APPENDIX B

DESCRIPTION OF WATER QUALITY FOR RIVER RESERVOIR SYSTEMS (WQRRS) MODEL

APPENDIX B. DESCRIPTION OF WATER QUALITY FOR RIVER-RESERVOIR SYSTEMS (WQRRS)

1.1 KEY FINDINGS

WQRRS simulation runs were run for Camanche Reservoir to assess the water quality (temperature and dissolved oxygen) of release water relative to different inflow rates, outflow rates and water surface elevations. The simulation runs were made to outline management recommendations for optimizing water quality for the MRFH and the Lower Mokelumne River. The simulation runs used combinations of constant inflow and outflow (through-flow) rates, ranging from 100 to 400 cfs at 100 cfs increments and at four water surface elevations (52-61 m above msl). The simulation results show that at any given through-flow rate, higher water surface elevation resulted in lower (0.6 - 2.2°C) release water temperatures. Also, at any given water surface elevation, higher through flows rates resulted in higher (0.3-1.9°C) release water temperatures and earlier destratification than lower through flow rates. Likewise, at any given through flow rate, higher water surface elevations resulted in higher dissolved oxygen levels in release water and, at any given water surface elevation, higher through flow rates produced higher dissolved oxygen levels in release water. The WQRRS model did not perform well in predicting dissolved oxygen levels. Although anoxic conditions occur in Camanche Reservoir in the late summer, the model did not predict levels below 2 mg/l.

The WQRRS model was calibrated for Lake Lodi to provide more accurate input data for Module 3 of the SNTEMP model for the Mokelumne River (see Appendix C). The WQRRS model for Lake Lodi was calibrated using water temperature profiles taken from in front of Woodbridge Dam. The calibration resulted in an overall mean difference between predicted and observed temperature profiles of -0.43°C and a maximum difference of 2.43°C.

1.2 INTRODUCTION

The Water Quality for River-Reservoir Systems (WQRRS) model developed by the U.S. Army Corps of Engineers at the Hydrologic Engineering Center at Davis, California, is composed of three separate but integral modules: the reservoir module, the stream hydraulic module, and the stream quality module. Only the reservoir module was used in this study.

In the reservoir module of WQRRS, the reservoir is represented conceptually by a series of one-dimensional horizontal layers, where each layer is characterized by an area, thickness, and volume. Water quality is assumed to be homogeneous within each layer. External inflows and withdrawals occur as sources or sinks within each layer. These are dispersed instantaneously and homogeneously mixed throughout each layer from the headwaters of the impoundment to the dam. As a result, longitudinal and latitudinal variation in water quality constituents cannot be analyzed. In the model, internal transport of heat and mass occurs only in a vertical direction. Internal transport is by advection and through an effective diffusion mechanism that combines the effects of molecular and turbulent diffusion and convective mixing.

A complete documentation manual for WQRRS is available from Hydrologic Engineering Center, Davis, California.

1.3 DEVELOPMENT OF THE WQRRS MODEL FOR CAMANCHE RESERVOIR

The WQRRS model for Camanche Reservoir was initially calibrated for EBMUD by CH2M HILL. The description of the methods and approaches taken in the modelling effort can be found in Appendix B of the Camanche Reservoir Improvement Project (CH2M HILL 1991).

BioSystems tested the model using all the calibration data to verify the results obtained by CH2M HILL and successfully duplicated their results. As stated in CH2M HILL's report, this model was calibrated using 1989 data, which represented a specific environmental condition. The year 1989 can be described as having a drought condition with low to average water surface elevation and storage capacity. Although it is not mentioned in CH2M HILL's report, 1989 was a very atypical hydrologic year. The model should be tested further using another data set for validation.

1.3.1 Sensitivity Analysis Runs for WQRRS Developed for Camanche Reservoir

The object of the sensitivity analysis for Camanche Reservoir was to assess the water quality (dissolved oxygen and temperature) of release water relative to different inflow rates, outflow rates, and water surface elevations (storage capacity). These relationships were used to outline a management recommendation for optimizing water quality for the Mokelumne River Fish Hatchery (MRFH) and the Lower Mokelumne River.

1.3.1.1 Assumptions Used for the Simulation Runs

After reviewing Camanche Reservoir historical flows for dry years, we concluded there was no "typical" flow operation. Therefore, a decision was made to run sensitivity analysis type simulations. The average annual water surface elevation for dry years was 52 m above msl. We used 52 m above msl as the lower end and 61 m above msl as the upper end of the simulated water surface elevations to be maintained throughout a simulation year to cover possible dry hydrological year conditions. A total of 16 scenarios were run using combinations of constant inflow and outflow (through flow) rates ranging from 100 to 400 cfs at 100 cfs increments and at four water surface elevations ranging from 52 to 61 m above msl at 3 m increments. Camanche Reservoir water quality and temperature simulation runs were made using the WQRRS model calibrated with 1989 data. (See Table B.1 for the combination of the simulation runs made.)

All the runs had the same values for meteorological data and initial and boundary conditions, which included inflow temperature, inflow dissolved oxygen levels, and other water quality parameters described in Appendix B of the Camanche Reservoir Improvement Project (CH2M HILL 1991).

The simulation calculation used daily time steps, but the model produced output for every fifth day to make the data set more manageable. After each run, the output file was condensed to show only release water quality.

1.3.1.2 Simulation Run Results

It is helpful to understand the processes of stratification and destratification in order to interpret the WQRRS results. Before discussing the results of the simulation runs, a general overview of the Camanche Reservoir's hydrological dynamics is described. The Camanche Reservoir is thermally stratified in the summer. When the reservoir is stratified, it is generally composed of three zones: the epilimnion, the metalimnion, and the hypolimnion. The epilimnion is the upper region which contains the warmest water of the reservoir. The metalimnion, also known as the thermocline, is the transitional area in which drastic changes in water temperature occur. The hypolimnion is the deepest region of the reservoir which contains the coolest and densest water. The size of the hypolimnion is determined, in part, by the volume of water in the reservoir before the onset of stratification. Generally, the larger the volume of the reservoir, the larger the size of the hypolimnion. Water is withdrawn from Camanche Reservoir from the bottom of the hypolimnion near the dam so, as water is withdrawn, the volume of the hypolimnion decreases. As the water from the hypolimnion flows out, it can be replaced by water from Pardee Reservoir or from the warmer Camanche metalimnion. This process occurs throughout the summer. Destratification in Camanche Reservoir typically occurs between late October and late November when heat loss from the reservoir exceeds heat gain. The time at which destratification occurs is dictated by the basin morphometry, the size of the hypolimnion, and meteorological conditions. Destratification occurs when surface waters cool, become denser, and mix with deeper water layers that have a similar density. Eventually the reservoir becomes isothermal, completing the destratification process.

The tabulated output results appear in Tables B.2 through B.5. Camanche Reservoir release water temperature is influenced by a combination of reservoir elevation, inflow from Pardee Reservoir, Camanche release flows, meteorological conditions, and seasons of the year.

The effects of different water surface elevations on release water temperature are as follows. At any given through flow rate, higher water surface elevations resulted in lower release water temperatures (0.6-2.2°C) (data obtained by comparing the maximum release water temperatures from the simulation runs) than lower water surface elevations (Figures B-1 through B-4 and Table B.7). Higher water surface elevations also result in destratification later in the season (Table B.6). These effects occur because the hypolimnion is larger at higher water surface elevations. Destratification occurs later because the large, cold hypolimnion requires more heat loss from the epilimnion and the metalimnion to attain an isothermal profile.

The effects of different water surface elevations on release water dissolved oxygen levels are as follows. At any given through flow rate, higher water surface elevations result in higher release water dissolved oxygen levels than lower water surface elevations (Figures B-5 through B-8). This is the result of the larger and more defined hypolimnion occurring at higher water surface elevations.

The effects of different through flow rates on release water temperatures are as follows. At any given water surface elevation, higher through flow rates were related to higher ((0.3-1.9°C) (data obtained by comparing the maximum release water temperatures from the simulation runs) release water temperatures and earlier destratification than lower through flow rates (Figures B-9 through B-12, Tables B.6 and B.7). At higher through flow rates, the hypolimnion water is replaced faster with slightly warmer inflow water, and the overall water temperature of the hypolimnion increases. This causes warmer release water temperatures since water in Camanche Reservoir is withdrawn from the bottom of the reservoir. When the hypolimnion is warmer, destratification is earlier because less heat loss is needed from the epilimnion and the metalimnion to equalize temperatures and densities with the hypolimnion.

The effects of different through flow rates on dissolved oxygen levels are as follows. At any given water surface elevation, higher through flow rates produced higher dissolved oxygen levels in the release water (Figures B-13 through B-16). Although inflow from Pardee Reservoir into Camanche Reservoir is slightly warmer than the hypolimnion, it is rich in oxygen. Therefore, at a higher inflow rate, more oxygen-rich water enters the hypolimnion, resulting in higher dissolved oxygen levels in the release water. At a lower inflow rate, less dissolved oxygen-rich water enters the hypolimnion, resulting in lower dissolved oxygen levels in the release water.

Since the same set of inflow temperatures and meteorological data was used for all simulation runs, the lowest temperature of the year (5.7° C), which occurred in January, was the same for all runs. However, the time and intensity of the highest temperatures vary because of different heat budgets associated with different water storage and through flow value. Table B.7 shows the peak temperature and time of occurrence for all simulation runs.

The WQRRS model did not perform well in predicting dissolved oxygen levels. Dissolved oxygen levels never dropped below 2 mg/l in simulations even though a review of the available data for Camanche Reservoir showed extended periods with no detectable oxygen. In dry years (only dry years are covered by existing data), dissolved oxygen levels in the hypolimnion of Camanche Reservoir typically decrease rapidly in late summer before the onset of destratification. Thus, the model is probably of little use for characterizing operating criteria for maintenance of specific oxygen levels.

The oscillations in release water temperatures seen in some of the figures are due to weak water column stability and the influence of similar inflow water temperatures and hypolimnion temperatures. Release water temperatures oscillated from May through November in simulation runs using water surface elevations of 52 m (through flow rates for

200, 300, and 400 cfs), 55 m (through flow rates for 200, 300, and 400 cfs), and 58 m (through flow rates for 300 and 400 cfs). During these runs, the hypolimnion gradually warms from May through November and approaches the level of inflow temperature. When inflow enters the reservoir, the model allocates it to a layer(s) with similar water temperatures. When inflow temperature is similar to that of the hypolimnion, there is a weak transitional area between the metalimnion and hypolimnion. In simulation runs that did not show oscillations in release water temperature, the size of the hypolimnion (relative to the release rate) was sufficient to keep the hypolimnion temperature lower than the inflow temperature. Since the slightly warmer inflow enters higher strata in the reservoir, the hypolimnion was stable. The oscillations in the dissolved oxygen levels of release water can be explained by the same phenomenon.

1.3.2 Development of Input Temperature for SNTEMP Simulation Runs Using WQRRS

A different set of simulation runs was completed using the WQRRS model for the Camanche Reservoir to provide input water temperature for SNTEMP (developed for the Mokelumne River) simulation runs (Appendix C, Section 1.4). The following section describes the assumptions used in these simulation runs.

1.3.2.1 Assumptions Used for the WQRRS Simulation Runs

Ten simulations were run using through flow rates of 100 cfs - 1,000 cfs at 100 cfs increments. Summaries from the Pardee Section Report for the years 1976 and 1977 provided inflow temperatures (into Camanche Reservoir) for dry year conditions.

Water surface elevation was kept at 52 m above msl, which is the mean water surface elevation at the Camanche Reservoir in the five dry years between 1964 and 1989.

Meteorological data from the Sacramento Airport were used in the simulation runs. Simulation runs used "normal" year meteorological condition; the definition of a "normal" meteorological year is discussed in Appendix C, Section 1.4.2.

1.3.2.2 WQRRS Simulation Run Results

The results of the WQRRS simulation runs for input temperature for SNTEMP simulation runs are similar to those described in Appendix B, Section 1.3.1.2 (Table B.8).

1.3.3 Development of Input Temperatures for the SNTEMP Simulations Using "Hot" Meteorological Conditions and LMRMP Flow

Six simulations were run to provide inflow temperatures for the SNTEMP simulation runs using "hot" meteorological conditions with the three LMRMP flow year types. For a further description of the SNTEMP part of the simulation runs, see Appendix C, Section 1.6.

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1.3.3.1 Assumptions Used for the Simulation Runs

Inflow and outflow rates were defined by the LMRMP flow (see Appendix C, Table C.2) and water surface elevation was maintained at 52 m above msl. However, to correct for evaporation loss, the actual inflow rate used was 13 cfs more than the LMRMP flow. Summaries from the Pardee Section Report for 1975 through 1985 provided the mean bi-monthly input water temperatures used for the simulation runs. Values for all other parameters used in the simulation runs were the same as those used in the sensitivity analysis runs discussed in Section 1.3.1.1.

Meteorological data used in these runs represented the "hottest" year and the 10 percent exceedence level. The definition for these year types are discussed in Appendix C, Section 1.5.2.3.

1.3.3.2 Simulation Run Results

The results of this set of simulation runs were used as inflow temperatures for the SNTEMP simulation runs. The results are shown in Table B.9.

1.4 DEVELOPMENT OF THE WQRRS MODEL FOR LAKE LODI

In spring every year (the model assumes 1 April), the 50 m wide flashboard Woodbridge Dam is installed in the Mokelumne River to form Lake Lodi. The lake provides water for the WID Canal. When the irrigation season is over in mid-October, the flash boards are removed and the lake is eliminated. While the Woodbridge Dam is in place, the Lake Lodi segment of the river impounds water and behaves like a long, narrow, shallow reservoir where thermal stratification occurs. As a result, SNTEMP is no longer valid for calculating water temperatures. Therefore, WQRRS was used to model this segment of the river. The goal of WQRRS for this segment was to provide a more accurate set of input data for Module 3 simulation. For further information concerning the SNTEMP model for Mokelumne River, see Appendix C.

1.4.1 Data File Preparation for WQRRS Model for Lake Lodi

WQRRS requires topographical, hydrological, meteorological, and water quality information in its input data file. The Lake Lodi WQRRS model was calibrated using the 1990 data since this was the most complete water temperature data set available. Topographic information describing the depth and volume relationships in Lake Lodi was obtained through EBMUD from the WID, and USGS topographical maps (7.5 minute series) provided length and elevation data.

Measured inflow, outflow, and water surface elevation data are necessary for the overall account of water transport through Lake Lodi but this information is not available. Thus, interpolations (based on discharge and distance) using the available flow data from three USGS gaging stations (11323500-below Camanche Dam, 11325500-at WID Canal, and

11325000-below Woodbridge Dam) were used to estimate the inflow rates to Lake Lodi. The outflow rate used for Lake Lodi is the sum of flow rates for the two gaging stations at WID Canal and below Woodbridge Dam.

Meteorological data are required for the heat budget algorithms in WQRRS to account for net heat gain or loss in the system from weather conditions. The air temperature, wind speed, dew point temperature, cloud cover, and air pressure data used in the model were from the Sacramento Airport. Input water temperatures came from "Lake Lodi Temperature and Dissolved Oxygen Profile" monitored by EBMUD.

1.4.2 Calibration Method for the WQRRS Model for Lake Lodi

The conventional WQRRS model calibration reduces the deviations between measured water balance and water quality (temperature) and their predicted values by adjusting various coefficients. Since there is no measured water balance data, the calibration of Lake Lodi uses only predicted temperatures. Calibrating the WQRRS model for Lake Lodi requires modifying the coefficients so that the model behaves like the actual system. This is done by changing the Secchi disc depth (measure of light transparency with depth), water column minimum stability (density gradient above which mixing of the water column occurs), effective diffusion rate (internal transport of heat and mass in the vertical direction), and their associated coefficients that alter the behavior of the system.

1.4.3 Calibration Result for the WQRRS Model for Lake Lodi

The model output best represents the water temperature profile near the dam. Thus, the predicted water temperature was compared to the observed data from in front of Woodbridge Dam. Fifteen sets of water temperature profiles were available for the summer months in 1990. Comparison of these two data sets showed the mean difference in temperature profile for the fifteen sets was -0.43°C and the maximum single deviation was 2.43°C (Figure B-17). The difference between the surface and bottom temperatures predicted by the model ranged between 8.4 and 1.9°C. The lake was stratified in all months between April and October. Withdrawals were assumed to be made from a level 1.8 m above the lake bottom.

Table B.1. Matrix of WQRRS sensitivity analysis runs made for Camanche Reservoir.

through flow rates (cfs)	WATER SURFACE ELEVATION METERS ABOVE MSL) MAINTAINED THROUGHOUT THE YEAR			
	52	55	58	61
100*	X	X	X	X
200*	X	X	X	X
300*	X	X	X	X
400*	X	X	X	X

*The actual inflow rate used was 13 cfs more than the out flow rate to correct for evaporation.

Table B.2. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Summary of release water temperature and dissolved oxygen level for simulation runs using water surface elevation of 52 m above msl and in/out flow rate of 100, 200, 300, and 400 cfs.

RELEASE WATER TEMPERATURE

	IN/OUT FLOW RATES			
DATE	100 cfs (Deg. C)	200 cfs (Deg. C)	300 cfs (Deg. C)	400 cfs (Deg. C)
01/08	5.9	5.9	5.9	5.9
01/10	5.7	5.8	5.8	5.8
01/15	5.7	5.8	5.8	5.9
01/20	5.7	5.8	5.9	5.9
01/25	5.8	5.9	6.0	6.1
01/30	5.9	6.1	6.1	6.3
02/04	6.1	6.2	6.3	6.4
02/09	6.0	6.1	6.2	6.3
02/14	6.0	6.1	6.2	6.3
02/19	6.1	6.2	6.3	6.5
02/24	6.2	6.4	6.5	6.7
03/01	6.4	6.6	6.7	6.9
03/06	6.6	6.8	7.0	7.1
03/11	6.8	7.0	7.2	7.4
03/16	7.0	7.2	7.4	7.7
03/21	7.1	7.4	7.6	8.0
03/26	7.3	7.6	7.9	8.3
03/31	7.5	7.8	8.2	8.7
04/05	7.7	8.0	8.5	9.1
04/10	7.9	8.3	8.7	9.5
04/15	8.1	8.5	9.0	9.8
04/20	8.2	8.8	9.5	10.5
04/25	8.5	9.0	9.8	10.9
04/30	8.7	9.3	10.1	11.3
05/05	8.9	9.6	10.5	11.6
05/10	9.1	9.9	10.9	11.7
05/15	9.3	10.2	11.2	11.6
05/20	9.5	10.5	11.7	11.6
05/25	9.7	10.8	11.7	11.6
05/30	9.9	11.1	11.6	11.6
06/04	10.1	11.3	11.9	11.9
06/09	10.3	11.6	11.9	12.0
06/14	10.5	11.9	12.0	12.0
06/19	10.8	12.1	12.2	12.3
06/24	11.0	12.2	12.2	12.3
06/29	11.2	12.2	12.2	12.2
07/04	11.4	12.4	12.5	12.6
07/09	11.6	12.5	12.6	12.6
07/14	11.8	12.5	12.6	12.6
07/19	12.0	12.7	12.8	12.8
07/24	12.2	12.8	12.8	12.8
07/29	12.4	12.8	12.8	12.8
08/03	12.6	13.0	13.0	13.1
08/08	12.8	13.3	13.5	13.8
08/13	13.0	13.5	13.7	13.8
08/18	13.2	13.6	13.7	13.7
08/23	13.4	13.7	13.7	13.7
08/28	13.5	13.7	13.7	13.6
09/02	13.7	13.8	13.8	13.8
09/07	13.8	14.1	14.3	14.5
09/12	14.0	14.4	14.8	15.0
09/17	14.2	14.7	14.7	14.7
09/22	14.4	14.7	14.7	14.6
09/27	14.5	14.7	14.6	14.6
10/02	14.6	14.6	14.6	14.6
10/07	14.7	14.7	14.7	14.7
10/12	14.7	14.7	14.7	14.7
10/17	14.8	14.8	14.8	14.9
10/22	15.0	15.2	15.3	15.6
10/27	15.0	15.2	15.3	15.3
11/01	15.1	15.1	15.1	15.1
11/06	15.3	14.9	14.7	14.7
11/11	14.9	14.9	14.6	14.5
11/16	14.3	14.4	14.4	14.4
11/21	14.1	14.1	14.1	14.1
11/26	13.2	13.2	13.2	13.2
12/01	12.4	12.4	12.4	12.4
12/06	11.9	11.9	11.9	11.9
12/11	11.1	11.2	11.2	11.2
12/16	10.4	10.4	10.4	10.4
12/21	9.3	9.3	9.3	9.4
12/26	8.6	8.6	8.7	8.7
12/31	8.0	8.0	8.1	8.2

RELEASE WATER DISSOLVED OXYGEN LEVEL

	IN/OUT FLOW RATES			
DATE	100 cfs (mg/l)	200 cfs (mg/l)	300 cfs (mg/l)	400 cfs (mg/l)
01/05	10.1	10.1	10.1	10.1
01/10	10.0	9.9	9.9	9.9
01/15	10.4	10.3	10.3	10.2
01/20	10.0	9.9	9.8	9.7
01/25	9.8	9.7	9.6	9.5
01/30	9.7	9.6	9.5	9.4
02/04	9.7	9.6	9.5	9.4
02/09	10.9	10.7	10.5	10.4
02/14	10.6	10.4	10.2	10.0
02/19	10.4	10.1	9.9	9.7
02/24	10.2	10.0	9.7	9.5
03/01	10.0	9.8	9.5	9.2
03/06	9.8	9.5	9.2	8.9
03/11	9.6	9.3	9.0	8.7
03/16	9.4	9.1	8.8	8.5
03/21	9.3	8.9	8.6	8.3
03/26	9.1	8.8	8.4	8.1
03/31	8.9	8.6	8.2	7.9
04/05	8.8	8.4	8.0	7.7
04/10	8.6	8.2	7.8	7.5
04/15	8.4	8.0	7.6	7.3
04/20	8.2	7.8	7.4	7.0
04/25	8.0	7.6	7.2	6.8
04/30	7.8	7.4	6.9	6.5
05/05	7.7	7.2	6.6	6.2
05/10	7.5	6.9	6.4	6.6
05/15	7.3	6.7	6.2	6.8
05/20	7.1	6.5	6.1	6.6
05/25	6.9	6.3	6.4	6.5
05/30	6.7	6.1	6.6	6.5
06/04	6.5	5.9	5.7	5.4
06/09	6.4	5.8	6.1	5.9
06/14	6.2	5.6	6.2	6.3
06/19	6.0	5.5	5.5	5.4
06/24	5.8	5.9	5.9	6.1
06/29	5.7	6.0	6.0	6.3
07/04	5.5	5.2	5.0	5.1
07/09	5.3	5.5	5.5	5.8
07/14	5.0	5.5	5.7	6.1
07/19	4.8	5.1	5.2	5.4
07/24	4.6	5.1	5.4	5.8
07/29	4.3	5.1	5.5	5.9
08/03	4.1	4.4	4.6	4.8
08/08	3.9	3.8	3.8	3.9
08/13	3.7	3.5	4.1	4.9
08/18	3.6	4.0	4.9	5.6
08/23	3.4	4.4	5.1	5.7
08/28	3.5	4.5	5.2	5.7
09/02	3.6	4.1	4.6	4.9
09/07	3.1	3.3	3.5	3.6
09/12	2.9	2.9	3.1	3.8
09/17	2.7	3.1	4.3	5.1
09/22	2.6	3.9	4.8	5.5
09/27	3.1	4.2	5.0	5.5
10/02	3.3	4.4	5.0	5.4
10/07	3.4	4.4	5.0	5.5
10/12	3.4	4.4	5.0	5.6
10/17	3.2	4.0	4.5	4.8
10/22	2.8	3.1	3.4	3.6
10/27	3.2	3.9	4.6	5.4
11/01	3.8	5.1	5.9	6.6
11/06	8.2	5.8	6.4	6.8
11/11	8.6	8.7	7.0	7.2
11/16	9.0	9.0	9.1	9.1
11/21	9.2	9.1	9.1	9.1
11/26	9.6	9.5	9.5	9.4
12/01	9.7	9.6	9.5	9.4
12/06	9.9	9.8	9.6	9.5
12/11	10.1	9.9	9.8	9.6
12/16	10.3	10.1	9.9	9.7
12/21	10.5	10.3	10.1	9.9
12/26	10.6	10.4	10.2	10.0
12/31	10.8	10.6	10.4	10.2

Table B.3. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Summary of release water temperature and dissolved oxygen level for simulation runs using water surface elevation of 55 m above msl and in/out flow rate of 100, 200, 300, and 400 cfs.

RELEASE WATER TEMPERATURE					RELEASE WATER DISSOLVED OXYGEN LEVEL				
	IN/OUT FLOW RATES					IN/OUT FLOW RATES			
DATE	100 cfs (Deg. C)	200 cfs (Deg. C)	300 cfs (Deg. C)	400 cfs (Deg. C)	DATE	100 cfs (mg/l)	200 cfs (mg/l)	300 cfs (mg/l)	400 cfs (mg/l)
01/05	5.9	5.9	5.9	5.9	01/05	10.0	10.0	10.1	10.1
01/10	5.7	5.8	5.8	5.8	01/10	9.9	9.9	9.9	9.9
01/15	5.7	5.7	5.8	5.8	01/15	10.3	10.3	10.3	10.2
01/20	5.7	5.8	5.8	5.9	01/20	9.9	9.9	9.8	9.8
01/25	5.8	5.8	5.9	5.9	01/25	9.7	9.6	9.6	9.5
01/30	5.9	5.9	6.0	6.1	01/30	9.6	9.5	9.5	9.4
02/04	6.0	6.1	6.2	6.2	02/04	9.5	9.5	9.4	9.3
02/09	5.9	6.0	6.1	6.2	02/09	10.9	10.7	10.6	10.5
02/14	5.9	6.0	6.1	6.2	02/14	10.6	10.4	10.3	10.1
02/19	6.0	6.1	6.2	6.3	02/19	10.3	10.2	10.0	9.8
02/24	6.1	6.2	6.3	6.4	02/24	10.2	10.0	9.8	9.6
03/01	6.2	6.4	6.5	6.6	03/01	10.0	9.8	9.7	9.5
03/06	6.4	6.6	6.7	6.8	03/06	9.8	9.6	9.4	9.2
03/11	6.6	6.7	6.9	7.1	03/11	9.7	9.5	9.2	9.0
03/16	6.8	7.0	7.1	7.3	03/16	9.5	9.3	9.1	8.8
03/21	6.9	7.1	7.3	7.6	03/21	9.3	9.1	8.9	8.7
03/26	7.1	7.3	7.6	8.0	03/26	9.2	9.0	8.7	8.5
03/31	7.3	7.5	7.8	8.3	03/31	9.0	8.8	8.6	8.3
04/05	7.4	7.8	8.1	9.0	04/05	8.9	8.7	8.4	8.2
04/10	7.6	8.0	8.4	9.3	04/10	8.7	8.5	8.2	7.9
04/15	7.8	8.2	8.7	9.9	04/15	8.6	8.3	8.0	7.7
04/20	8.0	8.4	8.9	10.4	04/20	8.4	8.1	7.8	7.4
04/25	8.2	8.7	9.2	10.9	04/25	8.2	7.9	7.6	7.1
04/30	8.3	8.9	9.5	11.3	04/30	8.1	7.7	7.3	6.8
05/05	8.5	9.1	9.9	11.7	05/05	7.9	7.5	7.1	6.5
05/10	8.7	9.4	10.2	11.7	05/10	7.7	7.3	6.9	6.9
05/15	8.9	9.6	10.5	11.5	05/15	7.5	7.1	6.6	7.0
05/20	9.0	9.9	10.9	11.5	05/20	7.4	6.9	6.4	6.8
05/25	9.2	10.1	11.2	11.6	05/25	7.2	6.7	6.2	6.6
05/30	9.4	10.3	11.4	11.6	05/30	7.0	6.5	6.0	6.5
06/04	9.5	10.6	11.7	11.9	06/04	6.8	6.3	5.8	5.5
06/09	9.7	10.8	11.9	12.0	06/09	6.7	6.2	5.9	6.0
06/14	9.9	11.1	11.9	12.0	06/14	6.5	6.0	6.4	6.4
06/19	10.1	11.3	12.1	12.3	06/19	6.4	5.8	5.6	5.4
06/24	10.2	11.5	12.2	12.2	06/24	6.2	5.7	6.0	6.1
06/29	10.4	11.8	12.2	12.2	06/29	6.0	5.5	6.1	6.3
07/04	10.5	12.0	12.4	12.6	07/04	5.9	5.3	5.2	5.2
07/09	10.7	12.2	12.5	12.6	07/09	5.7	5.1	5.5	5.8
07/14	10.9	12.4	12.5	12.6	07/14	5.5	4.9	5.8	6.1
07/19	11.1	12.6	12.7	12.8	07/19	5.3	4.7	5.1	5.3
07/24	11.3	12.7	12.7	12.8	07/24	5.0	5.1	5.5	5.8
07/29	11.4	12.7	12.7	12.8	07/29	4.8	5.3	5.5	5.8
08/03	11.6	12.8	12.9	13.0	08/03	4.6	4.7	4.7	4.8
08/08	11.8	13.0	13.2	13.5	08/08	4.4	4.0	3.9	3.9
08/13	12.0	13.3	13.5	13.7	08/13	4.2	3.8	3.6	4.5
08/18	12.1	13.5	13.6	13.6	08/18	4.0	3.6	4.7	5.4
08/23	12.3	13.5	13.6	13.6	08/23	3.9	4.4	5.1	5.5
08/28	12.5	13.6	13.6	13.6	08/28	3.7	4.6	5.1	5.5
09/02	12.7	13.7	13.7	13.8	09/02	3.5	4.2	4.5	4.8
09/07	12.8	13.9	14.1	14.2	09/07	3.4	3.5	3.5	3.6
09/12	13.0	14.1	14.4	14.7	09/12	3.2	3.1	3.1	3.1
09/17	13.2	14.3	14.6	14.7	09/17	3.1	2.9	3.1	4.3
09/22	13.3	14.5	14.6	14.6	09/22	2.9	3.2	4.3	5.1
09/27	13.5	14.5	14.6	14.5	09/27	2.8	4.0	4.7	5.4
10/02	13.7	14.6	14.6	14.6	10/02	2.7	4.2	4.9	5.1
10/07	13.9	14.6	14.6	14.6	10/07	2.5	4.3	4.9	5.3
10/12	14.0	14.6	14.6	14.6	10/12	2.4	4.3	4.9	5.4
10/17	14.2	14.7	14.7	14.8	10/17	2.3	3.9	4.3	4.7
10/22	14.4	15.0	15.1	15.3	10/22	2.2	3.0	3.2	3.3
10/27	14.5	15.1	15.2	15.3	10/27	2.1	3.5	3.9	4.5
11/01	14.7	15.0	15.1	15.1	11/01	2.3	4.5	5.3	6.1
11/06	14.7	14.8	14.7	14.7	11/06	3.3	5.2	6.0	6.6
11/11	14.8	15.0	14.6	14.5	11/11	8.4	8.6	6.8	6.9
11/16	14.3	14.4	14.4	14.5	11/16	8.9	8.9	9.0	9.0
11/21	14.1	14.2	14.2	14.2	11/21	9.1	9.1	9.1	9.1
11/26	13.2	13.3	13.3	13.3	11/26	9.5	9.5	9.5	9.4
12/01	12.4	12.5	12.5	12.5	12/01	9.7	9.6	9.6	9.5
12/06	11.9	12.0	12.0	12.0	12/06	9.9	9.8	9.7	9.6
12/11	11.2	11.3	11.3	11.3	12/11	10.1	10.0	9.8	9.7
12/16	10.5	10.5	10.5	10.5	12/16	10.3	10.1	10.0	9.9
12/21	9.4	9.5	9.5	9.5	12/21	10.5	10.3	10.2	10.0
12/26	8.7	8.8	8.8	8.8	12/26	10.6	10.5	10.3	10.2
12/31	8.1	8.2	8.2	8.3	12/31	10.8	10.7	10.5	10.3

C-101220

C-101220

Table B.4. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Summary of release water temperature and dissolved oxygen level for simulation runs using water surface elevation of 58 m above msl and in/out flow rate of 100, 200, 300, and 400 cfs.

RELEASE WATER TEMPERATURE

	IN/OUT FLOW RATES			
DATE	100 cfs (Deg. C)	200 cfs (Deg. C)	300 cfs (Deg. C)	400 cfs (Deg. C)
01/05	5.9	5.9	5.9	5.9
01/10	5.8	5.8	5.8	5.8
01/15	5.7	5.7	5.8	5.8
01/20	5.7	5.7	5.8	5.8
01/25	5.7	5.8	5.8	5.9
01/30	5.8	5.9	5.9	6.0
02/04	5.9	6.0	6.0	6.1
02/09	5.9	6.0	6.0	6.1
02/14	5.9	6.0	6.1	6.1
02/19	5.9	6.0	6.1	6.2
02/24	6.0	6.1	6.2	6.3
03/01	6.1	6.2	6.3	6.4
03/06	6.2	6.3	6.5	6.5
03/11	6.4	6.5	6.7	6.7
03/16	6.5	6.6	6.8	6.9
03/21	6.7	6.8	7.0	7.1
03/26	6.8	7.0	7.2	7.3
03/31	7.0	7.1	7.4	7.5
04/05	7.1	7.3	7.5	7.7
04/10	7.3	7.5	7.8	7.9
04/15	7.4	7.6	7.9	8.1
04/20	7.6	7.8	8.1	8.3
04/25	7.7	8.0	8.3	8.6
04/30	7.9	8.2	8.5	8.8
05/05	8.0	8.3	8.7	9.1
05/10	8.2	8.5	9.0	9.4
05/15	8.3	8.7	9.2	9.7
05/20	8.5	8.8	9.4	9.9
05/25	8.6	9.0	9.6	10.2
05/30	8.8	9.2	9.9	10.5
06/04	8.9	9.4	10.1	10.8
06/09	9.1	9.6	10.3	11.1
06/14	9.2	9.8	10.5	11.4
06/19	9.4	10.0	10.8	11.6
06/24	9.5	10.2	11.0	11.9
06/29	9.6	10.3	11.3	12.1
07/04	9.8	10.5	11.5	12.3
07/09	9.9	10.7	11.8	12.5
07/14	10.1	10.9	12.0	12.5
07/19	10.2	11.1	12.2	12.6
07/24	10.4	11.3	12.4	12.7
07/29	10.5	11.5	12.6	12.7
08/03	10.7	11.7	12.8	12.8
08/08	10.8	11.9	13.0	13.1
08/13	11.0	12.1	13.2	13.4
08/18	11.1	12.3	13.4	13.6
08/23	11.3	12.5	13.5	13.5
08/28	11.4	12.7	13.5	13.5
09/02	11.5	12.9	13.6	13.6
09/07	11.7	13.1	13.8	14.0
09/12	11.8	13.3	14.1	14.3
09/17	12.0	13.5	14.3	14.5
09/22	12.1	13.7	14.5	14.5
09/27	12.3	13.8	14.5	14.5
10/02	12.4	14.0	14.5	14.5
10/07	12.6	14.2	14.5	14.5
10/12	12.7	14.4	14.6	14.6
10/17	12.9	14.6	14.6	14.7
10/22	13.0	14.7	14.9	15.0
10/27	13.2	14.9	15.0	15.1
11/01	13.4	15.0	15.0	15.0
11/06	13.5	14.8	14.7	14.6
11/11	13.7	14.7	14.6	14.5
11/16	13.8	14.5	14.6	14.6
11/21	14.0	14.3	14.3	14.3
11/26	13.2	13.4	13.5	13.5
12/01	12.5	12.7	12.7	12.7
12/06	12.0	12.2	12.2	12.2
12/11	11.3	11.5	11.5	11.5
12/16	10.6	10.7	10.8	10.8
12/21	9.6	9.7	9.8	9.8
12/26	8.9	9.0	9.1	9.1
12/31	8.3	8.4	8.5	8.5

RELEASE WATER DISSOLVED OXYGEN LEVEL

	IN/OUT FLOW RATES			
DATE	100 cfs (mg/l)	200 cfs (mg/l)	300 cfs (mg/l)	400 cfs (mg/l)
01/05	10.0	10.0	10.0	10.0
01/10	9.9	9.9	9.8	9.8
01/15	10.3	10.2	10.2	10.2
01/20	9.9	9.8	9.8	9.7
01/25	9.6	9.5	9.5	9.4
01/30	9.4	9.4	9.3	9.3
02/04	9.3	9.3	9.3	9.2
02/09	10.8	10.7	10.6	10.5
02/14	10.5	10.4	10.3	10.1
02/19	10.2	10.1	10.0	9.9
02/24	10.1	10.0	9.8	9.7
03/01	9.9	9.8	9.7	9.5
03/06	9.7	9.6	9.5	9.4
03/11	9.6	9.5	9.4	9.2
03/16	9.5	9.3	9.2	9.0
03/21	9.3	9.2	9.0	8.9
03/26	9.2	9.0	8.9	8.7
03/31	9.0	8.9	8.7	8.6
04/05	8.9	8.7	8.6	8.4
04/10	8.8	8.6	8.5	8.2
04/15	8.6	8.4	8.3	8.1
04/20	8.5	8.3	8.1	7.9
04/25	8.3	8.1	7.9	7.7
04/30	8.2	7.9	7.8	7.5
05/05	8.0	7.8	7.6	7.3
05/10	7.8	7.6	7.4	7.1
05/15	7.7	7.4	7.2	6.9
05/20	7.5	7.3	7.0	6.7
05/25	7.4	7.1	6.8	6.5
05/30	7.2	6.9	6.6	6.3
06/04	7.1	6.8	6.5	6.1
06/09	6.9	6.6	6.2	5.9
06/14	6.8	6.4	6.1	5.7
06/19	6.6	6.3	5.9	5.6
06/24	6.5	6.1	5.7	5.4
06/29	6.3	6.0	5.6	5.3
07/04	6.2	5.8	5.4	5.1
07/09	6.0	5.6	5.2	5.3
07/14	5.9	5.5	5.1	6.0
07/19	5.7	5.3	4.9	5.1
07/24	5.5	5.1	4.7	5.7
07/29	5.3	4.8	4.5	5.9
08/03	5.1	4.6	4.6	4.9
08/08	4.9	4.4	4.2	4.1
08/13	4.7	4.3	4.0	3.8
08/18	4.5	4.1	3.8	4.1
08/23	4.4	3.9	4.3	5.2
08/28	4.2	3.8	5.0	5.5
09/02	4.0	3.6	4.6	4.8
09/07	3.9	3.5	3.7	3.6
09/12	3.7	3.3	3.3	3.3
09/17	3.6	3.2	3.1	3.1
09/22	3.4	3.1	3.2	4.4
09/27	3.3	3.0	4.5	5.2
10/02	3.1	2.9	4.7	5.0
10/07	3.0	2.8	4.9	5.3
10/12	2.9	2.7	4.9	5.4
10/17	2.8	2.6	4.4	4.7
10/22	2.6	2.6	3.3	3.3
10/27	2.5	2.5	3.8	4.2
11/01	2.4	3.3	4.6	5.2
11/06	2.3	4.3	5.4	6.0
11/11	2.3	5.6	6.2	6.6
11/16	2.8	8.8	8.9	8.9
11/21	8.6	9.0	9.0	9.0
11/26	9.2	9.4	9.4	9.4
12/01	9.4	9.6	9.5	9.5
12/06	9.7	9.8	9.7	9.6
12/11	9.9	9.9	9.8	9.8
12/16	10.1	10.1	10.0	9.9
12/21	10.3	10.3	10.2	10.1
12/26	10.5	10.4	10.3	10.2
12/31	10.7	10.6	10.5	10.4

Table B.5. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Summary of release water temperature and dissolved oxygen level for simulation runs using water surface elevation of 61 m above msl and in/out flow rate of 100, 200, 300, and 400 cfs.

RELEASE WATER TEMPERATURE	IN/OUT FLOW RATES				RELEASE WATER DISSOLVED OXYGEN LEVEL	IN/OUT FLOW RATES			
DATE	100 cfs (Deg. C)	200 cfs (Deg. C)	300 cfs (Deg. C)	400 cfs (Deg. C)	DATE	100 cfs (mg/l)	200 cfs (mg/l)	300 cfs (mg/l)	400 cfs (mg/l)
01/05	5.9	5.9	5.9	5.9	01/05	10.0	10.0	10.0	10.0
01/10	5.8	5.8	5.8	5.8	01/10	9.8	9.8	9.8	9.8
01/15	5.7	5.8	5.8	5.8	01/15	10.1	10.1	10.1	10.1
01/20	5.7	5.8	5.8	5.8	01/20	9.8	9.7	9.7	9.7
01/25	5.7	5.8	5.8	5.8	01/25	9.4	9.4	9.4	9.3
01/30	5.8	5.8	5.8	5.9	01/30	9.2	9.2	9.2	9.1
02/04	5.8	5.9	5.9	6.0	02/04	9.1	9.1	9.1	9.1
02/09	5.9	6.0	6.0	6.1	02/09	10.6	10.6	10.5	10.4
02/14	5.9	6.0	6.0	6.1	02/14	10.4	10.3	10.2	10.1
02/19	5.9	6.0	6.0	6.1	02/19	10.1	10.0	10.0	9.9
02/24	6.0	6.0	6.1	6.2	02/24	9.9	9.8	9.8	9.7
03/01	6.0	6.1	6.2	6.2	03/01	9.8	9.7	9.6	9.5
03/06	6.1	6.2	6.3	6.4	03/06	9.6	9.5	9.5	9.4
03/11	6.2	6.3	6.4	6.5	03/11	9.5	9.4	9.3	9.2
03/16	6.4	6.5	6.6	6.7	03/16	9.4	9.3	9.2	9.1
03/21	6.5	6.6	6.7	6.8	03/21	9.2	9.1	9.0	8.9
03/26	6.6	6.8	6.9	7.0	03/26	9.1	9.0	8.9	8.8
03/31	6.8	6.9	7.0	7.2	03/31	9.0	8.9	8.8	8.7
04/05	6.9	7.0	7.2	7.3	04/05	8.8	8.7	8.6	8.5
04/10	7.0	7.2	7.3	7.5	04/10	8.7	8.6	8.5	8.4
04/15	7.2	7.4	7.5	7.7	04/15	8.6	8.5	8.4	8.2
04/20	7.3	7.5	7.7	7.9	04/20	8.5	8.4	8.2	8.1
04/25	7.5	7.7	7.9	8.1	04/25	8.3	8.2	8.1	7.9
04/30	7.6	7.8	8.0	8.2	04/30	8.2	8.1	7.9	7.8
05/05	7.7	8.0	8.2	8.4	05/05	8.0	7.9	7.8	7.6
05/10	7.9	8.1	8.4	8.6	05/10	7.9	7.8	7.6	7.4
05/15	8.0	8.3	8.5	8.8	05/15	7.7	7.6	7.4	7.2
05/20	8.1	8.4	8.7	9.0	05/20	7.6	7.4	7.3	7.1
05/25	8.3	8.6	8.9	9.2	05/25	7.5	7.3	7.1	6.9
05/30	8.4	8.7	9.0	9.4	05/30	7.3	7.1	6.9	6.7
06/04	8.5	8.9	9.2	9.7	06/04	7.2	7.0	6.8	6.5
06/09	8.7	9.0	9.4	9.9	06/09	7.1	6.9	6.6	6.4
06/14	8.8	9.2	9.6	10.1	06/14	6.9	6.7	6.5	6.2
06/19	8.9	9.3	9.8	10.4	06/19	6.8	6.6	6.3	6.0
06/24	9.0	9.5	10.0	10.6	06/24	6.7	6.4	6.2	5.9
06/29	9.2	9.6	10.2	10.9	06/29	6.5	6.3	6.0	5.7
07/04	9.3	9.8	10.4	11.1	07/04	6.4	6.1	5.9	5.5
07/09	9.4	9.9	10.6	11.3	07/09	6.3	6.0	5.7	5.4
07/14	9.6	10.1	10.8	11.5	07/14	6.1	5.9	5.5	5.2
07/19	9.7	10.2	11.0	11.8	07/19	6.0	5.7	5.4	5.0
07/24	9.8	10.4	11.2	12.0	07/24	5.8	5.5	5.2	4.8
07/29	9.9	10.6	11.4	12.3	07/29	5.6	5.3	5.0	4.7
08/03	10.0	10.7	11.6	12.5	08/03	5.5	5.1	4.8	4.5
08/08	10.2	10.9	11.8	12.7	08/08	5.3	5.0	4.6	4.3
08/13	10.3	11.0	12.0	12.9	08/13	5.1	4.8	4.4	4.1
08/18	10.4	11.2	12.2	13.1	08/18	4.9	4.6	4.2	4.0
08/23	10.6	11.4	12.4	13.3	08/23	4.8	4.4	4.1	3.9
08/28	10.7	11.5	12.6	13.4	08/28	4.6	4.3	3.9	3.8
09/02	10.8	11.7	12.8	13.6	09/02	4.5	4.1	3.8	4.0
09/07	10.9	11.9	13.0	13.8	09/07	4.3	4.0	3.7	3.6
09/12	11.1	12.0	13.2	14.0	09/12	4.2	3.8	3.5	3.4
09/17	11.2	12.2	13.4	14.1	09/17	4.1	3.7	3.4	3.3
09/22	11.3	12.4	13.6	14.3	09/22	3.9	3.6	3.3	3.2
09/27	11.4	12.5	13.7	14.4	09/27	3.8	3.4	3.2	4.2
10/02	11.6	12.7	13.9	14.5	10/02	3.7	3.3	3.1	4.3
10/07	11.7	12.9	14.1	14.5	10/07	3.5	3.2	3.0	5.1
10/12	11.8	13.1	14.3	14.5	10/12	3.4	3.1	2.9	5.3
10/17	11.9	13.2	14.5	14.6	10/17	3.3	3.0	2.9	4.6
10/22	12.1	13.4	14.7	14.9	10/22	3.2	2.9	2.8	3.4
10/27	12.2	13.6	14.8	15.0	10/27	3.1	2.8	2.8	3.7
11/01	12.3	13.7	14.9	15.0	11/01	3.0	2.7	3.4	4.8
11/06	12.5	13.9	14.7	14.6	11/06	2.9	2.6	4.6	5.4
11/11	12.6	14.1	14.5	14.5	11/11	2.8	2.7	5.6	6.2
11/16	12.7	14.4	14.7	14.3	11/16	2.7	8.3	8.6	6.7
11/21	12.8	14.2	14.4	14.0	11/21	2.7	8.6	8.8	7.1
11/26	13.1	13.5	13.6	13.7	11/26	8.6	9.1	9.2	9.3
12/01	12.4	12.8	12.9	12.9	12/01	9.0	9.3	9.4	9.4
12/06	12.0	12.3	12.4	12.4	12/06	9.3	9.6	9.6	9.6
12/11	11.4	11.7	11.8	11.8	12/11	9.6	9.8	9.7	9.7
12/16	10.7	11.0	11.1	11.1	12/16	9.9	9.9	9.9	9.9
12/21	9.8	10.0	10.1	10.1	12/21	10.1	10.1	10.1	10.0
12/26	9.2	9.4	9.4	9.5	12/26	10.3	10.3	10.2	10.2
12/31	8.6	8.8	8.8	8.9	12/31	10.6	10.5	10.4	10.3

Table B.6. Summary of onset of destratification experienced in Camanche Reservoir during the simulation runs.

ONSET OF DESTRATIFICATION				
	Water Surface Elevation Maintained Throughout the Year (Meters above MSL)			
through flow rates (cfs)	**52**	**55**	**58**	**61**
100	1 Nov — 6 Nov	6 Nov — 11 Nov	16 Nov — 21 Nov	21 Nov — 26 Nov
200	27 Oct — 1 Nov	27 Oct — 1 Nov	1 Nov — 6 Nov	11 Nov — 16 Nov
300	22 Oct — 27 Oct	22 Oct — 27 Oct	22 Oct — 27 Oct	27 Oct — 1 Nov
400	22 Oct — 27 Oct	22 Oct — 27 Oct	22 Oct — 27 Oct	27 Oct — 1 Nov

Table B.7. Summary of highest release water temperatures for all simulation runs and date of occurrence.

Simulation Run (water surface elevation/ through flow rate)	Temperature (°C)	Onset of Destratification
52/100	15.3	06 Nov
52/200	15.2	27 Oct
52/300	15.3	27 Oct
52/400	15.6	22 Oct
55/100	14.8	11 Nov
55/200	15.1	27 Oct
55/300	15.2	27 Oct
55/400	15.3	27 Oct
58/100	14.0	16 Nov
58/200	15.0	01 Nov
58/300	15.0	01 Nov
58/400	15.1	27 Oct
61/100	13.1	26 Nov
61/200	14.4	16 Nov
61/300	14.9	01 Nov
61/400	15.0	01 Nov

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Table B.8. Output summary of WQRRS simulation runs for development of input temperature for SNTEMP simulation runs. Summary of release water temperatures.

MONTH	JULIAN DAY	100 (cfs)	200 (cfs)	300 (cfs)	400 (cfs)	500 (cfs)	600 (cfs)	700 (cfs)	800 (cfs)	900 (cfs)	1000 (cfs)
January	10	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.4
	15	6.2	6.2	6.3	6.3	6.4	6.3	6.4	6.4	6.5	6.5
	20	6.2	6.3	6.3	6.4	6.5	6.5	6.5	6.6	6.7	6.7
	25	6.3	6.4	6.5	6.6	6.7	6.6	6.7	6.8	6.9	7.0
	30	6.4	6.5	6.7	6.8	7.0	6.9	7.0	7.1	7.2	7.3
February	35	6.6	6.7	6.9	7.0	7.2	7.1	7.2	7.4	7.5	7.6
	40	6.8	6.9	7.1	7.3	7.4	7.4	7.5	7.6	7.8	7.9
	45	6.9	7.1	7.3	7.5	7.7	7.6	7.8	8.0	8.1	8.3
	50	7.1	7.3	7.6	7.8	8.0	7.9	8.1	8.3	8.4	8.6
	55	7.3	7.5	7.8	8.0	8.2	8.2	8.4	8.6	8.7	8.8
March	60	7.5	7.7	8.0	8.3	8.5	8.5	8.6	8.8	8.9	8.9
	65	7.6	8.0	8.2	8.5	8.7	8.7	8.8	8.9	8.9	8.9
	70	7.8	8.1	8.5	8.7	8.9	8.9	9.1	9.1	9.2	9.2
	75	8.0	8.3	8.7	9.0	9.2	9.1	9.2	9.3	9.3	9.4
	80	8.1	8.5	8.9	9.2	9.2	9.3	9.4	9.4	9.4	9.4
	85	8.3	8.7	9.1	9.3	9.3	9.3	9.4	9.3	9.3	9.4
	90	8.4	8.9	9.2	9.3	9.3	9.3	9.3	9.3	9.3	9.4
April	95	8.6	9.1	9.3	9.4	9.4	9.3	9.3	9.3	9.3	9.3
	100	8.7	9.2	9.4	9.5	9.5	9.4	9.5	9.5	9.5	9.5
	105	8.9	9.3	9.4	9.4	9.5	9.5	9.5	9.5	9.5	9.5
	110	9.0	9.4	9.5	9.6	9.8	9.5	9.5	9.5	9.5	9.5
	115	9.2	9.5	9.6	9.7	9.8	9.8	9.8	9.9	9.9	9.8
	120	9.3	9.6	9.6	9.7	9.8	9.8	9.8	9.8	9.8	9.8
May	125	9.4	9.7	9.8	10.0	10.2	9.8	9.8	9.8	9.8	9.8
	130	9.5	9.8	9.9	10.0	10.1	10.1	10.2	10.2	10.3	10.3
	135	9.6	9.8	9.9	9.9	10.0	10.1	10.1	10.1	10.1	10.2
	140	9.7	10.0	10.1	10.1	10.4	10.0	10.1	10.1	10.1	10.1
	145	9.8	10.1	10.3	10.4	10.7	10.5	10.6	10.7	10.7	10.7
	150	9.9	10.2	10.4	10.6	10.7	11.0	11.1	11.1	11.0	11.0
June	155	10.0	10.3	10.6	10.7	10.9	10.8	10.8	10.8	10.8	10.8
	160	10.1	10.4	10.7	11.0	11.3	11.2	11.3	11.4	11.5	11.6
	165	10.2	10.5	10.9	11.2	11.6	11.7	11.9	12.0	12.2	12.3
	170	10.3	10.7	11.0	11.4	11.9	11.9	11.9	12.0	12.0	11.9
	175	10.4	10.8	11.2	11.5	12.1	12.3	12.4	12.4	12.6	12.7
	180	10.5	10.9	11.3	11.7	12.2	12.8	13.0	13.1	13.3	13.3
July	185	10.6	11.0	11.4	11.9	12.4	12.5	12.5	12.5	12.6	12.6
	190	10.7	11.1	11.6	12.0	12.5	13.0	13.1	13.3	13.3	13.5
	195	10.8	11.2	11.7	12.2	12.5	12.6	12.8	12.8	12.9	12.9
	200	10.9	11.4	11.9	12.4	12.7	12.5	12.7	12.7	12.7	12.8
	205	11.0	11.5	12.0	12.6	13.0	13.2	13.4	13.6	13.7	13.7
	210	11.1	11.6	12.2	12.8	13.1	13.7	13.9	14.2	14.1	14.1
August	215	11.2	11.7	12.3	12.8	13.0	13.4	13.4	13.5	13.5	13.4
	220	11.3	11.8	12.5	12.8	12.9	13.1	13.1	13.2	13.2	13.2
	225	11.4	12.0	12.6	12.8	12.9	13.0	13.0	13.1	13.0	13.0
	230	11.5	12.1	12.8	13.0	13.1	12.9	12.9	13.0	13.0	13.0
	235	11.6	12.2	13.0	13.2	13.3	13.5	13.6	13.5	13.8	13.8
	240	11.7	12.4	13.0	13.1	13.2	13.5	13.6	13.5	13.9	13.8
September	245	11.8	12.5	13.1	13.2	13.5	13.3	13.3	13.3	13.5	13.4
	250	11.9	12.6	13.3	13.6	14.1	13.6	13.8	13.8	13.6	14.0
	255	12.0	12.7	13.5	13.7	13.9	14.5	14.8	14.8	14.9	15.3
	260	12.1	12.9	13.5	13.6	13.7	14.0	14.1	14.0	14.0	14.2
	265	12.2	13.0	13.5	13.5	13.6	13.8	13.8	13.8	13.7	13.9
	270	12.2	13.1	13.5	13.5	13.6	13.6	13.6	13.6	13.6	13.7
October	275	12.3	13.3	13.5	13.7	13.7	13.5	13.6	13.5	13.5	13.7
	280	12.4	13.4	13.8	14.2	14.6	14.0	14.1	14.1	14.2	14.3
	285	12.5	13.5	14.2	14.4	14.6	15.5	15.9	16.1	16.0	16.4
	290	12.6	13.7	14.1	14.2	14.4	14.7	14.6	14.7	14.6	14.9
	295	12.7	13.8	14.1	14.1	14.2	14.4	14.3	14.4	14.3	14.2
	300	12.8	13.9	14.1	14.1	14.2	14.2	14.2	14.2	14.1	14.1
November	305	12.9	13.9	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.0
	310	13.0	14.0	14.1	14.1	14.1	14.1	14.1	14.1	14.0	14.0
	315	13.1	14.0	14.1	14.0	14.1	14.0	14.0	14.0	14.0	14.0
	320	13.2	14.0	14.0	14.0	13.9	14.0	14.0	14.0	14.0	14.0
	325	13.4	13.7	13.8	13.6	13.5	13.9	13.9	13.9	13.9	13.8
	330	12.7	12.9	12.9	12.8	12.8	13.4	13.4	13.4	13.3	13.3
December	335	12.0	12.2	12.1	12.0	12.0	12.8	12.8	12.8	12.7	12.7
	340	11.4	11.5	11.4	11.3	11.2	12.0	12.0	12.0	12.0	12.0
	345	10.9	10.9	10.8	10.7	10.7	11.3	11.3	11.3	11.3	11.3
	350	10.5	10.4	10.3	10.3	10.2	10.7	10.7	10.8	10.8	10.8
	355	10.2	10.1	10.0	9.9	9.9	10.3	10.3	10.4	10.4	10.4
	360	9.9	9.8	9.7	9.7	9.7	10.0	10.0	10.1	10.1	10.1
	365	9.7	9.6	9.5	9.5	9.5	9.8	9.8	9.9	9.9	9.9

Table B.9. Output summary of WQRRS simulation runs for development of input temperature for SNTEMP simulation runs using hot meteorological conditions. Summary of release water temperature.

MXMETCC	Hottest meteorological year data using LMRMP Critical year flow
MXMETCD	Hottest meteorological year data using LMRMP Dry year flow
MXMETCW	Hottest meteorological year data using LMRMP Wet/Normal year flow
10METCC	10% exceedence level meteorological year data using LMRMP Critical year flow
10METCD	10% exceedence level meteorological year data using LMRMP Dry year flow
10METCW	10% exceedence level meteorological year data using LMRMP Wet/Normal year flow

JULIAN DATE		MXMETCC	MXMETCD	MXMETCW	10METCC	10METCD	10METCW
January	5	6.2	6.3	6.3	6.2	6.2	6.2
	10	6.3	6.3	6.3	6.3	6.3	6.3
	15	6.4	6.4	6.4	6.4	6.4	6.4
	20	6.5	6.6	6.6	6.5	6.6	6.6
	25	6.7	6.8	6.8	6.7	6.7	6.7
	30	6.9	7.0	7.0	6.8	6.9	6.9
February	35	7.0	7.1	7.1	7.0	7.1	7.1
	40	7.2	7.3	7.3	7.2	7.3	7.3
	45	7.4	7.5	7.5	7.3	7.5	7.5
	50	7.5	7.7	7.7	7.5	7.7	7.7
	55	7.7	7.9	7.9	7.7	7.9	7.9
March	60	7.9	8.1	8.1	7.9	8.1	8.1
	65	8.1	8.3	8.3	8.1	8.3	8.3
	70	8.2	8.4	8.4	8.2	8.5	8.5
	75	8.4	8.6	8.6	8.4	8.7	8.7
	80	8.6	8.8	8.8	8.6	8.9	8.9
	85	8.7	8.9	8.9	8.8	9.0	9.0
	90	8.9	9.0	9.0	8.9	9.1	9.1
April	95	9.1	9.2	9.2	9.1	9.2	9.2
	100	9.1	9.2	9.2	9.2	9.3	9.3
	105	9.2	9.3	9.3	9.3	9.3	9.3
	110	9.3	9.4	9.4	9.4	9.4	9.4
	115	9.4	9.5	9.5	9.5	9.5	9.5
	120	9.5	9.5	9.5	9.5	9.6	9.6
May	125	9.7	9.9	9.9	9.7	9.9	9.9
	130	9.8	9.8	9.8	9.8	9.9	9.8
	135	9.8	9.8	9.8	9.8	9.9	9.8
	140	10.0	10.3	10.3	10.1	10.3	10.4
	145	10.3	10.7	10.7	10.4	10.7	10.9
	150	10.4	10.6	10.6	10.4	10.6	10.6
June	155	10.7	10.6	11.1	10.7	10.7	11.2
	160	11.0	11.0	11.8	11.0	11.1	11.9
	165	11.3	11.4	11.6	11.3	11.4	11.6
	170	11.5	11.6	12.2	11.5	11.7	12.2
	175	11.8	12.0	12.9	11.8	12.0	13.0
	180	12.1	12.1	12.4	12.1	12.1	12.4
July	185	12.3	12.3	12.5	12.3	12.3	12.5
	190	12.3	12.3	12.5	12.3	12.3	12.5
	195	12.3	12.3	12.4	12.3	12.3	12.4
	200	12.6	12.6	12.9	12.6	12.6	13.0
	205	12.9	13.0	13.4	13.0	13.1	13.4
	210	13.0	13.0	13.1	13.0	13.0	13.2
August	215	12.9	13.0	13.0	13.0	13.0	13.0
	220	12.9	12.9	12.9	12.9	12.9	12.9
	225	12.8	12.9	12.8	12.9	12.9	12.8
	230	13.0	13.0	13.2	13.0	13.0	13.2
	235	13.0	13.0	13.2	13.0	13.0	13.2
	240	13.0	13.0	13.1	13.0	13.0	13.1
September	245	13.1	13.1	13.2	13.1	13.1	13.2
	250	13.4	13.5	13.8	13.4	13.5	13.8
	255	13.6	13.6	13.8	13.6	13.6	13.8
	260	13.6	13.6	13.7	13.6	13.6	13.7
	265	13.6	13.6	13.6	13.6	13.6	13.6
	270	13.5	13.6	13.5	13.5	13.6	13.6
October	275	13.4	13.7	13.7	13.5	13.7	13.7
	280	13.7	13.8	14.4	13.8	13.9	14.4
	285	13.9	14.1	14.3	13.9	14.0	14.3
	290	14.0	14.1	14.2	14.0	14.1	14.2
	295	14.0	14.1	14.1	14.1	14.1	14.2
	300	14.0	14.1	14.1	14.1	14.1	14.1
November	305	14.3	14.2	14.1	14.2	14.1	14.2
	310	14.2	14.0	13.9	14.2	14.0	14.1
	315	14.1	13.9	13.8	14.2	14.0	14.0
	320	14.0	13.8	13.7	14.1	13.9	13.9
	325	13.5	13.5	13.5	13.9	13.6	13.4
	330	12.8	12.8	12.8	13.6	13.3	13.2
December	335	12.2	12.2	12.2	13.1	13.1	13.1
	340	11.0	11.0	11.0	12.1	12.1	12.1
	345	10.1	10.1	10.1	11.4	11.4	11.4
	350	9.4	9.4	9.5	10.7	10.7	10.8
	355	9.0	9.0	9.1	10.0	10.0	10.0
	360	8.7	8.7	8.8	9.3	9.3	9.4
	365	8.4	8.4	8.6	8.8	8.8	8.9

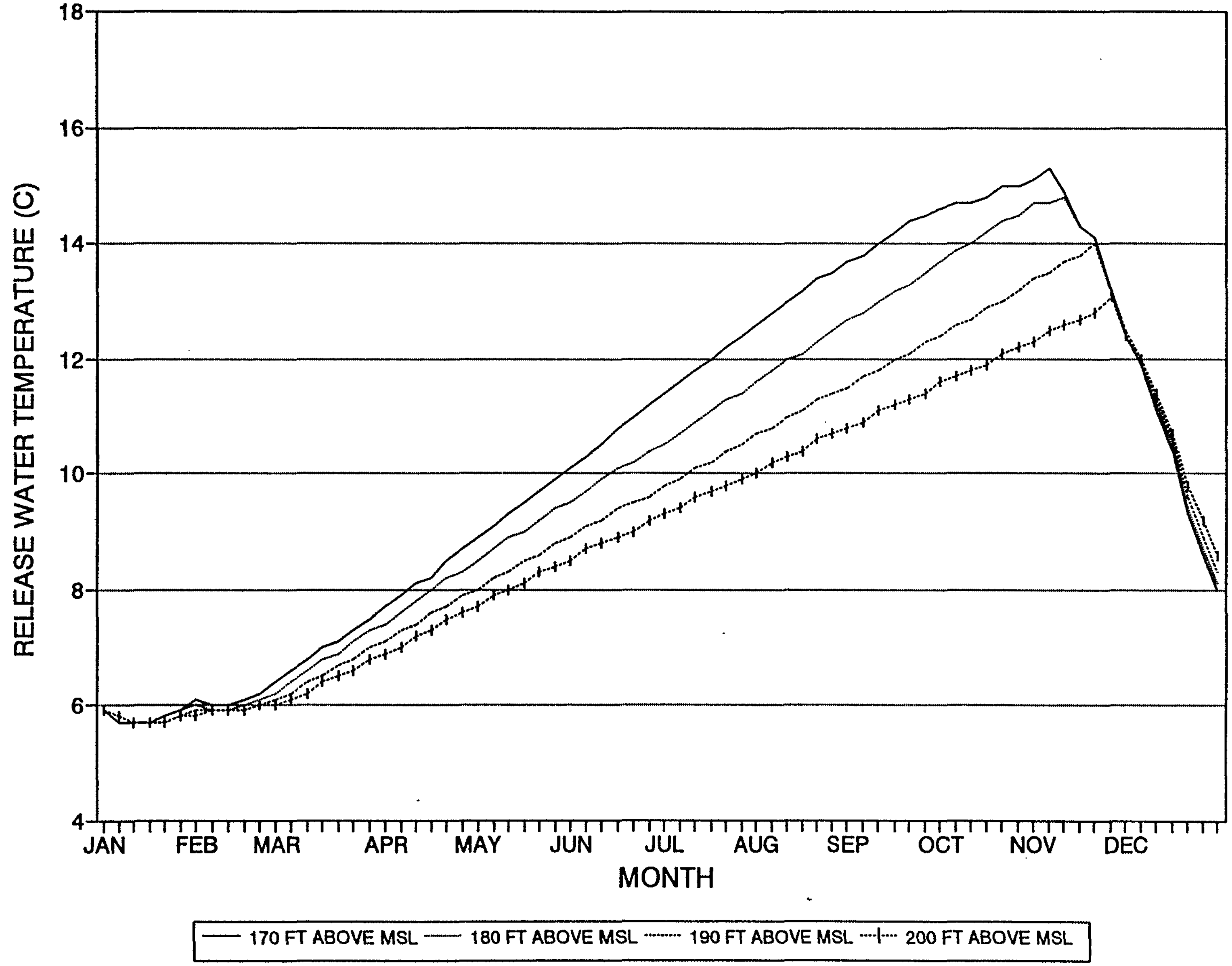

Figure B-1. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using release rate of 100 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

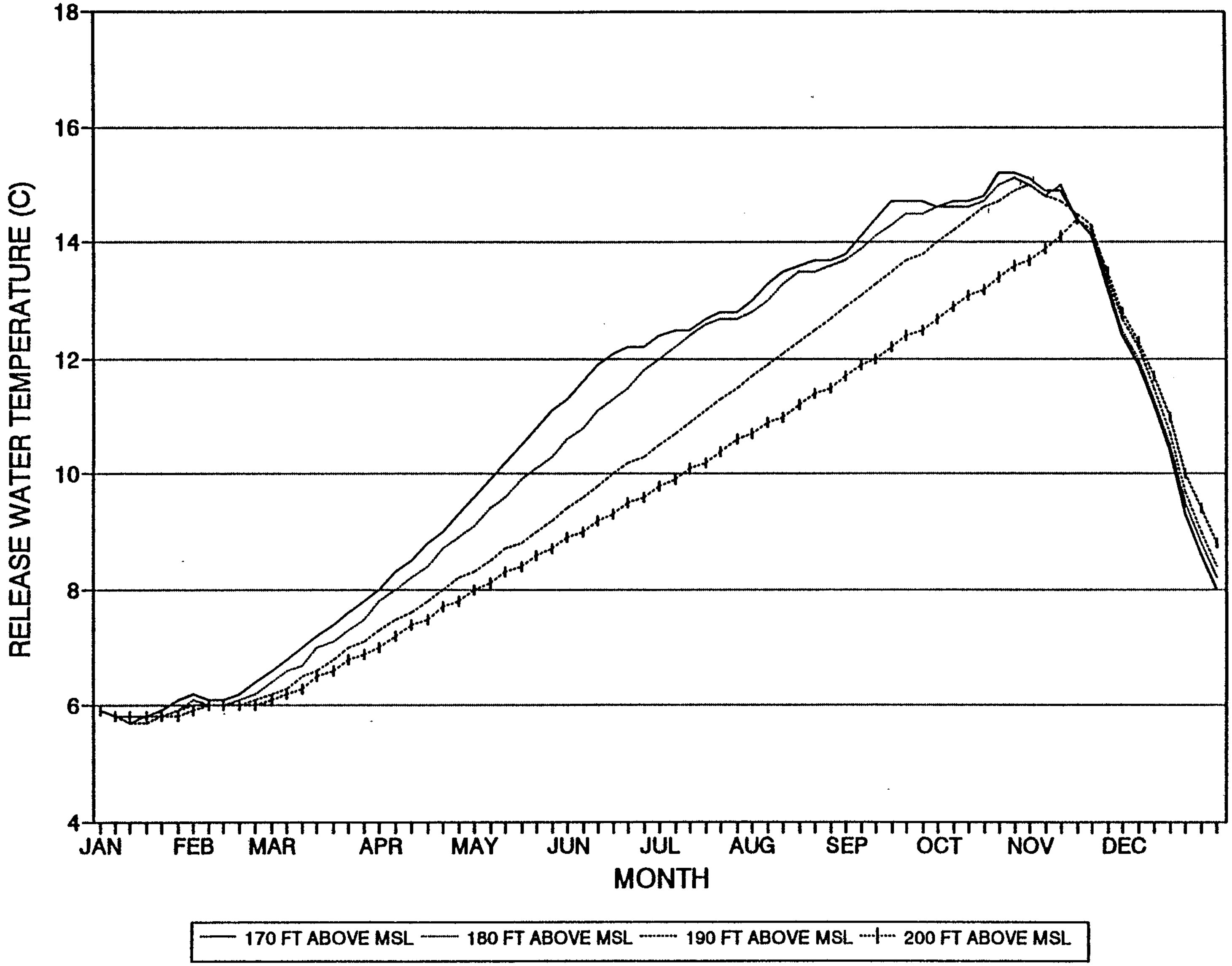

Figure B-2. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using release rate of 200 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

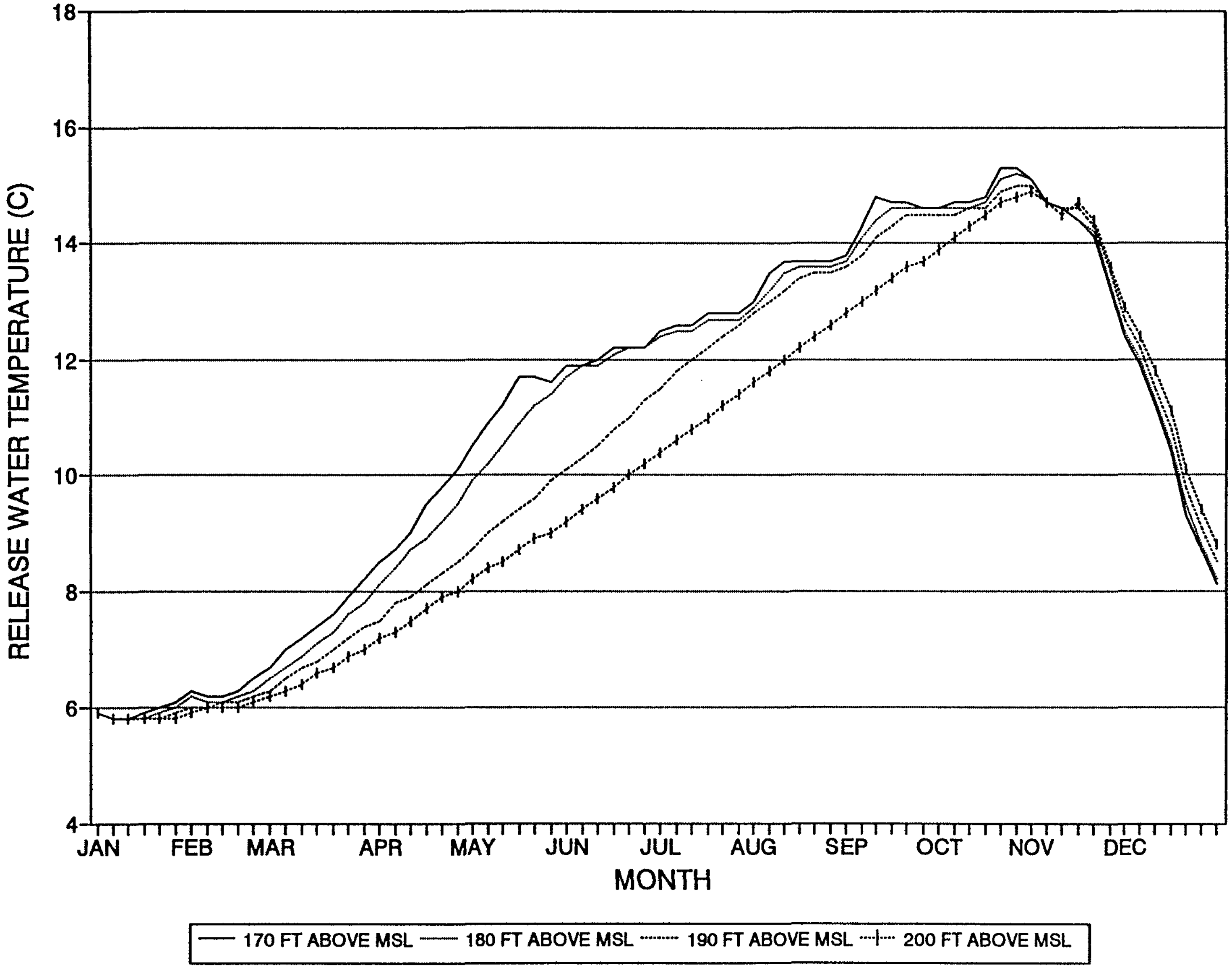

Figure B-3. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using release rate of 300 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

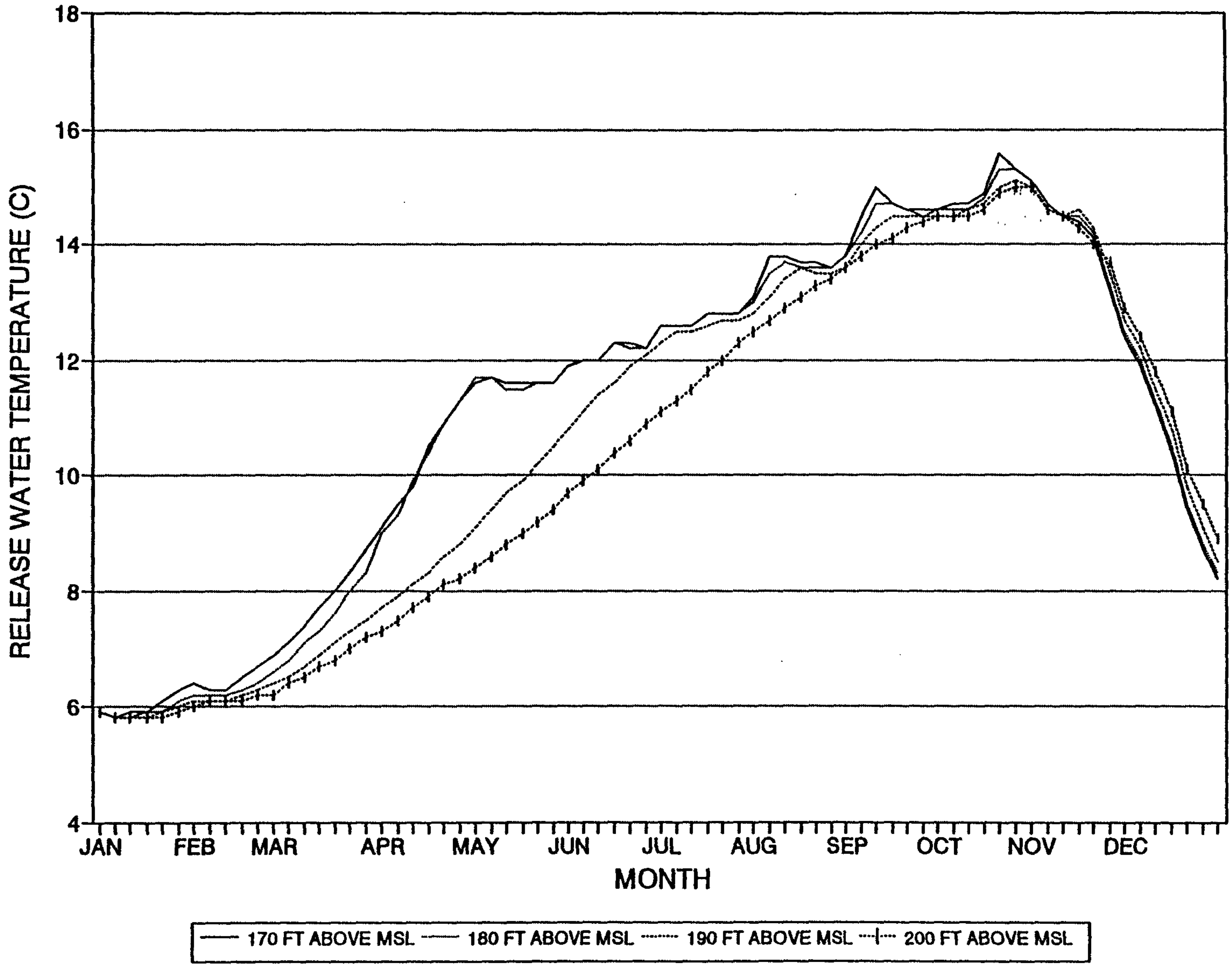

Figure B-4. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using release rate of 400 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

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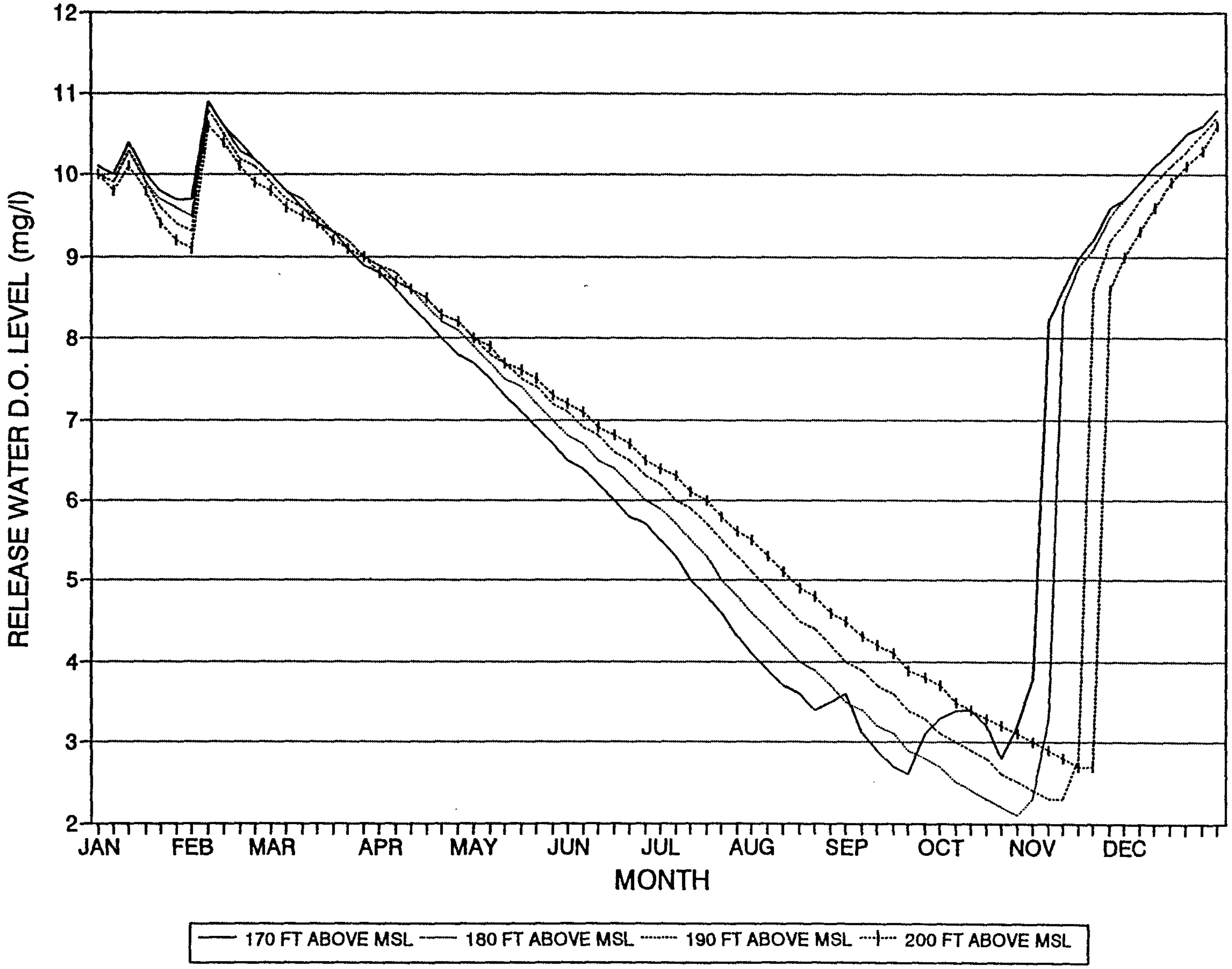

Figure B-5. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using release rate of 100 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

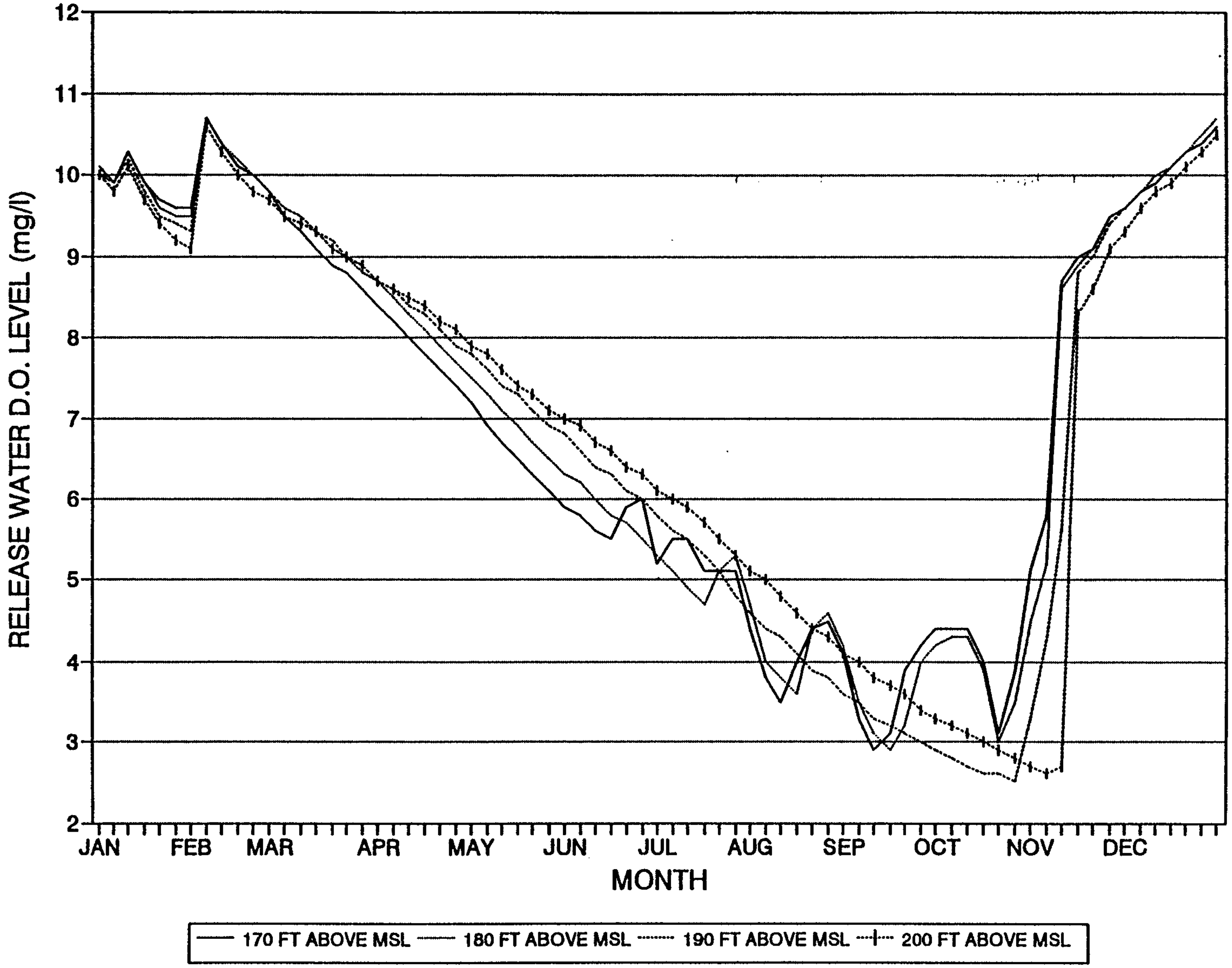

Figure B-6. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using release rate of 200 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

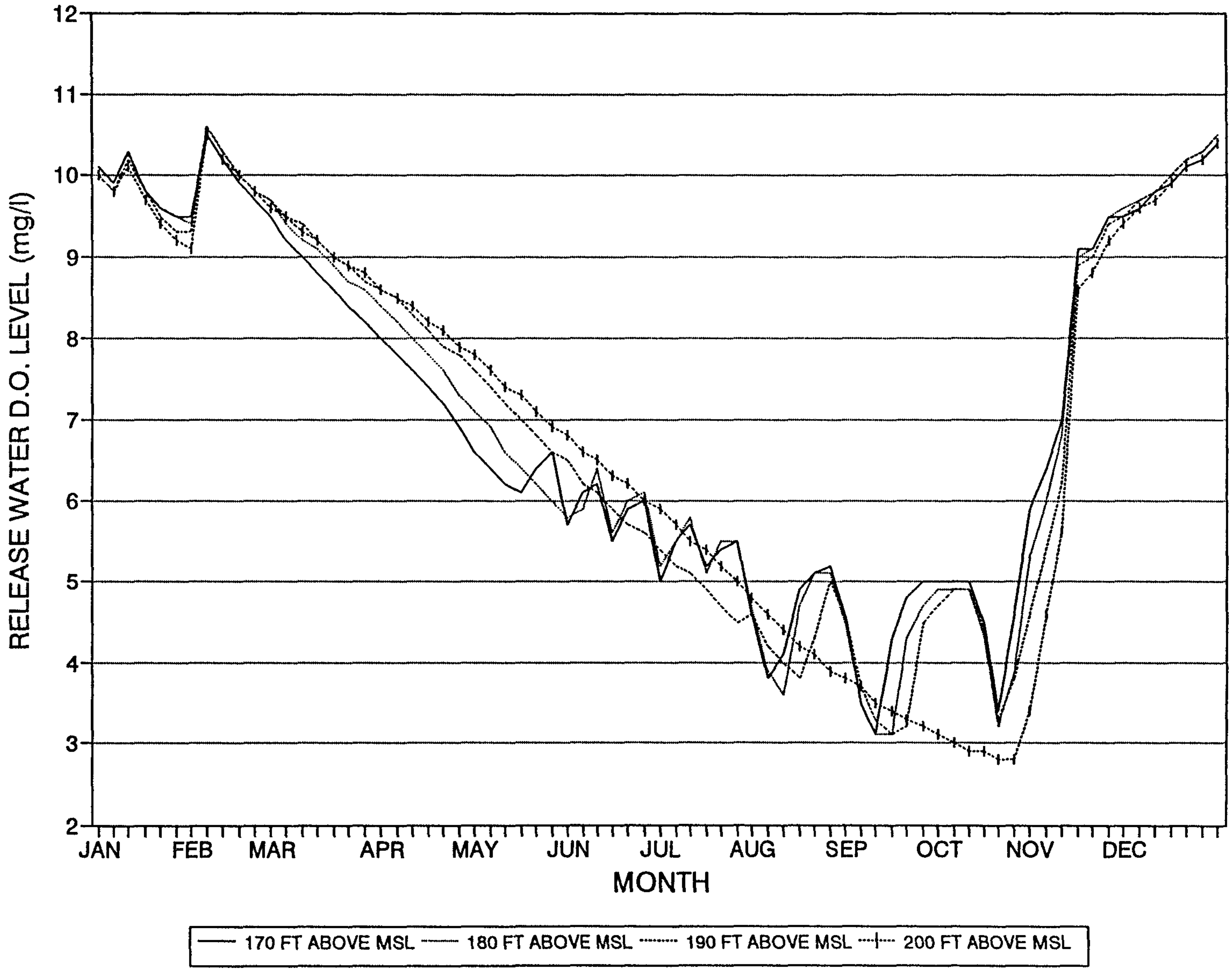

Figure B-7. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using release rate of 300 cfs for water surface elevations 52m, 55 m, 58 m, and 61 m above msl.

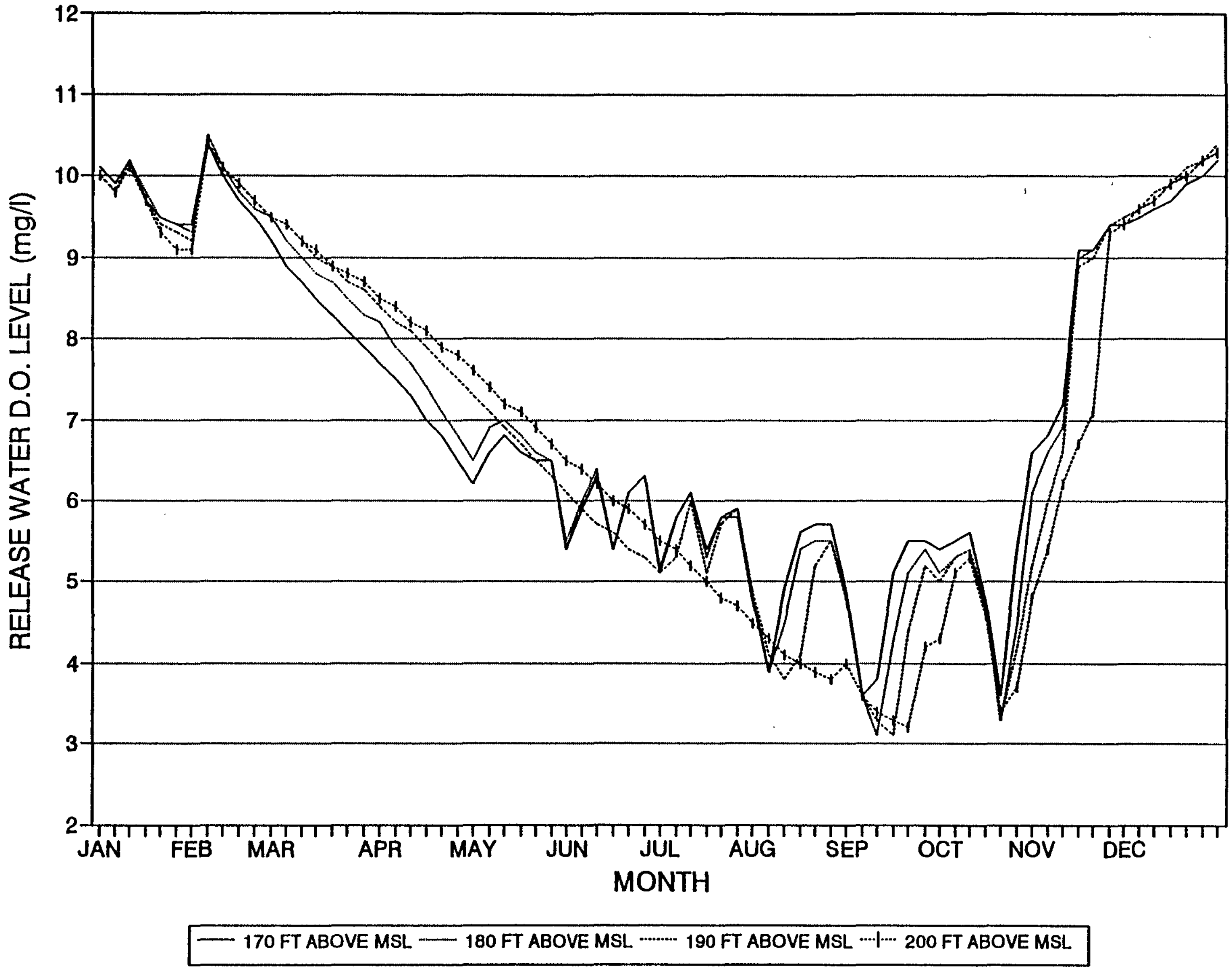

Figure B-8. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using release rate of 400 cfs for water surface elevations 52 m, 55 m, 58 m, and 61 m above msl.

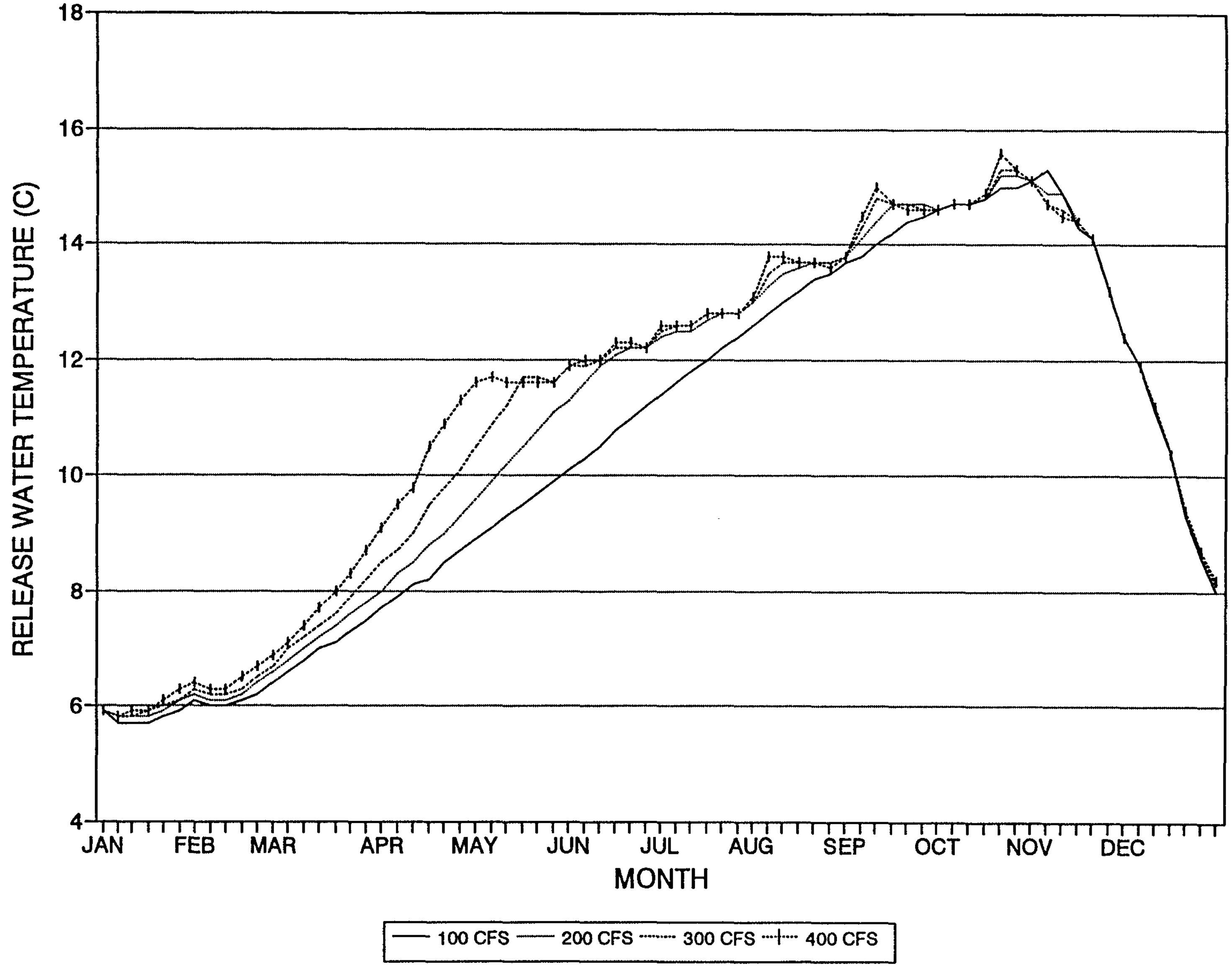

Figure B-9. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using water surface elevation of 52 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

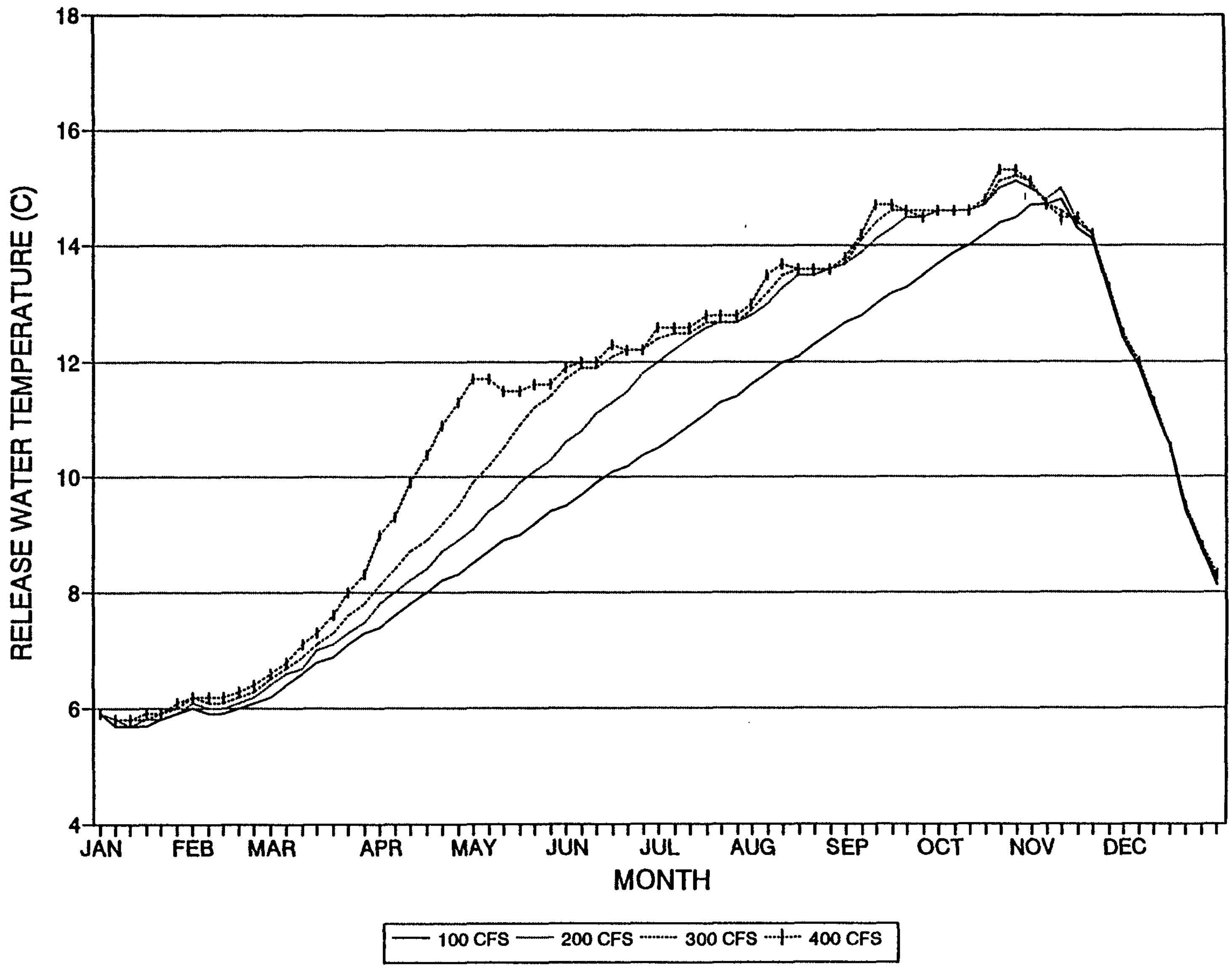

Figure B-10. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using water surface elevation of 55 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

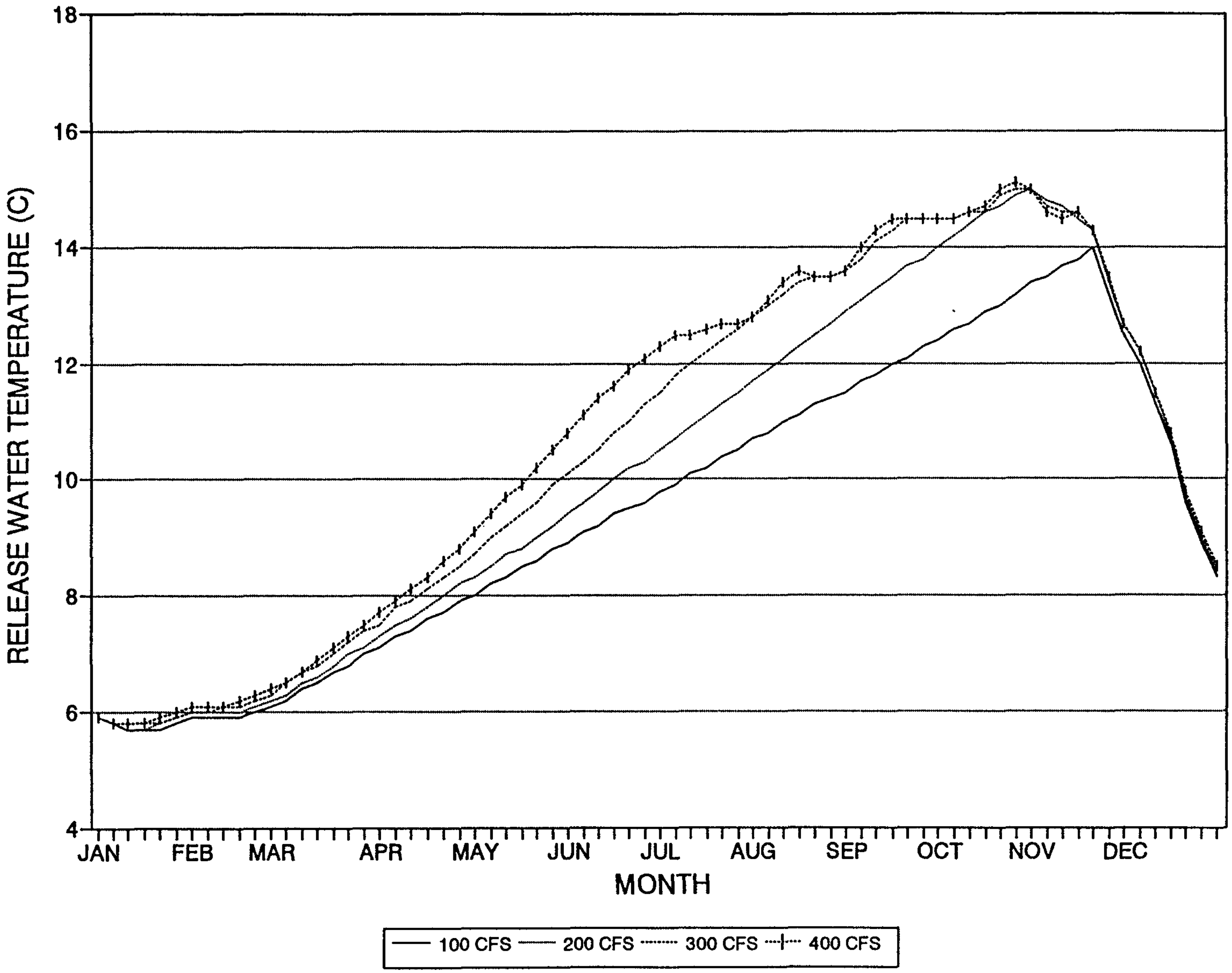

Figure B-11. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using water surface elevation of 58 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

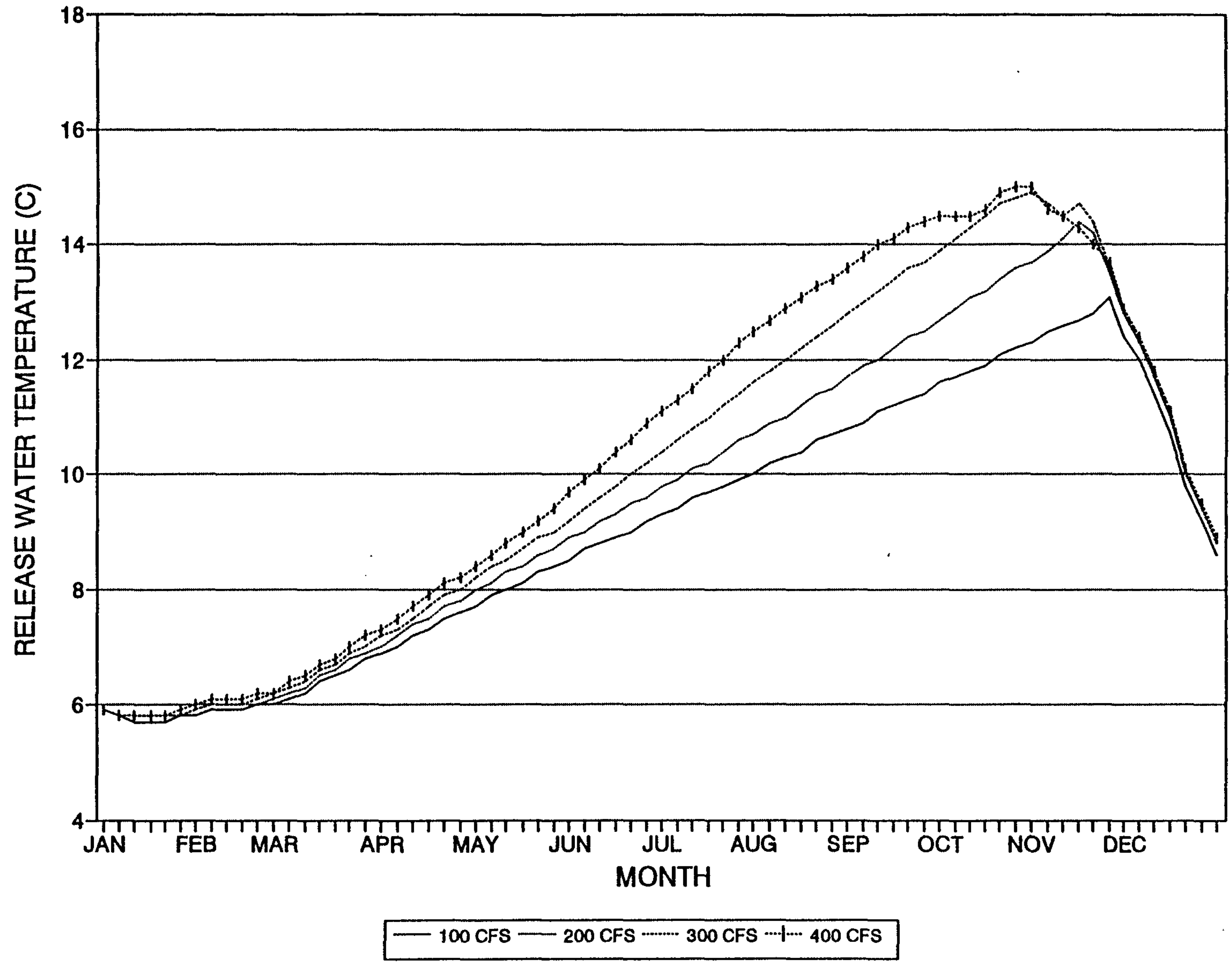

Figure B-12. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water temperature for simulation runs using water surface elevation of 61 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

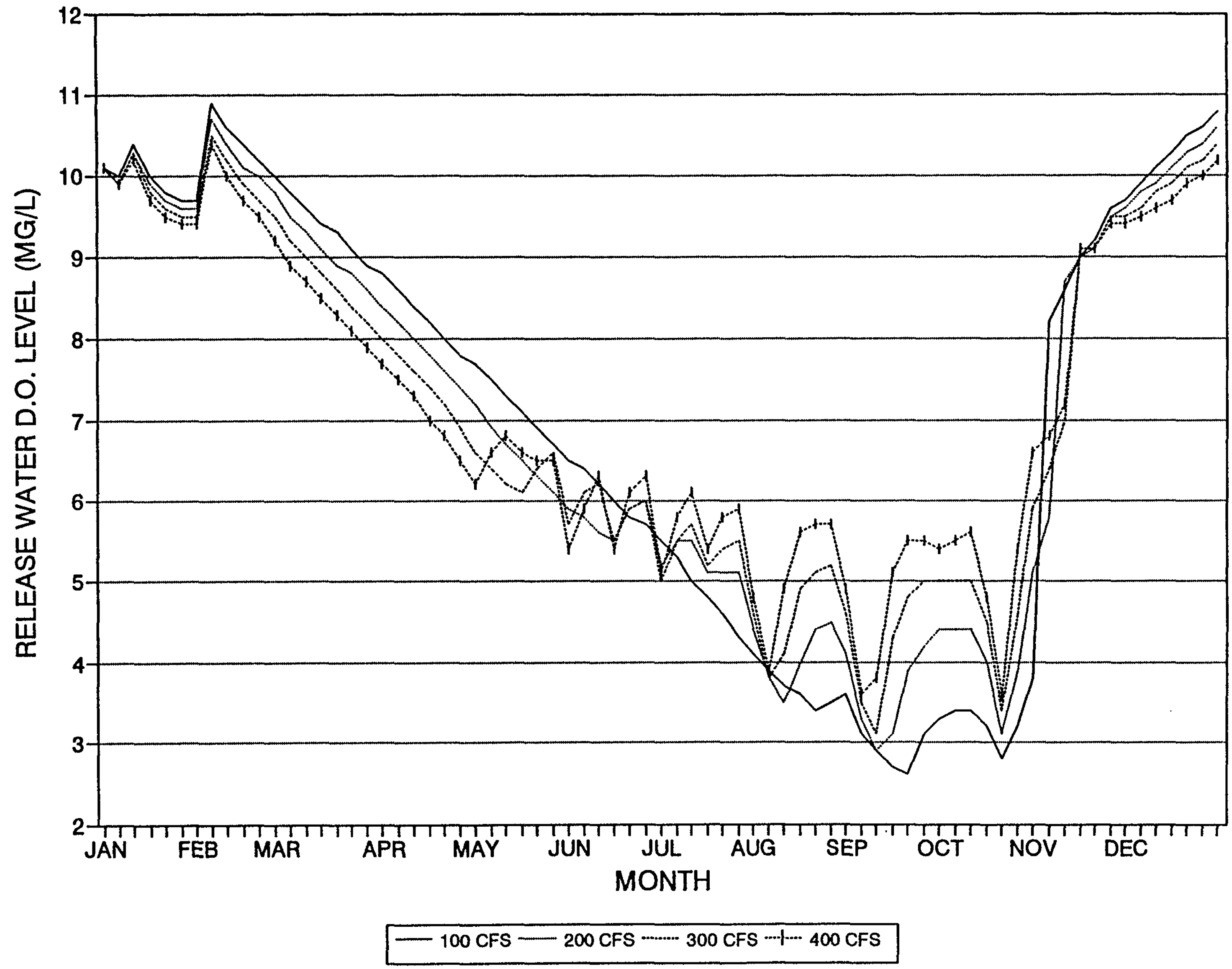

Figure B-13. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using water surface elevation of 52 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

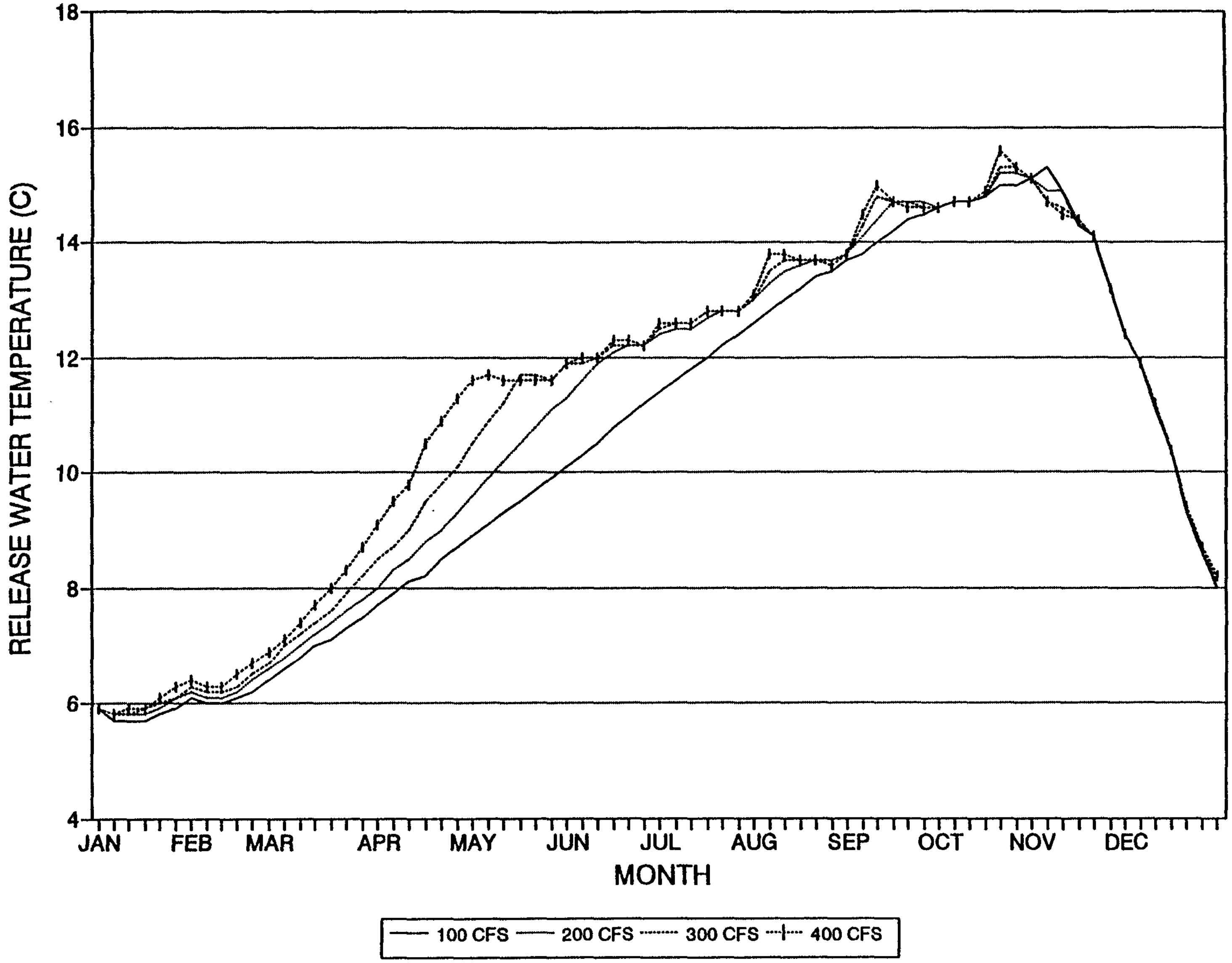

Figure B-14. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using water surface elevation of 55 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

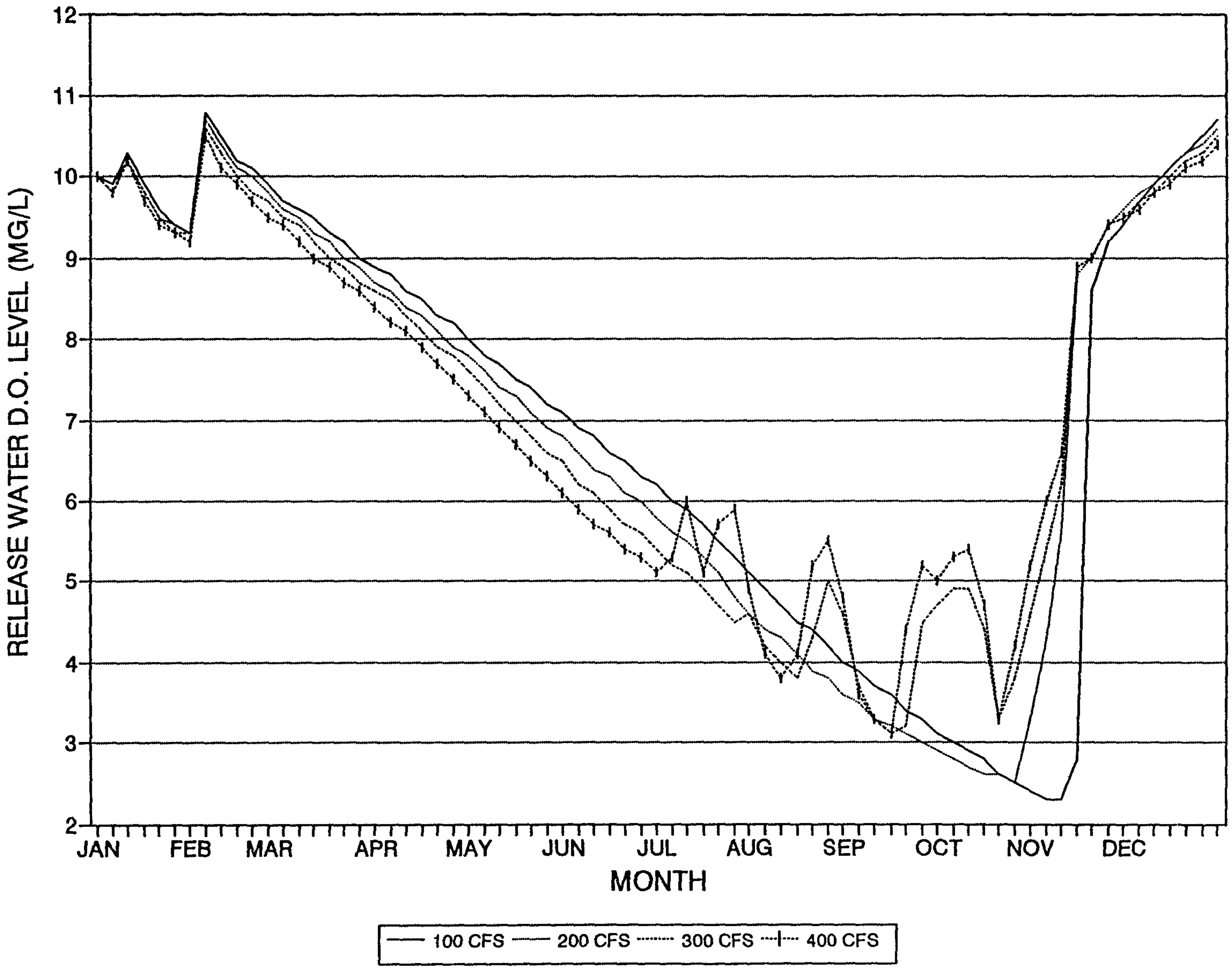

Figure B-15. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using water surface elevation of 58 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

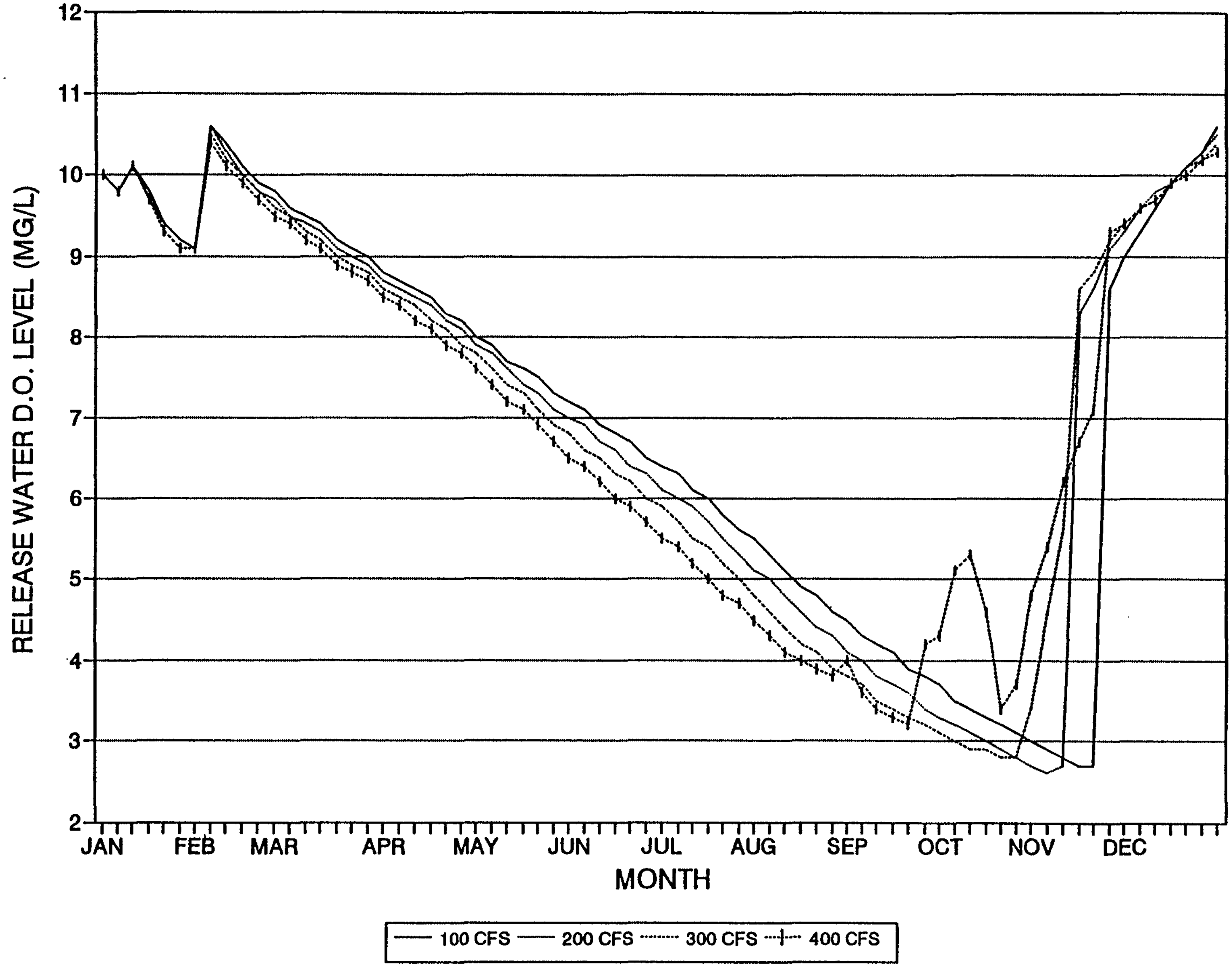

Figure B-16. Output summary of WQRRS sensitivity analysis runs for Camanche Reservoir. Graph of release water dissolved oxygen level for simulation runs using water surface elevation of 61 m above msl and in/out flow rate of 100, 200, 300 and 400 cfs.

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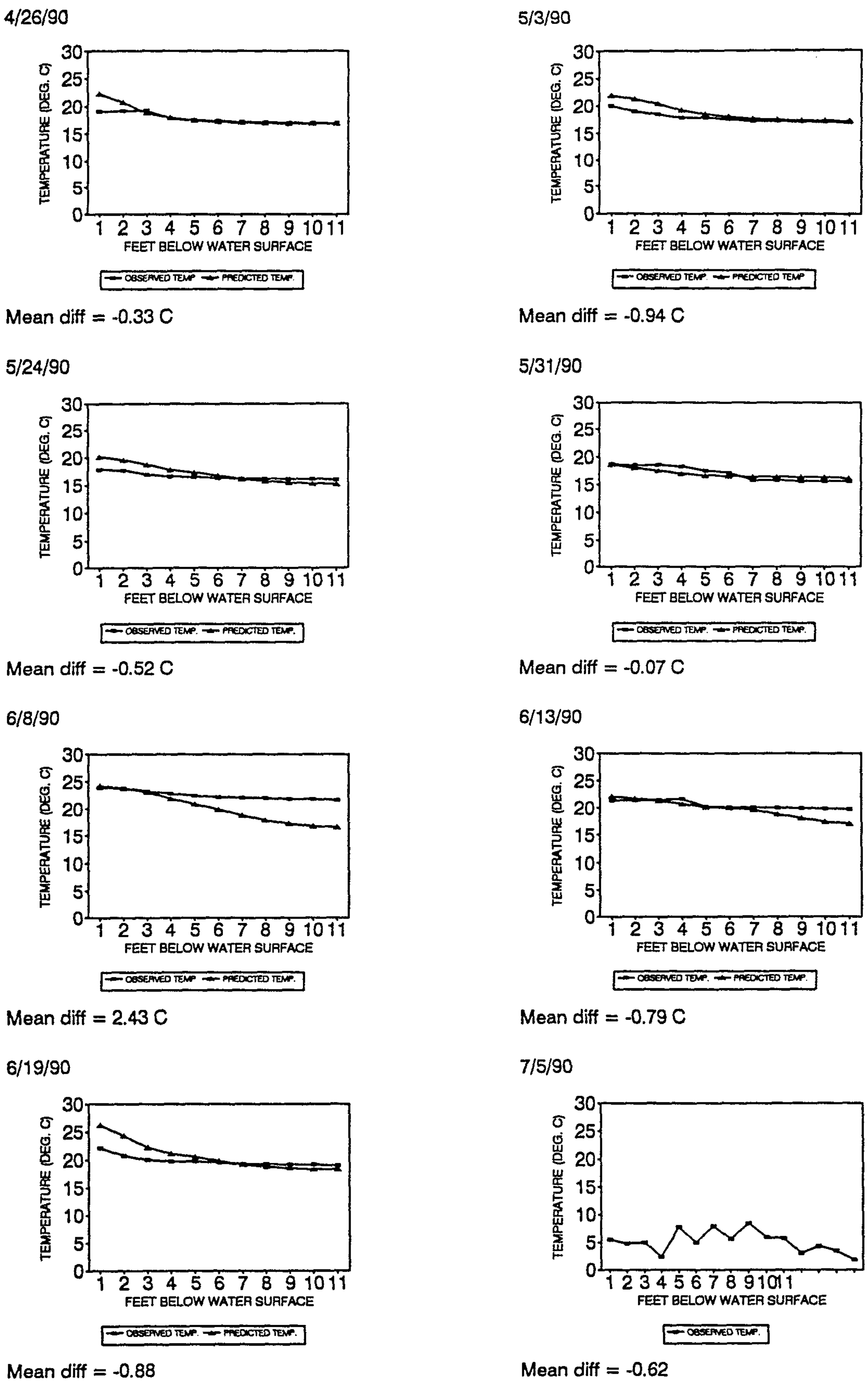
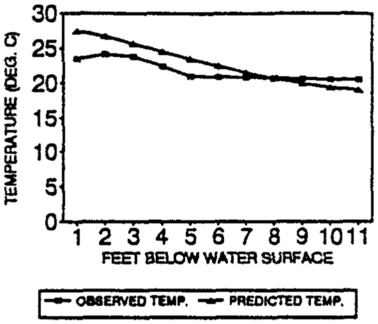


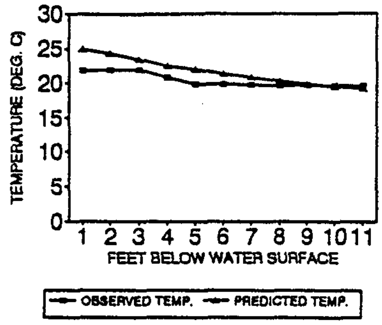
Figure B-17. WQRRS calibration results for Lake Lodi module. Comparison between predicted and observed data (observed data are from in front of Woodbridge Dam).

7/19/90



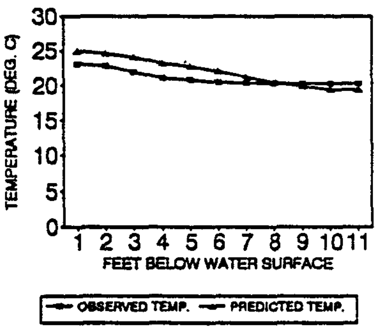
Mean diff = -1.07 C

7/26/90



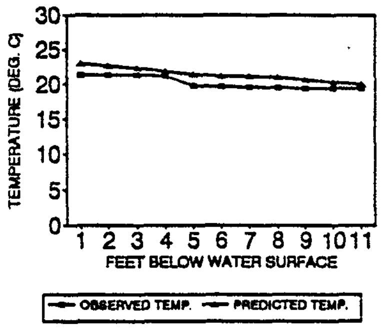
Mean diff = -1.25 C

8/2/90



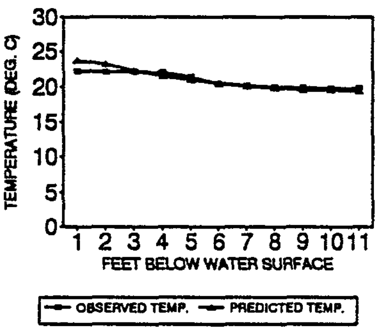
Mean diff = -0.92 C

8/16/90

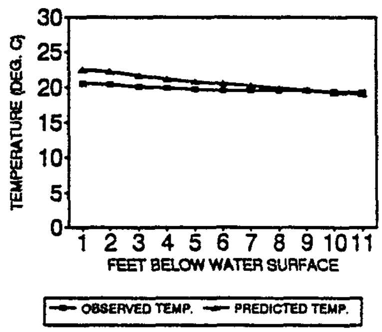


Mean diff = -1.24 C

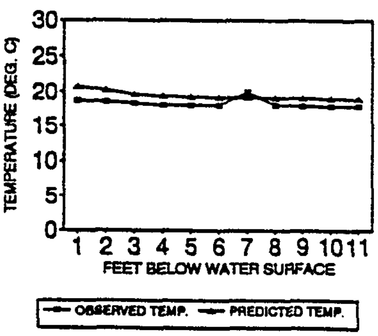
8/30/90



9/19/90



10/11/90



Mean diff = -1.12 C

MEAN DIFFERENCE FOR
ALL TEMPERATURE PROFILE = -0.43 C

MAXIMUM DIFFERENCE IN
TEMPERATURE PROFLIE = 2.43 C

Figure B-17. WQRRS calibration results for Lake Lodi module (cont.).

C —1 0 1 2 4 4