Evaluation of Additional Alternatives to Provide Cooler Water to the North Fork Feather River

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Pacific Gas and Electric Company
December 2004

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Mechanical Cooling Tower Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Construct and operate mechanical cooling towers on the North Fork Feather (NFFR) River to cool incoming river water and deliver it to the river below Rock Creek, Cresta and Poe Dams. The engineering firm of Black and Veatch provided the following conceptual feasibility assessment:

Assumptions: Divert, pipe and pump the existing required instream flow release amount at each dam into mechanical draft wet-type cooling towers located in the vicinity of each dam. The wet-type cooling tower was chosen because it has the smallest footprint in relation to other types of cooling towers. For this analysis a flow of 250 cubic feet per second (112,200 gpm) and a cooling requirement of 1 degrees C (1.8 degrees F) is used.

Calculations: The following design criteria were used:

- Feather River flow of 250 cfs is to be cooled 1 degree C (1.8 degree F.)
- Incoming river water temperature is 22 degrees C (71.6 degrees F.)
- Cooling is required during July and August
- Design Wet Bulb temperature 64 degrees F during July and August.
- Cooling tower selected for 5 degree F approach to wet bulb supply 69 degrees F water.

To cool this heat load (100,980,000 BTU) would require a 14 – 50' x 50' counter flow cooling tower cells. Each cell would require a 200 hp fan motor and 14 – 400 hp associated pumps to lift water into the cells. Each cell would have a height of about 75' depending upon the cooling range, the approach wet bulb temperature, the mass flow rate of water and the air velocity through each cell. At or below each dam an area of approximately 200' x 900' would be needed to site the cooling towers, piping, pumps and electrical equipment.

Siting Considerations: The cooling tower would need to be sited above the flood plain and ideally just below each dam with a side spill channel that discharged back into the river. Wet-type cooling towers can produce fog and water vapor which could cause automobile safety issues on the nearby Highway 70. Visual impacts of cooling towers would need to be considered.

The cooling tower would require a diversion dam, screening facility and large piping network to draw water and return water to the river.

A review of the topography, river flood plain and highway/railroad route locations below Rock Creek, Cresta and Poe dams was conducted. The review concludes that adequate space does not exist to site the cooling towers.

Other Considerations: The operation of the cooling tower fans and water pumps would require considerable electric power supply. The power requirements of the cooling towers are about 5,500 kW. New transmission/distribution lines and substations would be required at each site to supply the required electrical power.

An estimated Construction Cost Budget range for cooling towers, pumps, piping, stream dam with sand filter and bypass overflow stream is $9.8 to $13.5 million per river reach. Cooling towers will not maintain 69.8 F or less if stream flow is above 250 cfs or wet bulb is above 65 degrees F. These estimated costs are for a typical installation. They do not address the confined site conditions along the Feather River, architectural appearance, or other potential mitigation measures required to allow construction at these sites. They also do not include costs for utilities including the transmission lines to bring power supply to each site.

Conclusion: Adequate space does not exist to site cooling towers near Rock Creek, Cresta and Poe dams. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Mechanical Water Chillers Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Construct and operate mechanical water chillers on the North Fork Feather (NFFR) River to cool incoming river water and deliver it to the river below Rock Creek, Cresta and Poe Dams. The engineering firm of Black and Veatch provided the following conceptual feasibility assessment:

Assumptions: Divert, pipe and pump the existing required instream flow release amount at each dam into mechanical chillers located in the vicinity of each dam. For this analysis a flow of 250 cubic feet per second (112,200 gpm) and a cooling requirement of 1 degrees C (1.8 degrees F) is used.

Calculations: The following design criteria were used:

- Feather River flow of 250 cfs is to be cooled 1 degree C (1.8 degree F.)
- Incoming river water temperature is 22 degrees C (71.6 degrees F.)
- Cooling is required during July and August
- Design Wet Bulb temperature 64 degrees F during July and August.
- Cooling tower selected for 5 degree F approach to wet bulb supply 69 degrees F water.

A system employing high efficiency electrical centrifugal coolers with helper cooling towers is proposed. Based on the limited design criteria provided, the design cooling load for 250 cfs flow with a 1.8 degree F delta T is 8,461 tons of cooling.

The conceptual cooling system would consist of the following: 6 – 1500 ton package chillers, 3 – 6000 gpm river pumps, 3 – 3000 ton cooling tower cells, 6 – 3000 gpm cooling tower pumps, and support buildings. The chiller building would be a 90 ft. x 120 ft. pre-engineered building with outside high voltage switchgear and transformers. The estimated power requirement is 3600 kW at peak load. The cooling tower would be about 46 ft. wide by 150 ft. long with three cells with six vertical turbine pumps. The site area required for the cooling tower to allow proper air circulation would be about 130 ft. by 200 ft.

Primary cooling would be performed by the chillers. The system would be designed to operate the cooling tower to evaporative cool the river water when ambient wet bulb temperature is less than 61 degrees F and river water temperature is above 68 degrees F. When river water temperature is above 69.5 degrees F, the control system would activate the chiller cooling system and sequence chillers “on” based on upstream and downstream river temperature. Controls would stage each 3000 ton of capacity by starting river water cooling pumps, cooling tower pumps and cooling tower. Each chiller would modulate inlet vanes to maintain the leaving water temperature. The control system would be designed to operate the system without an operator, with remote control and monitoring.

Siting Considerations: The water chillers would need to be sited above the flood plain and ideally just below each dam with a side spill channel that discharged back into the river. The wet-type cooling towers associated with the chillers can produce fog and water vapor which could cause automobile safety issues on the nearby Highway 70. Visual impacts of cooling towers would need to be considered.

The water chillers would require a diversion dam, screening facility and piping network to draw water and return water to the river.

A review of the topography, river flood plain and highway/railroad route locations below Rock Creek, Cresta and Poe dams was conducted. The review concludes that adequate space does not exist to site the water chiller system.

Other Considerations: The operation of the water chillers and water pumps would require considerable electric power supply. The power requirements of the water chiller system are about 3,600 kW. New transmission/distribution lines and substations would be required at each site to supply the required electrical power.

An estimated Construction Cost Budget range for the system described above is $1,400 to $1,800 per ton, or $11.8 to 15.2 million, per installation. Total estimated cost for three sites is $35.4 to 45.6 million. These estimated costs are for a typical installation. They do not address the confined site conditions along the Feather River, architectural appearance, or other potential mitigation measures required to allow construction at these sites. They also do not include costs for utilities including the transmission lines to bring power supply to each site.

Conclusion: Adequate space does not exist to site water chiller system near Rock Creek, Cresta and Poe dams. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Well Water Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Drill, construct and operate water wells on the North Fork Feather River (NFFR) to deliver cooler well water to the river below Rock Creek, Cresta and Poe Dams.

Assumptions: For this analysis it is assumed an existing river flow of 200 cubic feet per second (89,766 gpm) is at 22 degrees C (71.6 degrees F) and will be cooled by 3 degrees C (5.4 degrees F) at the mixing point using well water. The 22 degrees C river water temperature represents the existing August 25% exceedance water temperature. The input location of the cold well water (mass balance to provide 3 degrees C cooling when initially mixed with the river water) is at or near each dam. The river water naturally heats up about 2 degrees C as it travels down each river reach resulting in a net benefit of about 1 degrees C cooling at the bottom of the river reach. The temperature of the well water is assumed to be 10 degrees C (50 degrees F).

Calculations: The well water delivery requirements calculation is:

$$\frac{(200\text{ cfs})(22\text{ degrees C}) + (x\text{ cfs})(10\text{ degrees C})}{200\text{ CFS} + x\text{ cfs}} = (22\text{ degrees C}) - (3\text{ degrees C})$$

x = 66 cfs

Therefore, it would require mixing 66 cubic feet per second or 29,623 gallons per minute of well water at 10 degrees C with 200 cubic feet per second at 22 degrees C NFFR water below each dam to achieve the desired cooling of 3 degrees C at the mixing point.

Siting Considerations: The wells, pumps and associated electrical equipment would need to be sited above the flood plain and ideally just below each dam with a side spill channel that discharged back into the river. Visual impacts of the well pumps and associated electrical equipment would need to be considered.

Local irrigation well pump suppliers and well drillers were contacted (Dickens Drilling, Nor-Cal Pump & Well Drilling). They indicated that the largest water wells in Plumas County are located in the Sierra Valley and produce about 1000 gallons per minute, pumping 1200 feet in depth. In Butte County the largest water wells produce about 2000 gallons per minute, pumping 180 feet in depth using 75 hp well pumps. An 8" diameter water well exists a Caribou which produces only 20 -30 gallons per minute. When asked about the potential water yield from deep wells in the Feather River Canyon, the well driller said to expect only 50 gallons per minute.

PG&E has extensive geology information for the NFFR area associated with seismic analysis. Both horizontal and vertical drilling and refractive testing has been done. Based on this data, the PG&E geologist does not believe there exists an aquifer in the

NFFR canyon area that can produce large amounts of well water. The general characteristics of the aquifers in this area are small and located in rock fractures.

A review of the topography, river flood plain and highway/railroad route locations below Rock Creek, Cresta and Poe dams was conducted. The review concludes that adequate space does not exist to site well pumps and the associated electrical equipment.

Other Considerations: The operation of the well pumps would require considerable electric power supply. New transmission/distribution lines and substations would be required at each site to supply the required electrical power.

Well water may have chemical characteristics (minerals and DO) that are incompatible with the State Water Resources Control Board's Basin Plan water quality objectives for the NFFR.

Conclusion: It is not likely an adequate aquifer exists near Rock Creek, Cresta and Poe dams. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Pumping Lake Oroville Water Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Construct and operate a water pipeline and pumping stations on the North Fork Feather River (NFFR) to deliver cooler water from the lower depths of Lake Oroville to Rock Creek, Cresta and Poe Dams.

Assumptions: For this analysis it is assumed an existing river flow of 200 cubic feet per second (89,766 gpm) is at 22 degrees C (71.6 degrees F) and will be cooled by 3 degrees C (5.4 degrees F) at the mixing point using Lake Oroville water. The 22 degrees C river water temperature represents the existing August 25% exceedance water temperature. The input location of the Lake Oroville pumped water (mass balance to provide 3 degrees C cooling when initially mixed with the river water) is just below each dam. The river water naturally heats up about 2 degrees C as it travels down the river reach resulting in a net benefit of about 1 degrees C cooling at the bottom of the river reach. The temperature of the Lake Oroville water is assumed to be 10 degrees C (50 degrees F). Lake Oroville thermally stratifies each year and water temperature data indicates 10 degree C water is located about 60-75 feet in depth below the surface.

There will be some heating effects to the pipeline water while in-route due to pumping and pipe surface heat transfer. This heating effect has not been calculated.

Calculations: The Lake Oroville water delivery requirements calculation is:

$$\frac{(200\text{ cfs})(22\text{ degrees C}) + (x\text{ cfs})(10\text{ degrees C})}{200\text{ CFS} + x\text{ cfs}} = (22\text{ degrees C}) - (3\text{ degrees C})$$

x = 66 cfs

Therefore, it would require mixing 66 cubic feet per second or 29,623 gallons per minute of Lake Oroville water at 10 degrees C with 200 cubic feet per second at 22 degrees C NFFR water below each dam to achieve the desired cooling of 3 degrees C at the mixing point. Pumping cold water from Lake Oroville to Rock Creek, Cresta and Poe dams would require a minimum of 198 cubic feet per second or 88,869 gallons per minute (not counting heat gain from pumping and conveyance).

Pipeline and pumping calculations: Pumping cold water from Lake Oroville upstream is basically one of engineering economics in which one would have to weigh the cost variables for different sized pipes, pumping capacities, pump efficiencies, pipeline route alternatives and cost of power. A 72” diameter pipe is a good starting assumption for the 198 cubic feet per second (Lake Oroville to Poe dam pipeline section). Using this size of pipe and assuming standard friction head losses the flow velocities would be about 7 feet per second. The pipe could be reduced to a 60” diameter for the Poe dam to Cresta dam pipeline section. Finally, the pipe could be reduced to a 48” diameter for the Cresta dam to Rock Creek dam section. The total pipeline length would be more that 30 miles. The approximate total elevation difference of a pipeline would be about 1600’. Numerous pumping stations would be required depending on the specific hydraulic grade and lift requirements. No pumping station estimate has been done at this time.

Siting Considerations: The pipeline, pumping stations and associated electrical equipment would need to be sited above the flood plain. Visual impacts of the pipeline, pumping stations, associated electrical equipment and access roads would need to be considered.

Pipeline construction in the NFFR canyon would have significant engineering, construction and environmental challenges. Major disruption of railroad and Highway 70 traffic would be expected during construction.

A review of the topography, river flood plain and highway/railroad route locations below Rock Creek, Cresta and Poe dams was conducted. No feasible pipeline route was determined.

Other Considerations: The operation of the pipeline and pumping stations would require considerable electric power supply. New transmission/distribution lines and substations would be required at each site to supply the required electrical power.

Lake Oroville water may have chemical characteristics (minerals and DO) that are incompatible with the State Water Resources Control Board’s Basin Plan water quality objectives for the NFFR.

Conclusion: Construction and operation of a large pipeline to transport Lake Oroville water to Rock Creek, Cresta and Poe dams would be a major engineering and construction task with significant environmental impacts and risks. There exists no feasible pipeline route. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Pipe Upper North Fork Feather River Water Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Construct and operate a diversion dam and gravity water pipeline to deliver cooler water from the Upper North Fork Feather River to immediately below Belden Dam.

Assumptions: During July and August the flows in the Upper North Fork Feather River just above Caribou Powerhouse are approximately 68 cubic feet per second. The measured mean water temperature for July and August 2002 was 15 to 15.9 degrees C. For this analysis it is assumed that 50 cubic feet per second at 15 degrees C of Upper North Fork Feather water is diverted and gravity piped about 1 mile to a point immediately below Belden Dam. Below Belden Dam it is mixed with existing river flow of 90 cubic feet per second at 22 degrees C (71.6 degrees F). The 22 degrees C river water temperature represents the existing August 25% exceedance water temperature. The input location of the Upper North Fork Feather River piped water is immediately below Belden Dam.

If an above-ground water pipeline was constructed, there will be heating effects to the pipeline water while in-route due to pipe surface heat transfer. This heating effect has not been calculated.

Calculations: The Upper North Fork Feather water cooling calculation is:

$$\frac{(90\ \text{cfs})(22\ \text{degrees C}) + (50\ \text{cfs})(15\ \text{degrees C})}{90\ \text{CFS} + 50\ \text{cfs}} = x\ \text{degrees C}$$

x = 19.5 degrees C

The mixing of 50 cubic feet per second at 15 degrees C Upper North Fork Feather River water with 90 cubic feet per second at 22 degrees C Belden Reservoir released water will result in 140 cubic feet per second of 19.5 degree C water at the mixing point. This would be a 2.5 degrees C water temperature reduction below Belden Dam.

Pipeline size calculations: Gravity piping of cold water from the Upper North Fork Feather River is basically one of engineering economics in which one would have to weigh the cost variables for different sized pipes, head necessary to overcome pipe friction and pipeline route/diversion dam location alternatives. An approximate minimum pipeline size of 48" diameter is necessary to gravity pipe a flow of 50 cubic feet per second for 1 mile. The calculated minimum pipeline size requires a 13' head (ignoring entrance losses and bend losses) which locates the diversion dam above Caribou Powerhouse.

Siting Considerations: The 1 mile pipeline and valve equipment would need to be sited above the flood plain. A diversion dam and pipeline intake would be sized to withstand large flood flows from the Upper North Fork Feather River. Visual impacts of the pipeline and diversion dam would need to be considered.

Pipeline and diversion dam construction in the Upper NFFR canyon would have significant engineering, construction and environmental challenges. Construction of a diversion dam and routing the pipeline through the existing Caribou Powerhouse area and along the Caribou road would be challenging.

Other Considerations: Currently the Upper North Fork Feather River water provides a localized cooling effect at the confluence with Caribou Powerhouse flows. This provides some cold water refuge for fish in the immediate area. The diversion dam would create fish passage issues.

Operation and maintenance of a large water pipeline through the Caribou Powerhouse area and along the Caribou road would have failure risks from auto collisions, road maintenance equipment and rock slides.

Conclusion: Construction and operation of a large pipeline to transport Upper North Fork Feather River water to Belden Dam would be a major engineering and construction task with significant environmental impacts and risks. There exists no feasible pipeline route that does not have major impacts on Caribou Powerhouse and Caribou road. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Pipe Yellow Creek Water Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Construct and operate a diversion dam and gravity water pipeline to deliver cooler water from Yellow Creek to immediately below Rock Creek Dam.

Assumptions: During July and August the flows in Yellow Creek just above its confluence with the North Fork Feather River (NFFR) are approximately 50 cubic feet per second. The measured mean water temperature for July and August 2003 was 15 to 16 degrees C. For this analysis it is assumed that 50 cubic feet per second at 16 degrees C of Yellow Creek water is diverted and gravity piped about 3 miles to a point immediately below Rock Creek Dam. Below Rock Creek Dam it is mixed with existing river flow of 200 cubic feet per second at 22 degrees C (71.6 degrees F). The 22 degrees C river water temperature represents the existing August 25% exceedance water temperature. The input location of the Yellow Creek piped water is immediately below Rock Creek Dam.

If an above-ground water pipeline was constructed, there will be heating effects to the pipeline water while in-route due to pipe surface heat transfer. This heating effect has not been calculated.

Calculations: The Yellow Creek water cooling calculation is:

$$\frac{(200\text{ cfs})(22\text{ degrees C}) + (50\text{ cfs})(16\text{ degrees C})}{200\text{ CFS} + 50\text{ cfs}} = x\text{ degrees C}$$

x = 20.8 degrees C

The mixing of 50 cubic feet per second at 16 degrees C Yellow Creek water with 200 cubic feet per second at 22 degrees C Rock Creek Reservoir released water will result in 250 cubic feet per second of 20.8 degree C water at the mixing point. This would be a 1.2 degrees C water temperature reduction below Rock Creek Dam.

Pipeline size calculations: Gravity piping of cold water from Yellow Creek is basically one of engineering economics in which one would have to weigh the cost variables for different sized pipes, head necessary to overcome pipe friction and pipeline route/diversion dam location alternatives. An approximate minimum pipeline size of 48" diameter is necessary to gravity pipe a flow of 50 cubic feet per second for 3 miles. The calculated minimum pipeline size requires a 13' head (ignoring entrance losses and bend losses) which locates the diversion dam near Belden Powerhouse. A smaller pipeline could be used if the diversion dam was located further up Yellow Creek creating more head (i.e. 42" diameter pipeline requires 25' head).

Siting Considerations: The 3 mile pipeline and valve equipment would need to be sited above the flood plain. A diversion dam and pipeline intake would be sized to withstand large flood flows from Yellow Creek. Visual impacts of the pipeline and diversion dam would need to be considered.

Pipeline construction in the NFFR canyon would have significant engineering, construction and environmental challenges. Major disruption of Highway 70 traffic would be expected during construction. Also, underground telephone lines traverse along Highway 70 which could be disrupted during construction.

A review of the topography, river flood plain and highway route locations at Rock Creek reservoir was conducted. Field reconnaissance concluded the pipeline route would be a combination of surface and underground pipeline following Highway 70. Significant portions of the pipeline would need to be buried under Highway 70 due to limited space.

Other Considerations: Currently Yellow Creek water provides a localized cooling effect at the confluence with the NFFR. This provides some cold water refuge for fish in the immediate area. The diversion of Yellow Creek would eliminate this local cool water refuge at the confluence.

Operation and maintenance of a large water pipeline along Highway 70 would have failure risks from auto collisions, road maintenance equipment and rock slides.

Conclusion: Construction and operation of a large pipeline to transport Yellow Creek water to Rock Creek dam would be a major engineering and construction task with significant environmental impacts and risks. There exists no feasible pipeline route that does not have major impacts on Highway 70. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Pipe Bucks Creek Powerhouse Water Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Construct and operate gravity water pipeline to deliver cooler water from the Bucks Creek Powerhouse to immediately below Cresta Dam.

Assumptions: During July and August the maximum flows through Bucks Creek Powerhouse are approximately 300 cubic feet per second. The measured mean water temperature for July and August 2003 was 14.3 to 16.7 degrees C. For this analysis it is assumed that 50 cubic feet per second at 16 degrees C of Bucks Creek Powerhouse water is diverted and gravity piped about 4 miles to a point immediately below Cresta Dam. Below Cresta Dam it is mixed with existing river flow of 200 cubic feet per second at 22 degrees C (71.6 degrees F). The 22 degrees C river water temperature represents the existing August 25% exceedance water temperature. The input location of the Bucks Creek Powerhouse piped water is immediately below Cresta Dam.

If an above-ground water pipeline was constructed, there will be heating effects to the pipeline water while in-route due to pipe surface heat transfer. This heating effect has not been calculated.

Calculations: The Bucks Creek Powerhouse water cooling calculation is:

$$\frac{(200\text{ cfs})(22\text{ degrees C}) + (50\text{ cfs})(16\text{ degrees C})}{200\text{ CFS} + 50\text{ cfs}} = x\text{ degrees C}$$

x = 20.8 degrees C

The mixing of 50 cubic feet per second at 16 degrees C Bucks Creek Powerhouse water with 200 cubic feet per second at 22 degrees C Cresta Reservoir released water will result in 250 cubic feet per second of 20.8 degree C water at the mixing point. This would be a 1.2 degrees C water temperature reduction below Cresta Dam.

Pipeline size calculations: Gravity piping of cold water from Bucks Creek Powerhouse is basically one of engineering economics in which one would have to weigh the cost variables for different sized pipes, head necessary to overcome pipe friction and pipeline route/diversion dam location alternatives. An approximate minimum pipeline size of 48" diameter is necessary to gravity pipe a flow of 50 cubic feet per second for 4 miles. The calculated minimum pipeline size requires a 13' head (ignoring entrance losses and bend losses). A pressurized water pipeline system along Highway 70 is not recommended.

Siting Considerations: The 4 mile pipeline and valve equipment would need to be sited above the flood plain. A Y-tap into the Bucks Creek Powerhouse penstock would be an engineering challenge due to the age and material composition of the existing penstock. A water pressure reducer system would be required at beginning of the pipeline. Visual impacts of the pipeline would need to be considered. One or two pipeline bridges crossing the NFFR would probably be required. Routing the pipeline through the Rock Creek Powerhouse area would be an engineering challenging.

Pipeline construction in the NFFR canyon would have significant engineering, construction and environmental challenges. Major disruption of Highway 70 traffic would be expected during construction. Also, underground telephone lines traverse along Highway 70 which could be disrupted during construction.

Other Considerations: Currently Bucks Creek Powerhouse water provides a localized cooling effect for the approximately 1 mile river reach to the Rock Creek Powerhouse. This provides cold water refuge for fish in the immediate area. The diversion of Bucks Creek Powerhouse water would eliminate some of the local cool water refuge in this reach.

Operation and maintenance of a large water pipeline along Highway 70 would have failure risks from auto collisions, road maintenance equipment and rock slides.

Conclusion: Construction and operation of a large pipeline to transport Bucks Creek Powerhouse water to Cresta Dam would be a major engineering and construction task with significant environmental impacts and risks. There exists no feasible pipeline route that does not have major impacts on Highway 70. Therefore, this alternative warrants no further evaluation.

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

New Reservoir Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Build and operate a large reservoir on the East Branch Feather River (EBFR) and its tributaries to provide thermally stratified cold water from its lower depths to reduce water temperatures at the EBFR at its confluence with the North Fork Feather River (NFFR) and downstream on the Belden, Rock Creek, Cresta and Poe river reaches.

Assumptions: A new dam and reservoir, if sized large enough, could store high winter/spring runoff and provide thermally stratified cold water from its lower depths during summer months. Based on Lake Almanor, Butt Valley Reservoir and Bucks Lake thermal stratification profiles, a new dam would need to be over 100 feet high in order to provide enough water depth and volume to supply sufficient quantities of cold water.

Three potential large reservoirs in the Upper Feather River basin were identified in the State of California Bulletin No. 3, titled Report on the California Water Plan, May, 1956 and the State of California, Department of Water Resources Bulletin No. 194, March 1974 titled Hydroelectric Energy Potential in California. The locations of the identified potential large reservoirs are as follows:
1) Humbug Valley Reservoir in Yellow Creek tributary to the NFFR
2) Genesee Reservoir on Indian Creek tributary to the EBFR
3) Squaw Queen Reservoir on Last Chance Creek tributary the Indian Creek then EBFR

A brief description of each potential large reservoir is attached.

PG&E and others have previously evaluated each of the above reservoir sites and have found them not feasible.

Calculations: Calculation of the water temperature influence of the EBFR water (water from potential Genesee and Squaw Queen Reservoirs) on the NFFR: Attached are graphs that overlay the mean daily streamflow in the EBFR and NFFR below Belden Powerhouse for July and August for several years' record. These graphs demonstrate the following:
1) At the confluence of the EBFR and the NFFR, the EBFR flows in July and August are approximately the same flow magnitude as those in the upstream NFFR. Therefore, using existing flows, any beneficial water temperature change made in the EBFR that reach the confluence will be reduced by 50% after mixing with the flows from the NFFR.
2) Below Belden Powerhouse the NFFR flows in July and August are approximately ten times greater than the EBFR flows. Therefore, using existing flows, any beneficial water temperature change made in the EBFR that reach the confluence will have a corresponding 10% temperature change result in the NFFR immediately below Belden Powerhouse after mixing occurs.

This dilution effect using existing flows is illustrated by the following example: A 1.0 degree C water temperature reduction in the EBFR will result in 1) a 0.5 degree C water temperature reduction in the NFFR from the confluence to Belden Powerhouse (1.8 mile reach) and 2) a 0.1 degree C water temperature reduction in the NFFR below Belden Powerhouse.

Calculation of the water temperature influence of the Yellow Creek water (water from the potential Humbug Valley Reservoir) on the NFFR: During July and August the flows in Yellow Creek just above its confluence with the NFFR are approximately 50 cubic feet per second. As shown on the attached graphs the combined Belden Powerhouse and EBFR flows are more that 30 times greater than the Yellow Creek flows. Therefore, using existing flows, any beneficial water temperature change made in Yellow Creek that reach the NFFR will have a corresponding 3% temperature change result in the NFFR immediately below Belden Powerhouse after mixing occurs.

This dilution effect using existing flows is illustrated by the following example: A 1.0 degree C water temperature reduction in Yellow Creek will result in a 0.03 degree C water temperature reduction in the NFFR below Belden Powerhouse.

Estimate of water temperature cooling effect of large reservoirs:

Humbug Valley Reservoir – Previous water temperature sampling on Yellow Creek in lower Humbug Valley demonstrates that Yellow Creek already is cold water (6-12 degrees C). Large cold water springs named Big Springs are located in central Humbug Valley which introduce significant cold water into Yellow Creek. If a dam and reservoir were constructed it is likely that thermal stratification would occur in the reservoir during the summer months. The cold spring water would stay in the lower portions of the reservoir however it would likely be warmed several degrees C due to the overall heating effects of the entire reservoir. Lake Almanor exhibits similar warming effects of cool spring water. Therefore, water released from the lower portions of Humbug Valley Reservoir is not expected to provide significant temperature benefits when compared to the existing conditions. For this analysis no evaluation of the water temperature benefits to the NFFR from increasing the quantity of water released from the lower portions of Humbug Valley Reservoir. The current July and August measured Yellow Creek flows in lower Humbug Valley are 30-40 cubic feet per second.

Genesee and Squaw Queen Reservoirs - Previous year 2003 water temperature sampling on Indian Creek in Genesee Valley demonstrates that Indian Creek water temperatures are cooler in the spring/early summer (5-19 degrees C) and warmer in the summer/early fall (16-20 degrees C). If a dam and reservoir were constructed it is likely that thermal stratification would occur in the reservoir during the summer months. The cooler water captured during spring and early summer would stay in the lower portions of the reservoir due to stratification. During summer and early fall months warmer Indian Creek water entering the reservoir would experience some mixing with the cooler lower portion of the reservoir however a well developed reservoir stratification will minimize the mixing effect. Therefore, water released from the lower portions of Genesee Reservoir during summer months is expected to provide temperature benefits when compared to the existing conditions. The estimated temperature benefit would be in the range of 6-8 degrees C at the release point at Genesee Dam. For this analysis no evaluation of the water temperature benefits to the NFFR from increasing the quantity of water released from the lower portions Genesee Reservoir. The July and August flows in Indian Creek in Genesee Valley are about 25-35 cubic feet per second.

Siting Considerations: Both Genesee and Squaw Queen Reservoirs are approximately 30 to 40 miles upstream of Belden Powerhouse and significant warming of EBFR river water will continue to occur. Intervening Indian Valley irrigation withdrawals downstream of Genesee and Squaw Queen reservoirs could reduce any water temperature benefits.

Significant environmental impacts of new large reservoir will need to be considered.

Other Considerations: Probability of obtaining additional storage water rights for new reservoirs is not likely unless adverse impacts on downstream prior water right holders are mitigated (i.e. DWR, Lake Oroville).

Water released from the lower portion of the reservoirs will have chemical characteristics (minerals and DO) that are incompatible with the State Water Resources Control Board's Basin Plan water quality objectives for the NFFR.

Conclusion: The identified potential large reservoirs at Genesee Valley and Squaw Valley could provide thermally stratified cooler water producing local water temperature benefits however those water temperature benefits are not expected to result in any measurable water temperature change to the NFFR below Belden Powerhouse. Therefore, this alternative warrants no further evaluation.

Brief Description of Potential Large Reservoir Sites on the East Branch Feather and Yellow Creek

Humbug Valley Dam and Reservoir - The potential dam location is on Yellow Creek at the south end of Humbug Valley in Section 18, T26N, R7E, MDBM. The approximate size of the dam would be over 1000' long and about 130' high which is very similar in size to the existing Butt Valley Dam. The reservoir created behind the dam would flood Humbug Valley. The reservoir would be about 3.5 miles long and 1.5 miles wide and have a total storage capacity of about 70,000 AF. The majority of the dam and reservoir site is located on PG&E land.

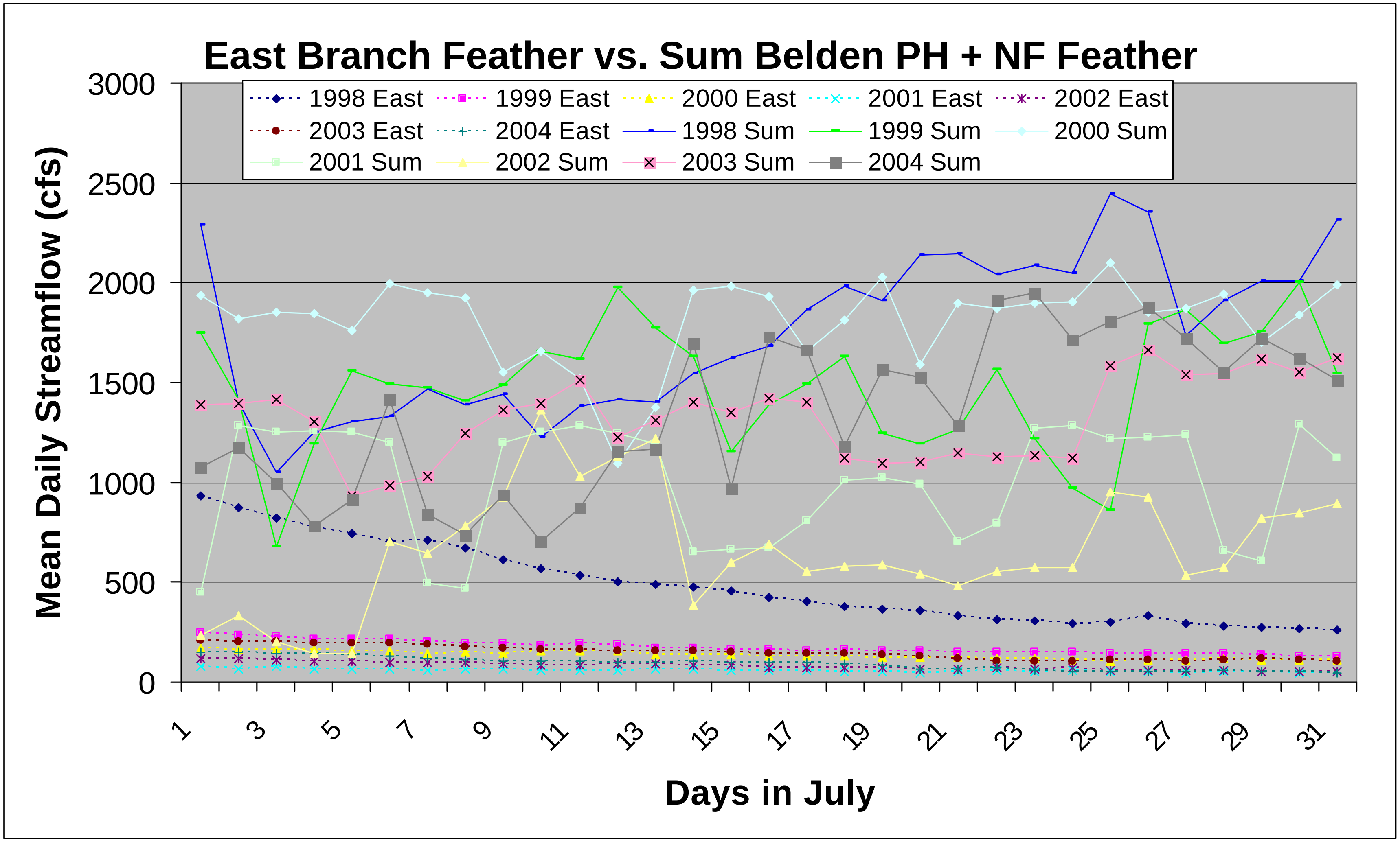
Previously identified issues include suitable geologic conditions at the dam site, flooding of existing stream habitat, flooding of existing wildlife habitat and flooding of cultural sites.

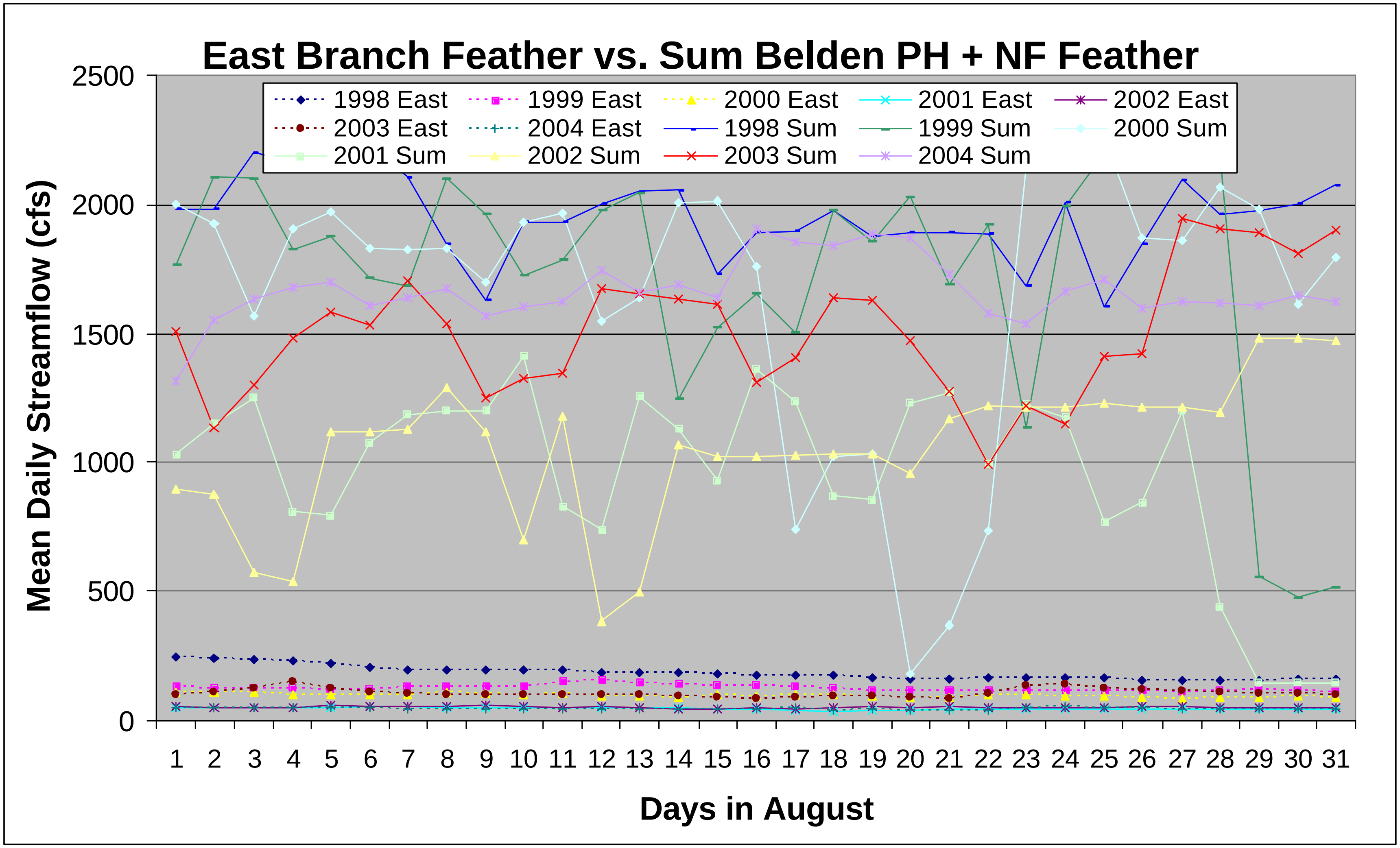
Genesee Valley Dam and Reservoir – Two potential dam locations exist on Indian Creek at the west end of Genesee Valley located in Section 7 and Section 9, T26N, R11E, MDBM. The approximate size of dam at site #1 would be about 1600' long and about 195' high which is very similar in size to the existing Canyon Dam. The approximate size of dam at site #2 would be about 4000' long and 160' high. The reservoir created behind the dam would flood Genesee Valley. The reservoir would be about 7 miles long and 1 mile wide and have a total storage capacity of about 250,000 AF. The majority of the dam and reservoir site is located on private land.

Previously identified issues include suitable geologic conditions at the dam site, flooding of private property and the small village of Genesee, flooding of existing stream habitat, flooding of existing wildlife habitat, flooding and relocation of existing roads and the availability of impervious material for earth-fill dam.

Squaw Queen Dam and Reservoir – Several potential dam locations exist on Last Chance Creek at the west end of Squaw Valley located in Section 1, T25N, R12E, MDBM. The approximate size of the dam would be over 1000' long and about 120' high which is very similar in size to the existing Butt Valley Dam. The reservoir created behind the dam would flood Squaw Valley. The reservoir would be about 7 miles long and 0.5 miles wide and have a total storage capacity of about 60,000 AF. The majority of the dam and reservoir site is located on Plumas National Forest land.

Previously identified issues include suitable geologic conditions at the dam site, flooding of existing stream habitat, flooding of existing wildlife habitat, flooding and relocation of existing roads and potential loss of stored water to the groundwater table because of the basaltic nature of most of the reservoir area.


East Branch Feather vs. Sum Belden PH + NF Feather
1998 East
1999 East
2000 East
2001 East
2002 East
2003 East
2004 East
1998 Sum
1999 Sum
2000 Sum
2001 Sum
2002 Sum
2003 Sum
2004 Sum
Mean Daily Streamflow (cfs)
0
500
1000
1500
2000
2500
3000
Days in July
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31


East Branch Feather vs. Sum Belden PH + NF Feather
Mean Daily Streamflow (cfs)
0
500
1000
1500
2000
2500
1998 East
1999 East
2000 East
2001 East
2002 East
2003 East
2004 East
1998 Sum
1999 Sum
2000 Sum
2001 Sum
2002 Sum
2003 Sum
2004 Sum
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Days in August

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Enlarging Existing Reservoir Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Enlarge and operate a existing reservoir on the East Branch Feather River (EBFR) and its tributaries to provide thermally stratified cold water from its lower depths to reduce water temperatures at the EBFR at its confluence with the North Fork Feather River (NFFR) and downstream on the Belden, Rock Creek, Cresta and Poe river reaches.

Assumptions: An enlarged dam and reservoir, if sized large enough, could store high winter/spring runoff and provide thermally stratified cold water from its lower depths during summer months. Based on Lake Almanor, Butt Valley Reservoir and Bucks Lake thermal stratification profiles, a new dam would need to be over 100 feet high in order to provide enough water depth and volume to supply sufficient quantities of cold water.

One potential enlarged reservoir in the Upper Feather River basin was evaluated. Round Valley Reservoir is located about 3 miles south of the community of Greenville. The current impoundment was built in 1865. It has a water storage capacity of 5,200 AF with a surface area of 4878 acres. The dam is 35 feet high and 325 feet long.

Calculations: Calculation of the water temperature influence of the EBFR water (water from potential enlarged reservoir) on the NFFR: Attached are graphs that overlay the mean daily streamflow in the EBFR and NFFR below Belden Powerhouse for July and August for several years' record. These graphs demonstrate the following:
1) At the confluence of the EBFR and the NFFR, the EBFR flows in July and August are approximately the same flow magnitude as those in the upstream NFFR. Therefore, using existing flows, any beneficial water temperature change made in the EBFR that reach the confluence will be reduced by 50% after mixing with the flows from the NFFR.
2) Below Belden Powerhouse the NFFR flows in July and August are approximately ten times greater than the EBFR flows. Therefore, using existing flows, any beneficial water temperature change made in the EBFR that reach the confluence will have a corresponding 10% temperature change result in the NFFR immediately below Belden Powerhouse after mixing occurs.

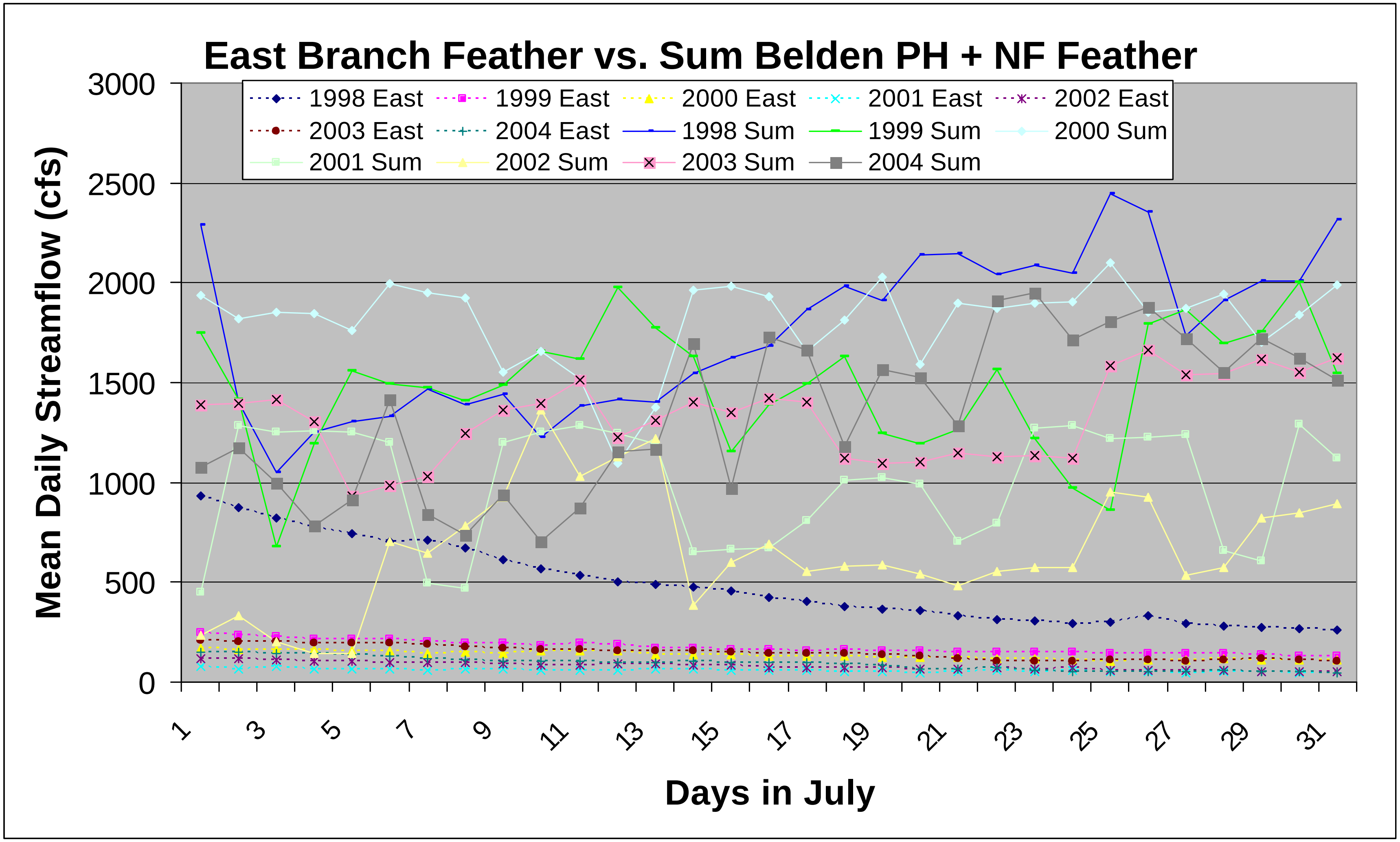
This dilution effect using existing flows is illustrated by the following example: A 1.0 degree C water temperature reduction in the EBFR will result in 1) a 0.5 degree C water temperature reduction in the NFFR from the confluence to Belden Powerhouse (1.8 mile reach) and 2) a 0.1 degree C water temperature reduction in the NFFR below Belden Powerhouse.

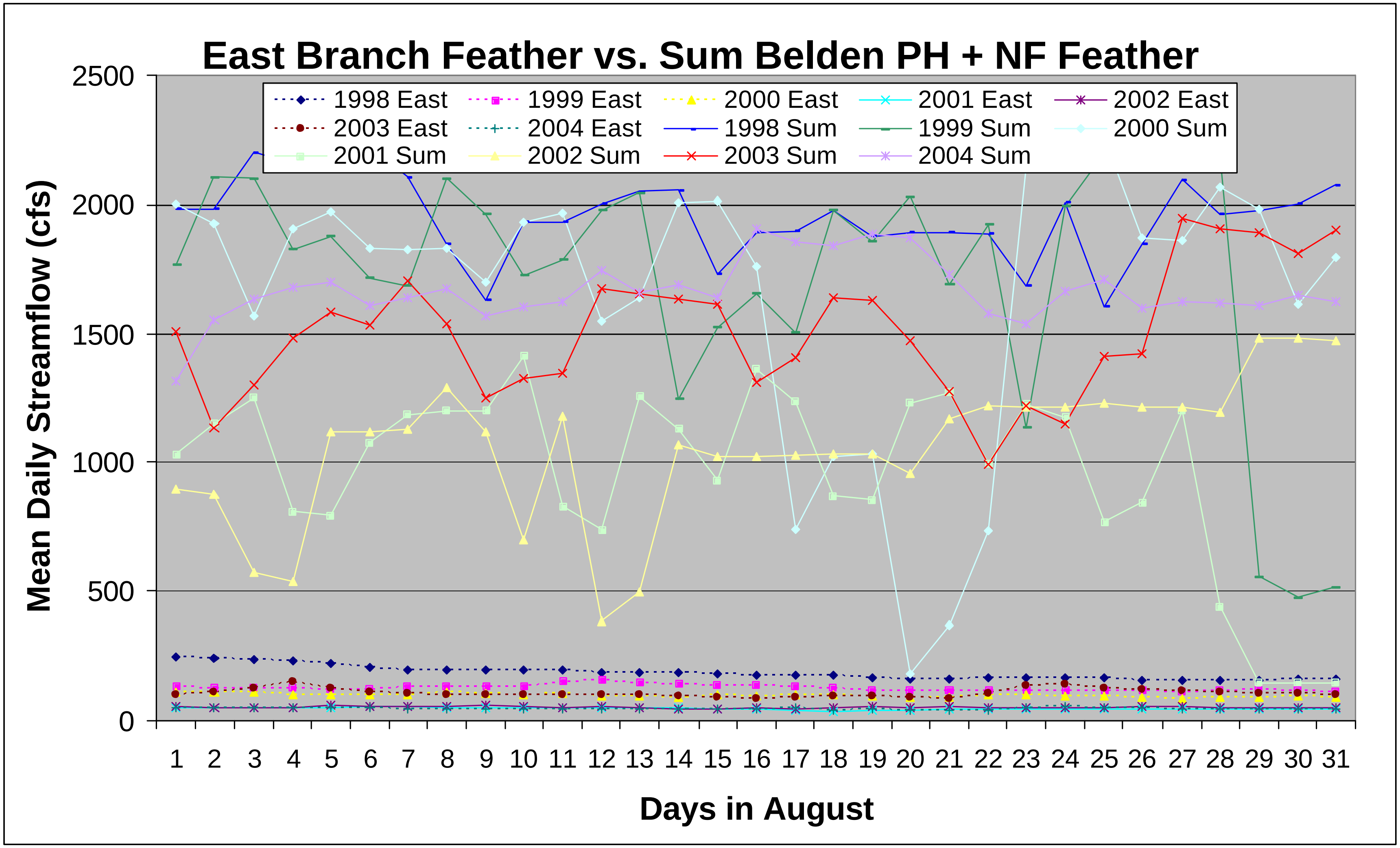
An analysis of the Round Valley watershed was conducted to determine the annual runoff. The Round Valley watershed has a drainage area of 9.12 sq. miles. Using nearby watershed precipitation, snow and river flow gage information the annual runoff from the Round Valley Basin was calculated to be 5,007 AF/year. It is concluded that the existing Round Valley Reservoir is sized appropriately for the annual runoff.

Siting Considerations: Not determined.

Other Considerations: Probability of obtaining additional storage water rights for new reservoirs is not likely unless adverse impacts on downstream prior water right holders are mitigated (i.e. DWR, Lake Oroville).

Conclusion: An evaluation of potential enlargement of Round Valley Reservoir was conducted. The annual runoff for the Round Valley basin is only 5,007 AF/year and would not produce enough water volume to fill an enlarged reservoir. Therefore, this alternative warrants no further evaluation.


East Branch Feather vs. Sum Belden PH + NF Feather
1998 East
1999 East
2000 East
2001 East
2002 East
2003 East
2004 East
1998 Sum
1999 Sum
2000 Sum
2001 Sum
2002 Sum
2003 Sum
2004 Sum
Mean Daily Streamflow (cfs)
0
500
1000
1500
2000
2500
3000
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
Days in July


East Branch Feather vs. Sum Belden PH + NF Feather
Mean Daily Streamflow (cfs)
0
500
1000
1500
2000
2500
1998 East
1999 East
2000 East
2001 East
2002 East
2003 East
2004 East
1998 Sum
1999 Sum
2000 Sum
2001 Sum
2002 Sum
2003 Sum
2004 Sum
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Days in August

Evaluation of Additional Alternative to Provide Cooler Water to the North Fork Feather River

Vegetation Management and River Shading Alternative

Pacific Gas and Electric Company
December 2004

Purpose of Analysis: This is intended to be a conceptual screening analysis to be used for evaluating the proposed alternative to determine if it warrants additional analysis or consideration.

Alternative Description: Perform streamside vegetation management on the East Branch Feather River (EBFR) and its tributaries to promote additional shading to reduce water temperatures at the EBFR at its confluence with the North Fork Feather River (NFFR) and downstream on the Belden, Rock Creek, Cresta and Poe reaches.

Assumptions: Water temperature monitoring on the 7.5 mile Belden Reach has demonstrated a water cooling effect of up to 1 degrees C resulting from river shading. The shading is a function of the river's geographic orientation in relation to sun's daily path, river area topography and riverside vegetation. The river flow characteristics of the Belden Reach have been significantly altered by the presence of Lake Almanor, Butt Valley and Belden dams. This results in limited high bank scouring flows allowing for dense vegetative growth. The Belden Reach has advantageous characteristics of geographic orientation in relation to sun's daily path, topography and vegetation that optimize river shading. Conceptually, a similar density of vegetative growth at the margins of the EBFR and its tributaries (with similar geographic orientation and river area topography) could result in comparable cooling effects as those observed in the Belden Reach.

Calculations: Calculation of the water temperature influence of the EBFR water on the NFFR:

Attached are graphs that overlay the mean daily streamflow in the EBFR and NFFR below Belden Powerhouse for July and August for several years' record. These graphs demonstrate the following:
1) At the confluence of the EBFR and the NFFR, the EBFR flows in July and August are approximately the same flow magnitude as those in the upstream NFFR. Therefore, any beneficial water temperature change made in the EBFR that reach the confluence will be reduced by 50% after mixing with the flows from the NFFR.
2) Below Belden Powerhouse the NFFR flows in July and August are approximately ten times greater than the EBFR flows. Therefore, any beneficial water temperature change made in the EBFR that reach the confluence will have a corresponding 10% temperature change result in the NFFR immediately below Belden Powerhouse after mixing occurs.

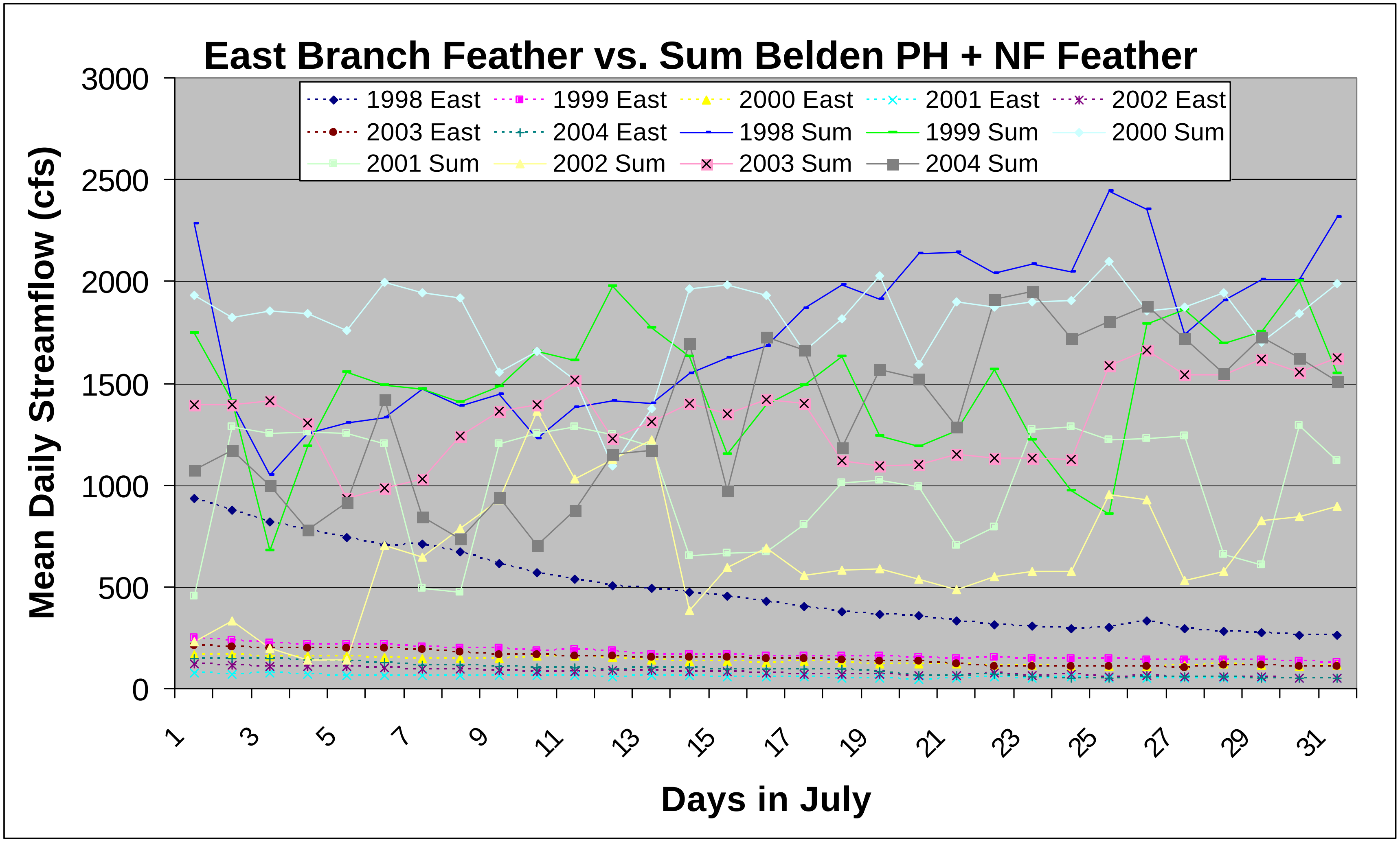
This dilution effect is illustrated by the following example: A 1.0 degree C water temperature reduction in the EBFR will result in 1) a 0.5 degree C water temperature reduction in the NFFR from the EBFR/UNFFR confluence to Belden Powerhouse (1.8 mile reach) and 2) a 0.1 degree C water temperature reduction in the NFFR below Belden Powerhouse.

Siting Considerations: Unlike the Upper NFFR, no significant large water storage facilities exist on the EBFR that have the ability to capture and control high flood flows. These periodic uncontrolled high flood flows control the geomorphic features of the river and the resultant riverside vegetation/majority canopy cover. Therefore, when compared to the Belden Reach, it is not expected that any degree of vegetative management on the EBFR will be effective in improving the existing density of vegetative growth and majority canopy cover at the margins of the EBFR and its tributaries.

Considerations of stream geographic orientation in relation to sun's daily path and area topography for any vegetative management on the EBFR will influence any expected water temperature benefits.

Other Considerations: Existing land management practices on private lands in the EBFR may not allow vegetation management to any large degree. Also, intervening Indian Valley irrigation withdrawals and the long water travel time to the NFFR could reduce any water temperature benefits from vegetation management.

Conclusion: Uncontrolled periodic high flood flows control the primary geomorphic features and the resultant riverside vegetation/majority canopy cover of the EBFR and its tributaries. Vegetation management on the EBFR and its tributaries may provide some local water temperature benefits however those water temperature benefits are not expected to result in any measurable water temperature change to NFFR below Belden Powerhouse. Therefore, this alternative warrants no further evaluation.


East Branch Feather vs. Sum Belden PH + NF Feather
Mean Daily Streamflow (cfs)
3000
2500
2000
1500
1000
500
0
1998 East
1999 East
2000 East
2001 East
2002 East
2003 East
2004 East
1998 Sum
1999 Sum
2000 Sum
2001 Sum
2002 Sum
2003 Sum
2004 Sum
1
3
5
7
9
11
13
15
17
19
21
23
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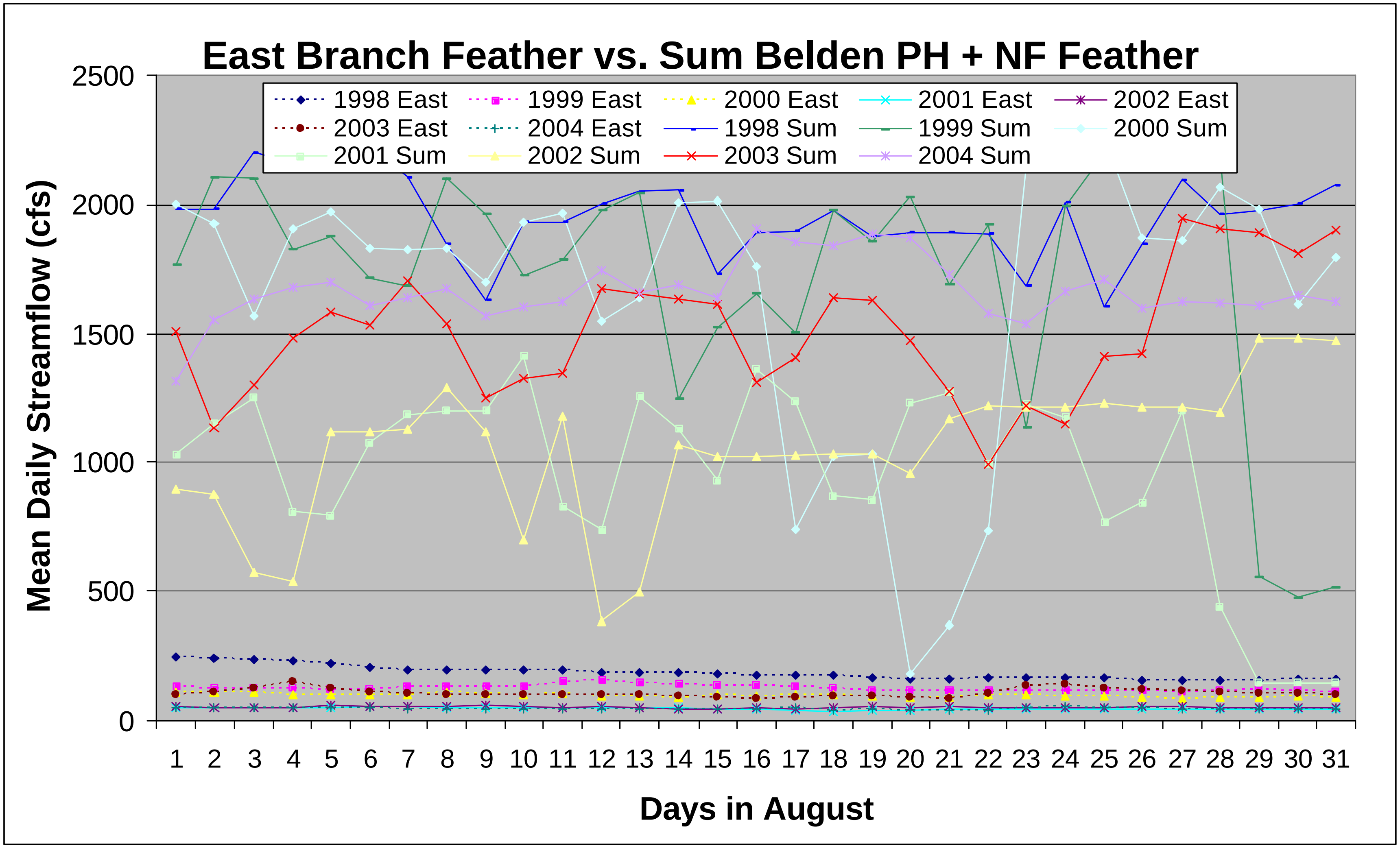
27
29
31
Days in July


East Branch Feather vs. Sum Belden PH + NF Feather
1998 East
1999 East
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2001 East
2002 East
2003 East
2004 East
1998 Sum
1999 Sum
2000 Sum
2001 Sum
2002 Sum
2003 Sum
2004 Sum
Mean Daily Streamflow (cfs)
0
500
1000
1500
2000
2500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Days in August