Appendix D

Lower American River Water Temperature Assessment

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Appendix D provides information on the evaluation of lower American River water temperatures. It includes a description of the lower American River temperature model, an assessment of temperature effects at Folsom Reservoir and Lake Natoma, and a comparison of the risk of warming approach used by EBMUD to the U.S. Bureau of Reclamation (Reclamation) temperature model for the lower American River. Supporting tables and graphics are included at the end of this appendix.

INTRODUCTION

The temperature assessment methodology estimates the monthly risk of temperature increases (i.e., warming risk assessment) in the lower American River of greater than 1° Fahrenheit (F) caused by simulated hydrology changes (Folsom Reservoir storage and American River flows) for each project alternative.

Temperature changes are assumed to be the result of Nimbus release temperature changes (caused by changes in Folsom Reservoir storage and associated changes in warming in Lake Natoma) and temperature changes in the American River (caused by Nimbus release flow changes). The effect of storage on Nimbus release temperatures was estimated based on regressions developed using the historical storage and temperature data. Temperature changes resulting from flow changes in the lower American River were estimated using a daily river temperature model. The location of 1-mile model segments along the river are shown in Figure 1.

The storage regressions and the daily temperature model were used to generate monthly warming coefficients resulting from Folsom Reservoir storage changes (Table 1) and American River flow changes (Table 2). The PROSIM hydrologic simulations of end-of-month Folsom Reservoir storage and average monthly American River flows were then evaluated using these monthly warming coefficients to determine the risk of warming (i.e., temperature change of greater than 1°F) for each alternative (Table 3).

The possible effects of the modified temperature control panels and a proposed temperature control device (discussed later in this appendix) for the raw water intake are not specifically included in the EBMUD temperature assessment. The seasonal operation procedures for these outlets has not yet been established.

Changes to Folsom Reservoir release elevations may allow increased flexibility in the timing of coldwater releases. However, changes in release temperatures resulting from such modifications will probably be less than 5°F for any particular month and, because there is a limited supply of cold water, seasonal temperature patterns in the future are expected to be similar to historic patterns (Figure 2). Consequently, temperature increases resulting from storage and flow reductions are likely to remain a concern for particular life stages of fish during particular months even if Folsom Reservoir temperature management operations are altered.

FOLSOM RESERVOIR AND LAKE NATOMA TEMPERATURE EVALUATION

Temperature effects in the upper part of the lower American River (from Folsom Dam to Nimbus Dam) were analyzed by comparing the end-of-month values for Folsom Reservoir storage, flow below Nimbus Dam, and Nimbus Fish Hatchery water temperatures from 1959 to 1995 (Figures 3 through 17). These graphs indicate that hatchery temperatures tend to be lower when both flow and Folsom Reservoir storage are higher. Conversely, high hatchery temperatures are associated with low flow and low storage. The hatchery data and the Folsom Reservoir storage values were used to develop monthly regression relationships between storage and Nimbus hatchery inflow temperatures (Table 1). Because the hatchery temperatures are similar to the Nimbus Dam release temperatures, these regression equations can be used to evaluate the effect of changes in Folsom Reservoir storage on Nimbus Dam release temperatures.

Nimbus flows tend to be higher when Folsom Reservoir storage is high, making it difficult to separate the effects of flow and storage on measured hatchery temperatures. As a result, the regression equations based on Folsom Reservoir storage include the effects of both reduced storage and reduced flows. Because both historical and simulated release flows tend to be reduced when storage declines, the historical regression equations can be used with simulated storage values to provide a good estimate of the overall effects (e.g., both storage level and flow effects) of Folsom Reservoir storage reductions caused by the project.

Table 1 shows the range of Nimbus temperatures predicted by the regression equations. For example, in July, water temperature at Nimbus is estimated to be 69°F when Folsom Reservoir storage is low (200,000 AF) and 60°F when storage is high (1,000,000 AF). The slopes of the equations are steeper during July–October, indicating that a reduction in storage during these months is expected to correspond to a larger increase in water temperatures at Nimbus.

The regression equations were used to estimate the change in Nimbus release temperature that would result from the changes in Folsom Reservoir storage simulated by PROSIM. For example, PROSIM results for July 1979 indicate a 17,000-AF storage reduction under Alternative 2 compared to Alternative 1. For July, the regression slope is -0.01087°F per thousand acre-foot. Consequently, a 0.18°F temperature increase is expected at Nimbus for this month.

LOWER AMERICAN RIVER TEMPERATURE MODEL

Model Description

To evaluate the effect of changes in flow below Nimbus Dam on water temperatures, a daily water temperature model for the lower American River was developed by Jones & Stokes Associates. Because day-to-day variations in temperature may affect fish, the daily model provides a more detailed evaluation of potential temperature effects than a monthly model. This model uses measured Nimbus Dam release temperatures (from the Nimbus Hatchery) and measured meteorologic data for a 10-year period (1986–1995), which allows an evaluation of potential temperature response under a wide range of release temperatures and meteorological conditions.

The Lower American River Temperature Model is a spreadsheet model that uses standard heat transfer equations. The model allows daily tracking of water temperatures in twenty-three 1-mile segments of the lower American River (Figure 1). Temperature in each segment is a function of the temperature in the upstream segment, depth, travel time through the segment (which is dependent on channel geometry as well as flow), and meteorological conditions. The model was derived from an hourly stream temperature model that has been used by Jones & Stokes Associates to simulate temperatures in Putah Creek and the Owens, Merced, and Guadalupe rivers (Jones & Stokes Associates 1995).

Meteorological data and water temperature data are required for model input and performance evaluation (or calibration). The

Nimbus Hatchery data were used to estimate the temperature of water released from Nimbus Dam to the upstream segment. Downstream measured temperature data were used to evaluate the ability of the model to simulate historical conditions. Meteorological data (air and dew point temperatures, solar radiation, and wind speed) were obtained from the California Irrigation Management Information System (CIMIS) station at Nicolaus and were used as model input for the daily average heat transfer equations.

Channel geometry characteristics vary with flow and are estimated with hydraulic geometry equations in the model. Initial estimates for width and depth coefficients were based on summary of discharge measurement data collected by the U.S. Geological Survey (USGS) at the Fair Oaks gage. The width equations generated a total lower American River surface area of 790 acres at 500 cubic feet per second (cfs) and 860 acres at 1,000 cfs. These width estimates are similar to estimates from the California Department of Fish and Game of 754 acres at 500 cfs and 833 acres at 1,000 cfs (California Department of Fish and Game and Beak Consultants 1992) and from the Reclamation temperature model of 721 acres at 500 cfs and 764 acres at 1,000 cfs (U.S. Bureau of Reclamation 1990).

The USGS discharge measurements are not made in channel areas with pools. Consequently, the original depth equation did not include the additional depth that pools and backwater from the Sacramento River adds to the river channel. A thalweg profile (showing maximum channel depths) for the length of the lower part of the river (Ayres Associates 1997) was used to estimate pool and backwater depth values that were added as constants to the initial depth equation estimate. Although depth has a large effect on diurnal temperature fluctuations, the effect of depth on average temperatures is not as important. The volume of each model segment is the area times the depth, and the travel time is the volume divided by the flow.

Model Performance

The performance of a model indicates how well the model can predict future conditions. Model performance is generally evaluated by comparing simulated values under historical conditions to measured values. No model is able to completely match measured data. Generally good model performance can improve the confidence in the model predictions. However, even models that are unable to match measured temperatures may still be used as planning tools for comparisons between alternatives and estimation of impacts. Fortunately, the American River temperature model matches measured temperatures well and can be used for estimating small changes in temperature.

The temperature model was used to simulate American River water temperatures for 1986 through 1995 using historical daily flow, meteorological conditions, and measured hatchery temperatures (Nimbus Dam release temperatures). These simulations were used to evaluate the ability of the model to match measured temperatures.

For 1986–1989, the only measured water temperatures available for evaluating model performance (i.e., the only temperatures measured downstream of Nimbus) were from the Fairbairn Water Treatment Plant (WTP). Although the simulated temperatures generally matched the measured temperatures in the treatment plant, the simulated temperatures tend to be cooler (Table 4). However, other temperature measurements taken near the Fairbairn WTP (Figures 18 and 19) indicate that the treatment plant temperatures are sometimes higher than temperatures measured in the river.

Comparisons of simulated temperatures with the temperatures measured at multiple other locations along the river from 1990 to 1994 indicate that the temperature model closely matches temperatures along the length of the river (Figures 20 through 24). Comparison of the daily water temperatures measured by Beak Consultants, California Department of Fish and Game (DFG), and EBMUD to the simulated daily temperatures indicate that, on average, the simulated temperatures deviate from the measured temperatures by approximately 1°F (Tables 5 through 9).

Simulated Temperature Response to Changes in Flow

The daily water temperature model of the lower American River (from Nimbus Dam to the confluence with the Sacramento River) was used to evaluate maximum potential water temperature impacts based on expected flow changes. The model was used to simulate a 10-year period of water temperatures (1986–1995) with Hodge flows and with Hodge flows plus 500 cfs (Tables 2 and 10–12, Figures 25–44) using the historical daily Nimbus release temperatures and meteorology. Using the historical daily Nimbus temperatures and daily meteorology allows the fluctuations associated with these factors to be incorporated in the warming risk assessment.

The temperature model results were used to estimate the maximum daily change in temperature at Goethe Park, Fairbairn WTP, and the river mouth for each month that was caused by the simulated 500 cfs flow change (Table 2). These maximum daily temperature changes for each month were used as interpolation coefficients to estimate the change in temperature resulting from the monthly flow changes simulated by PROSIM. However, under high flow conditions, temperatures are generally suitable for fisheries and the temperature response to a change in flow is reduced. Consequently, if Alternative 1 flows were greater than 500 cfs, reductions in flow were assumed to have negligible effects on temperatures. Generally, the maximum daily change in temperature (produced by the 500-cfs flow change) occurs on many days during each month. The maximum daily change is often 50% greater than the average temperature change for each month.

Flows established by the Hodge Decision (1990) were chosen as the lower flow level for the simulations because EBMUD is not permitted to take delivery of water at Folsom South Canal when diversions would reduce Nimbus releases to below the Hodge flows. Therefore, temperatures under Hodge flows represent the highest temperatures that would occur when EBMUD is taking delivery of water under Alternative 2. In addition, a flow change of 500 cfs is approximately the flow change needed to cause a 1°F temperature change in summer (see Table 2), thereby making the interpolations accurate for the 1°F or more temperature increases being evaluated.

Simulations show that flow reductions have minimal effects on temperatures at the upstream end of Goethe Park (the approximate lower end of the spawning habitat for chinook salmon and steelhead) (Table 10). There is a larger temperature response to reduced flow farther downstream at the Fairbairn WTP and at the river mouth (Tables 11 and 12). The largest temperature response to change in flow occurs in summer. For example, the average change in temperature due to the simulated differences in flow during July is 0.5°F at the upstream end of Goethe Park, 1.0°F at Fairbairn WTP, and 1.2°F at the river mouth. The monthly average temperatures and the average change in temperatures vary from year to year. In August, when release temperatures are highest, for instance, Hodge flow temperatures near the Fairbairn WTP vary from 67°F to 74°F (Table 11).

July of 1979 can be used in an example of how the daily temperature model results were used to estimate the potential warming in the lower American River. PROSIM results for July 1979 flow would be 3,400 cfs under Alternative 1 and 3,088 cfs under Alternative 2, a reduction of 312 cfs. The 1986–1995 daily temperature model simulations for July predict that the maximum daily temperature increases attributable to the 500-cfs flow reduction from 2,250 cfs to 1,750 cfs (July Hodge flow) are 0.7°F at Goethe Park, 1.3°F at Fairbairn WTP, and 1.8°F at the mouth of the American River. Using these simulated maximum temperature differences for a 500-cfs change leads to estimates of warming by 0.44°F at Goethe Park, 0.81°F at Fairbairn WTP, and 1.12°F at the mouth of the American River, respectively, for the July 1979 312-cfs reduction. When the 0.18°F warming estimated at Nimbus because of the Folsom Reservoir storage change is added to this river warming, the potential warming estimates increase to 0.62°F at Goethe Park, 0.99°F at Fairbairn WTP, and 1.30°F at the mouth of the American River.

Effect of Temperature Changes on Fisheries

The fish species included in this evaluation were fall-run chinook salmon, steelhead, American shad, and splittail. Temperature criteria for these fish are presented in Table 13. Because the potential occurrence of winter-run chinook juveniles in the lower American River (December–April) overlaps with the principal rearing and emigration periods for fall-run chinook salmon in the lower American River (January–June), the results of the water temperature assessment for fall-run chinook salmon rearing and emigration life stages can be used to evaluate potential impacts on winter-run chinook salmon.

The first step in evaluating potential temperature impacts on fish is to determine if temperatures are likely to exceed the temperature criteria defined for each evaluation species and life stage within the primary reaches and months in which those species and life stages occur. Table 5-6 compares the temperature threshold for each fish life stage to the simulated temperatures expected under Hodge Decision flows (i.e., the highest temperatures permitted when EBMUD is making water deliveries through the FSC).

Those reaches and months in which the highest monthly average temperature exceeded the temperature criteria for one or more of the evaluation species and life stages were identified as having the potential for temperature impacts.

For each reach and month in which the potential for temperature impacts existed, an incremental warming of 1°F was used to evaluate temperature impacts because a change of less than this magnitude cannot be differentiated from other sources of natural variability. When an increase of 1°F or greater was estimated to occur 10% or more of the time at one of the three reaches (Goethe Park, Fairbairn WTP, or the mouth of the American River), an alternative was considered to have significant impacts on the species and life stage of concern. Because temperature increases are larger farther downstream, the farthest downstream location for each life stage was used for the impact evaluation.

Warming Risk Assessment Results

For the purposes of impact analysis, the cumulative scenarios were compared with existing conditions in order to include the effect of operational differences between existing conditions and Alternative 1 as part of the cumulative effect. Results from the impact analysis are shown in Table 3, and results of comparisons between the cumulative scenarios and Alternative 1 conditions are shown in Table 14. Flow goals established by the anadromous fish restoration program (AFRP) and 2030 demands are used in Alternative 1. Although river flows are higher under existing conditions than under Alternative 1, temperatures at Nimbus are relatively warm because summer storage in Folsom Reservoir is lower. The warmer temperatures are compensated for by relatively cooler temperatures downstream, which are attributable to increased flows. In general, the temperatures under existing conditions are cooler than Alternative 1 temperatures. As a result, the differences between the cumulative scenarios and Alternative 1 are not as large as the differences between the cumulative scenarios and existing conditions.

Comparison of Warming Risk Assessment with Reclamation Temperature Model Results

The Reclamation monthly temperature model includes Folsom Reservoir, Lake Natoma, and the lower American River. The Folsom Reservoir model includes the effects of monthly inflows and inflow temperatures, monthly average meteorology, reservoir releases, and changes in storage. The release temperature is a function of the outlet elevations. The Folsom Reservoir temperature model assumes that several outlet elevations are available for blending flows to match desired target release temperatures.

The warming in Lake Natoma is assumed to increase as travel time increases, with the warming proportional to the difference between the Folsom Reservoir release temperature and the monthly equilibrium temperature (similar to monthly air temperature).

Review of the Folsom Reservoir temperature model results indicates that the effect of storage is relatively small in summer because the assumed target release temperatures can generally be satisfied. Warming in Lake Natoma is dependent on Folsom Reservoir release flows, which tend to be low when storage is low. Figures 45 through 50 show the results of the simulated Folsom Reservoir and Nimbus release temperatures for each month under Alternative 1. When plotted as a function of Folsom Reservoir storage, the monthly release temperatures (especially during spring and summer) do not vary because they are controlled by the specified monthly target temperatures. When plotted as a function of Folsom Reservoir release flows, the largest, warmest Nimbus release temperatures are associated with the lowest flows. Because the lowest release flows are associated with the lowest storage values, the Nimbus release temperatures are warmest for the lowest Folsom Reservoir storage.

This pattern is similar to the historical regressions (Figures 6 through 17) although, as the regression lines indicate, the simulated Nimbus release temperatures are often warmer than the historical temperatures. These differences may be caused by the relatively high summer target temperatures in the Reclamation model and other differences between the simulated conditions under Alternative 1 and historical conditions.

Figure 51 compares historical end-of-month Nimbus temperatures to those estimated for the existing conditions scenario using the EBMUD regressions and the Reclamation model. The Reclamation model simulates monthly average release temperatures. The average regression estimates for each month match the average historical data. Because storage effects and their associated flow effects do not account for all the variability in measured Nimbus temperatures, the range of monthly regression estimates is less than the range of historical data, especially during winter. The Reclamation estimates tend to be similar to or warmer than the historical data, with a range that is slightly less than the historical data range for each month.

For purposes of comparison, Figures 52 through 54 show temperature changes for the Alternative 2 cumulative scenario compared to existing conditions that were estimated using the Reclamation model and the EBMUD regression approach. In some of these graphs (e.g., July, August, and September) the existing conditions temperatures estimated by the Reclamation model are higher than those estimated using the historical regressions because the specified Reclamation target release temperatures are higher than the release temperatures obtained historically for those months. The results of these comparisons show that the temperature effects estimated with the two approaches varies with the month. In general, the Reclamation model simulates greater temperature changes than those estimated using the regressions.

To understand the estimated temperature changes, the monthly simulated changes in Folsom Reservoir storage and release flows were examined (Figures 55 through 57). Some of the largest temperature increases estimated by the Reclamation model (especially those seen in May and June) are caused by simulated large reductions in flow through Lake Natoma. However, these simulated flow reductions may not actually occur because operation of Folsom Reservoir is not governed by storage-flow thresholds in the same way that the PROSIM model results are. For example, if the Folsom Reservoir carryover storage drops below 310,000 AF, the release flow in October is reduced from 1,750 cfs to 800 cfs. Actual operations may yield a more gradual reduction of flow with lower storage, more similar to the historical relationships (Figures 6 through 17) that are incorporated in the storage regressions.

Another factor contributing to the differences in estimated temperature changes is that the Reclamation model includes the San Juan release flow in the procedure for calculating the Folsom Reservoir release temperatures. When the cold San Juan releases are higher (San Juan diversions are 50% higher for the Alternative 2 cumulative condition than for existing conditions), the model assumes that water going through the Folsom Reservoir power plant must be warmer to attain the same specified target temperature. As a result, the water being released into the river will be simulated as being warmer when the San Juan releases are higher, unless the model target temperatures are adjusted accordingly.

The comparison of the Alternative 2 cumulative scenario to existing conditions indicates the differences between the regressions and the temperature model, especially for September (Figure 5-4). Historically higher storage values have been associated with higher releases. However, the comparisons of the PROSIM flow and storage values show that a simulated reduction in storage does not necessarily cause a simulated reduction in flow. In September, for example, there is a tendency to have increased storage, but decreased flow (Figure 57). Part of the reason for this difference is that all the alternatives assume the AFRP storage-release flow relationship and the existing conditions scenario uses fixed monthly flow requirements.

Because the regressions are based primarily on storage changes, the storage increases seen in September produce estimates of cooler temperatures when the regression estimates are used. However, because the Reclamation model is trying to attain constant release temperatures from Folsom Reservoir, changes in Nimbus temperature occur mostly as a result of flow changes. Consequently, the reduction in flows in September produces estimates of warmer release temperatures using the Reclamation model. The October impacts estimated by the Reclamation model may be more scattered because simulated temperatures in Folsom Reservoir are increased at lower storage because the cold water has been used to meet target temperatures during summer.

Comparison of Historical and Future Folsom Reservoir Release Temperatures

Historical end-of-month temperatures from the Nimbus Fish Hatchery have been used to characterize the expected range of Nimbus release temperatures to the lower American River. However, because Reclamation has recently modified the temperature control panels to provide additional temperature management flexibility (modified in 1996, and first used in 1997), the future monthly release temperatures may not be accurately described by the historical range of Nimbus temperatures.

Nimbus temperatures are governed by Folsom Reservoir release temperature and the warming that occurs in Lake Natoma. The two major factors influencing monthly Folsom Reservoir release temperature are:

- the reservoir storage volume and meteorology, which controls the surface temperature and temperature profile, and
- the outlet elevation (depth), which is controlled by the temperature control panels attached to the penstock trash rack structures. The outlet elevation also has an effect on the temperature profile.

Warming in Lake Natoma is influenced by the meteorological conditions and the release flow rate that controls the residence time in Lake Natoma. The historical Nimbus temperatures have been influenced by each of these factors. However, future Nimbus temperatures may be managed by controlling the Folsom Reservoir outlet elevation (depth) differently from historical temperature panel operations, so that the future relationships between monthly Folsom Reservoir storage and release temperature may be different. The future flow management for the lower American River may also shift the historical monthly storage-flow relationships.

Folsom Temperature Control Panels for Turbine Releases

The ability to control the Folsom Reservoir release temperatures by regulating the outlet depth with the temperature control panels is limited because there are only three "panel-sections" with fixed top elevations that act as submerged weirs. Figure 58 shows the top elevations of the historical and modified panel sections. The top of the trash rack structure is at elevation 401 feet. This remains the highest outlet elevation unless the spillway gate is used (as in the 1995 gate failure shown in Figure 43). The penstock elevation is at 307 feet, and this is the deepest outlet elevation unless the low level river outlet is used. The panel sections must be raised whenever the surface elevation is within 27 feet of the panel top to prevent problems from cavitation (air entrainment into the turbine). The timing of the sequential raising of the three panel-sections will be slightly different in the future than in the past because the top elevation of the three panel sections has been modified. But the general pattern of seasonal warming of Folsom Reservoir release temperatures will not be substantially changed by the modified panel operation. Coolest release temperatures will be obtained immediately after a panel is raised; the release temperatures will then increase as warmer water from above the outlet elevation is drawn down to replace the cool water being released.

This characteristic temperature response of the fixed temperature control panels can be observed in the 1992 measurements from immediately downstream of Folsom Dam, shown in Figure 59. The third (lowest) panel section (with a top elevation of 375 feet) had to be removed in early July because the Folsom Reservoir elevation decreased to less than the 402 feet mean sea level (msl) minimum operating level to prevent cavitation (volume of about 400,000 AF), as indicated in Figure 59. This operation lowered the effective outlet elevation from the top of the panel section at 375 feet msl to the penstock centerline elevation at about 307 feet msl. There is a volume of approximately 185,000 AF between these two outlet elevations. The release temperature was about 65°F before the lower panel section was raised. The release temperature was reduced to less than 55°F when the lower panel was raised, but subsequently increased to greater than 70°F by the middle of August (one month later). The release temperature was cooler than necessary at the beginning of the period (cold water being used faster than necessary). Approximately 200,000 AF of water was released during this 1-month period. The available coldwater supply was simply not sufficient to sustain cool water releases for the remainder of summer.

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The modified panel sections will allow the coldwater pool to be used more gradually because the nine panels have been rearranged into three-panel sections. The lowest section of four panels (top elevation of 336 feet) can now remain in place until the end of summer, unless the surface elevation declines to less than about 363 feet (volume of about 185,000 AF). The middle section now has two panels (top elevation of 362 feet) that can remain in place until a water surface elevation of about 389 feet (volume of about 310,000 AF). Because the elevations of the top of these two panel sections are lower, raising these panels can be delayed until later in summer. Because the panel sections are shorter (the top of the lower panel is 30 feet above the penstock centerline of 307 feet, the middle section is 26 feet high, and the top section is 39 feet high), the change in temperature resulting from lifting the panel sections will be less than it was historically. This will allow the available coldwater supply to be released more slowly without overshooting the desired release temperature, as occurred in 1992.

Temperature Control Device for Water Supply Intake

The current raw water intake and associated Folsom and Roseville water supply is at elevation 317 feet msl, just 10 feet above the penstock centerline elevation of 307 feet. Therefore, the water supply diversions during summer (approximately 50,000 AF) are depleting the Folsom Reservoir coldwater supply. As future water diversions increase, the effects on reservoir temperatures will be greater.

Reclamation has proposed to install a temperature control device (TCD) that will involve "telescoping" panels that can be raised to any desired elevation, with a maximum elevation of 401 feet. If the panel elevation is maintained above the elevation of 65°F water throughout summer, approximately 50,000 AF (and perhaps 100,000 AF with future diversions) of cool water less than 65°F can be conserved for maintaining cooler downstream river temperatures in summer.

Effect of Reservoir Drawdown on Future Temperatures

The modified temperature panel sections and the planned TCD for the San Juan-Roseville-Folsom water supply outlet (located at elevation 317 feet) will not change the basic temperature patterns in Folsom Reservoir. These managed outlet elevations will allow more of the coldwater pool to be conserved during summer by using higher outlet elevations, but release temperatures from a particular outlet elevation will still become warmer as releases are made and the reservoir storage decreases during summer. Therefore, reservoir drawdown (caused by additional water supply diversions or releases) will increase the Folsom Reservoir release temperatures relative to the temperatures corresponding to higher Alternative 1 reservoir storage volumes, regardless of the future target temperature pattern and operation of the temperature control panels.

Because the effects of increased warming in Lake Natoma with lower flows will remain about the same, the overall net effects of reservoir drawdown on Nimbus release temperatures will be similar to those observed in the historical record at the Nimbus hatchery if the historical relationship between lower flows and lower storage is maintained. The TCD and temperature panels will be beneficial for temperature management of American River temperatures, but they will not likely cause the monthly range of Nimbus temperatures to shift dramatically from the historical range that has been used for the EBMUD risk of warming assessment.

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Table 1. Linear Regression Equations for Temperatures at Nimbus Dam as a Function of Folsom Storage

Month	Constant (°F)	Slope	Reduction in Storage Correlated with a 1°F Increase at Nimbus Dam (TAF)	Estimated Nimbus Temperature at a Folsom Storage of 200 TAF (°F)	Estimated Nimbus Temperature at a Folsom Storage of 1,000 TAF (°F)	Temperature Increase Correlated with a 100 TAF Decrease in Storage (°F)	N	R^2	Significance Level (P Value)
October	66.61	-0.01321	76	64.0	53.4	1.32	37	0.485	<0.001
November	55.97	-0.00428	234	55.1	51.7	0.43	37	0.151	0.009
December	49.17	-0.00186	539	48.8	47.3	0.19	37	0.020	0.205
January	48.22	-0.00231	433	47.8	45.9	0.23	37	0.034	0.138
February	50.21	-0.00344	291	49.5	46.8	0.34	37	0.057	0.078
March	54.64	-0.00576	174	53.5	48.9	0.58	37	0.148	0.009
April	59.45	-0.00716	140	58.0	52.3	0.72	37	0.157	0.008
May	63.88	-0.00831	120	62.2	55.6	0.83	37	0.260	0.001
June	65.97	-0.00839	119	64.3	57.6	0.84	36	0.319	<0.001
July	70.8	-0.01087	92	68.6	59.9	1.09	37	0.523	<0.001
August	73.15	-0.01262	79	70.6	60.5	1.26	37	0.739	<0.001
September	70.57	-0.01052	95	68.5	60.1	1.05	37	0.553	<0.001

Table 2. Simulated Temperatures under Hodge Flows and under Hodge Flows + 500 cfs for 1986–1995 Natoma Release Temperatures and Meteorological Conditions (°F)

	Nimbus Dam (mile 23)		Upstream End of Goethe Park (mile 15)				Fairbairn WTP (mile 7)				Mouth of the American River (mile 0)			
Month	Average Temperature	Hodge Flows (cfs)	Hodge Flows	Hodge Flows + 500 cfs	Difference	Largest Maximum Daily Difference	Hodge Flows	Hodge Flows + 500 cfs	Difference	Largest Maximum Daily Difference	Hodge Flows	Hodge Flows + 500 cfs	Difference	Largest Maximum Daily Difference
January	47.8	2,000	47.6	47.6	0.0	0.1	47.4	47.5	-0.1	0.2	47.3	47.4	-0.1	0.3
February	48.2	2,000	48.6	48.5	0.1	0.2	48.9	48.8	0.1	0.5	49.2	49.1	0.2	0.6
March	50.5	3,000	51.1	51.0	0.1	0.2	51.7	51.6	0.1	0.4	52.2	52.0	0.2	0.5
April	53.8	3,000	54.7	54.6	0.1	0.2	55.7	55.5	0.2	0.4	56.5	56.1	0.3	0.6
May	55.0	3,000	57.3	57.1	0.2	0.3	58.6	58.3	0.3	0.5	59.7	59.2	0.5	0.7
June	57.9	3,000	59.7	59.5	0.2	0.3	61.4	61.0	0.4	0.7	62.7	62.2	0.6	0.9
July	61.5	1,750	64.3	63.8	0.5	0.7	66.8	65.8	1.0	1.3	68.7	67.5	1.2	1.8
August	66.6	1,750	68.5	68.1	0.4	0.6	70.2	69.5	0.6	1.1	71.5	70.6	0.8	1.6
September	67.0	1,750	68.0	67.8	0.2	0.4	69.0	68.6	0.4	0.8	69.7	69.2	0.5	1.1
October	65.4	2,000	65.6	65.6	0.0	0.3	65.8	65.7	0.1	0.5	66.0	65.9	0.1	0.6
November	58.4	2,000	58.0	58.1	-0.1	0.1	57.7	57.8	-0.1	0.2	57.4	57.6	-0.2	0.2
December	51.9	2,000	51.3	51.4	-0.1	0.0	50.7	50.9	-0.2	0.0	50.2	50.5	-0.3	-0.1

Table 3. Percent of Months with Potential for at Least a 1°F Temperature Increase or Decrease at Locations along the American River

	Increase					Decrease				
	Alt 2	Alt 3	Alt 2 Cum	Alt 3 Cum	Full-Use Scenario	Alt 2	Alt 3	Alt 2 Cum	Alt 3 Cum	Full-Use Scenario
Nimbus Dam										
October	0	3	10	1	3	0	0	41	41	0
November	0	0	0	0	0	0	0	0	1	0
December	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0	0	0
February	0	0	6	1	0	0	0	0	0	0
March	0	0	20	14	0	1	1	0	0	0
April	0	0	21	16	0	1	1	0	0	0
May	0	0	19	16	0	1	1	1	1	0
June	0	0	17	9	0	1	1	3	3	0
July	0	0	19	14	0	1	1	10	16	0
August	0	0	13	6	0	1	1	31	31	0
Sepember	0	0	0	0	0	1	1	36	39	0
Goethe Park										
October	0	1	1	0	1	0	0	39	41	0
November	0	0	0	0	0	0	0	0	1	0
December	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0	0	0
February	0	0	1	1	0	0	0	0	0	0
March	0	0	14	11	0	1	1	0	0	0
April	0	0	23	19	0	1	1	0	0	0
May	0	0	24	20	0	1	1	0	0	0
June	0	0	24	20	0	1	1	0	0	0
July	0	0	60	47	0	1	1	6	7	0
August	0	0	54	33	0	1	1	9	10	0
Sepember	0	0	21	10	0	1	1	17	23	0
Fairbairn WTP										
October	0	0	3	0	0	0	0	39	40	0
November	0	0	0	0	0	0	0	0	1	0
December	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0	0	0
February	0	0	9	7	0	0	0	4	6	1
March	0	0	16	10	0	1	1	0	0	0
April	1	0	26	23	0	1	1	0	0	0
May	0	0	33	30	0	1	1	0	0	0
June	4	1	47	46	0	1	1	0	1	1
July	1	0	77	73	0	1	3	13	14	3
August	3	0	77	74	0	3	1	6	7	0
Sepember	1	0	47	26	0	1	1	6	13	0
Mouth of the American River										
October	0	0	4	0	0	0	0	37	39	0
November	0	0	0	0	0	0	0	0	1	0
December	0	0	0	0	0	0	0	0	0	0
January	0	1	1	1	1	0	0	0	1	0
February	0	0	9	7	0	0	0	9	10	1
March	0	0	16	13	0	1	1	1	0	0
April	1	0	29	23	0	1	3	0	1	1
May	1	0	36	33	0	1	1	0	0	0
June	7	1	51	51	0	3	1	4	9	1
July	3	0	79	76	0	1	3	11	19	4
August	4	1	83	79	1	3	3	4	6	3
Sepember	3	0	61	50	3	3	1	3	9	0

Note: Alternatives 2 and 3 and the full-use scenario are compared to Alternative 1. Cumulative scenarios are compared to existing conditions.

Table 4. Simulated and Measured Warming along the American River between the Nimbus Fish Hatchery and the Fairbairn WTP (°F)

	1986				1987				1988				1989				1990			
Month	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming
January	48.3	1.5	-0.3	1.8	49.8	-0.5	-1.7	1.2	48.4	0.5	-0.4	0.9	46.8	0.3	-1.3	1.5	46.9	1.8	-0.4	2.1
February	49.1	2.1	0.1	2.0	49.0	2.5	1.0	1.6	49.1	1.8	1.7	0.1	46.4	2.6	1.0	1.7	45.6	2.5	0.9	1.6
March	51.4	2.3	0.5	1.8	51.9	2.7	1.7	1.1	50.3	4.8	3.3	1.5	47.7	5.2	2.2	2.9	47.6	6.0	4.7	1.3
April	53.9	2.7	1.1	1.5	55.6	5.3	4.4	0.9	52.0	6.4	3.7	2.6	52.1	5.3	3.3	1.9	55.2	4.4	3.5	0.9
May	55.7	4.9	3.8	1.1	58.1	7.5	6.7	0.7	56.0	6.8	5.0	1.8	54.1	5.9	2.7	3.2	56.5	6.9	6.8	0.1
June	56.8	6.4	4.4	2.0	60.8	6.5	6.2	0.3	59.4	6.8	5.1	1.7	56.8	6.9	3.4	3.5	56.2	7.4	5.9	1.5
July	58.7	4.4	2.6	1.8	63.0	4.0	3.3	0.7	64.1	5.6	3 7	1.9	59.7	6.5	3.1	3.5	64.3	4.0	1.8	2.2
August	63.2	4.5	3.2	1.3	64.3	5.4	3.4	1.9	71.4	3.6	3.1	0.5	63.3	5.4	2.9	2.5	70.7	3.0	2.0	1.0
Sepember	63.9	3.7	2.7	1.0	66.9	2.6	2.0	0.6	71.5	2.1	1.4	0.7	63.8	4.4	2.2	2.1	67.9	3.4	2.4	1.0
October	64.1	--	--	--	66.1	--	--	--	67.1	--	--	--	62.7	--	--	--	65.6	--	--	--
November	59.1	--	--	--	61.9	--	--	--	60.6	0.0	-3.5	3.6	57.4	0.6	-0.5	1.1	57.4	--	--	--
December	54.7	--	--	--	53.2	--	--	--	52.0	-0.8	-3.5	2.7	51.4	-0.4	-1.8	1.4	49.4	--	--	--

	1991				1992				1993				1994				1995			
Month	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming	Measured Hatchery Temp	Measured Warming	Simulated Warming	Difference in Warming
January	44.9	1.9	-0.1	1.9	47.2	--	--	--	46.8	--	--	--	49.1	0.6	-0.3	0.9	49.4	-0.2	-0.2	0.0
February	48.3	4.2	3.1	1.1	48.5	3.5	1.9	1.7	47.0	1.7	0.4	1.3	49.0	1.5	0.4	1.1	50.4	--	--	--
March	50.8	3.5	1.6	1.9	52.7	4.0	3.2	0.8	50.0	2.0	1.3	0.7	51.1	3.5	2.4	1.1	51.4	--	--	--
April	54.4	6.4	6.3	0.1	56.4	--	--	--	52.4	3.3	2.4	0.9	53.4	6.0	4 4	1.6	52.1	2.0	0.9	1.0
May	56.4	8.1	7.2	0.9	58.8	7.0	5.6	1.4	53.5	3.3	2.1	1.2	56.2	7.2	6.4	0.8	52.9	4.7	1.0	3.7
June	58.0	6.2	4.3	1.9	61.0	5.0	2.5	2.5	55.4	4.0	2.4	1.6	59.9	6.2	4.9	1.3	54.2	5.7	1.9	3.8
July	61.0	6.1	3.5	2.6	60.3	6.6	3.2	3.4	60.1	3.3	2.3	1.0	64.3	5.7	3.8	1.8	59.1	5.0	1.6	3.4
August	64.8	4.4	2.4	1.9	69.5	3.4	2.3	1.1	63.4	3.0	2.5	0.5	70.0	4.4	2.7	1.7	65.5	4.1	2.7	1.4
Sepember	66.2	4.7	3.1	1.6	71.2	1.8	2.0	-0.2	64.9	2.9	2.2	0.6	70.6	3.2	1.7	1.4	62.9	3.6	1.8	1.8
October	65.8	--	--	--	69.0	-0.3	0.7	-1.0	64.0	1.4	0.5	0.9	66.6	0.2	-0.4	0.6	62.8	1.6	0.4	1.2
November	57.0	--	--	--	59.0	--	--	--	57.5	0.4	-0.7	1.1	57.1	-2.0	-1.9	-0.0	57.4	1.5	0.1	1.5
December	50.9	--	--	--	51.3	--	--	--	52.0	0.3	-1.2	1.5	50.5	-1.6	-1.4	-0.2	54.2	--	--	--

-- = no data.

Table 5. Monthly Averages of the Measured Daily Temperatures Minus the Simulated Daily Temperatures for 1990

Month	Ancil Hoffman Park[a]		Fairbairn WTP[a]		I-5 Bridge[b]	
	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference
January	--	--	--	--	--	--
February	--	--	--	--	--	--
March	--	--	--	--	--	--
April	--	--	--	--	--	--
May	-3.0	3.0	-1.9	1.9	--	--
June	-1.5	1.8	-0.8	1.6	--	--
July	0.0	0.5	-0.1	0.4	0.1	0.3
August	-0.2	0.3	-0.3	0.4	0.2	0.4
Sepember	-0.3	0.5	-0.3	0.6	-0.2	0.5
October	-0.7	0.7	-0.7	0.8	-0.4	0.7
November	-0.3	0.7	-0.4	0.8	-0.0	0.8
December	-0.2	0.7	-0.1	0.8	0.5	1.2
Minimum	-3.0	0.3	-1.9	0.4	-0.4	0.3
Average	-0.8	1.0	-0.6	0.9	0.0	0.7
Maximum	0.0	3.0	-0.1	1.9	0.5	1.2

Notes: A positive number indicates that measurements are warmer than simulated values.
-- = no data.
[a] Measured by Beak Consultants.
[b] Measured by EBMUD.

Table 6. Monthly Averages of the Measured Daily Temperatures Minus the Simulated Daily Temperatures for 1991

Month	Ancil Hoffman Park				Hagan Park[c]		H Street[c]		I-5 Bridge[c]	
	Difference[a]	Absolute Value of Difference[a]	Difference[b]	Absolute Value of Difference[b]	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference
January	--	--	0.8	0.9	1.0	1.1	--	--	1.4	1.6
February	--	--	-0.0	1.6	0.1	1.6	--	--	1.1	2.0
March	--	--	1.0	1.1	1.1	1.1	--	--	1.2	1.5
April	--	--	-0.7	1.3	-1.0	1.0	--	--	--	--
May	--	--	0.1	1.0	--	--	--	--	--	--
June	0.1	0.8	0.1	0.8	--	--	-1.7	1.7	--	--
July	0.2	0.4	0.2	0.5	--	--	0.5	0.9	0.3	0.4
August	0.6	0.8	0.6	0.8	0.9	1.1	0.2	2.1	0.9	1.0
Sepember	0.4	0.5	0.4	0.5	0.7	0.8	-3.4	3.4	0.5	0.6
October	-0.3	0.6	-0.3	0.6	0.2	0.6	-2.2	2.2	0.3	0.8
November	0.7	1.0	0.6	1.0	0.8	1.1	0.4	1.4	1.1	1.3
December	1.3	1.4	1.3	1.4	1.5	1.5	1.7	1.7	1.7	1.7
Minimum	-0.3	0.4	-0.7	0.5	-1.0	0.6	-3.4	0.9	0.3	0.4
Average	0.4	0.8	0.3	1.0	0.6	1.1	-0.6	1.9	0.9	1.2
Maximum	1.3	1.4	1.3	1.6	1.5	1.6	1.7	3.4	1.7	2.0

-- = no data.
[a] Measured by California Department of Fish and Game.
[b] Measured by Beak Consultants.
[c] Measured by EBMUD.

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Table 7. Monthly Averages of the Measured Daily Temperatures Minus the Simulated Daily Temperatures for 1992

	Ancil Hoffman Park				Hagan Park[c]		H Street[c]		Business 80[c]		SPRR[b]		I-5 Bridge[c]	
Month	Difference[a]	Absolute Value of Difference[a]	Difference[b]	Absolute Value of Difference[b]	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference
January	--	--	1.8	1.8	--	--	1.8	1.8	--	--	--	--	2.2	2.2
February	1.0	1.3	1.0	1.2	--	--	--	--	--	--	--	--	--	--
March	-0.0	0.5	-0.0	0.5	--	--	-0.4	0.6	--	--	--	--	0.4	0.6
April	-0.1	1.0	-0.1	1.0	-0.6	1.6	-0.1	1.1	--	--	0.1	1.1	1.0	1.4
May	-0.4	1.0	-0.4	1.0	0.2	1.3	-0.6	1.0	--	--	-0.4	1.0	1.0	1.4
June	0.5	0.6	0.5	0.6	1.5	1.6	0.5	0.5	--	--	0.1	0.4	1.1	1.1
July	0.4	0.7	0.4	0.7	1.9	1.9	0.4	0.7	--	--	0.0	0.7	1.2	1.2
August	0.1	0.5	0.9	0.9	0.5	0.6	-0.5	0.7	--	--	-0.7	0.9	0.5	0.7
Sepember	-0.2	0.4	--	--	-0.1	0.4	-0.5	0.7	-0.2	0.5	--	--	-0.2	0.7
October	-0.7	0.8	--	--	--	--	-0.9	1.0	-0.7	0.9	--	--	-0.7	1.0
November	1.0	1.2	--	--	--	--	0.8	1.1	0.9	1.2	--	--	1.0	1.2
December	1.0	1.1	--	--	--	--	1.5	1.6	1.8	1.8	--	--	3.0	3.0
Minimum	-0.7	0.4	-0.4	0.5	-0.6	0.4	-0.9	0.5	-0.7	0.5	-0.7	0.4	-0.7	0.6
Average	0.2	0.8	0.5	0.9	0.6	1.2	0.2	1.0	0.5	1.1	-0.2	0.8	1.0	1.3
Maximum	1.0	1.3	1.8	1.8	1.9	1.9	1.8	1.8	1.8	1.8	0.1	1.1	3.0	3.0

-- = no data.
[a] Measured by California Department of Fish and Game.
[b] Measured by Beak Consultants.
[c] Measured by EBMUD.

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Table 8. Monthly Averages of the Measured Daily Temperatures Minus the Simulated Daily Temperatures for 1993

	Ancil Hoffman Park[a]		Hagen Park[b]		H Street[b]		Business 80[b]		I-5 Bridge[b]	
Month	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference
January	0.2	0.7	0.2	0.7	0.9	1.3	0.6	1.0	1.4	1.4
February	0.3	0.4	0.1	0.4	0.5	0.7	0.4	0.6	--	--
March	0.1	0.4	-0.4	0.7	-0.3	0.6	-0.3	0.6	--	--
April	--	--	0.2	0.5	0.5	0.8	0.2	0.6	1.0	1.2
May	--	--	-0.1	0.6	0.3	0.8	-0.1	0.6	0.7	0.9
June	--	--	0.1	0.5	0.8	0.9	-0.0	0.7	0.7	0.9
July	--	--	-0.7	1.0	0.2	0.8	-1.7	1.9	-0.3	0.8
August	--	--	-0.8	0.8	0.9	1.3	-1.9	1.9	-0.9	1.0
Sepember	--	--	-0.0	0.3	0.3	0.7	-1.2	1.2	-0.3	0.5
October	--	--	-0.6	0.6	-0.1	0.9	-0.2	0.7	-0.9	0.9
November	--	--	0.5	0.9	0.1	0.9	2.0	2.0	0.6	1.0
December	--	--	0.3	0.4	0.4	0.5	2.7	2.7	0.8	0.8
Minimum	0.1	0.4	-0.8	0.3	-0.3	0.5	-1.9	0.6	-0.9	0.5
Average	0.2	0.5	-0.1	0.6	0.4	0.8	0.0	1.2	0.3	0.9
Maximum	0.3	0.7	0.5	1.0	0.9	1.3	2.7	2.7	1.4	1.4

-- = no data.
[a] Measured by California Department of Fish and Game.
[b] Measured by EBMUD.

Table 9. Monthly Averages of the Measured Daily Temperatures Minus the Simulated Daily Temperatures for 1994

	Hagen Park[a]		H Street[a]		Business 80[a]		I-5 Bridge[a]	
Month	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference	Difference	Absolute Value of Difference
January	0.0	0.5	0.2	0.6	2.1	2.1	-0.5	0.8
February	--	--	--	--	--	--	-0.2	0.8
March	--	--	--	--	--	--	-0.6	0.8
April	--	--	--	--	--	--	0.1	0.7
May	--	--	--	--	--	--	-0.3	0.9
June	-2.2	2.2	-1.5	1.5	-1.8	1.8	-0.9	1.1
July	-0.9	0.9	0.0	0.7	-1.7	1.7	--	--
August	-1.1	1.1	-1.6	1.6	-2.0	2.0	--	--
Sepember	-1.0	1.0	--	--	-0.6	0.9	--	--
October	--	--	--	--	1.2	1.4	0.9	1.4
November	--	--	--	--	2.9	2.9	1.3	1.3
December	--	--	--	--	2.2	2.2	--	--
Minimum	-2.2	0.5	-1.6	0.6	-2.0	0.9	-0.9	0.7
Average	-1.0	1.2	-0.7	1.1	0.3	1.9	-0.0	1.0
Maximum	0.0	2.2	0.2	1.6	2.9	2.9	1.3	1.4

-- = no data.
[a] Measured by EBMUD.

Table 10 Average Simulated Temperatures in the American River at the Upstream End of Goethe Park with Hodge Flows and Hodge Flows+500 cfs (°F)

	1986				1987				1988				1989				1990			
			Differences				Differences				Differences				Differences				Differences	
Month	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max
January	48.2	48.2	-0.0	0.1	49.3	49.3	-0.1	0.0	48.3	48.3	-0.0	0.1	46.5	46.6	-0.0	0.1	46.7	46.8	-0.0	0.0
February	49.7	49.6	0.1	0.2	49.3	49.2	0.1	0.1	49.6	49.5	0.1	0.2	46.6	46.6	0.0	0.1	45.9	45.8	0.0	0.2
March	52.1	52.0	0.1	0.2	52.3	52.2	0.0	0.1	51.0	50.9	0.1	0.1	48.4	48.3	0.1	0.2	48.6	48.5	0.1	0.2
April	54.8	54.7	0.1	0.2	56.7	56.5	0.1	0.2	52.8	52.7	0.1	0.2	53.3	53.2	0.2	0.2	56.3	56.2	0.1	0.2
May	57.2	57.0	0.2	0.3	59.7	59.5	0.2	0.3	57.2	57.0	0.1	0.2	55.7	55.5	0.2	0.2	57.8	57.7	0.2	0.2
June	58.9	58.6	0.3	0.3	62.5	62.3	0.2	0.3	60.9	60.7	0.2	0.2	58.9	58.6	0.2	0.3	58.2	58.0	0.3	0.3
July	61.9	61.3	0.6	0.7	65.4	65.0	0.5	0.6	66.6	66.2	0.5	0.6	62.8	62.2	0.6	0.7	66.8	66.4	0.5	0.6
August	65.7	65.2	0.5	0.6	66.5	66.1	0.4	0.5	72.8	72.5	0.3	0.4	65.5	65.1	0.4	0.5	72.0	71.7	0.2	0.4
September	64.9	64.7	0.2	0.4	68.0	67.8	0.2	0.4	72.0	71.9	0.1	0.3	65.0	64.8	0.2	0.4	68.9	68.7	0.2	0.3
October	64.5	64.4	0.1	0.2	66.5	66.4	0.1	0.2	67.4	67.3	0.0	0.1	62.9	62.8	0.0	0.2	65.8	65.8	0.0	0.2
November	58.8	58.8	-0.1	0.0	61.3	61.4	-0.1	-0.0	59.8	59.9	-0.1	-0.1	57.1	57.2	-0.1	0.0	57.1	57.2	-0.1	0.0
December	53.8	54.0	-0.1	-0.1	52.3	52.5	-0.2	-0.1	51.2	51.3	-0.1	-0.0	50.6	50.7	-0.1	-0.0	48.9	49.0	-0.1	-0.0

	1991				1992				1993				1994				1995			
			Differences				Differences				Differences				Differences				Differences	
Month	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max
January	44.9	44.9	-0.0	0.1	46.9	46.9	-0.1	0.0	46.7	46.7	-0.0	0.0	49.0	49.0	-0.0	0.0	49.4	49.4	-0.0	0.1
February	48.8	48.7	0.1	0.2	49.0	48.9	0.1	0.2	47.4	47.3	0.1	0.1	49.2	49.2	0.0	0.1	50.7	50.7	0.1	0.2
March	50.9	50.9	0.0	0.1	53.3	53.3	0.1	0.2	50.9	50.8	0.1	0.1	51.9	51.8	0.1	0.1	51.7	51.7	0.0	0.1
April	55.2	55.1	0.1	0.1	57.3	57.2	0.1	0.2	53.5	53.3	0.1	0.2	54.4	54.3	0.1	0.2	53.1	53.0	0.1	0.2
May	57.5	57.4	0.1	0.2	60.3	60.1	0.2	0.2	55.2	55.0	0.2	0.2	57.6	57.4	0.2	0.3	54.4	54.2	0.2	0.3
June	59.7	59.4	0.2	0.3	62.7	62.5	0.2	0.3	57.3	57.1	0.2	0.3	61.6	61.4	0.2	0.3	56.2	56.0	0.2	0.3
July	63.9	63.3	0.5	0.7	63.1	62.6	0.5	0.7	63.2	62.6	0.6	0.7	66.8	66.4	0.5	0.6	62.3	61.7	0.6	0.7
August	66.6	66.3	0.4	0.5	71.2	70.9	0.3	0.5	65.7	65.3	0.4	0.6	71.4	71.2	0.3	0.4	67.6	67.2	0.4	0.5
Sepember	67.6	67.3	0.3	0.4	71.8	71.7	0.1	0.2	66.3	66.0	0.3	0.4	71.2	71.0	0.1	0.2	64.7	64.3	0.3	0.4
October	66.0	66.0	0.0	0.3	69.1	69.1	0.0	0.1	64.3	64.3	0.1	0.2	66.5	66.5	-0.0	0.1	63.1	63.0	0.1	0.2
November	56.8	56.8	-0.0	0.1	58.7	58.8	-0.0	0.0	57.1	57.2	-0.1	0.0	56.3	56.5	-0.1	-0.0	57.5	57.4	0.0	0.1
December	50.3	50.4	-0.1	-0.0	50.7	50.8	-0.1	-0.0	51.4	51.5	-0.1	-0.1	49.9	50.0	-0.1	-0.0	53.7	53.8	-0.1	-0.0

Table 11. Average Simulated Temperatures in the American River near the Fairbairn Water Treatment Plant with Hodge Flows and Hodge Flows+500 cfs (°F)

Month	1986				1987				1988				1989				1990			
	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max
January	48.1	48.1	-0.0	0.1	48.8	48.9	-0.2	0.1	48.1	48.2	-0.0	0.1	46.3	46.4	-0.1	0.1	46.6	46.7	-0.0	0.0
February	50.2	50.0	0.2	0.5	49.5	49.4	0.1	0.2	50.1	49.9	0.2	0.3	46.8	46.7	0.1	0.3	46.1	46.0	0.1	0.5
March	52.8	52.7	0.2	0.3	52.7	52.6	0.1	0.2	51.7	51.5	0.2	0.3	49.1	48.9	0.2	0.3	49.5	49.3	0.2	0.3
April	55.6	55.4	0.2	0.3	57.7	57.4	0.3	0.3	53.6	53.4	0.2	0.3	54.5	54.2	0.3	0.4	57.3	57.1	0.3	0.4
May	58.6	58.3	0.4	0.5	61.1	60.8	0.4	0.5	58.3	58.0	0.3	0.4	57.1	56.8	0.4	0.5	59.0	58.7	0.3	0.4
June	60.8	60.3	0.5	0.6	64.1	63.7	0.4	0.5	62.2	61.9	0.3	0.4	60.7	60.3	0.5	0.5	60.1	59.6	0.5	0.6
July	64.7	63.6	1.1	1.3	67.5	66.7	0.8	1.1	68.9	68.0	0.9	1.0	65.6	64.5	1.1	1.3	69.1	68.2	0.9	1.1
August	68.0	67.1	0.9	1.1	68.3	67.6	0.7	0.9	74.0	73.5	0.5	0.8	67.4	66.7	0.7	0.9	73.1	72.7	0.4	0.7
Sepember	65.8	65.5	0.4	0.8	68.9	68.6	0.4	0.7	72.4	72.3	0.2	0.5	66.1	65.7	0.4	0.7	69.8	69.5	0.3	0.5
October	64.9	64.7	0.1	0.4	66.8	66.7	0.1	0.4	67.6	67.5	0.1	0.2	63.1	63.0	0.1	0.3	66.1	66.0	0.1	0.4
November	58.5	58.6	-0.1	0.0	60.7	60.9	-0.2	-0.1	59.0	59.3	-0.3	-0.1	56.8	56.9	-0.1	0.0	56.9	57.0	-0.1	0.1
December	53.1	53.3	-0.3	-0.1	51.5	51.8	-0.3	-0.1	50.5	50.8	-0.2	-0.1	49.9	50.2	-0.2	-0.1	48.5	48.6	-0.2	-0.1

Month	1991				1992				1993				1994				1995			
	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max	Hodge Flows	Hodge Flows + 500 cfs	Differences Avg	Differences Max
January	44.9	44.9	-0.0	0.1	46.5	46.7	-0.1	0.0	46.5	46.6	-0.0	0.0	48.9	48.9	-0.0	0.1	49.4	49.4	-0.0	0.2
February	49.3	49.1	0.2	0.3	49.4	49.2	0.2	0.4	47.7	47.6	0.1	0.2	49.3	49.3	0.1	0.3	51.1	51.0	0.1	0.3
March	51.1	51.1	0.0	0.2	53.9	53.8	0.1	0.4	51.7	51.5	0.2	0.3	52.6	52.4	0.2	0.2	52.1	52.0	0.1	0.2
April	55.9	55.7	0.2	0.2	58.2	58.0	0.2	0.3	54.5	54.2	0.2	0.4	55.4	55.1	0.2	0.4	54.1	53.9	0.2	0.4
May	58.6	58.4	0.3	0.4	61.8	61.4	0.4	0.5	56.7	56.3	0.4	0.4	58.9	58.6	0.3	0.5	55.8	55.5	0.3	0.5
June	61.2	60.8	0.4	0.5	64.1	63.8	0.4	0.5	59.2	58.7	0.5	0.6	63.2	62.8	0.4	0.5	58.0	57.6	0.5	0.7
July	66.4	65.4	1.0	1.3	65.7	64.7	1.0	1.2	65.9	64.9	1.1	1.3	69.0	68.2	0.8	1.1	65.1	64.0	1.1	1.3
August	68.3	67.6	0.6	0.9	72.7	72.1	0.6	0.9	67.8	67.0	0.8	1.1	72.7	72.2	0.5	0.7	69.4	68.7	0.7	0.9
Sepember	68.8	68.4	0.5	0.7	72.4	72.2	0.2	0.3	67.5	67.0	0.5	0.7	71.7	71.5	0.2	0.3	66.2	65.6	0.6	0.8
October	66.2	66.1	0.1	0.5	69.3	69.2	0.1	0.2	64.6	64.5	0.1	0.4	66.4	66.4	-0.0	0.1	63.4	63.3	0.1	0.3
November	56.6	56.7	-0.1	0.2	58.5	58.6	-0.1	0.0	56.8	56.9	-0.1	0.1	55.6	55.9	-0.2	-0.1	57.5	57.5	0.0	0.1
December	49.8	49.9	-0.2	-0.0	50.1	50.3	-0.2	-0.1	50.8	51.0	-0.2	-0.1	49.4	49.6	-0.2	-0.1	53.3	53.5	-0.1	-0.1

Table 12. Average Simulated Temperatures at the Mouth of the American River with Hodge Flows and Hodge Flows+500 cfs with Average Monthly and Maximum Daily Differences in Temperature (°F)

	1986				1987				1988				1989				1990			
			Differences				Differences				Differences				Differences				Differences	
Month	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max
January	48.0	48.1	-0.1	0.2	48.4	48.6	-0.2	0.1	48.1	48.1	-0.1	0.2	46.1	46.2	-0.1	0.1	46.5	46.6	-0.1	0.1
February	50.6	50.3	0.2	0.6	49.8	49.6	0.1	0.3	50.5	50.3	0.2	0.4	46.9	46.8	0.1	0.4	46.3	46.2	0.1	0.6
March	53.4	53.2	0.2	0.4	52.9	52.8	0.1	0.3	52.3	52.0	0.2	0.4	49.7	49.4	0.2	0.4	50.2	49.9	0.3	0.5
April	56.3	56.0	0.3	0.5	58.6	58.2	0.4	0.5	54.3	54.0	0.3	0.4	55.5	55.1	0.4	0.6	58.2	57.8	0.3	0.5
May	59.8	59.3	0.5	0.7	62.3	61.8	0.5	0.7	59.2	58.8	0.4	0.5	58.3	57.8	0.5	0.6	60.0	59.6	0.4	0.6
June	62.4	61.7	0.7	0.8	65.3	64.8	0.5	0.6	63.3	62.9	0.4	0.6	62.2	61.6	0.6	0.7	61.6	61.0	0.6	0.8
July	67.0	65.5	1.4	1.7	69.1	68.1	1.0	1.4	70.6	69.5	1.1	1.4	67.8	66.4	1.4	1.7	70.8	69.7	1.1	1.5
August	69.8	68.6	1.2	1.6	69.8	68.8	0.9	1.3	74.9	74.3	0.6	1.0	68.9	67.9	1.0	1.2	74.0	73.4	0.6	0.9
Sepember	66.5	66.1	0.5	1.1	69.7	69.2	0.5	0.9	72.8	72.6	0.2	0.7	66.9	66.4	0.5	0.9	70.5	70.1	0.5	0.6
October	65.2	65.0	0.2	0.6	67.0	66.9	0.2	0.5	67.8	67.7	0.1	0.3	63.3	63.1	0.1	0.4	66.2	66.1	0.1	0.5
November	58.3	58.4	-0.1	0.0	60.2	60.5	-0.3	-0.1	58.5	58.8	-0.3	-0.2	56.6	56.7	-0.1	0.1	56.6	56.8	-0.1	0.1
December	52.4	52.8	-0.4	-0.2	50.9	51.2	-0.4	-0.2	50.0	50.3	-0.3	-0.1	49.3	49.7	-0.3	-0.1	48.1	48.3	-0.2	-0.1

	1991				1992				1993				1994				1995			
			Differences				Differences				Differences				Differences				Differences	
Month	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max	Hodge Flows	Hodge Flows + 500 cfs	Avg	Max
January	44.8	44.9	-0.0	0.1	46.3	46.4	-0.2	0.1	46.5	46.5	-0.1	0.1	48.8	48.8	-0.1	0.1	49.4	49.4	-0.0	0.3
February	49.6	49.4	0.2	0.4	49.8	49.5	0.2	0.6	48.0	47.9	0.2	0.3	49.5	49.4	0.1	0.3	51.4	51.2	0.2	0.5
March	51.3	51.2	0.1	0.3	54.4	54.2	0.2	0.5	52.4	52.1	0.3	0.4	53.2	52.9	0.2	0.3	52.3	52.2	0.1	0.3
April	56.5	56.2	0.2	0.3	58.9	58.6	0.3	0.4	55.3	54.9	0.3	0.5	56.2	55.9	0.3	0.5	54.9	54.5	0.3	0.5
May	59.5	59.2	0.4	0.6	63.0	62.5	0.5	0.6	57.9	57.4	0.5	0.6	60.0	59.6	0.4	0.6	56.9	56.5	0.5	0.7
June	62.5	62.0	0.5	0.7	65.4	64.9	0.5	0.7	60.7	60.1	0.6	0.8	64.5	64.0	0.5	0.7	59.5	58.9	0.6	0.9
July	68.3	67.0	1.3	1.8	67.6	66.4	1.3	1.6	68.1	66.7	1.4	1.7	70.7	69.6	1.1	1.4	67.2	65.9	1.4	1.7
August	69.5	68.7	0.8	1.2	73.8	73.1	0.7	1.2	69.3	68.3	1.0	1.4	73.7	73.1	0.6	0.9	70.8	69.9	0.9	1.1
Sepember	69.8	69.2	0.6	0.9	72.8	72.5	0.3	0.5	68.5	67.8	0.6	1.0	72.1	71.8	0.3	0.4	67.4	66.6	0.8	1.0
October	66.4	66.3	0.1	0.6	69.4	69.3	0.1	0.3	64.8	64.6	0.1	0.6	66.3	66.3	-0.0	0.2	63.6	63.5	0.1	0.4
November	56.5	56.5	-0.1	0.2	58.3	58.4	-0.1	0.0	56.5	56.7	-0.1	0.1	55.1	55.4	-0.3	-0.1	57.5	57.5	0.0	0.2
December	49.3	49.6	-0.3	-0.1	49.6	49.9	-0.3	-0.1	50.4	50.6	-0.3	-0.1	49.0	49.2	-0.3	-0.1	53.0	53.2	-0.2	-0.1

Table 13. Temperature Thresholds for Life Stages of Chinook Salmon, Steelhead, American Shad, and Splittail in Relation to the Maximum Simulated Temperatures (at Hodge Flows) for 1986-1995

Month	Temperature-Sensitive Life Stages	Location Used for Evaluation	Temperature Threshold[a] (°F)	Highest Monthly Average Temperature at Evaluation Location[b] (°F)
February	Chinook spawning and incubation	Goethe	56	50.7
	Steelhead spawning and incubation	Goethe	52	50.7
	Steelhead rearing	Fairbairn	61	51.1
	Chinook rearing and emigration	Mouth	61	51.4
	Splittail spawning	Mouth	68	51.4
March	Chinook spawning and incubation	Goethe	56	53.3
	Steelhead spawning and incubation	Goethe	52[a]	53.3
	Steelhead rearing	Fairbairn	61	53.9
	Chinook rearing and emigration	Mouth	61	54.4
	Splittail spawning	Mouth	68	54.4
	Steelhead smolting and emigration	Mouth	57	54.4
April	Steelhead spawning and incubation	Goethe	52[a]	57.3
	Steelhead rearing	Fairbairn	61	58.2
	Chinook rearing and emigration	Mouth	61	58.9
	Splittail spawning	Mouth	68	58.9
	Steelhead smolting and emigration	Mouth	57[a]	58.9
May	Steelhead spawning and incubation	Goethe	52[a]	60.3
	Steelhead rearing	Fairbairn	61[a]	61.8
	Chinook rearing and emigration	Mouth	61[a]	63.0
	Shad spawning	Mouth	68	63.0
	Steelhead smolting and emigration	Mouth	57[a]	63.0
June	Steelhead rearing	Fairbairn	61[a]	64.1
	Chinook rearing and emigration	Mouth	61[a]	65.4
	Shad spawning	Mouth	68	65.4
July	Steelhead rearing	Fairbairn	61[a]	69.1
August	Steelhead rearing	Fairbairn	61[a]	74.0
September	Steelhead rearing	Fairbairn	61[a]	72.4
October	Chinook spawning and incubation	Goethe	56[a]	69.1
	Steelhead rearing	Fairbairn	61[a]	69.3

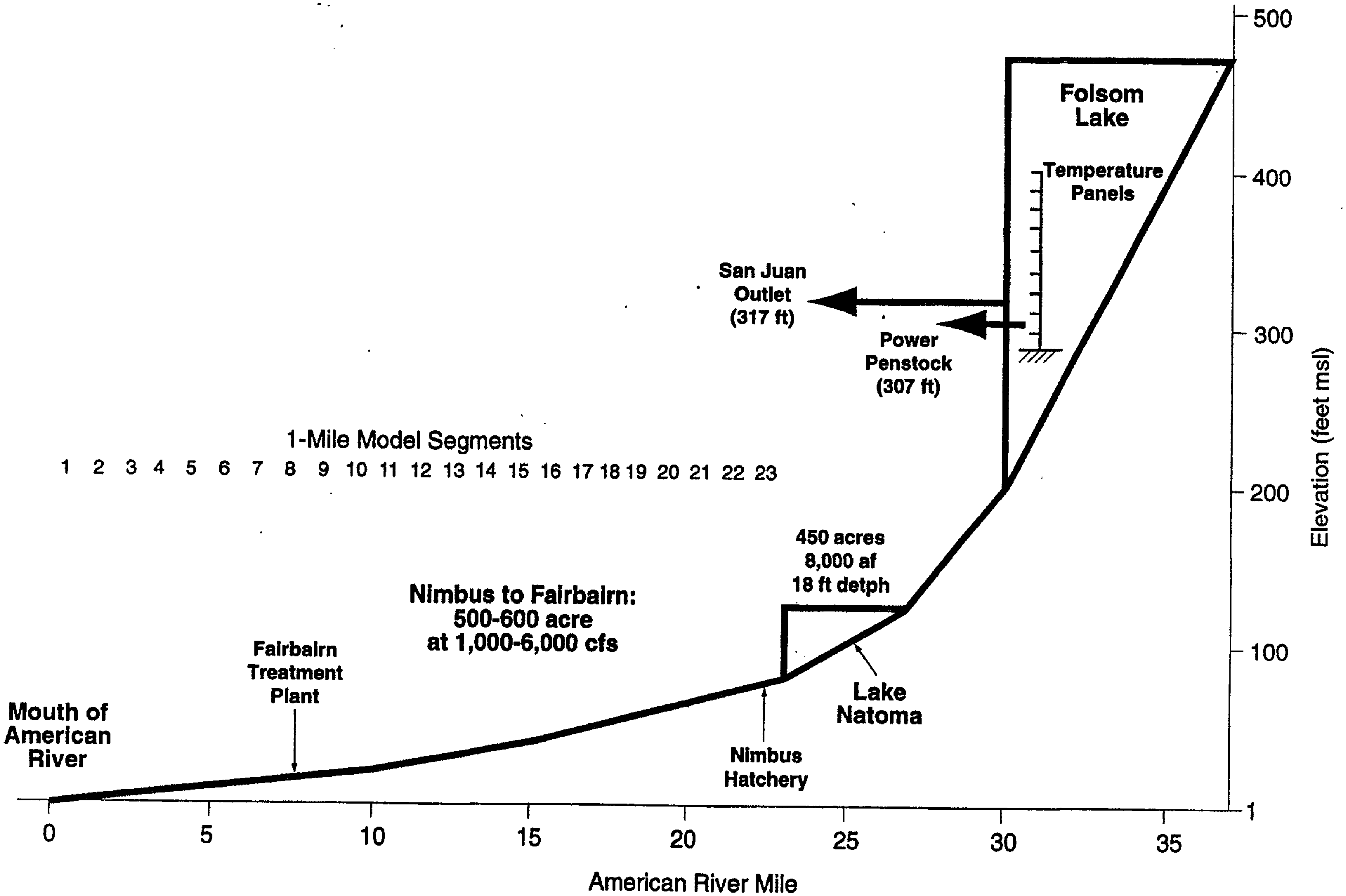
Notes: Water temperatures in November, December, and January did not increase in response to a decrease in flow.
[a] Temperatures are of concern because the threshold is exceeded by the highest monthly average.
[b] Simulated under Hodge flows.

Table 14. Percent of Months with Potential to Have at Least a 1°F Temperature Increase or Decrease at Four Locations along the Lower American River

	Increase			Decrease		
	Existing	Alternative 2 Cumulative	Alternative 3 Cumulative	Existing	Alternative 2 Cumulative	Alternative 3 Cumulative
Nimbus Dam						
October	49	10	4	0	0	0
November	1	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	1	0	0
March	0	0	0	9	0	0
April	0	1	0	11	0	0
May	3	3	0	9	0	0
June	3	1	0	4	0	0
July	20	6	1	4	0	0
August	46	17	4	1	0	0
Sepember	46	1	1	0	0	0
Goethe Park						
October	53	13	6	0	0	0
November	1	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	7	0	0
April	0	3	0	13	0	0
May	0	7	0	14	0	0
June	1	3	3	14	0	0
July	10	20	6	39	0	0
August	17	43	10	23	0	0
Sepember	31	27	6	3	0	0
Fairbairn WTP						
October	51	16	9	0	0	0
November	7	0	0	0	0	0
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	4	1	0	7	1	0
March	0	14	0	7	1	1
April	0	11	1	16	0	1
May	0	11	0	27	0	0
June	7	14	10	37	0	0
July	17	37	10	56	0	0
August	10	56	31	43	1	1
Sepember	29	57	30	9	0	0
Mouth of the American River						
October	49	20	9	0	0	0
November	7	0	0	0	0	0
December	0	0	0	0	0	0
January	1	0	0	0	0	0
February	7	1	1	7	1	0
March	1	16	3	7	1	1
April	1	11	3	16	0	1
May	1	16	3	27	0	1
June	13	23	21	46	0	0
July	17	44	26	61	0	1
August	10	59	46	53	1	1
Sepember	20	63	36	21	0	0

Note: Alternatives 2 and 3 are compared to Alternative 1.

C-085212



C—085212

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Figure 1
Schematic Diagram of Lower American River and Location of Temperature Model Segments

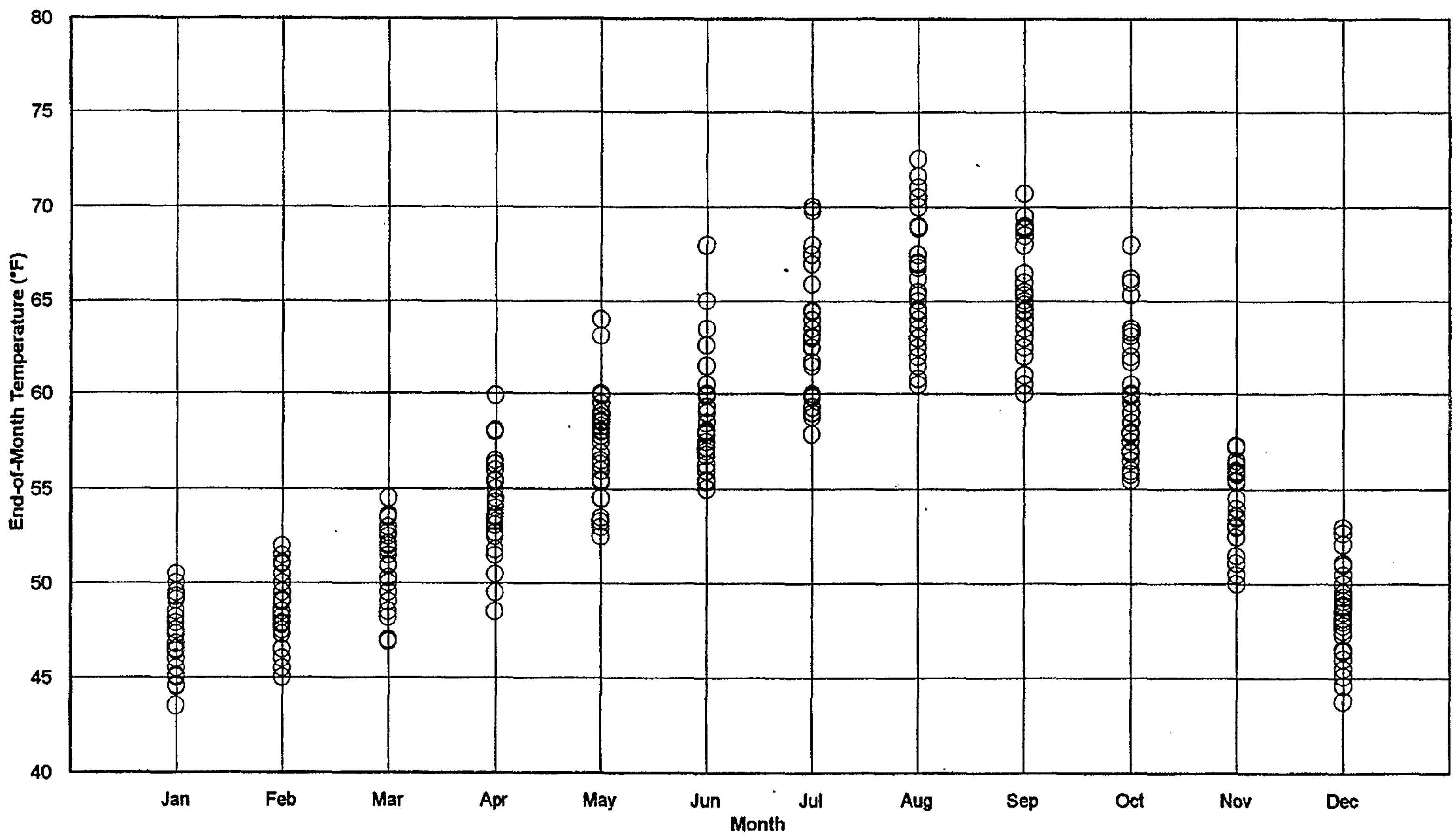
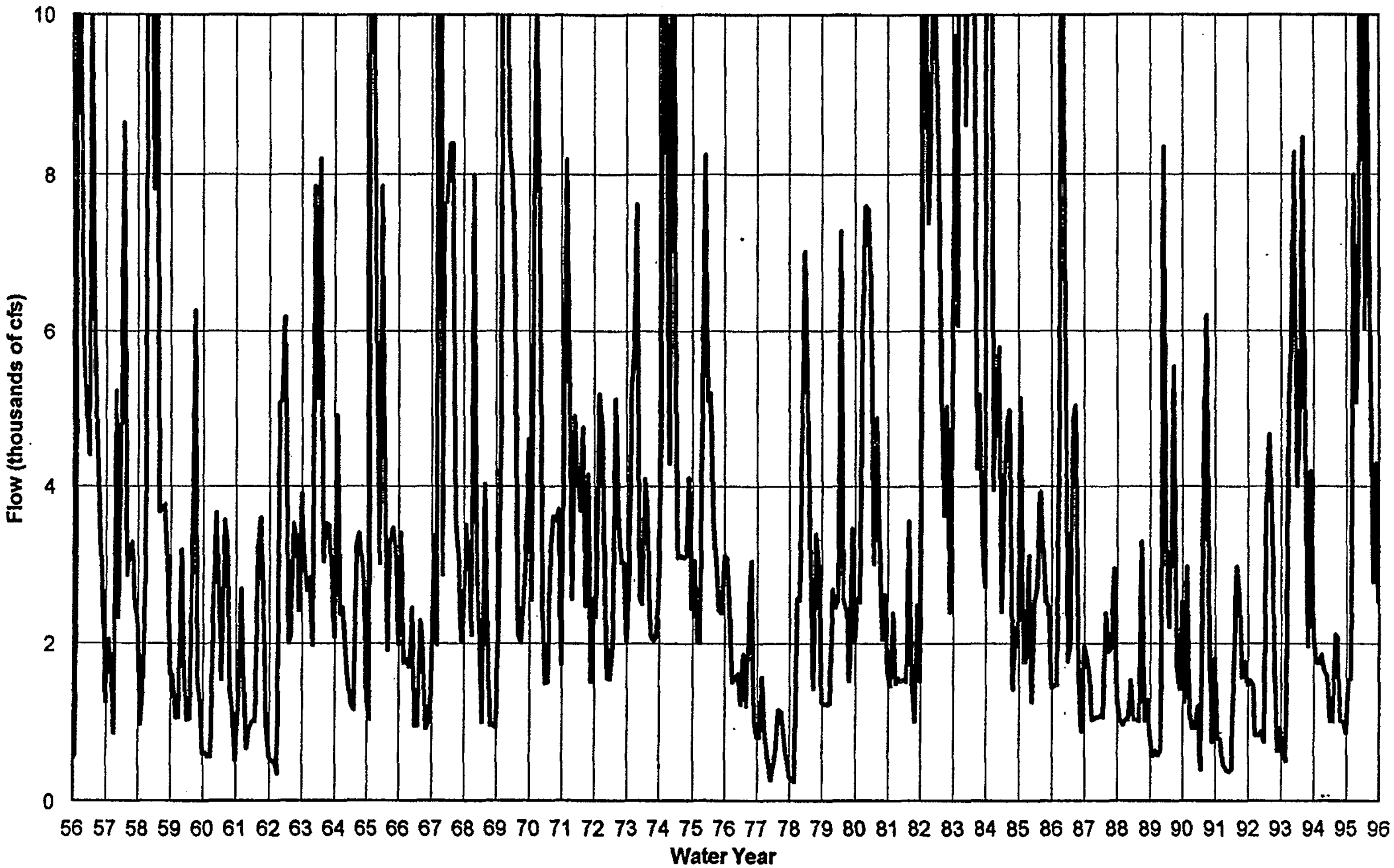


Figure 2
End-of-Month Hatchery Temperatures (1959-1995)
in the Lower American River

Jones & Stokes Associates, Inc.

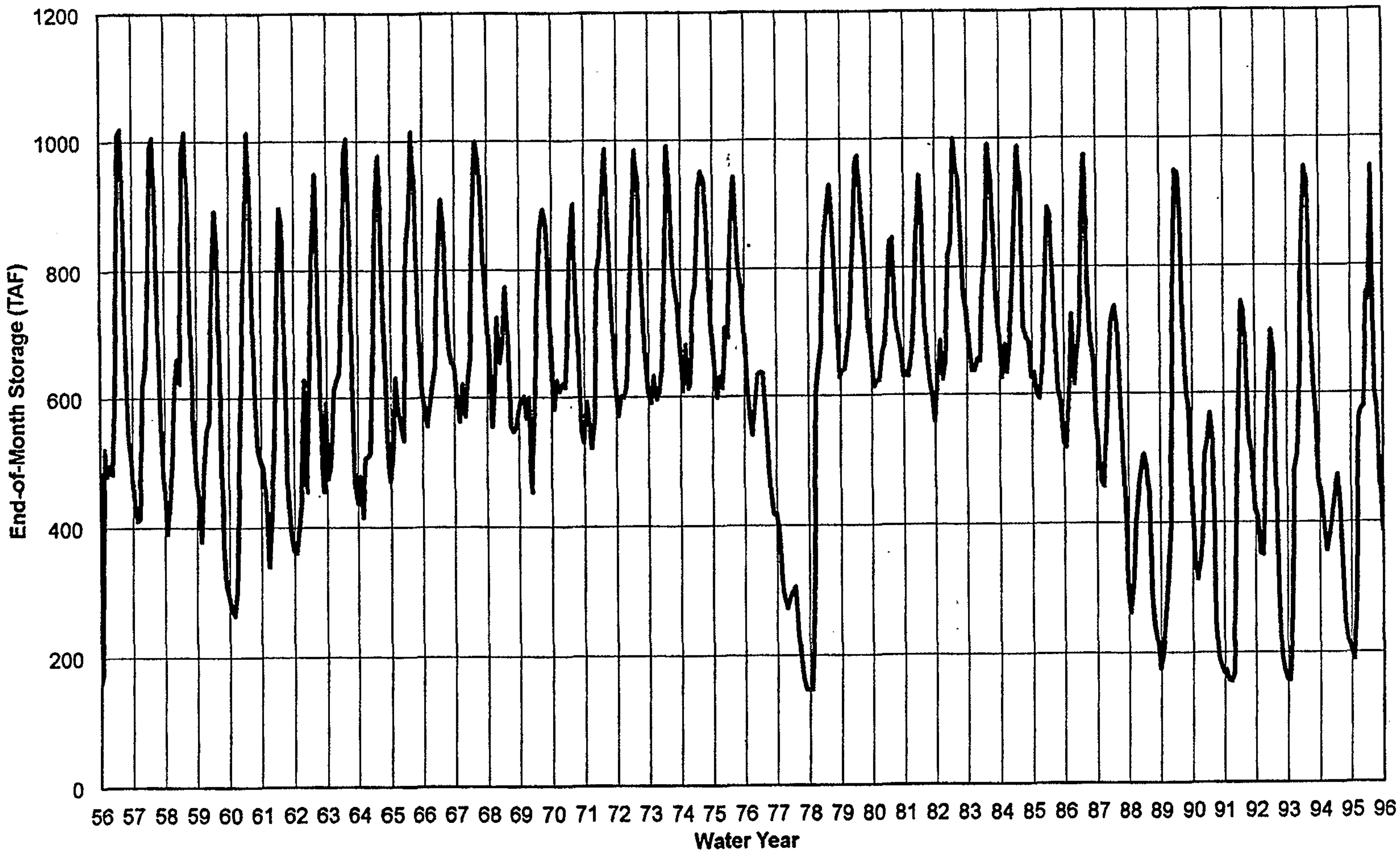


Source: WATSTORE database maintained by U.S. Geological Survey

Jones & Stokes Associates, Inc.

Figure 3
End-of-Month Flow in the
American River at Fair Oaks

C —0 8 5 2 1 4



Source: WATSTORE database maintained by U.S. Geological Survey
and CDEC database maintained by California Department of Water Resources

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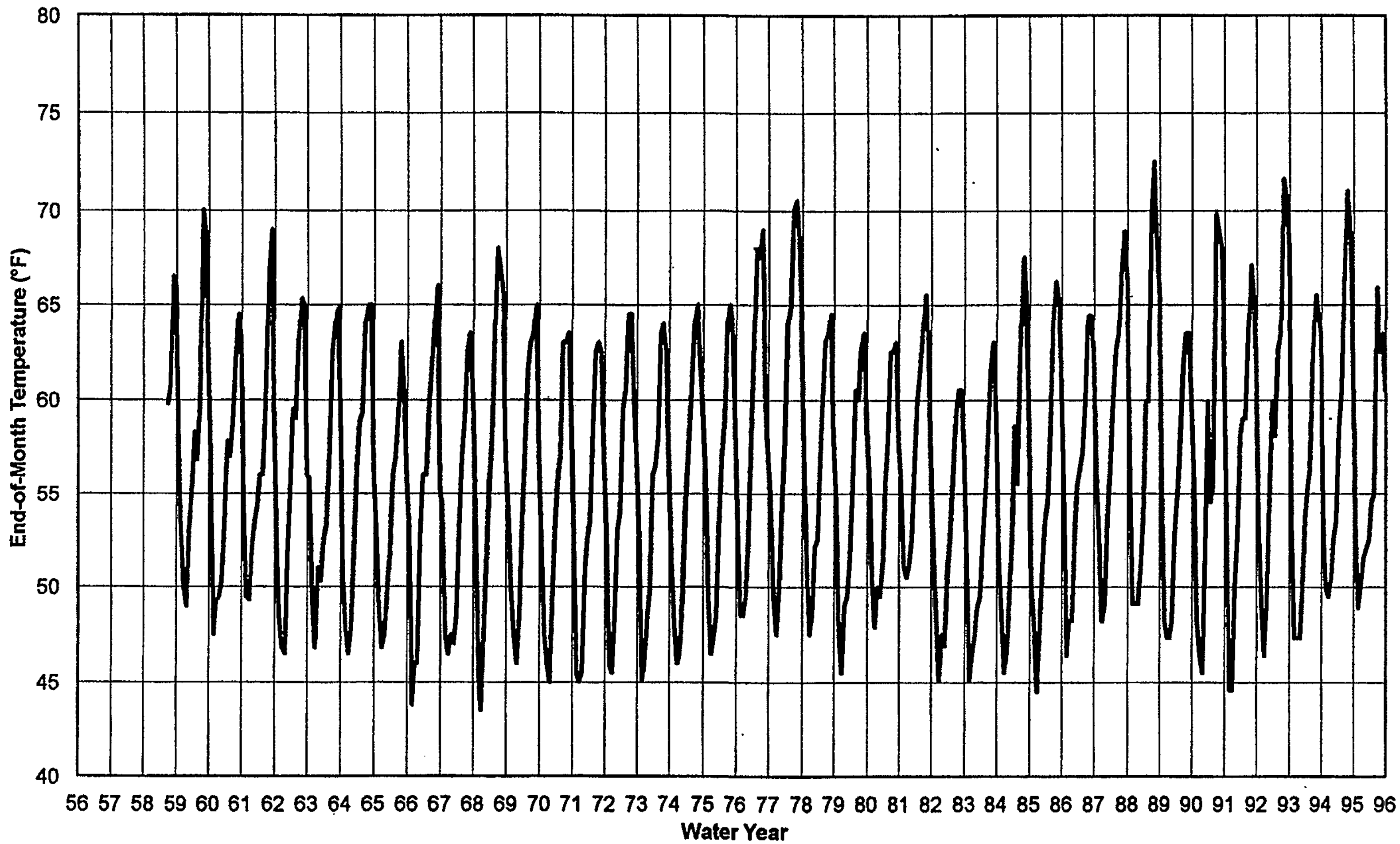
Figure 4
End-of-Month Storage in
Foslom Lake

C-085215



Source: California Department of Fish and Game annual reports from the Nimbus fish hatchery

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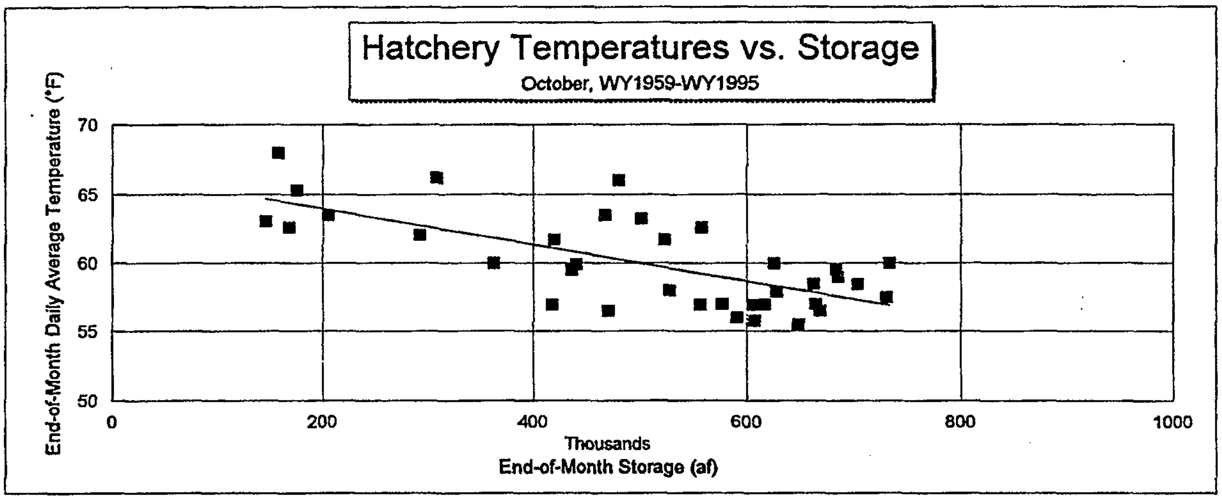
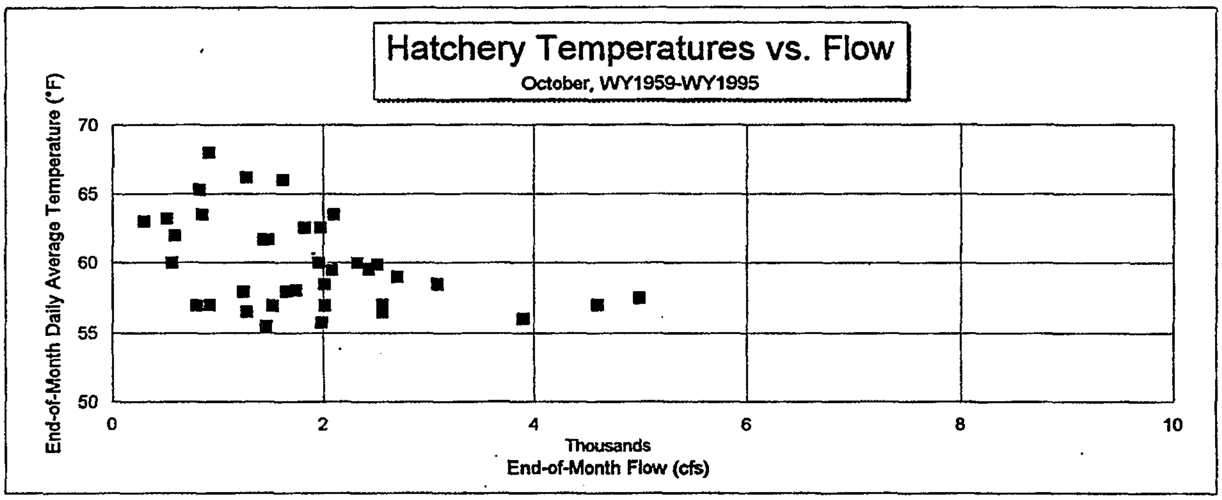
Figure 5
End-of-Month Inflow Temperature
at the Nimbus Fish Hatchery

C-085216





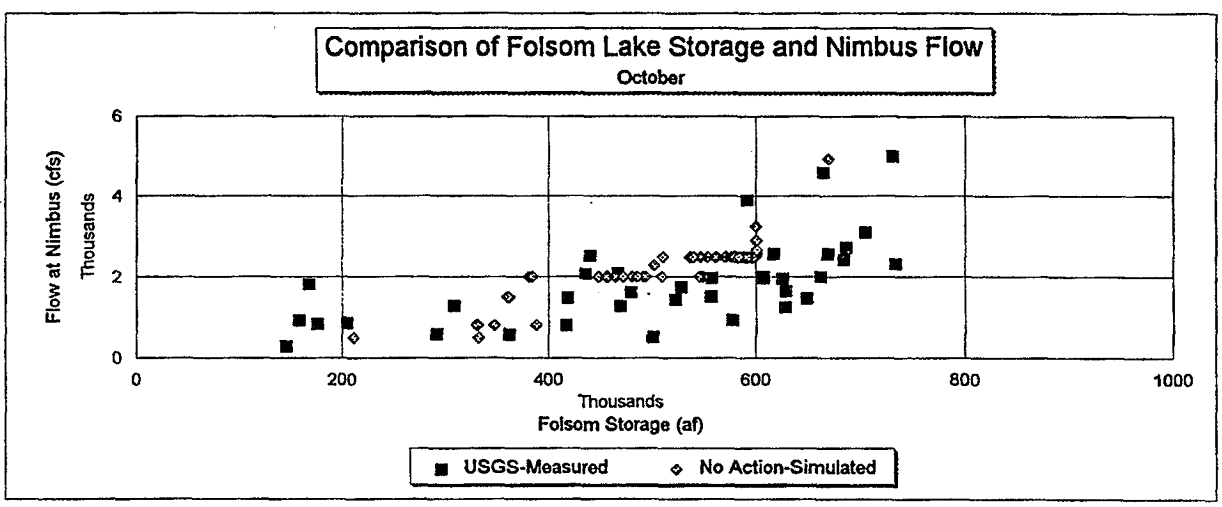


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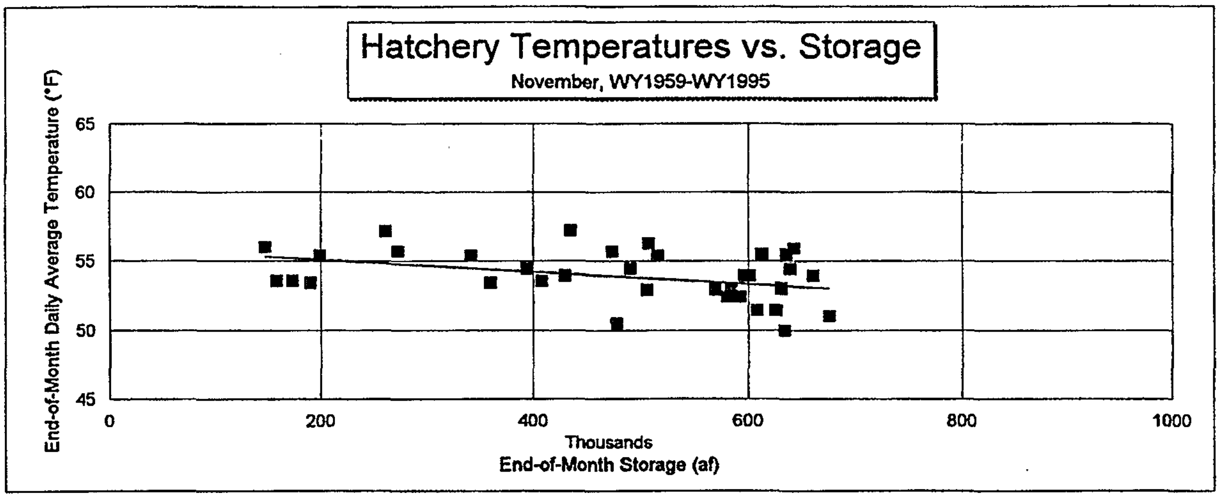
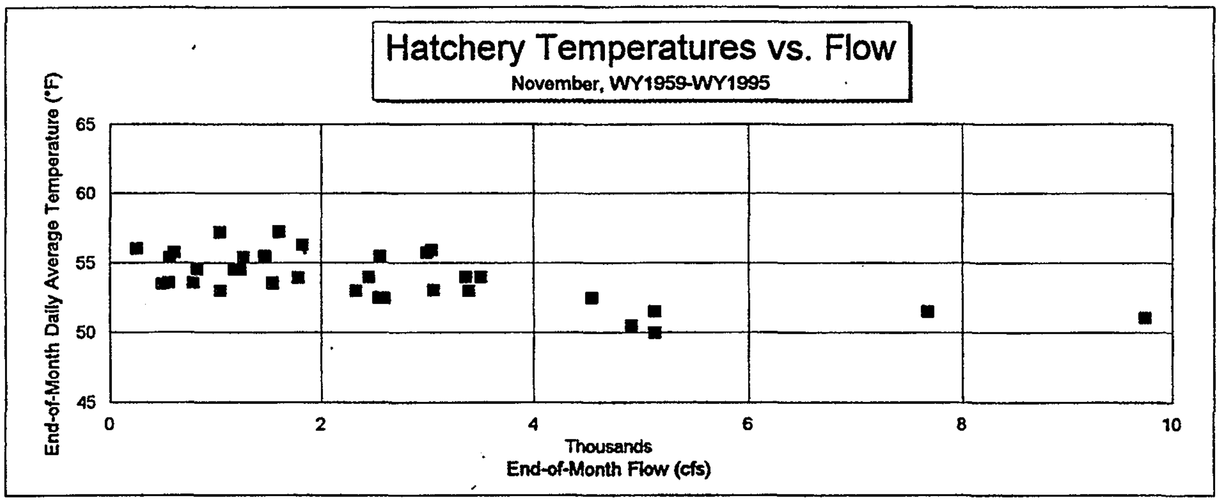
Figure 6.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of October for Water Years 1959-1995





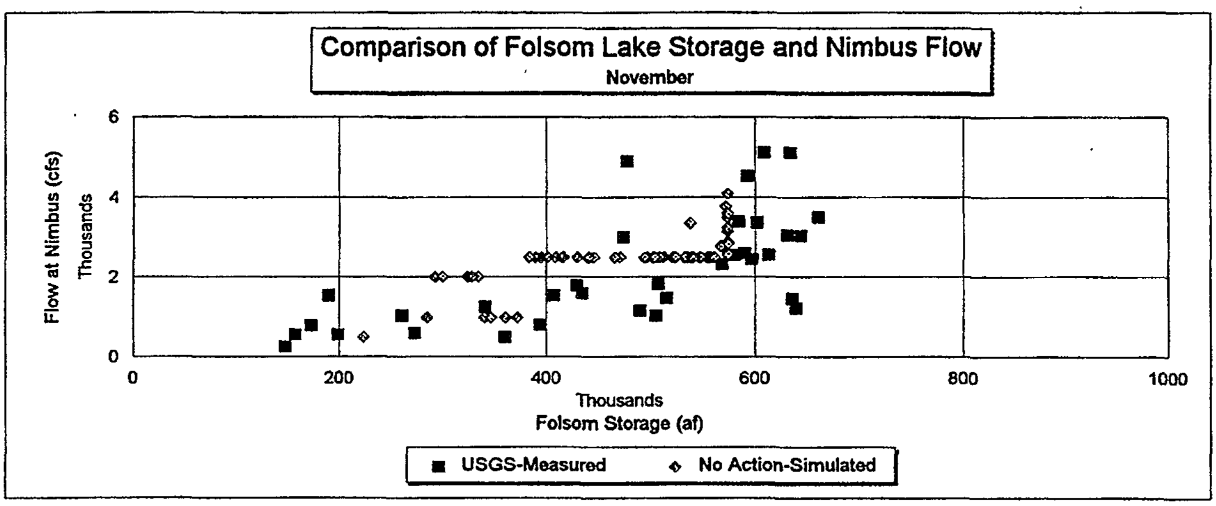


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Figure 7.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of November for Water Years 1959-1995

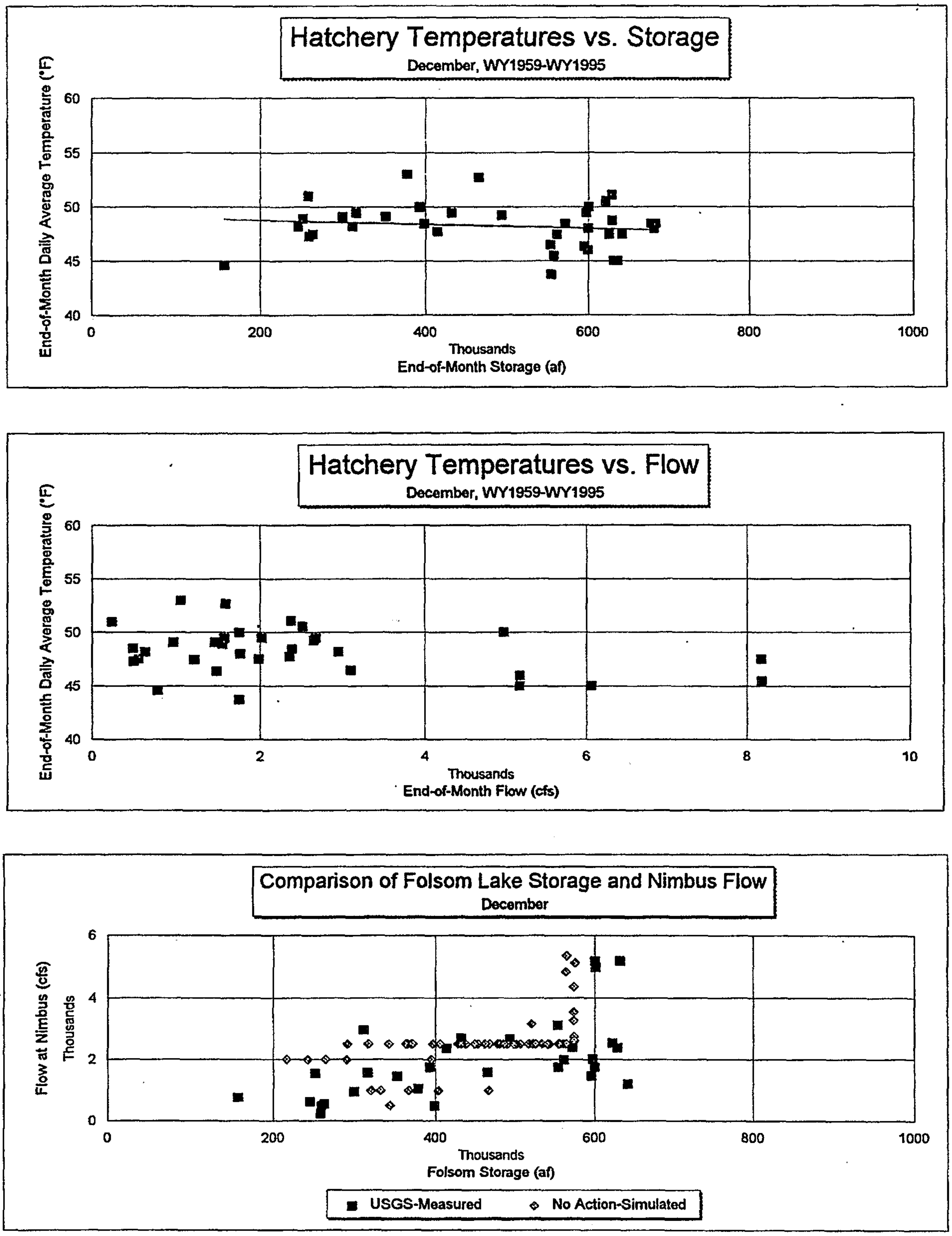

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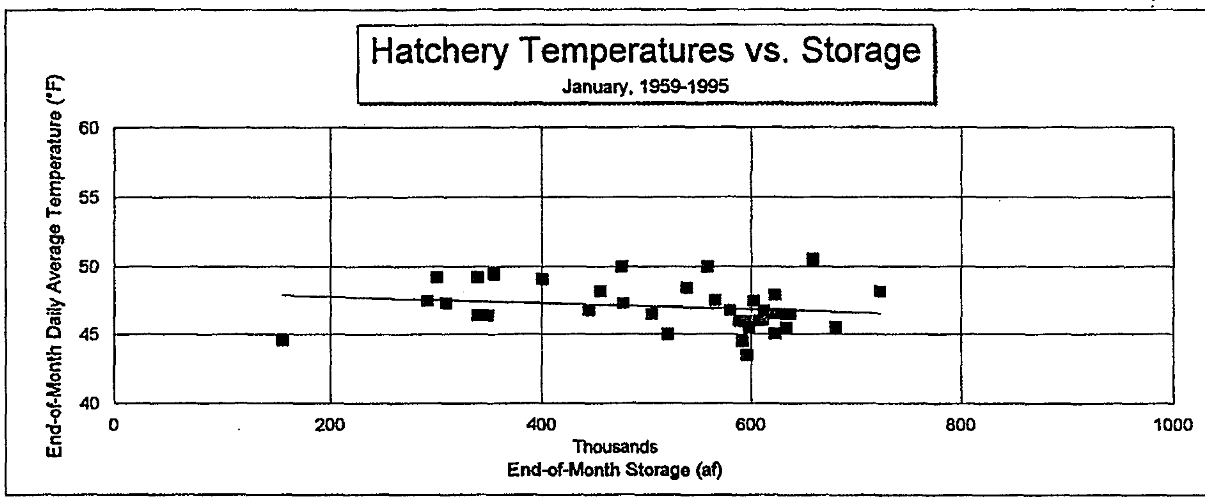
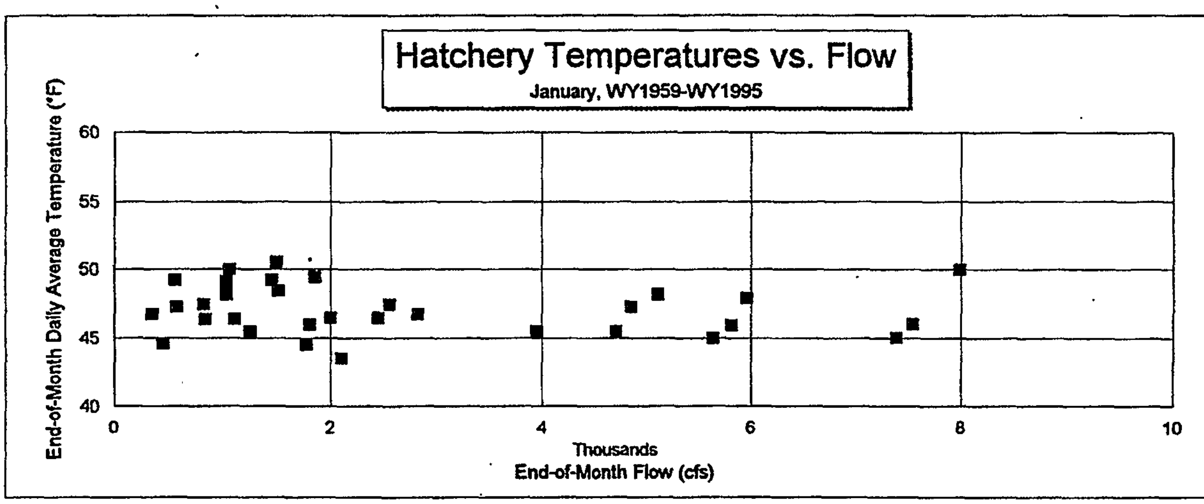
Figure 8.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of December for Water Years 1959-1995





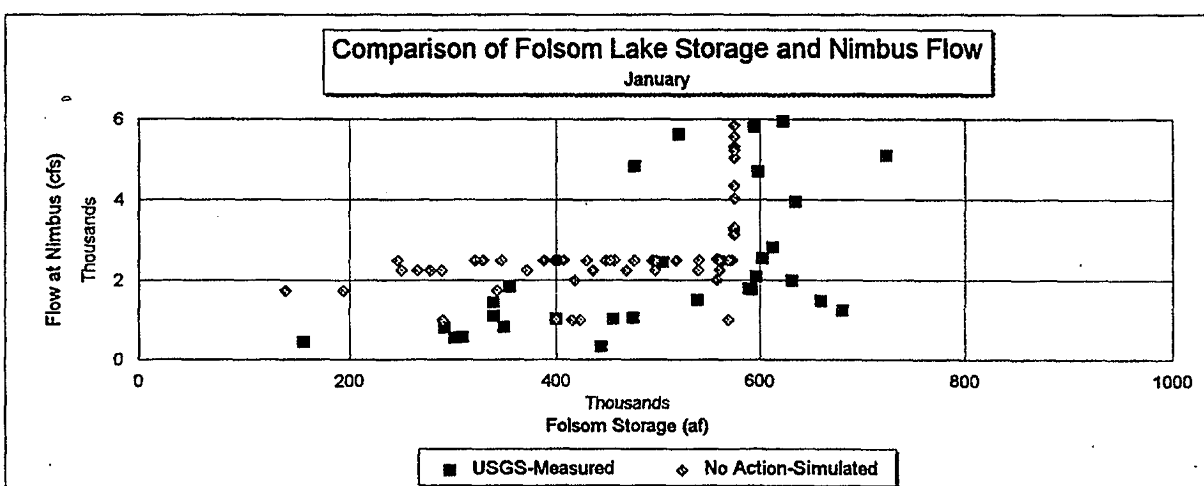


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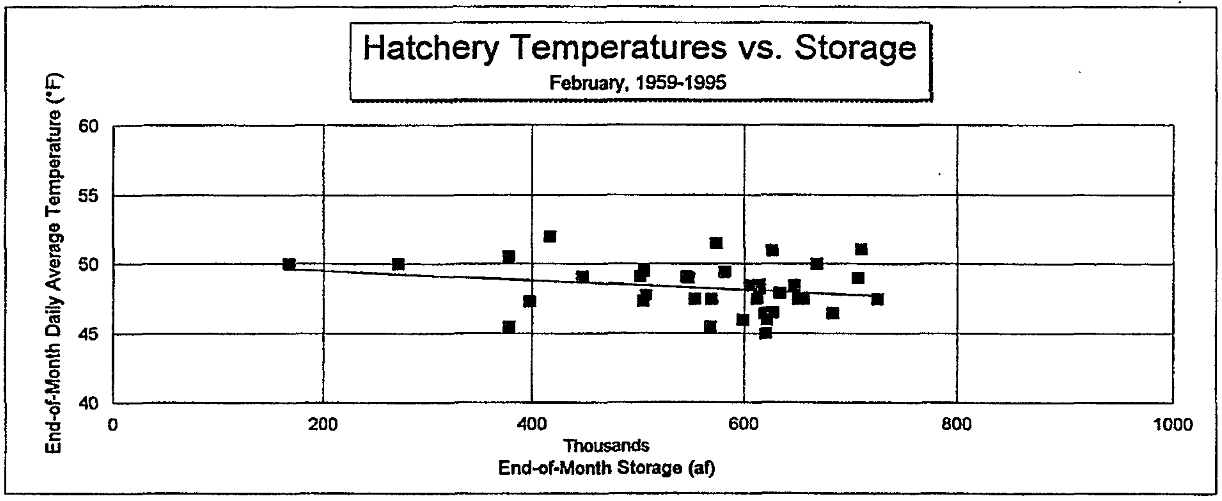
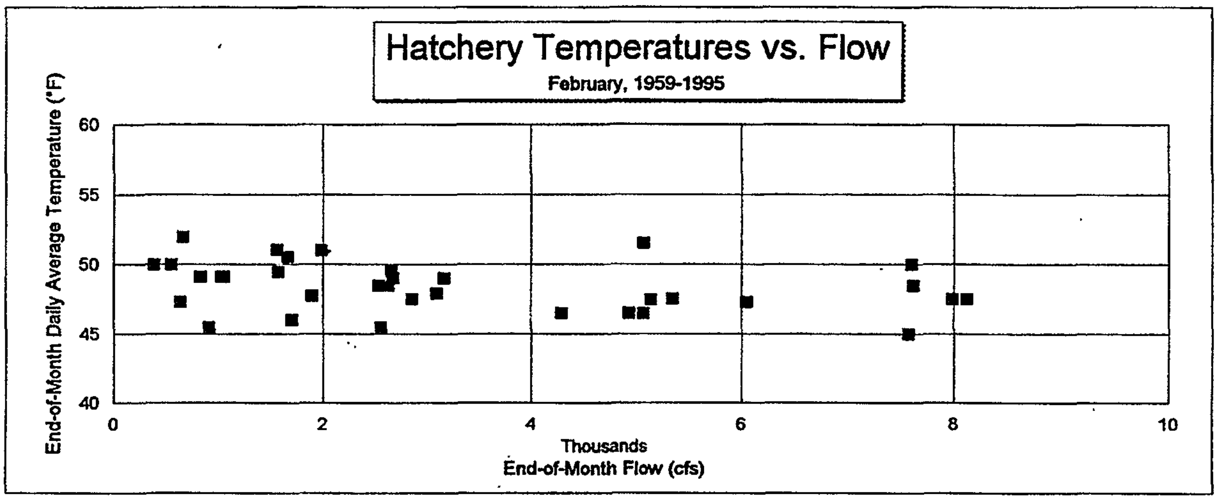
Figure 9.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of January for Water Years 1959-1995





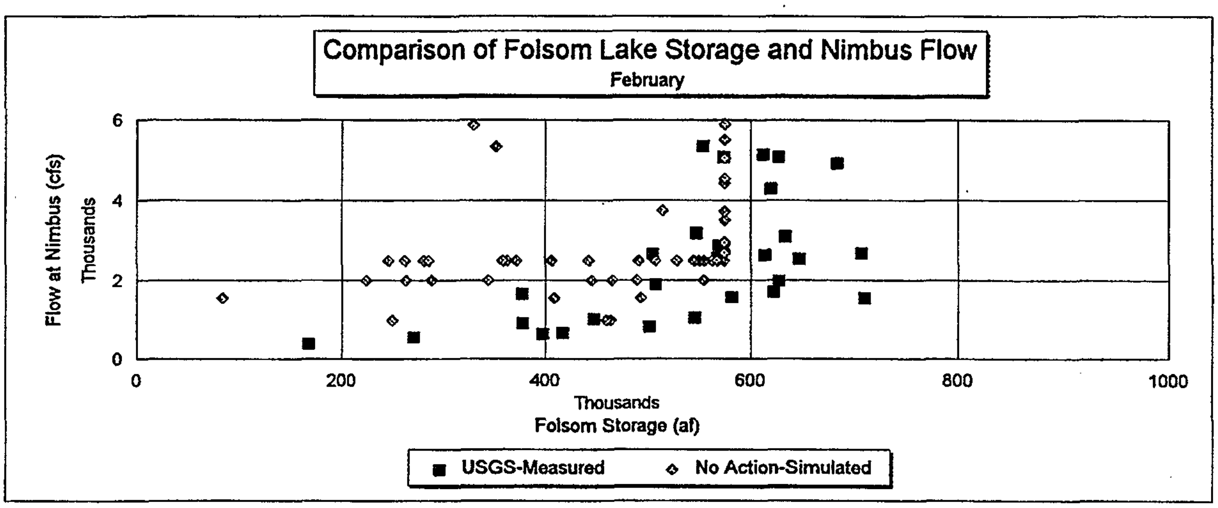


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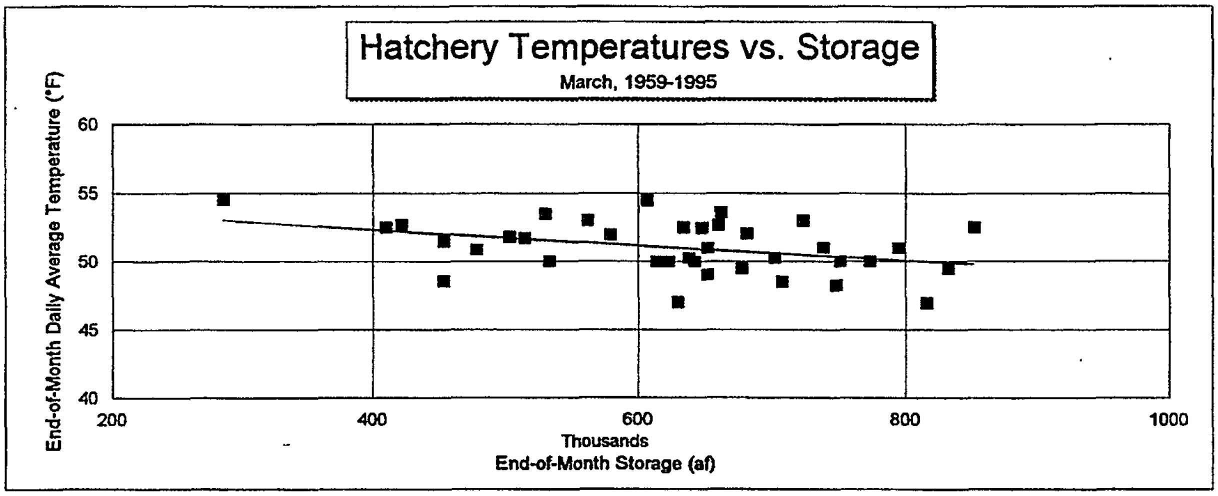
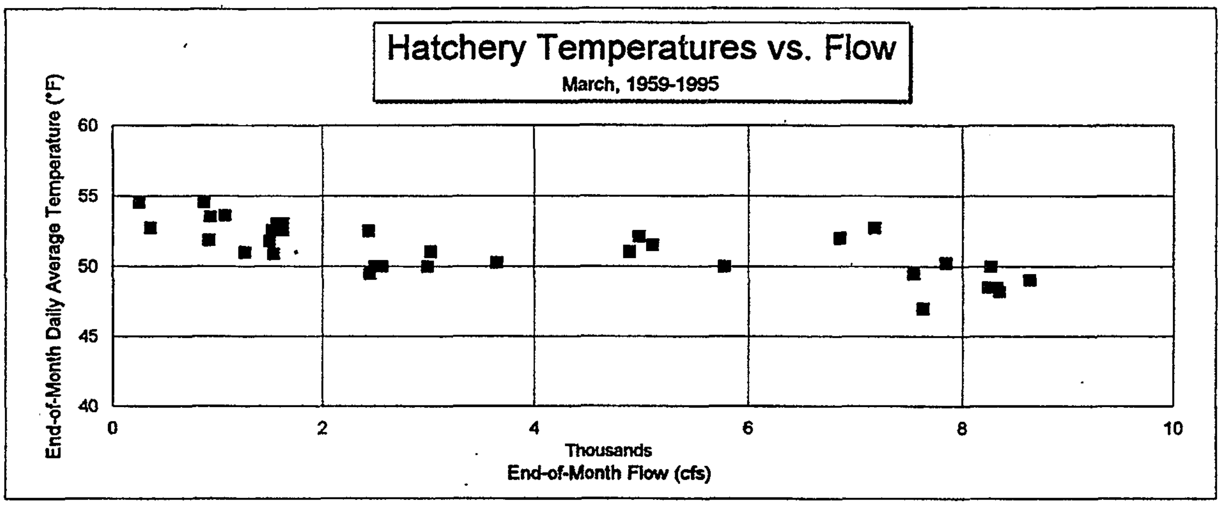
Figure 10.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of February for Water Years 1959-1995





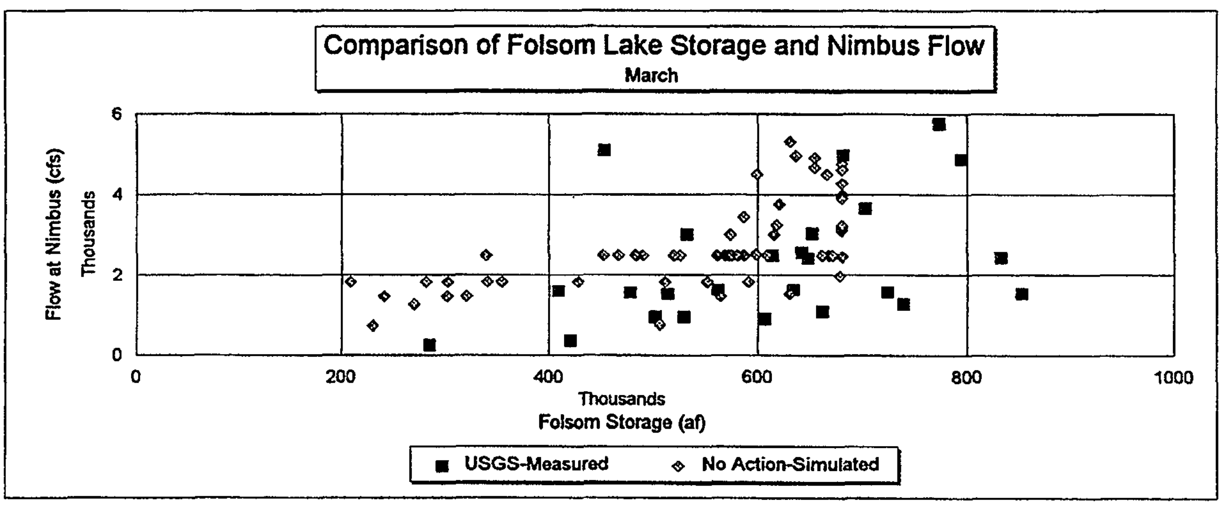


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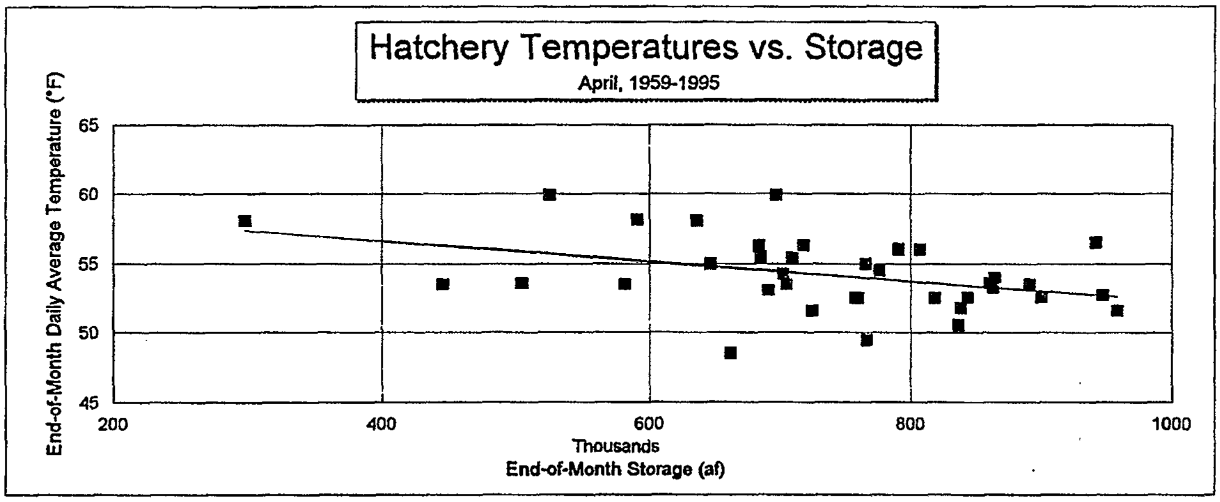
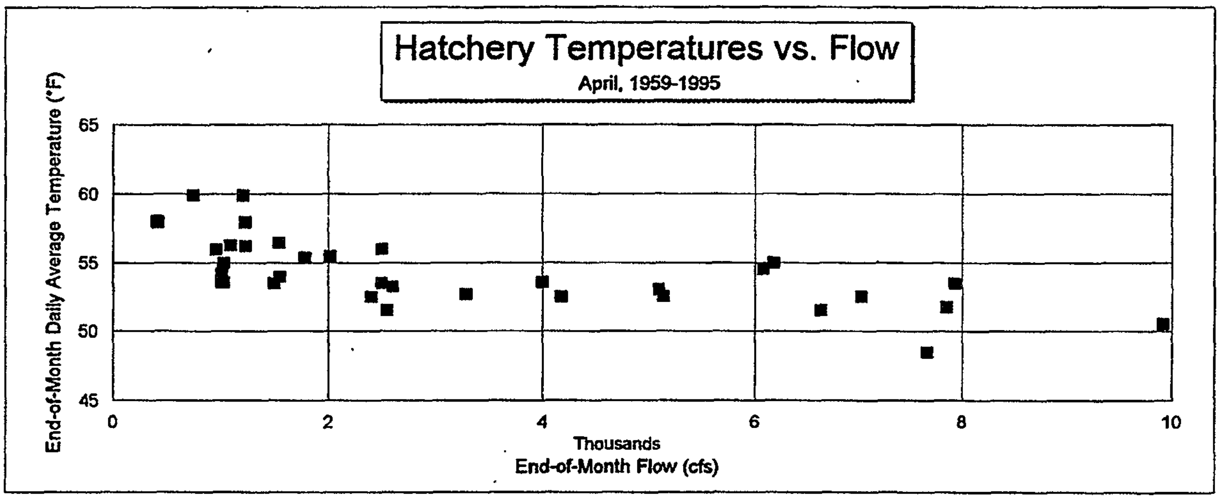
Figure 11.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of March for Water Years 1959-1995





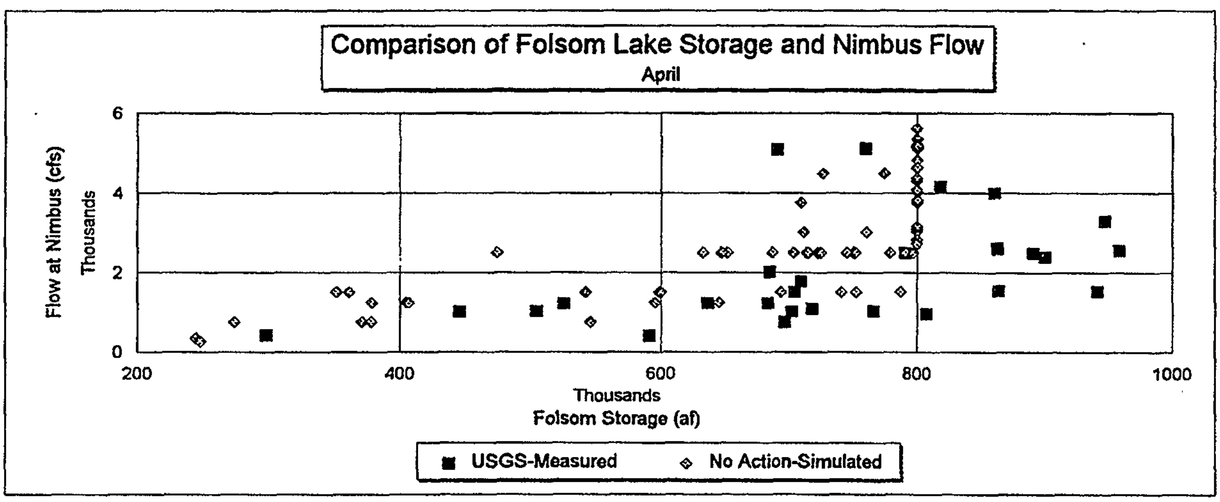


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Figure 12.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of April for Water Years 1959-1995

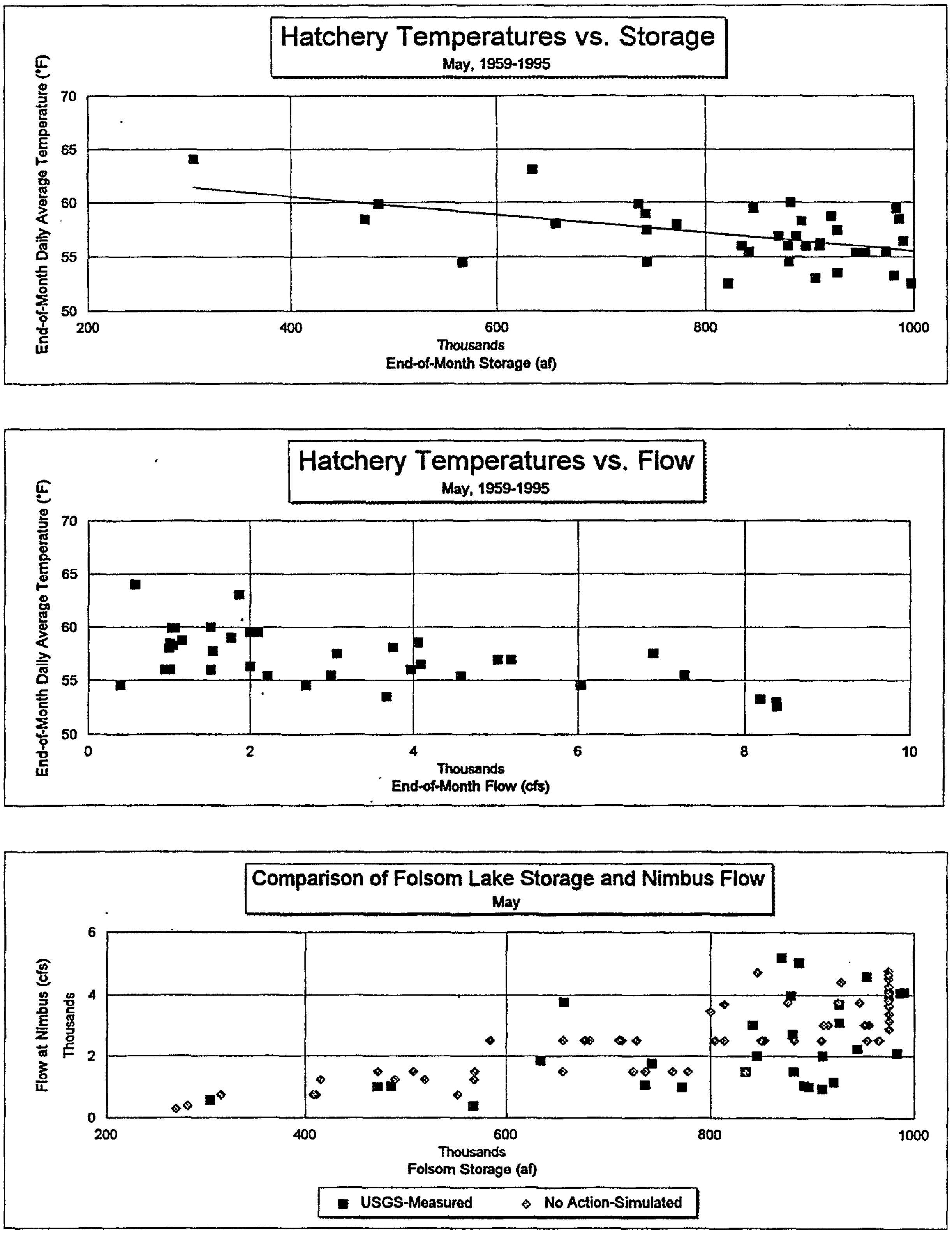

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Figure 13.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of May for Water Years 1959-1995

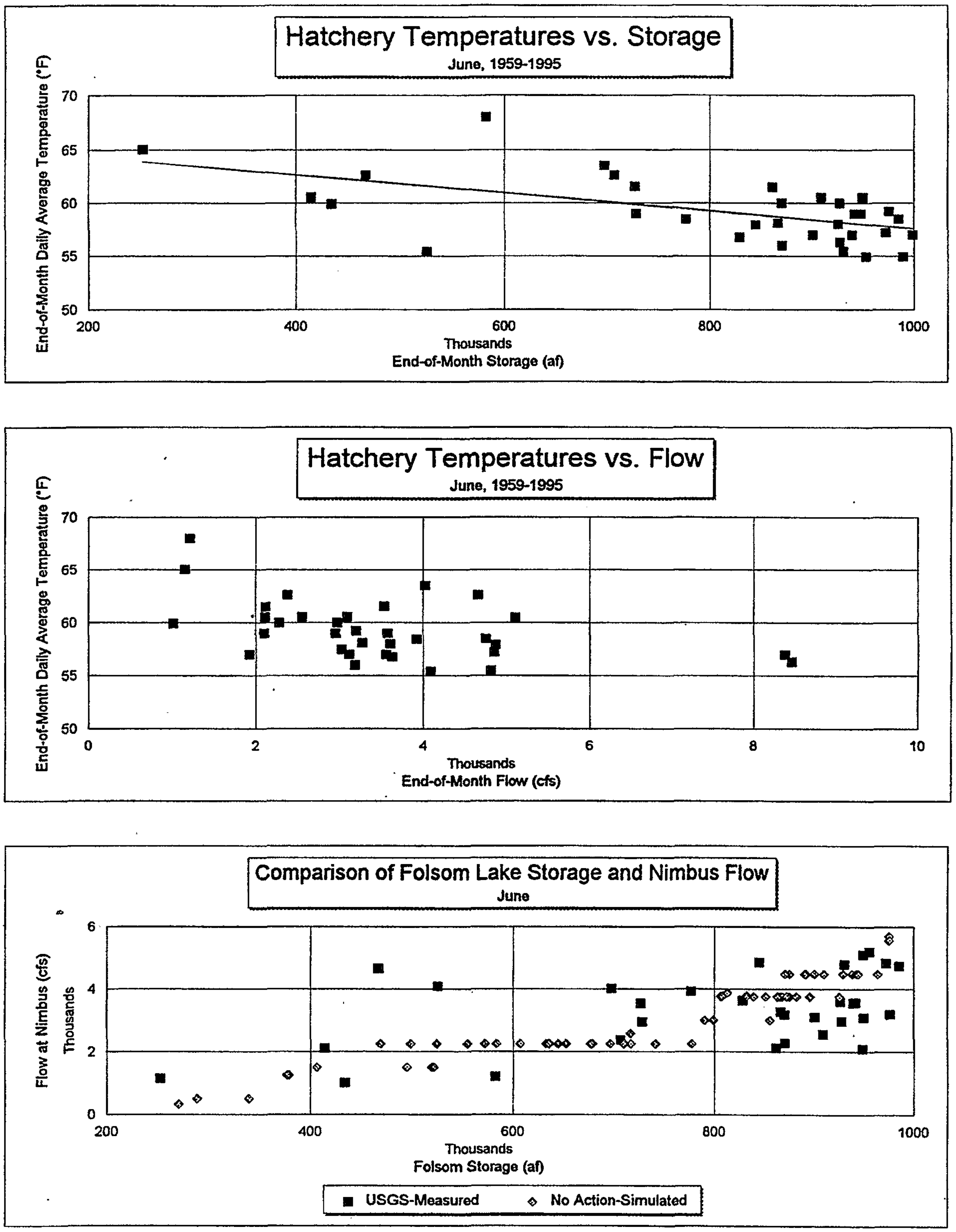

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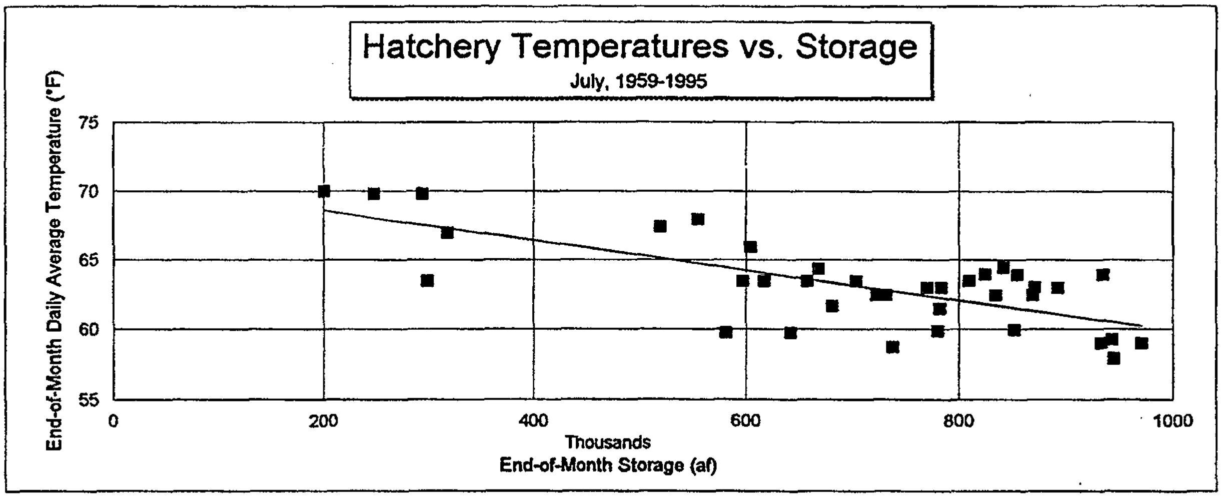
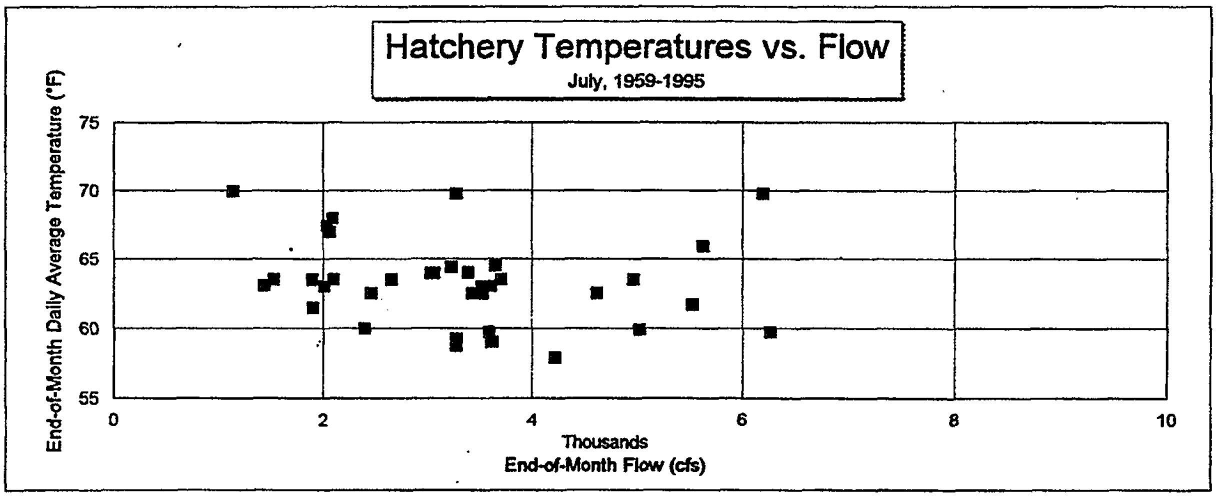
Figure 14.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of June for Water Years 1959-1995





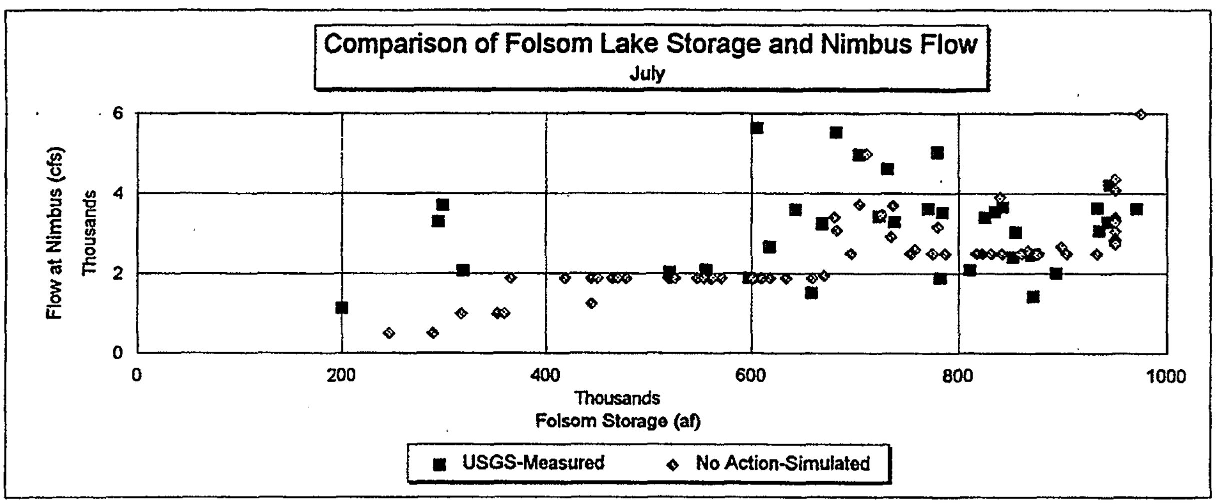


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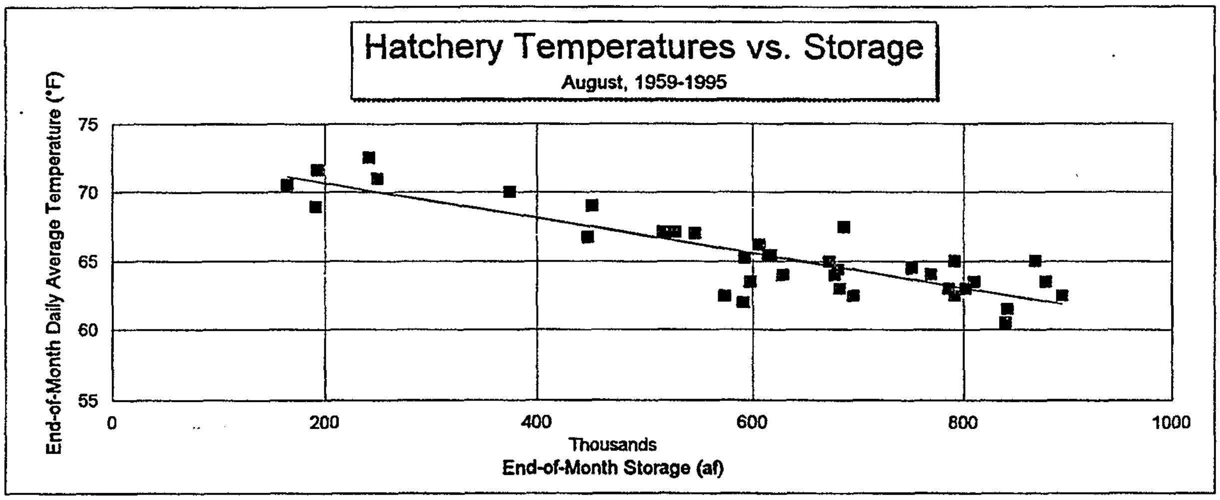
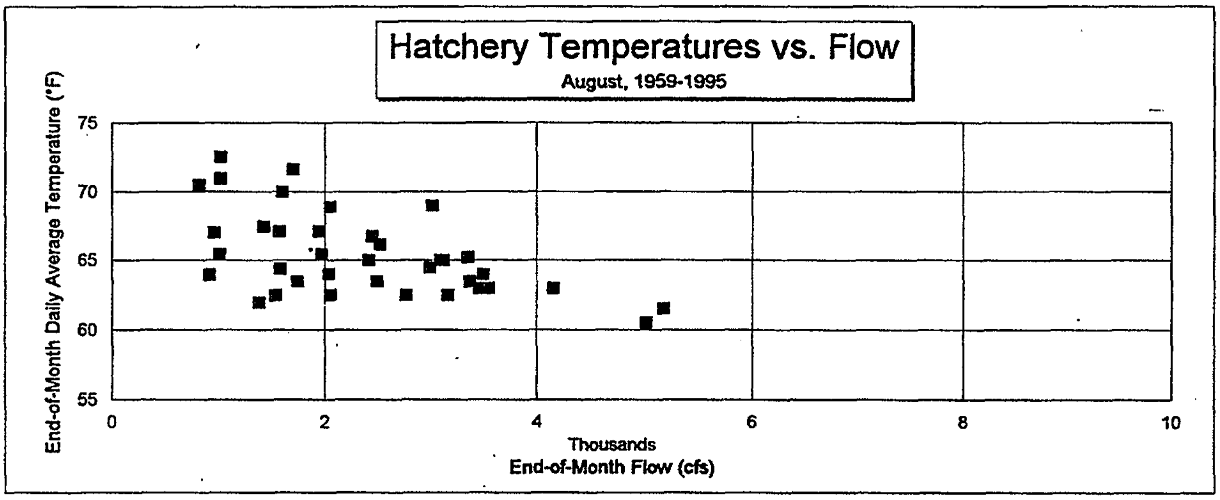
Figure 15.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of July for Water Years 1959-1995





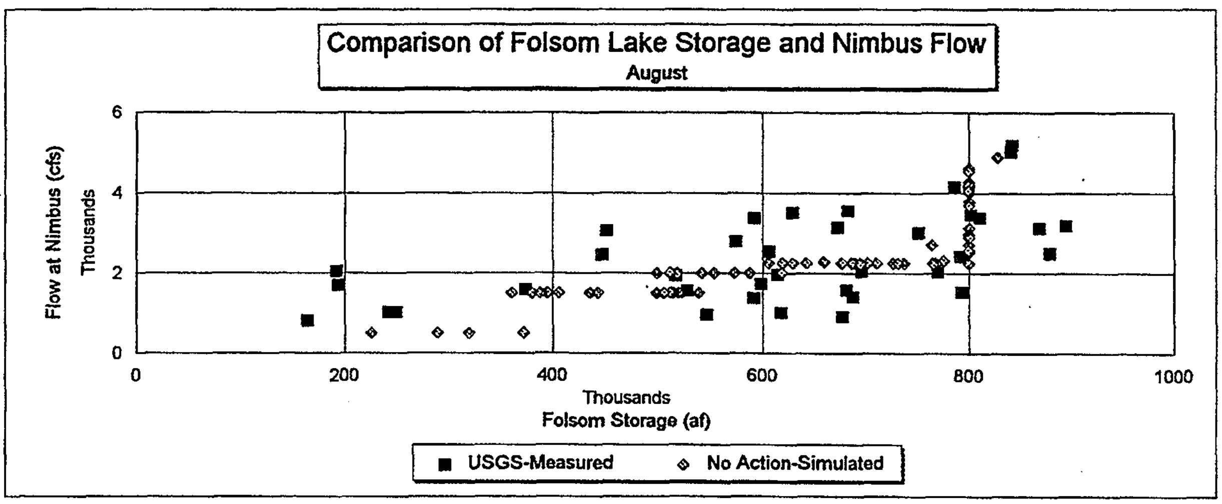


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Figure 16.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of August for Water Years 1959-1995

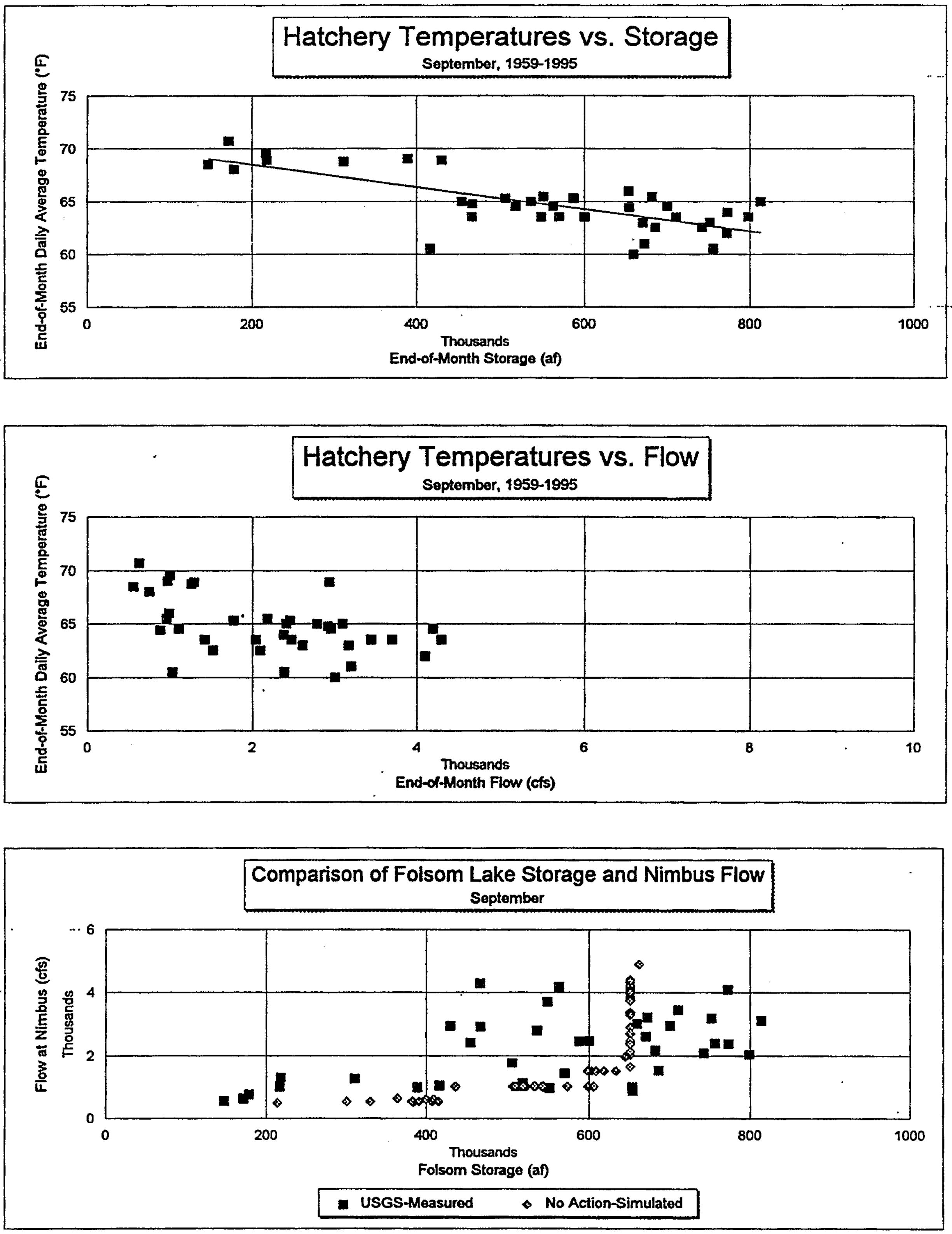

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Figure 17.
Comparison of Nimbus Hatchery Temperatures, Nimbus Flow, and Folsom Storage at the End of September for Water Years 1959-1995

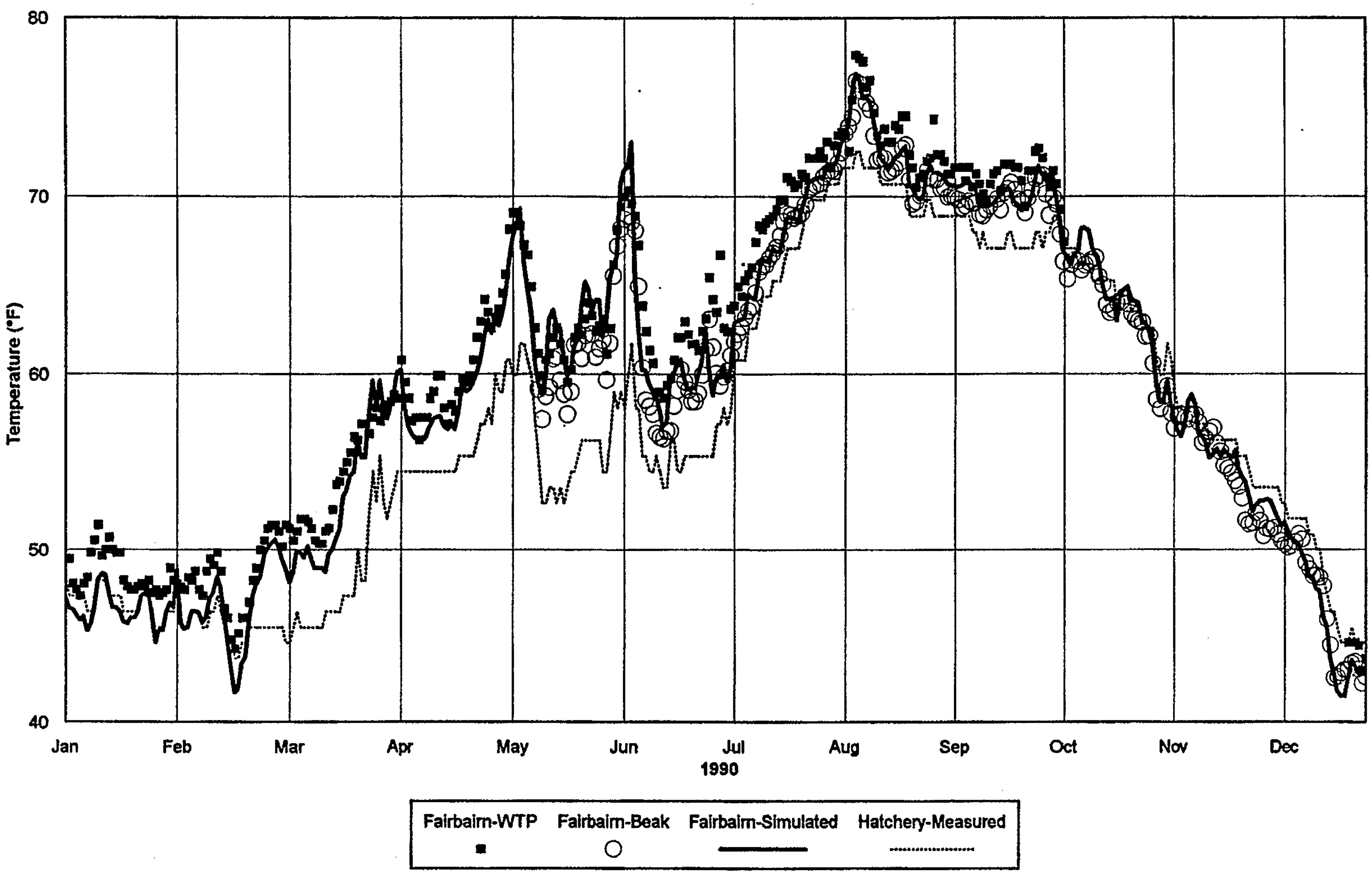

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Figure 18
Measured and Simulated Water Temperatures in the American River at the Fairbairn Water Treatment Plant for 1990

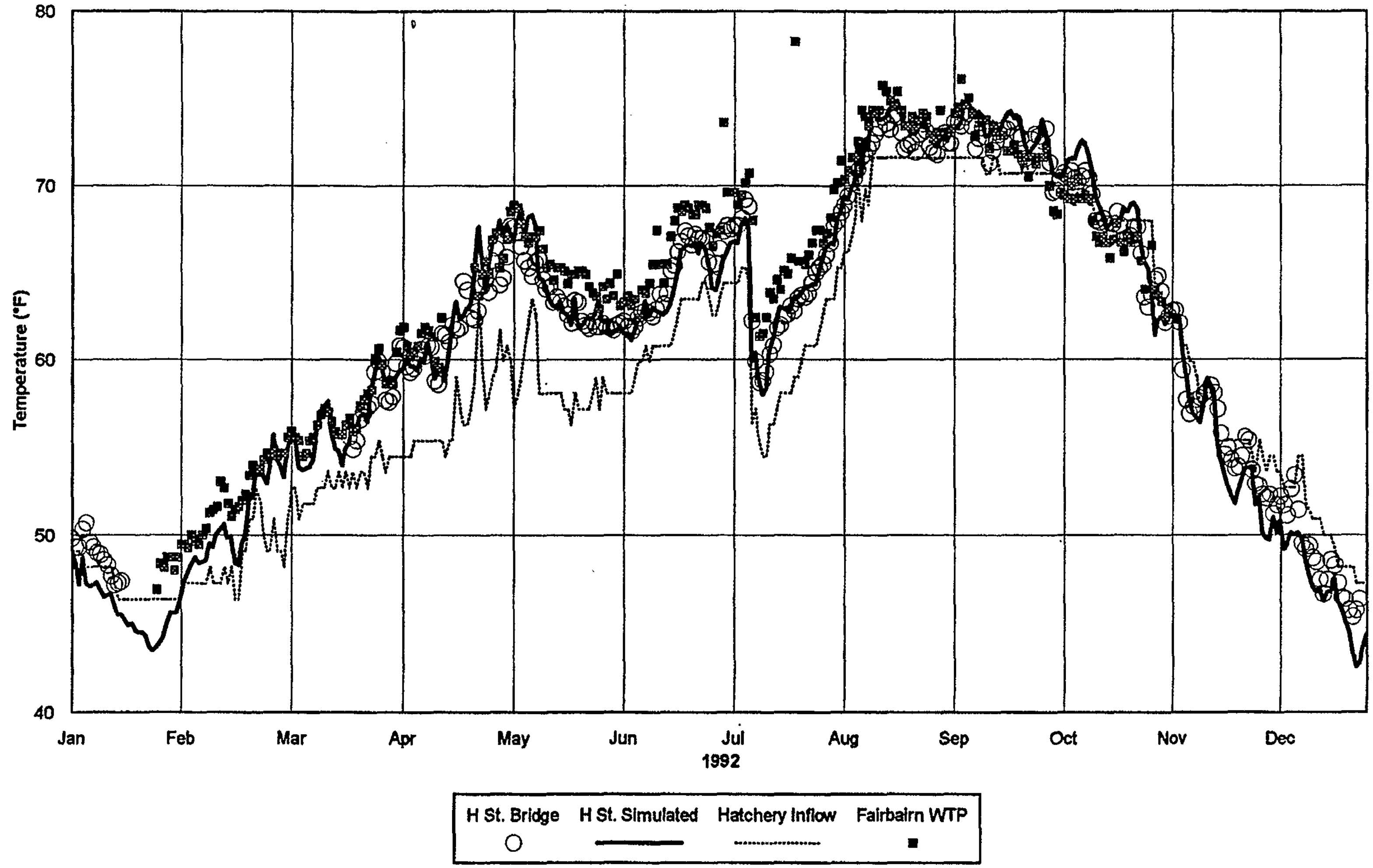

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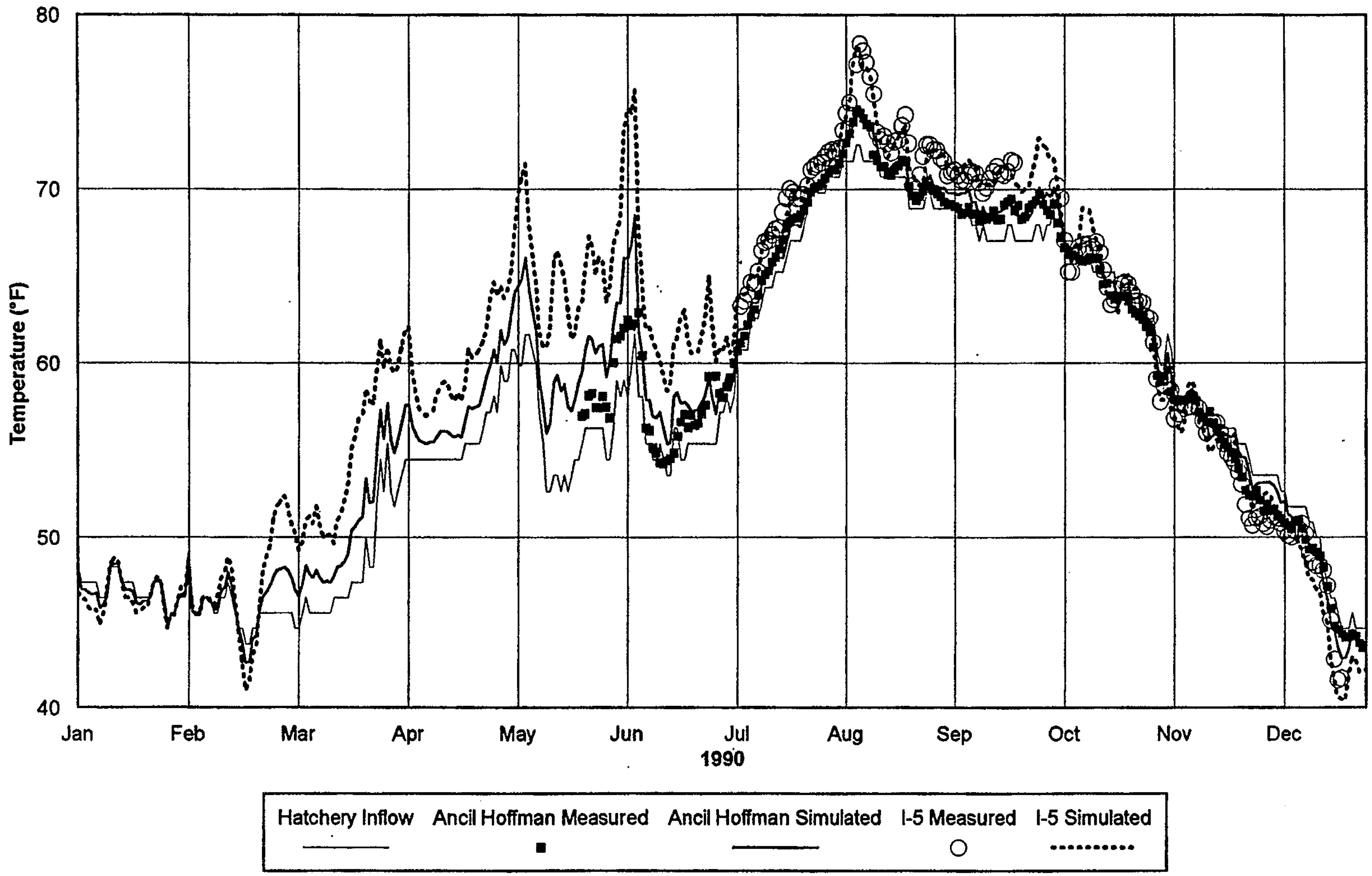
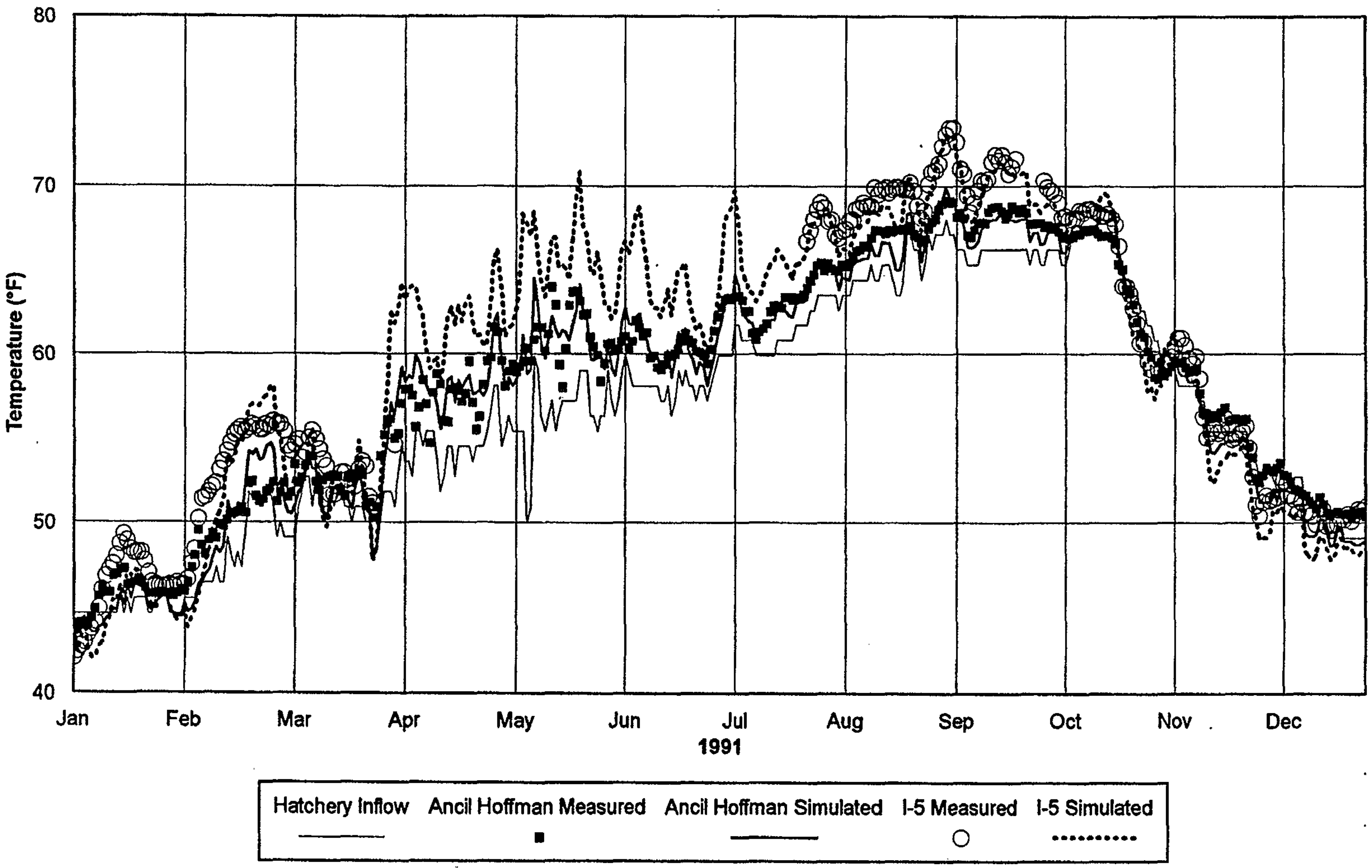
Figure 19

Measured and Simulated Water Temperatures in the American River at the H Street Bridge and the Fairbairn Water Treatment Plant for 1992



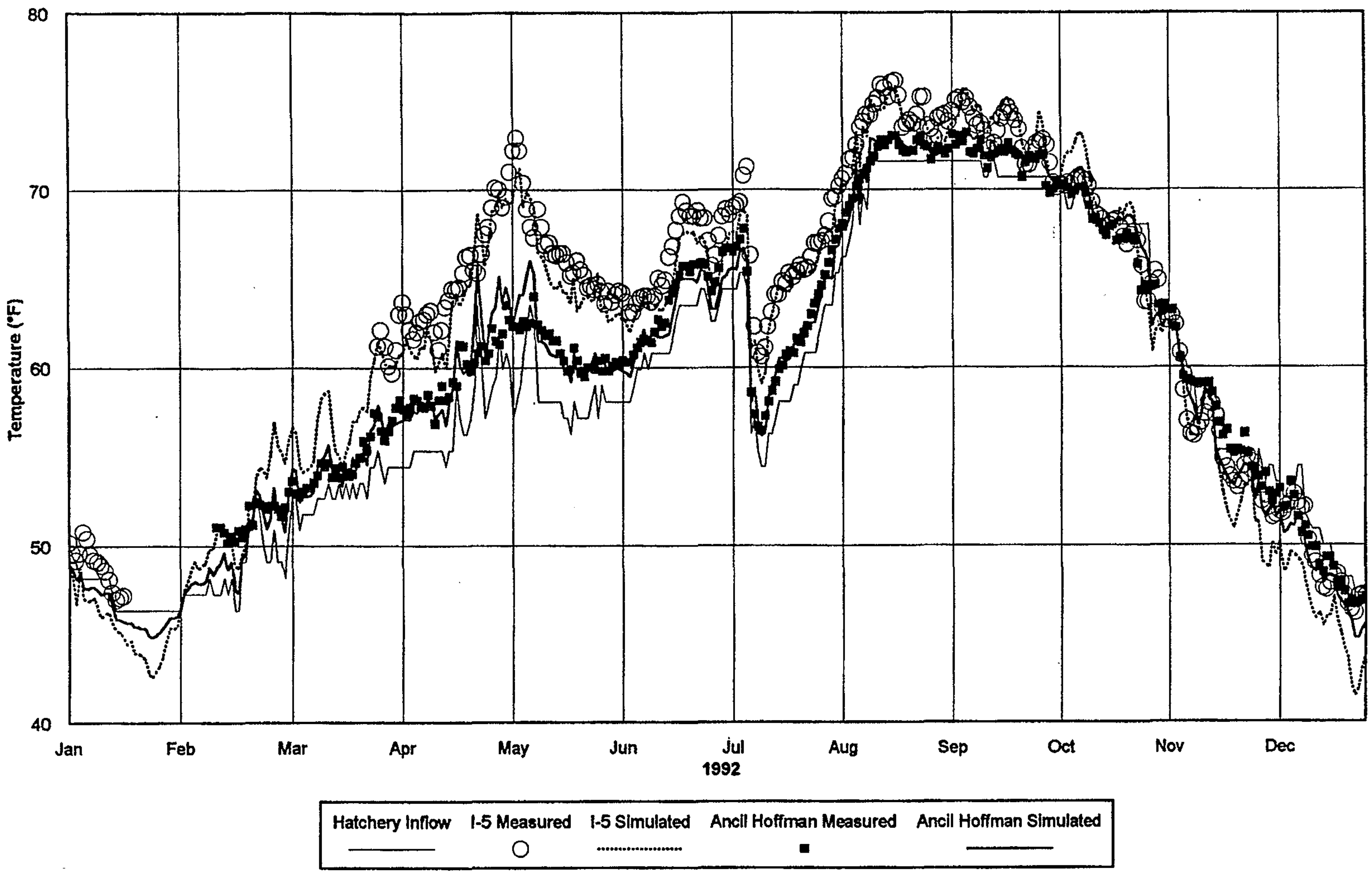
Jones & Stokes Associates, Inc.

Figure 20
Measured and Simulated Water Temperatures in the American River at Ancil Hoffman Park and the Interstate 5 Bridge for 1990



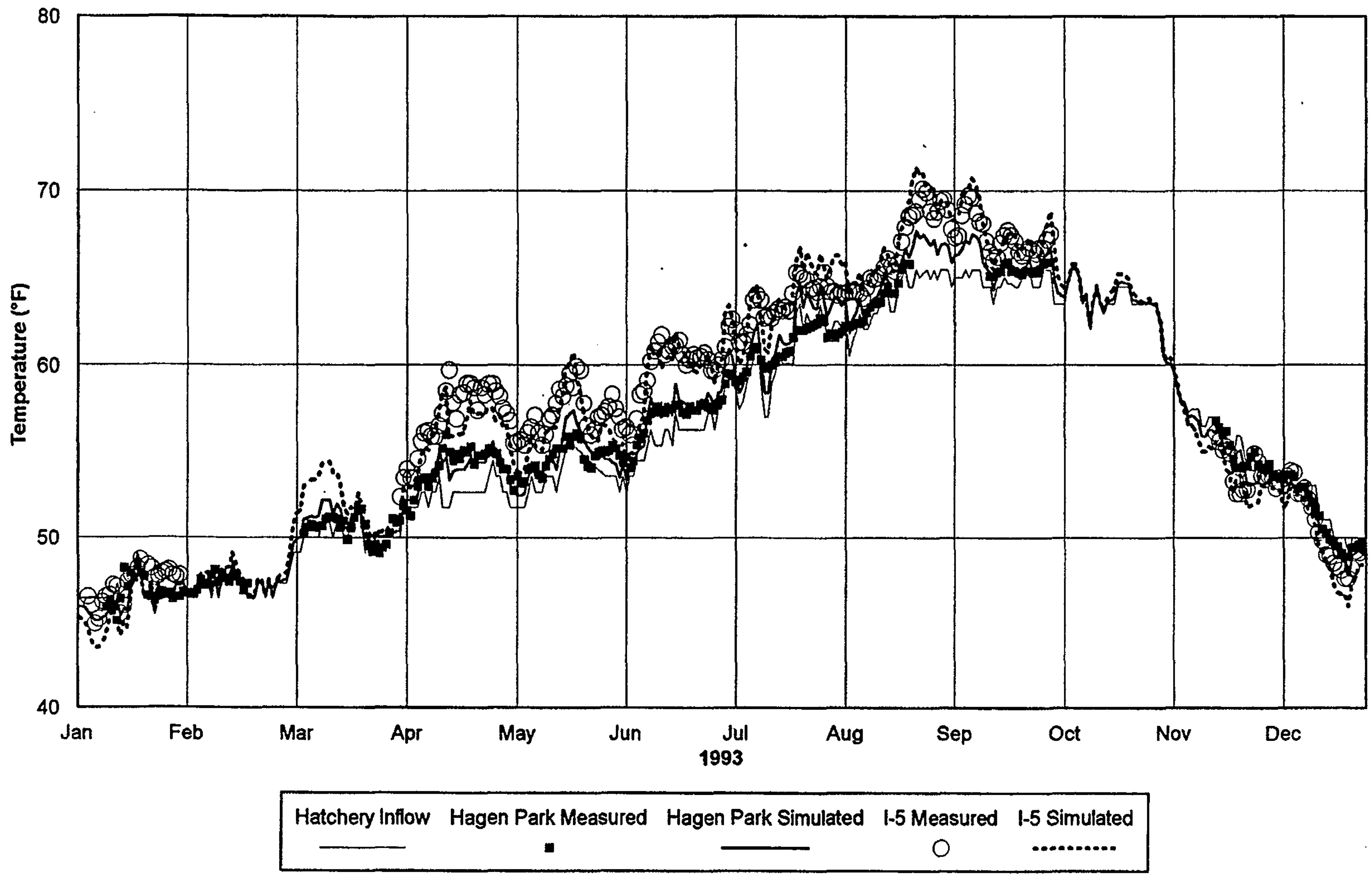
Jones & Stokes Associates, Inc.

Figure 21
Measured and Simulated Water Temperatures in the American River at Ancil Hoffman Park and the Interstate 5 Bridge for 1991



Jones & Stokes Associates, Inc.

Figure 22
Measured and Simulated Water Temperatures in the American River at the Interstate 5 Bridge and Ancil Hoffman Park for 1992



Jones & Stokes Associates, Inc.

Figure 23
Measured and Simulated Water Temperatures in the American River at Hagen Park and the Interstate 5 Bridge for 1993

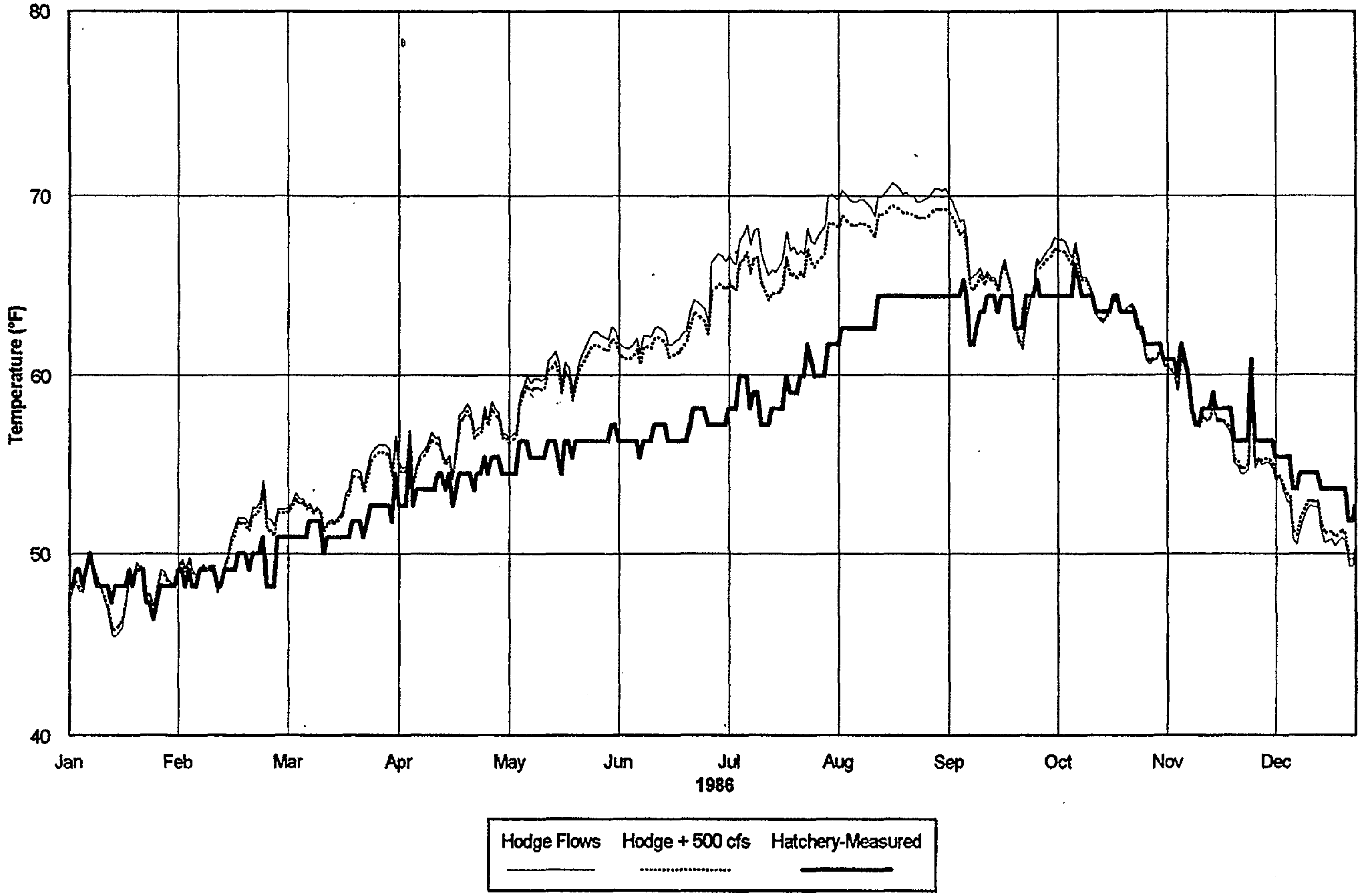


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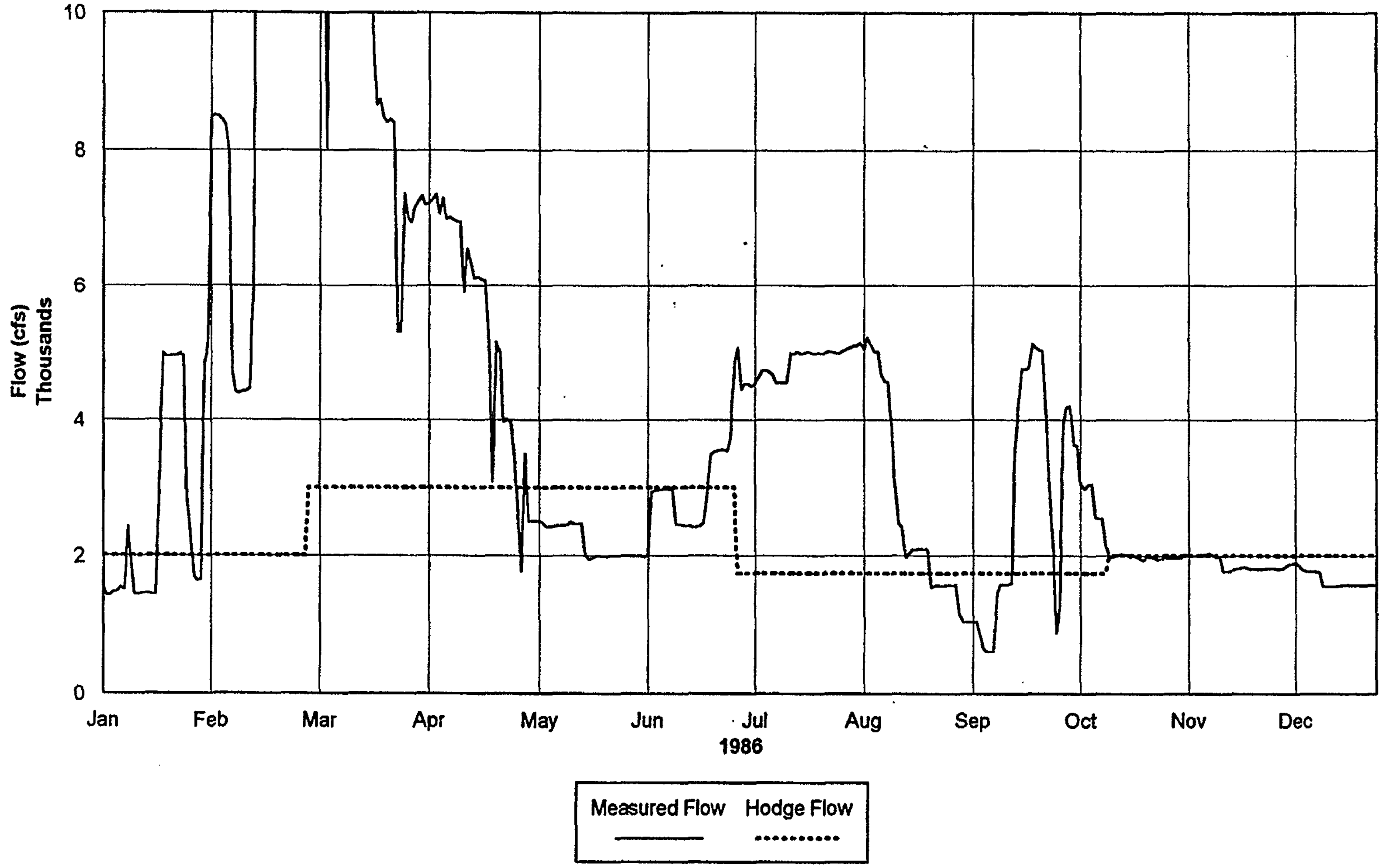
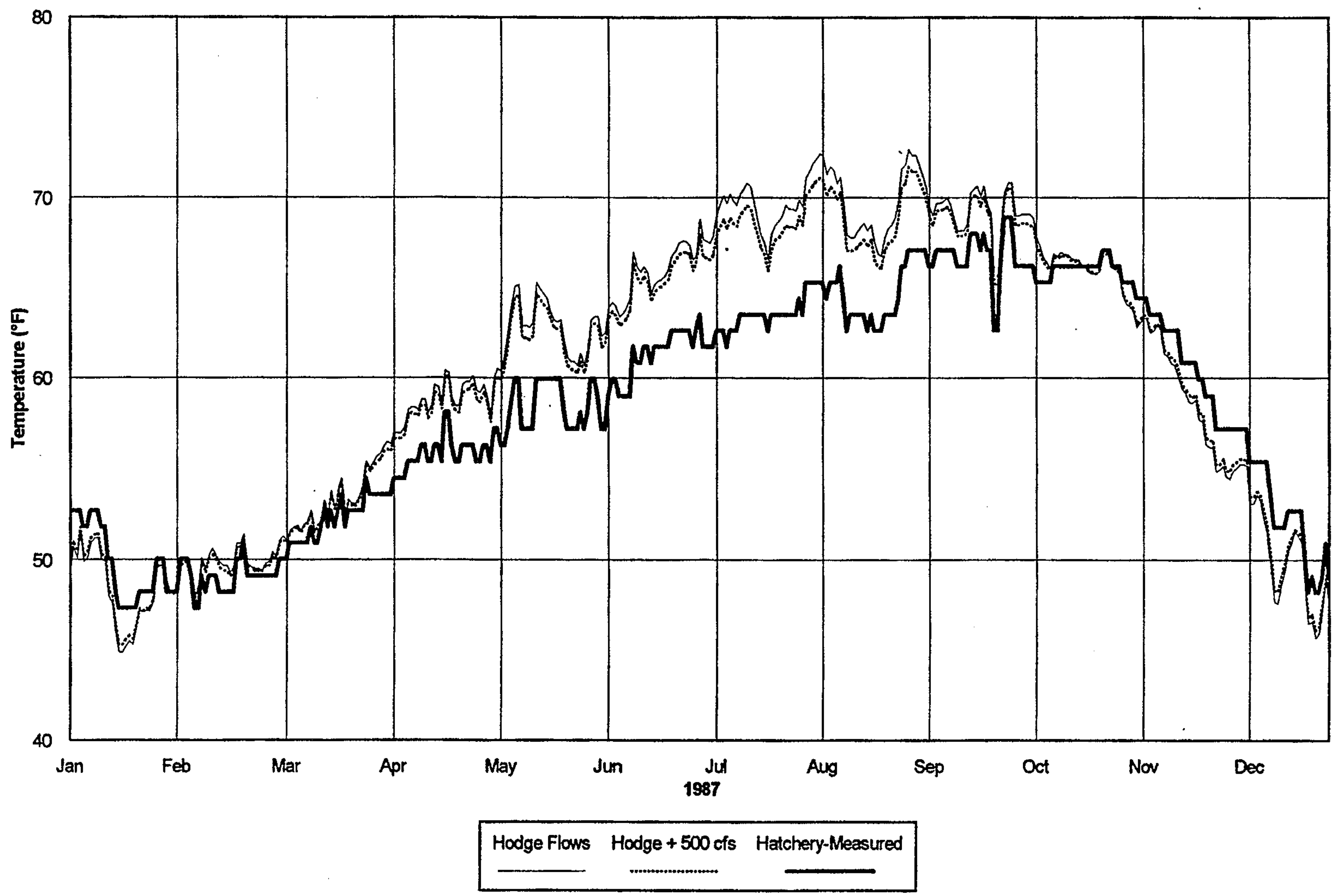
Figure 25
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1986

C—085235



Jones & Stokes Associates, Inc.

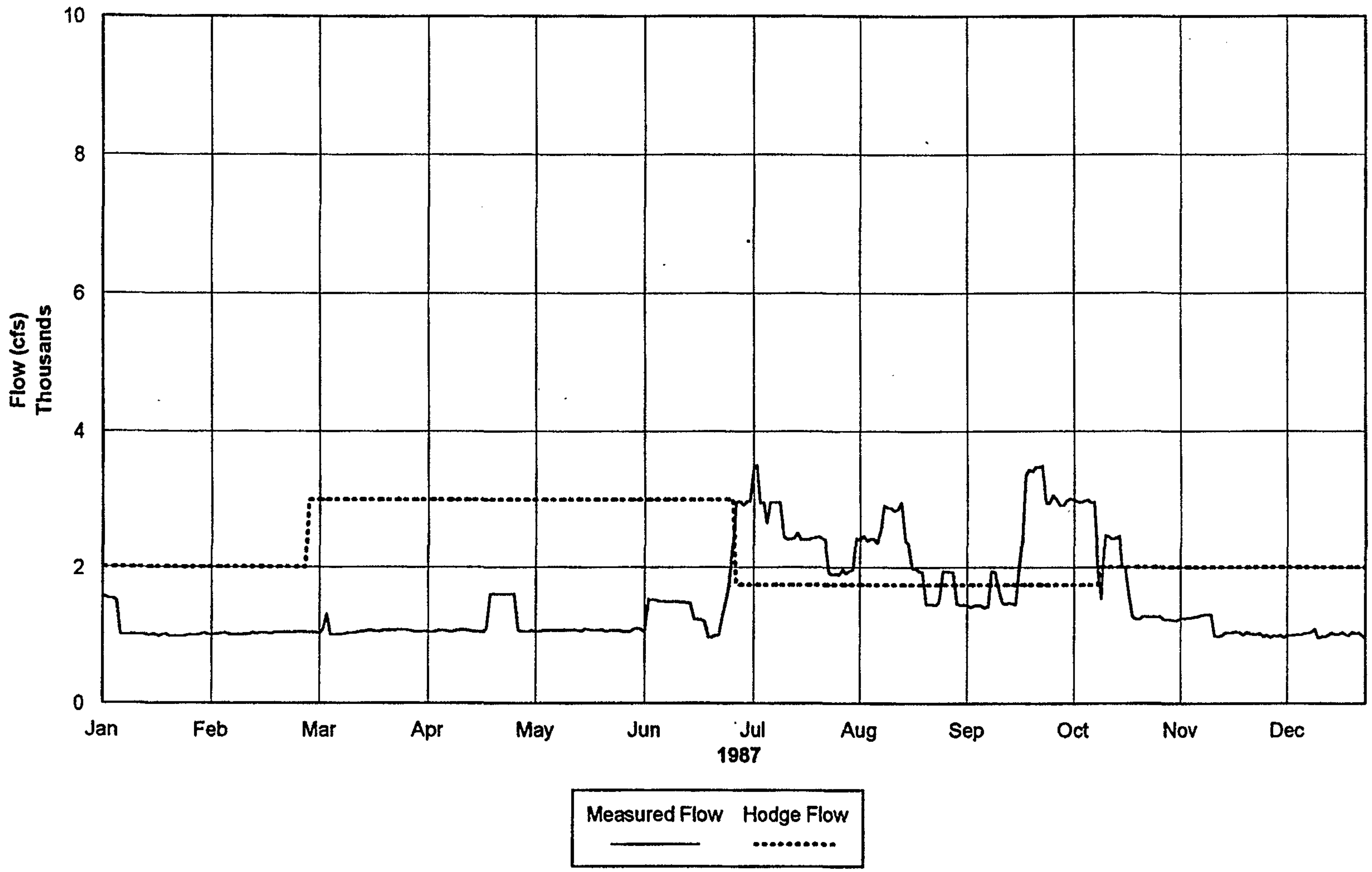
Figure 26
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1986



Jones & Stokes Associates, Inc.

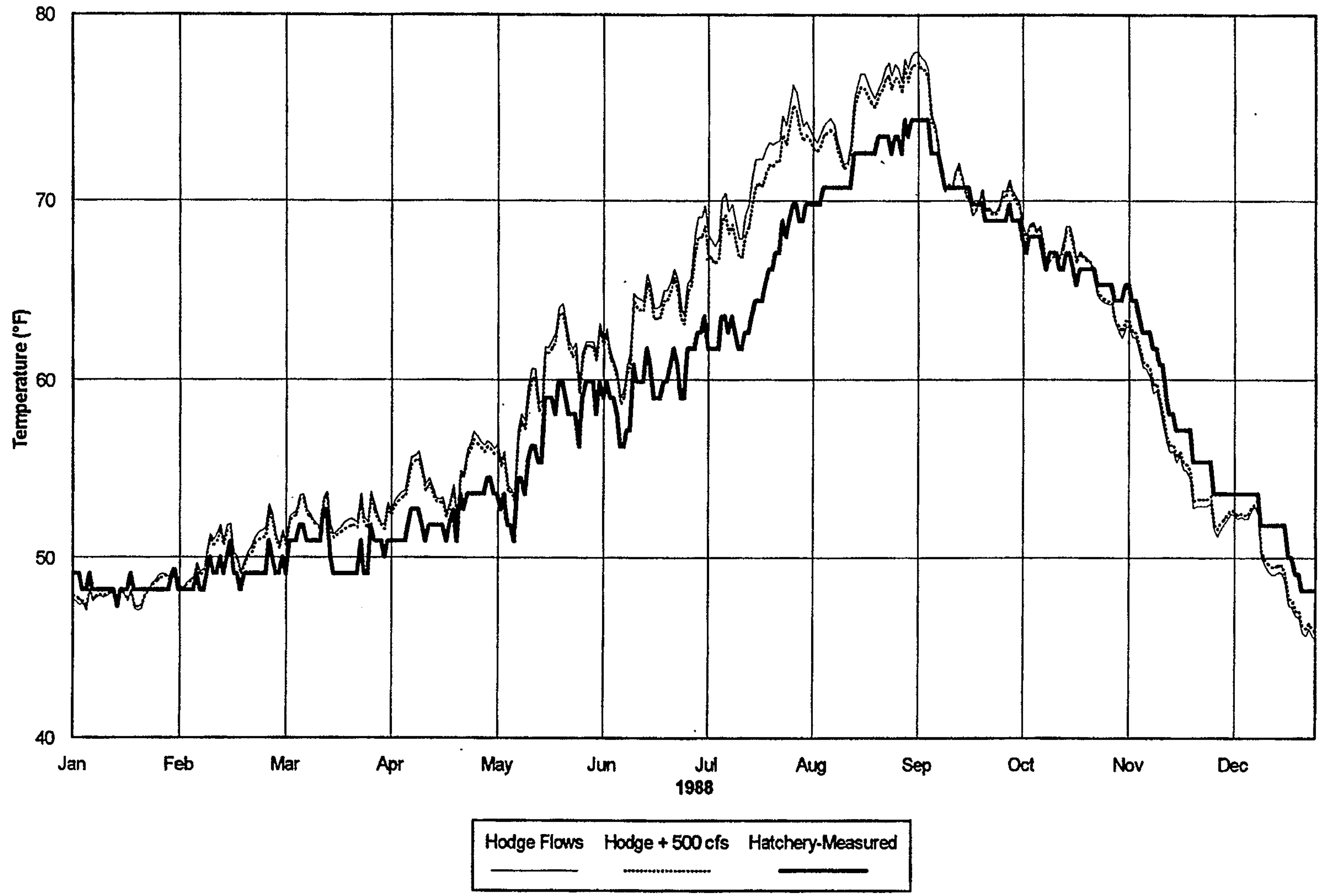
Figure 27
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1987

C-085237



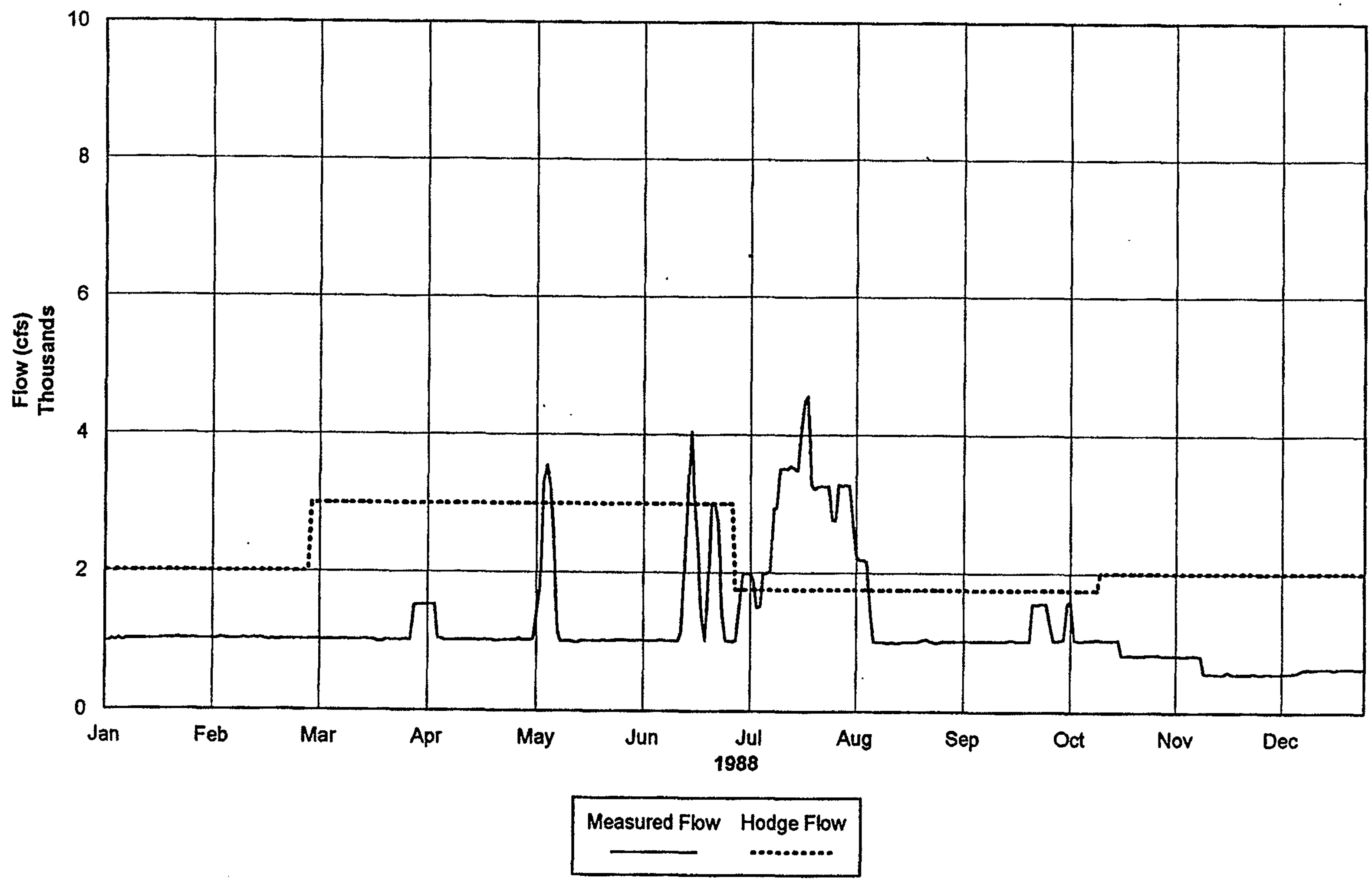
Jones & Stokes Associates, Inc.

Figure 28
Hodge Flows Compared to Flows Measured at Fair Oaks in 1987



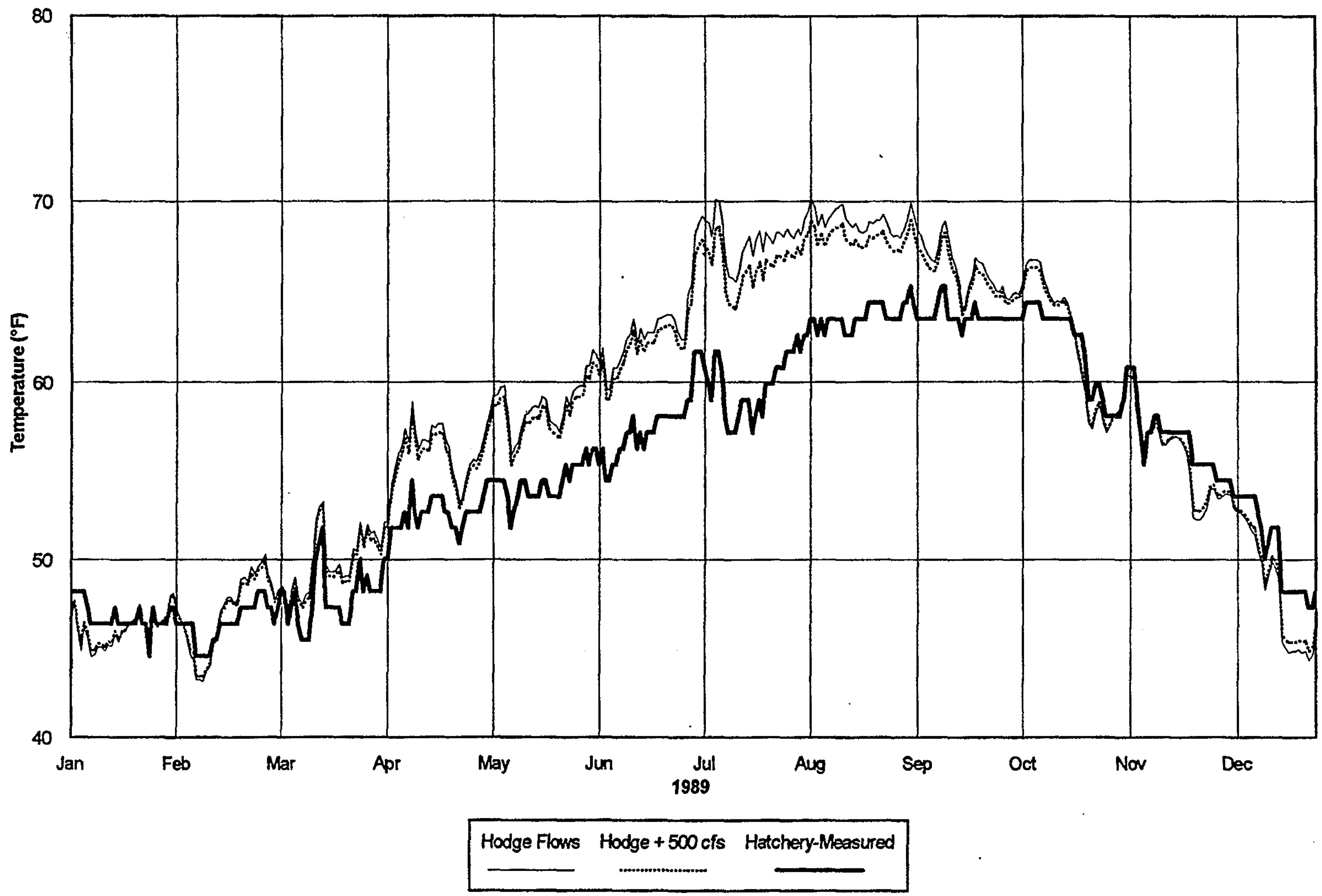
Jones & Stokes Associates, Inc.

Figure 29
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1988



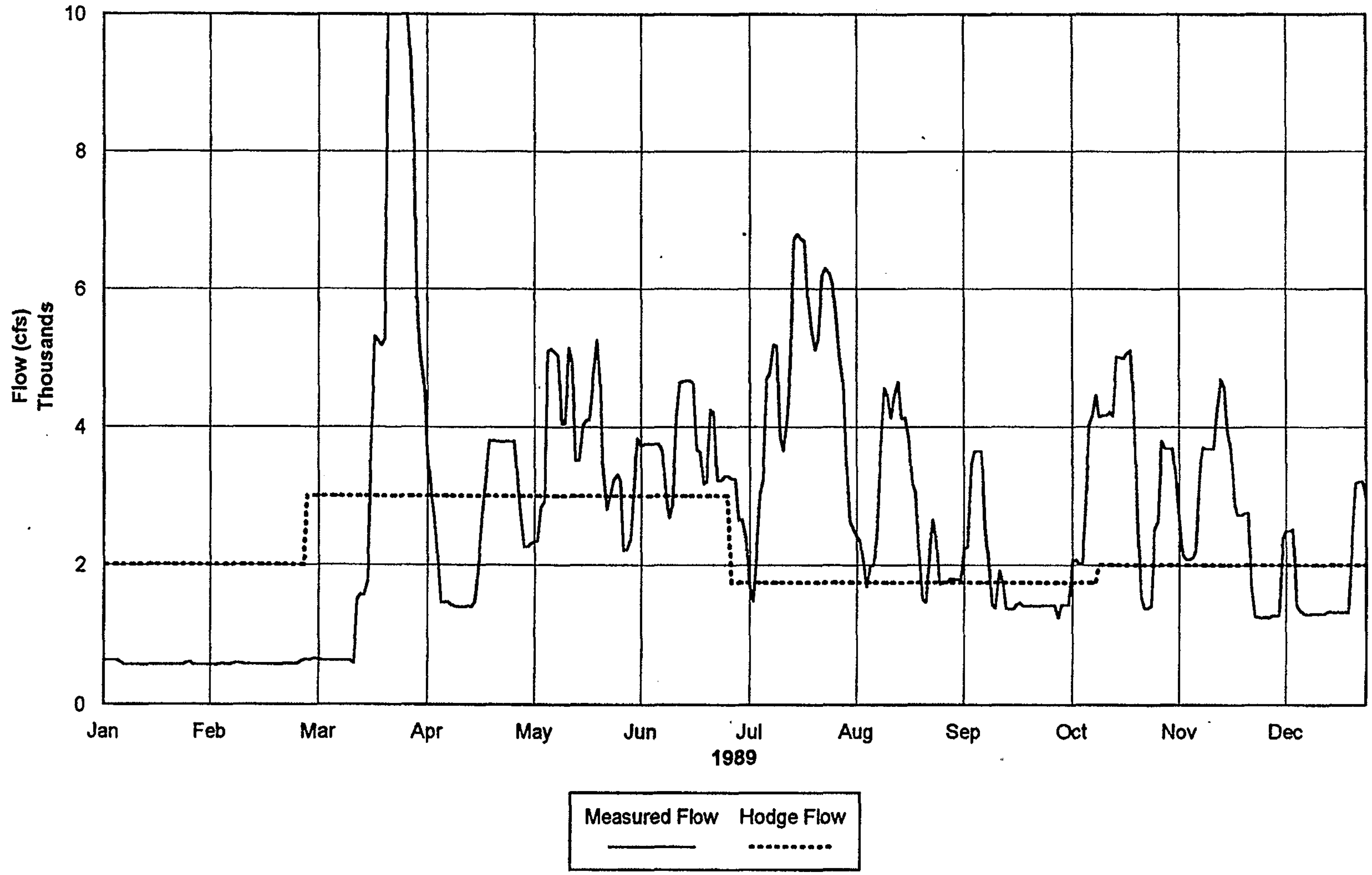
Jones & Stokes Associates, Inc.

Figure 30
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1988



Jones & Stokes Associates, Inc.

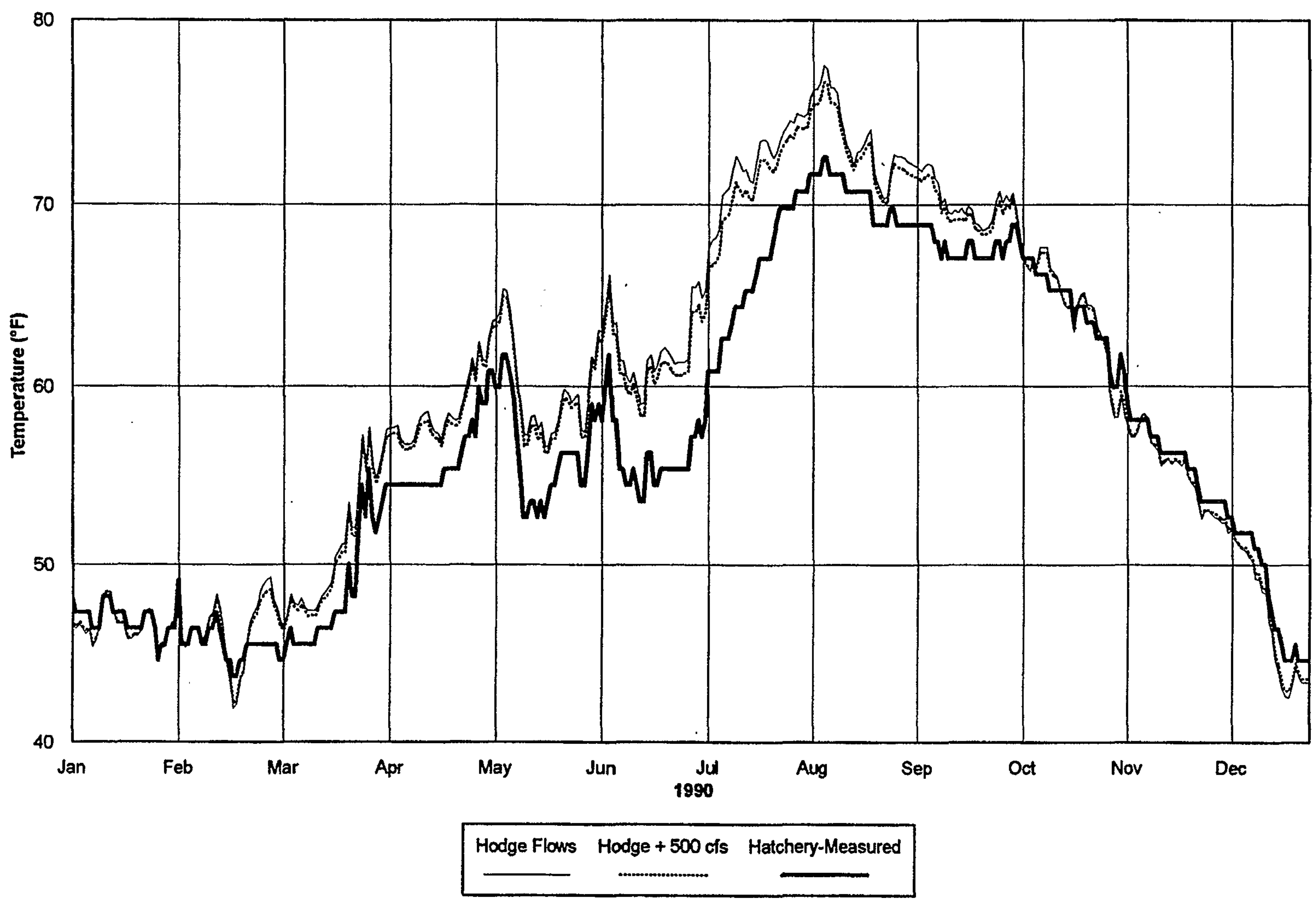
Figure 31
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1989



Jones & Stokes Associates, Inc.

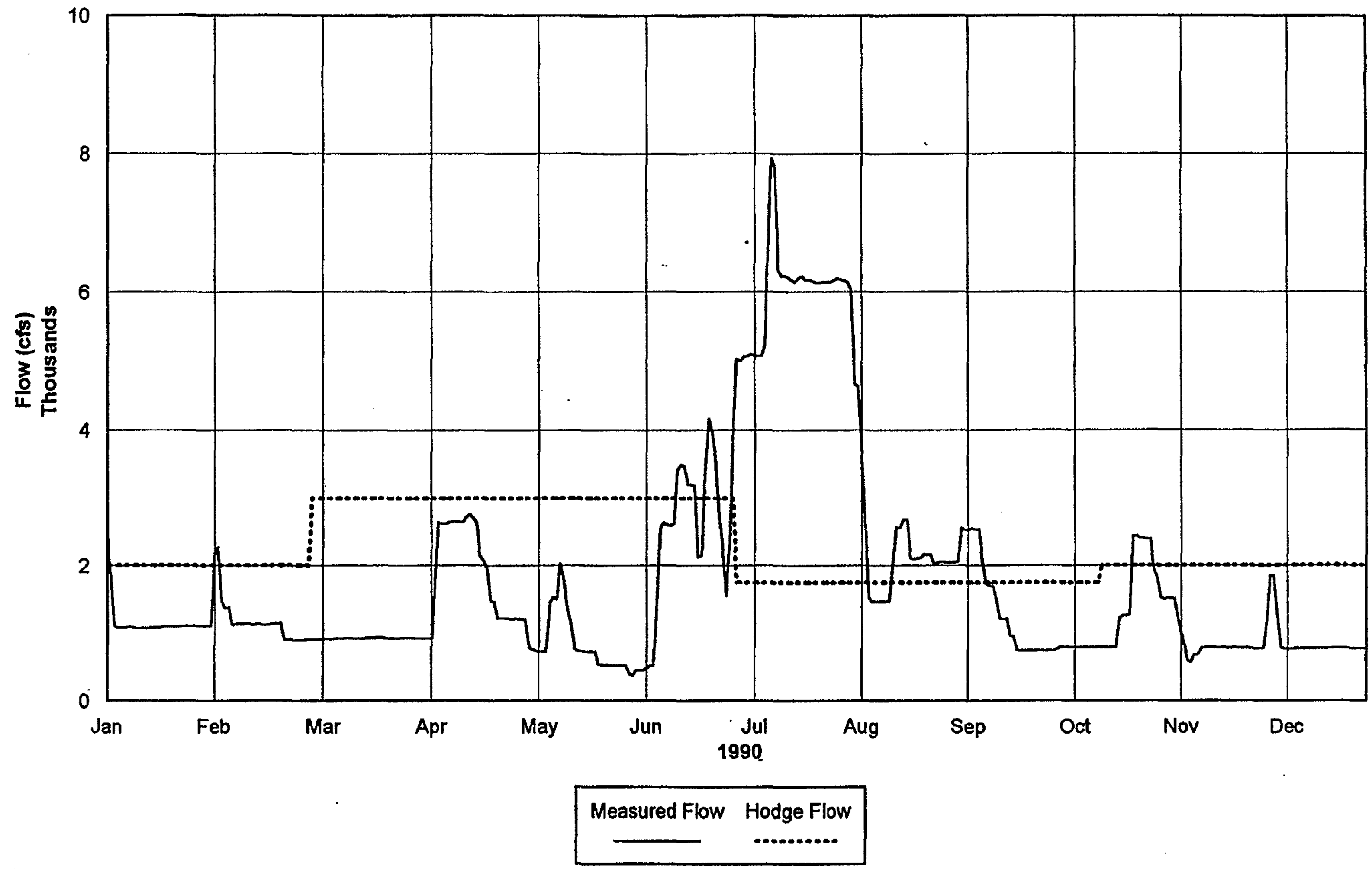
Figure 32
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1989

C-085242



Jones & Stokes Associates, Inc.

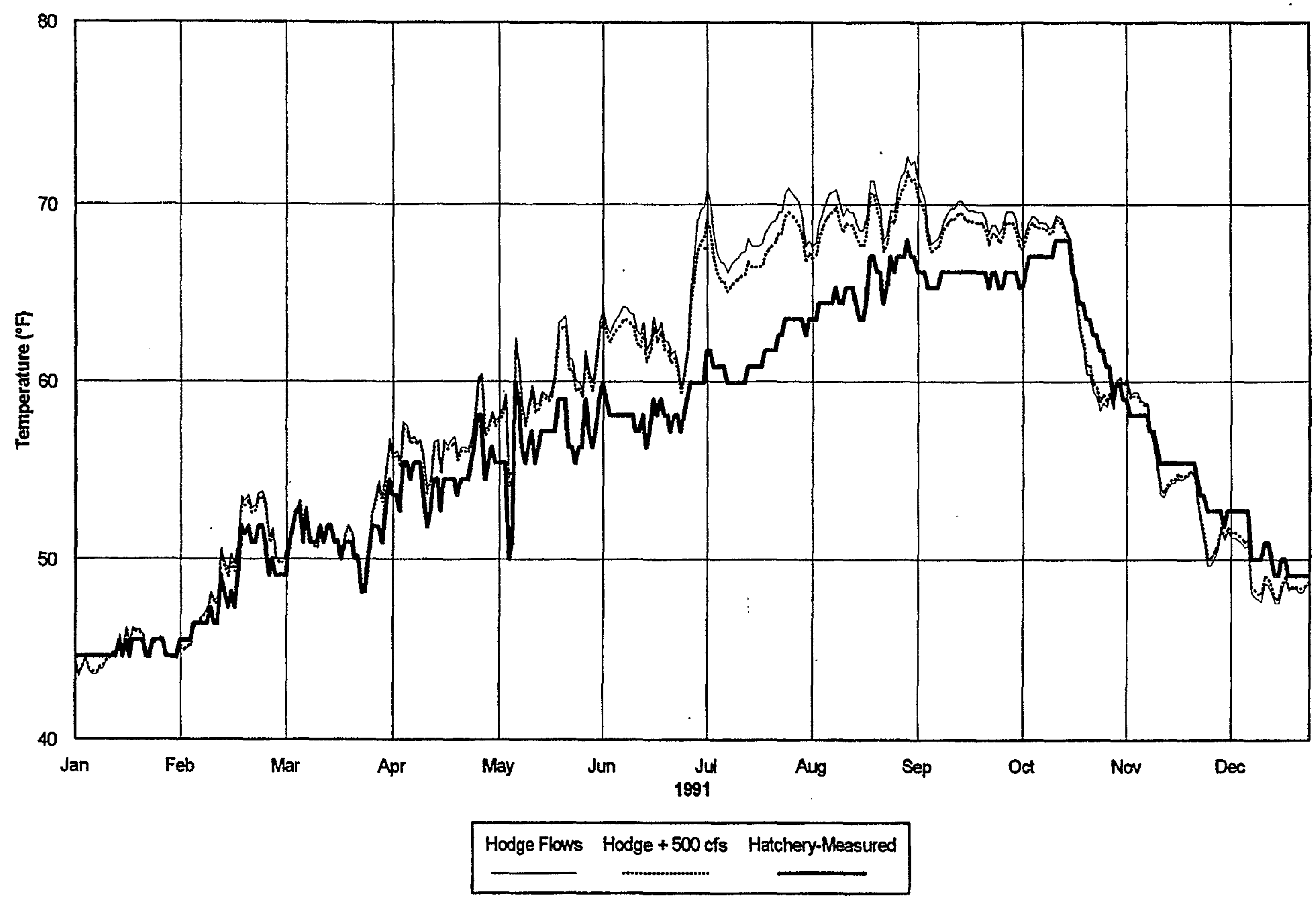
Figure 33
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1990



Jones & Stokes Associates, Inc.

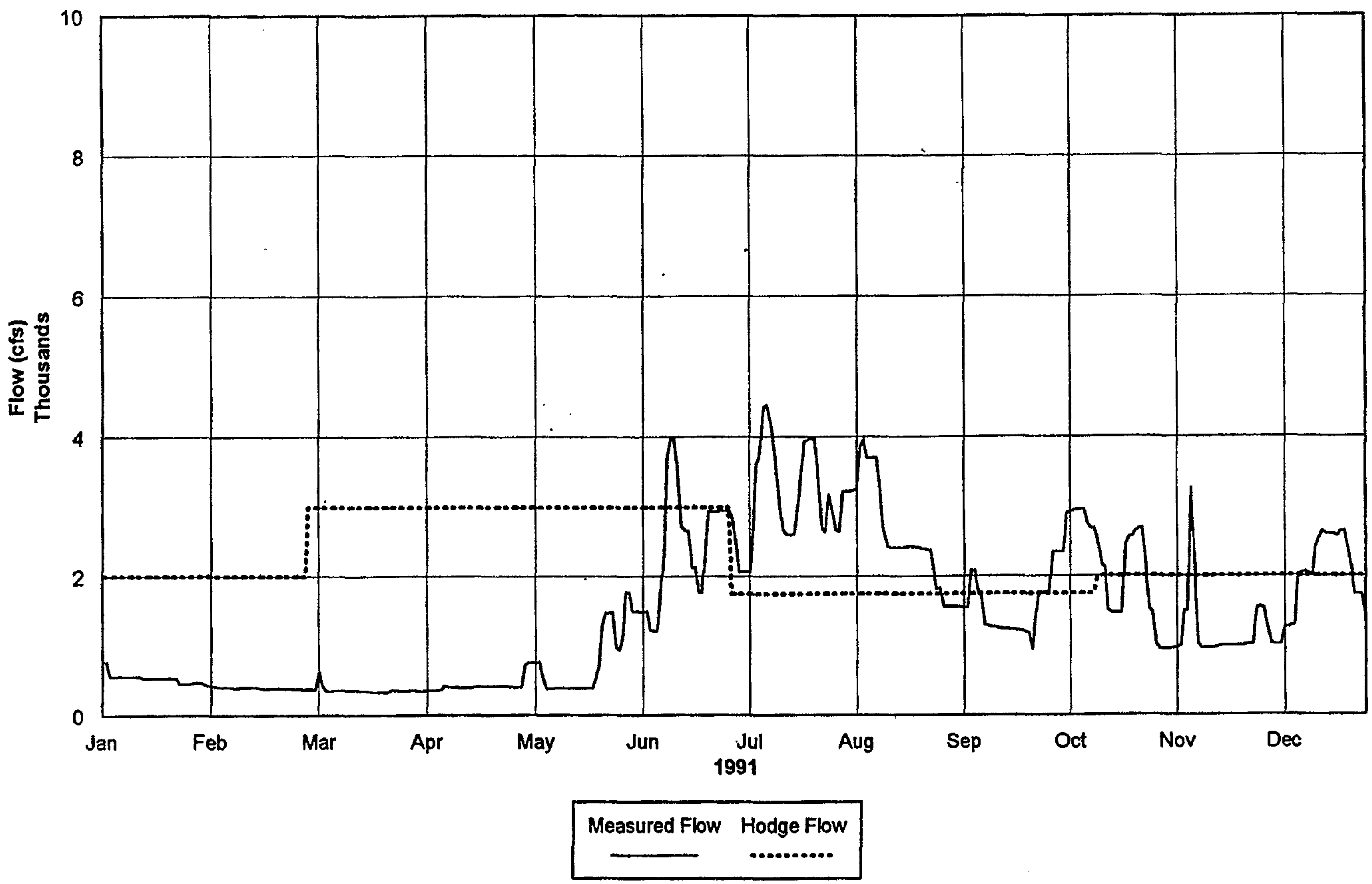
Figure 34
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1990

C-085244



Jones & Stokes Associates, Inc.

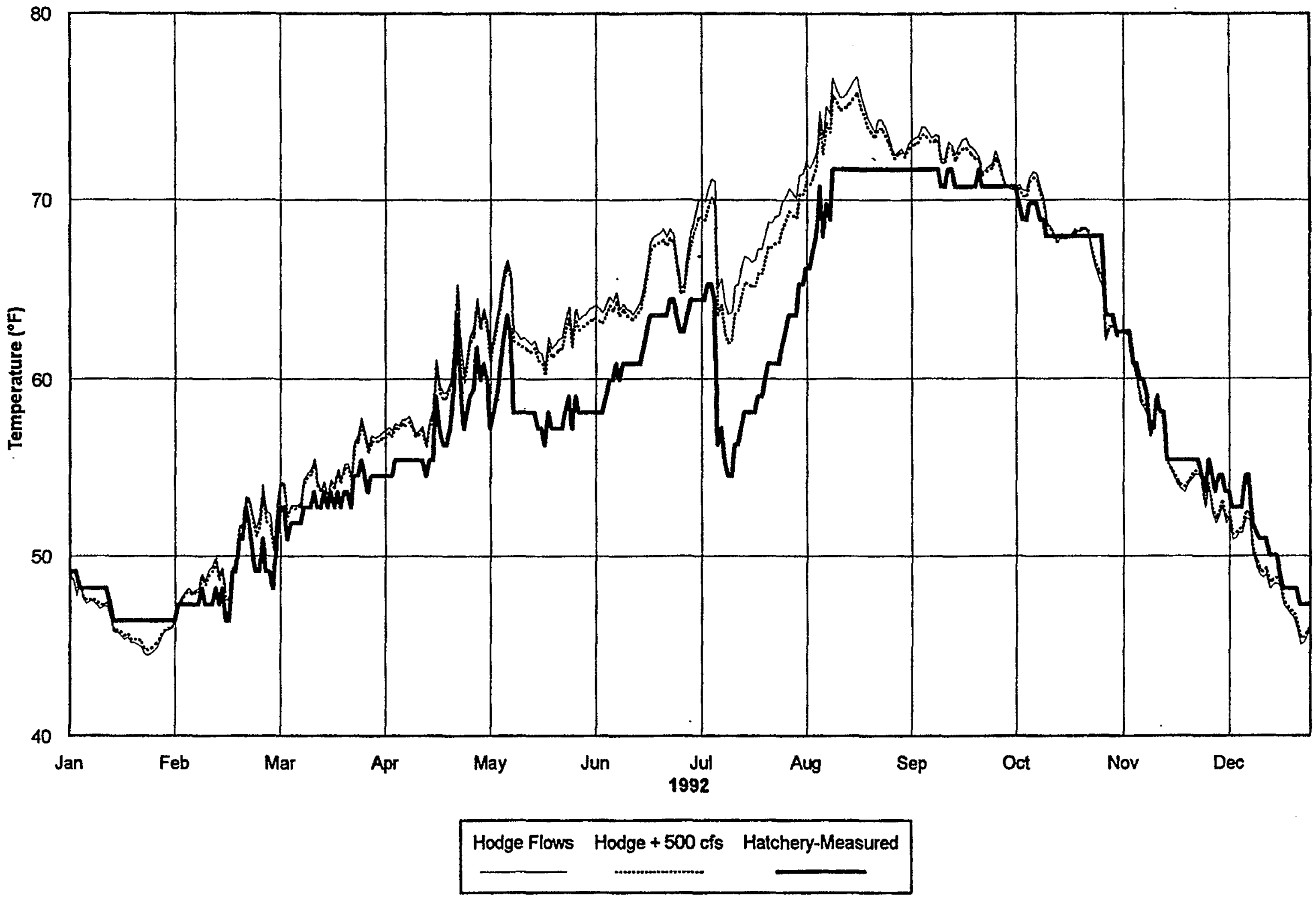
Figure 35
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1991



Jones & Stokes Associates, Inc.

Figure 36
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1991

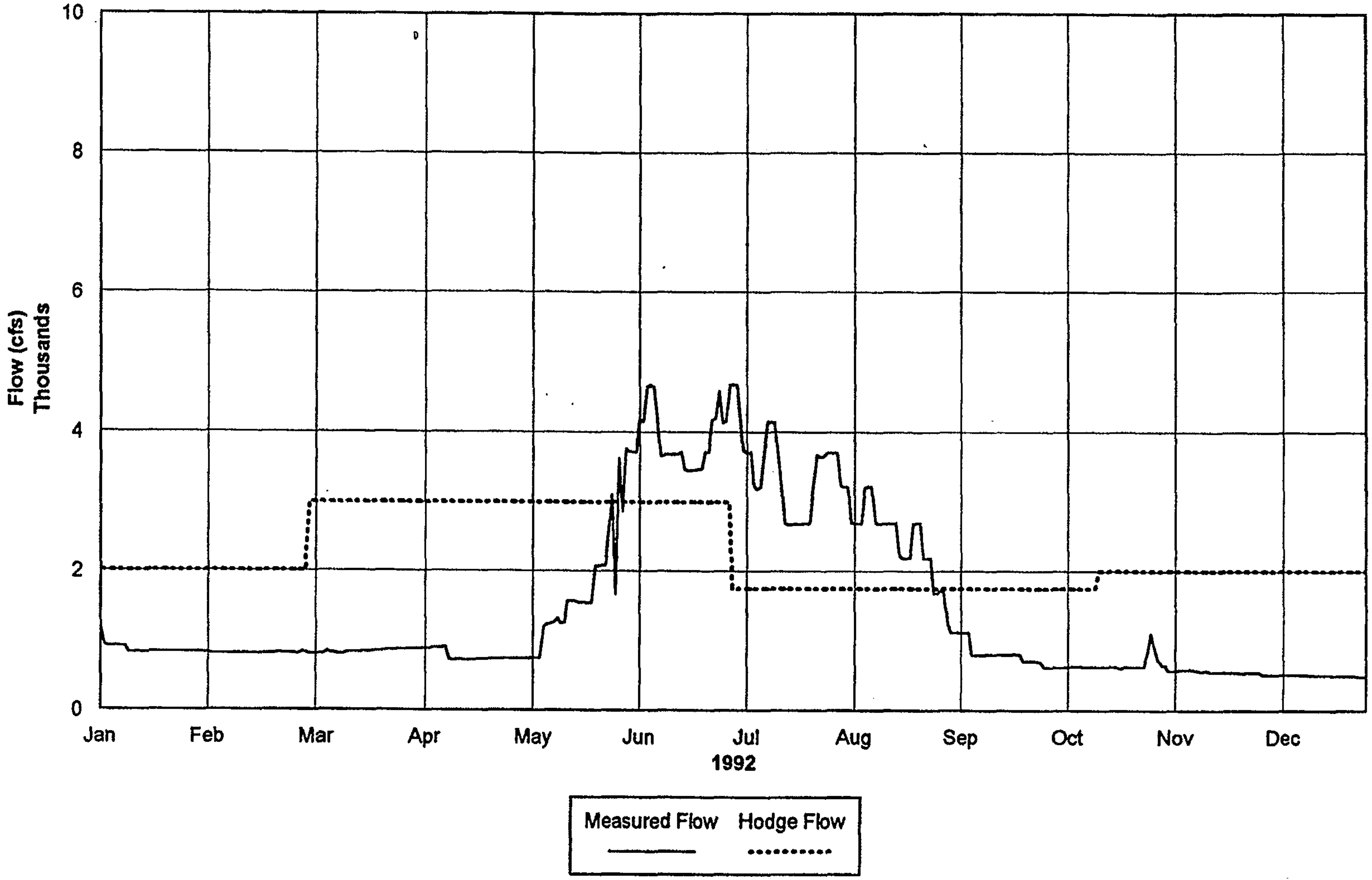
C-085246



Jones & Stokes Associates, Inc.

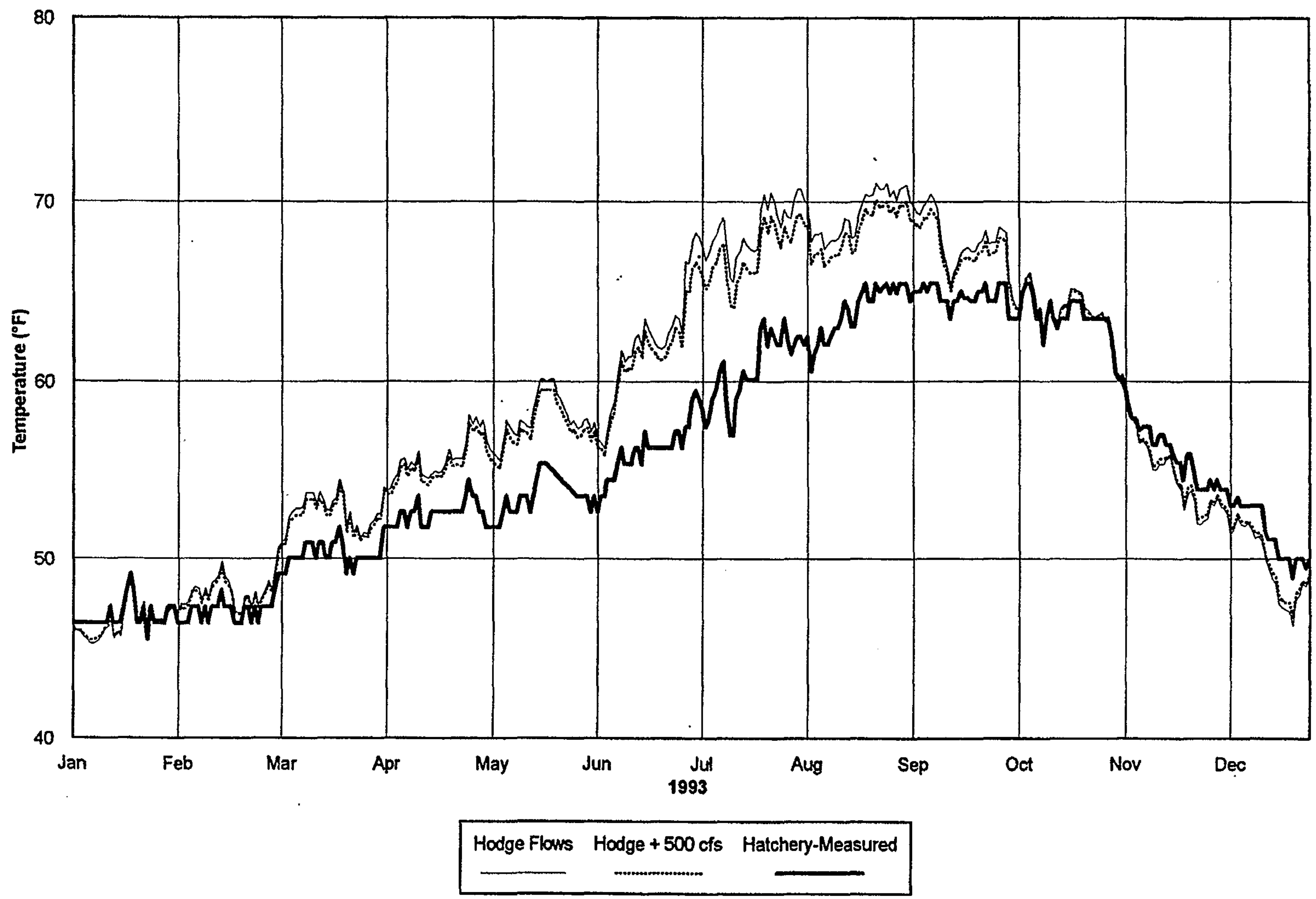
Figure 37
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1992

C-085247



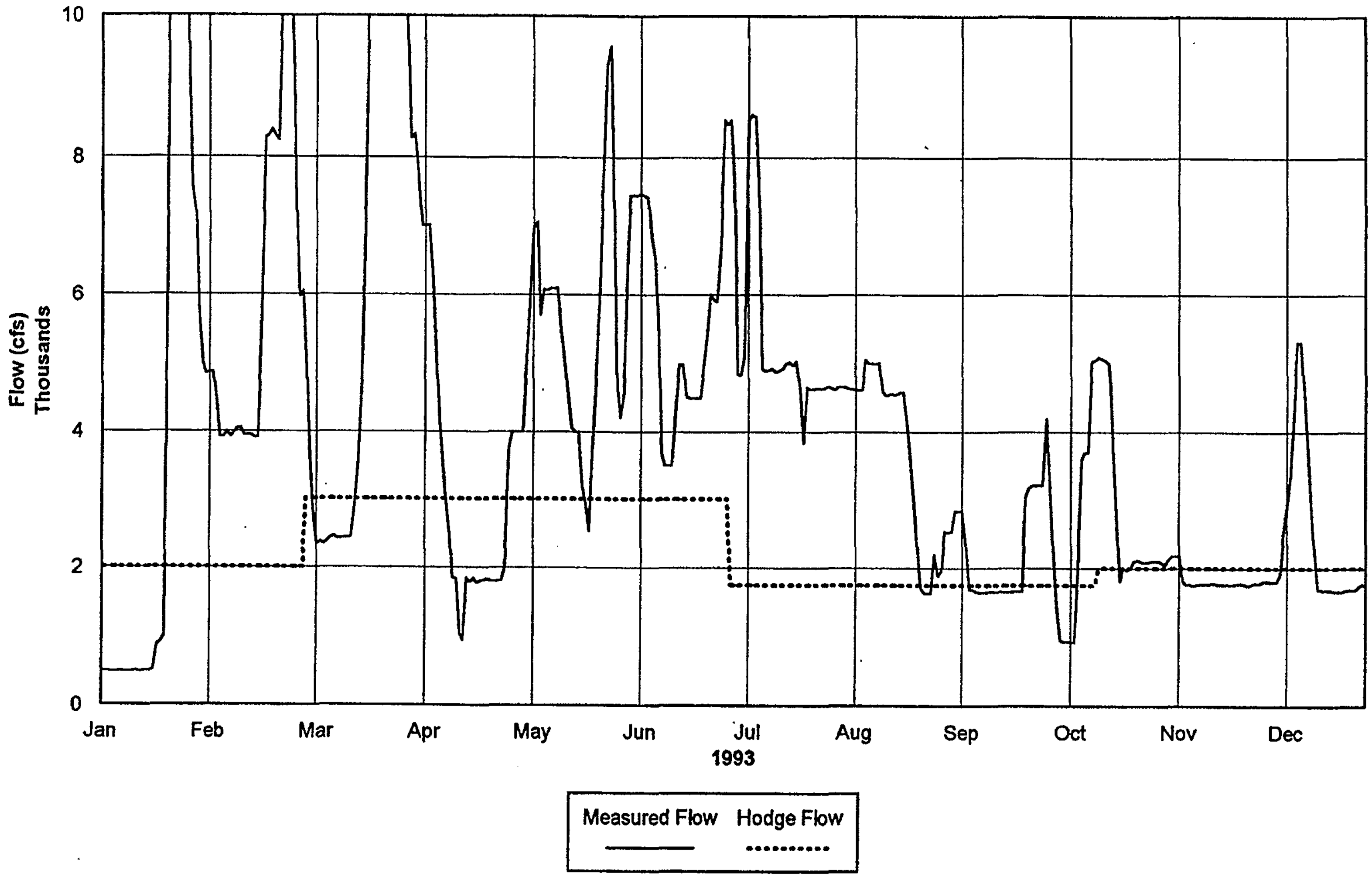
Jones & Stokes Associates, Inc.

Figure 38
Hodge Flows Compared to Flows Measured at Fair Oaks in 1992



Jones & Stokes Associates, Inc.

Figure 39
Simulated Temperatures at the Mouth of
the American River at Two Flow Levels for 1993



Jones & Stokes Associates, Inc.

Figure 40
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1993

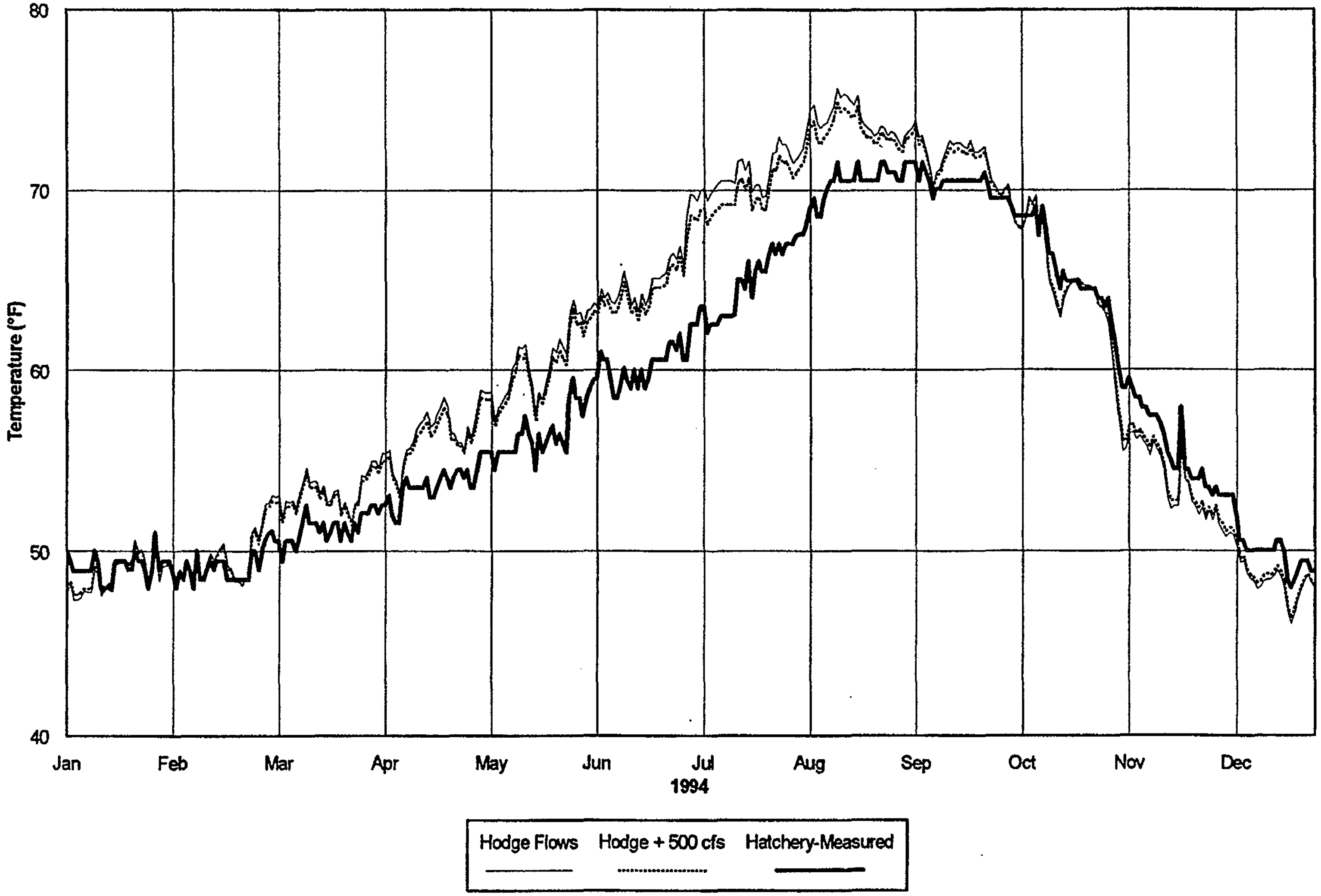


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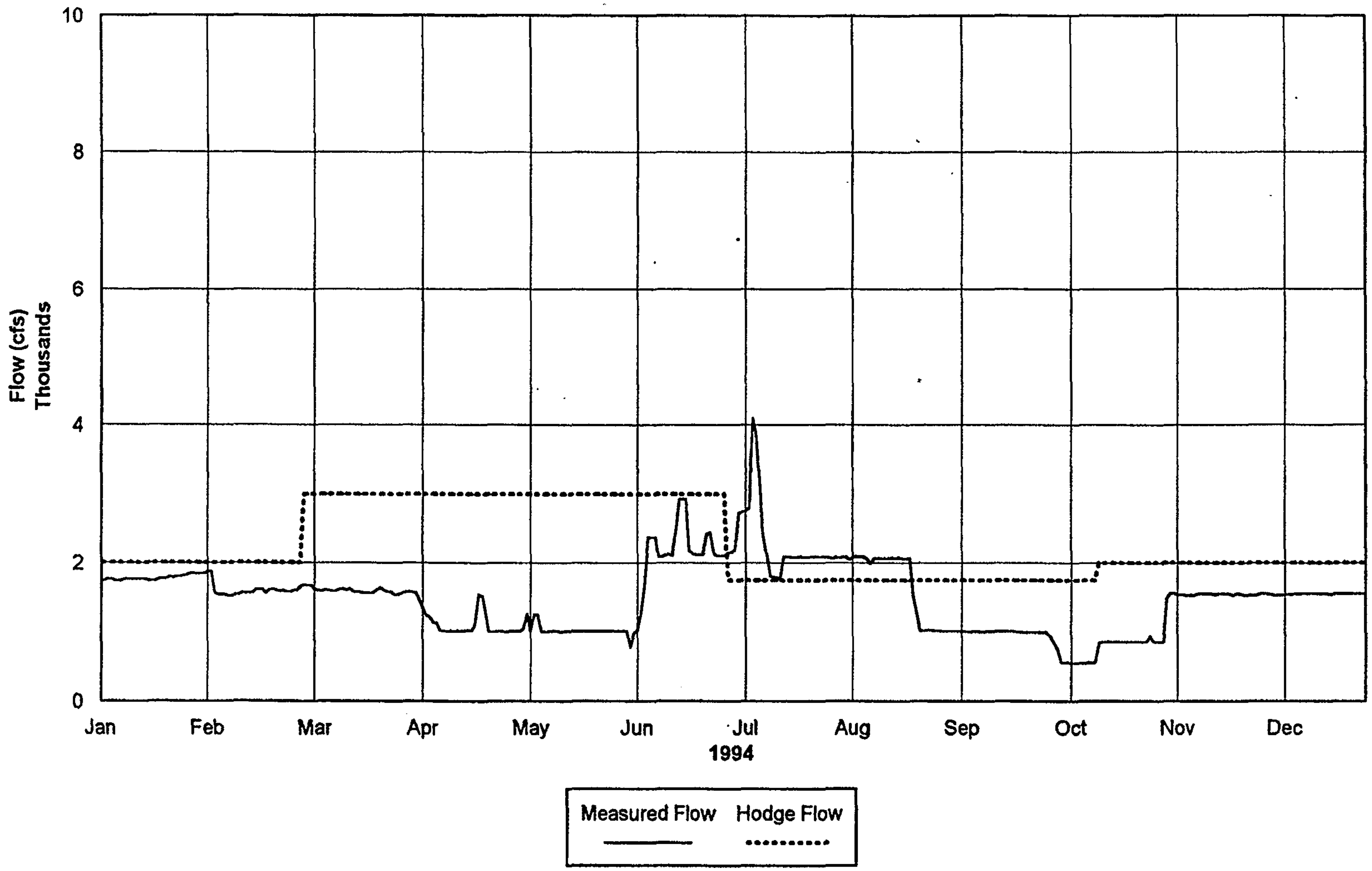
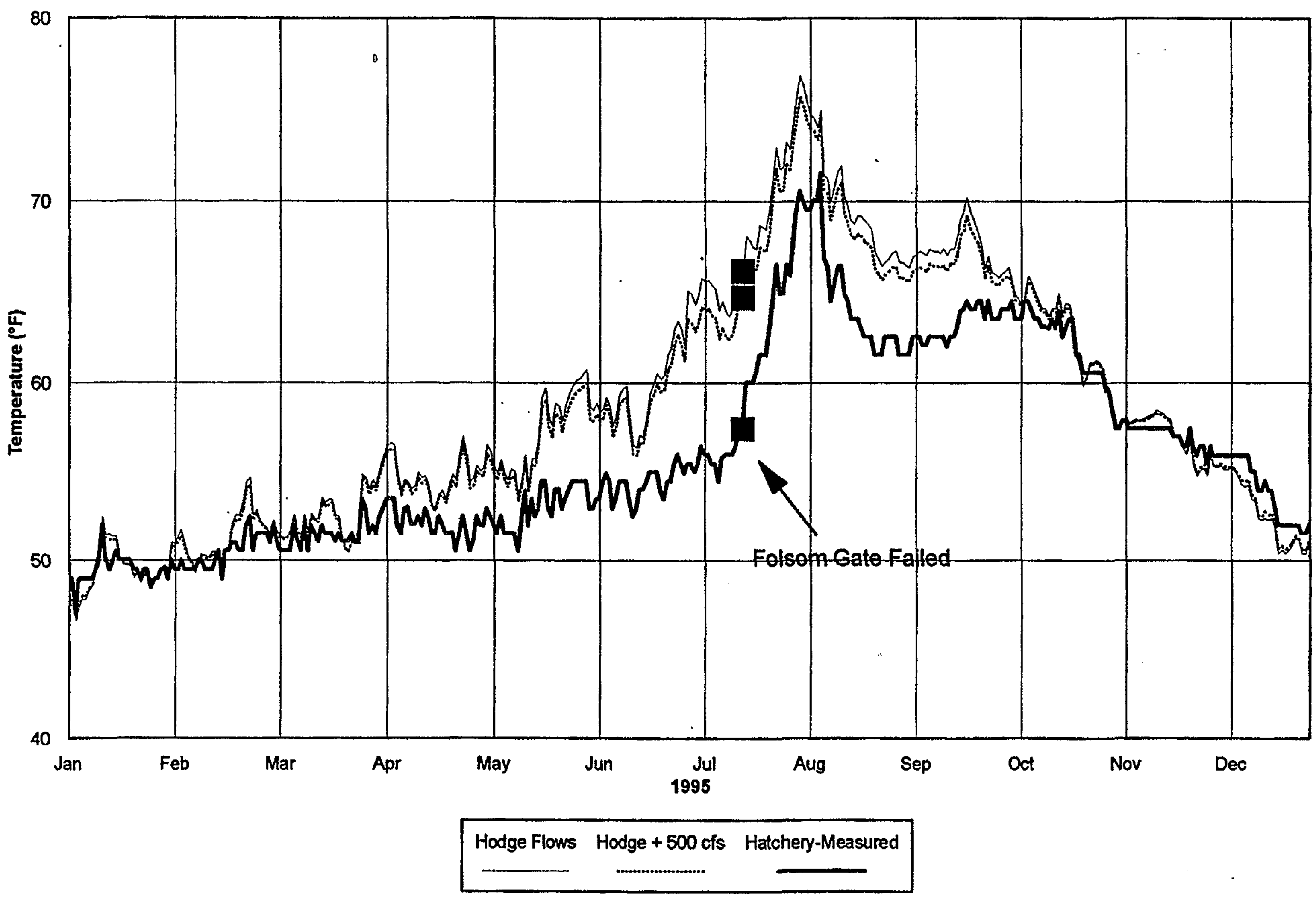
Figure 41
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1994



Jones & Stokes Associates, Inc.

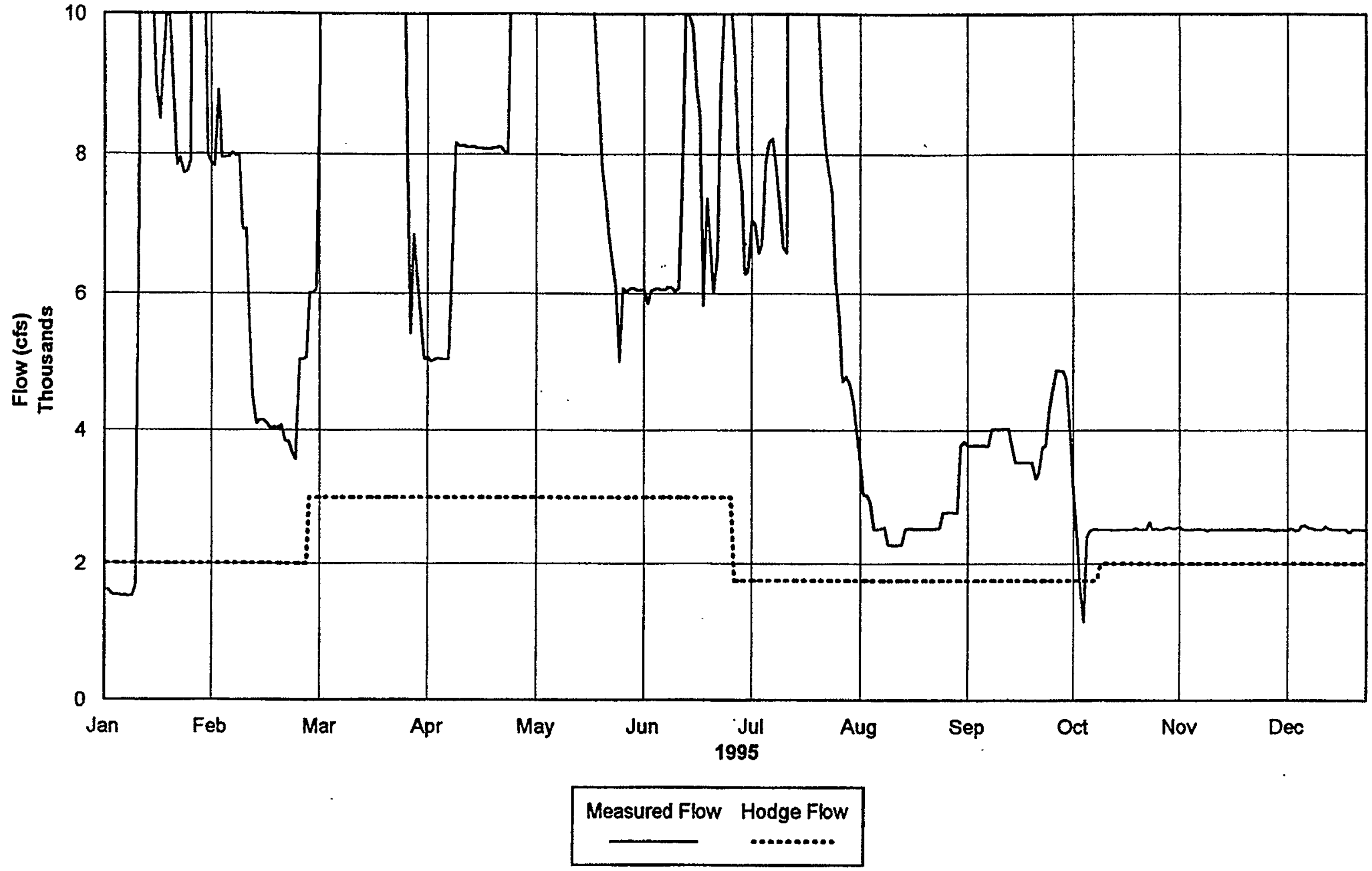
Figure 42
Hodge Flows Compared to Flows
Measured at Fair Oaks in 1994



Jones & Stokes Associates, Inc.

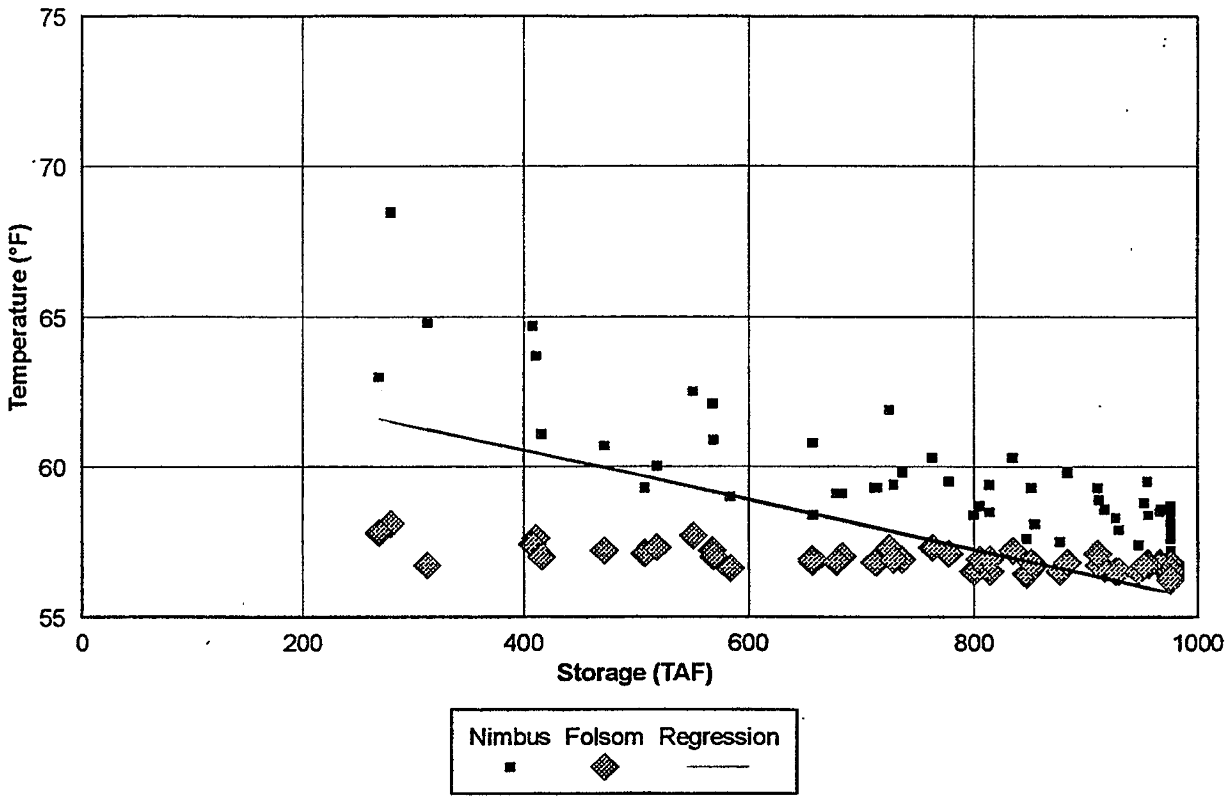
Figure 43
Simulated Temperatures at the Mouth of the American River at Two Flow Levels for 1995

C-085253



Jones & Stokes Associates, Inc.

Figure 44
Hodge Flows Compared to Flows Measured at Fair Oaks in 1995



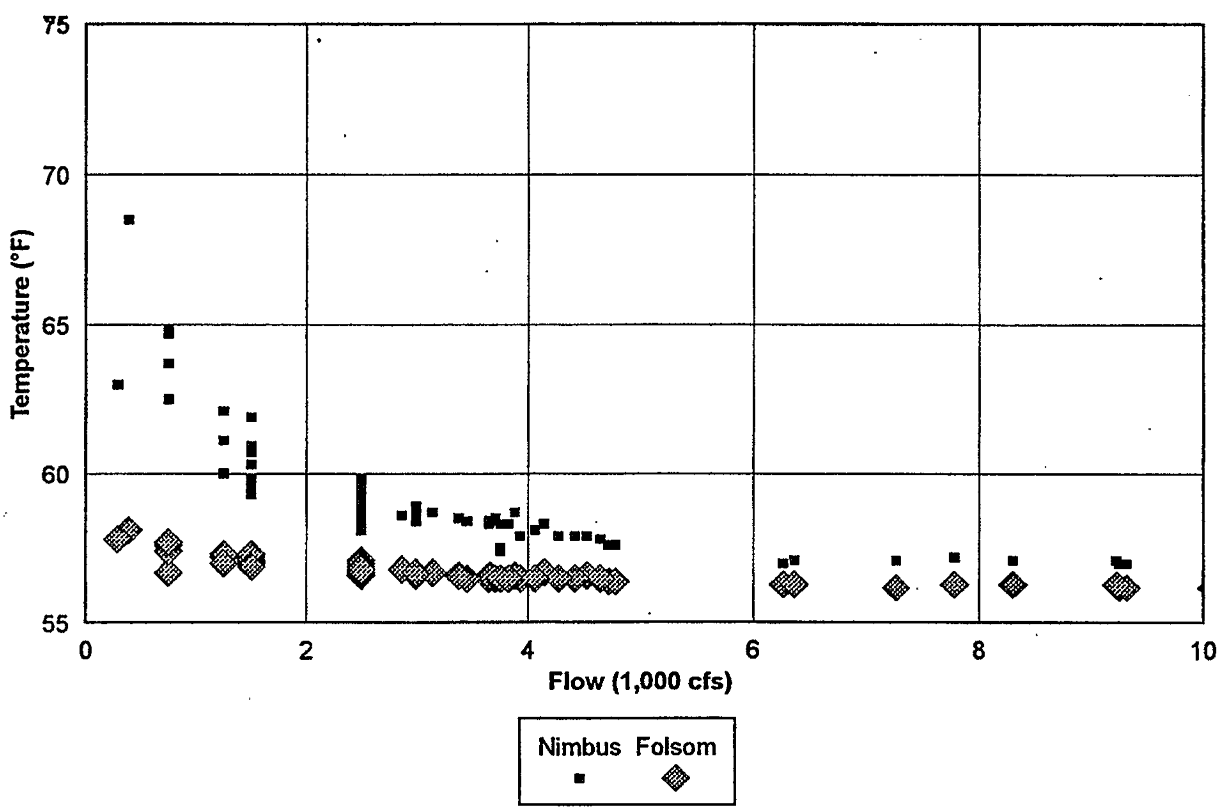


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Figure 45
Folsom and Nimbus Release Temperatures Estimated by the USBR Folsom Temperature Model for the No Action Alternative for May

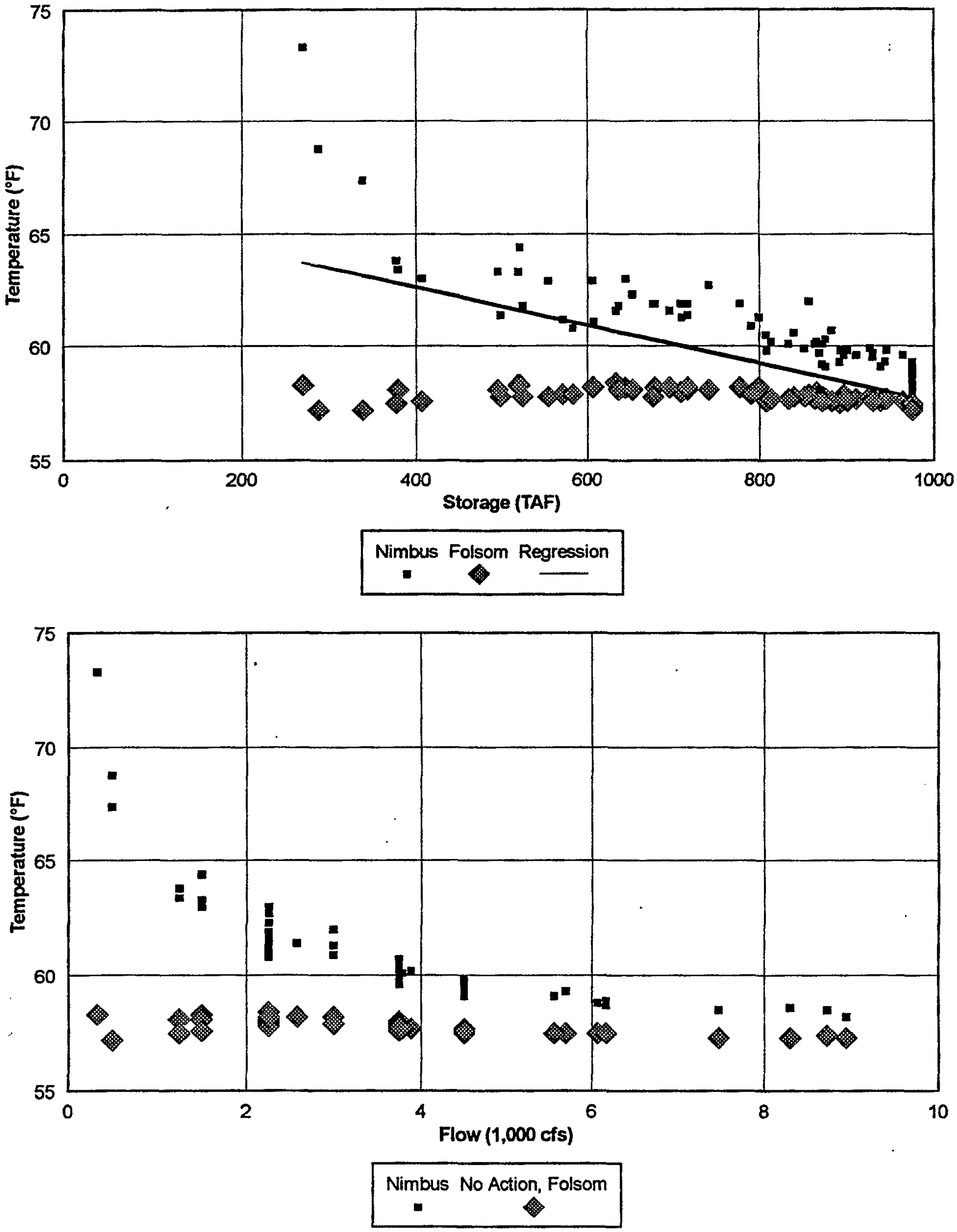
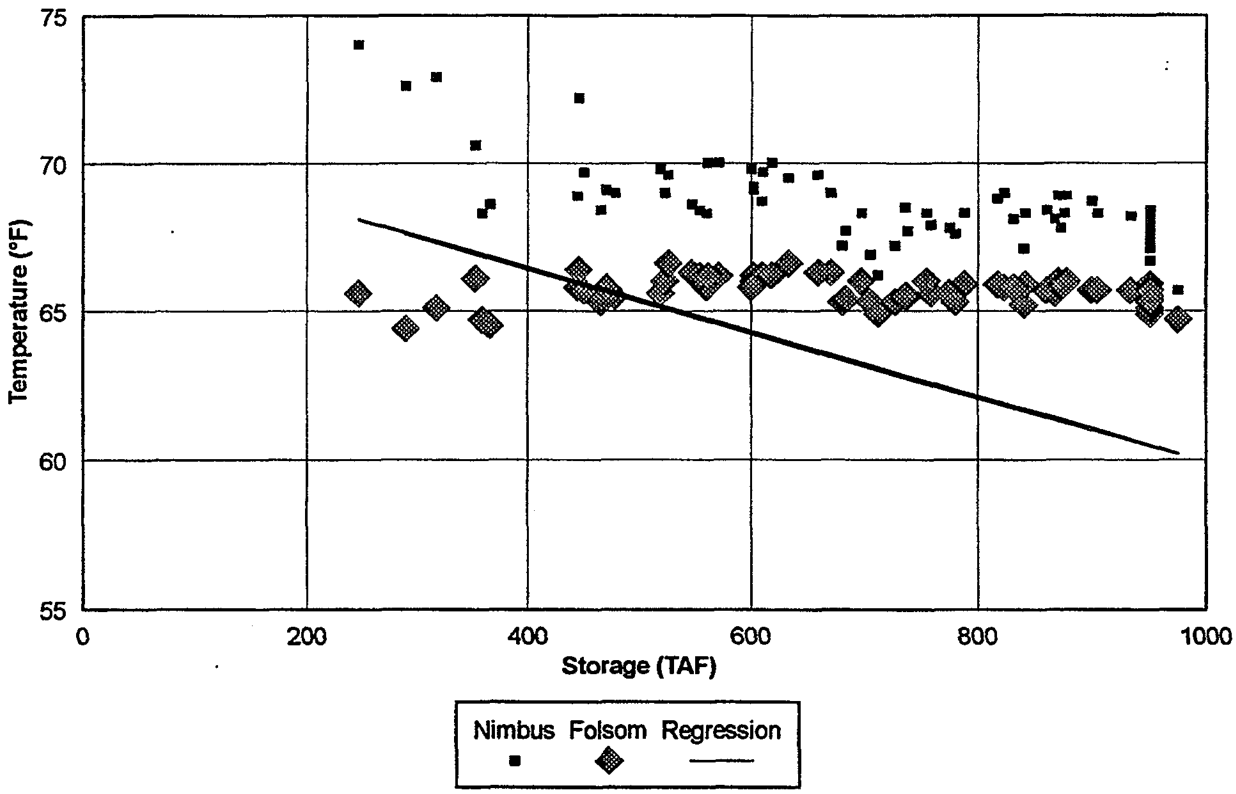
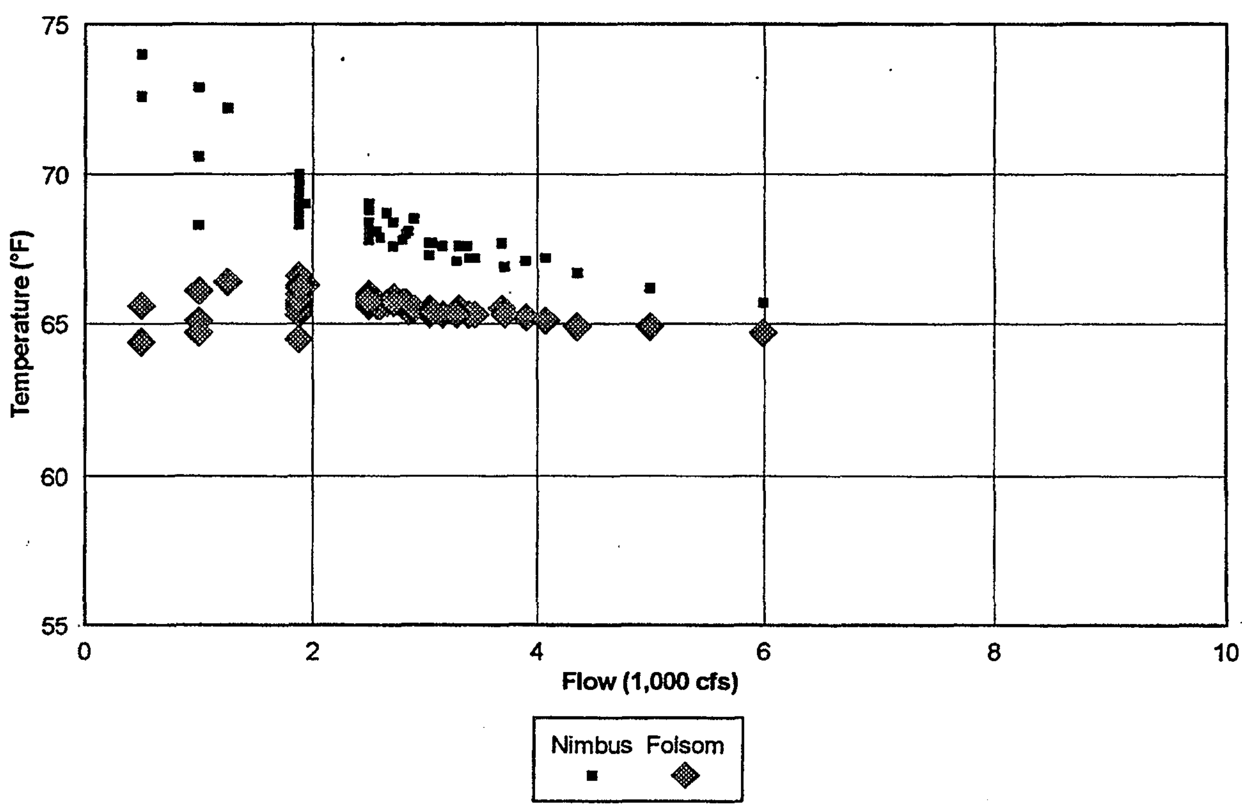


Figure 46
Folsom and Nimbus Release Temperatures Estimated by the USBR Folsom Temperature Model for the No Action Alternative for June

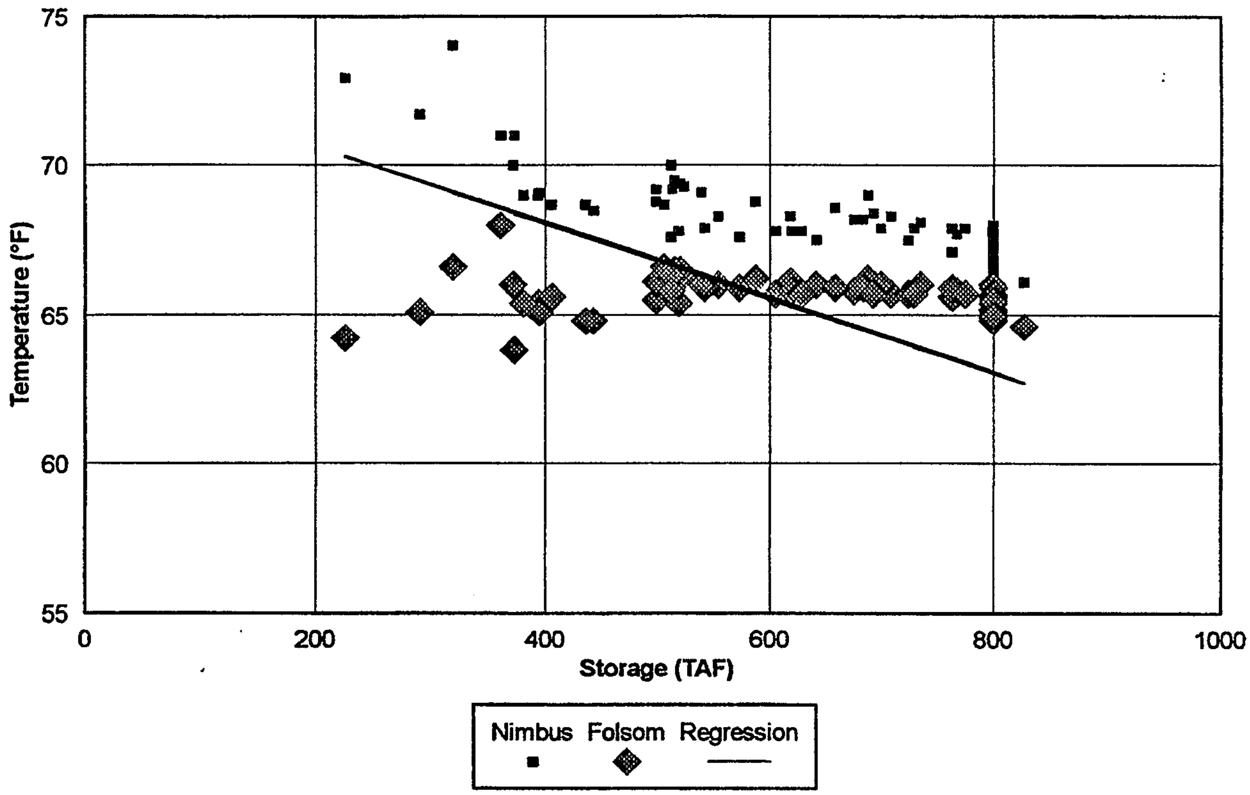
Jones & Stokes Associates, Inc.





Jones & Stokes Associates, Inc.

Figure 47
Folsom and Nimbus Release Temperatures Estimated by the USBR Folsom Temperature Model for the No Action Alternative for July



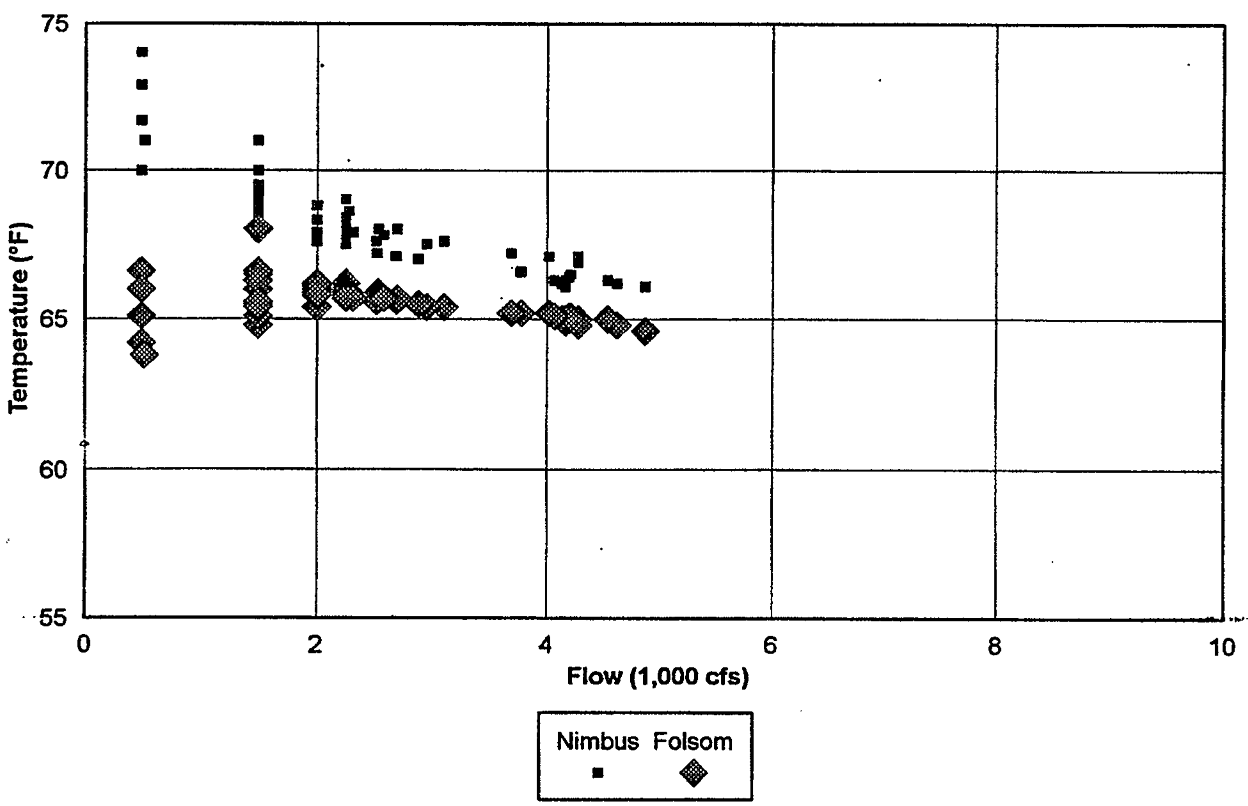


Figure 48
Folsom and Nimbus Release Temperatures
Estimated by the USBR Folsom Temperature
Model for the No Action Alternative for August

Jones & Stokes Associates, Inc.

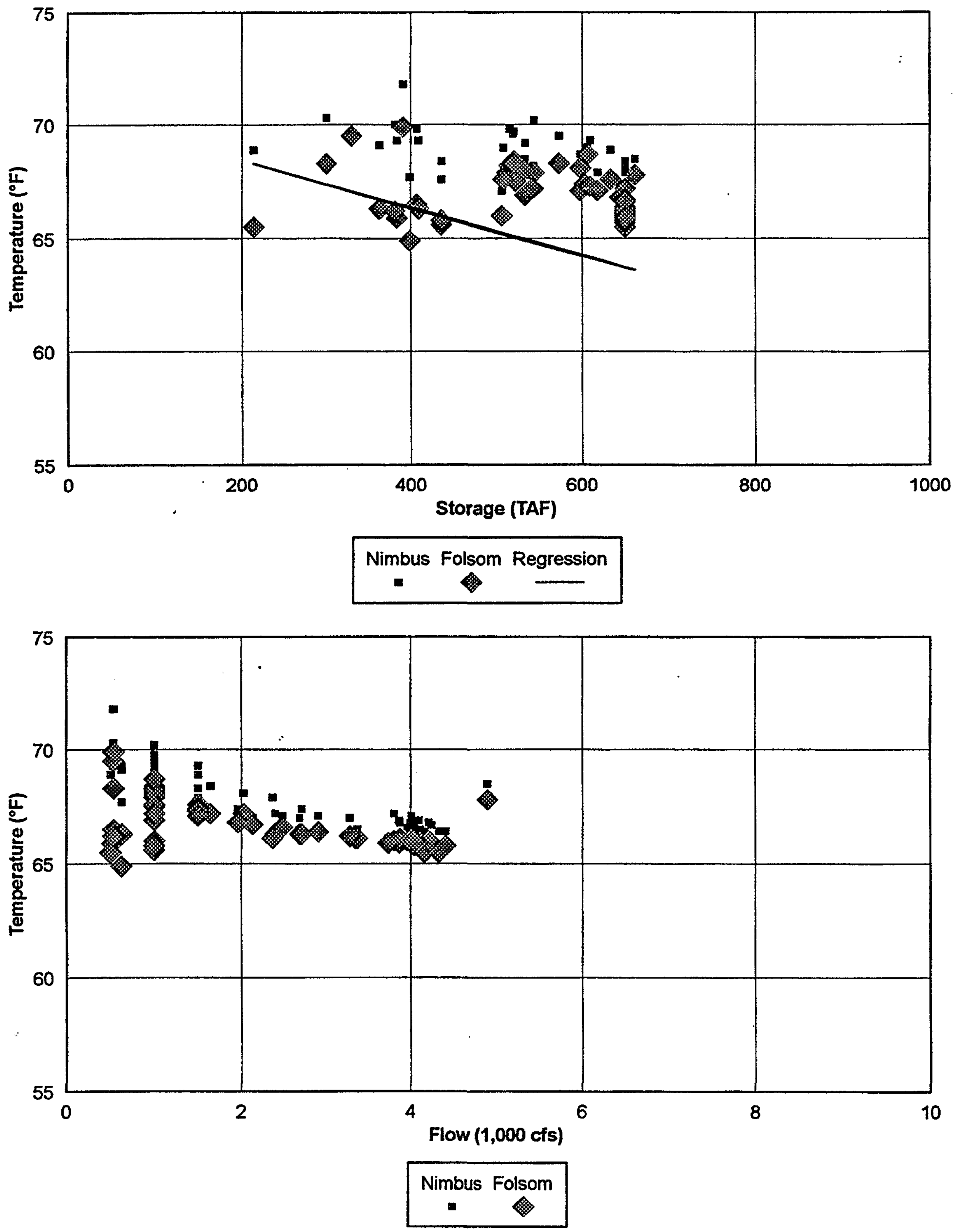
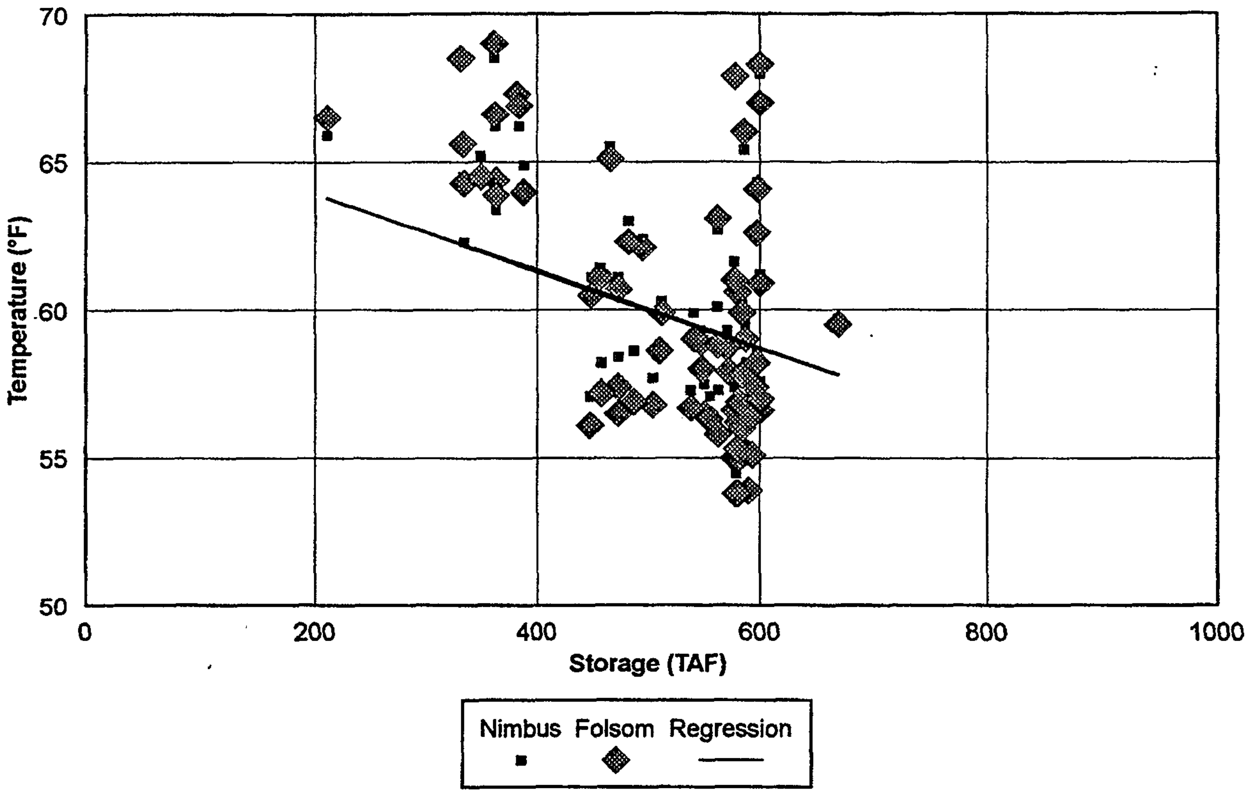
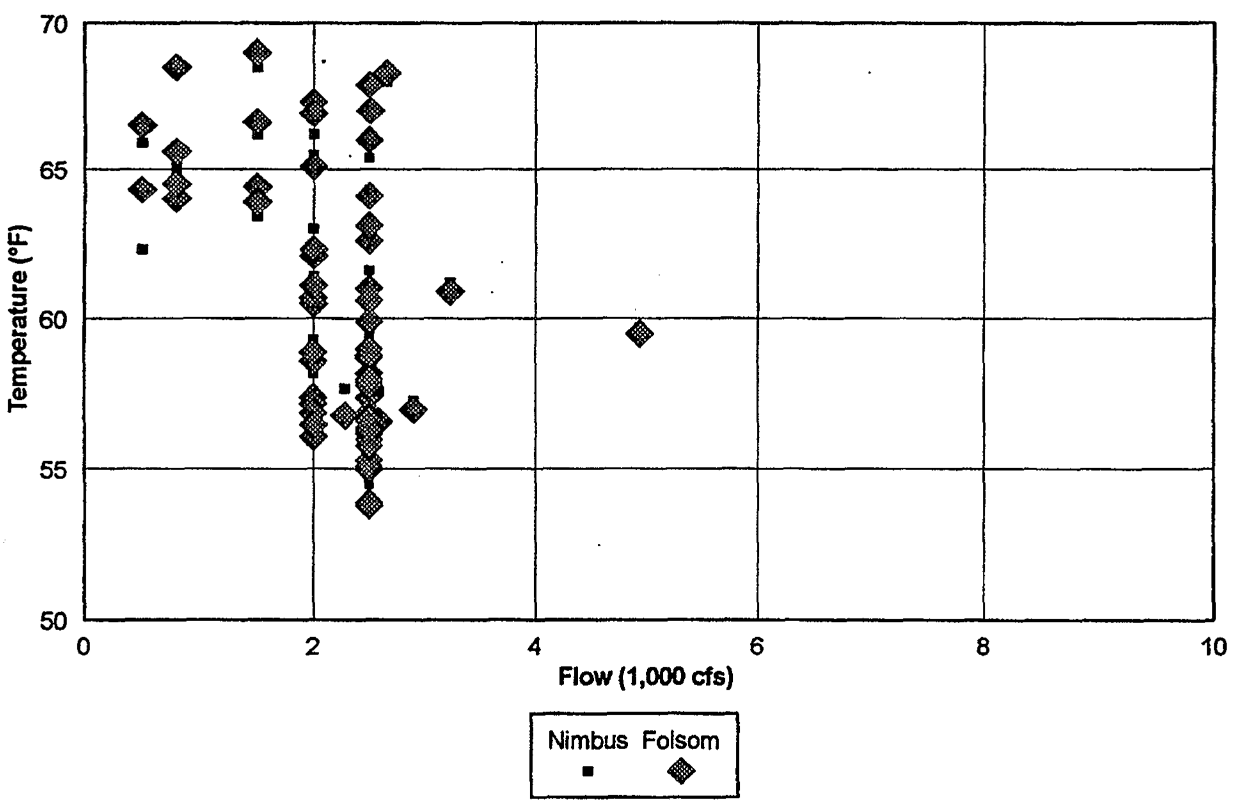


Figure 49
Folsom and Nimbus Release Temperatures Estimated by the USBR Folsom Temperature Model for the No Action Alternative for September

Jones & Stokes Associates, Inc.





Jones & Stokes Associates, Inc.

Figure 50
Folsom and Nimbus Release Temperatures Estimated by the USBR Folsom Temperature Model for the No Action Alternative for October

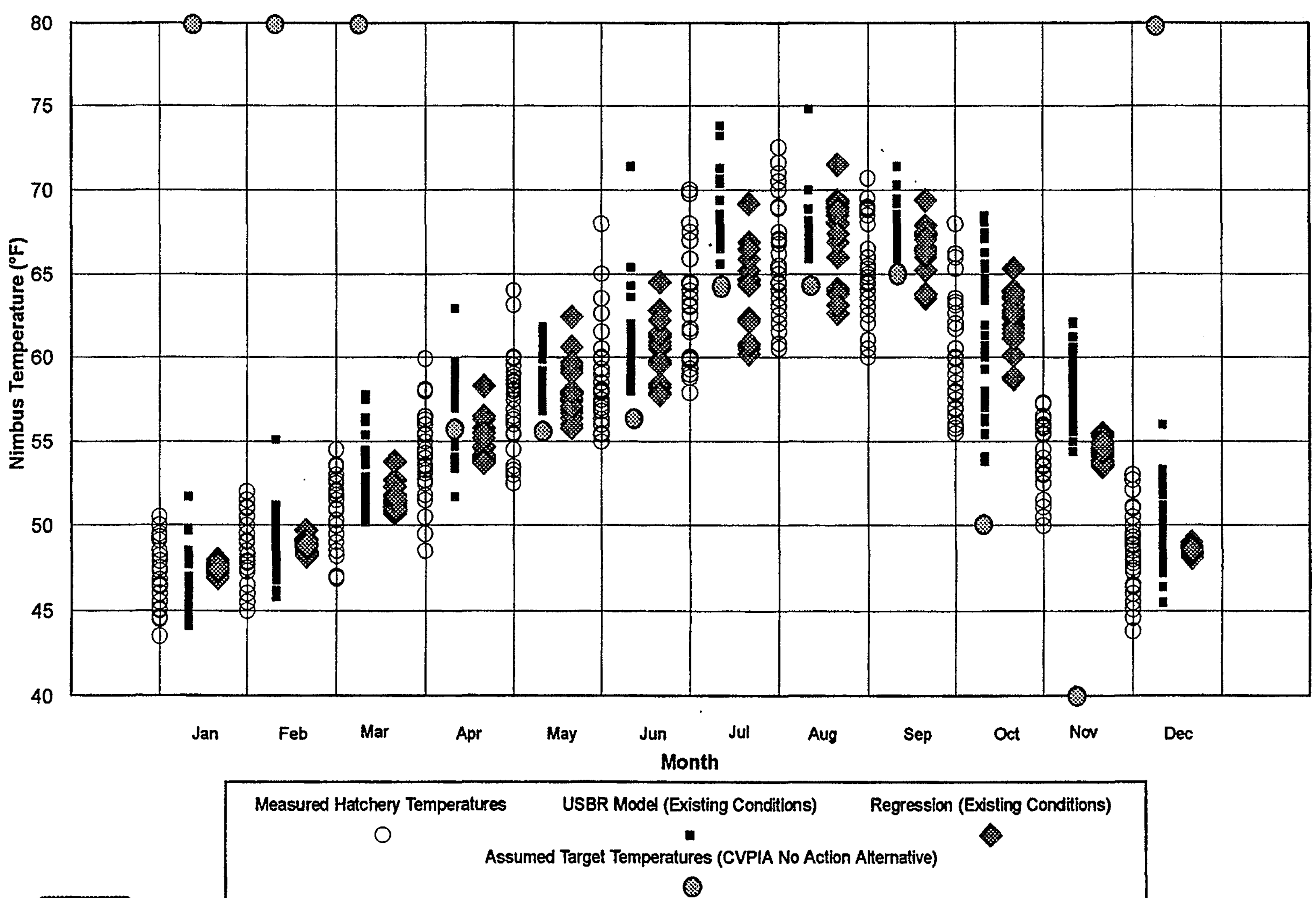


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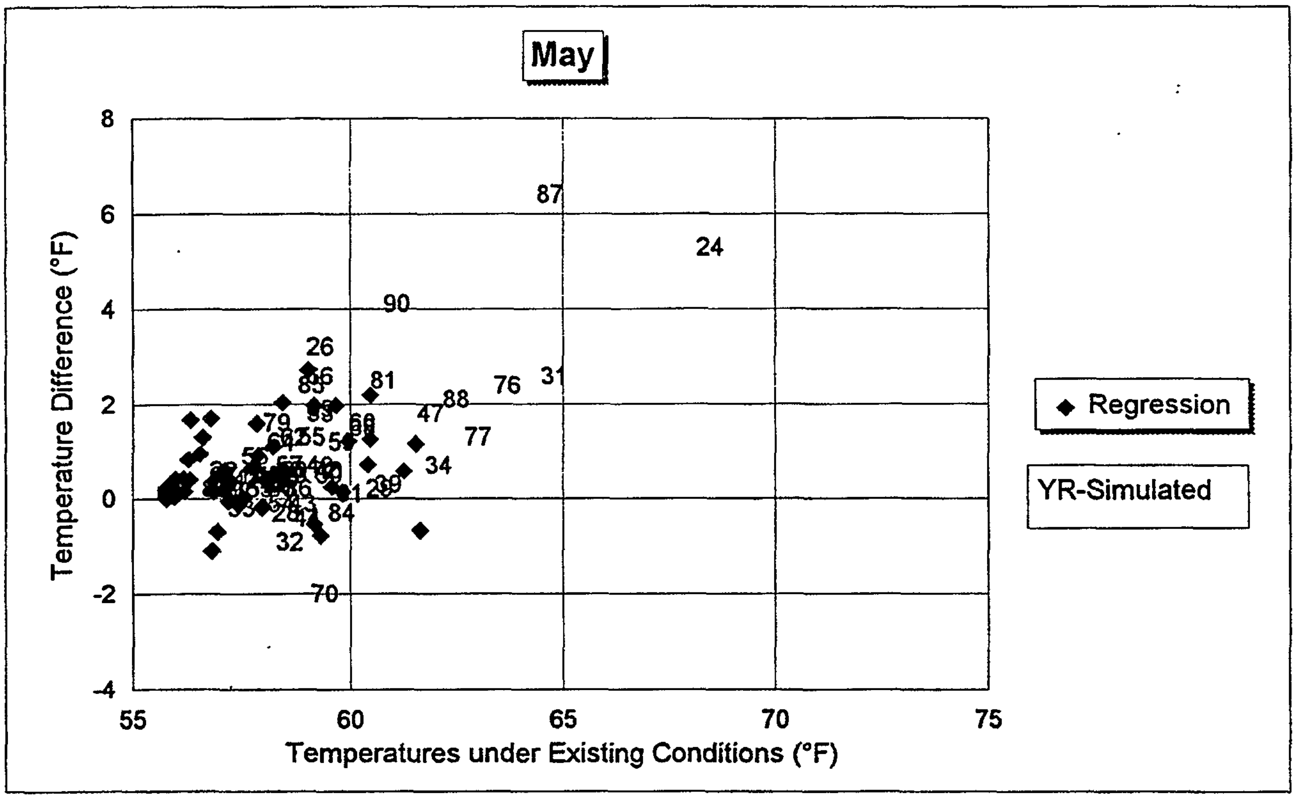
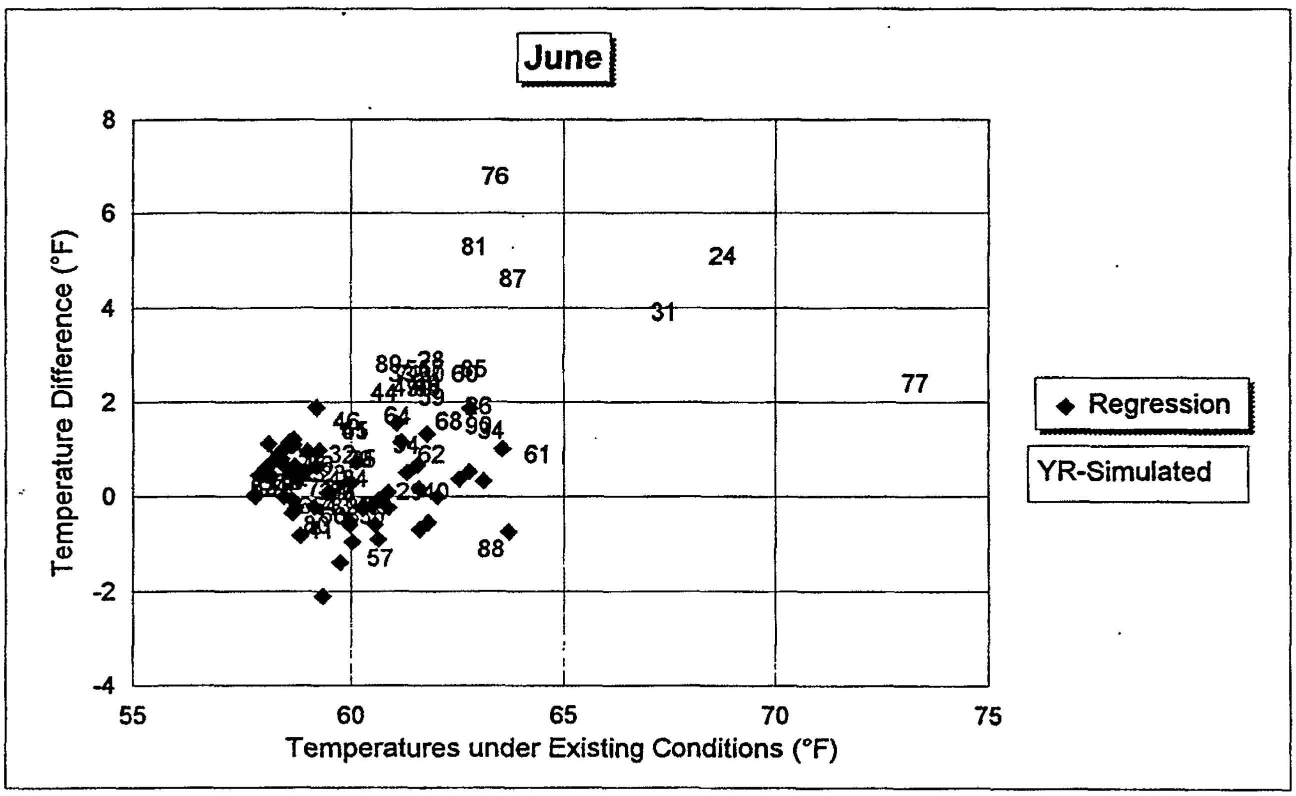
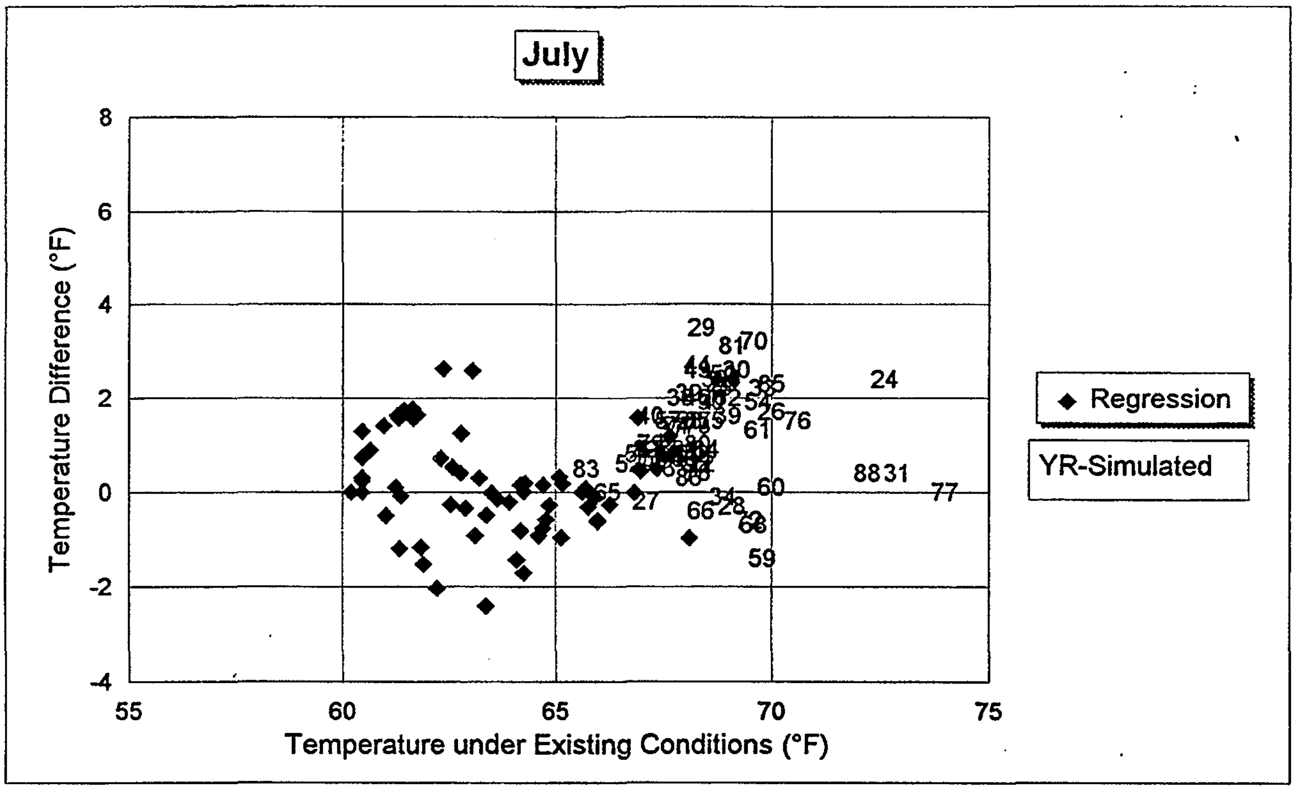
Figure 51
Thirty-Six Years of Measured and Estimated Temperatures at Nimbus Dam

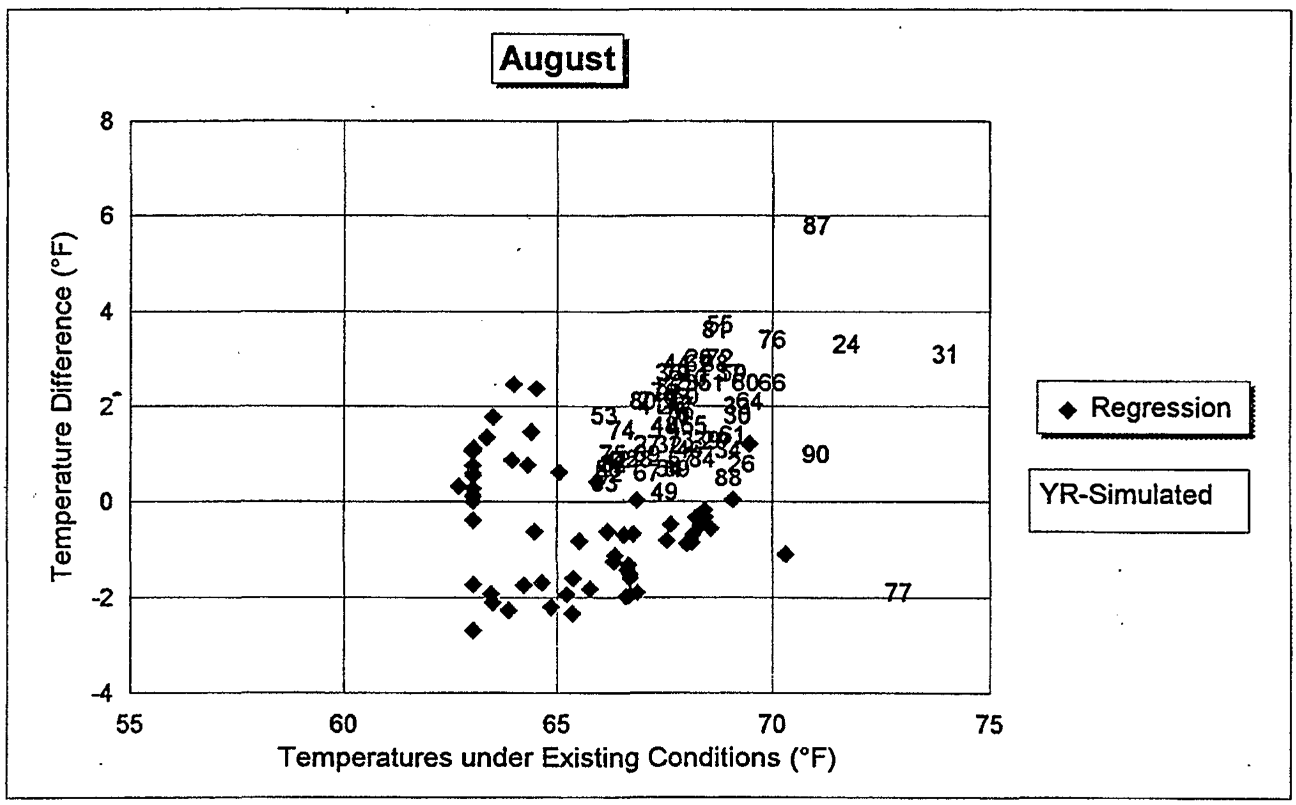




Jones & Stokes Associates, Inc.

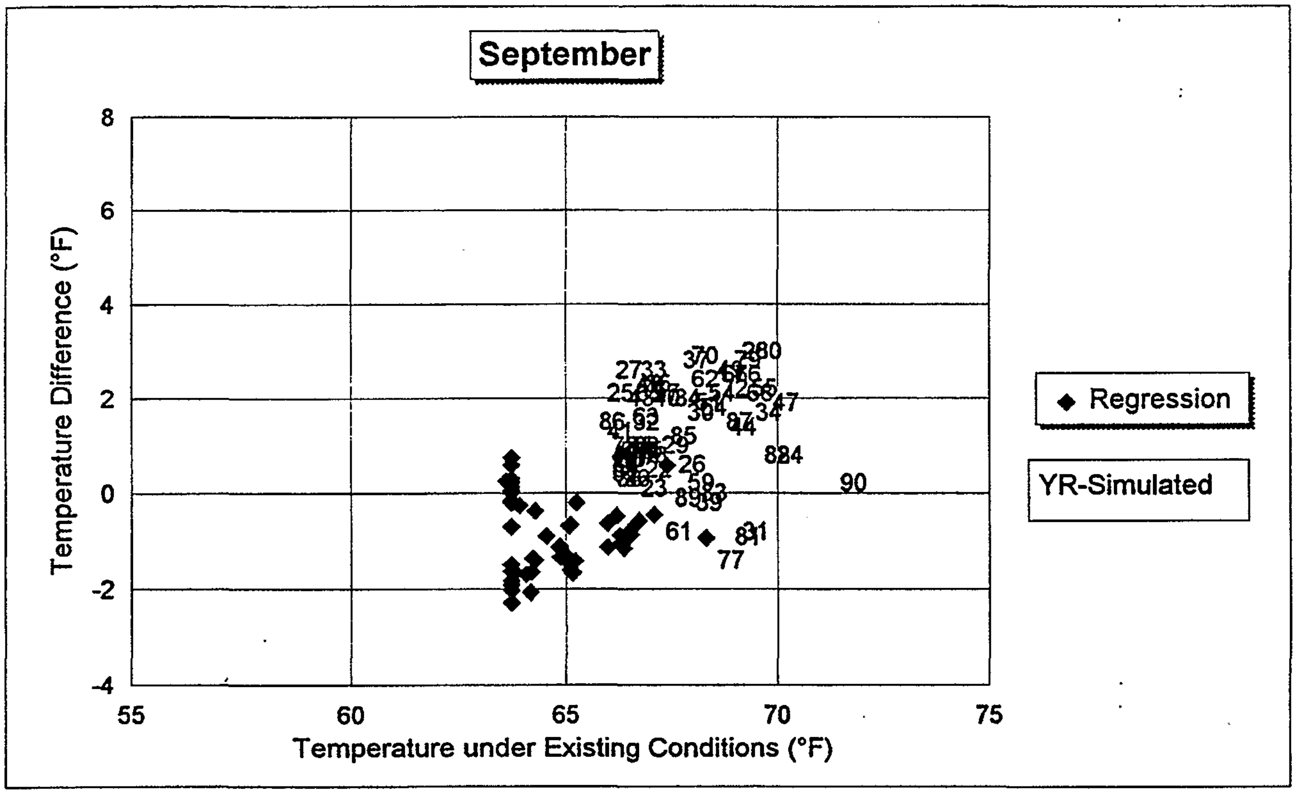
Figure 52.
Estimated Increase in Nimbus Release Temperature Caused by the Alternative 2 Cumulative Scenario as Compared to Existing Conditions for May and June

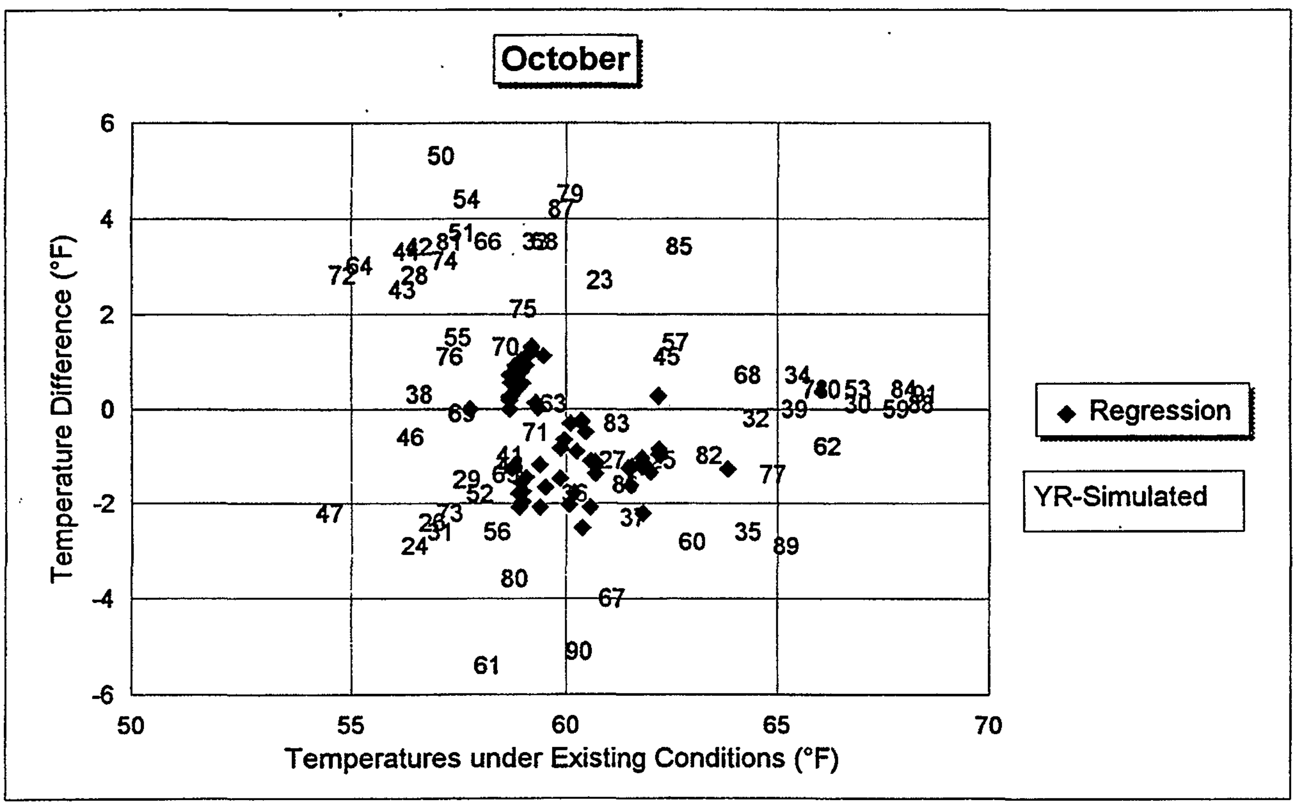




Jones & Stokes Associates, Inc.

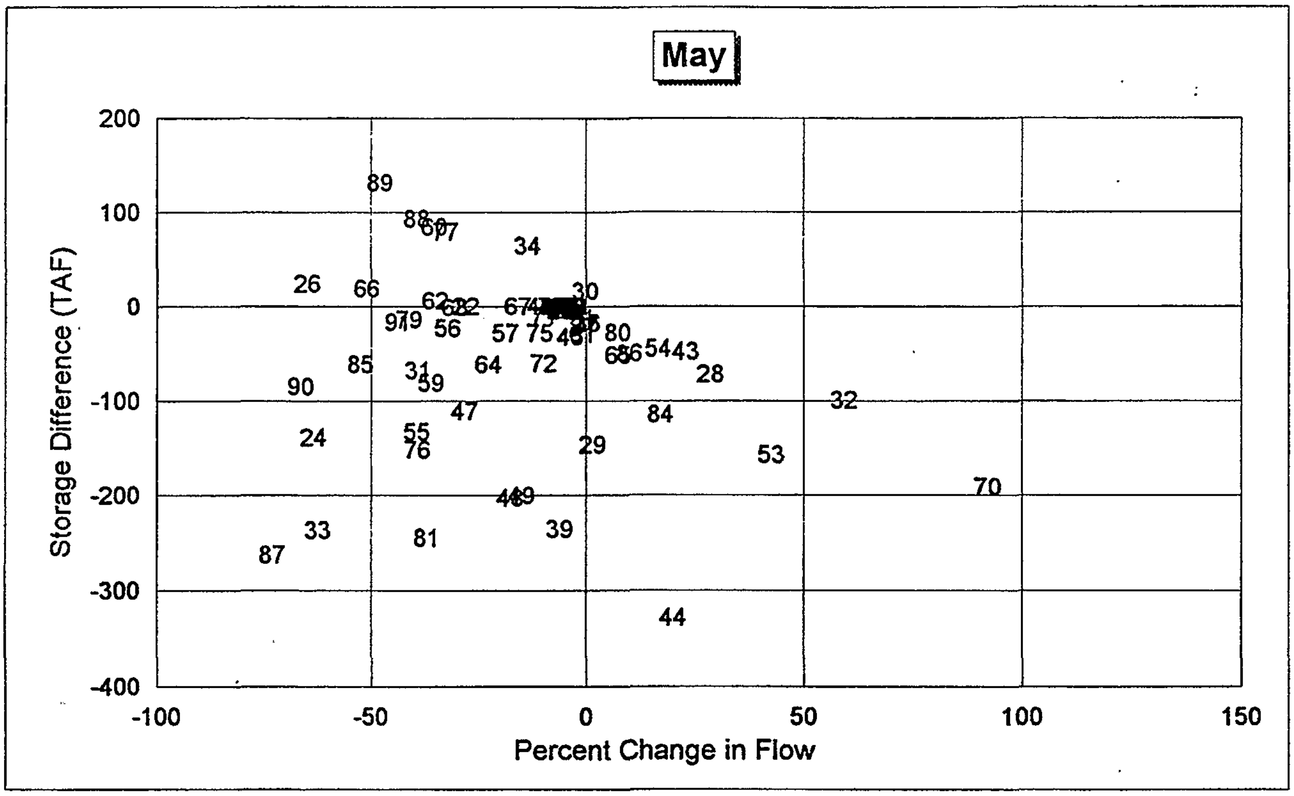
Figure 53.
Estimated Increase in Nimbus Release Temperature Caused by the Alternative 2 Cumulative Scenario as Compared to Existing Conditions for July and August





Jones & Stokes Associates, Inc.

Figure 54.
Estimated Increase in Nimbus Release Temperature Caused by the Alternative 2 Cumulative Scenario as Compared to Existing Conditions for September and October



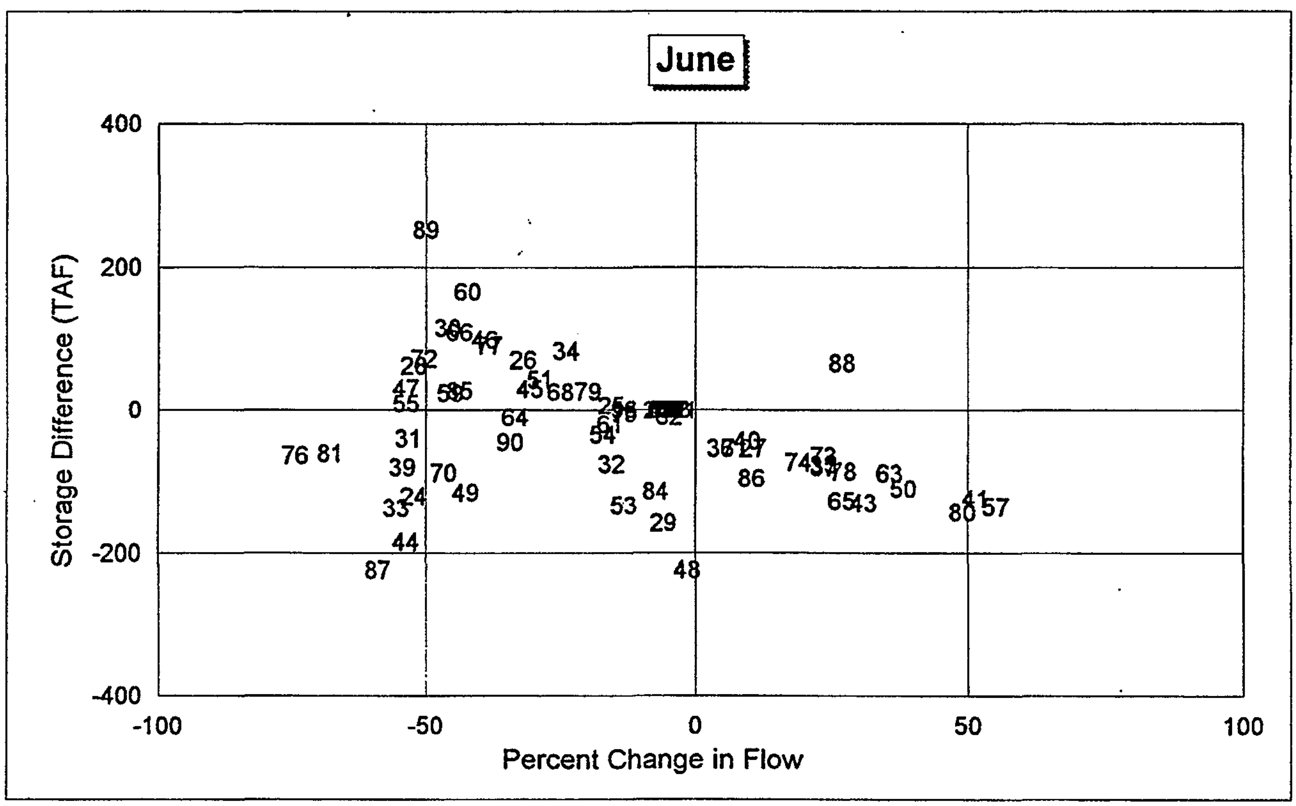


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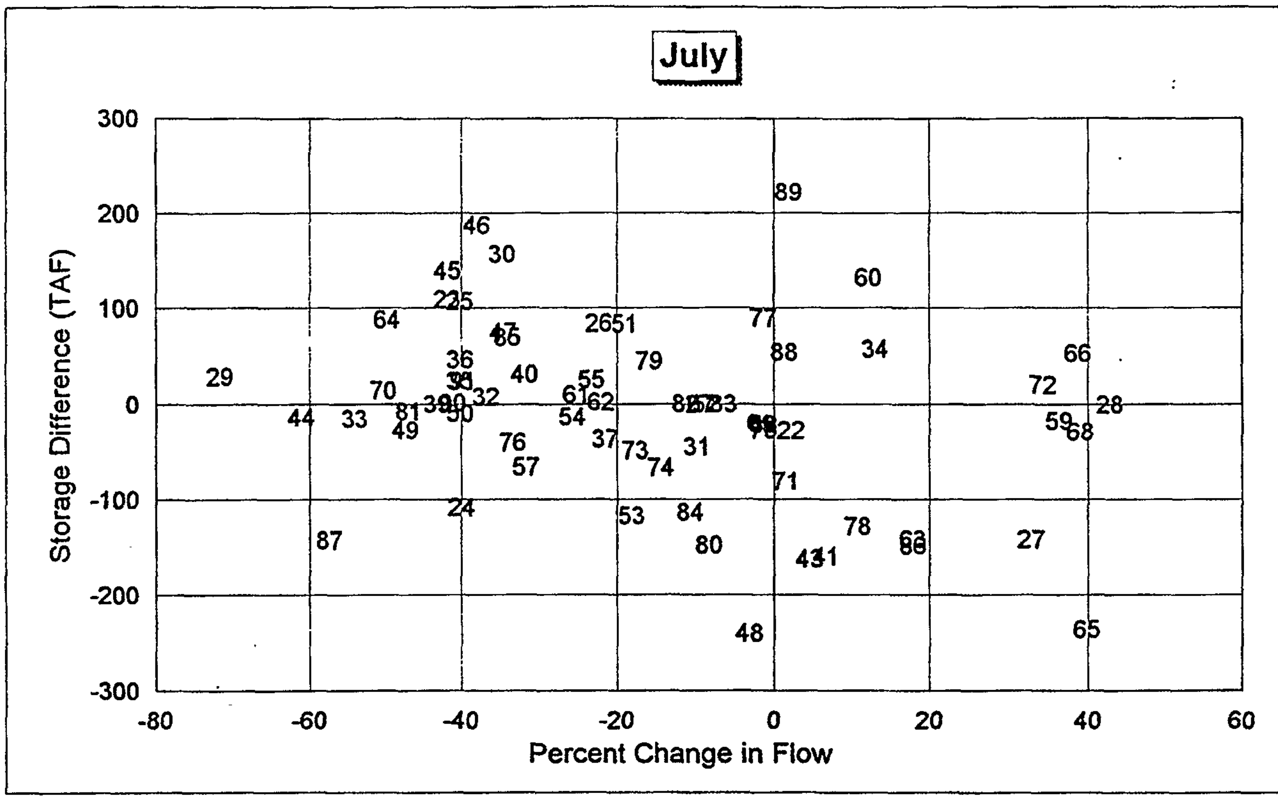
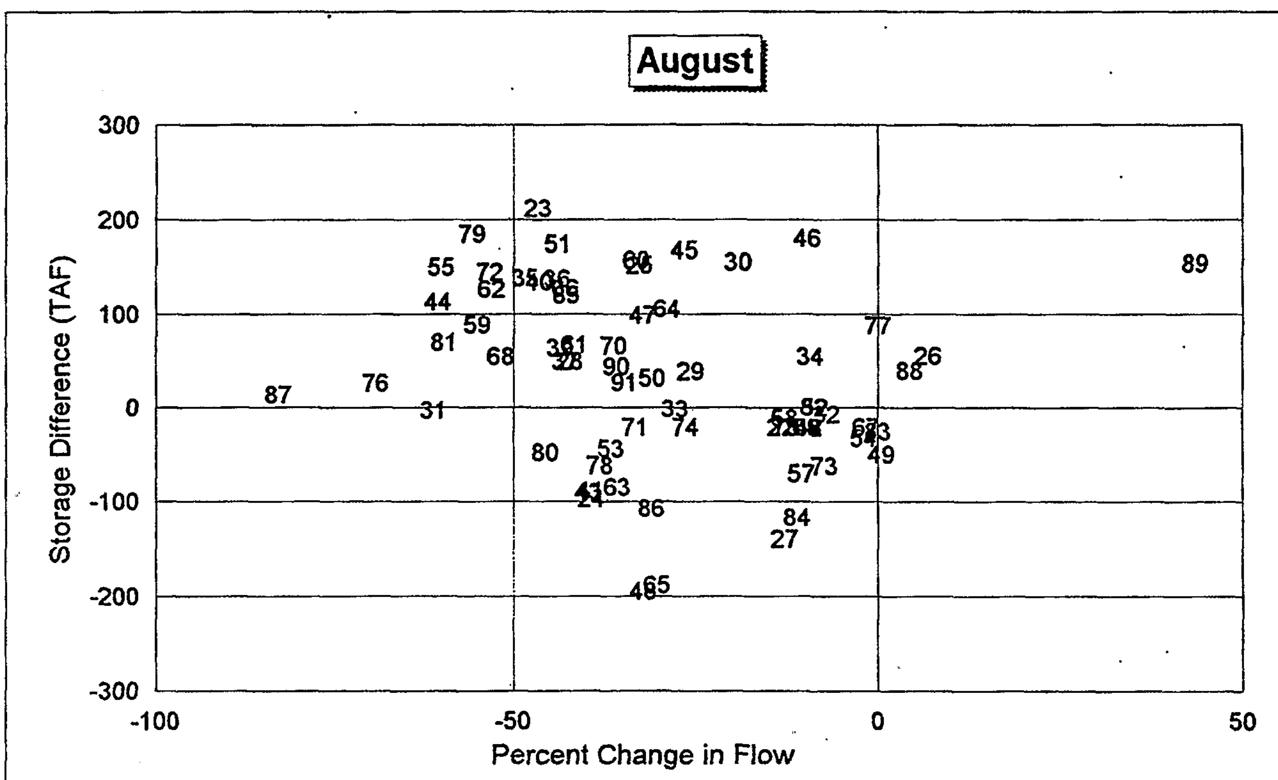
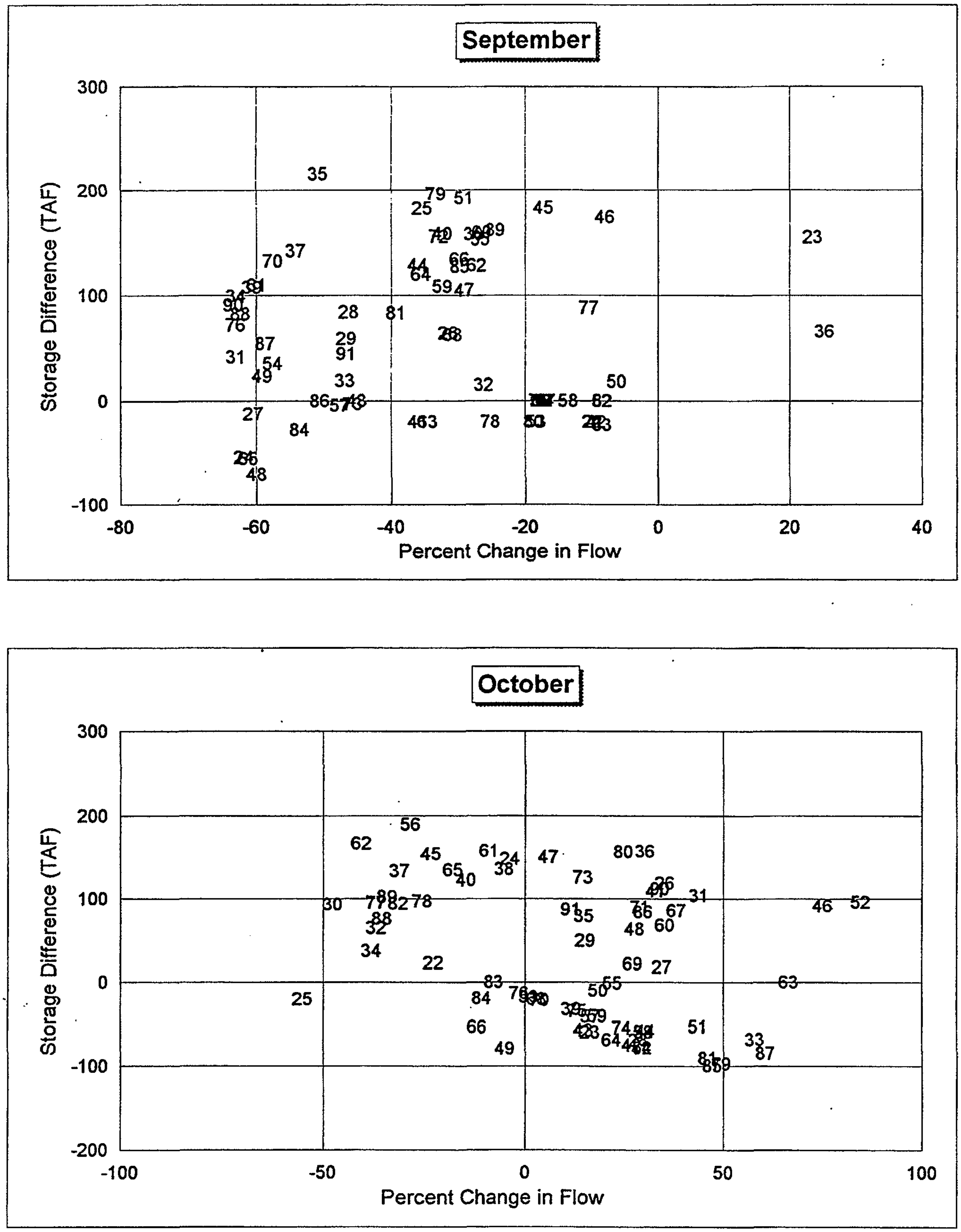
Figure 55.
Change in Flow and Storage Estimated by PROSIM to Occur as a Result of the Alternative 2 Cumulative Scenario as Compared to Existing Conditions for May and June





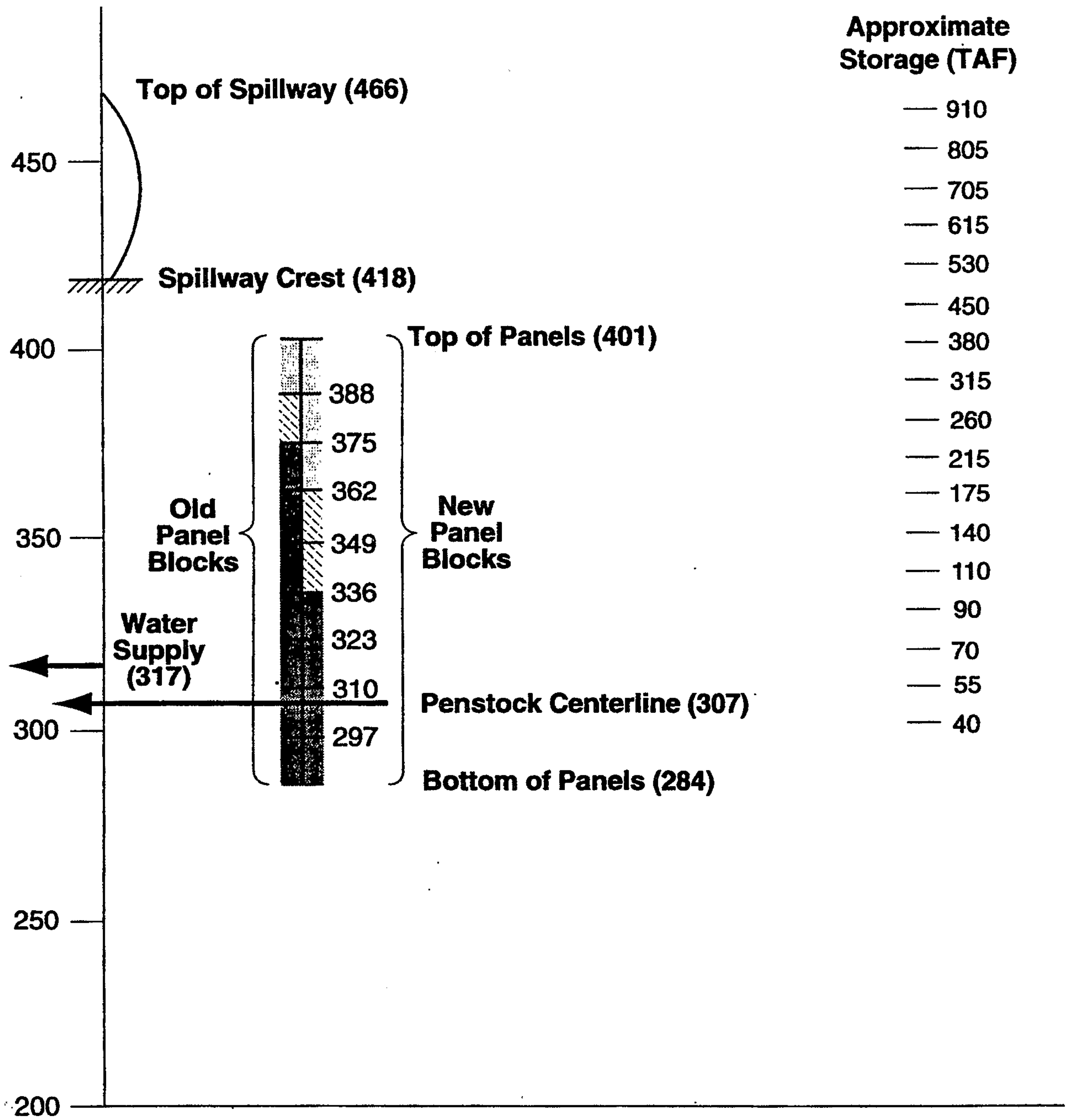
Jones & Stokes Associates, Inc.

Figure 56.
Change in Flow and Storage Estimated by PROSIM to Occur as a Result of the Alternative 2 Cumulative Scenario as Compared to Existing Conditions for July and August



Jones & Stokes Associates, Inc.

Figure 57.
Change in Flow and Storage Estimated by PROSIM
to Occur as a Result of the Alternative 2 Cumulative Scenario
as Compared to Existing Conditions for September and October



Top of Old Panel Sections	Minimum Storage	Top of New Panel Sections	Minimum Storage
401	595 TAF	401	595 TAF
388	490 TAF	362	310 TAF
375	395 TAF	336	185 TAF

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Figure 58
Folsom Reservoir Outlets and Temperature Control Panels

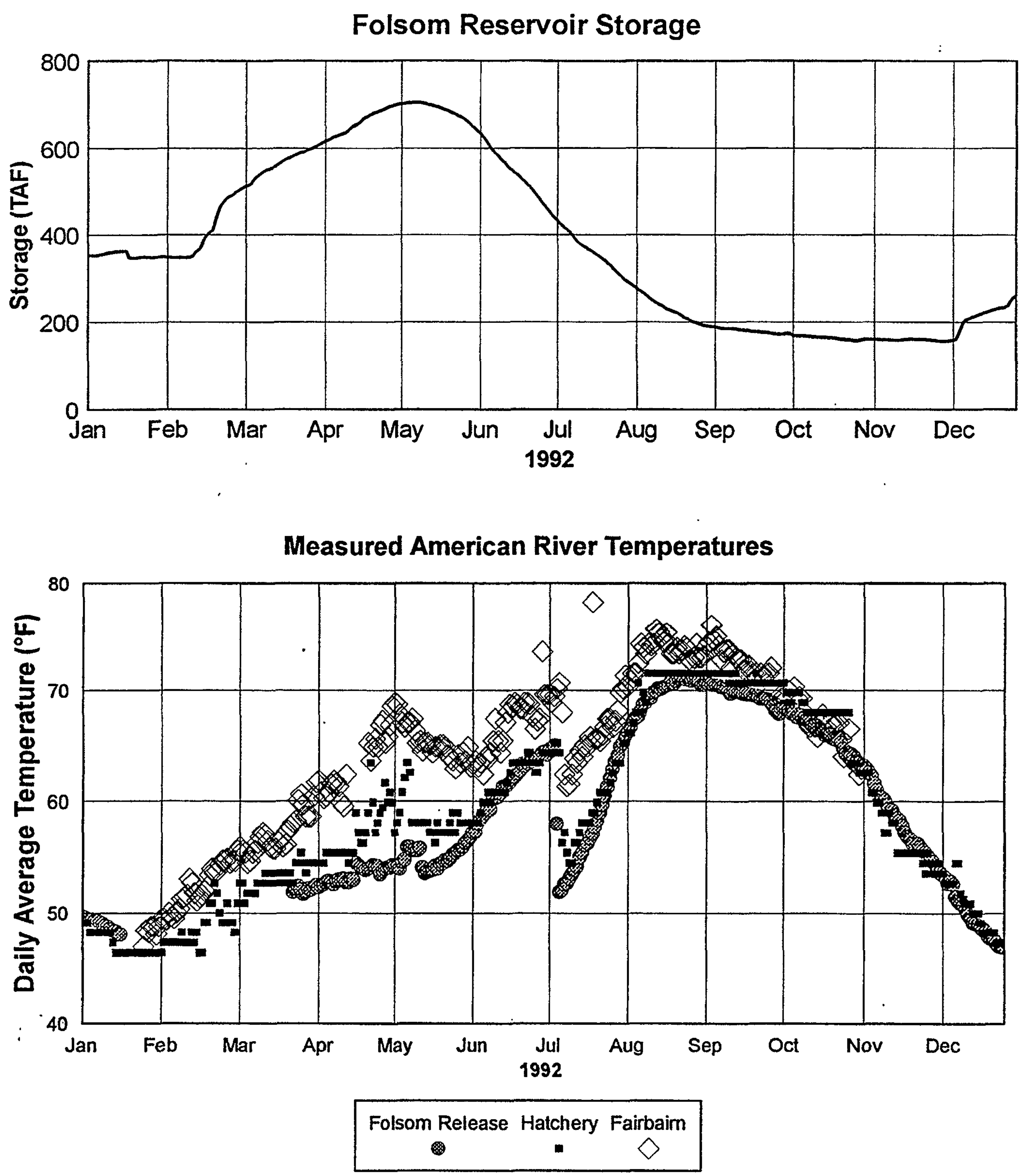

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Figure 59
Folsom Reservoir Storage and
American River Temperatures in 1992