Upper North Fork Feather River (FERC 2105)
Executive Summary
Of
Studies Conducted To Assess the Feasibility of Obtaining Colder Water in the North Fork Feather River

Pacific Gas and Electric Company
October 2004

Report Title: Lake Almanor Cold-water Feasibility Study: Hydraulic Model, IIHR Report No. 438, IIHR – Hydroscience and Engineering, The University of Iowa, Iowa City, Iowa 52242, July 2004

Executive Summary: In stipulated in the Rock Creek-Cresta FERC License No. 1962 and Appendix A of Relicensing Settlement Agreement in Rock Creek-Cresta Project (FERC License No. 1962), a hydraulic model study was conducted to evaluate the anticipated effectiveness of the Prattville Intake Modification control measures. The hydraulic model encompassed a 3.1 mile by 1.9 mile area of Lake Almanor surrounding Prattville Intake. Calibrated, validated and verified with both field data and two smaller scale 'test boxes', the model evaluated several modification alternatives, including several skimming curtains with different lengths and locations around Prattville Intake, a long pipe fitted with a hooded inlet and a short pipe fitted with a hooded inlet. Also tested in conjunction with these alternatives were dredged adjustments to the lake bathymetry in the vicinity of Prattville Intake. Test conditions included various flow releases, different stratification levels in different months and different water surface elevations.

The study produced the following conclusion:

1) A 770-feet-wide skimming curtain placed 900 feet offshore from the Intake with its bottom elevation at 4445 feet (PG&E datum), together with removal of portions of the levees bordering the submerged incised channel, comprise the modification best enabling Prattville Intake to release colder water during June, July and August.
2) Listed in the table are the model results at normal discharge flow of 1600 cfs for the various alternatives for June, July and August. The 770-feet skimming curtain with levees removed reduced outflow temperature at Butt Valley Powerhouse by 5.2, 5.0 and 4.5 °C for the August, July and June conditions, respectively.
3) With Prattville curtain, removal of the levees accounts for approximately a 1.5 °C to 2.0 °C reduction in outflow temperatures at Butt Valley Powerhouse for the August and July conditions, respectively.
4) The other alternative modifications tested (a long hooded pipe inlet, a short hooded pipe inlet and sundry excavation and reshaping of the lakebed in the vicinity of Prattville Intake) suggested some ability of releasing cold water, but was found not as effective as the modification comprising the 770-ft curtain and levee removal.

Summary of hydraulic-model data on outflow temperatures, T_{out}, and temperature reductions, ΔT_{out}, for 1,600 cfs water released from Prattville Intake.

Intake Configuration	June		July		August	
	T_{out} (^{o}C)	ΔT_{out} (^{o}C)	T_{out} (^{o}C)	ΔT_{out} (^{o}C)	T_{out} (^{o}C)	ΔT_{out} (^{o}C)
Existing configuration	16.5	-	19.1	-	21.0	-
Curtain added	12.2	4.3	14.7	4.4	17.6	3.4
Curtain added and levees removed	12.0	4.5	13.1	5.0	15.8	5.2
Long pipe with hooded inlet	-	-	-	-	17.5	3.5
Short pipe with hooded inlet	-	-	-	-	18.0	3.0

Report Title: Prattville Intake Modifications, Phase 3, Feasibility Study, Final Report, January 20, 2004, Black & Veatch

Executive Summary: This report documents a feasibility study, including cost opinions and construction schedules, of alternatives to provide a cold water withdrawal capability at the Prattville Intake at Lake Almanor. The alternatives for this feasibility study are based on the results of the hydraulic model testing performed at the Iowa Institute of Hydraulic Research laboratories in Iowa City, Iowa. The alternatives include:

1) Dredging the Prattville intake area
2) Three floating flexible curtain options (long movable, long fixed, short) with dredging at the Prattville intake area
3) A hooded pipe system with dredging at the Prattville intake area

The report provided conceptual designs, construction costs and schedules, and evaluation of the alternatives.

On August 31, 2004 Black & Veatch provided an up-dated opinion of probable cost of $17.8 million for the long fixed curtain with dredging.

Report Title: Upper North Fork Feather River In-stream Temperature Studies, 33 Years of Synthesized Reservoir Operations, Evaluation of Installation of Curtain and Modifications in Lake Almanor and Blending of Canyon Dam Outflows, DRAFT, January 2004

Executive Summary: The study evaluated the in-stream flow temperatures for the Seneca and Belden Reaches of the Upper North Fork Feather River for conditions with and without Prattville Curtain in Lake Almanor. Measures to conserve cold water by other measures, such as "fence" concept, and variable timing in curtain deployment were evaluated. Effects of blending the outflows from Canyon Dam were considered. Inflows for the analyses were based on 33 years of re-regulated flows developed in accordance with the Settlement Agreement signed in April 2004. Calculations of the outflow temperature from Lake Almanor were made with and without the installation of Prattville curtain. These outflows were routed through Butt Valley Reservoir under existing conditions. The outflow from Canyon Dam and from Caribou 1 and Caribou 2 were routed through the Seneca Reach and Belden Reach, respectively.

The results are summarized below:

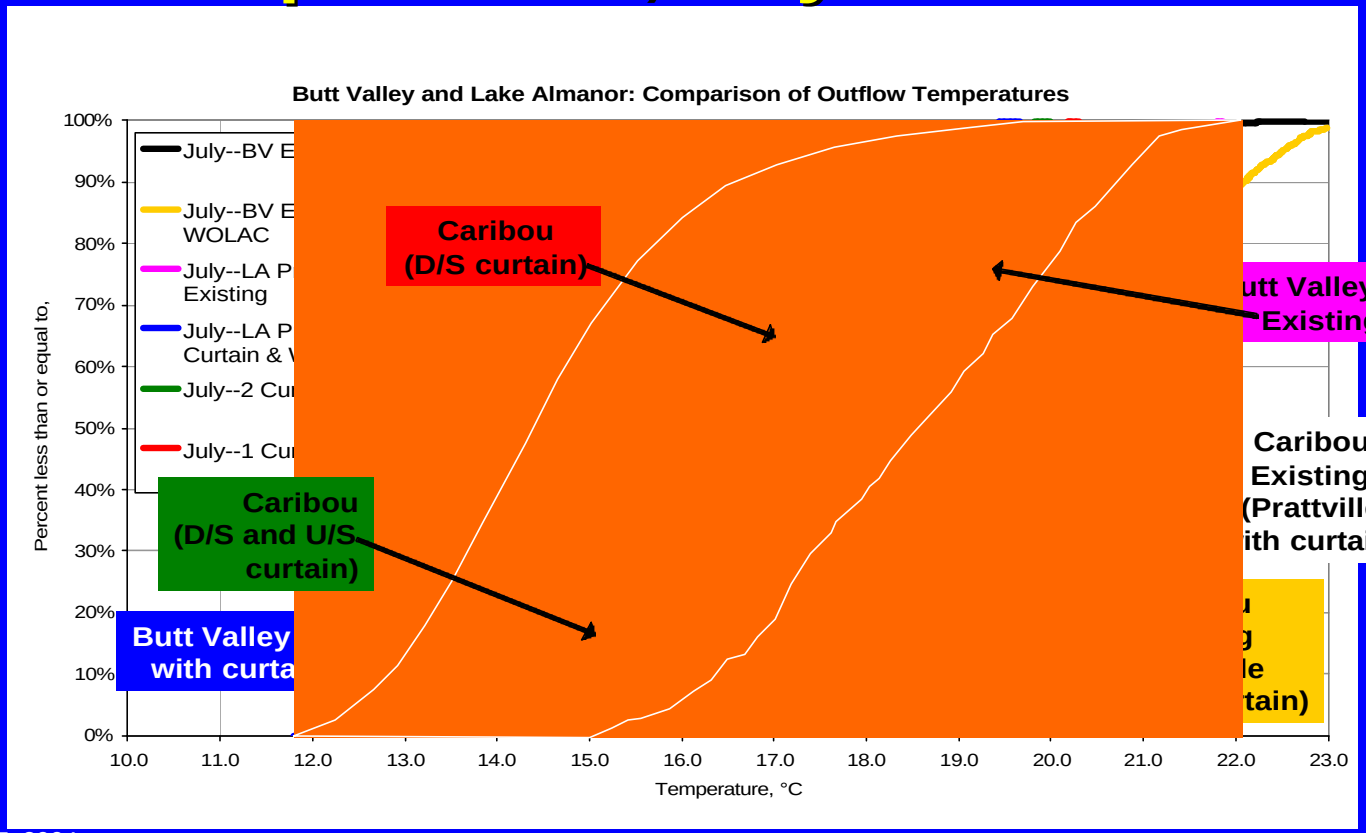
1) The "fence" to conserve cold water in early spring and summer is not necessary because there is little or no discharge of water through Prattville Intake during this period.
2) Exactly what date the curtain is deployed at the Prattville Intake has little effect on the temperatures of releases through the Prattville Intake during August and September.
3) Installation of the Prattville curtain, and an additional control measure consisting of removal of the levees, generally results in different temperature reductions in the outflow temperatures at Butt Valley Powerhouse and Caribou Powerhouses. Figures 1A and 1B show the temperature distribution curves, with and without various curtain options, for July and August, respectively. The information provided herein represents the latest prediction after the issuance of the draft report. From the latest simulation result, the temperature reductions at Butt Valley Powerhouse, based on the 50% exceedance level, are 3.8 °C in July and 3.5 °C in August.
4) Warming occurs in the Butt Valley Reservoir with and without Prattville curtain (Figures 1A and 1B). Warming in Butt Valley Reservoir is more pronounced if Prattville curtain is installed. Measures to minimize Butt Valley Reservoir warming under Prattville curtain condition were investigated. Two potential curtain options in Butt Valley Reservoir were considered, namely the one curtain and the two curtains cases. A downstream curtain, installed near the Caribou No. 1 and 2 intakes, represents the one curtain case, whereas the downstream curtain combined with an additional upper curtain near the reservoir entrance represents the two curtains case. Warming in Butt Valley Reservoir occurs naturally under the existing condition, varying from 0.9 to 3.3 °C depending on the month and the exceedance levels. With three curtains scenario (Prattville curtain and two

curtains in Butt Valley Reservoir), warming in Butt Valley Reservoir is minimized to a range of 0.9 to 1.9 ºC.

5) Stream temperature in Seneca Reach ranged from 12.5 to 15.5 ºC without Canyon Dam blending. The blending operation would result in temperatures up to 4.2 ºC warmer than the no blending case. With blending, the stream temperatures generally are less than 17 ºC.
6) Blending operation at Canyon Day would conserve the cold water pool in Lake Almanor, however, its effect is miniscule compared to the no blending operation.

Model results were updated in June 2004 after the issuance of the draft report. The updated simulation included evaluation of various curtains in Butt Valley Reservoir, and expansion of SNTEMP modeling to include downstream reaches (Rock Creek, Cresta and Poe). One set of simulation result depicting the daily average temperature profile for the entire NFFR watershed is shown in Figures 2A-2F. A complete updated simulation results will be provided in the final report. Additionally, model simulation to estimate the temperatures under Cold and Wet years are still in progress.

Prattville and Caribou Temperatures, July – 33 Years



June 7, 2004 41

Figure 1A July Temperature Distribution Curves for Butt Valley Powerhouse and Caribou Powerhouses with and without Various Curtain Options

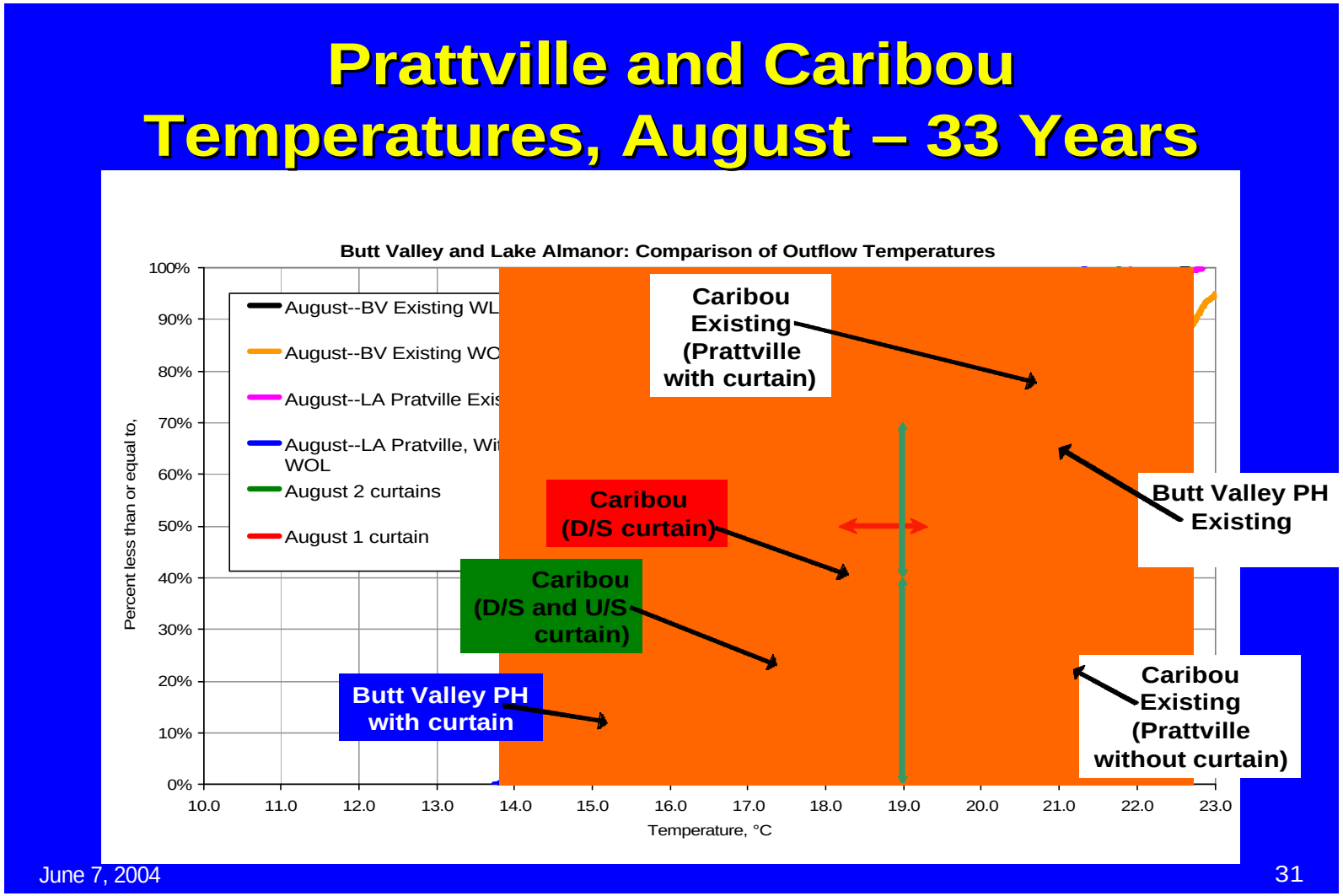


Figure 1B August Temperature Distribution Curves for Butt Valley Powerhouse and Caribou Powerhouses with and without Various Curtain Options

Miscellaneous Information

Temperature Reduction by the High Canyon Dam Release:
High instream flow release for Seneca Reach has been considered and the simulation result presented in the Final Application for License (Volume 1, FAL issued October 2002). Five stream release schedules (year-round release) in Seneca were simulated, varying from 35 cfs to 600 cfs for Seneca release. In that simulation series, the higher instream flow release in excess of 35 cfs is assumed to be offset by the equivalent reduction in the generation loss through Butt Valley Powerhouse. The attached table, reproduced from Table E2.6-14 of FAL, summarized the simulated water temperatures at Belden Dam. Since the instream flow releases as stipulated in the Settlement Agreement (April 2004) vary from 60 cfs to 150 cfs in the period June-September depending on the water year type, predictions averaged between the simulated results of 75 to 150 cfs are probably a reasonable representation for the condition under the Settlement Agreement. When the prediction under the 600 cfs Seneca release is compared to the averaged value between 75 to 150 cfs Seneca release, temperature reduction of 1.0 to 1.3 °C in July and August in normal water year and 2.3 to 2.5 °C temperature reduction in July in critical dry year are expected by the high Canyon Dam release. The cold-water benefits by high Canyon Dam release at Belden Dam are not as significant compared to the Prattville curtain condition depicted in Figures 2A-2F.

Table E2.6-14 (from Final Application for License, page E2-439)

Belden Dam Monthly Median Release Temperatures under Various Environmental Scenarios

Belden Dam Release Temperatures Under Various Environmental Scenarios (°C)										
Canyon Dam Release	Existing Prattville Intake Configuration					Modified Prattville Intake Configuration				
	35 cfs	75 cfs	150 cfs	300 cfs	600 cfs	35 cfs	75 cfs	150 cfs	300 cfs	600 cfs
	Average WY and Normal Meteorology									
June	17.1	17.0	17.0	16.3	15.0	13.8	13.9	14.0	14.2	13.9
July	20.1	**20.2**	**20.0**	19.6	**18.8**	15.5	15.6	15.8	16.0	16.2
August	21.1	**20.8**	**20.6**	20.3	**19.7**	18.6	18.6	18.6	18.8	18.9
September	18.7	18.7	18.5	18.2	18.3	18.6	18.6	18.5	18.5	18.9
	Average WY and Warm Meteorology									
June	17.9	17.7	17.9	17.2	15.7	13.8	14.0	14.3	14.5	14.4
July	21.1	**21.2**	**21.0**	20.6	**19.8**	16.5	16.6	16.7	16.8	17.2
August	22.0	**22.1**	**21.9**	21.5	**20.9**	19.2	19.2	19.1	19.3	19.6
September	20.7	20.7	20.4	20.1	20.0	19.5	19.6	19.5	19.6	20.3
	Dry WY and Normal Meteorology									
June	17.2	16.1	14.5	13.3	14.1	16.6	15.7	14.3	13.3	14.1
July	21.6	**20.9**	**19.5**	18.3	**17.9**	19.3	19.0	18.3	17.6	17.9
August	21.5	**20.8**	**19.5**	19.1	**20.4**	20.3	19.9	18.9	18.9	20.6
September	19.5	19.2	19.1	19.0	20.3	19.3	19.1	18.9	19.2	20.3
	Dry WY and Warm Meteorology									
June	18.1	16.9	15.1	13.8	15.1	17.3	16.3	14.8	13.8	15.2
July	22.6	**21.9**	**20.4**	18.9	**18.7**	20.1	19.7	18.9	18.3	18.8
August	22.8	**22.0**	**20.5**	20.0	**21.2**	20.8	20.4	19.5	19.6	21.5
September	20.6	20.9	20.6	20.3	21.4	20.3	20.2	20.0	20.2	21.5

Report Title: Simulation of Temperature and Dissolved Oxygen in Lake Almanor, California Using the CE-QUAL-W2 Water Quality Model, Jones and Stokes, March 2004.

Executive Summary: The CE-QUAL-W2 reservoir water quality model was used to simulate water quality conditions in Lake Almanor. The performance of the model was evaluated by assessing the match with 2000 and 2001 water quality measurements in the lake, particularly water temperature and dissolved oxygen (DO). The model was able to match the monthly profile measurements fairly well. The model was used to simulate the effect of placing a surface curtain (i.e., a large flexible sheet made of geotechnical fabric held in place with buoys and anchors) in front of the Prattville Intake (to the Butt Valley Powerhouse) to withdraw water from deeper areas in the lake and thereby reduce the withdrawal water temperatures. The effects of these changes on suitable habitat for cold-water fish (i.e., salmonids) in the lake were estimated using two methods: one that estimated suitable habitat using temperature and DO thresholds and another that calculated habitat values using suitability indices for temperature and DO.

The study produced the following conclusion:

1. The curtain would reduce the temperature and lower the DO (to 1-2 mg/l) in water being released from the Butt Valley Powerhouse.
2. The curtain would have only a small effect on the epilimnion water temperature, increasing it by 0-0.5 ^{o}C in some months in Lake Almanor (e.g., September 2000, from 17.5 to 18 ^{o}C).
3. The primary effect was to decrease the surface mixed layer (epilimnion) and lower the thermocline by 0-10 ft (maximum change occurred in July 2000 simulation).
4. The suitability index method of assessing the salmonid habitat was concluded to more realistically portray fish habitat (than the habitat method), and indicated that there was little change between the existing and with curtain condition.
5. The greater depth of the thermocline that is expected with the curtain condition is likely to move the zone of suitable fish habitat slightly deeper in the lake, but it is not likely to change the overall suitability of the lake for cold-water fish.

Report Title: Prattville Intake Modification and Potential Impacts to Lake Almanor Fishery Study, Thomas R. Payne and Associates, Interim Report June 2004.

Executive Summary: The objectives of this study are to access the impacts to Lake Almanor's lakes cold-water fishery resulting from the selective cold water withdrawal from the lake. Lake Almanor is a complex ecosystem with many parameters affecting the fishery. Using existing documentation, this study identifies and evaluates the following potential thermal curtain induced impacts:

- Impacts to lake salmonid habitat resulting from changes to lake temperatures and dissolved oxygen concentrations.
- Impacts to the burrowing mayfly (*Hexagenia limbata*) habitat.
- Impacts on pond smelt (*Hypomesus nipponensis*) entrainment.
- Impacts predicted at or resulting from the installation or operation of thermal curtain at other Northern California reservoirs.

The study results are summarized below:

1. The existing summertime conditions currently stress the salmonid populations.
2. Although the reservoir model predicts no major changes to lake DO concentrations and temperature (Jones and Stokes, 2004), those which are predicted reduce the available salmonid habitat.
3. Thermal curtain induced reductions during times in which the existing conditions severely limit available habitat constitute a substantial portion of that currently available.
4. During times in which the existing conditions are not limiting, the presence of the thermal curtain will have little impact on salmonid habitat.
5. The thermal curtain will reduce the DO concentrations in the Butt Valley powerhouse outflow.
6. The thermal curtain conditions will increase the available habitat for the burrowing mayflies (*Hexagenia limbata*) and in the absence of other limiting factors increase the population.
7. The thermal curtain will likely reduce or eliminate the pond smelt entrainment.
8. The reductions in entrainment will be greatest during times when the lake surface elevation is high.
9. Minimum changes to entrainment are expected at low lake elevations.
10. The physical, geographical, and operational differences in the other reservoirs evaluated for comparison prohibit the extrapolation of study results to Lake Almanor.
11. The methodologies used to assess impacts of the other thermal curtain may be applied to Lake Almanor to further understand the impacts of the thermal curtain.
12. Conduct additional research to define the parameters governing the utilization of habitat in Lake Almanor, such as: telemetry studies to determine salmonid utilization of the spring and riverine inflows; hydroacoustic surveys to refine the criteria used for pond smelt entrainment; and bioenergetic modeling to determine temperature effects on trout growth.

Study Title: Temperature-Conditioned Relative Suitability Index for the Belden, Rock Creek, Cresta, and Poe Reaches of PG&E's North Fork Feather River Hydroelectric Projects, Thomas R. Payne and Associates, Interim Report June 2004.

Executive Summary: The objective of this study is to quantify and better understand how a thermal curtain, when used in controlling the water release system from Lake Almanor into the North Fork Feather River (NFFR), may affect the downstream riverine habitat for the native species rainbow trout (juvenile and adult), hardhead (Forest Service sensitive and California Department of Fish and Game species of special concern), Sacramento sucker, and Sacramento pikeminnow, and the introduced smallmouth bass.

Temperature-conditioned relative suitability indices (RSI), also known as weighted usable area (WUA), throughout the NFFR from Belden Dam to Poe Powerhouse were generated under existing condition (no thermal curtain) under varying flow releases, for different water years (normal and dry), under different meteorological conditions (normal and extreme), and with different exceedance release temperatures from Lake Almanor (50% and 25%) from June through September. The resulting temperature-conditioned RSI by river reach study segment under existing operations were compared with those simulated under operation of a thermal curtain in place at the Prattville Intake Structure.

The study results are summarized below:

Upper Belden Reach: (Belden Powerhouse to confluence with the East Branch)

- Juvenile rainbow trout habitat predicted to change little, or negatively (up to –14.7%) for most months. Only significant increase in habitat occurred in Aug. of both year types, with an increase 8.5% under normal (N) years and 16.7% in dry (D) years.
- Adult rainbow trout habitat changes shows similar pattern as juvenile trout, but not as extreme; maximum decrease was –4.6% (N) in June and maximum increase was 16.4 % (D) in Aug.

Lower Belden Reach: (Below confluence with the East Branch to Belden Powerhouse)

- Both juvenile and adult rainbow trout showed similar patterns and changes. Habitat changes ranged from 0 (Sept. both year types) to a maximum increase of about 14% in July. No decrease in habitat occurred.

Rock Creek Reach:

- Both juvenile and adult habitat changed similarly between year types (N & D) and between flow schedules (1st, 2nd, and 3rd 5-yr test flow periods). Habitat showed no or decreased levels (0 to –3.5%) in June and September in N and D years, and increases of 3.4% to 8.6% in July and August of N years and 13.7% to 25% in D years.
- Habitat changes for Sacramento sucker, pikeminnow and hardhead were also similar between species, life stages, and flow schedules. All habitat changes were negative, and ranged from –1.1% up to –13.7%. No positive changes in habitat occurred.

- Smallmouth bass habitat decreased under all year type and flow scenarios, ranging from –4.4% to 71.9%.

Cresta Reach:

- Rainbow trout results were similar to the Rock Creek Reach, but with slight differences in actual percent changes. Habitat showed no or decreased levels (0 to –2.3%) in June and September in N and D years, and increases of 0.5% to 2.4% in July and August of N years and 14.7% to 23.3% in D years.
- Habitat changes for Sacramento sucker, pikeminnow and hardhead were similar to the Rock Creek Reach, but with slight differences in actual percent changes. All changes in habitat were negative, ranging from –3.7% to –12.3%.
- Smallmouth bass habitat changes were similar to the Rock Creek Reach, only varying by a few percentage points between months and years. All habitat changes were negative, and ranged from –0.8% to –76%.

Poe Reach: (all four habitat curves resulted in the same value changes)

- Rainbow juvenile and adult habitat changes ranged from 0 to 5.5% for all months under both the 150 and 300 cfs release in N years. Slight habitat decreases occurred in June (up to –1.5%), and up to a 24% increase (August) occurred under the 150 cfs release in a D year.
- As for the Rock Creek and Cresta reaches above, habitat decreased for Sacramento sucker, pikeminnow, and hardhead under all year types and flow scenarios. Decreases in habitat ranged from –0.6% to –11.3%, depending on species, flow, and water year type.
- Smallmouth bass habitat also decreased under all water year types and flow scenarios, ranging from –0.7% to –71.6%.

Report Title: Rock Creek – Cresta Project FERC No. 1962, Ecological Resources Committee, Annual Report on 2003 Operation and Monitoring License Condition 22 And Annual Water Temperature Monitoring Report License Condition 4.C, Final Report, May 28, 2004

Executive Summary: As a part of the Rock Creek – Cresta Project's license required annual water temperature monitoring, a test was performed to determine the water temperature effects of selectively operating Caribou No. 1 and Caribou No. 2 Powerhouses. Caribou No. 1 Powerhouse intake is located in a deeper portion of Butt Valley Reservoir thereby providing better access to the available pool of cooler water. Caribou No. 2 Powerhouse intake is located in a shallow cove. Butt Valley Reservoir thermally stratifies, however only a limited supply of lower level cool water is available.

The results of the test indicated that under current conditions, the preferential use of Caribou No. 1 over Caribou No. 2 Powerhouse produced the following results:

1) Under the best-case scenario, a 3 degrees C decrease in water temperature was observed at Belden Dam.
2) The same test yielded a 1.1 and 0.5 degrees C decrease in water temperature in the Rock Creek and Cresta bypass reaches respectively.
3) The reserve of cool water is limited in Butt Valley Reservoir, and the operation of Caribou No. 1 Powerhouse over Caribou No. 2 Powerhouse can at best provide only temporary periods (several days) of cool water.
4) After several days of Caribou No. 1 Powerhouse operation the reserve of cool water in Butt Valley Reservoir is exhausted causing water temperatures in Butt Valley Reservoir's hypolimnion to rapidly warm to temperatures that are similar to those observed entering the reservoir through Butt Valley Powerhouse.