

# Balancing Power and Non-Power Values on the North Fork of the Feather River: Adaptive Management of Whitewater Recreation Cost and Benefits

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## Abstract

**The relicensing conditions for two of Pacific Gas and Electric Company's hydroelectric plants on the North Fork of the Feather River included adaptive management conditions for recreational boating flow releases. These conditions called for special releases on designated days so that flows were appropriate for whitewater boating. The conditions also provided for adapting the number of days based on actual recreational usage. Four years of boater use data were collected and analyzed. The value of the recreational usage was estimated, as was the value of the electrical generation foregone as a result of these special flow releases. This paper analyzes the costs and benefits associated with the recreational boating releases, offering a quantitative interpretation of the FERC requirement to give "equal consideration" to power and non-power values. Based on 2001 to 2005 use data, we conclude that the license conditions reasonably approximate "equal consideration". However, the analysis does suggest some ways to further optimize the tradeoff between power and non-power values.**

## BACKGROUND

Pacific Gas and Electric Company (PG&E) owns and operates several hydroelectric generating stations on the North Fork of the Feather River. These facilities are subject to license conditions regulated by the Federal Energy Regulatory Commission (FERC). The Electric Consumers' Protection Act of 1986 (16 USC 791a 825r, as amended) requires the FERC to give "equal consideration" to power and non power values when considering hydroelectric licensing alternatives. The exact meaning of equal consideration in this context is not entirely clear. FERC has not provided utilities or other responsible agencies with specific guidelines for making this comparison.

Two of PG&E's Feather River generating plants—Rock Creek and Cresta were relicensed in 2001. The terms of the new license were developed as part of a collaborative process that involved the applicant (PG&E) FERC, and a wide range of interested parties. These interested parties included governmental agencies such as the US Fish and Wildlife Service (FWS), California agencies such as the California Department of Fish and Game (CDFG), conservation organizations such as the Natural Heritage Institute and river user groups such as the American Whitewater (AW). This collaborative process is a relative new approach to hydro relicensing whereby interested parties attempt to collaborate in reaching acceptable license terms through negotiations. This process is intended to avoid the often acrimonious and adversarial conditions that often occur during hydro licensing proceedings.

As part of its efforts to balance power and non-power values, PG&E performed a benefit-cost analysis of various flow alternatives. These alternatives examined the effects of using the river flows for power, fish habitat, and recreation uses such as fishing and whitewater boating. This economic analysis was presented to the collaborative to help define the trade-offs inherent in alternative flow regimes.

The Rock Creek-Cresta collaborative successfully reached an agreement on licensing terms that was ratified by the FERC in the license issued for Project No. 1962 in October of 2001. A unique condition of the license was several "adaptive management conditions" under which the flow requirement adjustments

were set down. Under adaptive management, flow requirements will be altered over time in response to changes in hydrologic conditions, biological conditions and recreation use.

One of the adaptive management conditions in the license relates to whitewater boating participation. The initial license conditions specified that special recreation boating flows would be released on certain weekend days to permit whitewater boaters to run the river. During the collaborative process, the expected cost of these flows (in terms of foregone power generation) was estimated. These costs were balanced against expected whitewater participation and estimated benefits of this use. The license conditions were an effort to balance these costs and benefits.

For the past four years (2002 to 2005) the whitewater recreation use has been monitored during the flow release periods. This monitoring provides data on the actual boating participation. By combining this use data with estimated benefits per user-day, the benefits of the flows can be estimated. The actual costs of these flows can be estimated by calculating the power that was foregone due to by-passing the generation plants during the boating flow periods and estimating the cost to replace this power during the by-pass flows. Thus the actual costs and benefits of providing recreation boating flows can be estimated. These estimates provide a very interesting measure of how successful the license conditions were in balancing power and non-power values.

## **RECREATION DATA**

The Rock Creek and Cresta reaches are located in the narrow, steep and very scenic Feather River Canyon. State Highway 70, which extends the entire length of the Project, provides river access at numerous turnouts. The Project is divided into the Rock Creek and Cresta reaches by their respective dams and powerhouses. The Rock Creek reach is an 8-mile Class III-IV boating run with a Class V stretch between Tobin Vista and the Storrie Bridge. The uppermost put-in is just below the Rock Creek Dam with two primary takeouts at Tobin Vista and Rock Creek Powerhouse. Rock Crest and Storrie bridges are two other sites used as take-out locations. The Cresta reach is a 5-mile run of predominantly Class III waters with a Class V section, at higher flows. The uppermost put-in is just below Cresta Dam with two primary takeouts, at Shady Rest and at Cresta Powerhouse.

Prior to the current License agreement, whitewater boating use was very limited. The uncertainty of the flows discouraged boaters from attempting the runs. Normal flows were below that needed for whitewater recreation. Whitewater recreation was not possible except during winter and spring periods when the dams happened to be spilling suitable flows. Even during these periods, flow fluctuations made recreation boating potentially hazardous. Under the 2001 license agreement, the boating community was notified well in advance of the boating releases. Flows were kept at predictable and usable levels during the scheduled releases. Shuttles were set up to conveniently relay private boaters back to the put-ins. Although the runs are fairly short, the very high scenic values contributed to the popularity of the runs.

Boater use data were collected by a variety of means during the 2002-2005 boating release periods. These data included interviews, boater counts, and remote cameras. The license specifies participation levels that trigger adjustments in the number of boater flow release days after the initial 5-year license period. If the usage exceeds the upper trigger for a given reach and month, and additional day of boating flows are added for that month. If the usage falls below the trigger, a day is removed. The boating use data were summarized in four reports. Table 1 summarizes the boater usage, the flows and the Use Triggers.

**Table 1: Use Triggers and Boater Use 2002-2005 (Adjusted Boater-Days)**

	Trigger (Up/Down)		Average Use (Boater Days)	
	Rock Ck.	Cresta	Rock Ck.	Cresta*
June	120/60	60/40	76	160
July	130/60	60/40	165	107
August	150/60	80/50	226	207
September	180/80	100/60	231	293
October	180/80	100/60	181	224

\* No boating flow releases were made for the Cresta Reach in June of 2003-2005 due to biological considerations.

Table 2 shows the detailed use data by reach, month and year. Note the Cresta reach use in June is zero after 2002. This is because boating releases were not made for Cresta in those years due to biological considerations. Note that the boating use has generally declined over time, perhaps due the novelty effect wearing off. Nevertheless, average use for the four years is well in excess of the upper triggers, suggesting that additional flows could be added in after the initial 5-year period. The average use on each reach generally increases from June through September, and then falls slightly in October. This is most likely because as the summer progresses, fewer rivers have sufficient flows for boating, while the NFFR is able to provide boating releases from water stored in Lake Almanor.

**Table 2: Boater Use by Month, Year and Reach 2002-2005**

	2002			2003			2004			2005			2002-2005 Use Total		
	Rock Ck.	Cresta	Total	Rock Ck.	Cresta	Total	Rock Ck.	Cresta	Total	Rock Ck.	Cresta	Total	Rock Ck.	Cresta	Total
June	114	160	274	104	NA*	104	39	NA*	39	47	NA*	47	304	160	464
July	277	NA*	333	161	220	381	118	70	188	102	83	185	658	429	1087
August	250	NA*	250	218	280	498	175	126	301	262	214	476	905	620	1525
September	261	406	667	270	389	659	142	124	266	251	253	504	924	1172	2096
October	300	442	742	155	226	381	83	72	155	186	155	341	724	895	1619
Total	1202	1064	2266	908	1115	2023	557	392	949	848	705	1553	3515	3276	6791

\* Data collection during these periods was incomplete.

Table 2 shows that boater use is generally higher in Rock Creek than on the Cresta reach. The Table also demonstrates a trend of increased use from June through September, followed by a drop in use from September to October. There is also a trend toward lower use over time (from 2002 through 2005), but this trend is not consistent.

## POWER VALUES

Water that is used for recreation boating flows necessarily bypasses the hydroelectric generating plants. The value of the bypass flows is a function of the amount of water bypassed, the “water duty” (generation megawatt-hours per acre-foot bypassed) and the cost of replacing the bypassed megawatt-hours.

In-stream flows cannot be adjusted instantly to provide recreation boating flows. The bypassed water volume is not limited to the extra flows during the boating periods, but also includes the flows used during the ramp-up and ramp-down periods during which the flows are gradually adjusted to their target levels. The boating flow level target is 1000 cfs for most release days. During July however, the flow target was set to 1200 cfs both areas. In June the target was 1600 cfs in both Cresta and Rock Creek. The interaction between the normally required flow rates and the boating target flows determines the volume of bypassed water. When combined with the water duty at each power plant, the volumes determine the foregone generation due to providing boating flows in each month and river reach. These release flows and their resultant foregone generation is summarized in Table 3.

**Table 3: Bypassed Flow Volumes and Foregone Generation Due to Boating Flow Releases by River Reach**

<b>Rock Creek Normal &amp; Wet Year</b>					
<b>Month</b>	<b>Min Flow Required</b>	<b>Boating Flow</b>	<b>Add'l Release</b>	<b>Total</b>	<b>Foregone Generation</b>
	<b>cfs</b>	<b>cfs</b>	<b>cfs</b>	<b>AF</b>	<b>MWh</b>
<b>June</b>	220	1600	1,380	1,495	670
<b>July</b>	180	1200	1,020	935	419
<b>August</b>	180	1000	820	718	322
<b>September</b>	180	1000	820	718	322
<b>October</b>	180	1000	820	718	322
<b>Cresta Normal &amp; Wet Year</b>					
<b>Month</b>	<b>Min Flow Required</b>	<b>Boating Flow</b>	<b>Add'l Release</b>	<b>Total</b>	<b>Foregone Generation</b>
	<b>cfs</b>	<b>cfs</b>	<b>cfs</b>	<b>AF</b>	<b>MWh</b>
<b>June</b>	240	1600	960	892	205
<b>July</b>	220	1200	980	978	225
<b>August</b>	220	1000	780	650	150
<b>September</b>	220	1000	780	650	150
<b>October</b>	220	1000	780	650	150

Table 3 reveals that the greater water duty in Rock Creek results in greater amounts of foregone generation than are foregone in Cresta. This is especially notable in June when the specified boater flow level is 1600 cfs.

The value of generation (and thus the cost of power foregone) due to boating flow releases, varied widely by month and year. Table 4 shows this variation.

**Table 4: PG&E System-wide Value of Power Generation on Release Days (Constant 2005\$/MWh)**

<b>Month</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>
<b>June</b>	\$14	\$ 54	\$ 43	\$ 46
<b>July</b>	\$ 19	\$ 55	\$ 68	\$ 82
<b>August</b>	\$ 40	\$ 48	\$ 51	\$ 93
<b>September</b>	\$ 41	\$ 47	\$ 46	\$102
<b>October</b>	\$ 38	\$ 47	\$ 57	\$101

Note that the value of generation was markedly lower in 2002 than is subsequent years. Within each year June costs are generally lower than later months.

The total cost of providing boater flows can be computed from the system-wide generation values and the forgone megawatt –hours of generation. Table 5 summarizes these costs for each boater-release day.

**Table 5: Total cost of providing recreation boater-flow releases (Constant 2005\$)**

	2002	2003	2004	2005	All Years
<b>Cresta</b>					
June	\$2,896	\$0	\$0	\$0	\$2,896
July	\$4,274	\$12,417	\$15,353	\$18,445	\$50,489
August	\$6,047	\$7,142	\$7,575	\$13,904	\$34,667
September	\$6,128	\$6,983	\$6,802	\$15,249	\$35,162
October	\$5,681	\$6,983	\$8,503	\$15,100	\$36,267
<b>Total</b>	<b>\$25,026</b>	<b>\$33,525</b>	<b>\$38,234</b>	<b>\$62,697</b>	<b>\$159,481</b>
<b>Rock Creek</b>					
June	\$9,454	\$36,261	\$29,090	\$30,809	\$105,613
July	\$7,959	\$23,123	\$28,590	\$34,348	\$94,020
August	\$13,010	\$15,366	\$16,299	\$29,915	\$74,590
September	\$13,184	\$15,025	\$14,636	\$32,810	\$75,655
October	\$12,224	\$15,025	\$18,295	\$32,488	\$78,032
<b>Total</b>	<b>\$55,831</b>	<b>\$104,799</b>	<b>\$106,910</b>	<b>\$160,370</b>	<b>\$427,910</b>
<b>Grand total</b>	<b>\$80,857</b>	<b>\$138,324</b>	<b>\$145,144</b>	<b>\$223,067</b>	<b>\$587,392</b>

### Cost Per Boater-Day

The interaction of the cost of the recreation boater flow releases interacts with the level of use in for each release day and river reach to yield a cost per boater-day. This interaction reveals a very wide range of costs to provide boater flows and per boater-day basis. Table 6 summarized this calculation.

**Table 6: Recreation Flow Cost per Boater-Day (Constant 2005\$)**

	2002	2003	2004	2005
<b>Rock Ck.</b>				
June	\$83	\$ 349	\$ 746	\$656
July	\$29	\$ 144	\$ 242	\$337
August	\$52	\$ 70	\$ 93	\$114
September	\$51	\$ 56	\$ 103	\$131
October	\$41	\$ 97	\$ 220	\$175
<b>Avg. Ann. Cost/Boater-Day</b>	<b>\$46</b>	<b>\$ 115</b>	<b>\$ 192</b>	<b>\$189</b>
<b>Cresta</b>				
June	\$18	NA	NA	NA
July	\$76	\$ 56	\$ 219	\$222
August	NA	\$ 26	\$ 60	\$ 65
September	\$15	\$ 18	\$ 55	\$ 60
October	\$13	\$ 31	\$ 118	\$ 97
<b>Avg. Ann. Cost/Boater-Day</b>	<b>\$24</b>	<b>\$ 30</b>	<b>\$ 98</b>	<b>\$ 89</b>

Rock Creek boater-day costs are generally higher than those for the Cresta reach, due primarily to Rock Creeks higher water duty. The higher flow targets for the June flows result in consistently high boater-day flow costs.<sup>1</sup> The costs were higher in 2004 and 2005 due to the high system-wide cost of power in those years.

The average boater-day cost was \$122 for Rock Creek and \$49 for Cresta, for an overall average of \$86 for the 2002 through 2005 period. Of the 36 boater flow days analyzed here, fourteen exhibit boater-day costs in excess of \$100. Eleven of these higher boater-day costs were for Rock Creek flows. The two highest cost days were for Rock Creek in June of 2004 and 2005. The lowest cost boater-days occurred during the lower power-cost period of 2002 and on the Cresta reach.

## Value of Boating-Days

Recreation boating generates both market-valued and non-market valued economic activity. Boaters spend money on travel, equipment, services and other expenses associated with river recreation. Although these market valued expenditures can benefit local economies, they are a transfer from one party to another and thus are neutral from a state or national economic perspective. Non-market values—how much the experience was worth to the recreationist over and above the actual expenditures constitute a net gain to the state or local economy. In the present instance, providing boaters with a new recreation opportunity creates a net economic gain. It is this net gain that is considered in balancing the net value of additional boating-days of recreation.

Although measuring non-market values is more difficult than the simple accounting needed for market valuation, there are well-established methods for making this measurement. A substantial body of literature reporting on non-market recreation value estimates, including measurement of river boating recreation benefits, has been compiled in a database<sup>2</sup>. The average of 57 studies of recreation boating trips reported in published literature yielded and mean value of \$111 and a median of \$77 per user-day. Although this value may be somewhat high, in that it includes values reported for once-in-a-lifetime trips such as Grand Canyon rafting trips, this database does provide a quantitative point of comparison for boating-day values on the North Fork of the Feather River.

Using the median value of \$77 per boater-day, the total non-market benefit of providing boating flows by year and reach are shown in Table 7.

**Table 7: Total Benefit of Providing Recreation Boater Flows (Constant 2005\$)**

	2002		2003		2004		2005	
	Rock Ck.	Cresta	Rock Ck.	Cresta	Rock Ck.	Cresta	Rock Ck.	Cresta
<b>June</b>	\$8,748	\$12,278	\$7,980	NA	\$2,993	NA	\$3,607	NA
<b>July</b>	\$21,255	\$4,297	\$12,354	\$16,882	\$9,055	\$5,371	\$7,827	\$6,369
<b>August</b>	\$19,184	NA	\$16,728	\$21,486	\$13,429	\$9,669	\$20,104	\$16,421
<b>September</b>	\$20,028	\$31,154	\$20,718	\$29,850	\$10,896	\$9,515	\$19,260	\$19,414
<b>October</b>	\$23,020	\$33,917	\$11,894	\$17,342	\$6,369	\$5,525	\$14,273	\$11,894
<b>Total</b>	<b>\$92,235</b>	<b>\$81,645</b>	<b>\$69,675</b>	<b>\$85,559</b>	<b>\$42,741</b>	<b>\$30,080</b>	<b>\$65,071</b>	<b>\$54,098</b>

## Cost Benefit Evaluation

Having estimated both the foregone power values and the non-market boating recreation values it is now possible to compare the costs and benefits from a societal standpoint. The cost of providing boater-days

<sup>1</sup> June boating flows for Cresta were discontinued after 2002 due to biological considerations.

<sup>2</sup> Developed by Dr. John Loomis, Colorado State University with assistance of Dr. Randall Rosenberger, Dr. Pamela Kaval and Dr. Ram Shrestha. May 2005

shown on Table 5 can be compared with the benefits shown on Table 7. By dividing the cost of providing recreation boating flows by the net benefits of these flows, the benefit/cost ratio is derived. It is generally understood that actions are beneficial when benefit/cost ratios are greater than 1.0 (benefits exceed costs). Table 8 shows the benefit/cost ratios for providing boating flows by reach month and year. B/C ratios greater than 1.0 are highlighted.

**Table 8: Benefit/Cost (B/C) ratios by river reach and month 2002 through 2005**

	2002		2003		2004		2005		2002-2005		Total
	Rock Ck.	Cresta	Rock Ck.	Cresta	Rock Ck.	Cresta	Rock Ck.	Cresta	Rock Ck.	Cresta	
June	0.93	<b>4.24</b>	0.22	NA	0.10	NA	0.12	NA	0.22	<b>4.24</b>	0.33
July	<b>2.67</b>	<b>1.01</b>	0.53	<b>1.36</b>	0.32	0.35	0.23	0.35	0.54	0.65	0.58
August	<b>1.47</b>	NA	<b>1.09</b>	<b>3.01</b>	0.82	<b>1.28</b>	0.67	<b>1.18</b>	0.93	<b>1.37</b>	<b>1.07</b>
September	<b>1.52</b>	<b>5.08</b>	<b>1.38</b>	<b>4.27</b>	0.74	<b>1.40</b>	0.59	<b>1.27</b>	0.94	<b>2.56</b>	<b>1.45</b>
October	<b>1.88</b>	<b>5.97</b>	0.79	<b>2.48</b>	0.35	0.65	0.44	0.79	0.71	<b>1.89</b>	<b>1.09</b>
Total	<b>1.65</b>	<b>3.26</b>	0.66	<b>2.55</b>	0.40	0.79	0.41	0.86	0.63	<b>1.58</b>	0.89

## Conclusions

Taken as a whole, the adaptive management program embodied in the licensing conditions was a good first approximation of balancing power and non-power values. The overall benefit/cost ratio (0.89) was reasonable close to 1.0, the point at which benefits of the program equal costs. Closer examination, however, shows that the program could be improved by providing more boater flows in certain cases and reducing them in other cases.

Power costs for replacing foregone hydroelectric generation also have a strong influence on B/C ratios. The lower replacement costs in 2002 produced B/C ratio well above 1.0 in both reaches and for all month except June. Conversely, the high cost of replacement power in 2005 cause B/C ratio to fall below 1.0 for all but two months on the Cresta reach. This effect suggests that the adaptive management program should somehow reflect the system-wide cost of replacement power. This suggestion presumes that replacement power costs can be predicted far enough in advance to provide the boating community with sufficient advance notice so that they can plan for an increase or decrease in boat-flow days. In the absence of a well-established electricity futures market in California, this might prove difficult to implement.

The timing and volumes of the recreation flow releases could be improved to provide higher B/C ratios. The June and July flows on the Rock Creek reach are costly in terms of foregone power values because of the high water duty and because the target flows for these months (1600 and 1200 cfs) are higher than the 1000 cfs flows in later months. Furthermore, even with the higher target flows, boater use on the Rock Creek Reach during these months is lower than during later months. In June and July, river flows are generally high in California. (Later in summer and fall, there are fewer boating destinations with sufficient flows for whitewater boating). These high cost/lower use conditions result in very high costs per boater-day. A better tradeoff might be reached by substituting added boating flows later in the season for these June and July flow days. For example, substituting a Rock Creek boater flow day in October for one in June would save an average of \$240 per boater day, assuming the monthly participation rates do not change.

Using the cost/benefit model developed for this study, a variety of tradeoffs could be evaluated, with the objective of finding other solutions that optimize both power generation values and boater use. Of course other considerations, notably environmental effects, would have to be considered in addition to the purely economic trade-offs evaluated here.

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