SECTION D
RIPARIAN FUNCTION

INTRODUCTION

Mendocino Redwood Company conducted an assessment of riparian function in the Southcoast Streams Watershed Analysis Unit (WAU) during the summer of 2007. 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 evaluation. The LWD potential assessment evaluates short-term (the next two to three 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 in-stream needs. The canopy closure and stream temperature assessment presents current canopy closure conditions and how these are related to the ongoing stream temperature monitoring. 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 Southcoast Streams WAU.

Four Calwater planning watersheds (Lower Alder Creek, Mallo Pass Creek, North Fork Alder Creek and Point Arena Creek) were surveyed within the Southcoast Streams WAU. A total of 17 stream segments totaling 3.6 miles (19,182 feet) were surveyed in 2007. The planning watershed abbreviations for Lower Alder Creek, Mallo Pass Creek, North Fork Alder Creek and Point Arena Creek are CA, CM, CN and GP, respectively.

LARGE WOODY DEBRIS RECRUITMENT AND IN-STREAM DEMANDS

METHODS

Short-term LWD recruitment potential (next 20-30 years) was evaluated in designated stream segments within the Southcoast Streams 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 field observations from the summer of 2007. 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 Species 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	Less than eight inches dbh (diameter at breast height)
2	Eight to 15.9 inches dbh
3	16 to 23.9 inches dbh
4	24 to 31.9 inches dbh
5	Greater than 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-1)

Table D-1. Description of LWD Recruitment Potential Rating by Riparian Stand Classification for the Southcoast Streams 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 bankfull channel for each sampled stream segment. *Functional LWD* provides some habitat or morphologic function in the stream channel (i.e. pool formation, scour, debris dam, bank stabilization, or gravel storage) and greater than four inches in diameter and six feet in length. 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 associated with an accumulation of three pieces or more was recorded and the number of LWD accumulations in the stream survey reach was tallied.

LWD pieces were also classified into categories representing physical characteristics. 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 piece can be calculated. 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, because the dimensions and calculated volume for these pieces are not known they would represent a minimum dimension. 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 size requirements listed below in Table D-2.

Table D-2. Key LWD Piece Size Requirements (adapted from Bilby and Ward, 1989)

Bankfull width (ft.)	Diameter (in.)	Length (ft.)		Minimum volume alternative* (yds^3)
0-10	13	1 or 1.5 times bankfull width**	OR	1
10-20	16	1 or 1.5 times bankfull width**		3
20-30	18	1 or 1.5 times bankfull width**		5
30-40	21	1 or 1.5 times bankfull width**		8
40-60	26	1 or 1.5 times bankfull width**		15
60-80	31	1 or 1.5 times bankfull width**		25
80-100	36	1 or 1.5 times bankfull width**		34

* A piece of LWD counts as a "key piece" if it does not meet the diameter and length criteria but exceeds this minimum volume.
** 1.0 times bankfull width if a rootwad is attached, 1.5 times bankfull width if not.

Debris jams (>10 pieces) were noted and total dimensions of the jam recorded. A correction factor is used to account for the void space within debris jams. Total number of pieces and number of key pieces were noted. Species and dimensions were not recorded 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 which 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 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 is derived from Bilby and Ward (1989) and Gregory and Davis (1992) and presented in Table D-3.

Table D-3. Target for Number of Key Large Woody Debris Pieces in Watercourses of the WAU.

Bankfull width	**Number of Key Pieces**		
	Per 328 feet (100 m)	**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, as 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 Southcoast Streams 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-4 shows how these three factors are used to determine the in-stream LWD demand.

Table D-4. In-stream LWD Demand

Channel LWD Sensitivity Rating

Recruitment Potential Rating

In-channel LWD On Target **In-channel LWD Off Target**	**LOW**	**MODERATE**	**HIGH**
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	Over 80% of surveyed segments by length have low or moderate LWD demand
MARGINAL	50-80% of surveyed segments by length have low or moderate LWD demand OR over 80% of stream segments have at least half of the target key LWD pieces desired.
DEFICIENT	Less than 50% of surveyed segments by length have low or moderate LWD demand, and low numbers of 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 then a LWD deficiency is assumed.

We consider key LWD for determination of both in-stream 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 AND IN-STREAM DEMANDS

RESULTS

The large woody debris recruitment potential and in-stream LWD demand for the Southcoast Streams 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 show in Table D-5 a, b, and c. The majority (69%) of the stream segments in the Southcoast Streams WAU had a high LWD demand (see Map D-1).

Debris jams were not abundant throughout Southcoast Streams (average of 14% of the total volume of large woody debris consisted of debris jams) but they did play a significant role in determining whether or not a stream segment exceeded the key piece target. Only 25% (4/16) of the segments in Southcoast Streams met the key piece target when debris jams were not included, but this drops to 0% if debris jams are not included in the calculation.

LWD species composition was largely redwood dominated (Table D-5b) with a WAU-wide average of 74% of the total volume in each segment. This analysis was limited to pieces not contained within debris jams. Fir species averaged 5% and hardwoods (including alders) constituted roughly 20% of the average volume in Southcoast Streams.

The majority of the segments (93%) in the Southcoast Streams WAU contained LWD that was not recently contributed to the stream. Only one segment contained a majority of LWD that was contributed within the past ten years. This may be a result of past riparian harvest or natural stand types. Needles to say, more LWD must be contributed to the stream channel in future years.

As shown in tables D-5 a, b and c, there is a need for large woody debris in most of the channel segments of the Southcoast Streams 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 recruitment potential in the Southcoast Streams WAU is marginal (see Map D-1). Roughly 50% of the segments observed had a low recruitment potential and the remaining were rated as moderate (see Table D-1 for clarification). No segments were rated as having a high recruitment potential. The low recruitment potential throughout the Southcoast Streams WAU is most likely due to past riparian harvest practices. As much as possible, these types of areas will have to be managed to attempt to provide for future stream LWD and habitat.

Table D-5 (a). Large Woody Debris Pieces

Stream Segment Name	ID	Functional LWD Pieces w/o Debris Jams	Functional LWD Pieces w/ Debris Jams	Number Debris Jams	Number Debris Accum.	Functional LWD (#/100m) w/o Debris Jams	Function-al LWD (#/100m) w/ Debris Jams	Key LWD w/o Debris Jams	Key LWD with Debris Jams	Key LWD /100m w/o Debris Jams	Key LWD /100m w/Debris Jams
Lower Alder Creek	CA03	8	8	0	0	1.7	1.7	0	0	0.0	0.0
Lower Alder Creek	CA05	19	19	0	0	4.2	4.2	0	0	0.0	0.0
Lower Alder Creek	CA08	5	5	0	0	1.4	1.4	0	0	0.0	0.0
Lower Alder Creek	CA10	6	6	0	0	2.0	2.0	0	0	0.0	0.0
Lower Alder Creek	CA12	14	14	0	6	2.7	2.7	3	3	0.6	0.6
Lower Alder Creek	CA14	35	35	0	8	7.2	7.2	0	0	0.0	0.0
Lower Alder Creek	CA17	17	17	0	5	5.6	5.6	2	2	0.7	0.7
Lower Alder Creek	CA21	34	64	2	2	11.5	21.6	3	6	1.0	2.0
Lower Alder Creek	CA30	10	25	1	8	3.0	7.5	6	7	1.8	1.8
Lower Alder Creek	CA34	30	40	1	8	10.4	13.8	0	2	0.0	0.7
Mallo Pass Creek	CM03	41	72	2	13	14.9	26.2	5	8	1.8	2.9
Mallo Pass Creek	CM05	61	156	5	25	16.7	42.7	9	34	2.5	9.3
Mallo Pass Creek	CM06	65	65	0	17	22.4	22.4	10	10	3.5	3.5
NF Alder Creek	CN01	14	14	0	3	5.1	5.1	2	2	0.7	0.7
NF Alder Creek	CN02	11	11	0	0	3.0	3.0	3	3	0.8	0.8
NF Alder Creek	CN03	2	2	0	0	0.7	0.7	1	1	0.4	0.4
Point Arena Creek	GP01	35	80	1	16	18.5	42.3	4	16	2.1	8.5

Table D-5 (b). Large Woody Debris Volume in Select Stream Segments of the Southcoast Streams 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	% of Total Volume in Debris Jams	% of Vol in Key Pieces w/o Jams	% of Total Volume By Species w/o Jams					% Current Recruitment (<10 yrs)
								RW	Fir	Alder	HW	Unk	
Lower Alder Creek	CA03	30	30	7	7	0%	0%	57%	0%	43%	0%	0%	25-50%
Lower Alder Creek	CA05	37	37	8	8	0%	0%	38%	45%	11%	6%	0%	0-25%
Lower Alder Creek	CA08	18	18	5	5	0%	0%	96%	0%	0%	4%	0%	0-25%
Lower Alder Creek	CA10	7	7	2	2	0%	0%	46%	0%	20%	33%	0%	0-25%
Lower Alder Creek	CA12	89	89	17	17	0%	48%	75%	0%	18%	7%	0%	0-25%
Lower Alder Creek	CA14	46	46	9	9	0%	0%	82%	2%	5%	6%	6%	0-25%
Lower Alder Creek	CA17	17	17	6	6	0%	39%	96%	0%	0%	0%	4%	0-25%
Lower Alder Creek	CA21	118	201	40	68	41%	9%	93%	3%	0%	3%	0%	0-25%
Lower Alder Creek	CA30	35	44	10	13	20%	56%	70%	0%	2%	27%	0%	
Lower Alder Creek	CA34	231	421	80	145	45%	0%	97%	0%	0%	1%	2%	0-25%
Mallo Pass Creek	CM03	260	451	95	164	42%	13%	78%	0%	20%	2%	0%	0-25%
Mallo Pass Creek	CM05	1400	2695	383	737	48%	4%	94%	6%	0%	0%	0%	0-25%
Mallo Pass Creek	CM06	134	134	46	46	0%	74%	96%	4%	0%	0%	0%	0-25%
NF Alder Creek	CN01	36	36	13	13	0%	57%	85%	5%	0%	9%	2%	
NF Alder Creek	CN02	17	17	5	5	0%	59%	43%	26%	0%	30%	0%	0-25%
NF Alder Creek	CN03	6	6	2	2	0%	73%	27%	0%	73%	0%	0%	0-25%
Point Arena Creek	GP01	360	627	191	332	43%	17%	83%	0%	9%	6%	3%	0-25%

Table D-5 (c). Select Physical Attributes[1] of LWD in the Southcoast Streams WAU.

Stream Segment Name	Stream Segment ID#	Piece Count						Volume					
		Root Associated		Buried		Alive		Root Associated		Buried		Alive	
		#	%	#	%	#	%	Yd^3	%	Yd^3	%	Yd^3	%
Lower Alder Creek	CA03	4	50%	0	0%	3	38%	235	71%	0	0%	170	51%
Lower Alder Creek	CA05	7	37%	0	0%	3	16%	184	39%	0	0%	34	7%
Lower Alder Creek	CA08	0	0%	1	20%	0	0%	0	0%	61	42%	0	0%
Lower Alder Creek	CA10	2	33%	1	17%	1	17%	40	33%	42	35%	24	20%
Lower Alder Creek	CA12	9	64%	0	0%	2	14%	432	73%	0	0%	108	18%
Lower Alder Creek	CA14	9	26%	23	66%	1	3%	241	50%	301	62%	24	5%
Lower Alder Creek	CA17	2	12%	10	59%	0	0%	22	10%	130	58%	0	0%
Lower Alder Creek	CA21	11	32%	15	44%	0	0%	187	45%	173	42%	0	0%
Lower Alder Creek	CA30	2	8%	6	24%	0	0%	57	12%	111	23%	0	0%
Lower Alder Creek	CA34	6	20%	18	60%	0	0%	121	23%	289	55%	0	0%
Mallo Pass Creek	CM03	7	17%	17	41%	3	7%	177	24%	320	43%	83	11%
Mallo Pass Creek	CM05	13	21%	26	43%	1	2%	256	25%	452	45%	23	2%
Mallo Pass Creek	CM06	14	22%	34	52%	0	0%	417	46%	400	44%	0	0%
NF Alder Creek	CN01	5	36%	5	36%	0	0%	247	71%	147	42%	0	0%
NF Alder Creek	CN02	5	45%	3	27%	1	9%	93	39%	36	15%	41	17%
NF Alder Creek	CN03	2	100%	0	0%	1	50%	46	100%	0	0%	33	73%
Point Arena Creek	GP01	4	11%	19	54%	1	3%	144	18%	214	27%	70	9%

1 Debris jams are not included in this data set. Multiple attributes can pertain to individual pieces so percentages may exceed 100%.

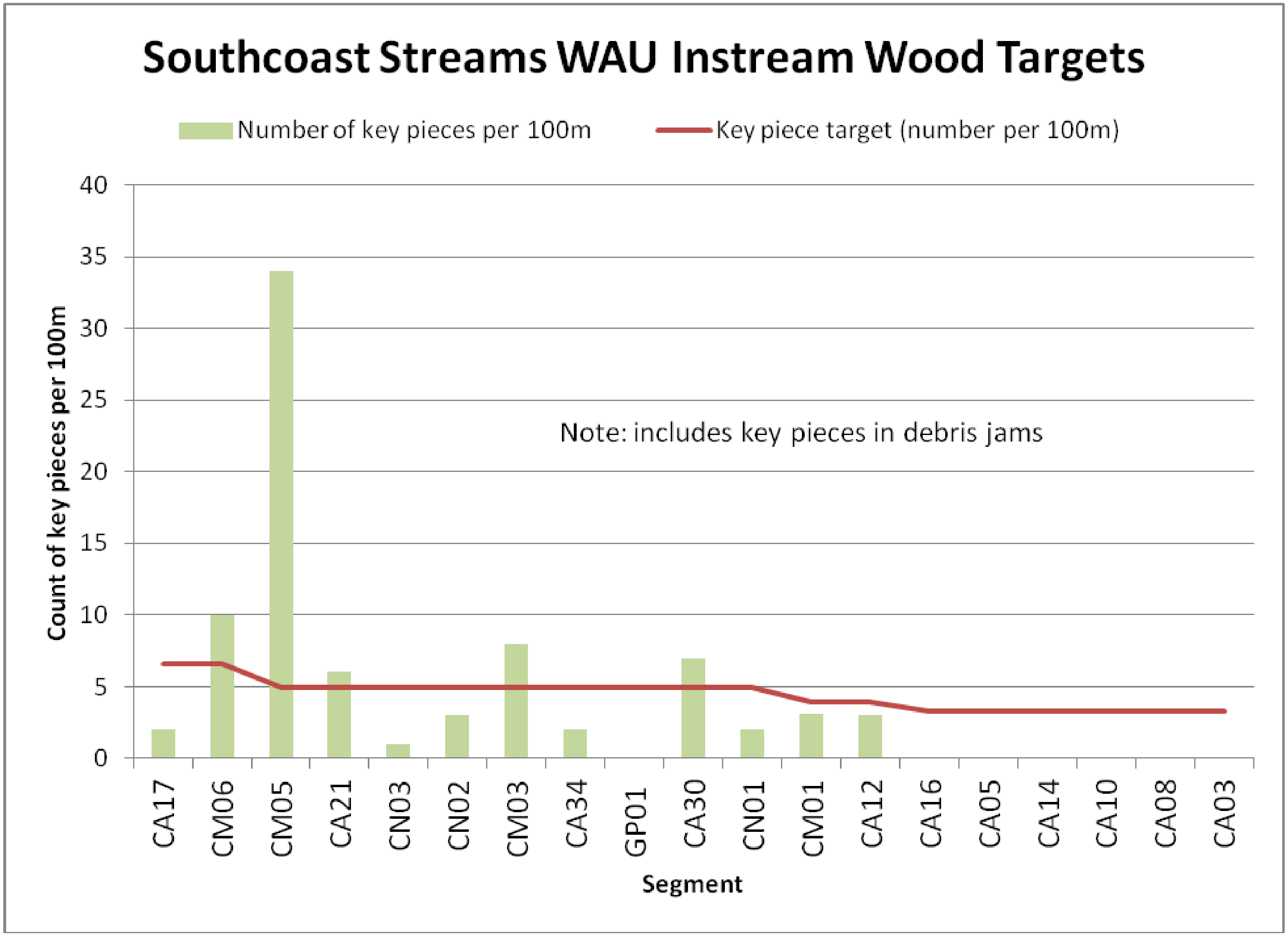

Southcoast Streams WAU Instream Wood Targets
Number of key pieces per 100m
Key piece target (number per 100m)
Count of key pieces per 100m
40
35
30
25
20
15
10
5
0
Note: includes key pieces in debris jams
CA17
CM06
CM05
CA21
CN03
CN02
CM03
CA34
GP01
CA30
CN01
CM01
CA12
CA16
CA05
CA14
CA10
CA08
CA03
Segment

Table D-6 shows the in-stream LWD quality rating for major streams and sections of stream or river in individual Calwater planning watersheds. This quality rating includes data from debris jams. Currently three planning watersheds in Southcoast Streams have a deficient LWD quality rating with Mallo Pass Creek being the only planning watershed rated as marginal.

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

Calwater Planning Watershed	**Percent of segments† with low or moderate demand**	**Percent of segments† meeting at least half of the key piece target**	**In-stream LWD Quality Rating***
Lower Alder Creek	22%	22%	DEFICIENT
Mallo Pass Creek	75%	100%	MARGINAL
North Fork Alder Creek	0%	50%	DEFICIENT
Point Arena Creeks	0%	0%	DEFICIENT

† - normalized by segment lengths
* – includes debris jams

CANOPY CLOSURE AND STREAM TEMPERATURE METHODS

Many physical factors can influence stream temperature. These include: solar radiation, air temperature, relative humidity, water depth and ground water inflow. Forest management can most influence solar radiation input, riparian air temperature and relative humidity by alteration of streamside vegetation and cover. Water depth and ground water inflow are more difficult to correlate to forest management practices. Therefore, our analysis focused on present canopy cover conditions for consideration of future forest management actions.

Canopy closure, over watercourses, was estimated from field measurements and 2007. A map (D-2) was produced for the Southcoast Streams WAU based on the field measurements of canopy. No aerial photographs were used to assess stream canopy.

In 2007, field measurements of canopy closure over select stream channels were performed. The field measurements were taken during the stream channel assessments in the Southcoast Streams WAU. The field measurements consisted of estimating canopy closure over a watercourse using a spherical densitometer and/or a solar pathfinder. 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. Solar pathfinder measurements were taken at one location in each segment sampled. The riparian stream canopy closure is shown in Map D-2.

Stream temperature has been monitored in the Southcoast Streams WAU since 1996. Stream temperature was measured with continuous recording electronic temperature recorders (HOBO Pro, Onset Instruments). 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. Stream temperature monitoring probe locations are also shown on Map D-2 indicated by the site identification code (for example, 47-1). The number below the site identification code (in parenthesis) is the most recent three year average MWAT (maximum weekly average temperature) in degrees Celsius. Table D-8 describes the temperature monitoring locations.

Table D-8. Stream Temperature Monitoring Locations and Time Periods in the Southcoast Streams WAU (see map D-2).

Temperature Station	Segment #	Stream Name	Years Monitored
89-01	CA03, CA05, CA08	Alder Creek (lower)	1994 - present
89-02	CA16, CA17, CN01, CN02, CN03	Alder Creek (upper)	1995 - present
89-03	CM02, CM03, CM05, CM06	Mallo Pass Creek	1999 - present
89-04	CM10, CA30	John Creek	2002 - present
89-05	CA12	Tin Can Creek	2002 - present
89-06	CA34	Nye Creek	2002 - present
89-07	CA14, CA21	Bee Tree Creek	2002 - present
94-01	GP01	Schooner Gulch (Point Arena Creek)	1996 - present

Maximum, maximum weekly average temperatures (MWAT), and maximum weekly maximum temperatures (MWMT) were calculated for each temperature monitoring site and year. Maximum weekly average temperatures (MWATs) and maximum weekly maximum temperatures (MWMT) were calculated by taking a seven day average of the mean and maximum daily stream temperature.

Maximum and mean daily temperatures were calculated for each temperature monitoring site and year and are presented in graphs in Appendix D. The instantaneous maximum temperature for each year is also reported.

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. MRC uses two 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 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 <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	Over 80% of surveyed watercourse segments have on-target effective shade.
MARGINAL	60-80% of surveyed watercourse segments have either (a) on-target effective shade or (b) over 70% canopy.
DEFICIENT	Less than 60% of surveyed watercourse segments have either (a) on-target effective shade or (b) less than 70% canopy.

CANOPY CLOSURE AND STREAM TEMPERATURE

RESULTS

Overall average canopy closure over watercourses is rated *on-target* in the Southcoast Streams WAU (Map D-2 and Table D-14). A majority of the stream segments (84%) were rated on-target for shade. Table D-9 lists shade and canopy data for all segments surveyed. Each segment typically has one solar pathfinder measurement. Occasionally, two measurements were taken in a single segment.

Table D-9. 2007 Field Observations of Stream Canopy Closure for Select Stream Channel Segments of the Southcoast Streams WAU.

Stream Name	Segment Number	Mean Shade Canopy (%)	Topography shading (%)	Bankfull width (ft)	Shade target (%)	Temp. station	Average MWAT (°C)	On-target for shade or temperature?	Average shade > 70%?
Lower Alder Creek	CA03	95%	25%	56	40%	89-01	16.3	YES	YES
Lower Alder Creek	CA05	65%	40%	50	40%	89-01	16.3	YES	**NO**
Lower Alder Creek	CA08	40%	15%	54	40%	89-01	16.3	YES	**NO**
Lower Alder Creek	CA10	92%	28%	53	40%	89-04	13.9	YES	YES
Lower Alder Creek	CA12	100%	30%	42	40%	89-05	13.8	YES	YES
Lower Alder Creek	CA14	80%	0%	51	40%	89-07	13.9	YES	YES
Lower Alder Creek	CA16	35%	10%	49	40%	89-02	17.8	**NO**	**NO**
Lower Alder Creek	CA17	95%	20%	12	90%	89-02	17.8	YES	YES
Lower Alder Creek	CA21	100%	40%	20	90%	89-07	13.9	YES	YES
Lower Alder Creek	CA30	93%	35%	25	90%	89-04	13.9	YES	YES
Lower Alder Creek	CA34	78%	13%	24	90%	89-06	14.1	**NO**	YES
Mallo Pass Creek	CM02	95%	30%	38	40%	89-03	13.0	YES	YES
Mallo Pass Creek	CM03	99%	30%	23	90%	89-03	13.0	YES	YES
Mallo Pass Creek	CM05	99%	30%	18	90%	89-03	13.0	YES	YES
Mallo Pass Creek	CM06	95%	20%	12	90%	89-03	13.0	YES	YES

Stream Name	Segment Number	Mean Shade Canopy (%)	Topography shading (%)	Bankfull width (ft)	Shade target (%)	Temp. station	Average MWAT (°C)	On-target for shade or temperature?	Average shade > 70%?
NF Alder Creek	CN01	91%	25%	25	90%	89-02	17.8	YES	YES
NF Alder Creek	CN02	100%	0%	21	90%	89-02	17.8	YES	YES
NF Alder Creek	CN03	90%	0%	20	90%	89-02	17.8	**NO**	YES
Point Arena Creek	GP01	92%	16%	20	90%	94-01	13.5	YES	YES

A majority of the stream segments in the Southcoast Streams WAU have stream temperatures preferred by salmonids, with the one exception being in the North Fork Alder Creek area. This is most likely due to the fact that this area is much farther away from the coast than the other planning watersheds. Instantaneous maximum temperatures recorded at all sites typically do not exceed the maximum lethal ranges for coho salmon (23C^{o}) and steelhead trout (26C^{o}) (Brett, 1952). MWAT values for many sites, however, are above the maximums for coho salmon (17-18 C^{o}) (Brett, 1952 and Becker and Genoway, 1979). See Tables D-10, D-11 and D-12. Air temperature data is listed in Table D-13. Figure 1 depicts the stream and air temperatures for the inland and coastal areas. The inland area is considered to be the North Fork Alder planning watershed (temperature station 89-02) and the average of the remaining sites comprise the coastal area.

Table D-10. Maximum Daily Stream Temperatures (C°) by Year for the Southcoast Streams WAU.

Station	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
T89-01		19.4	18.4	18.1	19.4	20	19.2	19.6	20.3	20.4	18.4	17.8	18	17.7	19.8
T89-02	19.6	19.8	18.7	22.1	20.7	20.5	21.1	24.7	21.4	22.4	20.9	19.9	20.1	19.2	22.4
T89-03	13.3	13.9	13.1	13.3	14.5	14.1	14.4	14.3	14.4	13.7	13.7	13.2	13.2	12.8	14.1
T89-04				14.9	15.2	16	15.9	17.6	16.1	16.7	15.4	14.8	15	14.6	16.9
T89-05				14.9	15.2	17.3		16.8	16	16.7	15.3	16.2	15	14.3	17.7
T89-06				14.8	16	15.7	17.4	17	16.3	14.8	13.7		15.8	15.1	15.3
T89-07				14.3	15.4	15.3	15.6	17.1	15.1	15.8	14.8	14.6	14.8	14.4	16.5
T94-01	15.6	15.7	12.9		15.2	16.3	15.4	16.1	16.2	15.4	14.9	14.4	14.3	13.9	15.9

Table D-11. Maximum Weekly Average Stream Temperature (MWAT C°) for the Southcoast Streams WAU.

Station	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
T89-01		16.7	16.1	16.1	16.7	18.2	17.2	17.9	18.1	17.6	16.3	15.9	15.7	15.4	17.7
T89-02	16.8	17.3	16.2	18.2	18.3	18.5	18.5	21.3	18.8	19.4	17.9	17.2	17.2	16.8	19.4
T89-03	12.7	13.3	12.6	12.9	13.9	13.9	13.7	13.9	13.8	13.1	13.2	12.5	12.8	12.3	13.8
T89-04				13.3	13.9	14.8	14.5	16.1	14.6	15.1	13.9	13	13.5	13	15.2
T89-05				13.3	14	15.4		15.8	14.8	15.2	13.8	13.1	13.3	12.9	15.2
T89-06				13.7	14.7	15.2	15.6	16.3	15	14.4	13.6		14.1	13.6	14.7
T89-07				13.3	14.4	14.4	14.5	16	14.3	14.6	13.8	13.3	13.5	13.4	14.9
T94-01	14.2	13.9	12.2		13.8	14.9	14.3	14.8	14.6	14.1	13.7	12.8	13.2	12.8	14.6

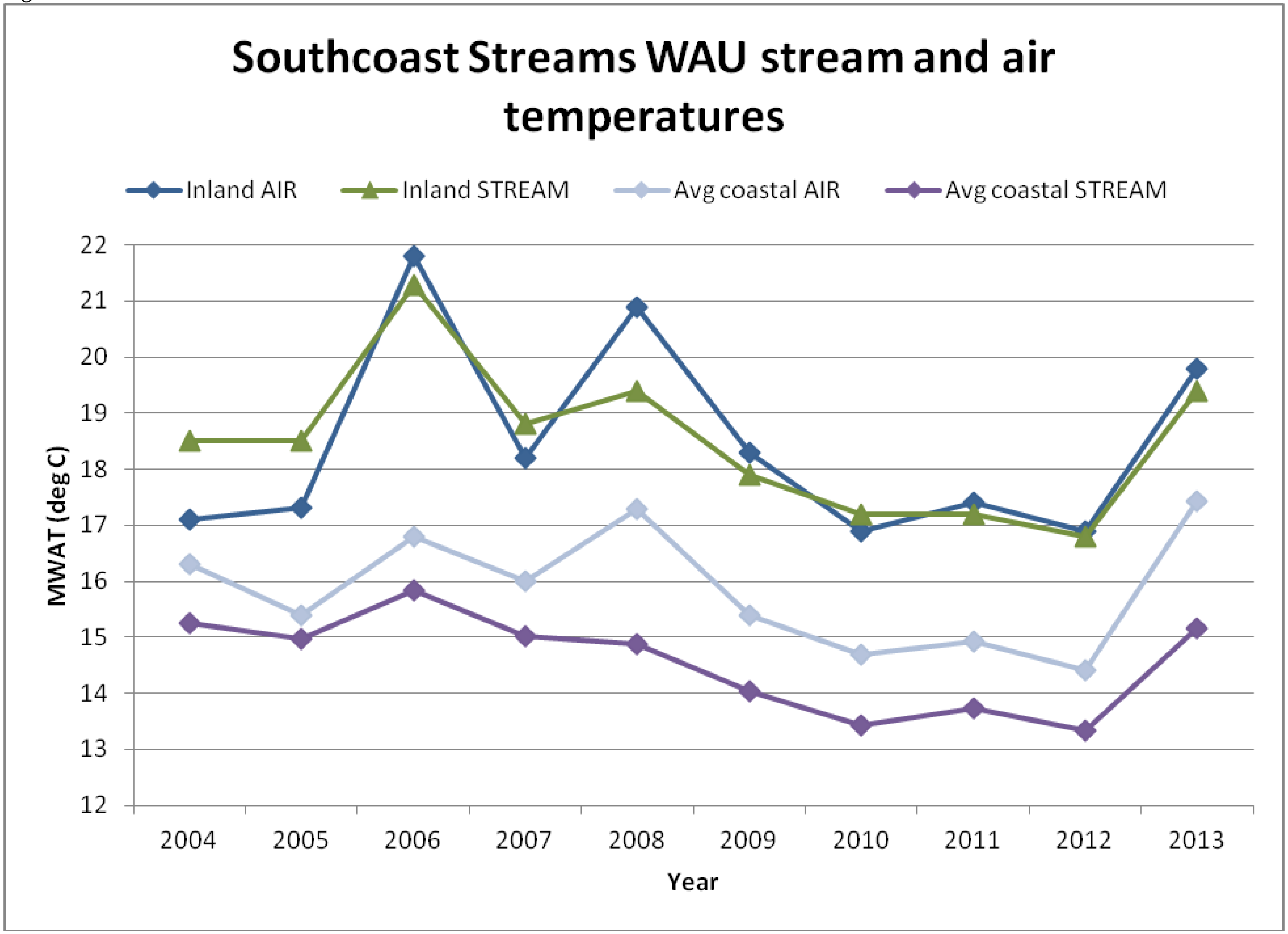
Table D-12. 7-Day Moving Average of the Daily Maximum Stream Temperature (MWMT C^o) for the Southcoast Streams WAU.

Station	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
T89-01		18.5	16.9	17.5	18.7	19.2	18.9	19.3	19.5	19	17.8	17.6	17.4	16.9	19.1
T89-02	18.3	19	17.8	20.8	19.9	19.9	20.6	23.6	20.7	21.2	20.2	19.2	19.2	18.7	21.3
T89-03	13	13.6	12.9	13.1	14.4	14.1	14.2	14.2	14.1	13.4	13.5	12.9	13	12.6	14
T89-04				14.1	14.5	15.6	15.5	16.9	15.4	15.9	14.8	14	14	13.9	16.2
T89-05				14.1	14.6	16.5		16.3	15.6	16.1	15	14.5	14.5	13.9	16.3
T89-06				14.1	15.4	15.4	16.9	16.6	15.6	14.6	14.1		15.1	14.3	15
T89-07				13.9	15	15.1	15.2	16.6	14.8	15.2	14.5	14.2	14.4	14.1	15.8
T94-01	15.1	14.8	12.6		14.9	15.8	15.1	15.6	15.6	15	14.6	13.5	14	13.5	15.7

Table D-13. Maximum Weekly Average Air Temperature (MWAT C^o) for the Southcoast Streams WAU.

Station	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
T89-01A	14.6	16.4	18	17	17.3	16.2	15.8	15.1	14.8	14.7	14.4	17.2
T89-02A	17.1		17.1	17.3	21.8	18.2	20.9	18.3	16.9	17.4	16.9	19.8
T89-03A			15.6	14.4	14.7	15	14.4	14.3	14.4	14.2	13.2	16.1
T89-04A			16	14.8	16.4	15.5	17.2	15.2	14.4			
T89-05A			15.8	14.9	16.6	16.7	18.1	16.2		15.1	15.2	17.4
T89-06A							18.4	16.1				
T89-07A		15.5	16.1	15.9	19	16.6	22	15.6	15.7	16.6	15.7	19
T94-01A							15.1	15.3	14.2	14	13.6	

Figure 1


Southcoast Streams WAU stream and air temperatures
Inland AIR
Inland STREAM
Avg coastal AIR
Avg coastal STREAM
22
21
20
19
18
17
16
15
14
13
12
MWAT (deg C)
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year

In general, instream canopy cover in the Southcoast Streams WAU is above desired targets and temperatures are at levels that are acceptable for salmon and steelhead, except for the North Fork Alder Creek planning watershed. Eleven of the 19 segments surveyed in the Southcoast Streams WAU had bankfull widths of less than 30 feet. All of those 11 segments had an average shade-canopy cover of greater than 90% (target for less than 30 foot bankfull width). Only one stream segment (CA16 measured instream shade of 35%) did not meet the minimum stream shade requirement of 40% for it's bankfull width (49 feet). In summary, 21% (four segments) of the segments surveyed (n=19) in the Southcoast Streams WAU did not meet the canopy cover targets, but 84% (16 segments) were classified as on-target for the stream shade quality rating due to low stream water temperatures. Below is a table of the stream shade quality ratings by planning watershed for the Southcoast Streams Watershed Analysis Unit.

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

Stream	Temperature monitoring location at outlet	Most recent three year average MWAT (°C)	Percent of segments with on-target shade	Stream Shade Quality Rating
Mallo Pass Creek	89-3	12.5	100%	ON-TARGET
Lower Alder Creek	89-1	15.7	82%	ON-TARGET
NF Alder Creek	89-2	17.1	67%	MARGINAL
Point Arena Creek	94-1	12.9	100%	ON-TARGET

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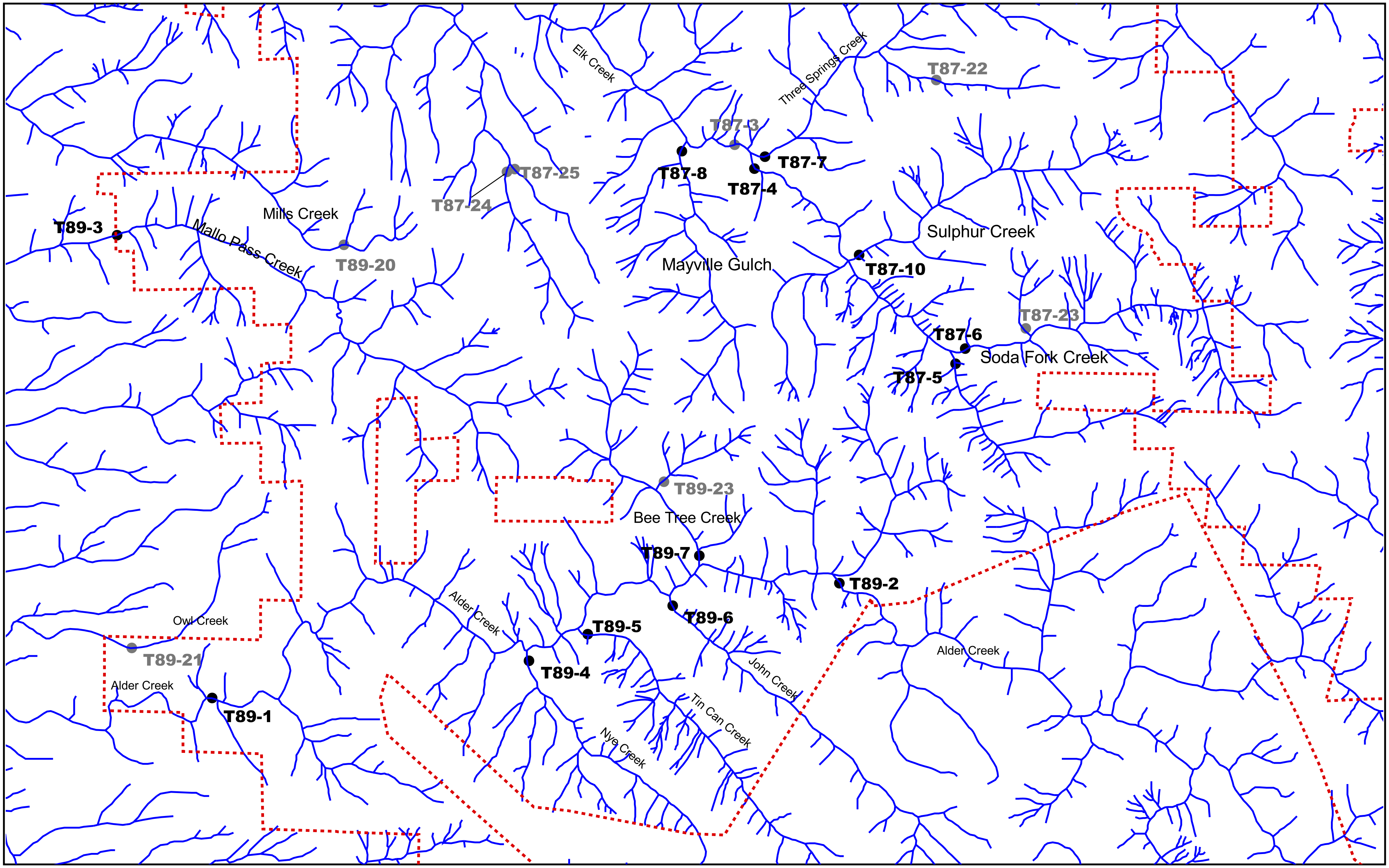
Appendix D

Map 15: Southern South Coast Stream Temperature Sites



Mendocino Redwood Company, LLC

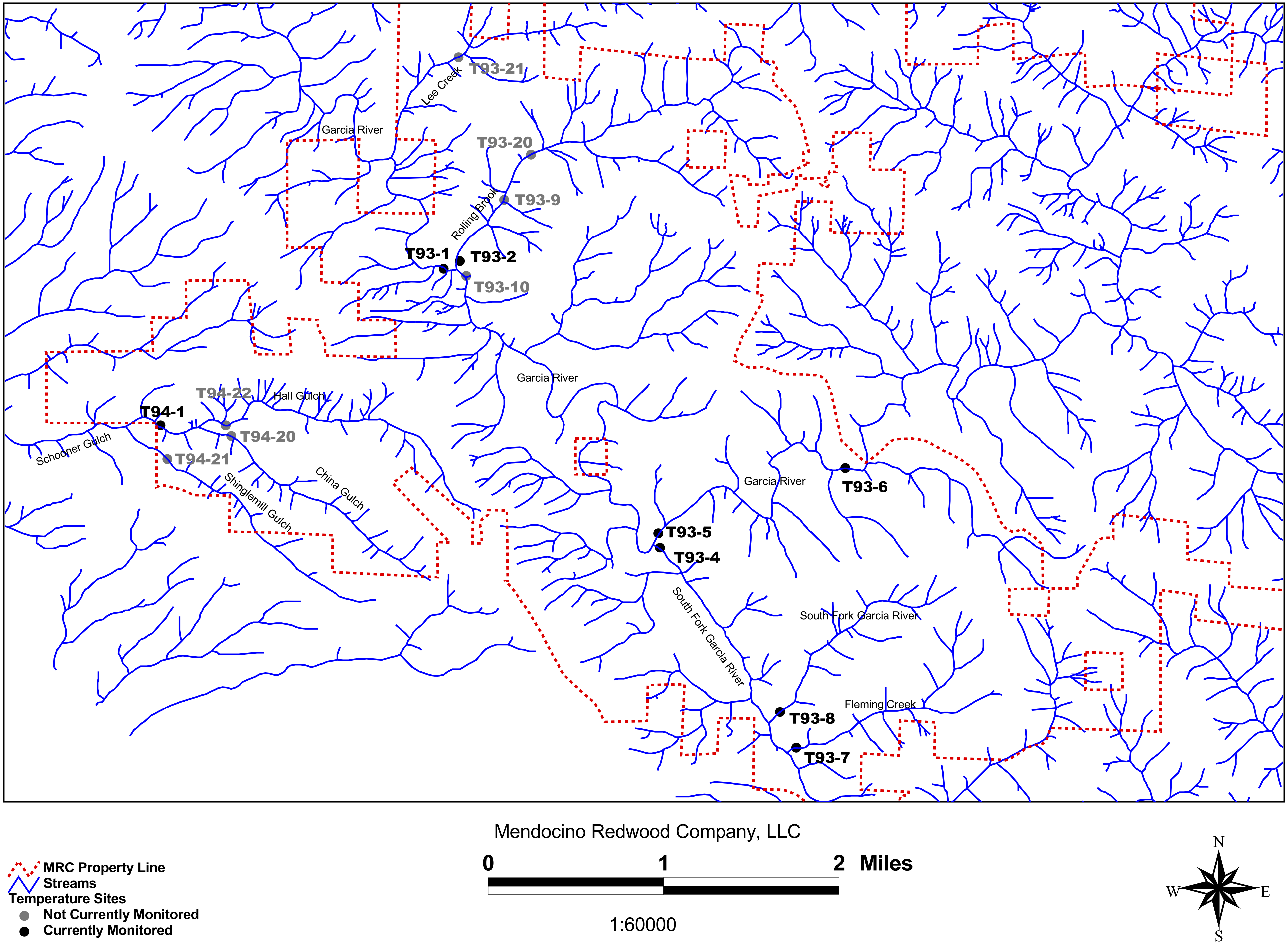
0 1 2 Miles

1:50000

MRC Property Line
Streams
Temperature Sites
Not Currently Monitored
Currently Monitored

N
W
E
S

Map 16: Garcia River Stream Temperature Sites



Mendocino Redwood Company, LLC

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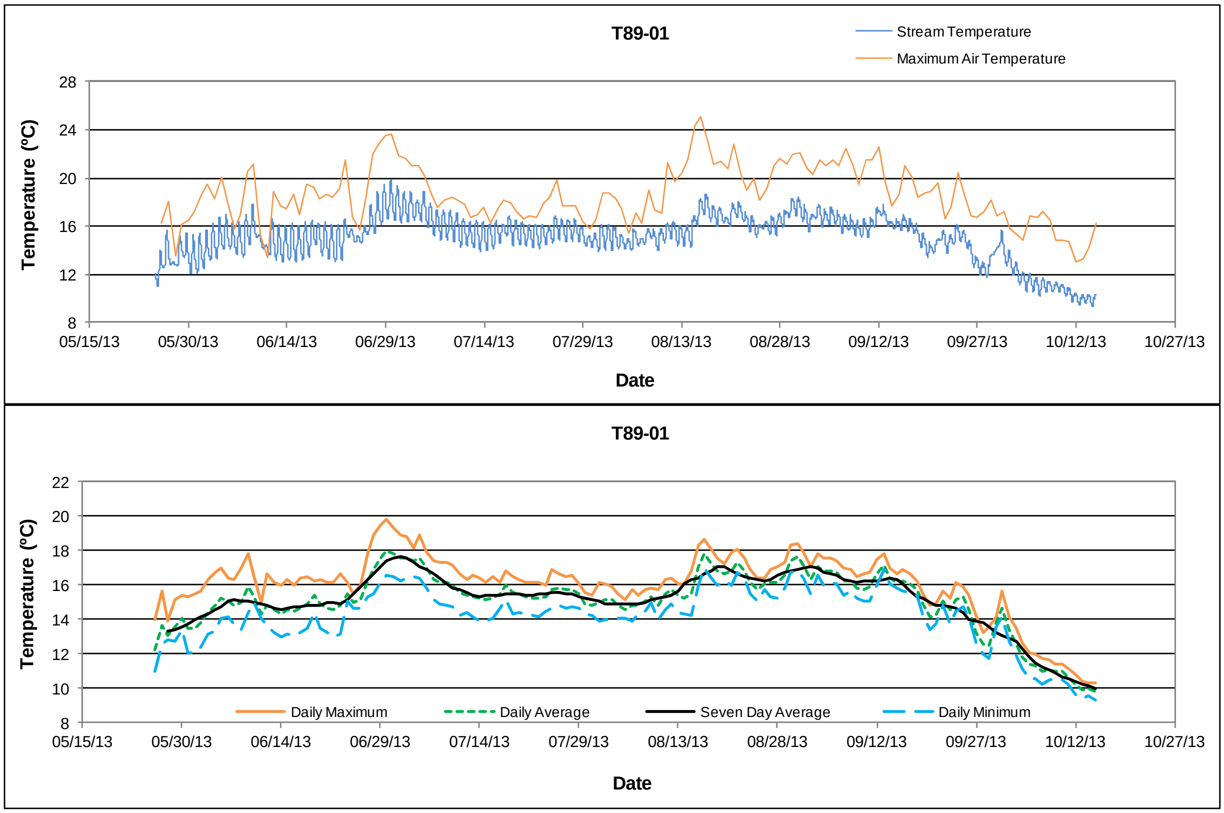


Figure 127. Maximum daily air temperature and daily and weekly stream temperature during summer 2013 at Alder Creek (T89-01) Mendocino County, California.

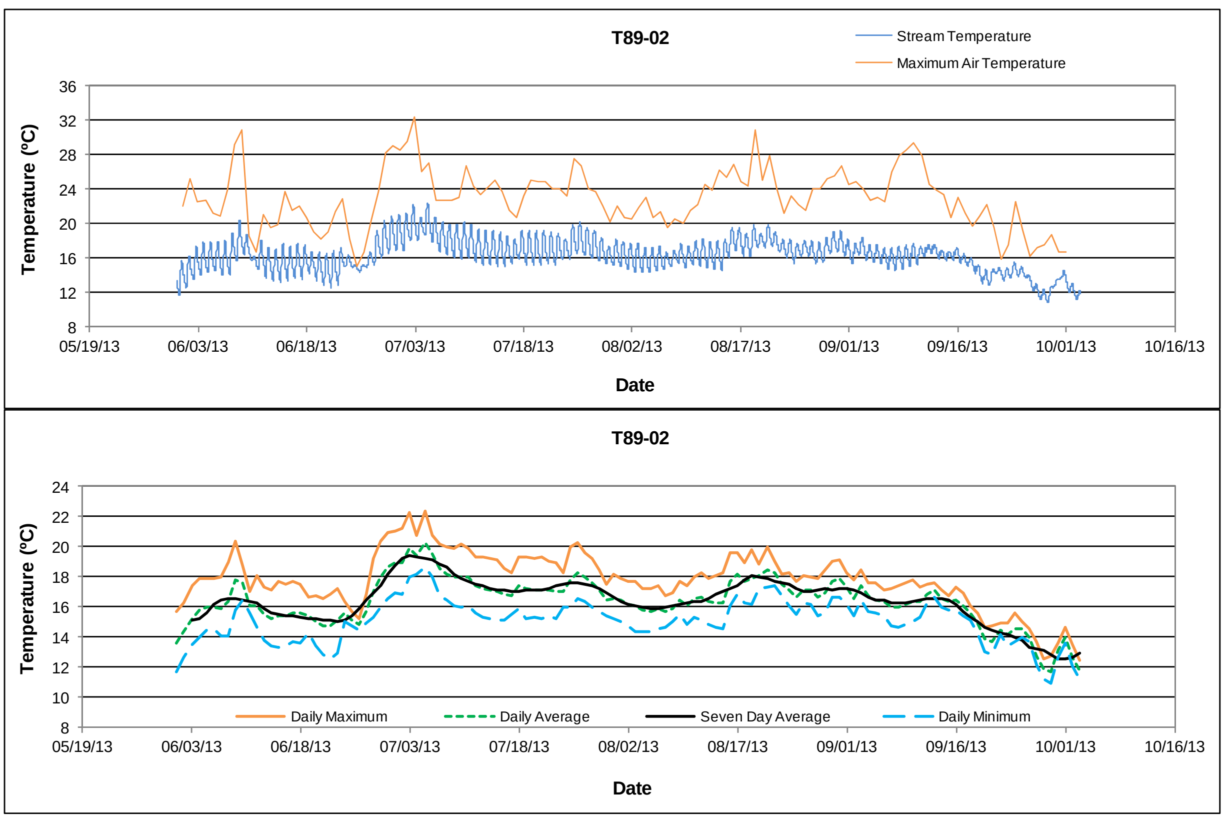


Figure 128. Maximum daily air temperature and daily and weekly stream temperature during summer 2013 at Alder Creek (T89-02) Mendocino County, California.

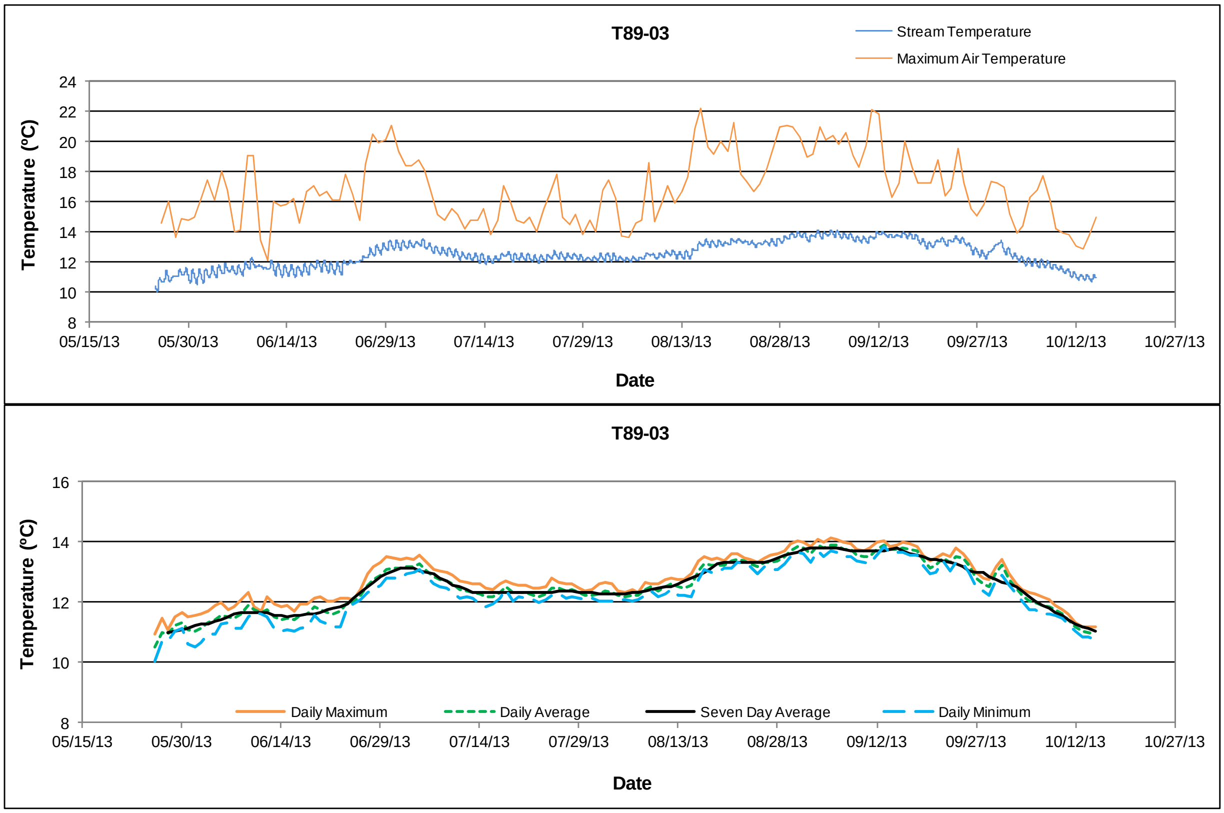


Figure 129. Maximum daily air temperature and daily and weekly stream temperature during summer 2013 at Mallo Pass Creek (T89-03) Mendocino County, California.

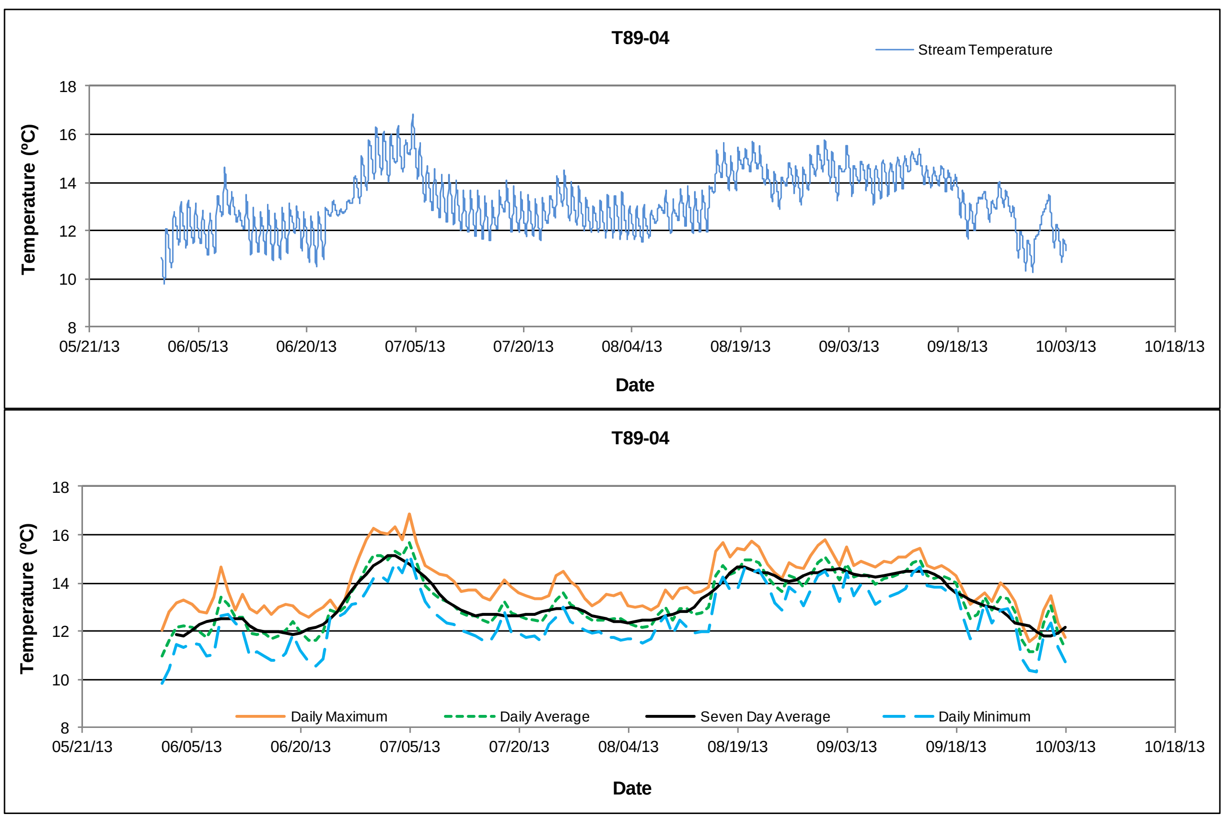


Figure 130. Daily and weekly stream temperature during summer 2013 at Nye Creek (T89-04) Mendocino County, California.

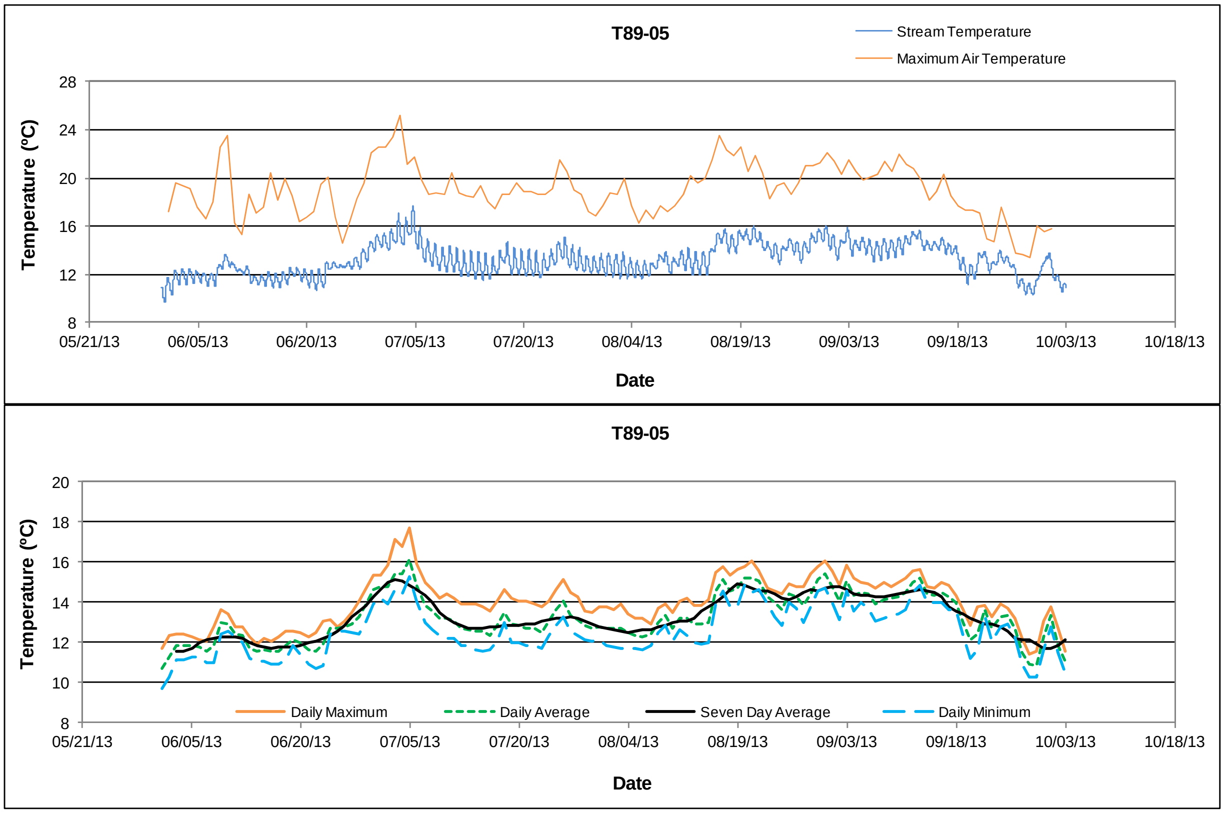


Figure 131. Maximum daily air temperature and daily and weekly stream temperature during summer 2013 at Tin Can Creek (T89-05) Mendocino County, California.

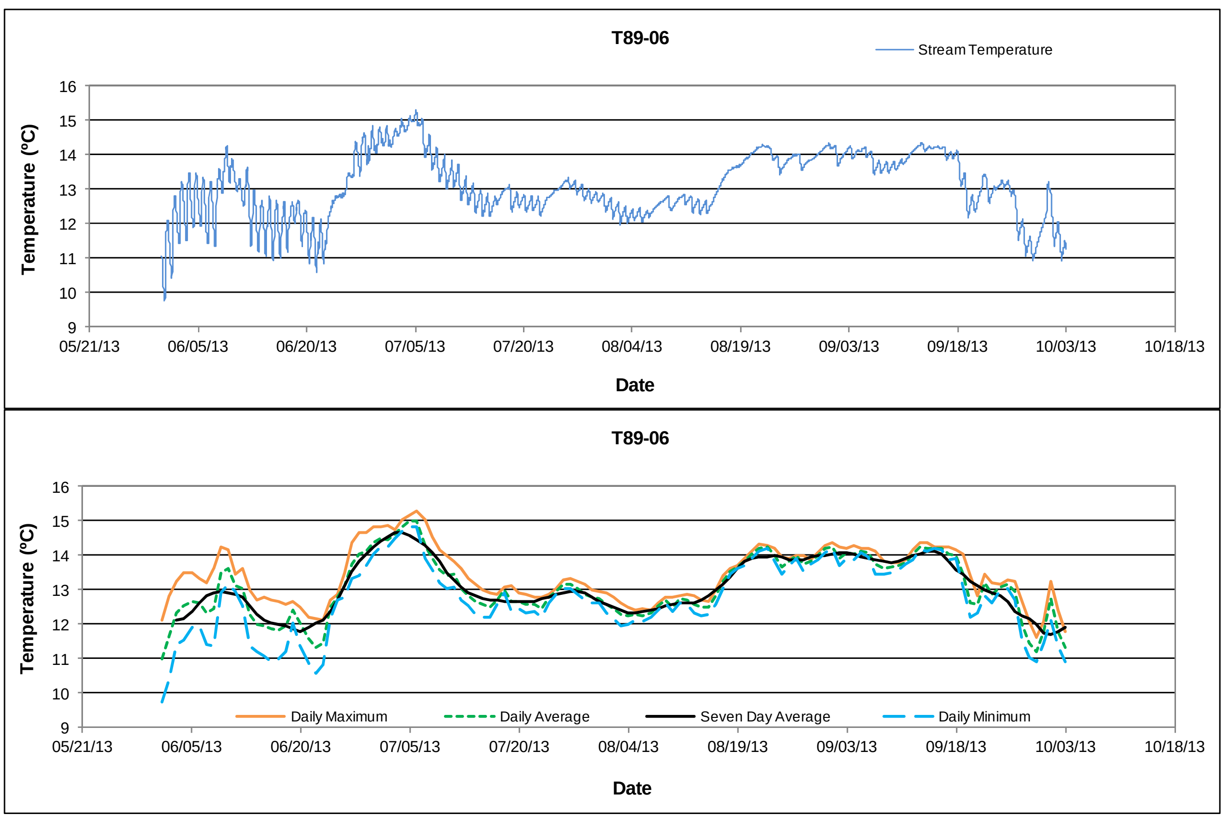


Figure 132. Daily and weekly stream temperature during summer 2013 at John Creek (T89-06) Mendocino County, California.

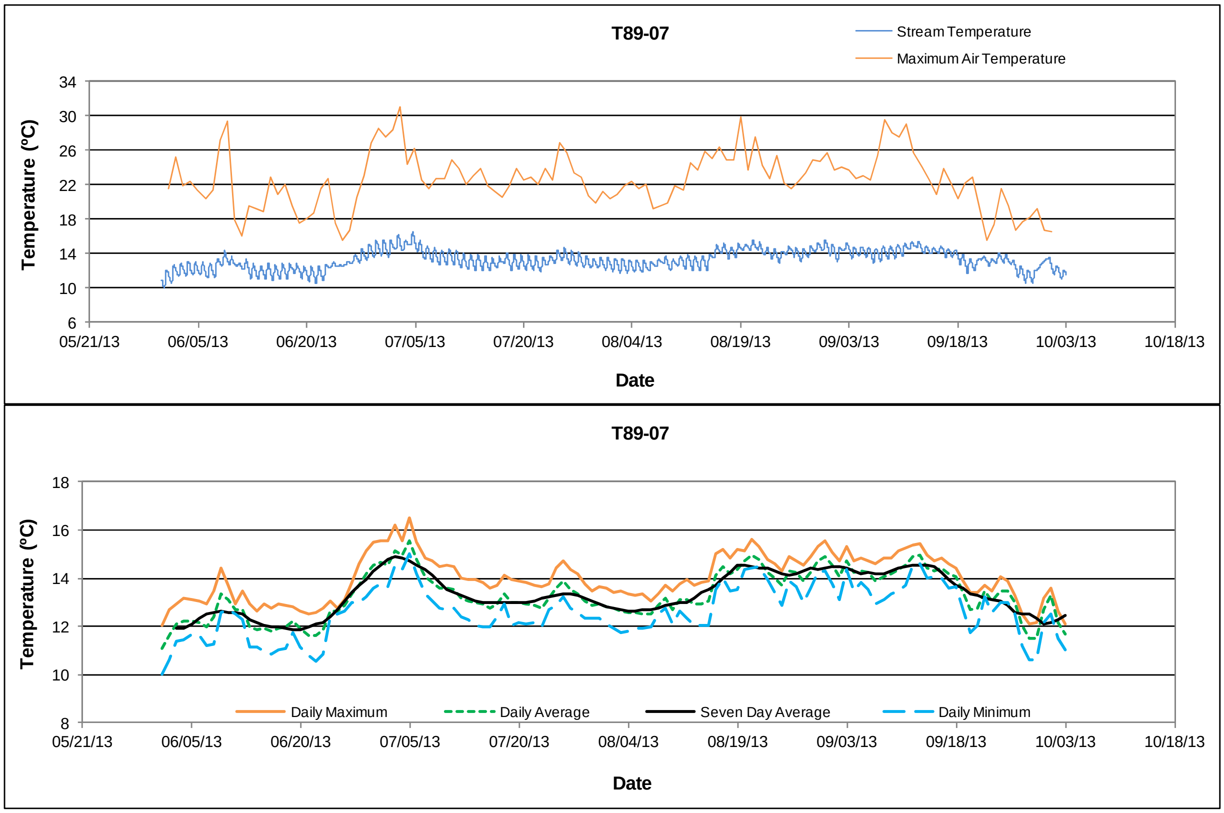


Figure 133. Maximum daily air temperature and daily and weekly stream temperature during summer 2013 at Bee Tree Creek (T89-07) Mendocino County, California.

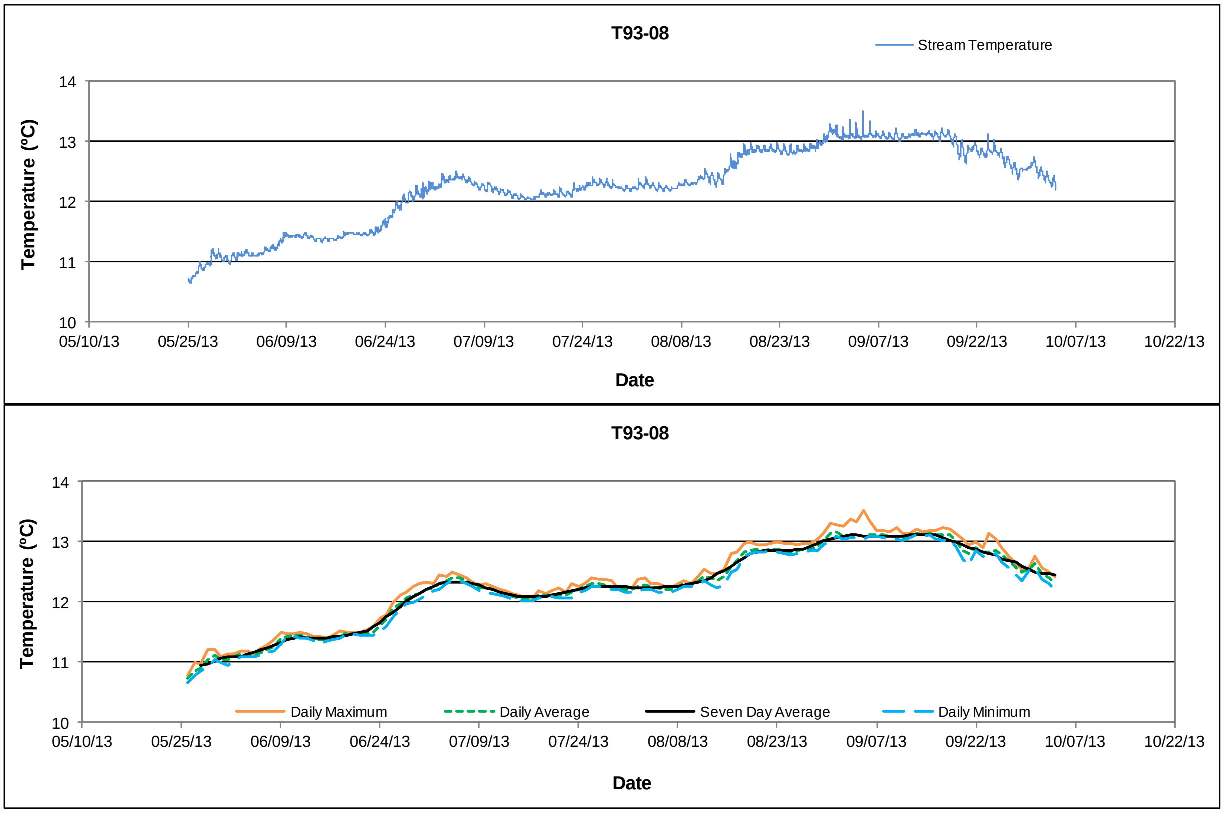


Figure 140. Daily and weekly stream temperature during summer 2013 at South Fork Garcia River (T93-08) Mendocino County, California.

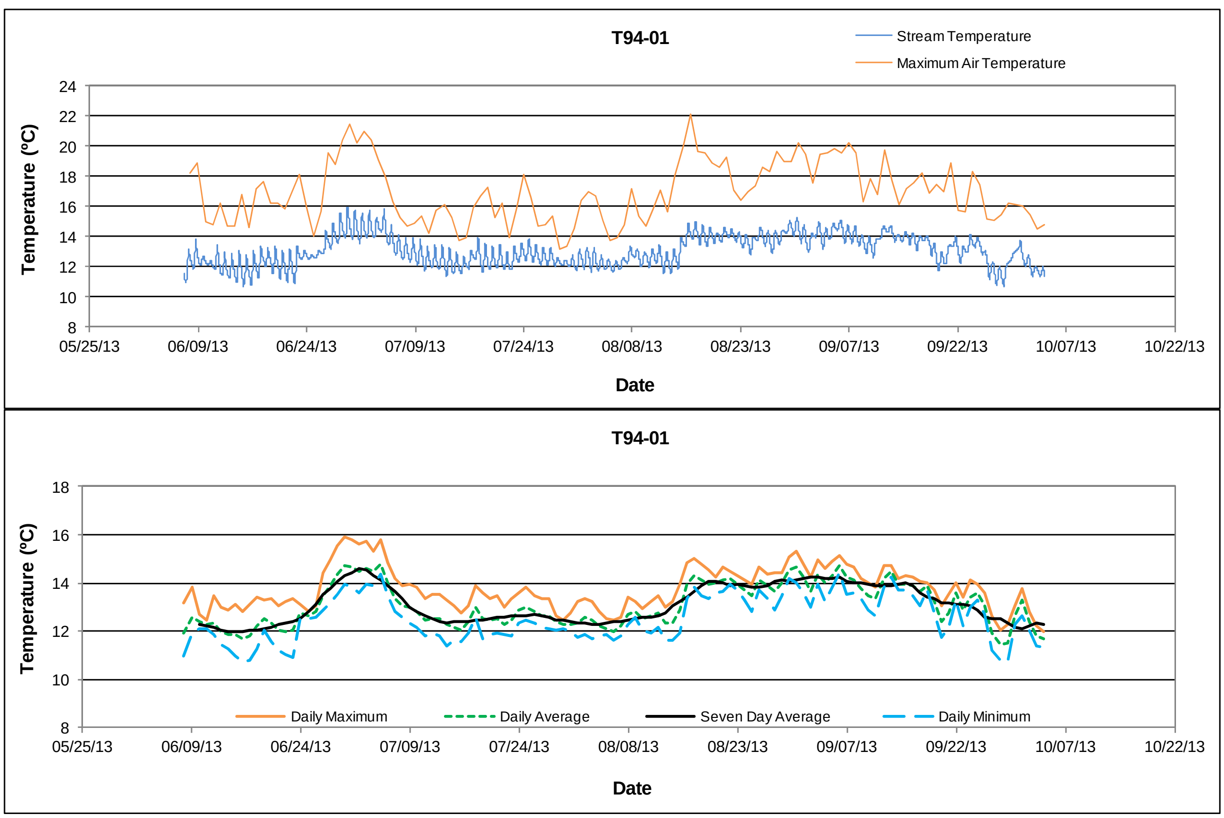
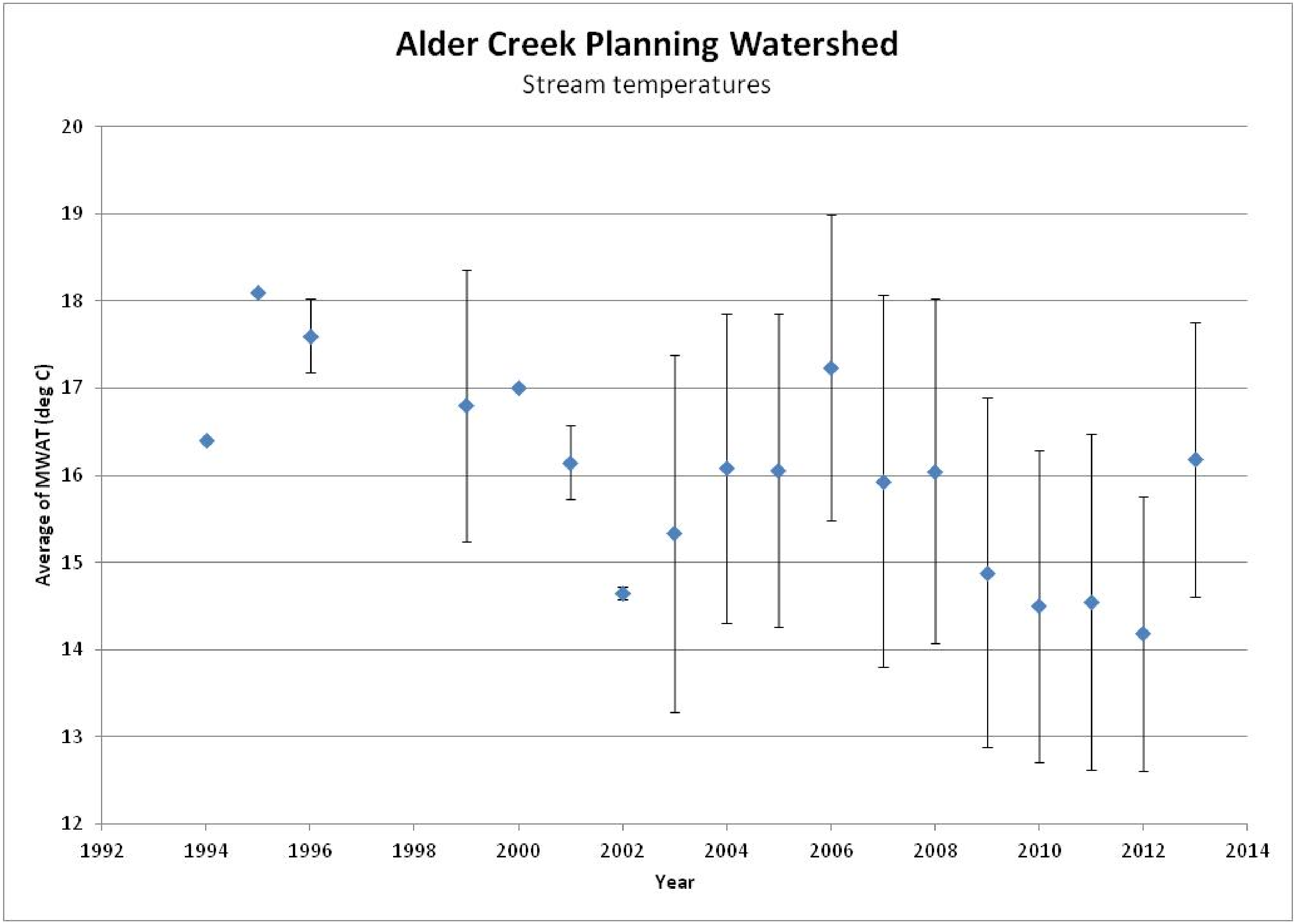
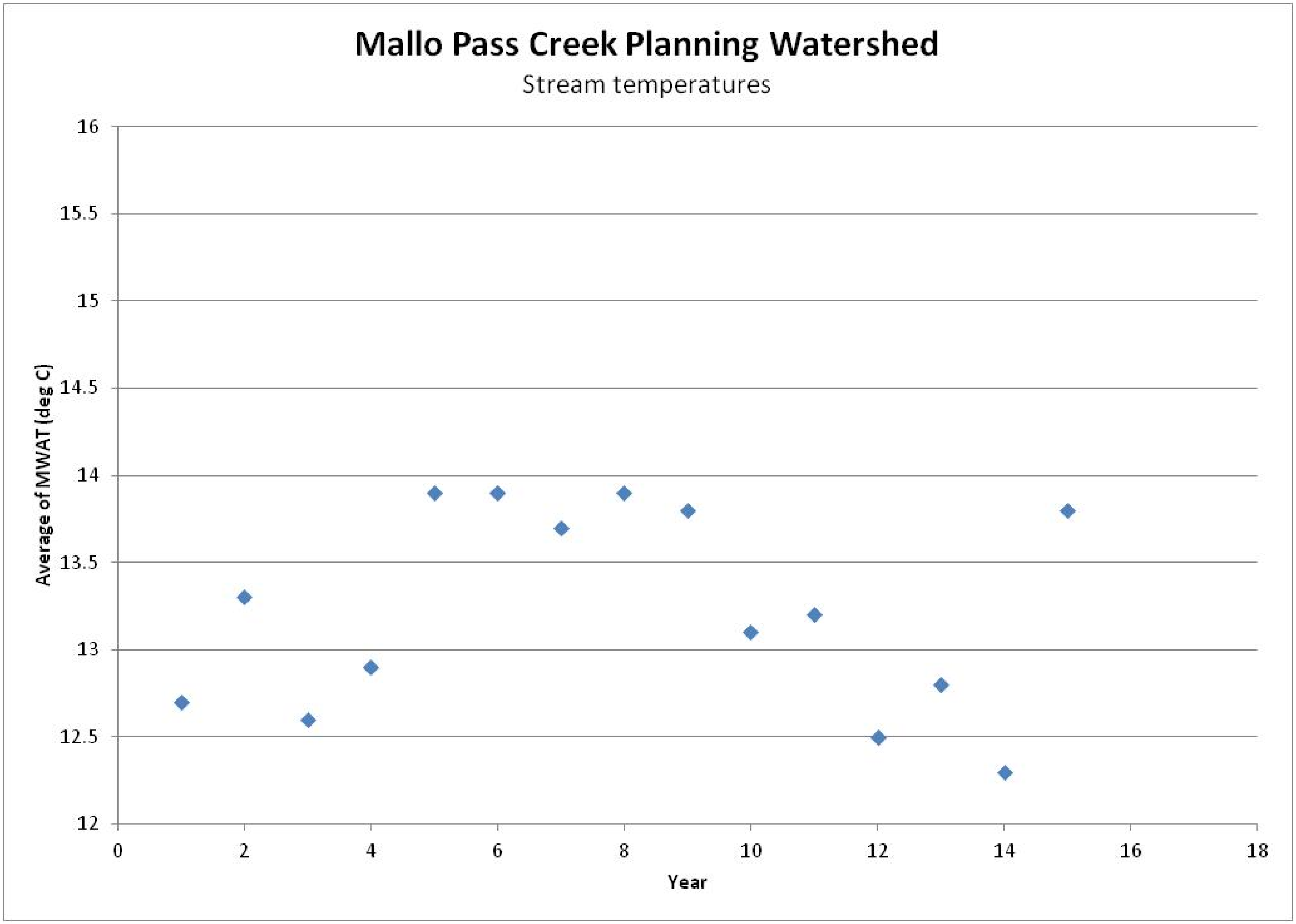


Figure 141. Maximum daily air temperature and daily and weekly stream temperature during summer 2013 at Schooner Gulch (T94-01) Mendocino County, California.

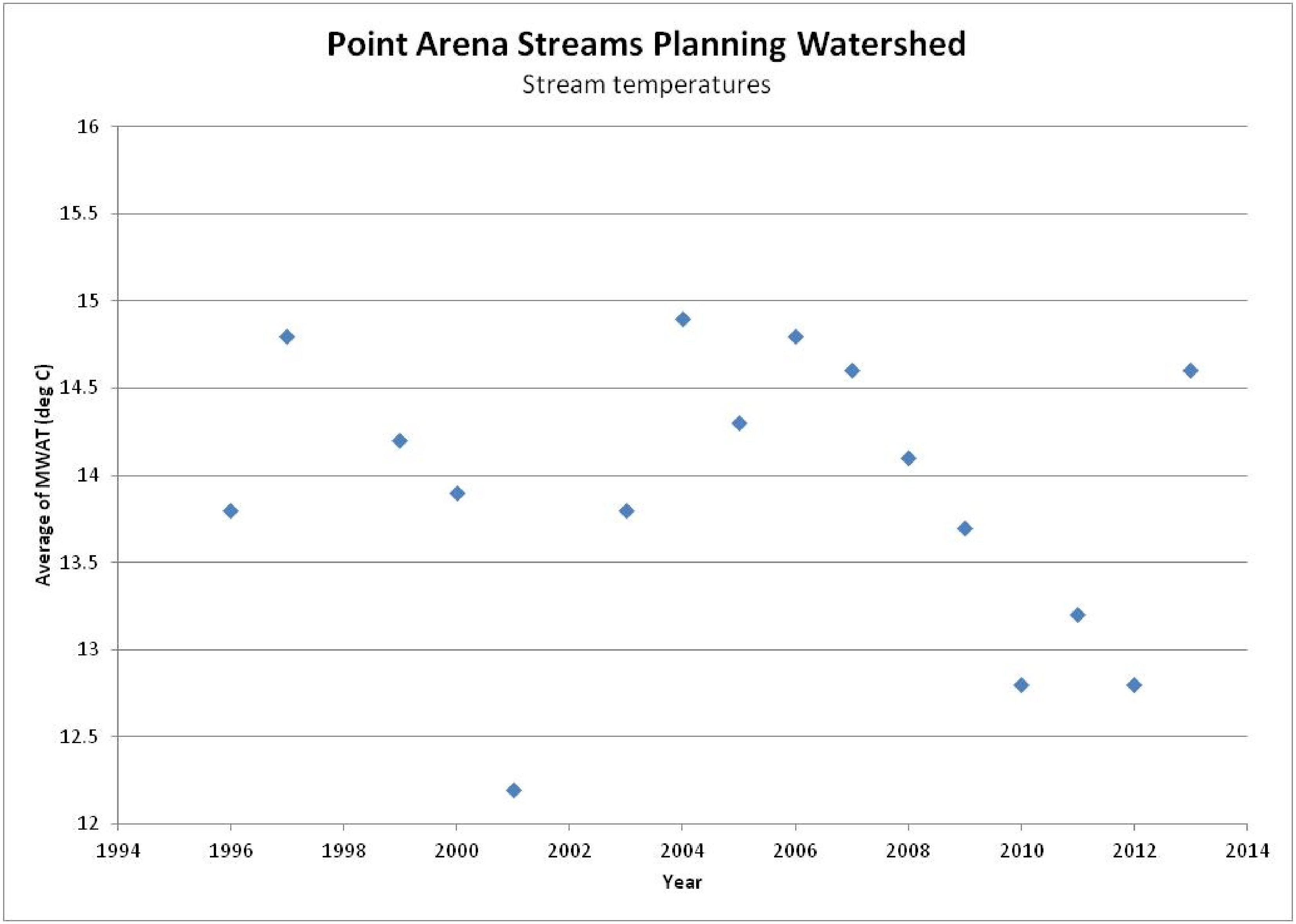


Sites 89-01, 89-02, 89-04, 89-05, 89-06, 89-07

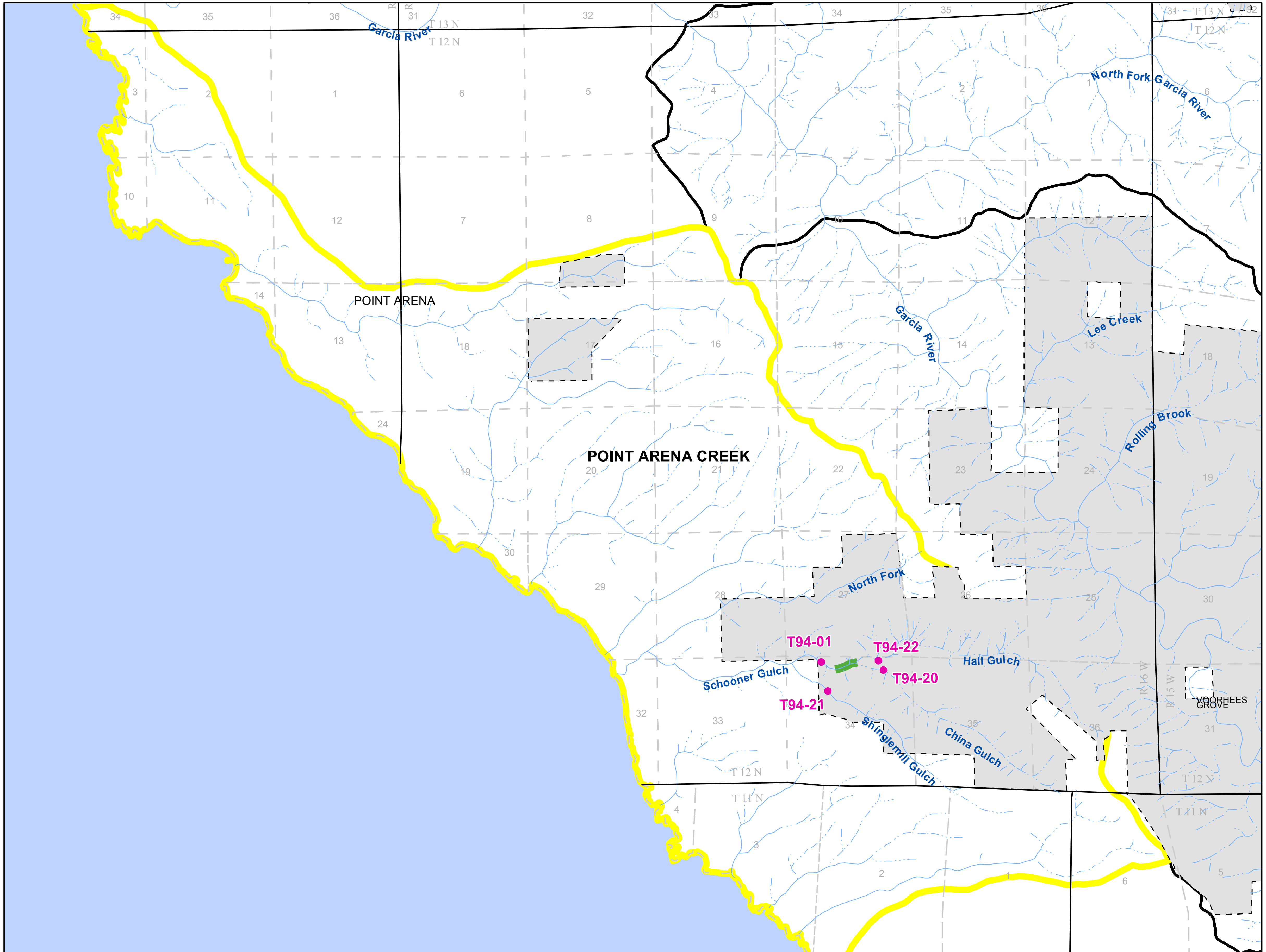


Mallo Pass Creek Planning Watershed
Stream temperatures
Average of MWAT (deg C)
16
15.5
15
14.5
14
13.5
13
12.5
12
0
2
4
6
8
10
12
14
16
18
Year

Site 89-03


Point Arena Streams Planning Watershed
Stream temperatures
Average of MWAT (deg C)
16
15.5
15
14.5
14
13.5
13
12.5
12
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year

Site 94-01



Southcoast Streams Watershed Analysis Unit

Point Arena Creek Planning Watershed

Map D-2 (b)
Stream Canopy Classification and Temperature Monitoring Locations

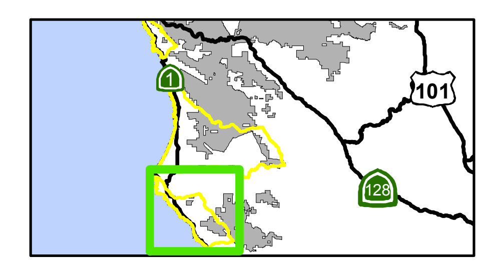
This map presents the canopy closure, over watercourses, for streams and rivers within the MRC ownership in the Southcoast Streams WAU. The canopy was estimated for four canopy closure classes from 2004 aerial photographs and 2005 field observations. The location of stream temperature monitored locations is also presented, these locations are monitoring each year during summer.

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

Temperature Monitoring Locations

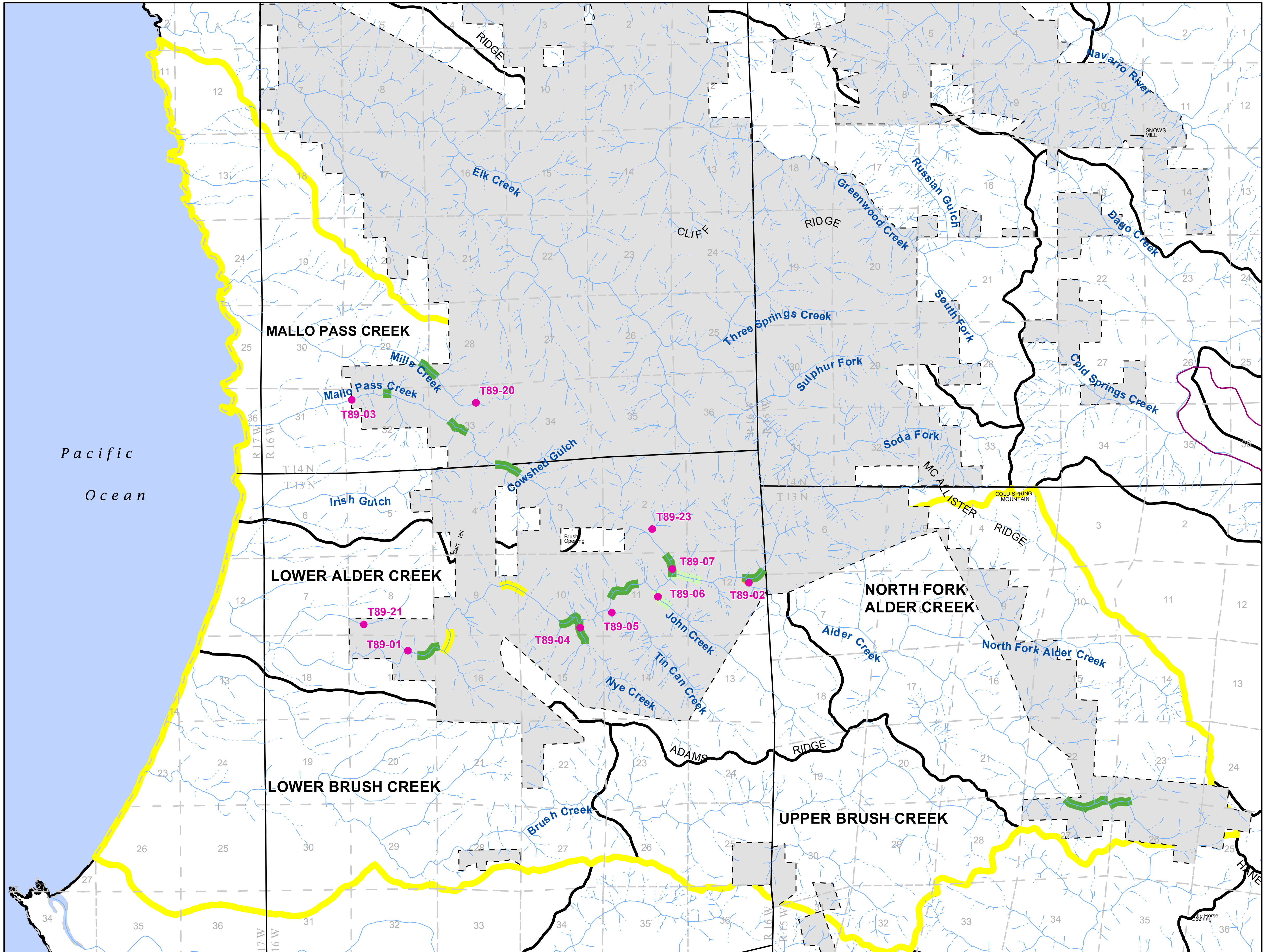
- MRC Ownership
- Planning Watershed Boundary
- Watershed Analysis Unit Boundary

Flow Class
- Class I
- Class II
- Class III



0 0.5 1 Miles

April 2014



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Southcoast Streams Watershed Analysis Unit

Mallo Pass, Lower Alder and N.F. Alder Creeks Planning Watersheds

Map D-2 (a)
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 Southcoast Streams WAU. The canopy was estimated for four canopy closure classes from 2004 aerial photographs and 2005 field observations. The location of stream temperature monitored 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

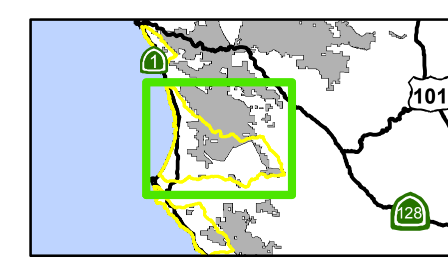
MRC Ownership

Planning Watershed Boundary

Watershed Analysis Unit Boundary

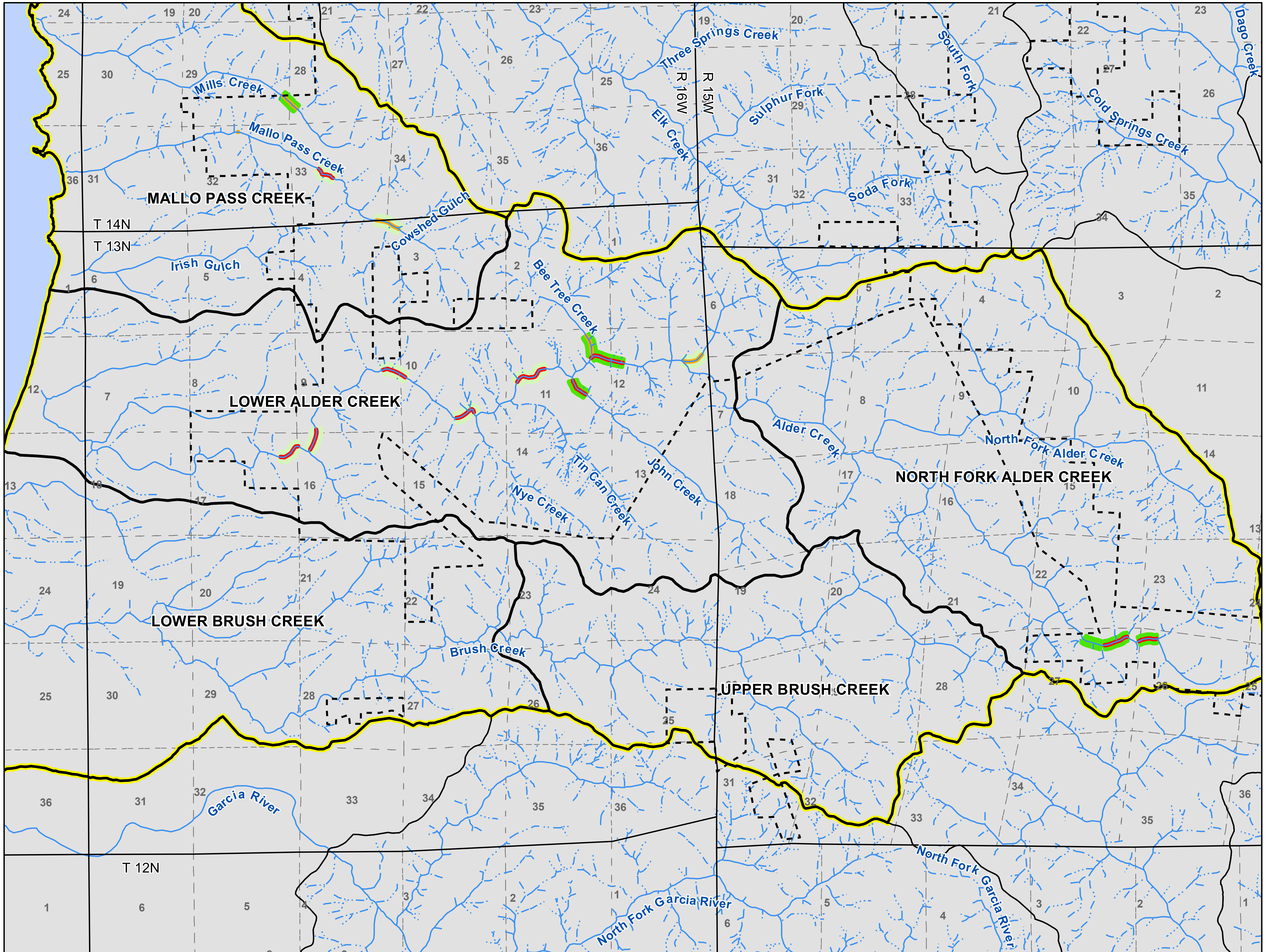
Flow Class

- Class I
- Class II
- Class III



0 0.75 1.5 Miles

April 2014



Southcoast Streams
Watershed Analysis Unit

Mallo Pass, Lower Alder, and N.F. Alder Creeks Planning Watershed

Map D-1 (b)
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 Southcoast Streams 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 stream-side stand characteristics, amount of LWD in the stream and the sensitivity of the stream channel to LWD from aerial photograph interpretation of 2004 photographs and field observations in 2005. 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

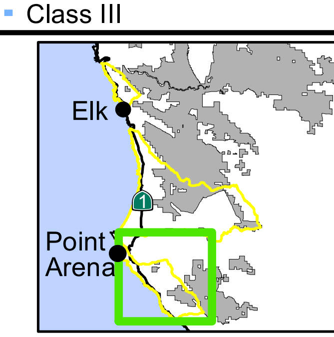
Instream LWD Demand

- High
- Moderate
- Low

- MRC Ownership
- Planning Watershed Boundary
- Alder Creek/Schooner Gulch Watershed Analysis Unit Boundary
- 200' Contour Interval

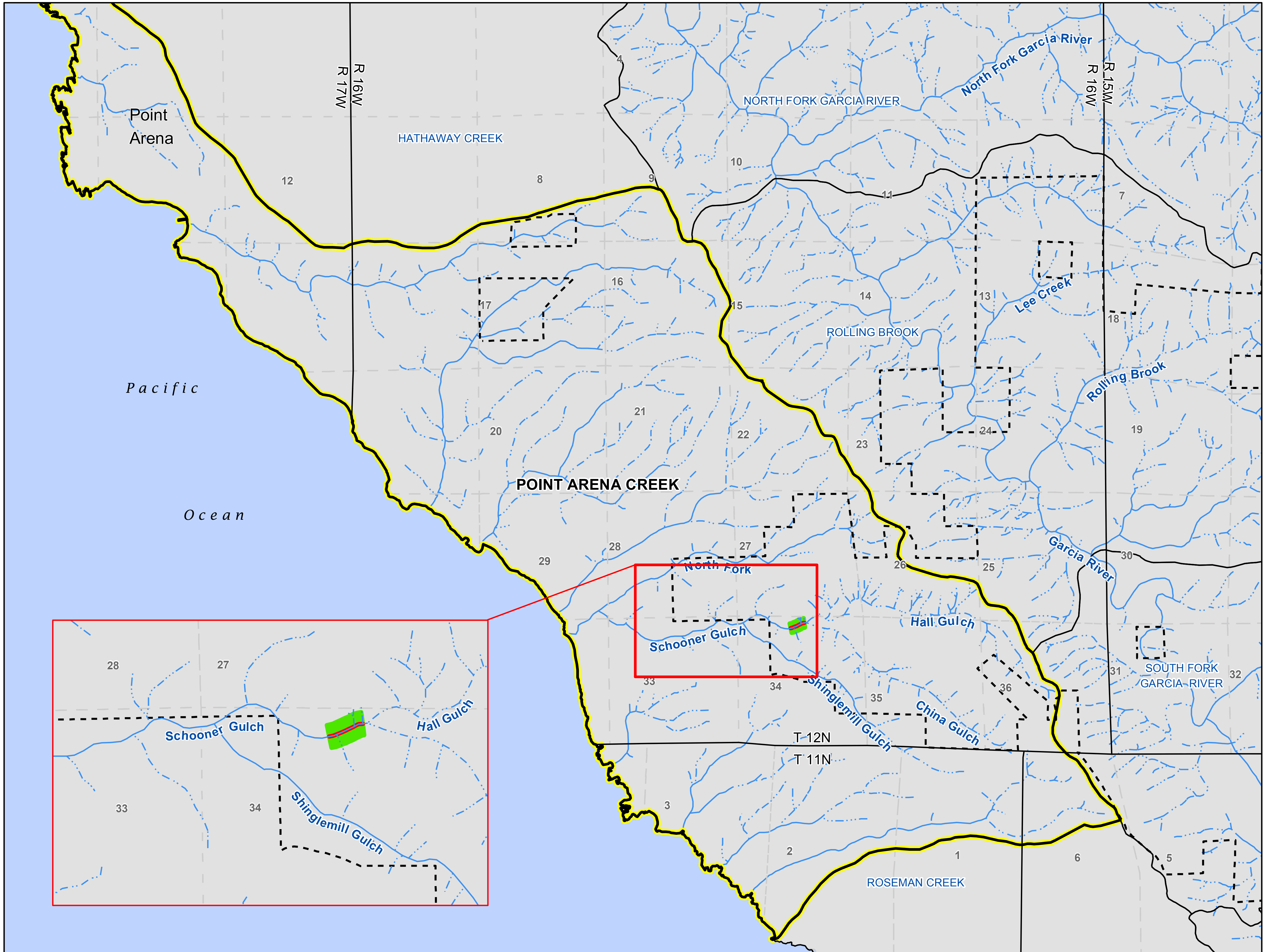
Flow Class

- Class I
- Class II
- Class III



0 0.5 1 Miles

April 2014



Southcoast Streams Watershed Analysis Unit

Point Arena Creek Planning Watershed

Map D-1 (a)
Large Woody Debris Recruitment Potential and Demand

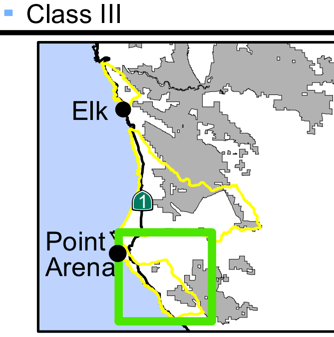
This map presents the large woody debris recruitment potential and in-stream large woody debris (LWD) demand for the streams on MRC lands in the Southcoast Streams WAU. This map provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. It is based on the stream-side stand characteristics, amount of LWD in the stream and the sensitivity of the stream channel to LWD from aerial photograph interpretation of 2004 photographs and field observations in 2005. 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
- Alder Creek/Schooner Gulch Watershed Analysis Unit Boundary
- 200' Contour Interval

Flow Class
- Class I
- Class II
- Class III



0 0.25 0.5 Miles

April 2014