APPENDIX C

STREAM NETWORK TEMPERATURE (SNTEMP) MODEL METHODOLOGY

APPENDIX C. STREAM NETWORK TEMPERATURE MODEL (SNTEMP) METHODOLOGY

1.1 KEY FINDINGS

The Stream Network Temperature Model (SNTEMP) was used to create a calibrated water temperature model for the Mokelumne River between Camanche Dam and the Cosumnes River confluence. This model was used to simulate the effects of altering the release temperature at Camanche Dam on the instream water temperature and the fisheries of the Mokelumne River. The Sacramento Airport weather station was chosen as the source for SNTEMP's meteorological data. As the source of meteorology data, this station has a conservative effect on SNTEMP results (prediction of higher water temperatures), since Sacramento air temperature is warmer than Lodi and air temperature strongly influences water temperature.

The calibration critera for the model were an overall mean difference of less than 1°C between observed and predicted water temperature and a maximum single difference of 1.5°C. Little of the temperature data for the calibration nodes overlap, especially for the reach below Woodbridge Dam. Because of the limited amount of temperature data available, all of the data was used to calibrate the models. As a result, no data were left for standard validation procedures.

Water temperatures in the Mokelumne River below Camanche Dam usually begin to rise in mid-February and continue to rise until mid- to late October when temperatures gradually begin to decrease (Figure C-7). During the heating period, water temperatures increase as stream water travels away from the source (Camanche Reservoir). Water temperature rises faster at lower flow rates than at higher flow rates, because there is less water to be heated by environmental factors. Conversely, at higher flow rates, temperatures increase more slowly. Although this trend is evident in all simulation runs, the most rapid temperature increases occurred in the 100 cfs simulation run. Also, the highest rate of temperature decrease occurred between 100 cfs and 200 cfs. At flow rates over 500 cfs, the amount of heat gain relative to flow rate increase is neglible.

During the critical part of the year (March through June), water temperatures at Bruella Road were positively correlated to Camanche release temperature (release water temperatures ranged between 10° and 15°C at 1°C increment), but it had little effect on simulated water temperatures at Ray Road. Between March and June at Bruella Road, the simulation runs for critical dry, dry, and wet/normal water years (LMRMP) showed an average gain of 0.4°C, 0.6°C, and 0.7°C, respectively, in simulated water temperature for every 1.0°C increase in the inflow water temperature. At Ray Road, dry and wet/normal water year simulations showed an average gain of 0.1° and 0.3°C, respectively, for every 1°C increase in the inflow temperature, while critical dry water year results showed no effects.

Within the range of relative humidity (36 to 89%) used in the calibration runs on the Mokelumne River, the water temperature at Bruella Road varied by about 0.5°C for a given air temperature. The simulated pattern of water temperatures at Bruella Road due to relative humidity was the same for air temperatures between 15° and 20°C (Figure C-18).

The effect of wind speed on the water temperature at Bruella Road for the range of wind speeds used in the calibration runs for the Mokelumne River is about 1.5°C. The simulated pattern of water temperatures at Bruella Road due to wind speed was the same for air temperatures between 15° and 20°C (Figure C-19).

Simulated water temperatures using the "hot" meteorological years were slightly higher than those in "normal" meteorological years during the winter months. However, for the critical months of the year (March through June), the differences in water temperature were minimal for different meteorological year types.

Using the critical LMRMP flow, a comparison of outputs using daily (198 days) and bi-monthly time steps showed that simulated water temperatures exceeded the 18°C criterion 33 times at Bruella Road; a difference of less than or equal to 1°C occurred 85.9 percent of the time. The simulation run using dry LMRMP flow resulted in simulated water temperatures exceeding the 18°C criterion 31 times at Bruella Road; differences of less than or equal to 1°C occurred 87.1 percent of the time. The simulation run using wet/normal LMRMP flow resulted in simulated water temperatures exceeding the 18°C criterion only twice; the difference was less than 1°C in both cases. At Ray Road, daily and bi-monthly time steps were compared only for the time when LMRMP flow provided extra flow for temperature control: April and May for dry LMRMP flow and April, May, and June for wet/normal LMRMP flow. For the simulation run using dry LMRMP flow for Ray Road, comparing 60 days of daily and bi-monthly time step outputs resulted in 25 days that exceeded the 18°C temperature criterion. The mean difference for the 25 days was 1.13°C, the minimum difference was 0.03°C, and the maximum difference was 2.71°C. A difference of less than or equal to 1°C occurred 48 percent of the time. For the simulation run using wet/normal LMRMP flow for Ray Road, a comparison between 91 days of daily and bi-monthly time step outputs resulted in 54 days that exceeded the 18°C temperature criterion. The mean difference for the 54 days was 1.56°C, the minimum difference was 0.02°C, and the maximum difference was 3.11°C. A difference of less than or equal to 1°C occurred 26 percent of the time (Figures C-34 and C-35).

1.2 DESCRIPTION OF STREAM NETWORK TEMPERATURE MODEL (SNTEMP)

The U.S. Fish and Wildlife Service's SNTEMP model predicts instream water temperatures based on historical or synthetic hydrological, meteorological, and stream geometry conditions. SNTEMP consists of a series of computer programs that solve a set of heat transfer equations for a simulated stream network. The stream network consists of a series of reaches connected by nodes. Each node represents a location where either a change occurs in the stream or where model output is required. Changes in the stream include dams, tributaries, confluences, and diversions; stream geometry includes azimuth, elevation, latitude, width, and shading. SNTEMP can predict water temperatures at any point in the network.

SNTEMP solves heat transfer equations for a steady-state condition. It assumes the rate of heat exchange to and from the stream is balanced at any given cross-section in the network, so that temperature is constant throughout the cross-section at any given instant. This rarely occurs in a real stream, but steady-state approximation is valid if the data are averaged over a long enough period. It is necessary to assume steady-state simplification to avoid excessive complexity in time-dependent equations. Once the appropriate input parameters of a river system are provided, the model calculates the downstream water temperature by determining the incremental gain or loss of heat over the length of the river. SNTEMP treats a stream as one dimensional, with no lateral or ertical variation in temperature.

1.3 METHODS

1.3.1 Development of SNTEMP for the Mokelumne River

Although SNTEMP is the best instream water temperature simulation model available, its inability to calculate vertical water temperature variations presents a problem for a section of the Mokelumne River. During the summer months (from April to mid-October), a segment of the Mokelumne River (Lake Lodi) is impounded primarily for agricultural diversion and seconarily for recreational purposes. This creates a seasonal lake/reservoir in a segment of the Mokelumne River where vertical stratification occurs. Because of this situation, temperature modeling of the Mokelumne River is separated temporally and spatially into four modules. By separating the Mokelumne River into segments, Lake Lodi can be isolated and a different temperature model applied. This model is the U.S. Army Corps of Engineers (COE) at the Hydrologic Engineering Center's Water Quality for River-Reservoir System (WQRRS). WQRRS can calculate and predict stratification. (The calibration of Lake Lodi module is discussed in further detail in Appendix B.) The remaining river segments are further divided by season (summer and winter months).

The water temperature model for the Mokelumne River consists of three separate SNTEMP models and one WQRRS model. Module 1 (SNTEMP) is calibrated for the entire reach of the Mokelumne River during the winter months (from mid-October through March). Module 2 (SNTEMP) is calibrated for the reach of the Mokelumne River from Camanche Reservoir to the beginning of Lake Lodi during the summer months. Module 3 (SNTEMP) is calibrated for the reach of the Mokelumne River from Woodbridge Dam to the confluence of the Cosumnes River during the summer months. The Lake Lodi module (WQRRS) is calibrated for the summer months. To run a simulation for the Mokelumne River for an entire year, all four of these modules must be executed separately in correct sequence. If only the winter months are of interest, Module 1 is sufficient; if only the summer months are of interest, the simulation must make use of Module 2, the Lake Lodi module, and Module 3 of reaches connected by nodes. Each node represents a location where either a change occurs in the stream or where model output is required. Changes in the stream include dams, tributaries, confluences, and diversions; stream geometry includes azimuth, elevation, latitude, width, and shading. SNTEMP can predict water temperatures at any point in the network.

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Meteorological data used to develop the Mokelumne River SNTEMP model were obtained through the National Climatic Data Center, Asheville, North Carolina. A weather station at Sacramento Airport, near the study site, provided the meteorology data for SNTEMP (air temperature, wind speed, relative humidity, and percentage of sunshine). Given the location (latitude and elevation) of the meteorological station, SNTEMP assumes adiabatic conditions and corrects the changes in air temperature, relative humidity, and atmospheric pressure (calculated by the model using site elevation) for the study site.

Both the Sacramento and Stockton airports were considered as sources of meteorological data for the Mokelumne River study site. Although the Stockton Airport is slightly closer to the Mokelumne River, the meteorological database at the Sacramento Airport is more extensive. Since SNTEMP is calibrated for Mokelumne River water temperature model using air temperature, we compared air temperature at the two airports. Mean daily air temperature between 1 January 1986 and 31 May 1990 (except for May 1988) was compared at the two airports to assess the difference in air temperature. We found that the mean difference (Sacramento minus Stockton) in air temperature between the two stations was -0.06°C (-0.1°F), the minimum single difference was -3.33°C (-6.0°F), the maximum single difference was 5.56°C (+10.0°F), and 86 percent of the records were within ± 1.11°C (2.0°F) of each other (see Figure C-2). We also compared the daily air temperature at Lodi and Sacramento between 1 January 1986 and 30 April 1990 (except for January - July, September, and October of 1988). Air temperature data were available for Lodi for only a limited number of years. The mean difference (Sacramento minus Lodi) in air temperature was 1.39°C (2.5°F) (see Figure C-3). Because Sacramento has more extensive meteorological records than Stockton and both stations have similar air temperatures, Sacramento was chosen as the source for SNTEMP's meteorological data. Using Sacramento as the source of meteorology data has a conservative effect on SNTEMP results (prediction of higher water temperatures), since Sacramento air temperature is warmer than Lodi and air temperature strongly influences water temperature.

1.3.3 Calibration Method for SNTEMP

Calibration is the process of fine-tuning the model to simulate the system's natural dynamics as closely as possible. The model can be calibrated at two general locations. The first is a series of global constants and coefficients located in the "Job Control" file. These apply to each of the meteorological variables: air temperature, wind speed, relative humidity, and percentage of sunshine. Constants and coefficients are associated with each of these parameters. If the parameters are set to a value other than 0, the results are a linear transformation of the original variable. This transformation applies directly to meteorological variables but is not an adjustment to the variable itself, which has been measured or determined from field data. The transformation is an adjustment of the heat transfer coefficients used in the model and entails a degree of uncertainty. This transformation also provides a means of correcting for local effects not detected by the meteorological stations. The second point at which calibration adjustments can be performed is in the "Time Period" file. This process is similar to the first calibration except that the process is localized to each time period chosen for a study.

The choice of which meteorological variable parameter to adjust is arbitrary and varies from study to study. The rule of thumb is to choose parameters that provide the best model performance. Since the effects of many meteorological input functions are correlated, it is usually not worthwhile to vary more than one set of parameters at a time. In the Mokelumne River study, air temperature was used to calibrate the model.

SNTEMP's statistical output for each calibration node includes the error for each time step (time period), the average error for the entire study period, and the correlation coefficient between observed and predicted temperatures.

1.4 CALIBRATION RESULTS

1.4.1 Calibration Results for Module 1

Module 1 covers the winter months that contain the time periods 1 through 6 (January through March) and 20 through 24 (mid-October through December). It contains 11 time periods per model year for eight years (1964, 1965, 1974, 1975, and 1987 through 1990). The calibration node is located near the middle of the study reach below Woodbridge Dam. Of the 88 possible calibration points for the eight years simulated, observed temperatures were availabel at only 42 points. The observed temperatures at these points were compared to predicted temperatures from model runs to assess model performance. The statistical output produced by SNTEMP for error terms for each time period reflects the observed data. The total mean difference between the observed and predicted data was 0.05°C and the maximum single error term was 1.5°C (see Figure C-4).

1.4.2 Calibration Results for Module 2

Module 2 covers the summer months, which contain the time periods 7 through 19 (April through mid-October). It contains 13 time periods per model year for the eight years mentioned above. The calibration node is located near the end of the study reach at the beginning of Lake Lodi. Of the 104 possible calibration points for the eight years simulated, observed temperatures were available at only 18 points. The observed temperatures at these points were compared to predicted temperatures from model runs to assess model performance. The statistical output produced by SNTEMP for error terms for each time period reflect the observed data. The total mean difference between the observed and predicted data was 0.11°C and the maximum single error term was 0.91°C (see Figure C-5).

1.4.3 Calibration Results for Module 3

Module 3 also covers the summer months that contain the time periods 7 through 19 (April through mid-October). It contains 13 time periods for a model year for the eight years mentioned above. The calibration node is located near the end of the study reach at Ray Road. Of the 104 possible calibration points for the eight years simulated, observed temperatures were available at only 11 points. The observed temperatures at these points were compared to predicted temperatures from model runs to assess model performance.

The statistical output produced by SNTEMP for error terms for each time period reflects the observed data. The total mean difference between the observed and predicted data was 0.03°C and the maximum single error term was 0.54°C (see Figure C-6).

The calibration criterion was an overall mean difference in air temperature between observed and predicted of less than 1°C and maximum single difference of 1.5°C. There was a very limited amount of over-lapping temperature data for the calibration nodes, especially for the reach below Woodbridge Dam. The limited amount of temperature data available required use of all data to calibrate the models. No data was left for standard validation procedure.

1.5 SNTEMP SIMULATION RUNS FOR THE MOKELUMNE RIVER

1.5.1 Description of SNTEMP Simulation Runs for the Mokelumne River

The object of the simulation runs for the Mokelumne River was to describe the relationship between water temperature and flow rate at various locations and to serve as a basis for flow recommendations and impact evaluation. A review of the historical hydrology data showed there was no "typical" flow regime in the stream, so we conducted sensitivity analysis simulation runs. Ten simulations were run using inflow rates (Camanche Reservoir release rate) ranging from 100 to 1,000 cfs at 100 cfs increments. Results were tabulated as flow rate vs. water temperature at all internal nodes in the Mokelumne River (Table C.1). This information was used to develop the Lower Mokelumne River Management Plan (LMRMP fish flow) for different hydrological year types.

1.5.2 Assumptions

Before a simulation can be run using a calibrated SNTEMP model, the parameters that influence the model must be defined. The parameters considered in this set of simulation runs include inflow rate, inflow temperature, and meteorological condition. Assumptions for these parameters are described below.

INFLOW RATE
The inflow rates (flow rate below Camanche Dam, which is the beginning point of the model) used in this set of simulation runs range from 100 to 1,000 cfs at 100 cfs increments. The inflow rate is kept constant throughout a simulation year.

INFLOW TEMPERATURE
Inflow temperatures were derived from the simulation results of the WQRRS developed for Camanche Reservoir. These included 10 WQRRS simulation runs using Camanche Reservoir inflow and outflow rates of 100 to 1,000 cfs in 100 cfs increments with surface elevation set at 52m (average dry year conditions). WQRRS simulation runs for Camanche Reservoir are discussed further in Appendix B.

METEOROLOGICAL DATA

The meteorology input file for this set of simulation runs used "normal" year meteorological data. A "normal" year was defined by using mean daily air temperature records from 1964 to 1987. Each year was separated into three data sets: January through March, April through mid-October, and mid-October through December. The average air temperature for each set was calculated and sorted in an ascending order; exceedence was calculated (for each of the three sets of air temperature data per year) using the following equation:

$$P = 100 - ([m/(n+1)*100])$$

where P = probability of exceeding a given value
m = rank value for variable
n = total number of ranks

The "normal" year selected had a P value of 50+ percent. Based on this information, 1974 provided the meteorological data for the time between January and March, 1979 for April through mid-October, and 1973 for mid-October through December. Once the years were selected, the other required meteorological information (relative humidity, wind speed, and percentage of sunshine) was derived from the selected year's data.

The sequence of the four modules in the simulation runs is the same as in the calibration section. The outputs for all internal nodes were requested in this run.

1.5.3 Results

Simulation results are tabulated in Table C.1. Water temperatures in the Mokelumne River below Camanche Dam usually begin to rise in mid-February and continue to rise until mid to late October when temperatures begin to fall (Figure C-7). During the heating period, water temperatures increase as stream water travels away from the source (Camanche Reservoir) (Figure C-8). Water temperature rises faster at lower flow rates than at higher flow rates, because there is less water to be heated by environmental factors. Conversely, at higher flow rates, temperatures increase more slowly. Although this trend is evident in all simulation runs, the most rapid temperature increases occurred in the 100 cfs simulation run. Of all consecutive runs, the highest rate of temperature increase occurring between 100 cfs and 200 cfs. At flow rates over 500 cfs, the amount of heat gain relative to flow rate increase is minimal (Figure C-9). During the cooling period, the trend reverses (Figure C-10); however, the effect of increases in flow rate on water temperature is less dramatic (note y axis scales). During the cooling period, the large difference in the net heat budget between 100 and 200 cfs was not seen (Figure C-11).

1.6 SENSITIVITY OF SNTEMP MODELS

1.6.1 Sensitivity Analysis of SNTEMP to Release Water Temperature From Camanche Reservoir

1.6.1.1 Assumptions

A series of sensitivity analysis runs were made to determine the sensitivity of downstream temperatures to Camanche release temperature using the LMRMP flow scenarios for critical dry, dry, and wet/normal water year types, especially for the months of March, April, May, and June, when LMRMP provides additional flow for temperature control measures. The assumptions for the parameters considered in this set of simulation runs — inflow rate, inflow temperature, and meteorological condition — are described below. Two internal nodes, Bruella Road and Ray Road, were chosen as the output nodes for the model runs.

SNTEMP INFLOW RATE
The inflow rates (Camanche release) for Module 1 and Module 2 used EBMUDSIM output for projected operations (LMRMP flow, column 3) for critical dry, dry, and wet/ normal year types (see Table C.2). The inflow rates for the Lake Lodi module and flow rates at all internal nodes in SNTEMP were calculated using a discharge-distance relationship based on two known discharge rates and distances. An appropriate percentage distribution (as described by EBMUD) of riparian diversions, channel losses, NSJWCD, and WID diversions are accounted for in these calculations. The inflow rates for Module 3 also used the LMRMP fish flow (Woodbridge release).

SNTEMP INFLOW TEMPERATURE
The inflow temperatures for Module 1 and Module 2 ranged between 10°and 15°C (constant at one release temperature throughout a simulation year) at 1°C increments for the three LMRMP flow year types. The inflow temperature for the Lake Lodi module used the simulated temperature from Module 2, and the inflow temperature for Module 3 used the release temperature from the Lake Lodi module.

SNTEMP METEOROLOGICAL DATA
The meteorological data for all modules used "normal" year conditions from Sacramento Airport. (The definition of *normal* is provided in Section 1.4.2.)

1.6.1.2 Results

Sensitivity analysis results are presented in Table C.3. Figures C-12 through C-17 present results for March through June, when LMRMP provides additional flow for temperature control. During the critical part of the year (March through June), water temperatures at Bruella Road were positively correlated to inflow temperature, but inflow temperature had little effect on simulated water temperatures at Ray Road. Between March and June at Bruella Road, the simulation runs for critical, dry, and wet/normal water years showed an average gain of 0.4°C, 0.6°C, and 0.7°C, respectively, in simulated water temperature for every 1.0°C increase in the inflow water temperature. At Ray Road, dry and wet/normal water year simulations showed an average gain of 0.1° and 0.3°C, respectively, for every 1°C increase in the inflow temperature, while critical dry water year results showed no effects.

1.6.2 Sensitivity of SNTEMP to Meteorological Variables

Not all of the meteorological data required for the SNTEMP runs were available in daily format. Daily values are averaged for each time period. Daily air temperatures and percentage sunshine values were available for the time periods used in the determination of meteorological year types, but relative humidity and wind speed were available only as monthly means. Therefore, a sensitivity analysis of SNTEMP was performed for relative humidity and wind speed to determine how each of these parameters influenced the model's behavior.

1.6.2.1 Sensitivity of SNTEMP to Relative Humidity

This sensitivity analysis used Module 2 of the SNTEMP developed for the Mokelumne River to determine the effect of relative humidity on water temperature at Bruella Road. All possible variables, except for relative humidity, were kept constant at "typical" values observed in other simulation runs. Relative humidity values used in the SNTEMP simulation runs for the Mokelumne River ranged between 36 and 89 percent.

Inflow rate was kept constant at 300 cfs, inflow temperature at 13°C, wind speed at 3.5 meters per second (m/s), and sunshine at 85 percent. The effect of relative humidity (10% - 90% at 10% intervals) on water temperature was assessed at air temperatures between 15° and 20°C.

Within the range of relative humidity used in the simulation runs on the Mokelumne River (36 to 89%), the water temperature at Bruella Road varies by about 0.5°C (Figure C-18). The range and pattern of water temperature variations at Bruella Road due to relative humidity remained constant for all air temperatures between 15° and 20°C. Therefore, using monthly values (the only available relative humidity data) should not greatly affect the results of SNTEMP simulation runs.

1.6.2.2 Sensitivity of SNTEMP to Wind Speed

The wind speed sensitivity analysis was devised to determine the effect of wind speed on water temperature at Bruella Road. It used Module 2 of the SNTEMP developed for the Mokelumne River. All possible variables, except for wind speed, were kept constant at "typical" values observed in other simulation runs. Wind speeds used in the SNTEMP simulation runs for the Mokelumne River ranged between 1.5 and 3.5 m/s.

The inflow rate was kept constant at 300 cfs, inflow temperature at 13°C, relative humidity at 70 percent, and percentage sunshine at 85 percent. The effect of wind speed (in the range of 1.0 to 4.0 m/s) on water temperature was checked at air temperatures between 15° and 20°C.

The effect of wind speed on the water temperature at Bruella Road for the range of wind speeds used in the simulation runs for the Mokelumne River is about 1.5°C (Figure C-19). The range and pattern of water temperature variation at Bruella Road due to wind speed remained constant for all air temperatures between 15° and 20°C. Thus, using monthly values (the only available wind speed data) should not greatly affect the results of SNTEMP simulation runs.

1.6.2.3 Sensitivity of SNTEMP to "Hot" Meteorological Conditions

SNTEMP runs using "hot" meteorological data sets in conjunction with the three LMRMP flow year types (critical dry, dry, and wet/normal) were compared to runs using "normal" meteorological data. Two internal nodes, Bruella Road and Ray Road, were chosen as the output nodes for the model runs.

Assumptions

INFLOW RATE
The inflow rate was defined by the LMRMP flows.

INFLOW TEMPERATURE
Release temperatures from Camanche Reservoir WQRRS runs were used as inflow temperatures (see Appendix B).

METEOROLOGICAL DATA
Two sets of meteorological data were used in this set of runs. The method described in Section 1.4.2 was used to determine the two "hot" meteorological data. "Hot" years were defined using mean daily air temperature for the period of record between 1963 and 1990. Each year was separated into four data sets: January through March, April through June, July through mid-October, and mid-October through December. The average air temperature for each set was calculated and the averaged values sorted in ascending order. Exceedence was calculated (for each of the four sets of air temperature data per year) using the equation shown in Section 1.4.2.

The two "hot" years selected were the hottest within this record period and the years at 10+ percent exceedence level. Based on this information, 1986 and 1988 provided the meteorological data for the time period between January and March, 1989 and 1973 for April through June, 1975 and 1984 for July through mid-October, and 1981 and 1976 for mid-October through December for the hottest and 10+ percent year, respectively.

Results

The results of the simulation runs are shown in Figures C-20 through C-25 and Table C.4. In all simulation runs, simulated water temperatures for the "hot" meteorological years were slightly higher than those in "normal" meteorological years during the winter months. However, for the critical months of the year (March through June), the differences in water temperature were minimal for different meteorological year types.

1.6.3 Sensitivity of SNTEMP to Daily Time Step

1.6.3.1 Assumptions

This sensitivity analysis was devised to measure the loss in sensitivity to daily climate variation due to use of bi-monthly time steps in the model. The analysis used Module 2, Module 3, and the Lake Lodi module of the water temperature model developed for the Mokelumne River. The assumptions used in this set of runs are the same as those used in Section 1.5.1, except for the time step. Two internal nodes, Bruella Road and Ray Road, were chosen as the output nodes for the model runs.

The change in time step required some changes in the meteorology data file. Daily values for air temperature and percentage sunshine replaced the bi-monthly values. Existing bi-monthly wind speed and relative humidity values were repeated daily because daily values were not available.

1.6.3.2 Results

The results of these simulation runs appear in Figures C-26 through C-28 and C-31 through C-33. There are 198 days in Module 2 using daily time step. When we compared the outputs for daily and bi-monthly time steps for the simulation run using the critical LMRMP flow, we found that simulated water temperatures exceeded the 18°C criterion 33 times at Bruella Road; a difference of less than or equal to 1°C occurred 85.9 percent of the time. The simulation run using dry LMRMP flow resulted in simulated water temperatures exceeding the 18°C criterion 31 times at Bruella Road; differences of less than or equal to 1°C occurred 87.1 percent of the time (Figures C-29 and C-30). The simulation run using wet/normal LMRMP flow resulted in simulated water temperatures exceeding 18°C criteria only twice and the difference was less than 1°C in both cases.

At Ray Road, daily and bi-monthly time steps were compared only for the time when LMRMP flow provided extra flow for temperature control: April and May for dry LMRMP flow and April, May, and June for wet/normal LMRMP flow. For the simulation run using dry LMRMP flow for Ray Road, comparing 60 days of daily and bi-monthly time step outputs resulted in 25 days that exceeded the 18°C temperature criterion. The mean difference for the 25 days was 1.13°C, the minimum difference was 0.03°C, and the maximum difference was 2.71°C. A difference of less than or equal to 1°C occurred 48 percent of the time. For the simulation run using wet/normal LMRMP flow for Ray

Road, a comparison between 91 days of daily and bi-monthly time step outputs resulted in 54 days that exceeded the 18°C temperature criterion. The mean difference for the 54 days was 1.56°C, the minimum difference was 0.02°C, and the maximum difference was 3.11°C. A difference of less than or equal to 1°C occurred 26 percent of the time (Figures C-34 and C-35).

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Table C.1. Predicted Mokelumne River water temperature (°C) by location and time period.

MOKELUMNE RIVER @ HIGHWAY 88 BRIDGE

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.33	6.27	6.30	6.34	6.38	6.39	6.42	6.45	6.52	6.54
	2	7.73	7.05	7.02	7.00	7.06	7.11	7.18	7.28	7.36	7.44
February	3	7.53	7.17	7.35	7.45	7.57	7.74	7.89	8.05	8.17	8.33
	4	7.60	7.41	7.81	7.97	8.15	8.39	8.53	8.72	8.81	8.86
March	5	8.95	8.35	8.62	8.80	8.96	9.09	9.19	9.24	9.25	9.28
	6	9.74	9.05	9.45	9.52	9.53	9.53	9.55	9.50	9.49	9.52
April	7	10.76	9.87	10.04	9.91	9.86	9.79	9.78	9.75	9.72	9.70
	8	11.59	10.54	10.50	10.31	10.20	10.19	10.14	10.13	10.09	10.04
May	9	11.92	10.92	10.77	10.66	10.55	10.45	10.46	10.42	10.42	10.43
	10	12.78	11.61	11.44	11.35	11.26	11.21	11.21	11.20	11.12	11.10
June	11	14.16	12.59	12.38	12.25	12.20	12.19	12.20	12.24	12.29	12.28
	12	14.31	12.90	13.05	12.99	12.94	13.03	13.06	13.05	13.16	13.17
July	13	15.43	13.78	13.72	13.52	13.41	13.32	13.40	13.39	13.38	13.44
	14	15.45	14.02	14.11	13.98	14.02	13.95	14.01	14.15	14.11	14.04
August	15	15.59	14.32	14.04	13.80	13.63	13.50	13.43	13.48	13.41	13.37
	16	15.74	14.51	14.15	14.01	13.90	13.91	13.91	13.79	14.04	13.95
September	17	15.33	14.45	14.35	14.41	14.38	14.35	14.50	14.44	14.38	14.68
	18	14.83	14.31	14.10	14.00	13.95	13.84	13.85	13.79	13.74	13.90
October	19	14.89	14.46	14.58	14.63	14.80	14.87	14.99	15.07	15.02	15.28
	20	15.13	14.71	14.65	12.59	14.50	14.40	14.35	14.36	14.29	14.21
November	21	14.51	14.41	14.26	12.90	14.13	14.09	14.08	14.07	14.04	14.04
	22	12.88	13.19	13.30	13.78	13.27	13.26	13.28	13.29	13.23	13.21
December	23	10.78	10.97	11.13	14.02	11.24	11.26	11.27	11.32	11.32	11.33
	24	9.69	9.66	9.79	14.32	9.91	9.94	9.96	10.03	10.05	10.05

MOKELUMNE RIVER @ RIVER MILE MARKER 55

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.56	6.42	6.40	6.41	6.43	6.44	6.46	6.48	6.54	6.57
	2	10.16	8.56	8.07	7.80	7.70	7.65	7.63	7.67	7.71	7.75
February	3	8.82	7.97	7.87	7.84	7.87	7.98	8.09	8.21	8.31	8.45
	4	8.28	7.83	8.04	8.13	8.26	8.46	8.58	8.76	8.84	8.89
March	5	11.08	9.69	9.50	9.45	9.47	9.51	9.54	9.55	9.53	9.53
	6	12.12	10.56	10.43	10.26	10.12	10.03	9.98	9.89	9.83	9.83
April	7	13.82	11.83	11.36	10.94	10.70	10.51	10.40	10.29	10.21	10.14
	8	15.15	12.84	12.10	11.56	11.22	11.05	10.89	10.78	10.69	10.58
May	9	15.21	13.09	12.31	11.85	11.53	11.29	11.18	11.05	10.99	10.94
	10	16.58	14.14	13.23	12.74	12.39	12.17	12.04	11.93	11.78	11.69
June	11	19.18	15.98	14.79	14.12	13.73	13.47	13.31	13.21	13.15	13.06
	12	18.80	15.93	15.13	14.60	14.25	14.13	14.00	13.88	13.89	13.83
July	13	20.68	17.34	16.22	15.47	15.00	14.67	14.55	14.41	14.29	14.26
	14	19.98	17.09	16.23	15.63	15.35	15.08	14.98	14.99	14.87	14.73
August	15	19.57	17.04	16.00	15.35	14.90	14.59	14.38	14.31	14.15	14.05
	16	19.59	17.15	16.07	15.51	15.14	14.94	14.80	14.59	14.74	14.59
September	17	18.25	16.36	15.69	15.43	15.21	15.05	15.09	14.97	14.86	15.10
	18	16.58	15.45	14.93	14.65	14.48	14.30	14.25	14.14	14.06	14.18
October	19	16.34	15.41	15.22	15.11	15.17	15.18	15.24	15.29	15.22	15.44
	20	16.60	15.64	15.30	15.06	14.92	14.77	14.67	14.64	14.55	14.45
November	21	14.83	14.63	14.44	14.33	14.27	14.20	14.18	14.17	14.13	14.12
	22	11.84	12.53	12.83	12.91	12.99	13.03	13.08	13.11	13.08	13.07
December	23	10.12	10.57	10.83	10.96	11.05	11.10	11.13	11.20	11.22	11.23
	24	9.79	9.73	9.82	9.86	9.92	9.94	9.96	10.04	10.06	10.06

MOKELUMNE RIVER @ ELLIOT ROAD

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.61	6.45	6.42	6.43	6.45	6.46	6.47	6.50	6.55	6.58
	2	10.63	8.91	8.33	8.00	7.87	7.79	7.76	7.78	7.80	7.84
February	3	9.07	8.16	8.00	7.94	7.95	8.05	8.14	8.26	8.35	8.48
	4	8.41	7.93	8.10	8.17	8.29	8.48	8.60	8.77	8.85	8.90
March	5	11.48	10.00	9.72	9.62	9.60	9.62	9.64	9.63	9.60	9.60
	6	12.57	10.91	10.67	10.45	10.28	10.16	10.09	9.99	9.92	9.91
April	7	14.38	12.27	11.68	11.20	10.91	10.69	10.56	10.43	10.34	10.26
	8	15.79	13.36	12.48	11.87	11.49	11.28	11.08	10.96	10.84	10.72
May	9	15.79	13.57	12.68	12.15	11.78	11.50	11.36	11.22	11.14	11.08
	10	17.23	14.70	13.66	13.08	12.68	12.41	12.25	12.12	11.95	11.85
June	11	20.01	16.73	15.36	14.58	14.11	13.79	13.59	13.46	13.37	13.26
	12	19.54	16.60	15.63	15.00	14.58	14.41	14.24	14.09	14.09	14.00
July	13	21.53	18.12	16.81	15.94	15.40	15.01	14.85	14.67	14.53	14.47
	14	20.73	17.77	16.74	16.04	15.69	15.37	15.23	15.21	15.06	14.91
August	15	20.21	17.63	16.46	15.73	15.22	14.87	14.62	14.52	14.35	14.23
	16	20.22	17.72	16.53	15.88	15.45	15.21	15.03	14.80	14.92	14.76
September	17	18.78	16.79	16.02	15.68	15.43	15.23	15.25	15.10	14.98	15.21
	18	16.91	15.71	15.13	14.82	14.62	14.42	14.35	14.24	14.15	14.25
October	19	16.60	15.62	15.37	15.23	15.27	15.26	15.31	15.35	15.28	15.49
	20	16.88	15.86	15.47	15.19	15.03	14.86	14.76	14.72	14.62	14.51
November	21	14.90	14.68	14.49	14.37	14.30	14.24	14.21	14.19	14.15	14.14
	22	11.65	12.38	12.72	12.83	12.92	12.97	13.03	13.07	13.04	13.04
December	23	9.99	10.47	10.76	10.90	11.01	11.06	11.10	11.17	11.19	11.21
	24	9.81	9.75	9.83	9.87	9.92	9.95	9.97	10.04	10.06	10.06

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Table C.1. Predicted Mokelumne River water temperature (°C) by location and time period (cont.).

MOKELUMNE RIVER @ BRUELLA ROAD

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.72	6.54	6.49	6.48	6.49	6.49	6.50	6.52	6.58	6.60
	2	11.56	9.71	8.93	8.49	8.27	8.13	8.05	8.04	8.03	8.04
February	3	9.59	8.59	8.31	8.18	8.14	8.20	8.27	8.37	8.44	8.56
	4	8.69	8.16	8.23	8.27	8.36	8.53	8.64	8.79	8.87	8.91
March	5	12.26	10.69	10.22	10.00	9.92	9.88	9.86	9.83	9.78	9.76
	6	13.43	11.69	11.22	10.89	10.64	10.48	10.37	10.24	10.15	10.12
April	7	16.19	14.21	13.19	12.46	11.98	11.62	11.37	11.16	11.00	10.86
	8	17.79	15.59	14.29	13.39	12.78	12.39	12.07	11.84	11.64	11.45
May	9	17.52	15.61	14.37	13.57	13.00	12.57	12.30	12.06	11.90	11.77
	10	19.12	17.03	15.62	14.72	14.08	13.64	13.33	13.08	12.83	12.65
June	11	22.21	19.75	17.95	16.77	15.98	15.42	15.02	14.73	14.52	14.31
	12	21.55	19.31	17.86	16.87	16.19	15.79	15.46	15.18	15.06	14.89
July	13	23.76	21.26	19.47	18.21	17.35	16.72	16.35	16.01	15.74	15.57
	14	22.74	20.50	19.01	17.96	17.32	16.80	16.48	16.32	16.06	15.83
August	15	21.93	20.01	18.55	17.52	16.78	16.24	15.84	15.61	15.34	15.13
	16	21.89	20.03	18.56	17.62	16.94	16.51	16.19	15.84	15.84	15.60
September	17	20.38	18.62	17.52	16.91	16.46	16.14	16.02	15.80	15.62	15.76
	18	17.94	16.82	16.07	15.60	15.29	15.01	14.87	14.71	14.58	14.63
October	19	17.43	16.53	16.08	15.81	15.73	15.65	15.64	15.64	15.54	15.71
	20	17.41	16.34	15.84	15.50	15.30	15.10	14.96	14.90	14.78	14.67
November	21	15.02	14.79	14.60	14.47	14.39	14.31	14.28	14.25	14.21	14.19
	22	11.29	12.06	12.46	12.62	12.75	12.83	12.90	12.96	12.95	12.96
December	23	9.74	10.27	10.59	10.77	10.89	10.96	11.02	11.09	11.12	11.15
	24	9.87	9.79	9.85	9.88	9.93	9.96	9.97	10.04	10.06	10.06

MOKELUMNE RIVER @ BELOW WOODBRIDGE DAM

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.86	6.69	6.61	6.57	6.57	6.55	6.56	6.57	6.61	6.63
	2	12.73	11.27	10.26	9.60	9.21	8.94	8.76	8.66	8.59	8.54
February	3	10.27	9.43	8.98	8.72	8.59	8.56	8.57	8.62	8.66	8.75
	4	9.06	8.61	8.52	8.48	8.52	8.63	8.71	8.84	8.91	8.94
March	5	13.20	12.02	11.30	10.89	10.65	10.50	10.40	10.30	10.21	10.15
	6	14.42	13.16	12.41	11.88	11.50	11.23	11.03	10.84	10.69	10.61
April	7	16.93	15.63	14.97	14.53	14.00	13.77	13.53	13.30	13.07	12.93
	8	17.47	16.73	16.07	15.47	14.97	14.60	14.33	14.00	13.77	13.60
May	9	19.60	18.80	18.13	17.23	16.80	16.20	15.90	15.50	15.23	14.93
	10	22.60	21.93	20.77	19.67	19.13	18.17	17.83	17.53	16.63	16.47
June	11	24.83	23.93	23.07	21.40	20.60	19.87	19.40	19.07	18.73	18.47
	12	23.97	23.03	22.53	21.13	20.33	19.43	18.97	18.57	18.37	18.07
July	13	25.60	24.27	23.37	22.13	21.33	20.60	20.23	19.73	19.37	19.23
	14	27.33	25.50	24.23	23.20	22.30	21.33	20.97	20.53	20.33	19.50
August	15	26.17	24.97	23.90	22.93	21.87	21.03	20.33	19.97	19.53	19.13
	16	24.50	23.73	22.77	21.90	20.80	20.13	19.67	19.23	19.07	18.80
September	17	24.97	23.70	22.47	21.67	20.77	20.17	19.77	19.37	19.07	19.03
	18	22.87	21.63	20.67	19.57	18.90	18.50	17.73	17.40	17.17	16.97
October	19	21.23	20.20	19.53	18.60	18.23	18.07	17.73	17.60	17.40	17.40
	20	18.05	17.25	16.64	16.21	15.91	15.64	15.45	15.34	15.19	15.04
November	21	15.15	14.99	14.80	14.66	14.56	14.48	14.43	14.39	14.33	14.31
	22	10.81	11.42	11.88	12.14	12.33	12.46	12.58	12.67	12.69	12.72
December	23	9.37	9.84	10.20	10.43	10.60	10.71	10.79	10.88	10.93	10.98
	24	9.93	9.86	9.88	9.90	9.94	9.96	9.97	10.04	10.05	10.06

MOKELUMNE RIVER @ RIVER MILE MARKER 32

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.90	6.76	6.67	6.63	6.61	6.60	6.60	6.60	6.64	6.66
	2	12.91	11.77	10.76	10.06	9.62	9.30	9.08	8.95	8.85	8.78
February	3	10.39	9.71	9.24	8.95	8.78	8.73	8.72	8.75	8.77	8.84
	4	9.14	8.77	8.64	8.58	8.59	8.69	8.76	8.88	8.94	8.97
March	5	13.33	12.43	11.71	11.25	10.96	10.78	10.64	10.53	10.41	10.34
	6	14.55	13.61	12.85	12.29	11.87	11.56	11.33	11.11	10.94	10.84
April	7	18.54	16.85	15.95	15.28	14.68	14.39	14.03	13.78	13.51	13.33
	8	18.76	17.61	16.83	16.13	15.57	15.11	14.76	14.43	14.17	13.97
May	9	21.35	20.02	19.07	18.09	17.56	16.90	16.53	16.08	15.77	15.43
	10	23.57	22.71	21.63	20.53	19.85	18.93	18.47	18.14	17.24	17.03
June	11	26.66	25.33	24.29	22.64	21.72	20.92	20.33	19.91	19.50	19.19
	12	25.42	24.21	23.45	22.09	21.22	20.27	19.79	19.30	19.04	18.69
July	13	26.64	25.43	24.41	23.12	22.24	21.47	20.99	20.46	20.05	19.85
	14	30.42	28.12	26.35	25.03	23.91	22.77	22.30	21.71	21.39	20.52
August	15	26.02	25.43	24.51	23.57	22.60	21.70	20.97	20.59	20.12	19.69
	16	24.64	24.12	23.33	22.48	21.44	20.72	20.27	19.78	19.57	19.27
September	17	24.73	24.06	23.03	22.24	21.35	20.73	20.29	19.83	19.50	19.42
	18	21.58	21.38	20.76	19.83	19.17	18.77	18.00	17.69	17.44	17.23
October	19	21.49	20.71	19.99	19.12	18.67	18.50	18.08	17.94	17.72	17.69
	20	18.15	17.54	16.95	16.49	16.17	15.89	15.68	15.54	15.38	15.23
November	21	15.18	15.06	14.89	14.75	14.65	14.56	14.50	14.46	14.40	14.37
	22	10.76	11.24	11.68	11.96	12.17	12.32	12.45	12.55	12.59	12.63
December	23	9.33	9.71	10.06	10.31	10.49	10.61	10.70	10.80	10.86	10.91
	24	9.96	9.90	9.91	9.92	9.95	9.97	9.99	10.05	10.06	10.07

Table C.1. Predicted Mokelumne River water temperature (°C) by location and time period (cont.).

MOKELUMNE RIVER @ RAY ROAD

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.91	6.79	6.70	6.65	6.63	6.61	6.61	6.61	6.65	6.67
	2	12.96	11.98	11.00	10.29	9.82	9.48	9.24	9.10	8.98	8.90
February	3	10.42	9.83	9.36	9.06	8.88	8.81	8.79	8.81	8.83	8.89
	4	9.16	8.84	8.70	8.62	8.63	8.72	8.78	8.89	8.95	8.98
March	5	13.37	12.60	11.89	11.42	11.12	10.91	10.77	10.64	10.52	10.43
	6	14.59	13.79	13.05	12.48	12.04	11.72	11.48	11.25	11.07	10.96
April	7	18.92	17.36	16.38	15.66	15.02	14.68	14.30	14.02	13.73	13.54
	8	19.05	17.97	17.15	16.44	15.85	15.37	15.00	14.65	14.37	14.16
May	9	21.69	20.48	19.51	18.50	17.93	17.25	16.85	16.38	16.04	15.69
	10	23.74	23.01	21.99	20.91	20.21	19.29	18.80	18.45	17.55	17.31
June	11	26.94	25.83	24.79	23.21	22.25	21.42	20.79	20.33	19.90	19.55
	12	25.66	24.64	23.85	22.55	21.66	20.71	20.19	19.67	19.38	19.01
July	13	26.80	25.83	24.84	23.59	22.69	21.90	21.38	20.83	20.39	20.17
	14	30.82	29.01	27.26	25.87	24.68	23.50	22.94	22.30	21.94	21.04
August	15	25.99	25.58	24.76	23.87	22.93	22.04	21.31	20.90	20.42	19.98
	16	24.67	24.27	23.56	22.75	21.74	21.02	20.56	20.05	19.82	19.51
September	17	24.68	24.19	23.26	22.49	21.62	20.99	20.54	20.07	19.72	19.63
	18	21.29	21.29	20.79	19.94	19.31	18.90	18.15	17.83	17.58	17.36
October	19	21.55	20.90	20.22	19.36	18.89	18.70	18.27	18.11	17.88	17.83
	20	18.17	17.65	17.09	16.63	16.30	16.01	15.79	15.65	15.48	15.32
November	21	15.19	15.09	14.93	14.79	14.69	14.59	14.54	14.49	14.43	14.40
	22	10.75	11.16	11.59	11.87	12.09	12.25	12.38	12.49	12.53	12.58
December	23	9.32	9.65	10.00	10.24	10.43	10.55	10.65	10.76	10.82	10.88
	24	9.97	9.91	9.92	9.93	9.96	9.98	9.99	10.05	10.06	10.07

MOKELUMNE RIVER @ RIVER MILE MARKER 24

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.92	6.82	6.73	6.68	6.66	6.64	6.63	6.63	6.67	6.68
	2	12.99	12.22	11.30	10.58	10.09	9.73	9.47	9.30	9.17	9.08
February	3	10.45	9.98	9.52	9.20	9.01	8.93	8.89	8.89	8.90	8.96
	4	9.18	8.91	8.77	8.68	8.68	8.75	8.80	8.91	8.96	8.99
March	5	13.39	12.80	12.13	11.65	11.33	11.10	10.94	10.79	10.66	10.56
	6	14.61	14.01	13.31	12.74	12.29	11.94	11.68	11.44	11.25	11.13
April	7	19.18	17.93	16.92	16.15	15.47	15.08	14.66	14.36	14.05	13.83
	8	19.25	18.37	17.56	16.83	16.22	15.72	15.32	14.95	14.65	14.42
May	9	21.90	20.98	20.03	19.04	18.42	17.72	17.28	16.79	16.42	16.05
	10	23.85	23.31	22.42	21.40	20.69	19.78	19.26	18.87	17.98	17.72
June	11	27.09	26.33	25.38	23.92	22.95	22.09	21.42	20.92	20.45	20.06
	12	25.78	25.08	24.33	23.12	22.23	21.28	20.73	20.18	19.85	19.45
July	13	26.89	26.24	25.34	24.18	23.27	22.47	21.91	21.34	20.87	20.61
	14	31.00	29.87	28.29	26.90	25.68	24.46	23.82	23.12	22.69	21.77
August	15	25.98	25.73	25.06	24.25	23.36	22.49	21.76	21.33	20.83	20.37
	16	24.68	24.42	23.82	23.08	22.14	21.43	20.95	20.43	20.17	19.84
September	17	24.65	24.33	23.54	22.81	21.98	21.34	20.87	20.39	20.03	19.91
	18	21.08	21.20	20.82	20.07	19.48	19.08	18.36	18.03	17.77	17.54
October	19	21.59	21.12	20.48	19.68	19.20	18.97	18.53	18.35	18.10	18.04
	20	18.19	17.79	17.26	16.81	16.47	16.17	15.94	15.79	15.61	15.44
November	21	15.19	15.12	14.98	14.84	14.74	14.65	14.58	14.54	14.48	14.44
	22	10.74	11.06	11.47	11.75	11.98	12.14	12.29	12.40	12.45	12.51
December	23	9.30	9.58	9.91	10.15	10.34	10.48	10.58	10.69	10.76	10.82
	24	9.97	9.93	9.93	9.93	9.96	9.98	9.99	10.05	10.06	10.07

MOKELUMNE RIVER @ RIVER MILE MARKER 19 (CONFLUENCE OF COSUMNES RIVER)

	TIME PERIOD	FLOW RATES BELOW CAMANCHE DAM 100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	1	6.92	6.85	6.77	6.71	6.69	6.66	6.65	6.65	6.68	6.69
	2	13.01	12.47	11.64	10.94	10.43	10.04	9.76	9.56	9.41	9.30
February	3	10.46	10.12	9.70	9.38	9.17	9.07	9.01	9.00	9.00	9.04
	4	9.19	8.99	8.85	8.75	8.73	8.79	8.83	8.93	8.98	9.00
March	5	13.40	13.00	12.40	11.92	11.58	11.33	11.15	10.99	10.84	10.73
	6	14.63	14.21	13.59	13.04	12.58	12.22	11.94	11.69	11.48	11.34
April	7	19.31	18.45	17.51	16.72	16.02	15.58	15.13	14.79	14.45	14.21
	8	19.35	18.75	18.01	17.29	16.67	16.15	15.73	15.33	15.01	14.76
May	9	21.99	21.41	20.58	19.65	19.00	18.29	17.82	17.30	16.91	16.52
	10	23.88	23.57	22.85	21.95	21.25	20.37	19.82	19.40	18.53	18.23
June	11	27.13	26.73	25.96	24.71	23.75	22.89	22.18	21.64	21.13	20.71
	12	25.83	25.43	24.80	23.76	22.90	21.97	21.39	20.81	20.44	20.02
July	13	26.92	26.56	25.85	24.82	23.95	23.15	22.57	21.97	21.48	21.18
	14	31.05	30.50	29.29	28.02	26.81	25.60	24.88	24.13	23.62	22.69
August	15	25.97	25.84	25.35	24.66	23.85	23.03	22.32	21.86	21.35	20.88
	16	24.68	24.54	24.09	23.45	22.60	21.91	21.42	20.89	20.61	20.26
September	17	24.63	24.45	23.84	23.18	22.40	21.77	21.29	20.80	20.42	20.27
	18	20.98	21.10	20.85	20.23	19.69	19.30	18.62	18.28	18.01	17.77
October	19	21.61	21.31	20.77	20.04	19.56	19.29	18.85	18.65	18.39	18.30
	20	18.19	17.92	17.46	17.03	16.68	16.38	16.14	15.97	15.78	15.61
November	21	15.20	15.15	15.03	14.90	14.80	14.71	14.64	14.59	14.53	14.49
	22	10.73	10.96	11.32	11.61	11.84	12.01	12.16	12.28	12.34	12.41
December	23	9.30	9.50	9.80	10.04	10.24	10.38	10.49	10.61	10.68	10.74
	24	9.98	9.94	9.94	9.94	9.97	9.98	9.99	10.04	10.06	10.07

Table C.2. Camanche releases (flows in cfs) required to meet proposed LMRMP fish flows (does not include City of Lodi).

MONTH	REQUIRED FLOW AT CAMANCHE DAM	RESULTING FLOW AT CAMANCHE DAM	RIPARIANS: CAMANCHE TO WID	CHANNEL LOSS CAMANCHE TO WID	NSJWCD	WID	REQUIRED FLOW AT WOODBRIDGE DAM	RESULTING FLOW AT WOODBRIDGE DAM	RIPARIANS: WID TO TIDEWATER	CHANNEL LOSS: WID TO TIDEWATER	FISH FLOW
WET/NORMAL YEAR											
January	200	200	2	65	0	0	100	133	1	6	126
February	200	200	2	58	0	0	100	140	1	6	134
March	200	200	5	71	0	7	100	117	2	7	108
April	100	269	15	76	0	53	125	175	7	8	161
May	100	649	38	80	55	126	350	350	16	8	326
June	300	903	55	85	77	186	500	500	24	8	468
July	325	481	52	86	88	223	20	31	22	9	0
August	200	401	34	83	55	206	20	23	15	8	0
September	100	265	18	67	34	126	20	20	8	7	6
October	200	251	8	52	20	61	110	110	3	5	51
November	300	357	4	53	0	0	300	300	2	5	293
December	300	300	6	68	0	0	200	226	3	7	217
Total (af)	152,000	269,800	14,400	50,900	19,900	59,700	114,800	124,900	6,200	5,000	113,700
DRY YEAR											
January	200	200	2	65	0	0	100	133	1	6	126
February	200	200	2	58	0	0	100	140	1	6	134
March	200	200	5	71	0	6	100	118	2	7	109
April	100	269	15	76	0	55	125	175	7	8	161
May	100	562	38	80	0	94	350	350	16	8	326
June	300	300	55	85	0	126	20	34	24	8	2
July	200	309	52	86	0	139	20	31	22	9	0
August	200	260	34	83	0	120	20	23	15	8	0
September	100	184	18	67	0	79	20	20	8	7	6
October	150	150	8	52	0	23	60	66	3	5	58
November	200	257	4	53	0	0	200	200	2	5	193
December	200	274	6	68	0	0	200	200	3	7	191
Total (af)	129,200	194,100	14,400	51,000	0	38,900	80,100	89,900	6,200	5,000	78,700
DRY YEAR											
January	100	117	2	65	0	0	50	50	1	6	43
February	100	110	2	58	0	0	50	50	1	6	44
March	100	132	5	71	0	6	50	50	2	7	41
April	100	166	15	76	0	55	20	20	7	8	6
May	100	236	38	80	0	94	20	24	16	8	0
June	300	300	55	85	0	126	20	34	24	8	2
July	100	309	52	86	0	139	20	31	22	9	0
August	100	260	34	83	0	120	20	23	15	8	0
September	100	184	18	67	0	79	20	20	8	7	6
October	100	104	8	52	0	23	20	20	3	5	11
November	100	157	4	53	0	0	100	100	2	5	93
December	100	149	6	68	0	0	75	75	3	7	66
Total (af)	84,200	134,200	14,400	51,000	0	38,900	28,000	29,900	6,200	5,000	18,700

Table C.3. SNTEMP sensitivity to Camanche release temperature using LMRMP flows. Release temperature from Camanche into Mokelumne ranges between 10 and 15° C.

CRITICAL YEAR — PREDICTED WATER TEMPERATURE AT BRUELLA ROAD WHEN THE RELEASE TEMPERATURE IS:

MONTH	TIME PERIOD	10 (Deg. C)	11 (Deg. C)	12 (Deg. C)	13 (Deg. C)	14 (Deg. C)	15 (Deg. C)
January	1	7.90	8.21	8.52	8.82	9.11	9.40
	2	12.16	12.44	12.72	13.00	13.27	13.53
February	3	10.32	10.60	10.88	11.15	11.41	11.67
	4	9.41	9.69	9.97	10.25	10.52	10.78
March	5	12.35	12.66	12.97	13.27	13.57	13.86
	6	13.23	13.54	13.85	14.14	14.44	14.72
April	7	14.30	14.69	15.07	15.44	15.81	16.17
	8	15.43	15.81	16.18	16.55	16.91	17.26
May	9	14.27	14.77	15.25	15.73	16.20	16.67
	10	15.24	15.73	16.21	16.68	17.15	17.60
June	11	16.12	16.68	17.24	17.79	18.33	18.86
	12	15.73	16.29	16.85	17.40	17.95	18.48
July	13	16.70	17.28	17.86	18.43	18.98	19.54
	14	16.10	16.69	17.27	17.84	18.40	18.95
August	15	16.50	17.02	17.53	18.03	18.52	19.01
	16	16.46	16.98	17.49	17.99	18.49	18.97
September	17	16.46	16.90	17.33	17.76	18.18	18.60
	18	14.76	15.21	15.66	16.10	16.53	16.96
October	19	16.14	16.36	16.58	16.79	16.99	17.19
	20	16.26	16.51	16.76	17.00	17.24	17.48
November	21	13.21	13.60	13.99	14.37	14.75	15.11
	22	10.41	10.82	11.23	11.63	12.02	12.40
December	23	9.58	10.00	10.41	10.82	11.22	11.61
	24	9.97	10.39	10.80	11.21	11.60	11.99

DRY YEAR — PREDICTED WATER TEMPERATURE AT BRUELLA ROAD WHEN THE RELEASE TEMPERATURE IS:

MONTH	TIME PERIOD	10 (Deg. C)	11 (Deg. C)	12 (Deg. C)	13 (Deg. C)	14 (Deg. C)	15 (Deg. C)
January	1	8.54	9.06	9.56	10.06	10.56	11.04
	2	11.53	12.03	12.52	13.01	13.48	13.95
February	3	10.23	10.74	11.24	11.74	12.22	12.70
	4	9.61	10.12	10.63	11.13	11.62	12.10
March	5	11.79	12.28	12.75	13.22	13.68	14.13
	6	12.47	12.95	13.42	13.89	14.34	14.79
April	7	13.03	13.61	14.18	14.74	15.29	15.84
	8	13.83	14.41	14.97	15.53	16.08	16.62
May	9	12.07'	12.83	13.59	14.34	15.09	15.83
	10	12.54	13.30	14.06	14.81	15.56	16.30
June	11	16.12	16.68	17.24	17.79	18.33	18.86
	12	15.73	16.29	16.85	17.40	17.95	18.48
July	13	16.70	17.28	17.86	18.43	18.98	19.54
	14	16.10	16.69	17.27	17.84	18.40	18.95
August	15	16.50	17.02	17.53	18.03	18.52	19.01
	16	16.46	16.98	17.49	17.99	18.49	18.97
September	17	16.46	16.90	17.33	17.76	18.18	18.60
	18	14.76	15.21	15.66	16.10	16.53	16.96
October	19	15.03	15.40	15.77	16.12	16.47	16.82
	20	15.05	15.46	15.86	16.25	16.64	17.02
November	21	12.27	12.85	13.42	13.98	14.54	15.09
	22	10.30	10.89	11.47	12.04	12.61	13.17
December	23	9.75	10.38	11.01	11.63	12.24	12.84
	24	10.00	10.63	11.25	11.87	12.48	13.09

WET-NORMAL YEAR — PREDICTED WATER TEMPERATURE AT BRUELLA ROAD WHEN THE RELEASE TEMPERATURE IS:

MONTH	TIME PERIOD	10 (Deg. C)	11 (Deg. C)	12 (Deg. C)	13 (Deg. C)	14 (Deg. C)	15 (Deg. C)
January	1	8.54	9.06	9.56	10.06	10.56	11.04
	2	11.53	12.03	12.52	13.01	13.48	13.95
February	3	10.23	10.74	11.24	11.74	12.22	12.70
	4	9.61	10.12	10.63	11.13	11.62	12.10
March	5	11.79	12.28	12.75	13.22	13.68	14.13
	6	12.47	12.95	13.42	13.89	14.34	14.79
April	7	13.03	13.61	14.18	14.74	15.29	15.84
	8	13.83	14.41	14.97	15.53	16.08	16.62
May	9	11.84	12.63	13.42	14.20	14.97	15.74
	10	12.26	13.05	13.83	14.61	15.39	16.16
June	11	12.33	13.17	14.01	14.85	15.68	16.51
	12	12.18	13.02	13.86	14.70	15.53	16.36
July	13	14.71	15.43	16.14	16.84	17.54	18.23
	14	14.29	15.01	15.72	16.42	17.12	17.81
August	15	14.66	15.33	15.98	16.63	17.28	17.91
	16	14.63	15.30	15.96	16.61	17.25	17.89
September	17	15.00	15.58	16.15	16.71	17.27	17.82
	18	13.67	14.26	14.84	15.41	15.97	16.53
October	19	13.54	14.11	14.67	15.22	15.77	16.30
	20	13.50	14.10	14.69	15.28	15.86	16.43
November	21	11.74	12.42	13.10	13.76	14.42	15.08
	22	10.23	10.92	11.60	12.27	12.94	13.60
December	23	9.77	10.43	11.08	11.73	12.37	13.00
	24	10.00	10.66	11.31	11.95	12.59	13.23

Table C.3. SNTEMP sensitivity to Camanche release temperature using LMRMP flows. Release temperature from Camanche into Mokelumne ranges between 10 and 15° C (cont.).

CRITICAL YEAR — PREDICTED WATER TEMPERATURE AT RAY ROAD WHEN THE RELEASE TEMPERATURE IS:

MONTH	TIME PERIOD	10 (Deg. C)	11 (Deg. C)	12 (Deg. C)	13 (Deg. C)	14 (Deg. C)	15 (Deg. C)
January	1	7.00	7.03	7.05	7.08	7.10	7.12
	2	12.98	12.99	13.01	13.02	13.04	13.05
February	3	10.46	10.48	10.50	10.51	10.53	10.55
	4	9.21	9.23	9.25	9.26	9.28	9.30
March	5	13.36	13.37	13.39	13.40	13.42	13.43
	6	14.57	14.58	14.59	14.61	14.62	14.63
April	7	19.35	19.35	19.35	19.35	19.35	19.35
	8	19.37	19.37	19.37	19.37	19.37	19.37
May	9	22.00	22.00	22.00	22.00	22.00	22.00
	10	23.88	23.88	23.88	23.88	23.88	23.89
June	11	27.11	27.11	27.11	27.11	27.11	27.11
	12	25.80	25.80	25.80	25.80	25.80	25.80
July	13	26.90	26.90	26.90	26.90	26.90	26.90
	14	31.03	31.04	31.04	31.04	31.04	31.04
August	15	25.97	25.97	25.97	25.97	25.97	25.97
	16	24.68	24.68	24.68	24.68	24.68	24.68
September	17	24.62	24.62	24.62	24.62	24.62	24.62
	18	20.94	20.94	20.94	20.94	20.94	20.94
October	19	21.61	21.61	21.61	21.61	21.61	21.61
	20	18.20	18.20	18.20	18.20	18.20	18.20
November	21	14.84	14.91	14.98	15.05	15.12	15.18
	22	10.65	10.74	10.83	10.92	11.00	11.08
December	23	9.34	9.41	9.49	9.56	9.63	9.69
	24	9.98	10.05	10.12	10.19	10.25	10.32

DRY YEAR — PREDICTED WATER TEMPERATURE AT RAY ROAD WHEN THE RELEASE TEMPERATURE IS:

MONTH	TIME PERIOD	10 (Deg. C)	11 (Deg. C)	12 (Deg. C)	13 (Deg. C)	14 (Deg. C)	15 (Deg. C)
January	1	7.50	7.68	7.85	8.02	8.19	8.35
	2	12.58	12.73	12.88	13.02	13.16	13.30
February	3	10.40	10.57	10.74	10.90	11.06	11.22
	4	9.34	9.52	9.70	9.87	10.04	10.20
March	5	13.01	13.13	13.25	13.37	13.48	13.59
	6	14.11	14.23	14.34	14.46	14.57	14.67
April	7	17.37	17.52	17.67	17.82	18.11	18.17
	8	17.83	17.96	18.07	18.18	18.42	18.44
May	9	17.73	18.02	18.29	18.60	18.86	19.11
	10	19.41	19.74	20.02	20.34	20.64	20.92
June	11	27.10	27.10	27.10	27.11	27.11	27.11
	12	25.80	25.80	25.80	25.80	25.80	25.80
July	13	26.90	26.90	26.90	26.90	26.90	26.90
	14	31.03	31.04	31.04	31.04	31.04	31.04
August	15	25.97	25.97	25.97	25.97	25.97	25.97
	16	24.68	24.68	24.68	24.68	24.68	24.68
September	17	24.62	24.62	24.62	24.62	24.62	24.62
	18	20.94	20.94	20.94	20.94	20.94	20.94
October	19	21.31	21.33	21.37	21.38	21.43	21.46
	20	17.86	17.91	17.95	18.00	18.04	18.08
November	21	13.98	14.23	14.47	14.71	14.94	15.16
	22	10.53	10.80	11.06	11.32	11.57	11.82
December	23	9.52	9.84	10.14	10.45	10.74	11.03
	24	9.99	10.30	10.61	10.91	11.20	11.49

WET-NORMAL YEAR — PREDICTED WATER TEMPERATURE AT RAY ROAD WHEN THE RELEASE TEMPERATURE IS:

MONTH	TIME PERIOD	10 (Deg. C)	11 (Deg. C)	12 (Deg. C)	13 (Deg. C)	14 (Deg. C)	15 (Deg. C)
January	1	7.50	7.68	7.85	8.02	8.19	8.35
	2	12.58	12.73	12.88	13.02	13.16	13.30
February	3	10.40	10.57	10.74	10.90	11.06	11.22
	4	9.34	9.52	9.70	9.87	10.04	10.20
March	5	13.01	13.13	13.25	13.37	13.48	13.59
	6	14.12	14.23	14.35	14.46	14.57	14.67
April	7	17.35	17.50	17.65	17.80	18.09	18.16
	8	17.82	17.94	18.06	18.17	18.41	18.43
May	9	17.58	17.86	18.17	18.45	18.75	19.09
	10	19.21	19.54	19.87	20.17	20.49	20.79
June	11	19.66	20.07	20.48	20.89	21.36	21.76
	12	18.77	19.19	19.60	20.04	20.45	20.86
July	13	26.89	26.89	26.89	26.89	26.90	26.90
	14	31.03	31.03	31.03	31.03	31.03	31.03
August	15	25.97	25.97	25.97	25.97	25.97	25.97
	16	24.68	24.68	24.68	24.68	24.68	24.68
September	17	24.62	24.62	24.62	24.62	24.62	24.62
	18	20.94	20.94	20.94	20.94	20.94	20.94
October	19	20.83	20.90	20.96	21.02	21.07	21.12
	20	16.95	17.11	17.28	17.44	17.59	17.75
November	21	13.29	13.67	14.05	14.42	14.78	15.14
	22	10.45	10.85	11.24	11.63	12.01	12.39
December	23	9.55	9.91	10.25	10.59	10.93	11.25
	24	10.00	10.35	10.69	11.03	11.36	11.68

Table C.4. Sensitivity analysis of Mokelumne River water temperature to hot meteorology.

SENSITIVITY TO DIFFERENT METEOROLOGICAL CONDITIONS

MXMETC	Hottest meteorology data file using Critical LMRMP flow.
MXMETD	Hottest meteorology data file using Dry LMRMP flow.
MXMETW	Hottest meteorology data file using Wet/Normal Critical LMRMP flow.
10METC	10% exceedence level meteorology data file using Critical LMRMP flow.
10METD	10% exceedence level meteorology data file using Dry LMRMP flow.
10METW	10% exceedence level meteorology data file using Wet/Normal LMRMP flow.
NLMETC	Normal meteorological data file using Critical LMRMP flow.
NLMETD	Normal meteorological data file using Dry LMRMP flow.
NLMETW	Normal meteorological data file using Wet/Normal LMRMP flow.

SIMULATED WATER TEMPERATURE (CELCIUS) AT BRUELLA ROAD

TIME PERIOD		MXMETC	MXMETD	MXMETW	10METC	10METD	10METW	NLMETC	NLMETD	NLMETW
1	January	9.25	8.29	8.23	8.18	7.58	7.52	6.71	6.59	6.53
2		13.87	11.67	11.47	11.29	9.86	9.68	11.20	9.86	9.69
3	February	11.00	9.85	9.67	10.95	9.72	9.49	9.54	8.82	8.61
4		11.94	10.58	10.37	10.83	9.83	9.61	8.76	8.46	8.25
5	March	13.25	12.06	11.88	12.55	11.52	11.32	11.79	10.96	10.76
6		15.29	13.70	13.53	13.45	12.40	12.24	12.86	11.96	11.79
7	April	15.06	13.32	13.32	12.70	11.73	11.73	13.89	12.54	12.54
8		16.32	14.30	14.30	15.40	13.74	13.74	15.17	13.53	13.53
9	May	14.91	12.29	12.01	14.91	12.35	12.02	14.14	11.89	11.68
10		14.77	12.65	12.41	14.90	12.70	12.54	15.34	12.87	12.63
11	June	16.41	16.41	13.51	16.14	16.18	13.44	16.63	16.67	13.53
12		17.06	17.11	14.43	17.62	17.69	14.64	16.72	16.78	14.28
13	July	17.79	17.79	16.31	18.90	18.90	17.06	18.03	18.03	16.49
14		17.47	17.49	16.33	16.84	16.85	15.89	17.76	17.76	16.58
15	August	17.90	17.93	16.51	17.66	17.66	16.31	17.95	17.97	16.52
16		17.30	17.30	16.21	17.64	17.64	16.44	17.98	17.98	16.69
17	September	17.32	17.33	16.57	17.29	17.30	16.55	17.93	17.93	17.10
18		17.20	17.21	16.41	16.34	16.35	15.76	16.36	16.36	15.76
19	October	14.96	14.80	14.68	15.63	15.34	15.06	16.94	16.43	15.89
20		17.37	16.78	15.98	15.60	15.37	15.03	17.27	16.71	15.97
21	November	17.66	16.68	16.12	16.83	15.98	15.53	14.72	14.60	14.42
22		14.53	14.47	14.07	12.06	12.63	12.72	11.76	12.33	12.49
23	December	10.43	11.36	10.78	10.25	11.31	10.67	10.04	11.13	10.60
24		10.16	10.18	10.13	8.24	9.05	9.09	9.55	9.86	9.82
ANNUAL AVERAGE		14.97	14.23	13.55	14.26	13.74	13.09	14.13	13.67	13.01

DIFFERENCE IN WATER TEMPERATURE FROM CORRESPONDING NORMAL YEAR SIMULATION RUNS IN DEGREES CELSIUS AT BRUELLA ROAD

TIME PERIOD		MXMETC	MXMETD	MXMETW	10METC	10METD	10METW
1	January	2.5	1.7	1.7	1.5	1.0	1.0
2		2.7	1.8	1.8	0.1	0.0	-0.0
3	February	1.5	1.0	1.1	1.4	0.9	0.9
4		3.2	2.1	2.1	2.1	1.4	1.4
5	March	1.5	1.1	1.1	0.8	0.6	0.6
6		2.4	1.7	1.7	0.6	0.4	0.5
7	April	1.2	0.8	0.8	-1.2	-0.8	-0.8
8		1.2	0.8	0.8	0.2	0.2	0.2
9	May	0.8	0.4	0.3	0.8	0.5	0.3
10		-0.6	-0.2	-0.2	-0.4	-0.2	-0.1
11	June	-0.2	-0.3	-0.0	-0.5	-0.5	-0.1
12		0.3	0.3	0.2	0.9	0.9	0.4
13	July	-0.2	-0.2	-0.2	0.9	0.9	0.6
14		-0.3	-0.3	-0.3	-0.9	-0.9	-0.7
15	August	-0.1	-0.0	-0.0	-0.3	-0.3	-0.2
16		-0.7	-0.7	-0.5	-0.3	-0.3	-0.3
17	September	-0.6	-0.6	-0.5	-0.6	-0.6	-0.6
18		0.8	0.9	0.7	-0.0	-0.0	0.0
19	October	-2.0	-1.6	-1.2	-1.3	-1.1	-0.8
20		0.1	0.1	0.0	-1.7	-1.3	-0.9
21	November	2.9	2.1	1.7	2.1	1.4	1.1
22		2.8	2.1	1.6	0.3	0.3	0.2
23	December	0.4	0.2	0.2	0.2	0.2	0.1
24		0.6	0.3	0.3	-1.3	-0.8	-0.7
ANNUAL AVERAGE		0.84	0.56	0.55	0.13	0.07	0.08

Table C.4. Sensitivity analysis of Mokelumne River water temperature to hot meteorology (cont.)

SENSITIVITY TO DIFFERENT METEOROLOGICAL CONDITIONS

MXMETC	Hottest meteorology data file using Critical LMRMP flow.
MXMETD	Hottest meteorology data file using Dry LMRMP flow.
MXMETW	Hottest meteorology data file using Wet/Normal Critical LMRMP flow.
10METC	10% exceedence level meteorology data file using Critical LMRMP flow.
10METD	10% exceedence level meteorology data file using Dry LMRMP flow.
10METW	10% exceedence level meteorology data file using Wet/Normal LMRMP flow.
NLMETC	Normal meteorological data file using Critical LMRMP flow.
NLMETD	Normal meteorological data file using Dry LMRMP flow.
NLMETW	Normal meteorological data file using Wet/Normal LMRMP flow.

SIMULATED WATER TEMPERATURE (CELCIUS) AT RAY ROAD

TIME PERIOD		MXMETC	MXMETD	MXMETW	10METC	10METD	10METW	NLMETC	NLMET	NLMETW
1	January	10.93	9.98	9.96	9.18	8.63	8.60	6.91	6.81	6.79
2		16.75	15.31	15.24	13.35	12.25	12.19	12.93	12.06	12.00
3	February	12.09	11.50	11.45	12.57	11.58	11.50	10.41	9.91	9.83
4		13.40	12.58	12.51	12.08	11.34	11.26	9.16	8.94	8.86
5	March	15.20	14.57	14.54	14.51	13.81	13.76	13.33	12.79	12.74
6		18.07	17.13	17.10	15.32	14.70	14.67	14.55	13.98	13.95
7	April	22.31	19.83	19.80	17.18	15.46	15.44	19.35	17.26	17.23
8		21.47	19.48	19.45	19.40	17.73	17.70	19.37	17.74	17.72
9	May	23.73	18.33	18.16	23.79	18.41	18.26	22.00	17.63	17.50
10		22.59	18.48	18.30	22.83	18.65	18.49	23.88	19.56	19.39
11	June	26.03	26.02	19.26	25.60	25.59	18.90	27.11	27.10	20.21
12		26.30	26.30	19.87	28.26	28.26	20.76	25.80	25.80	19.74
13	July	26.27	26.27	26.26	29.53	29.53	29.52	26.90	26.90	26.89
14		30.29	30.29	30.29	28.42	28.42	28.41	31.04	31.04	31.03
15	August	26.12	26.12	26.12	25.57	25.57	25.57	25.97	25.97	25.97
16		23.76	23.76	23.76	24.34	24.34	24.34	24.68	24.68	24.68
17	September	23.65	23.65	23.65	23.36	23.36	23.36	24.62	24.62	24.62
18		22.58	22.58	22.57	20.80	20.80	20.80	20.94	20.94	20.94
19	October	18.93	18.56	18.16	19.64	19.79	19.26	21.61	21.41	21.02
20		18.32	18.17	17.74	15.92	15.88	15.75	18.20	18.05	17.62
21	November	19.20	18.42	17.74	18.38	17.54	16.90	15.11	14.96	14.78
22		15.10	14.92	14.59	11.24	11.80	12.08	10.95	11.45	11.76
23	December	10.08	10.65	10.42	9.69	10.48	10.19	9.42	10.21	10.00
24		10.82	10.59	10.54	7.80	8.43	8.51	9.90	9.92	9.90
ANNUAL AVERAGE		19.75	18.90	18.23	18.70	18.01	17.34	18.51	17.91	17.30

DIFFERENCE IN WATER TEMPERATURE FROM CORRESPONDING NORMAL YEAR SIMULATION RUNS IN DEGREES CELSIUS AT RAY ROAD

TIME PERIOD		MXMETC	MXMETD	MXMETW	10METC	10METD	10METW
1	January	4.02	3.17	3.17	2.27	1.82	1.81
2		3.82	3.25	3.24	0.42	0.19	0.19
3	February	1.68	1.59	1.62	2.16	1.67	1.67
4		4.24	3.64	3.65	2.92	2.40	2.40
5	March	1.87	1.78	1.80	1.18	1.02	1.02
6		3.52	3.15	3.15	0.77	0.72	0.72
7	April	2.96	2.57	2.57	-2.17	-1.80	-1.79
8		2.10	1.74	1.73	0.03	-0.01	-0.02
9	May	1.73	0.70	0.66	1.79	0.78	0.76
10		-1.29	-1.08	-1.09	-1.05	-0.91	-0.90
11	June	-1.08	-1.08	-0.95	-1.51	-1.51	-1.31
12		0.50	0.50	0.13	2.46	2.46	1.02
13	July	-0.63	-0.63	-0.63	2.63	2.63	2.63
14		-0.75	-0.75	-0.74	-2.62	-2.62	-2.62
15	August	0.15	0.15	0.15	-0.40	-0.40	-0.40
16		-0.92	-0.92	-0.92	-0.34	-0.34	-0.34
17	September	-0.97	-0.97	-0.97	-1.26	-1.26	-1.26
18		1.64	1.64	1.63	-0.14	-0.14	-0.14
19	October	-2.68	-2.85	-2.86	-1.97	-1.62	-1.76
20		0.12	0.12	0.12	-2.28	-2.17	-1.87
21	November	4.09	3.46	2.96	3.27	2.58	2.12
22		4.15	3.47	2.83	0.29	0.35	0.32
23	December	0.66	0.44	0.42	0.27	0.27	0.19
24		0.92	0.67	0.64	-2.10	-1.49	-1.39
ANNUAL AVERAGE		1.24	0.99	0.93	0.19	0.11	0.04

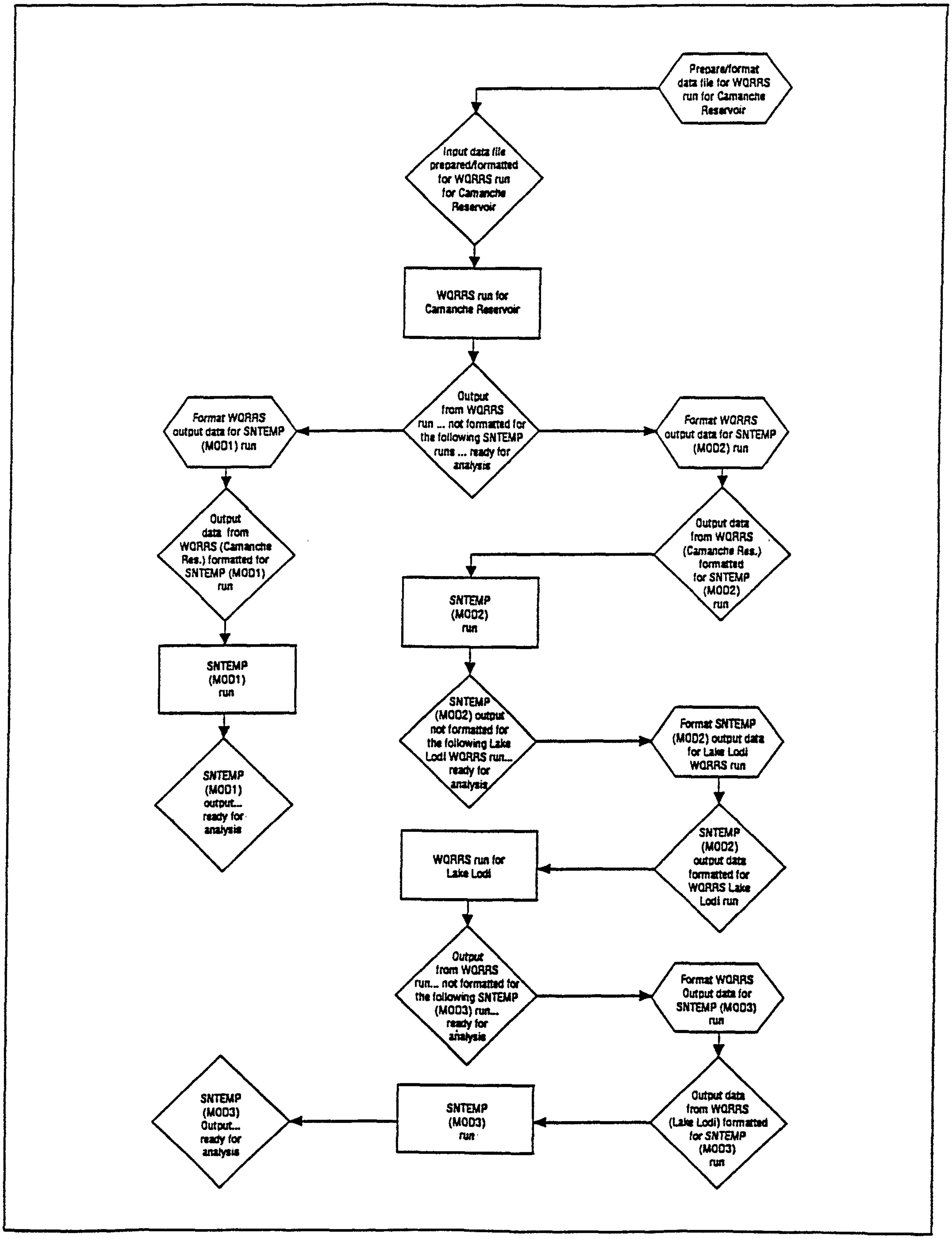

Figure C-1. Flow chart of Mokelumne River water temperature model scheme.

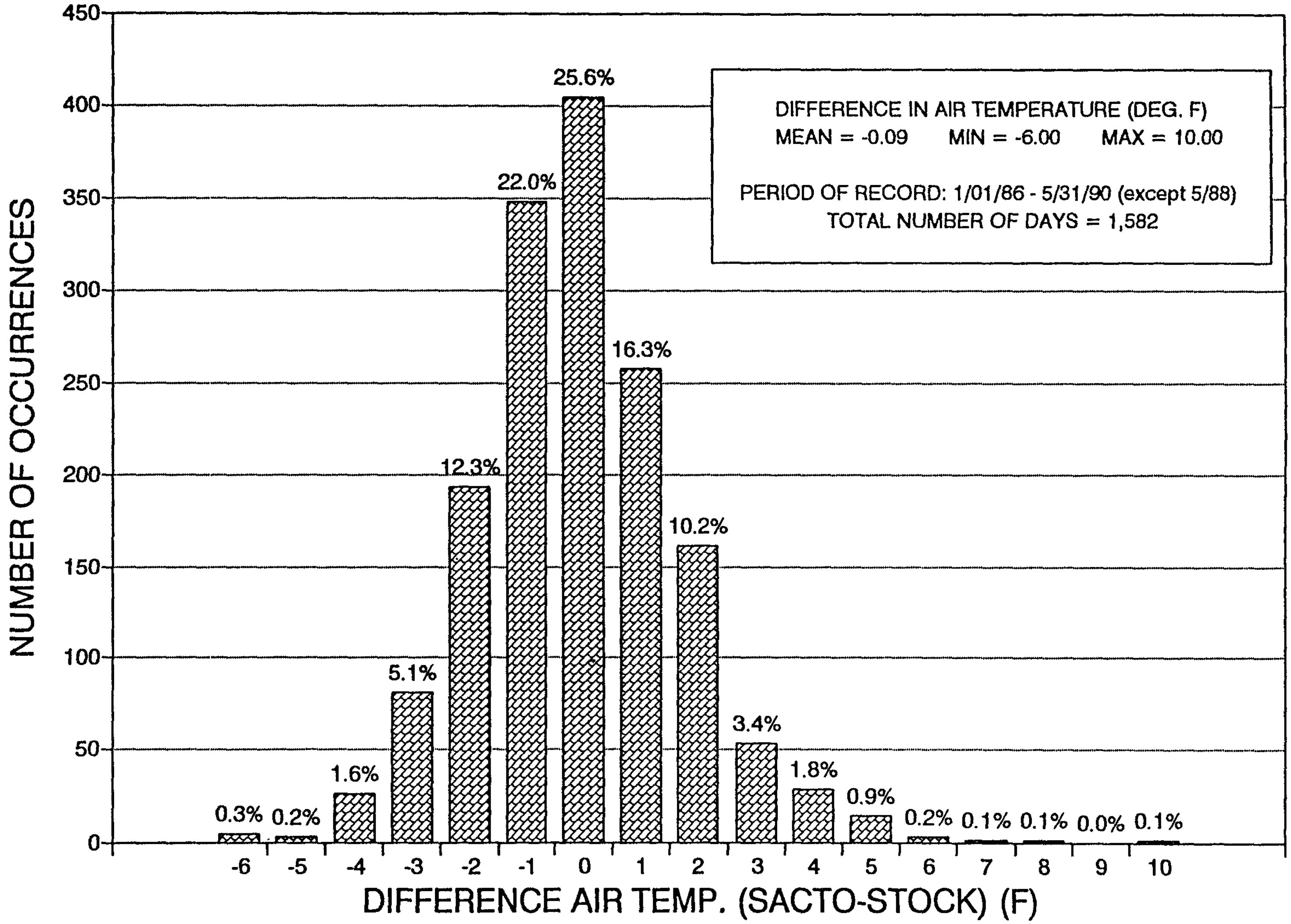

Figure C-2. Frequency distribution for difference in air temperature between Sacramento and Stockton Airport.

C-101269

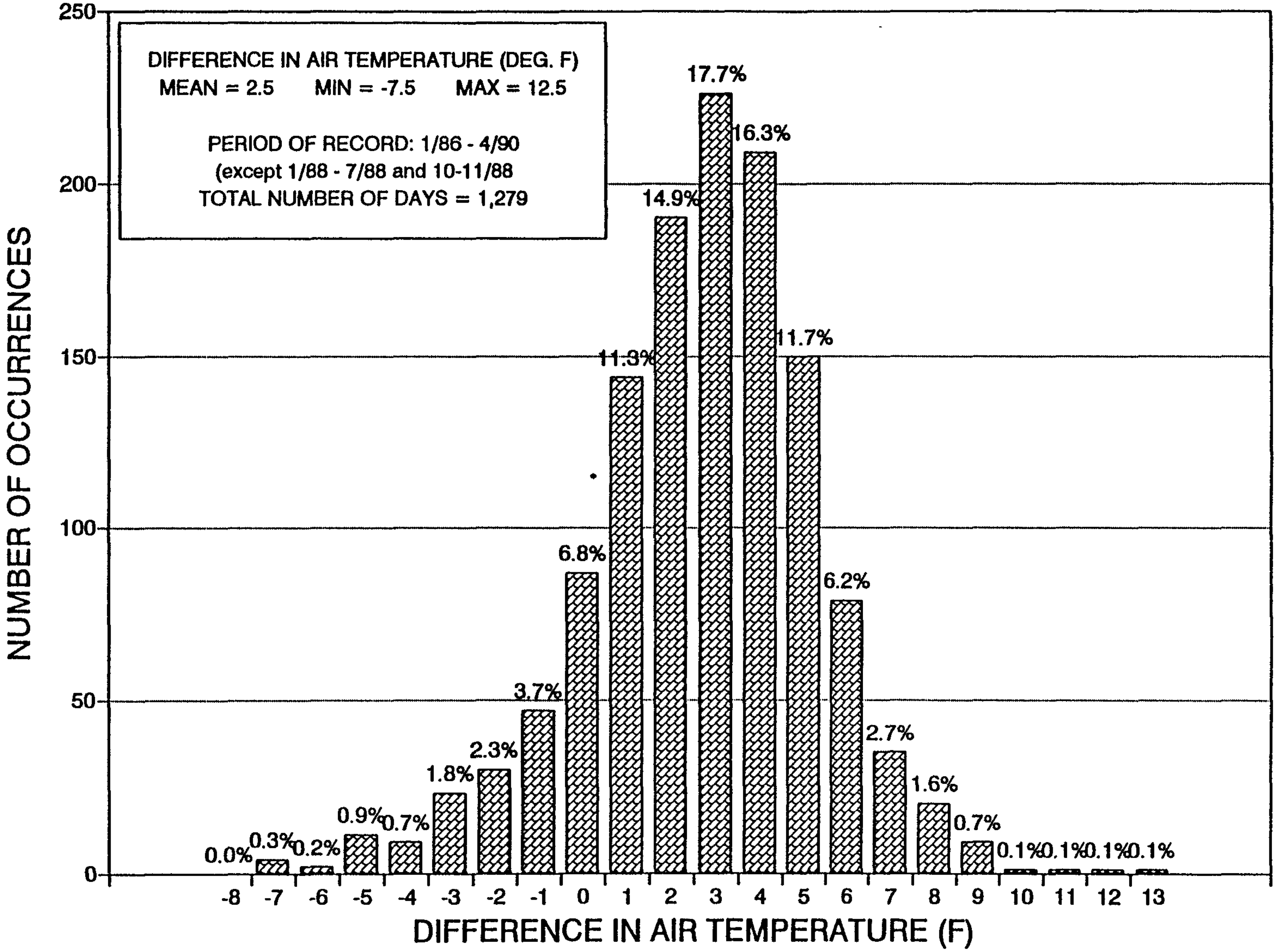

Figure C-3. Frequency distribution for difference in aire temp[erature between Sacramento and Lodi.

C—101269

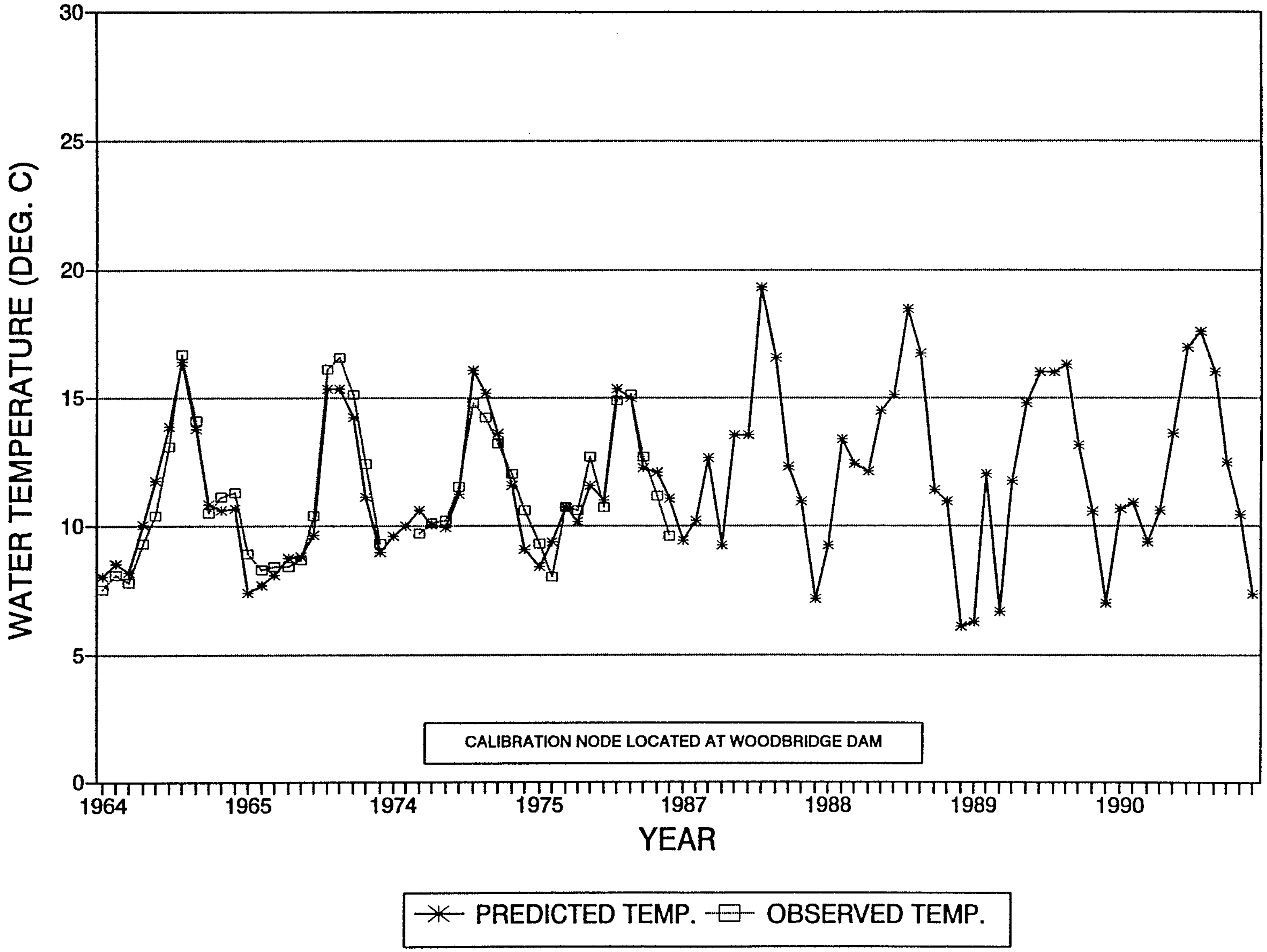

Figure C-4. SNTEMP calibration result for Module 1.

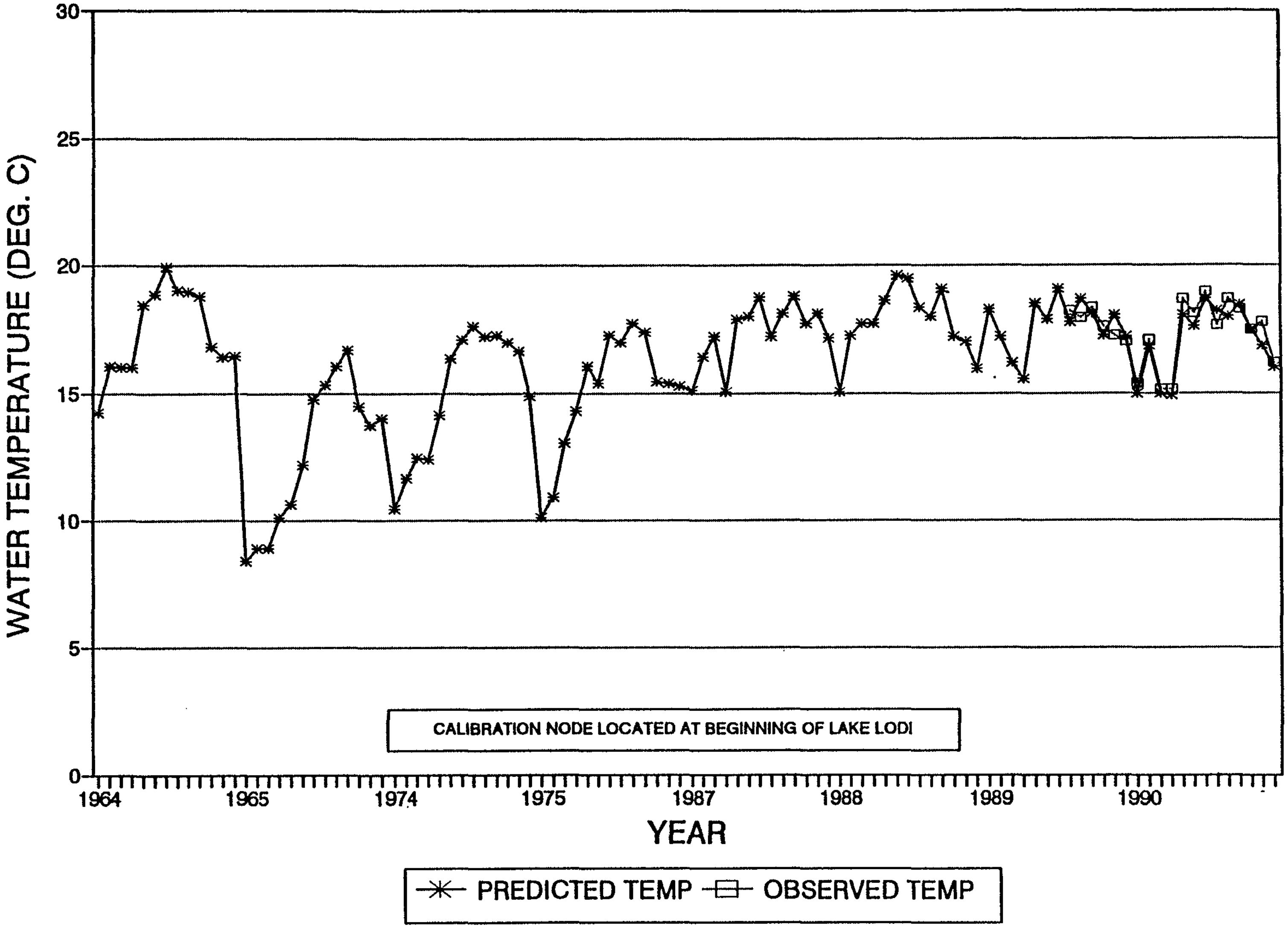

Figure C-5. SNTEMP calibration result for Module 2.

C—101271

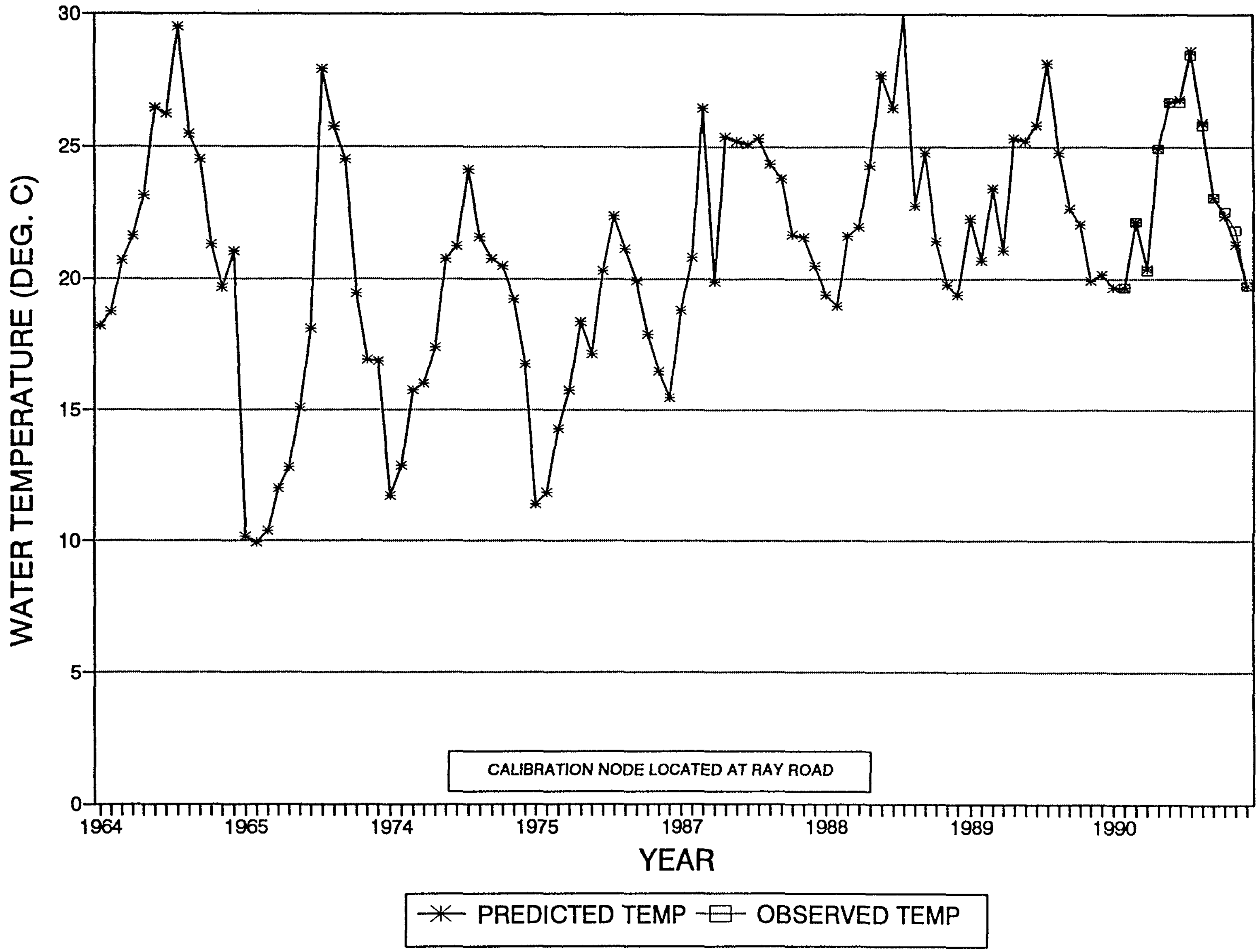

Figure C-6. SNTEMP calibration result for Module 3.

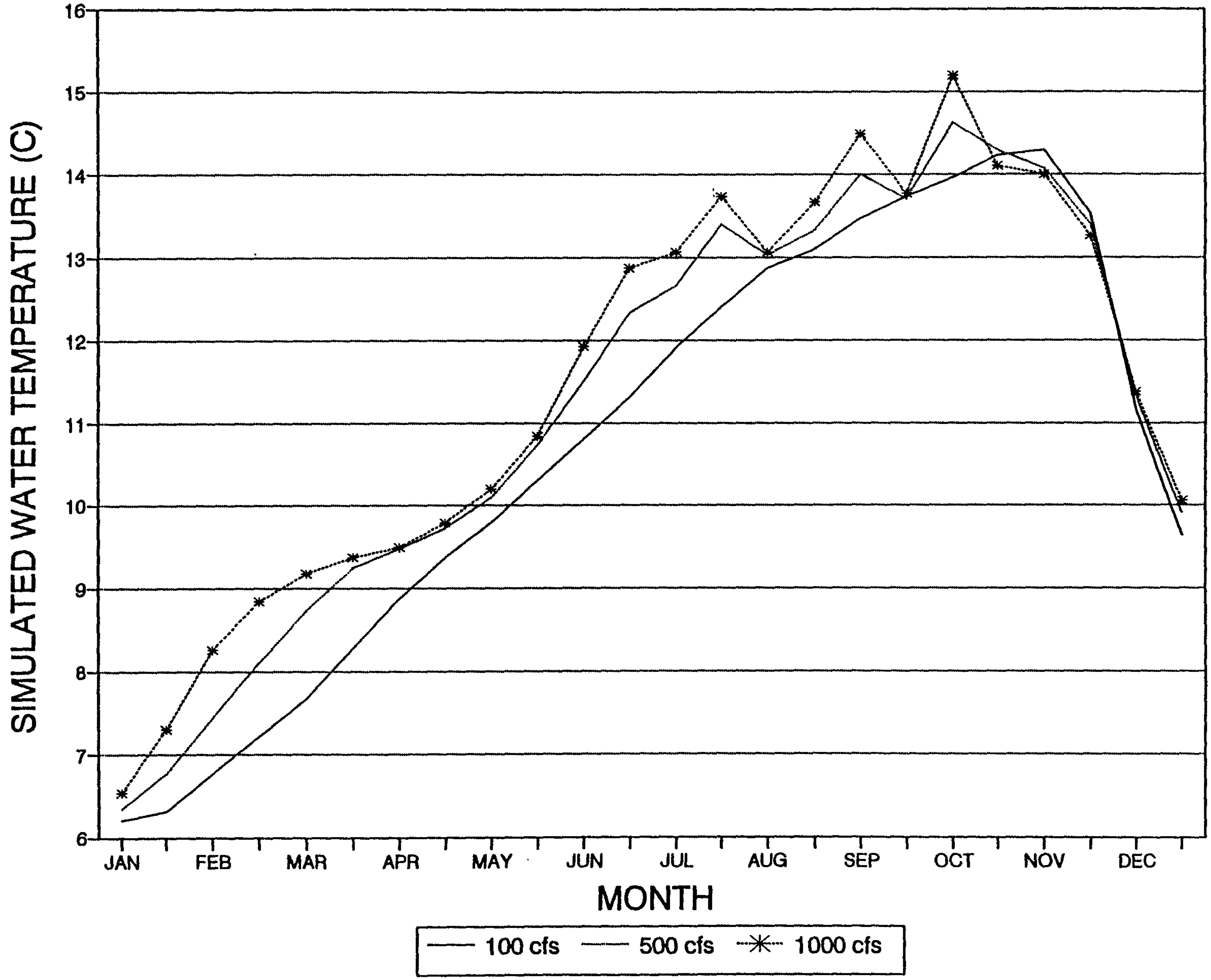

Figure C-7. Simulated water temperature for the Mokelumne River below Camanche Dam.

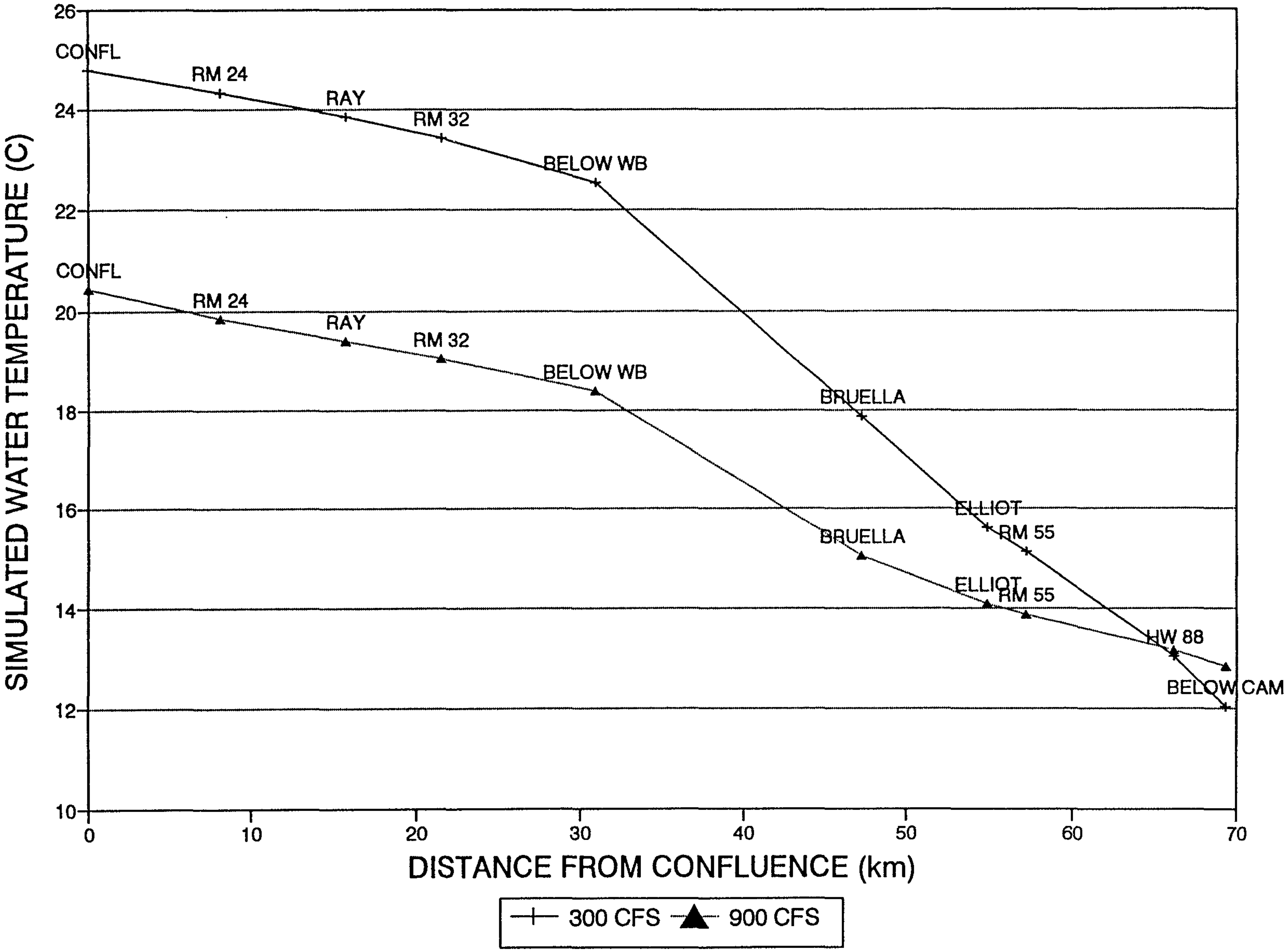

Figure C-8. Simulated water temperature between Camanche Dam and the Cosumnes River during the heating period (June 16-30).

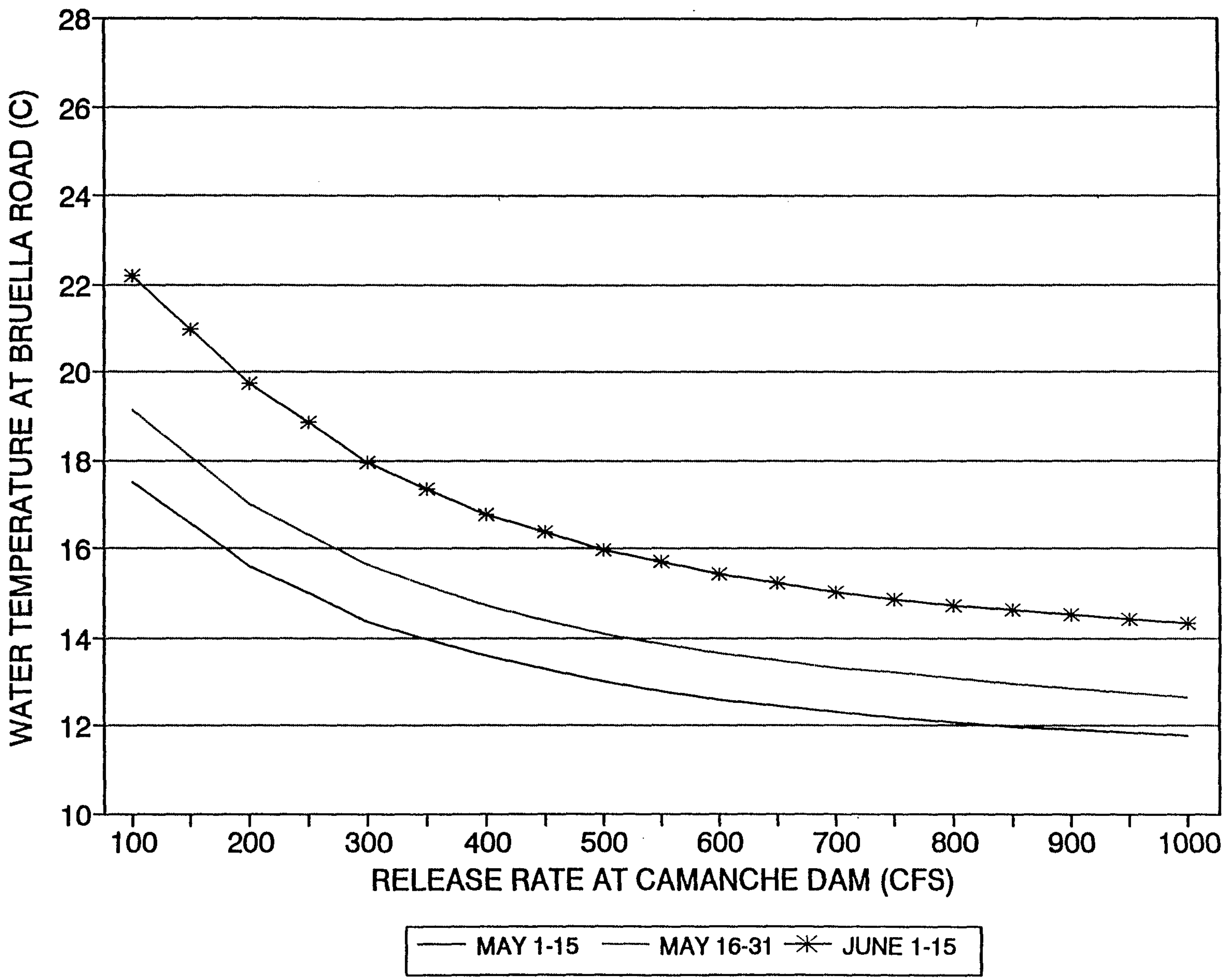

Figure C-9. Simulated water temperature at Bruella road during the heating period (June 16-30).

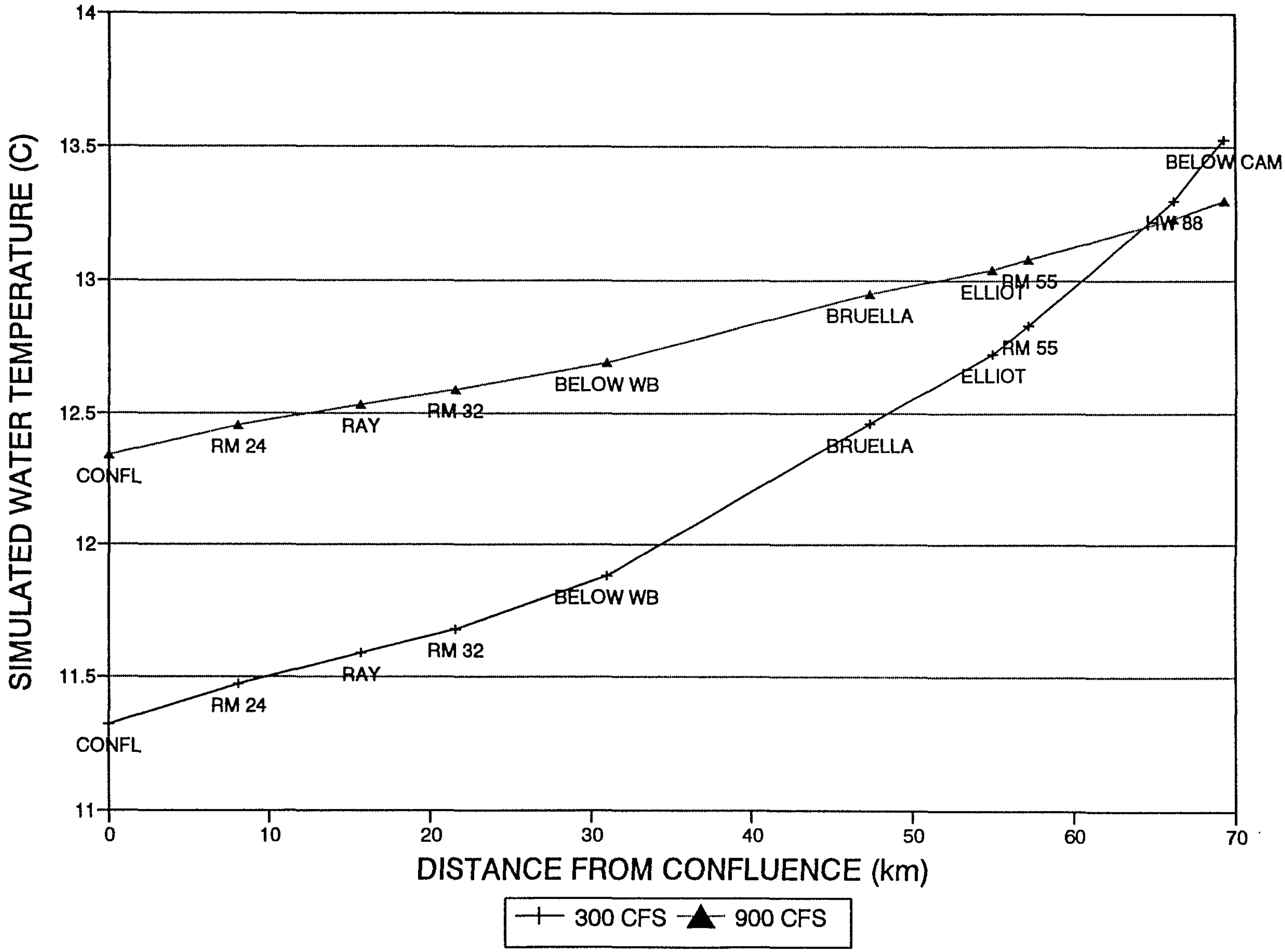

Figure C-10. Simulated water temperature between Camanche Dam and the Cosumnes River during the cooling period (November 16-30).

C—101276

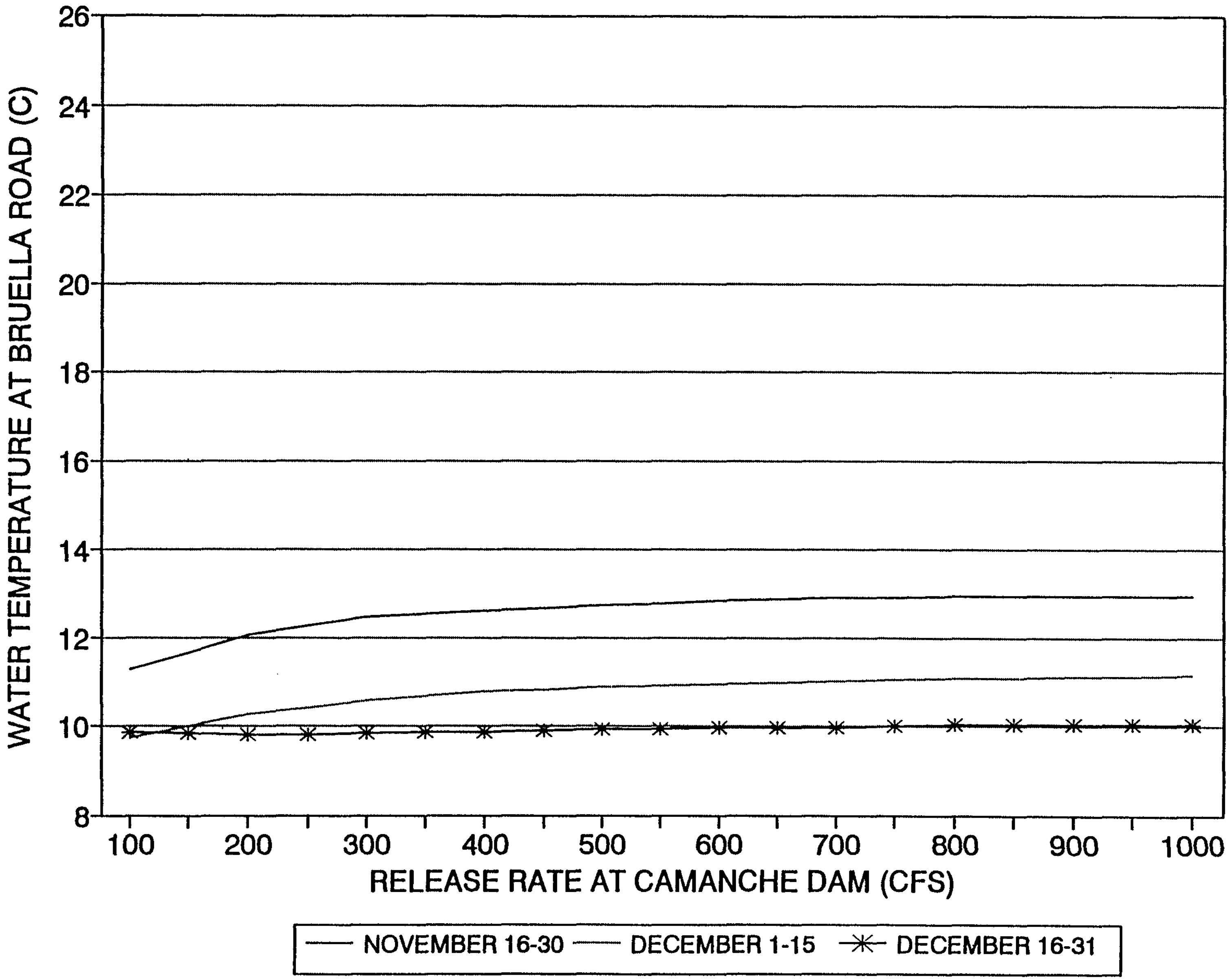

Figure C-11. Simulated water temperature at Bruella Road during the cooling period (November 16-30).

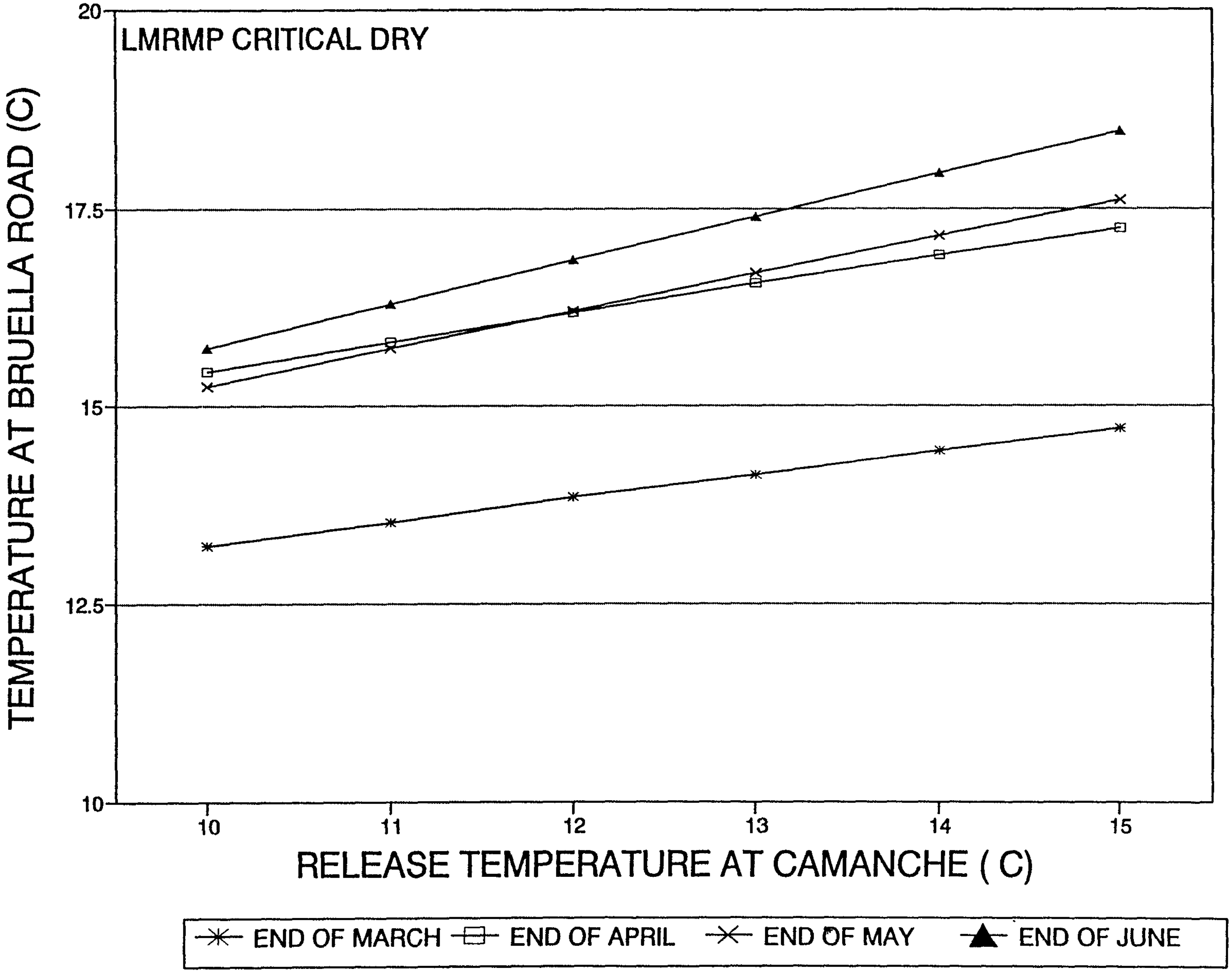

Figure C-12. SNTEMP sensitivity analysis result at Bruella road to release water temperature from Camanche Reservoir using critical dry year LMRMP flow.

C-101278

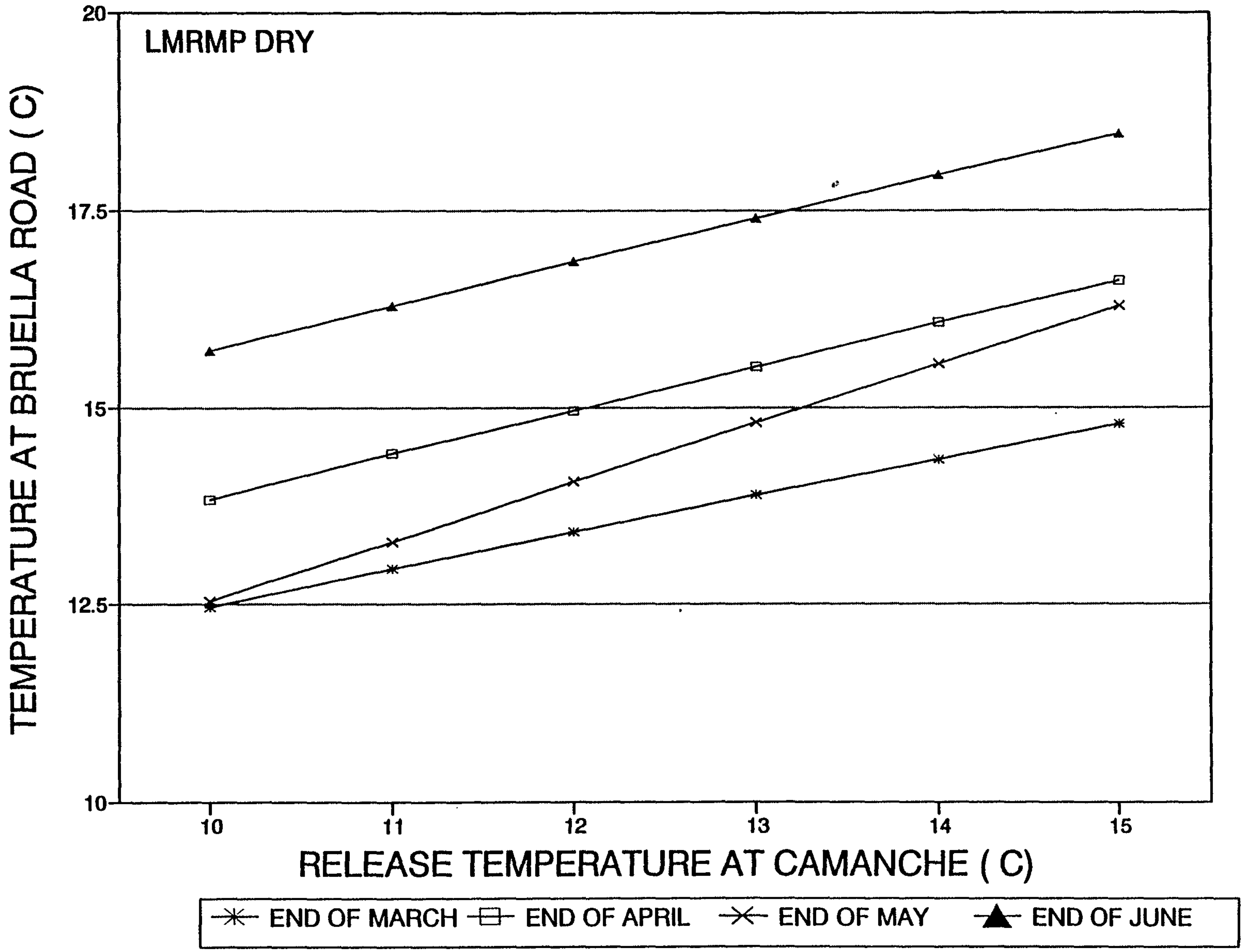

Figure C-13. SNTEMP sensitivity analysis result at Bruella Road to release water temperature from Camanche Reservoir using dry year LMRMP flow.

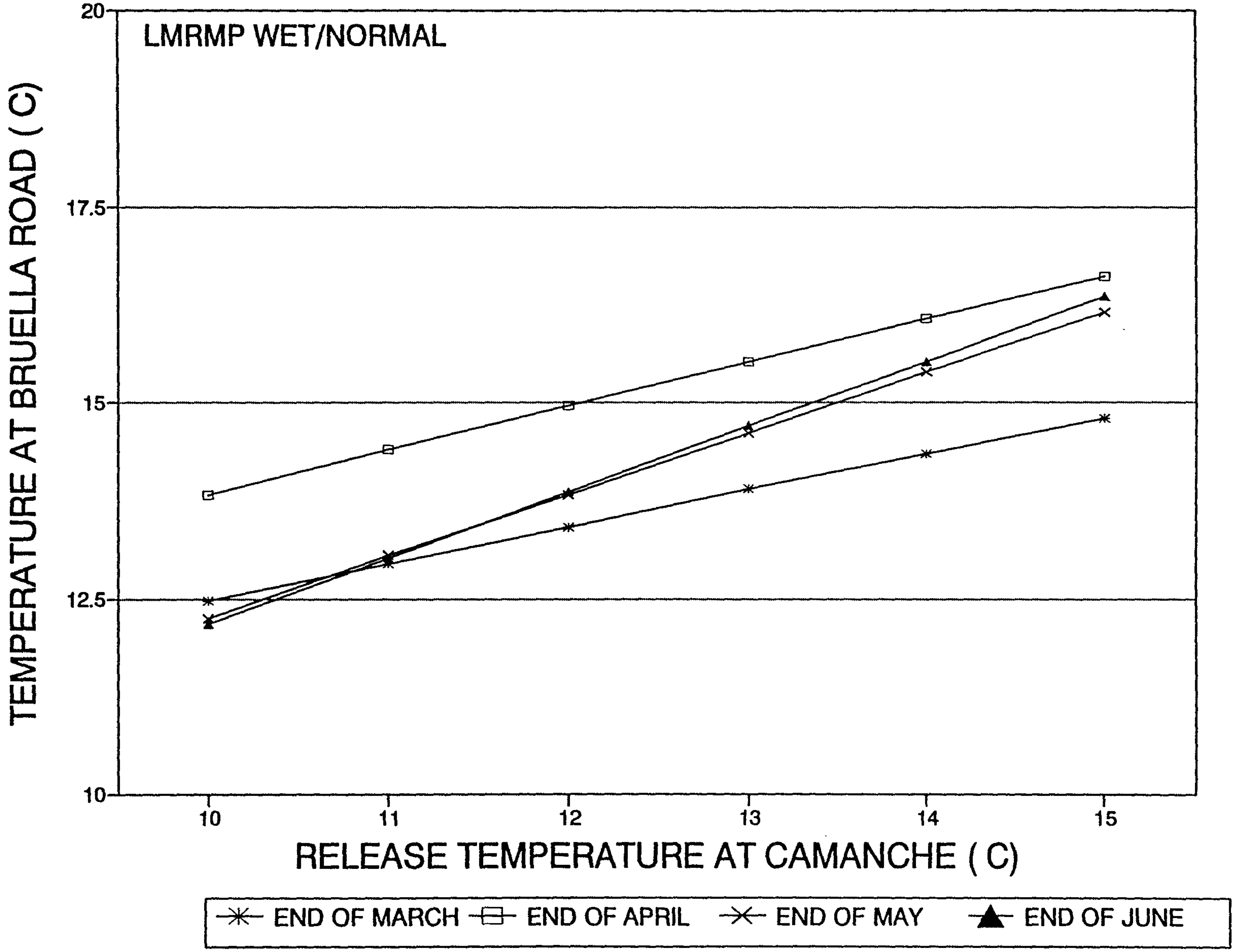

Figure C-14. SNTEMP sensitivity analysis result at Bruella Road to release water temperature from Camanche Reservoir using wet/normal year LMRMP flow.

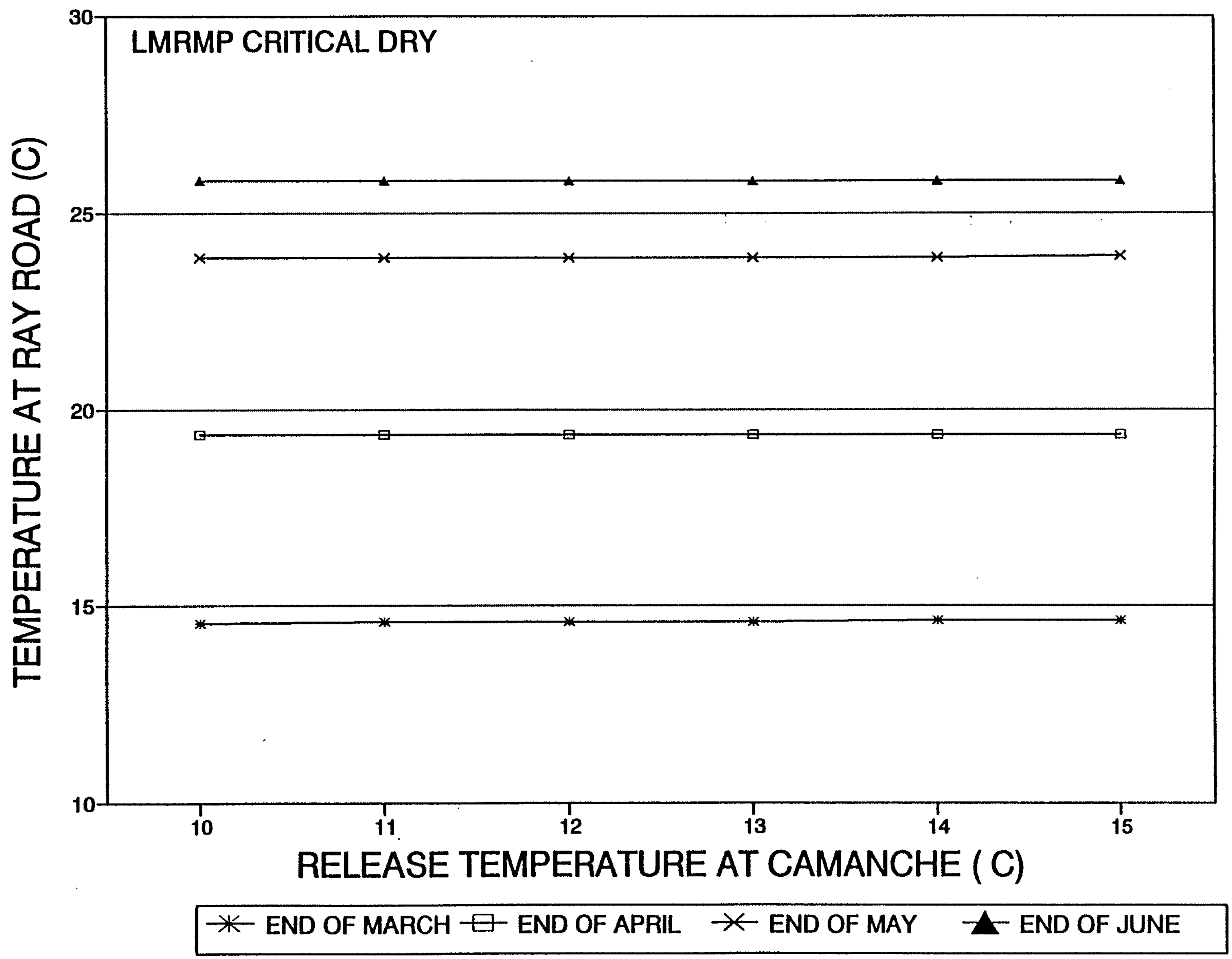

Figure C-15. SNTEMP sensitivity analysis result at Ray Road to release water temperature from Camanche Reservoir using critical dry year LMRMP flow.

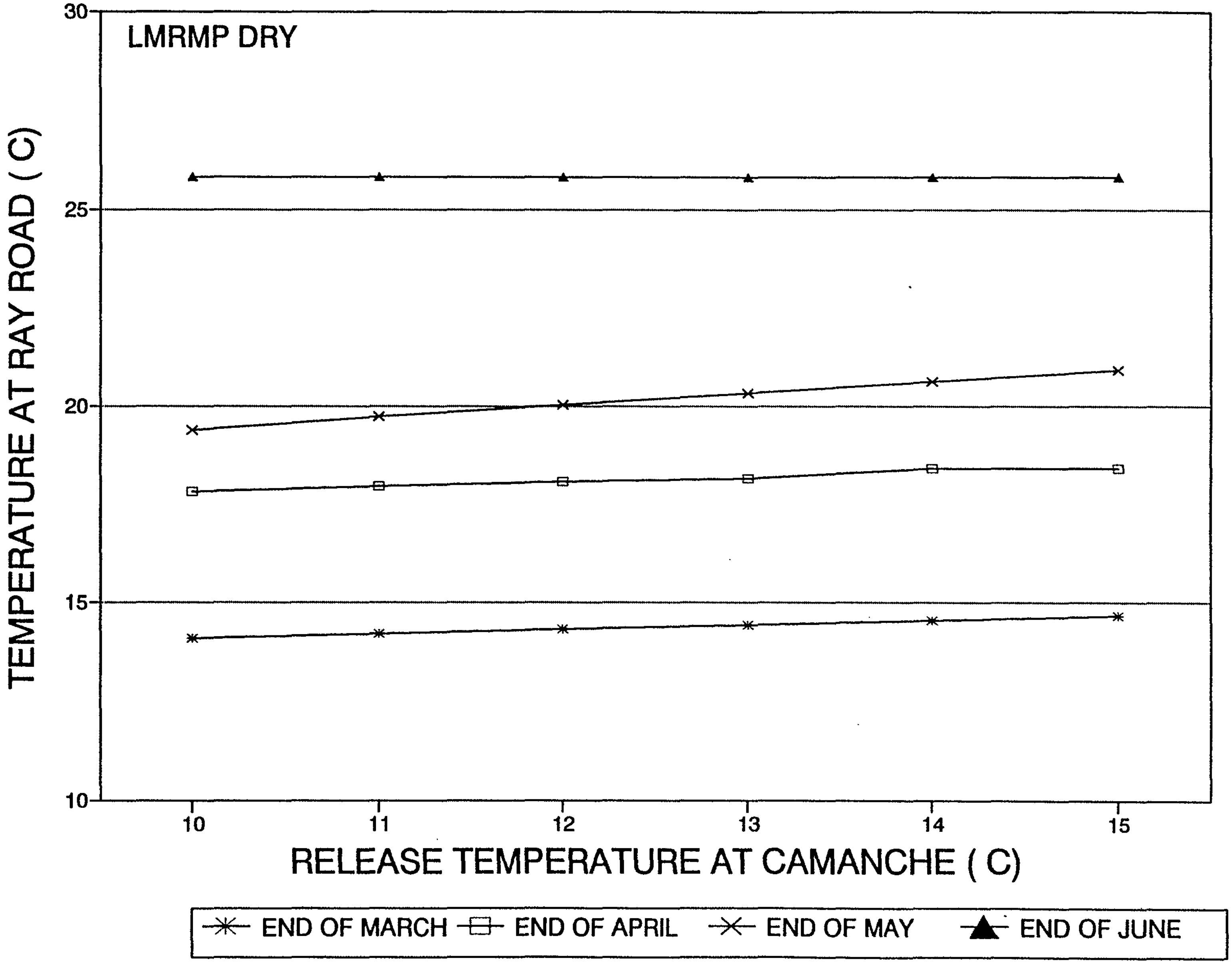

Figure C-16. SNTEMP sensitivity analysis result at Ray Road to release water temperature from Camanche Reservoir using dry year LMRMP flow.

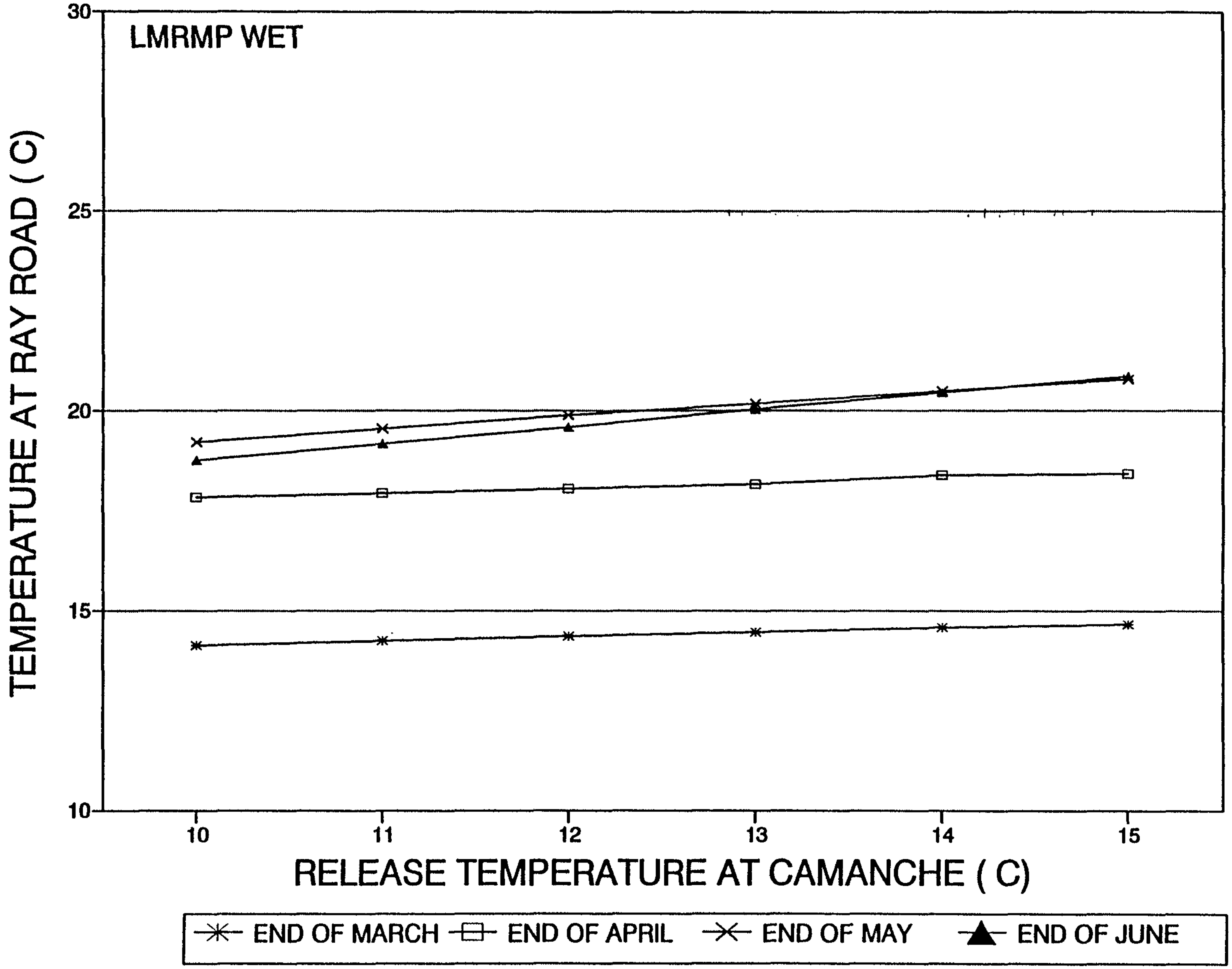

Figure C-17. SNTEMP sensitivity analysis result at Ray Road to release water temperature from Camanche Reservoir using wet/normal year LMRMP flow.

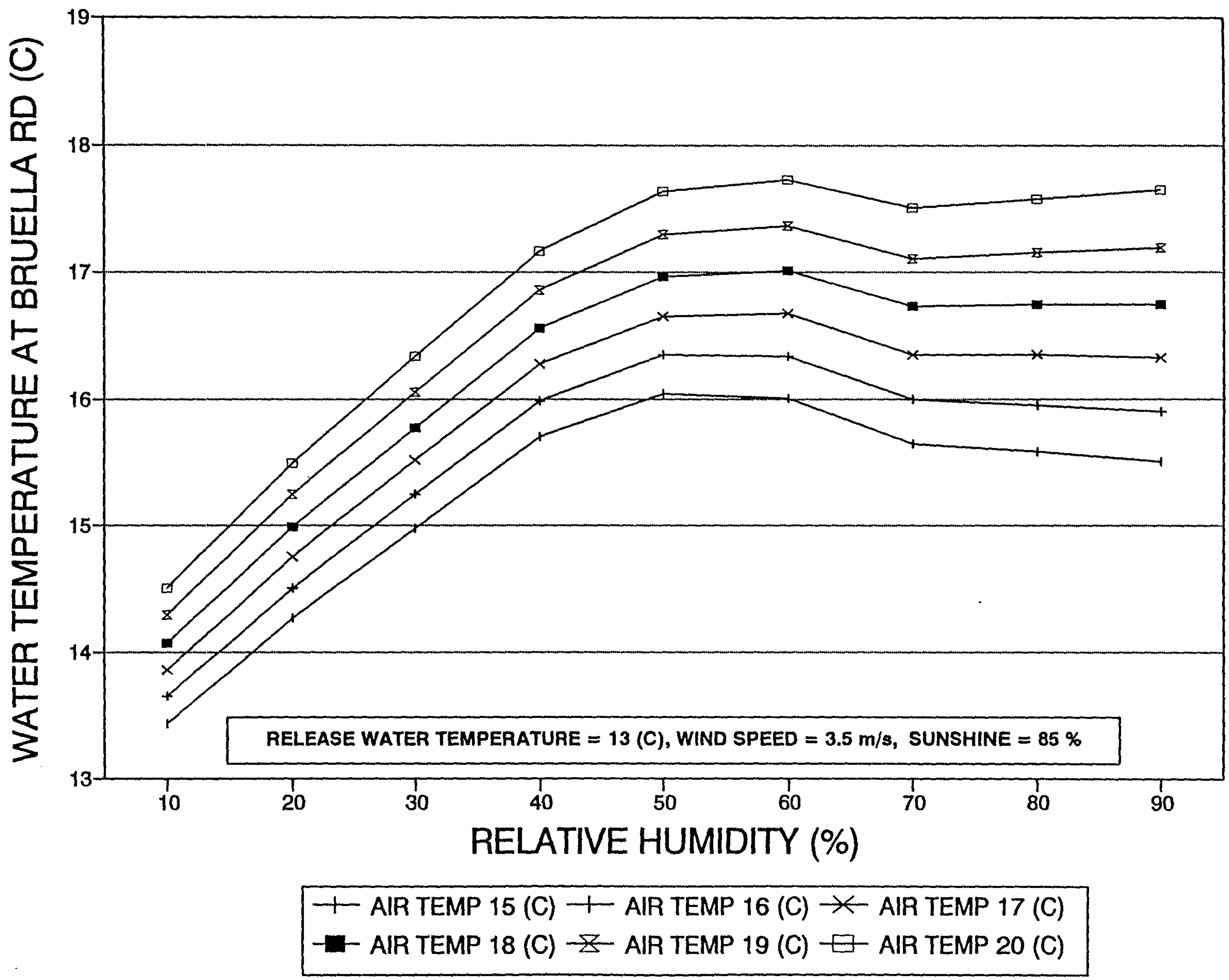

Figure C-18. SNTEMP's sensitivity to relative humidity.

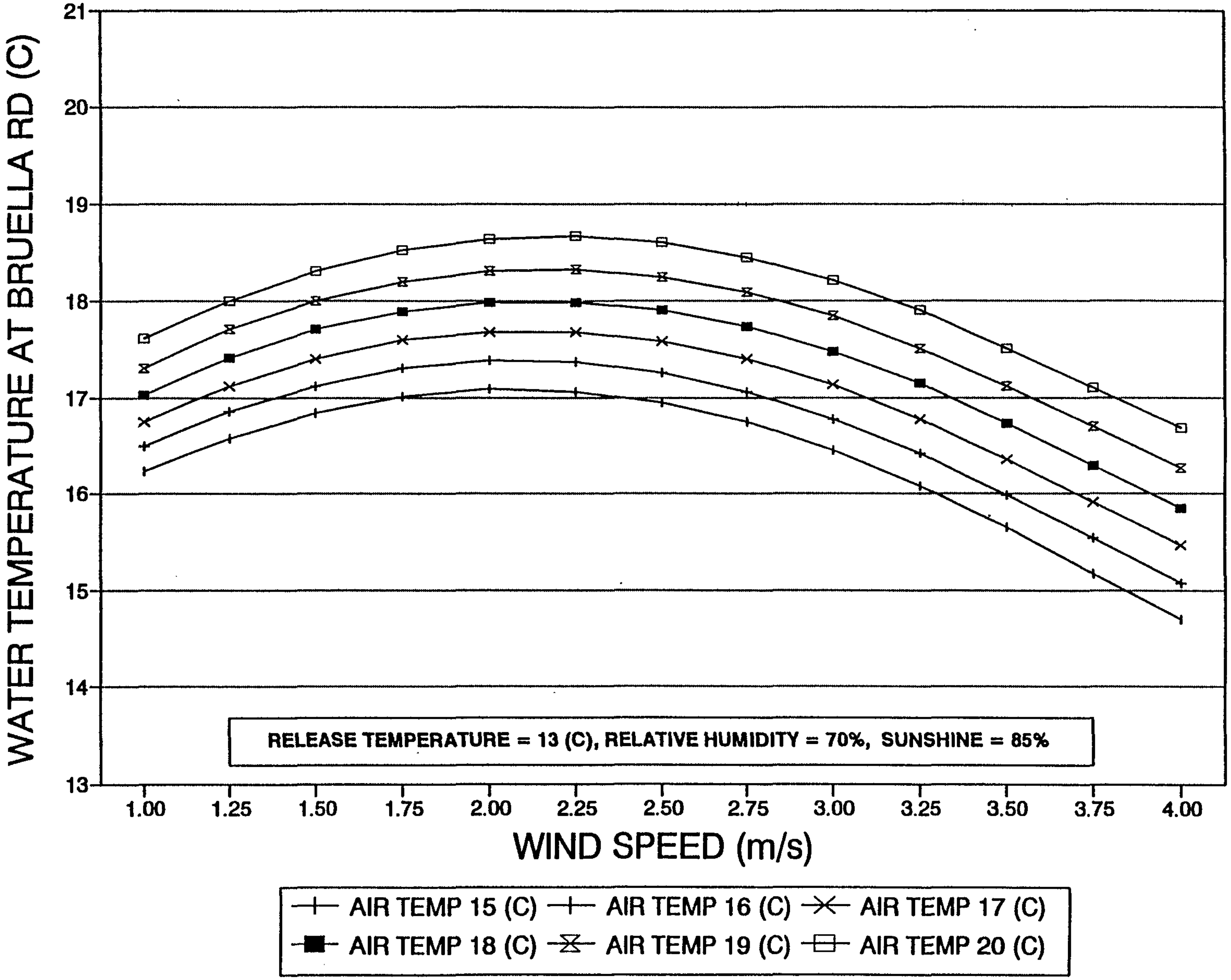

Figure C-19. SNTEMP's sensitivity to wind speed.

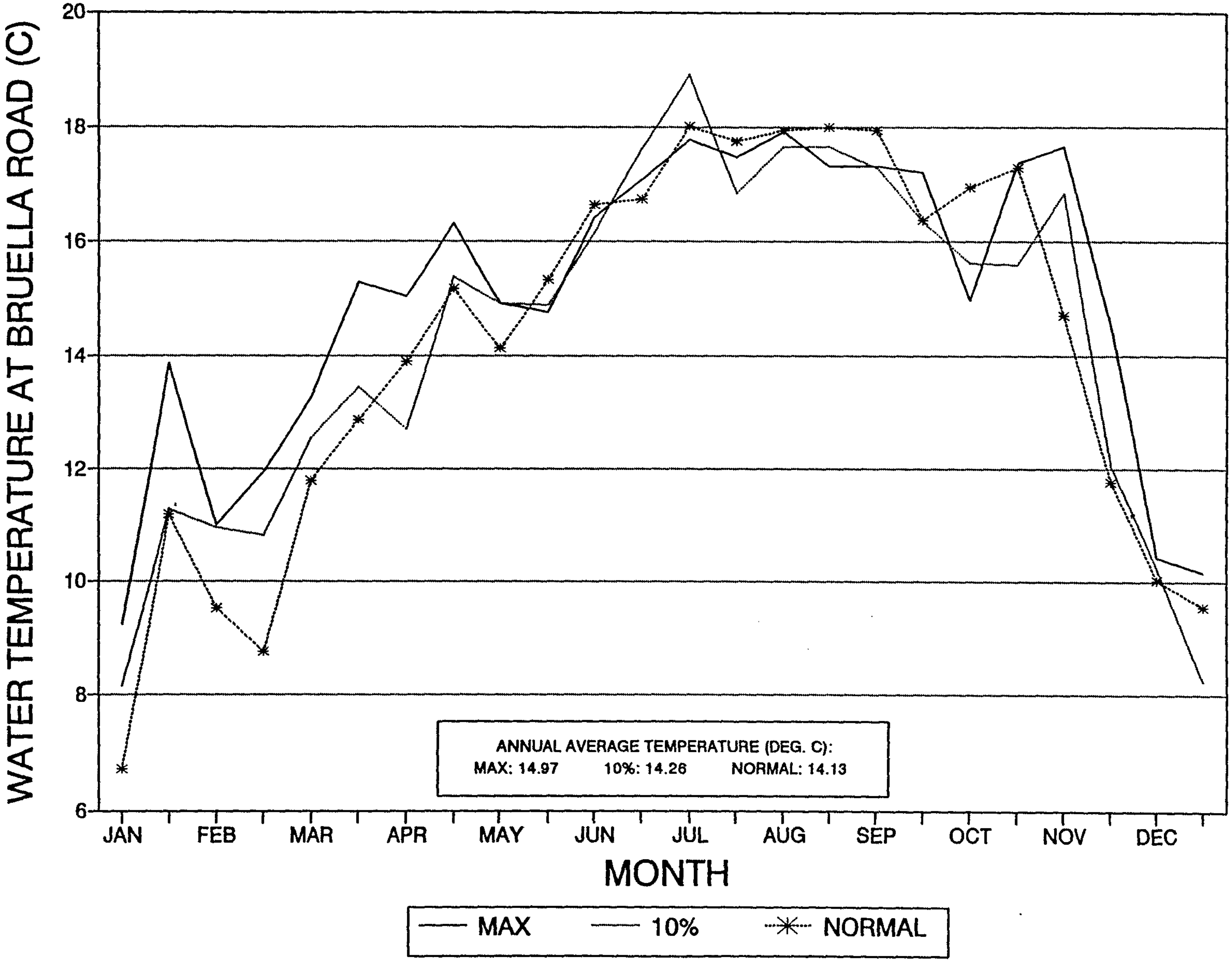

Figure C-20. Sensitivity of SNTEMP to different meteorological conditions using critical dry year LMRMP flow at Bruella Road.

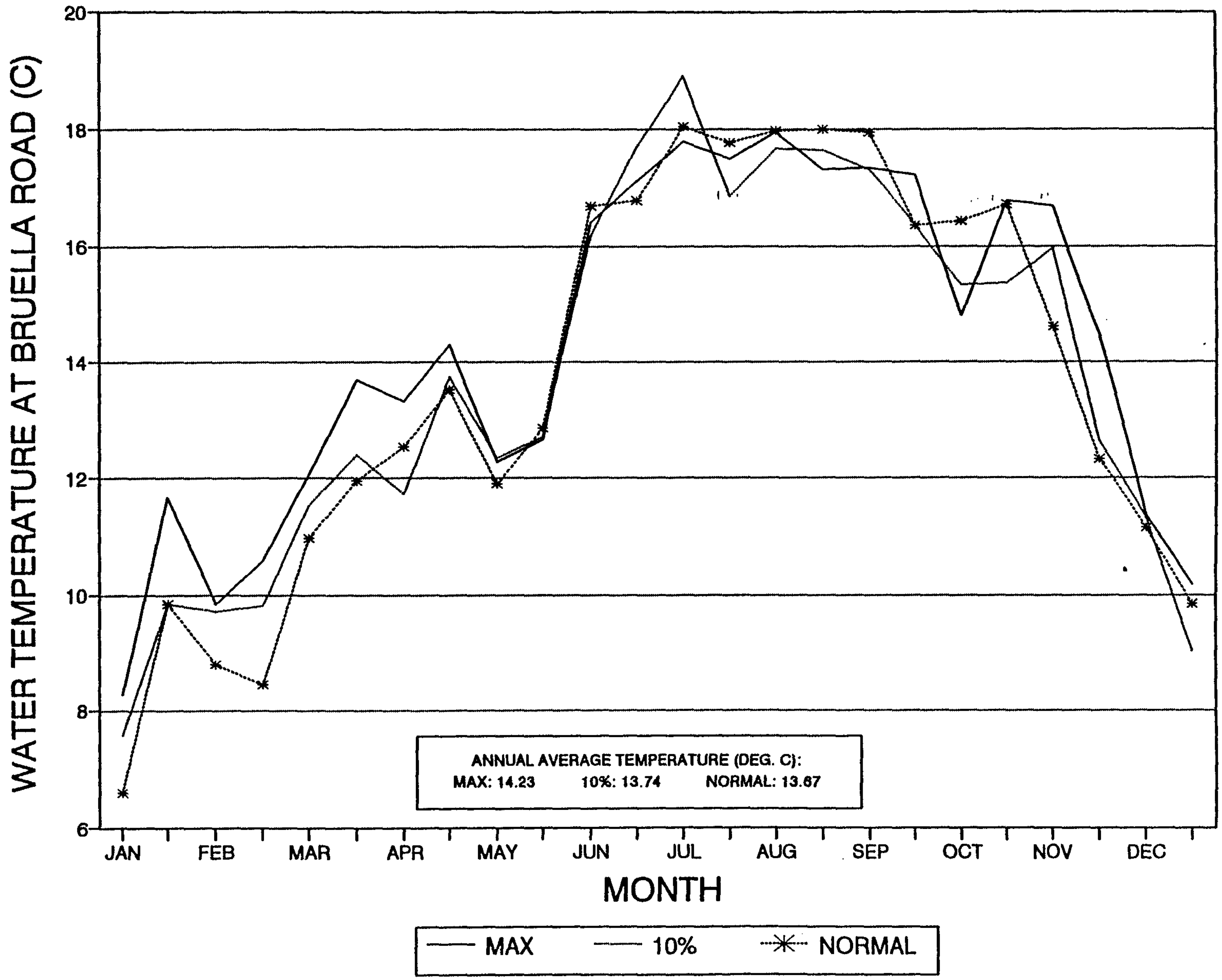

Figure C-21. Sensitivity of SNTEMP to different meteorological conditions using dry year LMRMP flow at Bruella Road.

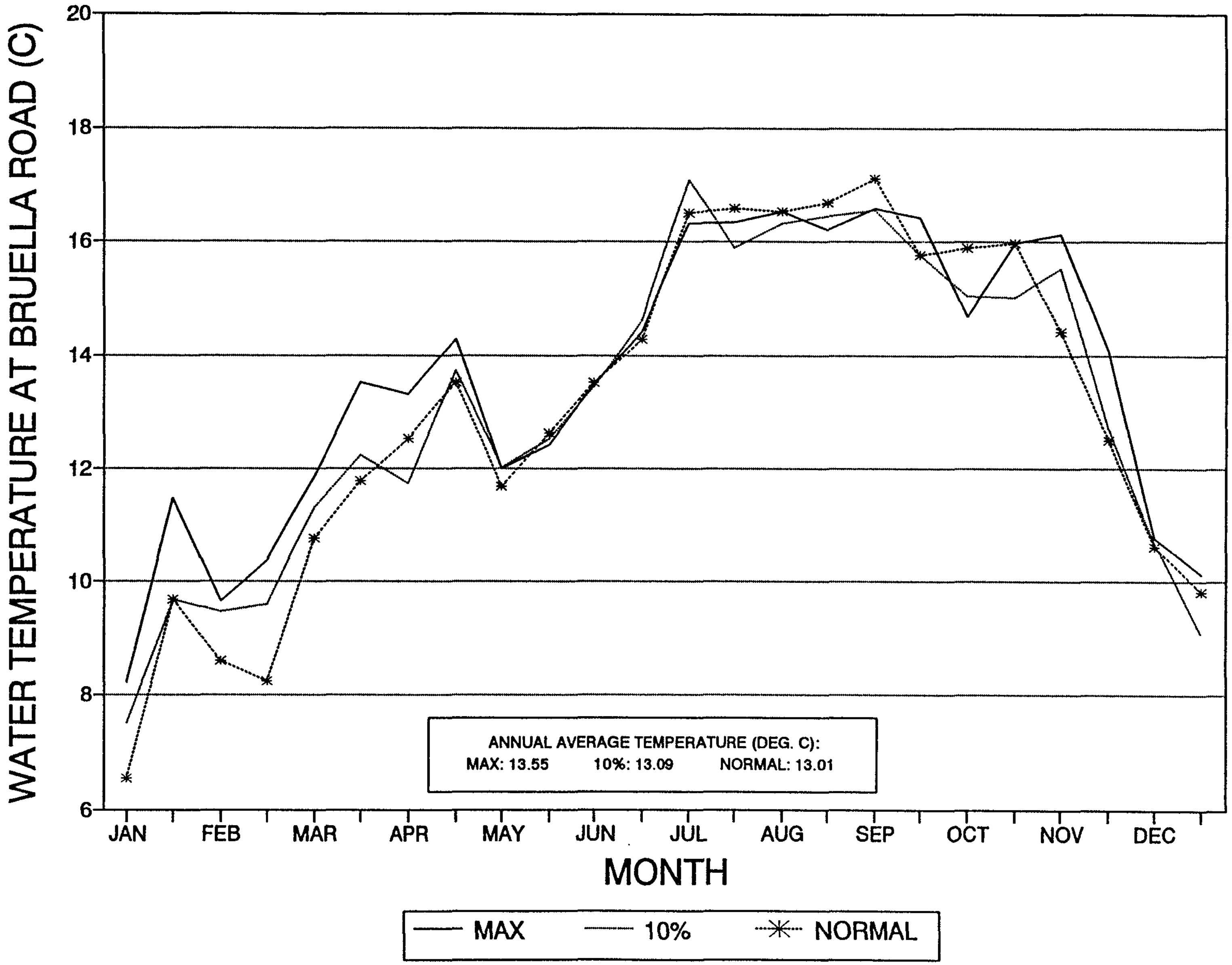

Figure C-22. Sensitivity of SNTEMP to different meteorological conditions using wet/normal year LMRMP flow at Bruella Road.

C-101288

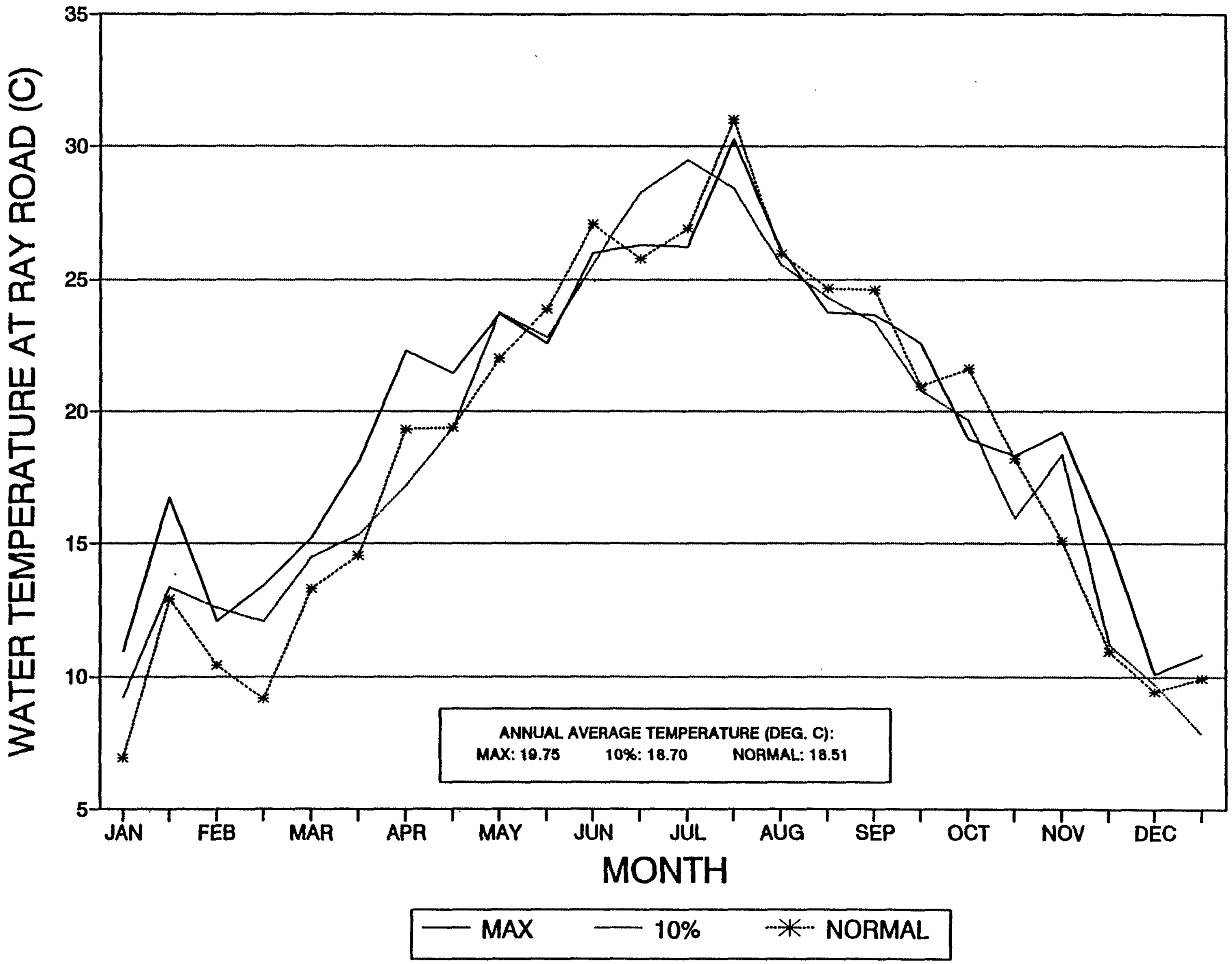

Figure C-23. Sensitivity of SNTEMP to different meteorological conditions using critical year LMRMP flow at Ray Road.

C-101289

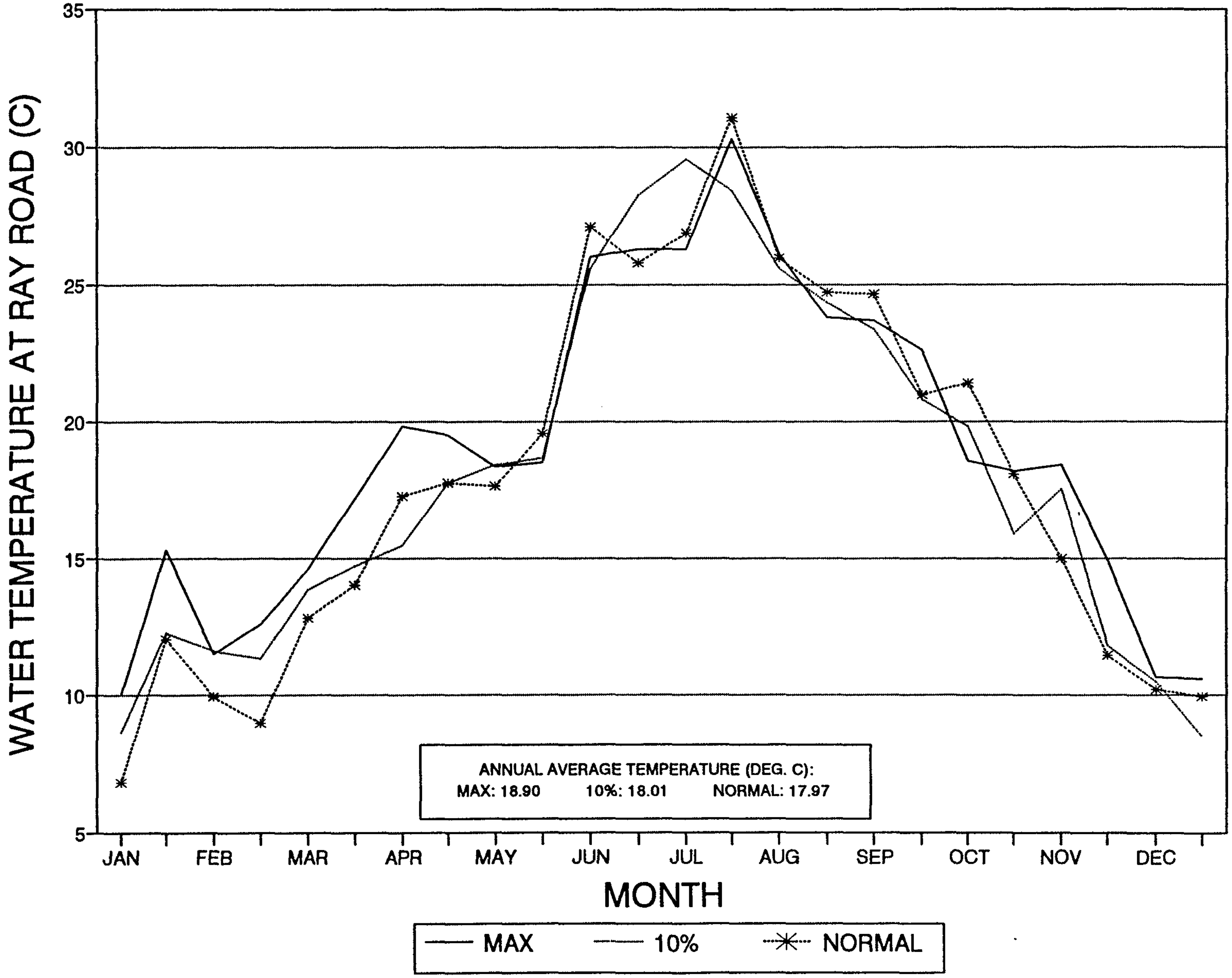

Figure C-24. Sensitivity of SNTEMP to different meteorological conditions using dry year LMRMP flow at Ray Road.

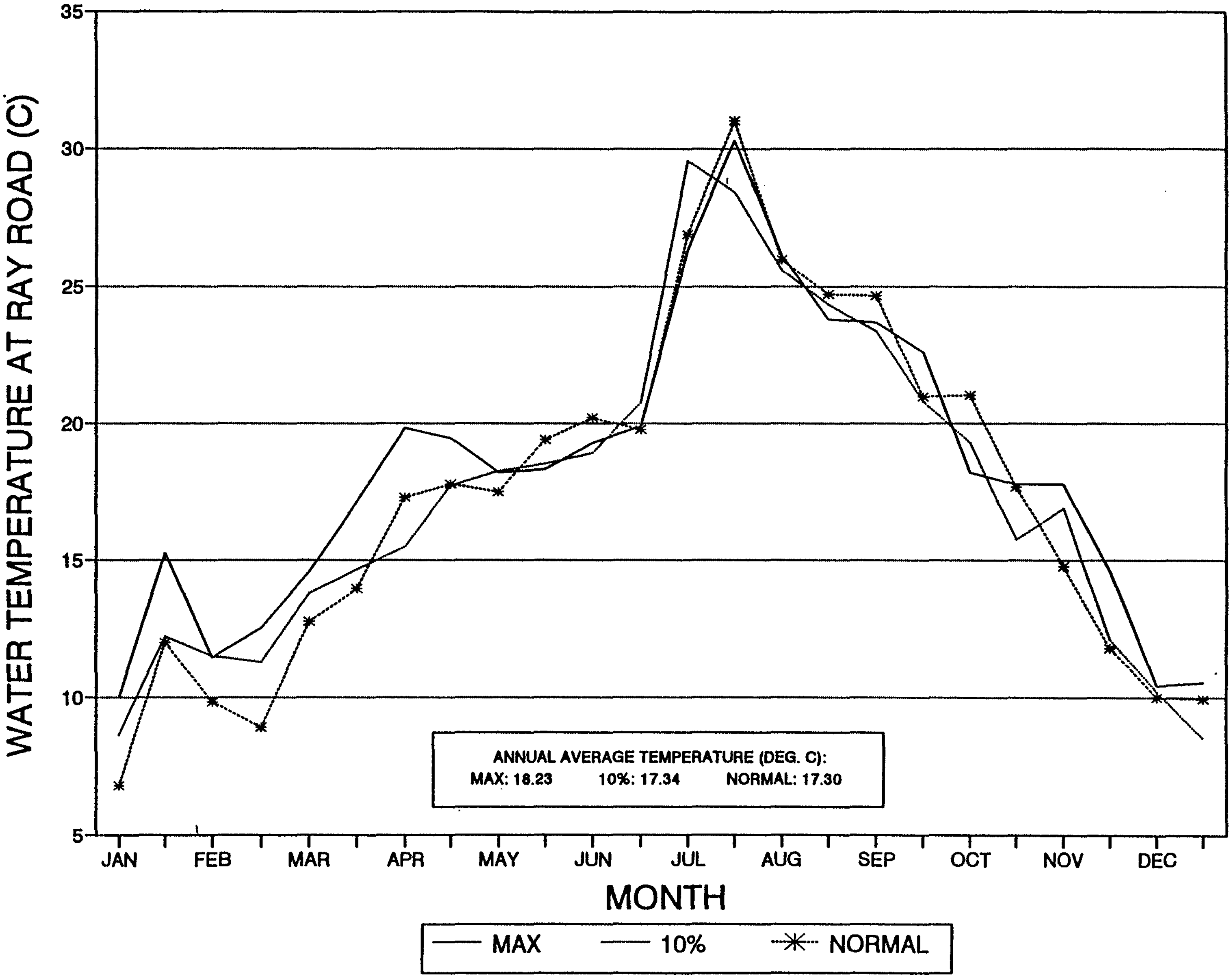

Figure C-25. Sensitivity of SNTEMP to different meteorological conditions using wet/normal year LMRMP flow at Ray Road.

C-101291

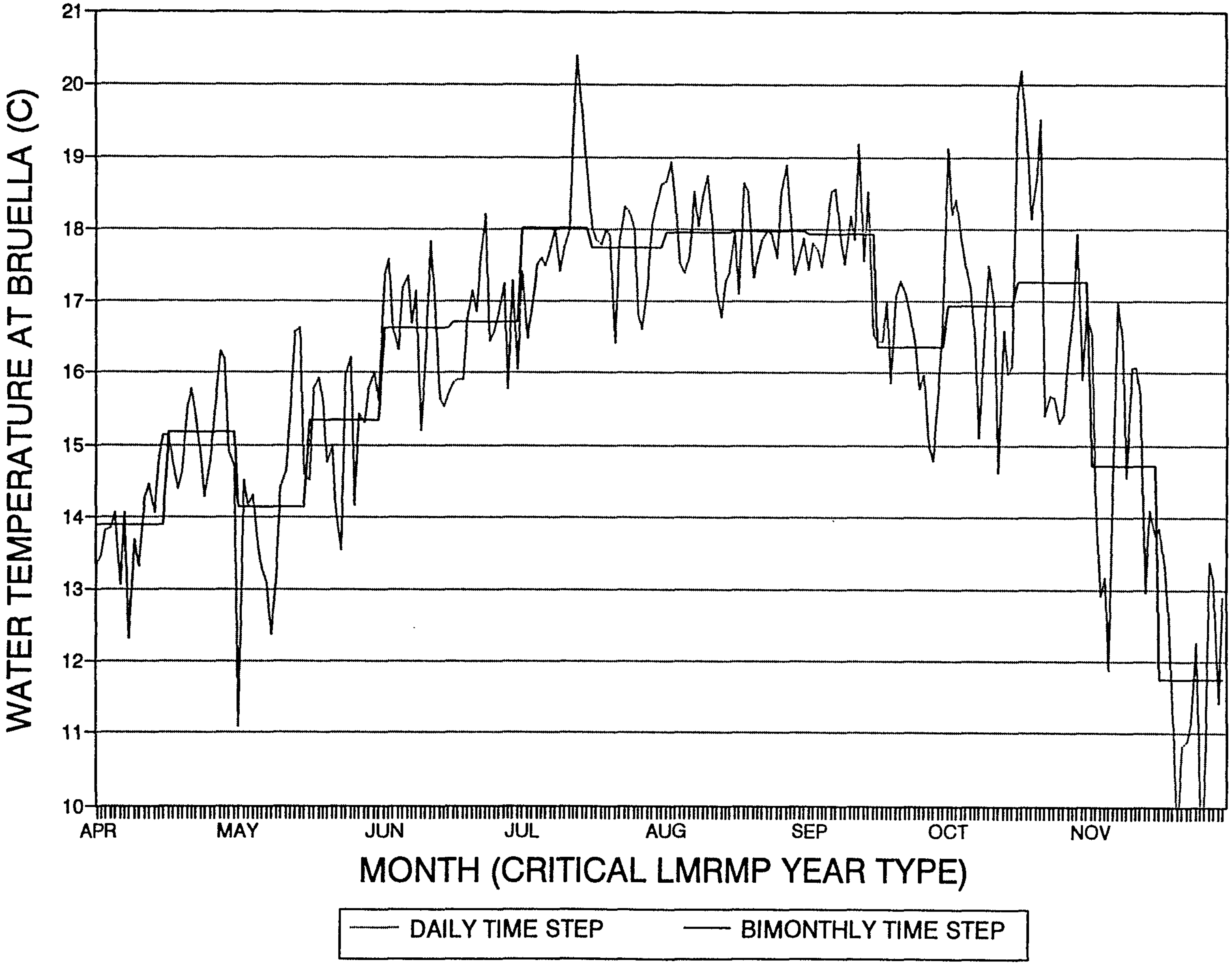

Figure C-26. SNTEMP simulation run results comparing bi-monthly and daily time step outputs at Bruella Road for critical LMRMP flow.

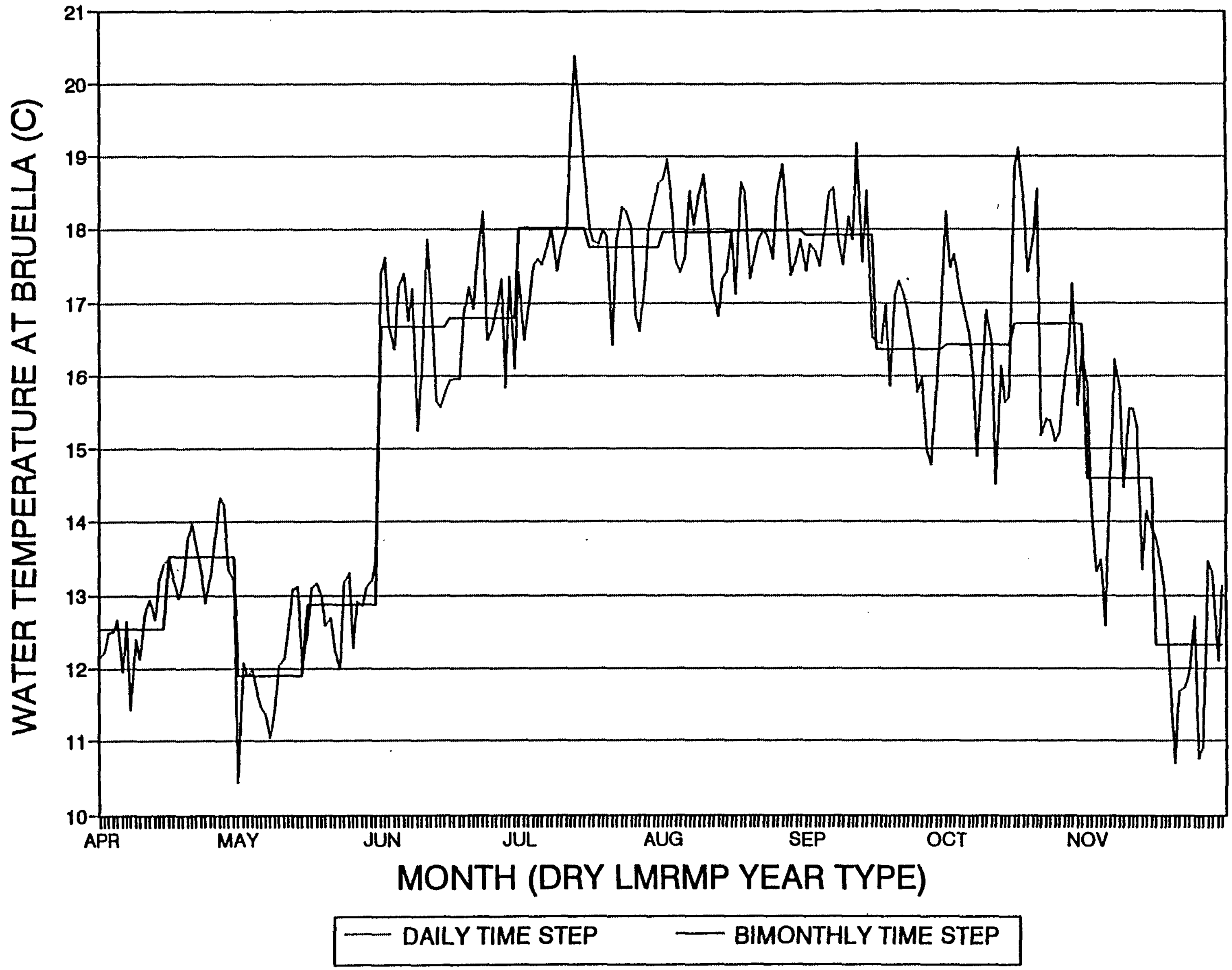

Figure C-27. SNTEMP simulation run results comparing bi-monthly and daily time step outputs at Bruella Road for dry LMRMP flow.

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C-101293

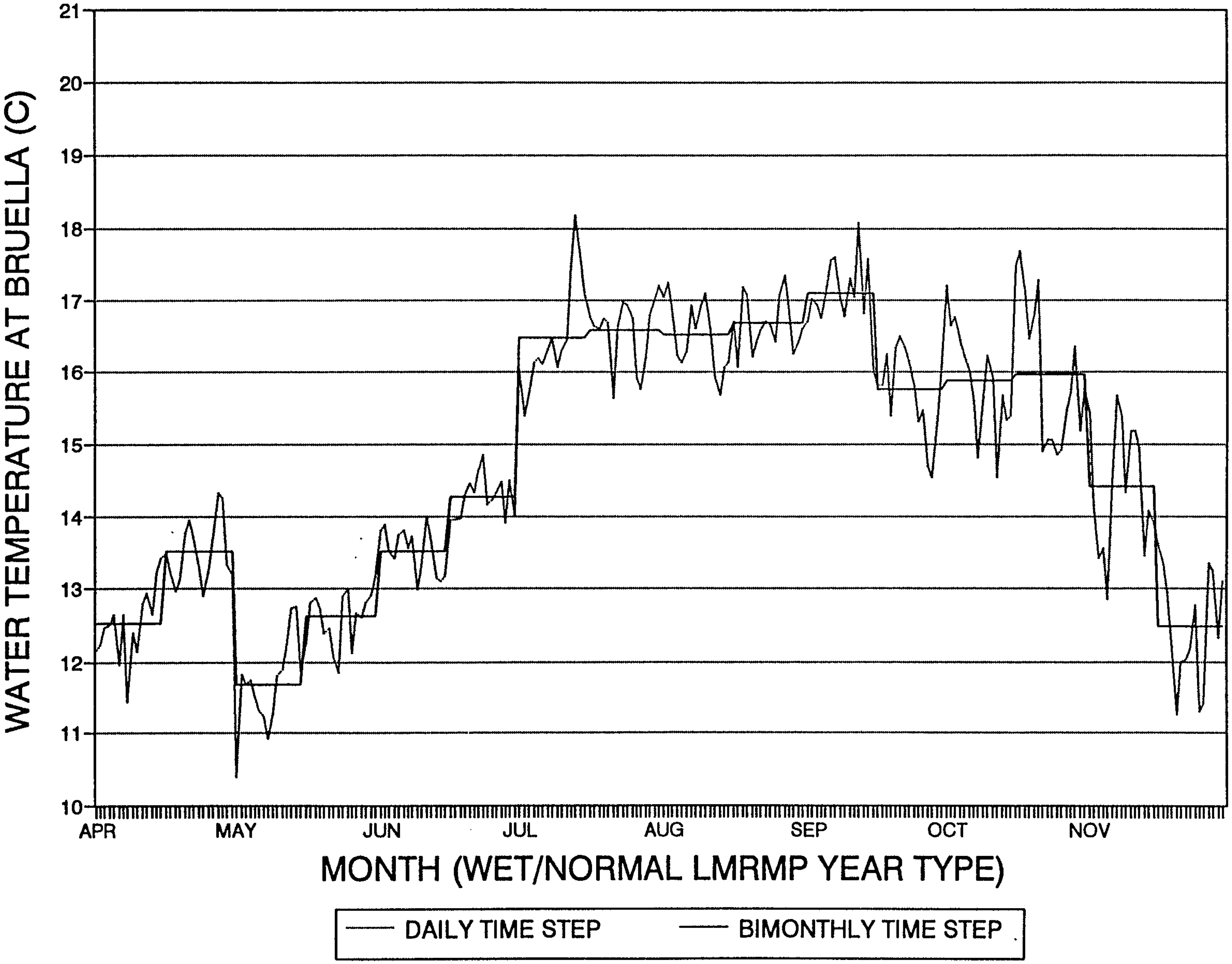

Figure C-28. SMTEMP simulation run results comparing bi-monthly and daily time step outputs at Bruella Road for wet/normal LMRMP flow.

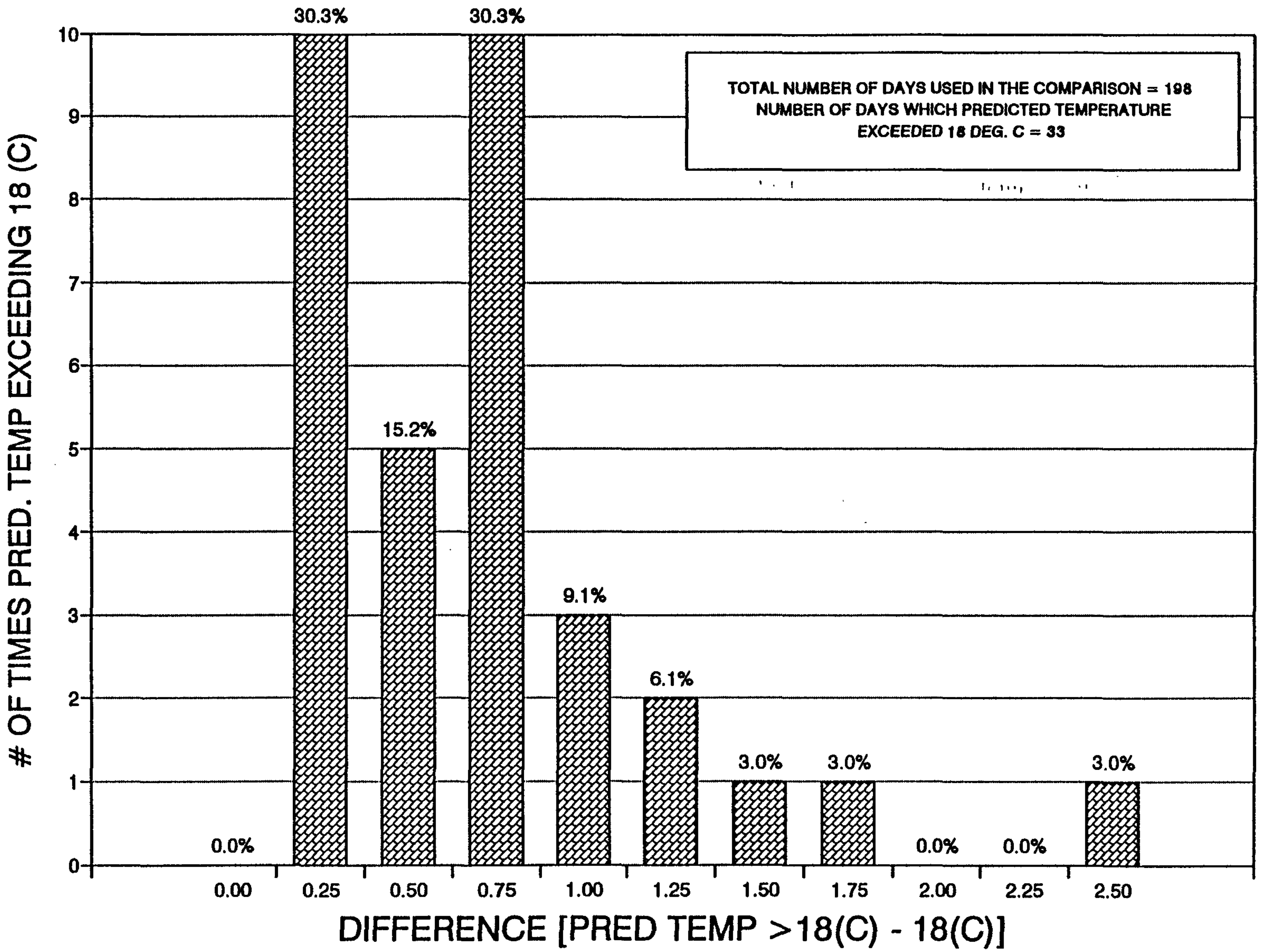

Figure C-29. Frequency distribution for differences in water temperature which exceeded 18°C temperature criteria at Bruella Road for critical LMRMP flow for April through mid-October.

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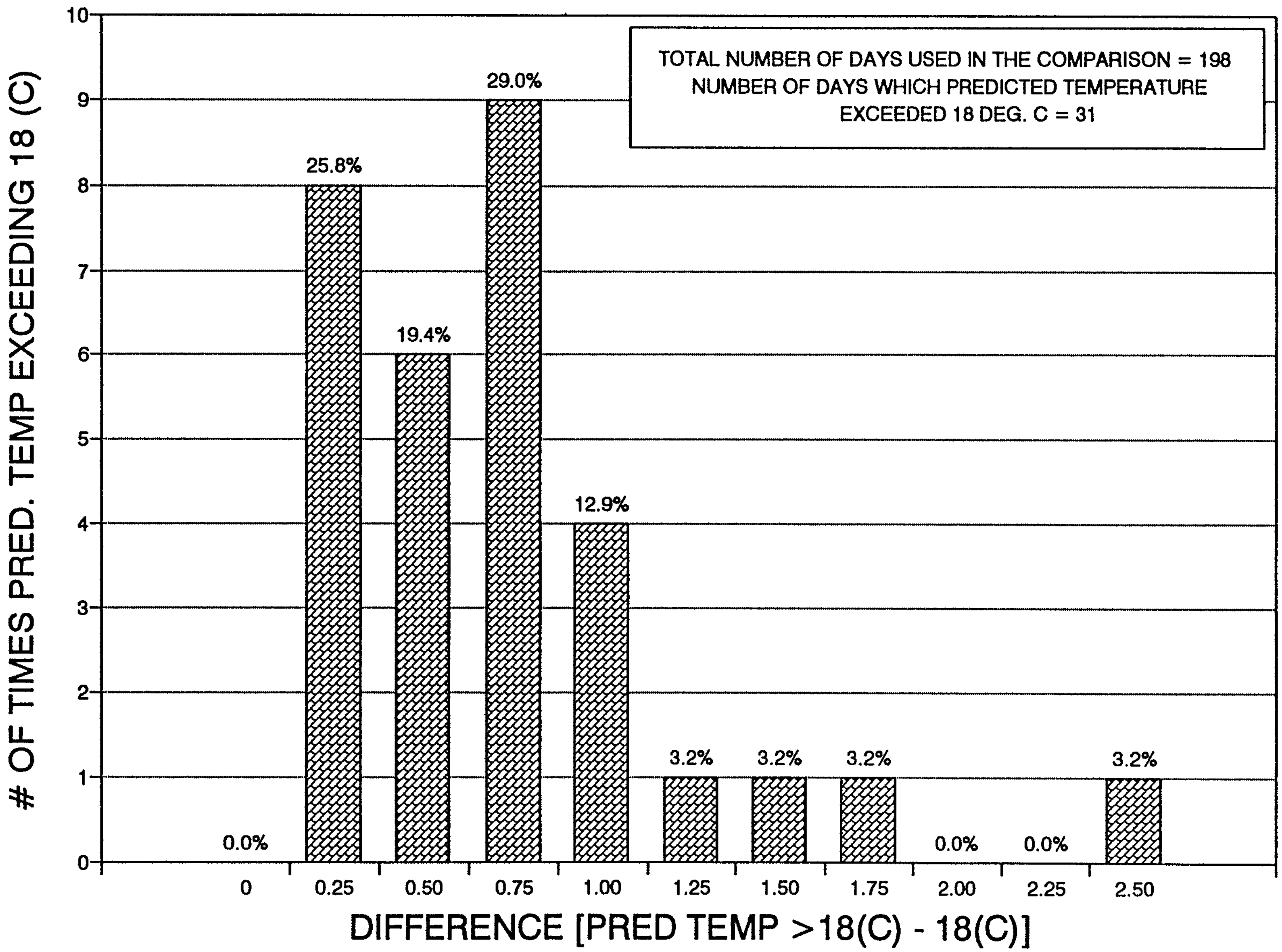

Figure C-30. Frequency distribution for differences in water temperature which exceeded 18°C temperature criteria at Bruella Road for dry LMRMP flow for April through mid-October.

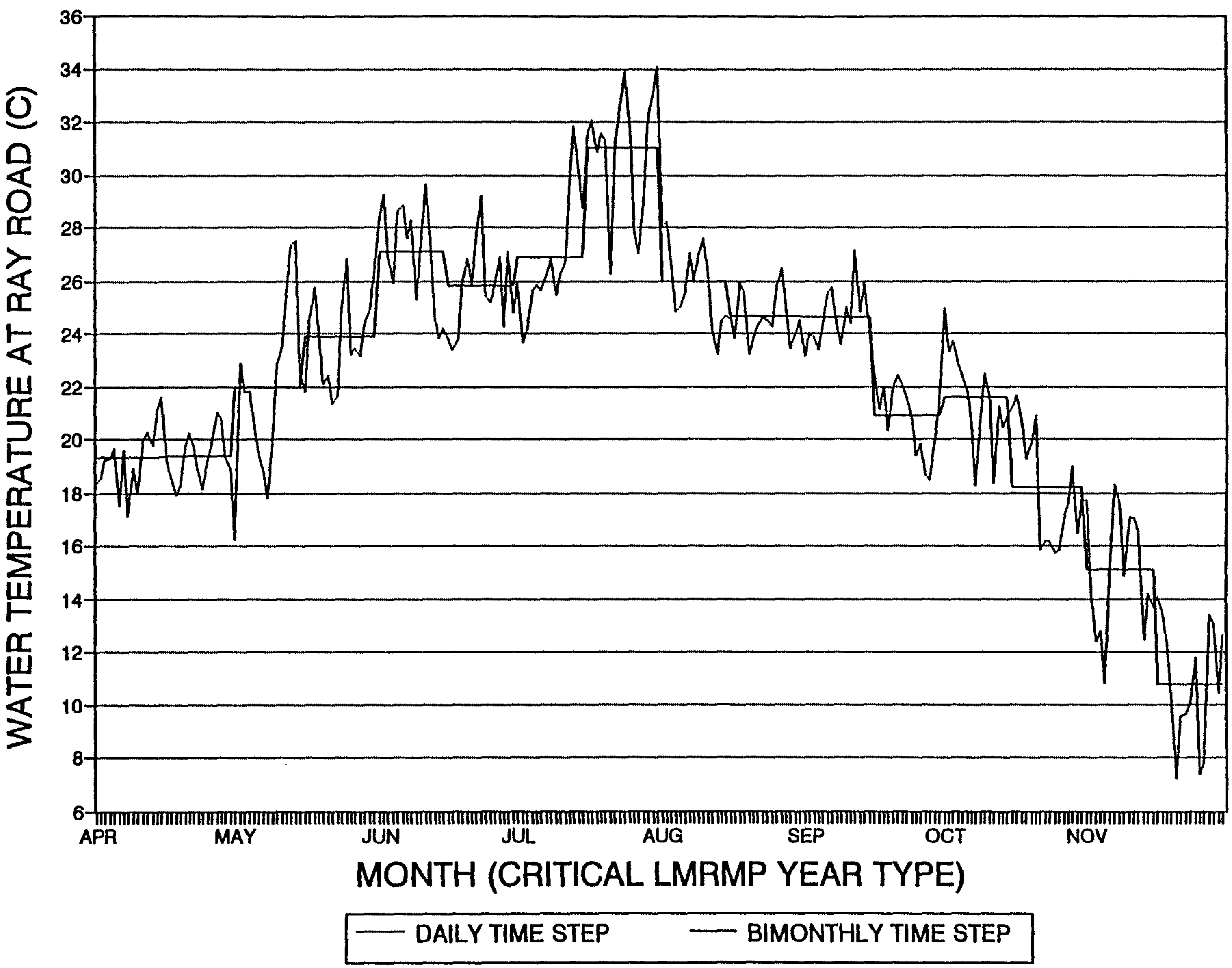

Figure C-31. SNTEMP simulation run results comparing bi-monthly and daily time step outputs at Ray Road for critical LMRMP flow for April through November.

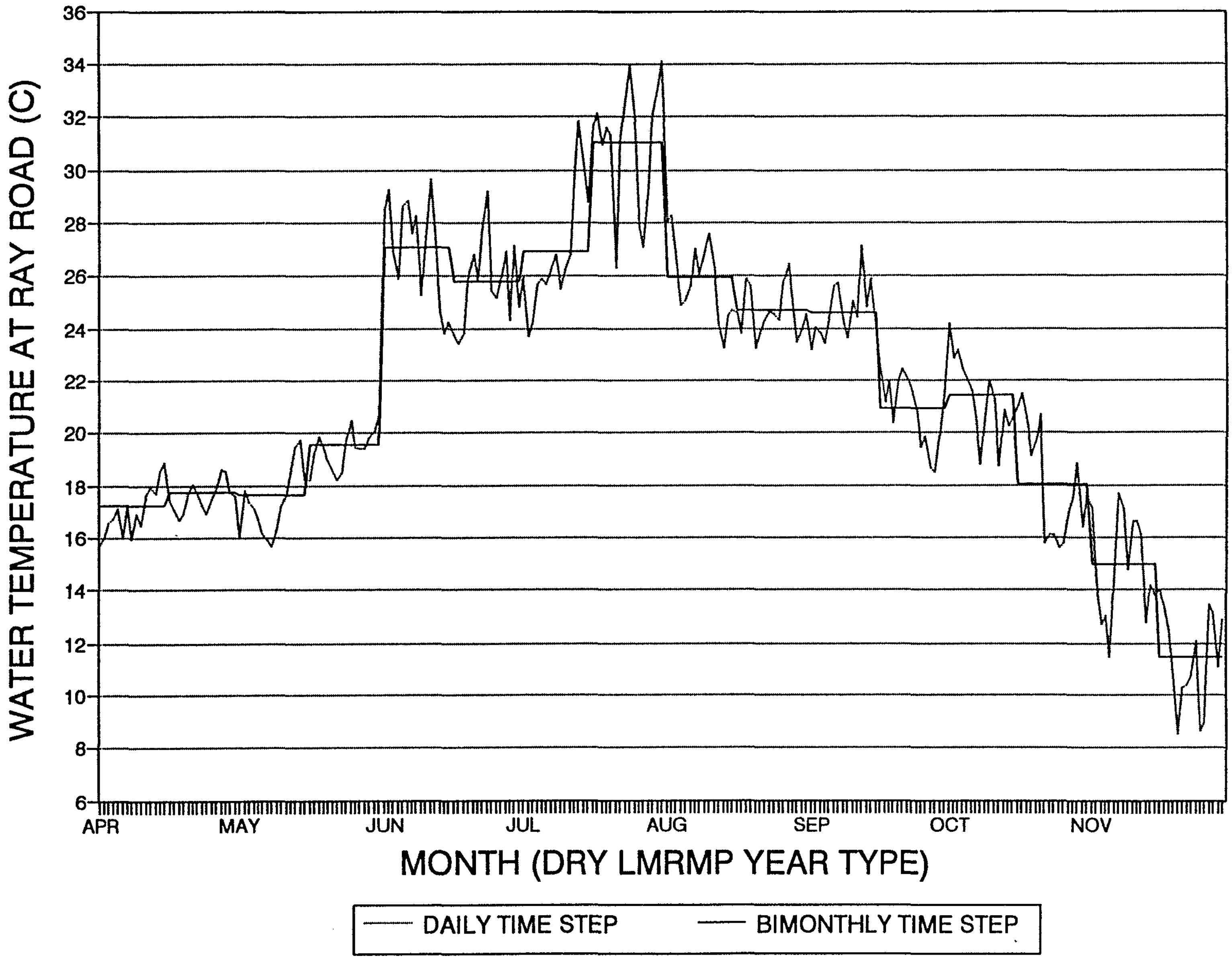

Figure C-32. SNTEMP simulation run results comparing bi-monthly and daily time step outputs at Ray Road for dry LMRMP flow.

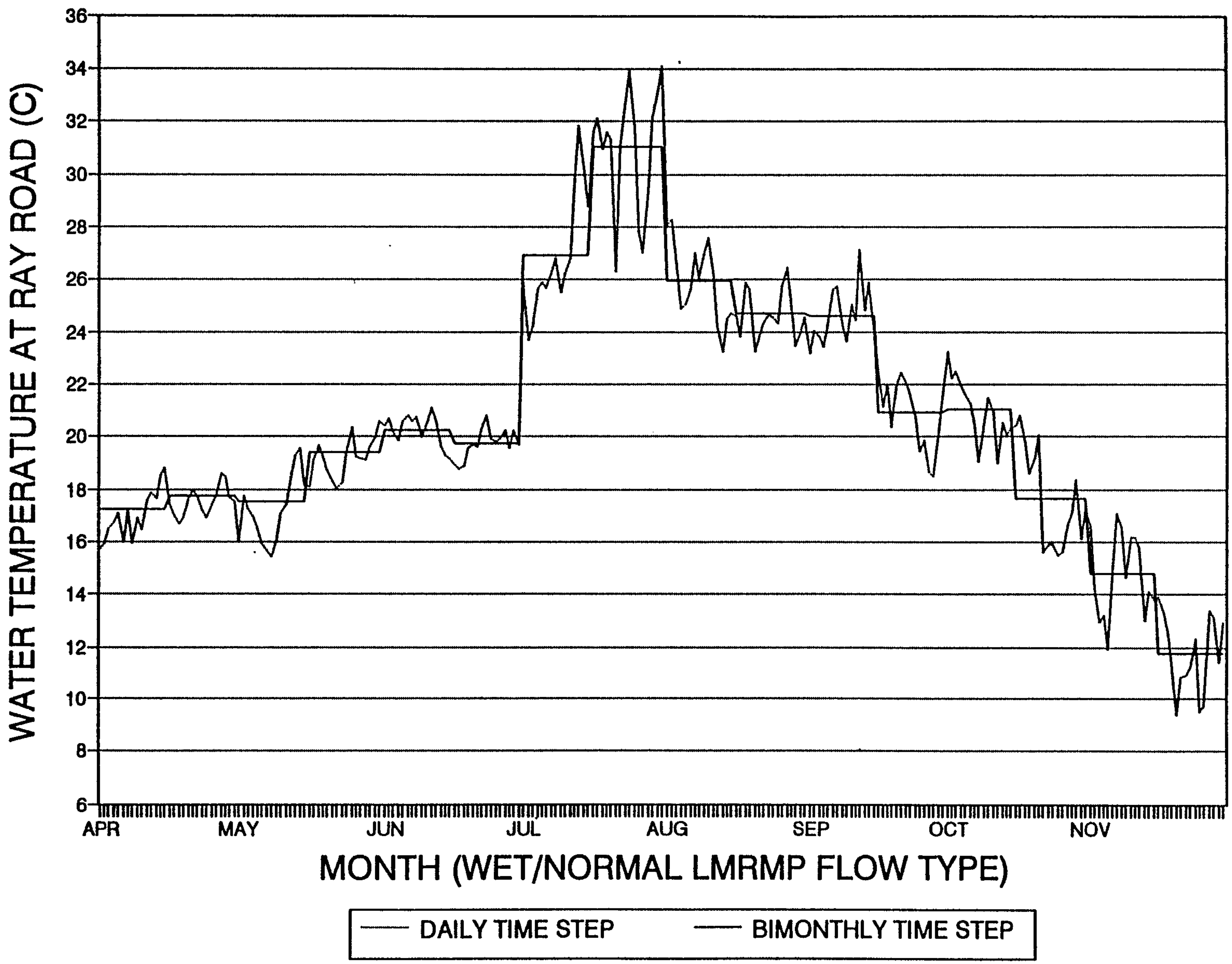

Figure C-33. SNTEMP simulation run results comparing bi-monthly and daily time step outputs at Ray Road for wet/normal LMRMP flow.

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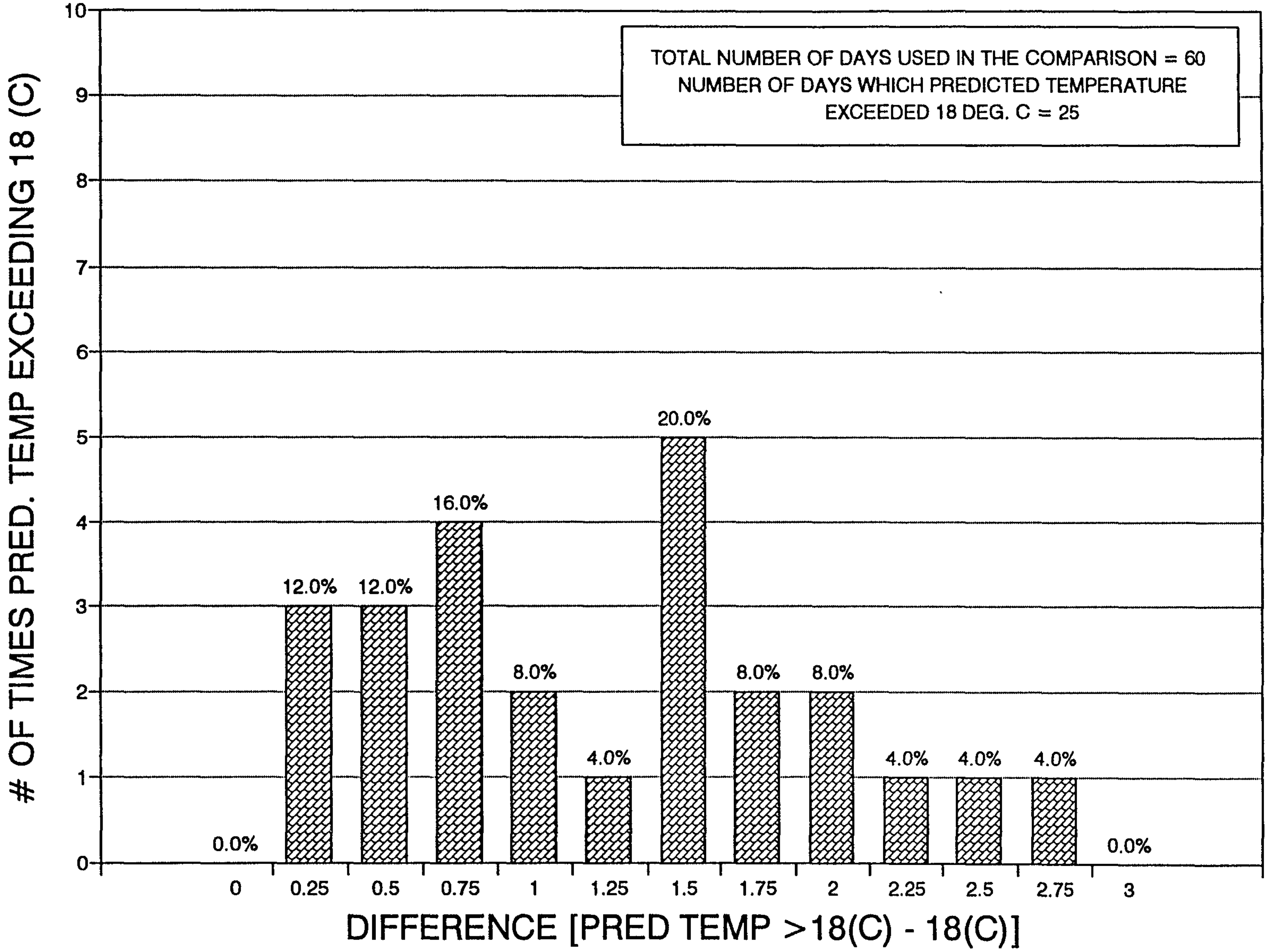

Figure C-34. Frequency distribution for differences in water temperature which exceeded 18°C temperature criteria at Ray Road for dry LMRMP flow for April through May.

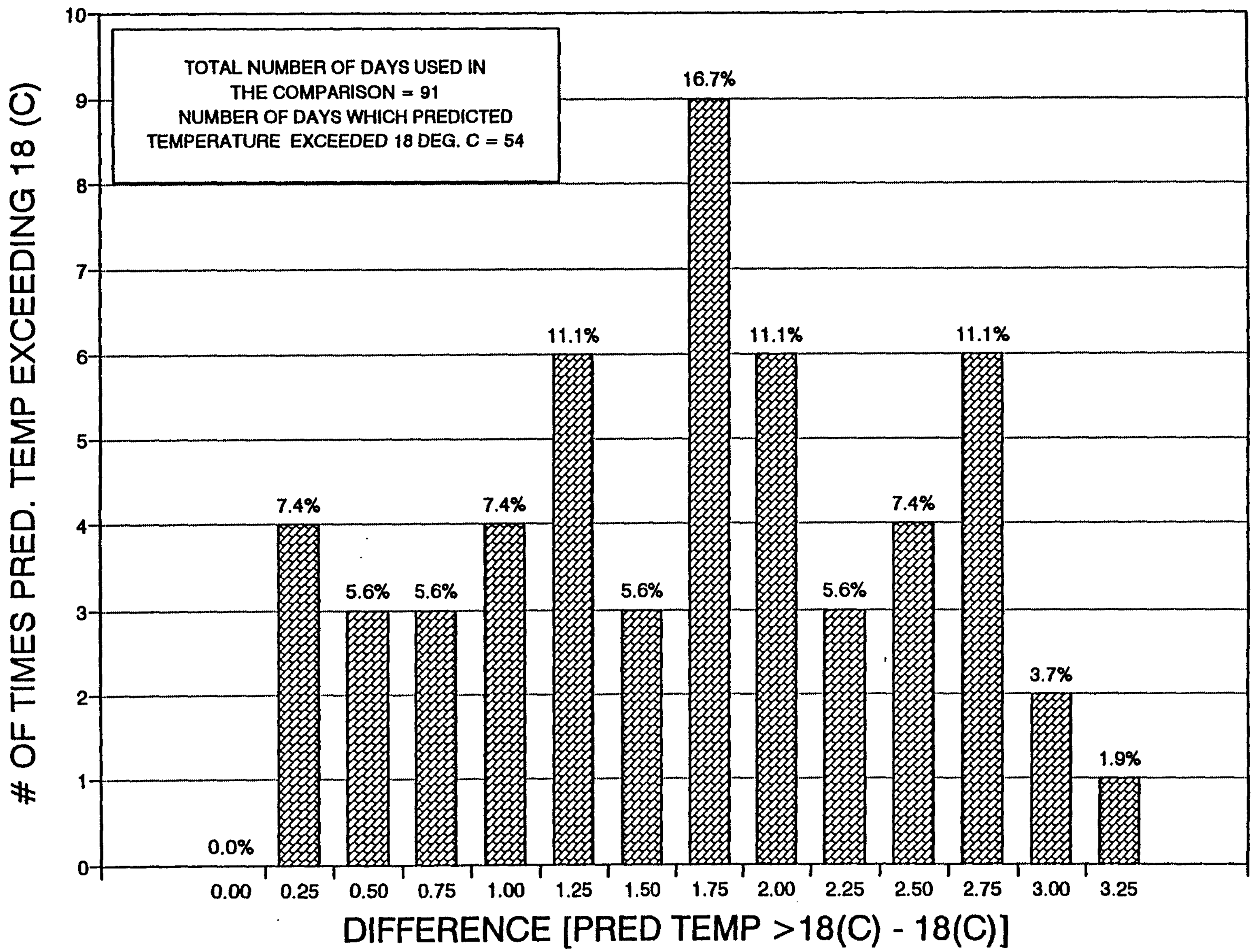

Figure C-35. Frequency distribution for differences in water temperature which exceeded 18°C temperature criteria at Ray Road for wet/normal LMRMP flow for April through June.

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