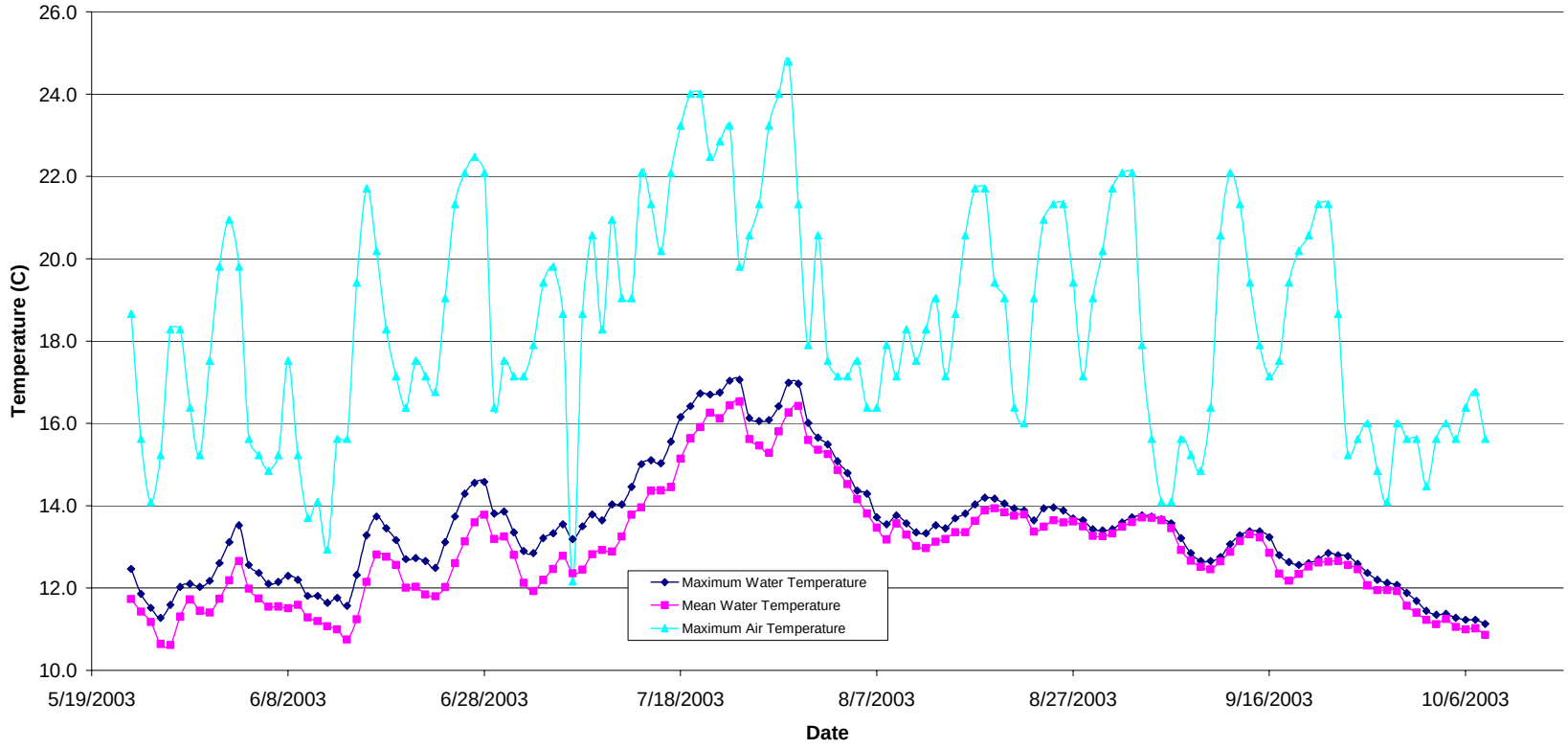


Figure T41-03. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Bond Creek (Site T41-03), Mendocino County, California.

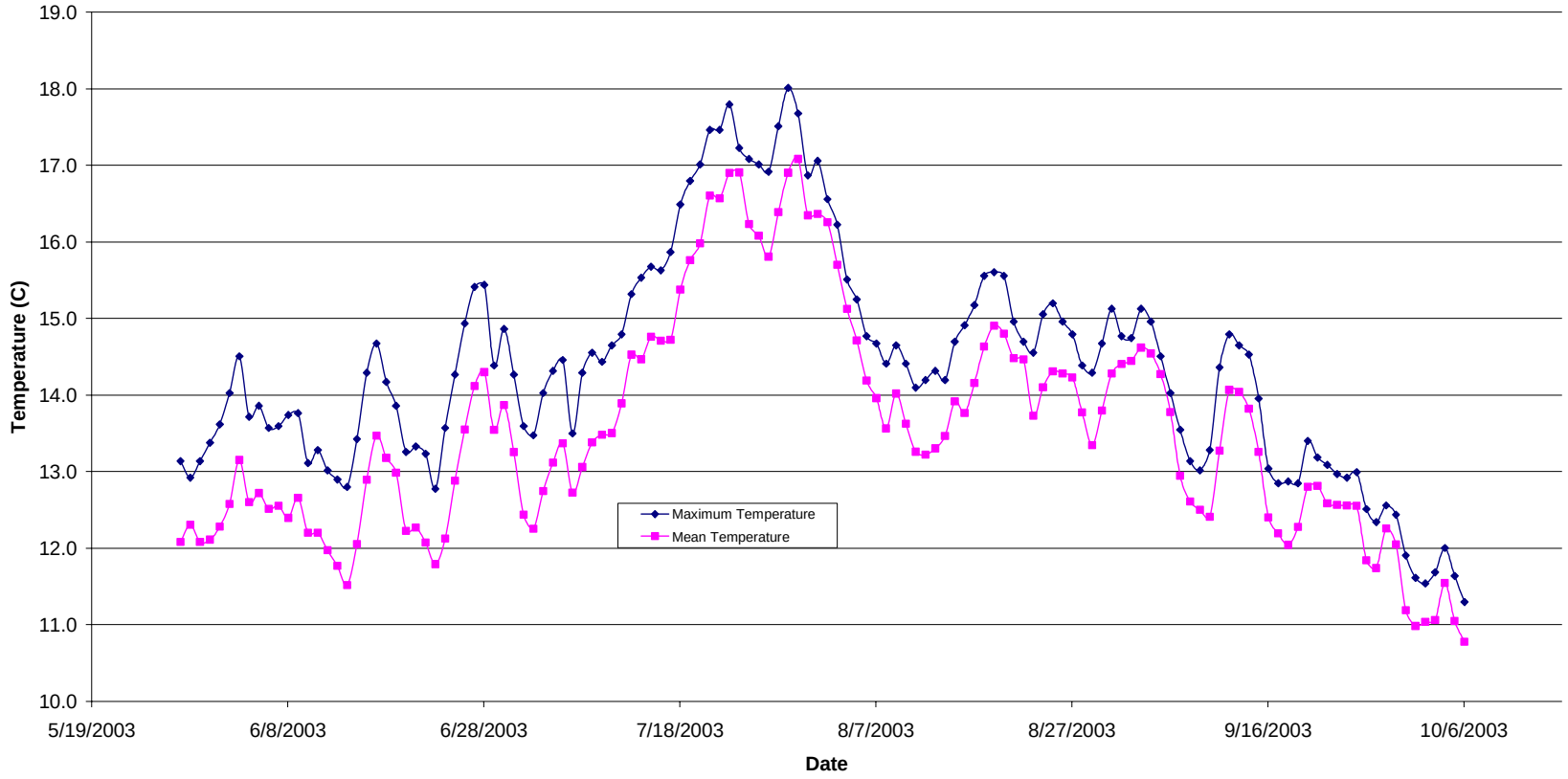


Figure T41-04. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Hollow Tree Creek (Site T41-04), Mendocino County, California.

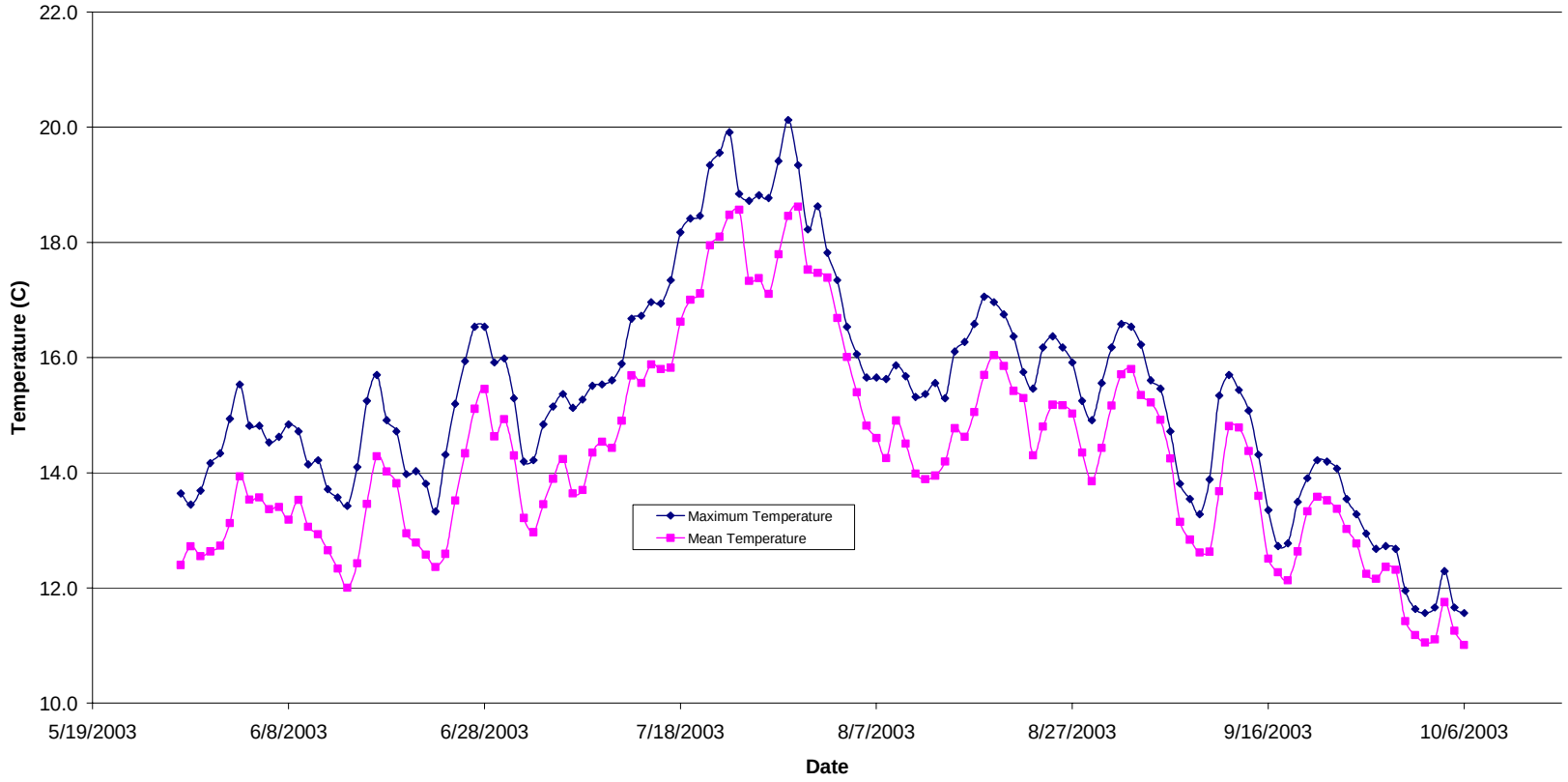


Figure T41-05. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Michael's Creek (Site T41-05), Mendocino County, California.

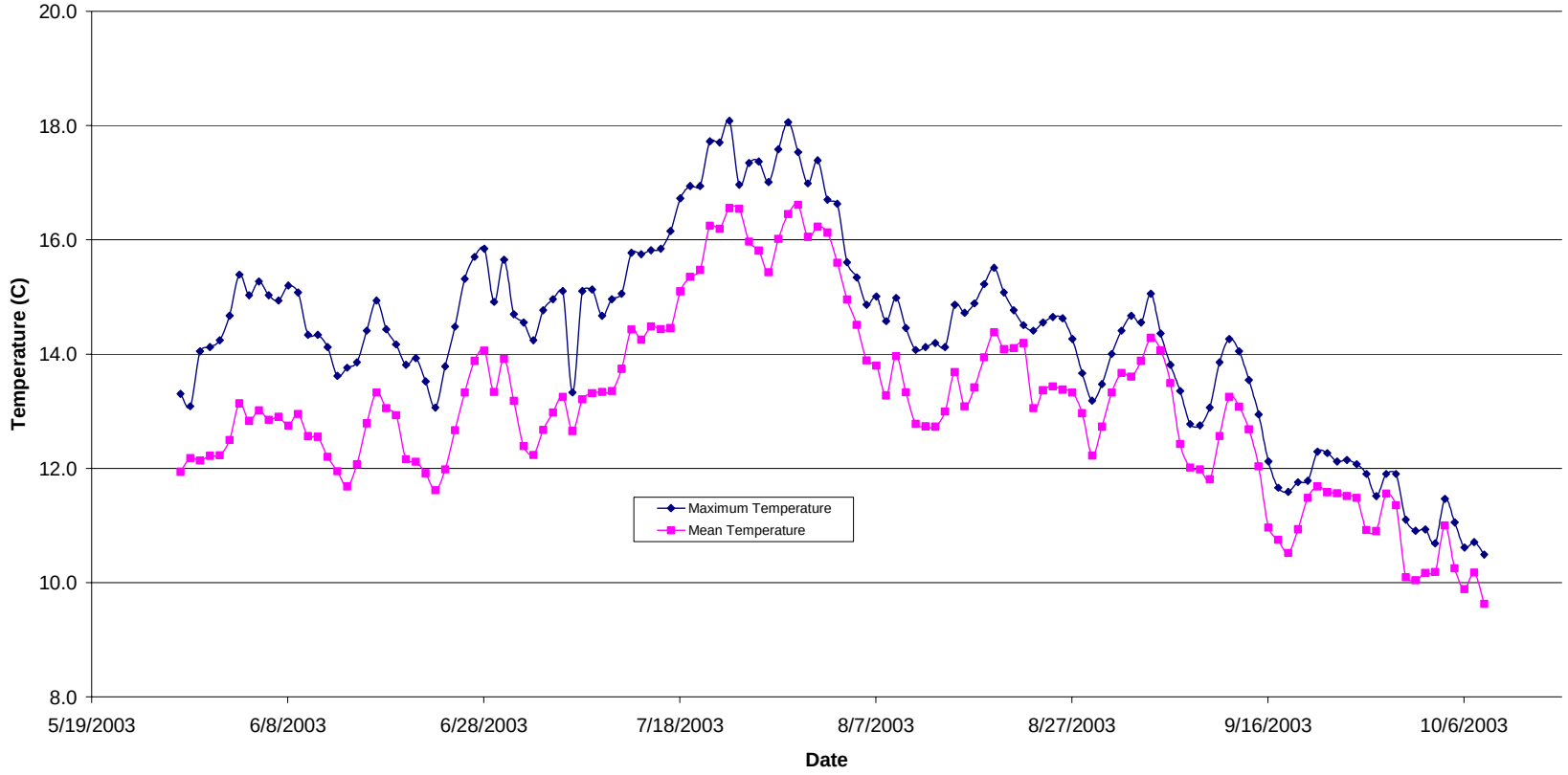


Figure T41-06. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Huckleberry Creek (Site T41-06), Mendocino County, California.

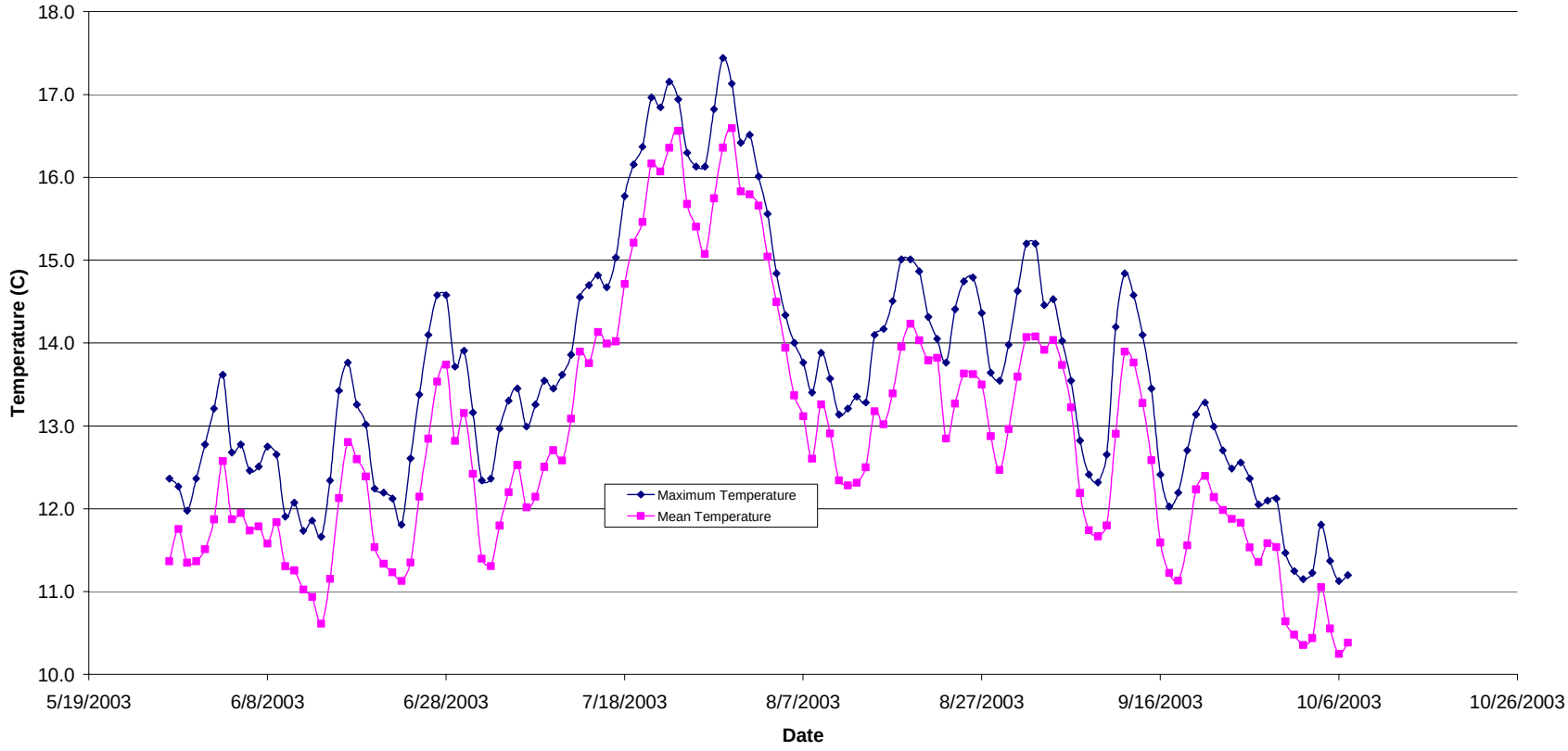


Figure T41-07. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Hollow Tree Creek (Site T41-07), Mendocino County, California.

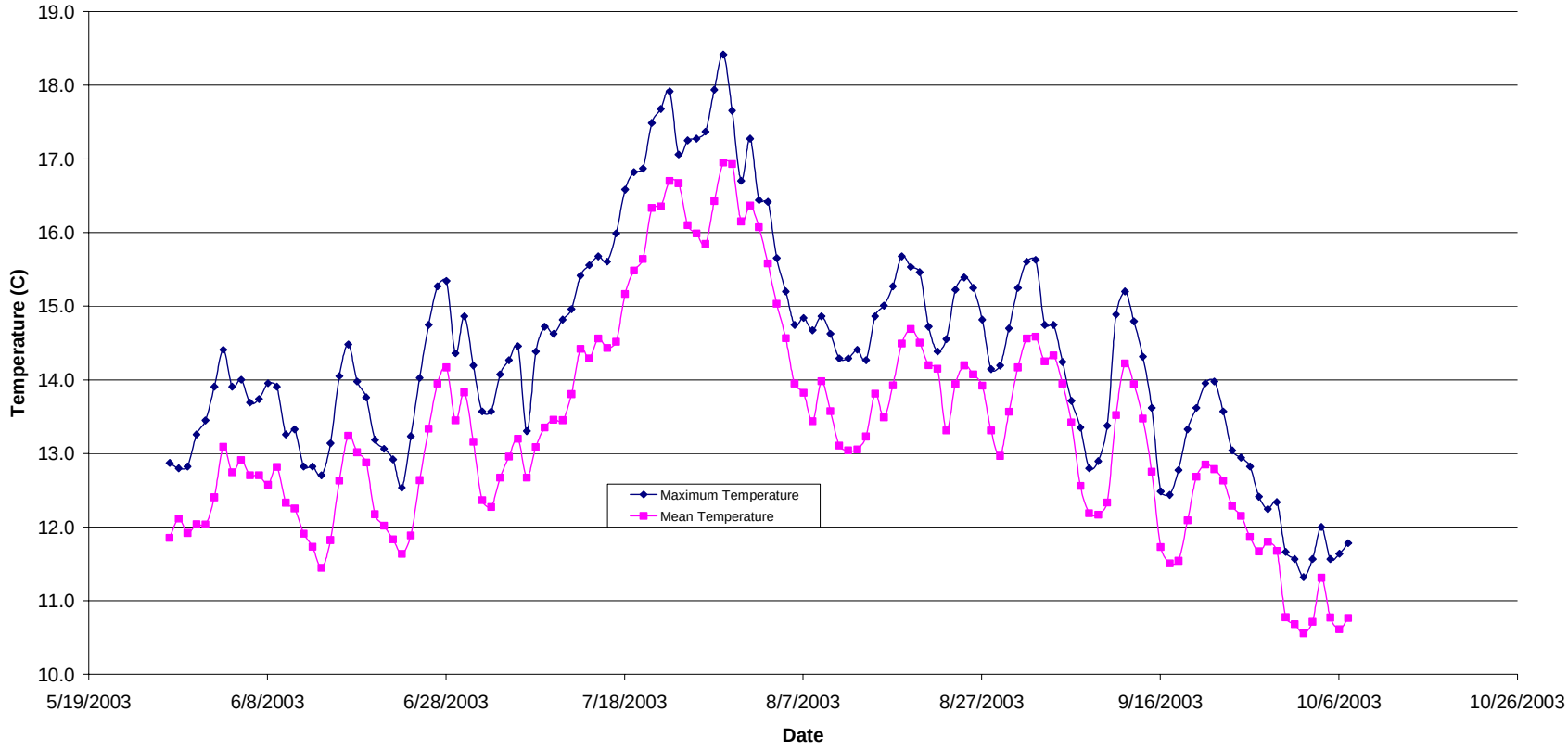


Figure T41-10. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Bear Wallow Creek (Site T41-10), Mendocino County, California.

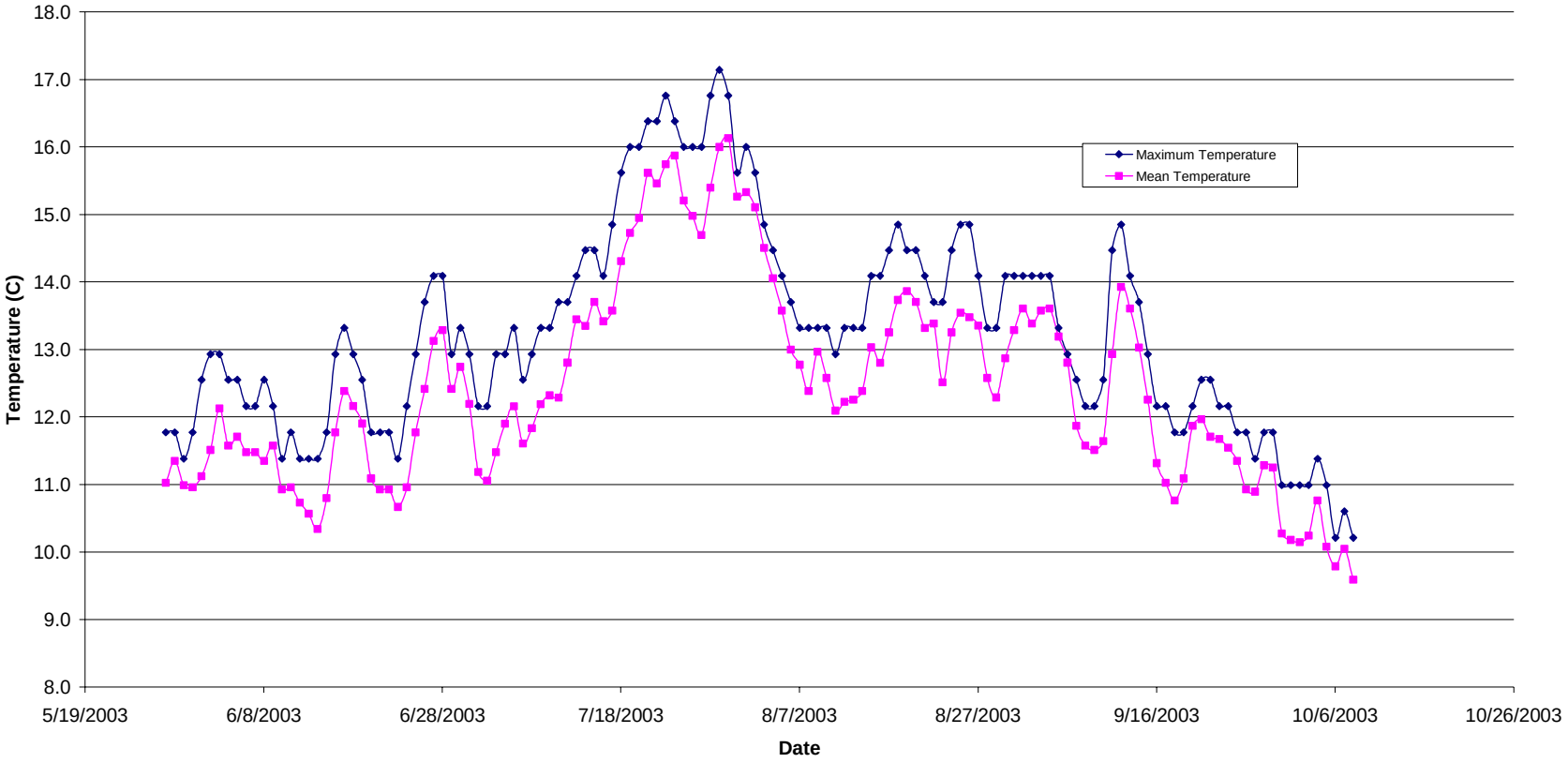


Figure T55-01. Mean and Maximum Daily Stream Temperatures During Summer 2003 at Jack O' Hearts Creek (Site T55-01), Mendocino County, California.

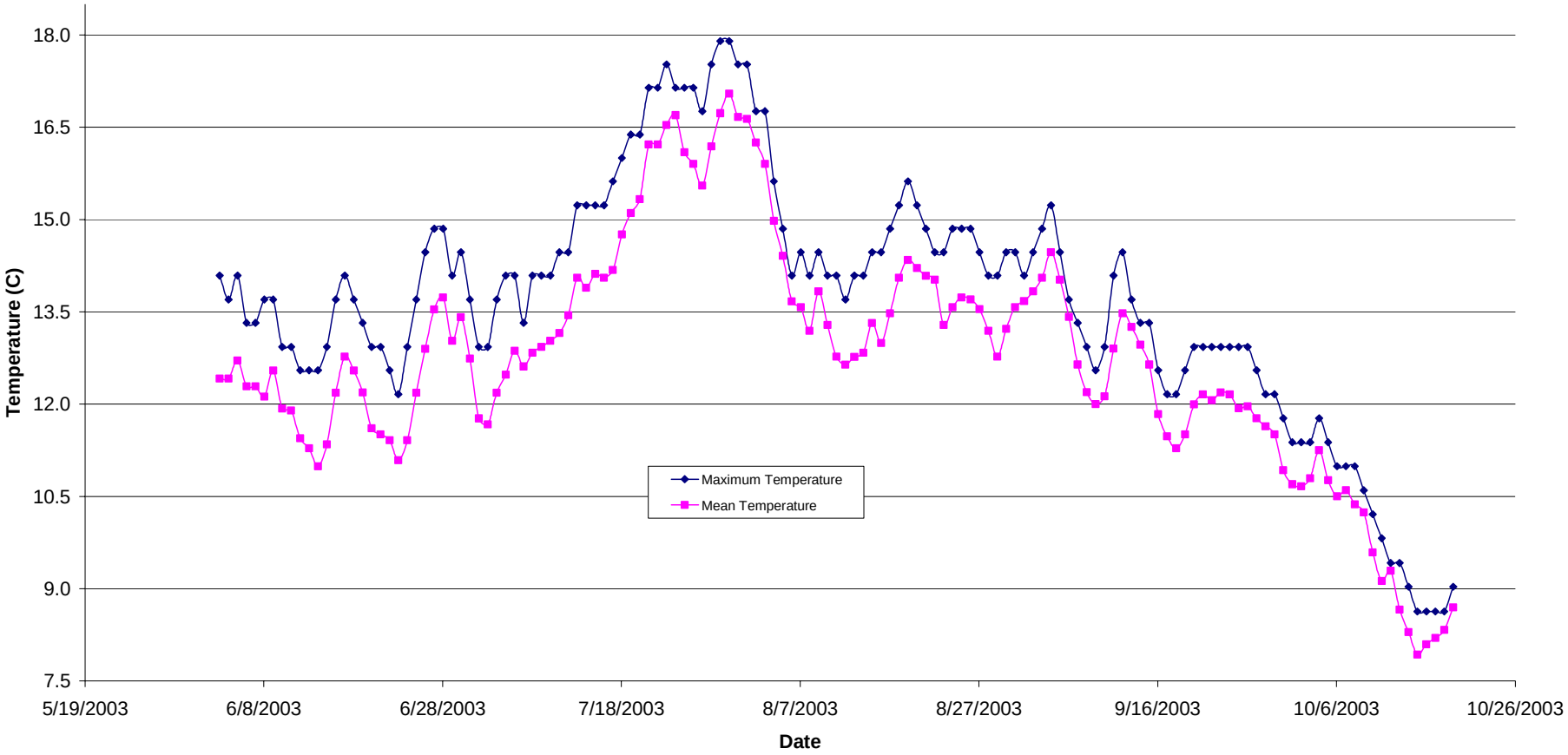


Figure T41-01. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Hollow Tree Creek (Site T41-01), Mendocino County, California.

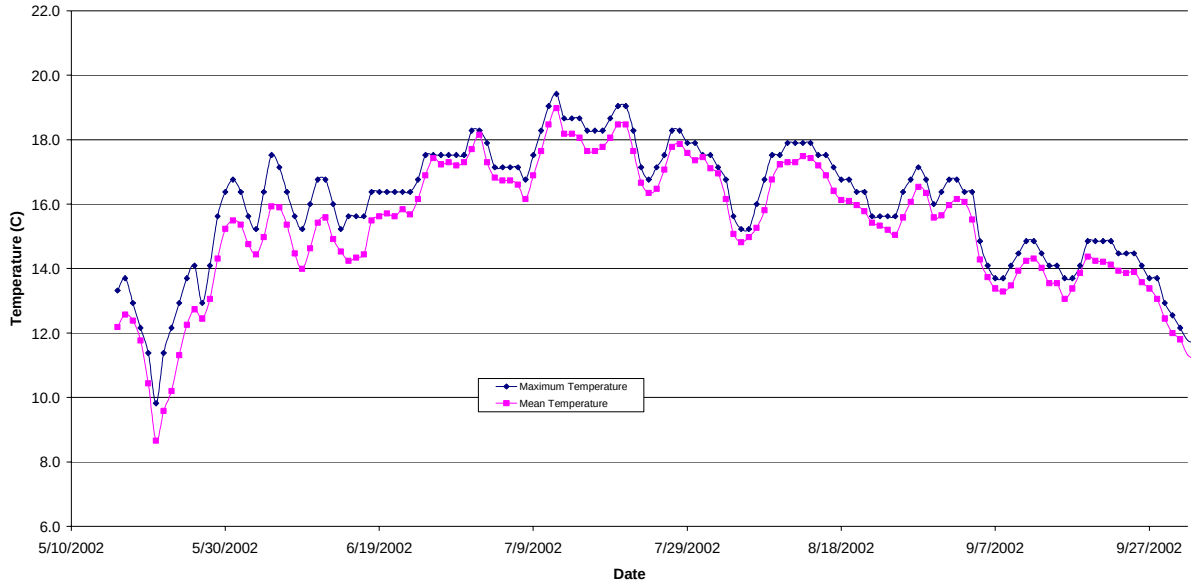


Figure T41-02. Maximum Daily Air Temperature and Mean and Maximum Daily Stream Temperatures During Summer 2002 at Redwood Creek (Site T41-02), Mendocino County, California.

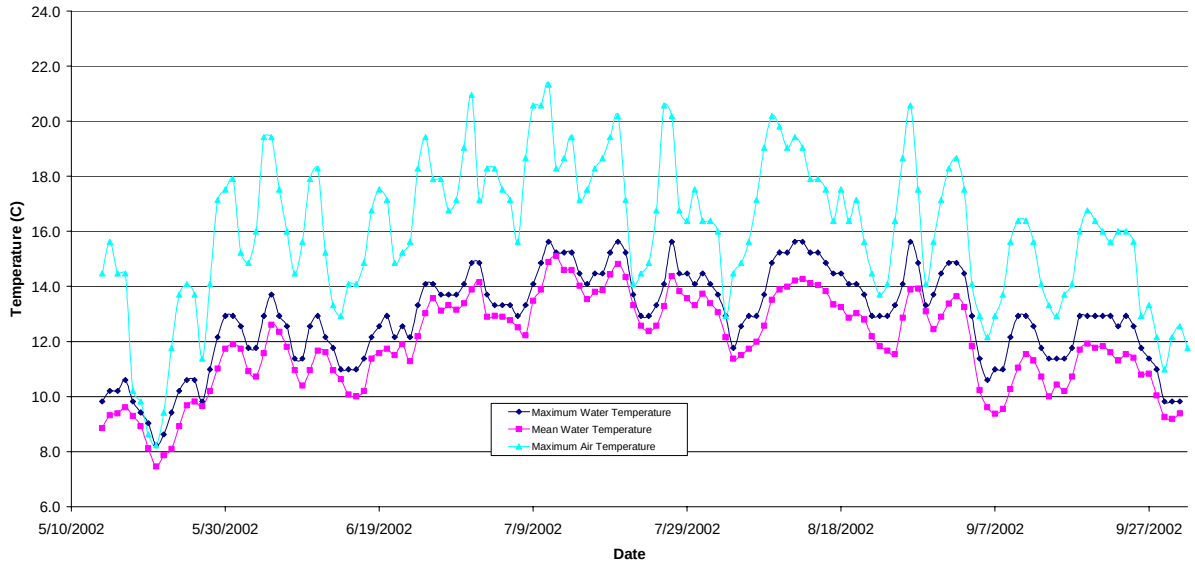


Figure T41-03. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Bond Creek (Site T41-03), Mendocino County, California.

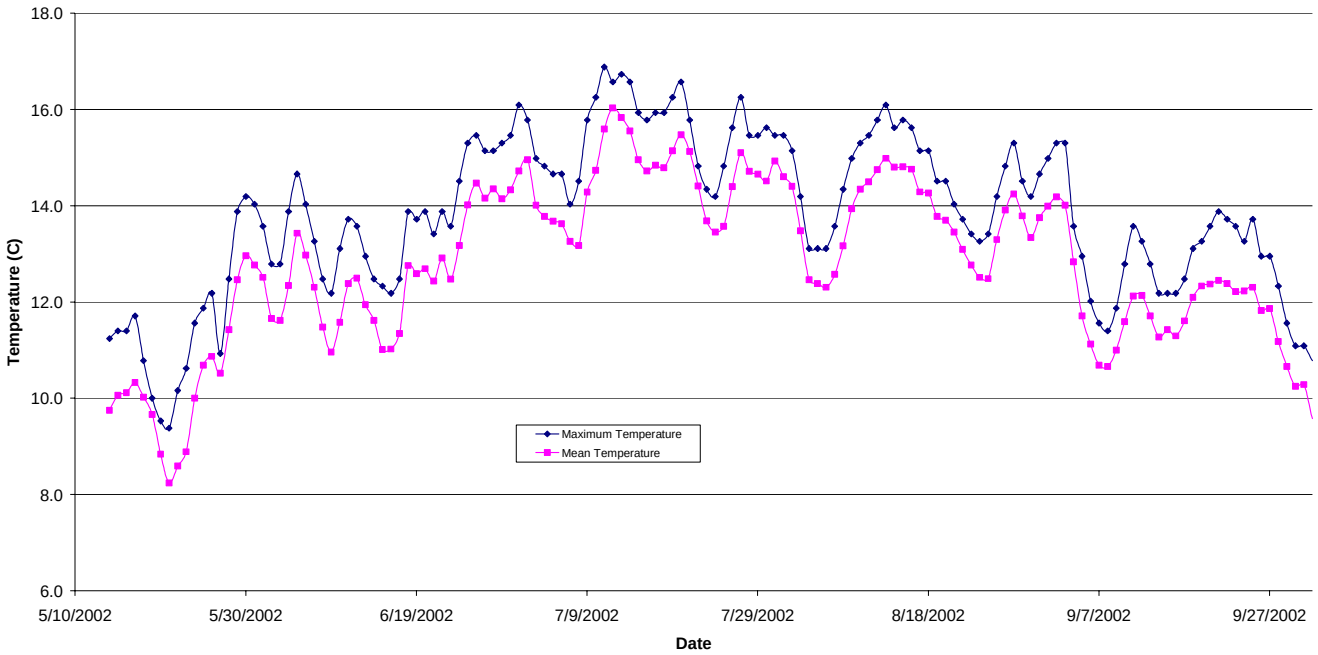


Figure T41-04. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Hollow Tree Creek (Site T41-04), Mendocino County, California.

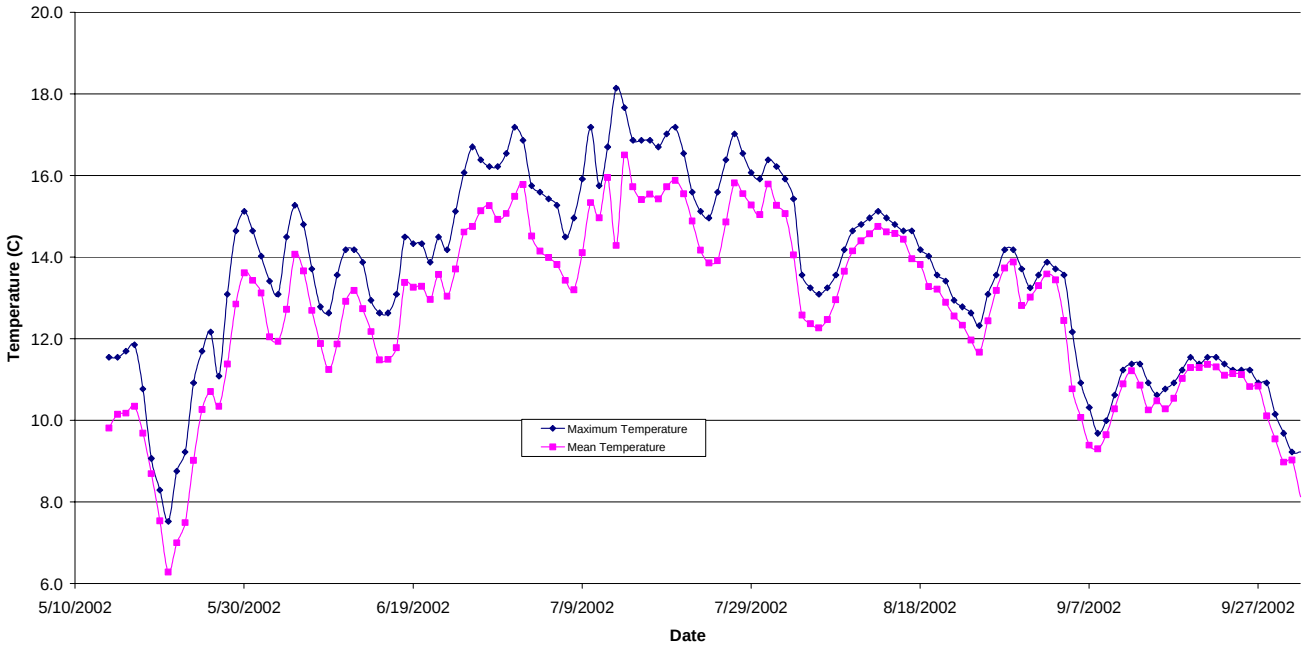


Figure T41-05. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Michael's Creek (Site T41-05), Mendocino County, California.

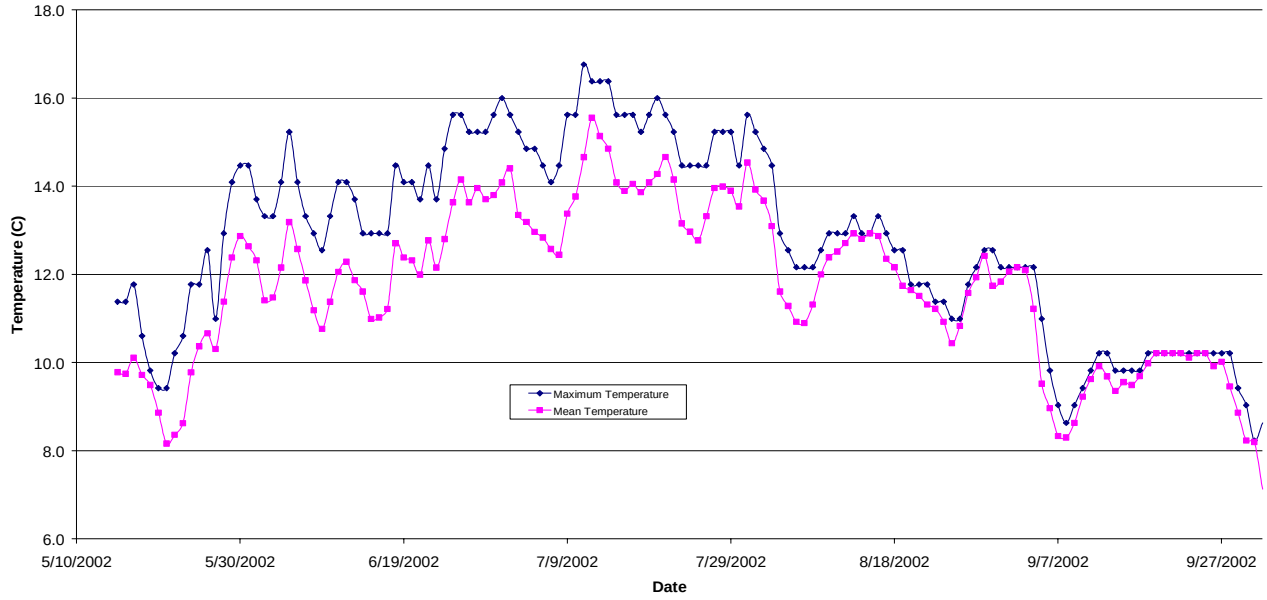


Figure T41-06. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Huckleberry Creek (Site T41-06), Mendocino County, California.

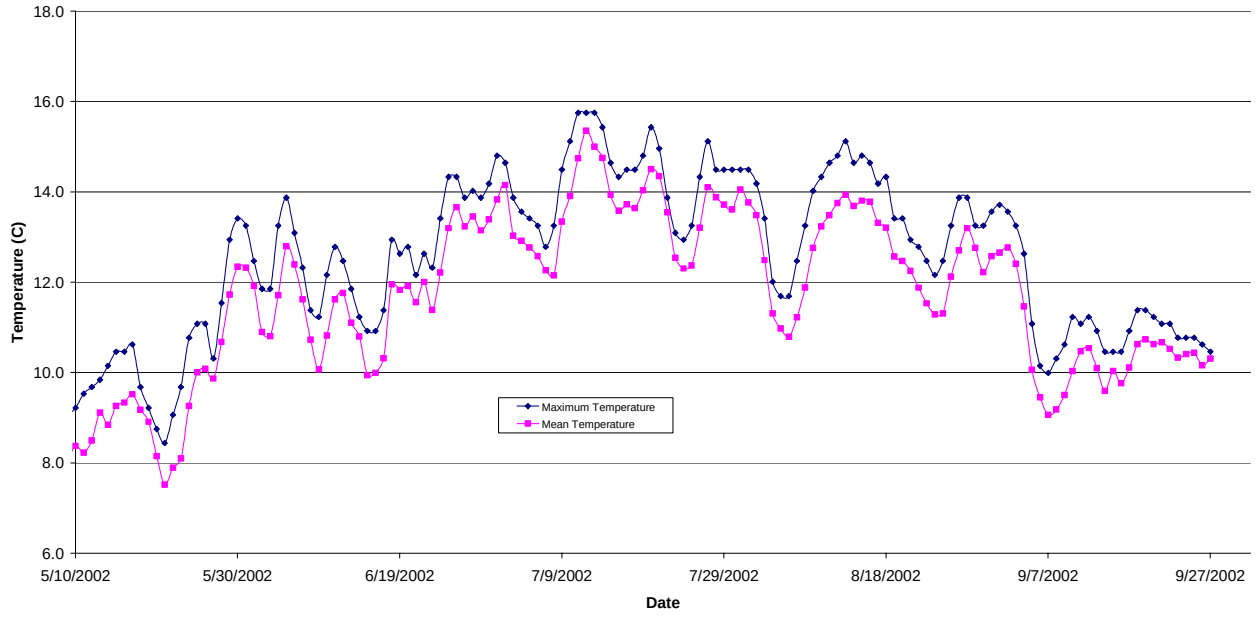


Figure T41-10. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Bear Wallow Creek (Site T41-10), Mendocino County, California.

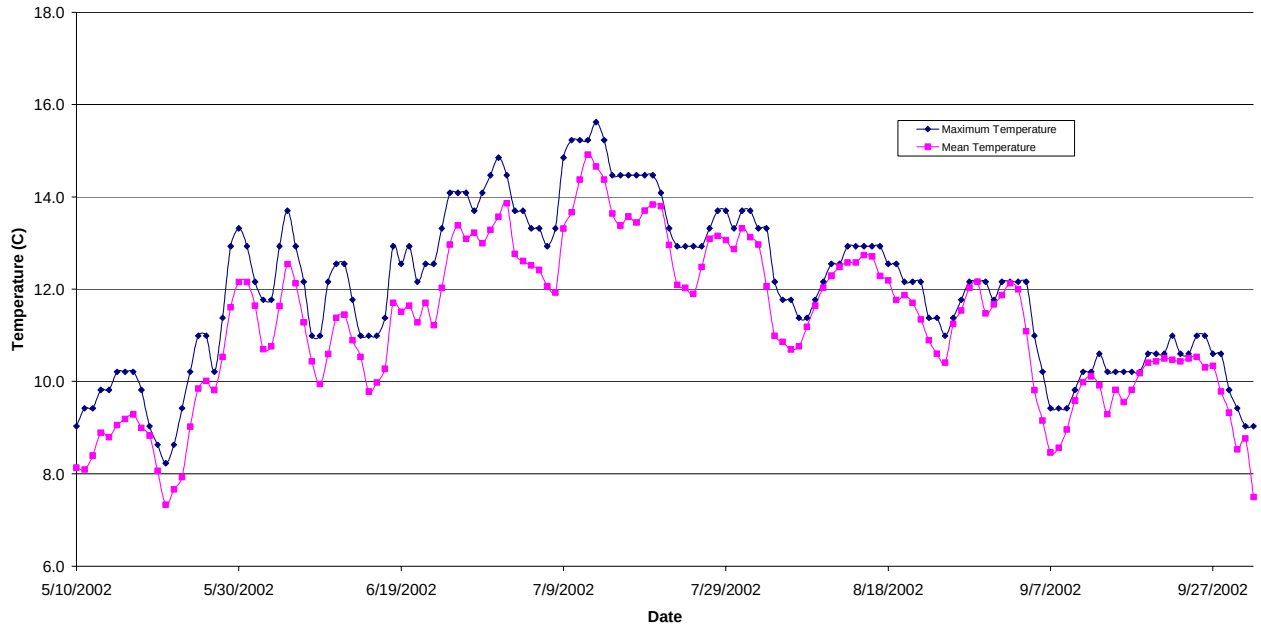


Figure T41-11. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Little Bear Wallow Creek (Site T41-11), Mendocino County, California.

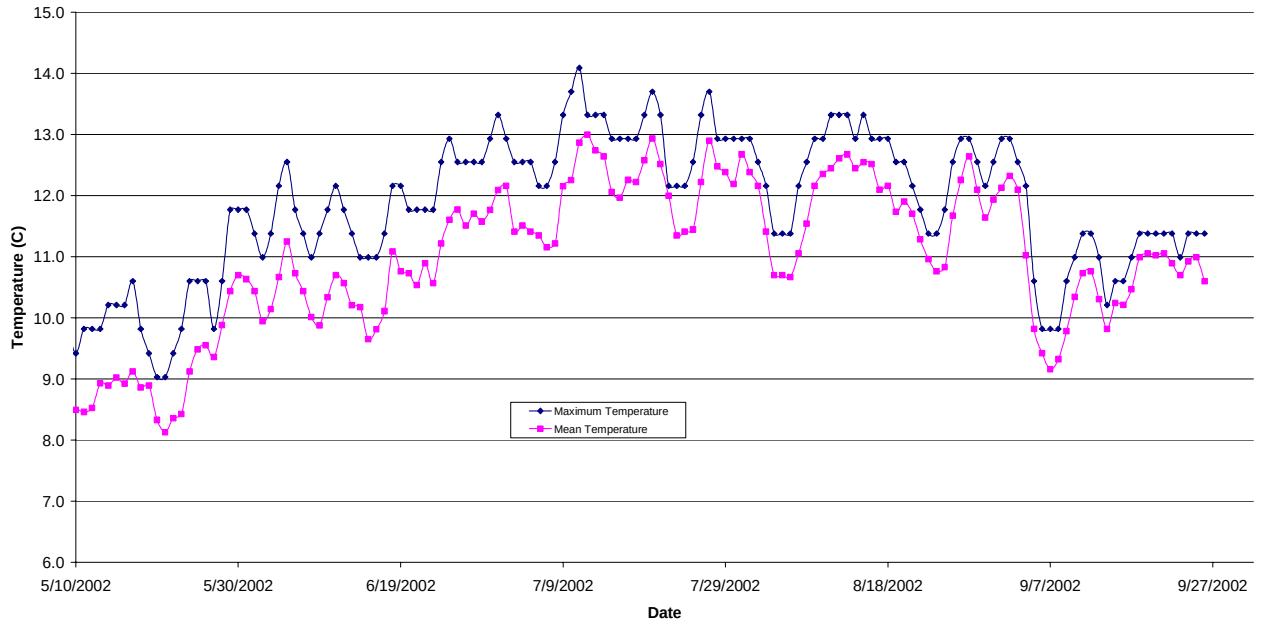
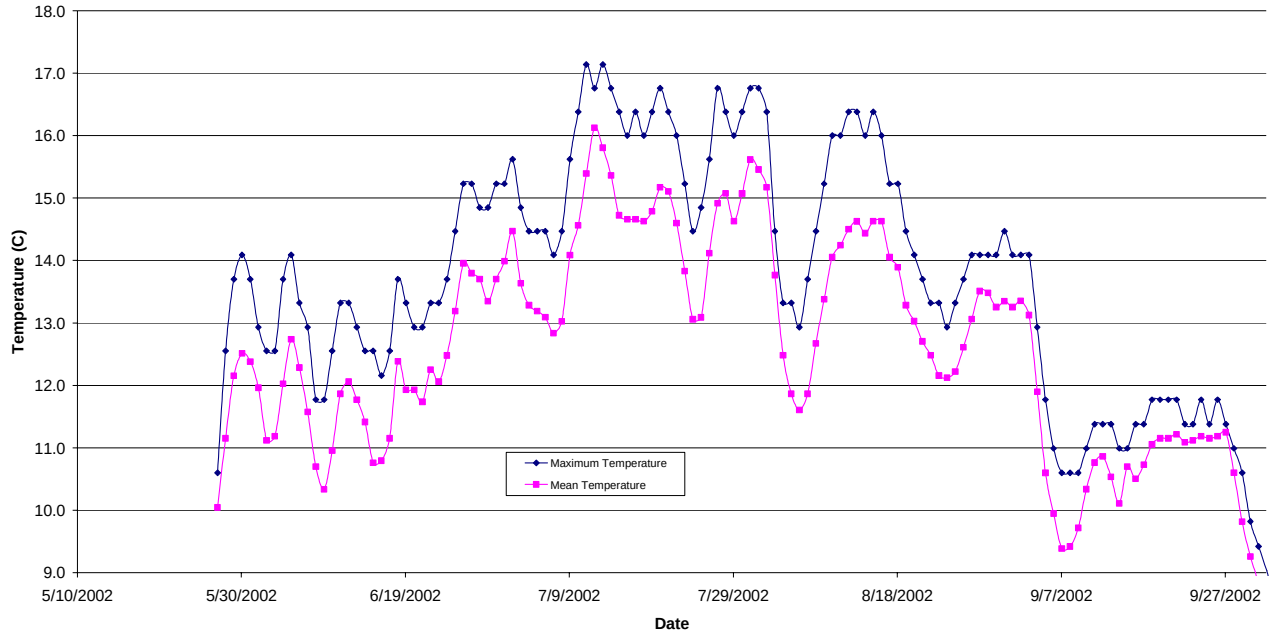
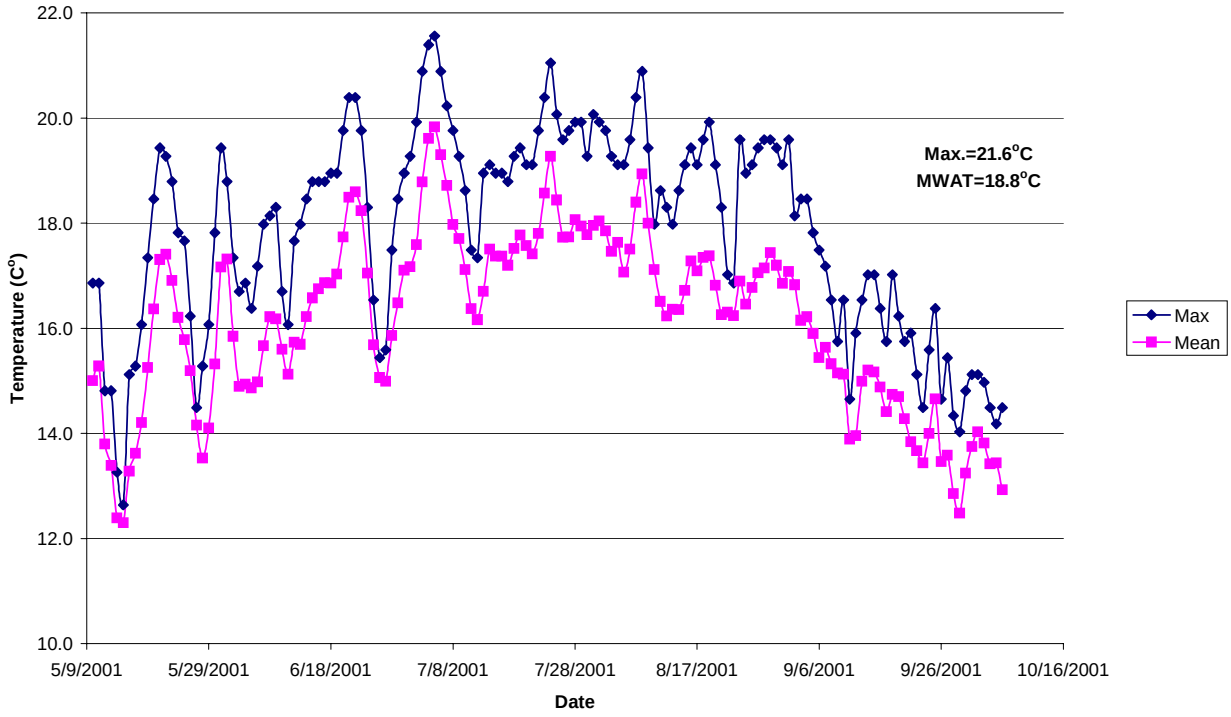


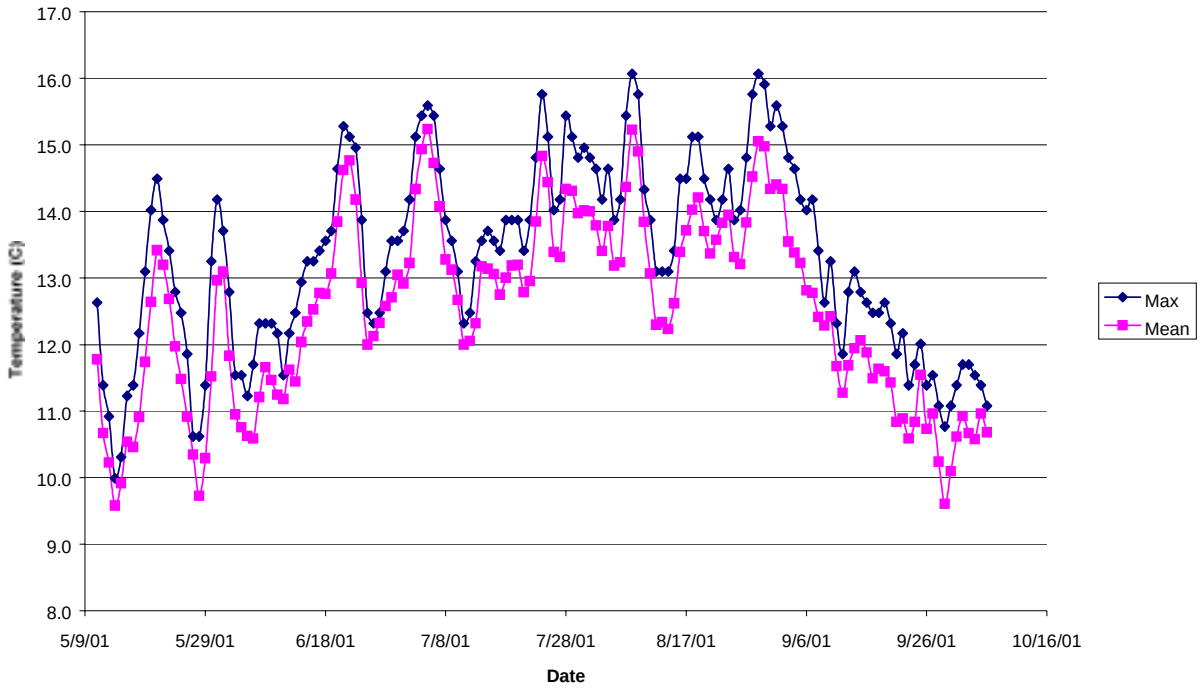
Figure T55-01. Mean and Maximum Daily Stream Temperatures During Summer 2002 at Jack O' Hearts Creek (Site T55-01), Mendocino County, California.



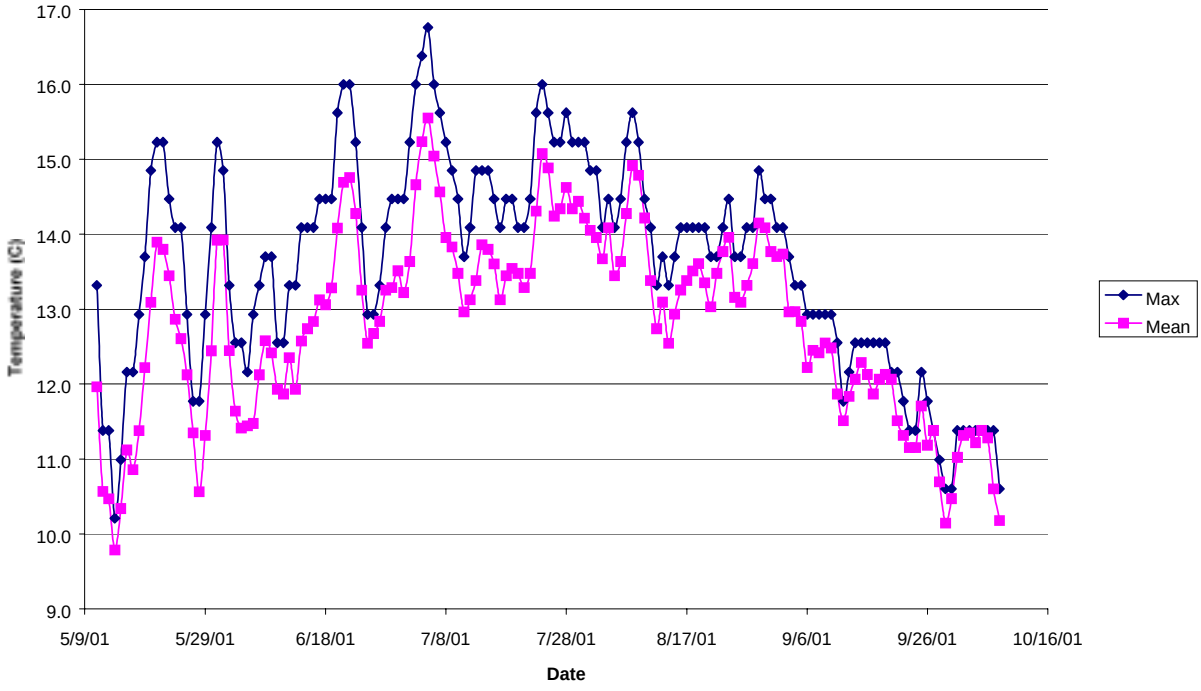
Hollow Tree Creek (41-1) @Property Line Maximum and Mean Daily Stream Temperatures During Summer 2001.



Mean and Maximum Daily Stream Temperatures During Summer 2001 at Redwood Creek (Site 41-2), Mendocino County, California.



Mean and Maximum Daily Stream Temperatures During Summer 2001 at Bond Creek (Site 41-3), Mendocino County, California.



Mean and Maximum Daily Stream Temperatures During Summer 2001 at Hollow Tree Creek (Site 41-4), Mendocino County, California.

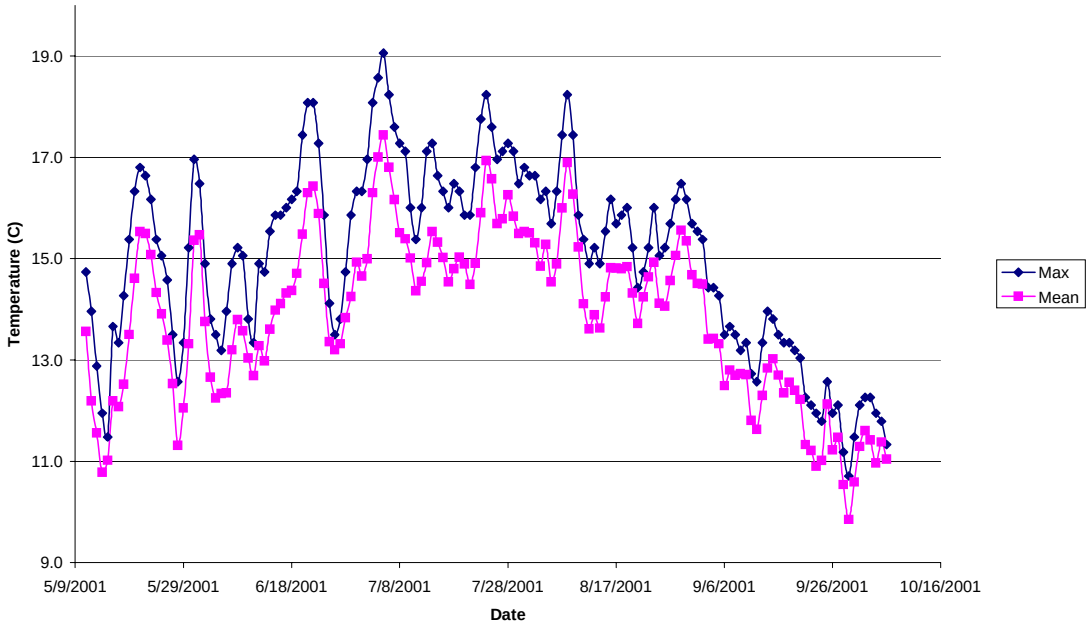


Figure 5. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Michaels Creek (Site 41-5), Mendocino County, California.

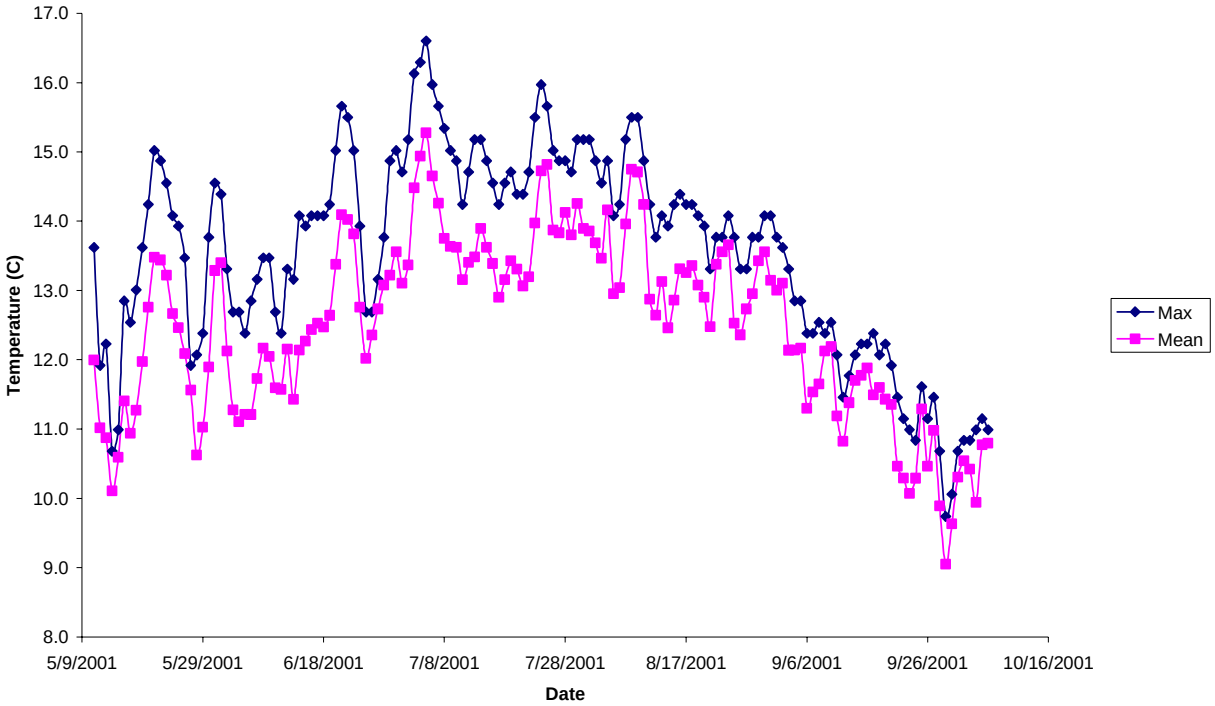


Figure 6. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Huckleberry Creek (Site 41-6), Mendocino County, California.

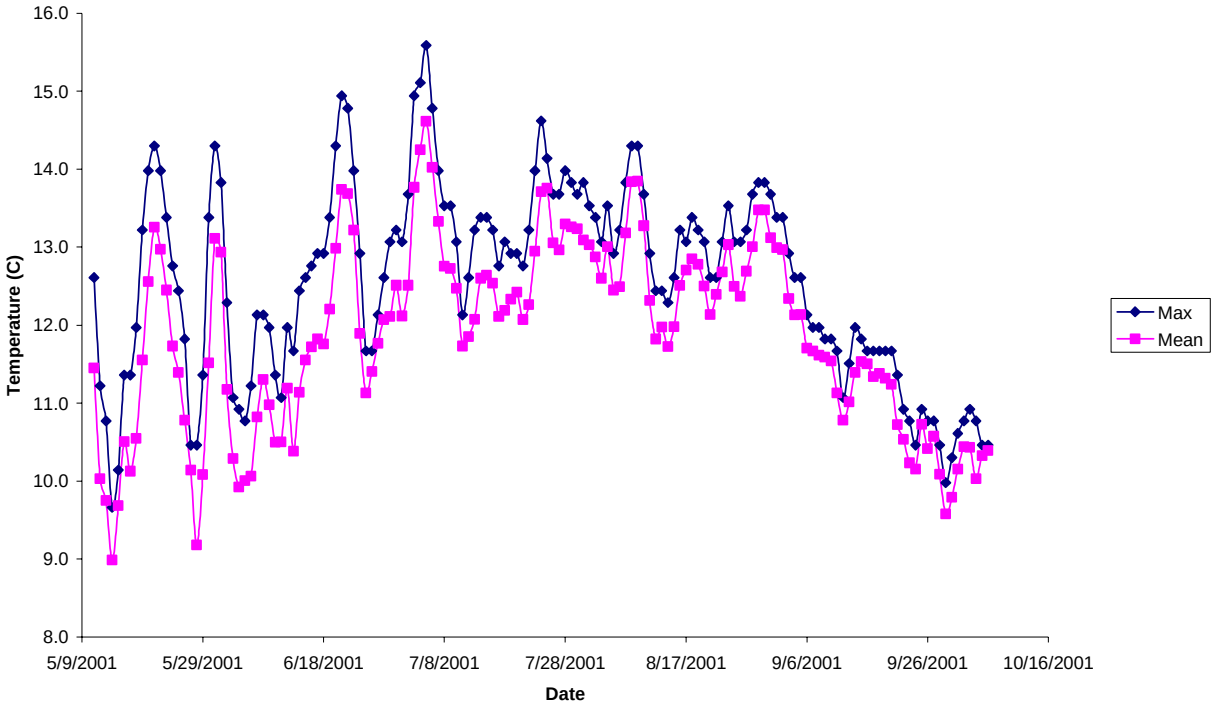


Figure 7. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Hollow Tree Creek (Site 41-7), Mendocino County, California.

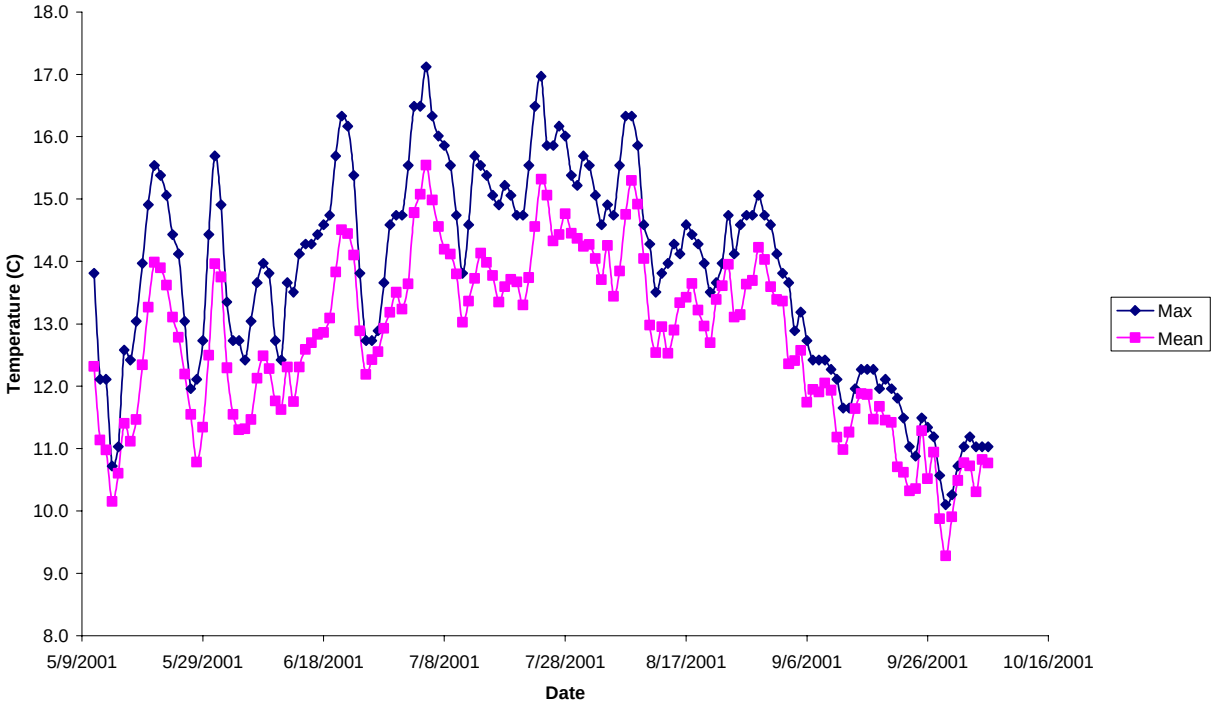


Figure 27. Mean and Maximum Daily Stream Temperatures During Summer 2001 at Jack Of Hearts Creek (Site 55-1), Mendocino County, California.

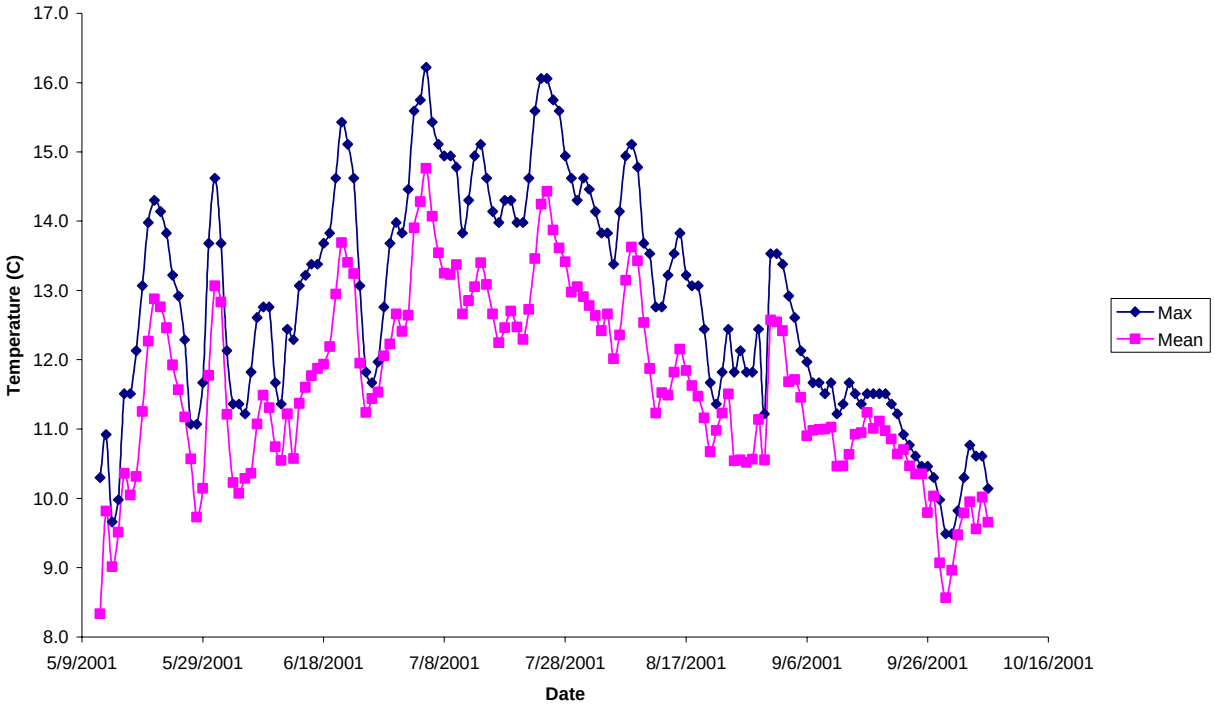


Figure 2. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Hollow Tree Creek (Site 41-1), Mendocino County, California.

Figure 4. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Redwood Creek (Site 41-2), Mendocino County, California.

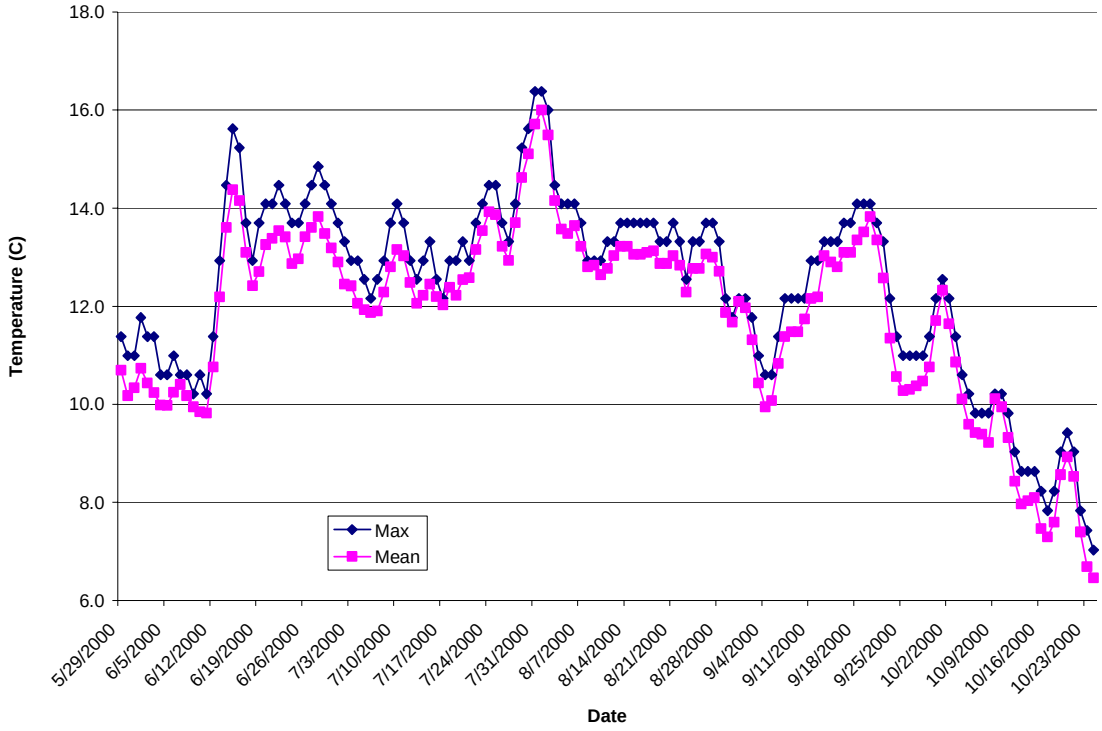


Figure 7. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Bond Creek (Site 41-3), Mendocino County, California.

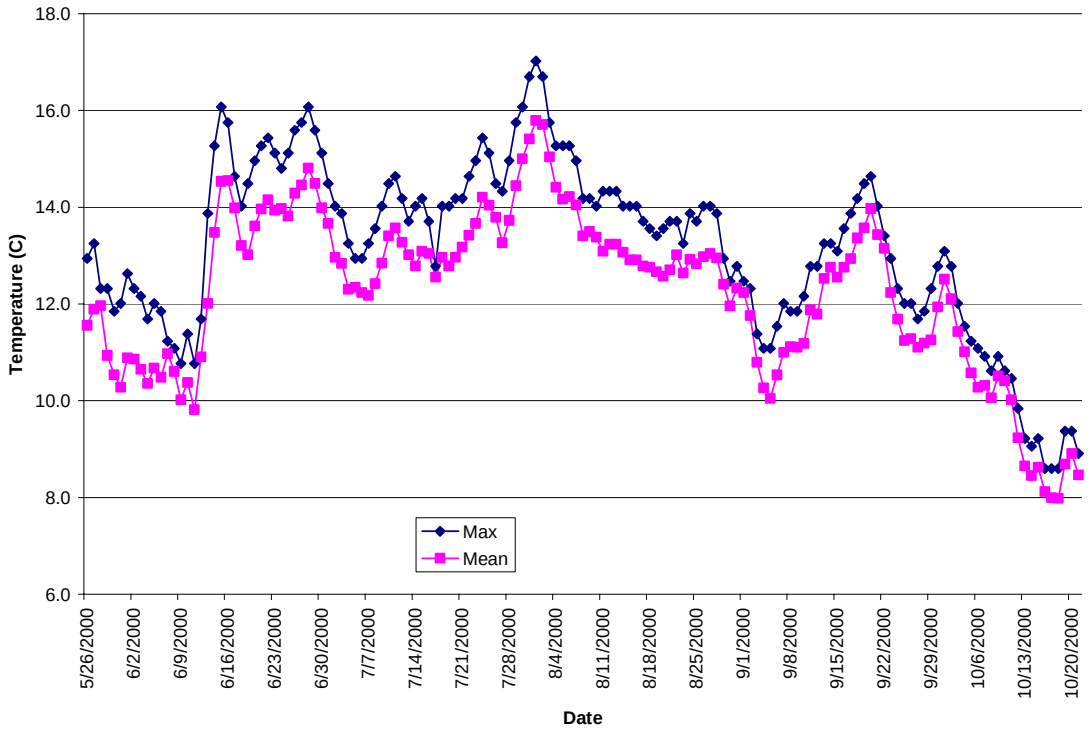


Figure 9. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Hollow Tree Creek (Site 41-4), Mendocino County, California.

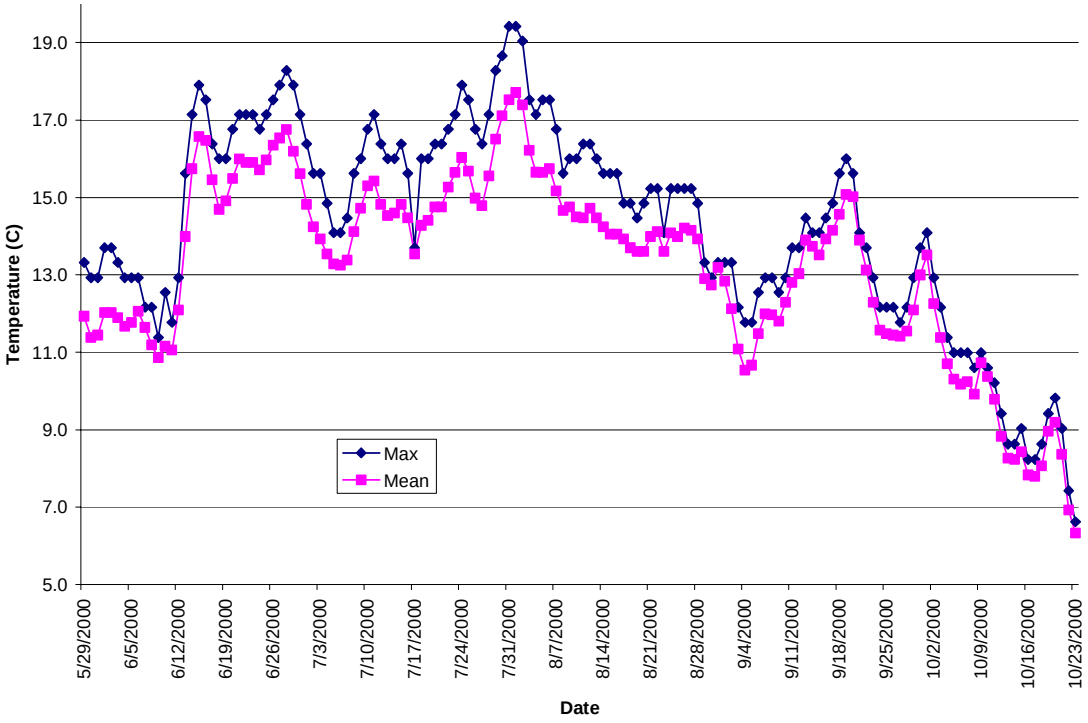


Figure 11. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Michaels Creek (Site 41-5), Mendocino County, California.

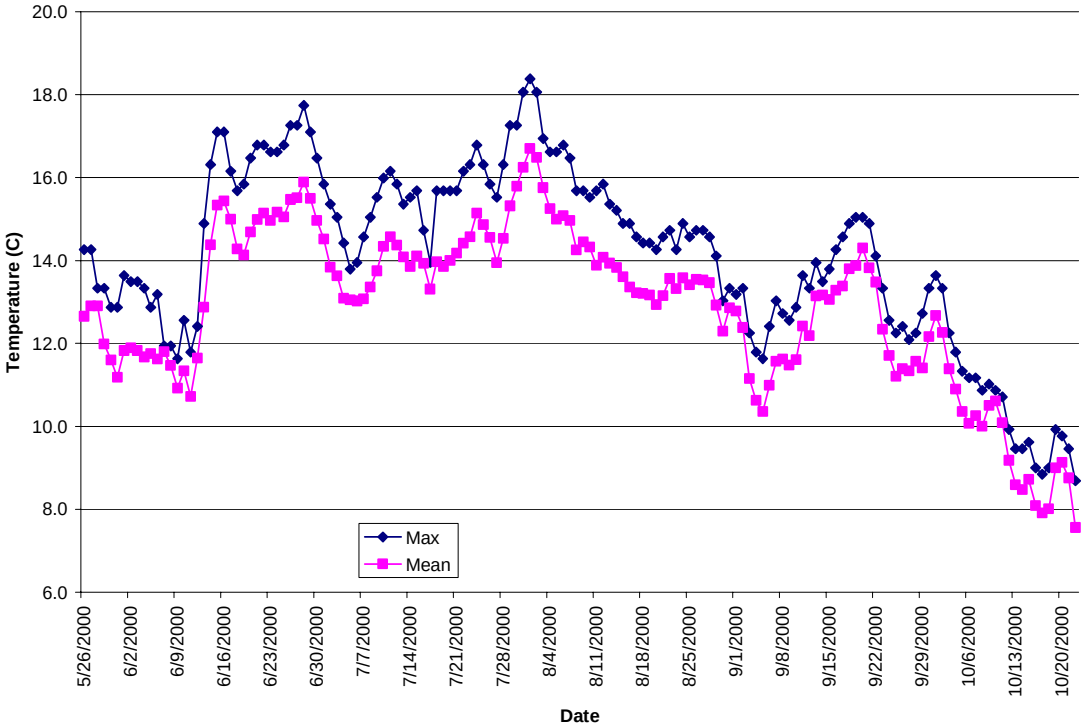


Figure 13. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Huckleberry Creek (Site 41-6), Mendocino County, California.

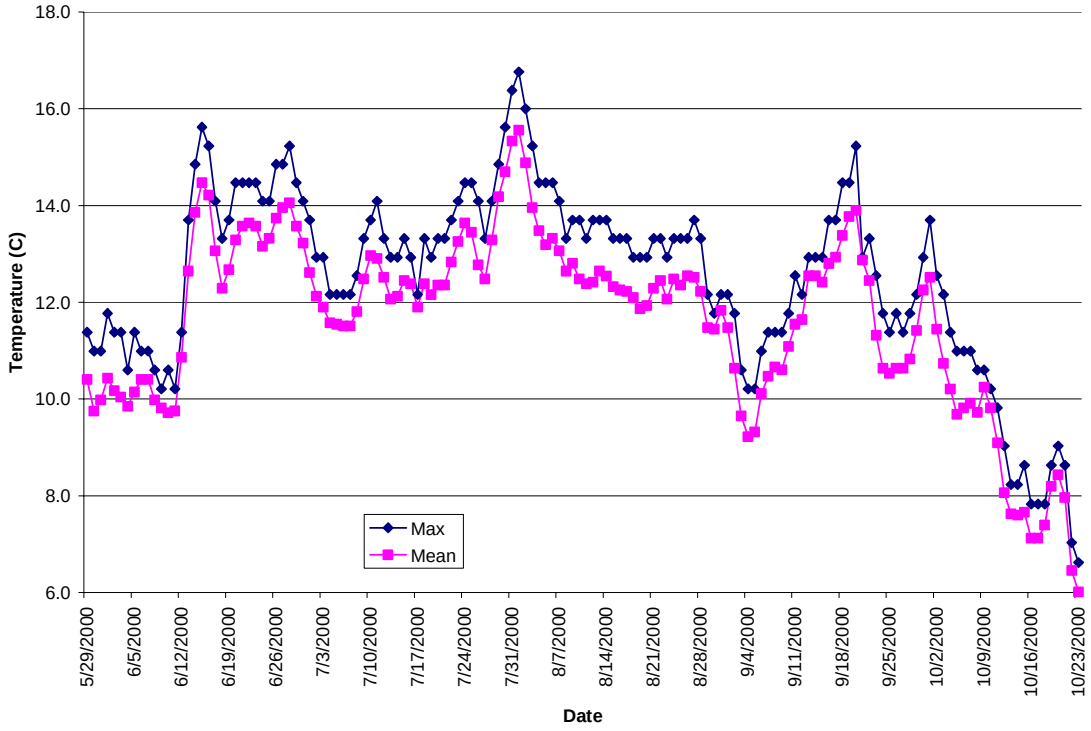


Figure 15. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Hollow Tree Creek (Site 41-7), Mendocino County, California.

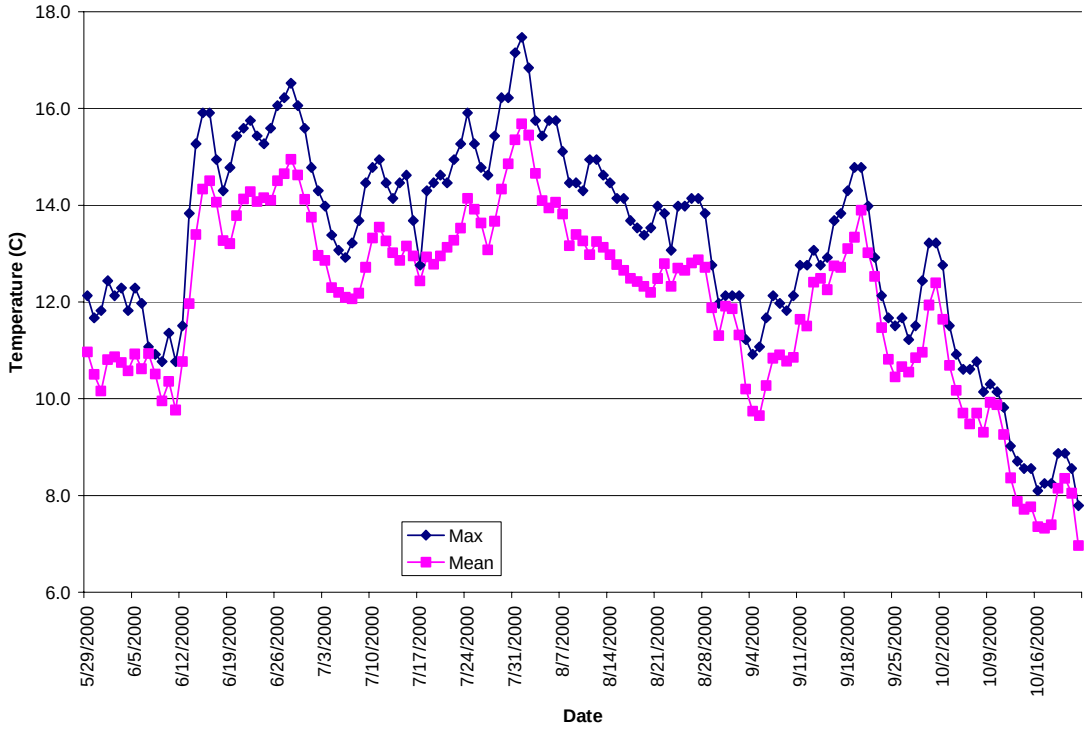


Figure 1. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Hollow Tree Creek (Site 41-1), Mendocino County, California.

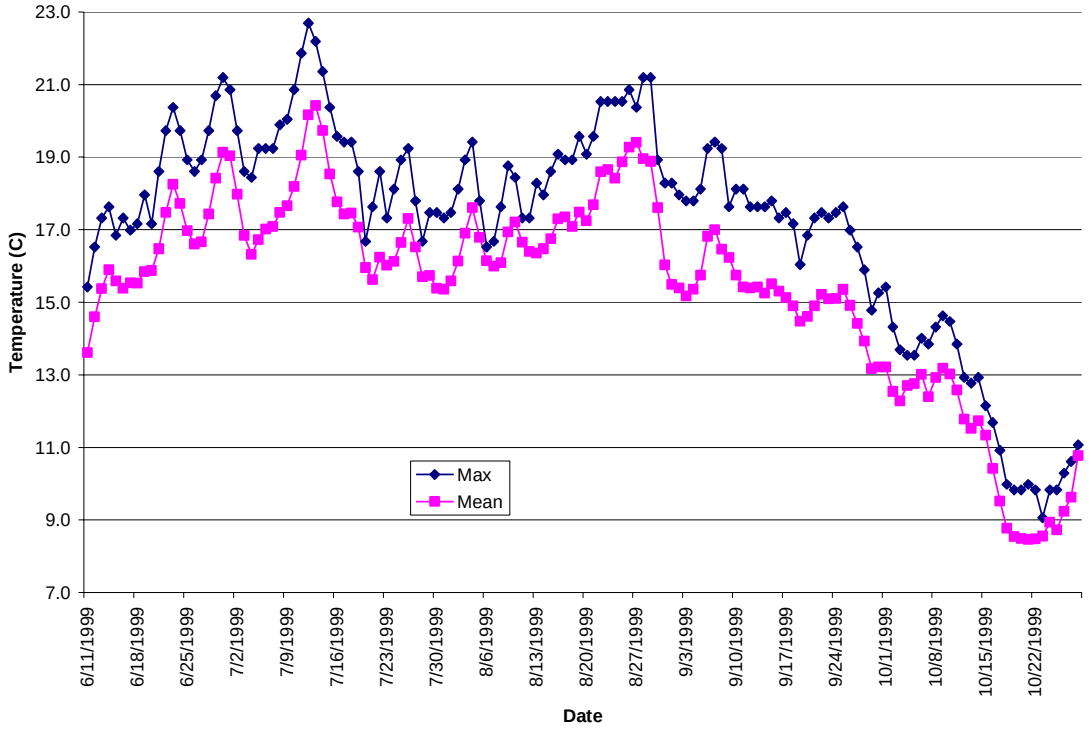


Figure 3. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Redwood Creek (Site 41-2), Mendocino County, California.

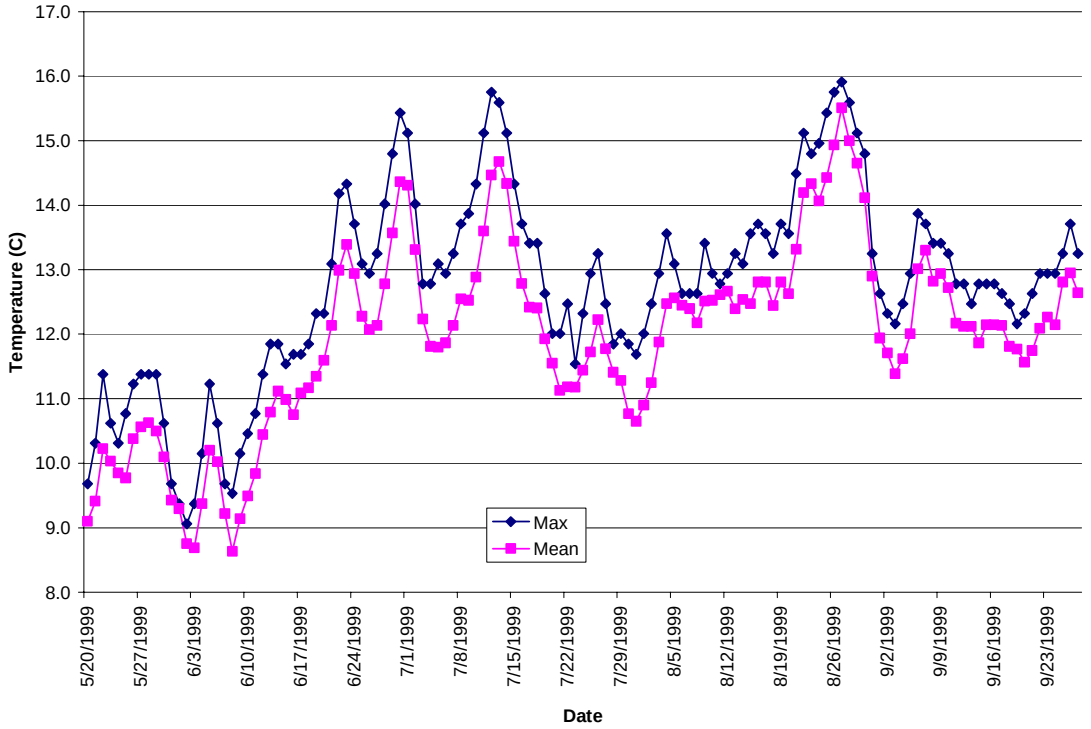


Figure 6. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Bond Creek (Site 41-3), Mendocino County, California.

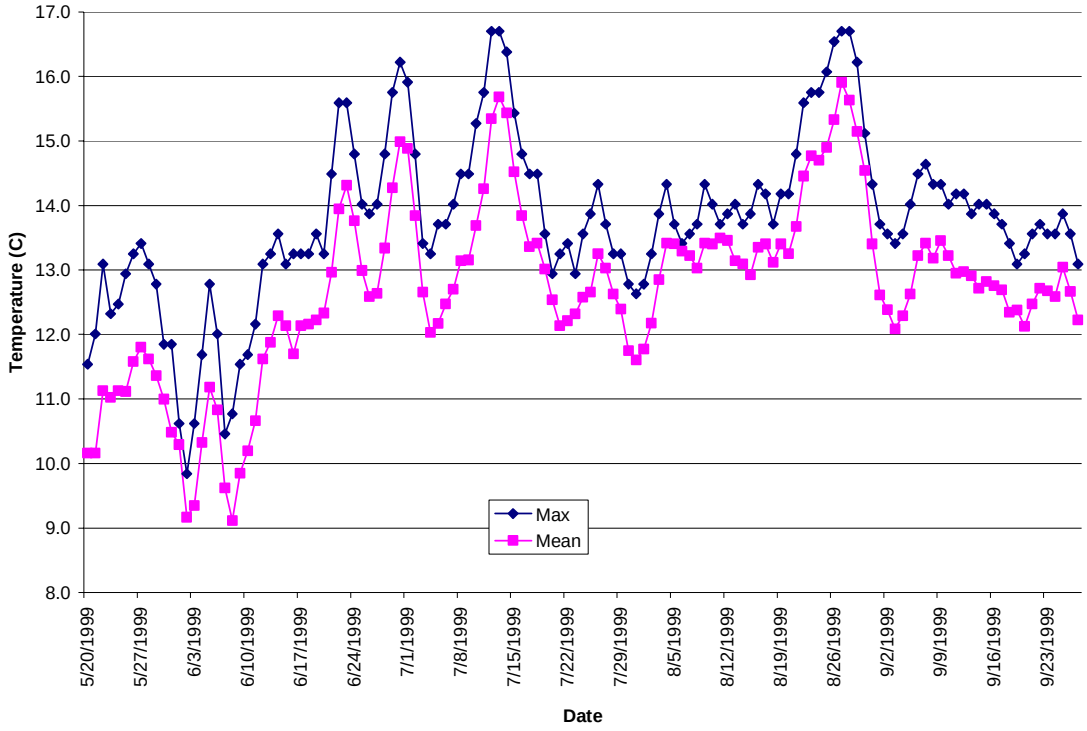


Figure 8. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Hollow Tree Creek (Site 41-4), Mendocino County, California.

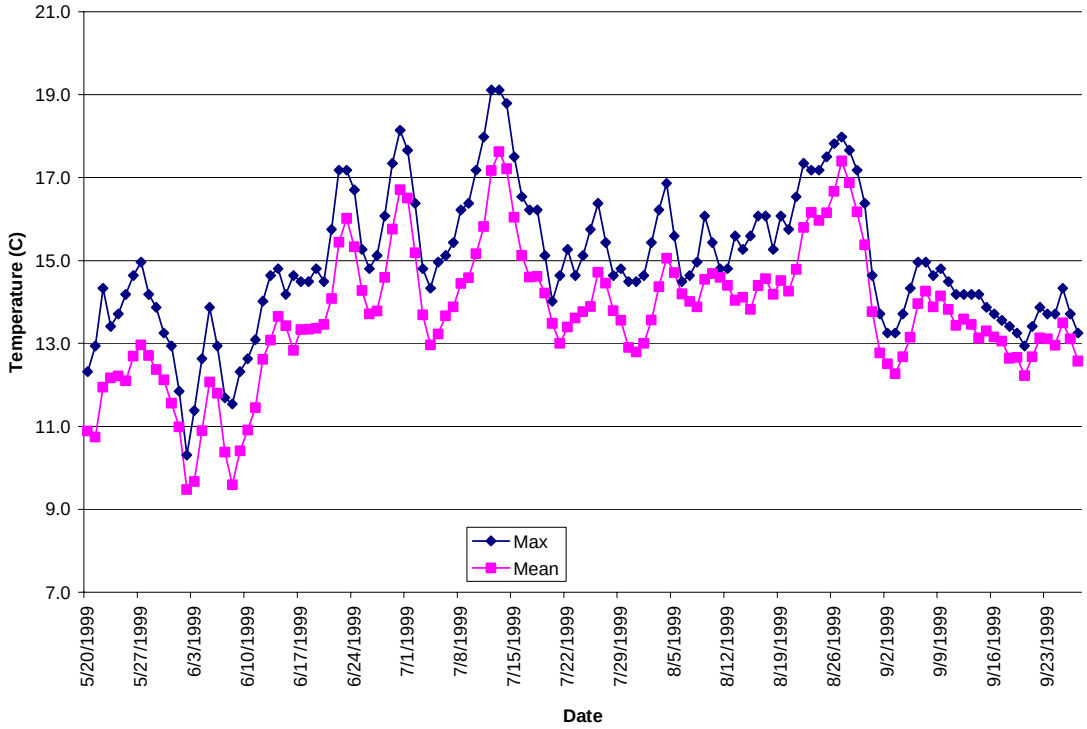


Figure 10. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Michaels Creek (Site 41-5), Mendocino County, California.

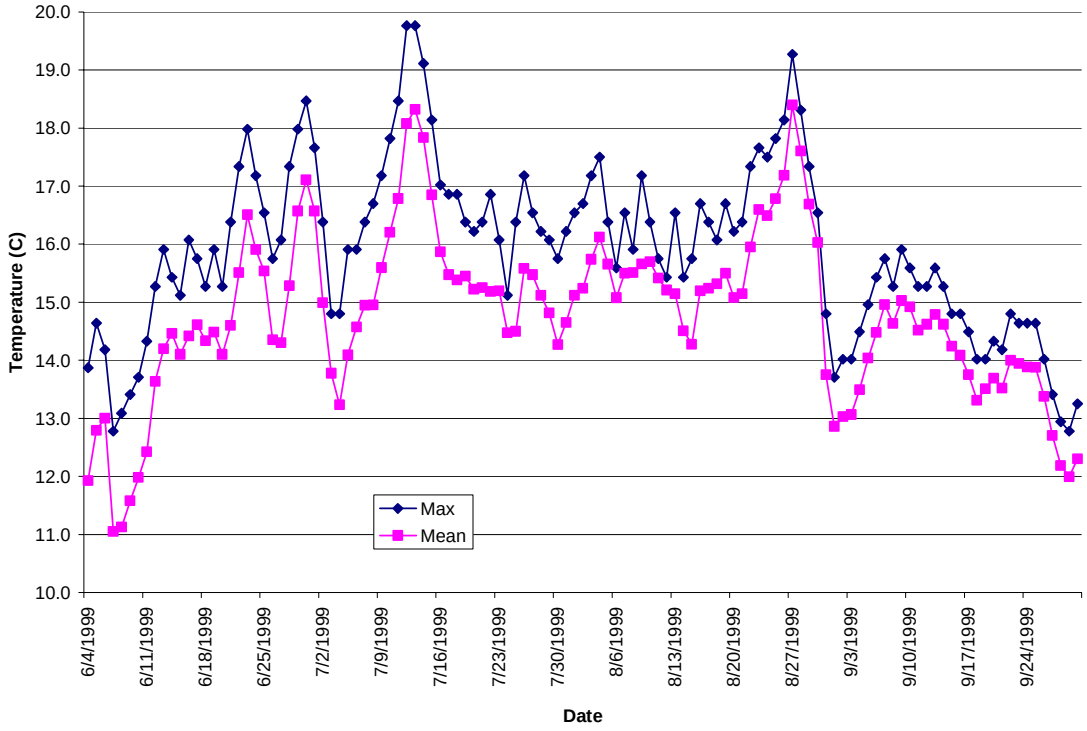


Figure 12. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Huckleberry Creek (Site 41-6), Mendocino County, California.

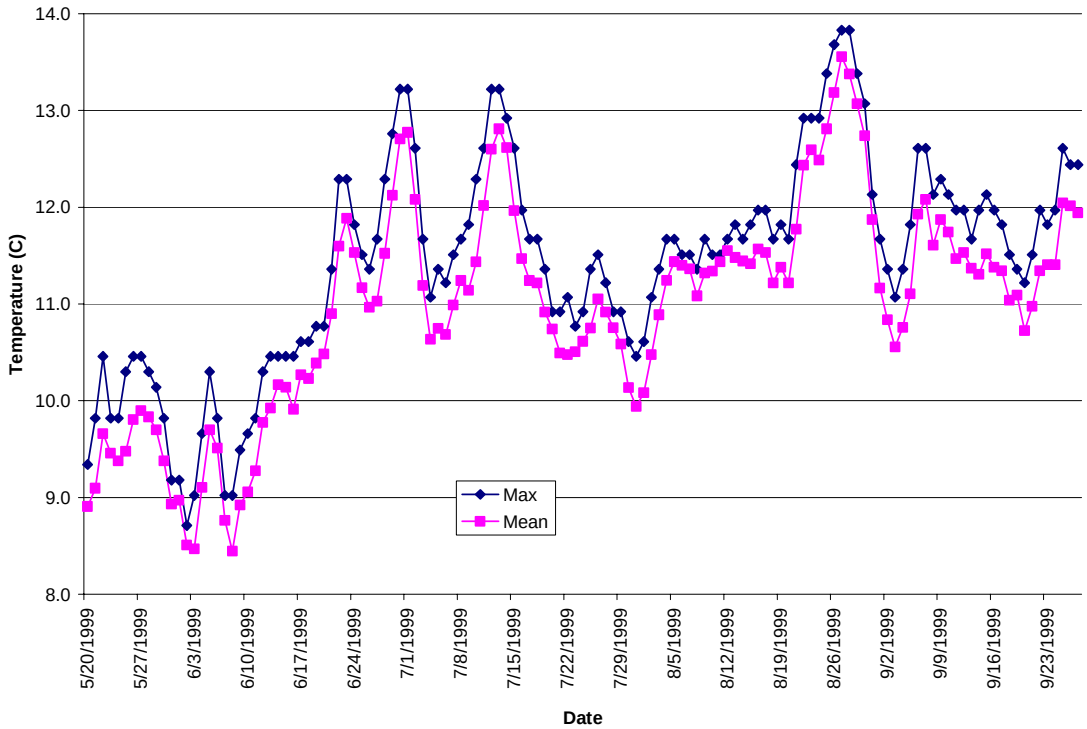


Figure 14. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Hollow Tree Creek (Site 41-7), Mendocino County, California.

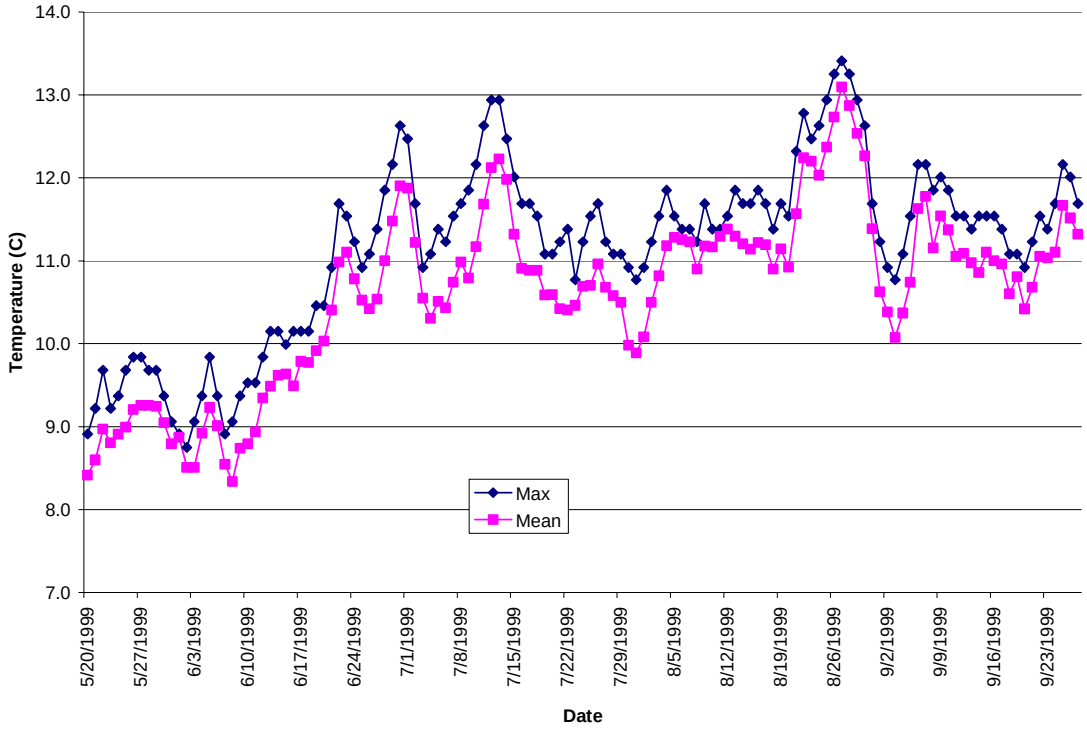


Figure 5. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Bond Creek (Site 41-3), Mendocino County, California.

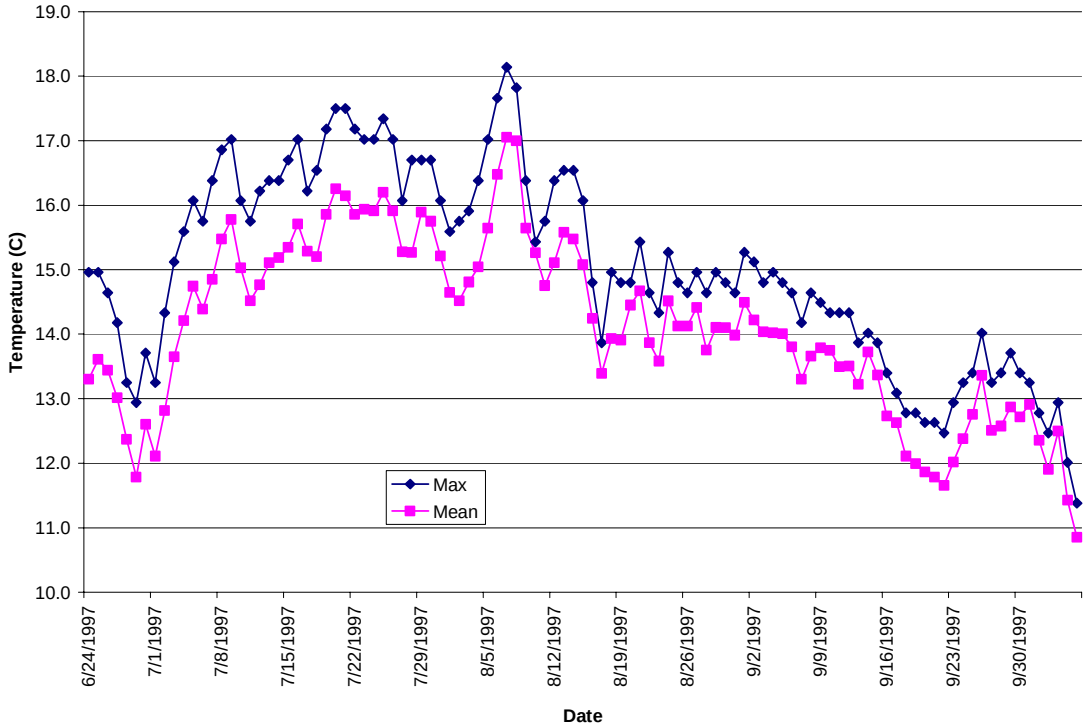


Figure 16. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Walters Creek (Site 41-8), Mendocino County, California.

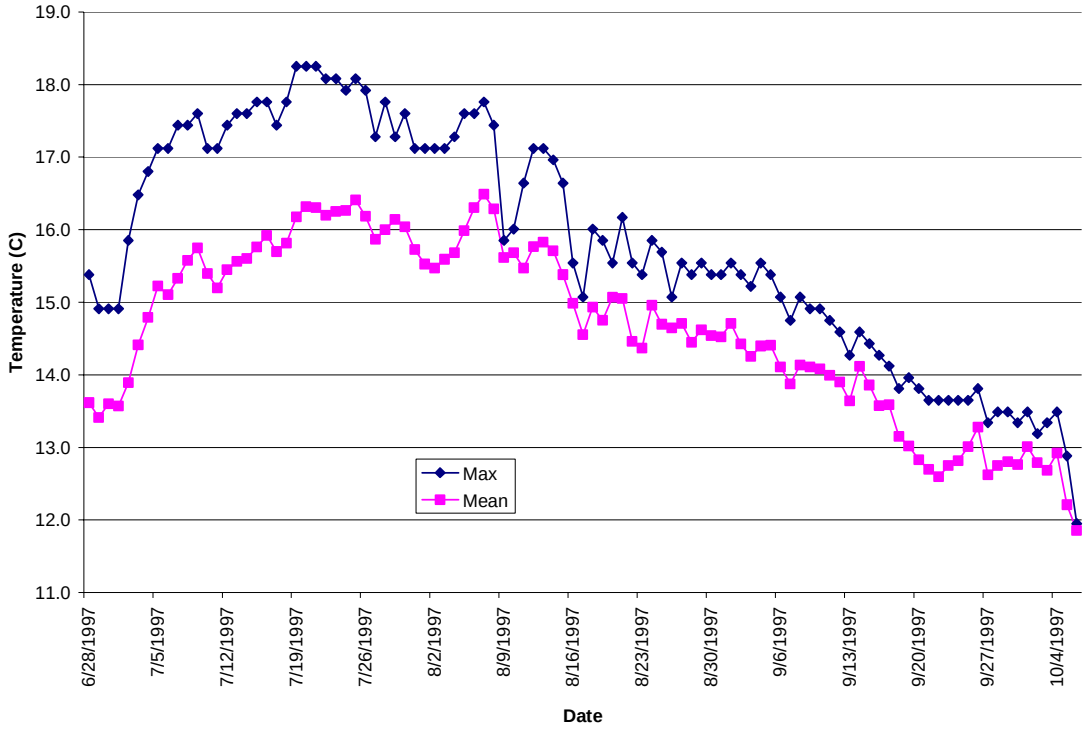


Figure 17. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Waldron Creek (Site 41-9), Mendocino County, California.

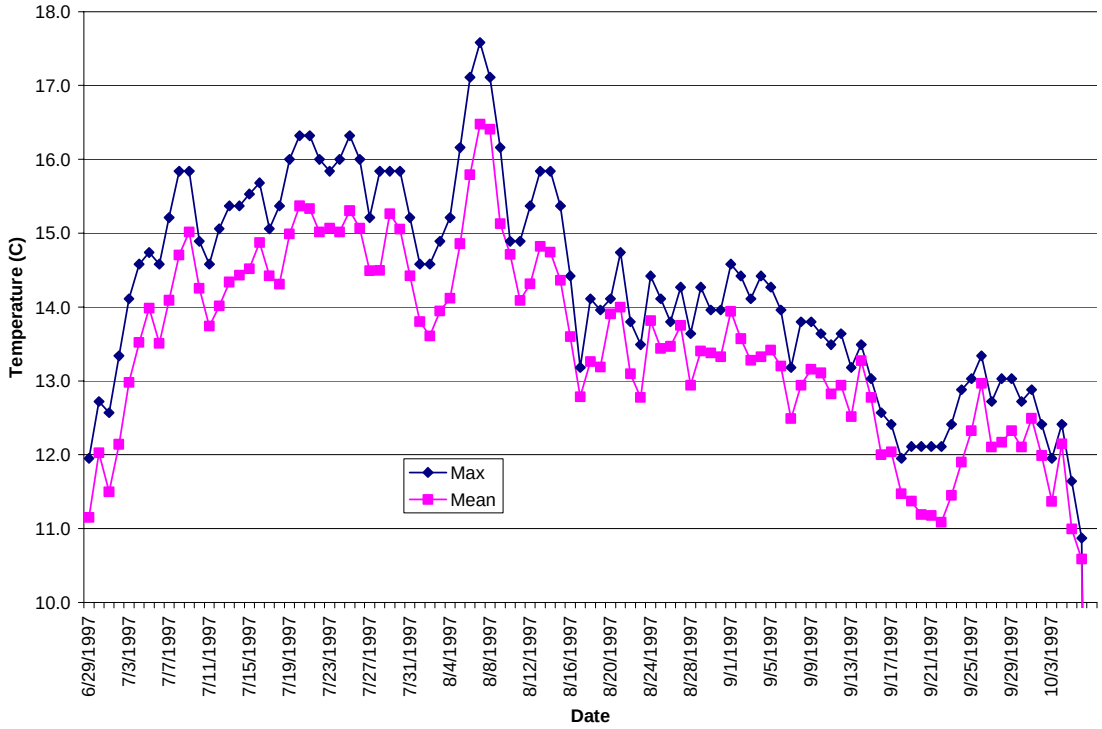


FIGURE 5. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1996) AT BOND CREEK (MAP NO. 2; MONITORING SITE NO. 41-3), MENDOCINO CO., CALIFORNIA

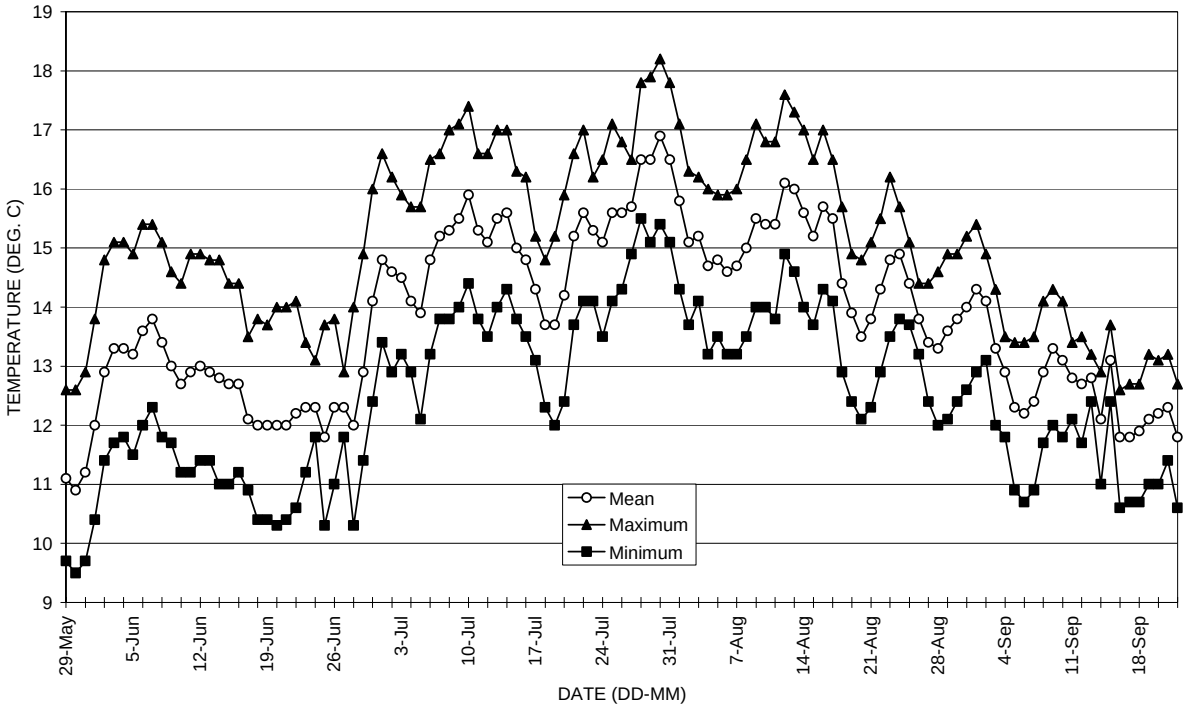


FIGURE 7. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1996) AT MICHAELS CREEK (MAP NO. 2; MONITORING SITE NO. 41-5), MENDOCINO CO., CALIFORNIA.

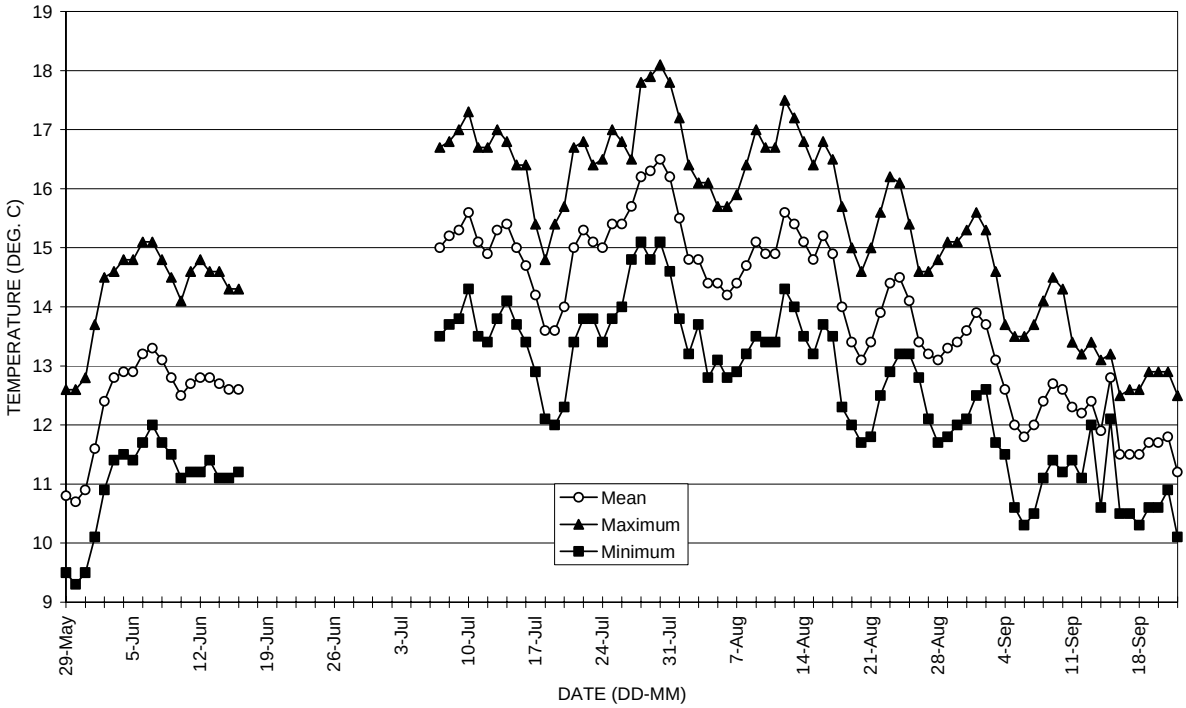


FIGURE 2. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE - SEPTEMBER 1995) AT HOLLOW TREE (MAP NO. 1; MONITORING SITE NO. 41-1), MENDOCINO CO., CALIFORNIA.

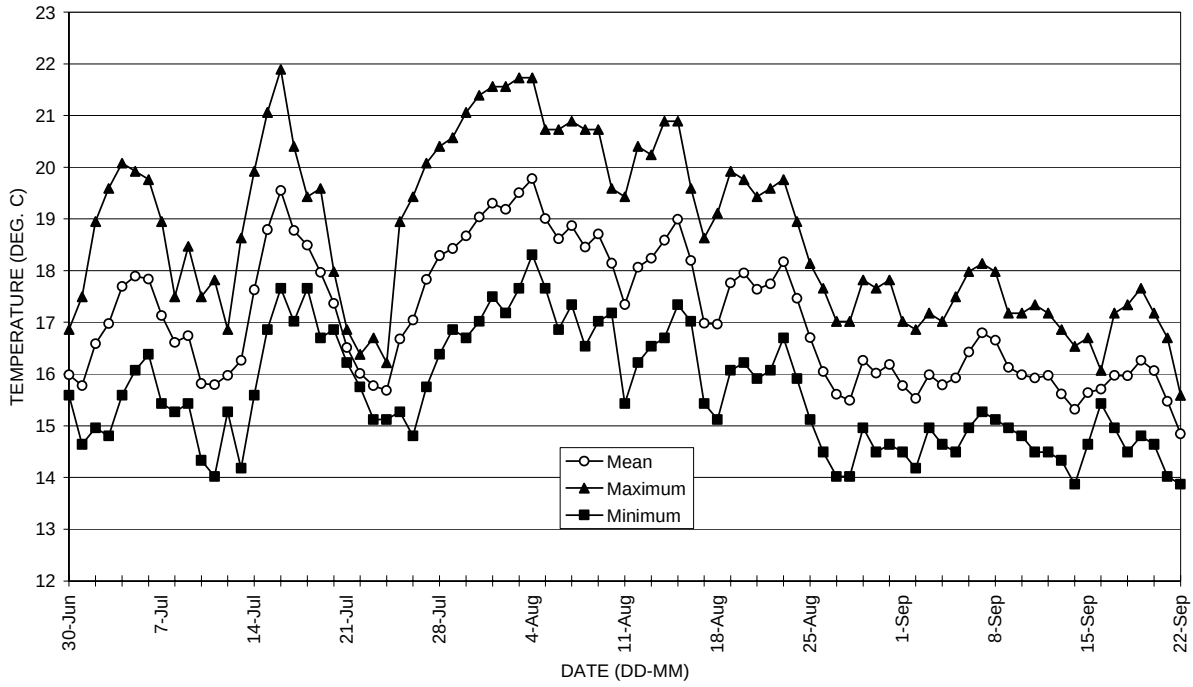


FIGURE 4. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE - SEPTEMBER 1995) AT REDWOOD CREEK (MAP NO. 2; MONITORING SITE NO. 41-2), MENDOCINO CO., CALIFORNIA.

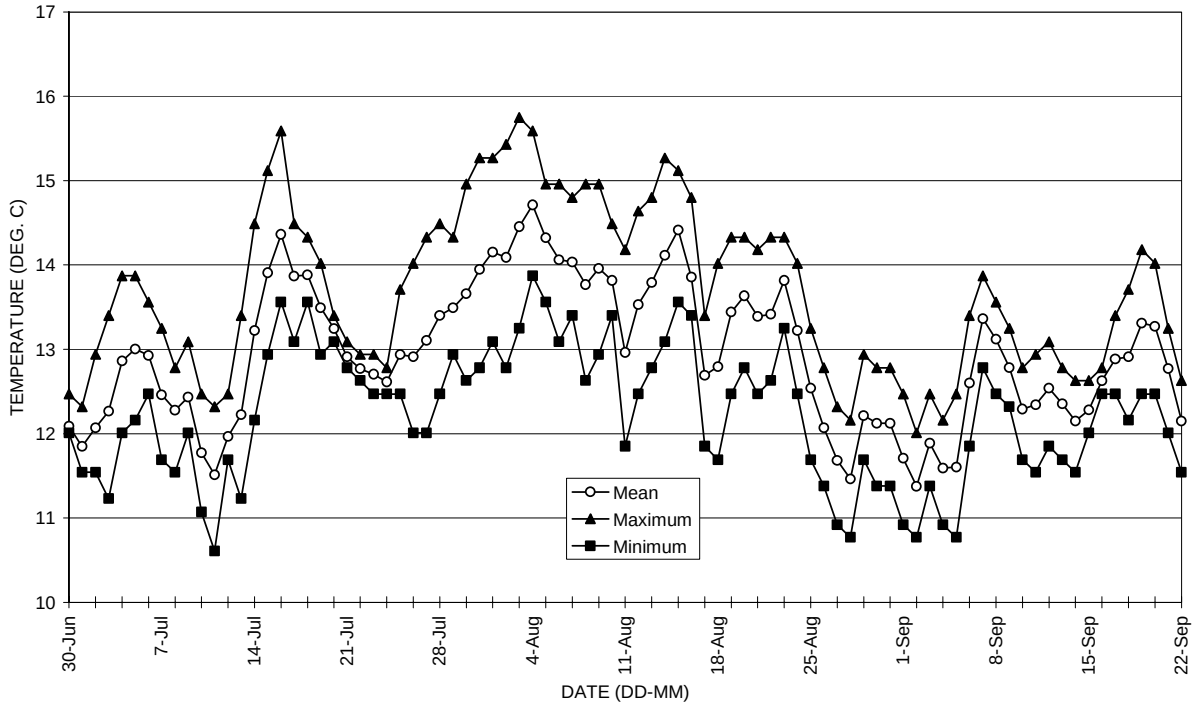


FIGURE 9. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE - SEPTEMBER 1995) AT HUCKLEBERRY CREEK (MAP NO. 2; MONITORING SITE NO. 41-6), MENDOCINO CO., CALIFORNIA.

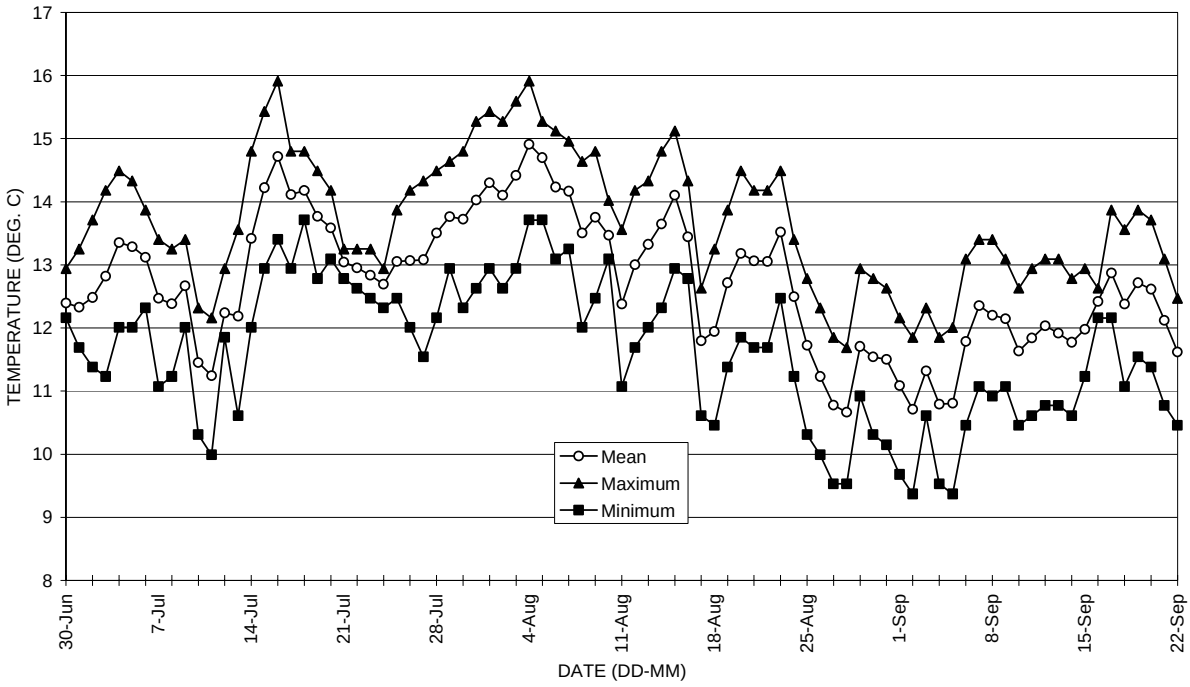


FIGURE 11. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE - SEPTEMBER 1995) AT HOLLOW TREE (MAP NO. 2; MONITORING SITE NO. 41-7), MENDOCINO CO., CALIFORNIA.

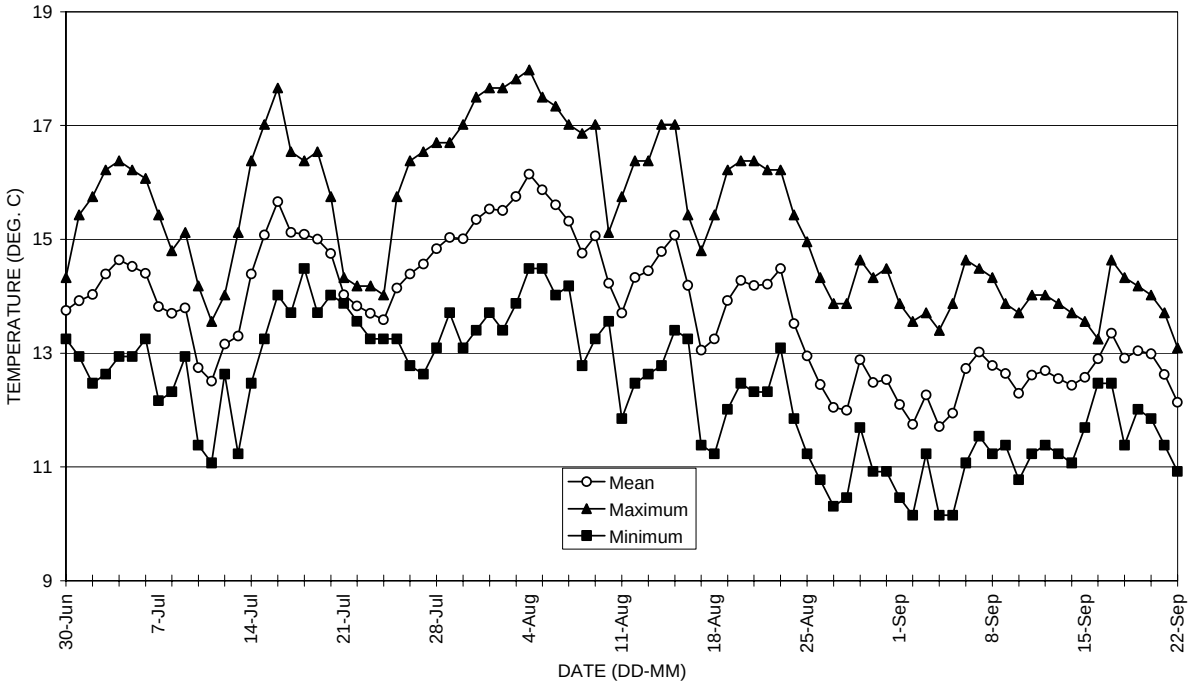


FIGURE 1. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT HOLLOW TREE (MAP NO. 1; MONITORING SITE NO. 41-1), MENDOCINO CO., CALIFORNIA.

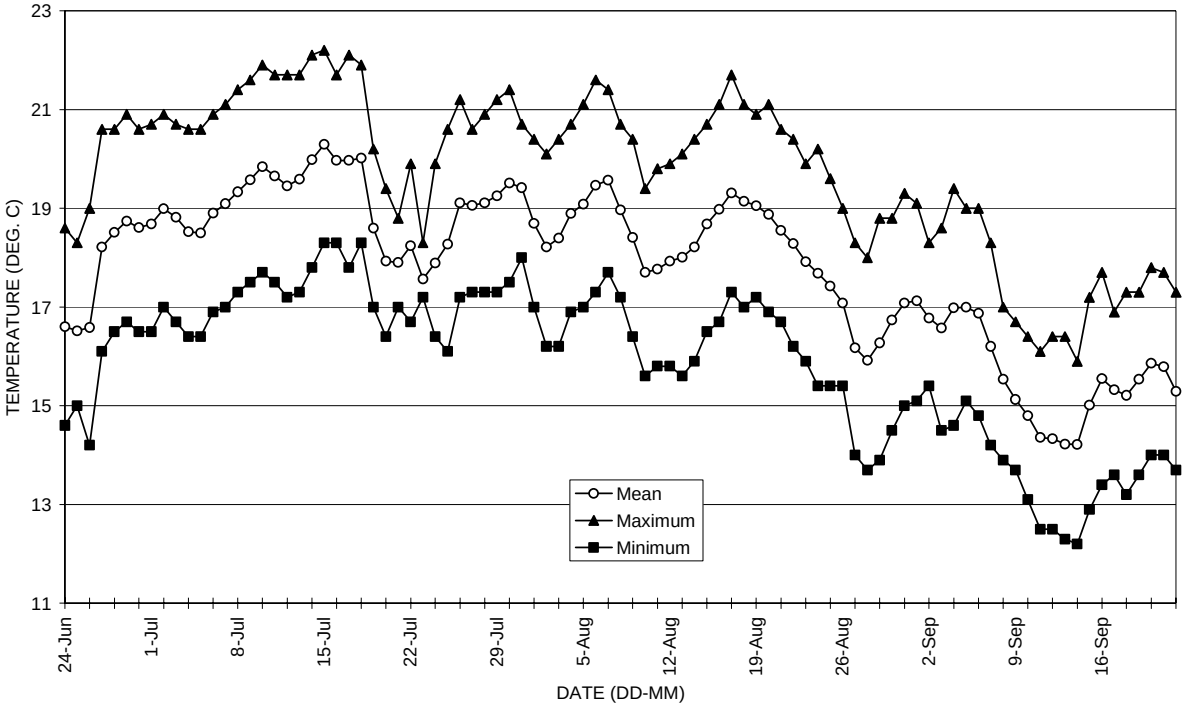


FIGURE 3. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT REDWOOD CREEK (MAP NO. 2; MONITORING SITE NO. 41-2), MENDOCINO CO., CALIFORNIA.

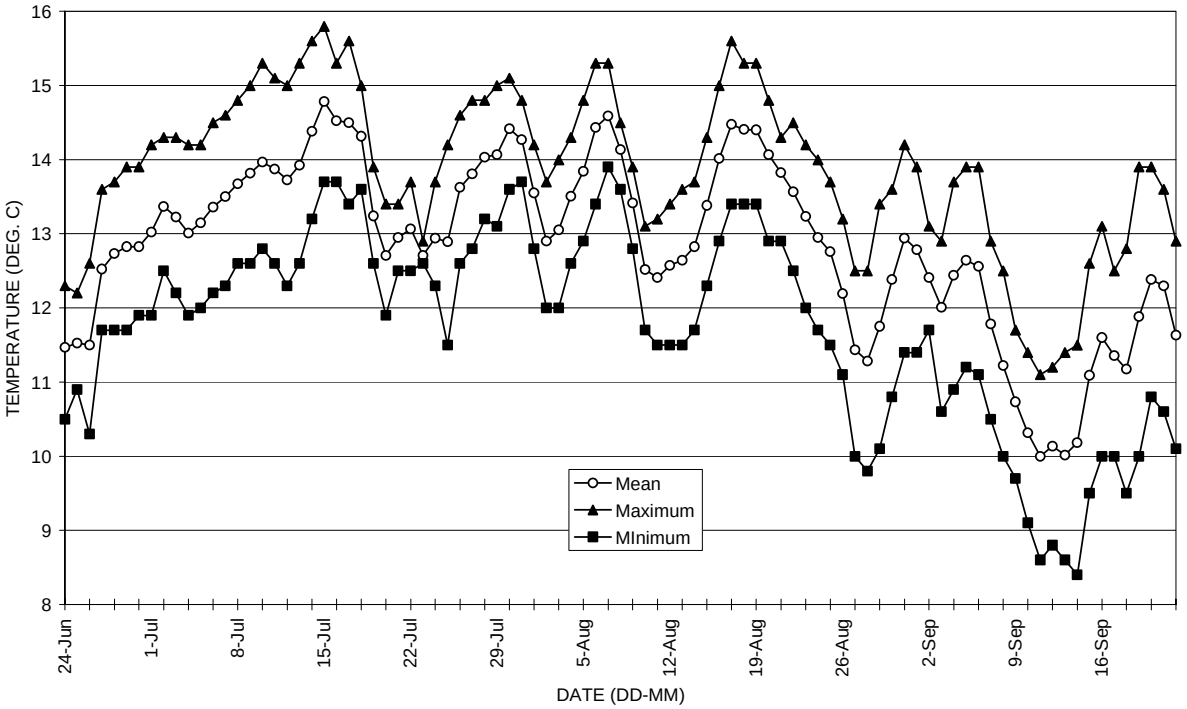


FIGURE 8. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT HUCKLEBERRY CREEK (MAP NO. 2; MONITORING SITE NO. 41-6), MENDOCINO CO., CALIFORNIA.

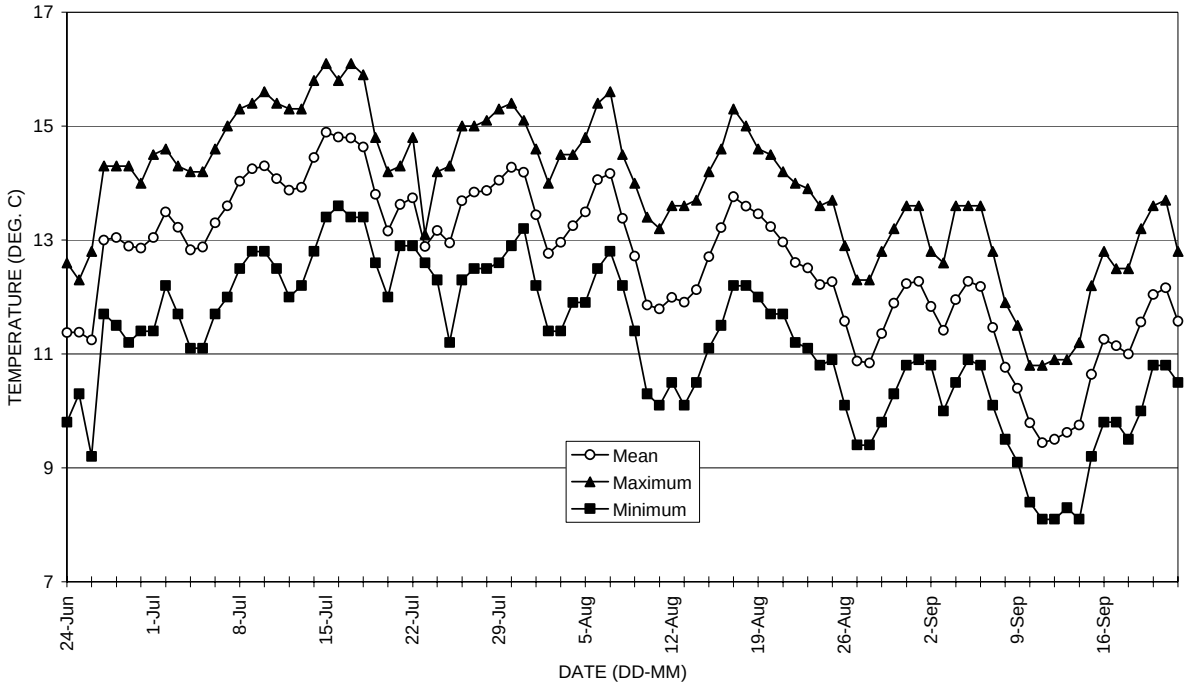


FIGURE 10. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT HOLLOW TREE (MAP NO. 2; MONITORING SITE NO. 41-7), MENDOCINO CO., CALIFORNIA.