ASSESSMENT OF CHANGES TO THE GLEN CANYON DAM ENVIRONMENTAL IMPACT STATEMENT PREFERRED ALTERNATIVE FROM DRAFT TO FINAL EIS

October, 1995

[RICK L. GOLD]
[: BOR]

We believe that this letter and enclosures, along with the meetings and discussions we have had, fulfill Commissioner Beard's commitment to address the concerns of various members of the environmental community expressed in the letter of March 28, 1995.

Sincerely,

Rick L. Gold

Rick L. Gold
Deputy Regional Director

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ASSESSMENT OF CHANGES TO THE GLEN CANYON DAM ENVIRONMENTAL IMPACT STATEMENT PREFERRED ALTERNATIVE FROM DRAFT EIS TO FINAL EIS

July, 1995
Revised October, 1995

I. INTRODUCTION

In early 1993 Western Area Power Administration (Western) approached the Glen Canyon Dam Environmental Impact Statement (EIS) cooperating agencies with a proposal to change two parameters of the existing interim flow criteria for Glen Canyon Dam. Those two requests were for:

(1) Increasing the upramp rate from 2,500 cfs/hour to 4,000 cfs per hour, and

(2) Increasing the maximum flow from 20,000 cfs to 25,000 cfs

Western requested that the Glen Canyon Environmental Studies (GCES) Scientific Coordination Group evaluate the recommendations. Reclamation and the cooperating agencies initially reviewed this issue and unanimously agreed to propose a deviation from the interim flow criteria to incorporate the change in these two parameters. Consultations as perscribed in the Grand Canyon Protection Act were completed, and a recommendation forwarded for implementation. Concurrent with these efforts, it was determined by the Commissioner of Reclamation that the proposed changes should be dealt with in the EIS process. As a result of this decision, no deviations from interim flow criteria were implemented. In response to that determination and guidance, and with input from the public and cooperating agencies on the draft EIS, the preferred alternative for the final EIS was revised to include the changes in those two parameters. The revised preferred alternative was publically discussed for inclusion in the final EIS at the May, June, August, and November 1994 Cooperating Agencies meetings, and was broadly accepted by that group without exceptions being raised by the various interest groups present. In addition, there were two articles on the revised preferred alternative in the Fall 1994 EIS Newsletter which was distributed to about 16,000 people nationwide. The changes were included in the final EIS alternative analysis of the preferred alternative. The Bureau of Reclamation (Reclamation) completed the review process through the EIS team with evaluation by the GCES Scientific Coordination Group led by the Senior Scientist.

The primary reason for these changes is to benefit hydropower. The Interim Operating Criteria were based on results from GCES Phase I, professional judgement, and were designed to be environmentally conservative over the interim period. With the benefit of the additional GCES Phase II results and

EIS impact analyses, the upramp and maximum flow criteria were found to be overly conservative for the long term.

With the concurrance of the Cooperating Agencies, the preferred alternative identified in the final EIS reflected the changes requested by Western. Concern was raised by the environmental community that the changes had not gone through a rigorous enough scientific review prior to inclusion in the final EIS preferred alternative. The **objective** of this document is to highlight the scientific information upon which the determination of the impact of the changes were made and to present more detail on the analyses presented in the final EIS.

The analyses described in this document are based on existing information, interpolation of GCES research flow results, and on additional model simulations with the revised operational criteria.

The relationship between riverflows and sediment resources is the most important element in defining the ecosystem of the Colorado River in Glen and Grand Canyons. Sediment is therefore the key indicator resource of ecosystem response because nearly all canyon resources are strongly linked to sediment. There would have to be a significant change in the long-term sand storage before the changes in the preferred alternative could make a significant difference to downstream resources.

II. BACKGROUND

The Glen Canyon Dam Interim Operating Criteria (interim flows) were implemented by Reclamation in November 1991 after three months of testing, considerable deliberation by the Glen Canyon Dam cooperators, and recommendations made by the GCES Scientific Coordination Group. The **purpose** of the interim flows was to operate the dam in a conservative manner with the goal of avoiding adverse impacts to downstream resources in Glen and Grand Canyons, especially sediment which was and is believed to be the resource most sensitive to dam operations. The time period for the interim flows was defined to be from the end of the Research Flows (July 1991) until implementation of the Record of Decision. The interim flow criteria were based on information from GCES Phase I and some preliminary information from GCES Phase II. No specific studies were conducted on the particular parameter levels (see Table 1). The criteria were purposely designed to be conservative for protection of the natural and cultural resources. The specific objectives were:

(1) Store sediment in the channel of the Colorado River
(2) Minimize the erosion of the beaches in the Grand Canyon
(3) Minimize the impacts to the biological resources
(4) Protect the cultural resource areas being impacted by erosion

Specific operating criteria at Glen Canyon Dam included: ramping rates, maximum flows, minimum flows, and allowable daily fluctuations. The criteria were set conservatively because for the majority of the GCES Phase II technical studies, only preliminary, non-peer reviewed, results were available. It was intended that the interim flows result in a net storage of sand by reducing the movement of sand downstream. The interim flow criteria are defined in Table 1.

Table 1. Interim Flow Parameters

Minimum releases (cfs)	Maximum releases (cfs)	Allowable daily fluctuations (cfs/24hr)	Ramp rate (cfs/hr)
8,000 between 7a.m. and 7p.m. 5,000 at night	20,000	5,000 6,000 or 8,000 (based on monthly volumes)	2,500 up 1,500 down

The baseline for impact comparison in the EIS is the no action alternative (based on historic dam operations). Using cause and effect relationships developed through GCES and impact analysis from the interdisciplinary, interagency EIS team; the draft EIS was prepared and distributed to the public. Public comments were received from over 30,000 people. Revisions to the draft EIS were made based on these comments and the final EIS was completed. After completion of the GAO audit, the Secretary will issue a ROD, the selected alternative will be implemented, and the adaptive management process will formally begin.

The EIS team concluded the following:

- The No Action, Maximum Powerplant Capacity, and High Fluctuating Flow Alternatives have similar impacts; too much sand transport capacity which jeopardizes the long-term storage of sand.

- The Interim Low Fluctuating Flow, Existing Monthly Volumes, and Year-Round Steady Flow Alternatives have similar impacts; they maximize long-term sand storage but provide only limited system dynamics (deposition and erosion of sandbars). Limited system dynamics would result in vegetation encroachment on sandbars and net erosion above the normal high river stage.

- The Moderate Fluctuating Flow, Modified Low Fluctuating Flow (preferred alternative), and the Seasonally Adjusted Steady Flow Alternatives have similar impacts. They provide long-term sand storage and system dynamics (deposition and erosion of sandbars). The changes to the preferred alternative between the draft and final EIS do not change this conclusion.

III. Interim Flow Monitoring Results

The interim operating criteria, first tested in August 1991, have been successful in meeting their original objectives. Based on monitoring (Schmidt, 1994; Cluer and Dexter, 1994; Beus and Avery, 1993 Ayers and McKinney, 1995; and Stevens and Ayers, 1994) the results can be separated into the following sections:

A. Physical System

1. The maximum flow criteria of 20,000 cfs was successful in trapping sediment in river pools and eddies.

2. Sediment is moving downstream but at a rate sufficiently slow to allow net accumulation in the channel.

3. The backwaters are in the process of filling, thereby eliminating them as sources of habitat for native and non-native fish.

4. Erosion of the beaches in the Grand Canyon, especially in the critical reaches has slowed but is still going on. In several instances local debris flows and tributary flash floods have buried or eroded the beaches.

Results from monitoring the interim flows confirmed that there is still a need for a high controlled flow to move sediment from the main channel up onto the beaches.

B. Biological System

1. The trout population has begun to rebuild in the Lees Ferry area with increased numbers of naturally produced fish and better fish condition factors.

2. The cladophora beds have expanded in size.

3. The numbers of Gammarus lacustris have increased substantially in the Lees Ferry drift.

4. The riparian areas utilized for nesting by the Southwestern Willow Flycatcher have stabilized in size.

5. The marshes have filled in with sediment, dried out and are showing an increase in riparian plants.

6. The riparian zone has migrated down to the 20,000 cfs level.

IV. IMPACTS OF THE PREFERRED ALTERNATIVE CHANGES

Only two criteria of the preferred alternative (the upramp rate limit and the maximum flow) were changed between the draft and final EIS. The maximum daily change in flow, minimum flow, and the down ramp rate criteria were not changed. Changes to the maximum flow and upramp rate criteria would have no effect on the monthly release volumes.

Use of the increased upramp is expected to occur almost every day. Use of the increased maximum flow criteria would be infrequent especially during minimum release years because the maximum flow criterion would often be over ridden by the monthly release volume and the maximum allowable daily change criterion.

No linkage was found between upramp limits and negative effects to the physical or biological resources of Glen and Grand Canyons.

Since use of the increased maximum flow criteria would be infrequent, differential impacts were judged to be insignificant based on impact analyses of other EIS alternatives.

It should be noted that in high and medium release volume years the potential for extended periods of 20,000 to 25,000 cfs flows would be quite likely; especially during the summer and winter seasons when release volumes are high. This is unchanged from the draft EIS.

A. Increasing the Upramp Rate

A range of research flows was conducted from June 1990 through July 1991 as part of the GCES Phase II program. These included high (3,000 cfs to 19,000 cfs) and low (3,000 cfs to 10,000 cfs) fluctuating flows with fast (about 7,000 cfs/hour) and slow (about 3,200 cfs/hour) up and down ramp rates. There were also several approximately steady flow periods during which the ramp rates were less than 1,000 cfs/hour. GCES Phase II identified cause and effect relationships between the range of fluctuations (and downramp rates) and adverse impacts to canyon resources. However, no cause and effect relationships between upramp rates and adverse impacts to canyon resources were identified. The draft EIS (a public document peer reviewed by GCES, the National Research Council, and the EIS Cooperating Agencies) states on page 95 that up ramp rates have not been linked to sandbar erosion. The draft EIS also states on page 190 that "Rapid increases in river stage would have little or no effect on sandbars."

Based on work completed by Budhu and Gobin (1994), Cluer and Dexter (1994) and the U.S. Geological Survey (Carpenter, et. al., 1995) it was determined that the upramp rate would have <u>no impact</u> on the erosion of the beaches. This conclusion was based on:

1. The downramp has been shown to be the primary controlling factor in beach erosion (Budhu and Gobin, 1994). The downramp would remain the same (1,500 cfs/hr) and therefore the upramp should not cause any concern for beach erosion.

2. Ground water studies by Carpenter, et. al. (1995) have shown that the volume of water stored in the beaches, river stage fluctuation, and downramp rates are controlling the dynamics of the ground water return flow and seepage erosion.

3. Rill erosion studies performed by the National Park Service (Werrell, et. al, 1993) have shown that the rate of decline in river stage induces water trapped in the sediment to cut away at beach faces.

4. The Smith and Wiele (1994) model showed that the higher upramp wave would be attenuated by lower Marble Canyon and therefore no impact would be found downstream.

Therefore, it was concluded that as long as the downramp rate is maintained at 1,500 cfs/hr and the daily fluctuation is limited to between 5,000 cfs and 8,000 cfs per day, the upramp rate could be changed with no anticipated impact on the sediment resources.

Increases in the release rate and corresponding increase in river stage tend to increase available habitat for fish. The rate of increase is likely to have no effect on the aquatic ecosystem. There should be no impacts to the biological resources below lower Marble Canyon as a result of the increase in ramping rates because the effects will be largely attenuated prior to reaching lower Marble Canyon. All size classes of trout and native fish should be able to accommodate the increase. Since upramp rates are not related to beach erosion, no impacts are anticipated to occur to riparian areas or terrestrial populations associated with the near shore environment.

Cultural resources depend on the sediment resource. Since the increase in the upramp rate would not negatively effect the sediment resource, it would not impact the cultural resources contained within the sediment deposits.

The impacts of increasing the upramp rate on recreation resources below Glen Canyon Dam are also expected to be minimal. Effects on boating operations have not been linked to upramp rates. Boating operations are still linked to changes in river stage and minimum flows. Based on Table 2, the safety effects on wading anglers should be minimal. As shown, increasing the upramp rate from 2,500 cfs/hr to 4,000 cfs/hr results in a stage change of 0.66 feet (8 inches) more per hour. While this additional change in stage will be noticeable, it is unlikely to result in a difference in the rate of wading mishaps.It is important, however, that anglers be well informed about ramping rates to reduce any potential safety related impacts.

Table 2. Change in River Stage as Flow Changes

Location	Change in River Stage (feet/hr) @ 2,500 cfs/hr	@ 4,000 cfs/hr	Difference
USGS gauge below Glen Canyon Dam			
from 5,000 cfs	1.26	1.92	0.66
from 15,000 cfs	0.80	1.23	0.43
USGS gauge at Lees Ferry			
from 5,000 cfs	0.84	1.27	0.43
from 15,000 cfs	0.47	0.73	0.26

Note: Lees Ferry calculations do not account for attenuation

To place this in perspective, it should be noted that the increased upramp rate is still far below the upramp rate under the no action alternative which was limited only by the physical capability of the powerplant.

B. Increasing the Maximum Flow

The maximum flow cap of 20,000 cfs was established in 1991 based on the preliminary information and results. It was agreed by the scientists that the interim flow period should be a period of storing sediment. In order to store sediment during this period, the maximum flow criteria of 20,000 cfs was implemented, realizing that is was a conservative limit.

As shown in Table 3, increasing the maximum flow from 20,000 cfs to 25,000 cfs will result in a 1.37 foot (16 inch) increase in river stage at Glen Canyon Dam. At Lees Ferry, the increase in stage will be 0.76 feet (9 inches).

Table 3. River Stage and Maximum Flow

Location	River Stage (feet) @ 20,000 cfs	@ 25,000 cfs	Difference
USGS gauge below Glen Canyon Dam	35.53	36.90	1.37
USGS gauge at Lees Ferry	10.57	11.33	0.76

Evaluation of the direct and cumulative effects of increasing the maximum flow focused on two critical elements: (1) duration; and (2) frequency. Of primary use were the sand balance analysis by Randle, Strand, and Streifel (1993), the flow and sediment model results of Smith and Wiele (1994), the eddy model of Nelson, et. al. (1993) and the results of Budhu and Gobin (1994) related to tractive force along the beach faces. Supporting documentation on the status of the sediment deposits in the Grand Canyon based on ongoing interim flow monitoring by Schmidt (1994), Cluer and Dexter (1994), Beus and

Avery (1993), and Beus, et. al (1995) provided additional data on ongoing beach response.

Again the primary area of concern focused on the critical reach of river from Lees Ferry to the confluence with the Little Colorado River. This reach is the most sensitive to long-term erosion due to the limited sediment input when compared to the potential for sediment transport. The reach above Lees Ferry receives almost no sediment input, and is essientally armored with a layer of cobble. There was little movement of this cobble substrate during the high flows of 1983, and therefore the reach should remain stable under the flow regime of the preferred alternative.

Final EIS Analysis.—Sandbars (including camping beaches) go through natural cycles of deposition and erosion. High riverflows will transport sand—if available—from the river bed and deposit it as sandbars in eddies. Riverflows, rain, wind, and foot traffic all tend to erode these sandbars with time. The cycle of deposition and erosion continues as long as there is sand available in the system. Thus, sandbars depend on the availability of sand storage in the river and occasional high flows to redeposit the sand.

Long-term sand storage depends on the sand supply from tributaries and sand transport capacity of the river. Resource managers have some control over the sand transport capacity through dam operations, but no control over the sand supply from tributaries. Sand in Grand Canyon is transported by nearly all riverflows, the amount transported increases exponentially with riverflow (see figure 1). The total amount of sand transported over the long term depends on the magnitude, duration, and frequency of high riverflows. Over the long-term, the smaller the sand transport the greater the sand storage.

Because there is no change in either the monthly release volumes or the operating criteria for the maximum daily change in flow, the increase in the maximum flow criteria would not result in a substantial increase in the number of hours when dam releases are greater than 20,000 cfs. The number of hours when dam release are greater than 25,000 cfs would not change. Therefore, there would not be a substantial increase in long-term sand transport capacity nor a substantial decrease in sand storage. This is supported by impact analysis of the alternatives presented in the draft EIS (page 182 and Appendix D, pages 4-5).

In the analysis for the draft EIS, future hourly-flow releases from Glen Canyon dam were modeled by the EDF (Power Resource Committee, 1993) for each fluctuating flow alternative using the EDF "Peak Shaving Model." For each alternative in the draft EIS, sand transport capacity was then computed for each hour of the 20-year simulation. Based on these results, long-term sand storage was computed for each alternative using 85 hydrologic scenarios (each being 50 years) from the CRSS model (Randle, Strand, and Streifel, 1993).

The operating criteria for range in daily flow fluctuations, up and down ramp rates, and maximum flows of the Moderate Fluctuating Flow alternative were all greater than those of the preferred alternative in both the draft and final EIS.Results from this analysis showed that the probability of a net gain in riverbed sand after 20 and 50 years was 61 and 70 percent for the Moderate

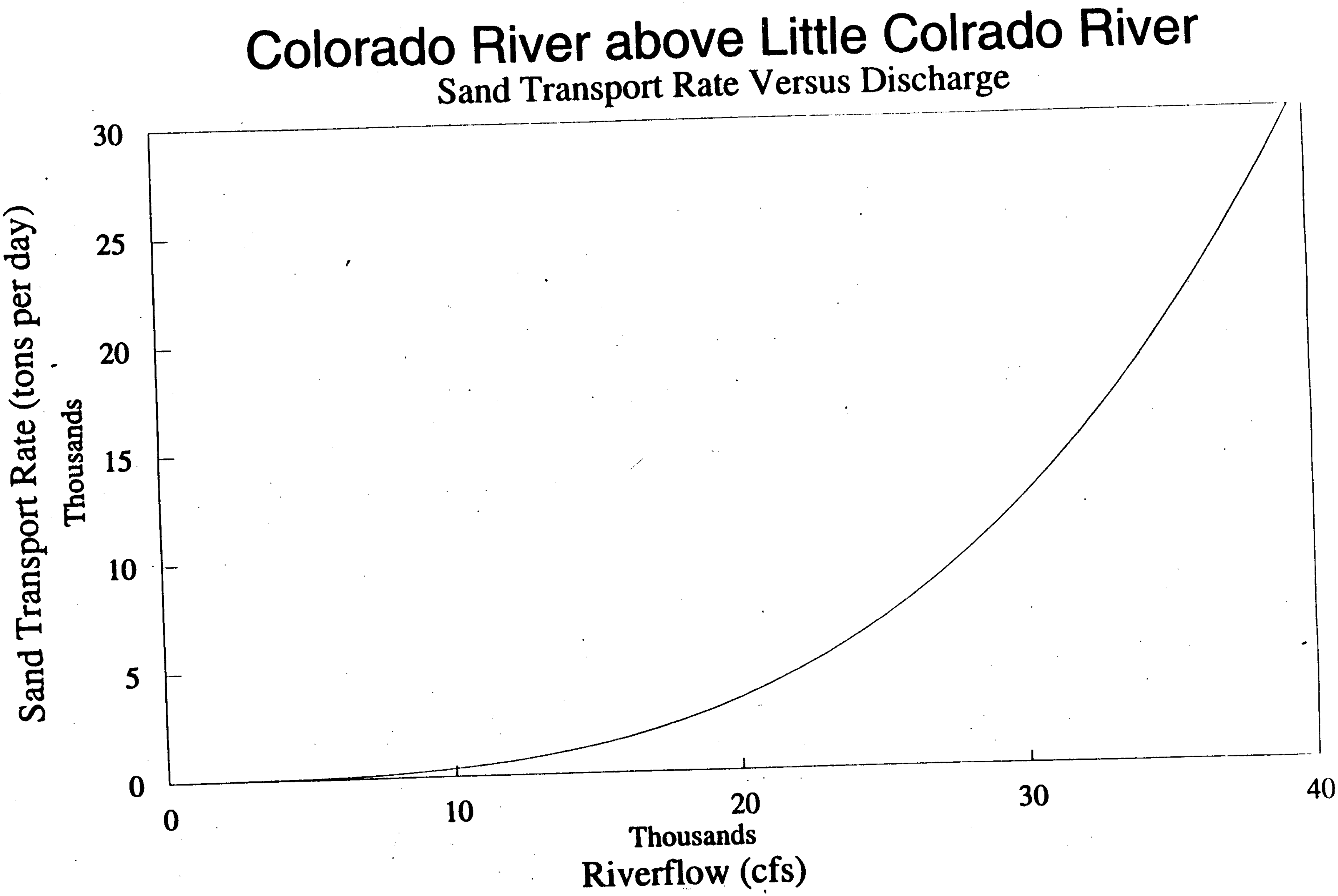

Figure 1.—Empirical relationship between riverflow and sand transport for the Colorado River above LCR. The threshold velocity required to move medium sand (0.5 mm) at 50 °F is about 0.4 feet per second. Sand is transported at nearly all riverflows in Grand Canyon because average river velocities are normally greater than 1 foot per second—even in pools at 5,000 cfs.

Fluctuating Flow Alternative and 64 and 73 percent for the preferred Modified Low Fluctuating Flow Alternative (draft EIS, pages 54-55, 184, 187, and 194). Results from these two alternatives differ by 3 percentage points.

For the final EIS, the Peak Shaving Model was used to simulate hourly releases for the revised preferred alternative for the same 20-years and used in the power economic impact analysis. By interpolating between impact analysis results from the interim Low and Moderate Fluctuating Flow Alternatives, the increase in number of hours when the flow is between 20,000 and 25,000 cfs was expected to be small. Since only a small increase was predicted, little difference in sand transport capacity was expected to result. Consequently, no additional analysis of the long-term sand transport capacity or sand storage was conducted.

Expanded Analysis: Recently, an additional analysis of the sand transport capacity was conducted due to concerns expressed by the environmental community. Using the previous Peak Shaving Model results, the percentages of days and hours that flows exceed specific discharges were quantified and are shown in Table 4 for selected alternatives. These results are from a variety of years with annual volumes ranging from 8 million to 18 million acre-feet. As shown in the table, the changes in the preferred alternative result in a 3.5 percentage-point increase over the Interim Low Fluctuating Flow Alternative in the number of hours when the flow is greater than 20,000 cfs. Peak Shaving Model results indicate that during minimum release years (less than or equal to 8.3 million acre-feet), flows would be greater than 20,000 cfs during 2.6 percent of the hours and greater than 22,000 cfs during 1.1 percent of the hours.

Again using the results from the peak shaving model, sand transport capacity was computed for each hour of the 20 year simulation for the final preferred alternative. The computed sand transport capacity for the 20-year period was compared among the No Action, Moderate Fluctuating Flow, interim Low Fluctuating Flow, and the modified Low Fluctuating Flow Alternatives (see figure 2). As shown, there is a substantial reduction in sand transport capacity between the no action alternative and the action alternatives. However, the differences in sand transport capacity for the interim Low Fluctuating Flow, modified Low Fluctuating Flow, and Moderate Fluctuating Flow are quite small. As anticipated, there is no significant difference in sand transport capability, and thus sand storage between the interim Low and modified Low Fluctuating Flow alternatives.

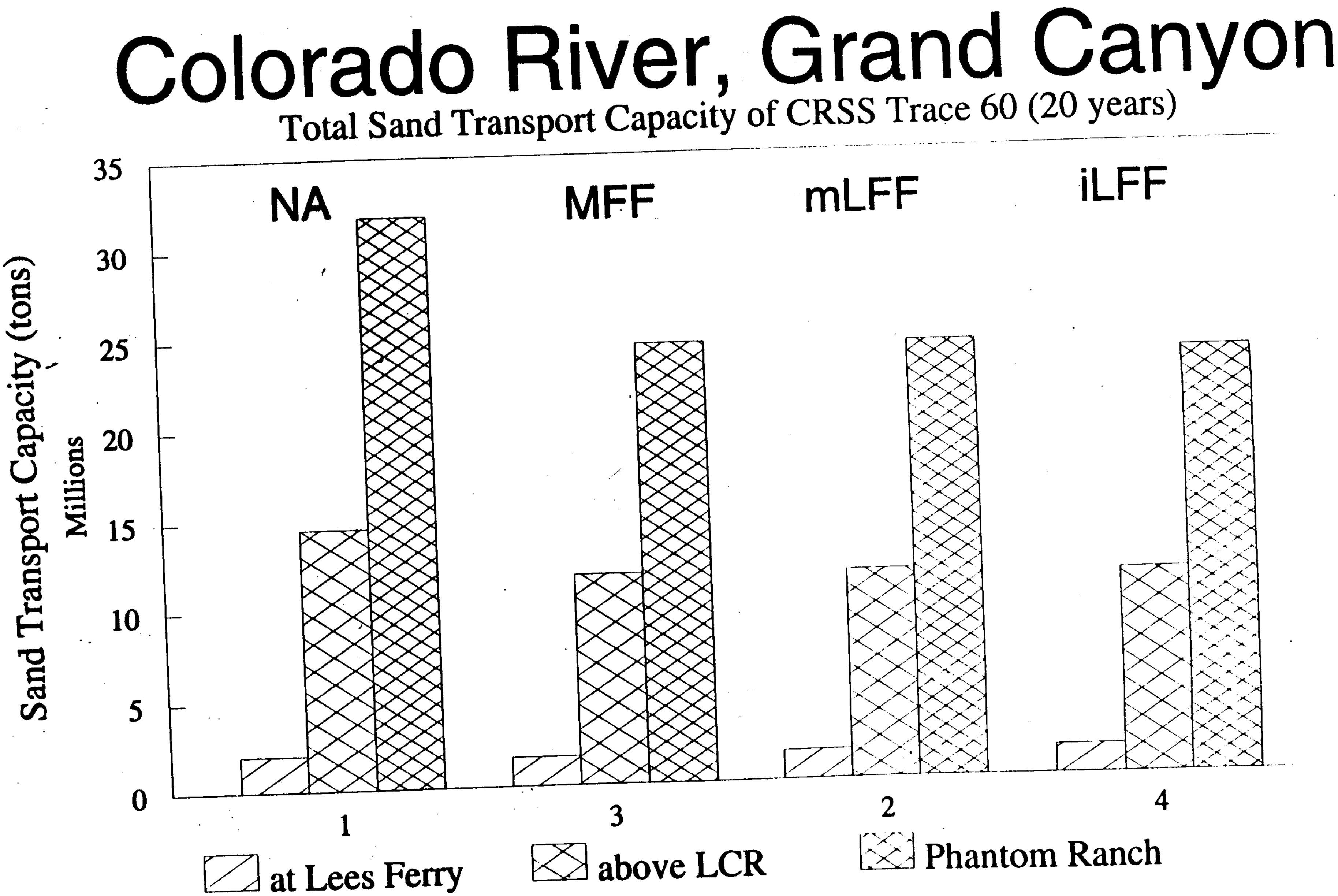

Figure 2.—Comparison of sand transport over a 20-year period for various EIS alternatives.

TABLE 4. PERCENT OF DAYS AND HOURS THAT FLOWS EXCEED GIVEN DISCHARGES FOR SELECTED ALTERNATIVES

		20,000 (cfs)	21,000 (cfs)	22,000 (cfs)	23,000 (cfs)	24,000 (cfs)	25,000 (cfs)
NA	(days)	72.2	64.6	55.3	40.5	25.7	14.4
	(hours)	25.4	21.8	18.2	13.5	8.8	5.5
iLFF	(days)	10.6	7.6	5.9	3.4	3.4	2.9
	(hours)	10.6	7.6	5.9	3.4	3.4	2.9
mLFF	(days)	29.0	22.7	18.8	12.4	7.7	2.9
	(hours)	14.1	10.5	8.8	5.5	4.5	2.9
MFF	(days)	22.6	15.9	12.2	7.7	6.6	4.3
	(hours)	13.4	9.5	7.8	4.9	4.3	3.3

Sources: iLFF, mLFF, and MFF (Rosekrans, 1995). NA (staff).

Note: To compute the average duration that a given flow is exceeded, multiply the percent days times 24 hours per day and then divide by the percent hours.

When the percent of days and hours are equal for a given alternative and flow, it means that flow would be exceeded all day (i.e. 24 hours).

Occasional flows between 20,000 and 25,000 cfs may cause minor amounts of localized beach building and provide water to riparian vegetation. A 3.5 percentage-point increase in the number of hours when 20,000 cfs would be exceeded would not conflict with the purposes of the 30,000-cfs habitat maintenance flow. This is because the habitat maintenance flows would be scheduled during minimum release years when 20,000 cfs would be exceeded 2.6 percent of the hours, and 22,000 cfs would be exceeded 1.1 percent of the hours.

At the anticipated level of usage of the increase in maximum flow (see Table 4), no impacts should occur to the terrestrial or aquatic resources below the dam. Sustained use of flows at the 25,000 cfs level would cause vegetation currently existing in the 20,000 to 25,000 cfs zone to show some stress from inundation. Limited use is made of this area for nesting, but the vegetation does provide substrate for insect production and for feeding of terrestrial species. Marsh habitats will be temporarily expanded as water seeps into existing backwaters and reattachment areas. Nearshore aquatic habitats will shift in location and size as the maximum flow level is increased, but this should not impact the short-term survival of individual species. No additional erosion of marsh or riparian zones is anticipated to occur.

Some individuals have argued that an increase in the maximum flow constraint will lead to increased exchanges of river water with low velocity backwaters, and a corresponding change in backwater temperatures. This outcome is more easily postulated when changing from steady flow conditions. Under fluctuating flow conditions, the extent of differential backwater warming effects remains to be established. In addition, only small numbers of backwaters exist at the present time (only one in the reach near the mouth of the LCR). These backwaters are associated with reattachment bars. Once a reattachment bar is submerged, the exchange rate of water and temperature between the river and the backwater increases. Reattachment bars are normally submerged at flows of 20,000 cfs. Since these bars are submerged at 20,000 cfs, they are also submerged at 25,000 cfs.

V. CONCLUSIONS

If the duration of flows between 20,000 and 25,000 cfs is at a low level, and the occurrences are infrequent, then no significant or measurable impacts would occur compared to conditions under interim flows. To the extent that impacts do occur they are not expected to be adverse.

Since all canyon resources are linked to sediment, sediment is the key indicator resource. Based on the analysis by Randle, Strand, and Streifel (1993), a maximum flow criteria of 25,000 cfs does not appear to significantly increase the rate of sand transport in the Grand Canyon.

Occasional flows between 20,000 and 25,000 cfs may result in minor and localized beach building and provide water to marsh habitats.

With the information presently available, the increase in the up-ramping rate from 2,500 cfs/hour to 4,000 cfs/hour and the increase in maximum flow from 20,000 cfs to 25,000 cfs would not lead to long-term degradation of the gains made during interim operations for canyon resources.

The final EIS preferred alternative would result in substantial benefits to canyon resources over the short and long term when compared with the no action alternative. Therefore, the final EIS preferred alternative meets the full spirit and intent of the Grand Canyon Protection Act.

At the present, we see little evidence that backwater warming will be affected by the envisioned increases in either the upramp rate or the maximum flow criteria.

Based on the all available information, the changes to the preferred alternative between the draft and final EIS would not result in a significant long-term impacts. The magnitude of any impacts that do occur would likely be less than that caused by the variability in tributary flow.

Some individuals have asserted that changing both the upramp rate and the maximum flow constraint at the same time is a poor experimental design. Viewed from the purely scientific viewpoint, it would be better to change variables one at a time in a controlled experiment. However, there are already many uncontrolled variables, and the interests lie in measuring the possible resource impact, if any, which might result from jointly changing both criteria. As described in this document, the best available information indicates that the long-term impact of changing both criteria at once will be difficult, if not impossible to detect.

Even though both parameters would be changed at the same time, for 8 months of an 8.23 maf year only the upramp would be used. The ability to operationally exceed 20,000 cfs only exists in months in which releases are in excess of 900,000 acre feet. In a minimum release year, the most probable months that increases above 20,000 cfs would occur are December, January, July and August. Evaluation of the upramp rate effects can be initiated immediately with evaluation of the increases in maximum flow relegated to the months with the highest volumes.

The changes in operations discussed above will be monitored as part of the Adaptive Management Program, and future changes in operations will be made if the scientific evidence supports it.

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APPENDIX A
Hydrology 101 / AOP Procedures

General Background

In the West, reservoirs serve as a moderating control over river flows by storing spring snowmelt runoff and releasing the water during the remainder of the year. The spring peaks can be quite large and releases are usually substantially smaller. The size of this difference directly affects the change in reservoir storage throughout the year. If this difference is large, the reservoir gains storage quickly in the spring and gradually loses storage during the remainder of the year. Water year 1995 is a good example of this phenomenon.

The monthly pattern of releases also affects reservoir storage. If the releases resemble a "natural" or unregulated hydrograph with high releases in the spring, reservoir storage would not change but the releases would vary widely. Conversely, if releases are held constant throughout the year, it is the reservoir levels that would fluctuate greatly.

Typical dam operation consists of balancing these reservoir storage and release objectives. Often, storage targets dictate releases. Releases are adjusted in response to inflow to meet these target storage levels.

In the case of Glen Canyon Dam, statutes and compacts govern the nature of annual releases as well as storage levels. A minimum objective release of 8.23 MAF was set by the 1970 Operating Criteria in an effort to meet "Law of the River" commitments to the Lower Basin States and Mexico. During periods of low inflow, this minimum objective release has the effect of drawing down Lake Powell and stabilizing Lake Mead storage. The drawdown of 1988 - 1994 was directly a result.

Storage equalization provisions in the 1968 Colorado River Basin Project Act also serve to keep the two large reservoirs relatively equal in content. At present this is a one-way equalization, occurring only if Lake Powell contents are greater than Lake Mead contents. The 1968 Act also contains an Upper Basin "storage insurance" clause, eliminating equalization if Lake Powell content drops below a level determined to protect Upper Basin consumptive uses, and a spill avoidance clause designed to avoiding wasting project water.

With these controls in place, determining monthly releases is sometimes a difficult matter. It begins by estimating future inflow, then adjusting future releases until storage objectives and release commitments are met. Five factors are key to these decisions: delivery requirements, reservoir inflow, storage, forecasts and potential forecast errors, and the downstream environment of the Grand Canyon.

To facilitate these determinations required by the various Acts and Compacts, the Colorado River Management Work Group was established by Reclamation in 1986. This group was originally comprised of the Basin States, Reclamation and Western, but has gradually grown to include a wide range of interests. The AOP process is now much more a public process with decisions appropriately discussed and debated. Risks and benefits are clearly stated and greater analysis accompanies the proposed plan. While the final decisions still lie with the Secretary of the Interior, this process has produced greater involvement, a broader range of ideas, and better decision making. Discussions in the group satisfy the consultation provisions of the 1968 Act and the 1992 Grand Canyon Protection Act regarding the AOP prepared under the 1968 Act.

The work group discusses many key issues regarding monthly and annual operation of Glen Canyon Dam. In recent years these issues included surplus/normal determinations, spill avoidance procedures, meeting firm power commitments, and research flows (including the spike flow). Since the AOP covers one water year (October 1 through September 30), Reclamation seeks comments from the group on its production of computer analysis and narrative for issuance by the Secretary of the Interior on October 1 of each year. Several meetings are held each year, typically starting in the spring and concluding in August. Several alternative hydrologic scenarios are considered for the following year, illustrating the range of decisions and conditions that could be expected. The resulting plans of operation include consideration of all project purposes.

Other key dates during each year's operation are January 1 and July 31. These respectively represent the dates when the first spring runoff forecast is available and when the reservoir is at its fullest point. The January 1 target affects the expected winter drawdown and is a springboard for future changes in scheduled release decisions which react to changing weather and forecast conditions. The July 31 target represents a compromise among maximizing conservation storage, avoiding spills, and dam safety issues. Both of these targets are adjusted until the storage and release regime comply with existing statutes and meet project needs.

Typical Reservoir Conditions

If reservoir storage is low and Lake Powell is not expected to fill, annual releases of 8.23 MAF are likely. Less risk of spills and over release of water and greater flexibility in determining releases usually exist when the reservoir is not expected to fill. The pattern of these monthly releases usually matches that of firm power commitments with higher releases during winter and summer months. Monthly release volumes vary between about 0.55 MAF and 0.9 MAF. Annual releases are sometimes required to be higher than 8.23 MAF to balance storage levels between Lakes Powell and Mead. The magnitude and duration of these equalization releases are unknown until much of the spring runoff has passed, usually late-June or July. Thus equalization water is usually released during the summer months prior to the end of the water year.

If reservoir storage is high and Lake Powell is expected to fill, annual releases nearly match the annual inflow. To manage water during full reservoir conditions, the highest priority must be given to dam safety concerns. The risk of spilling water becomes a factor, with dam safety as well as economic and environmental implications. Releases must be scheduled to preserve the greatest amount of flexibility for the peak storage months of June and July, without unduly risking the over release of water in storage. Often, this requires high releases during the winter to evacuate space in the reservoir and moderate releases during the spring to preserve operational flexibility. This produces the lowest reservoir storage during March and the highest storage during July. Avoiding anticipated spills is one of the 1968 Act provisions that is closely tied to dam safety concerns and also ensures that high flood flows do not damage the canyon ecosystems. With full reservoir conditions there are usually small margins for error in making these release decisions.

If the reservoir storage is in between these two situations, the objectives become more complex. Potential spills as well as over release of water on an annual basis are both risks. Release decisions are a careful balancing act and sometimes planned releases change dramatically with each new runoff forecast, usually occurring monthly and even bi-weekly during peak inflow periods. Changes in monthly releases on short notice can cause difficulties with power scheduling, recreational use, and research in the Grand Canyon.

Forecast errors introduce a great measure of uncertainty in planning future releases. The scheduling of releases must account for this to avoid the risks cited earlier. Continual updating and reanalyzing of basin conditions help to counter the weather variability which is the greatest cause of forecast errors. These errors are often as much as several MAF during mid-winter, a significant percentage of the total April - July runoff volume. The 1995 runoff was a good example of how abnormal weather patterns can greatly affect runoff. Since each year is different, both with respect to inflow volumes and forecast errors, the monthly release pattern changes continually, adjusting to changing forecasts. However, the basic principles remain the same.

APPENDIX B
Hydropower 101

This additional information on hydropower and power operations is intended to supplement the treatment of Hydropower in the Final GCDEIS, pgs 166-173. More information is provided on how Western consults with Reclamation in shaping hydropower releases within monthly release volumes, forecasts loads and schedules resources within its control, and makes real-time adjustments on a daily and hourly basis.

Marketing of CRSP Power

Western markets Glen Canyon and other Colorado River Storage Project electrical resources collectively as part of the Salt Lake City Area Integrated Projects (SLCA/IP). This energy and capacity is distributed under contract to wholesale firm power customers in the six western states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming.

The services offered by Western include long-term wholesale firm capacity and energy, short-term wholesale firm capacity and energy, and non-firm energy. The principal component, long-term wholesale firm power, serves Reclamation project use requirements and a portion of the total load of a large number of qualified preference customers. Almost all SLCA/IP customers have supplemental suppliers to satisfy customer demands in excess of SLCA/IP capacity and energy allocations since in low release years SLCA/IP cannot meet all of the customer load demands.

Each preference power customer has a contract which has a summer and winter season capacity and energy allocation. Customers are allowed to receive their maximum seasonal SLCA/IP firm capacity allocation during their historical peak-load month, with lesser amounts of capacity delivered in the remaining months of the season based on the customer's historical load pattern. SLCA/IP firm energy is also marketed in this manner.

Shaping of Powerplant Releases - Seasonal and Monthly

Through the development of the Annual Operating Plan, Reclamation attempts to incorporate comments from the Basin States, other Federal and State agencies, and the public on the coordinated operations of the Colorado River Upper Basin dams, including Glen Canyon. Western uses monthly release patterns from the AOP to assess impacts to power operations, purchase power expenses and Colorado River Basin Fund cashflow. Western's involvement in the AOP process typically includes suggestions of minor variations in monthly or seasonal release patterns or closer coordination of special releases between sites as possible ways to minimize associated expenses while satisfying all reservoir operation, environmental study, and power customer contract obligations.

Generally, firm power requirements involve scheduling higher monthly water releases in peak load months (typically December, January, July and August), and lower releases of water in months when electric power demand is less. This allows Western the limited ability to schedule greater purchases in low load months, when purchases are more economical. Long-term planning involves the determination of purchase power expenses, financial impacts to Basin Fund cashflows, and the sufficiency of established wholesale firm power rates.

Using forecasted powerplant monthly release volumes, Western patterns releases within constraints at each powerplant to estimate available hourly SLCA/IP energy and capacity and to assess the need for seasonal purchases or sales. For Glen Canyon, hourly generation patterns are assumed for a typical weekday (Monday through Friday), and typical weekend days (Saturday, and Sunday) taking into account the daily fluctuation limit, ascending and descending ramp rates, and minimum and maximum flows.

Seasonal and monthly decisions are then made whether to utilize either existing long-term energy purchase contracts, short-term or spot-market energy purchases, or combinations of these and other sources to satisfy contractual load obligations. Given the monthly pattern of forecasted releases, Western typically plans to purchase a majority of the on-peak energy during non-peak or "shoulder" months when it is usually least expensive. However, given restricted releases at Glen Canyon and Flaming Gorge and the pattern of monthly releases across a range of possible hydrologic conditions, purchases may be required during peak months and during on-peak hours for both weekend and weekdays at significantly greater expense. Purchase decisions are based on long-term purchase obligations, spot market energy prices, transmission availability, and any scheduled unit outages affecting other utilities, which affects prices and transmission.

If SLCA/IP surpluses are expected, Western would quantify the magnitude of these surpluses, assess associated risks and benefits, and may extend short-term energy and capacity offers to existing firm power customers.

Changes to forecasted reservoir operations can be expected throughout the water year due to the uncertainties of weather, expected snowpack, temperature patterns and streamflows (i.e, forecast error). Reclamation has recognized the significance of forecast errors and the need for an operational buffer at Lake Powell in its floodflow avoidance measures. As the monthly planned release volumes are modified to reflect changing conditions, Western must accommodate these changes in its load/resource planning and subsequent purchase or surplus sale activities.

Shaping of Powerplant Releases - Daily Basis

Generally, just as there is a seasonal pattern to Western's customer load demand, so also is there a daily pattern. During the night ("off-peak" hours), electrical demand is low. As people go to work in the morning, business and industrial demand for electricity increase. In the summer, this increase reaches a peak in the late afternoon. In the winter, there is also an additional peak around 10:00 a.m. As people return home in the evening, residential load begins to increase, displacing industrial load. Finally, electrical demand drops off sharply by midnight.

The ability to meet these demands is highly dependent on the volume of water available for generation. During less than average release years the water supply is insufficient to meet contract peak demands, thus optimal use of this limited supply reduces the cost of purchases. As a result, scheduled hourly powerplant releases usually follow this demand for electricity. During offpeak hours powerplant releases are typically reduced to minimum release requirements whenever possible to save water for on-peak generation, and energy is purchased to serve off-peak loads. Hydrogeneration is therefore scheduled within release constraints against the hourly load to maximize the value of the limited energy supply. However, uncertainty in hourly load and other factors (e.g., downramp restrictions) prevent the optimal scheduling of the hydropower resource.

Changes in forecasted inflow and release volumes introduce uncertainty in monthly available hydropower. In addition, Western's daily power scheduling must also address the full range of other events within each month or season which typically require changes in powerplant releases. These include changes in customer demand, generating unit outages, emergency requests for generation assistance, and unscheduled deviations from pre-scheduled activities.

For each weekday, 24-hour advance hourly schedules of expected energy demand are required from SLCA/IP firm power customers. Western schedulers then determine total hourly firm requirements for the upcoming day. For weekends, advance schedules may cover longer periods, up to 4 days during holiday periods and are particularly difficult to predict. In addition, customers may vary their daily schedule throughout the month. As a result, Western often schedules hourly releases in average or typical patterns, particularly on weekends. In these cases less than full use is made of generation capacity, primarily to avoid violation of release constraints caused by real-time changes in demands. Thus the hourly operation of the powerplants is less than optimal and does not exactly follow the generation that might be predicted by an "after the fact" analysis using perfect knowledge of hourly demands.

Real-time Adjustments in Releases

During actual real-time dispatching of releases, expected purchases and sales must be adjusted to reflect conditions of scheduled transmission line outages and critical transmission line loadings, and to ensure that specific transmission contract paths are being used. Western's dispatchers must be flexible to adapt to real-time power system needs and uncertain conditions, such as (a) economic market opportunities, (b) emergency deliveries, (c) transmission overloads or contractual schedule limits, (d) unscheduled customer deviations from power schedules, and (e) changes in forecasted reservoir operations, unit availability, and powerplant constraints. These conditions may make it economically beneficial to try to buy or sell more or less power than anticipated. Also, when adjacent utilities lose resources due to forced outages or maintenance requirements, they may seek emergency assistance from the Federal systems which was unanticipated.

Transmission overloads or contractual schedule limits may restrict planned resource exchanges. Mid-month changes in water release volumes due to changes in forecasted runoff affects the water resources available. Such changes may require disposing of more or less hydropower energy. These all may alter the anticipated Federal energy available for load or marketing on a real-time basis and limit the capability of optimally using hydropower.

Factors Which Affect Maximum Releases

Glen Canyon powerplant release constraints are key components of the Interim Flow restrictions. The absolute limits of 5,000 and 20,000 cfs have particular importance to aquatic and sediment resources. The extent of daily fluctuations affect all downstream resources.

The frequency that releases exceed a certain flow are tied directly to the monthly release volume and peak energy demands. Historic operating practices under the constrains of Interim Flows have shown that peak releases do not reach 20,000 cfs unless the monthly release volume is at least 900,000 AF (daily average of 15,000 cfs). This is intuitive since the maximum allowable daily fluctuation of 8,000 cfs effectively limits the departure from the daily average. The uncertainties of power system load, purchase cost and availability, and transmission capability have historically tended to keep generation from strictly matching loads. Therefore, maximum releases are fairly predictable, largely a function of average daily release and allowable daily fluctuations. Variance from this equation largely results from the uncertainties cited earlier.

Summary

Many factors influence the actual hourly releases that occur at each SLCA/IP hydropower facility within Western's control. A number of these factors are outside Western's ability to directly determine on an hour-by-hour basis. Western has recently instituted planning practices which consider the uncertainty of the factors and the magnitude of their influence on actual hourly releases at Glen Canyon. Certain practices, such as average-day planning for purchases, 24-hour advance schedule customer requirements, and weekend generation margins, have attempted to reduce the likelihood of release violations. However, key factors will remain uncertain in the future under constrained operations at Glen Canyon. These factors include the monthly hydropower available, the daily or weekly customer demands, and future spot-market conditions. These factors, either alone or in combination, will continue to compound the difficulty to plan supplemental energy purchases at the optimal least cost.